24-May-10	09:30 – 10:00	Invited Oral	Main Hall

MOXAMH — Special Opening Presentation

Chair: K. Oide, KEK (Ibaraki)

MOXAMH01 **International Collaboration with High Energy Accelerators** – *A. Wagner (DESY)*
International collabollations on high energy physics will be described, referring its long history and with emphasis on the recent activity based on ICFA.

24-May-10	10:00 – 10:30	Invited Oral	Main Hall

MOXBMH — Circular Colliders

Chair: K. Oide, KEK (Ibaraki)

MOXBMH01 **LHC Commissioning and First Operation** – *S. Myers (CERN)*
The LHC hardware and beam commissioning and initial operation will be reviewed both in terms of beam and hardware performance. The implemented machine protection measures and their impact on LHC operation will be presented.

24-May-10	11:00 – 11:30	Invited Oral	Main Hall

MOYAMH — Synchrotron Light Sources and FELs

Chair: O.S. Brüning, CERN (Geneva)

MOYAMH01 **The First Angstrom X-rays Free Electron Laser** – *J.N. Galayda (SLAC)*
The Linac Coherent Light Source free-electron laser was commissioned on 10 April 2009. The facility has begun operating for atomic/molecular/optical science experiments. Commissioning results have been presented*. Performance of the facility in its first user run (1 October - 21 December) and current machine development activities will be presented.

24-May-10	11:30 – 12:00	Invited Oral	Main Hall

MOYBMH — Hadron Accelerators

Chair: O.S. Brüning, CERN (Geneva)

MOYBMH01 **World-wide Efforts on Rare Isotope and Radioactive Beams** – *O. Kamigaito (RIKEN Nishina Center)*
Study on atomic nuclei has expanded remarkbly to a broad range of region far from stability since 1980's when a number of accelerator facilities launched scientific programs on rare isotopes and radioactive beams. Today, second-generation accelerator facilities dedicated to research on the rare isotopes and radioactive beams are either operating, under construction, or being proposed. Various types of accelerators are currently used, depending on the goal of research on a variety of unstable nuclei. Based on the recent activity of the radioactive Ion Beam Facility at RIKEN, this presentation provides a world wide overview of the activity on radioactive beams.

24-May-10	12:00 – 12:30	Invited Oral	Main Hall

MOYCMH — Applications of Accelerators

Chair: O.S. Brüning, CERN (Geneva)

MOYCMH01 **Relativistic Ion Beams for Treating Human Cancer** – *W.T. Chu (LBNL)*
At LBNL in Berkeley, clinical trials were conducted (1975-1992) for treating human cancer using ion beams from the Bevalac and treated about 700 patients with helium-ion and about 300 patients with neon-ion beams.* Clinical trials (1997-2005) at GSI in Darmstadt, Germany used carbon-ion beams to treat about 250 patients. In 1994, NIRS in Chiba, Japan, commissioned its first-in-the-world ion-beam therapy facility, HIMAC, which accelerates ions as heavy as argon nuclei to 800 MeV/nucleon. Following it, several carbon-ion therapy facilities have been, or will be soon, constructed in: Hyogo (2001) and Gunma (2010), Japan; Heidelberg (2009), Marburg (2010) and Kiel (2012), Germany; Pavia (2010), Italy; Lyon (2013), France; Wiener Neustadt (2013), Austria; Shanghai and Lanzhou, China; and Minnesota and California, USA. Technical specifications of these facilities are: ion sources delivering all ion species from proton to carbon,

accelerator energy of 430 MeV/n (30-cm range in tissue), beam intensity of about 10^9 pps (to deliver 1 Gy/min into 1-liter volume), repetition rate of about 0.5 Hz with long spill (for beam scanning), and treatment beam delivery and patient safety systems.

24-May-10	14:00 – 15:00	Invited Oral	Main Hall

MOZMH — Hadron Accelerators

Chair: G.-H. Luo, NSRRC (Hsinchu)

MOZMH01 **Experience and Lessons with the SNS Superconducting Linac** – *Y. Zhang (ORNL)*

Experience and lessons with the SNS superconducting linac over the first 5 years of commissioning and operation are reviewed. As the beam power was ramped up to 1 MW, the linac beam loss has been maintained below 1 W/m and residual activation has been held to a safe level. This can be attributed mainly to a robust accelerator design as well as to dedicated beam dynamics studies during this period. In addition to a review of both transverse and longitudinal beam phase-space measurements, we will review several hardware lessons learned with this high-power proton linac – such as nonlinear multipole components of the linac quadrupoles, beam collimators, high-order-mode couplers of the superconducting cavities, and cavity piezo tuners.

MOZMH02 **World-wide Development of Intense Highly Charged Superconducting ECR Ion Sources** – *H.W. Zhao (IMP)*

Advancement of nuclear physics and high power heavy ion accelerator is always a driving force for persistent development of highly charged ECR ion source. Increasing demands for more intense and higher charge state heavy ion beams have dramatically promoted development of ECR ion source technology and physics. This talk will provide an overview of intense highly charged superconducting ECR ion sources built by the worldwide laboratories in the last few years. The key technologies, challenges and main issues related to construction and operation of high performance superconducting ECR ion source will be reviewed. The latest results of intense highly charged ion beam production from the superconducting ECR ion sources will be presented. Beam quality study and transmission of intense highly charged ion beams are also reviewed in order to achieve high injection efficiency for cyclotron and heavy ion Linac. Future development and the next generation highly charged ECR ion source will be discussed.

24-May-10	15:00 – 15:40	Contributed Oral	Main Hall

MOOCMH — Synchrotron Light Sources and Circular Colliders

Chair: G.-H. Luo, NSRRC (Hsinchu)

MOOCMH01 **Accelerator Physics Issues for the TPS** – *C.-C. Kuo, H.-P. Chang, H.C. Chao, M.-S. Chiu, P.J. Chou, G.-H. Luo, A. Rusanov, H.-J. Tsai, F.H. Tseng (NSRRC)*

Taiwan Photon Source (TPS) is a low emittance third-generation light source which is currently under construction in the NSRRC site in Taiwan. TPS consists of 24 double-bend cells and its circumference is 518.4 m. A 496.8-m booster with multi-bend structure is designed. The alternative lattices, such as high/low betax, chicanes with double-vertical-waists in the long straights, and short bunches with low momentum compactions, etc., are investigated. Orbit and coupling corrections and stability issues are studied. Touschek lifetime and effects due to insertion devices are simulated. Works on impedance estimation and instability simulations are performed.

MOOCMH02 **Overview of Short Pulse X-ray Generation using Crab Cavities at SPring-8** – *T. Fujita, H. Hanaki, T. Nakazato (JASRI/SPring-8) K. Akai, K. Ebihara, T. Furuya, K. Hara, T. Honma, K. Hosoyama, A. Kabe, Y. Kojima, S. Mitsunobu, Y. Morita, H. Nakai, K. Nakanishi, M. Ono, Y. Yamamoto (KEK) M. Matsuoka, K. Sennyu, T. Yanagisawa (MHI) M. Monde (Mitsubishi Heavy Industries Ltd. (MHI))*

We have been developing a system to generate a short pulse X-ray using crab cavities at SPring-8 Storage Ring. The ring holds 30-m long straight sections and the vertical beam size at the center of the straight sections is 6.5 micrometers in standard deviation. If we install four superconducting crab cavities and a mini-pole undulator in one of the straight sections, we can convert the time distribution of the electron bunch into the spatial distribution. After slicing the emitted photons with vertical slits, we can obtain a sub-picosecond X-ray pulse. In this scheme, the maximum repetition rate of the short pulse X-ray is the same as the acceleration frequency of the ring (508MHz) and user experiments at other beam-lines are not disturbed by this short pulse generation. We are planning to install KEKB type crab cavities as vertical deflectors. Phase fluctuation among crab cavities must be reduced less than 14 mdeg in order to avoid residual deflection in the vertical direction. In this paper, we report an overview of the short pulse generation scheme and topics of hardware development for stabilization of the RF phase fluctuation.

24-May-10	15:40 – 16:00	Contributed Oral	Main Hall

MOOCMH — Synchrotron Light Sources and Circular Colliders

Chair: G.-H. Luo, NSRRC (Hsinchu)

MOOCMH03 **Beam Commissioning Status of Superconducting Crab Cavities in KEKB** – *Y. Yamamoto, K. Akai, K. Ebihara, T. Furuya, K. Hara, T. Honma, K. Hosoyama, A. Kabe, Y. Kojima, S. Mitsunobu, Y. Morita, H. Nakai, K. Nakanishi, M. Ono (KEK) T. Kanekiyo (Hitachi Technologies and Services Co., Ltd.)*

Two superconducting crab cavities have been operated stably without any significant trouble for three years in KEKB since Feb/2007. At present (Dec/2009), maximum beam current with 'Crab ON' achieves 1200mA for HER (High Energy Ring, electron) and 1640mA for LER (Low Energy Ring, positron), respectively. RF trip rate per day due to crab cavity during 'physics run' was 2.8/day for HER and 0.4/day for LER at the beginning, and is 0.8/day for HER and 0.1/day for LER at present, respectively. Although Piezo actuator was frequently broken down at the beam abort with RF trip of the crab cavity, it was controlled stably by only LLRF (Low Level RF) feed-back system without Piezo actuator. Maximum HOM (Higher Order Mode) power, which is measured at HOM dampers made from ferrite, is 9.1kW for HER and 14.6kW for LER at the maximum beam current, respectively. LER crab voltage, which had suddenly dropped from 1.50MV to 1.10MV on March/2007, was gradually recovered from 1.14MV to 1.33MV in 2008.

24-May-10	14:00 – 15:00	Invited Oral	Room A

MOZRA — Accelerator Technology

Chair: K. Wittenburg, DESY (Hamburg)

MOZRA01 **Commissioning Experience and Recent Results for the Cornell High Power ERL Injector** – *F. Loehl (CLASSE)*

The development of high current, high brightness electron guns is critically important for FEL and ERL light source facilities. In this talk we will review the technical requirements of such projects and the status of ongoing research throughout the community including results of emittance measurements and high current beam performance.

MOZRA02 **Trends in the Development of Insertion Devices for a Future Synchrotron Light Source** – *C.-S. Hwang, S.D. Chen (NSRRC) T.M. Uen (NCTU)*

An in-vacuum undulator with a room-temperature permanent magnet and a superconducting wiggler has become a mature technology and is widely used; it can adopt a short-period length in a medium-energy facility to provide an enhanced photon flux in the hard x-ray region. A cryogenic permanent magnet is applicable for an in-vacuum undulator to enhance the remanence field (Br) and the coercivity force. In future, a cryogenic permanent-magnet undulator and a superconducting wiggler will become mainstream to fulfill a user's requirement of a discrete and a continuous spectrum, respectively, but superconducting technology with HTS wires will have the best potential for the development of insertion devices after the next decade. HTS bulk magnets with magnet flux density 17 T are applicable even for a superconducting undulator; such an undulator can decrease the period length to about 10 mm. A small magnet gap with an extremely- short-period length (about 5 mm) has been studied with a stacked-layer of thin HTS tapes for a superconducting undulator. This report is a review to describe the current and future developments of insertion devices for a medium-energy storage ring and FEL facility.

24-May-10 15:00 – 16:00	Contributed Oral	Room A

MOOCRA — Accelerator Technology

Chair: K. Wittenburg, DESY (Hamburg)

MOOCRA01 **The Magnetic Model of the LHC in the Early Phase of Beam Commissioning** – *E. Todesco, B. Auchmann, L. Bottura, G. Deferne, L. Deniau, S.D. Fartoukh, M. Giovannozzi, P. Hagen, M. Lamont, RV. Remondino, F. Schmidt, R.J. Steinhagen, M. Strzelczyk, W. Venturini Delsolaro, J. Wenninger, R. Wolf (CERN) N.J. Sammut (University of Malta, Faculty of Engineering)*

The relation between field and current in each family of the Large Hadron Collider magnets is modeled with a set of empirical equations (FiDeL) whose free parameters are fitted on magnetic measurements. They take into account of residual magnetization, persistent currents, hysteresis, saturation, decay and snapback during initial part of the ramp. Here we give a first summary of the reconstruction of the magnetic field properties based on the beam observables (orbit, tune, coupling, chromaticity) and a comparison with the expectations based on the large set of magnetic measurements carried out during the 5-years-long production. The most critical issues for the machine performance in terms of knowledge of the relation magnetic field vs current are pinned out.

MOOCRA02 **Design and Test of the First Long Nb3Sn Quadrupole by LARP** – *G. Ambrosio, G. Chlachidze, M.J. Lamm, A. Nobrega, E. Prebys (Fermilab) S. Caspi, H. Felice, P. Ferracin, G.L. Sabbi (LBNL) T.W. Markiewicz (SLAC) J. Schmalzle, P. Wanderer (BNL)*

The first Nb3Sn Long Quadrupole (LQS01) designed and fabricated by the US LHC Accelerator Research Program (LARP) reached its target gradient of 200 T/m during the first test. LQS01 is a 90 mm aperture, 4 meter long quadrupole with Nb3Sn coils made of RRP 54/61 strand (by Oxford Superconducting Technology). The two-layer coil design is based on the LARP 1m Technological Quadrupoles (TQC and TQS). The mechanical structure is based on the TQS structure implementing an aluminum shell preloaded by using bladders and keys. In 2005 LARP, in agreement with DOE and CERN, set the goal of reaching 200 T/m in a long Nb3Sn quadrupole by the end of 2009. Achieving this goal in the first test shows the maturity reached by the Nb3Sn technology for possible application to particle accelerators. Additional tests have been performed aiming at reproducing the performance of the most recent TQ models in order to demonstrate that there are no significant scale-up issues with this technology.

MOOCRA03 **Femtosecond Synchronization of Laser Systems for the LCLS** – *J.M. Byrd, L.R. Doolittle, G. Huang, J.W. Staples, R.B. Wilcox (LBNL) J. Arthur, J.C. Frisch, W.E. White (SLAC)*

The scientific potential of femtosecond x-ray pulses at linac-driven FELs such as the LCLS is tremendous. Time-resolved pump-probe experiments require a measure of the relative arrival time of each x-ray pulse with respect to the experimental pump laser. In order to achieve this, precise synchronization is required between the arrival time diagnostic and the laser which are often separated by hundreds of meters. We describe an optical timing system based on stabilized fiber links which has been developed for the LCLS to provide this synchronization. Preliminary results show stability of the timing distribution at the sub-10 fsec level and overall synchronization of the x-rays and pump laser of less than 40 fsec. We present details of the implementation and LCLS and potential for future development.

25-May-10 08:30 – 10:30	Invited Oral	Main Hall

TUXMH — Circular Colliders

Chair: A.N. Skrinsky, BINP SB RAS (Novosibirsk)

TUXMH01 **RHIC Luminosity Upgrade Program** – *W. Fischer (BNL)*

The Relativistic Heavy Ion Collider (RHIC) operates with either ions or polarized protons. After increasing the heavy ion luminosity by two orders of magnitude since its commissioning in 2000, the current luminosity upgrade program aims for an increase by another factor of 4 by means of 3D stochastic cooling and a new 56 MHz SRF system. An Electron Beam Ion Source is being commissioned that will allow the use of uranium beams. Electron cooling is considered for collider operation below the current injection energy. For the polarized proton operation both luminosity and polarization are important. In addition to ongoing improvements in the AGS injector, the development of a new high-intensity polarized source has started. In RHIC a number of upgrades are under way to increase the intensity and polarization transmission to 250 GeV beam energy. Electron lenses will be installed to partially compensate the head-on beam-beam effect.

TUXMH02 **LHC Optics Model Measurements and Corrections** – *R. Tomas (CERN)*

Optics stability during all phases of operation is crucial for the LHC. The optical properties of the machine have been optimized based on a detailed magnetic model of the SC magnets and on their sorting. Tools and procedures have been developed for rapid checks of beta beating, dispersion, and linear coupling, as well as for prompt optics correction. Initial optics errors, correction performance and optics stability from the first LHC run will be reported, and compared with expectations. Possible implications for the collimation cleaning efficiency and LHC machine protection will be discussed.

25-May-10 09:30 – 10:30	Contributed Oral	Main Hall

TUOAMH — Circular Colliders

Chair: A.N. Skrinsky, BINP SB RAS (Novosibirsk)

TUOAMH01 **Beam Based Setup of LHC Collimators in IR3 and IR7: Accuracy and Stability** – *D. Wollmann, R.W. Assmann, C. Bracco, R. Losito, A. Masi, S. Redaelli, A. Rossi, V. Vlachoudis (CERN)*

The LHC has two dedicated cleaning insertions: IR3 for momentum cleaning and IR7 for betatron cleaning. The collimation system has been specified and built with tight mechanical tolerances (e.g. jaw flatness ~ 40 μm) and is designed to achieve a high accuracy and reproducibility of the jaw positions. The practically achievable cleaning efficiency of the present Phase-I system depends on the precision of the jaw centering around the beam, the accuracy of the gap size and the jaw parallelism against the beam. The reproducibility and stability of the system is important to avoid the frequent repetition of beam based alignment which is currently a lengthy procedure. Within this paper we describe the method used for the beam based alignment of the collimators installed in the two LHC cleaning insertions and the achieved accuracy and stability of the system.

TUOAMH02 **LHC Crab-cavity Aspects and Strategy** – *R. Calaga (BNL) J.-P. Koutchouk, R. Tomas, J. Tuckmantel, F. Zimmermann (CERN)*

The 3rd LHC Crab Cavity workshop (LHC-CC09) took place at CERN in October 2009. It reviewed the current status and identified a clear strategy towards a future crab-cavity implementation. Following the success of crab cavities in KEK-B and the strong potential for luminosity gain and leveling, CERN will pursue crab crossing for the LHC upgrade. We present the summaries of the various workshop sessions which have led to the LHC crab-cavity strategy, covering topics like layout, cryomodule design, construction, integration, validation, and planning.

TUOAMH03 **Channeling and Volume Reflection Based Crystal Collimation of the Tevatron Circulating Beam Halo (T980)** – *V.D. Shiltsev, G. Annala, R.A. Carrigan, A.I. Drozhdin, T.R. Johnson, A.M. Legan, N.V. Mokhov, R.E. Reilly, D.A. Still, R. Tesarek, J.R. Zagel (Fermilab) R.W. Assmann, V.P. Previtali, W. Scandale (CERN) Y.A. Chesnokov, I.A. Yazynin (IHEP Protvino) V. Guidi (INFN-Ferrara) Yu.M. Ivanov (PNPI) S. Peggs (BNL)*

The T980 crystal collimation experiment is underway at the Tevatron to study various crystal types and parameters and evaluate if this technique would increase TeV beam-halo collimation efficiency at high-energy hadron colliders such as the Tevatron and the LHC. The setup has been substantially enhanced during the Summer 2009 shutdown by installing a new O-shaped crystal in the horizontal goniometer, adding a vertical goniometer with two alternating crystals (O-shaped and multi-strip) and additional beam diagnostics. First measurements with the new system are quite encouraging, with channeled and volume-reflected beams observed on the secondary collimators as predicted. Investigation of crystal collimation efficiencies with crystals in volume reflection and channeling modes are described in comparison with an amorphous primary collimator. Results on the system performance are presented for the end-of-store studies and for entire collider stores. Planning is underway for dedicated studies during a Tevatron post-collider physics running period.

25-May-10	11:00 – 12:30	Invited Oral	Main Hall

TUYMH — Beam Dynamics and Electromagnetic Fields

Chair: S.R. Koscielniak, TRIUMF (Vancouver)

TUYMH01 **Review of Beam Dynamics Issues in MW Class Ion Linacs** – *R.D. Duperrier (CEA)*

An important issue for the new high power class ion linac projects is the preservation of the beam quality through the acceleration in the linac. An extremely low fraction of the beam (from 10^{-4} down to 10^{-7}) is sufficient to complicate the hands on maintenance in such accelerator. This paper reviews the theory and the codes for the design and simulation of MW ion linacs. Basics rules for the definition of their architecture and the results applied to existing machines and projects are covered.

TUYMH02 **Electron Cloud at Low Emittance in CesrTA** – *M.A. Palmer, J.P. Alexander, M.G. Billing, J.R. Calvey, J.A. Crittenden, G. Dugan, N. Eggert, M.J. Forster, S. Greenwald, D.L. Hartill, W.H. Hopkins, D.L. Kreinick, Y. Li, X. Liu, J.A. Livezey, R.E. Meller, S.B. Peck, D.P. Peterson, D.H. Rice, N.T. Rider, D. L. Rubin, D. Sagan, R.M. Schwartz, J.P. Shanks, J.P. Sikora (CLASSE) F. Antoniou, S. Calatroni, M. Gasior, Y. Papaphilippou, J. Pfingstner, G. Rumolo, H. Schmickler, M. Taborelli (CERN) J.M. Byrd, J.N. Corlett, S. De Santis, M.A. Furman, R. Kraft, D.V. Munson, G. Penn, D.W. Plate, M. Venturini (LBNL) J.W. Flanagan, K. Kanazawa, H. Sakai, K. Shibata, Y. Suetsugu (KEK) K.C. Harkay (ANL) R. Holtzapple (CalPoly) J.K. Jones, A. Wolski (Cockcroft Institute) M.T.F. Pivi, L. Wang (SLAC) C.-Y. Tan, R.M. Zwaska (Fermilab)*

The Cornell Electron Storage Ring (CESR) has been reconfigured as a test accelerator (CesrTA) for a program of electron cloud (EC) research at ultra low emittance. The instrumentation in the ring has been upgraded with local diagnostics for measurement of cloud density and with improved beam diagnostics for the characterization of both the low emittance performance and the beam dynamics of high intensity bunch trains interacting with the cloud. Finally a range of EC mitigation methods have been deployed and tested. Measurements of cloud density and its impact on the beam under a range of conditions will be presented and compared with simulations. The effectiveness of a range of mitigation techniques will also be discussed.

TUYMH03 **Developing Peta-Scalable Algorithms for Beam Dynamic Simulations** – *J. Xu, P.F. Fisher, M. Min, B. Mustapha, J.A. Nolen, P.N. Ostroumov (ANL)*

Peta-scalable software packages for beam dynamic simulations are being developed and used at the Argonne Leadership Computing Facility. The standard Particle-In-Cell (PIC) method and direct Vlasov solvers in 4 dimensions have been developed and benchmarked with respect to each other. Both of them have been successfully run on 32 thousands processors on BG/P at Argonne National Laboratory. Challenges and prospects of developing Vlasov solvers in higher dimensions will be discussed. Several scalable Poisson solvers have been developed and incorporated with these software packages. Domain decomposition method has been used for the parallelization. In the future developments, these algorithms will be applied to hundreds of thousands processors for peta-scale computing. These software packages have been applied for the design of accelerators, and some large scale simulations will be shown and discussed.

25-May-10	14:00 – 16:00	Invited Oral	Main Hall

TUZMH — Beam Instrumentation and Feedback

Chair: T. Nakamura, JASRI/SPring-8 (Hyogo-ken)

TUZMH01 **Minimal Invasive Beam Profile Monitors for High Intense Hadron Beams** – *P. Forck (GSI)*

Non-destructive profile measurements are preferred not only for single-pulse diagnostics at different locations in a transfer line, but also to enable time resolved observations of stored the beam within a synchrotron. Moreover, the large beam power available at modern hadron accelerators excludes intersecting materials like screens, SEM-grids or scanners. Over the last years advanced concepts were realized: Ionization profile monitors are based on residual gas ionization and their spatially resolved detection. A complimentary method uses single photons detection of beam induced residual gas excitation. A third method is based on the deflection of a crossing electron beam to reconstruct the beam's transverse distribution. At LINACs for negative hydrogen acceleration, a scanning laser beam combined with a photo-electron detector was developed. The transverse profile can be monitored by means of a dedicated pick-up for the determination of the beam's quadrupole moment, i.e. the difference of the horizontal and vertical beam variance. The physical principles and technical realizations of these monitors are discussed.

TUZMH02 **Feedback Requirements for SASE-FELs** – *H. Loos (SLAC)*

The talk will provide an overview of required feedback systems to guarantee stable and successful SASE operation as well as successful experiments. Recent developments and examples of various systems (including feedbacks for long bunch trains) will be discussed.

25-May-10	15:00 – 16:00	Contributed Oral	Main Hall

TUOCMH — Beam Instrumentation and Feedback

Chair: T. Nakamura, JASRI/SPring-8 (Hyogo-ken)

TUOCMH01 **Pulse-to-pulse Beam Modulation and Event-based Beam Feedback Systems at KEKB Linac** – *K. Furukawa, T.T. Nakamura, M. Satoh, T. Suwada (KEK)*

Beam injections to KEKB and Photon Factory are performed with pulse-to-pulse modulation at 50Hz. Three very different beams are switched every 20ms in order to inject those beams into KEKB HER, LER and Photon Factory (PF) simultaneously. Human operators work on one of those three virtual accelerators, which correspond to three-fold accelerator parameters. Beam charges for PF injection and the primary electron for positron generation are 50-times different, and beam energies for PF and HER injection are 3-times different. Thus, the beam stabilities are sensitive to operational parameters, and if any instability in accelerator equipment occurred, beam parameter adjustments for those virtual accelerators have to be performed. In order to cure such a situation, beam energy and orbit feedback systems are installed that can respond to each of virtual accelerators independently.

TUOCMH02 **Stabilization and Fine Positioning to the Nanometre Level of the CLIC Main Beam Quadrupoles** – *K. Artoos, C. Hauviller, C.G.R.L. Collette, M. Guinchard, S.M. Janssens, A.M. Kuzmin, F. Lackner, M.V. Sylte (CERN)*

The CLIC main beam quadrupoles need to be stabilized to 1 nm integrated R.M.S. displacement at 1 Hz. The choice was made to apply active stabilization with piezoelectric actuators in a rigid support with flexural guides. The advantage of this choice is the possibility to make fast incremental nanometre positioning of the magnet with the same actuators. The study and feasibility demonstration is made in several steps from a single degree of freedom system (s.d.o.f.) with a small mass, a s.d.o.f. with a large mass, leading to the demonstration including the smallest (type 1) and largest (type 4) CLIC main beam quadrupoles. The paper discusses the choices of the position and orientation of the actuators and the tailored rigidities of the flexural hinges in the multi degree of freedom system, and the corresponding MIMO control system. The compatibility with the magnet support and micrometer alignment system is essential. The status of the study and performed tests will be given.

TUOCMH03 **Initial Experience with the Machine Protection System for LHC** – *R. Schmidt, J. Wenninger (CERN)*

Nominal beam parameters at 7TeV/c will only be reached after some years of operation, with each proton beam having a stored energy of 360MJ. However, a small fraction of this energy is sufficient to damage accelerator equipment or experiments in case of uncontrolled beam loss. The correct functioning of the machine protection systems is vital during the different operational phases already for initial operation. When operating the complex magnet system, with and without beam, safe operation relies on the protection and interlock systems for the superconducting circuits. For safe injection and transfer of beam from SPS to LHC, transfer line parameters are monitored, beam absorbers must be in the correct position and the LHC must be ready to accept beam. At the end of a fill and in case of failures beams must be properly extracted onto the dump blocks, for some failures within less than few hundred microseconds. Safe operation requires many systems: beam dumping system, beam interlocks, beam instrumentation, equipment monitoring, collimators and absorbers, etc. We describe the commissioning of the LHC machine protection system and the experience during the initial operation.

25-May-10 08:30 – 10:30	Invited Oral	Room A

TUXRA — Synchrotron Light Sources and FELs

Chair: F. Perez, CELLS-ALBA Synchrotron (Cerdanyola del Vallès)

TUXRA01 **Commissioning of PETRA III** – *K. Balewski (DESY)*

PETRA III is a new hard x-ray synchrotron radiation source at DESY in Hamburg operating at 6 GeV with an extremely low horizontal emittance of 1 nmrad. The new light source is the result of a conversion of the former storage ring PETRA II. The conversion was carried out from middle of 2007 till March 2009. One eighth of the 2304 m long storage ring was completely rebuild and houses now 14 undulator beam lines as well as the optical and experimental hutches. The remaining seven eighths have been modernized and refurbished and in addition twenty 4 m long damping wigglers have been installed. These are required to achieve the small design emittance. Commissioning of the new light source started at the end of March 2009. In this paper we present the results that have been achieved during commissioning and the experience gained during the first user runs.

TUXRA02 **Status Report on Japanese XFEL Construction Project at SPring-8** – *T. Shintake (RIKEN/SPring-8)*

SASE based X-ray free-electron laser is now under construction at the SPring-8 site. This project is aiming at realization of SASE FEL of 1 angstrom initially and approaches to seeded XFEL in the second stage. For this future extension, a very unique system was adopted, composed of a low emittance SHB-based injector with CeB6 cathode thermionic gun, normal conducting high gradient C-band acceleration system and high performance in-vacuum undulators. This presentation will provide a comprehensive project review and recent project progress.

25-May-10 09:30 – 10:30	Contributed Oral	Room A

TUOARA — Synchrotron Light Sources and FELs

Chair: F. Perez, CELLS-ALBA Synchrotron (Cerdanyola del Vallès)

TUOARA01 **FLASH Upgrade** – *K. Honkavaara, B. Faatz, J. Feldhaus, S. Schreiber, R. Treusch (DESY) J. Rossbach (Uni HH)*

The free-electron laser user facility FLASH at DESY, Germany has been upgraded. The upgrade started in autumn 2009 after almost 2 years of a very successful second user period. The beam energy is increased to 1.2 GeV by installing a 7th superconducting accelerating module. The new module is a prototype for the European XFEL. Among many other upgrades, 3rd harmonic superconducting RF cavities are installed in the injector. The main purpose is to flatten and - to a certain extend - to shape the longitudinal electron beam phase space improving the dynamics behavior of the beam. The seeding experiment sFLASH is being commissioned, an important step forward to establish seeded FEL radiation for user experiments. After the ongoing commissioning, the 3rd user period will start this summer. In many aspects FLASH will be an FEL with a new quality of performance: a wavelength approaching the carbon edge and the water window, tunable pulse width, and with thousands of pulses per second. This report summarizes the recently finished upgrade of FLASH and reports on the results of the ongoing commissioning and the expected performance as a free electron laser user facility.

TUOARA02 **The FERMI@Elettra Commissioning** – *G. Penco, E. Allaria, L. Badano, S. Bassanese, M. Bossi, D. Castronovo, G. Ciani, S. Cleva, P. Craievich, M.B. Danailov, R. De Monte, G. De Ninno, A.A. Demidovich, S. Di Mitri, M. Ferianis, O. Ferrando, S. Ferry, L. Froehlich, G. Gaio, R. Ivanov, M. Lonza, A.A. Lutman, S.V. Milton, M. Petronio, M. Predonzani, F. Rossi, L. Rumiz, C. Scafuri, G. Scalamera, P. Sigalotti, S. Spampinati, C. Spezzani, M. Trovo, M. Veronese (ELETTRA) L. Pavlovic (Uni LJ)*

The FERMI@Elettra injector, comprised of a high-gradient, s-band, photocathode rf gun, the PC gun driven laser, the first two accelerating sections, controls, and suite of diagnostics has been commissioned in 2009. The electron beam has been characterized in terms of charge, energy, energy spread and transverse emittance, and results are provided in this paper. In early 2010 linac commissioning up to 250MeV continued, and by using the RF deflecting cavity, the slice parameters of the beam have been measured. Moreover, studies on the laser pulse shaping and the relative optimization of the longitudinal ramp profile required by the nominal bunch configuration are presented in this paper.

TUOARA03 **Characterization of the THz Source at SPARC** – *E. Chiadroni, F. A. Anelli, M. Bellaveglia, M. Boscolo, M. Castellano, L. Cultrera, G. Di Pirro, M. Ferrario, L. Ficcadenti, D. Filippetto, S. Fioravanti, G. Gatti, E. Pace, R.S. Sorchetti, C. Vaccarezza (INFN/LNF) P. Calvani, S. Lupi, D. Nicoletti (Università di Roma I La Sapienza) A. Cianchi (Università di Roma II Tor Vergata) B. Marchetti (INFN-Roma II) A. Mostacci (Rome University La Sapienza) A.R. Rossi (Istituto Nazionale di Fisica Nucleare)*

The region of the spectrum from 0.3 to 5 THz is of great interest for several experiments in different areas of research. A THz radiation source can be produced at SPARC as coherent transition radiation emitted by either a compressed or longitudinally modulated beam intercepting a metal foil placed at 45^{o} with respect to the beam propagation. Results on the characterization of the THz source at SPARC are described in the paper.

25-May-10 11:00 – 12:30	Invited Oral	Room A

TUYRA — Hadron Accelerators

Chair: A. Roy, IUAC (New Delhi)

TUYRA01 **Project X: A Multi-MW Proton Source at Fermilab** – *S.D. Holmes (Fermilab)*

As the Fermilab Tevatron Collider program draws to a close, a strategy has emerged of an experimental program built around the high intensity frontier. The centerpiece of this program is a superconducting H^- linac that will support world leading programs in long baseline neutrino experimentation and the study of rare processes. Based on technology shared with the International Linear Collider, Project X will provide multi-MW beams at 60-120 GeV from the Main Injector, simultaneous with very high intensity beams at lower energies. Project X also supports development of a Muon Collider as a future facility at the energy frontier.

TUYRA02 **Challenges and Solutions for J-PARC Commissioning and Early Operation** – *T. Koseki (J-PARC, KEK & JAEA)*

The J-PARC accelerator facility consists of a 400 MeV H^- linac, a 3-GeV RCS, a 50-GeV MR (Main Ring) and related experimental facilities. Beam commissioning of the facility is started from the upstream accelerators while construction of the downstream accelerators and experimental facilities is in progress. The beam commissioning of MR, MLF(Materials and Life science experimental Facility) and Hadron experimental facility started in JFY 2008. In this presentation, we present an overview of the J-PARC commissioning status. Recent progress of MR commissioning will be described in more detail. The talk will focus on the issues, challenges, solutions, and lessons learned during the commissioning and early operations of J-PARC.

TUYRA03 **Production of a 1.3 MW Proton Beam at PSI** – *M. Seidel (PSI)*

With an average beam power of 1.3MW the PSI proton accelerator facility is presently at the worldwide forefront of high intensity accelerators. This talk describes critical aspects and recent improvements related to generation and transport of the high intensity beam in a cyclotron based facility. The installation of new accelerating resonators in the second of two cyclotrons led to a significant improvement in view of beam intensity but also the reliability of the facility. Besides the overall performance and further upgrade plans the discussed topics include: space charge dominated beam dynamics, beam loss handling, activation and specialized technical interlock systems.

25-May-10 14:00 – 16:00	Invited Oral	Room A

TUZRA — Applications of Accelerators

Chair: P. Schmor, TRIUMF (Vancouver)

TUZRA01 **The Role of Accelerators in the Energy Problem** – *R.L. Sheffield, E.J. Pitcher (LANL)*

Nearly all risks to future generations arising from long-term disposal of used LWR nuclear fuel are attributable to the transuranic elements and long-lived fission products, about 2% of its content. The transuranic elements of concern are plutonium, neptunium, americium, and curium. Long-lived (>100,000-year half-life) isotopes of iodine and technetium are also created by nuclear fission of uranium. If we can reduce or otherwise securely handle this 2% of the used fuel, the toxic nature of the remaining used fuel after a few centuries of cooling is below that of the natural uranium ore that was originally mined for nuclear fuel. Only a small fraction of the available energy in the fuel is extracted on a single pass and the majority of the 'problem wastes' could be burned in fast-neutron spectrum reactors or sub-critical accelerator driven transmuters. The goals of accelerator transmutation are some or all of the following: 1) to significantly reduce the impacts due to the minor actinides on the packing density and long-term radiotoxicity in the repository design, 2) preserve/use the energy-rich component of used nuclear fuel, and 3) reduce proliferation risk.

TUZRA02 **Accelerator Applications for Basic and Applied Research at JINR** – *I.N. Meshkov, A.N. Sissakian, G.V. Trubnikov (JINR)*

This presentation will describe the accelerators - basic facilities at JINR and briefly discuss research programs for applications and basic research, which are performed at these accelerators.

25-May-10	15:00 – 16:00	Contributed Oral	Room A

TUOCRA — Applications of Accelerators

Chair: P. Schmor, TRIUMF (Vancouver)

TUOCRA01 **New Treatment Facility Project at HIMAC** – *K. Noda (NIRS)*

Based on more than ten years of experience of the carbon cancer therapy with HIMAC, we have proposed a new treatment facility for the further development of the therapy with HIMAC. This facility will consist of three treatment rooms: two rooms equipped with horizontal and vertical beam-delivery systems and one room with a rotating gantry. For the beam-delivery system of the new treatment facility, a 3D hybrid raster-scanning method with gated irradiation with patient's respiration has been proposed. A R&D study has been carried out toward the practical use of the proposed method. In the R&D study, we have improved the beam control of the size, the position and the time structure for the proposed scanning method with the irradiation gated with patient's respiration. Further, owing to the intensity upgrade of the HIMAC synchrotron, we can successfully extend the flattop duration, which can complete one fractional irradiation with one operation period. The building construction of the new treatment facility will be completed at March 2010 and treatment of 1st patient is scheduled at March 2011. We will report the recent progress on the new treatment facility project at HIMAC.

TUOCRA02 **HIGS - A High-intensity, Mono-energetic, and Tunable Source of Polarized Gamma-rays** – *Y.K. Wu (FEL/Duke University)*

After years of development, High Intensity Gamma-ray Source (HIGS) at Duke University, the most powerful Compton gamma-ray source in the 1 to 100 MeV region, has recently become a dedicate light source facility for scientific research. Driven by the kW power of a storage ring FEL, the HIGS produces high-intensity gamma-ray beams with an exceptionally high flux, a total flux up to few 10^10 g/s and a spectral flux of more than 10^3 g/s/eV, in the few MeV to 10 MeV region. With the present configuration, the HIGS has a wide energy tuning range from 1 to 100 MeV, a high degree of polarization (nearly 100%) switchable among linear, left-, and right-circular polarizations, and a high energy-resolution as low as 0.8% (FWHM). The planned future upgrades will enable the HIGS to produce high-energy gamma-ray beams up to 160 MeV, providing a precision tool for the photo-pion physics research. With these outstanding capabilities, the HIGS is a world-class Compton gamma-ray source for frontier research in a wide range of scientific areas from nuclear physics to astrophysics, from medicine to industry.

TUOCRA03 **Present Status and Future of FFAGs at KURRI and the First ADSR Experiment** – *Y. Ishi, M. Inoue, Y. Kuriyama, J.-B. Lagrange, Y. Mori, T. Planche, M. Takashima, T. Uesugi, E. Yamakawa (KURRI) H. Imazu, K. Okabe, I. Sakai, Y. Takahoko (University of Fukui, Faculty of Engineering)*

World's first ADSR experiments which use spallation neutrons produced by high energy proton beams accelerated by the FFAG synchrotron has started since March 2009 at KURRI. In these experiments, the prompt and delayed neutrons which indicate neutron multiplication caused by external source have been detected. The accelerator complex for ADSR study in KURRI consists of three FFAG proton rings. It delivers the 100MeV proton beam to the W target located in front of the subcritical nuclear fuel system constructed in the reactor core of KUCA (Kyoto University Critical Assembly) at 30Hz repetition rate. Current status of the facility and the future plans of ADSR system and high intensity pulsed spallation neutron source which employ a newly added 700MeV FFAG synchrotron to the existing FFAG complex in KURRI will be presented.

26-May-10	08:30 – 12:30	Invited Oral	Main Hall

WEXMH — Circular Colliders
Chair: H. Koiso, KEK (Ibaraki)

WEXMH01 **Status and Performance of BEPCII** – *Q. Qin, J.Q. Wang, L. Ma, C. Zhang (IHEP Beijing)*
BEPCII is the upgrade project of the Beijing Electron Positron Collider (BEPC) with its design luminosity of $1x10^{33}cm^{-2}s^{-1}$ @1.89 GeV. The construction of BEPCII was completed in May 2008. The collider has been operated for high energy physics experiments since February 2009 with 1/5 of design luminosity at psi(3680). The luminosity has been steadily increased during the operation. Status and updated performance of BEPCII will be reported.

WEXMH02 **Future Electron-Hadron Colliders** – *V. Litvinenko (BNL)*
Future projects for electron-hadron colliders will be reviewed. Existing designs will be presented and, when possible, compared. The challenges and required R&D program will be discussed.

26-May-10	09:30 – 10:30	Contributed Oral	Main Hall

WEOAMH — Circular Colliders
Chair: H. Koiso, KEK (Ibaraki)

WEOAMH01 **Beam Tests of a Clearing Electrode for Electron Cloud Mitigation at KEKB Positron Ring** – *Y. Suetsugu, H. Fukuma, K. Shibata (KEK) M.T.F. Pivi, L. Wang (SLAC)*
In order to mitigate the electron cloud instability (ECI) in a positron ring, an electron clearing electrode with a very thin structure has been developed. The electrode has been tested with an intense positron beam of the KEKB B-factory using a test chamber. A drastic reduction in the electron density around the beam was demonstrated in a dipole magnetic field (0.78 T). The clearing electrode was then applied to the actual copper beam pipe (94 mm in diameter) with antechambers for wiggler magnets of KEKB. The feed-through was revised to improve reliability, and the length was modified to fit a real magnet. The input power into the electrode was estimated to be approximately 80 W/m. The clear reduction in the electron density was also observed by applying a voltage of +500 V to the electrode. The design of clearing electrodes has now reached a high reliability and it is suitable for accelerator applications.

WEOAMH02 **Recent Progress of KEKB** – *Y. Funakoshi (KEK)*
KEKB is an e^-/e^+ collider for the study of B physics and is also used for machine studies for future machines. The peak luminosity of KEKB, which is the world-highest value, has been still increasing. This report summarizes recent progress at KEKB.

WEOAMH03 **Low Secondary Electron Yield Carbon Coatings for Electron-cloud Mitigation in Modern Particle Accelerators** – *C. Yin Vallgren, A. Ashraf, S. Calatroni, P. Chiggiato, P. Costa Pinto, H.P. Marques, H. Neupert, M. Taborelli, W. Vollenberg, I. Wevers, K. Yaqub (CERN)*
Electron-cloud is one of the main limitations for particle accelerators with positively charged beams of high intensity and short bunch spacing, as SPS at CERN. The Secondary Electron Yield (SEY) of the inner surface of the vacuum chamber is the main parameter governing the phenomenon. The effect could be eliminated by coating the magnets vacuum chambers with a material of low SEY, which does not require bake-out and is robust against air exposure. For such a purpose amorphous carbon coatings were produced by magnetron sputtering of graphite targets. They exhibit maximum SEY between 0.9 and 1.1 after air transfer to the measuring instrument. After 1 month air exposure the SEY rises to values between 1.1 and 1.4. Storage under nitrogen or by packaging in Al foil makes this increase negligible. The coatings have a similar XPS C1s spectrum for a large set of deposition parameters and exhibit an enlarged line-width compared to pure graphite. The static outgassing without bake-out depends on deposition parameters and is in a range from 1 to 10 times higher than that of stainless steel. Instead, electron stimulated outgassing is lower than for stainless steel and is dominated by CO.

26-May-10 11:00 – 12:30	Invited Oral	Main Hall

WEYMH — Linear Colliders, Lepton Accelerators and New Acceleration Techniques

Chair: G. Arduini, CERN (Geneva)

WEYMH01 **Status of the International Linear Collider** – *K. Yokoya (KEK)*

The general status of the International Linear Collider (ILC) project will be presented. After the publication of the RDR (Reference Design Report) in summer in 2007, the next milestone of the ILC project will be the Technical Design Report to be completed by the end of 2012. The GDE (Global Design Effort) has defined the period till 2010 summer as the Technical Design Phase 1 and is revisiting the design in RDR in the name of 'rebaselining'. The outline of the new design will be decided in March 2010 and will be reported in this talk together with the near future plan.

26-May-10 11:30 – 12:30	Contributed Oral	Main Hall

WEOBMH — Linear Colliders, Lepton Accelerators and New Acceleration Techniques

Chair: G. Arduini, CERN (Geneva)

WEOBMH01 **Operational Experiences Tuning the ATF2 Final Focus Optics Towards Obtaining a 37nm Electron Beam IP Spot Size** – *G.R. White, A. Seryi, M. Woodley (SLAC) S. Bai (IHEP Beijing) P. Bambade, Y. Renier (LAL) B. Bolzon (IN2P3-LAPP) Y. Kamiya (ICEPP) S. Komamiya, M. Orouku, Y. Yamaguchi, T. Yamanaka (University of Tokyo) K. Kubo, S. Kuroda, T. Okugi (KEK) E. Marin (CERN)*

The primary aim of the ATF2 research accelerator is to test a scaled version of the final focus optics planned for use in next-generation linear lepton colliders. ATF2 consists of a 1.3 GeV linac, damping ring providing low-emittance electron beams (<12pm in the vertical plane), extraction line and final focus optics. The design details of the final focus optics and implementation at ATF2 are presented elsewhere* . The ATF2 accelerator is currently being commissioned, with a staged approach to achieving the design IP spot size. It is expected that as we implement more demanding optics and reduce the vertical beta function at the IP, the tuning becomes more difficult and takes longer. We present here a description of the implementation of the overall tuning algorithm and describe operational experiences and performances

WEOBMH02 **Multi-bunch Beam Extraction by using Strip-line Kicker at KEK-ATF** – *T. Naito, S. Araki, H. Hayano, K. Kubo, S. Kuroda, T. Okugi, N. Terunuma, J. Urakawa (KEK)*

The beam extraction experiment using the strip-line kicker has been carried out at KEK-ATF. The specification of the International linear collider (ILC) is that the long bunch train (1320 - 5120 bunches), which has the bunch spacing of 189 - 480ns, is compressed to 3 or 6ns bunch spacing into the DR, and again decompressed from the DR. The kicker manipulates the changes of the bunch spacing. The kicker requires a fast rise/fall time (3 or 6ns) and a high repetition rate (3 or 6MHz). A multiple strip-line kicker system is the most promising candidate to realize the specification for the ILC*. The beam extraction experiment at KEK-ATF** using prototype of the strip-line kicker was done by following parameters, up to 30 bunches of the multi-bunch in the DR, which has 5.6ns bunch spacing, are extracted bunch-by-bunch with 308ns interval to the extraction line. The stored multi-bunch was extracted successfully. The detail of the experiment and the result are reported.

WEOBMH03 **The Baseline Positron Production and Capture Scheme for CLIC** – *O. Dadoun, P. Lepercq, F. Poirier, A. Variola (LAL) R. Chehab (IN2P3 IPNL) T. Omori (KEK) L. Rinolfi, A. Vivoli (CERN) V.M. Strakhovenko (BINP SB RAS)*

The CLIC study considers the hybrid source using channeling as the baseline for unpolarised positron production. The hybrid source uses a few GeV electron beam impinging on a crystal tungsten target. With the tungsten crystal oriented on its $< 111 >$ axis it results an intense, relatively low energy photon beam due mainly to channeling radiation. Those photons are then impinging on an amorphous tungsten target producing positrons by e^+e^- pair creation. The downstream capture section is based on an adiabatic matching device and a 2 GHz pre-injector linac. The resulting studies are presented here.

26-May-10 14:00 – 16:00	Invited Oral	Main Hall

WEZMH — Beam Instrumentation and Feedback

Chair: I.S. Ko, PAL (Pohang, Kyungbuk)

WEZMH01 **Beam Diagnostics with Synchrotron Radiation in Light Sources** – *S. Takano (JASRI/SPring-8)*

This presentation will cover the topics of synchrotron radiation monitors for light sources, including transverse beam profile measurement, longitudinal bunch profile measurement, and bunch purity measurement. It will also cover developments of beam diagnostics based on observation of x-rays from a dedicated insertion device.

WEZMH02 **Instrumentation for the ATF2 Facility** – *N. Terunuma (KEK)*

This presentation will cover the development of the tuning methods, beam stabilization and reliability, and instrumentation including laser wires, high resolution BPMs and fast feedback, to achieve the beam of a few nano meters size required for the ILC final focus.

26-May-10 15:00 – 16:00	Contributed Oral	Main Hall

WEOCMH — Beam Instrumentation and Feedback

Chair: I.S. Ko, PAL (Pohang, Kyungbuk)

WEOCMH01 **First Beam Test of the Tilt Monitor in the ATF2 Beam Line** – *D. Okamoto (Tohoku University, Graduate School of Science) Y. Honda, T. Tauchi (KEK) T. Sanuki (Tohoku University, School of Scinece)*

We have studied a beam orbit tilt monitor for stabilizing the beam orbit in ATF2. Once we can measure a beam orbit tilt with high precision at one point, we can relate this data with the beam position profile at the focal point. A tilt monitor is composed of a single rectangular sensor cavity and a waveguide to extract the signal. In the sensor cavity, there is the most basic resonant mode called monopole mode. This monopole mode is perpendicular to the nominal beam axis, and excited by the beam tilt. We extract this monopole mode. As the result, the amplitude of the extracted signal is proportional to the tilt angle. The tilt monitor is almost indepnedent with beam postion, so we can get the tilt date independently. According to our simulation, the sensitivity is estimated about 35nrad in the vertical direction. The prototype was completed and installed in the test area on the ATF2 beamline. The first beam test will be performed in December 2009. We will report this result and future update plan.

WEOCMH02 **Recent Developments of the Beam Arrival Time Monitor with Femtosecond Resolution at FLASH** – *M.K. Bock, M. Felber, P. Gessler, K.E. Hacker, H. Schlarb, B. Schmidt (DESY) F. Loehl (CLASSE) S. Schulz (Uni HH)*

At FLASH an optical synchronisation system with femtosecond stability is now being installed and commissioned. The system is based on pulses from a passively modelocked fibre laser which are distributed in length-stabilised fibres to various end-stations. Several modifications and improvements with respect to the original layout, especially concerning permanent operation and reliability, are already incorporated at this stage. The electron bunch arrival-time monitors (BAM), based on electro-optical modulation, are an integral part of the system. Built on the experiences with first prototypes, the most recent version of the BAM, installed prior to the first bunch compressor, includes essential changes affecting the optical layout, the mechanical and thermal stability as well as the electronics for read-out and controls. The revised BAM showed improved performance and will be complemented by a second congenerous BAM after the first bunch compressor during the present FLASH upgrade. The experiences with installation as well as the scope of improvements as to simplification and long-term stability will be presented.

WEOCMH03 **Bunch Length Measurements by SR/Laser Cross-Correlation** – *W.J. Corbett (SLAC) D.R. Daranciang, A. Lindenberg, A. Miller (Stanford University) A.S. Fisher, X. Huang, W.Y. Mok, J.A. Safranek, H. Wen (SLAC)*

By operating SPEAR3 in the quasi-isochronous (low-alpha) mode, one can produce synchrotron radiation with pulse durations of order 1ps. Applications include pump-probe x-ray science and the production of THz radiation. Measurements of short pulse lengths are difficult, however, because the light intensity is low and streak camera resolution is of order 2ps. Bunch arrival time and timing jitter are also important factors. In order to further quantify the pulse length and timing system performance, a 5MHz, 50fs mode-locked laser was used to cross-correlate with the visible SR beam in a BBO crystal. The 800nm laser pulse was delayed with a precision mechanical stage and the product SHG radiation detected with a photodiode / lock-in amplifier using the ring frequency as reference. In this paper we report on the experimental setup, preliminary pulse length measurements and prospects for further improvement.

26-May-10 08:30 – 10:30 Invited Oral Room A

WEXRA — Synchrotron Light Sources and FELs

Chair: V.P. Suller, LSU/CAMD (Baton Rouge, Louisiana)

WEXRA01 **Review of Third Generation Light Sources** – *W. Namkung (PAL)*

In 1994, ESRF in Grenoble opened the era of third-generation light sources, and the first batch of third-generation machines immediately followed with ALS, Elettra, TLS, PLS, and Spring-8 in hard and soft X-ray regimes. For high brightness, these machines adopted a low-emittance storage-ring lattice and many straight sections for advanced undulators. With ever-growing user demands from materials science to life science research, many more facilities followed in this decade. The machine operations dramatically improved for more effective user services, along with technological advances in advanced diagnostics and controls, survey and alignments, top-up injections, super-conducting cavities, and in-vacuum undulators. There are now about 70 light sources in the world, and important scientific discoveries are driven from these facilities, including research resulting in a few Nobel Prizes. In this paper, we review the advancement of these third-generation machines.

WEXRA02 **Echo Enhanced Harmonic Generation** – *G.V. Stupakov (SLAC)*

Recently a new concept*, ** for FEL seeding has been proposed that should allow generation of much higher harmonics of the laser modulation than previously envisioned. The Echo-enabled Harmonic Generation (EEHG) FEL uses two modulators in combination with two dispersion sections to generate in the beam a high-harmonic density modulation starting with a relatively small initial energy modulation of the beam. The EEHG seeding technique makes feasible a one stage seeding of soft x-ray FELs. An experimental installation is now being constructed at SLAC to demonstrate the EEHG in the NLCTA facility.

26-May-10 09:30 – 10:30	Contributed Oral	Room A

WEOARA — Synchrotron Light Sources and FELs

Chair: V.P. Suller, LSU/CAMD (Baton Rouge, Louisiana)

WEOARA01 **Operational Status of the Shanghai Synchrotron Radiation Facility** – *Z.T. Zhao, H.G. Xu (SINAP)*

The Shanghai Synchrotron Radiation Facility (SSRF), a 3.5GeV storage ring based third generation light source, started its user operation with 7 beamlines in May 2009. During the passed year, the facility reliably operated about 4000 hours for user experiments. This paper presents the operational status of the SSRF in the first year and its future performance improvement plans.

WEOARA02 **Progress Report of SESAME Project** – *A. Nadji, T.H. Abu-Hanieh, A. Al-Adwan, M.A. Al-najdawi, A. Amro, M. Attal, S. Budair, D.S. Foudeh, A. Hamad, A. Kaftoosian, T.A. Khan, F. Makahleh, S.A. Matalgah, M. Sbahi, M.M. Shehab, H. Tarawneh, S. Varnasseri (SESAME)*

The construction of SESAME, a 2.5 GeV, and 3rd generation synchrotron-light source is under progress. The first electron beam from the Microtron at low energy (less than 10 MeV) could be obtained on July, 14th, 2009 and reproduced several times. The tests of the injection and extraction system as well as the hydraulically and electrical tests of the main magnets of the Booster are complete and the vacuum chambers tests are underway. The Booster RF cavity and its plunger have been conditioned successfully by 1.7 kW CW RF power. The installation of the Booster is expected to start after the completion of the shielding. The design of the completely new storage ring is finalised and the Phase 1 beamlines is updated.

WEOARA03 **Novosibirsk Free Electron Laser Facility: Two-orbit ERL with Two FELs** – *N. Vinokurov, E.N. Dementyev, B.A. Dovzhenko, Ya.V. Getmanov, E.I. Kolobanov, V.V. Kubarev, G.N. Kulipanov, L.E. Medvedev, S.V. Miginsky, L.A. Mironenko, V. Ovchar, K.V. Palagin, B.Z. Persov, V.M. Popik, T.V. Salikova, M.A. Scheglov, S.S. Serednyakov, O.A. Shevchenko, A.N. Skrinsky, V.G. Tcheskidov, Y.F. Tokarev, P. Vobly, N.S. Zaigraeva (BINP SB RAS) B.A. Knyazev, N. Vinokurov (NSU)*

The Novosibirsk ERL has rather complicated magnetic system. One orbit (11-MeV) for terahertz FEL lies in the vertical plane. Other four orbits lie in the horizontal plane. The beam is directed to these orbits by switching on of two round magnets. In this case electrons pass through RF cavities four times, obtaining 40-MeV. At the 4th orbit the beam is used in FEL, and then is decelerated four times. At the 2nd orbit (20 MeV) we have a bypass with another FEL. When bypass magnets are switched on, the beam passes through this FEL. The length of bypass is chosen to provide the delay necessary to realize deceleration at the3rd pass through accelerating cavities. In 2008 two of four horizontal orbits were assembled and commissioned. The electron beam was accelerated twice and then decelerated down to low injection energy. First multi-orbit ERL operation was demonstrated successfully. In 2009 the first lasing at the second FEL, installed on the bypass of the second track, was achieved. The wavelength tunability range is 40 - 80 micron. Energy recovery of a high energy spread used electron beam was optimized. Third and fourth orbit assembly is in progress.

26-May-10 11:00 – 12:30	Invited Oral	Room A

WEYRA — Hadron Accelerators

Chair: H. Okamoto, HU/AdSM (Higashi-Hiroshima)

WEYRA01 **The FAIR Accelerators: Highlights and Challenges** – *O. Boine-Frankenheim (GSI)*

The FAIR accelerator project at GSI should increase the intensity of primary proton and heavy ion beams by up to two orders of magnitude, relative to the existing GSI facility. In addition to the design of the new synchrotron SIS-100 and the storage rings, the intensity upgrade of the SIS-18 synchrotron plays a key role for the FAIR project. Recently a new record beam intensity for intermediate charge state uranium ions has been achieved in the SIS-18. Still several challenges related to beam intensity effects and phase space conservation have to be mastered in order to reach the beam parameters required for the injection into SIS-100. In SIS-100 beam loss control and machine protection are of major concern. Lost energetic heavy ions can cause a more severe damage of accelerator components than the corresponding amount of protons. Gradual beam loss of energetic ions is expected to occur in SIS-100 mainly during slow extraction of intense beams. Coherent transverse instabilities induced by the beam pipe impedance are a potential cause of fast beam loss and emittance increase. Cures and protection measures together with the result of simulation studies will be summarized.

26-May-10 11:30 – 12:30	Contributed Oral	Room A

WEOBRA — Beam Dynamics and Electromagnetic Fields

Chair: H. Okamoto, HU/AdSM (Higashi-Hiroshima)

WEOBRA01 **Benchmarking of the NTRM Method on Octupolar Nonlinear Components at the CERN-SPS Synchrotron** – *A.S. Parfenova, G. Franchetti (GSI) R. Tomas, G. Vanbavinckhove (CERN)*

The measurement of synchrotron nonlinear components is an essential step for devising an effective compensation scheme for improving machine performances. A validation test of a recently proposed method called nonlinear tune response matrix (NTRM) for measuring circular accelerator nonlinear components is undergoing in a CERN-GSI joint effort. The test consists in the attempt of reconstructing few controlled octupolar components in the SPS synchrotron. In this proceeding we report on the SPS benchmarking experiment and discuss the performances the NTRM method applied to this measurements.

WEOBRA02 **Simulation of E-Cloud Driven Instability and its Attenuation using a Simulated Feedback System in the CERN SPS** – *J.-L. Vay, M.A. Furman, G. Penn, M. Venturini (LBNL) J.D. Fox, C.H. Rivetta (SLAC)*

Electron clouds impose limitations on current accelerators that may be more severe for future machines, unless adequate measures of mitigation are taken. Recently, it has been proposed to use feedback systems operating at high frequency (in the GHz range) to damp single-bunch transverse coherent oscillations that may otherwise be amplified during the interaction of the beam with ambient electron clouds. We have used the simulation package WARP-POSINST to study the growth rate and frequency patterns in space-time of the electron cloud driven transverse instability in the CERN SPS accelerator with, or without, an idealized feedback model for damping the instability. We will present our latest simulation results, contrast them with actual measurements and discuss the implications for the design of the actual feedback system.

WEOBRA03 **Beam Break-up Estimates for the ERL at BNL** – *I. Ben-Zvi, R. Calaga, H. Hahn, L.R. Hammons, E.C. Johnson, A. Kayran, J. Kewisch, V. Litvinenko, W. Xu (BNL)*

A prototype ampere-class superconducting energy recovery linac (ERL) is under advanced construction at BNL. The ERL facility is comprised of a five-cell SC Linac plus a half-cell SC photo-injector RF electron gun, both operating at 703.75 MHz. The facility is designed for either a high-current mode of operation up to 0.5 A at 703.75 MHz or a high-bunch-charge mode of 5 nC at 10 MHz bunch frequency. The R&D facility serves a test bed for an envisioned electron-hadron collider, eRHIC. The high-current, high-charge operating parameters make effective higher-order-mode (HOM) damping mandatory, and requires to determination of HOM tolerances for a cavity upgrade. The niobium cavity has been tested at superconducting temperatures and has provided measured dipole shunt impedances for the estimate of a beam breakup instability. The facility will be assembled with a highly flexible lattice covering a vast operational parameter space for verification of the estimates and to serve as a test bed for the concepts directed at future projects.

26-May-10 14:00 – 16:00 Industry Room A

WEIRA — Session for Industry

Chair: N. Ozaki, Technology Consultancy for Energy, Environment and Advanced Technologies (Zushi, Kanagawa)

WEIRA01 **Experience of Academia-industry Collaboration on Accelerator Projects in Asia** – *A. Yamamoto (KEK)*

Japan has a long history of academia-industry collaboration on accelerator technology development. A recent example is superconducting cavity manufacture for the linear collider as well as a number of collaboration in superconducting magnets for circular colliders and physics experiments. Experience with Academia-industry Collaboration on Accelerator Projects in Japan and global Asia will be presented.

WEIRA02 **Present Status of the Accelerator Industry in Asia** – *C.-X. Tang (TUB)*

Different kinds of accelerators, such as electron linacs, cyclotrons, microtrons, HV DC accelerators, synchrotrons and betatrons, can be used in radiotherapy, Non-Destructive Test, and irradiations. The accelerator industry in Asia almost covers all of the accelerators and application areas above. In this paper, the status and the trend of the accelerator industry in Asia will be introduced. Typical examples, in the areas of medial and industrial applications, will be described about their technology, achievement and relationship with universities or institutes. For the accelerator technology is strongly relied on the development of components, we will also briefly introduce the industry in Asia of some components, such as rf power sources, HV power sources (modulator), magnets and so on.

WEIRA03 **Experience of Academia-industry Collaboration on Accelerator Projects in Europe** – *D. Einfeld (CELLS-ALBA Synchrotron)*

European industry has participated in the LHC Project for technology development, component design and system construction. A good relationship in academia-industry collaboration has led to successful results for the project. Industry plays an important role for component design, manufacture and system construction in the XFEL project. The long history of academia-industry collaboration in the accelerator field in Europe is presented.

WEIRA04 **Present Status and Future Outlook of the Accelerator Industry in Europe** – *R. Ursic (I-Tech)*

After LHC completion, maintenance and operation of the facility provide a good opportunity for accelerator industry in Europe. Other big facilities like XFEL, FAIR, FERMI@ELETTRA and MAX IV are now under way. The challenges of the accelerator industry in Europe and its future outlook will be presented.

WEIRA05 **Experience in Academia-industry Collaboration on Accelerator Projects in North America** – *W.-T. Weng (BNL)*

The experiences of collaboration between research laboratories and industries in the research and production for accelerator components in North America will be reviewed. Major projects involving industrial participation such as, Tevatron, CEBAF, RHIC, SSC, SNS, LCLS, .. etc will be covered on their scope, methodology, and performances. Compared to the practices in Europe and Japan, our activities in this domain were somewhat limited without well-established tradition and policy. A successful collaboration can contribute to both the quality of the products and the cost of their production. The lessons learned and suggestions to improve our effort for future projects will also be highlighted.

WEIRA06 **Present Status of the Accelerator Industry in North America** – *J.E. Clayton (Varian Medical Systems, Oncology Systems)*

Several projects for synchrotron light source facilities and medical accelerators are proposed in North America. Application of accelerators for homeland security system is also under consideration. Project X is a typical example of a big next generation accelerator project. The current status of the accelerator industry in North America will be presented.

27-May-10 08:30 – 10:30	Invited Oral	Main Hall

THXMH — Linear Colliders, Lepton Accelerators and New Acceleration Techniques

Chair: C. Zhang, IHEP Beijing (Beijing)

THXMH01 **Commissioning of the EMMA Non-Scaling FFAG** – *T.R. Edgecock (STFC/RAL)*
EMMA is the world's first non-scaling fixed field alternating gradient accelerator and is being constructed at the STFC Daresbury Laboratory. Experience from the initial commissioning phases (from early 2010) will be reported and lessons for future machines of a similar type will be discussed. The present experimental status and future plans will also be reported.

THXMH02 **International Design Study of a Neutrino Factory** – *J.S. Berg (BNL)*
By providing an extremely intense source of neutrinos from the decays of muons in a storage ring, a Neutrino Factory will provide the opportunity for precision measurements and searches for new physics amongst neutrino interactions. An active international collaboration is addressing the many technical challenges that must be met before the design for a Neutrino Factory can be finalized. An overview of the accelerator complex and the current international R&D program will be presented, and the key technical issues will be discussed.

27-May-10 09:30 – 10:30	Contributed Oral	Main Hall

THOAMH — Linear Colliders, Lepton Accelerators and New Acceleration Techniques

Chair: C. Zhang, IHEP Beijing (Beijing)

THOAMH01 **Recirculating Linear Accelerators for Future Muon Facilities** – *S.A. Bogacz (JLAB) K.B. Beard, R.P. Johnson (Muons, Inc)*
Neutrino Factories and Muon Colliders require rapid acceleration of short-lived muons to multi-GeV and TeV energies. A Recirculating Linear Accelerator (RLA) that uses superconducting RF structures can provide exceptionally fast and economical acceleration to the extent that the focusing range of the RLA quadrupoles allows each muon to pass several times through each high-gradient cavity. A new concept of rapidly changing the strength of the RLA focusing quadrupoles as the muons gain energy is being developed to increase the number of passes that each muon will make in the RF cavities, leading to greater cost effectiveness. We discuss the optics and technical requirements for RLA designs, using RF cavities capable of simultaneous acceleration of both μ+ and μ- species, with pulsed Linac quadrupoles and arc magnets to allow the maximum number of passes. The design will include the optics for the multi-pass linac and droplet-shaped return arcs.

THOAMH02 **High Frequency, High Gradient Dielectric Wakefield Acceleration Experiments at SLAC and BNL** – *J.B. Rosenzweig, G. Travish (UCLA) M.J. Hogan (SLAC) P. Muggli (USC)*
Given the recent success of >GV/m dielectric wakefield accelerator (DWA) breakdown experiments at SLAC, and follow-on coherent Cerenkov radiation production at the UCLA Neptune, a UCLA-USC-SLAC collaboration is now implementing a new set of experiments that explore various DWA scenarios. These experiments are motivated by the opportunities presented by the approval of FACET facility at SLAC, as well as unique pulse-train wakefield drivers at BNL. The SLAC experiments permit further exploration of the multi-GeV/m envelope in DWAs, and will entail investigations of novel materials (e.g. CVD diamond) and geometries (Bragg cylindrical structures, slab-symmetric DWAs), and have an over-riding goal of demonstrating >GeV acceleration in ~33 cm DWA tubes. In the nearer term before FACET's commissioning, we are planning measurements at the BNL ATF, in which we drive ~50-200 MV/m fields with single pulses or pulse trains. These experiments are of high relevance to enhancing linear collider DWA designs, as they will demonstrate potential for high efficiency operatio with pulse trains.

THOAMH03 **Control and Pulsewidth-measurement of Laser Accelerated Electron Beams** – *H. Kotaki, S.V. Bulanov, Y. Hayashi, T. Homma, M. Kando, K. Kawase, J. Koga, M. Mori (JAEA)*
Laser wakefield acceleration (LWFA) is regarded as a basis for the next-generation of charged particle accelerators. In experiments, it has been demonstrated that LWFA is capable of generating electron bunches with high quality: quasi-monoenergetic, low in emittance, and a very short duration of the order of ten femto-seconds. Such femtosecond bunches can be used to measure ultrafast phenomena. In applications of the laser accelerated electron beam, it is necessary to generate a stable electron beam and to control the electron beam. A 40 fs laser pulse with the energy of 200 mJ is focused onto a supersonic gas jet. We succeed to generate a stable electron beam by using a Nitrogen gas target. The profile of the electron beam can be manipulated by rotating the laser polarization. When we use a S-polarized laser pulse, a 20 MeV electron beam is observed with an oscillation in the image of the energy spectrum. From the oscillation, the pulse width of the electron beam is calculated to at most a few tens fs. The direction of the electron beam can be controlled by changing the gas-jet position. The self-injected electron beam can be controlled by the control of the laser and gas jet.

27-May-10 11:00 – 12:30	Invited Oral	Main Hall

THYMH — Hadron Accelerators

Chair: T. Roser, BNL (Upton, Long Island, New York)

THYMH01 **Lanzhou Cooler Storage Ring Commissioning** – *J.C. Yang, J.W. Xia, Y.J. Yuan (IMP)*
CSR has recently made significant progress in commissioning a variety of light to heavy ion in the cooler ring. Also, carbon therapy was successfully carried out. A significant achievement is the energy modulation extraction using slow extraction realizing 3D conformal treatment.

27-May-10 11:30 – 12:30	Contributed Oral	Main Hall

THOBMH — Hadron Accelerators

Chair: T. Roser, BNL (Upton, Long Island, New York)

THOBMH01 **The Proton Engineering Frontier Project** – *B.H. Choi, K.Y. Kim (KAERI)*
Since launched in 2002 to develop a high current 100 MeV, 20 mA proton linac and beam facilities, the Proton Engineering Frontier Project has fully developed and integrated the low energy part, consisting of a 50 keV ion source, 3 MeV RFQ, and 20 MeV DTL with a 24% high duty factor. Successfully commissioned by achieving the designed peak beam current of 20 mA and beam energy of 20 MeV, the linac started user beam services in 2007 with limited operation conditions. Fabrication of the high energy part of the linac, composed of seven DTL tanks, and components of the 20 MeV and 100 MeV beam facilities are underway. The 20 MeV and 100 MeV beam facilities consist of five beamlines, respectively, and are designed to deliver characterized proton beams for applications in various fields by meeting user requirements. In addition, site preparation and construction works are in progress. Being completed in early 2012 as scheduled, the proton linac facility will be utilized in core R&D projects in multi-disciplines, from nano, bio-life, materials, energy, environment, and medical, to basics science.

THOBMH02 **Results from the 2009 Beam Commissioning of the CERN Multi-turn Extraction** – *M. Giovannozzi, E. Benedetto, A. Blas, T. Bohl, S. Cettour Cave, K. Cornelis, D.G. Cotte, H. Damerau, M. Delrieux, J. Fleuret, F. Follin, T. Fowler, P. Freyermuth, H. Genoud, S.S. Gilardoni, S. Hancock, O. Hans, Y. Le Borgne, D. Manglunki, E. Matli, G. Metral, E. Métral, M. Newman, L. Pereira, F.C. Peters, Y. Riva, F. Roncarolo, L. Sermeus, R.R. Steerenberg, B. Vandorpe, J. Wenninger (CERN) F. Franchi (ESRF)*
Following the analysis of the results obtained during the first year of beam commissioning of the CERN multi-turn extraction, a number of changes have been introduced in the beam manipulations performed in the CERN Proton Synchrotron. This includes a different control of the linear chromaticity, the setting of the non-linear magnets used to split the beam, and the longitudinal structure in the PS. The results obtained during the

2009 run are presented and discussed in detail, including the beam performance in both the PS and the SPS, as well as the optics measurements in the transfer line between the two circular machines.

THOBMH03 **Coulomb Crystal Extraction from an Ion Trap for Application to Nano-beam Source** – *K. Ito, H. Higaki, K. Izawa, H. Okamoto (HU/AdSM) H. Takeuchi (Hiroshima University, Faculty of Science)*

An ion plasma confined in a compact trap system is Coulomb crystallized near the absolute zero temperature. The emittance of the crystallized ion plasma is close to the ultimate limit, far below those of any regular ion beams. This implies that, if we can somehow accelerate a crystal without serious heating, an ion beam of extremely low emittance becomes available*. Such ultra-low emittance beams, even if the current is low, can be used for diverse purposes including precise single ion implantation to various materials and for systematic studies of radiation damage effects on semiconductors and bio-molecules. We performed proof-of-principle experiments on the extraction of Coulomb crystals from a linear Paul trap system developed at Hiroshima University. A string crystal of 40Ca+ ions is produced with the Doppler laser cooling technique and then extracted by switching DC potentials on the trap electrodes. We demonstrate that it is possible to transport the ultra-low temperature ion chain keeping its ordered configuration.

27-May-10 08:30 – 10:30	Invited Oral	Room A

THXRA — Accelerator Technology

Chair: C. Adolphsen, SLAC (Menlo Park, California)

THXRA01 **First Operational Experience with the LHC Cryogenic System** – *S.D. Claudet (CERN)*

The cryogenic system of the Large Hadron Collider (LHC) is the largest in the world in terms of refrigeration capacity with about 140 kW at 4.5 K, distributed superfluid helium with 25 km of superconducting magnets below 2 K and cryogen inventory above 120 tons of helium. The challenges involved in the design, construction, installation, commissioning as well as the first operating experience will be addressed. Identified weak points and actions taken will be reported with observed impact on operation. Perspectives for LHC will be presented and general considerations for future large cryogenic systems will be briefly proposed.

THXRA02 **Review of SRF Cavities for ILC, XFEL and ERL Applications** – *H. Hayano (KEK)*

Linear accelerator systems with superconducting RF technology have become increasingly important to reach high-quality, high current beam conditions required by the high-energy physics and photon science communities. The International Linear Collider, for instance, calls for very challenging (beam conditions). Similarly, the XFEL requires (beam conditions) and future ERLS require (high average current). In this talk, we review the needs and challenges of SCRF linac beam physics and technology for present and future applications.

27-May-10	09:30 – 10:30	Contributed Oral	Room A

THOARA — Accelerator Technology

Chair: C. Adolphsen, SLAC (Menlo Park, California)

THOARA01 **IHEP 1.3 GHz SRF Technology R&D Progress** – *J. Gao, Y.L. Chi, J.P. Dai, S.P. Li, W.M. Pan, Y. Sun, J.Y. Zhai (IHEP Beijing)*

1.3 GHz superconducting radio-frequency (SRF) technology is one of the key technologies for the ILC and the future XFEL and ERL projects of China. With the aim to develop this technology, IHEP has started a program to build an SRF Accelerating Unit in the frame of ILC collaboration. The SRF Accelerating Unit contains a 9-cell 1.3 GHz superconducting cavity, a short cryomodule, a high power input coupler, a tuner, a low level RF system and a high power RF source, etc. This unit will serve as a horizontal test stand (HTS). Recent progress of the components R&D is presented, as well as SRF facilities operation experience, i.e. the CBP machine, pretuning machine and BCP facility for 9-cell cavities.

THOARA02 **Preparation Phase for the European XFEL Cavity Production** – *W. Singer, S. Aderhold, A. Brinkmann, R. Brinkmann, J. Iversen, G. Kreps, L. Lilje, A. Matheisen, W.-D. Moeller, D. Reschke, A. Schmidt, J.K. Sekutowicz, X. Singer, H. Weise (DESY) P.M. Michelato (INFN/LASA)*

The preparation phase for the European XFEL cavity production includes a number of actions. Material issues: qualification of high purity niobium vendors, verifying of large grain material as a possible option, construction of the scanning device for the niobium sheets. Mechanical fabrication issues: accommodation of the TESLA cavity design to the XFEL demands, device construction for RF measurement of components, integration of the helium tank and it's welding to the cavity into the fabrication sequence, documentation and data transfer, application of a new high resolution camera for inspection of the inside surface. Treatment and RF measurement: establishing the XFEL recipe, in particular the final surface treatment (final 40 μm EP or short 10 μm Flash BCP), and the cavity preparation strategy (vertical acceptance test with or without helium tank welded, with or without assembly of HOM antennas), construction of the cavity tuning machine. About 50 prototype cavities are produced at the industry, treated (partially in industry and partially at DESY) and RF-tested at DESY. The XFEL requirements are fulfilled with a yield of approx. 90%.

THOARA03 **ILC Marx Modulator Development Program Status** – *C. Burkhart, A.L. Benwell, T.G. Beukers, M.A. Kemp, R.S. Larsen, D.J. MacNair, K.J.P. Macken, M.N. Nguyen, J.J. Olsen, T. Tang (SLAC)*

A Marx-topology klystron modulator is under development for the International Linear Collider (ILC) project*. It is envisioned as a lower cost, smaller footprint, and higher reliability alternative to the present, bouncer-topology, baseline design. The application requires 120 kV (±0.5%), 140 A, 1.6 ms pulses at a rate of 5 Hz. The Marx constructs the high voltage pulse by combining, in series, a number of lower voltage cells. The Marx employs solid state elements; IGBTs and diodes, to control the charge, discharge and isolation of the cells. Active compensation of the output is used to achieve the voltage regulation while minimizing the stored energy. The developmental testing of a first generation prototype, P1, has been completed. This modulator has been integrated into a test stand with a 10 MW L-band klystron, where each is undergoing life testing. Development of a second generation prototype, P2, is underway. The P2 is based on the P1 topology but incorporates an alternative cell configuration to increase redundancy and improve availability. Status updates for both prototypes are presented.

27-May-10 11:00 – 12:30	Invited Oral	Room A

THYRA — Beam Dynamics and Electromagnetic Fields
Chair: J. Urakawa, KEK (Ibaraki)

THYRA01 **Beam-beam Interaction in Novel, Very High Luminosity Parameter Regimes** – *M. Zobov (INFN/LNF)*

To achieve luminosities significantly higher than in existing machines, future storage-ring based colliders will need to operate in novel parameter regimes combining ultra-low emittance, large Piwinski angle and high bunch charge; implementation of techniques such as a "crab waist" will add further challenges. Understanding the beam-beam interaction in these situations will be essential for the design of future very high luminosity colliders. Recent developments in modeling tools for studying beam-beam effects, capable of investigating the relevant regimes, will be discussed and examples, including tests with crab waist collisions in DAΦNE, will be presented.

27-May-10 11:30 – 12:30	Contributed Oral	Room A

THOBRA — Beam Dynamics and Electromagnetic Fields
Chair: J. Urakawa, KEK (Ibaraki)

THOBRA01 **Synchrotron Oscillation Damping due to Beam-beam Collisions** – *A. Drago, P. Raimondi, M. Zobov (INFN/LNF)*

In DAΦNE, the Frascati $e+/e^-$ collider, the crab waist collision scheme has been successfully implemented in 2008 and 2009. During the collision operations for Siddharta experiment, an unusual synchrotron damping effect has been observed. Indeed, with the longitudinal feedback switched off, the positron beam becomes unstable with beam currents in the order of 200-300 mA. The longitudinal instability is damped by bringing the positron beam in collision with a high current electron beam (~2A). Besides, we have observed a shift of ~600Hz in the residual synchrotron sidebands. Precise measurements have been performed by using a commercial spectrum analyzer and by using the diagnostics capabilities of the DAΦNE longitudinal bunch-by-bunch feedback. This damping effect has been observed in DAΦNE for the first time during collisions with the crab waist scheme. Our explanation is that beam collisions with a large crossing angle produce a longitudinal tune shift and a longitudinal tune spread, providing Landau damping of synchrotron oscillations.

THOBRA02 **Suppression of Transverse Instabilities by Chromaticity Modulation** – *Y. Shoji (NewSUBARU/SPring-8, Hyogo), T. Nakamura, N. Kumagai, S. Matsui, H. Ohkuma, T. Ohshima, H. Takebe (JASRI/SPring-8) A. Ando, S. Hashimoto, Y. Shoji (NewSUBARU/SPring-8, Hyogo) K. Kumagai (RIKEN Nishina Center)*

Transverse beam instabilities were suppressed with chromaticity modulation (CM)* in the electron storage ring, New SUBARU. The horizontal and vertical betatron tune spread inside a bunch were introduced by CM with synchrotron oscillation frequency driven by an AC sextuple magnet**, to obtain Landau damping of the coherent bunch motion. The tune spread in a bunch is usually introduced by octupole field, however, its high nonlinearity reduces the dynamic aperture. And usual feedback against instabilities work only on m=0 mode and it is not easy to be applied to hadron synchrotrons because of their varying revolution period. The CM scheme has not such disadvantages. The damping time of coherent motion excited by external kick was measured and was found as less than 1ms, one order faster than that without CM. To observe the effect on instabilities, we intentionally tuned an HOM in a cavity to excite a horizontal multi-bunch instability. The instability peak in the spectrum of the beam motion was vanished with CM turned on and the instability was suppressed. We also observed the increase of the threshold current of the vertical single-bunch mode-coupling instability by factor 3 with CM.

THOBRA03 **Observation of Transverse-Longitudinal Coupling Effect at UVSOR-II** – *M. Shimada (KEK) M. Adachi, M. Katoh, S.I. Kimura (UVSOR) M. Hosaka, Y. Takashima, N. Yamamoto (Nagoya University) T. Takahashi (KURRI) T. Tanikawa (Sokendai - Okazaki)*

It was theoretically predicted that, when the electron pulse length comes into the femto-second range, transverse motion of the electrons is strongly coupled with the longitudinal one and makes significant effect on the pulse shape. In the experiments, a fine dip structure was created on the electron bunches circulating in a storage ring by a so-called laser bunch slicing technique and then the evolution of the structure was measured through the spectrum of the coherent synchrotron radiation. When the ring was operated in a low-alpha mode, the shape of the dip structure was oscillating with the transverse betatron frequency, which clearly indicates the existence of the longitudinal-transverse coupling effect. This understanding will be crucially important for generation and transportation of ultra-short electron bunches in light sources or colliders for high energy physics. In this presentation, the dependency of the CSR signal intensity on the wavelength of the THz CSR and the electron beam current are also reported.

27-May-10	13:30 – 15:30	Prize Presentations	Main Hall

THPPMH — Prize Presentations

Chair: W. Namkung, PAL (Pohang, Kyungbuk)

THPPMH01 **Accelerating Polarized Protons to High Energy** – *M. Bai (BNL)*

High energy polarized proton beams are desired for exploring the proton spin structure as well as other spin dependent measurements. However, depolarizing mechanisms due to the interaction between the spin motion and the magnetic fields challenges accelerating polarized protons to high energy in circular accelerators. Several decades of efforts in developing techniques to preserve polarization to high energy have finally led to the success of the polarized proton program at the Brookhaven Relativistic Heavy Ion Collider (RHIC). Designed to provide polarized proton collisions up to 250GeV, RHIC is equipped with two Siberian snakes to avoid both intrinsic and imperfection depolarizing resonances. Currently, polarization has been preserved up to 100 GeV at RHIC with precise control of orbit and betatron tunes. The polarized protons were first brought into collisions at 250GeV in RHIC in 2009, and depolarizations were observed between 100 GeV to 250 GeV. This presentation reports the progress of RHIC polarized proton program. Strategies of how to preserve the polarization through the RHIC injectors are also presented.

THPPMH02 **The Joy of Accelerator Physics** – *J. Wei (TUB)*

Since introduced to accelerator physics in 1986, I had the fortune to study and work with some best physicists in the field on most exciting projects. My first assignment was to simulate transition-crossing in RHIC; a shocking 86% beam loss led to a redesign of its rf system and earned me a Ph. D. The thesis introduced me to a great mentor. For the past 18 years we worked on the topic of crystalline beams as a hobby and as means of meeting friends. Fourteen years through the cycle of design, R&D, construction, and commissioning of RHIC not only introduced me to the fascinating world of accelerator physics (transition crossing, intra-beam scattering, stochastic cooling, IR correction, electron cloud) but also trained me as a physicists for accelerator projects. Since then, I had the opportunity to work and lead teams of physicists and engineers on accelerator projects: US-LHC/AP at BNL, SNS/AP at ORNL, SNS ring, CSNS in China, and now CPHS at Tsinghua. The accelerator profession is uniquely rewarding that physical ideas and dreams can be turned into reality through engineering projects, during which one experiences endless learning in physics, technology, teamwork and friendship.

THPPMH03 **Four Decades of Colliders (from the ISR to LEP to the LHC)** – *S. Myers (CERN)*

I will briefly describe CERN's colliders starting with the ISR, going through LEP, and finishing with the LHC. The common threads will be discussed in terms of people and techniques. I will start by describing the incredible impact on accelerator physics of the almost forgotten, first ever hadron collider, the ISR. I will then present the construction and 12 years of operation of LEP. Finally I will also provide the first results of beam operation in the LHC as well as the plans for the near and far future.

THPPMH04 **IPAC'10 Award for the JACoW Collaboration** – *V.RW. Schaa (GSI) C. Petit-Jean-Genaz (CERN)*

The Chair and Deputy will receive the award of the IPAC'10 Organizing Committee on behalf of the JACoW Collaboration.

27-May-10	15:30 – 16:00	Entertainment	Main Hall

THEMH — Spirit of Tea Ceremony

Chair: S.-I. Kurokawa, KEK (Ibaraki)

THEMH01 **The Spirit of Tea** – *G. Sen (Grand Master of Tea)*

Chado, or the Way of Tea, is a comprehensive cultural practice that embraces the arts, religion, philosophy, social life – virtually every aspect of life. A practice such as this is truly rare. The ideals underlying the Way of Tea are known in Japanese as Wa, Kei, Sei, Jaku. In English, these are Harmony, Respect, Purity, and Tranquility. Over the past fifty years, I have personally sought to impart the spirit of this Way to people worldwide, expressing my goal through the phrase, "Peacefulness through a Bowl of Tea." I sincerely hope that, through this Urasenke Konnichian web site, knowledge of Chado will reach far and wide around the globe, and its ideals might further contribute to the attainment of genuine World Peace and Happiness, the mutual goal of all humanity

28-May-10	08:30 – 09:00	Invited Oral	Main Hall

FRXAMH — Special Presentation

Chair: C. Biscari, INFN/LNF (Frascati (Roma))

FRXAMH01 **CP Violation and B-factory Experiments** – *M. Kobayashi (KEK)*

Development of studies of CP violation will be discussed. The mechanism of CP violation in the six-quark model will be explained together with a brief history of flavor physics. Results from the B-factories in SLAC and KEK have shown that dominant source of CP violation observed in the laboratory experiments is flavor mixing in the six-quark model.

28-May-10	09:00 – 09:30	Invited Oral	Main Hall

FRXBMH — Circular Colliders

Chair: C. Biscari, INFN/LNF (Frascati (Roma))

FRXBMH01 **Next Generation B-factories** – *M. Masuzawa (KEK)*

The KEKB and PEP-II B factories have achieved world record luminosities while doubling or tripling their original design luminosities. The demand now from the physics community is for Super B Factories with orders of magnitude higher luminosities than those achieved by the present generation of machines. This talk will discuss the next-generation B factories, which aim to push back the luminosity frontier in the search for physics beyond the Standard Model.

28-May-10 09:30 – 10:30	Invited Oral	Main Hall

FRXCMH — Linear Colliders, Lepton Accelerators and New Acceleration Techniques

Chair: C. Biscari, INFN/LNF (Frascati (Roma))

FRXCMH01 **Towards CLIC Feasibility** – *J.-P. Delahaye (CERN)*

The CLIC study is a site independent study exploring technological developments to extend linear colliders into the Multi-TeV colliding beam energy range at reasonable cost and power consumption. A conceptual design report (CDR) of an electron-positron Compact LInear Collider (CLIC) with a 3 TeV center-of-mass collision energy is presently being prepared including results of 25 years of R&D to address the feasibility of its novel and promising technology, especially in an ambitious Test Facility, CTF3. The R&D is performed by a multi-lateral CLIC/CTF3 collaboration strong of 37 volunteer institutes from 19 countries from which the outstanding work and results are reported.

FRXCMH02 **Plasma Accelerators for Future Colliders** – *C. Joshi (UCLA)*

Recent experiments on beam-driven Plasma Wakefield Acceleration has shown spectacular results- that 42 GeV electrons can be made to double their energy in less than one meter using collective fields in a plasma. Simulations have shown that it is possible to not only obtain high energy gains but also to have small energy spread and emittances needed for a future collider application from such a device. Furthermore the overall energy extraction efficiency from the drive beam to the accelerating beam can be made to be very high. It is the purpose of the FACET facility now under construction at SLAC to address these critical issues in the next five years. Based on the luminosity requirements of high energy physicists for a 1 TeV CM electron-positron collider, a strawman design study of a plasma wakefield accelerator linear collider (PWFA-LC) has been carried out. This talk will review the the results obtained to-date, the proposed upcoming program on FACET and discuss the roadmap for a PWFA-LC.

28-May-10 11:00 – 12:30	Invited Oral	Main Hall

FRYMH — Special Closing Presentations

Chair: A. Noda, Kyoto ICR (Uji, Kyoto)

FRYMH01 **International Energy Related Developments, ITER and IFMIF** – *N.R. Holtkamp (ITER)*

An overview of the ITER project will be presented together with other major projects within the worldwide Fusion programme, especially IFMIF (The International Fusion Materials Irradiation Facility). IFMIF is a high intensity deuteron accelerator for material irradiation research with a prototype to be constructed in Japan by an international team. ITER is the worlds largest Tokamak under construction in Cadarache (France), with seven parties (China, Europe, India, Japan, Korea, Russia and the US) contributing ninety percent of the project In-Kind. These two major activities together with the upgrade of the Japanese Tokamak JT-60SA as well as the development of a worldwide platform for fusion research are the pillars of research to develop Fusion as a realistic source of energy for the future.

FRYMH02 **Cloud Project: Climate Research with Accelerators** – *J. Kirkby (CERN)*

The CLOUD Project, where a high-energy physics accelerator is being used to study atmospheric and climate science for the first time, will be described.

FRYMH03 **The Pierre Auger Observatory: Cosmic Accelerators and the Most Energetic Particles in the Universe** – *J. Bluemer (KIT, KCETA)*

Cosmic ray particles can produce extended air showers that have a total energy of more than 100 EeV, which is a hundred million times more than the TeV particles that we produce in accelerators. How do the cosmic accelerators work? Where are they and what are they accelerating? How do the supposedly extragalactic particles propagate to Earth? Do they offer a new kind of astronomy? The Pierre Auger Observatory is an international project dedicated to find answers to these - and many more - questions. The presentation reviews the goals, achievements and plans for a better understanding of ultra-high energy cosmic rays.

24-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area A
MOPEA — Poster Session			

MOPEA001 **Production and Characterisation of Inverse Compton Scattering X-rays with a 17 MeV Electron Beam** – *A.S. Chauchat, J.P. Brasile (THALES) A. Binet, V. Le Flanchec, J-P. Nègre (CEA) J.-M. Ortega (CLIO/ELISE/LCP)*

Inverse Compton scattering is a well-known process to produce X-rays. Thanks to recent progress in accelerators and laser field, such sources have been developed worldwide. The ELSA facility (CEA DAM DIF, Arpajon, France), a linear electron accelerator, has just made its own source. The 17 MeV electron beam interacts with a 532 nm laser to provide a pulsed 10 keV X-ray source. Careful spatial and temporal overlappings of the bunches were required to observe the X-ray profile on radio-luminescent imaging plates. The aim of this source is to validate some technical process and simulation codes to design a compact X-ray source for industrial and medical applications. Instrumentation developments and experimental results are presented.

MOPEA002 **Eye Tumour Therapy in Berlin** – *A. Denker (HMI) D. Cordini, J. Heufelder, R. Stark, A. Weber (Charite) C.R. Rethfeldt, J.R. Roehrich (HZB)*

The ion beam laboratory ISL at the Hahn-Meitner-Institute (HMI) Berlin supplied light and heavy ion beams for research and applications in solid state physics, industry, and medicine. Since 1998, eye tumours are treated with 68 MeV protons in collaboration with the University Hospital Benjamin Franklin, now Charité - Campus Benjamin Franklin. In autumn 2004 the board of directors of the HMI decided to close down ISL at the end of 2006. In December 2006, a cooperation contract between the Charité and the HMI was signed to assure the continuity of the eye tumour therapy, at the moment the only facility in Germany. The accelerator operation will be continued with reduced man-power, requiring changes in the set-up of the accelerators. A new, facile injector for protons is foreseen. Increasing the reliability will be a key issue. The last two years of operation of ISL as a full multi-purpose accelerator will be shown and examples of the research work will be demonstrated. The conversion of a multi-ion, variable energy accelerator to a dedicated accelerator for eye tumour therapy will be discussed.

MOPEA003 **Linac Commissioning at the Italian Hadrontherapy Centre CNAO** – *B. Schlitt, G. Clemente, C.M. Kleffner, M.T. Maier, A. Reiter, W. Vinzenz, H. Vormann (GSI) C. Biscari (INFN/LNF) E. Bressi, M. Pullia, E. Vacchieri, S. Vitulli (CNAO Foundation) A. Pisent, P.A. Posocco, C. Roncolato (INFN/LNL)*

The Centro Nazionale di Adroterapia Oncologica (CNAO) presently under commissioning in Pavia, Italy, will be the first Italian facility for the treatment of deeply seated tumours with proton and carbon ion beams. The CNAO accelerator comprises a 7 MeV/u injector linac and a 400 MeV/u synchrotron. The 216.8 MHz linac is a copy of the linac at the Heidelberg Ion-Beam Therapy Centre (HIT) and consists of a 400 keV/u 4-rod type RFQ and of a 20 MV IH type drift tube linac. In 2004, a collaboration between CNAO and GSI was established for construction and commissioning of the linac. GSI supervised the manufacturing of the linac and of its technical systems, performed copper-plating, assembly, and tuning (together with IAP Frankfurt), and delivered complete beam diagnostics systems. The RFQ was tested at GSI with proton beams together with the BD systems prior to delivery to CNAO. Installation and commissioning in Pavia were performed in collaboration by CNAO, GSI, and INFN. RFQ and thereafter IH linac were successfully commissioned in two steps in 2009, both with (H3)+ and carbon ion beams. The results of the linac commissioning will be reported as well as a comparison to the HIT linac.

MOPEA004 **Accelerators Tailored for Medical Use in Particle Therapy** – *M. Braeuer (Siemens Med)*

Siemens Healthcare is building ion-accelerators as part of the IONTRIS system for Particle Therapy*. The requirements on the ion beam properties and the accelerators have been derived from the needs of the medical application. An overview is given, how Siemens accelerators match these requirements. Furthermore the supervision of beam properties with medical devices during patient irradiation is outlined. Experiences from the beam commissioning of the medical system at the Heidelberg facility** are shown. This includes the commissioning of the supervision systems, which trigger the fast beam-off systems.

MOPEA005 **Status of the SIEMENS Particle Therapy Accelerators IONTRIS** – *P. Urschütz, S. Emhofer, V.L. Lazarev, M. Leghissa, H. Rohdjess, R. Schedler, B. Steiner, E. Tanke (Siemens Med) H.K. Andersen, M. Budde, F. Bødker, J.S. Gretlund, I. Jensen, H.B. Jeppesen, C.V. Nielsen, C.G. Pedersen, S.V. Weber (Siemens DK)*

Siemens has earned three contracts to deliver IONTRIS Particle Therapy accelerator systems* to be operated in Marburg and Kiel, both in Germany, and in Shanghai, China. The accelerator part consists of an injector (7 MeV/u protons and light ions) and a compact synchrotron able to accelerate proton beams up to 250 MeV and carbon ions up to 430 MeV/u. These beams can be slowly extracted and delivered to a choice of fixed-angle horizontal, semi-vertical and vertical beam-ports. An overview of the design will be given and the status of the installation and commissioning work for the first two projects will be shown.

MOPEA006 **Operational Status and Further Enhancements of the HIT Accelerator Facility** – *A. Peters, R. Cee, E. Feldmeier, M. Galonska, Th. Haberer, S. Scheloske, C. Schömers, T. Winkelmann (HIT)*

Since November, 15th 2009 patients are treated with protons and carbon ions at the Heidelberg Ionbeam Therapy Centre (HIT). The facility - two ion sources, an injector linac and a compact synchrotron - is operated in 24/7-mode with high availability. The HIT beam time schedule is discussed along the statistics automatically generated by the control system. Besides the patient treatment in the first horizontal room beam time is also used to develop enhanced treatment software in the second horizontal room as well as for commissioning the gantry place. Additionally, biophysics studies are served at a separate experimental place. In parallel, an upgrade program for the accelerator is under way: at first a test bench for a third ion source, later on dedicated to He beams, will be used to study several ideas to increase the injector performance. Furthermore operation mechanisms are under progress to control directly the synchrotron dipole and quadrupole fields as well as to regulate the spill structure - the aim of both developments is to form a uniform and extremely stable extracted beam with high duty cycle. An overview on this entire accelerator R&D at HIT will be given.

MOPEA007 **Fast Raster Scanning System for HIMAC New Treatment Facility** – *T. Furukawa, T. Inaniwa, Y. Iwata, K. Katagiri, K. Mizushima, K. Noda, S. Sato, T. Shirai, Y. Takei, E. Takeshita (NIRS)*

Construction of new treatment facility as an extension of the existing HIMAC facility, in which all treatment room will be equipped with a 3D pencil beam scanning system, is in progress at NIRS. The challenge of this project is to realize treatment of a moving target by scanning irradiation, because pencil beam scanning is more sensitive to organ motions compared with the conventional broad-beam irradiation. To accomplish practical moving target irradiation, a prototype of the scanning irradiation system was constructed and installed into existing HIMAC physics experiment course. One of the most important features of the system to be tested is fast scanning toward moving target irradiation with a relatively large number of rescannings within an acceptable irradiation time. Commissioning of the prototype is successfully in progress cooperating with highly stabilized beam provided by the HIMAC accelerator complex. We will report the design of the system and the status of the beam study.

MOPEA008 **Multiple-energy Operation with Quasi-DC Extension of a Flat Top at HIMAC** – *Y. Iwata, T. Furukawa, K. Noda, T. Shirai, E. Takada (NIRS) T. Fujimoto, T. Kadowaki, H. Uchiyama (AEC)*

Tumor therapy using energetic carbon ions, as provided by the HIMAC, has been performed since June 1994, and more than 5000 patients were treated until now. With the successful clinical results over more than ten years, we are constructing a new treatment facility. The new facility would have three treatment rooms; two of them have both horizontal and vertical fixed-irradiation-ports, and the other has a rotating-gantry-port. For all the ports, a scanning irradiation method is applied. The new facility is constructed in conjunction with the HIMAC, and heavy-ion beams will be provided by the HIMAC accelerators. To fulfill requirements for the scanning irradiation, we proposed multiple-energy operation with the quasi-DC extension of a flat top. With this operation, the beam energy can be successively varied within a single synchrotron-cycle, and therefore no energy degrader or the range shifter is required. The beam acceleration and extraction tests of the multiple-energy operation were successfully made. We will present the development of this operation as well as results of the beam acceleration tests.

MOPEA009 **Beam Transport Line and Gantry Design for New Treatment Facility at HIMAC** – *T. Shirai, T. Furukawa, Y. Iwata, K. Noda, S. Sato, E. Takeshita (NIRS) T. Fujimoto, Y. Sano (AEC)*

Based on the experience of the treatment at HIMAC, we have constructed the new treatment facility of the carbon therapy for the further therapeutic developments. The research subjects are the fast 3D scanning system toward the adaptive therapy and a gantry system for the intensity modulated carbon therapy. The carbon beam with 430 MeV/n is provided from upper synchrotron of HIMAC and transported to three treatment rooms including a gantry through a new high energy beam line. The optics and magnet design of the beam transport have been fixed and the components are under construction. The rotating gantry also has been designed, concerning the beam optics, the magnets and the mechanical structure. The height and the weight of the gantry are 7m and 350t.

MOPEA010 **Beam Measurement of X-band Linac for Compton Scattering X-ray Generation** – *T. Natsui (UTNL) K. Lee, M. Uesaka (The University of Tokyo, Nuclear Professional School) A. Mori (University of Tokyo) F. Sakamoto (Akita National College of Technology)*

We are developing an X-band linac system for monochromatic X-rays source. The monochromatic X-ray is obtained by Compton scattering. Our system has an X-band (11.424 GHz) 3.5-cell thermionic cathode RF gun, traversing wave accelerating tube and a Q-switch Nd:YAG laser with a wavelength of 532 nm. We adopt a laser pulse circulation system. The RF gun can generate multi-bunch electron beam. We aim to generate 1 μs maximum energy electron beam and collide it to circulated laser pulse. I will present a current status of beam measurement of this linac.

MOPEA012 **A Compact and High-Proton-Yield Microwave Ion Source for Proton Linac** – *T. Iga, S. Hara, T. Seki (Hitachi, Ltd., Energy and Environmental System Laboratory)*

A compact and high-proton-yield 2.45 GHz microwave ion source has been developed and tested on an AccSys Model PL-7 linac. The ion source employs permanent magnets, a back yoke and an extraction electrode, both of which are made of iron. This design helps to generate a suitable axial magnetic field in a plasma chamber with smaller magnets. Thus, it allows the whole diameter of the source to be as small as 115mm while that of the plasma chamber is 72mm. The chamber is partially lined with a boron nitride cup. Microwave power is fed to the plasma chamber through a double ridged waveguide and a vacuum window. Pulsed hydrogen ion beams of 32 mA were extracted from 5 mm diameter extraction aperture with proton fraction of 90 % or higher at 30 kV beam energy and with incident microwave power of 1.3 kW. The ion source-linac measurements showed that a peak proton current of 13.1 mA was obtained with pulse duration of 50 us and a pulse repetition frequency of 16 Hz at the exit of the linac when the linac input current was 19.6 mA. These performances will be desirable for linac applications such as proton therapy systems, PET isotope production systems, neutron generation systems, etc.

MOPEA013 **Laser-driven Proton Accelerator for Medical Application** – *M. Nishiuchi, P.R. Bolton, T. Hori, K. Kondo, A.S. Pirozhkov, A. Sagisaka, H. Sakaki, A. Yogo (JAEA) Y. Iseki, T. Yoshiyuki (Toshiba) S. Kanazawa, H. Kiriyama, M. Mori, K. Ogura, S. Orimo (JAEA/Kansai) A. Noda, H. Souda, H. Tongu (Kyoto ICR) T. Shirai (NIRS)*

The interaction between the high intensity laser and the solid target produces a strong electrostatic proton acceleration field (1 TV/m) with extraordinary small size, contributing to downsizing of the particle accelerator. The proton beam exhibits significant features. having very small source size(~10 um), short pulse duration (~ps) and very low transverse emittance. However it is a diverging beam (half angle of ~10 deg) with wide energy spread of ~100 %. Because of these peculiar characteristics the proton beam attracts many fields for applications including medical applications. To preserve these peculiar characteristics, which are not possessed by those beams from the conventional accelerators, towards the irradiation points, we need to establish a peculiar beam transport line. As the first step, here we report the demonstration of the proto-type laser-driven proton medical accelerator beam line in which we combine the laser-driven proton source with the beam transport technique already established in the conventional accelerator for the purpose of comparison between the data and the particle transport simulation code, PARMILA*.

MOPEA014 **DNA Double-Strand Break Induction in A549 Cells with a Single-Bunch Beam of Laser-Accelerated Protons** – *A. Yogo (JAEA)*

We report the demonstrated irradiation effect of laser-accelerated protons on human cancer cells. In-vitro (living) A549 cells are irradiated with a proton beam having a single bunch duration of 20 ns and a beam flux of $\sim 10^{14} cm^{-2} s^{-1}$*. The dynamics differ by seven orders of magnitude to the case of a typical Ion Beam Therapy (IBT) operation with a synchrotron: 0.4 s in bunch duration and $\sim 10^{7} cm^{-2} s^{-1}$ in beam flux. We have measured the yield of DNA double-strand break with phosphorylated histone H2AX immunostaining method and estimated Relative Biological Effectiveness (RBE) of the laser-accelerated protons.

MOPEA015 **Calculation of the Radiation Shielding for Laser-driven Proton Therapy Equipment** – *H. Sakaki, P.R. Bolton, T. Hori, M. Nishiuchi (JAEA) K. Niita (RIST)*

JAEA is considering the conceptual design of the 80MeV laser-driven proton radiotherapy equipment. The high-energy photon and the electron are generated from the laser irradiation point besides the proton necessary which used the therapy. Because these radiations, other than the proton, are not used for the therapy, an efficient radiation shielding is demanded on the equipment. Then, we were evaluated and the shielding method was examined. In this report, it reports on the outcome.

MOPEA016 **The Beam Characteristics of Intensity-modulated Radiotherapy 6MeV Standing Wave Accelerating Tube** – *H. Chen, Q.X. Jin, Y. Z. Lin (TUB)*

The method of intensity-modulated radiotherapy (IMRT) is increasingly concerned by the medical world in recent years. Based on the performance characteristic of IMRT accelerator, a 6MeV S-band on axis-coupled SW, Suitable for IMRT, electron linear accelerating tube has developed in Accelerator Lab of Tsinghua University. This paper provides the design performance characteristics of the tube and the results of the high-power tests.

MOPEA017 **C-band 9 MeV / 12 MeV SW Electron Linear Accelerating Tube Design** – *Q.X. Jin, H. Chen, D.C. Tong (TUB)*

In this paper, the design and performance characteristics of accelerating tube for C-band SW electron linac are discussed. The tube can accelerate electrons to 9 MeV or 12 MeV. Its length is about 620 mm, and a Pierce electron gun has been used. A 2.5 MW pulsed magnetron at 5712 MHz is served as the tube's RF power source. The two energy modes are performed by turning RF power source and the injecting voltage of electron gun.

MOPEA018 **Study of the Install a Small Animal Experiment Equipment in a MC-50 Cyclotron LEPT Beam Line** – *M.H. Jung, J.-K. Kil, K. R. Kim, S.J. Ra (KAERI)*

Proton therapy has features of minimal effect on tumor surrounding healthy tissue and huge damage on tumor volumes specifically. Due to these characteristics of proton therapy the number of patients with receiving proton therapy is increasing every year. Proton therapy is useful for tumor treatment but still not know mechanism of proton beam that how to kill the tumor cells. In korea, a lot of current research progressed at the cellular level by using a proton accelerator, the animal experiments was not held virtually because of the absence of the device. In this study, we installed a animal experiment device for proton beam irradiation in MC-50 cyclotron LEPT (Low Energy Proton Therapy) beam line. Bouls and collimator, we easily made to be installed and we used PMMA sheet in order to reduce the energy. In addition, we used ridge filter type modulator for making SOBP and depth-dose measurement system for a proton beam dosimetry.

MOPEA019 **Study on the Injection System for Compact Cyclotron Mass Spectrometry** – *D.G. Kim, H.-C. Bhang, J.Y. Kim (SNU) J.-W. Kim (NCC, Korea) C.C. Yun (Chung-Ang University)*

Accelerator mass spectrometry (AMS) using a cyclotron has been studied because the system can be more compact and economical compared to the widespread commercial Tandem AMS. However, the previous efforts to build such a system showed that it has weakness in stability and transmission efficiency. To increase transmission efficiency it is important for the injection system to match not only the transverse phase space of a beam but also the longitudinal phase space with cyclotron acceptance. We plan to adopt a sawtooth RF buncher to increase transmission efficiency in the acceleration region of the cyclotron and a radial injection beam line. A goal in designing the injection line is to minimize the number of beam line elements to keep the system compact. The design of the injection system was carried out using the codes such as TRANSPORT and TRACE-3D. A prototype of the injection system is being constructed, and some results will be presented.

MOPEA020 **Overview of the MedAustron Design and Technology Choices** – *M. Benedikt, J. Gutleber, M. Palm, W. Pirkl (CERN) U. Dorda, A. Fabich (EBG MedAustron)*

MedAustron is a synchrotron based accelerator facility for cancer treatment in Austria currently in the development phase at CERN. The design is based on the PIMMS* and CNAO** synchrotron . In addition to the clinical application, the accelerator will also provide beams for non-clinical research in the fields of medical radiation physics, radiation biology and experimental physics with an extended proton energy range beyond medical requirements to 800 MeV. The differences to others facilities will be detailed, specifically the used source technologies and configuration (starting up with p and C allowing a later upgrade to ion species for p to neon), the HEBT design (rotator, gantry), and the online verification of all relevant beam parameters. The current project status together with the project schedule with planned patient treatment in 2014 is presented.

MOPEA021 **PAMELA: Overview and Status** – *K.J. Peach, J.H. Cobb, S.L. Sheehy, H. Witte, T. Yokoi (JAI) M. Aslaninejad, M.J. Easton, J. Pasternak (Imperial College of Science and Technology, Department of Physics) R.J. Barlow, H.L. Owen, S.C. Tygier (UMAN) C.D. Beard, P.A. McIntosh, S.M. Pattalwar, S.L. Smith, S.I. Tzenov (STFC/DL/ASTeC) N. Bliss, T.J. Jones, J. Strachan (STFC/DL) T.R. Edgecock, J.K. Pozimski (STFC/RAL) R.J.L. Fenning, A. Khan (Brunel University) I.S.K. Gardner, D.J. Kelliher, S. Machida (STFC/RAL/ASTeC) M.A. Hill (GIROB) C. Johnstone (Fermilab) B. Jones, B. Vojnovic (Gray Institute for Radiation Oncology and Biology) R. Seviour (Cockcroft Institute, Lancaster University)*

The status of the PAMELA (Particle Accelerator for MEdical Applications) project to design an accelerator for proton and light ion therapy using non-scaling Fixed Field Alternating Gradient (ns-FFAG) accelerators is reviewed and discussed.

MOPEA022 **PAMELA: Lattice Solution for a Medical C^{6+} Therapy Facility** – *S.L. Sheehy, K.J. Peach, H. Witte, T. Yokoi (JAI) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC)*

PAMELA (Particle Accelerator for MEdicaL Applications) employs novel non-scaling Fixed Field Alternating Gradient (NS-FFAG) technology in the development of a proton and C^{6+} particle therapy facility. One of the challenges of this design is the acceleration of high energy C^{6+} in a lattice which enables high flexibility and reliability for treatments, yet remains minimal in size and complexity. Discussed here is the Carbon 6+ lattice solution in terms of both design and performance.

MOPEA023 **Engaging Schools and the Public with Accelerator Physics** – *S.L. Sheehy (JAI)*

Accelerator physics is often viewed as a difficult subject to communicate to schools and the public. The "Accelerate!" project, initiated in the UK in 2008, engages audiences with accelerator physics through a 45-minute live, interactive demonstration show, using basic physics demonstrations to explain the physics of particle accelerators and what they are used for. Feedback has been overwhelmingly positive from all areas, and demand for the show is very high, with over 3000 students involved in the first year of running. The program is also contributing to the science communication skills of physics graduate students. I discuss how to portray basic accelerator concepts through easy to access demonstrations and initial results of audience evaluation of the show.

MOPEA024 **Portable X-Ray Imaging using an Array of Electron Microemitters** – *G. Travish, J.B. Rosenzweig, A.M. Tremaine (UCLA) R.B. Yoder (Manhattanville College)*

For the past century, medical imaging has relied on fundamentally the same approach for producing x-rays: the x-ray tube. The tube implies x-ray systems are heavy, not portable, and expensive. This paper presents a method that would allow the x-ray source to move from a bulky and fragile tube to a flat-panel system produced in much the same way as modern televisions are made. The method relies on a combination of field generation within pyroelectric crystals and field enhancement from sharp emitters. X-ray energies in the range from 10-100kV can be produced through bremsstrahlung, matching well with the needs of common medical imaging.

MOPEA025 **Accelerator Production Options for 99Mo** – *K.J. Bertsche (SLAC)*

Shortages of 99Mo, the most commonly used diagnostic medical isotope, have caused great concern and have prompted numerous suggestions for alternate production methods. A wide variety of accelerator-based approaches have been suggested. In this paper we survey and compare the various accelerator-based approaches.

MOPEA026 **Update on the Innovative Carbon/Proton Non-scaling FFAG Isocentric Gantries for the Cancer Therapy** – *D. Trbojevic (BNL)*

There is a dramatic increase in number of proton/carbon cancer therapy facilities in recent years due to their clear advantage over other radiation therapy treatments. The cost of ion cancer therapy is still prohibitive for most of the hospitals, and the dominant costs are beam delivery systems. We previously presented designs of carbon and proton isocentric gantries using non-scaling alternating gradient fixed field magnets (NS-FFAG) *, where gantry magnet size and weight are dramatically reduced. The weight of the transport elements of our NS-FFAG carbon isocentric gantry is 1.5 tons compared to 130 ton gantries recently constructed Heidelberg C facility at Heidelberg. We have also designed a proton NS-FFAG permanent magnet gantry with an estimated weight of 500 kg. We present an update on these designs.

MOPEA027 **A Compact Affordable Proton Cancer Therapy Accelerator with Permanent Magnets** – *D. Trbojevic, I. Ben-Zvi, M. Blaskiewicz (BNL)*

The number of proton/carbon ion cancer therapy facilities is growing with an enormous rate due to a clear dose advantage with respect to other radiation therapies. Unfortunately, such facilities are still not affordable for many hospitals. Beam delivery systems, including gantries, are the most expensive part of an ion therapy facility. We have presented a non-scaling Fixed Field Alternating Gradient (NS-FFAG) proton/carbon isocentric gantry designs with dramatic reductions in weight and cost over conventional gantries. Here, we present a compact proton accelerator with an NS-FFAG racetrack lattice. The two arcs are made of Halbach permanent separated function magnets, allowing proton acceleration from 30-250 MeV with small orbit offsets within the arcs through the whole energy range. Matched straight sections are used for a single turn injection/extraction and acceleration. Advantages of this accelerator for therapy over a cyclotron are: variable energy without degraders, and single-turn extraction that avoids beam loss and residual radiation present in cyclotrons. A fast acceleration rate represents an advantage over synchrotrons. A fast 3D IMPT spot scanning is achievable.

MOPEA028 **Lattice Design for the ERL Medium Energy Electron Ion Collider in RHIC** – *D. Trbojevic, J. Beebe-Wang, X. Chang, Y. Hao, A. Kayran, V. Litvinenko, B. Parker, V. Ptitsyn, N. Tsoupas (BNL) E. Pozdeyev (FRIB)*

We present a medium-energy (4 GeV) electron ion collider (MeRHIC) lattice design for the Relativistic Heavy Ion Collider (RHIC). MeRHIC represents a staged approach towards the higher energy eRHIC, with MeRHIC hardware being reused for eRHIC. The lattice design includes two Energy

Recovery Linacs (ERLs), multiple isochronous arcs connected to the ERLs, an interaction region design, a low energy ERL with a polarized electron source, and connecting beam lines.

MOPEA029 **Ion Beams by Laser Ion Source for Modification of Polymers** – *L. Velardi, M.V. Siciliano (INFN-Lecce) V. Nassisi (LEAS) F. Paladini (Laboratorio di Elettronica Applicata e Strumentazione, LEAS,) A.C. Rainò (INFN-Bari)*

Ion implantation for modification of polymeric surfaces is shown. The treated biomaterials were samples of Ultra High Molecular Weight Polyethylene (UHMWPE). Implantations of C and Ti ions were performed by using a LIS (Laser Ion Source) accelerator. The utilized laser to induce ablation was an excimer KrF, of 248 nm and 20 ns of pulse duration. Within the apparatus, a pierced chamber was mounted for the expansion and extraction of the plume, and it was put at an high positive voltage of 40 kV in order to accelerate the extracted positive ions toward the UHMWPE samples. Contact angle, roughness and Fourier Transform Infra Red (FT-IR) measurements were performed before and after the treatments in order to have information about the modification of the surface characteristics. An increase of the wettability and hardness was obtained by ion implantation.

MOPEA030 **Material Recognition System using 950 keV X-band Linac with Dual Energy X-ray Scintillator Array** – *K. Lee, E. Hashimoto, S. Hirai, M. Uesaka, T. Yamamoto (The University of Tokyo, Nuclear Professional School) T. Natsui (UTNL)*

Dual energy X-ray system using high energy X-ray from linear accelerator (Linac) applies two times X-ray irradiation which have different energy spectrum each other in many cases. Two different X-rays yield two tomography images which is analyzed through numerical calculation with pixel values for material recognition of a object. However if the X-ray generation is not stable, the results of numerical calculation shows irregular tendency during the inspection. We propose the scintillator array in detection part, because two tomography images are obtained by just one irradiation. That leads to the time saving during inspection and the cost down for additional facilities. The optimal condition is researched to increase the ability of material recognition in interesting materials designing the detector with CsI and CdWO4 scintillators. We focus on the discrimination between heavy materials and light materials with the system in the research. X-ray source is 950 keV X-band Linac we developed for industrial application, which produce pulsed X-ray, 10 pps with around 400 mA beam current.

MOPEA031 **Application of Liquid Cluster Ion Beams in Surface Processing** – *H. Ryuto, G.H. Takaoka, M. Takeuchi (Kyoto University, Photonics and Electronics Science and Engineering Center)*

A liquid cluster ion beam irradiation system has been developed for surface processing and modification of solid materials used in the semiconductor industry. The liquid clusters are produced by the adiabatic expansion method. The vapor pressure of the source materials such as water or ethanol is increased by heating, and ejected to a vacuum chamber through a supersonic nozzle. The ionized clusters by the electron impact ionization are accelerated to typically 3-9 kV after the elimination of monomers by the retarding voltage method, and irradiated on the solid surfaces. The sputtering yield of silicon by the ethanol cluster ion beam irradiation was more than 100 times larger than that by an argon monomer ion beam. On the other hand, the radiation damage and surface roughness caused by the ethanol cluster ion beam irradiation decreased when the mean cluster size was increased by increasing the retarding voltage. Irradiation effects of liquid cluster ion beams on polymers are also discussed.

MOPEA032 **Carbon Implantation by Polyatomic Ion Source of Organic Liquids** – *M. Takeuchi, H. Ryuto, G.H. Takaoka (Kyoto University, Photonics and Electronics Science and Engineering Center)*

In order to establish a shallow implantation of polyatomic carbons, a polyatomic ion source for organic liquids with a high-vapor pressure was developed. Vapor of n-octane was ionized by an electron bombardment, and the ion current of 230 μA was obtained at an extraction voltage of 2 kV. The mass spectra indicated that C_3H_7 ion was the highest in the ion concentration and some fragmentations of octane molecule took place, which might be caused by the electron bombardment. Depth profile of carbon into single crystalline silicon irradiated with C_3H_7 or C_6H_{13} at different acceleration voltage was analyzed by X-ray photoelectron spectroscopy. As a result, the implanted depth increased with increase of the acceleration voltage. In addition, the C_6H_{13} was implanted deeper than the C_3H_7 at the same incident energy per atom even though shallow implantation due to binary collision effect had been expected. The depth profile are also discussed in comparison with computer simulation results.

MOPEA033 **Characteristics of the Electron Linac Based Coherent Radiation Light Source at OPU** – *S. Okuda, T. Kojima, R. Taniguchi (Osaka Prefecture University)*

The coherent synchrotron and transition radiation from the bunched electron beams of a linear accelerator (linac) has continuous spectra in a submillimeter to millimeter wavelength range at relatively high peak-intensity. The coherent radiation has been applied to absorption spectroscopy for various kinds of matters. However, the number of such light sources are very small. A new pulsed coherent transition radiation light source has been established by using the electron beams of a 18 MeV S-band electron linac at Osaka Prefecture University (OPU). In the linac pulsed electron beams are injected from a thermionic triode gun with a cathode-grid assembly at pulse lengths of 5 ns-4 μs at a pulse repetition rate of 500 pulses/s in maximum. The light source will be also applied to the pump-probe experiment using the pulsed electron beam or the pulsed coherent radiation as a beam for pumping matters and the coherent radiation for probing them. The transient properties of the matters excited with the electron beams or the coherent radiation will be investigated. The characteristics of the light source are reported.

MOPEA034 **Study of Positron Production System using Superconducting Electron Linac** – *N. Hayashizaki (RLNR) R. Kuroda, N. Oshima, R. Suzuki (AIST) E.J. Minehara (WERC)*

Positron that is the antiparticle of the electron, by the specific character, can evaluate vacant spaces in microstructure from atomic level to nanometer level, which is difficult in other measurement methods. In the case of high functional material, this structure often relates directly to the performance, and the evaluation method that uses the positron beam is expected as a useful measurement tool to develop a new material. If it is able to produce more high-intense and low-energy positron beam with an accelerator, the microstructure evaluation is carried out in prompt and high accuracy for various demands of the material analysis. We have studied a positron production system using a superconducting electron linac instead of normal conducting one. Electron beam accelerated with the superconducting linac is irradiated on tantalum and converted to bremstrahlung photons, and positron beam is produced by pair creation of them. The designed acceleration energy of the superconducting electron linac is 15-40 MeV and the maximum beam power is 10 kW. The system configuration and the progress status will be presented.

MOPEA035 **Pulse Radiolysis with Supercontinuum Probe Generated by PCF** – *Y. Hosaka, R. Betto, A. Fujita, K. Sakaue, M. Washio (RISE) S. Kashiwagi (ISIR) R. Kuroda (AIST) K. Ushida (RIKEN)*

We have been studying a pump-probe pulse radiolysis as an application of the S-band photo cathode RF-Gun. Pump-probe spectroscopy is well-known method of pulse radiolysis measurement. We had used 5MeV electron beam obtained from the photo cathode RF-Gun as a pump beam, and used the white light emitted from Xe flash lamp or generated by self-phase modulation in the water cell as a probe light. However, the white probe light with high intensity, good stability and broad spectrum is a key issue for pump-probe pulse radiolysis. Supercontinuum light with photonic crystal fiber (PCF) is a new technique of white light generation. Short pulse laser through PCF spreads its spectrum by nonlinear optical effect. Supercontinuum light has very continuous spectrum, and it is studied for various applications recently. For applying supercontinuum light as a probe of pulse radiolysis experiment, we have generated a supercontinuum radiation with 7 picoseconds pulse width IR (1064nm) laser and PCF, and measured its properties. The experimental results of supercontinuum generation and design of a supercontinuum based pulse radiolysis system will be presented.

MOPEA036 **Design of High Brightness Light Source based on Laser-Compton Undulator for EUV Lithography Mask Inspection** – *K. Sakaue, A. Endo, M. Washio (RISE)*

We will present a design of high brightness light source for EUV lithography mask inspection. The required system parameters are minimum brightness of 2500W/mm2/Sr at 13.5nm/2% bandwidth. Our design consists of super-conducting DC RF-gun as a radiator and 10.74nm CO2 laser stacked in an optical cavity as a laser undulator. Recent achievements of each component technologies, which is 1.3GHz SC-RF-gun, 10kW average power short pulse CO2 laser, and laser storage optical super-cavity, indicate the feasibility of producing required brightness based on laser Compton undulator. Design parameters of high brightness EUV source, the technological gap of the present component technologies and required further developments will be resented at the conference.

MOPEA037 **Activation and Discoloration of Polymer by Proton Beam** – *S.J. Ra, M.H. Jung, K. R. Kim (KAERI)*

In our earlier study, we investigated activation of proton irradiation and secondary neutron irradiation in PMMA, PS, and soda lime glass and we also investigated color changes of them. The color changes recovered noticeably after annealing the irradiated samples in air at room temperature for 2~3 months then we researched paper and found that there are two kind of discolorations; permanent and annealable. In our proton accelerator facility, the use of optical property polymers are frequent so these discoloration could be possible to cause unexpected failure. In this work, 45MeV proton beams (MC-50 Cyclotron, KIRAMS) were irradiated in matters, then we investigated activation of polymers and studied the relation between LET effect and discoloration of them.

MOPEA038 **Gamma-Ray Source for Nuclear Resonance Fluorescence Based on Compton Storage Ring** – *P. Gladkikh, E.V. Bulyak, V.A. Skomorokhov (NSC/KIPT) T. Omori, J. Urakawa (KEK)*

Nuclear resonance fluorescence (NRF) is the one of the most promising methods of the nuclear waste management and of the modern technologies of the nonproliferation of nuclear weapons. There are a few proposals of the usage of NRF *,**. Yet linac and energy recovery linac are suggested as the electron source for the Compton scattering (CS) of the laser photons. The storage ring is capable to produce sufficiently higher beam intensity and is more effective since the electrons interact with the laser pulse many times. The storage ring with the electron energy from 240 to 530 MeV is proposed for the CS of 1.16 eV laser photons in the report. Maximal energy of the scattered gamma rays lies within range from 1 MeV to 5 MeV. It allows detecting of practically any isotope in analyzed objects. The specificity of the proposed storage ring is usage of the crab-crossing of the electron and laser beams. Due to crab-crossing we expect to obtain the gamma beam intensity approximately $5*10^{13}$ gammas / s for laser flash energy 5 mJ stored in the optical cavity. Both electron beam and gamma beam parameters are studied analytically and by simulation of the CS in the designed ring lattice.

MOPEA039 **Beam Study for FFAG Accelerator at KURRI** – *Y. Kuriyama, Y. Ishi, J.-B. Lagrange, Y. Mori, T. Planche, M. Takashima, T. Uesugi, E. Yamakawa (KURRI) H. Imazu, K. Okabe, I. Sakai, Y. Takahoko (University of Fukui, Faculty of Engineering)*

In Kyoto University Research Reactor Institute (KURRI), The FFAG accelerator complex for accelerator driven sub-critical reactor (ADSR) project has been already constructed and world first ADSR experiment has been done at May, 2009. In the main ring, proton beams of 11.5 MeV are injected and accelerated up to 100 MeV. During the acceleration, two different types of beam loss have been observed. To investigate these beam loss, betatron and synchrotron motion have been measured experimentally. The details of measurements will be described in this presentation.

MOPEA040 **Study on Neutronics Design of an Accelerator Driven Subcritical Reactor** – *C. Bungau (Manchester University) R.J. Barlow (UMAN) R. Cywinski (University of Huddersfield)*

Thorium fueled Accelerator Driven Subcritical Reactors have been proposed as a more comprehensive alternative to conventional nuclear reactors for both energy production and for burning radioactive waste. Several new classes have been added by the authors to the GEANT4 simulation code, extension which allows the state-of-the-art code to be used for the first time for nuclear reactor criticality calculations. In this paper we investigate the impact of the subcriticality and injected proton beam energy on the ADSR performance for novel ADSR configurations involving multiple accelerator drivers and associated neutron spallation targets within the reactor core.

MOPEA041 **Multi-GeV High-Current SRF Linacs for Very Large Power Stations** – *R.P. Johnson, C.M. Ankenbrandt (Muons, Inc) M. Popovic (Fermilab)*

A Superconducting RF (SRF) Linac can be used for an accelerator-driven subcritical (ADS) nuclear power station to produce more than 5 GW electrical power in an inherently safe region below criticality, generating no greenhouse gases, producing minimal nuclear waste and no byproducts that are useful to rogue nations or terrorists, incinerating waste from conventional nuclear reactors, and efficiently using abundant thorium fuel that does not need enrichment. First, the feasibility of the accelerator technology must be demonstrated. We describe the Linac parameters that can enable this vision of an almost inexhaustible source of power and we discuss how the corresponding reactor technology can be matched to these parameters.

MOPEA042 **Epicyclic Helical Channels for Parametric Resonance Ionization Cooling** – *A. Afanasev, V. Ivanov, R.P. Johnson (Muons, Inc) S.A. Bogacz, Y.S. Derbenev (JLAB) V. Morozov (ODU)*

Muon beam ionization cooling is a key element in the design of next-generation low-emittance and high-luminosity muon colliders. New approaches in that cooling could greatly improve the performance and capabilities of these colliders. To obtain low-emittance muon beams, a new concept is being developed that combines ionization cooling in a Helical Cooling Channel (HCC) with parametric resonances. The novelty consists of creating alternating orbit dispersion in the HCC by imposing an additional helical field of opposite helicity. In this project we first develop a theoretical description of an alternating-dispersion muon cooling channel that includes a solenoid with two superimposed transverse helical fields with different characteristic periods. We then conduct an extensive numerical analysis of the orbital motion in such a channel by identifying the periodic orbit, its stability region, its characteristic parameters and their control. This analysis will provide the basis for full-scale engineering-design simulations.

MOPEA043 **Quasi-Monoenergetic Photon Source Based on Electron-Positron Annihilation** – *A. Afanasev, R.J. Abrams, C.M. Ankenbrandt, K.B. Beard, M.A.C. Cummings, R.P. Johnson, T.J. Roberts, C. Y. Yoshikawa (Muons, Inc) M. Popovic (Fermilab)*

High-intensity photon beams have important applications in cargo screening, detection of fissile and other dangerous materials. Availability of an intense photon source that is a) monoenergetic and b) energy-tunable would add a significant value for the above applications. We performed a conceptual study of a nearly monoenergetic photon source that is based on electron-positron annihilation. Several technical possibilities were considered, including the beams of counter- and co-moving electrons and positrons, as well as positron annihilation on a fixed target. The energy of produced photons can be controlled by varying the energies of the positron and electron beams. The fixed-target option provides the simplest technical solution, for which the positron source may be either an intense positron emitter (22Na) or accelerator-based. The positron beam is then accelerated to a collision energy by a variable-energy RF linac. Flexible simulation tools are developed for this and future studies

MOPEA044 **Quasi-monochromatic Positrons using Dipole and Wedge** – *R.J. Abrams, C.M. Ankenbrandt, C. Y. Yoshikawa (Muons, Inc)*

Positrons produced by electrons impinging on a target cover a broad momentum range. By bending the positrons 180^{o} in a dipole magnetic field the momenta are dispersed according to their momenta along the exit plane of the magnet. A wedge-shaped absorber placed at the exit plane can reduce the momenta accordingly to produce a quasi-monochromatic beam of positrons. Simulation results are presented for 2 to 10 MeV/c quasi-mono-chromatic positrons produced by 75 MeV electrons on a tungsten target.

MOPEA045 **Positron Production for a Compact Tunable Intense Gamma Ray Source** – *C. Y. Yoshikawa, A. Afanasev, C.M. Ankenbrandt, K.B. Beard (Muons, Inc) D.V. Neuffer (Fermilab)*

A compact tunable gamma ray source has many potential uses in medical and industrial applications. One novel scheme to produce an intense beam of gammas relies on the ability to create a high flux of positrons. We present various positron production methods that are compatible with this approach for producing the intense beam of gammas.

MOPEA046 **Design and Experimental Plan of an Inverse Compton Scattering Gamma Ray Source** – *S. Boucher, P. Frigola, A.Y. Murokh, M. Ruelas, R. Tikhoplav (RadiaBeam) M. Babzien (BNL) I. Jovanovic (Purdue University) J.B. Rosenzweig, G. Travish (UCLA)*

Special Nuclear Materials (e.g. U-235, Pu-239) can be detected by active interrogation with gamma rays (>6 MeV) through photofission. For long-range detection (~1 km), an intense beam of gamma rays (~10^{14} per second) is required in order to produce measurable number of neutrons. The production of such fluxes of gamma rays, and in the pulse formats useful for detection, presents many technical challenges, and requires novel approaches to the accelerator and laser technology. RadiaBeam is currently designing a gamma ray source based on Inverse Compton Scattering (ICS) from a high-energy electron beam. To achieve this, improvements in photoinjector, linac, final focus, and laser system are planned. In this paper, we describe these improvements, as well as an ongoing project to demonstrate key aspects of the our design at the BNL ATF.

MOPEA047 **Design of a Compact, Inexpensive Linac for Use in Self-contained Irradiators** – *S. Boucher, X.D. Ding, A.Y. Murokh (RadiaBeam)*

Self-contained irradiators are used for a number of applications, such as blood irradiation to prevent Graft-Versus-Host-Disease, biomedical and radiation research, and detector calibration. They typically use a sealed $Cs^{-1}37$ source to irradiate an item within a treatment compartment. The US National Research Council has identified as a priority the replacement of such high-activity sources with alternative technologies, in order to prevent them from falling into the hands of terrorists for use in a Radiological Dispersal Device ("dirty bomb"). RadiaBeam Technologies is developing a novel, compact, low-cost linear accelerator "the MicroLinac" for use in self-contained irradiators in order to effectively replace $Cs^{-1}37$ in such devices. A previous version of the MicroLinac, originally developed at SLAC, was designed to produce 1 MeV electron energy and 10 μA of average current. RadiaBeam has redesigned the linac to produce 1.5 MeV and 20 μA current, in order to match the penetration and dose rate of a typical blood irradiator. This paper describes the new design of the MicroLinac and our future development plans.

MOPEA048 **Highlights of Accelerator Activities in France on behalf of the Accelerator Division of the French Physics Society** – *B. Cros (Laboratoire de Physique des Gaz et des Plasmas, Universite Paris-Sud) P. Ausset (IPN) M.A. Baylac (LPSC) F. Chautard (GANIL) J. Denard (SOLEIL) F. Kircher, J.-L. Lemaire (CEA) P. Maccioni (SDMS) J.-L. Revol (ESRF) R. Roux (LAL)*

The French Physics Society is an association the purpose of which is to promote physics and physicists. In this context, the accelerator physics and associated technology division is in charge of the promotion of accelerator activities in France. This paper presents the missions and actions of the division, highlighting those concerning young scientists. A brief presentation of the laboratories, institutes or facilities who are the main actors in the field will then be given. Significant projects which are underway or planned will be described, including medical applications. The major contribution of France to international projects will then be introduced. Finally the cultural and technical relations between industry and laboratories will be discussed.

MOPEA049 **Application of Particle Accelerators to High Energy Density Physics Research: The HEDgeHOB Collaboration** – *N.A. Tahir, T. Stoehlker (GSI) V.E. Fortov, I. Lomonosov, A. Shutov (IPCP) R. Piriz (Universidad de Castilla-La Mancha) R. Redmer (Rostock University)*

Intense particle beams lead to volumetric heating of solid targets that generates large samples of High Energy Density (HED) matter. Such samples are very suitable to study the thermophysical properties of this important state of matter that spans over numerous fields of basic and applied physics. Facility for Antiprotons and Ion Research (FAIR) at Darmstadt, will generate very powerful bunched beams of the heaviest particles (uranium) that will deposit unprecedented high levels of specific power in the target. Extensive theoretical work has been carried out over the past decade to design HED physics experiments at the FAIR. So far, four different experimental schemes have been proposed. These include, HIHEX (Heavy Ion Heating and Expansion, which is suitable to study equation-of-state properties of HED matter), LAPLAS (Laboratory Planetary Science, which is suitable to generate physical conditions that exist in the interiors of the giant planets), Study of the growth of the Richtmyer-Meshkov instability and finally , the ion beam driven Ramp Compression which is suitable to study material properties like shear modulus and yield strength, under dynamic conditions.

MOPEA050 **Prototype Development of a 15 MeV Electron Linac** – *T.S. Dixit, S.T. Chavan, R. Krishnan, C.S. Nainwad, S.N. Pethe, K.A. Thakur, T. Tiwari, M.M. Vidwans (SAMEER) A. Deshpande (Sokendai)*

A successful development of a 6 MeV electron radiotherapy machine at SAMEER, India was reported earlier*. Now a 15 MeV electron linac prototype is designed, developed and tested at our site. We have measured a beam current of 80 mA at the X-ray target attached to the linac. Energy gained by electrons in a cavity chain of about 1.2 m length is measured to be more than 15 MeV using a 6 MW klystron power source. An RF window capable of handling 12kW average power is attached to the linac tube and it is cooled by water. The final linac parameters measured were at par with the designed values. A high voltage modulator and control console for the linac are designed and developed in house. This paper will describe key aspects of the design and development process of the complete system. Also future applications are planned like-dual energy dual mode linac for radiotherapy, cargo scanning system and compact compton X-ray source using this technology is briefed in this paper.

MOPEA051 **Preliminary Design of the AEGIS Test Facility** – *L. Dassa, D. Cambiaghi (Università di Brescia) L. Dassa (I.N.F.N.) D. Perini (CERN)*

The AEGIS experiment is expected to be installed at the CERN Antiproton Decelerator in a very close future, since the main goal of the AEGIS experiment is the measurement of gravity impact on antihydrogen, which will be produced on the purpose. Antihydrogen production implies very challenging environmental conditions: at the heart of the AEGIS facility 50 mK temperature, 10^{-12} mbar pressure and a 1 T magnetic field are required. Interfacing extreme cryogenics with ultra high vacuum will affect very strongly the design of the whole facility, requiring a very careful mechanical design. This paper presents an overview of the actual design of the AEGIS experimental facility, paying special care to mechanical aspects. Each subsystem of the facility - ranging from the positron source to the recombination region and the measurement region - will be shortly described. The ultra cold region, which is the most critical with respect to the antihydrogen formation, will be dealt in detail. The assembly procedures will be considered too, as they are expected to be critical to make the set-up phase easier, as well as to make possible any future improvement of the facility itself.

MOPEA052 **Sub-micrometer Resolution Transverse Electron Beam Size Measurement System based on Optical Transition Radiation** – *A.S. Aryshev, N. Terunuma, J. Urakawa (KEK) S.T. Boogert, V. Karataev (JAI) D.F. Howell (OXFORD-physics)*

Optical Transition Radiation (OTR) appearing when a charged particle crosses a boundary between two media with different dielectric properties has widely been used as a tool for transverse profile measurements of charged particle beams in various facilities worldwide. The resolution of the conventional monitors is defined by so-called Point Spread Function (PSF) dimension - the source distribution generated by a single electron and projected by an optical system onto a screen. In our experiment we managed to create a system which can practically measure the PSF distribution. We demonstrated that is it is non-uniform. In this paper we represent the development of a novel sub-micrometer electron beam profile monitor based on the measurements of the PSF structure. The visibility of the structure is sensitive to micrometer electron beam dimensions. In this report we shall represent the recent experimental results. The future plans on the optimization of the monitor will also be presented.

MOPEA053 **A Compact Soft X-ray Source based on Thomson Scattering of Coherent Diffraction Radiation** – *A.S. Aryshev, S. Araki, M.K. Fukuda, J. Urakawa (KEK) V. Karataev (JAI) G.A. Naumenko (INPR) A. Potylitsyn, L.G. Sukhikh, D. Verigin (TPU) K. Sakaue (RISE)*

High-brightness and reliable sources in the VUV and the soft X-ray region may be used for numerous applications in such areas as medicine, biology, biochemistry, material science, etc. 4th generation light sources based on X-ray free electron lasers are being built in a few world's leading laboratories. However, those installations are very expensive and the access to wider community is very limited. We propose a new approach to produce the intense beams of X-rays in the range of less than 500 eV based on compact electron accelerator. An ultimate goal of the project is to create a compact soft X-ray source based on Thomson scattering of Coherent Diffraction Radiation (CDR) using a small accelerator machine. CDR is generated when a charged particle moves in the vicinity of an obstacle. The radiation is coherent when its wavelength is comparable to or longer than the bunch length. The CDR waves will be generated in an opened resonator formed by two mirrors. In this report we represent the status of the experiment. The pilot experimental results and general hardware design will be demonstrated.

MOPEA054 **Design of an E-g Converter for a 10 MeV Electron Beam** – *L. Auditore (INFN - Gruppo Messina) L. Auditore, R.C. Barnà, D. Loria, E. Morgana, A. Trifirò, M. Trimarchi (Università di Messina) G. Di Bella (Università di Messina, Facoltà di Ingegneria)*

In the last years, the INFN-Gruppo Collegato di Messina has designed and setup an x-ray source based on the 5 MeV electron linac hosted at the Dipartimento di Fisica - Università di Messina. In the meanwhile, and in the framework of an European funding, the group has setup the Centro Ricerche at Villafranca Tirrena (Messina, Italy) which holds a 10 MeV electron linac and which is, at the moment, mainly devoted to industrial Radiation Processing applications. Nevertheless, to the aim to provide also x-ray beams, an e-g converter has been designed by means of the MCNP4C2 simulation code and optimized for a 10 MeV electron beam. A wide investigation has been performed to choose material and thickness for the e-g converter in order to provide the highest x-ray yield. Then, angular distribution and energy spectrum have been simulated to characterize the produced bremmstrahlung beam. Also the target activation has been investigated. Finally, thermal analysis has been performed using a finite element model code, Deform 2D, to choose the definitive mechanical settings of the e-g converter.

MOPEA055 **Development of the Focusing System for a Highly Bright X-ray Generator** – *T. Sakai, M. Ikeda, S. Ohsawa, T. Sugimura (KEK) N. Sakabe (FAIS)*

A new type of rotating anticathode X-ray generator has been developed, in which the electron beam irradiates the inner surface of a U-shaped Cu anticathode. A high-flux electron beam is focused on the inner surface of the anticathode by optimizing the geometry of the bending magnet. In order to minimize the sizes of the X-ray source, the electron beam is focused in a short distance by the combined function magnets. A shape on the surface of the bending magnet was determined by simulation. The beam trajectories and bending magnet were optimized by the General Particle Tracer(GPT) and Opera-3D code simulation. The result of simulation clearly shows that the bending magnet gap surface angle parameters are important to the beam focused in a short distance. FWHM sizes of the beam from the simulation were obtained to be 0.45mm(horizontal) and 0.05mm(vertical) of which the anticathode with a beam voltage and current were 120kV and 75mA, respectively. The effective brilliance to be about 500kW/mm^2 simulated predict that with the supposition of a two-dimensional Gaussian distribution. In this paper, the optimization of the focusing magnet and the results of the prototype test are reported.

MOPEA056 **Lifetime Measurement of HBC Stripper Foil using 3.2 MeV Ne$^+$ for RCS of J-PARC** – *Y. Takeda, Y. Irie, H. Kawakami, M. Oyaizu, I. Sugai, A. Takagi (KEK) T. Hattori, K.K. Kawasaki (TIT)*

Japan Proton Accelerator Research Complex (J-PARC) requires thick carbon stripper foils (200-500 ug/cm^2) to strip electrons from the H$^-$ beam supplied by the linac before injection into the Rapid Cyclic Synchrotron. A H$^-$ beam of 181MeV energy is injected into the 3 GeV Rapid Cycling Synchrotron (RCS) with a pulse length of 0.5 ms, a repetition rate of 25 Hz, and an average beam current of 200 μA. The H$^-$ ions are stripped into protons by a charge stripper foil in the injection section. For this high-energy and high-intensity beam, the conventional carbon stripper foils will be ruptured in a very short time. Thus, long-lived thick carbon stripper foils are needed to this high-power accelerator. For this purpose, we are described R and D of long-lived Hybrid Boron-mixed Carbon foils (HBC-foils) of 100 - 500 μg/cm^2 by arc discharge method. The preparation procedure is described and lifetime measurement by using a 3.2MeV Ne$^+$ DC beam of 2-3 μA are reported.

MOPEA057 **Social Aspects of Japanese High Energy Accelerators** – *K. Hirata (GUAS) E. Kikutani, M. Sekimoto (KEK) Y. Takaiwa (Tsukuba University of Technology, Kasuga Campus)*

Japanese research to build accelerators for high energy physics started with Electron Synchrotron at Institute of Nuclear Study, Tokyo (INS). The development was slow in the beginning, in particular before the construction of KEK-PS. After the experience of TRISTAN, KEKB, one of the best colliders in the world, was eventually constructed. We will review the history of high energy accelerators in Japan from physics, technological and particularly social points of view referring to documents at KEK and other archives. This is the first of a series of papers and will outline the over-all view.

MOPEA058 **Measurement of the Parametric X-rays with the Rocking Curve Method** – *Y. Hayashi, S.V. Bulanov, T. Homma, M. Kando, K. Kawase, H. Kotaki (JAEA)*

Parametric X-ray generation is one of the ways to obtain a monochromatic X-ray. The X-ray is generated through the interaction between high energy electrons and a crystal. The relationship between an X-ray wavelength and an angle of emission is followed by the Bragg condition. Therefore the monochromatic energy of the X-ray can be varied continuously by rotating the crystal. This tunability of X-ray wavelength is suitable for various applications. Usually a single photon counting method is utilized for measuring of the parametric X-rays. Although this method has an advantage to obtain clear energy spectrum, it takes long time. Here, we have measured 10 keV parametric X-rays with applying a rocking curve method. In this scheme, a large number of parametric X-rays are detected simultaneously. This enables us to find and tune the parametric X-ray quickly. As a result, we could find the sharp peak from this method with the Microtron accelerator (150MeV, 20 - 30 pC) at JAEA and a Si crystal. Since the peak angle is consistent to the Bragg condition for the 10 keV parametric X-ray generation, we think 10 keV photons have been generated through the parametric X-ray mechanism.

MOPEA059 **Laser Acceleration of Negative Ions by Coulomb Implosion Mechanism** – *T. Nakamura, S.V. Bulanov, H. Daido, T. Esirkepov, A. Faenov, Y. Fukuda, Y. Hayashi, T.K. Kameshima, M. Kando, T. Pikuz, A.S. Pirozhkov, M. Tampo, A. Yogo (JAEA/Kansai)*

Intense laser pulse is utilized to generate compact sources of electrons, ions, x-rays, neutrons. Recently, high energy negative ions are also observed in experiments using cluster or gas target*. To explain the acceleration of negative ions from laser-generated plasmas, we proposed Coulomb implosion mechanism**. When clusters or underdense plasmas are irradiated by an intense laser pulse, positive ions are accelerated inside the clusters or in the self-focusing channel by the Coulomb explosion. This could lead to the acceleration of negative ions towards target center. The maximum energy of negative ions is typically several times lower than that of positive ions. A theoretical description and corresponding Particle-in-Cell simulations of Coulomb implosion mechanism are presented. We show the evidence of the negative ion acceleration observed in our experiments using high intensity laser pulse and the cluster-gas targets.

MOPEA060 **Reconstructions of the Control System for the Charge Exchange System at the 3GeV RCS in J-PARC** – *M. Kawase, M. Kinsho, O. Takeda, Y. Yamazaki, M. Yoshimoto (JAEA/J-PARC)*

The charge exchange device for 3GeV RCS in J-PARC, which require that a broken foil is exchanged for a new foil by remote control and automatically in vacuum. The control system's important task will be to control under the unified management of the vacuum system and foil driving system and to support EPICS. This device consists of the vacuum system using PLC (Programmable Logic Controller) and the foil driving system using MCU (Multi Control Unit). A workstation (WS) was required, and we developed control system which control under the unified management of 2 different type of system. The uniform management control system became complex system. In fact, therefore control system was unfinished system, it did not protect trouble such as the vacuum gate valve closed while transfer rod insert in the ring. Each algorithm of PLC, MCU and WS was reviewed, and the control system that was able to do the unified management was restructured. Each algorithm of PLC, MCU and WS was debugged so that this control system is made remote control using EPICS. We introduce the reconstruction of the control system for the charge exchange system at the RCS in J-PARC.

MOPEA061 **Status Report on RAPID, 1.7MV Tandem Accelerator System, the University of Tokyo** – *S. Ito, H. Matsuzaki, Y. Miyairi, A. Morita, N. Nakano, Y. Sunohara (The University of Tokyo)*

RAPID (Rutherford Backscattering Spectroscopic Analyzer with Particle Induced X-ray Emission and Ion Implantation Devices), the University of Tokyo has been dedicated to various scientific and engineering studies in a wide range of fields by the ion beam analysis availability, including RBS, NRA, PIXE and ion implantation. The system consists of a 1.7MV tandem accelerator (Model 4117-HC,provided by HVEE corp., Netherland), two negative ion sources (a Cs sputter solid ion source and duoplasmatron gas ion source) and three beam lines. RAPID was installed in 1994 at Research Center for Nuclear Science and Technology, the University of Tokyo at first and since then it has been used for various research fields using ion beams. As the Center was reorganized to be a department of School of Engineering in 2005, the educational utilization came to be an important mission of RAPID. Besides several application studies with PIXE analysis, environmental analysis (pond sediments and atmospheric SPM (Suspended Particulate Matter) is performed as a student experiment. Recently, a low level ion irradiation system was also developed and applied for the study of CR-39 track detector with proton beam.

MOPEA062 **Development of Advanced QuantumRadiation Source based on S-band Compact Electron Linac** – *R. Kuroda (AIST)*

Advanced quantum radiation sources such as a laser Compton scattering X-ray source and a coherent THz radiation source have been developed based on an S-band compact electron linac at AIST in Japan. The laser Compton scattering X-ray source using a TW Ti:Sa laser can generate a hard X-ray pulse which has variable energy of 12 keV - 40 keV with narrow bandwidth by changing electron energy and collision angle for medical and biological applications. The coherent THz radiation source based on the electron linac has been also developed instead of a conventional laser based THz source. The designed THz pulse has high peak power more than 1 kW in frequency range between 0.1 - 2 THz. The THz pulse will be generated with coherent radiation such as synchrotron radiation and transition radiation using an ultra-short electron bunch with bunch length of less than 0.5 ps (rms). The coherent synchrotron radiation in the THz region has been already generated and it will be applied to the THz time domain spectroscopy (TDS). In this work shop, we will report present status of our advanced quantum radiation sources.

MOPEA063 **Development of a Positron Probe Microanalyzer** – *N. Oshima, A. Kinomura, T. Ohdaira, R. Suzuki (AIST) M. Fujinami (Chiba University) K. Shoji, A. Uedono, H. Watanabe (University of Tsukuba, Institute of Applied Physics)*

We have developed a positron probe microanalyzer (PPMA) which is also called by a scanning positron microscope. The PPMA injects a slow positron microbeam into a sample and measure positron lifetimes which are strongly dependent on the size (0.1-10 nm) of the defects at the positron annihilation site. By scanning the lateral injection position (x, y) and the implantation depth (z) of the positron microbeam we can obtain three dimensional defect mappings*. A slow positron beam generated by a LINAC is focused by two magnetic lenses**,***. Minimum diameter of the slow positron microbeam obtained at a sample is about 30 micrometers. Beam techniques used for the PPMA will be presented.

MOPEA064 **Accelerator Mass Spectrometry at the Tsukuba 12 MV Pelletron Tandem Accelerator** – *K. Sasa, N. Kinoshita, Y. Nagashima, K. Sueki, T. Takahashi, Y. Tosaki (UTTAC) K. Bessho, H. Matsumura (KEK) Y. Matsushi (University of Tokyo, Research Center for Nuclear Science and Technology)*

Accelerator Mass Spectrometry (AMS) is a highly sensitive mass spectrometric method for measuring rare isotopes. The technique is mainly applied in chronology, earth and environmental sciences to date samples using long-lived radioisotopes. With a multi-nuclide AMS system on the 12 MV Pelletron tandem accelerator at the University of Tsukuba (Tsukuba AMS system), we are able to measure environmental levels of long-lived radioisotopes of C-14, Al-26, Cl-36, Ca-41 and I-129 by employing a molecular pilot beam method. The high terminal voltage of 12 MV is an advantage for AMS to detect heavy radioisotopes. The principle of AMS and applications with the Tsukuba AMS system will be reported in this paper.

MOPEA065 **DPIS for Warm Dense Matter** – *K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology) K. Horioka (TIT) M. Okamura (BNL)*

Warm Dense Matter (WDM) is an challenging problem because WDM, which is beyond ideal plasma, is low temperature and high density state with partially degenerate electrons and coupled ions. WDM is a common state of matter in astrophysical objects such as cores of giant planets and white dwarfs. The WDM studies require large energy deposition into a small target volume in a shorter time than the hydrodynamical time and need uniformity across the full thickness of the target. Since moderate energy ion beams (~ 0.3 MeV/amu) can be useful tool for WDM physics*, we propose WDM generation using Direct Plasma Injection Scheme (DPIS). In the DPIS, laser ion source is connected to the Radio Frequency Quadrupole (RFQ) linac directly without the beam transport line. The discussions of DPIS for WDM are presented.

MOPEA066 **Recent Progress of MeV Ultrafast Electron Diffraction at Tsinghua University** – *R.K. Li, H. Chen, Q. Du, T. Du, Y.-C. Du, Hua,,J.F. Hua, W.-H. Huang, J. Shi, C.-X. Tang, L.X. Yan (TUB)*

Recent years have witnessed rapid advances of MeV ultrafast electron diffraction (UED), in which high quality, ultrashort, MeV electron pulses from a photocathode radio-frequency gun will be employed as probes for ultrafast structural dynamics studies. We optimized the configuration of a MeV UED system using numerical simulation and built a prototype machine at the Tsinghua Thomson scattering X-ray source (TTX) facility. We report the experimental optimization results in this paper.

MOPEA067 **PIC Simulation of the Coaxial Magnetron for Low Energy X-band Linear Accelerators** – *Jq. Qiu, H. Chen, C.-X. Tang (TUB)*

For the miniaturization of low energy linear accelerators, X-band pulsed magnetron with stable performance of 1.5 MW peak power is needed to be developed. This paper presents the 3D particle-in-cell (PIC) of an X-band coaxial magnetron. A time evolved electron flow exhibits N/2 spokes in the simulations, which confirms the generation of pi-mode. Computer modeling indicates the mode competition in the startup process according to the spectra. By changing the DC voltage, we got the voltage-current characteristics of this magnetron, and comparison with the experiment was also been presented.

MOPEA068 **The High Current Solid Target for the RFT-30 30MeV Cyclotron** – *M.G. Hur, I.J. Kim, S.W. Kim, J.H. Park, S.D. Yang (KAERI)*

Generally, most of the radioisotopes produced by cyclotron are used in nuclear medicine area such as diagnostic or therapeutic purpose using PET or SPECT. The RFT-30 cyclotron has been installed at ARTI (Advanced Radiation Technology Institute; KAERI) for the medical RI production and proton beam related research. This cyclotron designed up to 500 μA proton beam power at 30 MeV. The development of the high current target for RI production depends on the beam power (P(W) = E(MeV) x I(uA)). In case of solid target, high current is one of the reasons for target temperature rising and production yield variation. In order to reduce this phenomenon, more effective target cooling methods are necessity. In this report, we suggest solid target with metal foam for the high current beam irradiation and shows simulation result.

MOPEA069 **Apparatus for Platinum Nano Particle Synthesis by Proton Beam Irradiation** – *J.-K. Kil (KAERI)*

We made an experiment apparatus for the investigation of nano particle synthesis by proton inducing. It is composed of water tank, thin sample case with large area, ultrasonic oscillator, beam entrance window, monitoring camera, etc. Pt nano particle characteristics are influenced by the condition of the solution, such as concentrations of H2PtCl6, CTAB, SDS and IPA. (CTAB; cetyl trimethylammonium bromide, SDS; sodium dodecyl sulfate, IPA; isoprophyl alcohol) The experiment apparatus was designed that Pt nano particles were fabricated fore conditions. For a proton induced synthesis, some parameters, such as beam energy, beam current, flux, total dose, dose rate, etc. are also known as important process variables. To identify the effects of these irradiation parameters, we investigated the properties of nano particles according to the changes of these parameters. The energy was changed in the range of 10 ~ 40 MeV, beam current 10 nA ~ 10 uA. It could be examined by using an experiment apparatus developed for this purpose.

MOPEA070 **Uniform Irradiation Method using 2D Motion Stage at theTarget** – *K. R. Kim, M.H. Jung, J.-K. Kil, S.J. Ra (KAERI)*

Uniform irradiation is very important for many kinds of experiments of proton beam utilization. In general, scanning magnet have been used for the uniform irradiation of high energy proton beam in the type of wobbler scanning, raster scanning, spiral scanning, etc. In the case of using magnets, it is not easy and needs high cost because the magnet size and power become bigger with increase of beam energy accordingly. In this paper, we proposed simpler method and apparatus for uniform irradiation using 2D motion stage. It is composed of two motor systems for X- and Y-direction motion. We obtain uniform irradiation results by realization of many kinds of scanning method. The proton energy and beam current are about 40 MeV and 1~10 nA respectively. The uniform scanning area was checked by using GAF film, MD-55 and HD-810. The stage can be used for the beam alignment and measurement of beam center and size at any position of beam line.

MOPEA071 **The Solid Target Control System for the RFT-30 30 MeV Cyclotron in KAERI** – *I.J. Kim, S.M. Choi, M.G. Hur, S.W. Kim, J.H. Park, S.D. Yang (KAERI)*

The solid target of the RFT-30 30 MeV cyclotron in KAERI was designed to produce the metalic radioisotopes, such as Zn-62, Cu-67, $G{\cdot}10^{-68}$, Pd-103, and In-111. The target control system should provide high reliability to prevent any kind of failure. Moreover, the operating procedures and maintenance cycle should be optimized and well organized to cover the unexpected situations. In this study, a simulation of the control system for the solid target in KAERI was carried out to confirm the operability of the solid target transport system. The receiving and irradiation stations are connected each other through square tube, and the control software was also checked. The developed solid target control system controls vacuum, cooling, and the whole procedures before, during, and after the irradiation.

MOPEA072 **Matlab Middle Layer Implementation in PLS Storage Ring** – *E.H. Lee (PAL)*

The middle-layer software toolbox provides a library of functions that access either machine hardware via EPICS or the AT simulator. This software, which is a collaborative effort between Lawrence Berkeley National Laboratory (LBNL) and Stanford Linear Accelerator Center (SLAC), was recently implemented in the PLS ring. By using implemented MML, tune correction, chromaticity correction, orbit correction, lattice analysis, insertion device feedforward etc. are being performed in PLS storage ring. As result, systematic PLS ring operation and data management of beam parameters are expected. In this presentation, we will describe the implemented MML in detail and the result of performance improvement of PLS storage ring.

MOPEA074 **Resonant Transition Radiation Induced by Ultra-short Electron Bunch from Aluminum Foil Stacks** – *W.C. Cheng (National Chiao Tung University) N.Y. Huang (NTHU) W.K. Lau (NSRRC) J. Tang (Academia Sinica, Research Center for Applied Sciences)*

The feasibility of using ultra-short electron bunch to ultrafast resonant transition radiation (RTR) in the X-ray range is being investigated. The results of simulation study are presented in this paper. In our study, we assumed a 27 MeV cylindrically symmetric ellipsoid electron bunch of 42 pC which is normal incident onto an aluminum foil stack with vacuum spacing as radiator. Since the shortest accessible electron bunch from our drive linac is 50fs, we expected that the duration of X-ray pulses can be as short as the electron bunches. Spectral as well as angular distributions of the RTR as generated by electron bunches at different durations are being calculated numerically.

MOPEA075 **GEANT4 Validation Studies at the ISIS Muon Facility** – *A. Bungau, R. Cywinski (University of Huddersfield) C. Bungau (Manchester University) P.J.C. King, J.S. Lord (STFC/RAL)*

GEANT4 provides an extensive set of alternative hadronic models. Simulations of the ISIS muon production using three such models applicable in the energy range of interest are presented in this paper and compared with the experimental data.

MOPEA076 **Geometry Optimization of the ISIS Muon Target** – *A. Bungau, R. Cywinski (University of Huddersfield) C. Bungau (Manchester University) P.J.C. King, J.S. Lord (STFC/RAL)*

ISIS is the world's most successful pulsed spallation neutron source that provides beams of neutrons and muons that enable scientists to study the properties of the matter at the atomic level. Restrictions are imposed on the muon target regarding thickness as this will affect the proton transmission to the second neutron target. However, it could be possible to improve the muon production by optimizing the target geometry. Currently the muon target is a 7 mm thick graphite plate oriented at 45 degrees with respect to the proton beam. A set of slabs placed at variable distance is proposed instead of the 7 mm thick graphite target. The performance of the set of slabs is examined in this paper.

MOPEA077 **Material Studies for the ISIS Muon Target** – *A. Bungau, R. Cywinski (University of Huddersfield) C. Bungau (Manchester University) P.J.C. King, J.S. Lord (STFC/RAL)*

The ISIS neutron spallation source uses a separate muon target 20 m upstream of the neutron target for MuSR research. Because ISIS is primarily a neutron source, it imposes restrictions upon the muon target, which normally are not present at other muon facilities like PSI or TRIUMF. In particular it is not possible to use thicker targets and higher energy proton drivers because of the loss of neutrons and the increased background at neutron instruments. In this paper we investigate possible material choices for the ISIS muon target for increased muon yield.

MOPEA078 **Target Optimisation Studies for the European Spallation Source** – *A. Bungau, R. Cywinski (University of Huddersfield) C. Bungau (Manchester University)*
The European Spallation Source (ESS) is one of Europe's biggest and most prestigious science projects to design and construct the next generation facility for research with neutrons. ESS will be the world's most powerful spallation source and it will provide a unique tool for research into the atomic structure and dynamics of matter. We investigate the effects of the dimensions of the ESS spallation target on the total neutron yield integrated over the neutron energy and emission angle. We also investigate different material choices for the ESS target.

MOPEA079 **Impact of the Energy of the Proton Driver on Muon Production** – *A. Bungau, R. Cywinski (University of Huddersfield) C. Bungau (Manchester University) P.J.C. King, J.S. Lord (STFC/RAL)*
Simulations studies have been carried out to examine the impact of the energy of the proton driver on muon production. The muon flux is calculated as a function of proton energy over a wide range, which covers the energies at the existing muon and neutron facilities worldwide. The muon and higher energy pion yields are normalised per beam current and accelerator power. The case of a higher energy of the proton driver at the ISIS muon facility is also examined.

MOPEA080 **Electron Beam Polarization Measurement using Touschek Lifetime Technique** – *C. Sun, J.Y. Li, S.F. Mikhailov, V. Popov, W. Wu, Y.K. Wu (FEL/Duke University) A. Chao (SLAC) H. Xu, J. Zhang (USTC/NSRL)*
Touschek lifetime of an electron beam in a storage ring depends on the beam polarization through the intrabeam scattering effect. Consequently, the electron beam polarization can be determined by comparing the measured Touschek lifetime of a polarized beam and an unpolarized beam. In this paper, we report a systematic experimental procedure to study the radiative polarization of a stored electron beam. Based upon this technique, we have successfully observed the polarization build-up of a 1.15 GeV electron beam in the Duke storage ring. Using the Touchek lifetime data, we are able to determine the equilibrium degree of the electron beam polarization and the time constant for the polarization build-up process.

MOPEA081 **Spatial and Spectral Characteristics of Compton Gamma Beams** – *C. Sun, Y.K. Wu (FEL/Duke University)*
Compton scattering of a laser beam with a relativistic electron beam has been used to generate an intense, highly polarized, and nearly monoenergetic gamma-ray beam at several facilities. The ability of predicting the spatial and spectral distributions of a Compton gamma-ray beam is crucial for the optimization of the operation of a Compton light source as well as for the applications utilizing the Compton beam. Based upon the Lorentz invariant Compton scattering cross section, we have derived an analytical formula to study the Compton scattering process. Using this formula, we have developed an integration code to produce the smooth results for the spatial and spectral distributions of the Compton beam. This code has been characterized at the High Intensity Gamma-ray Source (HIGS) facility at Duke University for varying electron and laser beam parameters as well as different gamma-ray beam collimation conditions.

MOPEA082 **The ALPHA Project at Indiana University** – *S.-Y. Lee, P.E. Sokol (IUCF)*
We are building a low energy electron storage ring that has many desirable properties, such as varying momentum compaction factor, damping partition numbers, favorable betatron tunes for multiturn accumulations, and excellent dynamic aperture. This storage ring can be used for debunching rf linac beams in one turn, for compression of linac pulses, and more importantly for a compact photon source based on inverse Compton scattering of laser beams.

MOPEA083 **Using High-brightness Particle Beams for Astrophysics Experiments in the Laboratory** – *P. Muggli (UCLA) B.A. Allen (USC) J.L. Martins, S.F. Martins (Instituto Superior Tecnico) L.O. Silva (GoLP) V. Yakimenko (BNL)*
High-brightness particle beams offer a unique opportunity for experiments that replicate in the laboratory situations that are relevant to astrophysical situations. A relativistic electron beam with a transverse dimension larger than the plasma collisionless skin depth is subject to the current filamentation instability. Numerical simulations of the Brookhaven

Accelerator Test Facility beam show that the result of the CFI saturates over only 2cm of plasma with a density of 10^{17}/cc. A new kind of relativistic beam, a 'fireball' beam with equal number of electrons and positrons will soon become available at the SLAC FACET facility under construction. In this case the Weibel instability leads to the breakup of the beam in transverse filaments in only 10cm of plasma. In both cases the instability leads to the emission of excess radiation from the beam particles trapped in the magnetic field of the filaments. Filamentation of electron or electron/ positron sheets colliding with ambient plasma could be at the origin of the generation of large magnetic fields for example in the afterglow of gamma ray bursts. Numerical simulation results and initial experimental results will be presented.

MOPEA084 **Femtosecond Relativistic Electron Diffraction** – *C.M. Scoby, J.T. Moody, P. Musumeci (UCLA)*

High brightness ultrashort electron beams have been produced at the UCLA Pegasus photoinjector lab for use in time-resolved electron diffraction applications. Beams have been generated with high enough charge to obtain single shot diffraction patterns of thin solid targets. These beams contain a few pC at 3.5 MeV in a 200 fs pulse. Rf and magnetic compression schemes are planned to obtain shorter pulses and optimize the time resolution. Pump-probe experiments on thin metal foils have already shown promising results on picosecond time scales*. Current research focuses on materials with processes that are observable on the sub-100 fs scale (e.g., non-thermal melting of graphite and the lattice expansion of InSb). To overcome rf jitter and synchronization problems, electro-optic sampling is used as a single shot time-of-arrival diagnostic to help reconstruct the melting "movie." Additionally, the ability to resolve lower-probability diffraction angles in the pattern has been used to set an upper bound on beam emittance in a low-emittance regime where more conventional slit-based measurement techniques are not possible.

MOPEA085 **The NSLS MeV UED Commissioning Results** – *X.J. Wang, Y. Hidaka, C.C. Kao, J.B. Murphy, S. Pjerov, Y. Shen (BNL)*

NSLS pioneered the concept of MeV Ultrafast Electron diffraction (UED) based on a photocathode RF gun*, and a dedicated MeV facility now being assembled at the NSLS Source Development Lab (SDL). The NSLS MeV UED is designed to have 100 fs time resolution for the single-shot diffraction experiment; the NSLS MeV UED setup has the built-in 3-D electron beam instrumentation and single photon detector. One of the unique features of the NSLS MeV UED is that, it can used to study the ultra-bright electron and fundamental limit of the electron sources. After a brief description of the NSLS MeV UED, we will present the intial commissioning results.

24-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area B

MOPEB — Poster Session

MOPEB001 **Multi-function Corrector Magnet** – *L.O. Dallin (CLS)*

Storage rings require corrector magnets for a variety of tasks. Foremost are small dipole magnets for both horizontal and vertical correction. In light sources, for example, other corrector magnets are needed to compensate for the effect of changing insertion device operation points. These can include quadrupole, skew quadrupole, sextupole and skew sextupole corrections. As well octupole magnets may be desirable to improve dynamic aperture in small emittance lattices. One magnet can perform all these tasks. This is achieved by having separate windings with separate power supplies on an octopole yoke. The simultaneous excitation of any combination of modes can be achieved through superposition. Corrections are necessarily limited to avoid saturation effects that will degrade the superposition.

MOPEB002 **ASTRID2 Synchrotron Magnets** – *N. Hauge, E.B. Christensen, C.W.O. Ostenfeld (Danfysik A/S)*

At Aarhus University in Denmark, a new synchrotron radiation source is being built. The 46-m circumference storage ring ASTRID2 with 6-fold symmetry will operate at 580 MeV to produce bright UV and soft x-ray radiation. Danfysik A/S is awarded the contract for the design, manufacture and delivery of all storage ring magnets mounted on girders. The contract for the injection proces magnets with their pulse generators is also awarded to Danfysik A/S. The design and layout of key magnets will be presented including the Combined Function Dipole Magnets, Injection Bumper Magnets and Septum Magnet. The fast Extraction Kicker Magnet for the converted ASTRID booster synchrotron will also be presented.

MOPEB003 **Design and Performance of Printed Circuit Steering Magnets for the FLASH Injector** – *K. Floettmann (DESY)*
Printed circuit boards offer a simple method for the design of hysteresis free, compact air coil magnets. The emphasis for the steering magnets developed for the FLASH injector is placed on a high integrated field strength for a short magnetic length to cope with space limitations in the injector beam line. The possibility to combine a pair of orthogonal steerers at the same longitudinal position has been realized by two layers of printed circuit boards. Design principles and magnetic measurements will be discussed.

MOPEB004 **Magnetic Modeling, Measurements and Sorting of the CNAO Synchrotron Dipoles and Quadrupoles** – *C. Priano, G. Bazzano, D. Bianculli, E. Bressi, M. Pullia (CNAO Foundation) M.C.L. Buzio, R. Chritin, D. Cornuet, J.M. Dutour, P. Leclere, L. Vuffray (CERN) I. De Cesaris (EBG MedAustron) E. Froidefond (LPSC) C. Sanelli (INFN/LNF)*
CNAO is a synchrotron accelerator presently under commissioning in Pavia. The aim of this accelerator is to treat tumors with hadrons and to perform advanced clinical and radiobiological research. The CNAO will irradiate patients with protons (60-250 MeV range) and carbon ions (120-400 MeV/u range) in three treatment rooms with four beam lines. Future upgrade with gantries is foreseen. In this paper we will describe the design, magnetic measurements and sorting criterion used for the sixteen synchrotron ring dipoles and twenty-four quadrupoles built by Ansaldo Superconductors (Italy). The magnetic measurements results are compared with magnetic simulation done by using the code OPERA from Vector Fields.

MOPEB005 **Commissioning of the Centro Nazionale di Adroterapia Oncologica (CNAO)** – *G. Bazzano (CNAO Foundation)*
The National Centre for Oncological Hadrontherapy (CNAO) will be the first Italian facility for the treatment of deep located tumours with proton and carbon ion beams. The extracted particle energy spans between 60 and 250 MeV for protons and 120 and 400 MeV/u for carbon; the equivalent beam range is 3 to 27 g/cm^2. The facility consists of a synchrotron with five extraction lines. Three treatment rooms are now equipped for fixed beam treatment, two with horizontal beam only and one with horizontal and vertical beams. The fifth line delivers the beam to an experimental room. Future expansion with up to two more treatment rooms and different delivery system (i.e. gantry) is under study. During 2009 the commissioning of the injector chain (Low Energy Transfer Line, RFQ, LINAC and Medium Energy Beam transfer line, MEBT) and the first turn in the synchrotron were successfully completed. The recent advances in the commissioning and performance of the CNAO complex are being reported in this contribution.

MOPEB006 **Design Study of Combined Function Type Magnets for HiSOR-II** – *S. Hanada (Hiroshima University, Graduate School of Science) A. Miyamoto, S. Sasaki (HSRC)*
The HiSOR-II is a storage ring planned as a successive machine of HiSOR, a present ring at Hiroshima Synchrotron Radiation Center. This accelerator has the circumference equal to or less than 50 m, and it has the emittance about 14 nm-rad and aims at the beam energy of 700 MeV. In the HiSOR-II project, we decided to adopt electromagnets with combined function. This type magnet has an advantage for constructing a small storage ring by reducing the total number of magnet, though it has a difficulty for the independent tuning of multipole field components. In addition, we decided to share a single return yoke between a bending magnet and adjacent quadrupole magnets. In this paper, we discuss about a possible magnetic interference between a bending magnet and a quadrupole magnet. Calculation is made with magnetic field simulation cord RADIA to analyze interference effect and examine the possibility of adoption to HiSOR-II storage ring. Also, we perform the tracking simulation of the beam with the mapping data of a magnetic field provided by this three-dimensional magnetic field analysis. By the simulation, the dynamic aperture is determined.

MOPEB007 **Multi-Element Corrector Magnet for the Storage Ring NewSUBARU** – *Y. Shoji (NewSUBARU/SPring-8, Laboratory of Advanced Science and Technology for Industry (LASTI))*

A multi-element octupole-base corrector magnet is designed and fabricated. The new corrector magnet will be installed in the electron storage ring NewSUBARU in place of vertical steering (skew dipole) magnets. It has coil windings to produce skew quadrupole, skew sextupole, normal octupole, and the skew dipole field. The skew dipole element is used to achieve vertical steering. The skew quadrupole and the skew sextupole elements are for the resonance correction. The normal octupole element is used to control the higher order dispersion function and the higher order momentum compaction factor. In this design the main coil is wound around the return yoke instead of the pole. We expect improvement of the beam lifetime and injection efficiency during normal operation as well as improved isochronism during extreme quasi-isochronous operation. In designing the magnet, careful consideration is given to field interference caused by a neighboring magnet, set close to the corrector magnet of comparable yoke and bore diameter dimensions. The magnetic field with field interference is calculated using OPERA-3D.

MOPEB008 **Magnetic Field Measurement required for High Luminosity Accelerator** – *K. Egawa, M. Masuzawa (KEK)*

The KEKB is a high luminosity accelerator which achieved the highest luminosity record of $2.1\text{x}10^{34}$. It requires the precise and stable beam control to keep its high luminosity continually. Slight change of the magnetic field may easily deteriorate the performance of the collisions of the very small and thin beams. The field measurement accuracy better than 10^{-4} has been already achieved. The resolution of the measurement has reached to a few 10^{-5}. But it is known by the beam studies that the field change less than 10^{-4} may cause deterioration of the luminosity. The requirement on the stability of magnetic field will be stricter for future nano beam colliders. We have studied the effects of the following conditions on the magnetic field by using some KEKB magnets: changes of the magnetic field due to air or cooling water temperature, changes due to initialization conditions, field coupling between the adjacent magnets, effect of excitation of the adjacent magnet and behavior of the magnetic field under polarity change have been measured. These studies are not only useful for the existing KEKB but also important for future nano beam accelerators.

MOPEB009 **Low Leakage Field Septa for J-PARC Main Ring Injection System Upgrade** – *K. Fan, K. Ishii, H. Matsumoto, N. Matsumoto (KEK)*

Injection into the J-PARC main ring is implemented by 4 kickers and 2 pulsed septa at 3 GeV in a long straight section. To accommodate the injection beam of 54 pmm.mrad, both septa have large physical acceptance of 81 pmm.mrad. However, large aperture leads to large end fringe field interfereing the circulating beam and causing beam loss, which has been observed even at low beam intensity during the beam commissioning. To provide users a proton beam with high beam power, the injection beam intensity will increase greatly in future, which creates difficulties for the present injection system. To accommodate these high intensity beams with low beam loss, the injection system needs to be upgraded. Taking account the strong space charge effects, even larger physical is needed to reduce the localized beam loss, which creates severer end fringe leakage field. This paper will discuss the problems encountered in operating the present septa, and give an optimized design for the new septa.

MOPEB010 **Development of a High Radiation Resistant Septum for JPARC Main Ring Injection System** – *K. Fan, K. Ishii, H. Matsumoto (KEK)*

The J-PARC is a high intensity proton accelerator complex, which consists of a LINAC, a Rapid Cycling Synchrotron (RCS) and a Main Ring (MR). The MR injection system employs a high-field septum to deflect the incoming beam from the RCS, which has been used for the beam commissioning study with low beam intensity successfully. Relative large beam losses in the injection area have been observed, which is proportional to the injection beam intensity. In future, the beam intensity will increase about 100 times to realize high beam power (~MW) operation required from neutrino experiments. The beam loss at the injection region is expected increase greatly due to the space charge effects, which creates severe radiation problems. Since the present injection septum coil is organic insulated, which will be destroyed under such a severe irradiation quickly. To cope with this problem, a new high radiation resistant injection septum magnet is developed, which uses inorganic insulation material (Mineral Insulated Cable - MIC) to prevent the septum from radiation damage. This paper investigates different effects caused by the MIC and gives an optimization design.

MOPEB011 **Magnetic Field Ripple Reduction of Main Magnets of the J-PARC Main Ring using Trim Coils** – *S. Igarashi, T. Oogoe, H. Someya, S. Yamada (KEK) Y. Kuniyasu (MELCO SC) S. Nakamura (J-PARC, KEK & JAEA)*

Efforts have been made to reduce the magnetic field ripple of the bending, quadrupole and sextupole magnets of the J-PARC main ring using the trim coils of the magnets. The quadrupole magnet has 24 turn main coil and 11 turn trim coil per pole those can be considered as a primary winding and a secondary winding of a transformer. When the trim coil is shorted, the induced trim coil current cancels the field ripple. The field ripple of the quadrupole magnet was reduced by a factor of 6 by shorting trim coil. The trim coil current, however, deforms the acceleration field pattern if the coil is shorted all the time of the current pattern of flat bottom, acceleration, flat top and recovery. The MOSFET relay was used to short the coil and to reduce the field ripple during the flat bottom and flat top. The circuits were built for the quadrupole and sextupole magnets. The plan has been made to wind optimized trim coils for the bending magnets.

MOPEB012 **An Experience of Using the Ceramic Coated Coil for the Low Field Septum Magnets at the J-PARC Fast Extraction** – *K. Ishii, K. Fan, H. Matsumoto, S. Tokumoto (KEK)*

Low field septum magnets are used in the J-PARC main ring as a part of the fast extraction apparatus. An insulation of the septum coil and its support method are key technologies to prevent the coil vibration caused by a pattern excitation. A thermal expansion and an enough radiation resistivity are issues at a 3000A operation in vacuum. Ceramics is one of the attractive candidates to provide the radiation hardness. We chose a ceramic coating method to an electric insulation of the coils. It was developed for adapting with the hard material to obtain the mechanically strong ceramic layers, which defeat a frictional wear. Due to an anchor effect on the hard material the ceramic layers can be tightly fixed on its surface. Therefore, it is not easy to obtain the strong layers if the ceramic coating applies to a soft material such as copper coils. We studied various kinds of ceramic materials, spray methods, coating thickness, and found the good combination to achieve the strong coating layers. For the coil support method we adopted a double thin stainless steel bands to allow the mechanical friction. In this paper an experience of the development for the septum coils is described.

MOPEB013 **LEBT with Hybrid Magnets in a Proton Linac for Compact Neutron Source** – *S. Ushijima, H. Fujisawa, M. Ichikawa, Y. Iwashita, H. Tongu, M. Yamada (Kyoto ICR)*

A compact neutron source using Li(p,n) or Be(p,n) reaction is proposed. The proton linac consists of ECR ion source, LEBT(Low Energy Beam Transport), RFQ linac and post accelerator. We assume that energy of the proton beam is 3MeV and its peak current is 40 mA operated at the repetition rate is 25Hz with the pulse width of 1ms. The beam from the ion source should be matched to the RFQ, where solenoid coils can handle the large current beam in this LEBT section. To reduce energy consumption in LEBT we're trying to design the Hybrid Electromagnet that consists of solenoid coils and permanent magnets. We use PANDIRA, TRACE-2D, and PBGUNS computer codes in order to simulate the magnetic field and the beam transport through LEBT. In this paper the design of this magnet and the result of its beam matching based on simulation will be presented.

MOPEB014 **Status of PLS-II Magnet system** – *D.E. Kim, H.S. Han, Y.-G. Jung, K.R. Kim, H.-G. Lee, S.H. Nam, K.-H. Park, H.S. Suh (PAL)*

Pohang Light Source (PLS) is planning a major upgrade of the storage ring to meet the more demanding requirement from the synchrotron light users. The main features of the major upgrade are (1) increasing the electron beam energy from 2.5 GeV to 3.0 GeV for more higher energy X-ray photons, (2) decreasing the electron beam emittance from 1.89 nm to 5.8 nm to increase the photon brilliances, and (3) increasing the number of straight sections to install the insertion devices from 10 to 20 to meet the demand for insertion devices. in the upgraded PLS (PLS-II), there will be

24 combined function dipole magnets, 96 quadrupole magnets, and 144 sextupole magnets with some auxiliary magnets for electron beam injection. In this report, the physical design features, mechanical aspects of the magnet design are described.

MOPEB015 **Magnet Design for the Medium and High Energy Beam Transport Lines of the IFMIF-EVEDA Accelerator** – *C. Oliver, B. Brañas, A. Ibarra, I. Podadera Aliseda, I. Rodriguez, F. Toral (CIEMAT) A. Mosnier (CEA)*

The IFMIF-EVEDA accelerator will be a 9 MeV, 125 mA cw deuteron accelerator which will verify the validity of the design of the future IFMIF accelerator. A Medium Energy Beam Transport line (MEBT) is necessary to handle the high current beam from the RFQ to the Superconducting RF accelerating cavities (SRF) whereas a High Energy Beam Transport line (HEBT) is used to match the beam from the SRF to the beam dump. The high space charge and beam power determine the beam dynamics in both transport lines. As a consequence, magnets with strong fields in a reduced space are required. Along the transport beamlines, there are different types of quadrupoles with steerers and a dipole. Special care is devoted to maximize the integrated fields in the available space. Both 2-D and 3-D magnetic calculations are used to optimize coil configurations. Several options have been considered: quadrupoles with independent or nested steerers, and straight or curved dipole. Magnetic performance and cost, both of magnet and power supply, have been taken into account for final choice. In this paper, the design of the resistive magnets of the MEBT and HEBT of the IFMIF-EVEDA accelerator is presented.

MOPEB016 **Development of Upgraded Magnetic Instrumentation for CERN's Real-time Reference Field Measurement Systems** – *M.C.L. Buzio, P. Galbraith, S.S. Gilardoni, L. Walckiers (CERN)*

At CERN, the control of five of the accelerators in the injector chain (i.e. PS, PS Booster, SPS, LEIR and AD) is based upon real-time magnetic measurements in a reference magnet. These systems ("B-trains") include usually a field marker to signal the achievement of a given field value, complemented by one or more pick-up coils to integrate flux changes. Recently, some issues have been raised concerning long-term reliability and possible performance improvements, in terms of both resolution and operational flexibility, for these systems. This paper reports the results of R&D activities launched to address these concerns, namely: the development of a novel ferrite gradient compensator to enable dynamic NMR field marking in the PS' combined function magnets; and the preliminary design of a standardized electronic acquisition and conditioning system aimed at enabling the requested improvements and at facilitating rapid maintenance interventions.

MOPEB017 **Magnetic Performance of Permanent and Fast-pulsed Quadrupoles for the CERN's Linac 4 Project** – *M.C.L. Buzio, A.M. Lombardi, S. Ramberger, L. Walckiers (CERN)*

Linac 4 is the injector upgrade currently under construction at CERN to improve luminosity and reliability for the whole accelerator chain. This machine will include about 120 high-gradient, 20 mm aperture Halbach-array permanent quadrupoles (PMQ) housed in the Drift Tube tanks, as well as about 80 electromagnetic quadrupoles (EMQ) with power cycles approx. 2 ms long. This paper is concerned with the magnetic measurements carried out at CERN on the first batch of PMQ, including several prototypes from different manufacturers, as well as those done on several spare Linac 2 EMQs reused in Linac 4's 3 MeV test stand. We first describe the test setup, focusing our attention on a prototype test bench based on technology developed for the LHC and able to carry out high-precision harmonic measurements in both continuously-rotating and stepping-coil mode (FAME*). Next we present the results obtained in terms of integral field strength and quality, with special emphasis on the analysis of very fast eddy current transients in the EMQs. Finally, we discuss the expected impact of these findings on the operation of the machine.

MOPEB018 **Measurement and Active Compensation of Sextupolar Field Errors in LHC Cryodipoles** – *M.C.L. Buzio, J. Garcia Perez, L. Walckiers (CERN)*

One of the main requirements for the operation of the Large Hadron Collider at CERN is the correction of the dynamic multipole errors produced in the main magnets*. In particular, integrated sextupole errors in the main dipoles must be kept well below 0.1 units to ensure acceptable chromaticity. The feed-forward control of the LHC is based on the Field Description for the LHC (FiDel), a semi-empirical mathematical model capable of forecasting the magnet's behaviour in order to generate suitable corrector current waveforms. Measurement campaigns were recently undertaken to validate the model making use of a novel fast rotating-coil magnetic measurement system (FAME)**, able to detect superconductor decay and snapback transients with unprecedented accuracy and temporal resolution. In this paper we discuss the test setup and the results obtained both on the test bench and in the actual operation of the accelerator.

MOPEB020 **Measurement of Accelerator Lattice Magnet Prototypes for TPS Storage Ring** – *F.-Y. Lin, C.-H. Chang, H.-H. Chen, J.C. Huang, M.-H. Huang, C.-S. Hwang, J.C. Jan, C.Y. Kuo, C.-S. Yang (NSRRC)*

Taiwan Photon Source (TPS) is a new third generation synchrotron storage ring with energy 3 GeV, which consists of 24 double-bend cells and its circumference is 518.4 m. Various accelerator lattice magnets which consist of 48 bending magnets, 240 quadrupoles and 168 multifunction sextupole magnets. All magnets pole profiles, edge shim and magnet end chamfer were designed in TOSCA and RADIA magnetic computation code. In order to verify the magnetic field quality of computation code, prototype magnets have been manufactured in this year. Two measurement systems, hall probe and rotating coils, were used for magnetic field mapping. This paper presents magnetic field mapping results of prototype magnets and compared with original magnetic circuit designs.

MOPEB021 **Field Shimming of the Superconducting Undulator by using the Cryogenic Hall Probe** – *J.C. Jan, C.-H. Chang, C.-S. Hwang, F.-Y. Lin (NSRRC)*

A magnet array of superconducting undulator SU15, with 130 poles and length 0.98 m, was constructed, and the field measurement and training are also performed at National Synchrotron Radiation Research Center (NSRRC). The NbTi wires were excited to 1.36 T @ 497 A after 28 times quench. A cryogenic Hall probe (length 2500 mm) was used to characterize the distribution of the magnetic field of magnet arrays in the 5.6-mm magnetic gap. The measurement region of the cryogenic Hall probe is greater than 1200 mm in the vertical dewar. The length shrinkage or expansion of the Hall probe depends on the thermal variation at both ends of the Hall probe. The length of the Hall probe will be evaluated in the field measurement region. The reproducibility of the measurement system was verified in the same experiment. A field shimming method involving a trim iron piece was used to correct for deviations of the magnetic field. This paper discusses the measurement accuracy in the cryogenic Hall probe system and presents results of the field shimming.

MOPEB022 **Magnet Field Crosstalk Effect of TPS Storage Ring Magnets** – *C.Y. Kuo, C.-H. Chang, C.-S. Hwang (NSRRC)*

The free space between magnets of TPS storage ring is very tight, especially the space between quadrupole and sextupole magnets. The minimum space between the yoke of quadrupole and sextupole is about 150mm, and the space between coils is only 10mm. In this case, the significant magnetic field distortions could have an impact on the performance of machine. Two magnets simulation compare to the individual magnet were performed in TOSCA 3D model. The crosstalk effect shows that the sextupole component increases from 0.0004% to 0.04% in the quadrupole magnet and the quadrupole component increases from 0.0006% to 0.06% in the sextupole magnet. This paper will discuss the crosstalk effect and how to reduce the effect by different algorithm.

MOPEB023 **Magnetic Field Mapping and Integral Transfer Function Matching of the Prototype Dipoles for the NSLS-II at BNL** – *P. He, M. Anerella, G. Ganetis, R.C. Gupta, A.K. Jain, P. Joshi, M. Rehak, J. Skaritka, P. Wanderer (BNL)*

The National Synchrotron Light Source-II (NSLS-II) storage ring at Brookhaven National Laboratory (BNL) will be equipped with 54 dipole magnets having a gap of 35 mm, and 6 dipoles having a gap of 90 mm.

The large aperture magnets are necessary to allow the extraction of long-wavelength light from the dipole magnet to serve a growing number of users of low energy radiation. The dipoles must not only have good field homogeneity (0.015% over a 40 mm x 20 mm region), but the integral transfer functions and integral end harmonics of the two types of magnets must also be matched. The 35 mm aperture dipole has a novel design where the yoke ends are extended up to the outside dimension of the coil using magnetic steel nose pieces. A Hall probe mapping system has been built with three Group 3 Hall probes mounted on a 2-D translation stage. The probes are arranged with one probe in the midplane of the magnet and the others vertically offset by ±10 mm. The field is mapped along a nominal 25 m radius beam trajectory. The results of measurements in the as-received magnets, and with modifications made to the nose pieces will be presented.

MOPEB024 **A Homogeneous Superconducting Combined Multipole Magnet for the Large Acceptance Spectrometer S3, based onFlat Racetrack Coils** – *O. Delferriere, A. Drouart, C. Mayri, J. Payet, J.-M. Rifflet (CEA)*

S3 (Super Separator Spectrometer) is a device designed for experiments with the very high intensity heavy ion stable beams of SPIRAL2. It will be set-up at the exit of the linear accelerator LINAG at GANIL (Caen, France). It will include a target resistant to very high intensity, a first stage momentum achromat for primary beam suppression, a second stage mass spectrometer and a dedicated detection system. This mass spectrometer includes a set of four large aperture quadrupole triplets with embedded multipolar corrections. These magnets are a combination of three multipoles which could be realized with superconductor wound in flat racetrack coils. This paper describes the multipole geometry. It is adapted to big aperture as demonstrated by 3D magnetic simulations, including harmonic analysis and integral field homogeneity. A preliminary mechanical design of a triplet is proposed to fit in the available space of the spectrometer.

MOPEB025 **SIS100 Fast Ramped Magnets and their Cryopump Functionality for the Operation with High Intensity Intermediate Charge State Heavy Ions** – *E.S. Fischer, A. Mierau, P. Schnizer, St. Wilfert (GSI) W. Gaertner, G. Sikler (BNG)*

The FAIR SIS100 accelerator at GSI Darmstadt will be equipped with fast ramped superconducting magnets. The high current Uranium beam modes with intermediate charge states, require ultra low vacuum pressures that can be achieved in long term operation only by cold beam pipes acting as a cryopump with stable temperatures well below 12 K for all operating cycles. The straightforward layout for reliable cooling usually conflicts with an efficient design for fast ramped superconducting accelerator magnets, strongly affected by AC loss generation, field distortion and mechanical stability problems. A full functional vacuum chamber design for SIS 100 has to take into account all these conflicting boundary conditions and trade off between mechanical stability, acceptable field distortions, AC loss minimisation and achievable temperatures. We discuss the cooling conditions for the dipoles and for the beam pipe including first test results. The analysis of the principal design aspects for the vacuum chamber with respect to the magnets operation parameters and an integral design approach are given. We present a technological feasible solution for model testing and full scale manufacturing.

MOPEB026 **Magnet Design of the ENC Interaction Region** – *P. Schnizer, E.S. Fischer (GSI) P.G. Akishin (JINR) K. Aulenbacher, A. Jankowiak, U. Ludwig-Mertin (IKP) C. Montag (BNL)*

The Electron Nucleon Collider, proposed as an extension to the High Energy Storage Ring (HESR), is currently investigated and a first layout of the Interaction Region (IR) proposed. The limited size of the machine, the low beam energy and the Lorentz force vector pointing in the same direction for both beams make the IR design demanding. In this paper we present the parameters of the IR magnets, show the boundary conditions given by the beam dynamics and the experiments. We present first 2D designs for the electron and proton triplet magnets along with the separating dipole next to the collision point. Different methods to shield the beam in the spectrometer dipoles are investigated and presented.

MOPEB027 **3D Static and Dynamic Field Quality Calculations for Superconducting SIS100 Corrector Magnets** – *K. Sugita, E.S. Fischer, P. Schnizer (GSI) P.G. Akishin (JINR) A. Mierau (TEMF, TU Darmstadt)*

Superconducting magnets are planned to be installed at the SIS100 accelerator ring for FAIR. The error compensation multipole corrector and the steerer are built as nested magnets to save longitudinal space in the ring, the chromaticity sextupole is a superferric magnet. We present the dynamic field quality of the SIS100 dipole and the vacuum chamber deterioration next to the 2D and 3D field quality of the multipole corrector and of the chromaticity corrector. The quality of the injection field of the SIS100 dipole is mainly dominated by eddy currents as soon as the field ramp starts. We show its AC losses concerning the hydraulic limits for cooling the magnet with forced two phase helium flow and conclude on the maximum chromaticity correction which is feasible for the foreseen magnet design. The results are discussed in respect of recent beam dynamic calculations on the ramp.

MOPEB028 **Large-Scale Computation of Transient Electromagnetic Fields Regarding the Field Quality in the Aperture of the SIS100 Dipole Magnet** – *S. Koch, T. Weiland (TEMF, TU Darmstadt)*

For the computation of the electromagnetic fields in large accelerator components, such as the superconducting dipole magnets to be installed in the heavy-ion synchrotron SIS100 at GSI, Darmstadt in context of the FAIR project, very large numerical models are required. By using parallelization techniques in combination with higher-order finite element approaches, full 3D solutions for the complicated geometry can be obtained in reasonable computational time. This is important, in particular, if repeated simulations need to be performed as in case of the determination of the sensitivity of the results to parametric changes, e.g. due to manufacturing tolerances. For that purpose, a parallelized 3D simulation tool is developed and applied to the prototype of the SIS100 dipole magnet. The results for the field quality during transient operation considering eddy currents in the conductive parts of the assembly are reported.

MOPEB029 **Theoretical and Experimental Analysis of Molecular Gas Conduction Heat Load in K-500 Superconducting Cyclotron** – *P. Bhattacharyya (DAE/VECC)*

During energization of K-500 Superconducting Cyclotron Magnet,the pressure in insulation vacuum chamber increases non-linearly with increase in circulating current in the superconducting electromagnet. Increase in number of gas molecule increases the molecular gas conduction heat load to the cryostat. This phenomena increases the Heat Load into the cryostat significantly. As a result pressure inside the cryogenic chamber increases rapidly,and relief valve opens, finally triggers the interlock to dump the circulating current. It was very much needful to understand and quantify its effect to the system. A lot of theoretical and experimental analysis has been carried out to quantify the exact amount of this heat load because of the increasing pressure in the insulation vacuum chamber. Also analysis has been done to design additional pumping module to take care of this additional gas load.

MOPEB030 **Cryostat Support System Analysis during Cool-down for the Superconducting Cyclotron and its Verification** – *S. Saha, M. Ahammed, R.K. Bhandari, P. Bhattacharyya, J. Chaudhuri, A. Dutta Gupta, B.C. Mandal, B. Manna (DAE/VECC)*

A superconducting-magnet-cryostat for K-500 cyclotron has been fabricated and installed at VEC Centre, Kolkata. The cryostat has a stainless steel bobbin on which the Nb-Ti superconducting coils are wound. The bobbin along with the coil is cooled with liquid helium down to 4.2 K temperature. The bobbin is suspended inside a vacuum chamber with the help of three horizontal and six vertical glass-epoxy support-links. A detail analysis is made to predict the movement of the coil and the support link forces. The results of analysis is verified with the experimental data and found in very good agreement with the analysis. This paper presents the details of analysis as well as how the results are used to formulate the methodology for safe operation of support links and proper alignment of the coil. Instead of doing detail 3D analysis, this analytical formulation can be used for estimating the bobbin movement and support forces with reasonable accuracy.

MOPEB031 **Design of Wide Aperture Quadrupole Magnets for FAIR Energy Buncher** – *P.R. Sarma, R.K. Bhandari, S. Bhattacharya, T. Bhattacharyya, C.N. Nandi, G.P. Pal, S. Roy (DAE/VECC)*

The energy buncher of the Super Fragment Separator (Super FRS) Section in Facility for Antiproton and Ion Research (FAIR), GSI requires a number of wide aperture quadrupole and sextupole magnets. These are superferric magnets using superconducting coils, iron poles and yokes, which are immersed in a liquid helium bath. The large aperture of the magnets introduces a large fringe field effect. On the other hand, the field uniformity required is very high, about $8x10^{-4}$ for the quadrupoles. The aperture is 70 cm, and the quadrupole length is 120 cm for the long variety and 80 cm for the shorter variety. Special design features are needed for achieving this field uniformity. We have optimized the end-champhering to bring down the field tolerance to $9x10^{-4}$ over a wide range of field level from 0.1 T/m to 5.2 T/m for the longer quadrupole.

MOPEB032 **Design of Super-ferric Dipole Magnet with Self-Correction Coils** – *K. Ruwali (RRCAT) K. Hosoyama (KEK)*

Design of a super-ferric dipole magnet with self-correction coils is carried out. The design field of super-ferric magnet is 0.8 T. It is impossible to design a magnet without higher order multipole in the magnet aperture. By adopting the self-correction coil scheme we can do online correction of unwanted fields inside the magnet aperture during the whole operating cycle irrespective of their origin. The mechanism of self-correction coils depends on the principle that a perfect multipole winding, of zero resistance and short circuited, will always carry an induced current to give exact cancellation, within its aperture, of any corresponding multipole field generated by an external source. The main error harmonic in case of dipole magnet is sextupole component. In order to compensate it, a self-correction coils having sextupole configuration is planned to placed inside the magnet aperture. A super-ferric dipole magnet has been fabricated and tested for its magnetic performance at 4.65 K. Operation mechanism of self-correction coil will be discussed.

MOPEB033 **Operation of Superconducting Combined Function Magnet System for J-PARC Neutrino Beam Line** – *T. Ogitsu, Y. Fujii, N. Hastings, M. IIda, N. Kimura, Y. Makida, T. Nakadaira, H. Ohhata, T. Okamura, K. Sakashita, K. Sasaki, S. Suzuki (KEK) H. Kakuno (University of Tokyo)*

A superconducting magnet system for the J-PARC neutrino beam line was completed in the end of 2008. The system consists of 14 doublet cryostats; each contains 2 combined function magnets (SCFM). The SCFM uses two single layer left/right asymmetric coils that produce a dipole field of 2.6 T and quadrupole of 19 T/m. By 2008, the world first SCFM had been developed and tested successfully at KEK. The mass-production was started in 2005, and completed by summer 2008. The system installation and commissioning took place from Feb. 2008 to Mar. 2009. The beam operation was started in April 2009 and the first neutrino beam was generated on April 23rd. Since then beam operation and commissioning to increase beam intensity has been performed to achieve the near term milestone of 100 kW beam operation. The paper briefly summarizes the history of SCFM development and the system construction. The beam operation experience of the SCFM system is then discussed in the paper mostly.

MOPEB034 **Progress of Design Study of Interaction Region Quadrupoles for the SuperKEKB** – *M. Tawada, Y. Funakoshi, H. Koiso, A. Morita, Y. Ohnishi, N. Ohuchi, K. Oide, K. Tsuchiya, Z.G. Zong (KEK)*

KEK is studying the design of the interaction region quadrupoles for the SuperKEKB of which the two beams of 4GeV/7GeV for LER/HER have a crossing angle of 83 mrad. For each beam, the final beam focusing system consisting of superconducting and permanent magnets is studied. The superconducting quadrupoles close to the interaction point for each beam are located in the compensation superconducting solenoid which cancels the solenoid field by the particle detector, Belle. These magnet parameters are optimized to obtain higher luminosity. In this paper, the design progress of final focusing system and magnets will be reported.

MOPEB035 **Present Status of the RCNP Cyclotron Facility** – *K. Hatanaka, M. Fukuda, M. Kibayashi, S. Morinobu, K. Nagayama, H. Okamura, T. Saito, H. Tamura, T. Yorita (RCNP)*

The RCNP accelerator cascade consists of an injector Azimuthally Varying Field (AVF) cyclotron (K=140) and a ring cyclotron (K=400). It provides ultra-high-quality beams and moderately high-intensity beams for a wide range of research in nuclear physics, fundamental physics, applications, and interdisciplinary fields. The maximum energy of protons and heavy ions are 400 and 100 MeV/u, respectively. Experimental apparatuses are used like a pair spectrometer, a neutron time of flight facility with a 100 m long tunnel, a radioactive nuclei separator, a super-thermal ultra cold neutron (UCN) source, a white neutron source, and a RI production system for nuclear chemistry. Such ultra high resolution measurements as dE/E = 5x10-5 are routinely performed with the Grand-Raiden spectrometer by utilizing the dispersion matching technique. The UCN density was observed to be 15 UCN/cm^3 at the experimental port at a beam power of 400 W. Some topics on the research are discussed in the talk.

MOPEB036 **A HTS Scanning Magnet and AC Operation** – *K. Hatanaka, M. Fukuda, J. Nakagawa, T. Saito, T. Yorita (RCNP) T. Kawaguchi (KT Science Ltd.) K. Noda (NIRS) Y. Sakemi (CYRIC)*

A scanning magnet using high-temperature superconductor (HTS) wire was designed, fabricated, and tested for its suitability as beam scanner. After successful cooling tests, the magnet performance was studied using DC and AC currents. With DC current the magnet was successfully operated to generate designed field distributions and effective length. In AC mode, the magnet was operated at frequencies of 30-59 Hz and a temperature of 77 K as well as -10--20 Hz and 20K. The power loss dissipated in the coils was measured and compared with the model calculations. The observed loss per cycle was independent of the frequency and the scaling law of the excitation current was consistent with theoretical predictions for hysteretic losses in HTS wires.

MOPEB037 **Development of Current Leads for the Superconducting Correctors in the SuperKEKB-IR** – *Z.G. Zong, N. Higashi, N. Ohuchi, M. Tawada, K. Tsuchiya (KEK)*

To supply the electrical power for the superconducting correctors in the interaction region of the proposed SuperKEKB, a kind of vapor cooled current leads is designed, which consists of 8 brass leads and can transport currents to 4 correctors simultaneously. The design current of the leads is about 50 A. The thermal and electrical behaviors have studied by the finite elements method and the cryogenic experiment is also planed to validate the performance. In this paper the design will be presented and the finite element model will be compared with the experimental data.

MOPEB038 **Design and Manufacture of Superconducting Magnet for the Wiggler in SAGA-LS** – *T. Semba, T. Yamamoto (Hitachi Ltd.) M. Abe (Hitachi, Ltd., Power & Industrial Systems R&D Laboratory) Y. Iwasaki, T. Kaneyasu, S. Koda, Y. Takabayashi (SAGA)*

A 4T superconducting wiggler for 1.4GeV synchrotron radiation facility SAGA-LS is under development. The wiggler consists of one superconducting magnet as main-pole and two normal conducting magnets as side-poles. The superconducting coils are wound with NbTi wires on iron poles, which is directly cooled by a GM cryocooler. The structure of the wiggler aims compactness and cryogen-free operation. In this paper, its magnet design and maufacturing process will be presented.

MOPEB039 **Progress on Design and Construction of MICE Coupling Solenoid Magnets** – *L. Wang, X.L. Guo, H. Pan, H. Wu, S.X. Zheng (ICST) A.J. DeMello, M.A. Green, D. Li, S.P. Virostek, M.S. Zisman (LBNL) S.Y. Li (HUST)*

A pair of superconducting coupling solenoids are to be applied in the Muon Ionization Cooling Experiment (MICE). The solenoid made of commercial copper stabilized niobium titanium conductors has an inner diameter of 1.5 meter, a length of 285 mm and a thickness of -10-6 mm It is to provide a central field of about 2.6 T at full current of 210 A, and the coil peak field up to 7.4 T. The coupling magnet will be cooled by two cryocoolers with total cooling capacity of 3.0 W at 4.2 K, and powered by a single 300 A power supply through a pair of binary leads. The magnet is to be passively protected by cold diodes and resistors across sections of coil and by quench back from the 6061 Al mandrel in order to lower the quench voltages and the hot spot temperature. The engineering design and construction of the MICE coupling magnets were carried out by the Institute of Cryogenics and Superconductivity Technology in Harbin Institute of Technology in collaboration with the Lawrence Berkeley National Laboratory. This paper is to present the updated engineering design and the fabrication processing technique for the magnets.

MOPEB040 **Superconducting Magnets for the NICA Facility at JINR: Status of the Design and Construction Plans** – *A.D. Kovalenko, N.N. Agapov, V.D. Kekelidze, H.G. Khodzhibagiyan, I.N. Meshkov, Yu.K. Potrebennikov, A.N. Sissakian, A. Sorin, G.V. Trubnikov (JINR)*

NICA (Nuclotron-based Ion Collider fAcility) is the new accelerator complex currently under construction at JINR. The facility is aimed to provide collider experiments with heavy ions up to uranium (gold at the beginning stage) with a centre of mass energy up to 11 GeV/u and an average luminosity up to 10^{27} cm^{-2} s^{-1}. The collisions of polarized deuterons and protons are foreseen also. The accelerator complex includes two injector linacs, a superconducting booster synchrotron, a 6 GeV/u superconducting synchrotron (existing Nuclotron) and a collider consisting of two storage rings. Different modifications of superferric magnets based on a hollow composite NbTi cable operating at 4.5 K is proposed to be used for the NICA booster and collider rings. The twin-aperture collider dipole consists of two vertically assembled cold masses placed inside a common thermal shield and a common cryostat. The dipole good field aperture is fixed to 60 mm. The 2 T option, which design is very similar to the Nuclotron's one, was fixed as basis for the collider of 350 m long. R&D work on a curved 4 T Cosine(θ)-dipoles based on a hollow Nuclotron-type cable is proposed to be continued.

MOPEB041 **Calculation and Design of the Magnet Package in the Superconducting SRF Linac of IFMIF** – *S. Sanz, B. Brañas, L. García-Tabarés, I. Podadera Aliseda, F. Toral (CIEMAT) P. Bosland, P. Bredy, G. Disset, N. Grouas, P. Hardy, V.M. Hennion, H. Jenhani, J. Migne, A. Mohamed, F. Orsini, J. Plouin, J. Relland (CEA) E.N. Zaplatin (FZJ)*

The IFMIF-EVEDA accelerator will be a 9 MeV, 125 mA CW deuteron accelerator which aims to validate the technology that will be used in the future IFMIF accelerator. The SRF Linac design is based on superconducting Half Wave Resonators (HWR) cavities operating at 4.4 K. Due to space charge associated to the high intensity beam, a strong superconducting focusing magnet package is necessary between cavities, with nested steerers and a Beam Position Monitor (BPM). First of all, this paper describes the preliminary study, the purpose of which was to choose between two options: quadrupoles or a solenoid, both using NbTi wire. The solenoid option shows more advantages, mainly associated to available space and reliability. Then, the electromagnetic and mechanical design of the solenoid and the steerers are reported. Special care is taken with shielding design in order to accomplish the fringe field limit at the cavities. An active shield configuration using an anti-solenoid has been adopted, avoiding remanent magnetization associated to passive shielding materials. Finally, the calculation of the resistive current leads is briefly explained.

MOPEB042 **Towards a Consolidation of LHC Superconducting Splices for 7 TeV Operation** – *F.F. Bertinelli, N. Catalan-Lasheras, P. Fessia, C. Garion, S.J. Mathot, A. Perin, C.E. Scheuerlein, S. Sgobba, H.H.J. Ten Kate, J.Ph. G. L. Tock, A.P. Verweij (CERN)*

Following the analysis of the September 2008 LHC incident, the assembly process and the quality assurance of the main 13kA interconnection splices were improved, with new measurement and diagnostics methods introduced. During the 2008-2009 shutdown ~5% of these 10 000 splices were assembled with these improvements implemented, but essentially maintaining the original design. It is known today that a limiting factor towards 7 TeV operation is the resistance at warm of ~15% of the original main 13kA interconnection splices, associated to the electrical continuity of the copper stabiliser. A Task Force has been set up at CERN to evaluate the need for, develop and test design improvements and prepare the implementation of a consolidation campaign starting with the shutdown 2010-2011. Important issues of resource and time requirements, co-activity with other systems requiring interventions are also considered, leading to alternative scenarios. In addition all other superconducting splices are also being reviewed. Particular attention is being given to the long-term performance of splices, both for metallurgical and mechanical reasons, and other less known potential failure modes.

MOPEB043 **New Techniques for Mechanical Measurements in the Superconducting Magnet Models** – *M. Guinchard, K. Artoos, A.H.J. Gerardin, A.M. Kuzmin (CERN)*

Force transducers based on strain and capacitive gauges have been developed and used for monitoring the coil pre-stress during assembly and excitation of magnet models. This paper will summarize and compare the new techniques of mechanical measurements use at CERN for the New Inner Triplet Project. Furthermore the paper will give a comparison of the gauge performances (Creep effects, temperature effects, etc.) and will present the performances of the new data acquisition system developed at CERN to measure simultaneously the strain gauges, the capacitive gauges and other external parameters for the magnet.

MOPEB044 **High-current Bus Splice Resistances and Implications for the Operating Energy of the LHC** – *M. Koratzinos, F.F. Bertinelli, Z. Charifoulline, K. Dahlerup-Petersen, R. Denz, C.E. Scheuerlein, R. Schmidt, A.P. Siemko, A.P. Verweij (CERN) R.H. Flora, H. Pfeffer, J. Strait (Fermilab)*

At each interconnection between LHC main magnets, a low-resistance solder joint must be made between superconducting cables to provide a continuous current path through the superconductor, and between the surrounding copper stabilizer to provide a current path in case the cable quenches. About 10,000 such joints exist in the LHC. An extensive campaign has been undertaken to characterize and map the resistances of both types of joints. All of the superconducting cable splices were measured using the enhanced protection system of the LHC superconducting circuits. No high-resistance superconductor splices were found above 3 nano-Ohms. Non-invasive measurements of the stabilizer joints were made at 300K in 5 of the 8 sectors, and at 80K in 3 sectors. More precise local measurements were made on suspect interconnects that were opened up, and poor joints were repaired. However, it is likely that additional imperfect stabilizer joints still exist in the LHC. A statistical analysis is used to place bounds on the remaining worst-case resistances. This sets limits on the maximum operating energy of the LHC, prior to a more extensive intervention.

MOPEB045 **Commissioning of the LHC Magnet Powering System in 2009** – *M. Solfaroli Camillocci, G. Arduini, B. Bellesia, J. Coupard, M. Koratzinos, M. Pojer, R. Schmidt, H. Thiesen, A. Vergara-Fernández, M. Zanetti, M. Zerlauth (CERN)*

On 19th September 2008 the Large Hadron Collider (LHC) experienced a serious incident, caused by a bad electrical joint, which stopped beam operation just a few days after its beginning. During the following 14 months the damage was repaired, additional protection systems were installed and the measures to avoid a similar incident were taken (i.e. new layer of the Magnet Quench Protection System [nQPS], more efficient He release valves). As a consequence, a large number of powering tests had to be repeated or carried out for the first time. The re-commissioning of the already existing systems as well as the commissioning of the new ones has been carefully studied, then performed taking into account the history of each of the eight LHC sectors (warm-up, left at floating temperature,'). Moreover, a campaign of measurements of the bus-bar splice resistances has been carried out with the nQPS in order to spot out non conformities, thus assessing the risk of the LHC operation for the initial energy level. This paper discusses how the guidelines for the LHC 2009 recommissioning were defined, providing a general principle to be used for the future re-commissioning.

MOPEB046 **First Operational Experience with the LHC Superconducting Magnet Circuits after the Incident, Consolidations and Second Commissioning Campaign** – *A.P. Siemko, N. Catalan-Lasheras, L. Rossi, R. Schmidt (CERN)*

The complex magnetic system of the LHC is requiring more than 1700 main superconducting dipole and quadrupole magnets distributed in the underground tunnel along a circumference of 26.7 km. The main magnets are accompanied by almost 8000 superconducting corrector magnets of various size and magnetic field. The magnetic system has initially been commissioned in the years 2007-2008. After a short period of beam operation in September 2008, that showed an excellent performance in terms of magnetic field quality, a severe incident on 19th of September happened at 75% of the nominal current in one of the eight LHC sectors. The incident consisted in an electric arc, caused by a defective joint in the main dipole bus bar, and produced direct and collateral damages. Several other weak points were revealed by the incident. Most of them can be traced to insufficient integration of the various technical systems. The repair campaign took one year and included improvements and consolidation of several subsystems. In the second half of 2009 the entire magnetic system of the LHC has been re-commissioned. This paper will report on the operational experience gained with the restart of the machine.

MOPEB047 **Method for Choosing the Optimum Current for Superconducting Magnets** – *T.M. Taylor (CERN)*

The choice of optimum conductor and operating current for superconducting magnets depends on a number of parameters and constraints. Besides the safe provision of accurate magnetic field(or field gradient)in a "good field" aperture over a given length, other parameters impacting on the choice of conductor include ramp rate and protection against damage in the event of a quench. Constraints include those deriving from the availability of cryogenics, and the space allocation for power converters, energy extraction equipment and the associated connecting feeder system. Finally there is the constraint of minimizing cost of the system as a whole, taking into account the ease of manufacture as based on the collective experience that has been accumulated over the years. The report addresses these issues and presents a roadmap for guiding the choice of conductor and operating current, together with some examples.

MOPEB048 **Helical Combined Function Magnets for the Proton Ring of PAMELA** – *H. Witte, K.J. Peach (JAI) N. Bliss, T.J. Jones, J. Strachan (STFC/DL) S.M. Pattalwar (STFC/DL/ASTeC)*

We report on the progress of the magnet design for PAMELA, which is a design study of a non-scaling FFAG for charged particle therapy. This paper focuses on the magnet design for the proton ring. The proton lattice of PAMELA requires combined function magnets with multipole field components up to decapole. We present a magnet design based on superconducting helical coils, where the helical path of the conductor creates a field which contains all required multipole components. Helical coils are particularly well suited, as they allow to generate high quality fields in a large bore and confined space. Trim coils are added to allow tunability of the individual field components. The coil design has sufficient temperature margin and the field quality is adequate for the desired application. For operation we envisage a recondensing bath cryostat which contains one triplet.

MOPEB049 **Helical Combined Function Magnets for the Carbon Ring of PAMELA** – *H. Witte (OXFORDphysics) N. Bliss, T.J. Jones, J. Strachan (STFC/DL) S.M. Pattalwar (STFC/DL/ASTeC) K.J. Peach (JAI)*

We report on the progress of the magnet design for PAMELA, which is a design study of a non-scaling FFAG for charged particle therapy. In this paper we outline a conceptual design of the magnets for the carbon ring. The requirements of the carbon lattice are similar to those of the proton lattice of PAMELA in that both require large bore combined function magnets with multipole field components up to decapole. In comparison to the proton ring the carbon lattice permits more geometric flexibility, which allows to optimize the design with respect to performance, field shape and fringe field extent. We present a conceptual magnet design based on superconducting helical coils, where the helical path of the conductor creates a field which contains all required multipole components.

MOPEB050 **Superconducting Magnets for SCRF Cryomodules at Front End of Linear Accelerators** – *V.S. Kashikhin, N. Andreev, Y. Orlov, D.F. Orris, M.A. Tartaglia (Fermilab)*

Linear accelerators based on a superconducting technology need various superconducting magnets installed inside SCRF Cryomodules. At front end of Linear Accelerators installed relatively weak iron-dominated magnets. The focusing quadrupoles have integrated gradients in the range of

1 T - 4 T, and apertures 35 mm - 90 mm. At Fermilab were designed superconducting dipole correctors, and quadrupoles for various projects. In the paper presented these magnet designs, and test results of fabricated dipole corrector. There are also briefly discussed: magnetic and mechanical designs, quench protection, cooling, fabrication, and assembly inside cryomodule.

MOPEB051 **Design of Helical Solenoid Combined with RF Cavity** – *V.S. Kashikhin, N. Andreev, V. Kashikhin, M.J. Lamm, A.V. Makarov, G.V. Romanov, K. Yonehara, M. Yu, A.V. Zlobin (Fermilab)*

Helical Solenoids (HS) were proposed for a muon beam ionization cooling. There are substantial up to 30 MeV/m energy losses during passing the muon beam through an absorber. The main issue of such system is the energy recovery. A conventional RF cavity has diameter which is too large to be placed inside HS. In the paper presented results of dielectric filled RF cavity design. The proposed cavity has helical configuration. Presented Helical Cooling Channel module design which includes: high pressure vessel, RF cavity, and superconducting HS. Discussed parameters of this module sub-systems and shown results of muon beam tracking in combined magnetic and electric 3D fields.

MOPEB052 **120-mm Superconducting Quadrupole for Interaction Regions of Hadron Colliders** – *A.V. Zlobin, V. Kashikhin, N.V. Mokhov, I. Novitski (Fermilab)*

Magnetic and mechanical designs of a superconducting quadrupole magnet with 120-mm aperture suitable for interaction regions of hadron colliders are presented. The magnet is based on a two-layer shell-type coil and a cold iron yoke. Special spacers made of a low-Z material are implemented in the coil midplanes to reduce the level of radiation heat deposition in the coil. The quadrupole mechanical structure is based on a thick aluminum collar supported by the iron yoke and stainless steel skin. Magnet parameters including maximum field gradient, field quality and temperature margin for NbTi or Nb3Sn coils at the operating temperatures of 1.9 K and 4.5 K are reported. The level and distribution of radiation heat deposition in the coil and other magnet components are discussed.

MOPEB053 **Magnet Designs for Muon Collider Ring and Interaction Regions** – *A.V. Zlobin, V.Yu. Alexakhin, V. Kashikhin, N.V. Mokhov (Fermilab)*

Conceptual designs of superconducting magnets (dipoles and quadrupoles) for a muon collider with a 1.5 TeV c.o.m. energy and an average luminosity of 10^{34} $cm^{-2}s^{-1}$ are presented. All magnets are based on the Nb3Sn superconductor and designed to provide an adequate operation field/field gradient in the aperture with the critical current margin required for reliable machine operation. In contrary to proton machines, the dipole magnets should have open midplanes, and, for some of them, the required good field quality region needs to have a vertical aspect ratio of 2:1 that imposes additional challenges for the magnet design. Magnet cross-sections were optimized to achieve the best possible field quality in the magnet aperture occupied with beams. The magnets and corresponding protective measures are designed to handle about 0.5 kW/m of dynamic heat loads from the muon beam decays. Magnet parameters are reported and compared with the requirements.

MOPEB054 **Modeling the High-Field Section of a Muon Helical Cooling Channel** – *A.V. Zlobin, E.Z. Barzi, V.S. Kashikhin, M.J. Lamm, V. Lombardo, M.L. Lopes, M. Yu (Fermilab) R.P. Johnson, S.A. Kahn, M. Turenne (Muons, Inc)*

The Helical Cooling Channel (HCC) is a technique proposed for six-dimensional (6D) cooling of muon beams. The HCC for muon collider and some other applications is usually divided into several sections each with progressively stronger fields, smaller aperture, and shorter helix period to achieve the optimal muon cooling rate. Novel magnet design concepts based on simple coils arranged in a helical solenoid configuration have been developed to provide HCC magnet systems with the desired parameters. The level of magnetic field in the HCC high-field sections suggests using a hybrid coil structure with High Temperature Superconductors (HTS) in the innermost coil layers and Nb3Sn superconductor in the outer coil layers. The development of the concepts and engineering designs of hybrid helical solenoids based on advanced superconductor technologies, with special emphasis on the use of HTS for high fields at low temperature is the key step towards a practical HCC. This paper describes the conceptual designs and parameters of a short HTS model of a hybrid helical solenoid, and discusses the structural materials choices, fabrication techniques, and first test results.

MOPEB055 **YBCO Conductor Technology for High Field Muon Cooling Magnets** – *S.A. Kahn, G. Flanagan, R.P. Johnson, M. Turenne (Muons, Inc) F. Hunte, J. Schwartz (North Carolina State University)*

YBCO superconductors originally developed for high temperature operation carry significant critical current even in the presence of extremely high magnetic field when operated at low temperature. The final stage of phase space cooling for a muon collider uses a solenoid magnet with fields approaching 50 T. As part of an R&D effort we present measurements of mechanical and electromechanical properties of the YBCO conductor. We examine the critical current verses magnet field angle at 4.2 K in a magnetic field. Quench properties of the conductor such as minimum quench energy threshold and quench propagation velocity will be measured to establish safe operational conductions for the muon cooling magnets. In this paper we describe a conceptual picture for a high field solenoid to be used for muon phase space cooling that incorporates these low temperature properties of YBCO.

MOPEB056 **Multi-purpose Fiber Optic Sensors for Superconducting Magnets** – *M. Turenne, R.P. Johnson (Muons, Inc) F. Hunte, J. Schwartz (North Carolina State University)*

Superconducting magnets constructed from Bi2212, YBCO, and Nb3Sn materials are showing great promise for high magnetic field applications such as particle accelerators, NMR, and fusion reactors. The limits of compatibility of fiber optic sensors with high temperature processing of Bi2212 and Nb3Sn, magnet winding, and sensitivity during cryogenic operation of these superconducting magnets are being explored. Preliminary results of an ongoing investigation of the feasibility of fiber optic sensors to monitor strain, temperature and irradiation, and to detect quenches are discussed. Two sensing methods, Rayleigh backscatter and fiber Bragg gratings, are analyzed to determine their appropriateness for monitoring superconducting magnets. Early results suggest that optical fibers may be a viable solution to the sensors that are needed for monitoring the cryogenic operation and heat treatment process of these magnets.

MOPEB057 **YBCO Roebel Cable for High-field Low-loss Accelerator Magnets** – *M. Turenne, G. Flanagan, R.P. Johnson (Muons, Inc) F. Hunte, J. Schwartz (North Carolina State University)*

High field accelerator magnets are needed for high energy physics applications. Superconducting materials able to reach these fields with low losses are required, and YBCO Roebel cable is being developed to address this issue. Characterization of commercially available Roebel cables for high field low temperature superconducting magnets is needed. YBCO Roebel cable with low AC losses is being developed and has limited commercial availability. Its behavior is not fully understood, however, especially in liquid helium and at high magnetic fields. YBCO Roebel cable will be acquired from a commercial vendor and characterized at cryogenic temperatures, in varying magnetic fields, and different strain configurations. A comprehensive behavior analysis will be performed, including operational and fatigue limits. Characterization of YBCO Roebel cable at low temperatures will be performed, including determination of the current flow path in steady-state and during quench using magneto-optical imaging, investigation of the effects of strand insulation, and examination of the mechanical and quench behavior at 4.2 K, 77 K, and varying magnetic fields.

MOPEB058 **Characterization of YBCO Coated Conductors for High Field Magnets** – *M. Turenne, G. Flanagan, R.P. Johnson (Muons, Inc) J. Schwartz (North Carolina State University)*

Fusion energy sources require superconducting magnets beyond today's capabilities in order to achieve safe and reliable operation. New sensors which are immune to electromagnetic noise are needed to provide rapid quench protection for operational systems as well as to measure temperature and strain for studies of magnet behavior for engineering development. Optical fibers will be imbedded within Nb3Sn and YBa2Cu3Ox (YBCO) cables to monitor strain, temperature, and irradiation, and to detect quenches in cable-wound magnets using fiber Bragg gratings and

Rayleigh scattering. Protection methods for YBCO magnets, which have very slow quench propagation velocities, will be developed. Associated instrumentation will allow real-time measurements to aid the development of high-field magnets that are subject to large Lorentz forces, to allow the effective detection of quenches so that the stored energy of operating magnets can be extracted and/or dissipated without damaging the magnet, and to determine the level of irradiation exposure to the conductor as a function of location.

MOPEB059 **Assembly and Test of a 120 mm Bore 15 T Nb3Sn Quadrupole for the LHC Upgrade** – *S. Caspi, D.W. Cheng, D.R. Dietderich, H. Felice, P. Ferracin, R.R. Hafalia, R. Hannaford, G.L. Sabbi (LBNL) G. Ambrosio, R. Bossert, V. Kashikhin, A.V. Zlobin (Fermilab) M. Anerella, A.K. Ghosh, J. Schmalzle, P. Wanderer (BNL)*

Advanced superconductors such as Nb3Sn are being considered for future magnet upgrades of the Large Hadron Collider (LHC) at CERN. The US LHC Accelerator Research Program (LARP) has developed a large bore (120mm) Nb3Sn IR quadrupole (HQ) capable of reaching 15 T at its conductor and a gradients of 199T/m at 4.4K and 219T/m at 1.9K. HQ is addressing coil alignment and accelerator field quality in a shell-based mechanical structure. In this paper we summarize the fabrication, assembly and initial test results of the 1 m long two-layer magnet.

MOPEB060 **Lessons Learned for the MICE Coupling Solenoid from the MICE Spectrometer Solenoid** – *M.A. Green, A.J. DeMello, D. Li, F. Trillaud, S.P. Virostek, M.S. Zisman (LBNL) X.L. Guo, H. Pan, L. Wang, H. Wu, S.X. Zheng (ICST)*

Tests of the spectrometer solenoids have taught us some important lessons. The spectrometer magnet lessons learned fall into two broad categories that involve the two stages of the coolers that are used to cool the magnets. On the first spectrometer magnet, the problems were centered on the connection of the cooler 2nd-stage to the magnet cold mass. On the second spectrometer magnet, the problems were centered on the cooler 1st-stage temperature and the connections between leads, the cold mass support intercept, and the shields to the cooler first-stage. If the cooler 1st-stage temperature is too high, the refrigerator will not produce full 2nd stage cooling. If the 1st-stage temperature is too high, the temperature of the top of the HTS leads. As a result, more heat goes into the 4 K cold mass and the temperature margin of the top of the HTS leads is too small, which are in a magnetic field. The parameters that affect the magnet cooling are compared for the MICE coupling magnet and the spectrometer magnet.

MOPEB061 **Fabrication, Testing and Modeling of the MICE Superconducting Spectrometer Solenoids** – *S.P. Virostek, M.A. Green, F. Trillaud, M.S. Zisman (LBNL)*

The Muon Ionization Cooling Experiment (MICE), an international collaboration sited at Rutherford Appleton Laboratory (RAL) in the UK, will demonstrate ionization cooling in a section of a realistic cooling channel using a muon beam. A five-coil superconducting spectrometer solenoid magnet will provide a 4 tesla uniform field region at each end of the cooling channel. Scintillating fiber trackers within the 400 mm diameter magnet bore tubes measure the emittance of the beam as it enters and exits the cooling channel. Each of the identical 3 meter long magnets incorporates a three-coil spectrometer magnet section and a two-coil section that matches the solenoid uniform field into the MICE cooling channel. The cold mass, radiation shield and leads are kept cold by means of three two-stage cryocoolers and one single-stage cryocooler. After incorporating several design changes to improve the magnet cooling and reliability, the fabrication and acceptance testing of the spectrometer solenoids has been completed. The key features of the spectrometer solenoid magnets are presented along with the details of a finite element model used to predict the thermal performance of the magnets.

MOPEB062 **Design and Testing of Cryogenic Systems Dedicated to Neutron Sources** – *S. Crispel, M. Bonneton (Air Liquide, Division Techniques Avancées) M.F.D. Simon (F4E) R. Thiering (ANSTO)*

Thanks to its experience in past projects in the field of neutron sources, Air Liquide DTA was involved in recent years in two major projects : a new Cold Neutron Source (OPAL) at ANSTO, Australia and a Spallation Neutron Source at ISIS, United Kingdom. The OPAL CNS is a liquid deuterium moderated source operating with a cold box with a refrigeration capacity of 5 kW at 25K designed and manufactured by Air Liquide DTA. ISIS Target Station 2 is a liquid hydrogen and solid methane moderated source for which Air Liquide DTA provided two Helium cold boxes (about 600W) operating at 20K derived from the standard Helial product, one customised cryogenic hydrogen loop, and very specific remote dismountable cryogenic transfer lines. These two cryogenic systems were fully commissioned on Air Liquide DTA dedicated test area before delivery to the customers. The purpose of this paper is to give a compared overview of the design and testing of the proposed cryogenic systems for these two projects.

MOPEB063 **Neutron Source at the DAΦNE Beam Test Facility** – *G. Mazzitelli, R. Bedogni, B. Buonomo, M. De Giorgi, A. Esposito, L. Quintieri (INFN/LNF) P. Valente (INFN-Roma)*

A neutron source, based on photo-neutron production, has been designed and is under construction to upgrade the electron/positron/ photon DAΦNE Beam Test Facility (BTF). We present the feasibility study, the solution chosen and the optimization done in order to maximize the neutron/photon yield as well as the comparison between different simulation codes (FLUKA/GEANT4/MCNPX). The first experimental test is foreseen in March 2010.

MOPEB064 **Study for FFAG-ERIT Neutron Source** – *K. Okabe (University of Fukui, Faculty of Engineering) Y. Ishi, Y. Mori, T. Uesugi (KURRI)*

As for BNCT (boron neutron capture therapy) medical applications, an accelerator-based intense thermal or epithermal neutron source has been strongly requested recently. A scaling type of FFAG accelerator with ERIT (energy/emittance recovery internal target) scheme has been developed for this purpose. In this scheme, the beam emittance degradation caused by the neutron production target are cured by ionization cooling method. In this presentation, recent beam study of ionization cooling and neutron production will be described.

MOPEB065 **MICE Liquid Hydrogen Absorber** – *S. Ishimoto, S. Suzuki (KEK) Y. Kuno, M.Y. Yoshida (Osaka University) W. Lau (OXFORDphysics)*

MICE liquid hydrogen absorber was developed, and is going to be installed at RAL/ISIS. MICE equipment has three AFC (absorber focusing coil) models. Each AFC module has a 20 l liquid hydrogen absorber, center length is 35 cm and diameter is 30 cm. The minimum thickness of aluminum absorber windows is 0.3 mm at center. AFC has two more windows to keep the leaked hydrogen inside for safety purpose. Liquid hydrogen was supplied by a Cryocooler, CRYOMEC PT407 or Sumitomo RDK415 in the preparation stage. Both cooling power was 1.5 W at 4.2 K. We will report the hydrogen absorber contraction and test results.

MOPEB066 **Beam Commissioning of Spallation Neutron and Muon Source in J-PARC** – *S.I. Meigo, M. Futakawa, M. Ohi, S. Shinichi (JAEA/J-PARC) H. Fujimori (KEK/JAEA)*

In J-PARC, Materials and Life Science experimental Facility (MLF) is aimed at promoting experiments using the world highest intensity pulsed neutron and muon beams which are produced at a thick mercury target and a thin carbon graphite target by 3-GeV proton beams, respectively. The first beam was achieved at the target without significant beam loss in May 2008. It is succeeded stable operation with beam power of larger than 300 kW. After beam irradiation, the residual dose of radiation on the beam transport line is remarkably small where the highest dose is 20 microSv/h. In order to confirm stable operation of the facility, especially for the wellness of the target, it is important to obtain the beam profile at the target. We developed new technique by using imaging plate which is attached on the target vessel by remote handling technique via master slave manipulators. It is found that the beam profile shows good agreement with the calculation. It is also found that the beam scattering effect on the muon production target shows good agreement with the simulation calculation.

MOPEB067 **The Novel Method of Focusing-SANS with Rotating Magnetic Sextupole Lens and Very Cold Neutrons** – *M. Yamada, M. Ichikawa, Y. Iwashita, T. Kanaya, H. Tongu (Kyoto ICR) K.H. Andersen, P.W. Geltenbort, B. Guerard, G. Manzin (ILL) M. Bleuel (RID) J.M. Carpenter, L. Jyotsana (ANL) M. Hino, M. Kitaguchi (KURRI) K. Hirota (RIKEN) S.J. Kennedy (ANSTO) K. Mishima, H.M. Shimizu, N.L. Yamada (KEK)*

We have developed a motorized magnetic lens for focusing of pulsed white neutron beams. The lens is composed of two concentric permanent magnet arrays, in sextupole geometry, with bore of 15 mm and magnet length of 66 mm. The inner magnet array is stationary, while the outer array is rotated (the frequency of the modulation of magnetic field inside the bore $\nu \leq$ 25Hz), providing a sextupole magnetic field gradient range of $1.5\text{x}10^4\text{T/m}^2 \leq g' \leq 5.9\text{x}10^4\text{T/m}^2$. By synchronization of a pulsed neutron beam with the sinusoidal modulation of the magnetic field in the lens, the beam is focused, without significant chromatic aberration, over a wide neutron wavelength band. We have constructed a focusing-SANS (Small Angle Neutron Scattering) test bed on the PF2-VCN (Very Cold Neutron) beam line at the Institut Laue-Langevin in Grenoble. The beam image size matched the source size (~ 3mm) over of wavelength range of 30Å $\leq \lambda \leq$ 48Å with focal length of ~ 2.3 m. Further, we have demonstrated the performance of this device for high resolution time-of-flight (tof) SANS for a selection of polymeric & biological samples, in a compact geometry of just 5 m.

MOPEB068 **Nuclear Data Measurements with a Pulsed Neutron Facility based on an Electron Linac** – *G.N. Kim (Kyungpook National University) W. Namkung (POSTECH)*

We report the activities by using the pulsed neutron facility which consists of an electron linear accelerator, a water-cooled Ta target, and a 12-m time-of-flight path. It can be possible to measure the neutron total cross-sections in the neutron energy range from 0.01 eV to few hundreds eV by using the neutron time-of-flight method. A 6LiZnS(Ag) glass scintillator was used as a neutron detector. The neutron flight path from the water-cooled Ta target to the neutron detector was 12.1 m. The background level was determined by using notch-filters of Co, In, Ta, and Cd sheets. In order to reduce the gamma rays from Bremsstrahlung and those from neutron capture, we employed a neutron-gamma separation system based on their different pulse shapes. The present measurements of several samples (Dy, Nb) are in general agreement with the evaluated data in ENDF/B-VII. The resonance parameters were extracted from the transmission data from the SAMMY fitting and compared with the previous ones. We also report the isomeric yield ratios for isomeric pairs produced from photonuclear reactions by using the bremsstrahlung photons from the 70-MeV electron linac.

MOPEB069 **CERN nTOF an Intense White Neutron Time-of-flight Facility for High-resolution Neutron Data Measurements** – *V. Vlachoudis (CERN)*

The neutron Time of Flight (nTOF) facility at CERN is an intense source of white neutron flux obtained by the spallation process of 20 GeV/c protons onto a solid lead target. The outstanding characteristics of this facility: high neutron flux $1.0{\cdot}10^6$ n/cm^2/pulse at the location of the experimental area at 200m, wide spectral function from thermal up to GeV, low repetition rates and the excellent energy resolution of $2.0{\cdot}10^{-4}$ open new possibilities for high precision cross section measurements, using samples of modest mass. The facility has being recently refurbished, featuring a new spallation target, improved cooling and ventilation systems. The new design has superior performances than the original one. The facility resumed operation in 2008 pursuing an intense experimental program on Astrophysics, Fission fragment distribution, transmutation and fundamental physics with neutron-neutron scattering. The present paper will discuss the main physics results obtained in nTOF so far, the plan for the future measurements, as well the perspectives for the possible upgrades foreseen in the facility.

MOPEB070 **Application of Cubes in Different Fields of Science** – *I.D. Valova (ICSR)*

Subject of this paper is to study the use of a common geometric figure CUBE in various fields of science ’ fuzzy sets and neural systems, multiprocessor systems and in multidimensional models for analytical data processing. It is shown also how such scientific sectors use some concepts as one-dimensional cube, two-dimensional cube, etc. Developments in one discipline often underpin others, or lead to new challenges in other research areas. Many important emerging research areas are on the interface between traditional disciplines. We present further a classification of software products depending on way of data storage in one-cube or multi-cube structure. An approach to analysis of multidimensional models in OLAP systems as outlined in this paper is application of Intuitionistic Fuzzy Evaluations (IFE), aiming to provide new functional possibilities to developers of systems for on-line analytical data processing and business analysts by utilization of IF evaluations. Key words: fuzzy sets and neural systems, multiprocessor systems, multidimensional models, IF estimations

MOPEB071 **Low Voltage Very High Current SCR Controlled Magnet Power Supply** – *P.A.E. Elkiaer, A. Jensen, C. Nielsen, C. Soerensen (Danfysik A/S)*

Danfysik A/S has developed a novel approach in constructing a low voltage, very high current and highly stable magnet power supply using parallel SCR converter stages. The design is well suited for driving superconducting magnets in a two quadrant operation. A ±10V 18kA power supply has been built to EPFL Lausanne with four parallel converters showing excellent performances and a very low installation time. One of the major difficulties in paralleling SCR converters is the current sharing between the individual converters, which becomes even harder at low voltages. The novel design, which will be presented here, assures current sharing within a few percent in the whole working area. The power supply has been developed having the following highlights in mind: High accuracy and stability (50ppm.), Good current sharing between parallel coupled converters without band width degradation, Very high current, One or two quadrant operation and Computer controlled. This paper describes the power converter topology ensuring the excellent current sharing.

MOPEB072 **Results of RRR Measurements along the Production Chain of Nb RRR Sheets, starting from the Ingot to the finished Cavity.** – *S. Grawunder, F. Schoelz (W.C. Heraeus GmbH COPY, Materials Technology Dept.) R. Grill (Plansee Metall GmbH) W. Singer, X. Singer (DESY) B. Spaniol (W.C. Heraeus GmbH, Materials Technology Dept.)*

The RRR value of high pure Nb is showing strong relations to the individual production steps. Mainly the different kind of internal stresses caused by the several production steps are resulting in the variation of the RRR value. This work shows the RRR values along the complete production chain from the molten Ingot till to the finished cavity. The influence of the RRR value caused by stresses and the release of that stresses by vacuum annealing is shown.

MOPEB073 **Single Crystal Niobium Development** – *H. Umezawa, K. Takeuchi (Tokyo Denkai Co., Ltd.) F. Furuta, T. Konomi, K. Saito (KEK) K. Nishimura (TKX Corporation)*

KEK and Tokyo Denkai have developed new niobium ingot slicing technique. 150 pieces of the large grain niobium discs can be sliced in two days by using of this technique. Tokyo Denkai installed the slicing machine in December 2009. During the development of the slicing technique, we found that crystal growth mechanism in Electron Beam Melting. It gave us the suggestion to make a single crystal niobium ingot. This paper describes the production process of low cost and short production time niobium discs and single crystal niobium ingot development.

MOPEB074 **Calculation and Design of a High Voltage Electron Accelerator** – *J. Yang, T. Hu (HUST)*

High voltage electron accelerators are currently utilized in various industrial applications for crosslinking compounds, polymerization, sterilization, and vulcanization. The conceptual design of a high voltage electron accelerator for radiation technologies is considered in the paper. The electron accelerator adopts the body structure of Van de Graff accelerator and the high voltage power supply of Cockcroft-Walton accelerator. It consists of electron gun, accelerating tube, power supply, scanning magnet, scan chamber and etc. The design of the high voltage electron accelerator is given. The electron optical characteristic is discussed. The main paremeters of the accelerator are also presented.

MOPEB075 **Successfully Managing the Experimental Area of a Large Physics Experiment, from Civil Engineering to the First Beams** – *F. Butin (CERN)*

The role of "Experimental Area Manager" supported by a well organized, charismatic and motivated team is absolutely essential for managing the huge effort needed for a multi-cultural, multi-disciplinary installation of cathedral-size underground caverns housing a billion dollar physics experiment. Between the years 2002 and 2008, we supervised and coordinated the ATLAS work site at LHC, from the end of the civil engineering to the first circulating beams, culminating with 240 workers on the site, 24 hours a day, 7 days a week, with activities taking place simultaneously on the surface, in the 60 m shafts and in the 100 m underground experimental cavern. We depict the activities preparation scheme (including tasks ranging from the installation of 280 ton cranes to super-delicate silicon detectors), the work-site organization method, the safety management that was a top priority throughout the whole project, and the open-communication strategy that required maintaining permanent public visits. The accumulation of experience enables us to summarize the critical success factors for a timely and successful completion of such a vast and complex project.

MOPEB076 **A Mobile X-Ray Computed Tomography System for the Inspection of the Interconnection Regions of the LHC** – *L.R. Williams, F. Caspers, J.M. Dalin, J.Ph. G. L. Tock (CERN) V. Haemmerle, C. Sauerwein, I. Tiseanu (RAYSCAN)*

For the inspection of certain critical elements of the LHC machine a mobile computed tomography system has been developed and built. This instrument has to satisfy stringent space, volume and weight requirements in order to be usable and transportable to any interconnection location in the LHC tunnel. Particular regions of interest in the interconnection zones between adjacent magnets are the plug in modules (PIM), the soldered splices in the superconducting bus-bars and the interior of the quench diode container. This system permits detailed inspection of these regions without needing to break the cryo vacuum. Limited access for the x-ray tube and the detector required the development of a special type of partial tomography, together with suitable reconstruction techniques for 3 D volume generation from radiographic projections. We present the layout of the complete machine and the limited angle tomography as well as a number of radiographic and tomographic inspection results.

24-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area C

MOPEC — Poster Session

MOPEC001 **Numerical Analysis of Machine Background in the LHCb Experiment for the Early and Nominal Operation of LHC** – *M.H. Lieng (UNIDO) R. Appleby, H. Burkhardt, G. Corti, Y.I. Levinsen (CERN) V. Talanov (IHEP Protvino)*

We consider the formation of machine background induced by proton losses in the long straight section of the LHCb experiment at LHC. Both sources showering from the tertiary collimators located in the LHCb insertion region as well as local beam-gas interaction are taken into account. We present the procedure for, and results of, numerical studies of such background for various conditions. Additionally expected impact and on the experiment and signal characteristics are discussed.

MOPEC002 **Dynamic Aperture Studies and Field Quality Considerations for the LHC Upgrade Optics** – *B.J. Holzer, S.D. Fartoukh, F. Schmidt (CERN)*

The layout of the interaction region for the LHC upgrade project is based on a number of new magnets that will provide the required strengths to focus the colliding beams as well as to separate them after the collision. As in the nominal LHC, a triplet of quadrupole magnets is foreseen for the upgrade optics and in addition a separator dipole to limit the parasitic bunch crossings of the two counter rotating bunch trains. Due to the smaller beta function at the IP however, the requirements for the free aperture of these IR magnets are more demanding and the effect of the higher order multipoles is more severe than under the nominal LHC conditions. Using the tracking simulations to study these effects, target values for the multipole coefficients of the new magnets have been defined as well as a multipole correction scheme that will be used to compensate those field errors which cannot be avoided due to design and construction tolerances. Based on these considerations the required field quality of the new LHC low beta magnets is discussed and the resulting dynamic aperture for different multipole correction scheme is presented.

MOPEC003 **Operational Experience during Initial Beam Commissioning of the LHC** – *K. Fuchsberger, R. Alemany-Fernandez, G. Arduini, R.W. Assmann, R. Bailey, O.S. Brüning, B. Goddard, V. Kain, M. Lamont, A. Macpherson, M. Meddahi, G. Papotti, M. Pojer, L. Ponce, S. Redaelli, M. Solfaroli Camillocci, W. Venturini Delsolaro, J. Wenninger (CERN)*

After the incident and more than one year without beam the commissioning of the LHC started again on November 20, 2009. Closed orbits were established for both beams and the beams were captured within eight hours. Conditions which allowed first collisions at 450GeV were established only after three days. This paper describes the experiences and issues encountered in the first weeks of commissioning with beam. Machine set-up and the commissioning procedures are detailed. The measurements performed and the key results from this period are described.

MOPEC004 **Stability and Reproducibility of the LHC** – *K. Fuchsberger, R. Alemany-Fernandez, G. Arduini, R.W. Assmann, R. Bailey, O.S. Brüning, V. Kain, M. Lamont, A. Macpherson, G. Papotti, M. Pojer, L. Ponce, S. Redaelli, M. Solfaroli Camillocci, W. Venturini Delsolaro, J. Wenninger (CERN)*

During the first weeks after the restart of the LHC on November 20, 2009 first operational experience with this new machine could be gained. Measurements during this period showed that the magnet model of the machine had delivered optics close to nominal. The key parameters were very stable and reproducible between different fills. This paper illustrates these aspects on the basis of measurements during the early commissioning period and describes the procedures which were established to further improve the reproducibility.

MOPEC005 **Kick Response Measurements during LHC Injection Tests and Early LHC Beam Commissioning** – *K. Fuchsberger, S.D. Fartoukh, B. Goddard, V. Kain, M. Meddahi, F. Schmidt, J. Wenninger (CERN)*

The transfer lines from the SPS to the LHC, TI2 and TI8, with a total length of almost 6km are the longest ones in the world. For that reason even small systematic optics errors are not negligible because they add up and result in an injection mismatch in the LHC. Next to other lattice measurement methods Kick-response measurements were the most important sources of information during the early phases of beam commissioning of these transfer lines and the LHC ring. This measurement technique was used to verify orbit-corrector and BPM gains as well as to sort out optics errors. Furthermore fits to off-momentum kick response turned out to be an appropriate method to establish a model for systematic errors of the transfer line magnets. This paper shortly describes the tools and methods developed for the analysis of the taken data and presents the most important results of the analysis.

MOPEC006 **JMAD - Integration of MADX into the JAVA World** – *K. Fuchsberger, W. Herr, V. Kain, G.J. Mueller, S. Redaelli, F. Schmidt, J. Wenninger (CERN)*

MADX (Methodical Accelerator Design) is the de-facto standard software for modeling accelerator lattices at CERN. This feature-rich software package is implemented and still maintained in the programming languages C and FORTRAN. Nevertheless the controls environment of modern accelerators at CERN, e.g. of the LHC, is dominated by JAVA applications. A lot of these applications, for example for lattice measurement and fitting, require a close interaction with the numerical models, which are all defined by the use of the proprietary MADX scripting language. To close this gap an API to MADX for the JAVA programming language (JMAD) was developed. Already the current implementation provides access to a large subset of the MADX capabilities (e.g. twiss-calculations, matching or querying and setting arbitrary model parameters) without any necessity to define the models in yet another environment. This paper describes shortly the design of this project as well as the current status and some usage examples.

MOPEC007 **Operational Experience during the LHC Injection Tests** – *K. Fuchsberger, R. Alemany-Fernandez, G. Arduini, R.W. Assmann, R. Bailey, O.S. Brüning, B. Goddard, V. Kain, M. Lamont, A. Macpherson, M. Meddahi, G. Papotti, M. Pojer, L. Ponce, S. Redaelli, M. Solfaroli Camillocci, W. Venturini Delsolaro, J. Wenninger (CERN)*
In October and November 2009 two injection tests took place in preparation of the LHC restart on November 20, 2009. During these injection tests beam was injected through the TI2 transfer line into sector 23 of ring 1 and through TI8 into the sectors 78, 67 and 56 of ring 2. The beam time was dedicated to injection steering, optics measurements and debugging of all the systems involved. Because this way many potential problems could be sorted out in advance, these tests contributed heavily to the fast and smooth progress after the restart. This paper describes the experiences and issues encountered during these tests as well as related measurement results.

MOPEC008 **Characterization of Interaction-point Beam Parameters using the pp Event-Vertex Distribution Reconstructed in the ATLAS Detector at the LHC** – *R. Bartoldus, I. Aracena, P. Grenier, D.W. Miller, E. Strauss, D. Su (SLAC) J. Beringer, P. Loscutoff (LBNL) H. Burkhardt, W. Kozanecki, S.M. White (CERN) J. Walder (Lancaster University)*
We present results from the measurement of the 3-D luminosity distribution by the ATLAS Inner Detector during early running. The spatial distribution of pp interactions is reconstructed by a dedicated algorithm in the high-level trigger that fits tracks and primary event vertices in real time. The number of these vertices provides online monitoring of the instantaneous luminosity, while luminous centroids mirror IP-orbit and RF-phase drifts. Similarly, the x, y and z luminous widths reflect the evolution of the transverse & longitudinal emittances. The length scales of the beam-position monitors and IP orbit bumps, that directly impact the accuracy of the transverse convoluted beam sizes measured during beam-beam scans, are calibrated offline against the displacement of the luminous centroid measured, during these same scans, by the ATLAS trackers; this significantly improves the absolute accuracy of the luminosity calibration by van der Meer scans. Finally, the simultaneous determination, during such scans, of the transverse convoluted beam sizes (from the luminosity variation) and of the corresponding luminous sizes can be used to unfold the transverse IP sizes of the two beams.

MOPEC009 **LHC Abort Gap Cleaning** – *M. Meddahi, S. Bart Pedersen, A. Boccardi, A.C. Butterworth, B. Goddard, G.H. Hemelsoet, W. Höfle, D. Jacquet, M. Jaussi, V. Kain, T. Lefevre, E.N. Shaposhnikova, D. Valuch (CERN) A.S. Fisher (SLAC) E. Gianfelice-Wendt (Fermilab)*
Unbunched beam is a potentially serious issue in the LHC as it may quench the superconducting magnets during a beam abort. Unbunched particles, either not captured by the RF system at injection or leaking out of the RF bucket, will be removed by using the existing damper kickers to excite resonantly the particles in the abort gap. We summarize the beam simulations underlying our proposed abort-gap cleaning strategy at different energies. The plans for the commissioning of this system are described, and the first results from beam commissioning are presented.

MOPEC010 **LHC Aperture Measurements** – *S. Redaelli, M.C. Alabau Pons, M. Giovannozzi, G.J. Mueller, F. Schmidt, R. Tomas, J. Wenninger (CERN)*
The mechanical aperture of the Large Hadron Collider (LHC) is a critical parameter for the operation of the machine due to the high stored beam intensities in the superconducting environment. Betatron and momentum apertures must be therefore precisely measured and optimized. In this paper, we present the results of beam-based measurements of the LHC aperture. The experimental results are compared with the expectations from the as-built model of the LHC aperture, taking into account the optics imperfections of the superconducting magnets. The impact of these measurements on various aspects of the LHC operation are also discussed.

MOPEC011 **The Online Model for the Large Hadron Collider** – *S. Redaelli, M.C. Alabau Pons, K. Fuchsberger, M. Giovannozzi, W. Herr, M. Lamont, G.J. Mueller, F. Schmidt,*

M. Strzelczyk, R. Tomas, G. Vanbavinckhove (CERN)
The control of the high intensity beams of the CERN Large Hadron Collider (LHC) is particular challenging and requires a precise knowledge of the critical beam and machine parameters. In recent years efforts were devoted to the design of a software infrastructure aimed at mimicking the behavior of the LHC. An online model of the machine, based on the accelerator design tool MADX, has been developed to support the commissioning and the operation of the LHC. This model is integrated into the JAVA-based LHC software framework and provides the full computing power of MADX, including the best knowledge of the machine aperture and magnetic models. The MADX implementation is server-based and provides various facilities for optics computation to other application clients. In this paper, we present the status of the MADX online application and illustrate how it has been used during the LHC commissioning. Possible future implementations are also discussed.

MOPEC012 **Impedance of the Crab Cavity Dipole Mode and Impact on the LHC Machine Protection** – *Y. Sun, F. Zimmermann (CERN)*
Crab cavities are proposed for a LHC luminosity upgrade, by introducing the effective head-on collision at IP. In this paper, the impedance of the (detuned) dipole mode is considered, in particular with acceleration. The impact on the machine protection in case of a cavity trip is studied in detail.

MOPEC013 **Vernier Scan Results from the First RHIC Proton Run at 250 GeV** – *K.A. Drees (BNL) S.M. White (CERN)*
Using the vernier scan or Van der Meer scan technique, where one beam is swept stepwise across the other while measuring the collision rate as a function of beam displacement, the transverse beam profiles, the luminosity and the effective cross section of the detector in question can be measured. This report briefly recalls the vernier scan method and presents results from the first RHIC polarized proton run at 250 GeV/beam in 2009.

MOPEC014 **First Luminosity Scans in the LHC** – *S.M. White, R. Alemany-Fernandez, H. Burkhardt, M. Lamont (CERN)*
Once circulating beams have been established in the LHC the first step towards collisions is to remove the physical separation used to avoid collisions during injection and ramp. A residual separation can remain after the collapsing of the separation bumps. The so-called Van Der Meer method allows for a minimization of this unwanted separation by transversally scanning one beam through the other. The beam sizes at the IP can also be determined by this method and used to give an absolute measurement of the luminosity. We report on how this measurement was implemented and performed in the LHC to optimize and calibrate luminosity and provide a detailed analysis of the first results.

MOPEC015 **Single-pass Beam Measurements for the Verification of the LHC Magnetic Model** – *F. Zimmermann, M. Giovannozzi, S. Redaelli, Y. Sun, R. Tomas, W. Venturini Delsolaro (CERN) R. Calaga (BNL)*
During the 2009 LHC injection tests, the polarities and effects of specific quadrupole and higher-order magnetic circuits were investigated. A set of magnet circuits had been selected for detailed investigation based on a number of criteria. On or off-momentum difference trajectories launched via appropriate orbit correctors for varying strength settings of the magnet circuits under study - e.g. main, trim and skew quadrupoles; sextupole families and spool piece correctors; skew sextupoles, octupoles - were compared with predictions from various optics models. These comparisons allowed confirming or updating the relative polarity conventions used in the optics model and the accelerator control system, as well as verifying the correct powering and assignment of magnet families. Results from measurements in several LHC sectors are presented.

MOPEC016 **Interaction of Macro-Particles with the LHC Proton Beam** – *F. Zimmermann, M. Giovannozzi (CERN) A. Xagkoni (National Technical University of Athens)*
We study the interaction of macro-particles residing inside the LHC vacuum chamber, e.g. soot or thermal-insulation fragments, with the circulating LHC proton beam. The coupled equations governing the motion and charging rate of metallic or dielectric micron-size macro-particles are solved numerically to determine the time spent by such "dust" particles close to the path of the beam as well as the resulting proton-beam losses, which could lead to a quench of superconducting magnets and, thereby, to a premature beam abort.

MOPEC017 **Amplitude and Tune Diffusion Near Synchro-betatron Resonances** – *T. Sen (Fermilab)*

When beams collide at an angle, synchro-betatron resonances (SBRs) can be excited which can lead to emittance growth and loss of luminosity. We consider the detailed dynamics of a bunch near a low order SBR driven by these collisions. The strength of particle amplitude diffusion changes significantly within the bunch core and is correlated to the tune diffusion. The diffusion process also transitions from regular to anomalous diffusion which changes the time scale of growth at different amplitudes. These results are applied to the crossing angle collisions in the LHC.

MOPEC019 **Tune Dependency of Beam-beam Emittance Growth with a Static Offset in Collision in the LHC** – *T. Pieloni (PSI) W. Herr (CERN) J. Qiang (LBNL)*

LHC bunches experience small unavoidable offsets at the collision points. Although the geometrical loss of luminosity is small, one may have to consider an increase of the beam transverse emittance, leading to a deterioration of the experimental conditions. In this work we evaluate and understand the dynamics of multiple beam-beam interactions with static offsets at the LHC collision points. A study of the emittance growth rate as a function of the betatron tune is presented.

MOPEC020 **Simulation of the LHC BRAN Luminosity Monitor for High Luminosity Interaction Regions** – *J. Stiller (Heidelberg University) H.S. Matis, A. Ratti, W.C. Turner (LBNL) R. Miyamoto (BNL) S.M. White (CERN)*

The LHC BRAN luminosity detector monitors the high luminosity interaction regions (Atlas and CMS). This chamber, which is an Argon gas ionization detector measures the forward neutral particles from collisions the interaction region. To predict and improve the understanding of the detector's performance, we produced a detailed model of the detector and its surroundings in FLUKA. In this paper, we present the model and results of our simulations including the detector's estimated response to interactions for beam energies of 3.5, 5.0, and 7.0 TeV.

MOPEC021 **First Results from the LHC Luminosity Monitor** – *A. Ratti, H.S. Matis, W.C. Turner (LBNL) E. Bravin, S.M. White (CERN) R. Miyamoto (BNL)*

The Luminosity Monitor for the LHC is ready for operation during the planned 2009-2010 run. The device designed for the high luminosity regions is a gas ionization chamber, that is designed with the ability to resolve bunch by bunch luminosity as well as survive extreme levels of radiation. The devices are installed at the zero degree collision angle in the TAN absorbers ±140m from the IP and monitor showers produced by high energy neutrons from the IP. They are used in real time as a collider operations tool for optimizing the luminosity at ATLAS and CMS. A photomultiplier based system is used at low luminosities and also available. We will present early test results, noise and background studies and correlation between the gas ionization and the PMT. Comparison with ongoing modeling efforts will be included.

MOPEC022 **Compact 400-MHz Half-wave Spoke Resonator Crab Cavity for the LHC Upgrade** – *Z. Li, T.W. Markiewicz, C.-K. Ng, L. Xiao (SLAC)*

Crab cavities are proposed for the LHC upgrade to improve the luminosity. There are two possible crab cavity installations for the LHC upgrade: the global scheme at Interaction Region (IR) 4 where the beam-beam separation is about 420-mm, and the local scheme at the IR5 where the beam-beam separation is only 194-mm. One of the design requirements as the result of a recent LHC-Crab cavity workshop is to develop a 400-MHz cavity design that can be utilized for either the global or local schemes at IR4 or IR5. Such a design would offer more flexibility for the final upgrade installation, as the final crabbing scheme is yet to be determined, and save R&D cost. The cavity size of such a design, however, is limited by the beam-beam separation at IR5 which can only accommodate a cavity with a horizontal size of about 145-mm, which is a design challenge for a 400-MHz cavity. To meet the new design requirements, we have developed a compact 400-MHz half-wave spoke resonator (HWSR) crab cavity that can fit into the tight spaces available at either IR4 or IR5. In this paper, we present the optimization of the HWSR cavity shape and the design of HOM, LOM, and SOM couplers for wakefield damping.

MOPEC023 **RHIC Performance during the FY10 200 GeV Au+Au Heavy Ion Run** – *K.A. Brown, L. Ahrens, J.G. Alessi, M. Bai, J. Beebe-Wang, M. Blaskiewicz, J.M. Brennan, D. Bruno, R. Connolly, T. D'Ottavio, K.A. Drees, W. Fischer, W. Fu, C.J. Gardner, D.M. Gassner, J.W. Glenn, M. Harvey, T. Hayes, L.T. Hoff, H. Huang, J.S. Laster, R.C. Lee, V. Litvinenko, Y. Luo, W.W. MacKay, M. Mapes, G.J. Marr, A. Marusic, R.J. Michnoff, M.G. Minty, C. Montag, J. Morris, S. Nemesure, B. Oerter, F.C. Pilat, V. Ptitsyn, G. Robert-Demolaize, T. Roser, T. Russo, P. Sampson, J. Sandberg, T. Satogata, V. Schoefer, C. Schultheiss, F. Severino, K. Smith, D. Steski, S. Tepikian, C. Theisen, P. Thieberger, D. Trbojevic, N. Tsoupas, J.E. Tuozzolo, M. Wilinski, A. Zaltsman, K. Zeno, S.Y. Zhang, R. de Maria (BNL)*

Since the last successful RHIC Au+Au run in 2007 (Run7), the RHIC experiments have made numerous detector improvements and upgrades. In order to benefit from the enhanced detector capabilities and to increase the yield of rare events in the acquired heavy ion data a significant increase in luminosity is essential. In Run7 RHIC achieved an average store luminosity of <L>=12x10^{26} cm^{-2} s^{-1} by operating with 103 bunches (out of 110 possible), and by squeezing to β*=0.8 m. Our goal for this year's run, Run10, was to achieve an average of <L>=27x10^{26} cm^{-2} s^{-1}. The measures taken were decreasing β* to 0.6 m, and reducing longitudinal and transverse emittances by means of bunched-beam stochastic cooling. In addition we introduced a lattice to suppress intra-beam scattering (IBS) in both RHIC rings, upgraded the RF system, and separated transition crossings in both rings while ramping. We present an overview of the changes and the results in terms of Run10 increased instantaneous luminosity, luminosity lifetime, and integrated luminosity.

MOPEC024 **RHIC BBLR Measurements, 2009** – *R. Calaga, W. Fischer, G. Robert-Demolaize (BNL)*

Long range beam-beam experiments were conducted during the Run 2009 in the yellow and the blue beams of the RHIC accelerator with DC wires. The effects of a long-range interaction with a DC wire on colliding and non-colliding bunches with the aid of orbits, tunes, and losses were studied. Results from distance and currents scans and an attempt to compensate a long-range interaction with a DC wire is presented.

MOPEC026 **Status of the RHIC Head-on Beam-beam Compensation Project** – *W. Fischer, E.N. Beebe, D. Bruno, A.V. Fedotov, D.M. Gassner, R.C. Gupta, J. Hock, A.K. Jain, R.F. Lambiase, Y. Luo, M. Mapes, W. Meng, C. Montag, B. Oerter, M. Okamura, A.I. Pikin, D. Raparia, G. Robert-Demolaize, Y. Tan, R. Than, J.E. Tuozzolo, W. Zhang, R. de Maria (BNL)*

In polarized proton operation the luminosity of RHIC is limited by the head-on beam-beam effect, and methods that mitigate the effect will result in higher peak and average luminosities. Two electron lenses, one for each ring, are being constructed to partially compensate the head-on beam-beam effect in the two rings. An electron lens consists of a low energy electron beam that creates the same amplitude dependent transverse kick as the proton beam. We discuss design consideration, present the main parameters, and estimate the performance gains.

MOPEC027 **Development and Evaluation of IBS Suppression Lattices at RHIC** – *V. Litvinenko, M. Bai, K.A. Brown, D. Bruno, P. Cameron, R. Connolly, J. Cupolo, A.J. Della Penna, K.A. Drees, A.V. Fedotov, G. Ganetis, Y. Luo, N. Malitsky, A. Marusic, M.G. Minty, C. Montag, F.C. Pilat, V. Ptitsyn, T. Roser, T. Satogata, S. Tepikian, D. Trbojevic, N. Tsoupas (BNL)*

In this paper we present the results on the development of an Intra-Beam Scattering (IBS) suppression lattice for RHIC heavy ion operation and discuss possible future directions. In Run-8 (2008) we used the IBS lattice for the first time in one of the RHIC rings during d-Au operations. This year (Run 10) we plan using the IBS suppression lattice in both rings for Au-Au operation at 100 GeV/n. We compare the performance of the IBS suppression lattice with the performance of the best RHIC standard lattice as used last for Au-Au operations in Run 7 (2007).

MOPEC028 **Recent Triplet Vibration Studies in RHIC** – *M.G. Minty, R.J. Michnoff, C. Montag, V. Ptitsyn, T. Satogata, C. Schultheiss, P. Thieberger (BNL)*

In an effort to better understand the dynamics relating to vibrations of the quadrupole triplet magnets near the interaction regions of RHIC, measurements have recently been performed to better characterize these vibrations and their effects on the counter-rotating beams. Using high precision accelerometers and geophones installed at one triplet, the characteristic frequencies of the motion have been monitored and compared to those obtained from measurements of the beam positions. Using additionally actuators mounted directly on the cryostats, dynamic damping of the mechanical vibrations has been successfully demonstrated. In this report we present the results of these measurements together with data acquired with driven sinusoidal oscillations of variable amplitude from which the specifications for required corrector magnet strengths for trajectory feedback control were derived. These are shown to agree well with independently acquired turn-by-turn trajectory measurements obtained under normal operating conditions. Options for mitigation of the vibrations are presented lastly.

MOPEC029 **Global Orbit Feedback in RHIC** – *M.G. Minty, A. Marusic, R.J. Michnoff, V. Ptitsyn, G. Robert-Demolaize, T. Satogata (BNL)*

For improved reproducibility of good operating conditions and ramp commissioning efficiency, new dual-plane slow orbit feedback during the energy ramp has been implemented in the RHIC accelerators. The orbit feedback is based on steering the measured orbit, after subtraction of the dispersive component, to the design orbit at injection and to the BPM-based reference orbit along the ramp. Using multiple correctors and BPMs, an SVD-based algorithm is used for determination of the applied corrections. The online model is used as a basis for matrix computations. In this report we describe the feedback design, review the changes made to realize its implementation, and assess system performance.

MOPEC030 **High Precision Tune and Coupling Measurements and Tune/Coupling Feedback in RHIC** – *M.G. Minty, A.J. Curcio, W.C. Dawson, C. Degen, Y. Luo, G.J. Marr, B. Martin, A. Marusic, K. Mernick, P. Oddo, T. Russo, V. Schoefer, R. Schroeder, C. Schultheiss, M. Wilinski (BNL)*

Precision measurement and control of the betatron tunes and betatron coupling in RHIC are required for establishing and maintaining both good operating conditions and, particularly during the ramp to high beam energies, high proton beam polarization. While the proof-of-principle for simultaneous tune and coupling feedback was successfully demonstrated earlier, routine application of these systems has only become possible recently. Following numerous modifications for improved measurement resolution and feedback control, the time required to establish full-energy beams with the betatron tunes and coupling regulated by feedback was reduced from several weeks to a few hours. A summary of these improvements, select measurements benefitting from the improved resolution and a review of system performance are the subject of this report.

MOPEC031 **Chromaticity Feedback at RHIC** – *M.G. Minty, A. Marusic, C. Schultheiss, S. Tepikian (BNL)*

In this report we describe application of chromaticity feedback during the energy ramp in RHIC. We describe the feedback design and the measurement technique and review the advantages and disadvantages of two different processing algorithms. Operational experience including operation with existing tune and coupling feedback is presented with supporting experimental data.

MOPEC032 **Effect of 10 Hz Triplet Vibrations on RHIC Performance** – *M.G. Minty (BNL)*

In this report we present recent experimental data from RHIC illustrating the effect of slow (~10 Hz) vibrations of the triplet quadrupole magnets in the interactions regions on the precision of measured beam properties and evaluate the impact of these vibrations on collider performance. Improved resolution of the betatron tune measurements has allowed for detection of significant tune modulations experienced by both beams in both planes of magnitude appreciable relative to the total beam-beam parameter. Comparison of the discrete frequencies in the spectra of the measured beam positions and betatron tunes indicate that the source of tune modulation is feed-down from the sextupole magnets which result from the closed-orbit deviations induced by the vibrating triplets. In addition we present experimental data which show that the effect of the modulations on the closed orbit of the two counter-rotating beams is such as to produce modulated crossing angles at the interaction points.

MOPEC033 **RHIC Performance as a 100 GeV Polarized Proton Collider in Run-9** – *C. Montag, L. Ahrens, M. Bai, J. Beebe-Wang, M. Blaskiewicz, J.M. Brennan, K.A. Brown, D. Bruno, R. Connolly, T. D'Ottavio, K.A. Drees, A.V. Fedotov, W. Fischer, G. Ganetis, C.J. Gardner, J.W. Glenn, H. Hahn, M. Harvey, T. Hayes, H. Huang, P.F. Ingrassia, J.P. Jamilkowski, A. Kayran, J. Kewisch, R.C. Lee, D.I. Lowenstein, A.U. Luccio, Y. Luo, W.W. MacKay, Y. Makdisi, N. Malitsky, G.J. Marr, A. Marusic, M.P. Menga, R.J. Michnoff, M.G. Minty, J. Morris, B. Oerter, F.C. Pilat, P.H. Pile, E. Pozdeyev, V. Ptitsyn, G. Robert-Demolaize, T. Roser, T. Russo, T. Satogata, V. Schoefer, C. Schultheiss, F. Severino, M. Sivertz, K. Smith, S. Tepikian, P. Thieberger, D. Trbojevic, N. Tsoupas, J.E. Tuozzolo, A. Zaltsman, A. Zelenski, K. Zeno, S.Y. Zhang (BNL)*

During the second half of Run-9, the Relativistic Heavy Ion Collider (RHIC) provided polarized proton collisions at two interaction points with both longitudinal and vertical spin direction. Despite an increase in the peak luminosity by up to 40%, the average store luminosity did not increase compared to previous runs. We discuss the luminosity limitations and polarization performance during Run-9.

MOPEC034 **Experience with Split Transition Lattices at RHIC** – *C. Montag, M. Blaskiewicz, J.M. Brennan, S. Tepikian (BNL)*

During the acceleration process, heavy ion beams in RHIC cross the transition energy. When RHIC was colliding deuterons and gold ions during Run-8, lattices with different integer tunes were used for the two rings. This resulted in the two rings crossing transition at different times, which proved beneficial for the "Yellow" ring, the RF system of which is slaved to the "Blue" ring. For the symmetric gold-gold run in FY2010, lattices with different transition energies but equal tunes were implemented. We report the optics design concept as well as operational experience with this configuration.

MOPEC035 **Optimizing the Beam-beam Alignment in an Electron Lens using Bremsstrahlung** – *C. Montag, W. Fischer, D.M. Gassner (BNL) E. Haug (University of Tuebingen)*

Installation of electron lenses for the purpose of head-on beam-beam compensation is foreseen at RHIC. To optimize the relative alignment of the electron lens beam with the circulating proton (or ion) beam, photon detectors will be installed to measure the bremsstrahlung generated by momentum transfer from protons to electrons. We present the detector layout and simulations of the bremsstrahlung signal as function of beam offset and crossing angle.

MOPEC036 **Operational Non-linear Corrections in the RHIC Low β* Interaction Regions** – *F.C. Pilat, S. Binello, M.G. Minty, C.M. Zimmer (BNL)*

A method has been developed to operationally measure and correct the non-linear effects of the final focusing magnets in the Relativistic Heavy Ion Collider (RHIC). This method enables control over the effects of multipole errors by applying closed orbit bumps and then analyzing the resulting betatron tune and orbit shifts. The essence of these corrections is the minimization of the linear and quadratic tune shifts caused by an orbit bump. We have successfully tested and used this method during the last 8 years of RHIC operation. We describe here the foundation of the IR bump technique, valid for all orders followed by particular examples of application to the sextupole, skew sextupole and octupole effects. The corrections have increased the beam lifetime, reduced tune modulation due to driven off-axis beam in the sextupole, and increased measured dynamic aperture. We will also describe the future plans for automation of sextupole and octupole correction as well as the experimental program to assess the feasibility of decapole and dodecapole corrections.

MOPEC037 **High Beta Operation Scenarios for Crab Cavities in the Insertion Region 4 of the CERN Large Hadron Collider** – *R. de Maria, R. Calaga (BNL) M. Giovannozzi, Y. Sun, R. Tomas, F. Zimmermann (CERN)*

IR4 is a potential candidate for the installation of crab cavities in the CERN Large Hadron Collider. In this paper we present several operational scenarios in which the effect of the kick imparted by the cavity is enhanced by performing a dynamic unsqueeze of the beta function at collision energy. Linear optics, power supply requirements, beam aperture and finally potential luminosity increase studies will be discussed in order to rank and assess the feasibility of the various options.

MOPEC038 **Commissioning of FFAG Accelerator at Kyushu University** – *T. Fujinaka (Kyushu University, Center for Accelerator and Beam Applied Science) N. Ikeda, Y. Yonemura (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering)*

150-MeV FFAG accelerator is under construction at Center for Accelerator and Beam Applied Science on Ito Campus to promote activities in all related scientific, medical, engineering and educational field at Kyushu University. In this paper, status of the development of hardware and beam commissioning results are described.

MOPEC039 **Developments for Beam Intensity Increase and Beam Quality Improvement in the RCNP Cyclotrons** – *M. Fukuda, K. Hatanaka, H. Kawamata, M. Kibayashi, T. Saito, H. Tamura, T. Yorita (RCNP)*

An upgrade program of the RCNP cyclotron facility for increase of beam intensity and improvement of beam quality is in progress to meet requirements from research in nuclear physics and industrial applications using secondarily produced particles such as neutrons, muons and radioisotopes. A 2.45 GHz ECR ion source using a set of permanent magnets was developed for high intensity proton beam production. The proton beam intensity more than 0.5 mA at an extraction energy of 15 keV has been obtained with a proton ratio more than 80 %. The quality of the pre-accelerated beam from the K140 injector AVF cyclotron has been improved by a flat-top(FT) acceleration system to enhance the beam transmission to the K400 ring cyclotron. Transversal resonant mode of a dee electrode with a span angle of 180 degrees was investigated to achieve the FT acceleration in the frequency region from 50 to 60 MHz. In this paper, developments for high intensity proton beam acceleration and beam quality improvement using the FT acceleration system of the AVF cyclotron will be mainly presented.

MOPEC040 **Magnet Shaping with an Improved Matrix Method for a 10 MeV Compact Cyclotron** – *B. Qin, Z. Chen, D. Li, K.F. Liu, Y.Q. Xiong, J. Yang, L. Zhao (HUST)*

A 10 MeV compact cyclotron CYCHU-10 is under development in the Huazhong University of Science and Technology (HUST), with the purpose of short-life isotopes production for PET facility. The field mapping was performed by a Cartesian measurement system with a Hall probe. The field isochronism was achieved by magnet pole shaping with an improved matrix method. As well as the beam dynamics was studied on the measured field.

MOPEC041 **Calculation of Second Order Moments for an Ion Beam in a Degrader** – *N.Yu. Kazarinov, V.I. Kazacha (JINR)*

In order to decrease the energy of an ion accelerated in a cyclotron on value of some MeV/eau it is possible to run an ion beam through a thin metal foil (degrader). One can calculate the final ion energy, angular and energy stragglings, which the beam attains in the degrader, for example, by means of code LISE++. The formulae for calculation of the beam second order moments after degrader were obtained. The formulae for calculation of final beam momentum spread, new values of rms beam emittances, Twiss parameters and the dispersion functions were also obtained. The new ion beam parameters allow one to calculate the beam transportation along the beam line after degrader.

MOPEC042 **Synchrocyclotron Design for a Dual Cyclinac Hadrontherapy Center** – *A. Garonna (EPFL) U. Amaldi, A. Garonna (TERA)*

Hadrontherapy, the technique of tumor radiotherapy employing heavy ion beams, is developing rapidly(*). The TERA Foundation proposes an innovative dedicated accelerator, called Cyclinac(**). It is composed of a 230 MeV/u cyclotron providing fast pulsed beams of H^{2+}, for proton therapy with standard techniques, or C^{6+}, injected into a high gradient linac. Its energy can thus be modulated from pulse to pulse (up to 400 MeV/u), for optimal irradiation of solid tumors with the most modern techniques of dose active spreading. A preliminary design of a superconducting synchrocyclotron for this application is presented. Its advantages are the reduced construction and operating costs (small magnet and low RF power consumption), and the good adaptation of its beam characteristics to therapy (low current and fast repetition rate). The magnet features a central field of 5 T, which has azimuthal symmetry and decreases with the radius, ensuring radial and vertical focusing. The weight is around 300 t. Ions are produced in an EBIS, injected axially and resonantly extracted at 1 m radius. The RF is mechanically modulated by a rotating capacitor, providing the required 400 Hz repetition rate.

MOPEC043 **Error Study of a Novel Non-linear, Nonscaling FFAG** – *D.J. Kelliher, S. Machida (STFC/RAL/ASTeC) S.L. Sheehy (JAI)*

A novel nonlinear, nonscaling FFAG ring has been designed for proton and ion acceleration. It can be used for proton and carbon therapy as well as a proton driver for various facilities such as a high intensity neutrino factory. The machine has novel features including variable energy extraction and a high repetition rate of about 1 kHz. Taking as an example the PAMELA proton ring, under study at the John Adams Institute in Oxford, we present results of an error study. A calculation of alignment tolerance is made, in which the effects of translational and rotational misalignments are included. The effect of magnetic field errors in the triplet magnets on the dynamic aperture of the machine is investigated.

MOPEC044 **FFAG Lattice with Superperiod Structure** – *S. Machida (STFC/RAL/ASTeC)*

The lattice of a Fixed Field Alternating Gradient (FFAG) accelerator normally has high symmetry. The whole ring consists of many identical cells which have a simple FODO, double or triplet focusing unit. There is, however, no real reason for an FFAG lattice to have high symmetry, except for a linear nonscaling design which relies on high symmetry to avoid betatron resonances. We propose an FFAG lattice design with a superperiod that makes it possible to have long straight sections for injection, extraction and rf cavities. We discuss how to introduce a superperiod structure. The impact on dynamic aperture, dispersion function, longitudinal dynamics as well as the advantage of having long straight sections will be presented.

MOPEC045 **A Novel HNJ Scheme for PAMELA** – *J.K. Pozimski, M. Aslaninejad, J. Pasternak (Imperial College of Science and Technology, Department of Physics) K.J. Peach, T. Yokoi (JAI)*

PAMELA (Particle Accelerator for MedicaL Applications) is a fixed field accelerator using Non-Scaling FFAG technology with the capability for rapid beam acceleration under design. PAMELA aims to design a hadron cancer therapy facility, with a target beam repetition rate of 1kHz, which is far beyond that of conventional synchrotron. To realize this high repetition rate, the rf system and acceleration scheme is crucial. For conventional systems the combination of a high field gradient and a high duty factor is a significant challenge, on the other hand HNJ schemes while highly efficient suffer from the available space and other difficulties. In this paper a variation of a HNJ utilizing several cavities running at selected off HN frequencies will be presented together with results from simulations of the acceleration process.

MOPEC046 **Modelling of the EMMA ns-FFAG Injection Line using GPT** – *R.T.P. D'Arcy (UCL) D.J. Holder, B.D. Muratori (Cockcroft Institute)*

EMMA (Electron Machine with Many Applications) is a prototype nonscaling Fixed Field Alternating Gradient (NS-FFAG) accelerator presently under construction at Daresbury Laboratory, UK. The energy recovery linac ALICE will serve as an injector for EMMA within the energy range of 10 to 20 MeV. The injection line consists of a symmetric 30^{o} dogleg to extract the beam from ALICE, a matching section and a tomography section for transverse emittance measurements. This is followed by a transport section to the injection point of the EMMA ring. Commissioning of the EMMA injection line started in early 2010. A number of different injection energy and bunch charge regimes are planned; for some of the regimes the effects of space charge will be significant. It is therefore necessary to model the electron beam transport in this line using a code capable of both calculating the effect of, and compensating for, space charge. Therefore the General Particle Tracer (GPT) code has been used. A range of injection beam parameters have been modelled for comparison with experimental results.

MOPEC047 **High Current Proton FFAG Accelerators** – *R.J. Barlow, A.M. Toader, S.C. Tygier (UMAN)*

Accelerator Driven Subcritical Reactors require a high currents of energetic protons. We compute the limits imposed by space charge, and explore what can be achieved using various proposed FFAG lattices. Limitations due to beam losses and reliability are also discussed

MOPEC048 **Beam Extraction of PAMELA NS-FFAG** – *T. Yokoi, K.J. Peach, H. Witte (JAI)*

PAMELA (Particle Accelerator for MEdicaL Application) aims to design a particle therapy facility using Non-scaling FFAG (Fixed Field Alternating Gradient) accelerator. In the beam extraction in PAMELA, the biggest challenge is the flexible energy variability, which is desirable for better dose field formation. The feature is a unique feature of PAMELA for a fixed field accelerator. To realize energy variable beam extraction, PAMELA employs vertical extraction using large a aperture kicker magnet. In the paper, the detail of the extraction scheme, hardware specifications are discussed.

MOPEC049 **CW (Isochronous) High Intensity FFAG Proton Drivers for HEP and ADS** – *C. Johnstone (Fermilab) M. Berz, K. Makino (MSU) S.R. Koscielniak (TRIUMF) P. Snopok (UCR)*

The FFAG has become a baseline accelerator design for HEP muon collider/neutrino factory facilities, and a recent innovation has coupled stable-tune designs with isochronous orbits making the FFAG capable of fixed-frequency acceleration, as in the cyclotron, but with strong focusing. Even quasi-isochronous orbits would permit rapid, >100Hz, swept-frequency RF, a rate well beyond the 60 Hz capability of present swept-frequency technology in rapid-cycling synchrotrons. With isochronous behavior, and space-charge resistant, strong-focusing optics, the FFAG has the capability for a high-intensity proton driver. As such, this new breed of CW accelerator would have a broad impact on facilities using medical accelerators, proton drivers for muon and neutron production, accelerator-driven nuclear reactors, and waste transmutation. The concept is described here and supported by advanced simulations.

MOPEC050 **Injection and Extraction System for the KEK Digital Accelerator** – *T. Adachi, T. Kawakubo (KEK) T. Yoshii (Nagaoka University of Technology)*

New acceleration system using an induction cell has been developed at KEK by using KEK 12-GeV PS*. We call an accelerator using the induction acceleration system "Digital Accelerator". The PS-Booster is now being renovated as the first Digital Accelerator (DA) by introducing the induction acceleration instead of rf**. Argon ion beam from the ECR ion source is injected to the DA by an electrostatic beam kicker. Another electrostatic device with the same structure is used for chopping the beam before injection. The accelerated beam is extracted by the existing extraction system, which comprises bump, septum and kicker magnets. Since these magnets are installed in a vacuum chamber, vacuum pressure deteriorates due to outgas from them. In order to reduce a beam loss in the DA ring, the pressure level is crucial especially for an ion beam. Therefore, we decided to put the septum magnet outside the vacuum chamber and insert a vacuum duct in the gap, since it dominantly contributes to the vacuum pressure more than the other magnets. This paper describes the electrostatic beam chopper, injection kicker and septum magnet containing the vacuum duct for the KEK DA and beam dynamics.

MOPEC051 **Induction Acceleration System for KEK Digital Accelerator** – *T. Iwashita, T. Adachi, T. Arai, Y. Arakida, M. Hasimoto, H. Someya, K. Takayama, M. Wake (KEK) T.S. Dixit (SAMEER) K. Mochiki, T. Sano (Tokyo City University)*

The KEK-DA (Digital Accelerator) is a modification of the KEK 500 MeV booster*, in which an induction acceleration system is employed. It has an ability to accelerate arbitrary ions with their possible charge states**. An outline of the acceleration scenario is described and a necessary control system fully integrating the induction acceleration system is given in details. The KEK-DA is a rapid cycle synchrotron operating at 10 Hz; the accelerating pulse voltage must be dynamically varied in time to follow the ramping magnetic field. A novel technique combining the pulse density control and intermittent operation of acceleration cells is required. The intelligent gate control system which uses 1 GHz digital signal processors (DSPs) has been designed. Construction of the KEK-DA is in the final stage; installation of the induction cells and the power supplies are done. The whole system including gate control system is demonstrated with high voltage outputs,long-term stability of the system through a heat run is examined. Also a future plan which replaces DSPs by FPGA (Field Programmable Gate Array)is discussed.

MOPEC052 **KEK Digital Accelerator for Material and Biological Sciences** – *K. Takayama, T. Adachi, T. Arai, Y. Arakida, M. Hasimoto, T. Iwashita, E. Kadokura, M. Kawai, T. Kawakubo, K. Koyama, T. Kubo, T. Kubo, H. Nakanishi, K. Okamura, H. Someya, A. Takagi, M. Wake (KEK) T. Kikuchi, T. Yoshii (Nagaoka University of Technology) K.W. Leo (Sokendai) K. Mochiki, T. Sano (Tokyo City University) M. Okamura (RBRC) K. Okazaki (Nippon Advanced Technology Co. Ltd.) H. Tanaka (Iwate university)*

A novel circular accelerator capable of accelerating any ions from an extremely low energy to relativistic energy is discussed. A digital accelerator (DA)* is based on the induction synchrotron concept, which had been demonstrated in 2006. All ions are captured and accelerated with pulse voltages generated by induction acceleration cell (IAC). The IAC is energized by the switching power supply, in which power solid-state conductors are employed as switching elements and their tuning on/off is maneuvered by gate signals digitally manipulated from the circulating signal of an ion beam. Acceleration synchronized with the revolution of the ion beam is always guaranteed. The concept is realized by renovating the KEK 500 MeV booster into the DA, introducing a laser ablation ion source. Ion energy of 85-140 MeV/au and intensity of 10^{+9} - 10^{+10} /sec are estimated and these ions will be delivered without any large-scale injector. Companion papers** will discuss more details of instruments of DA. Applications for innovative material sciences and life sciences will be briefly introduced as well as the outline of DA.

MOPEC053 **Ion Source and Low Energy Beam Transport for the KEK Digital Accelerator** – *K. Takayama, T. Adachi, T. Arai, Y. Arakida, M. Hasimoto, T. Kawakubo, K. Koyama, T. Kubo, T. Kubo, H. Nakanishi, A. Takagi, K. Zhang (KEK) T. Kikuchi (Nagaoka University of Technology) K.W. Leo (Sokendai) K. Okazaki (Nippon Advanced Technology Co. Ltd.)*

KEK digital accelerator (DA) capable of accelerating all species of ion* is an induction synchrotron employing no large scale injectors. At the beginning of its operation, Ar ions from the ECR ion source (ECRIS) embedded in the 200 kV high voltage terminal (HVT) are directly injected into KEK-DA though the low energy BT line (LEBT). The permanent magnet ECRIS was assembled at KEK. Its characteristics such as a charge-state spectrum, emittance, and intensity are presented. The 200 kV HVT has been also assembled at KEK. Its voltage stability in the pulse mode operation, where a plasma of 1 msec is created by x-band microwaves at 10 Hz, is discussed. The LEBT consists of the Eintzel lens, momentum analyzer, B magnets with edge focusing, electrostatic chopper**, and a combination of Q magnets. In the upper LEBT from the ion extraction hall to the entrance of the analyzer, possible charge-state ions are contaminated in the space-charge limit and beam focusing is realized through the Eintzel lens and tandem acceleration gaps. In the lower LEBT from the analyzer to the KEK-DA injection point, the lattice has been optimized so as to meet optics matching at the injection point.

MOPEC054 **Mechanical and Cryogenic System Design of the 1st Cryomodule for the IFMIF Project** – *N. Grouas, P. Bosland, P. Bredy, G. Disset, P. Hardy, V.M. Hennion, H. Jenhani, J. Migne, A. Mohamed, F. Orsini, J. Plouin, J. Relland (CEA) B. Branas Lasala, I. Podadera Aliseda, S. Sanz, F. Toral (CIEMAT) E.N. Zaplatin (FZJ)*

The IFMIF project aims to build a high intensity material irradiation facility which one of the main components is a high intensity deuteron accelerator. A prototype of this accelerator will be built in Rokkasho in Japan.

It includes a cryomodule composed of 8 superconducting cavities (HWR) powered by 200 kW couplers to accelerate the deuteron beam from 5 MeV to 9 MeV. The beam is focused inside the cryomodule by 8 superconducting solenoids. The cryomodule design has to respect some severe beam dynamics requirements, in particular a restricted space for the component interfaces and an accurate alignment to be kept during cooling down. A double cryogenic system has been designed as it is necessary to control the cavity cooling independently from the solenoid one. The cryomodule design should also be compatible with its environment in the Rokkasho building. This paper gives then a general overview of the 1rst cryomodule current design and its interfaces. It defines the concept chosen for the Cryogenic System, explains the method foreseen for the assembly and alignment and describes the integration study in Rokkasho.

MOPEC055 **Status of the CW RF Power Couplers for the SRF Linac of the IFMIF Project** – *H. Jenhani, P. Bosland, P. Bredy, M. Desmons, G. Devanz, G. Disset, N. Grouas, P. Hardy, V.M. Hennion, J. Migne, A. Mohamed, F. Orsini, J. Plouin, J. Relland (CEA) B. Branas Lasala, I. Podadera Aliseda, S. Sanz, F. Toral (CIEMAT) F.M. Mirapeix (TTI) E.N. Zaplatin (FZJ)*

The driver of the International Fusion Material Irradiation Facility (IFMIF) consists of two 125 mA, 40 MeV CW deuteron accelerators. A superconducting option for the 5 to 40 MeV linac based on Half-Wave Resonators (HWR) has been chosen. The first cryomodule houses 8 HWR's supplied by high power RF couplers; each of them should be able to operate at 200 kW in CW. This paper will give an overview of the RF design of the 175 MHz CW power coupler. The detailled mechanical studies and the realization will be performed by the Industry. Global approach of the contract with the Industry and the organization of the intermediate validation tests will be discussed. In a second part, the choices and the last advances concerning the couplers RF power test stand will be described.

MOPEC056 **The Accelerator Prototype of the IFMIF/EVEDA Project** – *A. Mosnier, P.-Y. Beauvais, R. Gobin, J.-F. Gournay, P. Joyer, J. Marroncle, P.A.P. Nghiem, F. Orsini (CEA) B. Brañas, A. Ibarra, P. Méndez, I. Podadera Aliseda, J. Sanz, F. Toral (CIEMAT) M. Comunian, A. Facco, A. Palmieri, A. Pepato, A. Pisent (INFN/LNL) P. Garin, Ch. Vermare (IFMIF/EVEDA) R. Heidinger (Fusion for Energy) H. Kimura, T. Kojima, T. Kubo, S. Maebara, S. O'hira, Y. Okumura, K. Shinto, H. Takahashi, K. Yonemoto (JAEA)*

The objectives of the IFMIF/EVEDA project are to produce the detailed design of the entire IFMIF facility, as well as to build and test a number of prototypes, including a high-intensity CW deuteron accelerator (125 mA @ 9 MeV). Most of the accelerator components (Injector, RFQ, Superconducting RF-Linac, Transport Line and Beam Dump, RF Systems, Local control systems, beam instrumentation) are designed and provided by European institutions (CEA/Saclay, CIEMAT, INFN/LNL, SCK-CEN), while the RFQ couplers, the supervision of the control system and the building including utilities constructed at Rokkasho BA site are provided by JAEA. The coordination between Europe and Japan is ensured by an international project team, located in Rokkasho, where the accelerator will be installed and commissioned. The design and R&D activities are presented, as well as the schedule of the prototype accelerator.

MOPEC057 **Study and Realization of the First Superconducting Half Wave Resonator Prototype for the SRF Linac of the IFMIF Project** – *F. Orsini, P. Bosland, P. Bredy, G. Disset, N. Grouas, P. Hardy, V.M. Hennion, H. Jenhani, J. Migne, A. Mohamed, J. Plouin, J. Relland (CEA) B. Branas Lasala, I. Podadera Aliseda, S. Sanz, F. Toral (CIEMAT) E.N. Zaplatin (FZJ)*

In the framework of the International Fusion Materials Irradiation Facility (IFMIF), which consists of two high power CW accelerator drivers, each delivering a 125 mA deuteron beam at 40 MeV, an accelerator prototype is presently under design for the first phase of the project. A superconducting option has been chosen for the 5 MeV RF Linac, based on a cryomodule composed of 8 low-beta Half-Wave Resonators (HWR), 8 Solenoid Packages and 8 RF couplers. This paper will focus on the HWR sub-system: the RF, thermo-mechanical design, and the realization of the first prototype of HWR will be presented. The resonator tuning frequency is controlled by an innovant Cold Tuning System (CTS), located in the central region of the cavity. The different options for tuning will be discussed and the final thermo-mechanical design will be detailed. First validation test results of the CTS are expected for the conference.

MOPEC058 **StrahlSim, A Computer Code to Simulate the Dynamic Vacuum in Heavy Ion Accelerators** – *P. Puppel (IAP) L.H.J. Bozyk (TU Darmstadt) P.J. Spiller (GSI)*

StrahlSim is a unique code which simulates the dynamic vacuum in heavy ion accelerators. Dynamic vacuum effects are one of the most challenging problems for accelerators using intermediate charge state, high intensity ion beams. Intermediate charge state ions are exposed to a high probability of charge exchange due to interactions with residual gas particles. Ions which underwent a charge change will be deflected differently with respect to the reference ion in dispersive elements and hit the vacuum chamber where an energy-dependent gas desorption takes place. The pressure rise in the accelerator due to this desorption process becomes dependent on the intensity of the ion beam and is referred to as dynamic vacuum. The StrahlSim code is a tool that combines systematic and dynamic beam loss mechanisms, vacuum gas composition and vacuum pumping systems of an accelerator and accounts for the relevant ionization and electron capture cross sections at the actual beam energy. StrahlSim makes it possible to estimate the transmission of heavy ion accelerators, to estimate the pumping power needed to stabilize the dynamic vacuum and to create time dependent longitudinal pressure profiles.

MOPEC059 **The Frankfurt Neutron Source FRANZ** – *U. Ratzinger, L.P. Chau, M. Heilmann, O. Meusel, D. Mäder, Y.C. Nie, D. Noll, H. Podlech, S. Schmidt, C. Wiesner (IAP) M. Heil (GSI) R. Reifarth (IKF)*

An intense 2 MeV, 200 mA proton beam will drive a neutron source by the reaction Li7(p,n)B·10^7 on solid as well as on liquid lithium targets. Actually, the facility is under construction at the physics faculty new experimental hall in Frankfurt. To study in detail the burning of elements in stars by the s-process, a pulsed beam operation with a bunch compressor at the linac exit will offer several Ampere beam current within 1 ns pulse length and with 250 kHz rep. rate at the n - production target. As the upper limit of generated neutrons and the total n- flux at this source are well defined the sample for neutron capture measurements can be placed after a time of flight path as short as 0.8 m only. This will provide highest accessible pulsed neutron flux rates for neutron energies in the 1 - 500 keV range. The highly space charge dominated bunch forming process as well as the ion source, the rf coupled 175 MHz RFQ/DTL - resonator and the target development will be explained.

MOPEC060 **Engineering Design and First Prototype Tests of the IFMIF-EVEDA RFQ** – *A. Pepato, R. Dima, F. Scantamburlo (INFN- Sez. di Padova) M. Comunian, F. Grespan, A. Palmieri, A. Pisent, C. Roncolato (INFN/LNL) D. Dattola, P. Mereu (INFN-Torino)*

In the framework of the IFMIF/EVEDA project, the RFQ is a 9.8 m long cavity, with very challenging mechanicals specification. In the base line design, the accelerator tank is composed of 18 modules that are flanged together. The construction procedure of each module foresees the horizontal brazing of the four electrodes and then the vertical brazing of the flanges. A RFQ prototype, composed of 2 modules, aimed at testing all the mechanical construction procedure is under construction. In this article, the progress of the prototype construction and the progresses in the design and engineering phase, as well the description of all the fabrication phases is reported.

MOPEC061 **The IFMIF RFQ Real-scale Aluminum Model: RF Measurements and Tuning** – *A. Palmieri, F. Grespan (INFN/LNL)*

In order to validate the tuning and stabilization procedures established for the IFMIF RFQ, a campaign of low power tests on an aluminum real-scale RFQ built on purpose has been carried out. Such campaign consisted of the determination of mode spectra, the measurements of the electric field distribution with bead pulling technique, and the implementation of the tuning procedure. The main outcomes and results obtained are reported in the article.

MOPEC062 **Perturbation Analysis on a Four-vane RFQ** – *A. Palmieri, A. Pisent (INFN/LNL)*

An important issue for high intensity RFQs (tenth of mA beam current and more) is the necessity of keeping the beam losses as low as possible, in order to allow reliable and safe maintenance of the machine. Typically, beam dynamics outcomes driven by these constraints result both in a RFQ length that is considerably higher than the wavelength and in an intra-vane voltage admitted variation with respect to the design value that must not exceed a few percent. Therefore an analytical tool is needed in order to foresee the effect of geometric perturbations on the voltage profile, in order to give an indication on the permitted ranges of geometrical errors in the RFQ construction. In this article a five conductors transmission line equivalent circuit for the four-vane RFQ is presented and the effects of geometrical perturbations on the voltage profile are analyzed in some particular cases. The case study is the IFMIF RFQ (125 mA deuteron current, 9.8 m length, 175 MHz frequency), whose features are particularly suitable for this kind of analysis.

MOPEC063 **Wideband Low-output Impedance RF System for the ISIS Second Harmonic Cavity** – *Y. Irie, S. Fukumoto, K. Muto, H. Nakanishi, A. Takagi (KEK) D. Bayley, I.S.K. Gardner, R.J. Mathieson, A. Seville, J.W.G. Thomason (STFC/RAL/ISIS) J.C. Dooling, D. Horan, R. Kustom, M.E. Middendorf (ANL) T. Oki (Tsukuba University)*

A low-output-impedance RF system for the second harmonic cavity in the ISIS synchrotron has been developed by collaboration between Argonne National Laboratory (US), KEK (Japan) and Rutherford Appleton Laboratory (UK). The system has less than 30 Ω of output impedance over wide frequency range of 2.7-6.2 MHz. However, distortions of voltage waveform in the driver stage have been a long-standing issue. It was found such distortions were generated depending upon the higher-order-modes of the anode-choke impedance. In this report, method to realize the smooth sinusoidal waveform in the wideband system is presented.

MOPEC064 **Construction of J-PARC Accelerator Complex** – *M. Yoshioka, H. Kobayashi (KEK)*

The J-PARC accelerator complex consists of a linear accelerator (330 m long, 181 MeV), a rapid cycling synchrotron (3 GeV RCS, 350 m circumference, 25 Hz) and a slow cycling synchrotron (MR, 30 GeV as a first step energy, 1600 m circumference, typically with 3.5 sec cycle). The RCS provides high intensity proton beam to the materials and life science facility and the MR. The MR has two beam extraction lines. One is a slow extraction system for the hadron physics, and other a fast extraction system for neutrino science. We have to challenge many issues to complete construction of the J-PARC accelerator facility on-schedule in 2008 despite all the hardships, such as the problems included in the original design, technology choices and fabrication procedure of the machine components, and construction of conventional facilities. As a first step of operation, we could commission all accelerator facilities and provide beam to all experimental facilities in 2009 successfully. We will report about analysis of these issues and how to solve them, which is a necessary step to realize the design beam power as a next step, and to challenge the future upgrade beyond the original design.

MOPEC065 **Recent Status and Future Plan of J-PARC MA Loaded RF Systems** – *M. Yoshii, K. Hara, C. Ohmori, T. Shimada, H. Suzuki, M. Tada (KEK/JAEA) E. Ezura, K. Hasegawa, A. Takagi, K. Takata (KEK) M. Nomura, A. Schnase, F. Tamura, M. Yamamoto (JAEA/J-PARC)*

The Japan Proton Accelerator Complex includes the 3GeV rapid cycling synchrotron (RCS) and the 50GeV main ring synchrotron (MR). Both synchrotrons use the high field gradient magnetic alloy (MA) loaded cavities. In RCS, 11 RF systems have been fully operational since December 2008. The RCS RF systems are operated with dual-harmonic acceleration voltages. Beam acceleration and bunch shape manipulation are efficiently taking place. 120kW of the neutron user operation was started at the Material and Life science facilities in November 2009. In MR synchrotron, the 5th RF system were installed in August 2009, and therefore 5 RF systems are now in operation. Beam commissioning for delivering protons to the hadron facility and neutrino beam experimental facility are under way. The neutrino user experiment is intended to start January 2010. Proton beam operation with more than 100kW is required. The approaches to realizing high intensity operation and the MR upgrade plan will be presented.

MOPEC066 **Status of Mass Production of the ACS Cavity for the J-PARC Linac Energy Upgrade** – *H. Ao, K. Hirano, T. Morishita (JAEA/LINAC) H. Asano, N. Ouchi, N. Tsubota (JAEA/J-PARC) K. Hasegawa (JAEA) F. Naito, K. Takata (KEK) V.V. Paramonov (RAS/INR) Y. Yamazaki (J-PARC, KEK & JAEA)*

The mass production of the ACS (Annular Coupled Structure) cavity started from March 2009 for the J-PARC Linac energy upgrade from 181 MeV to 400 MeV. This upgrade project requires 18 ACS accelerating modules and two debunchers additionally within three years. The construction schedule is so tight that we have to optimize the fabrication process. For example the geometrical beta is varied for each accelerating module, thus the several test cells were fabricated and for the all beta before the mass production to confirm the initial design and the frequency tuning procedure. This paper describes our approach for the mass production and the current status and results.

MOPEC067 **Status of J-PARC RFQ** – *K. Hasegawa, T. Kobayashi, Y. Kondo, T. Morishita, H. Oguri (JAEA/J-PARC) Y. Hori, C. Kubota, H. Matsumoto, F. Naito, M. Yoshioka (KEK)*

The J-PARC RFQ (length 3.1m, 4-vane type, 324 MHz) accelerates a beam from the ion source to the DTL. The beam test of the linac was started in November 2006 and 181 MeV beam was successfully accelerated in January 2007. Since then, the linac has been delivered beams for commissioning of the linac itself, downstream accelerators and facilities. Trip rates of the RFQ, however, unexpectedly increased in Autumn 2008, and we have been suffering from this issue for user run operation since then. We tried to recover by tender conditioning, modification of RF control, improvement of vacuum properties and so on. By taking these measures, we manage to have 2 to 3 days continuous beam operation. In this report, we describe the status of the RFQ.

MOPEC068 **High Intensity Beam Operations in the J-PARC 3-GeV RCS** – *H. Hotchi (JAEA/J-PARC)*

We have recently demonstrated 300-kW output in the J-PARC 3-GeV RCS. In this paper we will discuss beam dynamics issues in such a high intensity beam operation together with the corresponding beam simulation results.

MOPEC069 **Status and Progress of the J-PARC 3-GeV RCS** – *M. Kinsho (JAEA/J-PARC)*

The J-PARC 3-GeV rapid cycling synchrotron (RCS) has been operated for the neutron and MLF users program from December 23rd, 2008. The RCS operations not only in support of the MLF but also were providing beam to support commissioning of the MR. In parallel we are challenging to realize higher beam power operations with better stability. Before scheduled maintenance last summer beam power was limited by the front end of about 20 kW, after that maintenance the RCS has been operated the beam power of more than 100 kW for MLF users. After beam deliver operation to the MR and MLF, while the priority has been given to their beam tuning, the RCS also continues further beam studies toward higher beam intensity. On December 7th, 2009, the RCS achieved the beam power of more than 300kW to the neutron production target with 25Hz. This presentation will concentrate itself on the outcome of the J-PARC RCS commissioning program, including the discussion on the issues of the high-power operation.

MOPEC070 **The Optimization of Beam Dynamics Design for CSNS/RCS** – *S. Wang (IHEP Beijing)*

The accelerator of China Spallation Neutron Source (CSNS) consists of a low energy linac and a Rapid Cycling Synchrotron (RCS). The opimization of beam dynamics design for RCS and two beam transport line are introduced, and the details design and some simulation results are presented.

MOPEC071 **Compact Pulsed Hadron Source Project Status** – *J. Wei, X. Guan, C.-K. Loong (TUB)*

The Compact Pulsed Hadron Source is a three-year construction project recently approved for construction at Tsinghua University, China. The consists of an accelerator front-end'a high-intensity ion source, a 3 MeV radiofrequency quadrupole linac (RFQ), and a 13 MeV drift-tube linac (DTL), a neutron target station'a beryllium target with solid methane and room-temperature water moderators/reflector, and experimental stations for neutron imaging/radiography, small-angle scattering, and proton irradiation. In the future CPHS may also serve as an injector to a ring for proton therapy and radiography or as the front end to an ADS test facility. In this paper, we describe the design and construction status, technical challenges, future extensions of the project.

MOPEC072 **Simulation based Analysis of the Correlation between the Thermo-mechanical and the High Frequency Electromagnetic Characteristics of a Current Monitor at the PSI Proton Accelerator Facilities** – *Y. Lee, P.-A. Duperrex, V. Gandel, D.C. Kiselev, U. Mueller (PSI)*

A new current monitor (MHC5) based on a re-entrant cavity tuned at the 2nd RF harmonic (-10-1 MHz) has been in operation since April 2009 at PSI. It monitors the current of the high intensity 590 MeV proton beam at 8 m downstream of the graphite meson production target (TgE). The scattered particles and their secondaries from TgE introduce a heavy thermal load approximately of 230 W on MHC5 at 2 mA beam intensity, which is carried away by active water cooling. The cooling mechanism of MHC5 is investigated by comparing measured data and numerical simulations. The inhomogeneous temperature profile in MHC5 results in thermo-mechanical deformations which should lead to a change in its HF electromagnetic characteristics. Indeed, an anomalous dynamic drift in the cavity RF was observed during operations, which had to be compensated for, in order to obtain correct beam current monitoring. In this paper, the physics of the observed RF drift is analyzed by using advanced multi-physics simulation technologies. Based on the analysis, a dynamic modeling of the resonating capacitor is presented, and the issue on the optimization of MHC5 for the planned 3 mA beam upgrade at PSI is discussed.

MOPEC074 **Injection Upgrade for the ISIS Synchrotron** – *B. Jones, D.J. Adams, S.J.S. Jago, H. V. Smith, C.M. Warsop (STFC/RAL/ISIS)*

The ISIS Facility at the Rutherford Appleton Laboratory in the UK produces intense neutron and muon beams for condensed matter research. The accelerator facility consists of a 70 MeV H^- linac and a 50 Hz proton synchrotron accelerating up to $3.75x10^{13}$ protons per pulse from 70 to 800 MeV, delivering a mean beam power of 0.24 MW. Present upgrade studies are investigating how replacement of the existing linac and increased injection energy could increase beam power in the existing ISIS ring. Such an upgrade would replace one of the oldest sections of the ISIS machine, and with reduced space charge and optimised injection, may allow substantially increased intensity in the ring, perhaps towards the 0.5 MW regime. A critical aspect of such an upgrade would be the new higher energy injection straight. This paper summarises beam dynamics and hardware requirements for 180MeV H^- charge exchange injection into ISIS including; optimisation of the injection magnets; requirements for beam dumps and results of stripping foil simulations with estimates of stripping efficiency and foil heating.

MOPEC075 **Status of the RAL Front End Test Stand** – *A.P. Letchford, M.A. Clarke-Gayther, D.C. Faircloth, S.R. Lawrie, M. Perkins, P. Wise (STFC/RAL/ISIS) S.M.H. Alsari, S. Jolly, D.A. Lee, P. Savage (Imperial College of Science and Technology, Department of Physics) J.J. Back (University of Warwick) C. Gabor, D.C. Plostinar (STFC/RAL/ASTeC) A. Kurup (Fermilab) J.K. Pozimski (STFC/RAL)*

The Front End Test Stand (FETS) under construction at the Rutherford Appleton Laboratory is the UK's contribution to research into the next generation of High Power Proton Accelerators (HPPAs). HPPAs are an essential part of any future Spallation Neutron Source, Neutrino Factory, Muon Collider, Accelerator Driven Sub-critical System, Waste Transmuter etc. FETS will demonstrate a high quality, high intensity, chopped H-minus beam and is a collaboration between RAL, Imperial College and the Universtity of Warwick in the UK and the Universidad del Pais Vasco in Spain. This paper describes the current status and future plans of FETS.

MOPEC076 **Integrated Design Method and Beam Dynamics Simulations for the FETS Radio Frequency Quadrupole** – *S. Jolly, M.J. Easton (Imperial College of Science and Technology, Department of Physics) A.P. Letchford (STFC/RAL/ISIS) J.K. Pozimski (STFC/RAL)*

A 4m-long, 324MHz four-vane RFQ, consisting of four coupled sections, is currently being designed for the Front End Test Stand (FETS) at RAL in the UK. A novel design method, integrating the CAD and electromagnetic design of the RFQ with beam dynamics simulations, is being used to optimise the design of the RFQ. Basic RFQ parameters are produced with the RFQSIM code. A full CAD model of the RFQ vane tips is produced in Autodesk Inventor, based upon these parameters. This model is then imported into a field mapping code to produce a simulation of the electrostatic field around the vane tips. This field map is then used to model the beam dynamics within the RFQ using General Particle Tracer (GPT). Previous studies have been carried out using field mapping in CST EM Studio. A more advanced technique using Comsol Multiphysics and Matlab, that more tightly integrates the CAD modelling, field mapping and beam dynamics simulations, is described. Results using this new method are presented and compared to the previous optimisation process using field maps from CST.

MOPEC077 **Dual Harmonic Acceleration on the ISIS Synchrotron** – *A. Seville, D.J. Adams, D. Bayley, N.E. Farthing, I.S.K. Gardner, R.J. Mathieson, J.W.G. Thomason, C.M. Warsop (STFC/RAL/ISIS)*

The dual harmonic upgrade of the ISIS synchrotron at the Rutherford Appleton Laboratory in the UK is now operational and is producing the increased beam currents necessary to run ISIS Target Station Two while maintaining previous beam intensities at Target Station One. Four second harmonic (2RF) cavities have been installed and commissioned, and two of these are in routine operation improving trapping losses, increasing peak operating currents beyond 230 μA and allowing a new record operational 24 hour beam current average of 216.5 μA during the ISIS user cycle on 2nd October 2009. This paper reports on 2RF hardware commissioning, beam tests and reliability.

MOPEC078 **Commissioning of the Low Energy Beam Transport of the Front End Test Stand** – *J.J. Back (University of Warwick) J. Alonso (Fundación Tekniker) F.J. Bermejo (Bilbao, Faculty of Science and Technology) R. Enparantza (Fundación TEKNIKER) D.C. Faircloth, A.P. Letchford (STFC/RAL) C. Gabor (STFC/RAL/ASTeC) S.R. Lawrie (STFC/RAL/ISIS) J. Lucas (Elytt Energy) J.K. Pozimski, P. Savage (Imperial College of Science and Technology, Department of Physics)*

The Front End Test Stand (FETS) at the Rutherford Appleton Laboratory is intended to demonstrate the early stages of acceleration (0-3 MeV) and beam chopping required for high power proton accelerators, including proton drivers for pulsed neutron spallation sources and neutrino factories. A Low Energy Beam Transport (LEBT), consisting of three solenoids and four drift sections, is used to transport the H^- beam from the ion source to the FETS Radio Frequency Quadrupole. We present the status of the installation and commissioning of the LEBT, and compare particle dynamics simulations with preliminary measurements of the H^- beam transport through the LEBT.

MOPEC079 **A Tuning System for the FETS RFQ** – *S.M.H. Alsari, J.K. Pozimski, P. Savage, O. Zorba (Imperial College of Science and Technology, Department of Physics) A.P. Letchford (STFC/RAL/ISIS)*

The Front End Test Stand (FETS) is an experiment based at the Rutherford Appleton Laboratory (RAL) in the UK. The test stand is being constructed in collaboration between STFC, Imperial College London, ASTeC, the University of Warwick and the Universidad del Pais Vasco. This experiment will design, build and test the first stages necessary to produce a very high quality, chopped H^- ion beam as required for the next generation of high power proton accelerators (HPPAs). HPPAs with beam powers in the megawatt range have many possible applications including drivers for spallation neutron sources, neutrino factories, accelerator driven subcritical systems, waste transmuters and tritium production facilities. An automatic tuning system has been developed for the main 324MHz 4-vane RFQ accelerator and has been tested to fine tune the changes in the resonant frequency of a 324MHz 4-vane cold model RFQ, which been designed as part of the development of the test stand. This paper will present the electronics design of the automated tuning system along with the mechanical tuner structure. The design concepts will be discussed. Furthermore, results of the RF tuning would be presented.

MOPEC080 **Bunch Compression Strategies for a Future High Power Facility** – *L.J. Jenner (Imperial College of Science and Technology, Department of Physics)*

Many proposed high power facilities will ultimately require a high intensity proton source that can produce bunches only a few ns in length. A dedicated compression ring is one of the most efficient ways to achieve this via longitudinal phase rotation. This work describes a compression formula primarily optimised for a Project-X-like facility but with synergystic application to other facilities in mind. The issues and limitations of this strategy are discussed.

MOPEC081 **The Concept Design of the CW Linac of the Project X** – *N. Solyak, I.G. Gonin, A. Lunin, S. Nagaitsev, J.-F. Ostiguy, N. Perunov, V.P. Yakovlev (Fermilab)*

The concept design of the 2.5 GeV superconducting CW linac of the Project X is discussed. The linac structure and break points for different cavity families are described. The results of the RF system optimization are presented as well as the lattice design and beam dynamics analysis.

MOPEC082 **Lattice Design for CW Project X SC Linac** – *N. Solyak, I.G. Gonin, J.-F. Ostiguy, V.P. Yakovlev (Fermilab) N. Perunov (MIPT)*

In this paper, we discuss beam dynamics optimization for a proposed continuous wave (CW) Project-X superconducting (SC) linac. This 2.6 GeV linac has an average current (over few microseconds) of 1 mA, with a pulsed current of up to 5-10 mA. The beam power is 2.6 MW. The CW linac consists of a low-energy 325 MHz section (2.5 MeV - 470 MeV) containing three families of SC single-spoke resonators and one family of triple-spoke resonators followed by a high-energy 1.3 GHz SC section (470 MeV - 2.6 GeV) containing squeezed elliptical (β=0.81) and ILC-type (β=1) cavities. Transverse and longitudinal dynamics in the CW linac are modeled assuming a peak current 10 mA. Different options for focusing structures are considered: solenoidal, doublet, and triplet focusing in the low-energy section; FODO and doublet focusing in the high energy section.

MOPEC083 **Compensation of Space Charge in High-intensity Proton Accelerators with Trapped Electron Columns from Beam-induced Rest-gas Ionization** – *G. Stancari, V.D. Shiltsev, A. Valishev (Fermilab) A.A. Kabantsev (UCSD) G. Stancari (INFN-Ferrara)*

One of the main limitations of high-intensity accelerators is mutual charge repulsion between particles in the beam, resulting in phase-space dilution, beam losses, and radioactivation of components. Space charge is relevant for Project X, Fermilab's future plan for neutrino and flavor physics at the intensity frontier. A mitigation of the space-charge effect would directly translate into an enhanced discovery potential. The negative effects of Coulomb repulsion can in principle be compensated by forcing the beam through an oppositely-charged plasma column with the same charge distribution as the beam. The required total charge decreases with beam energy. We started investigations of a novel scheme of space-charge compensation in which electrons from the rest gas, ionized by the proton beam, are trapped in a solenoidal magnetic field with electrodes on each side. If the Larmor radius of the electrons in the magnetic field is small compared to the proton beam size, the electron density in the trap should closely mimic that of protons. The status of the theoretical modeling and experimental studies on electron column formation and stability are presented.

MOPEC084 **Simulations of Electron Cloud for Fermilab Main Injector** – *X. Zhang (Fermilab)*

To assess the effects of the electron cloud on Main Injector (MI) intensity upgrades for Project-X, simulations of the cloud buildup were carried out using POSINST and compared with ECLOUD. And some simulations results are also compared with the current electron cloud measurements done at current MI operations. Electron cloud buildup can be mitigated in various ways. A single clearing strip electrode held at a potential of 500V is discussed here. As well as the necessary beam scrubbing time is also roughly estimated.

MOPEC085 **Status of the SNS Power Ramp Up** – *M.A. Plum (ORNL)*

The Spallation Neutron Source accelerator complex consists of a 2.5 MeV H^- front-end injector system, a 186 MeV normal-conducting linear accelerator, a 1 GeV superconducting linear accelerator, an accumulator ring, and associated beam transport lines. Since initial operation began in 2006, the beam power has been steadily increasing toward the design goal of 1.4 MW. In September 2009 the power surpassed 1 MW for the first time, and operation at the 1 MW level is now routine. The status of the beam power ramp-up program and present operational limitations will be described.

MOPEC086 **Development of Very Small ECR H^+ Ion Source** – *M. Ichikawa, H. Fujisawa, Y. Iwashita, H. Tongu, S. Ushijima, M. Yamada (Kyoto ICR)*

We aim to develop a small and high intensity proton source for a compact accelerator based neutron source. Because this proton source shall be located close to RFQ for simplification, ratio of H^+ to molecular ions such as H^2 or H^3 must be large. Therefore, we selected an ECR ion source with permanent magnets as small and high intensity ion source. ECR ion sources can provide high H^+ ratio because of their high plasma temperature. Using permanent magnets makes the ion source small and running cost low. Because there is no hot cathode, longer MTBF is expected. Usually, gas is fed into ion sources continuously, even if ion sources run in pulse operation mode. But, continuous gas flow doesn't make vacuum in good level. So, we decided to install pulse gas valve directly to the plasma chamber. Feeding the gas only when the ion source is in operation reduces the gas load to the evacuation system and the vacuum level can be kept high. Up to now, we developed the first and second model of the ion source. And the research is being conducted using the second model. Recent experimental results will be presented.

24-May-10	16:00 – 18:00	Poster	Poster Hall D

MOPD — Poster Session

MOPD001 **Stepwise Ray-tracing Based Spin Tracking Simulations In AGS** – *F. Meot (CEA) H. Huang, W.W. MacKay, T. Roser (BNL)*

To preserve proton polarization through acceleration, it is important to have a correct model of the process. It has been known that with the insertion of the two helical partial Siberian snakes in the Alternating Gradient Synchrotron (AGS), the MAD model of AGS does not agree with experimental data. The stepwise ray-tracing code Zgoubi provides a tool to represent the real electro-magnetic fields in the modeling of the optics and spin dynamics for the AGS. Numerical experiments of resonance crossing, including spin dynamics in presence of two helical snakes, have beam performed in AGS lattice models, using Zgoubi. This contribution reports on the numerous results so obtained.

MOPD002 **Acceleration of Intermediate Charge State Heavy Ions in SIS18** – *P.J. Spiller (GSI)*

After partially completing the upgrade program of SIS18, the number of intermediate charge state heavy ions accelerated to the FAIR booster energy of 200 MeV/u, could be increased by a factor of 50. Meanwhile, more than 10^{10} Uranium ions with charge state 27+ have been accelerated with moderate beam loss by ionization and reasonably stable residual gas pressure conditions. The specific challenge for the SIS18 booster operation is the high cross section for ionization due to the low charge state in combination with gas desorption processes and the dynamic vacuum pressure. Especially for this operation mode which is requied to match the intensity requirements for FAIR, an extended upgrade program of SIS18 is presently ongoing and partially completed. The achieved progress in minimizing the ionization beam loss underlines that the chosen technical strategies described in this report are appropriate.

MOPD003 **Engineering Status of SIS100** – *P.J. Spiller (GSI)*

The engineering design, including the specifications for the accelerator components of the FAIR synchrotron SIS100 has been summarized in the Technical Design Report. The final stage of technical planning shall approach production readiness for the major technical systems in 2010. Significant progress has been achieved in the design of the cryomagnetic system with its main dipole and quadrupole modules, enabling the production of the first pre-series dipole magnet. Slight modifications of the lattice have been implemented to equalize most of the cryostat interconnections, leading to a simplified design and installation effort, and a reduced variety of components and spar parts. The new parallel tunnel allows optimal short interconnections between the supply units and power converters and the accelerator components. The status of the engineering design of SIS100 will be reported.

MOPD004 **Magnetic Field Correction in Normal Conducting Synchrotrons** – *E. Feldmeier, Th. Haberer, A. Peters, C. Schömers, R. Steiner (HIT)*

While ramping the magnets in a synchrotron the magnetic fields deviate from their set values. Especially the field errors in dipole and quadrupole magnets result in different problems during operation. At the Heidelberg Ion Therapy Center HIT a measuring system with extremely high precision has been developed. It can measure in real time integral magnetic fields with a precision of better than $5*10^{-5}$ in a reproducible way. A feedback control system for the magnetic fields is being installed and will be operational in Summer 2010. This control loop lets the magnets reach the nominal field much faster and thus shortens the dead time in a synchrotron cycle. The cycle can be reduced by 30% and more patients can be treated per year.

MOPD005 **Design of PEFP RCS** – *J.-H. Jang, Y.-S. Cho, H.S. Kim, H.-J. Kwon (KAERI) Y.Y. Lee (BNL)*

As a feasible extension plan of the proton engineering frontier project (PEFP) 100-MeV proton linac, the conceptual design of an rapid cycling synchrotron (RCS) is under progress. The main purpose of the synchrotron is a spallation neutron source and it also includes the slow extraction option for basic and applied science research. In the initial stage, the beam power is 60 kW by using a scheme of 100-MeV injection and 1-GeV extraction. There is a scheme to increase power to 500 kW through a 3-stage upgrade. The injection and extraction energies will be 200-MeV and 2-GeV respectively after the final upgrade. This article summarizes the present status of the RCS design. It includes the physics design including injection and acceleration, and conceptual design of some magnets and RF cavity.

MOPD007 **Design of the Nuclotron Booster in the NICA Project** – *A.O. Sidorin, I.N. Meshkov, V.A. Mikhaylov, G.V. Trubnikov (JINR) A.V. Butenko (JINR/LHE)*

The main goal of the Nuclotron booster construction are following: accumulation up to $4{\cdot}10^{+9}$ Au^{32+} ions; acceleration of the ions up to energy of 600 MeV/u that is sufficient for stripping of the ions to the bare nucleus state; simplification of the requirements to the vacuum conditions in the Nuclotron; forming of the required beam emittance at the energy of 100 MeV/u with electron cooling system. The features of this booster, the requirement to the main synchrotron systems and their parameters are presented.

MOPD008 **Status of the Nuclotron. 'Nuclotron-M' project** – *A.O. Sidorin, N.N. Agapov, G.V. Trubnikov (JINR) A.D. Kovalenko (JINR/LHE)*

The 'Nuclotron-M' project started in 2007 is considered as the key point of the first stage of the NICA/MPD project. General goal of the 'Nuclotron-M' project is to prepare all the systems of the Nuclotron for its long and reliable operation as a part of the NICA collider injection chain. Additionally the project realization will increase the Nuclotron ability for realization of its current experimental program. Results of the last runs of the Nuclotron operation are presented.

MOPD009 **Injector Complex of the NICA Facility** – *A.O. Sidorin, A. Govorov, V. Kobets, I.N. Meshkov, V. Monchinsky, G.V. Trubnikov (JINR) O.K. Belyaev (IHEP Protvino)*

The injector complex of the NICA facility consists of existing Alvarez-type linac LU-20 and new heavy ion linac HILac. The LU-20 is under modernization now, the HILac will be constructed during coming years. Parameters of the accelerators are presented.

MOPD010 **Lattice of the NICA Collider Rings** – *A.O. Sidorin, O.S. Kozlov, I.N. Meshkov, V.A. Mikhaylov, G.V. Trubnikov (JINR)*

Main element of the NICA facility is the collider equipped with stochastic and electron cooling systems to provide experiment with heavy ions like Au, Pb or U at energy from 1 to 4.5 GeV/u with average luminosity of the level of 10^{27} cm^{-2} s^{-1}. The possible lattices providing the required parameters are discussed.

MOPD011 **Project of the Nuclotron-based Ion Collider fAcility (NICA) at JINR** – *A.O. Sidorin, I.N. Meshkov, G.V. Trubnikov (JINR) A.D. Kovalenko (JINR/LHE)*

The Nuclotron-based Ion Collider fAcility (NICA) is the new accelerator complex being constructed at JINR aimed to provide collider experiments with heavy ions up to uranium at the center of mass energy from 4 to 11 GeV/u. It includes 6 Mev/u linac, 600 MeV/u booster, upgraded SC synchrotron Nuclotron and collider consisting of two SC rings, which provide average luminosity of the level of 10^{27} cm^{-2}s^{-1}.

MOPD012 **Routine Operation of ITEP-TWAC Facility and Machine Capabilities Development** – *N.N. Alexeev, P.N. Alekseev, A. Balabaev, V.I. Nikolaev, Y. Satov, V.A. Schegolev, B.Y. Sharkov, A. Shumshurov, V.P. Zavodov (ITEP)*

The ITEP-TWAC facility is in operation of ~4000 hours per year with proton and heavy ion beams in several modes of beam acceleration and accumulation. The new configuration of laser ion source with 5J and 100J CO2-lasers is used in routine operation for C, Si, Fe, ..-ion beam generation, acceleration of different ion species in booster synchrotron UK up to the energy of 200-400 MeV/u, stacking with multiple charge exchange injection technique of bare ions (nuclei) in the U10 accumulator ring or nuclei finish acceleration in the same U10 ring up to relativistic energies of 4 GeV/u for C^{6+} and 3.6 GeV/u for Fe^{26+}. Machine capabilities development is aimed at improvement of beams parameters and at extension of experimental area implementing of time sharing mode of operation for a number of users and running in parallel of several experiments and routine operation with various beams. The machine status and current results of activities aiming at both subsequent improvement of beam parameters, and extending of beam applications are presented.

MOPD013 **Upgrade of the Quench Protection Systems for the Superconducting Circuits of the LHC Machine at CERN: From Concept and Design to the First Operational Experience.** – *F. Formenti, Z. Charifoulline, G.-J. Coelingh, K. Dahlerup-Petersen, R. Denz, A.P. Siemko, J. Steckert (CERN) SF. Feher, R.H. Flora, H. Pfeffer (Fermilab)*

Two events, occurring in 2008 during commissioning of the LHC circuits, lead to fundamental changes to the scope of circuit protection. The discovery of aperture-symmetric quenches and the accidental rupture at 9kA of an interconnecting busbar resulted in an emergency program for development and implementation of new protection facilities. The new scheme comprises a distributed busbar supervision system with early warning capabilities based on high-precision splice resistance measurements and system interlocks for rapid de-excitation of the circuit in case of a sudden splice resistance increase. The developed symmetric quench detectors are digital systems with radiation-resistant FPGA logic controllers, having magnet heater firing capabilities. This program successfully allowed a safe re-powering of the collider. The concept of the new electronics boards, the associated controls software and the powering modules will be described. More than 14’600 extra cables and 6’000 new detector and control cards were added to the existing QPS system. A first evaluation of the system performance as well as a number of interesting discoveries made during the commissioning will be presented.

MOPD014 **Single-batch Filling of the CERN PS for LHC-type Beams** – *S. Hancock, C. Carli, J.F. Comblin, A. Findlay, K. Hanke, B. Mikulec (CERN)*

Since the CERN PS Booster cannot simultaneously provide the beam brightness and intensity required, the nominal (25ns bunch spacing) proton beam for the LHC involves double-batch filling of the PS machine. Linac 4, which is under construction, will eventually remove this restriction. In the meantime, the request for 50 and 75ns bunch spacings to mitigate electron cloud effects has lowered the intensity demand such that the Booster can meet this in a single batch without compromising beam brightness. Single-batch transfer means providing two bunches from each of three Booster rings and, in turn, that the bunch spacing is modified by the addition of an h=1 rf component to the h=2 in the Booster in order to fit the h=7 rf buckets waiting in the PS (whilst leaving one bucket empty for kicker purposes). Following the first experiments performed in 2008, the rf manipulations in the Booster have been refined and those in the PS have been modified to cope with single-batch beams. This latest work is presented for both the 50 and 75ns variants.

MOPD015 **Status of the Linac4 Project at CERN** – *K. Hanke, C. Carli, R. Garoby, F. Gerigk, A.M. Lombardi, S. Maury, C. Rossi, M. Vretenar (CERN)*

The construction of Linac4, a 160 MeV H^- Linac, is the first step in upgrading the LHC injector chain. Unlike CERN's present injector linac, Linac4 will inject into the subsequent synchrotron via charge exchange injection. In a first stage, it will inject into the existing CERN PS Booster. At a later stage, Linac4 has the option to be extended by a superconducting linac (SPL) which could then inject into a new synchrotron (PS2). Construction of Linac4 has started in 2008, and beam operation is presently planned for 2014. An overview of the Linac4 main parameters and design choices is given, and the status of the construction reported.

MOPD016 **Injection Upgrades for the ISIS Synchrotron** – *J.W.G. Thomason, D.J. Adams, D.J.S. Findlay, I.S.K. Gardner, S.J.S. Jago, B. Jones, A.P. Letchford, R.J. Mathieson, S.J. Payne, B.G. Pine, A. Seville, H. V. Smith, C.M. Warsop, R.E. Williamson (STFC/RAL/ISIS) J. Pasternak (STFC/RAL) C.R. Prior, G.H. Rees (STFC/RAL/ASTeC)*

The ISIS Facility based at the Rutherford Appleton Laboratory in the UK is the world's most productive spallation neutron source. Presently it runs at beam powers of 0.2 MW, with RF upgrades in place to supply increased powers for the new Second Target Station. Increasing injection energy into the synchrotron beyond the existing 70 MeV level has significant potential to increase intensity as a result of reduced space charge. This paper outlines studies for this upgrade option, which include magnet and power supply upgrades to achieve a practical injection system, management of increased injection region activation levels due to higher energy unstripped particles and ensuring the modified longitudinal and transverse beam dynamics during injection and acceleration are possible with low loss at higher intensity levels.

MOPD017 **Impedance Considerations for the Design of the Vacuum System of the CERN PS2 Proton Synchrotron** – *K.L.F. Bane, G.V. Stupakov, U. Wienands (SLAC) M. Benedikt, A. Grudiev, E. Mahner (CERN)*

In order for the LHC to reach an ultimate luminosity goal of 10^{35}, CERN is considering upgrade options for the LHC injector chain, including a new 50 GeV synchrotron of about 1.3 km length for protons and heavy ions, to be called the PS2. In this ring the proton energy is ramped from 4 GeV in 1.2 s, and the design (proton) current is 2.7 A. The present baseline of the vacuum system considers elliptical stainless steel chambers bakeable up to 300^{o}C, various coatings to mitigate electron cloud are under study. For a bare stainless steel or Inconel chamber, the resistive wall wake alone will lead to multi-bunch instability, whereas for transverse mode coupling (TMCI), the threshold is above the design beam current, though this instability may become an issue once other impedance contributions are taken into account. A copper layer of varying thickness is shown to raise the TMCI threshold but to have relatively little effect on the multi-bunch resistive-wall growth rate unless the coating is very thick. We are also studying the effect of the copper coating on the penetration of the guide field during the energy ramp, which sets an upper limit on the allowable thickness.

MOPD018 **A New Life for High Voltage Electrostatic Accelerators** – *P. Beasley, O. Heid, T.J.S. Hughes (Siemens AG, Healthcare Technology and Concepts)*

Air insulated Cockcroft-Walton (Grienacher) cascades have been historically used to generate high voltages for accelerating particles. This paper explores how this technology can be utilised through a system level approach to develop more compact accelerator configurations with much higher voltages and gradients. One such concept is presented that realises a 20MeV, 1mA tandem accelerator that has a footprint $\sim 2m^2$

MOPD019 **Tandem Accelerator as the Injector for the Medical-use Synchrotron at the Wakasa-wan Energy Research Center** – *S. Hatori, S. Fukumoto, T. Kurita, E.J. Minehara (WERC)*

We have operated the accelerator system which consists of a tandem accelerator and a synchrotron since the completion of the construction and beam commissioning at the Wakasa-wan Energy Research Center, Tsuruga, Japan in 2000. The acceleration voltage of the tandem accelerator amounts to 5 MV and is generated by the Dynamitron-type cascade voltage doubler rectifier. The beam from the tandem accelerator is transported to the MeV-ion experimental area for the irradiation to the industrial or biological material and for the ion beam analysis. The tandem beam is also injected to the 200 MeV proton synchrotron. The synchrotron beam has been used for the high energy irradiation and the cancer therapy. The tandem accelerator is used for a lot of purposes including cancer therapy, therefore, stable operation of the system and efficient sharing of the operation duration are required. Developments of the accelerator are presented putting a stress on the stable and efficient operation of the system in this paper.

MOPD020 **Ion Injector Based on Tandem Accelerator** – *A.V. Semenov, V.G. Cherepkov, V. Klyuev, E.S. Konstantinov, E.A. Kuper, V.R. Mamkin, A.S. Medvedko, P.I. Nemytov, V.V. Repkov, V.B. Reva, R.A. Salimov, D.V. Senkov, V.A. Vostrikov (BINP SB RAS)*

An electrostatic tandem accelerator with 1.25 MV at the high voltage terminal was designed, assembled and successfully commissioned at BINP. The accelerator of ELV-type will be used as injector for cancer therapy facility by carbon ions beams. The 10 keV beam of negative carbon ions with current up to 100 mkA is injected into the tandem and charge exchange in the vacuum heat insulation magnesium vapor target. The results of commissioning tests and beam parameters measurements are presented.

MOPD021 **Low Energy Ion Injector at KACST** – *M.O.A. El Ghazaly, A.A. Almukhem, A.M. Mandil (KACST) A.I. Papash (JINR) C.P. Welsch (Cockcroft Institute)*

At the National Centre for Mathematics and Physics (NCMP), at the King Abdulaziz City for Science and Technology (KACST), Saudi Arabia, a versatile low energy ion injector has been developed in collaboration with the QUASAR group. This project will allow for a broad experimental program with most different kinds of ions both in single pass setups, but also with ions stored in a fixed-energy electrostatic storage ring. In this contribution, the design of the injector is presented. It was designed for beams with energies of up to 30 kV/q and will allow for switching between different ion sources from e.g. duoplasmatron to electrospray ion sources and to thus provide the users with a wide range of different beams. The mechanical construction of the injector is summarized and the status of its assembly at KACST presented.

MOPD022 **Design of a Combined Fast and Slow Extraction for the Ultra-low Energy Storage Ring (USR)** – *G.A. Karamysheva, A.I. Papash (JINR) C.P. Welsch (Cockcroft Institute)*

The Ultra-Low energy Storage Ring (USR) within the future Facility for Low-energy Antiproton and Ion Research (FLAIR) will decelerate antiproton beams from 300 keV to energies of only 20 keV. Cooled beams will then be extracted and provided to external experiments. The large variety of planned experiments requires a highly flexible longitudinal time structure of the extracted bunches, ranging from ultra-short pulses in the nanosecond regime to quasi DC beams. This requires fast as well as slow extraction in order to cover whole range of envisaged beam parameters. A particular challenge was to combine elements for fast and slow extraction in one straight section of this electrostatic ring. In this contribution we present the results of beam dynamic simulations and describe the overall extraction scheme in detail.

MOPD023 **DITANET - Investigations into Accelerator Beam Diagnostics** – *C.P. Welsch (Cockcroft Institute) C.P. Welsch (The University of Liverpool)*

The Marie Curie Initial Training Network DITANET covers the development of advanced beam diagnostic methods for a wide range of existing or future accelerators, both for electrons and ions. The network brings together research centres like CERN or DESY, Universities, and private companies. DITANET currently has 27 partners from Europe and the USA and is committed to training young researchers in this field, performing cutting edge research in beam instrumentation, and exploiting synergies within this community. This contribution presents an overview of the research outcomes within the first two years of DITANET and summarizes the network's training activities.

MOPD024 **Scintillating Screen Studies for Low Energy, Low Intensity Beams** – *J. Harasimowicz, C.P. Welsch (Cockcroft Institute) L. Cosentino, P. Finocchiaro, A. Pappalardo (INFN/LNS) J. Harasimowicz (The University of Liverpool)*

Future atomic and nuclear physics experiments put challenging demands on the required beam instrumentation. Low energy (<1 MeV), low intensity (<10^7 pps) beams will require highly sensitive monitors. This is especially true for the Facility for Low-energy Antiproton and Ion Research (FLAIR) where antiproton beams will be decelerated down to 20 keV and as few as $5{\cdot}10^5$ particles per second will be slowly extracted for external experiments. In order to investigate the limits of scintillating screens for beam profile monitoring in the low energy, low intensity regime a structured analysis of several screen materials, including CsI:Tl, YAG:Ce and scintillating fibre optic plate (SFOP), has been done under different irradiation conditions with keV proton beams. This contribution will present the experimental setup and summarize the results of this study.

MOPD025 **Status of the SPIRAL 2 Superconducting LINAC** – *P.-E. Bernaudin, R. Ferdinand (GANIL) P. Bosland (CEA) G. Olry (IPN)*

SPIRAL2 is a radioactive beams facility, composed of a superconducting linac driver, delivering deuterons with an energy up to 40 MeV (5 mA) and heavy ions with an energy of 14.5 MeV/u (1 mA). The superconducting linac is composed of two families of quarter wave resonators: type A (optimized for β=0.07, 1 per cryomodule) and B (β=0.12, 2 per cryomodule). The accelerator is scheduled to be commissionned from mid-2011 onwards. The project is therefore in production phase. This paper summarizes the latest results and the status of the superconducting linac. All 16 type B cavities have been tested. Cryomodules from both families are presently beeing assembled in series. Installation in the new building shall begin in May 2011.

MOPD026 **Unsegmented vs. Segmented 4-vane RFQ: Theory and Cold Model Experiments** – *A. France, O. Delferriere, M. Desmons, Y. Le Noa, J. Novo, O. Piquet (CEA)*

The RF design of a RFQ should satisfied several conditions, namely: voltage profile required by beam dynamics, a tunable structure, RF stability and reasonable sensitivity to possible perturbations induced by power operation. Voltage profile may be obtained either by a dedicated profiling of 2D cross-section and/or slug tuner adjustment. Tunability is directly related to spatial distribution of tuners. RF stability requires sufficient separation between accelerating quadrupole mode and (i) adjacent quadrupole modes, or (ii) adjacent dipole modes. Quadrupole modes separation is directly related to RFQ length, and can be increased if necessary via segmentation; position of dipole modes spectrum w.r.t. quadrupole spectrum may be adjusted using rod stabilizers inserted at RFQ ends and on either side of coupling circuits. We present a thorough comparison of these two options for a 6-meter long structure at 352 MHz, and show they both lead to a tunable structure. The design includes 3D electromagnetic simulation and application of transmission line to tuning. The sensitivity of both designs to perturbations is also evaluated.

MOPD027 **The RF Design of the Linac4 RFQ** – *O. Piquet, O. Delferriere, M. Desmons, A. France (CEA) A.M. Lombardi, C. Rossi, M. Vretenar (CERN)*

In the Linac 4 and the SPL, a 3 MeV RFQ is required to accelerate the H^- beam from the ion source to the DTL input energy. While the 6-meter long IPHI RFQ was initially chosen for this application, a CERN study* suggested that a dedicated, shorter 3-meter RFQ might present several advantages. The 2D cross-section is optimized for lower power dissipation, while featuring simple geometrical shape suitable for easy machining. RF stability is evaluated using a 4-wire transmission model and 3D simulations, taking electrode modulation into account. The resulting RFQ is intrinsically stable and do not require rod stabilizers. End circuits are tuned with dedicated rods. RF power is fed via a ridged waveguide and a slot iris. Vacuum port assemblies are positioned prior to brazing to minimize RF perturbation. The 32 tuning slugs form a set of stable sampling, able to tune 9 modes. Tuner parameters are derived from bead-pull accuracy specification and fabrication tolerances. Signals delivered by pickup loops inserted in 16 of these tuners will be used to reconstruct the voltage profile under operation. Thermo-mechanical simulations are used to design temperature control specifications.

MOPD028 **Commissioning of a New CW Radio Frequency Quadrupole at GSI** – *P. Gerhard, W.A. Barth, L.A. Dahl, A. Orzhekhovskaya, K. Tinschert, W. Vinzenz, H. Vormann, S.G. Yaramyshev (GSI) A. Schempp, M. Vossberg (IAP)*

The super heavy element research is one of the outstanding projects at GSI. At SHIP* six new elements have been discovered; moreover, nuclear chemical experiments with transactinides were recently performed at TASCA**. This experimental program strongly benefits from high average beam intensities. In the past beam currents were raised significantly by a number of improvements. The present upgrade program comprises the installation of a superconducting (sc) 28 GHz ECR ion source, a new frontend (low energy beam transport and RFQ), and, in the long term, an sc cw Linac. For the short term, the new RFQ will raise the duty factor by a factor of two (50%), limited by the following accelerator only. This bottleneck will be resolved by the applied cw Linac. Beam tests with a newly developed sc CH cavity are scheduled for 2012. The setup of the RFQ as the major upgrade of the 20 year old HLI*** is in progress, the commissioning will be finished in March 2010. Besides a higher duty factor, improved longitudinal beam quality and transmission are expected. This paper reports on the challenging rf and beam commissioning.

MOPD029 **Development of a new Broadband Accelerating System for the SIS18 Upgrade at GSI** – *P. Hülsmann, R. Balss, H. Klingbeil, U. Laier, K.-P. Ningel, C. Thielmann, B. Zipfel (GSI)*

This paper describes the development of a new rf accelerating cavity based on novel magnetic alloy materials (MA-materials) for operation at harmonic number h=2 (f=0,43- to 2,8 MHz) to provide the necessary accelerating voltage for SIS18 injector operation with high intensity heavy ion beams in a fast operation mode with three cycles per second. The acceleration system consist of three units which are able to operate independently from each other. That is important, since each ion for FAIR has to cross the h=2-rf-system and in the case of a damage a reduced operation has to be ensured. Since the cavities are filled with lossy MA-ring-cores, which are iron based Finemet FT3M ring cores from Hitachi, the cavities show a broadband behaviour and thus no cavity tuning during the acceleration ramp will be necessary. Due to the high saturation field strength of Finemet (1,2 T) the overall length of all three cavity units can be very short. This is an important feature since due to many insertions which were additionally inserted into the synchrotron ring SIS12/18 in the meantime, the available length in SIS12/18 for the cavity units is with 4 m very short.

MOPD030 **The New cw-RFQ-Prototype** – *U. Bartz, J.M. Maus, A. Schempp (IAP)*

Abstract A short RFQ prototype was built for tests of high power RFQ structures. We will study thermal effects and determine critical points of the design. HF-Simulations with CST Microwave Studio and measurements were done. Conditioning of the facility with 20 kW/m and simulations of thermal effects with ALGOR are on focus now. First results and the status of the project will be presented.

MOPD031 **Development And Measurements on a Coupled CH Proton Linac for FAIR** – *R. B. Brodhage, H. Podlech, U. Ratzinger (IAP) G. Clemente, L. Groening (GSI)*

For the research program with cooled antiprotons at FAIR a dedicated 70 MeV, 70 mA proton injector is required. The main acceleration of this room temperature linac will be provided by six coupled CH-cavities operated at 325 MHz. Each cavity will be powered by a 3 MW klystron. For the second acceleration unit from 11.7 to 24.3 MeV a 1:2 scaled model has been built. Low level RF measurements have been performed to determine the main parameters and to prove the concept of coupled CH-cavities. For this second tank technical and mechanical investigations have been done in 2009 to prepare a complete technical concept for manufacturing. Recently, the construction of the prototype has started. The main components of this second cavity will be ready for measurements in spring 2010. At that time the cavity will be tested with dummy stems (made from aluminum) wich will allow precise frequency and field tuning. This paper reports on the technical development and achievements during the last year. It will outline the main fabrication steps towards that novel type of proton DTL.

MOPD032 **Superconducting CH-Cavity Development** – *M. Busch, M. Amberg, H. Podlech, U. Ratzinger (IAP)*

At the Institute for Applied Physics a superconducting CH-Cavity (Crossbar H-Mode) has been developed. It is the first multi-cell drift tube cavity for the low and medium energy range of proton and ion linacs. A 19 cell, $\beta = 0.1$ prototype cavity has been fabricated and tested successfully with a voltage of 5.6 MV corresponding to gradients of 7 MV/m. The construction of a new superconducting 325 MHz 7-gap CH-cavity has started. This cavity has an optimized geometry with respect to tuning possibilities, high power RF coupling, minimized end cell lengths and options for surface preparation. Static tuning is carried out by small niobium cylinders on the girders. Dynamic tuning is performed by a slow bellow tuner driven by a step motor and a fast bellow tuner driven by a piezo. Additional thermal and mechanical simulations have been performed. It is planned to test the cavity with a 10 mA, 11.4 AMeV ($\beta = 0.158$) beam delivered by the Unilac at GSI. Another cavity (f = 217 MHz, $\beta = 0.059$) is currently under development for the cw Heavy Ion Linac at GSI. It is the first of nine sc CH-Cavities planned for this project covering an energy range from 1.4 to 7.3 AMeV.

MOPD033 **Simulation for Beam Matching Section with RFQSIM** – *N. Mueller, P. Kolb, A. Schempp (IAP)*

The goal of the Frankfurt Funneling Experiment is to multiply beam currents by merging two low energy ion beams. In an ideal case this would be done without any emittance growth. Our setup consists of two ion sources, a Two-Beam-RFQ accelerator and a multi cell deflector which bends the beams to one common beam axis. The end section of the RFQ electrodes are designed to achieve a 3d focus at the crossing point of the two beam axis. New simulations with the RFQSIM-Code for a matching system with extended electrodes will be presented.

MOPD034 **A Beam Matching System for the Frankfurt Funneling Experiment** – *N. Mueller, M. Baschke, P. Kolb, A. Schempp (IAP)*

Funneling is a method to increase low energy beam currents in multiple stages. The Frankfurt Funneling Experiment is a model of such a stage. The experiment is built up of two ion sources with electrostatic lens systems, a Two-Beam-RFQ accelerator, a funneling deflector and a beam diagnostic system. The two beams are bunched and accelerated in a Two-Beam RFQ. A funneling deflector combines the bunches to a common beam axis. Current work is the construction and beam tests of a new beam transport system between RFQ accelerator and deflector. With extended RFQ-electrodes the drift between the Two-Beam-RFQ and the rf-deflector will be minimized and therefor unwanted emittance growth reduced. First rf and beam measurements with the improved Two-Beam-RFQ will be presented.

MOPD035 **Four-Rod RFQ Tuning** – *J.S. Schmidt, A. Schempp (IAP)*

The particle design of a RFQ uses a constant voltage along the structure. To reach this constant distribution we us tuning plates inserted between the stems, to change the local frequency. The final positions of the plates is using an iterative process of several flatness measurements. To reduce tuning time a program was written to find initial positions for them. The program will be described and the results will be compared with measurements.

MOPD036 **Simulations of Buncher-cavities with Large Apertures** – *P.L. Till, P. Kolb, A. Schempp, J.S. Schmidt, M. Vossberg (IAP)*

Buncher-cavities re-accelerate, bunch or re-bunch particle beams. A special form of these buncher-rf-cavities is a spiral-structure. Two different spiral resonators were simulated and build for the new EBIS LINAC at Brookhaven National Laboratory. These buncher-cavities have a remarkably large aperture of 100 mm. To optimize the cavities to the BNL-frequency of 100 MHz, simulations have been carried out. The impact of changing the gap width, drifttube-, and spiral arm-length on the design of the spiral cavities, has been analyzed. Results of simulations and measurement will be presented.

MOPD037 **Recent Studies on a 3-17MeV DTL for EUROTRANS with Respect to RF Structures and Beam Dynamics** – *C. Zhang, M. Busch, F.D. Dziuba, H. Klein, H. Podlech, U. Ratzinger (IAP)*

EUROTRANS is a EUROpean Research Programme for the TRANSmutation of High Level Nuclear Waste in an Accelerator-Driven System. Frankfurt University is responsible for the development of the 352MHz injector which mainly consists of a 3MeV RFQ and a 3-17MeV CH-DTL. Based on the beam dynamics design, the CH-cavities were designed with the concern to optimize the RF properties. In the cavity design, the tube-gap configurations were modified, so the beam dynamics has been adjusted to fit the new effective gap voltage profiles accordingly. A comparison of the beam dynamics results before and after the RF optimization is presented.

MOPD038 **Back-to-Back Cavities for Very Low Energy High Power Side Coupled Linacs** – *F. Galluccio, V.G. Vaccaro (Naples University Federico II and INFN)*

The design of BBAC (Back-to-Back Accelerating Cavity) tiles has been shown to be suitable for proton Side Coupled Linacs down to energies as low as 24 MeV. In this paper it will be shown that this design can be extended with profit down to 18 MeV, provided that in the process of optimization the standard quality indices, shunt impedance and energy gradient, are used in combination with the temperature rise in the cavities. A particular attention should also be devoted to the thermo-mechanical stress and strain due to the non-uniform temperature distribution.

MOPD039 **Development of Neutral Beam Injector System for ITER: Activities at the Test Facility** – *V. Antoni (Consorzio RFX, Associazione Euratom-ENEA sulla Fusione)*

In the framework of the strategy for the development and the procurement of the neutral beam injector (NBI) systems for ITER, it has been proposed to build in Padova, Italy, a test facility, including two experimental devices: a full size plasma source with 100 kV acceleration and a full size NBI at full beam power (1 MV, 40 A). These two different devices will separately address the main scientific and technological issues of the NBI for ITER. The plasma source will address the ITER performance requirements in terms of current density, uniformity, and electron/ion ratio in stationary operation at full current. The 1 MV NBI will address the aspects related to voltage holding up to 1 MV with the beam on and the optimisation of the beam optics in the presence of high thermal loads on the acceleration grids. The main design choices will be presented as well as an overview of the design of the main components of the systems.

MOPD040 **Secondary Particles in the Acceleration Stage of High Current, High Voltage Neutral Beam Injectors: the Case of the Injectors of the Thermonuclear Fusion Experiment ITER** – *G. Serianni, P. Agostinetti, V. Antoni, G. Chitarin, E. Gazza, N. Marconato, N. Pilan, P. Veltri (Consorzio RFX, Associazione Euratom-ENEA sulla Fusione) M. Cavenago (INFN/LNL) G. Fubiani (GREPHE/LAPLACE)*

The thermonuclear fusion experiment ITER, requires 33 MW of auxiliary heating power from two Neutral Beam Injectors (NBI), each of them providing 40 A of negative deuterium ions. The EU activities oriented to the realisation of the electrostatic accelerator comprise the construction in Padova of SPIDER, a facility devoted to the optimisation of the beam source. SPIDER parameters are: 100 keV acceleration, 40/60 A (deuterium/hydrogen) current. For the optimised SPIDER accelerator the present contribution provides a characterisation of secondary particles, which include electrons produced by impact of ions on grid surfaces, stripped from negative ions inside the accelerator, and produced by ionisation of the background gas, and the corresponding positive ions. Currents and heat deposited on the various grids and spatial distribution by secondaries will be described. It is found that most of the heat loads on the accelerator grids is due to electrons; moreover the features of secondaries exiting the accelerator and back-streaming towards the source will be presented. The results will be compared with old investigations concerning the NBI 1 MeV accelerator.

MOPD041 **Recent Progress in the Beam Commissioning of J-PARC Linac** – *M. Ikegami (KEK) A. Miura, G.H. Wei (JAEA/J-PARC) H. Sako (JAEA)*

The user operation of J-PARC linac was started in December 2008, and it has been operated with the limited beam power of less than 1.2 kW making efforts at improving hardware availability. Since November 2007, the beam power from the linac has been increased to 7.2 kW that corresponds to 120 kW from the downstream 3-GeV synchrotron. We also performed a high-power demonstration run with 18 kW (or 300 kW from the synchrotron) that corresponds to the design beam power for the present configuration. In the course of the beam power ramp-up, we have suffered from significant beam losses in the beam transport line after the linac. Accordingly, the emphasis of the beam tuning has been shifted to the mitigation of the uncontrolled beam losses. Some of the loss mechanisms are identified in the beam studies, and we have succeeded in mitigating them. In this paper, we present recent progress in the beam commissioning of J-PARC linac with emphasis on the effort to mitigate the beam losses.

MOPD042 **Commissionning of the IFMIF/EVEDA Accelerator Prototype Objectives, Organization and Plans** – *Ch. Vermare, P. Garin (IFMIF/EVEDA) P.-Y. Beauvais, A. Mosnier (CEA) A. Facco, A. Pisent (INFN/LNL) R. Heidinger (Fusion for Energy) A. Ibarra (CIEMAT) H. Kimura, S. Maebara, S. O'hira, Y. Okumura, K. Shinto, H. Takahashi (JAEA)*

In the frame of the IFMIF/EVEDA project, a high-intensity (125 mA) CW deuteron accelerator will be installed and commissioned at the Rokkasho's Broader Approach (BA) site. The main objective of this 9 MeV prototype is to provide information on the feasibility of the design, the manufacturing and the operation of the two linacs (up to 40 MeV) foreseen for IFMIF*. Based on the requirements for each System (Accelerators, Lithium target and Tests Facility) which are deduced from the IFMIF fusion material irradiation requirements, given by the users, the objectives of this accelerator prototype are defined and presented here. Also, because of the distributed nature of the design work and the procurement of the accelerator, organization of the installation and commissioning phase is essential. The installation and commissioning schemes, the organization proposed and the overall plans are presented.

MOPD043 **Thermal Characteristics of a New RFQ for J-PARC** – *Y. Kondo, K. Hasegawa, T. Morishita (JAEA/J-PARC) H. Matsumoto, F. Naito (KEK)*

A new RFQ for the J-PARC linac is under construction for more stable operation. The requirement of this RFQ is almost same as the now-operating one; the resonant frequency is 324MHz, the injection energy is 50 keV, the extraction energy is 3 MeV, peak beam current is 30 mA, and RF duty is 1.5%. The resonant frequency tuning during operation will be done by adjusting the temperatures of the cooling waters. In this paper, thermal characteristics of this RFQ and control system of the cooling water temperature is described.

MOPD044 **Fabrication of the New RFQ for the J-PARC Linac** – *T. Morishita, K. Hasegawa, Y. Kondo (JAEA/J-PARC) H. Baba, Y. Hori, H. Kawamata, H. Matsumoto, F. Naito, M. Yoshioka (KEK)*

The J-PARC RFQ (length 3.1m, 4-vane type, 324 MHz) accelerates a negative hydrogen beam from 0.05MeV to 3MeV toward the following DTL. As the trip rates of the practically using RFQ increased in autumn 2008, we started the preparation of a new RFQ as a backup machine. The beam dynamics design of the new RFQ is the same as the current cavity, however, the engineering and RF designs are changed. The processes of the vane machining and the surface treatments have been carefully considered to reduce the discharge problem. The vacuum brazing technique has been chosen for vane integration. In this report, the detailed design will be described with the progress of the fabrication of the new RFQ.

MOPD045 **Design and Simulation of C^{6+} Hybrid Single Cavity Linac for Cancer Therapy** – *L. Lu, T. Hattori, N. Hayashizaki (RLNR)*

A new type Linac, HSC (hybrid single cavity) linac for cancer therapy, which configuration combines RFQ (Radio Frequency Quadrupole) accelerating structure and DT (Drift Tube) accelerating structure is being finished designs and simulations now. This HSC linac design had adopted advanced power-efficiency-conformation, IH (Interdigital H) structure, which acceleration efficiency is extremely high in the low-middle energy region, and had also adopted most advanced computer simulation technology to evaluate cavity electromagnetic distribution. The study purposes of this HSC linac focus to design of injector linac for synchrotron of cancer radiotherapy facilities. Here, this HSC linac has an amazing space effect because of compact size by coupled complex acceleration electrode and integrated the peripheral device which is made operation easy to handle.

MOPD046 **Construction of New Injector Linac for RI Beam Factory at RIKEN Nishina Center** – *K. Yamada, S. Arai, M.K. Fujimaki, T. Fujinawa, N. Fukunishi, A. Goto, Y. Higurashi, E. Ikezawa, O. Kamigaito, M. Kase, M. Komiyama, H. Kuboki, K. Kumagai, T. Maie, M. Nagase, T. Nakagawa, J. Ohnishi, H. Okuno, N.S. Sakamoto, Y. Sato, K. Suda, H. Watanabe, T. Watanabe, Y. Watanabe, Y. Yano, S. Yokouchi (RIKEN Nishina Center) H. Fujisawa (Kyoto ICR)*

A new additional injector (RILAC2) is constructed at RIKEN Nishina Center in order to enable the independent operation of the RIBF experiments and super-heavy element synthesis. The RILAC2 consists of a 28 GHz superconducting ECR ion source, a low-energy beam transport with a prebuncher, a four-rod RFQ linac, a rebuncher, three DTL tanks, and strong Q-magnets between the rf resonators for the transverse focusing. Very heavy ions with m/q of 7 such as $^{136}Xe^{20+}$ and $^{238}U^{35+}$ will be accelerated up to the energy of 680 keV/u in the cw mode and be injected to the RIKEN Ring Cyclotron without charge stripping. The RFQ linac, the last tank of the DTL, and the bunchers have been converted from old ones in order to save the cost. Construction of the RILAC2 started at the end of the fiscal 2008. The RFQ and DTLs will be installed in the AVF cyclotron vault and be tested in March 2010. The ECR ion source and low-energy beam transport will be set on the RILAC2 in 2010 summer, and the first beam will be accelerated in 2010 autumn. We will present the details of the linac part of RILAC2 as well as the progress of construction which includes the result of high power test of resonators.

MOPD047 **Design of the RFQ Accelerator for the Compact Pulsed Hadron Source at Tsinghua University** – *Q.Z. Xing (TUB)*

The design progress of the Radio Frequency Quadrupole (RFQ) accelerator for the Compact Pulsed Hadron Source (CPHS) at Tsinghua University is presented in this paper. The beam dynamics are studied by the simulation of the proton beam in the RFQ accelerator with the code of PARMTEQM. The objective is to obtain the optimum structure of the RFQ accelerator with high transmission rate and tolerable total length of 3 meters. The RFQ accelerates protons from 50 keV to 3 MeV, with the RF frequency of 325 MHz. To save space and cost, no Medium-Energy-Beam-Transport (MEBT) will be placed upstream of the RFQ.

MOPD048 **The Primary Design of the DTL for the CPHS** – *S.X. Zheng, X. Guan, J. Wei (TUB) J.H. Li (CIAE) Y.L. Zhao (IHEP Beijing)*

Compact Pulsed Hadron Source (CPHS) was initiated at Tsinghua University to develop a university neutron source based on a 13 MeV, 50 mA proton linac which consists of ECR ion source, LEBT, RFQ and DTL. The primary design of the DTL for the CPHS is presented in this paper, which include the RF structure, dynamics calculation, RF field optimization and error analysis. This DTL can accelerate 50 mA proton beam from 3MeV to 13 MeV. PMQs is adopted in drift tubes.

MOPD049 **Conceptual Design of 50MHz RFQ for Rare Isotope Beams** – *Y.-S. Cho, J.-H. Jang, H.S. Kim, H.-J. Kwon (KAERI)*

We are designing a Radio Frequency Quadrupole (RFQ) as a lower energy part for a linear accelerator project in Korea, that can accelerate rare isotope beams to 200MeV/u. The RFQ accelerates the 10-keV/u heavy ion beams from ion sources (hydrogen molecules to uranium) or the rare isotope beams by in-flight separation, and injects the 300-keV/u beam to the superconducting linac. For the rf frequency, we chose 50 MHz for the rf frequency and four-vane with windows for the structure to operate the RFQ at CW mode. In the conference we will present the conceptual design.

MOPD050 **Operation of the PEFP 20MeV Proton Linac at KAERI** – *H.-J. Kwon, E.-M. An, Y.-S. Cho, I.-S. Hong, J.-H. Jang, D.I. Kim, H.S. Kim, H.R. Lee, K. Min, B.-S. Park, K.T. Seol, Y.-G. Song, S.P. Yun (KAERI)*

The 20MeV proton accelerator has been operating since 2007 when it got a operational license at Korea Atomic Energy Research Institute (KAERI) by Proton Engineering Frontier Project (PEFP). Beam properties such as emittnace and profile were measured at the low energy beam transport (LEBT) to characterize the beam into the RFQ. In addition, several parts were modified to test the adaptability of those which would be used for the 100MeV linac. The cooling method for the quadrupole magnet current lead was modified to the water cooling, and the main vacuum pumping system for the DTL changed to ion pump. Moreover, the modulator for the 100MeV linac was installed and tested in the 20MeV linac test bench. In this paper, the beam property measurement results and modification of the linac are presented.

MOPD051 **Design of KONUS IH-DTL for a Medical Accelerator** – *G. Hahn, D.H. An, H.B. Hong, H.S. Jang, I.S. Jung, J. Kang, K.U. Kang, G.B. Kim, Y.-S. Kim, H. Yim (KIRAMS)*

Design of 200MHz, 4MeV/u DTL (Drift Tube Linac) for a medical synchrotron is discussed. The cavity design is based on interdigital H type drift tube structure applying the KONUS (Kombineirte Null Grad Strukur) concept. 10 keV/u C^{4+} and H^{+} are considered as source particles. To reduce the beam loss at low energy accelerating section, RFQ with 610 keV/u extraction energy is used in front of the DTL. Two design procedure of DTL with KONUS concept were performed. For the first procedure, a constant electric field strength within the confines of 1.6 Kilpatrick limit is assumed along the whole drift tubes. For the second, a gradient shape voltage distribution which is the result of MWS simulation is used for reality. To focus the beam inside the DTL, two magnetic quadrupole triplet wrapped by metallic tube are used. This poster shows the schematic design of DTL, as well as the result of beam dynamics.

MOPD052 **Progress Work on High-current Heavy Ion Linac for ITEP TWAC Facility** – *V.A. Andreev, N.N. Alexeev, A. Kolomiets, V.A. Koshelev, V.G. Kuzmichev, S. Minaev, B.Y. Sharkov (ITEP)*

The new heavy ion high current injector for ITEP-TWAC Facility is now under construction at ITEP for acceleration of ions with 1/3 charge to mass ratio up to energy of 7 MeV/u and beam current of 100 mA. The 81.5 MHz RFQ section based on 4 vane resonator with magnetic coupling windows is constructed for the beam energy of 1.566 MeV/u. The RF tuning of RFQ section has been presently completed and basically confirms the expected parameters calculated by 3D OPERA codes. The windows improve both azimuthal and longitudinal stabilization of the operating mode by increasing the separation from parasitic modes. The second section of 163 MHz H-type resonator is designed and in progress for construction. Status of machine construction activity and beam dynamics calculation are presented.

MOPD053 **Conceptual Design of the ESS LINAC** – *M. Eshraqi, M. Brandin, I. Bustinduy, C.J. Carlile, H. Hahn, M. Lindroos, C. Oyon, S. Peggs, A. Ponton, K. Rathsman (ESS) R. Calaga, T. Satogata (BNL) A. Jansson (Fermilab)*

A three year design update for the European Spallation Source (ESS) linac is just starting and a full review of this work will be presented. The acceleration in the medium energy part of the LINAC using the spoke cavities have been optimized and the rest of the machine has been redesigned to incorporate this optimization. The ESS LINAC will deliver an average power of 5~MW to the target in the nominal design and the possibility to upgrade to 7.5~MW has been included in all the design steps.

MOPD054 **Mechanical Design, Brazing and Assembly Procedures of the Linac4 RFQ** – *S.J. Mathot, P. Bourquin, A. Briswalter, Th. Callamand, J. Carosone, N. Favre, J.-M. Geisser, A.M. Lombardi, V. Maire, M. Malabaila, D. Pugnat, Ph. Richerot, B. Riffaud, C. Rossi, M.A. Timmins, A. Vacca, M. Vretenar (CERN)*

The Linac4 RFQ will accelerate the H^{-} beam from the ion source to the energy of 3 MeV. The RFQ is composed of three sections of 1 meter each, assembled by means of ultra high vacuum flanges and an adjustable centering ring. The complete 3-m long RFQ will be supported isostatically over 3 points like a simple beam in order to minimise the maximum deflection. The ridge line, used to feed the RF power into the RFQ, will be supported via springs and its position adjusted in such way that no strain is introduced into the RFQ at the moment of its connection. The mechanical design has been done at CERN where the modules are completely manufactured, heat treated and brazed also. In that way, all of the processes are carefully controlled and the influence, notably of the heat treatments, has been understood in a better way. Since 2002 several four vanes RFQ modules have been brazed at CERN for the TRASCO and IPHI projects. A two-step brazing procedure has been tested. This technique is actually used for the assembly of the CERN Linac4 RFQ. This paper describes the design, the mechanical procedures adopted for machining and assembly and the first results obtained.

MOPD055 **Accelerating Structures Pre-stripping Section the MILAC Heavy Ion Linear Accelerator** – *V.A. Bomko, Ye.V. Ivakhno, A.P. Kobets, J.V. Meleshkova, Z.O. Ptukhina, S.S. Tishkin, B.V. Zajtsev (NSC/KIPT)*

Researches on development of new variants of accelerating structures with A/q=20 pre-stripping section PSS-20 are carried out. On an initial part of acceleration of ions from 6 keV/u up to 150 keV/u high capture in process of acceleration of the injected ions is provided interdigital (IH) accelerating structure with Radio-Frequency Quadrupole (RFQ) focussing. On the second part of acceleration of ions from 150 keV/u up to 1 MeV/u the highest rate of acceleration is created interdigital (IH) accelerating structure with drift tubes with the modified net focussing. Mathematical modelling geometrical and dynamic characteristics of accelerating structures pre-stripping section PSS-20 is executed. Updatings devices of adjustment which provide reception of the set working frequency 47,2 MHz, and also necessary distribution of an electric field along accelerating channels are developed.

MOPD056 **The Mechanical Engineering Design of the FETS RFQ** – *P. Savage, S.M.H. Alsari, S. Jolly (Imperial College of Science and Technology, Department of Physics) S.R. Lawrie, A.P. Letchford, P. Wise (STFC/RAL/ISIS) J.K. Pozimski (STFC/RAL)*

This paper will present the mechanical engineering design for a 324 MHz 4-vane RFQ, which has been developed for the Front End Test Stand (FETS) project based at the Rutherford Appleton Laboratory (RAL) in the UK. The design criteria will be discussed along with particular design features of the RFQ including the tuners, vacuum ports, main body cooling pocket design and the support / alignment structure. Different techniques for creating the RF and vacuum seal between major and minor vanes are also discussed.

MOPD057 **Assessing the Transmission of the H^- Ion Beam on the Front End Test Stand** – *S.R. Lawrie, D.C. Faircloth, A.P. Letchford, M. Perkins (STFC/RAL/ISIS) C. Gabor (STFC/RAL/ASTeC) J.K. Pozimski (Imperial College of Science and Technology, Department of Physics)*

The Front End Test Stand (FETS) at the Rutherford Appleton Laboratory is entering the next stage of construction and commissioning, with the three-solenoid magnetic Low Energy Beam Transport (LEBT) line being installed. As such, a thorough characterization of the beam leaving the Penning H^- ion source has been performed to gain knowledge of what will be injected into the LEBT. This includes measurements of the beam current through two toroids and the transverse emittance using slit-slit scanners. These measurements were performed over a wide range of source discharge and extraction parameters in order to understand how the transmission may be improved. Preliminary results of the beam after the LEBT will be given in order to assess the quality of the transported beam which will be injected into the FETS RFQ.

MOPD058 **Combined Electromagnetic-Thermal-Structural Simulation of the Four-metre Radio Frequency Quadrupole to be Installed on the Front End Test Stand** – *S.R. Lawrie, A.P. Letchford (STFC/RAL/ISIS) J.K. Pozimski, P. Savage (Imperial College of Science and Technology, Department of Physics)*

The Front End Test Stand being constructed at the Rutherford Appleton Laboratory (RAL) is entering the next stage of commissioning, with the three-solenoid magnetic Low Energy Beam Transport (LEBT) currently being installed and tested. The next major component to be manufactured is the 3 MeV, 324 MHz, four metre Radio Frequency Quadrupole (RFQ). The mechanical design is almost complete so a comprehensive Finite Element Model (FEM) of the entire RFQ has been made in ANSYS to ensure the electromagnetic, thermal and structural properties are sound. The results of the FEM - in particular the cooling strategy and expected resonant frequency shift due to thermal expansion - will be presented in this paper.

MOPD059 **Design of the RAL Front End Test Stand MEBT** – *D.C. Plostinar (STFC/RAL/ASTeC)*

The Medium Energy Beam Transport (MEBT) line for the Front End Test Stand (FETS) at RAL will transport a 60 mA, 2ms, 50 pps H^- beam at 3 MeV. It uses a number of quadrupoles, re-bunching cavities and a fast-slow chopping system. In this paper we present the underlying MEBT design philosophy, beam dynamics simulations and implementation details.

MOPD060 **Design Optimisation and Particle Tracking Simulations for PAMELA Injector RFQ** – *M.J. Easton, M. Aslaninejad, S. Jolly, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics) K.J. Peach (JAI)*

The PAMELA (Particle Accelerator for MEdicaL Applications) project aims to design an ns-FFAG accelerator for cancer therapy using protons and carbon ions. For the injection system for carbon ions, an RFQ is one option for the first stage of acceleration. Our integrated RFQ design process* has been developed further using Comsol Multiphysics for electric field modelling. The design parameters for the RFQ are automatically converted to a CAD model using Autodesk Inventor, and the electric field map for this model is simulated in Comsol. Particles can then be tracked through this field map using Pulsar Physics' General Particle Tracer (GPT). Our software uses Visual Basic for Applications and MATLAB to automate this process and allow for optimisation of the RFQ design parameters based on particle dynamical considerations. Possible designs for the PAMELA RFQ, including super-conducting and normal-conducting solutions, will be presented and discussed, together with results of the field map simulations and particle tracking for these designs.

MOPD061 **650 MHz Option for High-energy Part of the Project X linac** – *V.P. Yakovlev, I.G. Gonin, N. Perunov, N. Solyak (Fermilab)*

650 MHz option for the high energy part of the 2.6 GeV, CW Project X linac is discussed. It may give significant benefits compared to current 1.3 GHz option based on the utilization of ILC-type beta=1 cavities. Results of the break point optimization for linac stages, cavity optimization and beam dynamics optimization are presented. Possible reduction in the number of cryomodules and linac length compared to the current linac project version is discussed. Cryogenic losses are analyzed also.

MOPD062 **H-Mode Accelerating Structures with PMQ Focusing for Low-Beta Ion Beams** – *S.S. Kurennoy, J.F. O'Hara, E.R. Olivas, L. Rybarcyk (LANL)*

We are developing high-efficiency normal-conducting RF accelerating structures based on inter-digital H-mode (IH) cavities and the transverse beam focusing with permanent-magnet quadrupoles (PMQ), for beam velocities in the range of a few percent of the speed of light. Such IH-PMQ accelerating structures following a short RFQ can be used in the front end of ion linacs or in stand-alone applications, e.g. a compact deuteron-beam accelerator up to the energy of several MeV. Results of the combined 3-D modeling - including electromagnetic computations, beam-dynamics simulations with high currents, and thermal-stress analysis - for a full IH-PMQ accelerator tank will be presented. The accelerating field profile in the tank is tuned to provide the best beam propagation using coupled iterations of electromagnetic and beam-dynamics modeling. A cold model of the IH-PMQ tank is being manufactured, and we hope to report results of its measurements.

MOPD063 **Experimental Study of SNS MEBT Chopper Performance** – *A.V. Aleksandrov (ORNL)*

The chopper system for the Spallation Neutron Source (SNS) provides a gap in the beam for clean extraction from the accumulator ring. It consists of a pre-chopper in the low energy beam transport and a faster chopper in the medium energy beam transport (MEBT). It took several iterations to develop a working design with the required parameters. In this paper we describe the latest design of the MEBT chopper deflector and give results of the experimental verification of the chopper effectiveness, the gap cleanness and the rise time measured with high resolution using the SNS laser wire. The effect on the losses will be discussed as well.

MOPD064 **Bunched Beam Stochastic Cooling at COSY and Application to the NICA Project** – *T. Katayama (GSI) T. Kikuchi (Nagaoka University of Technology) R. Maier, D. Prasuhn, R. Stassen, H. Stockhorst (FZJ) I.N. Meshkov (JINR)*

The stochastic cooling is employed to reduce the momentum spread of accelerated 2 GeV proton beam at COSY. In addition the barrier voltages are successfully used to compensate the mean energy loss of the beam due to the thick internal target such as pellet target. To analyze the experimental results at COSY, we have developed the particle tracking code which simulate the particle behavior under the influences of stochastic cooling force, Schottky diffusion, thermal diffusion and IBS effects. The synchrotron motion due to the RF fields are included with 4th order symplectic way. The simulation results are well in agreement with the observed cooling process for the case of barrier voltage as well as RF field of harmonic number=1. In the present paper, the systematic analysis of the experimental results with use of the developed tracking codes are described. In addition the process of short bunch formation at the heavy ion collider at NICA project is investigated with use of the stochastic cooling. In that case the strong IBS effects are main limiting factor of making and keeping the short bunch as well as the space charge effects. Details of the simulation study will be presented.

MOPD065 **Beam Accumulation with Barrier Voltage and Stochastic Cooling** – *T. Katayama, M. Steck (GSI) T. Kikuchi (Nagaoka University of Technology) R. Maier, D. Prasuhn, R. Stassen, H. Stockhorst (FZJ) I.N. Meshkov (JINR)*

Anti-proton beam accumulation at CERN and FNAL has been performed with use of stochastic stacking in the momentum space. Thus accumulated beam has a large momentum spread and resultantly large radial beam size with large dispersion ring. In the present proposed scenario, beams from the pre-cooling ring are injected into the longitudinal empty space prepared by the barrier voltages and subsequently the stochastic cooling is applied. After the well cooling, barrier voltages will prepare again the empty space for the next beam injection. We have simulated the stacking process up to 100 stacking with use of the bunched beam tracking code including the stochastic cooling force and the diffusion force such as Schottky diffusion term, thermal diffusion, IBS effects. The synchrotron motion by barrier voltages are included with 4th order symplectic method. Examples of the application to 3 GeV anti-proton beam for the HESR ring in FAIR project are presented as well as the accumulation of heavy ion beam 3.5 GeV/u Au, at the NICA collider at JINR project.

MOPD066 **A Novel Method for the Preparation of Cooled Rare Isotope Beams** – *M. Steck, C. Brandau, C. Dimopoulou, C. Kozhuharov, F. Nolden (GSI)*

The ESR storage ring at GSI is operated with a wide range of heavy ions. In addition to stable heavy ions also rare isotope beams are studied in various experiments. A novel method to provide one- or few-component cooled fragment beams has been demonstrated experimentally. This technique uses a primary high energy heavy ion beam (several hundred MeV/u) bombarding a thick target in front of the storage ring. The reaction products are first separated by the magnetic structure of the storage ring. After storage of isotopes in a rigidity window of typically ± 2 per mille the isotopes are cooled to the same velocity by electron cooling. The cooled ions are circulating on different orbits according to their mass and charge. The momentum spread of the individual components is on the order 0.01 per mille or smaller depending on the intensity. The different components are radially well separated in regions with large dispersion. By the use of mechanical scrapers beam components in a certain radial region, corresponding to a range in masses and charges, can be selected, This way the stored rare isotope beam is curtailed to the components of choice.

MOPD067 **Status of the 2 MeV Electron Cooler for COSY/ HESR** – *J. Dietrich, V. Kamerdzhiev (FZJ) M.I. Bryzgunov, A.D. Goncharov, V.M. Panasyuk, V.V. Parkhomchuk, V.B. Reva, D.N. Skorobogatov (BINP SB RAS)*

The 2 MeV electron cooling system for COSY-Jülich was proposed to further boost the luminosity even in presence of strong heating effects of high-density internal targets. The project is funded since mid 2009. Manufacturing of the cooler components has already begun. The space required for the 2 MeV cooler is being made available in the COSY ring. The design and construction of the cooler is accomplished in cooperation with the Budker Institute of Nuclear Physics in Novosibirsk, Russia. The 2 MeV cooler is also well suited in the start up phase of the High Energy Storage Ring (HESR) at FAIR in Darmstadt. It can be used for beam cooling at injection energy and is intended to test new features of the high energy electron cooler for HESR. Two new prototypes of the modular high voltage system were developed, one consisting of gas turbines the other based on inductance-coupled cascade generators. The new 2 MeV electron cooler is described in detail and tests of components are reported.

MOPD068 **Stochastic Momentum Cooling Experiments with a Barrier Bucket Cavity and Internal Targets at COSY-Jülich in Preparation for HESR at FAIR** – *H. Stockhorst, R. Maier, D. Prasuhn, R. Stassen (FZJ) T. Katayama (GSI) L. Thorndahl (CERN)*

Numerical studies of longitudinal filter and time-of-flight (TOF) cooling suggest that the strong mean energy loss due to an internal Pellet target in the High Energy Storage Ring (HESR) at the FAIR facility can be compensated by cooling and operation of a barrier bucket (BB) cavity. In this contribution detailed experiments at COSY to compensate the mean energy loss are presented. The internal Pellet target was similar to that being used by the PANDA experiment at the HESR. A BB cavity was operated and either TOF or filter stochastic momentum cooling was applied to cool a proton beam. Experimental comparisons between the filter and TOF cooling method are discussed. Measurements to determine the mean energy loss which is used in the simulation codes are outlined. The experiments proved that the mean energy loss can be compensated with a BB cavity. Results are compared with numerical tracking simulations which include the synchrotron motion in a barrier bucket as well as in an h = 1 cavity and stochastic momentum cooling. A detailed discussion of the tracking simulation code will be outlined in a separate contribution to this conference.

MOPD069 **Ionization Cooling in a Low-energy ion Ring with Internal Target for Beta-beams Production** – *E. Benedetto (National Technical University of Athens)*

A compact ring with an internal target for the production of Li-8 or B-8 as neutrino or antineutrino emitters has been proposed*, to enhance the flux of radioactive isotopes for a beta-beam facility. The circulating beam is expected to survive for thousands of turns and, according to this scheme, the ionization cooling provided by the target itself and a suitable RF system will be enough to keep the beam transverse and longitudinal emittances under control. The ionization cooling potential for a preliminary ring design is here investigated by means of tracking simulations and analytical considerations, keeping in mind that a correct modeling of the beam-target interactions is fundamental for these studies. Technological issues for such a ring and possible show-stoppers are also briefly discussed.

MOPD070 **Numerical Study on Simultaneous Use of Stochastic Cooling and Electron Cooling with Internal Target at COSY** – *T. Kikuchi, N. Harada, T. Sasaki, H. Tamukai (Nagaoka University of Technology) J. Dietrich, R. Maier, D. Prasuhn, R. Stassen, H. Stockhorst (FZJ) T. Katayama (GSI)*

A small momentum spread of proton beam has to be realized and kept in a storage ring during an experiment with a dense internal target such as a pellet target. A stochastic cooling alone does not compensate the mean energy loss by the internal target. Barrier bucket operation will cooperate effectively the energy loss. In addition, the further small momentum spread can be realized with use of an electron cooling. In the present study, the simulation results on the simultaneous use of stochastic cooling and electron cooling at COSY are presented.

MOPD071 **Horizontal-Vertical Coupling for Three Dimensional Laser Cooling** – *T. Hiromasa, M. Nakao, A. Noda, H. Souda, H. Tongu (Kyoto ICR) K. Jimbo (Kyoto IAE) T. Shirai (NIRS)*

In order to achieve three dimensional crystal beam, laser cooling forces are required not only in the longitudinal direction, but also in the transverse directions. With the resonance coupling method*, transverse temperature is transmitted into longitudinal direction, and we have already demonstrated horizontal laser cooling experimentally **. In the present paper, we describe an approach to extend this result to three dimensional cooling. The vertical cooling requires that the horizontal oscillation couples with the vertical oscillation. For achieving horizontal-vertical coupling, a solenoid in electron beam cooling apparatus is utilized with an experiment (Q_x=2.07,Q_y=1.07). For various solenoidal magnetic fields from 0 to 40Gauss, horizontal and vertical betatron tunes are measured by beam transfer function. For a certain region of the solenoidal magnetic field, these tunes are mixed up each other. By optimization of such a coupling, we aim to proceed to three dimensional laser cooling.

MOPD072 **Optical Measurement of Transverse Laser Cooling with Synchro-Betatron Coupling** – *M. Nakao, T. Hiromasa, A. Noda, H. Souda, H. Tongu (Kyoto ICR) M. Grieser (MPI-K) K. Jimbo (Kyoto IAE) H. Okamoto (HU/AdSM) T. Shirai (NIRS) A.V. Smirnov (JINR)*

Experiments of transverse laser cooling for 24Mg+ beam have been performed at the small ion storage and cooler ring, S-LSR. It is predicted that the longitudinal cooling force is transmitted to the horizontal direction with synchro-betatron coupling at the resonant condition*. The laser system consists of a 532nm pumping laser, a ring dye laser with variable wavelength around 560nm, and a frequency doubler. The horizontal beam size and the longitudinal momentum spread were optically measured by a CCD and a PAT (Post Acceleration Tube) respectively**, ***. The CCD measures the beam size by observing spontaneous emission from the beam and records in sequence of 100ms time windows the development of the beam profile. The time variation of the beam size after beam injection indicates the transverse cooling time. The initial horizontal beam size, which was about 1mm, was decreased by 0.13mm in 1.5s. The longitudinal momentum spread measured by PAT is increased at the resonant condition. This suggests transverse temperature was transferred to longitudinal direction by synchro-betatron coupling. Both measurements denote the horizontal cooling occurred only in the resonant condition ****.

MOPD073 **Transverse Laser Cooling by Synchro-betatron Coupling** – *H. Souda, T. Hiromasa, M. Nakao, A. Noda, H. Tongu (Kyoto ICR) M. Grieser (MPI-K) K. Jimbo (Kyoto IAE) H. Okamoto (HU/AdSM) T. Shirai (NIRS) A.V. Smirnov (JINR)*

Transverse laser cooling with the use of a synchro-betatron coupling is experimentally demonstrated at the ion storage/cooler ring S-LSR. Bunched 40keV 24Mg+ beams are cooled by a co-propagating laser with a wavelength of 280nm. Synchrotron oscillation and horizontal betatron oscillation are coupled by an RF drifttube at a finite dispersive section (D = 1.1m) in order to transmit longitudinal cooling force to the horizontal degree of freedom*. Time evolution of horizontal beam size during laser cooling was measured by a CCD camera**. Horizontal beam sizes were reduced by 0.13mm within 1.5s after injection when the tune values satisfy a difference resonance condition, ν_s - ν_h = integer, at the operating tunes of (ν_h, ν_v, ν_s)=(2.067, 1.10^4, 0.067) and (2.058, 1.10^1, 0.058). Without resonance condition, the size reduction was negligibly small. The momentum spread was 1.7x10^{-4} on the resonance otherwise 1.2x10^{-4}. These results show that the horizontal heats are transferred to the longitudinal direction through the synchro-betatron coupling with the resonance condition and are cooled down by a usual longitudinal bunched beam laser cooling.

MOPD074 **Beam Lifetime with the Vacuum System in S-LSR** – *H. Tongu, T. Hiromasa, M. Nakao, A. Noda, H. Souda (Kyoto ICR) T. Shirai (NIRS)*

S-LSR is a compact ion storage and cooler ring to inject beam of the 7MeV proton and the 40MeV Mg+. The average vacuum pressure measured by the vacuum gauges without beam was achieved up to about 4x10^{-9} Pa in 2007. Many experiments have been carried out using the proton and Mg beam, for example the one-dimensional beam ordering of protons utilizing the electron cooler, the extraction tests of the short bunched beam and the laser cooling for the Mg beam had been performed. The beam lifetime can be estimated with the vacuum pressure or the loss-rate of the beam energy. The values of the estimated lifetime are nearly equal to the measured lifetime values. The present status of the proton beam lifetime and the vacuum pressure is reported.

MOPD075 **Effect of Secondary Ions on the Electron Beam Optics in the Recycler Electron Cooler** – *A.V. Shemyakin, L.R. Prost, G.W. Saewert (Fermilab)*

Antiprotons in Fermilab's Recycler ring are cooled by a 4.3 MeV, 0.1 - 0.5 A DC electron beam (as well as by a stochastic cooling system). Efficiency of the electron cooling system is critically dependent on the transverse velocities of the electrons in the cooling section. Several indirect measurements indicated that secondary ions may accumulate in the electron beam and increase these velocities, thus deteriorating the cooling rate. For instance, while keeping focusing settings optimum, the cooling rate was maximal when the electron beam current reached 0.1 - 0.2A, and dropped with further increase of the current. A new capability to clear ions was implemented by way of interrupting the electron beam for several microseconds with a repetition rate of up to 15 Hz. This paper describes the reasoning behind the hypothesis of the adverse effect of the ions background, prior observations, and the results of measurements with ion clearing. In particular, for a beam current of 0.3A, the longitudinal cooling rate was increased by factor of ~ 2 (after optimizing focusing) when ions were removed.

MOPD076 **Helical Cooling Channel Designs and Simulations for Muon Colliders** – *K. Yonehara (Fermilab) Y.S. Derbenev (JLAB) R.P. Johnson (Muons, Inc)*

Fast muon beam six dimensional phase space cooling is the most essential requirement for muon colliders. We have investigated the optimization of a helical cooling channel (HCC) using numerical simulations based on parameters that we believe can be achieved with magnet and RF systems that are now being developed. The first end-to-end cooling simulations for a HCC with three segments, each with increasing magnetic field strength and RF frequency to match the beam size as it is cooled, show 6-d cooling approaching six orders of magnitude with less than 20% beam loss. We discuss the HCC simulations, their optimization, and their expected evolution as more and more practical engineering constraints are included in the design.

MOPD077 **Progress on Analytical Modeling of Coherent Electron Cooling** – *G. Wang, M. Blaskiewicz, V. Litvinenko, S.D. Webb (BNL)*

We report recent progress on analytical studies of Coherent Electron Cooling. Velocity modulation in the modulator section is studied and a closed form solution is obtained for infinite homogeneous electron plasma. We investigate diffraction effects in the FEL amplifier under certain assumptions and obtain the transverse electron density distribution. Finally, we apply the transverse electron beam distribution as obtained from the FEL amplifier and calculate the electron density evolution inside the kicker section using an infinite electron plasma model.

MOPD078 **Large Aperture Electron Beam Scan with Vibrating Wire Monitor in Air** – *S.G. Arutunian, M.M. Davtyan, I.E. Vasiniuk (YerPhI)*

The Vibrating Wire Monitor (VWM) with aperture 20 mm was developed for scan of electron beam with large transversal sizes. Test experiments with VWM placed in air were done on the 20 MeV electron beam of Yerevan Synchrotron Injector with 4-7 uA at outlet. A new design of VWM is proposed for scan of the beam with even greater transversal sizes.

MOPD079 **A Novel Synchrotron Radiation Interferometer for the Australian Synchrotron** – *K.P. Wootton (Monash University, Faculty of Science) M.J. Boland (ASCo)*

A new arrangement for the synchrotron radiation interferometer was proposed - as far as is known, it is unique in the world. The Young's-type interferometer is composed of two independent and optically identical paths, each with a single slit on a motorised translating stage. These two single slit patterns are interfered to produce a double slit diffraction pattern. This arrangement permits rapid scanning of the profile of fringe visibility as a function of slit separation. The interferometer was used on two beamlines at the Australian Synchrotron, the optical diagnostic and infrared beamlines. The interferometer was used to measure the coherence of the photon beam created by the electron beam source, for normal and low emittance couplings. A large change in fringe visibility was observed, proving the experimental arrangement. The interferometer was validated in the measurement of the width of a hard-edged single slit, akin to Thompson and Wolf's diffractometer. Optical simulations and measurements inform proposed modifications to the optical diagnostic beamline, so as to implement the interferometer as a regular diagnostic tool.

MOPD080 **Upgrade of the Booster Beam Position Monitors at the Australian Synchrotron** – *E.D. van Garderen, A. C. Starritt, Y.E. Tan, K. Zingre, M.L.M. ten Have (ASCo)*

Thirty two Bergoz Beam Position Monitors are located in the Australian Synchrotron booster ring. They currently suffer from a poor signal-to-noise ratio and a low sample rate data acquisition (DAQ) system, provided by a portable DAQ device. This architecture is being upgraded to offer better performance. Phase matched low attenuation cables are being pulled and readout electronics will be located in two sites to reduce cable length. Data acquisition will be upgraded using a high accuracy PCI DAQ board. The board's trigger, originally delivered by a Delay Generator, will be generated by an Event Receiver output following our recent upgrade of the timing system. The new Linux driver will be EPICS-based, for consistency with our control system.

MOPD081 **Progress with Low Intensity Beam Diagnostics at ISAC** – *V.A. Verzilov (TRIUMF)*

The ISAC accelerators presently deliver various stable and radioactive CW heavy ion beams to experiments with energies ranging from 2keV/u up to about 4.5 MeV/u (for A/q = 6). Beam intensities also vary enormously being as low as a few hundred ions per second for certain radioactive ion species and as high as 100 enA for stable and pilot beams. Monitoring of beams with currents of less than ~0.5 epA requires a dedicated diagnostics instrumentation which typically makes use of radiation hard single particle detectors. Several such devices have been built and are under development at TRIUMF. Electron multiplier based SEEM monitors, solid state and scintillator detectors with a count rate capability in excess of 10^6 pps are employed. Device controls are integrated into the EPICS environment and provide standardized, simple and transparent operation. Details of the design, tests and beam measurements will be present.

MOPD082 **GEM-TPC Trackers for the Super-FRS at FAIR** – *M. Kalliokoski, F. Garcia, A. Numminen, E.M. Tuominen (HIP) R. Janik, M. Pikna, B. Sitar, P. Strmen, I. Szarka (Comenius University in Bratislava, Faculty of Mathematics Physics and Informatics) R. Lauhakangas (Helsinki University, Department of Physics)*

The Super-FRS is a superconducting fragment separator that will be built as part of the FAIR facility. For the slow-extraction part of the beam diagnostics system a total of 32 detectors are needed for beam monitoring and for tracking and characterization of the produced ions. Since GEM-TPC detectors can perform over wide dynamic range without disturbing the beam, they are suitable for this kind of in-beam detection. We have studied the performance of a prototype GEM-TPC. The current status of the prototype detector and the measurement results are shown.

MOPD083 **Improvements of the Set-up and Procedures for Beam Energy Measurements at BESSY II** – *P. Kuske, P.O. Schmid (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) R. Goergen, J. Kuszynski (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

With a 7T wiggler in operation any attempts to detect the resonant depolarization of the electron spins were unsuccessful at BESSY II. This was attributed to the severely reduced final degree of spin polarization in the alternating fields of the strong wiggler which on the other hand nearly double the radiation loss per turn. The key to a clear detection of the depolarization were the improvement of the sensitivity of the polarimeter based on the spin dependent Touschek scattering cross section and the more effective and thus full depolarization of the beam. In the paper the steps taken will be presented in detail. With these improvements in place the high precision energy determination of the stored beam can be performed once again in parallel to the normal user operation and without any noticeable perturbations to the beam.

MOPD084 **An Optical Electron Beam Imaging System of High Sensitivity at the Metrology Light Source** – *C. Koschitzki, A. Hoehl, R. Klein, R. Thornagel (PTB) J. Feikes, M.V. Hartrott, K. Holldack, G. Wuestefeld (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

For the operation of the Metrology Light Source (MLS)*, the electron storage ring of the Physikalisch-Technische Bundesanstalt (PTB), as a primary radiation source standard all storage ring parameters have to be known absolutely. For the measurement of the electron beam size and the monitoring of the stability of the orbit location a new imaging system has been set up, that operates at very different intensity levels covering more than

11 decades, given by the variation of the electron beam current. The system uses a commercial zoom lens for the achromatic optical imaging of the electron beam source point onto two different camera systems. One camera system is for life-imaging of the electron beam at electron beam currents from 200 mA down to some μA. The second system is a cooled CCD-camera that allows imaging of the electron beam size and location at very low currents, down to only one stored electron.

MOPD085 **Measurement and Correction of the Longitudinal and Transversal Tunes on the Fast Energy Ramp at ELSA** – *M. Eberhardt, F. Frommberger, W. Hillert, A. Roth (ELSA)*

At the electron stretcher accelerator ELSA of Bonn University, an external beam of either unpolarized or polarized electrons is supplied to hadron physics experiments. In order to correct dynamic effects caused by eddy currents induced during the fast energy ramp, the transversal tunes have to be measured in situ with high precision. These measurements are based on the excitation of coherent betatron oscillations generated by a pulsed kicker magnet. Horizontal oscillations were excited using one of the injection kicker magnets. Since its installation in 2009 a newly designed kicker magnet enables measurements in the vertical plane as well. Betatron oscillation frequencies were derived from a fast Fourier transform of the demodulated BPM signals, showing a well pronounced peak at the tune frequency. Using this technique, tune shifts were measured and corrected successfully on the fast energy ramp. Measurement and correction of coherent synchrotron oscillations are feasible as well, utilizing a quite similar technique. Coherent synchrotron oscillations are excited by a phase jump of the acceleration voltage using an electrical phase shifter in the reference RF signal path.

MOPD086 **Beam Position Monitoring based on Higher Beam Harmonics for Application in Compact Medical and Industrial Linear Electron Accelerators** – *M. Ruf, L. Schmidt (U. Erlangen-Nurnberg LHFT) S. Setzer (Siemens Med)*

The usability of conventional BPM topologies in compact linear accelerators used for medical and industrial applications is very limited due to tight space restrictions in such systems. To overcome these limitations, a different approach is introduced which is based on integrating the pickups into low-field regions of the accelerating structure and evaluating higher beam harmonics. Applications based on this approach will require RF frontends in frequency ranges beyond those covered by BPM dedicated hardware which is currently commercially available. Therefore, a demonstrator setup is presented which is capable of investigating suitable RF frontends for the proposed method. The demonstrator uses capacitive pickups of the button type for displacement sensing and allows for control of the beam position with the help of feedback steering coils which are typically used for compact linacs. Representative sensitivity measurement results based on the evaluation of the 2nd S-Band beam harmonic are also presented in this paper.

MOPD087 **Error Emittance and Error Twiss Functions - Reconstruction of Difference Orbit Parameters by BPMs with Finite Resolution** – *V. Balandin, W. Decking, N. Golubeva (DESY)*

The problem of errors, arising due to finite BPM resolution in the reconstructed orbit parameters, is one of the standard problems of the accelerator physics. Even so for the case of uncoupled motion the covariance matrix of reconstruction errors can be calculated "by hand", the usage of the obtained solution, as a tool for designing of a "good measurement system", is not straightforward. A better understanding of this problem is still desirable. We make a step in this direction by introducing dynamics into this problem, which seems to be static. We consider a virtual beam obtained as a result of the application of a reconstruction procedure to “all possible values” of BPM reading errors. This beam propagates along the beam line according to the same rules as any real beam and has all beam dynamical characteristics, such as emittances, dispersions, betatron functions, and all these values describe the properties of the BPM measurement system. As an application we formulate requirements for the BPM measurement system of high-energy intra-bunch-train feedback system of the European XFEL Facility in terms of the introduced concepts of error emittance and error Twiss parameters.

MOPD088 **Resolution Studies of Inorganic Scintillation Screens for High Energy and High Brilliance Electron Beams** – *G. Kube, C. Behrens (DESY) W. Lauth (IKP)*

Luminescent screens are widely used for particle beam diagnostics, especially in transverse profile measurements at hadron machines and low energy electron machines where the intensity of optical transition radiation (OTR) is rather low. The experience from modern linac based light sources showed that OTR diagnostics might fail even for high energetic electron beams because of coherence effects in the OTR emission process. An alternative way to overcome this limitation is to use luminescent screens, especially inorganic scintillators. However, there is only little information about scintillator properties for applications with high energetic electrons. Therefore a test experiment has been performed at the 855 MeV beam of the Mainz Microtron MAMI (University of Mainz, Germany) in order to study the spatial resolution. The results of this experiment will be presented and discussed in view of scintillator material properties and observation geometry.

MOPD089 **PETRA III Diagnostics Beamline for Emittance Measurements** – *G. Kube, J. Gonschior, U. Hahn, G. Priebe, H. Schulte-Schrepping, Ch. Wiebers (DESY) P. Ilinski (BNL) C.G. Schroer (TUD)*

PETRA III is the new 3rd generation hard X-ray synchrotron light source at DESY, operating at a beam energy of 6 GeV. Machine commissioning began in April 2009 and user operation starts in 2010. In order to achieve a high brilliance, damping wigglers with a total length of 80 m are installed to reduce the horizontal emittance down to an extremely low value of 1 nm rad. For a precise emittance online control, a dedicated diagnostics beamline was built up to image the beam profile with synchrotron radiation from a bending magnet in the X-ray region. The beamline is equipped with two interchangeable X-ray optical systems, a pinhole optic for standard operation and a high resolution compound refractive lens optic. In addition, the synchrotron radiation angular distribution can be exploited at high photon energies. In this presentation, first experience with the system will be reported.

MOPD090 **Upgrade and Evaluation of the Bunch Compression Monitor at the Free-electron Laser in Hamburg (FLASH)** – *C. Behrens, B. Schmidt, S. Wesch (DESY) D. Nicoletti (Università di Roma I La Sapienza)*

The control and stabilization of RF systems for accelerators has a considerable importance. In case of high-gain free-electron lasers (FEL) with magnetic bunch compressors, the RF phases determine the attainable bunch peak current, which is a relevant parameter for driving the FEL process. In order to measure the bunch peak current in a simple and fast but indirect way, both bunch compressors at FLASH are equipped with compression monitors (BCM) based on pyroelectrical detectors and diffraction radiators (CDR). They provide substantial information to tune the bunch compression and are used for beam-based feedback to stabilize RF phases. This monitor system becomes more important and more challenging after the installation of a third-harmonic RF system for longitudinal phase space linearization in front of the first bunch compressor. In this paper, we describe the hardware upgrade of the bunch compression monitor and show the expected performance by simulations of the CDR source and the radiation transport optics. Particle tracking simulations are used for generation of the simulated BCM-signal for various compression schemes. Comparison with experimental data will be presented.

MOPD091 **Picosecond to Femtosecond Temporal Overlap Measurements of Injected Electron and Soft X-ray Pulses at sFLASH** – *R. Tarkeshian, A. Azima, J. Boedewadt, H. Delsim-Hashemi, V. Miltchev, J. Rossbach, J. Rönsch-Schulenburg (Uni HH) R. Ischebeck (PSI) E. Saldin, H. Schlarb, S. Schreiber (DESY)*

sFLASH is a seeded FEL experiment at DESY, which uses a 38nm high harmonic gain (HHG)-based XUV-beam laser in tandem with FLASH electron bunches at the entrance of a 10m variable-gap undulator. The temporal overlap between the electron and HHG beams is critical to the seeding process. Use of a 3rd harmonic accelerating module provides a high current electron beam (at the kA level) with ~ 600fs FWHM bunch duration. The length of the HHG laser pulse will be ~30fs FWHM. The desired overlap is achieved in steps. First is the synchronization of the HHG drive laser (Ti: Sapphire, 800nm) and the incoherent spontaneous radiation from an upstream undulator. Next, the IFEL-modulated electron bunch will pass through a dispersive section, producing a density modulation in the beam. This in turn yields emission of coherent radiation from a downstream undulator or transition radiation screen when the longitudinal overlap of the two beams is achieved. The coherently enhanced light emitted will be then spectrally analyzed. The experimental layout, simulation results of generation and transport of both light pulses, and preliminary measurements are presented.

MOPD092 **The Diagnostics System at the Cryogenic Storage Ring CSR** – *M. Grieser, R. Bastert, K. Blaum, H. Buhr, D. Fischer, F. Laux, R. Repnow, T. Sieber, A. Wolf, R. von Hahn (MPI-K) A. Noda, H. Souda (Kyoto ICR)*

A cryogenic storage ring (CSR) is under construction at MPI für Kernphysik, which will be a unique facility for low velocity phase space cooled ion beams. Among other experiments the cooling and storage of molecular ions in there rotational ground state is planed. To meet this requirement the ring must provide a vacuum with a residual gas density below 10000 molecules/cm^3, which will be achieved by cooling the vacuum chamber of the ion beam to 2-10 K. The projected stored beam current will be in the range of 1 nA - 1 μA. The resulting low signal strengths on the beam position pickups, current monitors and Schottky monitor put strong demands on these diagnostics tools. The very low residual gas density of the CSR does not allow using a conventional residual gas monitor to measure the profile of the stored ion beam. Other methods were investigated to measure the profile of a stored ion beam. In the paper an overview of the CSR diagnostics tool and diagnostics procedures will be given.

MOPD093 **Nondestructive Beam Instrumentation and Electron Cooling Beam Studies at COSY** – *V. Kamerdzhiev, J. Dietrich (FZJ) C. Boehme (UniDo/IBS) T. Giacomini (GSI)*

To study electron cooling in a synchrotron nondestructive methods only are suitable. The ionization profile monitor (IPM) delivers real-time data in both transverse planes allowing detailed analysis of beam profile evolution in COSY. First attempts to use scintillation of residual gas (SPM) to measure beam profiles were very promising. Beam diagnostics based on recombination is usually used to optimize electron cooling of protons (H0-diagnostics). However, it is not available when cooling antiprotons. So the IPM and possibly the SPM are vital for electron cooling optimization in the HESR ring. The new beam instrumentation at COSY is introduced and its relevance for the new 2 MeV electron cooler project and the HESR are discussed. Results of beam studies performed during electron cooling beam times at COSY are presented.

MOPD094 **Single Bunch Operation at ANKA: Gun Performance, Timing and First Results** – *A. Hofmann, I. Birkel, M. Fitterer, S. Hillenbrand, N. Hiller, E. Huttel, V. Judin, M. Klein, S. Marsching, A.-S. Müller, N.J. Smale, K.G. Sonnad, P.F. Tavares (KIT)*

A new 90 kV e-gun had been installed at the 50 MeV microtron at ANKA. The emittance of the gun has been measured in long pulse mode (1 us, 200 mA) with a pepper-pot, resulting in 5 u.rad RMS normalised emittance. The single pulse width is less than 1 ns, resulting in a bunch purity in the storage ring of better 0.5 %. The old timing system for gun and injection elements based on 4 Stanford delay generator has now been replaced by an event driven system from Micro-Research Finland (MRF). This consists of one event generator and one event receiver. Visualisation and programming is achieved with PVSS from ETM Austria. The e-gun trigger can be adjusted in 10 ps steps. The entire system is phase locked to the 499.69 MHz RF signal.

MOPD095 **Various Improvements to Operate the 1.5 GeV HDSM at MAMI** – *M. Dehn, O. Chubarov, H. Euteneuer, R.G. Heine, A. Jankowiak, H.-J. Kreidel, O. Ott (IKP)*

During the last three years at the 1.5 GeV Harmonic Double Sided Microtron (HDSM)* of MAMI a lot of improvements concerning the longitudinal operation of the accelerator were tested and installed. To monitor the rf power dissipated in the accelerating sections, their cooling water flow and its temperature rise are now continuously logged. Phase calibration measurements of the linacs and the rf-monitors revealed nonlinearities of the high precision step-motor driven waveguide phase shifters. They were recalibrated to deliver precise absolute values. Thereby it is now possible to measure not only the first turn's phase very exactly, but also determine the linac's rf-amplitude within an error of less than 5%, using the well known longitudinal dispersion of the bending system. These results are compared to the thermal load measurements. For parity violating experiments the beam energy has to be stabilised to some ppm. A dedicated system measuring the time-of-flight through a bending magnet is now used in routine operation and controls the output energy via the proper linac phases.

MOPD096 **Plannar Microchannel Target** – *H.S. Zhang, K.Y. Gong, Y.F. Ruan (IHEP Beijing) J. Cao (IHEP Beiing)*

The analytic solution of a microchannel target for a uniform beam is given in one-dimentional model. The target surface temperature, maximum acceptable power density, and the function of various geometric parameter are deduced. The solution is modified for an axi-symmetric Gaussian beam. The analytic results are coincident with the numerical solution. A slit target used to measure beam energy spectrum for a beam with energy of 3.54MeV, average beam power of 36kW is developed.

MOPD097 **FERMI@Elettra Low-Energy RF Deflector FEM Analysis** – *D. La Civita, P. Craievich, M. Petronio (ELETTRA) Y.A. Kharoubi (Units)*

FERMI@Elettra is a soft X-ray fourth generation light source under construction at the ELETTRA laboratory. To characterize the beam phase space by means of measurements of the bunch length and of the transverse slice emittance two deflecting cavities will be positioned at two points in the linac. One will be placed at 250 MeV (low energy), after the first bunch compressor (BC1); the second at 1.2 GeV (high energy), just before the FEL process starts. The Low-Energy RF Deflector consists in a 5 cells, standing wave, normal conducting, RF copper cavity. A single ANSYS model has been developed to perform all of the calculations in a multi-step process. In this paper we discuss and report on results of electromagnetic, thermal, and structural analysis.

MOPD098 **Fast IR Array Detector for Transverse Beam Diagnostics at DAΦNE** – *A. Bocci, M. Cestelli Guidi, A. Clozza, A. Drago, A. Grilli, A. Marcelli, A.R. Raco, R.S. Sorchetti (INFN/LNF) A. De Sio, E. Pace (Università degli Studi di Firenze) L. Gambicorti (INOA) J.P. Piotrowski (VIGO System S.A.)*

At the LNF of INFN an IR array detector with a ns response time has been built and assembled in order to collect the IR image of the e-/e^+ sources at DAΦNE. Such detector is made by 32 bilinear pixels with a pixel size of 50x50 μm^2 and a response time of 1 ns. The device with its electronic board has been assembled for the installation on the e^+ ring of DAΦNE in the framework of an experiment funded by the INFN Vth Committee dedicated to beam diagnostics. A preliminary characterization of few pixels of the array and of the electronics has been carried out at the IR beamline SINBAD at DAΦNE. In particular the detection of the IR source of the e^- beam has been observed using four pixels of the array acquiring signals simultaneously with a 4 channels scope at 1GHz and at 4 Gsamples/s. The acquisition of 4 pixels allowed monitoring in real time differences in the bunch signals in the vertical direction. Preliminary analysis of data is presented and discussed. In particular we will outline how the differences in the signals can be correlated to small displacements of the source after the bunch refilling and during a complete shift of DAΦNE and before the refilling of electrons.

MOPD099 **High Brightness Beam Measurement Techniques and Analysis at SPARC** – *D. Filippetto, M. Bellaveglia, E. Chiadroni, A. Gallo, B. Marchetti (INFN/LNF) A. Cianchi (INFN-Roma II) A. Mostacci (Rome University La Sapienza) C. Ronsivalle (ENEA C.R. Frascati)*

Ultra-short electron bunch production is attractive for a large number of applications ranging from short wavelength free electron lasers (FEL), THz radiation production, linear colliders and plasma wake field accelerators. SPARC is a test facility able to accelerate high brightness beam from RF guns up to 150 MeV allowing a wide range of beam physics experiments. Those experiments require detailed beam measurements and careful data analysis. In this paper we discuss the techniques currently used in our machine; by combining quadrupoles, RF deflector, spectrometer dipole and reliable data analysis codes, we manage to characterize the 6D phase space and the beam slice properties. We focus on the ongoing studies on the emittance compensation in the velocity bunching regime.

MOPD100 **Very Fast Capacitive Probe for Electron Beams Pulses** – *V. Nassisi, M.V. Siciliano (INFN-Lecce) A. Lorusso (Laboratorio di Elettronica Applicata e Strumentazione, LEAS,)*

Real time diagnostic of short pulses is essential in sophisticate applications. Streak camera are able to detect sub ps pulses of particles beams, but during the diagnostic the beam is lost. Fast capacitive probes are simple devices conceived like a transmission line which allows during the measurement to utilise the beams. The probe electrodes must have suitable dimensions and forms. The central one is a folded ring in order to present the internal skin dimensions close to external one and a thickness able to contain the integrating resistor. This configuration avoids electromagnetic irradiations. The folded ring was 1.4 cm long and 0.8 cm thick, which introduce a delay time of about 100 ps. Analysing the behaviour of the probe with a 520 Ω integrating resistor, the voltage amplification resulted of $(3.6\pm0.1)x10^{-4}$ and as a consequence the current attenuation factor of 56±1 A/V. The rise time response was less than 185 ps, which was limited by oscilloscope bandwave. In vacuum electrical devices the capacitor probe can measure potential values of the order of 100 kV. Measurements of an electron beam delivered from a Zn by photoelectrical process will be presented*.

MOPD102 **Space Charge Analysis on the Multi-wire Proportional Chamber for the High Rate Incident Beams** – *K. Katagiri, T. Furukawa, K. Noda, E. Takeshita (NIRS)*

For the beam profile diagnosis of heavy ion cancer therapy in HIMAC (Heavy Ion Medical Accelerator in Chiba), a MWPC (Multi-Wire Proportional Counter) detector is employed as a beam profile monitor. Due to the high rate beams (~ 10^8 pps), a gain reduction of output signals, which is caused by space charge effects, have been observed in the scanning beam experiments at HIMAC. In order to reduce the gain reduction by optimizing the parameters of MWPCs including anode radius, and distance between electrodes, a numerical calculation code was developed by employing two-dimensional fluid model. In order to understand the relations between the gain reduction and space charge distribution, the temporal evolution of the ion/electron distribution were calculated for several hundredμseconds, which is significantly longer than the time period required for ions to travel between the electrodes. The output signal was also evaluated by the current flux into the anode and compared with that obtained by the beam experiment at HIMAC. The dependence of the gain reduction on the MWPC parameters was analyzed from these calculation results.

MOPD103 **Development of an Apparatus for Measuring Transverse Phase-space Acceptance** – *H. Kashiwagi, I. Ishibori, T. Ishizaka, S. Kurashima, N. Miyawaki, T. Nara, S. Okumura, W. Yokota, K. Yoshida, Y. Yuri, T. Yuyama (JAEA/TARRI)*

It is important to match the injection beam emittance to the acceptance of an accelerator for high beam transmission A system to evaluate transverse beam matching has been developed in the JAEA AVF cyclotron facility. In this presentation, concepts of an apparatus for transverse acceptance measurement will be reported. The apparatus consists of a phase-space collimator in the injection beam line and beam current monitor after the cyclotron. The collimator consists of two pairs of position defining slits and angle defining slits to inject an arbitrarily small portion of transverse phase-space into the cyclotron. Measurement of the acceptance is made by testing every portion in the whole phase-space, which should large enough to cover the acceptance. The acceptance can be estimated from the sum of the portions of the beam which passes through the system.

24-May-10	16:00 – 18:00	Poster	Poster Hall E

MOPE — Poster Session

MOPE001 **A Tank Circuit Monitoring a Large Number of Antiprotons in MUSASHI for the Production of Low Energy Antiproton Beams** – *H. Higaki, H. Okamoto (HU/AdSM) Y. Enomoto, C.H. Kim, N. Kuroda, Y. Matsuda, H.A. Torii, Y. Yamazaki (The University of Tokyo, Institute of Physics) H. Hori (MPQ) H. Imao, Y. Kanai, A. Mohri, Y. Nagata (RIKEN) K. Kira (Hiroshima University, Graduate School of Advanced Sciences of Matter) K. Michishio (Tokyo University of Science)*

In Antiproton Decelerator (AD) at CERN, unique low energy antiproton beams of 5.6 MeV have been delivered for physics experiments. Furthermore, the RFQ decelerator (RFQD) dedicated for Atomic Spectroscopy And Collisions Using Slow Antiprotons (ASACUSA) collaboration enables the use of 100 keV pulsed antiproton beams for experiments. What is more, Mono-energetic Ultra Slow Antiproton Source for High-precision Investigations (MUSASHI) in ASACUSA can produce antiproton beams with the energy of 100 ~ 1000 eV. Since the successful extraction of 250 eV antiproton beams reported in 2005, continuous improvements on beam quality and equipments have been conducted. Here, the basic properties of a tank circuit attached to MUSASHI trap are reported. Signals from a tank circuit provide information on the trapped antiprotons, as Shottky signals do for high energy beams in accelerators. In fact, it is known that this kind of trap-based beams are physically equivalent with those in a FODO lattice. Monitoring the tank circuit signals will be useful for on-line handling of the low energy antiproton beams from MUSASHI.

MOPE002 **Deflecting Cavity for Bunch Length Diagnostics in Compact ERL Injector** – *S. Matsuba (Hiroshima University, Graduate School of Science) Y. Honda, T. Miyajima (KEK)*

Energy Recovery Linac (ERL) as synchrotron light source is planned to construct in KEK. Before the construction of full-set of ERL, compact ERL to study the accelerator technologies will be constructed. For the injector, a high voltage photoemission gun with DC operation and measurement systems for the low emittance beam will be developed. In order to observe bunch length and longitudinal beam profile, we have designed a single-cell deflecting cavity with 2.6 GHz dipole mode. We describe the optimization of the cavity, mechanical design and the measurements results with simulation.

MOPE003 **Development of a Multi-stripline Beam Position Monitor for a Wide Flat Beam of XFEL/SPring-8** – *H. Maesaka, S.I. Inoue, S.M. Matsubara, Y. Otake (RIKEN/SPring-8)*

The x-ray FEL facility at SPring-8 produces a very short-bunch beam by using bunch compressors (BC) consisting of magnetic chicanes. Since the bunch compression ratio is strongly depends on the beam energy and the energy chirp, we need to monitor the energy from the beam position at the dispersive part of the BC with a 0.1% resolution. However, a beam profile at the dispersive part is horizontally flat and wide, maximally 50 mm, due to the large energy chirp of the beam. Therefore, we designed a multi-stripline beam position monitor. This monitor has a flat rectangular duct with a 70 mm width and a 10 mm height. Six stripline electrodes at individual intervals of 10 mm are equipped on each of the top and the bottom surface. Due to the small height of the monitor, each electrode is sensitive to the electron position within 10 mm in the horizontal. Therefore, the monitor provides a rough charge profile and the beam position which is calculated from the gravity center of the signals. We prepared a prototype of the monitor and tested it at the SCSS test accelerator. We confirmed that the position sensitivity was better than 0.1 mm, which corresponds to 0.1 % energy resolution.

MOPE004 **Development and Construction Status of the Beam Diagnostic System for XFEL/SPring-8** – *S.M. Matsubara, A. Higashiya, H. Maesaka, T. Ohshima, Y. Otake, T. Shintake, H. Tanaka, K. Togawa, M. Yabashi (RIKEN/SPring-8) H. Ego, S. Inoue, K. Tamasaku, T. Togashi, H. Tomizawa, K. Yanagida (JASRI/SPring-8)*

We report the design, performance, and installation of the beam diagnostic system of XFEL/SPring-8. The electron beam bunches of an XFEL accelerator are compressed from 1 ns to 30 fs by bunch compressors without emittance growth and peak-current fluctuation which directly cause SASE fluctuation. To maintain the stable bunch compression process, the accelerator requires rf caivty beam position monitors (BPM) with 100 nm resolution, OTR screen monitors (SCM) with a few micro-meter resolution, fast beam current monitors (CT) and temporal structure measurement systems with resolution under picosecond. The performance of the developed monitor instruments, such as the BPM, the SCM, and the CT, was tested at the SCSS test accelerator and satisfied with the requirements. To measure the temporal structure of the electron bunch, three type measurement systems, which are a streak camera, an EO sampling measurement, and a transverse deflecting cavity with a resolution of few-tens femtosecond, are being prepared. The streak camera and EO sampling shows the resolution of sub-picosecond. The installation of these beam diagnostic systems is going on smoothly.

MOPE005 **Countermeasure to Suppress the Filling Pattern Dependence of the BPM Electronics of SPring-8 Storage Ring** – *S. Sasaki, T. Fujita (JASRI/SPring-8)*

The signal processing electronics of the SPring-8 Storage Ring BPM were replaced during the summer shutdown of 2006, and put into operation. However, a large filling pattern dependence was observed. The cause was attributed to the nonlinear response of the diodes to large pulse signals. The diode were attached in front of the RF switches for protection from the electrostatic discharge damages on the switch IC. We took a countermeasure for the filling pattern dependence by reducing the pulse height with a band pass filter (BPF) in front of each channel. The BPF were attached and put into the operation from November 2008. The effect of the BPF was evaluated using the beam with changing the filling patterns and repeating the position measurements. The differences of the measured position data across the filling pattern change were found to be within 10μmeters, which was the same amount of the orbit drift during the filling pattern change. The reproducibility across the different filling pattern was expected to be better than 10μmeters, because orbit drift patterns arising from single kick like errors were observed in the differences of the position data.

MOPE006 **Feasibility Study of Radial EO-sampling Monitor to Measure 3D Bunch Charge Distributions with a Resolution of Femtosecond** – *H. Tomizawa, H. Dewa, H. Hanaki, S. Matsubara, A. Mizuno, T. Taniuchi, K. Yanagida (JASRI/SPring-8) T. Ishikawa, N. Kumagai (RIKEN/SPring-8) K. Lee, A. Maekawa, M. Uesaka (The University of Tokyo, Nuclear Professional School)*

We are developing a single-shot and non-destructive 3D bunch charge distribution (BCD) monitor based on Electro-Optical (EO) sampling with a manner of spectral decoding for XFEL/SPring-8. For fine beam tuning, 3D-BCD is often required to measure in real-time. The main function of this bunch monitor can be divided into longitudinal and transverse detection. For the transverse detection, eight EO-crystals surround the beam axis azimuthally, and a linear-chirped probe laser pulse with a hollow shape passes thorough the crystal. The polarization axis of the probe laser should be radially distributed as well as the Coulomb field of the electron bunches. Since the signal intensity encoded at each crystal depends on the strength of the Coulomb field at each point, we can detect the transverse BCD. In the longitudinal detection, we utilize a broadband square spectrum (> 400 nm at 800 nm of a central wavelength) so that the temporal resolution is < 30 fs if the pulse width of probe laser is 500 fs. In order to achieve 30-fs temporal resolution, we use an organic EO material, DAST crystal, which is transparent up to 30 THz. We report the first experimental results of this 3D-BCD monitor.

MOPE007 **Measurement of Low-Emittance Beam with Coded Aperture X Ray Optics at CesrTA** – *J.W. Flanagan, H. Fukuma, H. Ikeda, T.M. Mitsuhashi (KEK) J.P. Alexander, N. Eggert, W.H. Hopkins, M.A. Palmer, D.P. Peterson (CLASSE) B. Kreis (Cornell University)*

An x-ray beam size monitor based on coded aperture imaging* has been developed at CesrTA, for the purpose of making bunch-by-bunch, turn-by-turn measurements of low emittance beams. Using low-emittance beam (~44 pm, or 16 microns at the x-ray source point) we have been able to make detailed comparisons between the measured mask response and that predicted by theory, validating our simulations of the mask response. In turn, we demonstrate the ability to measure both integrated and single-bunch turn-by-turn beam sizes and positions for monitoring the progress of the low-emittance tuning of the machine, and for electron-cloud instability-related beam dynamics studies.

MOPE008 **Improved Measurement of Crabbing Angle by a Streak Camera at KEKB** – *H. Ikeda, J.W. Flanagan, H. Fukuma, T.M. Mitsuhashi (KEK)*

Crab cavities were installed in the KEKB rings in order to increase the luminosity. We measured the tilt of the bunches in the x-z plane using streak cameras. In a previous report*, the measured tilt in the HER was 2 times smaller than the expected crabbing angle, while the LER measurement was consistent with that expected. After the streak camera's vertical sweep speed was calibrated, the results were consistent with the expected crabbing angle in both rings.

MOPE009 **Improvement of the Resolution of SR Interferometer at KEK-ATF Damping Ring** – *T. Naito, T.M. Mitsuhashi (KEK)*

Some of the improvement were done for an SR interferometer with the Herschelian reflective optics*. Previously, the measured vertical beam size was limited to around 5μm with a double slit separation of 40mm and wavelength of 400nm at the ATF damping ring. Double slit separation was mainly limited to the effective aperture of the optical path between the source point and interferometer. This time, we re-aligned the optical path, and as a result, the effective aperture was increased. Using this re-alignment we can have a double slit separation of up to 60mm. To reduce air turbulence, the optical path was covered with a tight air duct. After these improvements were made, we succeeded in measuring a vertical beam size of 3.4μm with double slit separation of 60mm and wavelength of 550nm, which corresponds to 5pm of the vertical emittance assuming 3m of the beta function.

MOPE010 **Observation of Dust Trapping by Using Video Cameras** – *Y. Tanimoto, T. Honda, S. Sakanaka (KEK)*

Sudden decrease in the beam lifetime is sometimes observed in many electron storage rings. Such an event has been commonly attributed to dust trapping, but its mechanism has not been entirely elucidated yet. Our recent research at PF-AR has shown that trapped dust with certain conditions can be visually observed by video cameras, and the recorded movies revealed that the trapped dust moved longitudinally. In addition, the light emission from the dust indicated that its temperature reached -10-00 K or more. Thus, direct observation of trapped dust has been proved to be an effective way to investigate the dust trapping mechanism. We have carried on this research with advanced cameras, such as high-sensitivity or high-speed cameras, and the results will be presented.

MOPE011 **Shot-by-shot Beam Position Monitor System for Beam Transport Line from RCS to MR in J-PARC** – *M. Tejima, D.A. Arakawa, Y. Hashimoto (KEK) K. Hanamura (MELCO SC) N. Hayashi (JAEA/J-PARC) K. Satou, T. Toyama, N. Yamamoto (J-PARC, KEK & JAEA)*

To maintain the beam orbit of beam transport line from RCS to MR in J-PARC (3-50BT), 14 beam position monitors (BPMs) were installed. Their signals gathered in the local control building (D01) have been measured by using 14 digitizing oscilloscopes. The data acquisition system have a performance of shot-by-shot measurement.

MOPE012 **Performance of the Main Ring BPM during the Beam Commissioning at J-PARC** – *T. Toyama, D.A. Arakawa, S. Hiramatsu, S. Igarashi, S. Lee, H. Matsumoto, J.-I. Odagiri, M. Tejima, M. Tobiyama (KEK) K. Hanamura, S. Hatakeyama (MELCO SC) Y. Hashimoto, K. Satou, J. Takano (J-PARC, KEK & JAEA) N. Hayashi (JAEA/J-PARC)*
Experiences of operating BPM's during beam commissioning at the J-PARC MR are reported. The subjects are: (1) bug report, statistics and especially the effect of a beam duct step, (2) position resolution estimation (<30 micrometers with 1 sec averaging), (3) beam based alignment.

MOPE013 **Measurements of Proton Beam Extinction at J-PARC** – *K. Yoshimura, Y. Hashimoto, Y. Hori, Y. Igarashi, S. Mihara, H. Nishiguchi, Y. Sato, M. Shimamoto, Y. Takeda, M. Uota (KEK) M. Aoki, N. Nakadozono, T. Tachimoto (Osaka University)*
Proton beam extinction, defined as a residual to primary ratio of beam intensity, is one of the most important parameters to realize the future muon electron conversion experiment (COMET) proposed at J-PARC. To achieve the required extinction level of 10^{-9}, we started measuring beam extinction at main ring (MR) as the first step. The newly developed beam monitor was installed into the abort beam line and the first measurement was successfully performed by using the fast-extracted MR beam. We found that empty RF buckets of RCS, in which all protons were considered to be swept away by a RF chopper before injection to RCS,, contained about 10^{-5} of the main beam pulse due to chopper inefficiency. We are now developing a new beam monitor with improved performance for further studies at the abort line. In addition, we have started new measurements at the different stage of proton acceleration, i.e. at Linac, 3-50 BT line, and the main ring. In this paper, we present recent results and future prospect of beam extinction measurements.

MOPE014 **Development of a Nondestructive Beam Profile Monitor using a Nitrogen-molecule Gas-jet Sheet** – *Y. Hashimoto, T. Toyama (J-PARC, KEK & JAEA) T. Fujisawa (AEC) T. Morimoto (Morimoto Engineering) T.M. Murakami, K. Noda (NIRS) S. Muto (KEK) D. Ohsawa (Kyoto University, Radioisotope Research Center)*
A nondestructive beam profile monitor using a nitrogen-molecule gas-jet sheet has been developed for intense ion beams. The density of the gas-jet sheet corresponds to 1 x 10^{-3} Pa. A light emitted from nitrogen excited by an ion beam collision is measured with a high sensitive camera attached a radiation hard image intensifier. In tests, beam profiles of 6 MeV/u full-stripped oxygen beams whose peak current was 600 μA. were measured. This paper describes characteristics of the instruments and the beam test results.

MOPE015 **Application of a Single-wire Proportional Counter Tube to the Beam Loss Monitoring at J-PARC MR** – *K. Satou, Y. Hashimoto, T. Toyama (J-PARC, KEK & JAEA) H. Harada, K. Yamamoto (JAEA/J-PARC) S. Motohashi (Kanto Information Service (KIS), Accelerator Group) J.-I. Odagiri, M. Tejima (KEK)*
At the J-PARC MR, we have installed 316 Proportional counter tube Beam Loss Monitors (P-BLMs) at each Q-magnets and around some other components like collimators, kickers, and beam dumps. We also installed 40m long 20D coaxial cable using Air-filled Ionization Chambers (AICs). The total number of the AIC is 21 at present. Since the P-BLM has the maximum gain of 60000 at Bias=2kV, a low-level beam loss can be monitored in good time resolution of a several μs, thanks to a high output current. In addition to the beam loss monitoring, we measured residual dose of a beam pipe, down to the level of 20 μSv/h, by using the high gain ability. On the contrary to the improved output current, it includes so called gain reduction problem induced by high density space charges near the wire. We have investigated the output current sensitivity to controlled beam losses, cosmic rays, 10kGy/h class Co60 γ rays, and output current of the AIC. At the conference, the test results of the residual dose monitoring and the gain reduction problem will be reported.

MOPE016 **Beam Monitor System for Central Japan Synchrotron Radiation Research Facility** – *M. Hosaka, Y. Furui, H. Morimoto, A. Nagatani, K. Takami, Y. Takashima, N. Yamamoto (Nagoya University) M. Adachi, M. Katoh, H. Zen (UVSOR) T. Tanikawa (Sokendai - Okazaki)*

Central Japan Synchrotron Radiation Research Facility which provides synchrotron radiation for a large community of users is under construction in the Aichi prefecture, Japan. The light source accelerator complex consists of a linac, a booster synchrotron and a storage ring. We have developed beam monitor systems which play important role especially in the commissioning stage of the accelerators. An RF knockout system to observe betatron tune of the electron beam in the booster synchrotron and the storage ring has been designed. We paid special attention in an RF source fed to a shaker to realize efficient measurement of the tune of electron beam during acceleration. We made a test experiment using electron beam of a booster synchrotron of the UVSOR facility. We have also developed a BPM system which enables a single path beam monitoring. The signal processing is based on a fast digital oscilloscope and a simple preprocessor circuit which was developed to improve position resolution. The performance was evaluated using an injection beam pulse to the storage ring of the UVSOR.

MOPE017 **Status of the MICE Tracker System** – *H. Sakamoto (Osaka University)*

The Muon Ionization Cooling Experiment (MICE) is an accelerator and particle physics experiment aimed at demonstrating the technique of ionization cooling on a beam of muons. The transverse phase space will be measured by two identical trackers comprised of 5 measurement stations of scintillating fibre inside a 4T solenoid. Both trackers have been assembled and tested using cosmic rays and will be installed in the MICE hall at the Rutherford Appleton Laboratory in 2010. The design, construction and results from cosmic ray testing of both trackers are presented.

MOPE018 **A Negative Ion Beam Probe for Diagnostics of a High Intensity Ion Beam** – *K. Shinto (JAEA) O. Kaneko, M. Nishiura, K. Tsumori (NIFS) M. Kisaki, M. Sasao (Tohoku University, School of Engineering) M. Wada (Doshisha University, Graduate School of Engineering)*

We propose a negative ion beam probe system as a new scheme to diagnose beam profile of high power positive ion beams. Two RF linacs of IFMIF have to drive the neutron source by providing continuous-wave (CW) positive deuterium ion beams with the intensity of 125 mA each at the beam energy of 40 MeV. During the CW beam operations, the extreme intensity of the beam and the severe radiation levels make the beam diagnostics with conventional techniques in the transport lines terribly difficult. A beam of negative ions liable to lose the additional electron at the occasion of impact with a high energy particle can work as a probe to measure the positive ion beam profile. On possible configuration to achieve high intensity beam profile measurement is to inject a negative ion probe beam into the target beam perpendicularly, and measure the attenuation of the negative ion beam by beam-beam interaction at each position. We have started an experimental study for the proof-of-principle of the new beam profile monitoring system. The paper presents the status quo of this beam profile monitor system development and the prospects to apply the system to the IFMIF beam line controls.

MOPE019 **A Direct Measurement of the Longitudinal Phase Space for a Low Energy Electron Beam Using Energy Dependent Angular Distribution of Cherenkov Radiation** – *K. Nanbu, H. Hama, F. Hinode, M. Kawai, F. Miyahara, T. Muto, H. Oohara, Y. Tanaka (Tohoku University, School of Scinece)*

A thermionic RF gun has been developed to generate very short electron bunch for a THz light source at Tohoku University. Bunch compression scheme requires, in general, linear momentum distribution of the particles with respect to the longitudinal position, so that measurement of longitudinal phase space is significant for better bunch compression. However, such measurement for the low energy electrons is difficult because space charge effect is so strong that longer drift space should not be included. Consequently, we have performed deliberation for employing energy dependent angular distribution of Cherenkov radiation. Though the energy dependence of emission angle of Cherenkov radiation is rapidly getting small as increasing the beam energy, it is still 25 deg/MeV at an energy around 2.0 MeV when we use radiator having refractive index of 1.035. Thus the beam energy distribution can be measured if we observe Cherenkov ring with sufficient angular resolution. Since this method needs only thin radiator, the drift space length will be minimized. We will discuss limitation for resolutions of both the time and the energy as well.

MOPE020 **Beam Based Alignment of the Beam Position Monitor at J-PARC RCS** – *N. Hayashi, H. Harada (JAEA/J-PARC) M. Tejima (KEK) T. Toyama (J-PARC, KEK & JAEA)*

The J-PARC RCS is an M-Watt class rapid cycling synchrotron and it has delivered an intensive beam to the neutron target and the MR. In order to overcome large space charge effect, its physical aperture is designed to be more than 250mm in diameter. Even though its chamber size is very large, the BPM system gives precise data to determine beam optics parameters of the ring. For this purpose, only relative positions and resolutions are important. However, for much higher intensity, the absolute beam position and accurate COD correction are indispensable. We have carefully installed the BPM and measured the position with respect to the quadrupole magnet (QM) nearby. But it is also necessary to estimate its absolute position by using beam. If each QM could be controlled independently, the simple beam based alignment technique can be utilized, but it is not the case for RCS. There are seven families of QM, and only each family can be controlled at one time. We developed a new technique by expanding the simple method for the case of multiple QM focusing changed simultaneously, and applied to the J-PARC RCS. The paper describes this method and discussed about experimental results.

MOPE021 **Operational Performance of Wire Scanner Monitor in J-PARC Linac** – *A. Miura (JAEA/J-PARC) H. Akikawa, M. Ikegami (KEK) H. Sako (JAEA)*

A wire scanner monitor (WSM) is one of essential measurement devices for beam commissioning of current accelerators. J-PARC Linac also employs a number of WSMs for transverse beam profile. The transverse matching is performed based on the measured beam width. In addition, we have tried to measure halo component with the BSMs. In this paper, we present the experimental results obtained in a beam study to characterize the operational performance of the WSM.

MOPE022 **Development of Shintake Beam Size Monitor for ATF2** – *Y. Kamiya (ICEPP) S. Araki, T. Okugi, T. Tauchi, N. Terunuma, J. Urakawa (KEK) S. Komamiya, M. Orouku, T.S. Suehara, Y. Yamaguchi, T. Yamanaka (University of Tokyo)*

In this paper, we describe a system design and current status of Shintake beam size monitor. Shintake monitor is a laser-based beam diagnostics tool, which provides a non-invasive measurement of transverse beam sizes. The interaction target probing the electron beam is interference fringes build up by the two coherent lasers that have narrow bandwidth and long coherent length. A scale of the target structure corresponds to approximately one fourth of the laser wave length, and the smallest measurable size reaches down to several tens of nanometers. The monitor we described here is installed at the virtual interaction point of the ATF2 beam line, which is built to confirm the proposed final focus system for Future Linear Colliders. We adopt second harmonics of Nd:YAG laser of 532 nm wavelength, and phase stabilization feedback system to allow to measure the designed beam size of about 37 nm. To widen a measurable range up to about 5 microns (wire scanner's range), we also prepare three crossing modes that change an effective wavelength for the fringes. The monitor is used to measure a focus size during the tuning process. The system is based on the Shintake monitor for FFTB.

MOPE023 **Evaluation of Expected Performance of Shintake Beam Size Monitor for ATF2** – *Y. Yamaguchi, S. Komamiya, M. Orouku, T.S. Suehara, T. Yamanaka (University of Tokyo) S. Araki, T. Okugi, T. Tauchi, N. Terunuma, J. Urakawa (KEK) Y. Kamiya (ICEPP)*

ATF2 is the final focus test facility for ILC to realize and demonstrate nanometer focusing. One of the major goals of the ATF2 is an achievement of a 37 nm beam size in vertical. To achieve this goal, a beam size monitor capable of nanometer beam size measurement is inevitably needed. Shintake monitor satisfies the demand and is installed at the virtual interaction point of the ATF2. The monitor detects inverse Compton scattering photons emitted by collision between YAG laser photons and electron beam. Since the signal photons emit parallel to the electron beam, a gamma detector for Shintake monitor is located downstream of the focal point. The gamma detector is composed of multi-layer CsI scintillators, which acquire information on shower development owing to this structure. Since the Compton signal and higher energy background is different in shower development, they can be separated in the analysis. With this method, the detector shows high resolution even in severe background conditions. We measured the resolution of the detector in the beam test performed at the ATF2. Based on those measurements, expected performance of Shintake monitor is evaluated for about 37 nm beam size.

MOPE024 **Development of Radiation Registant Optics System for High Intensity Proton Beamline at the J-PARC** – *A. Toyoda, A. Agari, E. Hirose, M. Ieiri, Y. Katoh, A. Kiyomichi, M. Minakawa, T.M. Mitsuhashi, R. Muto, M. Naruki, Y. Sato, S. Sawada, Y. Suzuki, H. Takahashi, M. Takasaki, K.H. Tanaka, H. Watanabe, Y. Yamanoi (KEK) H. Noumi (RCNP)*

Optical beam measurement such as OTR(Optical Transition Radiation), ODR(Optical Diffraction Radiation), gas Cerenkov, and so on is a powerful tool to observe a two-dimensional information of high intensity beam profile, so that this method is widely used at various electron and hadron accelerators. However, high radiation field to damage an optical system gradually becomes a major issue with increasing the beam intensity to explore new physics. Our present effort is devoted to develop a high efficient optical system to resist such high radiation field. We newly designed an optical system composed of two spherical mirrors which do not have any lenses vulnerable to radiation. Detailed optics design and a result of optical performance test will be presented. Also we will report a result of a beam test experiment of this optics system combined with an OTR screen performed at high intensity proton extraction beamline of the J-PARC.

MOPE025 **Status of Beam Diagnostics for SESAME** – *S. Varnasseri (SESAME)*

SESAME machine consists of a 22.5 MeV microtron, 800 MeV booster and a 2.5 GeV storage ring. The electron beam diagnostics will play a major rule during the commisioning and normal operation with different modes of single bunch and multi bunch operations. Furthermore the beam parameteres during injection, acceleration and storing the beam will be measured, monitored and integrated into other subsystems. The major diagnostics components and the general design for booster and storage ring are reported in this paper.

MOPE026 **The Wire Scanner at BEPCII** – *Y.F. Sui (IHEP Beijing)*

To monitor the beam profile at the end of linac non-destructively, Wire scanner as a new diagnostic instrument was designed, manufactured and installed in 2007. After that, we had done beam test for several times using this device. This paper describes the whole system of wire scanner and beam test result.

MOPE027 **Simulations for the Measurements of Longitudinal Bunch Profile using Coherent Smith-Purcell Radiation** – *D. Wu, W. Liu, C.-X. Tang (TUB)*

The coherent Smith-Purcell radiation (CSPR) has been demonstrated as an efficient technique for measuring the longitudinal profile of beam bunches. To measure the ultrashort beam bunches, the simulations for the measurements using CSPR are anlyzed with tools of three dimensional particle-in-cell simulations and Kramer-Kronig reconstruction. Different parameters such as rms length of beam bunch and profiles of grating are studied. Furthermore, the measurement device based on a Martin-Puplett Interferometer is introduced, in which noises and attenuation can be reduced.

MOPE028 **Analysis and Calculation of Beam Energy Spread Monitor for HLS LINAC** – *J. Fang, P. Lu, Q. Luo, B. Sun, X.H. Wang (USTC/NSRL)*

The energy spread measurement by use the energy spectrum analysis system at HLS LINAC now is an intercepting measurement which can't measure the real injection beam. To achieve the non-intercepting measurement, a new Beam position monitor (BPM) with eight stripline electrodes in four-axis symmetry is designed, which can measure the energy spread at HLS LINAC in real time. This paper has introduced the physical structure of this new BPM which include eight 20 degree opening angle, 1/4 wavelength (26.2mm) length Stripline electrodes in detail, analyzed and calculated the electrode response and picking up the quadrupole component, and got the theoretical sensitivities of different methods. The BPM is simulated and calculated by CST Microwave Studio Program. The results shows the parameters such as characteristic impedance, electrode coupling degree, time-domain response and frequency-domain response etc are all meet the requirement of HLS LINAC and transfer line.

MOPE029 **Cold Test of S-band Re-entrant Cavity BPM for HLS** – *Q. Luo, J. Fang, B. Sun (USTC/NSRL)*

An S-band re-entrant cavity BPM is designed for new high brightness injector at HLS. To estimate the performance of the BPM, a prototype cavity is given and a cold test is performed. According to the results of computer simulation, it is confirmed that performance of real BPM can be estimated based on results of cold test. Position resolution of prototype BPM is better than 3 μm and cross-talk problem is detected. Ignoring nonlinear cross-talk, transformation matrix is a way to correct cross-talk.

MOPE030 **Bunch-by-bunch Beam Current Monitor for the HLS** – *T.J. Ma, C. Li, W.B. Li, P. Lu, B. Sun, L.L. Tang, Y.L. Yang (USTC/NSRL)*

A new beam current monitor (BCM) has been implemented on Hefei Light Source (HLS) recently. It has been used for bunch-by-bunch beam current measurement, which is useful for filling control and longitudinal feedback, etc. The BCM consists of three parts: the front-end circuit, a high sampling rate oscilloscope for beam current signal acquisition and the data processing system. The signals from the beam position monitor of the storage ring are manipulated by the front-end circuit first, then sampled by the Agilent MSO710^4 oscilloscope and transported into the control computer for data processing. The sampling rate of the oscilloscope is up to 4GHz and the trigger rate is 4.533 MHz. The data processing program is supported by the LabVIEW. The measurement of beam current in multi-bunch operation mode is described. Some important results are summarized.

MOPE031 **Control and Analysis System for Digital Feedback in HeFei Source** – *M. Meng, Y.B. Chen, J.H. Wang, Y.L. Yang, Z.R. Zhou (USTC/NSRL)*

In HLS we employ the TED FPGA based processor for digital feedback system. To make feedback system work better and more easily, we developed the control and analysis system based on matlab chiefly. The system do jobs as following: sampling data online and finishing its analysis; calculating fir filter parameters and generating .csv(format for FPGA) file to get the best gain and phase flexibly according to different beam working point; simulating the beam changes in different feedback gain and other stations to check whether the system work properly.

MOPE032 **Application of the Gige Vision Digital Camera for Beam Diagnostics in HLS** – *L.L. Tang, L.M. Gu, P. Lu, T.J. Ma, B. Sun, J.G. Wang, X.H. Wang (USTC/NSRL)*

GigE Vision (Gigabit Ethernet vision standard) is a new interface standard for the latest vision of cameras with higher performance compared to analogue vision standard and other digital vision standard. In recent years, the market of industrial vision components is evolving towards GigE Vision. This paper presents applications of digital camera comply with GigE Vision standard for the measurement of beam profile and emittance at the storage ring of HLS (Hefei Light Source). These cameras provide low distortion for image transmission over long distance with high image rate. Using the image of beam profile transmitted by GigE Vision digital camera, we calculated the horizontal and vertical center positions, and then we calibrated these center positions by BPM (Beam Position Monitor) system. According to the result of calibration and the pixel size of CCD sensor, transverse sizes of beam profile were calculated, further more the transverse emittance and coupling factor were calculated as well.

MOPE033 **A New Beam Profile Diagnostic System based on the Industrial Ethernet** – *Y.C. Xu, Y.Z. Chen, K.C. Chu, L.F. Han, Y.B. Leng, G.B. Zhao (SINAP)*

A new beam profile diagnostic system based on industrial Ethernet has been installed in Shanghai Deep Ultraviolet Free Electron Laser (SDUV-FEL) facility recently. By choosing GigE Vision cameras, the system provides better image quality over a long distance than before. Beam images are captured from the beam profile monitors which are controlled by air cylinders or step motors. In order to fit for the system expansibility and curtail the cables, all devices are operated through the Ethernet and distributed along the FEL facility. The approach to the design of the hardware and software will be described in this paper. Applications and experiment results will be shown in this paper as well.

MOPE034 **Data Acquisition for SSRF Ring Bunch Charge Monitor** – *Y.B. Leng, Y.B. Yan, L.Y. Yu, W.M. Zhou (SSRF)*
Bunch charge uniformity control is very important for storage ring top-up operation. In order to monitor filling pattern and measure bunch charge precisely an PXI waveform digitizer based data acquisition system was developed to retrieve bunch charge information from BPM pickup signals. Effective sampling rate could be extended to 400GHz by waveform rebuilding technology, which folds multi turns data into single turn with real time sampling rate of 8GHz. Online evaluation shows charge resolution could be better than 0.5% for 1nC range.

MOPE035 **Development of Electronics for Beam Position Monitor at ATF2 Interaction Point Region** – *A. Heo, E.-S. Kim, Y.I. Kim (Kyungpook National University) S.T. Boogert (Royal Holloway, University of London) Y. Honda (KEK) H.K. Park (KNU) D. Son (CHEP)*
Nanometer resolution Beam Position Monitors have been developed to measure and control beam position stability at the interaction point region of ATF2. The position of the beam focused has to be measured within a few nanometer resolution at the interaction point. In order to achieve this performance, electronics for this BPM was developed. Every component of the electronics have been simulated and checked by local test and using beam signal. We will explain each component and define their working range. Then, we will show the performance of the electronics measured with beam signal.

MOPE036 **Preliminary Implementation for the RF and Beam Current Monitor System Using EPICS** – *Y.-G. Song, E.-M. An, Y.-S. Cho, D.I. Kim, H.-J. Kwon (KAERI)*
The PEFP (Proton Engineering Frontier Project) is constructing a 100-MeV proton accelerator, consisting of a 50-keV proton injector, LEBT (Low Energy Beam Transport), a 3-MeV RFQ (Radio Frequency Quadrupole), a 20-MeV DTL (Drift Tube Linac), 100-MeV DTL, and beam lines. In order to monitor signals measured from RF components and beam current monitors equipped to the 20-MeV proton accelerator, the commercial digital sampling oscilloscopes (DSO) are used. The signals, which are measured from the DSOs, must be calibrated and transmitted promptly to accelerator operators. So LabView as Window PC-based software, which equipped with various VISA (Virtual Instruments Software Architecture) interface as a standard I/O language for instrumentation programming, was chosen to do this data acquisition. The LabView was built with EPICS middleware by using the Window-based shared memory approach. In this paper, the preliminary design and implementation on integrating EPICS and LabView for the RF and beam current monitor are described.

MOPE037 **Measurement of Beam Size at Pohang Light Source** – *J.Y. Ryu, E.-S. Kim, H.D. Kim, H.K. Park (KNU) C. Kim (PAL)*
The synchrotron-radiation interferometer was employed for the beam size measurement of electron beam circulating in the storage ring at 2.5 GeV Pohang Light Source. We measured the beam sizes in both vertical and horizontal directions as function of stored beam current. In this presentation, we will discuss the interferometer system, analysis method for the measurement and the measured results. We also compared the measured beam sizes with predicted values from the lattice parameters in the ring.

MOPE038 **Optimization of Two Dimensional SR Interferometer** – *C. Kim, I. Hwang, S.J. Park (PAL) H.K. Park, J.Y. Ryu (KNU)*
A two dimensional SR Interferometer is optimized for the beam size measurement in the diagnostic beam line of the PAL. Numerical studies are performed for design of the slit size and the slit separation. Their results are conformed by experiments as well. In addition, several components of the SR Interferometer are upgraded to improve measurement accuracy.

MOPE039 **Beam Parameter Measurements of fs-THz Linac at PAL** – *C.M. Yim, S. Noh (POSTECH) H.-S. Kang, C. Kim, I.S. Ko (PAL)*

At Pohang Accelerator Laboratory, a femto-second THz facility was constructed for the experiments using femto-second THz radiation. The fs-THz radiation is generated from 60-MeV electron linac which consists of a photocathode RF gun, two accelerating columns, and two magnetic-chicane bunch compressors. The coherent transition radiation (CTR) is used for THz radiation generation. To generate high intensity THz radiation, the electron bunch length should be smaller than 200 fs. We report THz image obtained using IR-CCD camera and measured beam parameters including bunch length, energy spread, charge, emittance, and transverse beam size.

MOPE040 **Investigation of the Formation of a Hollow Beam in the Plasma Lens** – *A.A. Drozdovsky, S.A. Drozdovsky, A. Golubev, A.P. Kuznetsov, Yu.B. Novozhilov, S.M. Savin, B.Y. Sharkov, V.V. Yanenko (ITEP)*

Application of a plasma lens to focusing of ion beams has a number of essential advantages. It is important that the focusing capabilities of the lens depend on the stage of plasma development. Under certain conditions a magnetic field is linear, that allow to focus the beam to a very small spot. In other conditions, the magnetic field is nonlinear, that allow formation of hollow and other beam structures. Hollow cylinder-shaped beams of high energetic heavy ions are efficient drivers for implosion targets to create matter in a highly compressed state. The work deals with the study the possibility of using a plasma lens to transformation the density distribution of ions in the beam. Calculations and measurements were performed for a C+6 and $F \cdot 10^{+26}$ beams of 200 MeV/a.u.m. energy. The obtained results and analysis are reported.

MOPE041 **Peculiarities of Bunch Shape Measurements of High Intensity Ion Beams** – *A. Feschenko, V.A. Moiseev (RAS/INR)*

Bunch shape monitors with low energy secondary electrons transverse modulation have found a use for measurements of longitudinal distribution of charge in bunches for ion linear accelerators. Temporal bunch structure is coherently transformed into the spatial distribution through transverse rf scanning. The fields of the analyzed beam can influence the trajectories of the secondary electrons thus resulting in a distortion of the transformation and hence to a deterioration of measurement accuracy revealed in worsening of a phase resolution and in appearance of an error of phase reading. The first error component aggravates observation of the bunch fine structure. The second one distorts the measured shape of the bunch as a whole. Two models have been used for the effect analysis. In the first model a target potential of the bunch shape monitor is supposed to be undistorted by the analyzed beam space charge. In the second model a target potential is completely defined by the potential of the analyzed beam bunch. The applicability of the two models is discussed. The results of simulations for typical beam parameters are presented for the latest bunch shape monitor elaborations.

MOPE042 **Measurement of the Energy Dependence of Touschek Electron Counting Rate** – *V.E. Blinov, V.A. Kiselev, S.A. Nikitin, I.B. Nikolaev, V.V. Smaluk (BINP SB RAS)*

After completion of VEPP-4M activities at the low energies we plan to start a data acquisition with KEDR detector in the region of the upsilon-mesons for precision mass measurement of these states using the resonance depolarization technique. At the 1.5-1.85 GeV range we measure the beam energy with an accuracy of 10^{-6}* by a fast change in Touschek particle counting rate while scanning the depolarizer frequency. For clarification of the Touschek polarimeter applicability at higher energies, we have measured a dependence of counting rate on the beam energy and compared it with our theoretical estimates**. Measurements have been performed at several energy points in a wide range: from 1850 up to 4000 MeV.

MOPE043 **Reversed Cherenkov-transition Radiation and Prospect of its Application to Beam Diagnostics** – *A.V. Tyukhtin, S.N. Galyamin (Saint-Petersburg State University) E.S. Belonogaya (LETI)*

We describe both analytically and numerically beams radiation in presence of media which can be realized as modern metamaterials. In particular, effects of reversed Cherenkov radiation (RCR)* and reversed

Cherenkov-transition radiation (RCTR)** are considered. These phenomena can be used for detection of charged particles and diagnostics of beams. Earlier we noted some useful properties of radiation in the case of the boundary between an ordinary medium and an isotropic left-handed metamaterial (LHM)*. Now we continue to analyze prospects of use of LHM for beam diagnostics. Moreover, we investigate RCR and RCTR in the case of certain anisotropic materials with properties being similar to properties of LHM. The useful features are reversed character of radiation and, particularly, existence of two thresholds for RCTR (lower threshold and upper one). This fact allows selection of particles (or beams) with energy in some predetermined range. The specific radiation patterns (having two or three lobes in anisotropic metamaterial) can be useful for particle energy measurement as well.

MOPE044 **Particles Energy Measurement Technique Based on Measuring of Waveguide Modes Frequencies** – *A.V. Tyukhtin, E.G. Doil'nitsina (Saint-Petersburg State University) A. Kanareykin (Euclid TechLabs, LLC)*

We consider the particles energy measurement method offered in our papers (footnotes). It is based on measurement of the modes frequencies in waveguide loaded with certain material. For this method, the modes frequencies must depend on the particles energy strong enough. Here we discuss the problem of selection of materials for this technique. It is shown that high precision of energy measurement can be reached by use of the system of specific parallel conductors. The approximate analytical approach for obtaining effective permittivity of such structure is developed. It is shown that selection of parameters of the structure allows ruling an effective permittivity characterized by both frequency dispersion and spatial one. The structure is simple enough for production. It allows measuring the particles energy for different predetermined ranges. The other ways of realization of the method are discussed as well. One of them consists in use of thin layer of ordinary dielectric. Selection of the layer thickness and dielectric constant allows obtaining strong enough dependence of frequency on Lorentz-factor in the relatively wide range.

MOPE045 **Simple Coherent Diffraction Radiation Technique for Bunch Length Measurement** – *G.A. Naumenko, M.V. Shevelev (Tomsk Polytechnic University, Nuclear Physics Institute) Yu.A. Popov, A. Potylitsyn, L.G. Sukhikh (TPU)*

Most of existing bunch length measurement methods using a coherent radiation are based on the measurement of the radiation spectral density distribution with a subsequent bunch length calculation using spectral density features. Usually to obtain a spectral density distribution a radiation beam is to be splittered into a two beams and autocorrelation function (interferogram) is measured using some types of interferometer, such as Michelson, Mach-Zehnder, Fabry-Perot or Martin-Pupplet ones. These schemes of interferometry are usually cumbersome and expensive. We suggest here a simple and cheap scheme, where interferometer is combined with a diffraction radiation target for a coherent radiation generation. For this purpose a composite backward DR target is used, which consist on two equidistant conductive plates. One of these plates may be moved along the electron beam and provide an interferogram due to the interference of the radiation from these two plates. This scheme was tested in a millimeter wavelength region on the 6.1 MeV bunched electron beam of microtron. It should be noticed this non-invasive diagnostics technique may be used for measurements of sub-mm bunch lengths.

MOPE046 **Coherent Cherenkov Radiation from a Short bunch Passing near a Target and Possibility of a Bunch Length Diagnostics** – *A. Potylitsyn, S.Yu. Gogolev, D.V. Karlovets, Yu.A. Popov, L.G. Sukhikh (TPU) G.A. Naumenko, M.V. Shevelev (Tomsk Polytechnic University, Nuclear Physics Institute)*

A noninvasive technique to determine a sub-mm length of electron bunches (rms < 100 um) based on a measurement of the coherent Cherenkov radiation (CChR) spectrum in THz range is proposed. CChR is generated when electron bunch moves in a vacuum near dielectric target. If the optical properties and geometry of a target are chosen in order to achieve a low absorption with a dispersion allowing expanding the Cherenkov cone, such target may be considered as the «natural Cherenkov prism». We demonstrated a feasibility of using of CsI prism for measurement of a bunch length in the range 50-200 um for Lorentz factor = 100. We also measured CChR power from Teflon target generated by the 6.1 MeV bunched electron beam with bunch rms length 1.2 mm and compared it with coherent diffraction radiation one for identical conditions. CChR seems to be a promising radiation mechanism for a new beam diagnostics technique.

MOPE047 **Photon Beam Position Measurements using CVD Diamond based Beam Position Sensor and Libera Photon at Swiss Light Source** – *P. Leban, D.T. Tinta (I-Tech) C. Pradervand (PSI)*

Measurements were done at Swiss Light Source on beamline X06 using four-pade CVD diamond sensor which was connected to Libera Photon, the new PBPM device from Instrumentation Technologies. The outputs of sensor are 4 current signals in nA range and are directly connected to the measuring unit without any amplifiers. External Bias voltage was used. Measurements consisted of: scanning the measurement range, frequency analysis of beam movement and analysis of photon beam flux influence on the measured position. The movement of the sensor was done by a stepper motor. Acquired data consisted of raw signal amplitudes and processed positions. Acquisitions were done at 10 kHz and 10 Hz rate.

MOPE048 **LIbera Hadron Beam Position Processor** – *M. Znidarcic (I-Tech)*

Libera is a product family delivering unprecedented possibilities for either building powerful single station solutions or architecting complex feedback systems in the field of accelerator instrumentation and controls. This paper presents development, functionality and performance of its member Libera Hadron, the hadron beam position processor. The Libera Hadron platform provides proven, scalable, high-performance infrastructure for instrumentation development. This powerful platform enables dramatic expansion of firmware and software possibilities for users, with consistent, known control system interfaces.

MOPE049 **Beam Stop Design and Construction for the Front End Test Stand at ISIS** – *R. Enparantza, I. Ariz, P. Romano, A. Sedano (Fundación TEKNIKER) F.J. Bermejo (Bilbao, Faculty of Science and Technology) D.C. Faircloth, A.P. Letchford (STFC/RAL/ISIS)*

A Front End Test Stand is being built at the Rutherford Appleton Laboratory in the UK to demonstrate a chopped H– beam of sufficiently high beam quality for future high-power proton accelerators (HPPA). The test stand consists on a negative Hydrogen ion source, a solenoid LEBT, a 324 MHz four vane RFQ, a MEBT composed of rebunching cavities and choppers and a set of diagnostics ending with a beam stop. The beam stop, which has to accept a 3 MeV, 60 mA, 2 ms, 50 Hz (10% duty factor) H– beam, consists of a coaxial double cone configuration where the inner cone's inner surface is hit by the beam and the inter-cone gap is cooled by high-speed water. The cones are situated inside a water tank and mounted at one end only to allow thermal expansion. In order to minimize both prompt and induced radiation pure aluminium is used, but the poor mechanical properties of pure aluminium are overcome by employing a metal spinning process that increases the yield strength to several times the original value of the non-deformed material. CFD and FEM codes have been used to avoid high temperature gradients, to minimize thermal stresses, and to minimize fatigue caused by the pulsed beam.

MOPE050 **Multi Optical Transition Radiation System for ATF2** – *J. Alabau-Gonzalvo, C. Blanch Gutierrez, J.V. Civera, A. Faus-Golfe, J.J. Garcia-Garrigos (IFIC) J. Cruz, D.J. McCormick, G.R. White (SLAC)*

In this paper we describe the design, installation and first calibration tests of a Multi Optical Transition Radiation (OTR) monitor system in the beam diagnostic section of the Extraction (EXT) line of ATF2, close to the multi wire scanner system. This system will be a valuable tool for measuring beam sizes and emittances from the ATF Damping Ring (DR). With an optical resolution of about 2 um an original OTR design demonstrated the ability to measure a 5.5um beam size in one beam pulse and to take many fast measurements. This gives the OTR the ability to measure the beam emittance with high statistics, giving a low error and a good understanding of emittance jitter. Furthermore the near by wire scanners will be a definitive test of the OTR as a beam emittance diagnostic device. The muti-OTR system design proposed here is based on the existing OTR1X, located after the septums at the entrance of the EXT line.

MOPE051 **Development, Characterization and Beam Performance Test of the Beam Position Monitor Series for the TBL line of the CTF3 at CERN** – *A. Faus-Golfe, C. Blanch Gutierrez, J.V. Civera-Navarrete, J.J. Garcia-Garrigos (IFIC)*
A set of 16 Inductive Pick-Ups (IPU) for Beam Position Monitoring (BPM) with its associated electronics were designed, constructed and characterized at IFIC for the Test Beam Line (TBL) of the 3rd CLIC Test Facility (CTF3) at CERN. In October 2009 the full set of IPUs, (BPS) was successfully installed in the TBL line. In this paper, we describe the prototyping and series production phases of the BPSs development, focusing in the implementation and the results analysis derived from their characterization tests. Two special test benches were designed and built to perform the characterization tests at low and high frequencies. The low frequency set up based on a wire-method test bench for emulating the beam position variations helped us to determine the BPS performance parameters at beam pulse time scale from 100μs/10kHz to 10ns/100MHz. On the other hand, the high frequency test setup, based on an adapted coaxial transmission line, was dedicated to obtain the BPS longitudinal coupling impedance at the beam microbunches time scale (83ps/12GHz). Furthermore, we also present the first beam performance tests made in the TBL line.

MOPE052 **Design of the New Emittance Meter for the 3 and 12 MeV LINAC4 H^- Beam** – *B. Cheymol, E. Bravin, D. Gerard, F. Roncarolo (CERN)*
As part of the CERN LHC injector chain upgrade, LINAC4 will accelerate H^- ions from 45 keV to 160 MeV. A movable diagnostics test bench will be used to measure the beam parameters during the different construction stages (at 45 keV, 3 MeV and 12 MeV) at first in a laboratory setup and later in the LINAC4 tunnel. Given the beam properties at 3 and 12 MeV, the existing slit-grid system developed for the measurement of the transverse emittance at the source (45 keV) cannot be reused at these higher energies. At 3MeV and above the energy deposition would damage the steel slit in a single LINAC4 pulse. For this reason a new slit has been designed following detailed analytical and numerical simulations for different materials and geometries. The energy deposition patterns as simulated by FLUKA for the different cases are presented in detail. In addition, the choice of SEM grid wires for achieving the required measurement accuracy in terms of material, diameter and spacing, are discussed.

MOPE053 **Commissioning of the LINAC4 Ion Source Transverse Emittance Meter** – *B. Cheymol, E. Bravin, A.E. Lokhovitskiy, U. Raich, F. Roncarolo, R. Scrivens (CERN)*
LINAC4 is the first step in the upgrade of the injector chain for the LHC and will accelerate H^- ions to 160 MeV. The ion source has initially been installed in a laboratory setup where its commissioning started at the end of 2009. A slit-grid system is used to monitor the transverse emittance at the exit of the source. Measurement results have been compared to analytical and numerical predictions of the system performance, addressing the system resolution, accuracy and sensitivity. This information has been used to improve the design of a new slit-grid system required for commissioning the linac at higher energies.

MOPE054 **Design of a 1.42 GHz Spin-Flip Cavity for Antihydrogen Atoms** – *S. Federmann, F. Caspers, E. Mahner (CERN) B. Juhasz, E. Widmann (SMI)*
The hyperfine transition frequency of hydrogen is known to a very high precision and therefore the measurement of this transition frequency in antihydrogen is offering one of the most accurate tests of CPT symmetry. The ASACUSA collaboration will run an experiment designed to produce ground state antihydrogen atoms in a CUSP trap. These antihydrogen atoms will pass with a low rate in the order of 1 per second through a spin-flip cavity where they get excited depending on their polarization by a 1.42 GHz magnetic field. Due to the small amount of antihydrogen atoms that will be available the requirement of good field homogeneity is imposed in order to obtain an interaction with as many antihydrogen atoms as possible. This leads to a requirement of an RF field deviation of less than ± 10 % transverse to the beam direction over a beam aperture with 100 mm diameter. All design aspects of this new spin-flip cavity, including the required field homogeneity and vacuum aspects, are discussed.

MOPE055 **Design for a Longitudinal Density Monitor for the LHC** – *A. Jeff, E. Bravin, T. Lefevre, A. Rabiller (CERN) A.S. Fisher (SLAC) C.P. Welsch (The University of Liverpool)*

Synchrotron radiation is currently used on LHC for beam imaging and for monitoring the proton population in the 3 microsecond abort gap. In addition to these existing detectors, a study has been initiated to provide longitudinal density profiles of the LHC beams with a high dynamic range and a 50ps time resolution. This would allow for the precise measurement both of the bunch shape and the number of particles in the bunch tail or drifting into ghost bunches. A solution is proposed based on counting synchrotron light photons with two fast avalanche photo - diodes (APD) operated in Geiger mode. One is free - running but heavily attenuated and can be used to measure the core of the bunch. The other is much more sensitive, for the measurement of the bunch tails, but must be gated off during the passage of the core of the bunch to prevent the detector from saturating. An algorithm is then applied to combine the two measurements and correct for the detector dead time, after pulsing and pile - up effects. Initial results from laboratory testing of this system are described in this paper.

MOPE056 **Design and Results of a Time Resolved Spectrometer for the 5 MeV Photoinjector for CTF3 (PHIN)** – *D. Egger (EPFL) A.E. Dabrowski, T. Lefevre (CERN)*

To improve the quality of the CLIC Test Facility 3 drive beam, it has been proposed that a photo injector replaces the actual thermionic gun. This would produce a lower emittance beam and minimize beam losses in the injector since the RF bunching and sub - harmonic bunching systems would not be needed anymore. Such a photo injector, named PHIN, is currently being developed at CERN. One of the difficulties is to provide a high intensity beam (3.5A) with a stable (0.1%) beam energy over 1.5us as well as a relative energy spread less than 1%. A 90^{o} spectrometer line featuring a segmented dump and an Optical Transition Radiation screen has been constructed and commissioned in order to study the time evolution of the beam energy along the pulse duration. In the following paper, we present the design as well as the results from the previous two PHIN runs.

MOPE057 **First Beam Measurements with the LHC Synchrotron Light Monitors** – *T. Lefevre, E. Bravin, G. Burtin, A. Guerrero, A. Jeff, A. Rabiller (CERN) A.S. Fisher (SLAC)*

On the Large Hadron Collider (LHC), the continuous monitoring of the transverse sizes of the beams relies on the use of synchrotron radiation and intensified video cameras. Depending on the beam energy different synchrotron light sources must be used. A dedicated superconducting undulator has been built for low beam energies (450 GeV to 3 TeV), while edge and centre radiation from a beam separation dipole magnet are used respectively for intermediate and high energies (up to 7 TeV). The emitted visible photons are collected using a retractable mirror, which sends the light into an optical system adapted for acquisition using intensified CCD cameras. This paper presents the performance of the imaging system in terms of spatial resolution, and comments on the light intensity obtained and the cross calibration performed with the wire scanners. Upgrades and future plans are also discussed.

MOPE058 **Measuring the Bunch Frequency Combination at CTF3** – *A.E. Dabrowski, S. Bettoni, E. Bravin, R. Corsini, S. Doebert, T. Lefevre, A. Rabiller, P.K. Skowronski, L. Soby, F. Tecker (CERN) D. Egger (EPFL) A. Ferrari (Uppsala University) C.P. Welsch (The University of Liverpool)*

The CTF3 facility is being built and commissioned by an international collaboration in order to test the feasibility of the proposed CLIC drive beam generation scheme. Central to this scheme is the use of RF deflectors to inject bunches into a Delay Loop and a Combiner Ring, in order to transform the initial bunch spacing of 1.5 GHz from the linac to a final bunch spacing of 12 GHz. The optimization procedure relies on several steps. The active length of each ring is carefully adjusted to within a few millimeters accuracy using a two - period undulator. The transverse optics of the machine must be set-up in a way so as to ensure the beam isochronicity. Diagnostics based on optical streak cameras and RF power measurements have been designed to measure the longitudinal behaviour of the beam during the combination. This paper presents their performance and highlights recent measurements.

MOPE059 **Commissioning and First Performance of the LHC Beam Current Measurement Systems** – *M. Ludwig, D. B. Belohrad, JJ.G. Gras, L.K. Jensen, O.R. Jones, OP. Odier, J.-J. Savioz, S. Thoulet (CERN)*

CERN's Large Hadron Collider (LHC) is equipped with three distinct types of intensity measurement systems: total intensity measurement using DC transformers (DCCTs) with a bandwidth up to a few kHz; total intensity measurements on a turn-by-turn basis for lifetime measurements using AC-coupled fast transformers (fast BCTs); bunch-by-bunch intensity measurements with a bandwidth up to a few hundred MHz also using the fast BCTs. In addition to providing intensity information these devices are part of the machine protection system, indicating whether or not there is beam circulating, transmitting intensity for evaluation of safe beam conditions and capable of triggering a beam dump if fast losses are detected. This paper reports on the commissioning of all these systems and their initial performance.

MOPE060 **Spectrometry in the Test Beam Line at CTF3** – *M. Olvegaard, A.E. Dabrowski, S. Doebert, T. Lefevre (CERN) E. Adli (University of Oslo)*

The CLIC study is based on the so - called two - beam acceleration concept and one of the main goals of the CLIC Test Facility 3 is to demonstrate the efficiency of the CLIC RF power production scheme. As part of this facility a Test Beam Line (TBL), presently under commissioning, is a small scale version of the CLIC decelerator. To perform as expected the beam line must show efficient and stable RF power production over 16 consecutive decelerating structures. As the high intensity electron beam is decelerated its energy spread grows by up to 60%. A novel segmented beam dump for time resolved energy measurements has been designed to suit the requirements of the TBL. As a complement, a diffusive OTR screen is also installed in the same spectrometer line. The combination of these two devices will provide a high spatial resolution measurement of both the energy and energy - spread with a nanosecond time response. This paper describes the design of the new segmented dump and presents the results from the first commissioning of the TBL spectrometer line.

MOPE061 **Gas Electron Multipliers for Low Energy Beams** – *J. Spanggaard, F. Arnold Malandain, P. Carriere, L. Ropelewski, G. Tranquille (CERN)*

Gas Electron Multipliers (GEM) find their way to more and more applications in beam instrumentation. Gas Electron Multiplication uses a very similar physical phenomenon to that of Multi Wire Proportional Chambers (MWPC) but for small profile monitors they are much more cost efficient both to produce and to maintain. This paper presents the new GEM profile monitors intended to replace the MWPCs currently used at CERN's low energy Antiproton Decelerator (AD). It will be shown how GEMs overcome the documented problems of profile measurements with MWPCs for low energy beams, where the interaction of the beam with the detector has a large influence on the measured profile. Results will be presented from profile measurements performed at 5 MeV using four different GEM prototypes, with discussion on the possible use of GEMs at even lower energies needed at the AD in 2012.

MOPE062 **Continuous Measurement and Control of Beta-Beating in the LHC** – *R.J. Steinhagen, A. Boccardi, E. Calvo Giraldo, M. Gasior, J.L. Gonzalez, O.R. Jones (CERN)*

The beta function has a fundamental impact on the LHC performance and on the functioning of its machine protection and collimation systems. A new beta-beat diagnostic system, prototyped at the SPS, has been used to verify the time-dependent variations of the LHC lattice with unprecedented 1% beta-beta resolution and at a measurement bandwidth of about 1 Hz.

MOPE063 **New On-line Gain Drift Compensation for Resonant Current Monitor under Heavy Heat Load** – *P.-A. Duperrex, V. Gandel, D.C. Kiselev, Y. Lee, U. Mueller (PSI)*

For high intensity beam operation (3mA, 1.8MW) in the PSI cyclotron, a new current monitor for proton beams has been installed during the 2009 maintenance period. This current monitor is an actively cooled re-entrant cavity with its resonance tuned at the 2nd RF harmonic (-10-1 MHz). Operating this system presents several challenges due to the heavy shower of energetic particles, the resonator being placed 8 m behind a graphite target. The resonator is actively cooled with water, its external surface was blackened to improve the radiation cooling and its mechanical structure was optimized for good heat conduction. The resonance characteristics are extremely sensitive to structural changes of the resonator. Because of non-uniform temperature distribution and dynamical changes the observed gain drift during operation is of the order of 10%. To correct these drifts 2 tests signals 50 kHz off the RF frequency are measured on-line during beam operation. They provide an innovative mean to estimate and to correct on-line the resonator gain. This paper will present the measurement method and the achieved performances.

MOPE064 **The European XFEL Beam Position Monitor System** – *B. Keil, R. Baldinger, R. Kramert, G. Marinkovic, P. Pollet, M. Roggli, M. Rohrer, V. Schlott, M. Stadler, D.M. Treyer (PSI) W. Decking, D. Lipka, D. Noelle, M. Siemens, T. Traber, S. Vilcins (DESY) O. Napoly, C.S. Simon (CEA) J.-P. Prestel, N. Rouvière (IPN)*

The European XFEL is an X-ray free electron laser user facility that is currently being built in Hamburg by an international consortium. The electron BPM system of the XFEL is developed by a collaboration of PSI, DESY, and CEA/Saclay/Irfu. Cavity BPMs will be used in all parts of the E-XFEL where highest resolution and lowest drift is required, e.g. in the undulators and some locations in the beam transfer lines. In the cryostats of the superconducting 17.5GeV main linac, 2/3rds of the BPMs will be buttons, while 1/3rd will be re-entrant cavities that promise higher resolution than buttons at low bunch charges. The transfer lines will also be equipped with cost-efficient button BPMs. The BPM electronics is based on a modular system concept, with a common FPGA-based digital back-end design for all BPMs and pickup-specific analog RF front-ends. This paper introduces the design concepts and reports on the project status and measurement results of BPM pickup and electronics prototypes.

MOPE065 **Transverse Phase-space Beam Tomography at PSI and SNS Proton Accelerators** – *D. Reggiani, M. Seidel (PSI) C.K. Allen (ORNL)*

Operation and upgrade of very intense proton beam accelerators like the PSI facility and the SNS spallation source at ORNL is typically constrained by potentially large machine activation. Besides the standard beam diagnostics, beam tomography techniques provide a reconstruction of the beam transverse phase space distribution, giving insights to potential loss sources like irregular tails or halos. Unlike more conventional measurement approaches (pepper pot, slits) beam tomography is a non destructive method that can be performed at high energies and, virtually, at any beam location. Results from the application of the Maximum Entropy Tomography (MENT) algorithm to different beam sections at PSI and SNS will be shown. In these reconstructions the effect of nonlinear forces is made visible in a way not otherwise available through wire scanners alone. These measurements represent a first step towards the design of a beam tomography implementation that can be smoothly employed as a reliable diagnostic tool.

MOPE066 **Application of BPM Data to Locate Orbit Noise Source** – *P.C. Chiu, J. Chen, K.T. Hsu, K.H. Hu, C.H. Kuo (NSRRC)*

To keep and achieve desired performance of a modern synchrotron light source, it requires continuous efforts including good design of the accelerator, good performed subsystems and sophisticated feedback system. While some wonders happen unexpectedly and could deteriorate performance of the light source. For examples, some strong source occasionally occurred especially after long shut down or malfunction of some corrector power supply and it would result in increased noise level. Non ideal injection element will cause large perturbation as well. This report presents algorithms to spatially locate source and summarize some of our practical experience to identify the source.

MOPE067 **Commissioning of the Photo Detachment Laser Wire at the Rutherford Front End Test Stand FETS** – *C. Gabor (STFC/RAL/ASTeC) D.A. Lee (Imperial College of Science and Technology, Department of Physics) A.P. Letchford (STFC/RAL/ISIS) J.K. Pozimski (STFC/RAL)*

The front end will consist of an ion source, a low energy beam transport, an RFQ, a MEBT including a set of slow / fast choppers and comprehensive non-destructive beam diagnostics based on photo detachment. The final aim is to demonstrate a high power, fast chopped H^- beam for possible future projects like Neutrino Factory, future Spallation Neutron Source (e.g. ISIS upgrade) or Muon Collider. A laser beam profile monitor based on photo detachment is planned for use at the RFQ injection energy. The main components are the laser, the optics to scan through the ion beam, the detector to collect the detached electrons and the DAQ. Initial commissioning has shown improvements to all the components are needed to measure a beam profile. This paper gives an overview of the diagnostics design, first results and modifications to the design.

MOPE068 **Diagnostic System Commissioning of the EMMA NS-FFAG Facility at Daresbury Laboratory** – *A. Kalinin, P.A. McIntosh, R.J. Smith (STFC/DL/ASTeC)*

We present preliminary results of beam diagnostics for the world's first Non-Scaling FFAG Accelerator 'EMMA'. Amongst other means, a single-shot/turn-by-turn BPM system is used, that was first tested on the ALICE injector. The BPM system utilizes a front-end conversion of button pickup signals into flat-top-envelope 700 MHz bursts, time-domain multiplexing (in each plane, signals are made spaced by 13.8 ns), and the manufacture of both synchronous detector and ADC clocks directly from the beam signal. The system performance is discussed; results of beam-based resolution measurement are given. First turn beam trajectories furthest from the Septum and Kicker are presented.

MOPE069 **A 2-D Laser-wire Scanner at PETRA-III** – *T. Aumeyr, G.A. Blair, S.T. Boogert, G.E. Boorman, A. Bosco (JAI) K. Balewski, E. Elsen, V. Gharibyan, G. Kube, S. Schreiber, K. Wittenburg (DESY)*

The PETRA-III Laser-wire, a Compton scattering beam size measurement system at DESY, Hamburg uses an automated mirror to scan a Q-switched laser across the electron beam and is developed from the system previously operated at PETRA-II. This paper reports on recent upgrades of the optics, vacuum vessel and data acquisition. First emittance measurements and related systematic studies are presented.

MOPE070 **ATF2 Cavity Beam Position Monitor System** – *S.T. Boogert, G.E. Boorman (JAI) R. Ainsworth, S. Molloy (Royal Holloway, University of London) A.S. Aryshev, Y. Honda, T. Tauchi, N. Terunuma, J. Urakawa (KEK) J.C. Frisch, J. May, D.J. McCormick, T.J. Smith, G.R. White, M. Woodley (SLAC) A. Heo, E.-S. Kim, H.-S. Kim, Y.I. Kim (Kyungpook National University) A. Lyapin (UCL) H.K. Park (KNU) M.C. Ross (Fermilab) S. Shin (PLS)*

The Accelerator Test Facility 2 (ATF2) in KEK, Japan, is a prototype scaled demonstrator system for the final focus required for a lepton linear collider. The ATF2 beam-line is instrumented with a total of 38 C and S band resonant cavity beam position monitors (BPM) with associated mixer electronics and digitizers. The current status of the BPM system is described, with a focus on operational techniques and performance.

MOPE071 **Coherent Diffraction Radiation Longitudinal Beam Profile Monitor for CTF3** – *M. Micheler, R. Ainsworth, G.A. Blair, G.E. Boorman, V. Karataev, K. Lekomtsev (JAI) R. Corsini, T. Lefevre (CERN)*

A setup for the investigation of Coherent Diffraction Radiation (CDR) from a conducting screen as a tool for non-invasive longitudinal electron beam profile diagnostics has been designed and installed in the Combiner Ring Measurement (CRM) line of the CLIC Test Facility (CTF3, CERN). This setup also allows the measurements of Coherent Synchrotron Radiation (CSR) from the last bending magnet. In this report the status of the monitor development and results on the interferometric measurements of CDR and CSR spectra are presented. The CDR and CSR signal dependence on the klystron phase is reported. Additionally, an off-centre adapter flange has been installed to block the background in the CRM line and studies presenting the effect of this flange are displayed. The future plans for the system improvements are also discussed.

MOPE072 **Electron Beam Quality Measurements on the ALPHA-X Laser-plasma Wakefield Accelerator** – *G.H. Welsh, M.P. Anania, C. Aniculaesei, E. Brunetti, R.T.L. Burgess, S. Cipiccia, D. Clark, B. Ersfeld, M.R. Islam, R.C. Issac, D.A. Jaroszynski, G.G. Manahan, T. McCanny, G. Raj, A. J. W. Reitsma, R.P. Shanks, G. Vieux, S.M. Wiggins (USTRAT/SUPA) W.A. Gillespie (University of Dundee) M.J. Loos,* *S.B. van der Geer (TUE) A. MacLeod (UAD)*

The Advanced Laser-Plasma High-Energy Accelerators towards X-rays (ALPHA-X) programme at the University of Strathclyde is developing laser-plasma wakefield accelerators to produce high energy, ultra-short duration electron bunches as drivers of radiation sources. Coherent emission will be produced in a free-electron laser by focussing the electron bunches into an undulator. To achieve net gain, a high peak current, low energy spread and low emittance are required. A high intensity ultra-short pulse from a 30 TW Ti:sapphire laser is focussed into a helium gas jet to produce femtosecond duration electron bunches in the range of 80 - 200 MeV. Beam transport is monitored using a series of Lanex screens positioned along the beam line. We present measurements of the electron beam energy spread as low as 0.7% (at 90 MeV) obtained using a high resolution magnetic dipole spectrometer. We also present pepper-pot measurements of the normalised transverse emittance of the order of 1 pi mm mrad. With further acceleration to 1 GeV, the beam parameters indicate the feasibility of a compact X-ray FEL with a suitable undulator.

MOPE073 **Optimization Studies of Planar Supersonic Gas-jets for Beam Profile Monitor Applications** – *M. Putignano (The University of Liverpool) K.-U. Kuehnel, M. Putignano (MPI-K) C.P. Welsch (Cockcroft Institute)*

Supersonic gas-jets have attracted much interest as experimental targets in several fields of science since they combine low internal temperatures with high directionality. Axisymmetric jets have found widespread application, triggering a wealth of studies on their properties, while only a limited number of detailed studies have been done on planar jets. In this paper, the design of a beam profile monitor based on a planar supersonic gas-jet for use in the Ultra-low energy Storage Ring (USR) at the Facility for Antiproton and Ion Research (FAIR) in Germany is described. Optimization of the monitor requires investigation into different characteristic jet parameters. For that purpose extensive simulation work with the Gas Dynamics Tool (GDT) was done. The results of these studies are presented together with a description of a novel nozzle-skimmer configuration and an experimental test stand to benchmark the numerical results.

MOPE074 **Development of a Fast, Single-pass, Micron-resolution Beam Position Monitor Signal Processor: Beam Test Results from ATF2** – *P. Burrows, R. Apsimon, D.R. Bett, G.B. Christian, B. Constance, H. Dabiri Khah, C. Perry, J. Resta-López, C. Swinson (JAI)*

We present the design of a stripline beam position monitor (BPM) signal processor with low latency (c. 10ns) and micron-level spatial resolution in single-pass mode. Such a BPM processor has applications in single-pass beamlines such as those at linear colliders and FELs. The processor was deployed and tested at the Accelerator Test Facility (ATF2) extraction line at KEK, Japan. We report the beam test results and processor performance, including response, linearity, spatial resolution and latency.

MOPE075 **Single Shot Transverse Emittance Measurement using Extended Pepper-pot in the DIAMOND Booster to Storage Ring Transfer Line** – *N. Delerue (JAI) S.I. Bajlekov (University of Oxford, Clarendon Laboratory) R. Bartolini, C. Christou, A.F.D. Morgan, G. Rehm, C.A. Thomas (Diamond)*

Single shot transverse emittance measurement is important for laser wakefield accelerators but also for future linac based machines such as X-ray FELS. We have developed a new method of single shot transverse emittance measurement using extended pepper-pots. We report on measurements performed at the DIAMOND light Source in the transfer line from the Booster to the Storage Ring. This location allows measurements at several different energies to be made and compared. The Validity and limits of this new method are discussed in the paper.

MOPE076 **Longitudinal Bunch Profile Diagnostics in the 50-femtoseconds Range using Coherent Smith-Purcell Radiation** – *N. Delerue, G. Doucas, E. Maclean, A. Reichold (JAI)*

We report on the possible utilisation of Smith-Purcell radiation to measure the longitudinal profile of 50-femtoseconds electron bunches. This length is typical for the bunches currently produced by Laser Wakefield Acceleration and is at the limit of what is achievable by alternative techniques, such as Electro-Optic sampling.

MOPE077 **Transverse Emittance Measurement of a H⁻ Beam at the CERN Linac 4 Test Stand using a Pepper-pot** – *N. Delerue, P. Jackson (JAI) O. Midttun, R. Scrivens, E. Tsesmelis (CERN)*

Pepper-pot based transverse emittance measurement has the advantage of providing a fast (single shot) measurement with a relatively simple hardware. We report on Pepper-pot based transverse emittance measurements made at the CERN Linac 4 test stand.

MOPE078 **Transverse Emittance Measurement at High Energy using Extended Pepper-pot** – *N. Delerue (JAI)*

Although the pepper-pot method has been used for decades at low energy to measure the transverse emittance of particles sources, it has only been extended to high energy very recently. We report on some of the recent measurements done at high energy (several hundred MeVs) and discuss the practical consideration of such measurements. We show demonstrate that an extended pepper-pot does not significantly affect the phase space of the beam and thus provides a valid transverse emittance measurement.

MOPE079 **The MICE PID Detector System** – *M.A. Rayner (OXFORD-physics) M. Bonesini (INFN MIB)*

The international Muon Ionization Cooling Experiment (MICE) will carry out a systematic investigations of ionization cooling of a muon beam. As the emittance measurement will be done on a particle-by-particle basis, a sophisticated beam instrumentation is needed to measure particle coordinates and timing vs RF. A PID system based on three time-of-flight detectors, two Aerogel Cerenkov counters and a KLOE-like calorimeter has been constructed in order to keep beam contamination (e, π) well below 1 %. The MICE TOF system will measure timing with a resolution better than 60 ps per plane, in a harsh environment due to high particle rates, fringe magnetic fields and RF backgrounds. Performances in beam of all detectors will be shown, as also future upgrades.

MOPE080 **Single Shot Emittance Measurement from Beam Size Measurement in a Drift Section** – *C.A. Thomas, C. Christou, A.F.D. Morgan, G. Rehm (Diamond) R. Bartolini, N. Delerue (JAI)*

Single shot emittance measurement is essential to assess the performance of new generation light sources such as linac based X-ray FELs or laser plasma wakefield accelerators. To this aim, we have developed a single shot emittance measurement using at least 3 screens inserted in the beam at the same time, measuring the beam size at different positions in a drift space in one shot. We present here test measurements performed at Diamond in the transfer line from the Booster to the Storage Ring, using thin OTR and also YAG screens. We also compare these measurements with results from the more conventional quadrupole scan method and also measurements using an OTR screen and an assembly of two cameras imaging the beam size and the beam divergence at a point near the waist of the beam. The validity and limits of the new method are discussed in the paper.

MOPE081 **Performance of a Streak Camera using Reflective Input Optics** – *C.A. Thomas, G. Rehm (Diamond) I.P.S. Martin (JAI)*

Electron bunch profile and length measurement from large bandwidth synchrotron radiation with a streak camera can be strongly limited by the chirp introduced by the length of material present in the input refractive optics of streak cameras. Elimination of the chirp can be done either by filtering the bandwidth of the synchrotron radiation pulses, by measuring time resolved spectra with the streak camera, or by replacing the front optics lenses by focussing mirrors. The first solution reduces the power available, thus limiting measurements to minimum bunch current that can be too high to assess the 'zero' current bunch length. The second elegant solution allows measurement of the bunch length with the whole bandwidth and available power but with loss of the second sweep axis in the camera, so that no beam dynamics can be observed. In order to prevent any pulse chirp, keep all the available power and capability of beam dynamics observation, we designed a new input optics exclusively with mirrors. We present here our design and the results of the system with our streak camera, measuring 2ps bunch in the new Diamond low-alpha lattice.

MOPE082 **Off-the-shelf EPICS Instrumentation for Remote Waveform Monitoring & Analysis** – *L. Shaw, C.D. Ziomek (ZTEC Instruments)*

Off-the-shelf instruments based on the LAN eXtensions for Instrumentation (LXI) standard that include embedded EPICS input/output controllers (IOCs) are an ideal solution for many particle accelerator applications. These applications require responsive remote control and real-time waveform monitoring for critical accelerator systems including machine protection, beam position monitoring and others. These instruments have the same feature sets and powerful analysis capabilities that today's high-end benchtop instruments have. With an embedded EPICS controller, the instruments easily integrate into the EPICS environment without the need for EPICS drivers or external controllers. They can be controlled and monitored by EPICS applications such as EDM and MEDM. These EPICS oscilloscopes and digitizers perform advanced real-time waveform math and analysis using on-board FPGAs and DSP. The paper will detail how ZTEC Instruments' EPICS oscilloscopes are being used at facilities around the world for real-time control and monitoring via EPICS.

MOPE083 **Comparative Measurements of Libera Brilliance and BSP100 *** – *S. Xu, H. Bui, G. Decker, R. Laird, F. Lenkszus, H. Shang (ANL)*

The Advanced Photon Source (APS) is a third-generation synchrotron light source in the United States. The BPM electronics plays an important part in the beam stability control. This paper presents comparative measurements of two BPM electronics: Libera Brilliance and APS FPGA-based BSP100. Some important parameters such as beam current dependence, electronics resolution and fill pattern dependence have been measured. These measurements were carried out in the lab and in the real system. The results will be useful for deciding which BPM electronics to deploy in the APS upgrade project.

MOPE084 **Tune Evaluation from Phased BPM Turn-by-turn Data** – *Y. Alexahin, E. Gianfelice-Wendt, W.L. Marsh (Fermilab)*

In fast ramping synchrotrons, like the Fermilab Booster, the usual methods for evaluating the betatron tunes from the spectrum of turn-by-turn data may fail due to fast decoherence of particle motion or rapid tune changes, in addition to the BPM noise. We propose a technique based on phasing of the signals from different BPMs. Although the number of the Fermilab Booster BPMs is limited to 48 per plane, this method allows to detect the beam tunes in conditions where the other algorithms were unsuccessful. In this paper we describe the method and its implementation in the Fermilab Booster control system. Results of measurements are also presented.

MOPE085 **Rapid-cycling Synchrotron with Variable Momentum Compaction** – *Y. Alexahin (Fermilab) D.J. Summers (UMiss)*

There are conflicting requirements on the value of the momentum compaction factor during energy ramp in a synchrotron: at low energies it should be positive and sufficiently large to make the slippage factor small so that it is possible to work closer to the RF voltage crest and ensure sufficient RF bucket area, whereas at higher energies it should be small or negative to avoid transition crossing. In the present report we propose a lattice with variable momentum compaction factor and consider the possibility of using it in a high repetition rate proton driver for muon collider and neutrino factory.

MOPE086 **Updated Electron Cloud Measurements in the Fermilab Main Injector using Microwave Transmission** – *N. Eddy, J.L. Crisp, I. Kourbanis, K. Seiya, J.C.T. Thangaraj, M. Wendt, R.M. Zwaska (Fermilab)*

The production of an Electron Cloud poses stability issues for future high intensity running of the Fermilab Main Injector. The microwave transmission technique has been employed to provide very sensitive measurements of the electron cloud development in the Fermilab Main Injector. During the 2009 shutdown, dedicated pickups were installed to facilitate the microwave measurements. Results from the new installations are reported.

MOPE087 **Submicron Multi-bunch BPM for CLIC** – *A. Lunin, N. Solyak, M. Wendt, V.P. Yakovlev (Fermilab) H. Schmickler, L. Soby (CERN)*

A common-mode free cavity BPM is currently under development at Fermilab within the ILC-CLIC collaboration. This monitor will be operated in a CLIC Main Linac multi-bunch regime, and needs to provide both, high spatial and time resolution. We present the design concept, numerical analysis, investigation on tolerances and error effects, as well as simulations on the signal response applying a multi-bunch stimulus.

MOPE088 **TE Wave Measurements of the Electron Cloud in the Cesr-TA Synchrotron Ring** – *S. De Santis (LBNL) M.G. Billing, M.A. Palmer, J.P. Sikora (CLASSE) B.T. Carlson (Grove City College)*

The CESR Damping Ring Test Accelerator collaboration (Cesr-TA) utilizes the CESR e+/e⁻ storage ring at Cornell University for carrying out R&D activities critical for the ILC damping rings. In particular, various locations have been instrumented for the study of the electron cloud effects and their amelioration. In this paper we present the results obtained using the TE wave propagation method to study the electron cloud evolution and its dependence on several beam and machine parameters. Whenever possible, we have also compared our measurements with those obtained by using retarding field analyzers (RFA) with good agreement. Amongst the results obtained, we were able to detect a strong resonance of the electron cloud with the TE wave in regions of the beampipe where a dipole-like magnetic field is also present. Besides the standard transmission method, we are also developing an alternative procedure, the so-called resonant BPM, which can be used for a more localized measurement of the electron cloud density, which has already yielded promising results.

MOPE089 **CESR Beam Position Monitor System Upgrade for CesrTA and CHESS Operations** – *M.A. Palmer, M.G. Billing, R.E. Meller, M.C. Rendina, N.T. Rider, C.R. Strohman (CLASSE) R. Holtzapple (CalPoly)*

The beam position monitor (BPM) system at the Cornell Electron Storage Ring (CESR) has been upgraded for use in both CESR Test Accelerator (CesrTA) and Cornell High Energy Synchrotron Source (CHESS) operations. CesrTA operates with electron and positron bunch trains with as little as 4ns bunch spacing. CHESS operates with simultaneous counter-rotating electron and positron trains with 14ns bunch spacing. The upgraded BPM system provides high resolution measurement capability as is needed for the CesrTA ultra low emittance operations, turn-by-turn digitization of multiple bunches for beam dynamics studies, and the capability for real-time dual beam monitoring in CHESS conditions. In addition to standard position measurement capability, the system is also required to measure betatron phase by synchronous detection of a driven beam for optics diagnosis and correction. This paper describes the characteristics of the BPM hardware upgrade, performance figures of the electronics designed for this purpose and the overall status of the upgrade effort. Examples of key measurement types and the analysis of data acquired from the new instruments will also be presented.

MOPE090 **CesrTA x-Ray Beam Size Monitor Operation** – *D.P. Peterson, J.P. Alexander, C.J. Conolly, N. Eggert, E. Fontes, W.H. Hopkins, B. Kreis, A. Lyndaker, M.P. McDonald, M.A. Palmer, M.C. Rendina, P. Revesz, N.T. Rider, J.J. Savino, R.D. Seeley (CLASSE) J.W. Flanagan (KEK)*

We report on the design and operation of the CesrTA x-ray beam size monitor (xBSM). The xBSM resolution must be sufficient to measure vertical beam sizes of order 10um by imaging 2-4keV synchrotron radiation photons onto a one-dimensional photodiode array. Instrumentation in the evacuated x-ray beam line includes upstream interchangeable optics elements (slits, coded apertures, and Fresnel zone plates), a monochromator and an InGaAs photodiode detector. The readout is a beam-synchronized FADC that is capable of parallel measurement of consecutive bunches with 4ns spacing. The xBSM has been used to measure beam sizes during the August 2009, November 2009, and April 2010 runs. Single turn measurements are fit to characteristic image shapes to extract beam sizes independent of position variations. The turn-averaged beam size provides feedback for low-emittance tuning.

MOPE091 **Techniques for Observation of Beam Dynamics in the Presence of an Electron Cloud** – *M.G. Billing, G. Dugan, R.E. Meller, M.A. Palmer, M.C. Rendina, N.T. Rider, J.P. Sikora, C.R. Strohman (CLASSE) R. Holtzapple (CalPoly)*

During the last several years CESR has been studying the effects of electron clouds on stored beams in order to understand their impact on future linear-collider damping ring designs. One of the important issues is the way that the electron cloud alters the dynamics of bunches within the train. Techniques for observing the dynamical effects of beams interacting with the electron clouds have been developed. These methods will be discussed and examples of measurements will be presented.

MOPE092 **Ultrashort Bunch Length Diagnostic with Sub-femtosecond Resolution** – *G. Andonian (RadiaBeam) G. Andonian, E. Hemsing, P. Musumeci, J.B. Rosenzweig, S. Tochitsky (UCLA)*

For successful operation and beam characterization, fourth generation light sources require the observation of sub-picosecond bunches with femtosecond resolution. In this paper, we report on the design and development of a novel technique to achieve sub-femtosecond temporal resolution of high brightness bunches. The technique involves the coupling of the electron beam to a high power laser in an undulator field, which is optimized to maximize the angular deviation of the bunch. The beam angular components are imaged on a distant screen yielding a sweep across angles in one dimension. The addition of an x-band deflecting cavity downstream of the undulator creates another sweep of the beam, in the perpendicular dimension. The temporal resolution of the bunch is dependent on the seed laser wavelength and the spatial resolution of the screen. Initial calculations show that for a CO2 laser (T~30fs) and a phosphor screen (~50micron spatial resolution), the longitudinal resolution is approximately l/200 of the laser wavelength, or ~150 attoseconds.

MOPE093 **A High Resolution Transverse Diagnostic based on Fiber Optics** – *R.B. Agustsson, G. Andonian, A.Y. Murokh, R. Tikhoplav (RadiaBeam)*

A beam profile monitor utilizing the technological advances in fiber optic manufacturing to obtain micron level resolution is under development at RadiaBeam Technologies. This fiber-optic profiling device would provide a lost cost, turn-key solution with nominal operational supervision and requires minimal beamline real estate. We are currently studying and attempting to mitigate the technical challenges faced by a fiber optic based diagnostic system with a focus on radiation damage to the fibers and its effect on signal integrity. Preliminary irradiation studies and conceptual operation of the system are presented.

MOPE094 **X-band Travelling Wave Deflector for Ultra-fast Beams Diagnostics** – *L. Faillace, R.B. Agustsson, A.Y. Murokh, E. Spranza (RadiaBeam) D. Alesini (INFN/LNF) J.B. Rosenzweig (UCLA)*

The quest for detailed information concerning ultra-fast beam configurations, phase spaces and high energy operation is a critical task in the world of linear colliders and X-ray FELs. Huge enhancements in diagnostic resolutions are represented by RF deflectors. In this scenario, Radiabeam Technologies has developed an X-band Travelling wave Deflector (XTD) in order to perform longitudinal characterization of the subpicosecond ultra-relativistic electron beams. The device is optimized to obtain a single digit femtosecond resolution using 100 MeV electron beam parameters at the Accelerator Test Facility (ATF) at Brookhaven National Laboratory; however, the design can be easily extended to be utilized for diagnostics of GeV-class beams. The XTD design fabrication and tuning results will be discussed, as well as installation and commissioning plans at ATF.

MOPE095 **A 10 MHz Pulsed Laser Wire Scanner for Energy Recovery Linacs** – *A.Y. Murokh, M. Ruelas, R. Tikhoplav (RadiaBeam) E. Pozdeyev (BNL)*

For high average current electron accelerators, such as Energy Recovery Linacs (ERL), the characterization of basic electron beam properties requires non-interceptive diagnostics. One promising non-destructive approach for a high average current beam diagnostic is the laser wire scanner (LWS). RadiaBeam Technologies is developing an inexpensive, standalone laser wire scanner system specifically adapted to ERL parameters.

The proposed system utilizes distinctive features of ERL beams, such as a relatively long bunch length and ultra-high repetition rate, to maximize photon count while using off the shelf laser technology. The RadiaBeam LWS prototype presently under development will be installed and commissioned at the Brookhaven National Laboratory (BNL) ERL facility. This system's design and projected performance are discussed herein.

MOPE096 **Progress Report on the Development of the Real Time Interferometer for Bunch Length Determination** – *G. Andonian, A.Y. Murokh, M. Ruelas, R. Tikhoplav (RadiaBeam) D. Dooley (Spectrum Detector) U. Happek (UGA) S. Reiche (PSI)*

This paper reports on the progress of the development of a bunch length diagnostic for high brightness beams. The diagnostic, termed the real time interferometer, is a single shot, autocorrelator that outputs the interferogram of coherent radiation emitted from compressed, high-brightness beams. The device uses all-reflective terahertz optics as well as a highly sensitive pyroelectric-based detector array. For initial testing, coherent transition radiation is used, however, the diagnostic can be used in a non-destructive manner if coherent edge or synchrotron radiation is employed. Current research includes diagnostic design and preliminary tests conducted at the BNL Accelerator Test Facility.

MOPE097 **Characterization of Slow Orbit Motion in the SPEAR3 Storage Ring** – *N. Sunilkumar (USC) J.A. Safranek (SLAC)*

SPEAR3 is a third-generation synchrotron light source storage ring. The beam stability requirements are ~10% of the beam size, which is about 1 micron in the vertical plane. Hydrostatic level system (HLS) measurements show that the height of the SPEAR3 tunnel floor varies by tens of microns daily. We present analysis of the HLS data, including accounting for common-mode tidal motion. We discuss the results of experiments done to determine the primary driving source of ground motion. We painted the accelerator tunnel walls white, and we temporarily installed Mylar over the asphalt in the center of the accelerator.

MOPE098 **Tomographic Measurement of Electron Beam Longitudinal Phase Space** – *D. Xiang, E.R. Colby, M.P. Dunning, C. Hast, R.K. Jobe, D.J. McCormick, J. Nelson, S.P. Weathersby, M. Woodley (SLAC)*

Understanding the nonlinearities in beam longitudinal phase space is essential for the ECHO-7 experiment at SLAC. In this paper we report the measurement of beam longitudinal phase space using the computerized tomography technique. The longitudinal phase space is rotated by changing the rf phase and reconstructed using the measured energy spectrums for various rf phases. The performance of the ECHO-7 experiment is estimated using the measured longitudinal phase space distribution.

MOPE100 **The Straightness Monitor System at ATF2** – *M.D. Hildreth (University of Notre Dame) A.S. Aryshev (Royal Holloway, University of London) S.T. Boogert (JAI) Y. Honda, T. Tauchi, N. Terunuma (KEK) G.R. White (SLAC)*

The demonstration of the stability of the position of the focused beam is a primary goal of the ATF2 project. We have installed a laser interferometer system that will eventually correct the measurement of high-precision Beam Position Monitors used in the ATF2 Final Focus Steering Feedback for mechanical motion or vibrations. Here, we describe the installed system and present preliminary data on the short- and long-term mechanical stability of the BPM system.

MOPE101 **Parasitic Profile Measurement of 1 MW Neutron Production Beam at SNS Superconducting Linac** – *Y. Liu, A.V. Aleksandrov, C.D. Long (ORNL)*

A laser wire system* has been developed in the Spallation Neutron Source (SNS) superconducting linac (SCL). The SNS laser wire system is the world largest of its kind with a capability of measuring profiles of an operational hydrogen ion (H-) beam at each of the 23 cryomodule stations along the SCL by using a single light source. Presently 9 laser wire stations have been commissioned that measure profiles of the H^- beam at energy levels from 200 MeV to 1 GeV. The laser wire diagnostics has no moving parts inside the beam pipe and can be run parasitically on a neutron production H^- beam. This talk reports our recent study of the laser wire profile measurement performance. Parasitic profile measurements have been conducted at multiple locations of SCL on an operational one-megawatt neutron production beam that SNS recently achieved as a new world record. We will describe experimental investigations of the laser wire system performance including the stability and repeatability of the measurement and the influence of the laser parameters. We will also discuss novel beam diagnostics capabilities at the SNS SCL by using the laser wire system.

MOPE102 **Charged Particle Beam Imaging System** – *B.N. Laprade, V.J. Grib, W.C. Netolicky (PHOTONIS) R. Connolly (BNL)*

The high energy physics community has long sought a capability to determine location and focus of charged particle beams racing through accelerator tubes. Imaging a charged particle beam traveling at nearly the speed of light without changing the velocity or focus has proved to be a challenging task. One approach is used by astronomers to determine the location of black holes by observing the gravitational effects on nearby stars. A similar approach for imaging high velocity charged particle beams has proven successful. The PHOTONIS electron beam imager consists of a large electron generator array, a matching microchannel plate assembly and a readout. Voltage is applied to the EGA to create a high density shower of relatively low energy electrons. These electrons are accelerated to the matching MCP assembly and readout. As the charged particle beam travels through the 'cold' electron shower, it will cast an electron shadow on the MCP. The width of the shadow and the timing information at arrival and departure provide critical information about the positioning and speed of the beam. These devices are UHV compatible and can be custom designed for each beam line.

MOPE103 **RHIC Spin Flipper Commissioning Status** – *M. Bai, W.C. Dawson, A.U. Luccio, Y. Makdisi, S. Nayak, P. Oddo, C. Pai, P.H. Pile, T. Roser (BNL) F. Meot (CEA)*

Commissioning of spin flipper in the RHIC (Relativistic Heavy Ion Collider) Blue ring during the 2009 RHIC polarized proton run showed significant global vertical coherent betatron oscillations induced by a two AC dipole plus four DC dipole configuration. These global orbital coherent oscillations affected collision rates and Yellow beam polarization when beams were in collision. The measured depolarizing strength of of the two AC dipoles at a phase difference of 180 degrees at injection with a different spin tune also confirmed that a single isolated spin resonance can not be induced in the presence of this global vertical coherent betatron oscillation. Hence, a new design was proposed to eliminate the coherent orbital oscillation outside the spin flipper with three additional AC dipoles. This paper presents the new design and supporting numerical simulations. In the RHIC 2010 Au run, only one AC dipole was inserted between the two original AC dipoles; and the measured closure of this AC dipole bump is also presented.

MOPE104 **Residual Gas X-ray Beam Position Monitor for PETRA III** – *P. Ilinski (BNL) U. Hahn, H. Schulte-Schrepping (DESY)*

A residual gas x-ray beam position monitor (RGXBPM) was developed for PETRA-III storage ring. This type of x-ray beam position monitors (XBMP) tend to overcome some deficiencies of the blade type XBPMs, which are currently employed at the third generation synchrotron facilities as "white" undulator beam XBPMs. While blade XBPMs provide a micron accuracy resolution, the signal depends on the undulator gap and is also affected by stray radiation from bending magnets and focusing optics. Residual gas XBPM detects position of the centre of gravity of the undulator radiation, it has no elements which are hit by the x-ray beam and comply with windowless concept of the PETRA-III beamlines. Residual gas beam profile monitors were first developed to provide beam profile measurements at charged particles accelerators. The spatial resolution of RGXBPM was substantially improved in order to comply with the requirements at the PETRA III storage ring. Due to limited space, a thorough electrostatic optimization of RGXBPM was needed to achieve required electrical field quality. Test results obtained at the ESRF and commissioning of the RGXBPMs at PETRA-III will be reported.

25-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area A

TUPEA — Poster Session

TUPEA001 **Electron Distribution Properties in Thermionic Diodes** – *R. Pakter, Y. Levin, F.B. Rizzato (IF-UFRGS)*

In this paper we investigate properties of the electron distribution in planar thermionic diodes. Because in these systems the collision duration time diverges, there is no local equilibrium, and one cannot a priori postulate an equation of state relating the beam density and the beam temperature, as for adiabatic or isothermal processes. Instead, given the properties of thermionic filaments - such as say the velocity distribution of the emitted electrons - one should solve the boundary-value problem posed by the Vlasov equation. This is the approach used in the present paper. By explicitly taking into account the collisionless aspects of the system, we obtain a solution without any assumptions on possible equations of state. To test the predictions of the theory we develop a molecular-dynamics simulation method, which accounts for the boundary conditions of the system. Excellent agreement is found between the simulations and theory*. In particular, our results show that the isothermal hypothesis occasionally used to simplify the analysis of such systems should not be employed.

TUPEA002 **The Influences of Initially Induced Inhomogeneity over the Dynamics of Mismatched Intense Charged Beams** – *R.P. Nunes (UFPel) F.B. Rizzato (IF-UFRGS)*

Although undesired in many applications, the intrinsic spurious spatial inhomogeneity that permeates real systems is the forerunner instability which leads high-intensity charged particle beams to its equilibrium. In general, this equilibrium is reached in a particular way, by the development of a tenuous particle population around the original beam, conventionally known as the halo. In this way, the purpose of this work is to analyze the influence of the magnitude of initial inhomogeneity over the dynamics and over the equilibrium characteristics of initially quasi-homogeneous mismatched beams. For that, all beam constituent particles, which are initially disposed in an equidistant form, suffer a progressive perturbation through random noise with a variable amplitude. Dynamical and equilibrium quantities are quantified as functions of the noise amplitude, which indirectly is a consistent measure of the initial beam inhomogeneity. The results have been obtained by the means of full self-consistent N-particle beam numerical simulations and seem to be an important complement to the investigations already carried out in prior works.

TUPEA003 **A Particle-core Model for Mismatched and Inhomogeneous Intense Charged Particle Beams** – *R.P. Nunes (UFPel) F.B. Rizzato (IF-UFRGS)*

Beams of charged particles usually reach their stationary state by the development of a halo. Halo formation in charged beams is in fact a macroscopic transcription of microscopic instabilities acting inside the beam and upon its constituent particles. In previous works, investigations have been carried out to understand the role of the initial envelope mismatch and of magnitude of inhomogeneity in the beam route to the equilibrium. Although in that works the action of the mentioned instabilities has been studied individually, it is clear that in real implemented beams both act together. In this sense, the main purpose of this work is to generalize previous models, considering now concomitantly the effects of the envelope mismatch and of the inhomogeneity. As a final product of the investigation, a particle-core model for beam constituent particles is presented. The agreement with full self-consistent N-particle beam numerical simulations is satisfactory and the results provided by the model seem to be more compatible with that would be expected experimentally.

TUPEA004 **Start-to-end Beam Dynamics Simulations for the Prototype Accelerator of the IFMIF/EVEDA Project** – *N. Chauvin, O. Delferriere, R.D. Duperrier, R. Gobin, A. Mosnier, P.A.P. Nghiem, D. Uriot (CEA) M. Comunian (INFN/LNL) C. Oliver (CIEMAT)*

The EVEDA (Engineering Validation and Engineering Design Activities) phase of the IFMIF (International Fusion Materials Irradiation Facility) project consists in building, testing and operating a 125 mA / 9 MeV prototype accelerator in Rokkasho-Mura (Japan). Because of high beam intensity and power, the different sections of the accelerator (injector, RFQ, MEBT, HWR linac and HEBT) have been optimized with the twofold objective of keeping a good beam quality and minimizing losses along the machine. Extensive start-to-end multi-particles simulations have been performed to validate the prototype accelerator design. A Monte Carlo error analysis has been carried out to study the effects of misalignments and field variations. In this paper, the results of these beam dynamics simulations, in terms of beam emittance, halo formation and beam loss, are presented.

TUPEA006 **Mismatch Induced Oscillations of Space Charge Dominated Beams under Smooth Focusing Approximation** – *H. Higaki, S. Fujimoto, K. Fukata (Hiroshima University) J. Aoki (Osaka University, Graduate School of Science) K. Ito, M. Kuriki, H. Okamoto (HU/AdSM)*

Space charge effects due to the strong Coulomb interactions expected in high intensity accelerator beams result in undesirable beam degradation and radio-activation of the vacuum tubes through halo formations. Various space charge effects have been studied intensively with particle simulations. This is partly because the analytical formulation of the nonlinear evolution in high intensity beams is not possible in general cases. And the systematic study of space charge effects with the real accelerators is not feasible. Although the development of computation environment is outstanding, some approximations are still necessary so far. Thus, it was proposed to use solenoid traps and linear Paul traps for investigating some properties of space charge dominated beams. The key idea is that the charged particles in these traps are physically equivalent with a beam in a FODO lattice. Some experimental results have been reported with the use of Paul traps. Here, a solenoid trap with a beam imaging system composed of a charge coupled device camera and a phosphor screen was employed to study the mismatch induced oscillations of a space charge dominated beams.

TUPEA007 **S-POD Experiments of Space-Charge-Dominated Beam Resonances** – *H. Okamoto, K. Ito, H. Sugimoto (HU/AdSM) H. Higaki (Hiroshima University) S.M. Lund (LLNL)*

S-POD (Simulator for Particle Orbit Dynamics) is a tabletop, non-neutral plasma trap system developed at Hiroshima University for fundamental beam physics studies. The main components of S-POD include a compact radio-frequency quadrupole trap, various AC and DC power supplies, a vacuum system, a laser cooler, several diagnostics, and a comprehensive computer control system. A large number of ions, produced through the electron bombardment process, are captured and confined in the RFQ trap to emulate collective phenomena in space-charge-dominated beams traveling in periodic linear focusing lattices. This unique experiment is based on the isomorphism between a one-component plasma in the laboratory frame and a charged-particle beam in the center-of-mass frame. We here employ S-POD to explore the coherent betatron resonance instability which is an important issue in modern high-power accelerators. Ion loss behaviors and transverse plasma profiles are measured under various conditions to identify the parameter-dependence of resonance stopbands. Experimental observations are compared with PIC simulation results obtained with the WARP code.

TUPEA008 **An Ultra-low Emittance Design of ERL Injector** – *J. Yamazaki, A. Enomoto, Y. Kamiya (KEK)*

One of the most important issues for ERL injectors is to generate electron beams with ultra-low emittance and to accelerate the beams through the injector without emittance growth. For this purpose, we have developed an efficient simulation code to investigate the mechanism of emittance growth due to space charge effect and to exploit its suppression method. In this code, the longitudinal motion is treated by the one-dimensional difference equations for macro-particles, while the radial motion is solved by the envelope equations for the pieces of sliced bunch. We find that the total emittance takes a minimum when all ellipses of sliced envelope have the same direction on the a-a’ plane, where a is the amplitude of sliced envelope and a’ its derivative along the longitudinal direction. The parameters of a 5 MeV injector were optimized by this code, assuming that the voltage of the DC electron gun is 330 kV and the initial particle distribution at the exit of the gun has a uniform ellipse. Even for such a low voltage gun, we obtained a minimum value of the rms normalized emittance, 0.10 mm, and the rms bunch length, 0.83 mm, the values of which were calculated by using PARMELA.

TUPEA009 **Effects of Wakefield in PLS-II LINAC** – *S.Y. Lee, E.-S. Kim (Kyungpook National University)*

We investigate effects of wakefield in Pohang Light Source (PLS-II) injector linac. The high current and short bunch of the electron beams in the PLS injector linac causes the wakefield effects on the beam quality dilution. We investigate the effects of longitudinal and transverse beam dynamics in the single bunch short-range and multi-bunch long-range wakefields effects. We also investigate the tolerances of the beam parameters due to the machine errors such as misalignments and magnetic field errors.

TUPEA010 **Estimations of Impedances in PLS-II Storage Ring** – *S.Y. Lee, J.G. Hwang, E.-S. Kim, H.J. Kim (Kyungpook National University)*

We estimate the effects of the resistive wall impedance of the elliptical aluminum vacuum chamber made of aluminum and growth rate of coupled-bunch instabilities in Pohang Light Source-II (PLS-II). The impedance of the aluminum vacuum chamber in the PLS-II is estimated to excite a transverse coupled-bunch instabilities. We also show that the transverse growth rate is bigger value than the damping rate. The growth rate is decreased by making longer the radius of circular pipe. It is shown that the transverse feedback system is necessary to suppress effect of the transverse coupled-bunch instability in PLS-II. We also estimate the impedance budget due to the RF cavity, bellows, tapers, slot and so on in the PLS-II.

TUPEA011 **Neutralized Ion Beam Dynamics Study in UNDULAC-E** – *A.V. Voronkov, E.S. Masunov, S.M. Polozov (MEPhI)*

The undulator linear accelerator using electrostatic undulator (UNDULAC-E) is suggested as an initial part of high intensity ion linac*. In UNDULAC ion beam accelerating and focusing are realized by of the combined field of two non-synchronous harmonics. Indeed, the main factor limiting beam intensity in ion accelerator is a space charge force. There exist, at least, two ways to increase ion beam intensity: to enlarge the beam cross section and to use the space charge neutralization. The ribbon ion beam dynamics in UNDULAC-E was discussed in**. Accelerating force value in UNDULAC is proportional to squared particle charge and oppositely charged ions with the identical charge-to-mass ratio can be accelerated simultaneously within the same bunch and the beam space charge neutralization can be realized. These methods will be studied analytically and verified by numerical simulation for UNDULAC-RF in this paper.

TUPEA012 **Beam Loading Effect of High Current Trawling Wave Accelerator Dynamic Study** – *A.V. Voronkov, E.S. Masunov, S.M. Polozov, V.I. Rashchikov (MEPhI)*

The beam loading effect is one of main problems limiting the beam current. Usually this effect takes into account only in high energy electron linacs. Due to low energy electron and, especially, ion linacs nowadays current increasing the beam loading effect should be considered here. Self consistent beam dynamics simulation methods with Coulomb field and beam loading effect are discussed. The simulation results are in good agreement with experiment which have been carried out on NRNU MEPhI electron linac.

TUPEA013 **New Approach to Optimization of RFQ Radial Matching Section** – *D.A. Ovsyannikov, A.D. Ovsyannikov (St. Petersburg State University)*

New approach to define geometry of the radial matching section in RFQ accelerator is suggested. Approach is based on the application methods of the control theory. In paper special functionals are introduced which allow optimize radial section parameters with taking into account space charge. This approach gives wider opportunities for the design of the radial matching section because it does not have certain prescribed laws of variation of focusing strength along the section.

TUPEA014 **Alignment and Magnet Error Tolerances for the High Energy Beam Transport Line for the IFMIF-EVEDA Accelerator** – *C. Oliver, B. Brañas, A. Ibarra (CIEMAT) A. Mosnier, P.A.P. Nghiem (CEA)*

The design of the future IFMIF accelerators will be validated with the 9 MeV, 125 mA deuteron accelerator IFMIF-EVEDA. For this validation phase, a High Energy Beam Transport line (HEBT) is designed to drive the beam toward a beam dump with the required expansion, under the hands-on maintenance constraint. It consists of eight quadrupoles and one dipole. Given the very high space charge regime and the very high power (1.1 MW), any small deviation from the nominal conditions could seriously compromise the HEBT objective. That is why possible misalignments and rotations of those magnets as well as power supply errors have been thoroughly studied. The error budget is fairly distributed among the tolerances for the different components, and effects of those errors on loss distribution and beam profile at the beam dump entrance carefully analysed.

TUPEA015 **Focusing of an Ultrashort Electron Beam for Head-on Inverse Compton X-ray Experiment** – *N.Y. Huang, S.S. Yang (NTHU) H. Hama (Tohoku University, School of Scinece) W.K. Lau (NSRRC)*

Design of an intense but tightly focused ultrashort electron beam for production of sub-hundred femtosecond X-ray pulses that based on head-on inverse Compton scattering (ICS) has been studied. The three dimensional (3D) space charge dynamics has been tracked and optimized throughout the whole beamline. It is found that electron pulses as short as 51 fsec can be produced by compressing the energy-chirped beam from a 2998 MHz rf gun with alpha magnet and rf linac operating at injection phase near zero crossing. This multi-bunch electron beam has an intensity of 38.7 pC per bunch and is accelerated to 27.6 MeV with an S-band linac structure. The compressed electron beam with normalized emittance ~ 3.2 mm-mrad is focused to 30 μm for scattering with an 800 nm, 3.75 mJ infrared Ti:Sapphire laser in the laser-beam interaction chamber. With this method, total peak flux of back-scattered X-ray photons as high as 7.9 x 10^{17} photons/sec is achievable with shortest wavelength of 0.7 Å.

TUPEA016 **Computer Simulation of Transient Self-consistent Dynamics of Intense Short-pulsed Electron Beams in RF Linac** – *A. Opanasenko, V.V. Mytrochenko, S.A. Perezhogin (NSC/KIPT)*

The electron injector for a storage ring is one of numerous applications of the rf linacs of intensive short-pulsed beams with duration about 100 ns, current about 1 A and energy of particles in a few ten MeB. Since acceleration of intensive short-pulsed beams takes place in transient mode, then the energy spread is determined by both intro- and multi- bunch spread. Getting the energy spread less than 1% is the actual problem. In this work we simulate numerically unsteady self-consistent dynamics of charged particles in an rf linac that consist of a low-voltage (25 keV) thermionic gun, a compact evanescent wave buncher, a traveling wave accelerating structure. For transient beam loading compensation a method of delay of a beam relatively rf pulse are applied. The simulation takes into account influence on the beam dynamic of such factors as: initial energy and phase spread; sliding of particles in relation to a wave in the initial part of accelerating section; temporal dependence of phase and energy of bunches at the enter of section; space charge field.

TUPEA017 **Transient Beam Loading Compensation at RF Acceleration of Intense Short-pulsed Electron Beams** – *A. Opanasenko (NSC/KIPT)*

Acceleration of intensive electron beams in transient mode with energy spread less than 1% is the actual problem for rf linacs. The transient beam loading phenomenon, consisting in coherent radiation of sequence of charged bunches, results in time dependence of electron energy loss within a beam pulse. In this work a method of delay of a beam relatively rf pulse for energy compensation at accelerating intense short-pulsed electron beams is discussed. An efficiency of the given method in depending on dispersion of group speed, phase advance per cell of an rf structure, an envelope profile of pulses both current and input rf field is studied. Contribution of non-resonant counter waves in the beam energy spread is estimated.

TUPEA018 **Analysis of Dynamics of Intensive Electron Beam in Disk-loaded Waveguide with Variable Phase Velocity** – *A. Opanasenko, V.S. Kovalenko, K. Kramarenko, V.A. Kushnir, V.V. Mytrochenko, Z.V. Zhiglo, A. I. Zykov (NSC/KIPT)*

At present work the results of numeral simulation of electron dynamics in an unhomogeneous disk-loaded waveguide which is used in the S-band linac are presented. Two approaches taking into account the self-fields of beam radiation are considered: the first method estimative based on the power diffusion equation; the second one based on of self-consistent equations of field excitation and particles motion. The self-consistent approach showed the presence of substantial phase slipping of particles in the homogeneous part of the rf structure, conditioned by the reactive beam loading.

TUPEA020 **Longitudinal and Transverse Effects of HOMs in the Project-X Linac** – *V.P. Yakovlev, N. Solyak, A. Vostrikov (Fermilab)*

Results of analysis are presented for the longitudinal and transverse effects of High-Order Mode (HOM) excitation in the acceleration RF system of the CW proton linac of the Project X facility. Necessity of HOM dampers in the SC cavities of the linac is discussed.

TUPEA021 **Longitudinal Drift Compression of Intense Charged Particle Beams** – *E. Startsev, R.C. Davidson (PPPL)*

To achieve high focal spot intensities in ion-beam-driven high energy density physics and heavy ion fusion applications, the ion beam must be compressed longitudinally by factors of ten to one hundred before it is focused onto the target. The longitudinal compression is achieved by imposing an initial velocity profile tilt on the drifting beam, and allowing the beam to compress longitudinally until the space-charge force or the internal thermal pressure stops the longitudinal compression of the charge bunch. In this paper, the problem of longitudinal drift compression of intense charged particle beams is analyzed analytically and numerically for the two important cases corresponding to a cold beam, and a pressure-dominated beam, using a one-dimensional warm-fluid model describing the longitudinal beam dynamics. The hodograph transformation is used to transform the nonlinear fluid equations into a single, second-order, linear partial differential equation (PDE). The general solution of this equation describing the intense beam system with stagnation point is analyzed and illustrated with several examples.

TUPEA022 **Simulations of the Full Impact of the LHC Beam on Solid Copper and Graphite Targets** – *N.A. Tahir (GSI) V.E. Fortov, I. Lomonosov, A. Shutov (IPCP) R. Piriz (Universidad de Castilla-La Mancha) R. Schmidt (CERN)*

Safety of the personnel and the equipment is an issue of great concern when operating with mighty particle beams like the ones generated by the LHC. Any uncontrolled release of even a very small fraction of the beam energy could cause considerable damage to the equipment. A worst case scenario is in which the entire beam is lost at a single point. Over the past years, we have carried out extensive numerical simulations to assess the consequences of an accident of this magnitude. We have simulated the thermodynamic and the hydrodynamic response of cylindrical targets made of solid copper and solid graphite, respectively, that are facially irradiated with one LHC beam. Our simulations show that the 7 TeV/c LHC protons will penetrate up to about 35 m in solid copper and about 10 m in solid graphite during the 89 μs beam duration time. In both cases, the target is severely damaged and a substantial part of the target is converted into High Energy Density Matter state.

TUPEA023 **The Design of Beam Abort System for the Super KEKB** – *T. Mimashi, N. Iida, M. Kikuchi (KEK) K. Abe (Hitachi Haramachi Electronics Co. Ltd.) K. Iwamoto (KFG) A. Sasagawa (KYOCERA Corporation) A. Tokuchi (Pulsed Power Japan Laboratory Ltd.)*

New beam abort system designed for KEKB upgrade, consists of horizontal and vertical kicker magnets, pulsed quadrupole magnets, a Lambertoson septum magnet and a beam dump. Water-cooling ceramic chambers are used for the kicker and pulsed quadrupole magnets. At the KEKB upgrade project, the beam abort gap is required to be less than 200 nsec. The beam currents are increased and their emittance is supposed to be much smaller than KEKB. In order to avoid melting the extraction Ti window, the pulsed quadrupole magnets will be installed. They enlarge the beam cross section at the extract window. The components for the SuperKEKB abort system are developed. The compact water-cooling ceramic chambers are developed to reduce the gap of kicker magnets and bore radius of the pulsed quadrupole magnets. The power supply for the kicker magnet is also developed to satisfy the 200 nsec rise time requirement.

TUPEA024 **The Basic Thermal Analysis of Beamline Cooling Components for the PLS-II Heat Load** – *K.H. Gil, J.Y. Huang, H.Y. Kim, J.H. Lim (PAL)*

Pohang Accelerator Laboratory is implementing the PLS-II (upgraded Pohang Light Source) project that enhances the operating conditions of PLS in operation from present 2.5 GeV and 200 mA to 3.0 GeV and 400 mA.

Thus, the overall re-evaluation of the beamline cooling performance for the new heat loads was made to be required. Thermal analyses on two simple general models of cooling parts of cooling components were conducted for heat loads of an in-vacuum undulator, a multipole wiggler and a typical bending magnet using ANSYS, respectively. The runs of the analysis for each case of the heat loads and models were executed varying the angle of inclination and the thickness to cooling channels of beam impinging surfaces chosen as major design parameters, and a 2-D distribution of maximum temperatures with respect to the two design parameters was obtained by picking up the maximum temperature computed in each run. Then, design criterions for the cooling parts of the PLS-II beamline components were deduced by evaluating the distribution. This presentation describes the details of the processes and results of the performed thermal analyses and examines the deduced design criterions.

TUPEA025 **Design and Thermo-mechanical Analysis of a High Heat Load Photon Absorber in PLS-II** – *T. Ha, C.D. Park (PAL) A. Sheng (NSRRC)*

The Pohang Light Source II (PLS-II) storage ring is designed to store increased beam energy and current of 3 GeV and 400 mA, respectively. The most critical photon absorber in the PLS-II storage ring will be subjected to a high photon power density of 211 W/mm^2 at normal incidence. To accommodate the high heat load, a crotch type photon absorber with fins is designed. We enhanced cooling efficiency at the edge of the photon absorber, where the power density is maximum, by extending the cooling channel beyond the edge of the body. This design enables us to use readily available oxygen free copper instead of aluminium oxide dispersion strengthened copper as a material for the absorber body. The detailed design and the results from thermo-mechanical analysis are presented in this paper.

TUPEA026 **High Reliability Design using Programmable Logic Devices applied to the Machine Interlock Systems of the LHC and SPS at CERN** – *M. Kwiatkowski, A. Castaneda, B. Puccio, I. Romera, B. Todd (CERN)*

Machine Interlock systems for the CERN SPS and LHC make extensive use of Programmable Logic Devices (PLD) to implement their safety critical functions. The dependability (reliability, safety, availability and maintainability) of these functions is difficult to determine: the use of Hardware Description Language (HDL) in the design phase requires careful consideration to ensure system behaviour. Simulation of function is a key consideration; behavioral simulation does not always give results which match real hardware, and although Gate-level simulations match hardware they are time consuming, making them somewhat impractical. In both cases, code coverage is a basic requirement. Hardware testing is also required to validate the implementation, proving that final hardware conforms to specification. This paper describes how the receiver module of the Safe Machine Parameter (SMP) system is being engineered, highlighting the techniques and processes which are currently being developed by CERN in order to maximize the safety of systems relying on PLD. The ultimate goal is to produce a set of guidelines which can be used to develop any dependable hardware which uses PLDs.

TUPEA027 **Interlocks for the LHC Magnet Powering System and Beam Operation** – *I. Romera, A. Castaneda, P. Dahlen, B. Puccio, B. Todd, M. Zerlauth (CERN)*

The correct functioning of the LHC machine interlocks is vital for safe operation throughout all operational phases of the Large Hadron Collider (LHC). The powering system with about 1700 electrical circuits powering almost 10000 magnets is the most complex subsystem in the LHC. The powering interlock systems, both for super conducting and normal conducting magnets, is essential for safe commissioning and operation of the magnet system. Any failure in the powering of a critical magnet must trigger an emergency beam dump. For a few electrical circuits with a decay time constant of a few seconds,installed at location of high beta function,an additional system for a very early detection of a failure has been added. Installation of the powering interlock systems started some years ago and the systems have been commissioned during two dedicated Hardware Commissioning Phases. This paper reports on the operational experience with the powering interlock systems,and details the interfaces with the beam interlock system and the tests to validate correct functionality. It also reports on the automated software tools,used on a regular basis to assess the readiness of main systems for beam operation.

TUPEA028 **Beam Stop Design Methodology and Considerations for a New SNS Momentum Beam Stop** – *Y. Polsky (ORNL)*

The use of a beam stop to absorb full or partial beam at various points along a particle accelerator is commonplace. The design of accelerator components such as magnets, linacs and beam instruments tends to be a fairly focused and collective effort within the particle accelerator community with well established performance and reliability criteria. Beam stop design by contrast has been relatively isolated and unconstrained historically with much more general goals. This combination of conditions has lead to a variety of facility implementations with virtually no standardization and minimal concensus on approach to development within the particle accelerator community. At the Spallation Neutron Source (SNS), for example, there are four high power beam stops in use, three of which have significantly different design solutions. This paper describes the design of a new off-momentum beam stop for the SNS. Content will be balanced between hardware description, analyses performed and the methodology used during the development effort. Particular attention will be paid to the approach of the design process with respect to future efforts to meet beam stop performance metrics.

TUPEA029 **Synchronized Clock System for Acceleration Pattern Generation and its Beam Tests in HIMAC Synchrotron** – *M. Kanazawa (NIRS)*

In the routine operation of HIMAC synchrotron, a pulse system of field change with 0.2 Gauss in the monitor dipole magnet (B-clock) is used to generate pattern data in the acceleration system. To eliminate error pulse due to noise in analogue field signal, a clock system locked to a 1.2kHz clock for a power supplies was developed, which can be used to generate pattern data of an acceleration system with maximum frequency of 192kHz. This 1.2kHz clock is synchronized to a power line frequency of 50Hz that will fluctuate about 0.1%, so the clock of 192kHz must also follow this frequency fluctuation. To demonstrate the performance of new clock system, we have tested beam acceleration, and compared with the conventional B-clock system. Acceleration efficiencies were checked with changing these clock rates in the both systems. With these tests, we have found that the relatively low clock rate in the newly developed system is enough to get good acceleration performance. In this paper the clock system, and their beam tests will be presented.

TUPEA030 **Transmission of Reference RF Signals through Optical Fiber at XFEL/SPring-8** – *T. Ohshima, N. Hosoda, H. Maesaka, S.M. Matsubara, Y. Otake (RIKEN/SPring-8)*

The pulse width of an X-ray laser at XFEL/SPring-8 is several tens femtoseconds, which requires reference rf signals to have the same time-stability. The reference signals with a low phase-noise oscillator are sent to instruments in 19" racks developed along an accelerator by an optical fiber system. The temperature drift of the fiber makes phase shifts of the reference signals. Therefore, the fiber is put in a thermal-insulated duct. By feeding temperature-controlled water (26.1 ± 0.1 deg. C) in a pipe attached to the duct, the fiber temperature was kept to be 26.2 ± 0.08 deg. C at the ambient temperature change of 29.1 ± 1.7 deg. C. From this temperature controllability, the phase shifts of the signals through a 400 m fiber of a thermal coefficient of 5 ps/km/K are 160 fs. Further reduction of the shifts is required and will be achieved by a fiber-length feedback control in a future plan. Vibration of the fiber also degrades the quality of the signals. The fiber is embedded on a vibration buffer material. A test to evaluate the effect of the vibration to the transmitted signal phase was carried out. The test result will be also shown in this paper.

TUPEA031 **Synchronization and Control System for Tsinghua Thomson Scattering X-ray Source** – *D. Qiang, Y.-C. Du, W.-H. Huang, C.-X. Tang, L.X. Yan (TUB)*

The Thomson scattering X-ray source in Tsinghua University includes a photocathode RF gun, a 30MeV electron linac, a picosecond UV drive laser, a terawatt femtosecond infrared laser system and some beam line instruments. These devices and systems need an integrated timing distribution system and a time synchronizer to lock the laser and RF phase. Recently, a high harmonic phase lock controller is built and the UV laser-RF rms time jitter is measured as less than 100fs; a FPGA based event generator is developed to distribute trigger events for laser amplification process and the linac RF system with 250ps time resolution; Finally, an EPICS based distributed control system is built to monitor and control all these sub-systems. The preliminary experiments on Thomson scattering and ultrafast electron diffraction are demonstrated.

TUPEA032 **A New Timing System: the Real-time Synchronized Data Bus** – *M. Liu, D.K. Liu, C.X. Yin, L.Y. Zhao (SINAP)*

Currently, the real-time data transfer system is widely implemented in the accelerator control system. If timing system and real-time data transfer system could be combined into one uniform system, it would be convenient to build distributed feedback system, fast interlock system and so on. So, a new timing system, the real-time synchronized data bus is developed to realize this idea. The architecture of the system and the hardware prototype design are introduced in the paper. The data exchange mechanism and system specification, including timing trigger synchronization accuracy, timing jitter relative to RF clock, data transfer rate and latency are described in detail. Redundant topology structure and fiber length compensation are specially considered. In the end, the results of testing in lab are presented.

TUPEA033 **Stable Transmission of RF Signals on Optical Fiber Links** – *J.M. Byrd, L.R. Doolittle, G. Huang, J.W. Staples, R.B. Wilcox (LBNL)*

Stabilized optical fiber links have been under development for several years for high precision transmission of timing signals for remote synchronization of accelerator and laser systems. In our approach, a master clock signal is modulated on an optical carrier over a fiber link. The optical carrier is also used as the reference in a heterodyne interferometer which is used to precisely measure variations, mainly thermal, in the fiber length. The measured variations are used to correct the phase of the transmitted clock signal. We present experimental results showing sub-10 fsec relative stability of a 200 m link a sub-20 fsec stability of a 2.2 km link.

TUPEA034 **Laser Recycler Using An Asymmetrical Con-focal Cavity** – *I. Yamane (KEK) M. Nakamura, H. Okuno (RIKEN Nishina Center)*

An asymmetrical con-focal cavity is composed of tow concave mirrors with different focal length, placed face to face, and their axes and focal points coincide. When a laser beam is injected in parallel with the mirror axis, from backward of and just outside of the mirror with the smaller focal length, the laser beam is trapped in the cavity and repeats reflection by mirrors. Then, the beam reflected by the mirror with the larger focal length passes every time the focal point and the period by which pulses return to the focal point is constant. Therefore, if the repetition period of the injected laser pulse is equal to the repetition period in the cavity, all laser pulses comes to the focal point at the same time and the beam intensity is stacked up. Calculation on the performance of an asymmetrical con-focal cavity shows that a laser pulse can be recycled more than a few tens turns and the beam intensity can be stacked to more than a few tens times of the original beam intensity when the laser beam is a Gaussian beam and the reflectance of the mirrors is 100%. Results of calculation is examined using a He-Ne laser and a pair of high reflection mirrors.

TUPEA035 **Drive Laser and Optical Transport Line for Photoinjector** – *Z.G. He, Q.K. Jia, X.E. Wang (USTC/NSRL)*

A Photo-Cathode RF Gun is under development at NSRL. In this paper, the drive laser system is introduced and performance parameters are presented. We adopt a BNL type gun with laser illuminating the cathode at oblique incidence. To orrect ’time slew’ and ’elliptical spot’ problems arisen on the cathode, an adjustable optical transport line is designed.

TUPEA036 **Laser Systems for Inverse Compton Scattering Gamma-ray Source for Photofission** – *I. Jovanovic, Y. Yin (Purdue University) S. Boucher, R. Tikhoplav (RadiaBeam) G. Travish (UCLA)*

One approach for detecting special nuclear material (SNM) at a distance is to use highly penetrating gamma-rays (>6 MeV) to produce photofission. We are investigating inverse gamma-ray sources (IGS), based on inverse Compton scattering (ICS) of a laser pulse on a relativistic electron bunch. Nearly monochromatic gamma rays with high brightness, very small source size and divergence can be produced in IGS. For the interaction drive laser recirculation it is necessary to meet the repetition rate requirements. Three implementations of laser recirculation are proposed for the interaction drive laser, which can significantly reduce the requirements on the interaction drive laser average power. It is found that the recently demonstrated recirculation injection by nonlinear gating (RING) technique offers unique advantages for beam recirculation in IGS.

TUPEA037 **Dual Harmonic Operation at SIS18** – *K.-P. Ningel, P. Hülsmann, H. Klingbeil, U. Laier, C. Thielmann, B. Zipfel (GSI)*
The heavy ion synchrotron SIS18 at the GSI facility will be upgraded by a dual harmonic RF acceleration system in the process of using SIS18 as booster for the future FAIR SIS100 accelerator. The dual harmonic mode will extend the SIS18 operating towards higher beam currents. As a part of a large LLRF upgrade at the synchrotron RF systems at GSI, new FPGA and DSP based electronics have been designed, built and commissioned. To prove the functionality of the LLRF equipment as well as the general dual harmonic topology, machine development experiments using the existing cavities have been performed. During these experiments, the main parameters of the control loop were determined. Additionally, the impact of RF gap voltage amplitude and phase variations onto the ion beam have been investigated, like e.g. creation of a dual harmonic bucket or fast changes in harmonic number. The experiments showed a high sensitivity of the ion beam to small deviations in the phase between both harmonics and thereby confirmed the requirements on the high precision regarding phase accuracy of the electronic setup especially for the closed loop phase control systems.

TUPEA038 **A Digital Baseband Low Level RF Control for the P-linac Test Stand at GSI** – *R. Eichhorn, A. Araz, U. Bonnes, F. Hug, M. Konrad (TU Darmstadt) G. Schreiber, W. Vinzenz (GSI) R. Stassen (FZJ)*
During the redesign of the low level RF system for the S-DALINAC, a baseband approach was chosen. The RF signals from/ to the cavity are converted into the baseband via I/Q Modulators/ Demodulators. The advantage of this design was realized lateron, as adaption of other frequencies becomes rather easy. The system, originally designed for 3 GHz superconducting cavity in cw operation is currently modified to control a 324 MHz room temperature CH cavity in pulsed operation. We will report on the rf control system principle, the required modifications and first results.

TUPEA039 **Optimization of Filling Procedure for TESLA-type Cavities for Klystron RF Power Minimization of European XFEL** – *V. Ayvazyan, S. Choroba, Z. Geng, G. Petrosyan, S. Simrock, V. Vogel (DESY)*
The Free Electron Laser in Hamburg (FLASH) is a user facility providing high brilliant laser light for experiments. It is also a unique facility for testing the superconducting accelerator technologies. FLASH cavities are operating at pulsed mode. There is a filling stage to build the RF voltage in the cavities and then follow a flattop for beam operation. By the limitation of the klystron pulse length the filling time of the cavities is limited to several hundred microseconds. In order to fill the cavities to the dedicated voltage usually large RF power is required for the filling stage. For European XFEL during RF operation the klystrons will be working quite near the saturation point for better efficiency. So lowering the unnecessary klystron peak power under closed loop operation is very important for close-limitation operation. The paper will present the method which allows decreasing the required klystron peak power as well as the reflected power by filling the cavity in resonance. Simulation results will be presented as well as experimental demonstrations at FLASH.

TUPEA041 **Drift Calibration Techniques for Future FELs** – *F. Ludwig, C. Gerth, K.E. Hacker, M. Hoffmann, G. Moeller, P. Morozov, Ch. Schmidt (DESY) W. Jalmuzna (TUL-DMCS)*
Future FELs (Free-Electron-Laser) requires a precise detection of the cavity field in the injector section with a resolution of significantly smaller than 0.01 degree (rms) in phase and amplitude 10^{-4} (rms) at 1.3GHz. The long-term stable SASE operation mainly suffers from injector accelerator components and the stability of the reference distribution. Especially thermal instabilities of the distributed cavity field detectors, probe pickup cables and their mechanical vibrations influence the energy stability dramatically on a scale of 10^{-3}, which is 10 times worse than desired. To eliminate the long-term amplitude and phase changes of the field detectors of the order of 10^{-3}/deg C, we tested calibration schemes by tracking the reference and injected the reference during the pulse pauses in laboratory and during FLASH operation at DESY. By applying the injected calibration method, we demonstrate firstly a dramatic phase and amplitude stability improvement from the ps-range to the 0.008 deg (peak-to-peak) range in phase and amplitude to $2 \cdot 10^{-4}$ (peak-to-peak) by a factor of about 100. In addition, we successfully tested the the injected calibration method during FLASH operation.

TUPEA042 **Recent LLRF Measurements of the 3rd Harmonic System for FLASH** – *M.G. Hoffmann, M. Hoffmann, F. Ludwig, P. Morozov, Ch. Schmidt (DESY)*

For future FELs (Free-Electron-Lasers) a 3rd harmonic system was proposed to increase the SASE intensity by linearization of the beam phase space after the first bunch compression section. At DESYs FLASH facility, a 3rd harmonic cavity system, consisting of four single cavities operating at 3.9GHz has been successfully tested at the module test stand. In this paper we present field regulation measurements using a step wised down converted field detector system and a model based designed LLRF field controller. First measurements showed a promising in loop vectorsum amplitude stability of about $2{\cdot}10^{-5}$ for pulse-to-pulse operation.

TUPEA043 **Phase Modulator Programming to Get Flat Pulses with Desired Length and Power from the CTF3 Pulse Compressors** – *H. Shaker (IPM) R. Corsini, H. Shaker, P.K. Skowronski, I. Syratchev, F. Tecker (CERN)*

The Pulse compressor is located after the klystron to increase the power peak by storing the energy at the beginning and releasing it near the end of klystron output pulse. In the CTF3 pulse compressors the double peak power is easily achieved according to our needs and the machine parameters. The magnitude of peak power, pulse length and flatness can be controlled by using a phase modulator for the input signal of klystrons. A C++ code is written to simulate the pulse compressor behavior according to the klystron output pulse power. By manually changing the related parameters in the code for the best match, the quality factor and the filling time of pulse compressor cavities can be determined. This code also calculates and sends the suitable phase to the phase modulator according to the klystron output pulse power and the desired pulse length and peak power. An additional code is written to correct the input phase by a feedback from the pulse compressor output for the better result.

TUPEA044 **Piezoelectric Actuators Control Unit** – *A. Gennai, F. Bedeschi, S. Galeotti, C. Magazzu, F. Paoletti, E. Pedreschi, F. Spinella (INFN-Pisa) D. Passuello (University of Pisa and INFN)*

Superconductive cavities for future linear accelerators, such as ILC, have extremely large quality factors requiring an effective stabilization with both slow and fast tuners. Piezoelectric actuators are the most common choice for fast tuners, but one drawback for a large scale application is the limited bandwidth and the large cost of commercially available drivers. In this paper we present a low cost driver which is ideally suited for fast tuner application, large system packaging and has an excellent flexibility in its implementation. Driving piezoelectric actuators having capacitive loads up to a few microfarads in the kHz range requires amplifiers with good current output capabilities at a few hundred volts. The Piezo Control Unit we developed for the ILC Test Area at Fermilab is composed by a 6U Eurocard crate hosting 5 Piezo Driver modules capable of driving up to 10 piezoelectric actuators. Main specifications include large voltage rails (-175 V to +175V), wide signal bandwidth (DC to10 kHz) and low output noise (<10 mVrms). The driver is equipped with both output voltage and output current monitor.

TUPEA045 **Local Control of Piezoelectric Actuators** – *F. Spinella, F. Bedeschi, S. Galeotti, A. Gennai, E. Pedreschi (INFN-Pisa) D. Passuello (University of Pisa and INFN)*

Active devices based on piezoelectric actuators are widely used to dump unwanted vibrations in a variety of applications; for instance fast tuners for superconducting RF cavities. In another poster, we describe a low cost modular system of drivers for piezoelectric actuators developed at INFN-Pisa; we show here that the same system can easily be extended, with the inclusion of a simple plug-in board, to include sufficient I/O and computing capability to allow control of the device up to frequencies in the kHz range. This implementation is extremely cost effective and can be used in all situations where a high granularity distributed control system is desirable. We also show our first test results obtained using this system to control a warm single cell 1.3 GHz cavity. The cavity is perturbed using a piezoelectric actuator to generate random noise, while another piezo is used in the control loop to stabilize the resonance frequency. We use the phase of the RF pickup from the cavity as a measure of the deviation from the resonance caused by the perturbation. This simple setup allows to easily test various control algorithms without the need to work at large complex facilities.

TUPEA046 **LLRF Controller Upgrade for the J-PARC 400 MeV LINAC** – *Z. Fang, S. Anami, Y. Fukui, M. Kawamura, C. Kubota, S. Michizono, F. Naito, K. Nanmo, S. Yamaguchi (KEK) H. Asano, K. Hasegawa, T. Itou, T. Kobayashi, S. Shinozaki, N. Tsubota (JAEA/J-PARC) E. Chishiro, H. Suzuki (JAEA)*

The output energy of the J-PARC LINAC will be upgraded from 181 to 400 MeV in the next two years by adding high-beta acceleration sections. The upgrade of the FPGA-based digital LLRF controller for the 400 MeV LINAC will be presented in this paper. The new LLRF control system works for both the 324 MHz low-beta and 972 MHz high-beta sections. Many functions are added into the LLRF controller, such as 1) working for different RF frequencies, 2) gradually increasing the feedback gains in the feedback loop instead of fixed ones, 3) automatic chopped-beam compensation, 4) automatically switching the beam loading compensation in accordance with the different beam operation mode, 5) input rf-frequency tuning carried out by a FPGA to match the rf cavities during the rf start-up, 6) autotuning of the rf cavity tuner by detecting the phase curve of the rf cavity during the field decay instead of the phase difference between the cavity input and output signals.

TUPEA047 **Digital LLRF System for STF S1 Global** – *S. Michizono, D.A. Arakawa, S. Fukuda, H. Katagiri, T. Matsumoto, T. Miura, Y. Yano (KEK)*

Global S1 will be operated at STF in KEK, where total 8 cavities will be installed. The digital llrf system to control the vector sum of the field gradients to be flat has been developed. All the digital llrf system including rf monitoring, piezo-control system will be shown. The new llrf system suitable for the DRFS scheme, which is also studied during S1 grobal, is also under development.

TUPEA048 **Low Level RF System for cERL** – *T. Miura, A. Akiyama, D.A. Arakawa, S. Fukuda, H. Katagiri, T. Matsumoto, S. Michizono, J.-I. Odagiri, Y. Yano (KEK)*

The compact ERL(cERL) is the energy recovery linac(ERL) test facility that is under construction at KEK. The stability of accelerating electric field of 0.1% rms in amplitude and 0.1deg. in phase is required for LLRF system. The status of LLRF system for cERL will be reported.

TUPEA049 **Phase and Amplitude Modulation of the RF Pulse of an Electron Linac for the High Quality Beam** – *M. Morio, K. Furuhashi, G. Isoyama, S. Kashiwagi, R. Kato, S. Suemine, N. Sugimoto, Y. Terasawa (ISIR)*

We are conducting to develop free electron laser (FEL) in the terahertz region using the L-band electron linac at ISIR, Osaka University. In order to generate a micro-bunched electron beam with uniform energy, the phase and amplitude of RF pulses were repeatedly controlled using a electrical phase shifter and an I-Q modulator for low level RF pulse. We achieved the undulations of flat-top of the input RF pulse for the accelerating structure were reduced to 0.2deg (p-p) and 0.88% (p-p) in the phase and amplitude within 7.6 us pulse duration, respectively. We will report the system and the measurements.

TUPEA050 **Dual-harmonic Phase Control in the J-PARC RCS** – *F. Tamura, M. Nomura, A. Schnase, T. Shimada, H. Suzuki, M. Yamamoto (JAEA/J-PARC) K. Hara, C. Ohmori, M. Tada, M. Yoshii (KEK/JAEA) K. Hasegawa (KEK)*

The wide-band RF cavities in the J-PARC RCS are operated in the dual-harmonic operation, in which each single cavity is driven by a superposition of the fundamental and the second harmonic RF signals. By the dual-harmonic operation large amplitude second harmonic signals for the bunch shape manipulation are generated without extra cavities. The phase control of the second harmonic RF is a key for the bunch shape manipulation. The fundamental RF signal is controlled by the phase feedback loop to damp the dipole oscillation. The second harmonic is locked to the phase of the vector-sum phase of the fundamental RF signals. We present the system detail and the performance in the beam operation of the RCS.

TUPEA051 **Application of Digital Narrow Band Noise to J-PARC Main Ring** – *A. Schnase, K. Hasegawa, M. Nomura, T. Shimada, H. Suzuki, F. Tamura, M. Yamamoto (JAEA/J-PARC) K. Hara, C. Ohmori, M. Tada, M. Yoshii (KEK/JAEA) T. Koseki, T. Toyama (J-PARC, KEK & JAEA) M. Tomizawa (KEK)*

Applying narrow band longitudinal noise to the beam in J-PARC Main Ring in flattop, while the acceleration voltage is off might help to counteract the effect of ripple on the slow extraction. For this purpose, a complex noise sequence output by DSP modulates a custom made DDS synthesizer to create single side spectra without carrier. The noise is calculated starting from a description in frequency domain. Then an algorithm creates narrow band spectra with optimized behavior in time domain. Frequency domain data is transformed to time domain, and the amplitude is smoothed. The smoothed data is transformed back to frequency domain, and the spectral shape is restored. This process repeats until the amplitude in time domain has converged, while the desired spectrum shape is preserved. Noise generated in this way can be tailored for different requirements. We show the signal properties, the hardware, and preliminary beam test results, when the noise is applied to the MR RF system.

TUPEA052 **Operation Status of DLLRF System in the Storage Ring of SSRF** – *X. Zheng, H.T. Hou, J.F. Liu, C. Luo, Zh.G. Zhang, S.J. Zhao (SINAP) Z.Q. Feng, Z. Li, D.Q. Mao, Y.B. Zhao, X. Zheng (Shanghai KEY Laboratory of Cryogenics & Superconducting RF Technology)*

The digital low level radio frequency (DLLRF) system in the storage ring of Shanghai Synchrotron Radiation Facility (SSRF) has been operational for more than one year. It has successfully maintained the amplitude and phase stability of the cavity field in the superconducting cavity even when the beam current in the storage ring reached 300mA at 3.5GeV. The operation status is reported in this paper and some challenges aiming at better diagnostics, maintenance and flexibility, are also discussed.

TUPEA053 **Piezo Control for Lorenz Force Detuned SC Cavities of DESY FLASH** – *K.P. Przygoda, A. Napieralski, T. Pozniak (TUL-DMCS) M.K. Grecki (DESY)*

DESY FLASH accelerator is composed of 6 accelerating modules. The single accelerating module contains 8 superconducting resonant cavities. Since FLASH operation is dedicated for various energy physics experiments such as high current beam acceleration or SASE tuning, the sc cavities are Lorentz force detuned when operated with high gradient accelerating fields*. The ACC 3, 5 and 6 cryomodules are equipped with piezo tuners allow compensating of dynamic detuning during the RF pulse. In order to assure the simultaneous control of all available piezo tuners a distributed, multichannel digital and analogue piezo control system was applied. The paper describes the main parts of the system as well as its efficiency measurements obtained during high current beam acceleration (9 mA tests) performed in DESY. The piezo tuners were operable for 23 cavities for several hours. Moreover, the first piezo sensor measurements using double stack piezos installed in ACC 6 cryomodule are briefly demonstrated.

TUPEA054 **Libera LLRF - Development and Tests** – *A. Kosicek, G. Jug (I-Tech)*

In this article we are presenting tests and development of digital low level RF control system Libera LLRF. Libera LLRF is a digital system small in size but powerful in terms of performance as tests revealed. Size of unit matches industrial standards and is in 19" 2U sustainable metal box that fits into racks. Development of the Libera LLRF reflects needs of accelerator's and their operators. With its capabilities it is a system that is able to control RF at 4th generation light sources. Concept of the Libera LLRF system also enables implementation of operator's own solutions in controlling RF. During preparations for testing Libera LLRF's features proved to be useful since little time was needed to install and operate the system. In some cases its features and capability enabled operators to identify and quickly resolve problems that were accelerator's components related.

TUPEA055 **Design and Implementation of a Pulsed Digital LLRF System for the RAL Front End Test Stand** – *H. Hassanzadegan, N. Garmendia (ESS Bilbao) F.J. Bermejo (Bilbao,* *Faculty of Science and Technology) V. Etxebarria (University of the Basque Country, Faculty of Science and Technology) D.J.S. Findlay, A.P. Letchford (STFC/RAL/ISIS)*

Design, implementation and some practical results of the pulsed digital LLRF system (amplitude, phase and tuning loops) of the RFQ for the ISIS front end test stand are presented. The design is based on a fast analog front-end for RF-baseband conversion and a model-based Virtex-4 FPGA unit for signal processing and PI regulation. Complexity of the LLRF timing is significantly reduced and the LLRF requirements are fulfilled by utilizing the RF-baseband conversion method compared to the conventional RF-IF approach. Validity of the control loops is ensured practically by hardware-in-the-loop co-simulation of the system in MATLAB-Simulink using an aluminium mock-up cavity. It was shown through extensive tests that the LLRF system meets all the requirements including amplitude and phase stability, dynamic range, noise level and additionally provides a full amplitude and phase control range and a phase margin larger than 90 degrees for loop stability.

TUPEA056 **CERN's PS Booster LLRF Renovation: Plans and Initial Beam Tests** – *M. E. Angoletta, A. Blas, A.C. Butterworth, A. Findlay, P.M. Leinonen, J.C. Molendijk, F. Pedersen, J. Sanchez-Quesada, M. Schokker (CERN)*

In 2008 a project was started to renovate the CERN's PS Booster (PSB) low-level RF (LLRF). Its aim is to equip all four PSB rings with modern LLRF systems by 2013 at the latest. Required capabilities for the new LLRF include frequency program, beam phase, radial and synchronization loops. The new LLRF will control the signals feeding the three RF cavities present in each ring; it will also shape the beam in a dual harmonic mode, operate a bunch splitting and create a longitudinal blow-up. The main benefits of this new LLRF are its full remote and cycle-to-cycle controllability, built-in observation capability and flexibility. The overall aim is to improve the robustness, maintainability and reliability of the PSB operation and to make it compatible with the injection from the future LINAC4. The chosen technology is an evolution of that successfully deployed in CERN's ion accumulator ring LEIR and it is based upon modular VME 64X hardware and extensive digital signal processing. This paper outlines the main characteristics of the software and hardware building blocks. Promising initial beam tests are shown and hints are included on the main milestones and future work.

TUPEA057 **CERN's LEIR Digital LLRF: System Overview and Operational Experience** – *M. E. Angoletta, J. Bento, A. Blas, E. Bracke, A.C. Butterworth, F. Dubouchet, A. Findlay, F. Pedersen, J. Sanchez-Quesada (CERN)*

The Low Energy Ion Ring (LEIR) is an accumulation ring in the Large Hadron Collider ion injector chain. After its successful start in 2005, it has been running in three operational campaigns. The LEIR LLRF system is the first all-digital low-level RF (LLRF) system to be made operational in a CERN circular machine. Composed of modular VME 64X hardware, it carries out extensive digital signal processing via Field Programmable Gate Arrays and Digital Signal Processors. System capabilities include beam control tasks, such as frequency program, beam phase, radial and synchronization loops, as well as cavity voltage/phase loops. All the system's control parameters are fully configurable, remotely and in-between cycles; extensive built-in diagnostics and signal observation features are available. The system has proven to be not only flexible and powerful but also extremely reliable. This is very important as the LEIR LLRF system is the pilot project for the LLRF renovation of other CERN's machines. This paper gives an overview of the main system building blocks and outlines their capabilities and operational features, along with results obtained during the first years of beam operation.

TUPEA058 **The EMMA LLRF System and its Synchronization with ALICE** – *A.J. Moss, S.P. Jamison, P.A. McIntosh (STFC/DL/ASTeC) B.B. Baricevic (I-Tech)*

The Low Level RF (LLRF) control system on EMMA (Electron Model for Many Applications), the world's first Non-Scaling Fixed Field Alternating Gradient (NS-FFAG) accelerator is presently being installed and commissioned at Daresbury Laboratory. The LLRF is required to synchronize with ALICE (Accelerators and Lasers in Combined Experiments) its injector, which operates at 1.3GHz, and to produce an offset frequency as required (+1.5Mhz to -4MHz) to then maintain the phase and amplitude of the 19 copper RF cavities of the EMMA machine. The design and commissioning of the LLRF system is presented.

TUPEA059 **Latest Results on Cavity Gradient and Input RF Stability at FLASH/TTF** – *S. Pei, C. Adolphsen (SLAC) J. Carwardine (ANL) N.J. Walker (DESY)*

The FLASH L-band (1.3 GHz) superconducting accelerator facility at DESY has a Low Level RF (LLRF) system that is similar to that envisioned for ILC. This system has extensive monitoring capability and was used to gather performance data relevant to ILC. Recently, waveform data were recorded with both beam on and off for three, 8-cavity cryomodules to evaluate the input RF and cavity gradient stability and study the RF overhead required to achieve constant gradient during the 800 microseconds pulses. In this paper, we present the experimental results and discuss the pulse-to-pulse input RF and cavity gradient stability.

TUPEA060 **A Compact X-band Linac for an X-ray FEL** – *K.L.F. Bane, C. Adolphsen, Z. Huang, Z. Li, C.D. Nantista, F. Wang, F. Zhou (SLAC)*

With the growing demand for FEL light sources, cost issues are being reevaluated. To make the machines more compact, higher-frequency room-temperature linacs are being considered, in particular, ones using C-band (5.7 GHz) rf technology where 40 MV/m gradients are possible. In this paper, we show that an X-band (11.4 GHz) linac using the technology developed for NLC/GLC can provide an even lower cost solution. In particular, stable operation is possible at gradients of 100 MV/m for single bunch operation, and 70 MV/m for multibunch operation. The concern of course is whether the stronger wakefields will lead to unacceptable emittance dilution. However, we show that the small emittances produced in a 250 MeV, low bunch charge, LCLS-like S-band injector and bunch compressor can be preserved in a multi-GeV X-band linac with reasonable alignment tolerances.

TUPEA061 **LLRF System Upgrade for the SLAC Linac** – *B. Hong, R. Akre, V. Pacak (SLAC)*

The Linac Coherent Light Source (LCLS) at SLAC is in full user operation and has met the stability goals for stable lasing. The 250pC bunch can be compressed to below 100fS before passing through an undulator. In a new mode of operation a 20pC bunch is compressed to what is believed to be about 10fS. Experimenters are regularly using this shorter X-ray pulse and getting pristine data. The 10fS bunch has timing jitter on the order of 100fS. Physicists are requesting that the RF system achieve better stability to reduce timing jitter. Drifts in the RF system require longitudinal feedbacks to work over large ranges and errors result in reduced performance of the LCLS. This paper describes the new RF system being designed to help diagnose and reduce jitter and drift in the SLAC linac.

TUPEA062 **LLRF and RF System Models for the LHC with Application to Longitudinal Dynamics Effects** – *T. Mastorides, J.D. Fox, C.H. Rivetta, D. Van Winkle (SLAC) P. Baudrenghien (CERN)*

Radio Frequency (RF) accelerating system noise and non-idealities can have detrimental impact on the LHC performance through longitudinal motion and longitudinal emittance growth. For example, disturbances on the accelerating voltage from system noise and harmonic/sub-harmonic spectral lines of the klystron power supply ripple can contribute to beam motion and diffusion. The LHC RF station-beam interaction is simulated via engineering-level models of the LLRF and RF systems to study the dynamics of the station and the beam. We model the RF station at high current and with future upgraded operating conditions of the LHC, study optimal configuration techniques, and estimate operational limits of the Beam-LLRF system. Non-idealities and noise of the implementation are modeled to study bunch centroid stability, position, and longitudinal motion. The Fokker-Planck diffusion coefficients that describe the bunch shape and diffusion are estimated as a function of the RF and Low Level RF configurations, and the system's technical characteristics. The effect of the operating configurations on the 50 Hz power supply ripple line and the related particle losses during the ramp are estimated.

TUPEA063 **Commissioning of the LHC Low Level RF System Remote Configuration Tools** – *D. Van Winkle, J.D. Fox, T. Mastorides, C.H. Rivetta (SLAC) P. Baudrenghien, A.C. Butterworth, J.C. Molendijk (CERN)*

We present a commissioning report of the suite of RF tools used for configuration of the LHC RF system for the start up in fall of 2009. The LHC LLRF system is a complex multi-loop system used to regulate the superconductive cavity gap voltage as well as to lower the impedance as seen by the beam. The RF system can have a profound impact on the stability of the beam; a mis-configured RF system has the potential of causing longitudinal instabilities, beam diffusion and beam loss. The system configurations are determined by the adjustment of offset, loop gain, net phase and signal level for the analog, digital, 1 turn and klystron polar feedback loops. Initial system commissioning as well as ongoing operation requires a consistent method of computer based remote measurement and adjustment of each RF station system configuration. We present a brief overview of the hardware, examples of commissioning results, and basics of the model based alignment algorithms[1]. The various alignment and identification routines with specific detail on the implementation of the 1 Turn feedback and cavity Q factor measurement routines are illustrated with machine data.

TUPEA064 **A 50 mA Deuteron ECR Ion Source for the PKUNIFTY Project** – *H.T. Ren, Q.F. Zhou (PKU/IHIP)*

A 2.45 GHz microwave-driven ion source has been developed to provide 50mA of deuteron ion beam (peak current) for the PKUNIFTY project. The ion source is an upgraded PMECR IV, and the total weight is less than 5 kg. Three coaxial NdFeB permanent magnet rings are used to generate the magnetic field of the source. In order to obtain a high current beam with low emittance, we added an aluminum liner in the discharge chamber and designed a new version tri-electrode extraction system with a 90^{o} cone apex angle. In our experiment, A 50 kV 83 mA deuteron beam has been extracted from the ECR ion source with normalized rms emittance less than 0.18 pi mm.mrad, and the deuteron fraction is about 81%. The stability of the ion source has also been tested. Details will be presented in this paper.

TUPEA065 **Analyze of the CSNS Step Like Field Magnet in Different Temperature Fields** – *Z.T. Lu, G. Feng, H. Hao, X.Q. Wang (USTC/NSRL) J. Tang (IHEP Beijing)*

Step like field magnet (SFM) is an important instrument between Rapid Cycling Synchronous (RCS) and the experimental target in China Spallation Neutron Source (CSNS). It is used for modulating the proton beam distribution from Gaussian distribution to uniform distribution to facilitate the thermal dissipation of spallation target. In this article, the magnetic field of the SFM for the CSNS in different temperature fields is studied by analyzing the magnet yoke deformation caused by temperature change and the corresponding field variation due to this deformation through ANSYS and OPERA-3D. The simulation results show that the current cooling scheme for the SFM is reasonable.

TUPEA066 **LANSCE Decadal Plans** – *K. Schoenberg (LANL)*

Los Alamos National Laboratory has recently obtained approval from the DOE to refurbish the existing LANSCE linac to provide continued operations for more than two decades. Also, the laboratory has made LANSCE the centerpiece of their future scientific endeavors. This effort is titled "Matter-Radiation Interactions in Extremes" (MaRIE). As the first in a new generation of scientific facilities for the materials community, the MaRIE experimental facility will be used to discover and design the advanced materials needed to meet 21st century national security and energy security challenges. Specifically, MaRIE will provide the tools scientists need to develop next-generation materials that will perform predictably and on demand for currently unattainable lifetimes in extreme environments.

TUPEA067 **Preliminary Ground Motion Measurements at LNF Site for the Super B Project** – *B. Bolzon, L. Brunetti, A. Jeremie (IN2P3-LAPP) M. Esposito, U. Rotundo, S. Tomassini (INFN/LNF)*

Preliminary measurements of ground motion have been done at the LNF for Super B site characterization. Vertical ground motion measured during 18 hours near a main road on surface was on average of around 70nm from 0.2Hz to 1Hz (earth motion), and varied between 12nm and 65nm from 1Hz and 100Hz (cultural noise) except between 8h and 9h40 where it increased up to 240nm due to traffic of rush hours ([3; 30] Hz). However, measurements done simultaneously on the surface and in a 50m depth hole show that cultural noise is well attenuated in depth on its entire bandwidth (from 1Hz up to at least 100Hz). Vertical ground motion measured for 20 minutes during the day outside rush hours in three other points located near various vibration sources was shown to be almost the same. Also, horizontal ground motion was shown to be not much higher than the vertical one compared to the expected vibration tolerances. To finish, measurements of ground motion coherence has been done for different distances on two different floors (soft and rigid) and compared to the one of ATF2 where a special floor was built for stability. Results show that the LNF floor is very promising for good coherence properties.

TUPEA068 **3D Visualization, Simulation and Virtual Reality in Accelerator Development** – *L. Hagge, N. Bergel, A. Herz, J. Kreutzkamp, V. Rupprecht, S. Suehl, N. Welle (DESY)*
Visualizing complex beamline designs, animating installation procedures and virtually walking through planned facilities - 3D modeling is a powerful tool with a broad range of applications in accelerator development. The poster describes established and emerging 3D modeling applications at the European XFEL and their benefits: 3D visualization enables inspection and compliance analysis of interfacing systems and components. Simulations enable early verification of e.g. safety and transportation concepts. Digital humans can be inserted into accelerator models to perform e.g. reachability and field-of-sight studies for installation works. Movies of transport and installation procedures can be created for staff training. And ultimately, stereo projection can be used to inspect and simulate designs and processes in virtual environments. 3D modeling helps discovering and resolving design issues earlier and leads to large savings in time and cost.

TUPEA069 **Thermionic Electron Gun Development for the 10 MeV RF Linacs** – *D. Bhattacharjee, S. Chandan, R.B. Chavan, K. Dixit, K.C. Mittal, R. Tiwari, V. Yadav (BARC-EBC) D.P. Chakravarthy, A.R. Chindarkar, L.M. Gantayet, S.R. Ghodke, D. Jayaprakash, A.R. Tillu (BARC)*
The 10 MeV Industrial RF Electron Linac at Electron Beam Centre (EBC), Navi Mumbai is commissioned and is delivering a stable beam power of 3 kW. Another similar 10 MeV RF electron accelerator is under commissioning stages at Electronics Corporation of India Limited (ECIL), Hyderabad and will be used for cargo scanning. A 50 keV indirectedly heated thermionic pulsed electron gun is used as injector for both these RF linacs. The gun is capable of delivering a maximum current of 1 A. This paper presents the gun design, development and testing, the mechanical modifications done in the gun, the grid biasing experiments to achieve maximum output current from the linac and the DC filament heating.

TUPEA070 **ECHARM - a Software for Calculation of Physical Quantities of Interest in Coherent Interaction of Relativistic Particles with Crystals** – *E. Bagli (INFN-Ferrara) V. Guidi (UNIFE) V.A. Maisheev (IHEP Protvino)*
We present an analytical model to calculate the physical quantities of interest experienced by relativistic particles in their motion aligned with periodic complex atomic structures. Classical physics equations and the expansion of periodic functions as a Fourier series have been used for the calculation. This method allows calculating the contribution from all the planes and axes inside the crystal, in contrast to other simulation codes for which the motion is evaluated only on nearest neighbors atomic strings. Based on the calculation technique we have developed the "ECHARM" program, which allows calculating one- and two- dimensional averaged physical quantities of interest. The calculation holds for the main axes of any orthorhombic and tetragonal structures and for any orientation in the cubic structure. To underline the capability of the program, complex structures such as zeolites have been worked out. Based on the "ECHARM" code, simulation of the relativistic particle motion within complex structures has been developed. With this code it is possible to simulate the motion in bent crystal to study planar and axial channeling volume reflection.

TUPEA071 **New Crystalline Materials for High Energy Channeling for the UA9 Collaboration** – *E. Bagli (INFN-Ferrara) S. Baricordi, P. Dalpiaz, V. Guidi, G. Martinelli, A. Mazzolari, D. Vincenzi (UNIFE)*
High energy channeling is exploited for beam steering, extraction, focusing, collimation, pairs and radiation production. Efficient interaction between charged particle beam requires a crystal with high crystalline quality and possibly high atomic number. For many years, constrained by

technological possibilities, the main material available with sufficiently high crystalline perfection has been silicon. Recent technological and crystal fabrication development allowed to obtain single crystal made of materials with atomic number higher than silicon. Usage of such materials opens up the possibility to increase channeling efficiency with respect to the performance obtained with silicon. In recent experiments conducted at CERN H8 external line with 400 GeV protons, different new materials (germanium, silicon-germanium graded concentration crystal and lithium niobate) have been successfully tested. In particular, lithium niobate offers the possibility to be deformed by piezo-electricity, e.g. for remote control of crystal deformation. Such feature envisages the realization of new schemes in channeling experiments.

TUPEA072 **Silicon Crystal Suited for Manipulation of Low Energy Charged-particle Beams by Coherent Interactions** – *A. Mazzolari (UNIFE) A. Carnera, D. De Salvador (Univ. degli Studi di Padova) V. Guidi (INFN-Ferrara)*

Channeling in a bent crystal is routinely used for high energy charged-particle beams manipulation, pairs and radiation production. Fraction of particles dechanneled from a crystal increases as increase the crystal length and is in inverse proportion to the beam energy. Operations at high energies allow using crystals some millimeters thick. At low energies (1 GeV) it is required the use of crystals some tenth of micrometer thin. Due to the lacking of so thin crystals, channeling experiments in bent crystals at so low energies are missing. Only recent development in crystals fabrication allowed obtaining silicon crystals of appropriate thickness. Such bent crystals, obtainable as thin as 40 μm, exploit quasi-mosaic deformation, offering (111) channeling planes or <111> axes. Bending mechanism assures that such crystals are free from unwanted anticlastic deformation, allowing intercepting beams as wide as some millimeter.

TUPEA073 **Status of Precise Temperature Regulation System for C-band Accelerator in XFEL/SPring-8** – *T. Hasegawa, T. Inagaki, Y. Otake, T. Sakurai (RIKEN/SPring-8) S. Takahashi (JASRI/SPring-8)*

The status of a precise temperature regulation system for a C-band accelerator in XFEL (X-ray Free Electron Laser) /SPring-8 is presented. It is essential to keep the constant temperature of an RF cavity for stable lasing. We installed a heater-assembly unit into a cooling water circuit of each RF cavity. By controlling the heater power, the temperature of cavity is stabilized. We have constructed a prototype of this system at the SCSS (SPring-8 Compact SASE Source) test accelerator to check its feasibility for the XFEL. The prototype significantly contributes to stable supply of SASE to users. For the XFEL, we simplified this system in view of expense and controllability. For example, to make one regulation system simultaneously controlling two C-band accelerating structures was tried. Keeping a temperature variation as tight as $\pm$0.02K at any operational mode can be achieved by this system. The preliminary test results of the system are also reported in this paper.

TUPEA074 **Kanthal Alloy based S-Band Collinear Load R&D for Linear Accelerators** – *Y. Sun, L.G. Shen, Z. Shu, X.C. Wang (USTC/PMPI) Y.J. Pei (USTC/NSRL)*

Collinear load is a substitute for waveguide load to miniaturize irradiation accelerators and make the system compact. A key technology is to design coaxial cavities coated with certain attenuating material inside which will terminate the residual power, meanwhile the operating frequency of 2856MHz retains. For lossy metals such as Kanthal (25%Cr-5%Al-Fe) alloy, a simulation design method is created based on a conventional cavity test structure. Simulations of the load cavities reveal that the resonance frequency falls linearly as circumferential coating increases, while it appears parabolic as longitudinal coating increases on the disks, with a minimum presenting at about 29mm away from the axis. Adjusting original cavity dimensions will compensate the deviation. Attenuation constants of the cavities rise linearly as the coating increases; however the coating on the disks affects more. Six load cavities of $2\pi/3$ mod are designed with uniform absorption of the remnant power. The total one-way attenuation achieves -18.83dB. The cavities have been developed, with Kanthal alloy thermal-sprayed inside and the resonance frequencies and Q factors are compared with theoretical values.

TUPEA075 **Electromagnetic Parameters Study of Microwave-absorbing Material Fe-Si-Al for Collinear Load by Coaxial Transmission-reflection Method** – *X.C. Wang, L.G. Shen, Z. Shu, Y. Sun (USTC/PMPI) Y.J. Pei (USTC/NSRL)*

Microwave-absorbing material is essential to LINAC collinear load, which is coated on the inner walls of several trailing accelerating cavities to transform the remnant microwave power into heat. Fe-85%Si-9.6%Al-5.4% alloy reveals low outgassing rate and high attenuation in applications of electronic vacuum devices, whereupon it is selected for collinear load R&D and the permittivity and permeability should be measured at 2856MHz. The coaxial transmission-reflection method is adopted and initial test of the coaxial fixture obtain the air electromagnetic parameters accurately. Further validation of the method is performed by dint of two PTFE rings, where the results agree with CST simulations considering the shape deviations of the specimens. Measurements of Al2O3 crystal (sapphire) and ZrO2 crystal demonstrate that the gap effect augments as a result of the high permittivity. CST simulations verify the conclusion. Eventually a scheme of Fe-Si-Al powder mixed with paraffin to form a wax mold is proposed and the permittivity and permeability of Fe-Si-Al are solved through electromagnetic parameters equivalent formulas of mixed medium.

TUPEA076 **Evaluation of Electron Cloud Density of Coated and Uncoated Sections in the CERN SPS by Means of the Microwave Transmission Method** – *F. Caspers, S. Federmann, E. Mahner, P.C. Pinto, D. Seebacher, M. Taborelli (CERN) B. Salvant (EPFL) C. Yin Vallgren (Chalmers University of Technology, Chalmers Tekniska Högskola)*

Electron cloud is a limitation to increasing the beam current in the CERN SPS in the frame of an intensity upgrade of the LHC complex. Coating the vacuum chamber with a thin amorphous carbon layer is expected to reduce the electron cloud build-up. Three SPS straight sections have been coated to study the performance of this carbon coating. The microwave transmission method is one possible way to monitor electron cloud and hence to test the effect of the coating. In this paper the evolution of the experimental setup for measurements of the electron cloud using LHC type beams with different bunch spacing will be described. Due to the low revolution frequency of about 43 kHz serious electromagnetic compatibility problems and intermodulation have been found. These effects and their mitigation are described. Finally we present the measurement results illustrating the possible reduction due to the carbon coating.

TUPEA077 **Low Secondary Electron Yield by means of Surface Magnetisation** – *I. Montero, L.S. Aguilera (CSIC) F. Caspers (CERN) L. Galan (UAM) D. Raboso (ESA-ESTEC)*

We are presenting first results of direct measurements of the secondary electron emission yield (SEY) for several magnetic materials like ferrites at energies of primary electrons from 5 to 10^{00} eV. In order to minimize the impact of surface charging, the primary electron beam had a short pulse modulation of 400ns with a very low repetition rate. This paper discusses a method of developing a secondary-electron-suppressing highly textured ferrite surface with low SEY by depositing a layer of very fine ferrite particles onto a substrate. The experimental results indicate that the SEY of the particulate ferrite surfaces is much lower than that of flat ferrites. In comparison we have confirmed that ordinary carbon coating with rather large grain size returns SEY value close to unity. However, a surface with very finely powdered carbon has a much smaller secondary emission yield of about 0.5, but the adhesion of these carbon powders to the surface is often not reliable enough for many applications. As a remarkable fact it has been found that gold- and also carbon-coated ferrites have SEY peak values lower than unity up to 1000eV.

TUPEA078 **Electron Injection to Circular Accelerator using Laser Wakefield Acceleration** – *Ya.V. Getmanov, O.A. Shevchenko (BINP SB RAS) N. Vinokurov (NSU)*

We consider a design of electron injection in circular accelerator using laser wakefield acceleration (LWFA) technique. Accelerators with this type of injector can be used for different purposes due to lower size, cost and low radiation hazard. To use the LWFA technique it is necessary to create a small gas cloud inside the accelerator vacuum chamber. But it leads to the increase of particle losses due to scattering in residual gas. Therefore we propose to use magnesium as evaporated gas because of its high absorbability ' its atoms stick to walls at first contact. We presented estimations of the LWFA-based injection system parameters, including maximum stored current. The propose technique looks very prospective for compact accelerators and storage rings.

TUPEA079 **Design of TPS Crotch Absorber** – *A. Sheng, J.-R. Chen, Y.T. Cheng, G.-Y. Hsiung, C.K. Kuan, C.Y. Yang (NSRRC)*

The Taiwan Photon Source (TPS) is a third generation synchrotron accelerator which the designed energy will be 3 GeV whereas the current is 500mA. The role of crotch absorber is designed to protect downstream UHV vacuum chamber. It is is the only mask component to absorb large amount of synchrotron radiation (bending magnet) in the storage ring. Crotch absorber is installed from transverse direction of the bending chamber to intercept the power. Two bent OFHC copper tubes are vacuum brazed on the copper mask. A 30 degree groove is machined to face bending magnet fan. The reason is not only to dissipate the heat but also to limit back scattering to the rest of chambers. Top and bottom of the absorber are bolted with beryllium copper springs; they will provide extra support for the absorber after it is installed in the Aluminum chamber. Three thermocouples will be embedded inside of the mask to monitor the temperature gradient. Final prototype of the crotch absorber with thermal analysis, design and machined parts are also presented in this paper.

TUPEA081 **RF Tests of Absorber Materials at Cryogenic Temperatures** – *F. Marhauser, T.S. Elliott, R.A. Rimmer (JLAB) E.P. Chojnacki (CLASSE)*

We have determined rf loss characteristics of various HOM absorber materials compromising lossy AlN and SiC ceramics for operation at cryogenic temperature. We have complemented recent results presented elsewhere by promising candidates and have determined their complex material properties to evaluate an efficient absorber shape when implemented into a realistic CEBAF cavity style HOM waveguide.

TUPEA082 **Versatile Device for In-situ Discharge Cleaning and Multiple Coatings of Long, Small Diameter Tubes** – *A. Hershcovitch, M. Blaskiewicz, J.M. Brennan, W. Fischer, C.J. Liaw, W. Meng (BNL) A.X. Custer, M.Y. Erickson, N.Z. Jamshidi, H.J. Poole (PVI) N. Sochugov (Institute of High Current Electronics)*

Electron clouds, which can limit machine performance, have been observed in many accelerators including RHIC at BNL. They can be suppressed by low secondary electron yield beam pipe surfaces. Additional concern for the RHIC machine, whose vacuum chamber is made from relatively high resistivity 316LN stainless steel, is high wall resistivity that can result in unacceptably high ohmic heating for superconducting magnets. The high resistivity can be addressed with a copper (Cu) coating; a reduction in the secondary electron yield can be achieved with a TiN or amorphous carbon (a-C) coating. Applying such coatings in an already constructed machine is rather challenging. We started developing a robotic plasma deposition technique for in-situ coating of long, small diameter tubes. The technique entails fabricating a device comprising of staged magnetrons mounted on a mobile mole for deposition of about 5 μm (a few skin depths) of Cu followed by about 0.1 μm of a-C. As a first step, a 15-cm Cu cathode magnetron is being designed and fabricated, after which, 30-cm long sample of the RHIC pipe are to be Cu coated. Deposition rates and affects on RF resistivity are to be measured.

25-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area B

TUPEB — Poster Session

TUPEB001 **Lattice Design Studies regarding the Super-B Project** – *F. Meot (CEA) N. Monseu (LPSC)*

Lattice design studies and related beam and spin dynamics simulations have been performed, in the framework of the international collaboration regarding the super-B project. The present contribution reports on this work.

TUPEB002 **Design, Test and First Experimental Results of the Clearing Electrodes for E-cloud Mitigation in the e^+ DAΦNE Ring** – *D. Alesini, A. Battisti, O. Coiro, T. Demma, S. Guiducci, V. Lollo, P. Raimondi, M. Serio, R.S. Sorchetti, M. Zobov (INFN/LNF)*

Metallic clearing electrodes have been designed to absorb the photo-electrons in the DAΦNE positron ring. They have been inserted in the wigglers and dipoles vacuum chambers and have been connected to external high voltage generators. In the paper we present the design of the devices and the results of the electromagnetic simulations related to both the transfer and longitudinal beam coupling impedances. We also present the results of the RF measurements and the first results with the DAΦNE circulating positron beam.

TUPEB003 **The SuperB Project Accelerator Status** – *M.E. Biagini, D. Alesini, R. Boni, M. Boscolo, T. Demma, A. Drago, M. Esposito, S. Guiducci, F. Marcellini, G. Mazzitelli, L. Pellegrino, M.A. Preger, P. Raimondi, R. Ricci, U. Rotundo, C. Sanelli, M. Serio, F. Sgamma, A. Stecchi, A. Stella, S. Tomassini, M. Zobov (INFN/LNF) M.A. Baylac, J.-M. De Conto, Y. Gomez-Martinez, N. Monseu, D. Tourres (LPSC) K.J. Bertsche, A. Brachmann, Y. Cai, A. Chao, M.H. Donald, A.S. Fisher, D. Kharakh, A. Krasnykh, N. Li, D.B. MacFarlane, Y. Nosochkov, A. Novokhatski, M.T.F. Pivi, J. Seeman, M.K. Sullivan, A.W. Weidemann, J. Weisend, U. Wienands, W. Wittmer, G. Yocky, A.C. de Lira (SLAC) S. Bettoni (CERN) A.V. Bogomyagkov, S.E. Karnaev, I. Koop, E.B. Levichev, S.A. Nikitin, I.B. Nikolaev, I.N. Okunev, P.A. Piminov, D.N. Shatilov, S.V. Sinyatkin, V.V. Smaluk, P. Vobly (BINP SB RAS) B. Bolzon, L. Brunetti, A. Jeremie (IN2P3-LAPP) J. Bonis, G. Le Meur, B.M. Mercier, F. Poirier, C. Prevost, C. Rimbault, F. Touze, A. Variola (LAL) F. Bosi (INFN-Pisa) A. Chancé, F. Meot, O. Napoly (CEA) R. Chehab (IN2P3 IPNL) E. Paoloni (University of Pisa and INFN)*

The SuperB project is an international effort aiming at building in Italy a very high luminosity e^+e^- (10^{36} cm^{-2} sec^{-1}) asymmetric collider at the B mesons cm energy. The accelerator design has been extensively studied and changed during the past year. The present design, - based on the new collision scheme, with large Piwinski angle and the use of 'crab' sextupoles, which has been successfully tested at the DAPHNE Phi-Factory at LNF Frascati, - provides larger flexibility, better dynamic aperture and in the Low Energy Ring spin manipulation sections, needed for having longitudinal polarization of the electron beam at the Interaction Point. The Interaction Region has been further optimized in terms of apertures and reduced backgrounds in the detector. The injector complex design has been also updated. A summary of the design status, including details on lattice and spin manipulation will be presented in this paper.

TUPEB004 **Super-B Lattice Studies** – *Y. Nosochkov, W. Wittmer (SLAC) M.E. Biagini, P. Raimondi (INFN/LNF) P.A. Piminov, S.V. Sinyatkin (BINP SB RAS)*

The Super-B asymmetric e^+e^- collider is designed for 10^{36} $cm^{-2}sec^{-1}$ luminosity and beam energies of 6.7 and 4.18 GeV for e^+ and e-, respectively. The machine will have the High and Low Energy Rings (HER and LER), and one Interaction Point (IP) with 60 mrad crossing angle. The INFN-LNF at Frascati is one of the proposed sites, and a lattice for short 1.3 km rings fitting to this site has been designed. The two rings are radially separated by 2 m except near the IP and in the dogleg on the opposite side of the rings. The injection sections and RF cavities are included. The lattice is optimized for a low emittance required for the desired high luminosity. Final Focus chromaticity correction is optimized for large transverse and energy acceptance. The "crab waist" sextupoles are included for suppression of betatron resonances induced at the IP collisions with large Piwinski angle. The LER spin rotator sections provide longitudinal polarization for the electron beam at IP. The lattice is flexible for tuning the design parameters and compatible with reusing the PEP-II magnets, RF cavities and other components. Design criteria and details on the lattice implementation are presented.

TUPEB005 **High Luminosity Interaction Region Design for Collisions with Detector Solenoid** – *C. Milardi, M.A. Preger, P. Raimondi, G. Sensolini, F. Sgamma (INFN/LNF)*

An innovatory interaction region has been recently conceived and realized on the Frascati DAΦNE lepton collider. The concept of tight focusing and small crossing angle adopted until now to achieve high luminosity in multibunch collisions has evolved towards enhanced beam focusing at the interaction point with large horizontal crossing angle, thanks to a new compensation mechanism for the beam-beam resonances. The novel configuration has been tested with a small detector without solenoidal field yielding a remarkable improvement in term of peak as well as integrated luminosity. The high luminosity interaction region has now been modified to host a large detector with a strong solenoidal field integral which significantly perturbs the beam optics introducing new design challenges in terms of interaction region optics design, beam transverse coupling control and beam stay clear requirements.

TUPEB006 **DAΦNE Developments for the KLO·10^{-2} Experimental Run** – *C. Milardi, D. Alesini, M.E. Biagini, C. Biscari, R. Boni, M. Boscolo, F. Bossi, B. Buonomo, A. Clozza, G.O. Delle Monache, T. Demma, E. Di Pasquale, G. Di Pirro, A. Drago, M. Esposito, A. Gallo, A. Ghigo, S. Guiducci, C. Ligi, F. Marcellini, G. Mazzitelli, F. Murtas, L. Pellegrino, M.A. Preger, L. Quintieri, P. Raimondi, R. Ricci, U. Rotundo, C. Sanelli, M. Serio, F. Sgamma, B. Spataro, A. Stecchi, A. Stella, S. Tomassini, C. Vaccarezza, M. Zobov (INFN/LNF) N. Arnaud, D. Breton, L. Burmistrov, A. Stocchi, A. Variola, B.F. Viaud (LAL) S. Bettoni (CERN) P. Branchini (roma3) E.B. Levichev, S.A. Nikitin, P.A. Piminov, D.N. Shatilov (BINP SB RAS) K. Ohmi (KEK) V.V. Smaluk (BINP) P. Valente (INFN-Roma)*

Recently the peak luminosity achieved on the DAΦNE collider has been improved by almost a factor 3 by implementing a novel collision scheme based on large Piwinski angle and Crab-Waist. This encouraging result opened new perspectives for physics research and a new run with the KLO·10^{-2} detector has been scheduled to start by spring 2010. The KLO·10^{-2} installation is a complex operation requiring a careful design effort and a several months long shutdown. The high luminosity interaction region has been deeply revised in order to take into account the effect on the beam caused by the solenoidal field of the experimental detector and to ensure background rejection. The shutdown has been also used to implement several other modifications aimed at improving beam dynamics: the wiggler poles have been displaced from the magnet axis in order to cancel high order terms in the field, the feedback systems have been equipped with stronger power supplies and more efficient kickers and electrodes have been inserted inside the wiggler and the dipole vacuum chambers, in the positron ring, to avoid the e-cloud formation. A low level RF feedback has been added to the cavity control in both rings.

TUPEB007 **Low Emittance Tuning Studies for SuperB** – *S.M. Liuzzo (University of Pisa and INFN) M.E. Biagini, P. Raimondi (INFN/LNF) M.H. Donald (SLAC)*

SuperB is an international project for an asymmetric 2 rings collider at the B mesons cm energy to be built in the Rome area in Italy. The two rings will have very small beam sizes at the Interaction Point and very small emittances, similar to the Linear Collider Damping Rings ones. In particular, the ultra low vertical emittances, 7 pm in the LER and 4 pm in the HER, need a careful study of the misalignment errors effects on the machine performances. Studies on the closed orbit, vertical dispersion and coupling corrections have been carried out in order to specify the maximum allowed errors and to provide a procedure for emittance tuning. A new tool which combines MADX and Matlab routines has been developed, allowing for both corrections and tuning. Results of these studies are presented.

TUPEB008 **Design of SuperKEKB based on the Nano-beam Scheme** – *H. Koiso (KEK)*

SuperKEKB is a major upgrade plan of KEKB aiming at the luminosity of 80/nb/s, 40 times higher than the luminosity record achieved at KEKB. Design strategy of SuperKEKB has changed from the high-current crab-crossing scheme to the nano-beam one. The vertical beam sizes will be squeezed to ~60 nm at the interaction point, which increase the luminosity by a factor of 20, while beam currents will only be doubled. In this paper, optimization of main machine parameters will be presented.

TUPEB009 **Installation of Skew Sextupole Magnets at KEKB** – *M. Masuzawa, K. Egawa, T. Kawamoto, Y. Ohsawa, T. Sueno, N. Tokuda (KEK)*

A new set of magnets, skew sextupole magnets, were designed, manufactured, measured and installed during the winter shutdown of 2009.

Twenty magnets were installed in the HER and eight magnets were installed in the LER. It was a challenging job for the magnet group to design, manufacture, measure the magnetic field and install them in the tunnel in just three months. Much effort to finish the installation in time and reduce the production cost was made at every step of the entire process. With these newly installed skew sextupole magnets, a significant luminosity boost was achieved. The production and installation of the skew sextupole magnets are described in this report.

TUPEB010 **SuperKEKB LER Lattice Design and Machine Error Simulation** – *A. Morita, H. Koiso, Y. Ohnishi, K. Oide (KEK)*
The lattice design concept for KEKB upgrade (so called as SuperKEKB) is changed from the high current crab crossing scheme to the nano-beam scheme. In the nano-beam scheme, two long bunches are collided each other within small cross section. Now, we are designing the low emittance lattice which squeeze the beam within 10μmeter in horizontal direction and within 60 nano meter in vertical direction at the interaction point. In this paper, we report current status of LER (Low Energy Ring) lattice design and preliminary result of machine error simulation.

TUPEB011 **KEKB Superconducting Accelerating Cavities and Beam Studies for Super-KEKB** – *Y. Morita, K. Akai, T. Furuya, A. Kabe, S. Mitsunobu, M. Nishiwaki, S. Takano (KEK)*
Eight superconducting accelerating cavities have been stably operated in the KEKB with sufficiently low trip rates. Two superconducting crab cavities were installed in 2007 and soon the crab crossing operation started. Recently the KEKB luminosity reached the world record of 2.1 x 10^{34} $cm^{-1}s^{-1}$. Stable operations of the accelerating cavities contributed for the luminosity increase. For the future Super-KEKB, we are developing a high power coupler for an input power of 600 kW and a HOM damper for RF power absorption more than 30 kW. The Super-KEKB requires RF operations with the high beam loading and the low RF voltage than the present KEKB operation. To suppress klystron output powers the external Q value has to be reduced. A new operation was proposed for superconducting cavities. In order to keep high RF voltages in each cavity, some cavities reverse its synchronous beam phase while the total RF voltage is kept as low as the required one. Beam studies were successfully carried out with one cavity reversed its synchronous beam phase.

TUPEB012 **Optics Measurement at the Interaction Point using Nearby Position Monitors** – *K. Ohmi (KEK)*
Optics parameters at the interaction point, beta, x-y coupling, dispersion and their chromatic aberrations, seriously affect the beam-beam performance as is shown in experiments and simulations. The control of the optics parameters is essential to maintain the high luminosity in KEKB. They drift day by day, or before and after the beam abort. They were often monitored at intervals of the operation with taking the study time. They are recently measured during the physics run using a pilot bunch without collision. We show the measured the optics parameters and their variations and discuss the relation to the luminosity.

TUPEB013 **Strong-strong Simulation for Super B Factories** – *K. Ohmi (KEK)*
Super B factories are designed with very low emittance and very low beta function at the interaction point. The two beams collide with a large crossing angle, thus the overlap area of the beams is limited at a small part of their length. Simulation of the beam-beam effects is hard because of the longitudinal slice of the beam is the order of 100. We discuss two methods for the simulation. One is a simplified method, which is mixture of the particle in cell and Gaussian approximation. The other is fully strong-strong simulation using the particle in cell. The shifted Green function is used to calculate the beam-beam force for less overlap of the beam distribution. Luminosity and its degradation due to IP optics errors in Super B factories are discussed.

TUPEB014 **Electron Cloud Instability in Low Emittance Rings** – *Y. Susaki, K. Ohmi (KEK)*
Single bunch instability caused by electron cloud can depend on emittance, because the electron oscillation period in positron bunch is large. The single bunch instability should appear as a head-tail motion with synchro-beta frequency. We discuss the single bunch instability in low emittance rings, CesrTA, Super B factories and ILC damping ring with focusing the threshold and synchro-beta oscillation.

TUPEB015 **Simulation of Electron Gun using GPU** – *K. Ohmi, Y. Susaki (KEK)*
Progress of Graphic Processor Unit (GPU) is marveled. The performance is 1TFlops per unit. Simulation of electron gun can be performed by particle-particle interactions, in which the calculation cost is NxN. Since the calculation of each interaction is very simple, GPU can demonstrate its ability. We show simulation results and discuss the possibilities to extend other simulations.

TUPEB016 **Optics Design in Nano-Beam Scheme for KEKB Upgrade** – *Y. Ohnishi, K. Akai, K. Egawa, H. Fukuma, Y. Funakoshi, N. Iida, T. Kamitani, M. Kikuchi, H. Koiso, M. Masuzawa, A. Morita, Y. Ogawa, K. Ohmi, N. Ohuchi, K. Oide, Y. Suetsugu, M. Tawada (KEK) P. Raimondi (INFN/LNF)*
KEKB upgrade has been planed to investigate a new physics beyond the standard model in a low energy lepton collider. In order to achieve the physics requirement, a luminosity of $8\text{x}10^{35}$ /cm^2/s is necessary at least. We adopted the Nano-Beam scheme to make the luminosity feasible. In the Nano-Beam scheme, emittance and beta function at an interaction point becomes ten times or twenty times smaller than KEKB. We present the optics design and discuss the lattice performance such as a dynamic aperture in the Nano-Beam scheme.

TUPEB017 **Effect of X-Y Coupling and it's Chromaticity in SuperKEKB** – *D.M. Zhou, K. Ohmi (KEK)*
Based on a baseline design of the optics of SuperKEKB rings, the X-Y coupling and it's chromaticity at interaction point (IP) were scanned using beam-beam codes developed at KEK. It was found that X-Y coupling and it's coupling can significantly degrade the luminosity performance. Comparing with the calculated parameters of the baseline optics with and without errors of magnets, tolerances on X-Y coupling and it's chromaticity at IP were defined for magnet alignment.

TUPEB018 **Coherent Synchrotron Radiation in the KEKB Low Energy Ring** – *D.M. Zhou, K. Ohmi (KEK)*
In KEKB low energy ring (LER), CSR impedance may be the unknown source which led to serious bunch lengthening. A dedicated code was developed to calculate the CSR impedance generated in the bending magnets and in the wigglers. We adopted the paraxial approximation originated by T. Agoh and K. Yokoya. Investigations were done to figure out the effects of shielding pipes with general cross section, resistive wall boundary, soft fringe field, and drifts between wiggler poles.

TUPEB019 **Evaluation of the Detector BG for SuperKEKB** – *M. Iwasaki, H. Aihara, C. Ng (University of Tokyo) Y. Funakoshi, H. Koiso, Y. Ohnishi (KEK) H. Nakano, H. Yamamoto (Tohoku University, Graduate School of Science)*
SuperKEKB is the upgrade plan of the current B-factory experiment with the KEKB accelerator at KEK. Its luminosity is designed to be $8\text{x}10^{35}$ /cm^2/s (40 times higher than KEKB) and the integrated luminosity is expected to be 50 ab-1. In SuperKEKB, it is important to evaluate the beam induced BG and design the interaction region (IR) to assure the stable detector operation. To estimate the beam induced BG, we construct the beam-line simulation based on the GEANT4 simulation. In this paper, we report the BG evaluation and the IR design for SuperKEKB.

TUPEB020 **Beam Dynamic Issues in the BEPCII Luminosity Commissioning** – *Q. Qin, N. Huang, D. Ji, Y. Jiao, Y.D. Liu, Y.M. Peng, D. Wang, J.Q. Wang, N. Wang, X.H. Wang, Y. Wei, X.M. Wen, J. Xing, G. Xu, C.H. Yu, C. Zhang, Y. Zhang (IHEP Beijing)*
As a tau-charm factory like collider, the upgrade project of the Beijing Electron Positron Collider (BEPCII), has reached its first design value of luminosity. During the commissioning of its luminosity, beam optics recovery, machine parameters measurement, detector solenoid compensation, and instability cure are main problems we met. Besides commissioning the machine, beams were delivered to the users from high energy physics and synchrotron radiation. This paper summarizes the accelerator physics issues in the BEPCII luminosity commissioning.

TUPEB021 **Conceptual Design of the Muon Collider Ring Lattice** – *Y. Alexahin, E. Gianfelice-Wendt, A.V. Netepenko (Fermilab)*

Muon collider is a promising candidate for the next energy frontier machine. However, in order to obtain peak luminosity in the $10^{35}/cm^2/s$ range the collider lattice design must satisfy a number of stringent requirements, such as low beta at IP (beta*<1 cm), large momentum acceptance and dynamic aperture and small value of the momentum compaction factor. Here we present a particular solution for the interaction region optics whose distinctive feature is a three-sextupole local chromatic correction scheme. Together with a new flexible momentum compaction arc cell design this scheme allows to satisfy all the above-mentioned requirements and is relatively insensitive to the beam-beam effect.

TUPEB022 **Muon Collider Interaction Region Design** – *Y. Alexahin, E. Gianfelice-Wendt, V. Kashikhin, N.V. Mokhov, A.V. Zlobin (Fermilab) V.Yu. Alexakhin (JINR)*

Design of a muon collider interaction region (IR) presents a number of challenges arising from low beta* < 1 cm, correspondingly large beta-function values and beam sizes at IR magnets, as well as the necessity to protect superconducting magnets and collider detectors from muon decay products. As a consequence, the designs of the IR optics, magnets and machine-detector interface are strongly interlaced and iterative. A consistent solution for the 1.5 TeV c.o.m. muon collider IR is presented. It can provide an average luminosity of $10^{34}/cm^2/s$ with an adequate protection of magnet and detector components.

TUPEB023 **High Gradient Final Focusing Quadrupole for a Muon Collider** – *S.A. Kahn, G. Flanagan, R.P. Johnson (Muons, Inc) R.C. Gupta, R. B. Palmer (BNL)*

To achieve the high luminosity required for a muon collider strong quadrupole magnets will be needed for the final focus in the interaction region. These magnets will be located in regions with space constraints imposed both by the lattice and the collider detector. There are significant beam related backgrounds from muon decays and synchrotron radiation which create unwanted particles which can deposit significant energy in the magnets of the final focus region of the collider. This energy deposition results in the heating of the magnet which can cause it to quench. To mitigate the effects of heating from the energy deposition shielding will need to be included within the magnet forcing the aperture to be larger than desired and consequently reducing the gradient. We propose to use exotic high magnetization materials for pole tips to increase the quadrupole gradient.

TUPEB024 **Solenoid Compensation for the SuperB Interaction Region** – *K.J. Bertsche (SLAC)*

We present an approach for compensating adverse effects of the detector solenoid in the SuperB Interaction Region (IR). We place compensating solenoids around the IR quadrupole magnets to reduce the magnetic fields nearly to zero. This allows more operational headroom for superconducting IR magnets and avoids saturation of ferric IR magnets. We place stronger compensating solenoids between IR magnets to reverse the magnetic field direction. This allows adjusting the total integrated solenoid field to zero, which eliminates coordinate plane rotation and reduces vertical beam displacements in the IR.

TUPEB025 **A Design for a Polarimeter for the Super-B Collider** – *M.K. Sullivan, K. C. Moffeit, Y. Nosochkov, U. Wienands, W. Wittmer, M. Woods (SLAC)*

We present a conceptual design for a polarimeter based on Compton scattering of laser light on the electron beam for the Super-B accelerator proposed for Frascati, Italy. The accelerator design has polarized electrons in the low-energy ring (4.18 GeV). We want to measure the polarization of every bunch every few seconds using a laser with 119 Mhz repetition rate. The spin rotator section has a second point between the solenoids and interaction point where the polarization is nearly longitudinal with helicity opposite to that found at the interaction point. We plan to use this point to measure the polarization as the possible location near the interaction point has too much background from the collision. We show the area in the accelerator where the polarimeter would be installed and describe the laser as well as the detectors for the Compton scattered electrons and photons.

TUPEB026 **Beam Fields and Energy Dissipation inside the Be Beam Pipe of the Super-B Detector** – *A. Novokhatski, M.K. Sullivan (SLAC)*

We study the bunch field diffusion and energy dissipation in the beam pipe of the Super-B detector, which consists of two coaxial Be thin pipes (half a millimeter). Cooling water will run between these two pipes. Gold and nickel will be sputtered (several microns) onto the beryllium pipe. The Maxwell equations for the beam fields in these thin layers are solved numerically for the case of infinite pipes. We also calculate the amplitude of electromagnetic fields outside the beam pipe, which may be noticeable as the beam current can reach 4 A in each beam. Results of simulations are used for the design of this central part of the Super-B detector.

TUPEB027 **A New Interaction Region Design for the Super-B Factory** – *M.K. Sullivan, K.J. Bertsche (SLAC) S. Bettoni (CERN) E. Paoloni (University of Pisa and INFN) P. Raimondi (INFN/LNF) P. Vobly (BINP SB RAS)*

A final focus magnet design that uses super-ferric magnets is introduced for the Super-B interaction region. The baseline design has air-core super-conducting quadrupoles. This idea instead uses super-conducting wire in an iron yoke. The iron is in the shape of a Panofsky quadrupole and this allows for two quadrupoles to be side-by-side with no intervening iron as long as the gradients of the two quads are equal. This feature allows us to move in as close as possible to the collision point and minimize the beta functions in the interaction region. The super-ferric design has advantages as well as drawbacks and we will discuss these in the paper.

TUPEB028 **Algorithm for Computation of Electromagnetic Fields of an Accelerated Short Bunch inside a Rectangular Chamber** – *A. Novokhatski, M.K. Sullivan (SLAC)*

We discuss the feasibility of an application of an implicit finite-difference approximation to calculate the fields of a bunch moving with no restriction inside the vacuum chamber.

TUPEB029 **Polarization in the SuperB Low Energy Ring** – *U. Wienands, K. C. Moffeit, Y. Nosochkov, W. Wittmer, M. Woods (SLAC) D.P. Barber (Cockcroft Institute) I. Koop, S.A. Nikitin, S.V. Sinyatkin (BINP SB RAS) P. Raimondi (INFN/LNF)*

The availability of longitudinally polarized electrons is an important aspect of the design of the proposed SuperB project at LNF Frascati. Spin rotators are an integral part of the design of the Interaction Region (IR). We have chosen a solenoid-dipole design; at the 4.18 GeV nominal energy this is more compact that a design purely based on dipole magnets. Integration with the local chromaticity correction of the ultra-low beta* IR has been achieved. The spin rotators are symmetric about the Interaction Point, this design saves a significant amount of length as the dipoles become a part of the overall 360 deg. bend. The layout leaves limited opportunity to setup the optics for minimum depolarization; this is acceptable since beam life time in SuperB at high luminosity is only about 5 min and up-to 90% polarized electrons will be injected continuously. In this way an average beam polarization of about 70% is maintained. Simulations and analytic estimates with the DESY code SLICKTRACK and other codes indicate such operation is feasible from a spin-dynamics point of view. The paper will discuss the overall spin-rotator design as well as the spin dynamics in the ring.

TUPEB030 **Frictional Cooling Demonstration Experiment** – *D.E. Greenwald (MPI für Physics)*

Simulations of a muon collider front end scheme utilizing frictional cooling show that frictional cooling is a viable technique for quickly producing collidable beams. The Frictional Cooling Demonstration (FCD) experiment at the Max-Planck-Institute for Physics, Munich, aims to demonstrate the working principle of frictional cooling on protons using a 10 cm long cooling cell. The experiment is nearing the final data taking stages. The status of the experiment is presented along with recent data. Simulation of the experiment setup is also presented.

TUPEB031 **Muon Collider Scheme based on Frictional Cooling** – *D.E. Greenwald (MPI für Physics)*

Muon colliders would open new frontiers of investigation in high energy particle physics, allowing precision measurements to be made at the TeV energy frontier. One of the greatest challenges to constructing a muon collider is the cooling of a beam of muons on a timescale comparable to the lifetime of the muon. Frictional cooling holds promise for use in a muon collider scheme. By balancing energy loss to a gas with energy gain from an electric field, a beam of muons is brought to an equilibrium energy in a time on the order of 100s of nanoseconds. A full muon collider front end scheme utilizing frictional cooling to produce high luminosity beams is presented.

TUPEB032 **Possibility of suppressing spontaneous undulator radiation** – *V. Litvinenko, V. Yakimenko (BNL)*

Short noise in the electron beam distribution is the main source of noise in high-gain FEL amplifiers, which may affect applications ranging from single- and multi-stage HGHG FELs [1] to an FEL amplifier for coherent electron cooling [2]. This noise also imposes a fundamental limit of about 10^6 on FEL gain, after which SASE FELs saturate. There are several advantages in strongly suppressing this short noise in the electron beam, and the corresponding spontaneous radiation. We present in this paper a novel active method of suppressing, by many orders-of-magnitude, the short noise in relativistic electron beams. We give a theoretical description of the process, and detail its fundamental limitation. We also propose a demonstration experiment on suppression of spontaneous undulator radiation from an electron beam at the Accelerator Test Facility (ATF) at BNL. We describe the method, the proposed layout and possible schedule

TUPEB033 **Proof-of-Principle Experiment for FEL-based coherent electron cooling** – *V. Litvinenko, I. Ben-Zvi, J. Bengtsson, M. Blaskiewicz, A.V. Fedotov, Y. Hao, A. Kayran, G. Wang, S.D. Webb (BNL) G.I. Bell, D.L. Bruhwiler, B.T. Schwartz, A.V. Sobol (Tech-X) G.A. Krafft, R.A. Rimmer (JLAB)*

Coherent electron cooling (CEC) has a potential to significantly boost luminosity of high-energy, high-intensity hadron-hadron and electron-hadron colliders [1]. In a CEC system, a hadron beam interacts with a cooling electron beam. A perturbation of the electron density caused by ions is amplified and fed back to the ions to reduce the energy spread and the emittance of the ion beam. To demonstrate feasibility of CEC we propose a proof-of-principle experiment at RHIC using one of JLab's SRF cryo-module. In this paper, we describe the experimental setup for CeC installed into one of RHIC interaction region. We present results of analytical estimates and results of initial simulations of cooling a gold-ion beam at 40 GeV/u energy via CeC.

TUPEB034 **Interaction Region Design for a Ring Ring Version of the LHeC Study** – *B.J. Holzer, S. Bettoni, O.S. Brüning, S. Russenschuck (CERN) R. Appleby (UMAN) J.B. Dainton, L.N.S. Thompson (Cockcroft Institute) M. Klein (The University of Liverpool) A. Kling, B. Nagorny, U. Schneekloth (DESY) P. Kostka (DESY Zeuthen) A. Polini (INFN-Bologna)*

The LHeC aims at colliding hadron-lepton beams with center of mass energies in the TeV scale. For this purpose the existing LHC storage ring is extended by a high energy electron accelerator in the energy range of 60 to 140 GeV. The electron beam will be accelerated and stored in a LEP like storage ring in the LHC tunnel. In this paper we present the layout of the interaction region which has to deliver at the same time well matched beam optics and an efficient separation of the electron and proton beams. In general the large momentum difference of the two colliding beams provides a very elegant way to solve this problem: A focusing scheme that leads to the required beam sizes of the electrons and protons is combined with an early but gentle beam separation to avoid parasitic beam encounters and still keep the synchrotron radiation level in the IR within reasonable limits. We present in this paper two versions of this concept: A high luminosity layout where the mini beta magnets are embedded into the detector design as well as an IR design that is optimised for maximum acceptance of the particle detector.

TUPEB035 **Simulations for Preliminary Design of Multi-Cathode DC Electron Gun for eRHIC** – *Q. Wu, I. Ben-Zvi, X. Chang, J. Skarita (BNL)*

The proposed electron ion collider, eRHIC, requires large average polarized electron current of 50mA, which is more than 20 times higher than the present experiment results of single polarization source, such as GaAs. To achieve the current requirement of eRHIC, we have designed the multi-cathode DC electron gun for injection. 24 GaAs cathodes will be prepared and emit electrons at the arranged pattern. Despite of ultra-high vacuum and precise timing, multi-cathode DC electron gun has high demand on the electric field symmetry, magnetic field shielding, and arcing prevention. In the paper, we present the 3D simulation results of the latest model for the multi-cathode DC electron gun. The results will give guidance to the actual design in the future.

TUPEB036 **Tune Resonance Phenomena in the SPS and Machine Protection via Fast Position Interlocking** – *T. Baer, B. Araujo Meleiro, T.B. Bogey, J. Wenninger (CERN) T. Baer (DESY)*

The Super Proton Synchrotron (SPS) at CERN with a peak energy of 450GeV is at the top of the LHC preaccelerator-complex. Apart from the LHC, SPS is with Tevatron the accelerator with the largest stored beam energy of up to 2.5MJ. The SPS has a known vulnerability to fast equipment failures that led to an uncontrolled loss of a high intensity beam in 2008, which resulted in major damage of a main dipole. The beam loss was caused by a fast tune decrease towards an integer resonance. Simulations and distinct experimental studies provide clear understanding of the beam dynamics at different SPS tune resonances. Diverging closed orbit oscillations, dispersion explosion and increased beta-beating are the driving effects that lead to a complete beam loss in as little as 3 turns (70μs). Dedicated experiments of fast failures of the main power converters reveal that the current interlock systems with a delay of 7-12ms are much too slow for an adequate machine protection. To counteract the vulnerability of the SPS, current research focuses on a new fast position interlock system which is planned to become operational in the second quarter of 2010.

TUPEB037 **Interaction-Region Design Options for a Linac-Ring LHeC** – *F. Zimmermann, S. Bettoni, O.S. Brüning, B.J. Holzer, S. Russenschuck, R. Tomas (CERN) H. Aksakal (N.U) R. Appleby (UMAN) S. Chattopadhyay, M. Korostelev (Cockcroft Institute) A.K. Ciftci, R. Ciftci, K. Zengin (Ankara University, Faculty of Sciences) J.B. Dainton, M. Klein (The University of Liverpool) E. Eroglu, I. Tapan (UU) P. Kostka (DESY Zeuthen) E. Paoloni (University of Pisa and INFN) A. Polini (INFN-Bologna) U. Schneekloth (DESY)*

In a linac-ring electron-proton collider based on the LHC ("LR-LHeC"), the final focusing quadrupoles for the electron beam can be installed far from the collision point, as far away as the proton final triplet (e.g. 23 m) if not further, thanks to the small electron-beam emittance. The inner free space could either be fully donated to the particle-physics detector, or accommodate "slim" dipole magnets providing head-on collisions of electron and proton bunches. We present example layouts for either scenario considering electron beam energies of 60 and 140 GeV, and we discuss the optics for both proton and electron beams, the implied minimum beam-pipe dimensions, possible design parameters of the innermost proton and electron magnets, the corresponding detector acceptance, the synchrotron radiation power and its possible shielding or deflection, constraints from long-range beam-beam interactions as well as from the LHC proton-proton collision points and from the rest of the LHC ring, the passage of the second proton beam, and the minimum beta* for the colliding protons.

TUPEB038 **Nonlinear Dynamics Induced by 1-D Model of Pinched Electron Cloud** – *G. Franchetti (GSI) F. Zimmermann (CERN)*

The presence of an electron cloud in an accelerator generates a number of interesting phenomena. In addition to electron-driven beam instabilities, the electron "pinch" occurring during a beam-bunch passage gives rise to a highly nonlinear force experienced by individual beam particles. A simple 1-dimensional model for the effect of the electron pinch on the beam reveals a surprisingly rich dynamics. We present the model and discuss simulation results.

TUPEB039 **RLA and ERL Designs for a Linac-Ring LHeC** – *F. Zimmermann, O.S. Brüning, J.A. Osborne, Y. Sun (CERN) C. Adolphsen (SLAC) S. Chattopadhyay (Cockcroft Institute) J.B. Dainton, M. Klein (The University of Liverpool) A.L. Eide (LPNHE)*

We consider three different scenarios for the recirculating electron linear accelerator (RLA) of a linac-ring type electron-proton collider based on the LHC (LHeC): i) a basic version consisting of a 60 GeV pulsed, 1.5 km long linac, ii) a higher luminosity configuration with a 60 GeV 4 km long cw energy-recovery linac (ERL), and iii) a high energy option using a 140

GeV pulsed linac of 4 km active length. This paper describes the footprint, optics of linac and return arcs, emittance growth from chromaticity and synchrotron radiation, a set of parameters, and the performance reach for the three scenarios.

TUPEB040 **Small Gap Magnet Prototype Measurements for eRHIC** – *Y. Hao, P. He, A.K. Jain, V. Litvinenko, G.J. Mahler, W. Meng, J.E. Tuozzolo (BNL)*

In this paper we present the design and prototype measurement of small gap (5mm to 10 mm aperture) dipole and quadrupole for the future high energy ERL (Energy Recovery Linac). The small gap magnets have the potential of largely reducing the cost of the future electron-ion collider project, eRHIC, which requires a 10GeV to 30 GeV ERL with up to 6 energy recovery passes (3.8 km each pass). We also studied the sensitivity of the energy recovery pass and the alignment error in this small magnets structure and countermeasure methods.

TUPEB041 **Overview of Beam-beam Effects in eRHIC** – *Y. Hao, V. Litvinenko, V. Ptitsyn (BNL)*

Beam-beam effects in eRHIC have a number of unique features, which distinguish them from both hadron and lepton colliders. Due to beam-beam interaction, both electron and hadron beams would suffer quality degradation or beam loss from without proper treatments. Those features need novel study and dedicate countermeasures. We study the beam dynamics and resulting luminosity of the characteristics, including mismatch, disruption and pinch effects on electron beam, in additional to their consequences on the opposing beam as a wake field and other incoherent effects of hadron beam. We also carry out countermeasures to prevent beam quality degrade and coherent instability.

TUPEB042 **The Transverse Linac Optics Design in Multi-pass ERL** – *Y. Hao, J. Kewisch, V. Litvinenko, E. Pozdeyev, V. Ptitsyn, D. Trbojevic, N. Tsoupas (BNL)*

In this paper, we analyzed the linac optics design requirement for a multi-pass energy recovery linac (ERL) with one or more linacs. A set of general formula of constrains for the 2-D transverse matrix is derived to ensure design optics acceptance matching throughout the entire accelerating and decelerating process. Meanwhile, the rest free parameters can be adjusted for fulfilling other requirements or optimization purpose. As an example, we design the linac optics for the future MeRHIC (Medium Energy eRHIC) project and the optimization for enlarging the BBU threshold.

TUPEB043 **Deflecting Synchrotron Radiation from the Interaction Region of a Linac-Ring LHeC** – *A.K. Ciftci, R. Ciftci (Ankara University, Faculty of Sciences) F. Zimmermann (CERN)*

In a linac-ring electron-proton collider based on the LHC, before and after the collision point the electron beam can be deflected with weak dipole magnets positioned in front of the superconducting final quadrupole triplets of the 7-TeV proton beam. Significant synchrotron radiation may be produced when the electron beam, of energy 60-140 GeV, passes through these dipole magnets. As an alternative or complement to shielding, parts of the synchrotron radiation could be extracted together with the electron beam. We propose using mirrors with shallow grazing angle to deflect the synchrotron radiation away from the proton magnets. Various LHeC options are considered. Limitations and challenges of this approach are discussed.

TUPEB044 **ELIC Polarized Beam Manipulation** – *H. K. Sayed (CASA) S.A. Bogacz, P. Chevtsov (JLAB)*

A unique design feature of a polarized Electron-Ion Collider (ELIC) based on CEBAF is its 'Figure-8' storage rings for both electrons and ions, which significantly simplifies beam polarization maintenance and manipulation. The proposed electron ion collider lattice was designed to preserve the CEBAF injected polarized beam with polarization up to 70 %. A set of spin rotators was developed to provide a longitudinally polarized beams at the interaction points out of the vertically polarized beams in the Arcs. The coupled beam trajectory due to the solenoids used in the spin rotator was decoupled by design. While electron (positron) polarization is maintained vertical in arcs of the ring, a stable longitudinal spin at four collision points is achieved through the vertical crossing bending magnet, solenoid spin rotators, and horizontal orbit bends. Spin matching technique needs to be implemented in order to enhance quantum self-polarization and minimize depolarization effects. Preliminary spin dynamics simulations show that with the ELIC spin control scheme and optics design of the storage ring, desired polarization of electron beams at all collision points is feasible.

TUPEB045 **Chromaticity Correction up to Second Order for ELIC** – *H. K. Sayed (CASA) S.A. Bogacz, Y. Roblin (JLAB)*

The proposed electron ion collider lattice exhibits unprecedentedly low betas at the Interaction Point IP ($\beta^* \sim$ 0.5cm) and rather large longitudinal acceptance of the collider ring ($\Delta p/p$ = 0.005). Both features make the chromatic corrections of paramount importance. Here the chromatic effects of the final focus quadruples are corrected both locally and globally. Local correction features a symmetric sextupole families around the IP, the betatron phase advances from the IP to the sextupoles are chosen to eliminate the second order chromatic aberration. Then a global interleaved families of sextupoles are placed in the figur$\cdot 10^{-8}$ straight sections, making use of the freely propagating dispersion wave from the arcs. Which in return minimizes the required sextupole strength and eventually leads to larger dynamic aperture of the collider. The resulting spherical aberrations induced by the sextupoles are mitigated by design; the straight section optics features an inverse identity transformation between sextupoles in each pair.

TUPEB046 **Design Studies of Interaction Region for a High Luminosity Eletron-ion Collider at JLab** – *Y. Zhang, S.A. Bogacz, Y.S. Derbenev, M. Hutton, G.A. Krafft, Y. Roblin, H. K. Sayed, B.C. Yunn (JLAB) M.K. Sullivan (SLAC) B. Terzic (Thomas Jefferson National Accelerator Facility (JLAB))*

The conceptual design of interaction regions for a polarized ring-ring electron-ion collider relys on many novel features (compared to other hadron colliders) to reach ultra high luminosity up to 10^{35} $cm^{-2}s^{-1}$. These design features include: ultra high collision frequency (up to 1.5 GHz), very small spot sizes at the collision point through strong final focusing (β^* is of the order a few mm), crab crossing colliding beams, and traveling focusing for very low ion energy. The design must accommodate several challenging requirements set by the nuclear physics experiments including long magnet free detector spaces and multiple non-identical detectors. This paper reports on recent progress in design studies and in particular focuses on several key R&D issues including: chromatic correction of the ring and interaction region, nonlinear dynamics effects, magnet design, beam-beam effect, crab crossing, synchrotron radiation, beamsstrahlung, detector background, and luminosity lifetime. Computer simulations on various beam dynamics topics will also be presented.

TUPEB047 **Design Studies of Front End of Ion Complex for a High Luminosity Electron-ion Collider at JLab** – *Y. Zhang, Y.S. Derbenev, G.A. Krafft, Y. Roblin, B.C. Yunn (JLAB) A. Belov (RAS/INR) V.V. Danilov (ORNL) J.R. Delayen (ODU) V.G. Dudnikov (Muons, Inc) B. Erdelyi, P.N. Ostroumov (ANL)*

An important task of a green-field design ion complex of a ring-ring electron-ion collider at JLab is formation of high intensity ion beams with high bunch repetition rate, small transverse emittance and very short bunch length, in order to enabling electron-ion collisions with very high luminosity. The front end of this complex consists of sources for polarized light ions and non-polarized heavy ions, LEBT/MEBT, a 200 MeV/c SRF linac and a 3 GeV/c figur$\cdot 10^{-8}$ shape pre-booster ring. The ion beam is also accumulated in the pre-booster ring before being injected into the low energy and medium energy storage/collider rings subsequently for further energy boosting. Electron cooling is utilized at all three rings for cooling ion beams at injection and final energies as well as at collision mode. This paper presents a conceptual design of the front end of this new ion complex with sufficient details and also focuses on several key R&D issues associated to this facility. Computer simulations on various beam manipulation processes including stacking and cooling, as well as beam dynamics will be also presented.

TUPEB048 **A High-Luminosity Medium Energy Electron-Ion Collider at JLab** – *Y. Zhang, S.A. Bogacz, P. Chevtsov, R. Ent, M. Hutton, G.A. Krafft, R. Li, P. Nadel-Turonski, Y. Roblin, H. K. Sayed, A.W. Thomas, M.G. Tiefenback, C. Weiss, B.C. Yunn (JLAB) J.R. Delayen (ODU) T. Horn, F. Klein (Catholic University of America) C. Hyde (Old Dominion*

University) B. Terzic (Thomas Jefferson National Accelerator Facility (JLAB))

The conceptual design of ELIC, a polarized ring-ring electron-ion collider based on CEBAF, has been continuously optimized to cover a wide center-of-mass energy region and to achieve high luminosity and polarization for supporting science programs. Recently, significant efforts have been made at JLab for exploring possibility of a low to medium energy polarized ring-ring electron-ion collider for the most interesting science program. Such medium energy collider with compact figur·10^{-8} shape rings and multiple interaction points will be the immediate goal at JLab while a high energy collider is reserved as a future upgrade option, as result of a consideration of science programs and an optimization of collider capability and project cost. Several design features including asymmetric final focusing, flat to round beam conversion and staged beam cooling will help to suppress collective instabilities and to improve the collider capability, pushing luminosity to the level above 10^{34} $s^{-1}cm^{-2}$. Significant progresses have also been made in accelerator R&D including interaction region design, beam-beam effects, high energy electron cooling, polarization tracking and chromatic corrections.

TUPEB049 **Electron Cooling for Electron-ion Collider at JLab** – *Y. Zhang, Y.S. Derbenev (JLAB) B. Terzic (Thomas Jefferson National Accelerator Facility (JLAB))*

A critical component of a conceptual design of a high luminosity electron-ion collider at JLab is an electron cooling facility which consists of a 10 mA, 33 MeV energy recovery linac and a circulator ring. This facility can also be operated at lower nucleon energies for enabling low energy collisions. A fast kicker has been designed for switching electron bunches between the linac and the circulator ring. This paper will be focused on optimization of the cooler design and development of advanced concepts for enhancing cooling efficiency and collider luminosity. The paper will also report progresses on simulation studies of high energy electron cooling and stability of a cooling electron beam in the circulator cooler ring.

TUPEB050 **Ion Bunch Length Effects on the Beam-beam Interaction in a High Luminosity Ring-ring Electron-ion Collider with Head-on Beam-beam Compensation** – *C. Montag, W. Fischer (BNL)*

The luminosity of a ring-ring electron-ion collider is limited by the beam-beam effect on the electrons. Simulation studies have shown that for short ion bunches this limit can be significantly increased by head-on beam-beam compensation via an electron lens. However, due to the large beam-beam parameter experienced by the electrons, together with an ion bunch length comparable to the beta-function at the IP, electrons perform a sizeable fraction of a betatron oscillation period inside both the long ion bunches and the electron lens. Recent results of our simulation studies of this effect will be presented.

TUPEB051 **Interaction Region Design for the Electron-nucleon Collider ENC at FAIR** – *C. Montag (BNL) A. Jankowiak (IKP) A. Lehrach (FZJ)*

To facilitate studies of collisions between polarized electron and protons at $\sqrt{s}$ = 14 GeV constructing an electron-nucleon collider at the FAIR facility has been proposed. This machine would collide the stored 15 GeV polarized proton beam in the HESR with a polarized 3.3 GeV electron beam circulating in an additional storage ring. We describe the interaction region design of this facility, which utilizes the PANDA detector.

TUPEB052 **MeRHIC Design Status** – *V. Ptitsyn, E.C. Aschenauer, M. Bai, J. Beebe-Wang, I. Ben-Zvi, M. Blaskiewicz, K.A. Brown, A. Burrill, R. Calaga, X. Chang, A.V. Fedotov, D.M. Gassner, H. Hahn, L.R. Hammons, Y. Hao, A. Kayran, R.F. Lambiase, V. Litvinenko, G.J. Mahler, M. Mapes, G.T. McIntyre, W. Meng, M.G. Minty, K.A. Mirabella, B. Oerter, B. Parker, A. Pendzick, S.R. Plate, T. Rao, T. Roser, S. Tepikian, R. Than, D. Trbojevic, N. Tsoupas, J.E. Tuozzolo, G. Wang, A. Zaltsman (BNL) E. Pozdeyev (FRIB) E. Tsentalovich (MIT)*

A medium energy electron-ion collider at RHIC (MeRHIC) is considered as a first stage of a high energy electron ion collider at BNL. A detailed design for a 4 GeV electron accelerator, based on energy recovery linacs, has been developed to supply the electron beam for collisions with polarized protons or ions circulating in RHIC in one of RHIC interaction regions. Modifications of existing RHIC accelerator to accommodate MeRHIC are minimal. The advance stage of MeRHIC design development has allowed for a detailed initial evaluation of the cost of this accelerator.

TUPEB053 **Measurements of Fast Transition Instability in RHIC** – *V. Ptitsyn, M. Blaskiewicz, P. Cameron, W. Fischer, R.C. Lee, S.Y. Zhang (BNL)*
A fast transition instability presents a limiting factor for ion beam intensity in RHIC. Several pieces of evidence show that electron clouds play an important role in establishing the threshold of this instability. In RHIC Runs 7 and 8 dedicated measurements of the instability, using different beam instrumentation tools (Button BPM, Wall Current Monitor, transition monitors) were done in order to observe the instability development over hundreds turns. The papers presents and discusses the results of those measurements in time and frequency domains.

TUPEB054 **Design of Positron Damping Ring for Super-KEKB** – *M. Kikuchi, T. Abe, K. Egawa, H. Fukuma, N. Iida, K. Kanazawa, K. Shibata, M. Tobiyama (KEK)*
Super-KEKB, an upgrade plan of the present KEKB collider, has recently changed its scheme from 'high current' option to 'nano-beam' scheme. In the latter the current is relatively low(4A/2.3A for LER/HER ring) compared to that of the high-current option(9.4A/4.1A), while the vertical beam size is squeezed to 60 nm at the interaction point to get the high luminosity. The emittance of the injected beam should be low and, since the Tousheck lifetime is very short(600 sec), the intensity of the positron beam is as high as 8 nC/pulse. For the electron beam a low-emittance high-intensity RF gun is adopted. For the positron beam a damping ring has been proposed. The design of the damping ring has been performed for the high-current option*. In this paper an updated design for the nano-beam scheme is presented.

TUPEB055 **Optics correction at BEPCII Storage Ring** – *D. Ji, Q. Qin, Y. Wei (IHEP Beijing)*
Optics correction is an important issue at BEPCII. Due to the errors in all kinds of components of a storage ring, the real optics of a storage ring is different from the design one. This paper introduces some developments of optics calibration at BEPCII storage ring. We use the method that fit the measured response matrix to the model response matrix to get the fudge factor of the quadrupole field and the sextupole field. On the other hand, in considering fringing fields of quadrupole magnet and interaction of quadrupole magnet iron core and sextupole magnet iron core, the model is calibrated.

TUPEB056 **Operation Experience with the LHC RF System** – *L. Arnaudon (CERN)*
The LHC ACS RF system is composed of 16 superconducting cavities, eight per ring, housed in a total of four cryomodules each containing four cavities. Each cavity is powered by a 300 kW klystron. The ACS RF power control system is based on industrial Programmable Logic Controllers (PLCs), but with additional fast RF interlock protection systems. Operational performance and reliability are described. A full set of user interfaces, both for experts and operators has been developed, with user feedback and maintenance issues as key points. Operational experience with the full RF chain, including the low level system, the beam control, the synchronisation system and optical fibres distribution is presented. Last but not least overall performance and reliability based on experience with beam are reviewed and perspectives for future improvement outlined.

TUPEB057 **Positron Production and Capture based on Low Energy Electrons for SuperB** – *F. Poirier, O. Dadoun, P. Lepercq, R. Roux, A. Variola (LAL) R. Boni, S. Guiducci, M.A. Preger (INFN/LNF) R. Chehab (IN2P3 IPNL)*
Providing a high quality and sufficient high current positron beam for the ultra high luminosity B-factory SuperB is a major goal. In this paper a proposition for positrons production and capture scheme based on low energy electrons up to1 GeV is presented. For this technique, several types of flux concentrator used to capture the positrons are being studied. The following accelerating section bringing the positrons up to 280 MeV and the total yield for L-band and S-band type accelerators are given. Also the result of the benchmark between Parmela and a LAL code based on Geant4 toolkit simulation is discussed.

TUPEB058 **Online Analyzer System for the Development of the Long-lived Charge-exchange Stripping Foils at the J-PARC** – *H. Fujimori, Z. Igarashi, Y. Irie, Y. Sato, M.J. Shirakata, I. Sugai, A. Takagi, Y. Takeda (KEK)*

The carbon stripping foil is the key element for the high-intensity proton accelerator. At KEK, the foil test system using the 650keV H^- Cockcroft-Walton accelerator is in operation, which can simulate the energy depositions to the foil with the same amount in the J-PARC. In order to quantatively observe the foil degradations (such as foil thinning, pin-hole production) during irradiation, online energy and particle analyzing system is under construction. This report outlines the design detail of the analyzing system including the detectors.

TUPEB059 **Injection Scheduling at SuperKEKB Complex through a Damping Ring** – *K. Furukawa, Y. Funakoshi, M. Kikuchi, K. Oide, M. Satoh, M. Suetake, T. Suwada (KEK)*

In the SuperKEKB project, a damping ring will be constructed at the middle of the linac in order to achieve a positron beam with lower emittance, which is required by the beam optics design at the interaction region. The injection and extraction scheme at the damping and main rings was designed satisfying several criteria, which include the RF frequencies at the linac and the rings synchronized with large integers of 49 and 275, dual beam bunches in a linac pulse, and rising and falling times of the kickers. The harmonic number of the damping ring was chosen to allow wider range of buckets to be filled in the main ring. In order to enable the full bucket selection, a pulse-to-pulse LLRF adjustment system will be installed at the latter half of the linac, based on the cascaded event timing system. Pulse-to-pulse injection switching between SuperKEKB, PF-AR with positron and Photon Factory with electron is also discussed.

TUPEB060 **Control of Time Uniformity and Duration of Electron Beam Extracted from a Synchrotron** – *Y.A. Bashmakov, V.A. Karpov (LPI)*

At the slow extraction of particles from a synchrotron the law of time variation of the intensity of extracted beam is primarily determined by the velocity of approach of the frequency of the betatron oscillations to the resonance value. The functional dependence of the required form of a changing of the exciting currents in the quadrupole lenses or in the gradient windings as the function of the beam particles distributions on the amplitudes of betatron and synchrotron oscillations is considered. The basic controlling parameters and the influence of the errors of control on the effectiveness of the work of the slow extraction system are discussed. The optimum algorithm of controlling actions according to the feedback principle is examined.

TUPEB061 **A Novel Extraction Scheme from a Synchrotron Using a Magnetic Shield** – *A.V. Bondarenko, S.V. Miginsky, N. Vinokurov (BINP SB RAS)*

A new beam extraction scheme from a synchrotron is put forward. The main difference from other schemes of extraction is the use of a magnetic shields instead of a septum. Magnetic shields are located in the central dipole magnets of a pulsed chicane. The magnetic shield is a multilayer copper-iron tube. Numerical simulations and experimental results for the magnetic shield are presented. A good accordance between them has shown. The advantages of the new scheme are easy technical implementation and compactness. The area of application is extraction from a synchrotron. The proposed scheme will be used in a new synchrotron radiation source in Novosibirsk.

TUPEB062 **Beam Commissioning and Performance Characterisation of the LHC Beam Dump Kicker Systems** – *J.A. Uythoven, E. Carlier, L. Ducimetière, B. Goddard, V. Kain, N. Magnin (CERN)*

The LHC beam dump system was commissioned with beam in 2009. This paper describes the operational experience with the kicker systems and the tests and measurements to qualify them for operation. The kicker performance was characterized with beam by measurements of the kicker waveforms using bunches extracted at different times along the kicker sweep. The kicker performance was also continuously monitored for each pulse with measurement and analysis of each kick pulse, allowing diagnostic of errors and of long-term drifts. The results are described and compared to the expectations.

TUPEB063 **Performance Studies for Protection against Asynchronous Dumps in the LHC** – *T. Kramer (EBG MedAustron) W. Bartmann, C. Bracco, B. Goddard, M. Meddahi (CERN)*

The LHC beam dump system has to safely dispose all beams in a wide energy range of 450 GeV to 7 TeV. A 3 μs abort gap in the beam structure for the switch-on of the extraction kicker field ideally allows a loss free extraction under normal operating conditions. However, a low number of asynchronous beam aborts is to be expected from reliability calculations and from the first year's operational experience with the beam dump kickers. For such cases, MAD-X simulations including all optics and alignment errors have been performed to determine loss patterns around the LHC as a function of the position of the main protection elements in interaction region six. Special attention was paid to the beam load on the tungsten collimators which protect the triplets in the LHC experimental insertions, and the tracking results compared with semi-analytical numerical estimates. The simulations are also compared to the results of beam commissioning of these protection devices.

TUPEB064 **Comparison of Emittance Growth for 450 GeV Rigidity Pb^{82+} Ions and p^+ in Thin Scatterers** – *B. Goddard, V. Kain, M. Meddahi (CERN)*

The beam profile screens in the long SPS to LHC transfer lines were used to measure with high precision the emittance growth arising from scattering. The effective thickness of the scatterer could be varied by adding thick Al2O3 fluorescent screens, with the emittance measurement made using very thin Ti OTR screens. The technique allows the intrinsic variation in the emittance from the injector chain to be factored out of the measurement, and was applied to Pb^{84+} and protons, both with 450 GeV rigidity. The results are presented and the possible applications to the accurate benchmarking of nuclear interaction codes discussed.

TUPEB065 **Phase-dependant Coupling at Injection from Tilt Mismatch between the LHC and its Transfer Lines** – *V. Kain, K. Fuchsberger, B. Goddard, D. Karadeniz, M. Meddahi (CERN)*

The tilt mismatch between the LHC and its transfer lines arises from the use of combined horizontal and vertical bends. The mismatch gives rise to several subtle optical effects, including a coupling at injection into the LHC which depends on the phase of the oscillation amplitude at the injection point. This coupling was observed for the first time in 2008, and in 2009 dedicated measurements were made. The results are described and compared with the expectations, and the operational implications detailed.

TUPEB066 **Injection Beam Loss and Beam Quality Checks for the LHC** – *B. Goddard, W. Bartmann, C. Bracco, L.N. Drosdal, V. Kain, M. Meddahi, A. Nordt, M. Sapinski (CERN)*

The quality of the injection into the LHC is monitored by a dedicated software system which acquires and analyses the pulse waveforms from the injection kickers, and measures key beam parameters and compares them with the nominal ones. The beam losses at injection are monitored on many critical devices in the injection regions, together with the longitudinal filling pattern and maximum trajectory offset on the first 100 turns. The paper describes the injection quality check system and the results from LHC beam commissioning, in particular the beam losses measured during injection at the various aperture limits. The results are extrapolated to full intensity and the consequences are discussed.

TUPEB067 **Beam Commissioning of the Injection Protection Systems of the LHC** – *W. Bartmann, R.W. Assmann, C. Bracco, B. Goddard, V. Kain, S. Redaelli, A. Rossi, D. Wollmann (CERN)*

The movable LHC injection protection devices in the SPS to LHC transfer lines and downstream of the injection kicker in the LHC were commissioned with low-intensity beam. The different beam-based alignment measurements used to determine the beam centre and size are described, together with the results of measurements of the transverse beam distribution at large amplitude. The system was set up with beam to its nominal settings and the protection level against various failures was determined by measuring the transmission and transverse distribution into the LHC as a function of oscillation amplitude. Beam losses levels for regular operation were also extrapolated. The results are compared with the expected device settings and protection level, and the implications for LHC operation discussed.

TUPEB068 **Aperture Measurements of the LHC Injection Regions and Beam Dump Systems** – *B. Goddard, W. Bartmann, C. Bracco, V. Kain, M. Meddahi, J.A. Uythoven (CERN)*
The commissioning of the beam transfer systems for LHC included detailed aperture measurements in the injection regions and for the beam dump systems. The measurements, mainly single pass, were made using systematic scans of different oscillation phases and amplitudes, and the results compared with the expectations from the physical aperture model of the LHC. In this paper the measurements and results are presented and compared with the specified apertures in these critical areas.

TUPEB069 **Results of 2009 Optics Studies of the SPS to LHC Transfer Lines** – *M. Meddahi, S.D. Fartoukh, K. Fuchsberger, B. Goddard, W. Herr, V. Kain, V. Mertens, J. Wenninger (CERN) D. Kaltchev (TRIUMF)*
In 2008, the SPS-to-LHC transfer line operation allowed for the first time to perform beam measurements in the last part of the lines and into the LHC. Beam parameters were measured and compared with expectation. Discrepancies were observed in the dispersion matching into the LHC, and also in the vertical phase advance along the line. In 2009, extensive theoretical and simulation work was performed in order to understand the possible sources of these discrepancies. This allowed establishing an updated model of the beam line, taking into account the importance of the full magnetic model, the limited dipole corrector strengths and the precise alignment of beam elements. During 2009, beam time was allocated in order to perform further measurements, checking and refining the optical model of the transfer line and LHC injection region and validating the different assumptions. Results of the 2009 optics measurements and comparison with the beam specification and model are presented.

TUPEB070 **Ring-Based Beam-Beam Chopper/Kicker** – *V.D. Shiltsev (Fermilab)*
We make a first look into the idea of utilizing of EM forces of a short and intense low-energy electron bunch circulating in a small ring for chopping or extraction of individual high-energy H^- or proton beam. Prospects of the method and its main limitations are identified and studied. Parameters of Fermilab's Project-X high intensity proton complex are considered for numerical example.

TUPEB071 **Mechanical Engineering and Design of the LHC Phase II Collimators** – *A. Bertarelli, G. Arnau-Izquierdo, A.P. Bouzoud, A. Dallocchio, G. Favre, B. Feral, L. Gentini, R. Perret, M.A. Timmins (CERN)*
Phase II collimators will complement the existing system to improve the expected high RF impedance and limited efficiency of Phase I jaws. An international collaborative effort has been launched to identify novel advanced materials responding to the very challenging requirements of the new collimators. Complex numerical calculations simulating extreme conditions and experimental tests are in progress. In parallel, an innovative modular design concept of the jaw assembly is being developed to allow fitting in alternative materials, minimizing the thermally induced deformations, withstanding accidents and tolerate high radiation doses. Phase II jaw assembly is made up of a molybdenum back-stiffener ensuring high geometrical stability and a modular jaw split in threes sectors. Each sector is equipped with a high-efficiency independent cooling circuit. Beam position monitors (BPM) are embedded in the jaws to accelerate setup time and improve beam monitoring. An adjustment system will permit to fine-tune the jaw flatness just before commissioning the system. A full scale collimator prototype is being manufactured by CERN workshops to validate each feature of the new design.

TUPEB072 **Beam-gas Loss Rates in the LHC** – *Y.I. Levinsen, R. Appleby, H. Burkhardt (CERN)*
We report on first observations and detailed simulations of beam gas rates in the LHC. For the simulations, a comprehensive tool has been set up to simulate in a few hours the expected beam gas losses when pressure maps, collimator settings, and/or beam optics changes. The simulation includes both elastic and inelastic scattering, with subsequent multiturn tracking of proton residues. This provides amongst others a more realistic collimator loss distributions from elastic interactions than what was previously available.

TUPEB073 **Dependence of Background Rates on Beam Separation in the LHC** – *Y.I. Levinsen, H. Burkhardt, S.M. White (CERN)*

Background and loss rates vary when beams are brought into collisions in the LHC and when the beam separation is varied during luminosity scans. We report on the first observations in the early LHC operation. The observed effects are analyzed and compared with models and simulation.

TUPEB074 **UA9 Instrumentation and Detectors in the CERN-SPS** – *R. Losito (CERN)*

The UA9 experiment was installed in the CERN-SPS in March '09 in view of investigating crystal assisted collimation in coasting mode. Inside a vacuum vessel, two 2 mm long silicon crystals, bent by about 150 microradians are mounted on accurate goniometers, and a small 10mm long tungsten target is used to compare the effect of crystals with that of a standard scatterer. A moveable 60 cm long block of tungsten is located downstream at about 90 degrees phase advance to intercept the deflected beam. Scintillators, gas GEMs and beam loss monitors measure nuclear loss rates induced by the interaction of the halo beam in the crystal itself. A Roman pot is installed in the path of the deflected particles in between the crystal and the collimator, equipped with a Medipix detector to reconstruct the transverse spot of the impinging beam. Finally UA9 takes advantage of an LHC-collimator prototype installed close to the Roman pot to help in setting the beam conditions and to reveal in a destructive manner the deflected beam shape. This paper describes in details the hardware installed, and the procedures developed to set-up and detect the channeling conditions.

TUPEB075 **Analysis of the Beam Loss Monitor during the Crystal Collimation Tests in UA9** – *D. Mirarchi (CERN)*

We present a detailed analysis of the beam loss data collected at the SPS during the 2009 machine developments devoted to test crystal collimation. Scintillator counters and Gas electron multiplier detectors were installed in special points to detect the effect of inelastic interaction of protons with the crystals in various orientation with respect to the beam. Clear correlations of the counting rates with the crystal positions and orientation were detected during the data-taking and were crucial to put the crystal in optimal channeling position. For one of the crystal the pattern of losses showed evidence of several planar and axial channeling conditions.

TUPEB076 **Studies of Collimation with Hollow Electron Beams** – *G. Stancari, A.I. Drozhdin, G.F. Kuznetsov, V.D. Shiltsev, D.A. Still, A. Valishev, L.G. Vorobiev (Fermilab) A.A. Kabantsev (UCSD) J.C. Smith (SLAC) G. Stancari (INFN-Ferrara)*

Using magnetically confined hollow electron beams for controlled halo removal in high-energy proton colliders such as the Tevatron or the LHC can potentially improve traditional collimation systems by reducing material damage, suppressing loss spikes, and improving the overall efficiency of the system. The results of simulations with various codes are presented, along with possible collimation schemes. A hollow gun was built and characterized at the Fermilab test stand. Measurements of perveance and profile are presented as a function of cathode voltage and magnetic field, and the electron beam stability is discussed. Finally, we examine possible tests that can be carried out in the Tevatron using the existing electron-lens setup.

TUPEB077 **Geant4 Simulations of the ALPHA Facility's Radiation Test Environment at IUCF** – *P.D. McChesney, S.-Y. Lee, P.E. Sokol (IUCF)*

The ALPHA electron accelerator at IUCF offers several new features for radiation survivability testing including RF mircostructure debunching and the production of a uniform rectangular radiation dose distribution via nonlinear beam spreading with octupole magnets. In particular, the use of nonlinear beam spreading eliminates the need for a collimator, resulting in the potential for a very low background radiation test environment. This paper presents the results and experimental validation of Geant4 simulations of the ALPHA radiation test area.

TUPEB078 **Construction and Bench Testing of a Rotatable Collimator for the LHC Collimation Upgrade** – *J.C. Smith, L. Keller, S.A. Lundgren, T.W. Markiewicz (SLAC)*

The Phase II upgrade to the LHC collimation system calls for complementing the 30 high robust Phase I graphite secondary collimators with 30 high Z Phase II collimators. The Phase II collimators must be robust in various operating conditions and accident scenarios. This paper reports on the final construction and testing of the prototype collimator to be installed in the SPS (Super Proton Synchrotron) at CERN. Bench-top measurements have demonstrated the device is fully operational and has the mechanical and vacuum characteristics acceptable for installation in the SPS.

TUPEB079 **Bench-top Impedance and BPM Measurements of a Rotatable Collimator for the LHC Collimation Upgrade** – *J.C. Smith, L. Keller, S.A. Lundgren, T.W. Markiewicz, L. Xiao (SLAC)*

The Phase II upgrade to the LHC collimation system calls for complementing the 30 high robust Phase I graphite secondary collimators with 30 high Z Phase II collimators. This paper reports on bench-top impedance measurements and testing of the integrated BPMs in the prototype collimator to be installed in the Super Proton Synchrotron (SPS) at CERN. Without careful design the beam impedance can result in unacceptable heating of the chamber wall or beam instabilities. The impedance measurements involve utilizing both a single displaced wire and two wires excited in opposite phase to disentangle the driving and detuning transverse impedances. Trapped mode resonances and longitudinal impedance are also measured and comparisons with simulations are presented. These measurements have demonstrated the device is fully operational and has the impedance characteristics and BPM performance acceptable for installation in the SPS.

TUPEB080 **A Comparison of Graphite and Thin Hi-Z Primary Collimators in the LHC** – *L. Keller, T.W. Markiewicz, J.C. Smith (SLAC) R.W. Assmann, C. Bracco (CERN) Th. Weiler (KIT)*

A current issue with the LHC collimation system is single-diffractive, off-energy protons from the primary collimators that pass completely through the secondary collimation system and are absorbed immediately downbeam in the cold magnets of the dispersion suppression section. Simulations suggest that the high impact rate could result in quenching of these magnets. We have studied replacing the 60 cm primary graphite collimators, which remove halo mainly by inelastic strong interactions, with 5.25 mm tungsten, which remove halo mainly by multiple coulomb scattering and thereby reduce the rate of single-diffractive interactions which cause losses in the dispersion suppressor.

25-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area C

TUPEC — Poster Session

TUPEC002 **Mechanical Studies and Field Stability Optimization of a 1.5 Cell SRF Gun Cavity** – *A. Neumann, A. Frahm, T. Kamps, O. Kugeler (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) M. Dirsat (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) P. Kneisel (JLAB) R. Nietubyc (The Andrzej Soltan Institute for Nuclear Studies, Centre Swierk) T. Rao, J. Smedley (BNL) J.K. Sekutowicz (DESY)*

In collaboration with international partners* a Superconducting RF photo-injector is being developed to be incorporated in the horizontal cavity test facility HoBiCaT at the Helmholtz Zentrum Berlin. The injector cavity is made of a 1.5 cell Nb structure with a Pb cathode deposited on the backwall of the half-cell. The cavity will be operated CW at a low RF bandwidth. To improve the field stability the mechanical design has been improved to reduce microphonics detuning due to backwall deformation. The evolution of the backwall design and the ANSYS based mechanical studies will be presented. RF field simulations will show the expected performance of the photo-injector's cavity.

TUPEC003 **The ELBE Accelerator Facility Starts Operation with the Superconducting RF Gun** – *R. Xiang, A. Arnold, H. Buettig, D. Janssen, M. Justus, U. Lehnert, P. Michel, P. Murcek, A. Schamlott, Ch. Schneider, R. Schurig, J. Teichert (FZD) T. Kamps, J. Rudolph, M. Schenk (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) I. Will (MBI)*

As the first superconducting rf photo-injector (SRF gun) in practice, the FZD 3+1/2 cell SRF gun is successfully connected to the superconducting linac ELBE. This setting will improve the beam quality for ELBE users. It is the first example for an accelerator facility fully based on superconducting RF technology. For high average power FEL and ERL sources, the combination of SRF linac and SRF gun provides a new chance to produce beams of high average current and low emittance with relative low power consumption. The main parameters achieved from the present SRF gun are the final electron energy of 3 MeV, 16 μA average current, and rms transverse normalized emittances of 3 mm mrad at 77 pC bunch charge. A modified 3+1/2 cell niobium cavity has been fabricated and tested, which will increase the rf gradient in the gun and thus better the beam parameters further. In this paper the status of the integration of the SRF gun with the ELBE linac will be presented, and the latest results of the beam experiments will be discussed.

TUPEC004 **Tuning and RF Characterization of Plane Wave Transformer (PWT) Linac Structures at RRCAT** – *S. Lal, K.K. Pant (RRCAT) S. Krishnagopal (BARC)*

Four and eight cell Plane Wave Transformer (PWT) linac structures have been developed as part of the injector development for the Compact Ultrafast Terahertz Free Electron Laser (CUTE-FEL) at RRCAT. In this paper, we discuss the tuning of resonant frequency and waveguide-cavity coupling coefficient for these structures, and compare results obtained from cold tests with those predicted by RF simulations. We also compare energy gain and RF properties of these structures, determined from transient and steady state behavior of the structure during recent high power tests, with those predicted by cold tests.

TUPEC005 **Development and Commissioning of the Injector for the CUTE-FEL** – *S. Lal, B. Biswas, S.K. Gupta, U. Kale, M. Khursheed, A. Kumar, V. Kumar, P. Nerpagar, K.K. Pant, A. Patel, A.K. Sarkar (RRCAT) S. Krishnagopal (BARC)*

The injector system for the Compact Ultrafast Terahertz Free Electron Laser (CUTE-FEL) consists of a 1 ns, 90 kV pulsed thermionic electron gun, a 476 MHz sub-harmonic prebuncher, and a standing wave, S-band Plane Wave Transformer (PWT) linac capable of accelerating beam to 10 MeV. Beam from this injector will be transported to the entrance of the undulator through a beam transport line, with the required diagnostic elements, that has been designed, developed and commissioned. The control system and the low and high power microwave lines have also been commissioned. In this paper, we discuss salient features of the injector system and results from recent commissioning trials of the injector.

TUPEC006 **Multiwavelengths Optical Diagnostic during Cs2Te Photocathodes Deposition** – *L. Monaco, P.M. Michelato, C. Pagani, D. Sertore (INFN/LASA)*

The production of Cs2Te photoemissive films used as laser driven electron sources in the high brightness photoinjectors at FLASH and PITZ, is a well established activity at INFN Milano since the '90s. Our total production is of more than 100 photocathodes, with an average QE of 8% (@ 254 nm) for fresh films and an operative lifetime that increased up to some months at FLASH. In the last two years, we have improved the standard diagnostic used during the cathode growth to better understand the material properties of the films. This activity is motivated by the need to improve the photocathode properties, mainly the energy distribution of the photoemitted electrons that influences the thermal emittance. The multiwavelengths diagnostic, i.e. the on-line measurements of the photocurrent and reflectivity from the film during its growth in the 239 nm ~ 436 nm range, has been deeply applied on several cathodes and the potentiality of this technique are discussed in this paper.

TUPEC007 **Construction of Injector System for SPring-8 X-FEL** – *H. Hanaki, T. Asaka, H. Ego, H. Kimura, T. Kobayashi, S. Suzuki, M. Yamaga (JASRI/SPring-8) T. Fukui, T. Inagaki, N. Kumagai, Y. Otake, T. Shintake, K. Togawa (RIKEN/SPring-8)*

The injector of the 8 GeV linac generates an electron beam of 1 nC, accelerates it up to 30 MeV, and compresses its bunch length down to 20 ps. Even slight RF instability in its multi-stage bunching section fluctuates the bunch width and the peak current of an electron beam and it accordingly results in unstable laser oscillation in the undulator section. The acceptable instabilities of the RF fields in the cavities, which permit 10% rms variation of the peak beam current, are only about 0.01% rms in amplitude and 120 fs rms in phase according to beam simulation. The long-term RF variations can be compensated by feedback control of the RF amplitude and phase, the short-term or pulse-to-pulse variations, however, have to be reduced as much as possible by improving RF equipment such as amplifiers. Thus we have carefully designed and manufactured the RF cavities, amplifiers and control systems, giving the highest priority to the stabilization of the short-term variations. Components of the injector will be completed by the end of the April 2010, and the injector will be perfected in the summer 2010. We will present the performance of the completed devices in the conference.

TUPEC008 **Cavity Detuning Method to Compensate Beam Energy Decrement in Thermionic RF Gun due to Back-bombardment Effect** – *H. Zen (UVSOR) M. A. Bakr, K. Higashimura, T. Kii, R. Kinjo, K. Masuda, K. Nagasaki, H. Ohgaki (Kyoto IAE) H. Zen (Sokendai - Okazaki)*

Thermionic RF guns are compact, economical and high brightness electron sources. However, when the guns are used for a driver linac of oscillator-type Free Electron Lasers (FELs), which requires moderate bunch charge (several tens pico-coulomb) and long macro-pulse duration (several micro-seconds), the guns have been suffered from the back-bombardment effect*. The effect induces beam current increment in a macro-pulse. And consequently the current increment leads to decrement of beam energy during a macro-pulse and significantly limits the beam macro-pulse duration after some bending magnets. Our group found a new energy compensation scheme called as cavity detuning** and the method was introduced to compensate the beam energy decrement in the thermionic RF gun used for KU-FEL***. In this presentation, we will introduce the principle of the method and experimental results. Detailed analysis of the method will be also presented.

TUPEC009 **Development of a Photocathode RF Gun for the L-band Linac at ISIR, Osaka University** – *S. Kashiwagi, K. Furuhashi, G. Isoyama, R. Kato, M. Morio, N. Sugimoto, Y. Terasawa (ISIR) H. Hayano, H. Sugiyama, J. Urakawa (KEK) H. Iijima, M. Kuriki (HU/AdSM)*

We conduct research on Free Electron Laser (FEL) in the infrared region and pulse radiolysis for radiation chemistry using the 40 MeV, 1.3 GHz L-band linac of Osaka University. At present, the L-band linac is equipped with a thermionic electron gun. It can accelerate a high-intensity single-bunch beam with charge up to 91 nC but the normalized emittance is large. In order to advance the research, we have begun development of a photocathode RF gun for the L-band electron linac in collaboration with KEK and Hiroshima University. We start the basic design of the RF gun cavity for the L-band linac at ISIR, Osaka University, based on the 1.5 cells, which is a normal conducting photocathode RF gun. A material of the cathode should be Cs2Te, which has the high quantum efficiency of a few percents, to produce a beam with high charge up to 30 nC/bunch. We improve the cooling system of the cavity for high duty operation to suppress the thermal deformation due to the heat load of input rf power. The simulation study has been also performed for the L-band linac at ISIR with a high charge electron beam. In this conference, we describe the details of the L-band photocathode RF gun development.

TUPEC010 **Development of a Thermionic RF Gun for Coherent THz Source at Tohoku University** – *F. Hinode, H. Hama, M. Kawai, F. Miyahara, T. Muto, K. Nanbu, H. Oohara, Y. Tanaka (Tohoku University, School of Scinece)*

A test accelerator for the coherent terahertz source (t-ACTS) has been under development at Laboratory of Nuclear Science, Tohoku University*. Intense coherent terahertz radiation will be generated by the very short electron bunch less than 100 fs using a thermionic RF gun (ITC RF-gun). ITC RF-gun is designed to have two cells uncoupled with each other, so that it can be operated at various combinations of different rf-power level and phase difference so as to optimize the longitudinal phase space distribution of the electron beam for bunch compression**. The gun employs single-crystal LaB6 cathode with small diameter of 1.8 mm to obtain a very small initial emittance with sufficiently high current density. The RF gun has been already manufactured and the measurement of RF characteristics is now in progress. We will present the results of low-power measurement and also discuss the effect of the cathode misalignment on the beam parameters such as transverse emittance and longitudinal phase space distribution.

TUPEC011 **Structure Design and Optimization of a Compact C-band Photocathode RF Gun** – *X.H. Liu, C.-X. Tang (TUB)*

In this paper, we present the preliminary structure design and optimization of a C-band photocathode RF gun for a compact electron diffraction facility. It will work at 5.712GHz. A dual coupler and elliptical iris between half-cell and full-cell are adopt in this gun for lower emittance and larger mode separation. A detailed 3D simulation of the C-band RF gun with coupler is performed. This paper likewise presents the beam dynamics parameters and analysis of this gun.

TUPEC012 **Experimental Studies of Thermal Emittance of the Mg Cathode at the NSLS SDL** – *H.J. Qian, C.-X. Tang (TUB) Y. Hidaka, J.B. Murphy, B. Podobedov, H.J. Qian, S. Seletskiy, Y. Shen, X.J. Wang, X. Yang (BNL)*

With a large difference between the work function (3.66 eV) and photon energy (4.66 eV), Magnesium (Mg) cathode is a good candidate for thermal emittance studies. Mg cathode has been in operation at the NSLS Source Development Lab (SDL) since 2006, and we have been routinely operating the Mg cathode with quantum efficiency (QE) better than 10^{-4}, while the best QE we observed is about $2x10^{-3}$. We have carried out systematic experimental studies of transverse emittance of the Mg cathode in a photocathode RF gun, and the measured projected emittance of the Mg cathode is better than that of Cu cathode reported in the literature. We also observed no thermal emittance change as the QE of the Mg cathode varied from 10^{-4} to 10^{-3}. Our experimental results could not be explained by the 3-step volume photoemission model, and they contradict the popular thermal emittance formula prediction.

TUPEC013 **R & D on a Compact EC-ITC RF Gun for FEL** – *Y.J. Pei (USTC/NSRL)*

Recently, great attention has been paid to short electron pulses because of requirement for FEL project. Our aim is a 0.2nC, 5ps, 2MeV electron bunch with a normalized emittance less than 10 mm mrad without compensation coil. To create such beams, an External Cathode Independently Tunable Cells RF gun (EC-ITCRF Gun) was advanced, which consists of two independent cavities and a diode gun. The RF power and its phase fed to the two cavities can be independently adjustable. The paper described simulating results of the beam dynamic in the gun and a test facility. After RF power exercising a week, the electric field in the cavities surface was reached 100MV/m and dark current was disappearance. Main parameters measured are as following: energy is of 1.98MeV, pulse bean current of 20A, beam width of 5ps and energy spread of 0.5% so on. Keyword: EC-ITC RF Gun, emittance, energy spread, external cathode

TUPEC014 **Upgraded Photocathode RF Gun for the fs-THz Facility at PAL** – *J.H. Hong, M.S. Chae, I.S. Ko, S.-I. Moon, Y.W. Parc (POSTECH) C. Kim, S.J. Park (PAL)*

The BNL type S-band photocathode RF gun is used at Pohang Accelerator Laboratory (PAL) to produce fs-THz radiation. In order to upgrade the fs-THz Facility at PAL, the requirement for new RF gun is following: 1 nC beam change, 60 Hz repetition rate and 1 mm mrad normalized rms transverse emittance. A dual feed photocathode RF gun is designed satisfy these requirement. The improvement includes some changes in the design. Two additional pumping ports are used to remove the field asymmetry. A larger radius and short length of the iris increases the mode separation. The coupling scheme is changed to make the fabrication simpler. The RF gun structure had been modeled using 3D field solver to provide the desired RF parameters and to obtain the field profile. Beam performance is improved as shown by the PARMELA simulations. In this paper the RF gun design and fabrication will be presented.

TUPEC015 **High Gradient Electrodes for a Diode - RF Electron Gun** – *C.H. Gough, R. Ganter, S. Ivkovic, E. Kirk, F. Le Pimpec, M. Paraliev, S. Tsujino (PSI)*

As part of the SwissFEL project at Paul Scherrer Institute, an electron gun test stand has been built and operated. The goal is to achieve an exceptionally low emittance beam with a charge of 200pC for XFEL application. The electron gun consists of a High Gradient (HG) pulsed diode followed by an RF acceleration structure. The diode has an adjustable gap and the cathode is pulsed at up to 500 kV. The electrons were extracted either from a near-flat cathode surface or a dedicated photo-source recessed in a hollow cathode surface. For the diode electrtodes, many metals, geometries and surface treatments were studied for their HG and photo emission suitability. Polished metal electrodes, single tips, field emitter arrays and electrodes coated with different Diamond Like Carbon (DLC) types were tested. In particular, we found that DLC coating had useful properties. Surface electric fields over 250MV/m (350 ~ 400kV, in pulsed mode) with negligible parasitic electron emission were achieved; when UV laser illumination was applied to DLC electrodes, it was possible to extract electron bunches of over 60pC at gradients up to 150MV/m.

TUPEC016 **Initial Design of a Superconducting RF Photoinjector Option for the UK's New Light Source Project** – *J.W. McKenzie, B.L. Militsyn (STFC/DL/ASTeC)*

The injector for the UK's New Light Source project is required to deliver low emittance 200 pC electron beams at a repetition rate of up to 1 MHz. Initial design of a photoinjector based around a 1.5 cell L-band superconducting RF gun able to meet these requirements is presented. Options involving a solenoid or a second cavity for focussing are considered as well as RF and beam dynamics simulation results.

TUPEC017 **Design of a VHF Photoinjector Option for the UK's New Light Source Project** – *J.W. McKenzie, B.L. Militsyn (STFC/DL/ASTeC)*

The injector for the UK's New Light Source project is required to deliver low emittance 200 pC electron beams at a repetition rate of up to 1 MHz. A possible solution to these requirements is an injector based around a normal conducting VHF RF gun. The injector design and results of beam dynamics simulations are presented for cases with and without an independent buncher cavity. Jitter analysis is also presented for both cases.

TUPEC018 **NEA GaAs Photocathode Preparation and QE Lifetime Study using the ALICE Load-lock System** – *N. Chanlek, R.M. Jones (UMAN) J.D. Herbert, L.B. Jones, K.J. Middleman, B.L. Militsyn (STFC/DL/ASTeC)*

Gallium Arsenide (GaAs) photocathodes have in recent year been widely used and have become the focus for use in modern accelerators and light sources such as the Accelerators and Lasers in Combined Experiments (ALICE) and the International Linear Collider (ILC). Once activated to a Negative Electron Affinity (NEA) state and illuminated by a laser, these materials can be used as a high-brightness source of both polarised and unpolarised electrons. This work presents an effective preparation procedure including heat cleaning, atomic hydrogen cleaning and the activation process for NEA GaAs photocathode. The stability of quantum efficiency (QE) and lifetime of NEA GaAs photocathode have been studied in the load-lock and photocathode preparation system for the ALICE photo- electron gun which has a base pressure in the order of 10^{-11} mbar. These studies are also supported with experimental evidence from surface science techniques such as Photoelectron Spectroscopy (XPS) and Low Energy Electron Diffraction (LEED) to demonstrate the processes at the atomic level.

TUPEC019 **Improved DC Gun Insulator Assembly** – *R. Sah, A. Dudas, M.L. Neubauer (Muons, Inc) G. Neil, K.E.L. Surles-Law (JLAB)*

Many user facilities such as synchrotron radiation light sources and free electron lasers require accelerating structures that support electric fields of 10-100 MV/m, especially at the start of the accelerator chain where ceramic insulators are used for very high gradient DC guns. These insulators are difficult to manufacture, require long commissioning times, and often exhibit poor reliability. Two technical approaches to solving this problem will be investigated. Firstly, inverted ceramics offer solutions for reduced gradients between the electrodes and ground. An inverted design will be presented for 350 kV, with maximum gradients in the range of 5-10 MV/m. Secondly, novel ceramic manufacturing processes will be studied, in order to protect triple junction locations from emission, by applying a coating with a bulk resistivity. The processes for creating this coating will be optimized to provide protection as well as be used to coat a ceramic with an appropriate gradient in bulk resistivity from the vacuum side to the air side of an HV standoff ceramic cylinder. Example insulator designs are being computer modelled, and insulator samples are being manufactured and tested

TUPEC021 **SW/TW Hybrid Photoinjector and its Application to the Coherent THz Radiation** – *A. Fukasawa, J.B. Rosenzweig, D. Schiller (UCLA) D. Alesini, L. Ficcadenti, B. Spataro (INFN/LNF) L. Faillace, L. Palumbo (Rome University La Sapienza)*

A unique SW/TW hybrid photoinjector are being developed under the collaboration of UCLA, LNF/INFN, and University of Rome. It can produce 240-fs (rms) bunch with 500 pC at 21 MeV. The bunch distribution has a strong spike (54 fs FWHM) and the peak current is over 2kA. As the bunch form factor at 1 THz is 0.43, it can produce coherent radiation at 1 THz. We are considering three types of way to generate it; coherent Cherenkov radiation (CCR), superradiant FEL, and coherent transition/edge radiation (CTR/CER). CCR used hollow dielectric with the outer surface metallic-coated. OOPIC simulation showed 21 MW of the peak power (5 mJ) at 1 THz. For FEL and CTR/CER simulation, QUINDI, which was written at UCLA to solve the Lienard-Wiechert potential, was used to calculate the radiation properties. In the contrast to CCR, their spectra were broad and their pulse lengths were short. They will be useful for fast pumping.

TUPEC022 **X-band Photoinjector Beam Dynamics Studies** – *F. Zhou, C. Adolphsen, Y.T. Ding, Z. Li, A.E. Vlieks (SLAC)*

SLAC is studying the feasibility of using an X-band RF photocathode gun to produce low emittance bunches for applications such as an MeV gamma source (in collaboration with LLNL) and an injector for a compact FEL. Systematic beam dynamics study are being done for a 5.5 cell X-band gun followed by several 53 cm long high-gradient X-band accelerator structures. A fully 3D program, ImpactT*, is used to track particles taking into account space charge forces, short-range longitudinal and transverse wakefields and the 3D rf fields in the structures, including the quadrupole component of the couplers. The effect of misalignments of the various elements (drive-laser, gun, solenoid and accelerator structures) are being evaluated. This paper presents these results and estimates of the expected bunch emittance versus bunch charge and cathode gradient.

TUPEC023 **Quantum Efficiency and Lifetime of GaAs cathode in SRF Electron Gun** – *E. Wang, I. Ben-Zvi, A. Burrill, J. Kewisch, T. Rao, Q. Wu (BNL) D. Holmes (AES) E. Wang (PKU/IHIP)*

RF electron guns with strained super lattice GaAs cathodes can produce higher brightness and lower emittance polarized electron beams, due to the higher field gradient at the cathode surface compared with DC guns. The vacuum in the gun must be better than 10^{-11} torr to obtain a sufficient cathode life time with high quantum efficiency (QE). Such high vacuum cannot be obtained easily in a normal conducting RF gun. We report on an experiment with a superconducting RF (SRF) gun, which can maintain a vacuum of nearly 10^{-12} torr because of cryo-pumping at the temperature of 4.2K . The GaAs cathode was activated by Cs'O treatment with a QE of 3% and exhibits a long lifetime in a preparation chamber. This cathode will be used in a 1.3 GHz - cell SRF gun to measure the destruction of the QE by ion and electron back-bombardment.

TUPEC024 **Heat Load by the GaAs Cathode in SRF Electron Gun** – *E. Wang, I. Ben-Zvi, A. Burrill, J. Kewisch, T. Rao, Q. Wu (BNL) D. Holmes (AES) E. Wang (PKU/IHIP)*

Superconducting RF (SRF) electron guns deliver higher brightness beams than DC guns because the field gradient at the cathode is higher. SRF guns with metal cathodes have been successfully tested. For the production of polarized electrons a Gallium-Arsenide (GaAs) cathode must be used, and an experiment to test this type of cathode is under way at BNL. Since the cathode will be normal conducting, the primary concern is cathode-driven heat load. We present measurements of the electric resistance of GaAs at cryogenic temperatures, a prediction of the heat load, and verification by measuring the quality factor of the gun with and without the cathode.

TUPEC025 **Artificial Intelligence Systems for Electron Beam Parameters Optimization at the Australian Synchrotron** – *E. Meier, G. LeBlanc (ASCo) S. Biedron (ELETTRA) M.J. Morgan (Monash University, Faculty of Science)*

We report the development of an artificial intelligent system for the optimisation of electron beam parameters at the Australian Synchrotron Linac. The system is based on state of the art developments in Artificial Intelligence techniques for video games and is adapted here to beam parameters optimisation problems. It consists of a genetically evolved neural network that mimics an operator's decisions to perform an optimisation task when no prior knowledge other than constraints on the actuators is available. The system's decisions are based on the actuators positions, the past performance of close points in the search space and the probability of reaching a better performance in the local region of the search space.

TUPEC026 **Determination of the Magnetic Characteristics in the Injection Septum for the Metrology Light Source in Berlin** – *O. Dressler (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) N. Hauge (Danfysik A/S) P. Kuske (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH)*

The pre-accelerator microtron supplies an electron beam at 10^5 MeV for the Metrology Light Source (MLS) of the Physikalisch-Technische Bundesanstalt (PTB) in Berlin. The beam is delivered via the transfer line to the injection septum and then into the storage ring. This septum magnet has its stainless steel vacuum beam pipe placed inside a laminated silicon iron magnet core. Hence, the pulsed magnetic field (half sine) used for the beam deflection must propagate through the thin metallic beam pipe. During the commissioning of the injection process, it became apparent that the calculated nominal pulse current for this energy and geometry had to be increased by 30 % to achieve proper beam transfer and accumulation. Two problems were apparent. Firstly, the injected beam trajectory had to be set at an angle away from the main beam axis. Secondly, the beam transfer from the septum entrance to exit was disturbed. As a first measure, the septum current pulse length was extended from 35 to 10^7 μs. Further on, the septum magnet was insulated from the transfer line beam pipe by a ceramic brake. This paper reports on measurements of pulsed magnetic fields inside the septum magnet.

TUPEC027 **Dynamics of Longitudinal Phase-Space Modulations in an RF Compressor** – *M. Migliorati (Rome University La Sapienza) M. Ferrario, C. Vaccarezza (INFN/LNF) C. Ronsivalle (ENEA C.R. Frascati) M. Venturini (LBNL)*

Velocity bunching (or RF compression) represents a promising technique complementary to magnetic compression to achieve the high peak current required in the linac drivers for FELs. Here we report on recent progress aimed at characterizing the RF compression from the point of view of the microbunching instability. We emphasize the development of a linear theory for the gain function of the instability and its validation against macroparticle simulations. We make comparisons with the microbunching instability developing through magnetic compressors and discuss possible implications of our results on the design of 4th generation light sources.

TUPEC028 **Microbunching Instability Effect Studies and Laser Heater Optimization for the SPARX FEL Accelerator** – *C. Vaccarezza, M. Ferrario (INFN/LNF) G. Dattoli, L. Giannessi, M. Quattromini, C. Ronsivalle (ENEA C.R. Frascati) M. Migliorati (Rome University La Sapienza) M. Venturini (LBNL)*

The effects of microbunching instability for the SPARX accelerator have been analyzed by means of different numerical simulation codes and analytical approach. The laser heater counteracting action has been also addressed in order to optimize the parameters of the compression system, either hybrid RF plus magnetic chicane or only magnetic, and possibly enhance the FEL performance.

TUPEC029 **Comparison between Hexaboride Materials for Thermionic Cathode RF Gun** – *M. A. Bakr, Y.W. Choi, K. Higashimura, T. Kii, R. Kinjo, K. Masuda, H. Ohgaki, T. Sonobe, S. Ueda, K. Yoshida (Kyoto IAE) H. Zen (UVSOR)*

RF gun has been chosen as injector for Kyoto University free electron laser because it can potentially produce an electron beam with high energy, small emittance, moreover inexpensive and compact configuration in comparison with other injectors. As for the RF gun cathode, thermionic cathode is simpler, easier to treat and reliable than photocathode. On the other hand, backbombardment electrons make cathode surface temperature and current density increase within the macropulse, as a result, beam energy and macropulse duration decrease, which means, it is difficult to generate stable FEL. The heating property of cathode not only depends on physical properties of the cathode material such as work function, but also backbombardment electrons energy. We investigated the heating property of six hexaboride materials against the backbombarding electrons by numerical calculation of the range and stopping power. In this investigation, the emission property of the cathode was also taken into account, since high electron emission is required for generation of high brightness electron beam. The results will be discussed.

TUPEC030 **Conceptual Design of Injection System for Hefei Light Source (HLS) Upgrade Project** – *G. Feng (USTC/NSRL)*

In order to obtain more straight sections for insertion devices and higher brilliance synchrotron radiation, an upgrade project of Hefei Light source (HLS) will be proceeded soon. A new injection system will be installed to improve injection efficiency and keep the machine running stably. There are four kickers will be used to generate a local injection bump. Effects of injection system to injecting beam and stored beam have been simulated considering errors. For the space limitation of septum to the physical aperture, dynamic aperture and beam lifetime of the ring are also given in the paper. About 100% injection efficiency is obtained after optimization.

TUPEC031 **The Operation of Injection System in the SSRF** – *M. Gu, Z.H. Chen, B. Liu, L. Ouyang, Q. Yuan (SINAP)*

The injection system composed of four kickers and two septa in the SSRF have been built and operated. The commissioning shows that fine injecting efficiency and smaller disturbance are carried out. The septum magnets are eddy current designs with a sheet of magnetic screening material around the stored electron beam to reduce the leakage field. The beam tube with RF finger flanges at each end is added to keep the continuity of impedance for the circulating beam. The pulser excite the septum with 60μsecond waveform of half sine-wave and 8kA peak current. Four identical kicker magnets provide the symmetric bump in 10 meter long straight sections. The excitation waveform is a 3.8μsecond half sine pulse up to 7 kA peak. The emphasis was on achieving the best possible tracking in time of the magnet field waveforms so that the residual closed orbit disturbance is minimized for top-up injection. The performance of the injection system with these pulsed magnets are described.

TUPEC032 **Injection Efficiency Monitering with Libera Brilliance Single Pass** – *M. Znidarcic (I-Tech) K.B. Scheidt (ESRF)*

Initially, the Libera Brilliance Single Pass was intended for beam position monitoring at injector system for the FEL machines, this was afterwards followed by the idea of using it on transfer lines on the 3rd generation light sources. The device can be used on pickup buttons and on striplines. The measurement principles and results of Libera Brilliance Single Pass at ESRF, as beam-charge monitor and injection-efficiency monitor, are presented.

TUPEC033 **Shielding Effectiveness of a Shielding Cabinet on Taiwan Light Source Storage Ring Septum Magnet** – *J.C. Huang, C.-H. Chang, C.-S. Hwang, C.Y. Kuo, F.-Y. Lin, C.-S. Yang (NSRRC)*

Pulsed magnet system of Taiwan Photon source(TPS) requires a very low stray field to avoid parasitic magnetic field into the stored beam. The stray field from storage ring(SR) injection septum is required to be less than 0.2 Gauss. The most common method to protect parasitic magnetic field is to use high permeability and conductivity material, such as a Mu-metal. A 1.2 ms half-sine wave pulse of up to 8280A current peak are supply to a septum and would result in eddy current loss in magnet and conductor current diffusion during the rapid charging on magnet. Moreover, competition between eddy current loss and magnetic permeability would lead to a complex phenomena inside the mumetal shielding cabinet and shielding performance. In this study, the magnetic shielding performance of a shielding cabinet was examined in different shielding cabinet geometry and thickness. The results were calculated in Opera software and show that there is a significant suppression of SR septum stray field when round shielding cabinet is in use.

TUPEC034 **Dual One-turn Coil for Extraction Kicker Magnet** – *K.L. Tsai, C.-S. Fann, K.T. Hsu, S.Y. Hsu, K.H. Hu, K.-K. Lin, C.Y. Wu (NSRRC) Y.-C. Liu (National Tsing-Hua University)*

The test results of a dual one-turn coil for the booster extraction kicker of TLS (Taiwan Light Source) will be presented in this report. The achieved capability of the test unit demonstrates that the rise-time is improved for beam extraction optimization. This is because the load inductance of the dual one-turn coil unit has been reduced effectively. The technical consideration of the measured rise/fall time, stability, and droop of the delivering pulsed current will be briefly discussed.

TUPEC035 **Design of the Recirculating Linac Option for the UK New Light Source** – *P.H. Williams, D.J. Dunning, N. Thompson (STFC/DL/ASTeC) D. Angal-Kalinin, J.K. Jones, P.H. Williams (Cockcroft Institute) R. Bartolini, I.P.S. Martin (JAI) J. Rowland (Diamond)*

We present progress in the design of the recirculating linac option for the UK New Light Source. Improvements in all accelerator sections have been made such that the output meets the required specifications to drive the seeded NLS FELs. Full start-to-end simulations and tolerance studies are presented together with a comparison to the baseline, single pass linac design.

TUPEC036 **Design of Post Linac Beam Transport for the UK New Light Source Project** – *D. Angal-Kalinin, P.H. Williams (STFC/DL/ASTeC) D. Angal-Kalinin, J.-L. Fernandez-Hernando, F. Jackson, S.P. Jamison, J.K. Jones, B.D. Muratori (Cockcroft Institute) R. Bartolini, I.P.S. Martin (JAI)*

The design of free electron laser (FEL) driver needs careful beam transport design to pass very short bunches through the switchyard/spreader to switch the beam to different FEL lines. The spreader design which allows flexibility in operation has been adapted following the LBNL design*. In order to measure the slice properties of the bunches two beam diagnostics lines are proposed, a straight one for beam commissioning purposes and a branch of the spreader similar to the FEL lines to measure the adverse effects that may arise due to passing the short bunches through the kicker and septum magnets. As a part of machine protection, post linac collimation system collimates the halo particles in transverse and energy planes. The design of the collimation, beam spreader, beam diagnostics lines and beam dump is discussed.

TUPEC037 **Beam Dump and Collimation Design Studies for NLS: Thermal and Structural Behaviour** – *J.-L. Fernandez-Hernando (STFC/DL/ASTeC)*

The proposed UK New Light Source project will need beam dump to absorb a bunch charge of 200 pC with the repetition rates starting from 1 KHz initially up to 1 MHz in the upgrade. We are exploring an option of a solid dump with a graphite core to absorb the beam power up to 450 kW for the upgrade option as this is the most challenging design. Since the beam dump design will also affect the building layout the choice of its design should be made at an early stage. Based on the feasibility studies of a solid dump, a decision not to go for more complex water dump can be taken. The post linac collimation section should protect the undulators from irradiation due to beam halo particles. This paper shows results and conclusions from simulations of the impact of the NLS beam on different solid beam dump solutions and the effect of the beam halo on the collimators.

TUPEC038 **Multipole Kickers for the ALS** – *G.C. Pappas (LBNL)*

For quadrupole or sextupole magnets, the field at the center is zero and will not disturb the stored beam, while the field away from the center increases in magnitude, giving a larger kick to the particles off axis. By pulsing such multipole magnets it is possible to improve the injection efficiency of the Advanced Light Source (ALS) in top off mode. The requirements for a multipole pole kicker injection scheme for ALS are to kick a 1.9 GeV beam by an angle of 10 mrad with a magnet of 1 meter length. Both quadrupole and sextupole magnets have been studied, as well as a dipole magnet with non-constant field magnitude across the center of the aperture. This paper describes the design and gives a comparison of each type of magnet as well as the modulators needed to drive them.

TUPEC039 **Injected Beam Dynamics in SPEAR3** – *W.J. Corbett, A.S. Fisher, X. Huang, J.A. Safranek (SLAC) W.X. Cheng (BNL) W.Y. Mok (Life Imaging Technology)*

As SPEAR3 moves closer to trickle-charge topup injection, the complex phase-space dynamics of the injected beam becomes increasingly important for capture efficiency and machine protection. In the horizontal plane the beam executes ~12mm betatron oscillations and begins to filament within 10's of turns. In the vertical plane the beam is more stable but a premium is placed on flat-orbit injection through the Lambertson septum and the correct optical match. Longitudinally, energy spread in the booster is converted to arrival-time dispersion by the strong R56 component in the transfer line. In this paper, we report on turn-by-turn imaging of the injected beam in both the transverse plane and in the longitudinal direction using a fast-gated ccd and streak camera, respectively.

TUPEC040 **Optimal Twiss Parameters for Top Off Injection in a Synchrotron Light Source** – *R.P. Fliller (BNL)*

Injection into a ring requires that the injected beam be optimally matched to the storage ring lattice. For on axis injection this requires that the twiss functions of the transfer line match the twiss functions of the lattice. When injection off axis, as is done in light sources for top off injection, the goal is to use the minimum phase space area in the storage ring. A. Streun* has given an analytical method to compute the twiss functions for top off injection into the SLS where injection occurs at a beam waist. We have extended his theory to include cases where there is no beam waist. A simple analytical formula is not possible in this case, however we give an algorithm to compute the twiss parameters of the injected beam given the storage ring lattice. We also compute the twiss functions for a variety of cases for the NSLS-II storage ring.

TUPEC041 **Beam Stacking in the NSLS-II Booster** – *R.P. Fliller, R. Heese, S. Kowalski, J. Rose, T.V. Shaftan (BNL)*

The National Synchrotron Light Source II (NSLS-II) is a state of the art 3 GeV third generation light source currently under construction at Brookhaven National Laboratory. The NSLS-II injection system consists of a 200 MeV linac and a 3 GeV booster synchrotron. The injection system needs to deliver 7.5 nC in 80 - 150 bunches to the storage ring every minute to achieve current stability goals in the storage ring. This is a very stringent requirement that has not been demonstrated at an operating light source, though it should be achievable. To alleviate the charge requirement on the linac, we have designed a scheme to stack two bunch trains in the booster. In this paper we discuss this stacking scheme. The performance of the stacking scheme is studied in detail at injection and through a full booster ramp. We show the the ultimate performance of the stacking scheme is similar to a single bunch train in the booster if the linac emittance meets the requirements. Increasing the emittance of the linac beam degrades the performance, but still allows an overall increase of train charge vs. one bunch train.

TUPEC042 **NSLS-II Transport Line Performance** – *R.P. Fliller, W.R. Casey, G. Ganetis, R. Heese, H.-C. Hseuh, P.K. Job, B.N. Kosciuk, R. Meier, D. Padrazo, I. Pinayev, J. Rose, T.V. Shaftan, O. Singh, J. Skaritka, C.J. Spataro, G.M. Wang (BNL)*

The NSLS-II injection system consists of a 200 MeV linac and a 3 GeV booster synchrotron and associated transport lines. The transport lines need to transport the beam from the linac to the booster and from the booster to the storage ring in a way that provide high injection efficiency. In this paper we discuss progress on specifying and prototyping the NSLS-II transfer lines including diagnostics, magnet specifications, and safety systems. Commissioning plans are also discussed.

TUPEC043 **NSLS-II Storage Ring Injection Orbit Bump System** – *R. Heese, R.P. Fliller, S. Kowalski, T.V. Shaftan, P. Singh (BNL)*

The injection into the NSLS-II storage ring will be done with four pulsed orbit kickers producing a 5.2 μsecond half sine wave in the standard way. However, the requirement for top-off operations while producing only 10% beam motion of the circulating bunches in the rest of the synchrotron makes timing, ripple and amplitude synchronization along with mechanical alignment and stability a challenge. Septum shielding will present a further challenge. Simulations on how to achieve this along with prototype results from the NSLS-II Pulsed Magnet Lab will be presented.

TUPEC044 **Extraction and Injection Kickers for NSLS-II Booster** – *R. Heese, R.P. Fliller, S. Kowalski, J. Rose, T.V. Shaftan, P. Singh (BNL)*

The extraction out of the NSLS-II booster toward the storage ring is extremely sensitive. Any ripple or droop of the extraction kicker 300 nsecond flat-top field pulse will result in emittance dilution and beam losses during the injection process. Simulations of the chosen method to overcome these requirements will be presented along with prototype results and measurements from the NSLS-II Pulsed Magnet Lab. Injection into the booster will be with four pulsed orbit kickers in the standard way. The requirements on these kickers are less stringent ’ however they must achieve a 100 nsecond rise-time and fall-time and be capable of being pulsed twice in 0.1 second during the booster injection cycle. Simulations and prototype results will be presented.

TUPEC045 **Requirements on the Booster Extraction System for the Best Injector Performance** – *T.V. Shaftan, A. Blednykh, Y. Kawashima, S. Krinsky, J. Rose, L.-H. Yu (BNL)*

Booster extraction presents a number of problems that include strengths and waveforms of the pulsed magnets and design of the vacuum chamber. Instabilities in the booster extraction may compromise the extracted beam quality deteriorating value of high-performance injector design. Here we discuss requirements and tolerances for the extraction system components and methods of increasing its performance.

TUPEC046 **Simulation of Medical Accelerator Linac (5 MeV, 6 A, 3 GHz) with MAGIC Electromagnetic Code** – *P. Gouard, S. Champeaux (CEA)*

The Linac contains an electron gun (45 kV, 6 A, 4micros @ 210 Hz), a buncher cavity and 8 accelerating cells (pi/2 mode @ 3 GHz). The buncher cavity is designed to improve the coupling between the electron beam and the accelerating cells. The output energy is 5 MeV. A malfunction has been experimentally identified as anomalous heating of the cathode and the anode is observed. We simulate here the Linac operation using 2D and 3D MAGIC electromagnetic PIC code in order to understand and suppress this phenomena. We show that electrons going back and eventually colliding with the cathode or the anode, are responsible for the heating. Eventually, a new design is proposed.

TUPEC048 **Coupling Impedance Contribution of Ferrite Devices: Theory and Simulation** – *L. Haenichen, W.F.O. Müller, T. Weiland (TEMF, TU Darmstadt) O. Boine-Frankenheim (GSI)*

Beam coupling impedances have been identified as an appropriate quantity to describe collective instabilities caused through beam-induced fields in heavy ion synchrotron accelerators such as the SIS-18 and the SIS-100 at the GSI facility. The impedance contributions caused by the multiple types of beamline components need to be determined to serve as input condition for later stability studies. This paper will discuss different approaches to calculate the Coupling Impedance contribution of ferrite devices, exploiting the abilities of both commercial codes such as CST STUDIO SUITE® and specific extensions of this code to address kicker related problems in particular. Before addressing actual beamline devices, benchmark problems with cylindrical and rectangular geometry will be simulated and the results will be compared with the corresponding analytical formulations.

TUPEC049 **Efficient 3D Space Charge Calculations with Adaptive Discretization based on Multigrid** – *G. Pöplau, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering)*

Precise and fast 3D space-charge calculations for bunches of charged particles are still of growing importance in recent accelerator designs. Whereas an adaptive discretization of a bunch is often required for efficient space charge calculations in practice, such a technique is not implemented in many computer codes. For instance, the FFT Poisson solver that is often applied allows only an equidistant mesh. An adaptive discretization following the particle density distribution is implemented in the GPT tracking code (General Particle Tracer, Pulsar Physics) together with a multigrid Poisson solver. The disadvantage of this approach is that jumps in the distribution of particles are not taken into account and the hierarchical construction of meshes in multigrid can not be used. In this paper we present an approach to an adaptive discretization which is based on the multigrid technique. The goal is that the error estimator needed for the adaptive distribution of mesh lines can be calculated directly from the multigrid procedure. The algorithm will be investigated for several particle distributions and compared to that adaptive discretization method implemented in GPT.

TUPEC050 **Analysis of the Measurement of Electron Cloud Density under Various Beam-optics Elements in KEKB LER** – *P. Jain (Sokendai) H. Fukuma, K. Kanazawa, Y. Suetsugu (KEK)*

Electron Cloud (ECLOUD) deteriorates the performance of proton and positron storage rings. Therefore it is desirable to understand the ECLOUD buildup in a given machine. The data taken by Retarded Field Analyzer (RFA) with a multi channel plate showed that the signal had the peaks coinciding with the positron bunch pattern if a high voltage of -2kV is applied to the retarded grid*. This suggests that the cloud electrons get maximum kick near the positron bunch. A computer program has been developed to study the near bunch ECLOUD density at KEKB LER (Low Energy Ring). In simulations, secondary electron emission is modeled according to the Furman and Pivi's model**. In this paper we compare the simulation results of the ECLOUD buildup with the experiments performed in KEK under different beam-optics elements.

TUPEC051 **Wake Field Analysis by Time Domain BEM with Initial Value Problem Formulation** – *H. Kawaguchi (Muroran Institute of Technology, Department of Electrical and Electronic Engineering)*

A Time Domain Boundary Element Method (TDBEM) has advantages of grid dispersion free property, treatment of electron bunch with curved trajectory, etc. in wake field analysis. On the other hand, the TDBEM has also serious problems of heavy calculation cost and large required memory which are main reasons why the TDBEM can not be widely used yet. For the large memory problem, moving window scheme was introduced into the TDBEM and it was shown that the TDBEM can be applied to very long accelerator structures*. This paper presents a new formulation of the TDBEM, an initial value problem formulation. To use the initial value problem formulation of the TDBEM, a new type of moving window scheme, which can be applied to curved trajectory or electron motion with smaller velocity than the speed of light, will be introduced.

TUPEC052 **Central Region Simulation for a Compact Cyclotron based on Matlab** – *Z. Chen, T. Hu, X. Hu, L. Zhao (HUST)*

A design for the central region of a 10Mev compact cyclotron has been completed in CAD, then a code for particle simulation in central region will be developed. The code based on Matlab realizes particle tracing by numerical integration. Electric and magnetic field of the central region have been calculated in TOSCA by using the 3D model. And this article will report the result of the particle tracing simulation, which includes the trajectory of the particles, beam centering, energy gain in the first several turns, etc.

TUPEC053 **Hellweg 2D Code for Electron Dynamics Simulations** – *S.V. Kutsaev (MEPhI)*

This paper introduces "Hellweg 2D" code, a special tool for electron dynamics simulation in waveguide accelerating structure. The underlying theory of this software is based on the numerical solutions of differential equations of particle motion. The effects considered in this code include beam loading, space charge forces, external focusing magnetic field. "Hellweg 2D" is capable to deal with multisectional accelerators. Along with a manual input of electrodynamical parameters of the cells, for disk-loaded structures they can be calculated automatically with a help of experimental data tables. In order to obtain the maximum capture in the buncher section, the optimizer of phase velocity and electric field strength functions is provided. The results of beam dynamics simulation of a hybrid accelerator with a standing wave buncher and traveling wave regular section are presented. In this accelerator both electrically and magnetically coupled structures are considered.

TUPEC054 **Modeling Nanometer Structured Laser Assisted Field Emission** – *B.S.C. Oswald, S. Tsujino (PSI) P. Leidenberger (IFH)*

Laser induced field emission has become an enabling technology for building ultra-low emittance electron sources for particle accelerators, such as the x-ray free-electron laser (SwissFEL) under development at the Paul Scherrer Institut (PSI). One approach consists of a sharp pyramidal tip with lateral dimensions of a few nanometers, illuminated by a laser to increase the extracted electron current. Another approaches uses conventional cathodes. In both cases, there are structural details on the nanometer scale, that determine the interaction between the laser and the cathode and thus directly the quantum efficiency of the emitter. We use a 3-d full-wave finite element time domain electromagnetic approach* to understand the nano-optical interaction between structure and laser pulse. For example, the lightning rod effect of sharp tips enhances the electric field in the vicinity. Also, optical antenna concepts have been proposed to enhance the electric field at the field emitter's tip so that higher currents can be extracted. We use dispersive material models for the metals in the optical region of the electromagnetic spectrum.

TUPEC055 **Computation of Electromagnetic Modes in the LOLA Cavity** – *H. Guo (PSI-LRF) A. Adelmann, C. Kraus, B.S.C. Oswald (PSI) P. Arbenz (ETH)*

The X-ray Free Electron Laser (SwissFEL) under development at the Paul Scherrer Institut (PSI) will employ a special type of a deflecting cavity, LOLA*, for beam diagnostics. Since this cavity's design breaks the symmetry, a complete 3-dimensional eigenmodal analysis is indispensable. The 3-dimensional eigenmodal solver femaxx employs the finite element method and has been developed in a collaboration between PSI and the Swiss Federal Institute of Technology Zurich (ETH). The femaxx code uses the graphical frontend program heronion for the application of boundary conditions, including symmetry, and generates a tetrahedral mesh. We use femaxx to analyze the existing LOLA cavity design**, compute electromagnetic eigenmodes with their corresponding eigenfrequencies, and associated performance figures. Since these are large computational problems femaxx has been optimized for distributed memory parallel compute clusters. For the further usage in the beam dynamics code OPAL we sample the eigenmodal fields on a 3-dimensional Cartesian grid.

TUPEC056 **Evolutionary Algorithms in the Design of RF Cavities** – *C. Lingwood, G. Burt (Cockcroft Institute, Lancaster University)*

The design of RF cavities is a multivariate multi-objective problem. Manual optimisation is poorly suited to this class of investigation, and the use of numerical methods results in a non-differentiable problem. Thus the only reliable optimisation algorithms employ heuristic methods. Using an evolutionary algorithm guided by Pareto ranking methods, a RF cavity design can be optimised for accelerating voltage (Vz) while maintaining acceptable surface fields and the correct operating frequency. Evolutionary algorithms are an example of a parallel meta-heuristic search technique inspired by natural evolution. Unlike many optimisation methods, EAs work from a population of solutions recombination operators are applied to share information. This allows for complex, epistatic (non-linear) and multimodal (multiple optima and/or sub-optima) optimization problems to be efficiently explored. Using the concept of domination the solutions can be ordered into Pareto fronts. The first of which contains a set of cavity designs for which no one objective (e.g. the accelerating voltage) without decrementing other objectives.

TUPEC057 **Advances With Merlin - A Beam Tracking Code** – *J. Molson, R.J. Barlow, H.L. Owen (UMAN) J. Molson, A.M. Toader (Cockcroft Institute)*
MERLIN is a highly abstracted particle tracking code written in C++ that provides many unique features, and is simple to extend and modify. We have investigated the addition of high order wakefields to this tracking code and their effects on bunches, particularly with regard to collimation systems for both hadron and lepton accelerators. Updates have also been made to increase the code base compatibility with current compilers, and speed enhancements have been made to the code via the addition of multi-threading to allow cluster operation on the grid. In addition, this allows for simulations with large numbers of particles to take place. Instructions for downloading the new code base are given.

TUPEC058 **Beam Dynamics in NS-FFAG EMMA with Dynamical Maps** – *Y. Giboudot, R. Nilavalan (Brunel University) T.R. Edgecock (STFC/RAL) A. Wolski (The University of Liverpool)*
The Non Scaling Fixed Field Alternating Gradient EMMA has a compact linear lattice. Effect of Fringe Field on the beam has to be studied carefully. A numerical magnetic field map is generated by magnet measurements or magnet design softwares. We developed a technique that produces from the numerical field map, a dynamical map for a particle travelling in the entire EMMA cell for a reference energy without acceleration. Since the beam dynamics change with energy, a set of maps have been produce with different reference energies between 10 and 20MeV. For each reference energy, simulated tune and time of flight (TOF) have been compared with results in Zgoubi - tracking directly through numerical field map. The range of validity of a single map has been investigated by tracking particle with large energy deviation. From that, a sensible acceleration scheme has been implemented.

TUPEC059 **Start-to-End Tracking Simulations of the Compact Linear Collider** – *J. Resta-López, J. Dale (JAI) B. Dalena, D. Schulte, F. Stulle, R. Tomas (CERN) A. Latina (Fermilab)*
We present the current status of the beam tracking simulations of the Compact Linear Collider (CLIC) from the exit of the damping ring to the interaction point, including the ring to main linac (RTML) section, main linac, beam delivery system (BDS) and beam-beam interactions. This model introduces realistic alignment survey errors, dynamic imperfections and also the possibility to study collective effects in the main linac and the BDS. Special emphasis is put on low emittance transport and beam stabilization studies, applying beam based alignment methods and feedback systems. The aim is to perform realistic integrated simulations to obtain reliable luminosity predictions.

TUPEC060 **Serpentine: A New Code for Particle Tracking** – *S. Molloy, S.T. Boogert (Royal Holloway, University of London)*
Serpentine is a Python library, written for the purpose of simulating charged particle accelerators. It has been written to allow for the simulation of both rings and single-shot machines in a light-weight way (i.e. without requiring significant computational resources for typical calculations, such as the determination of transfer matrices, or matching of Twiss parameters), and has been structured to be highly modular (i.e. allowing extension of the simulations to include effects not already included in the base installation). Through the use of the Universal Accelerator Parser (UAP), Serpentine has no need for a new lattice representation, and allows access to any lattice format understood by UAP. The operation of this code on several complex accelerator designs is demonstrated.

TUPEC061 **Scalable High-order Algorithms for Wakefield Simulations** – *M. Min, P.F. Fischer (ANL)*
NekCEM is a high-performance parallel code for simulating wakefields based on high-order discretizations*,**. We will present performance of NekCEM code at large count of processors. A newly developed communication kernel for NekCEM enables simulations on 10K-100K processors. We will demonstrate scalablity analysis for P>10K, depending on the number of grid points per processor for wakepotential simulations with a 9-cell TESLA cavity.

TUPEC062 **Advanced Multi-program GUI for Accelerator Modeling** – *T.J. Roberts (Muons, Inc) D.M. Kaplan (Illinois Institute of Technology)*

There are dozens of programs for designing and modeling accelerator systems, most of which have their own language for describing the system. This means a designer must spend considerable time learning the languages of different programs and converting system descriptions among them. This paper describes a project to develop a new language for accelerator modeling, together with a portable suite of programs to implement it. These programs will assist the user while editing, visualizing, developing, simulating, and sharing models of accelerator components and systems. This suite is based on a Graphical User Interface (GUI) that will permit users to assemble their system graphically and then display it and check its sanity visually, even while using modeling programs that have no graphical or visualization capabilities. Incorporating the concept of libraries as a primary component of the language will encourage collaboration among geographically diverse teams. The requirements for developing this language and its tools will be based on generality, flexibility, extensibility, portability, usability, and sharability.

TUPEC063 **Particle Tracking in Matter-dominated Beam Lines** – *T.J. Roberts, K.B. Beard (Muons, Inc) S. Ahmed, D. Huang, D.M. Kaplan, L.K. Spentzouris (Illinois Institute of Technology)*

The G4beamline program* is a useful and steadily improving tool to quickly and easily model beam lines and experimental equipment without user programming. Unlike most accelerator physics codes, it easily handles a wide range of materials and fields, being particularly well suited for the study of muon and neutrino facilities. As it is based on the Geant4 toolkit**, G4beamline includes most of what is known about the interactions of particles with matter. We are continuing the development of G4beamline to facilitate its use by a larger set of beam line and accelerator developers. A major new feature is the calculation of space-charge effects. G4beamline is open source and freely available at http://g4beamline.muonsinc.com.

TUPEC064 **Full 3D Electromagnetic Simulation of Coherent Synchrotron Radiation via the Lorentz-Boosted Frame Approach** – *J.-L. Vay, E. Cormier-Michel, W.M. Fawley, C.G.R. Geddes (LBNL)*

Numerical simulation of some systems containing charged particles with highly relativistic directed motion can be speeded up dramatically by choice of the proper Lorentz-boosted frame*. Orders of magnitude speedup has been demonstrated for simulations from first principles of laser-plasma accelerator, free electron laser, and particle beams interacting with electron clouds. We summarize the technique and the most recent examples. We then address the application of the Lorentz-boosted frame approach to coherent synchrotron radiation (CSR), which can be strongly present in bunch compressor chicanes. CSR is particularly relevant to the next generation of x-ray light sources and difficult to simulate in the lab frame because of the large ratio of scale lengths. It can increase both the incoherent and coherent longitudinal energy spread, effects that often lead to an increase in transverse emittance. We use the WARP code** to simulate CSR emission around dipole simple bends. We present some scaling arguments for the possible computational speed up factor in the boosted frame and initial 3D simulation results for some standard CSR test cases.

TUPEC065 **A Second-order Electromagnetic Algorithm for Curved Dielectric Boundaries on the Yee Mesh** – *C.A. Bauer, J.R. Cary, G.R. Werner (CIPS)*

Dielectric materials may be used in future particle accelerator cavities since they are more resistant to electrical breakdown than metals, especially at higher frequencies. The accurate simulation of dielectric boundaries for complex 3D geometries poses a significant challenge. We have developed an electromagnetic algorithm that simulates curved 3D dielectric interfaces between materials with anisotropic dielectric constants. The algorithm is based on the Yee mesh and has second-order error in resonant frequencies. We have also successfully combined our new dielectric algorithm with a second-order algorithm for curved metallic boundaries. This allowed second-order convergence to be shown by comparison with an analytically solvable problem. Results will be shown for simulations of a dielectric sphere with isotropic dielectric constant inside a spherical metallic cavity and a photonic crystal of ellipsoids that had an anisotropic dielectric constant.

TUPEC066 **Models and High-order Maps for Realistic RF Cavities using Surface Field Data** – *D.T. Abell, I.V. Pogorelov, P. Stoltz (Tech-X)*

Imagine a virtual cylinder passing through an rf cavity. Given field data on the surface of this cylinder, one can compute accurate high-order transfer maps for particles traversing the cavity*. This technique is robust against errors or noise present in the surface data; moreover, it is not limited to accelerating modes. We describe this technique and present recent work that uses VORPAL** field data as a starting point for modeling crab cavities. In addition, we present realistic models, including fringes, for several standing-wave modes. These models, which include a simple accelerating mode and a TM-110 (crab) mode, are useful for the accurate computation of transfer maps as well as for constructing model fields that can be used for testing and comparing a variety of rf cavity codes.

TUPEC067 **Simulations of Non-scaling FFAGs using PTC** – *D.T. Abell, G.I. Bell, A.V. Sobol (Tech-X) A.G. Ruggiero, D. Trbojevic (BNL)*

Non-scaling FFAGs are sensitive to a slew of resonances during the acceleration ramp*. An important consideration — because it affects the amount of rf power required — will be the speed at which resonances must be crossed. We present simulations of possible non-scaling FFAGs, focusing especially on the effects acceleration rate, misalignments, beam emittance, and magnet fringe fields using the code PTC**.

TUPEC068 **Generalized Dispersionless FDTD Algorithm for Cavity Wakefield Modeling** – *B.M. Cowan, R. Busby (Tech-X) J.R. Cary (CIPS)*

We present a modified FDTD update algorithm which achieves perfect dispersion behavior along a single axis in two or three dimensions without stringent constraints on the cell aspect ratio. We describe the algorithm and its dispersion and stability behavior, as well as charge conservation. We benchmark the algorithm against standard FDTD using a simulation of a bunch in a straight beam pipe. We then demonstrate the algorithm together with cut-cell boundaries, showing wakefields in a superconducting RF cavity.

TUPEC069 **VizSchema - a Unified Visualization of Computational Accelerator Physics Data** – *S.G. Shasharina, D. Alexander, J.R. Cary, M.A. Durant, S.E. Kruger, S.A. Veitzer (Tech-X)*

Data organization of simulations outputs differs from application to application. This makes development of uniform visualization and analysis tools difficult and impedes comparison of simulation results. VizSchema is an effort to standardize metadata of HDF5 format so that the subsets of data needed to visualize physics can be identified and interpreted by visualization tools. Based on this standard, we developed a powerful VisIt-based visualization tool. It allows a uniform approach for 3D visualization of large data of various kinds (fields, particles, meshes) from the COMPASS suite for SRF cavities and laser-plasma acceleration. In addition, we developed a specialized graphical interface to streamline visualization of VORPAL outputs and submit remote VORPAL runs. In this paper we will describe our approach and show some visualizations results.

TUPEC070 **Efficient Treatment of Space Charge Effects Using DA-based FMM Methods** – *H. Zhang, M. Berz, K. Makino (MSU)*

A method is presented that allows the computation of space charge effects of arbitrary and large distributions of particles in an efficient and accurate way. The method is based on an automatic multigrid-based decomposition of charges in near and far regions and the use of high-order differential algebra methods to obtain decompositions of far fields that lead to an error that scales with a high power of the order. Given an ensemble of N particles, the method allows the computation of the self-fields of all particles on each other with a computational expense that scales as N*log(N). Using remainder-enhanced DA methods, it is also possible to obtain rigorous estimates of the errors of the methods. Furthermore, the method allows the computation of all high order multipoles of the space charge fields that are necessary for the computation of high order transfer maps and all resulting aberrations. Examples of the performance of the approach are given, including the simulation of space charge effects in the initial rapid expansion phase of femtosecond laser based photoemission in a time resolving electron microscopy and the simulation of high intensity beams in heavy ion linacs.

TUPEC071 **Generic Model Host System Design** – *P. Chu, J. Wu (SLAC) G.B. Shen (BNL)*

There are many simulation codes for accelerator modeling. Each one has some strength but not all. Collaboration is formed for the effort of providing a platform to host multiple modeling tools. In order to achieve such a platform, a set of common physics data structure has to be set. Application Programming Interface (API) for physics applications should also be defined within a model data provider. A preliminary platform design and prototype will be presented.

TUPEC072 **Service Oriented Architecture for High Level Applications** – *P. Chu, S. Chevtsov, J. Wu (SLAC) G.B. Shen (BNL)*

High level applications often suffer from poor performance and reliability due to lengthy initialization, heavy computation and rapid graphical update. Service oriented architecture (SOA) is trying to separate the initialization and computation from applications to distributed service providers. Heavy computation such as beam tracking will be done periodically on a dedicated server and data will be available to client applications at all time. Industrial standard service architecture can help to improve the reliability and maintainability of the service providers. Robustness will also be improved by reducing the complexity of individual client applications.

TUPEC073 **State of the Art in Finite-element Electromagnetic Codes for Accelerator Modeling under SciDAC** – *C.-K. Ng, A.E. Candel, L. Ge, A.C. Kabel, K. Ko, L. Lee, Z. Li, G.L. Schussman, L. Xiao (SLAC)*

Advances in computational science have led to the development of a comprehensive suite of parallel finite-element electromagnetic codes under SciDAC support to address challenging large-scale problems facing the worldwide accelerator comminity. Named ACE3P, its codes employ the high-order finite-element method on unstructured grids for high-accuracy and high-fidelity modeling of complex accelerator structures. ACE3P's current capabilities include cavity design and optimization, wakefield computation, dark current and multipacting simulation, particle-in-cell rf gun modeling, and multiphysics analysis of rf, thermal and mechanical effects. This paper will present the latest application of ACE3P to the LHC Upgrade, CLIC, Project X, Laser Acceleration, CEBAF 12-GeV Upgrade and PEP-X. The outreach effort for the dissemination of ACE3P and its future R&D plans will also be discussed.

TUPEC074 **Beam Breakup Instabilities for Energy Recovery Linac Due to Off-axis Quadrupole Mode** – *G. Wang, I. Ben-Zvi, M. Blaskiewicz, J. Kewisch (BNL)*

A quadrupole mode wakefield with transverse offset can cause instabilities due to beam center oscillations as well as envelope oscillations. The thresholds of these instabilities set additional limitations on the beam current, cavity impedance and alignment errors. We present analytical derivations of single- and multi-bunch instability thresholds for a single quadrupole mode and compare these results with simulations.

TUPEC075 **Studies of Beam Dynamics for MeRHIC** – *G. Wang, M. Blaskiewicz, A.V. Fedotov, Y. Hao, J. Kewisch, V. Litvinenko, E. Pozdeyev, V. Ptitsyn (BNL)*

We present our studies on various aspects of the beam dynamics in Medium energy electron-ion collider at RHIC (MeRHIC), including the transverse beam break up instabilities, the energy loss due to wakefields, the electron beam emittance growth and energy loss due to synchrotron radiation, the electron beam losses due to Touschek effects and residue gas scattering, the beam-beam effects at the interaction region and the emittance growth of ion beam due to electron bunch to bunch noises. For all effects considered above, no showstopper has been found.

TUPEC076 **Beam Pinch Effect** – *L. Wang (SLAC)*

The e-p instability in recent high intensity rings is a serious problem. The beam becomes much stronger in the future storage rings, like ILC damping and SuperB factory,due to the small emittance. This paper study the beam pinch effect for strong beam region, where the electron oscillates several period during the bunch passage.

TUPEC077 **Long Lifetime Electron Cloud in Wiggler and Quadrupole Magnets of CesrTA** – *L. Wang, M.T.F. Pivi (SLAC)*

The Cornell Electron Storage Ring (CESR) has been reconfigured as an ultra low emittance damping ring for use as a test accelerator (CesrTA) for International Linear Collider (ILC) damping ring R&D. One of the primary goals of the CesrTA program are to investigate the interaction of the electron cloud with low emittance positron beam, to explore methods to suppress the electron cloud, and to develop suitable advanced instrumentation required for these experimental studies. This paper report the simulation of the electron-cloud formation in the wiggler and quadrupole magnets using 3D code CLOUDLAND. The transverse distribution of electron cloud in a wiggler magnet is similar to a dipole magnet except in the zero vertical field regions where the electrons have complicated trajectories and therefore a longer lifetime. Fortunately, these electrons are dominantly direct-photo-electrons and can be easily reduced by properly arranging photon absorbers. Simulations show that the electron cloud in a quadrupole magnet can be trapped for long time due to the mirror field effect.

TUPEC078 **A Two-dimensional FEM Code for Impedance Calculation in High Frequency Domain** – *L. Wang, G.V. Stupakov (SLAC)*

A new method, using the parabolic equation (PE), for the calculation of both high-frequency and small-angle taper (or collimator) impedances is developed in [1]. One of the most important advantages of the PE approach is that it eliminates the spatial scale of the small wavelength from the problem. As a result, the numerical solution of the PE requires coarser spatial meshes. We developed a new code based on Finite Element Method (FEM) which can handle arbitrary profile of a transition. As a first step, we completed and benchmarked a two-dimensional code. One of the important advantages of the code is its fast execution time.

TUPEC079 **Wakefield Study for SLAC Rotatable Collimator Design for the LHC Phase II Upgrade** – *L. Xiao, C.-K. Ng, J.C. Smith (SLAC)*

SLAC is proposing a rotatable collimator design for the LHC phase II collimation upgrade. This design has 20 facet faces on each cylindrical jaw surface and the two jaws, which will move in and out during operation, are rotatable in order to introduce a clean surface in case of a beam hitting a jaw in operation. When the beam crosses the collimator, it will excite broadband and narrowband modes that can contribute to the beam energy loss and power dissipation on the vacuum chamber wall and jaw surface. In this paper, the parallel eigensolver code Omega3P is used to search for all the trapped modes in the SLAC collimator design. The power dissipation generated by the beam in different vacuum chamber designs with different jaw end geometries is simulated. It is found that the longitudinal trapped modes in the circular vacuum chamber design with larger separation of the two jaws may cause excessive heating. Adding ferrite tiles on the vacuum chamber wall can strongly damp these trapped modes. The short-range wakefields will also be calculated to determine the broadband beam heating and transverse kick on the beam. We will present and discuss the simulation results.

TUPEC080 **Recent Enhancements to the ORBIT Code** – *J.A. Holmes (ORNL)*

At an age of twelve years, the collective beam dynamics particle tracking code, ORBIT, is considered mature. Even so, we continue to enhance ORBIT's capabilities. Two such enhancements are reported here. The first enhancement allows for the use of time dependent waveforms for the strengths of all magnetic elements, a capability that previously was limited to kickers and to RF cavities. This capability should prove very useful for applications to synchrotrons, in which tunes are often manipulated during acceleration. The second enhancement provides an internal calculation of the lattice functions. Previously, these had to be read from an external file, but given the capability of dynamically programming the lattice magnet strengths, it is extremely useful to be able to calculate the lattice functions on demand. Examples illustrating these new ORBIT capabilities will be presented.

TUPEC081 **Simulations and Measurements of Beam Breakup in Dielectric Wakefield Structures** – *P. Schoessow, C.-J. Jing, A. Kanareykin, A.L. Kustov (Euclid TechLabs, LLC) A. Altmark (LETI) W. Gai, J.G. Power (ANL)*

Beam breakup (BBU) effects resulting from parasitic wakefields are a serious limitation to the performance of dielectric structure based accelerators. We report here on numerical studies and experimental investigations of BBU and its mitigation. An experimental program is underway at the Argonne Wakefield Accelerator facility that will focus on BBU measurements in dielectric wakefield devices. We examine the use of external FODO channels for control of the beam in the presence of strong transverse wakefields. We present calculations based on a particle-Green's function beam dynamics code (BBU-3000) that we are developing. We will report on new features of the code including the ability to treat space charge. The BBU code is being incorporated into a software framework that will significantly increase its utility (Beam Dynamics Simulation Platform). The platform is based on the very flexible Boinc software environment developed originally at Berkeley for the SETI@home project. The package can handle both task farming on a heterogeneous cluster of networked computers and computing on a local grid. User access to the platform is through a web browser.

TUPEC082 **SimTrack: A Simple C++ Library for Particle Tracking** – *Y. Luo (BNL)*

SimTrack is a simple C++ library designed for numeric particle tracking in high energy accelerators. It adopts a 4th order symplectic integrator for optical transportat in the magnetic elements. 4-D and 6-D weak-strong beam-beam treatments are included for beam-beam studies. It provides versatile functions to manage elements and lines. New type of elements can be easily created in the library. It calculates Twiss and coupling, fits tunes and chromaticities, and corrects closed orbits. During tracking, the parameters of elements can be changed or modulated on the fly.

TUPEC083 **Numerical Simulation of Beam-beam Effects in the Proposed Electron-Ion Colider at Jefferson Lab** – *B. Terzic (CASA) Y. Zhang (JLAB)*

The beam-beam effects can cause a rapid growth of transverse beam emittances and significant degradation of the luminosity of a collider to an unacceptably low level. The ELIC, a proposed ring-ring electron-ion collider based on CEBAF, stores high repetition CW beams with very short bunch lengths, and collides them at up to 4 interaction points with very strong final focusing and crab crossing. All of these features can make the beam-beam effect very challenging. In this paper, we present simulation studies of the beam-beam effect in ELIC using a self-consistent strong-strong code BeamBeam3D developed at LBNL. This simulation study is used for validating the ELIC design and for optimizing its parameter set.

TUPEC084 **New Particle-in-cell Code for Numerical Simulation of Coherent Synchrotron Radiation** – *B. Terzic (CASA) R. Li (JLAB)*

Coherent synchrotron radiation (CSR) is an effect of curvature-induced self-interaction of a microbunch with a high charge as it traverses a curved trajectory. It can cause a significant emittance degradation, as well as fragmentation and microbunching of the beam bunch. In this paper, we present a new code for self-consistent simulations of beams affected by CSR. The code is of the particle-in-cell variety: the beam bunch is sampled by macroparticles, which are deposited on the grid; the corresponding forces on the grid are then computed using retarded potentials according to causality, and interpolated so as to advance the macroparticles in time. The retarded potentials are evaluated by integrating over the 2D path history of the bunch, with the charge and current density at the retarded time obtained from interpolation of the particle distributions recorded at discrete timesteps. The code is benchmarked against analytical results obtained for a rigid-line bunch, as well against the particle-particle code by Li (1998). Finally, we present the simulation results obtained for bending systems at Jefferson Lab free electron laser lattice.

25-May-10	16:00 – 18:00	Poster	Poster Hall D

TUPD — Poster Session

TUPD002 **Simulation and Observation of the Space Charge Induced Multi-Stream Instability of LinacμBunches in the SIS18 Synchrotron** – *S. Appel, T. Weiland (TEMF, TU Darmstadt) O. Boine-Frankenheim (GSI)*

For the future operation as an injector for the FAIR project the SIS18 synchrotron has to deliver intense and high quality ion bunches with high repetition rate. One requirement is that the initial momentum spread of the injected coasting beam should not exceed the limit set by the SIS18 rf bucket area. Also the Schottky spectrum should be used to routinely measure the momentum spread and revolution frequency directly after injection. During the transverse multi-turn injection the SIS18 is filled withμbunches from the UNILAC linac at 36 MHz. For low beam intensities theμbunches debunch within a few turns and form a coasting beam with a Gaussian-like momentum spread distribution. With increasing intensity we observe persistent current fluctuations and an accompanying pseudo-Schottky spectrum. We will explain that the multi-stream instability of theμbunch filaments is responsible for the turbulent current spectrum that can be observed a few 100 turns after injection. The current spectrum observed in the SIS18 and the results from a longitudinal simulation code will compared to an analytical model of the multi-stream instability induced by the space charge impedance.

TUPD003 **Electron Cloud Studies for SIS-18 and for the FAIR Synchrotrons** – *F.B. Petrov, T. Weiland (TEMF, TU Darmstadt) O. Boine-Frankenheim (GSI)*

Electron clouds generated by residual gas ionization pose a potential threat to the stability of the circulating heavy ion beams in the existing SIS-18 synchrotron and in the projected SIS-100. The electrons can potentially accumulate in the space charge potential of the long bunches. As an extreme case we study the accumulation of electrons in a coasting beam under conditions relevant in the SIS-18. Previous studies of electron clouds in coasting beams used Particle-In-Cell (PIC) codes to describe the generation of the cloud and the interaction with the ion beam. PIC beams exhibit much larger fluctuation amplitudes than real beams. The fluctuations heat the electrons. Therefore the obtained neutralization degree is strongly reduced, relative to a real beam. In our simulation model we add a Langevin term to the electron equation of motion in order to account for the heating process. The effect of natural beam fluctuations on the neutralization degree is studied. The modification of the beam response function as well as the stability limits in the presence of the electrons is discussed. Finally we will also address the electron accumulation in long bunches.

TUPD004 **Linear Betatron Coupling Studies in SIS18** – *W.M. Daqa (IAP) I. Hofmann, V. Kornilov, J. Struckmeier (GSI)*

For high current synchrotrons and for the SIS18 operation as booster of the projected SIS100 it is important to improve the multi-turn injection efficiency. This can be achieved by coupling the transverse planes with skew quadrupoles, which can move the particles away from the septum. Linear betatron coupling by skew quadrupole components in SIS18 including space charge effect was studied in an experiment using different diagnostic methods during the crossing of the difference coupling resonance. The beam loss was measured using a fast current transformer, the transverse emittance exchange was observed using a residual gas monitor and the coupled tunes were obtained from the Schottky noise spectrum. We compared the experimental results with simulation using PARMTRA which is a code developed at GSI.

TUPD005 **Analysis of bunch deformation caused by CSR and resistive impedence at ANKA** – *M. Klein, N. Hiller (KIT) A.-S. Müller, K.G. Sonnad (FZK)*

The ANKA light source is regularly operated with a low momentum compaction factor lattice where short bunches are created for the generation of coherent synchrotron radiation (CSR). Short bunches with high electron density can generate strong self fields which act back on the bunch. This can lead to bunch shape deformation and a microbunching instability which were studied theoretically for the ANKA low alpha parameters (Klein et al. PAC 09). We extended these studies to a comparison of calculated electron distributions and bunch profiles measured with a streak camera. The Haissinski equation was solved for the CSR and a resistive impedance to obtain the distortion of the bunches for different bunch length and bunch currents. The comparison shows that the theory predicts a much higher deformation caused by CSR as observed. However the simple resistive impedance model shows a good agreement with the measurements.

TUPD006 **3D Self-Consistent PIC Computation of a Transversal Tune Shift caused by an Electron Cloud in a Positron Storage Ring** – *A. Markovik, G. Pöplau, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering)*

The electron cloud, which is initially presumed as a homogeneous distribution of static electrons, changes its transverse centroid position very fast during the passage of even a single bunch. This is due to the strong focusing transverse field of the highly relativistic positron bunch. As the density of the electrons near the beam axis grows, its impact on the beam becomes stronger. The interaction of the electron cloud with the bunch results with the shift of the betatron tune of the coherent dipole motion of the beam. In this paper we simulated the dipole tune shift of the beam interacting with the electron cloud by taking also in to account the own space-charge forces of the electrons which strongly affect the motion of the electrons during the passage of the bunch. We computed the tune shift for different transverse size and density of the electron cloud.

TUPD007 **Peculiar Variations in Bunch Length Observed at KEKB** – *T. Ieiri (KEK)*

KEKB, an asymmetric electron/positron double-ring collider, utilizes the crab cavity to perform the head-on collision at the interaction point. We observed peculiar phenomena at the transition from the collision to non-collision, where the bunch length slightly changed, even though the beam current and the RF related parameters were almost constant. We also observed that the transverse beam size of both beams changed at the transition. An experimental study was carried out to investigate whether the bunch length would change or not, when the vertical beam size was intentionally changed. The bunch length was measured using a monitor based on the beam spectrum with a resolution of 0.01 mm. We found that the bunch length slightly changed together with the vertical beam size under non-colliding condition. We expect that the change in the bunch length is not caused by the colliding effects, but is related to the longitudinal space charge transformed from the transverse plane. Since the longitudinal space charge effect is negligible for the relativistic beams, some tilting effect of a bunch is suspected.

TUPD008 **Measurement of Wakefield Effects caused by Electron Cloud at KEKB** – *T. Ieiri, J.W. Flanagan, H. Fukuma, Y. Ohnishi, M. Tobiyama (KEK)*

Electron cloud instabilities are a great concern for the KEKB, an electron/positron collider. In order to study wakefield effects of electron cloud, a test bunch was injected behind a bunch train with the solenoid fields off, where cloud density rapidly decayed. A current-dependent tune shift and the tune spread of a test bunch were measured as a function of the bunch current while varying the bucket position of a test bunch. The vertical tune shift indicated a strong defocusing force together with widened tune spread in a region of relatively low cloud density and low bunch current. However, the vertical tune shift changed to a focusing force at high cloud density and high bunch current. On the other hand, the horizontal and vertical tune spreads tended to approach a constant value as increasing the bunch current. The turning current is approximately equal to the threshold current of the vertical size blow-up.

TUPD009 **Study of the Beam Dynamics for the 'Fast Extraction' Working Point of the J-PARC Main Ring** – *A.Y. Molodozhentsev, T. Koseki, M.J. Shirakata, M. Tomizawa (KEK) A. Ando, J. Takano (J-PARC, KEK & JAEA)*

During the early J-PARC Main Ring commissioning and the machine operation with the moderate beam power the 'fast extraction' bare working point has been chosen to provide the machine operation in the safe regime. We discuss main experimental results obtained so far and compare with the results of the computational model of the machine, including the first experimental approach to minimize the effect of the 'sum' linear coupling resonance. The strategy to increase the beam power without changing the operational working point is presented by keeping the moderate space-charge detuning. The advantage of the second harmonic MR RF cavity, including the estimation of the beam losses during the injection and acceleration processes, is discussed.

TUPD010 **Simulation of Longitudinal Emittance Control in J-PARC RCS** – *M. Yamamoto, M. Nomura, A. Schnase, T. Shimada, H. Suzuki, F. Tamura (JAEA/J-PARC) E. Ezura, K. Hara, K. Hasegawa, C. Ohmori, M. Tada, A. Takagi, K. Takata, M. Yoshii (KEK)*

The Longitudinal emittance in J-PARC RCS should be controlled to accelerate a high intensity proton beam with minimal beam loss. In order to study and minimize the beam loss during acceleration, the optimized way to add the 2nd higher harmonic rf has been calculated by a particle tracking code. Furthermore, the bunch shape at RCS extraction should be controlled and optimized for the MR injection. For this purpose, the optimum RCS acceleration pattern has been calculated. We describe the simulation results and the comparison with the beam test.

TUPD011 **Intra-beam Scattering Formulas with Debye Shielding** – *P.-CH. Yu, J. Wei (TUB) H. Okamoto (HU/AdSM) A. Sessler (LBNL)*

During the beam crystallization process, the main heating source is Intra-beam scattering (IBS), in which the Coulomb collisions among particles lead to a growth in the 6D phase space volume of the beam. The results of molecular dynamics (MD) simulation have shown an increase of heating rate as the temperature is increased from absolute zero, but then a peak in the heating rate, and subsequent decrease with ever increasing temperature*. This phenomenon has been carefully studied by Y. Yuri, H. Okamoto, and H. Sugimoto**. On the other hand, in the traditional IBS theory valid at high temperatures, heating rate is monotonically increasing as the temperature becomes lower***. In this paper we attempt to understand the "matching" at low temperatures between the MD results and traditional IBS theory, by including many body effects in the traditional IBS theory. In particular the Debye shielding is included. We shall present how the traditional theory is modified by shielding, and show how this effect improves the "matching" with the results from MD.

TUPD012 **A Characteristics Study for Cold Ion Beam Momentum Spread at HIRFL-CSR** – *L.J. Mao, G.H. Li, J. Li, J.W. Xia, J.C. Yang, X.D. Yang, Y.J. Yuan (IMP)*

Two electron cooling devices have been used at HIRFL-CSR in order to provide high quality heavy ion beams for nuclear and atomic research. The momentum spread is one of the most important characteristics of the beam quality. At HIRFL-CSR, the momentum spread is measured directly with the aid of longitudinal Schottky spectra system. In this paper, the measurements for various ion species are presented. At relatively high intensity, longitudinal Schottky spectra is double peak due to collective phenomena and the momentum spread can be obtained by fitting the spectra. The dependence of momentum spread on stored particle number is proportional to N**a. Moreover, the heating factor was investigated after switching off the electron cooling. The residual gas scattering, the intra-beam scattering and instabilities are studied according to the measured data.

TUPD013 **Assessment of CERN PSB Performance with Linac4 by Simulations of Beams with Strong Direct Space Charge Effects** – *C. Carli, B. Goddard, M. Martini, M. Scholz (CERN) M. Aiba (PSI)*

The performance of the CERN PS Booster (PSB) synchrotron is believed to be limited mainly by direct space charge effects at low energy. The main motivation to construct Linac4 is to raise the PSB injection energy to mitigate direct space charge effects. At present, simulation of the injection and the ow energy part of the cycle aim at defining Investigations on the influence of parameters of the injected beam on the performance of the PSB are described.

TUPD014 **Simulation of Space Charge Effects in Low-energy Electrostatic Storage Rings** – *A.I. Papash (MPI-K) A.I. Papash (JINR) C.P. Welsch (Cockcroft Institute)*

Electrostatic storage rings have proven to be invaluable tools for atomic and molecular physics. Due to the mass independence of the electrostatic rigidity, these machines are able to store a wide range of different particles, from light ions to heavy singly charged bio-molecules. However, earlier measurements showed strong space charge limitations; probably linked to non-linear fields that cannot be completely avoided in such machines. The nature of these effects is not fully understood. In this contribution, we present the results from simulating an electrostatic storage ring under consideration of non-linear fields as well as space charge effects using the computer code SCALA.

TUPD015 **Accurate Simulation of the Electron Cloud in the Fermilab Main Injector with VORPAL** – *P. Lebrun, P. Spentzouris (Fermilab) J.R. Cary (CIPS) P. Stolz, S.A. Veitzer (Tech-X)*
Precision simulations of the electron cloud at the Fermilab Main Injector have been studied using the plasma simulation code VORPAL. Fully 3D and self consistent solutions that includes Yee-type E.M. field maps generated by the cloud and the proton bunches have been obtained, as well detailed distributions of the 6D phase space occupied by the electrons. We plan to include such maps in the ongoing simulation of the space charge effects in the Main Injector. Simulations of the response of retarded field analyzers and microwave transmission experiments are ongoing.

TUPD016 **Induced Cyclotron Resonance of the Electron Cloud in Dipole Magnets** – *S. De Santis, J.M. Byrd, G. Penn (LBNL) M.G. Billing, J.R. Calvey, J.A. Livezey, M.A. Palmer, R.M. Schwartz, J.P. Sikora (CLASSE) M.T.F. Pivi (SLAC)*
Using the TE wave measurement technique to study the accumulation of low-energy electrons in the CESR ring has shown the presence of a strong resonance between electromagnetic wave and electron cloud in regions where a dipole magnetic field is also present. This resonance is much stronger than the classic cyclotron resonance, which depends on bunch spacing, and can radically modify the electron cloud distribution in the vacuum chamber as evidenced by RFA data. The resonance is strongly dependent on the TE wave frequency and its polarization with respect to the magnetic field orientation. We present our experimental results in the CESR chicane region for a variety of beam and TE wave conditions, as well as results from self-consistent electromagnetic simulations using WARP, a 3D PIC code.

TUPD018 **Electron-cloud Build-up Simulations in the Proposed PS2: Status Report** – *M.A. Furman (LBNL) Y. Papaphilippou, G. Rumolo (CERN) R. de Maria (BNL)*
A replacement for the PS storage ring is being considered, in the context of the future LHC accelerator complex upgrade, that would likely place the new machine (the PS2) in a regime where the electron-cloud (EC) effect might be an operational limitation. We report here our present understanding of the ECE build-up based on simulations. We focus our attention on the bending magnets and the field-free regions, and consider both proposed bunch spacings of 25 and 50 ns. The primary model parameters exercised are the peak secondary emission yield (SEY) $delta_max$, and the electron-wall impact energy at which SEY peaks, E_max. By choosing reasonable values for such quantities, and exploring variations around them, we estimate the range for the EC density n_e to be expected in nominal operation. We present most of our results as a function of bunch intensity N_b, and we provide a tentative explanation for a curious non-monotonic behavior of n_e as a function of N_b. We explore the sensitivity of n_e to other variables such as the beam pipe radius in the field-free regions.

TUPD019 **Theoretical Studies of TE-Wave Propagation as a Diagnostic for Electron Cloud** – *G. Penn, J.-L. Vay (LBNL)*
The propagation of TE waves is sensitive to the presence of an electron cloud primarily through phase shifts generated by the altered dielectric function, but can also lead to polarization changes and other effects, especially in the presence of magnetic fields. These effects are studied theoretically and also through simulations using WARP-POSINST. Full electromagnetic simulations are performed for CesrTA parameters, and used as a benchmark for simplified phase shift estimates that are also implemented in WARP/POSINST. Nonlinear effects such as electron heating are also examined.

TUPD020 **Studies of Space Charge Effects in the Proposed CERN PS** – *J. Qiang, R.D. Ryne (LBNL) A. Macridin, P. Spentzouris (Fermilab) Y. Papaphilippou (CERN) U. Wienands (SLAC) R. de Maria (BNL)*
A new proton synchrotron, the PS2, is under design study to replace the the current proton synchrotron at CERN for the LHC upgrade. Nonlinear space charge effects could cause significant beam emittance growth

and particle losses and limit the performance of the PS2. In this paper, we report on studies of the potential space-charge effects at the PS2 using three-dimensional self-consistent macroparticle tracking codes, IMPACT, MaryLie/IMPACT, and Synergia. We will present initial benchmark results among these codes. Effects of space-charge on the emittance growth, especially due to synchrotron coupling, and the aperture sizes will also be discussed.

TUPD021 **Method to Extract Transfer Maps in the Presence of Space Charge in Charged Particle Beams** – *E.W. Nissen, B. Erdelyi (Northern Illinois University) S.L. Manikonda (ANL)*

This research involves a method for combining the intricate diagnostic tools for calculating quantities of interest such as tunes, dispersion and resonances from the single particle map of the system, with an accurate approximation of space charge effects on the beam. The space charge calculation involves a novel method of potential integration which allows for rapid Taylor expansion around singularities. This will allow for an accurate computation of space charge induced tune shifts and resonances, as well as allowing for experimental setups to discriminate between space charge caused issues, and lattice caused issues. The code used was COSY Infinity 9.0 which uses Differential Algebras to determine numerical derivatives to arbitrary order, and Normal Form methods to extract information from the map. The effects of space charge are added to the map using Strang splitting. External confounding factors such as the earths magnetic field are also addressed.

TUPD022 **CesrTA Retarding Field Analyzer Modeling Results** – *J.R. Calvey, J.A. Crittenden, G. Dugan, S. Greenwald, Z. Leong, J.A. Livezey, M.A. Palmer (CLASSE) C.M. Celata (Cornell University) M.A. Furman, M. Venturini (LBNL)*

Retarding field analyzers (RFAs) provide an effective measure of the local electron cloud density and energy distribution. Proper interpretation of RFA data can yield information about the behavior of the cloud, as well as the surface properties of the instrumented vacuum chamber. However, due to the complex interaction of the cloud with the RFA, particularly in regions of high magnetic field, understanding these measurements can be nontrivial. This paper will examine different methods for interpreting RFA data via cloud simulation programs. Possible techniques include postprocessing the output of a simulation code to predict the RFA response, and incorporating an RFA model into the program itself.

TUPD023 **CesrTA Retarding Field Analyzer Measurements in Drifts, Dipoles, Quadrupoles and Wigglers** – *J.R. Calvey, Y. Li, J.A. Livezey, J. Makita, R.E. Meller, M.A. Palmer, R.M. Schwartz, C.R. Strohman (CLASSE) S. Calatroni, G. Rumolo (CERN) K.C. Harkay (ANL) K. Kanazawa, Y. Suetsugu (KEK) M.T.F. Pivi, L. Wang (SLAC)*

Over the course of the CesrTA program, the Cornell Electron Storage Ring (CESR) has been instrumented with several retarding field analyzers (RFAs), which measure the local density and energy distribution of the electron cloud. These RFAs have been installed in drifts, dipoles, quadrupoles, and wigglers; and data have been taken in a variety of beam conditions and bunch configurations. This paper will provide an overview of these results, and give a preliminary evaluation of the efficacy of cloud mitigation techniques implemented in the instrumented vacuum chambers.

TUPD024 **Progress in Studies of Electron-cloud-induced Optics Distortions at CesrTA** – *J.A. Crittenden, J.R. Calvey, G. Dugan, D.L. Kreinick, Z. Leong, J.A. Livezey, M.A. Palmer, D. L. Rubin, D. Sagan (CLASSE) M.A. Furman, G. Penn, M. Venturini (LBNL) K.C. Harkay (ANL) R. Holtzapple (CalPoly) M.T.F. Pivi, L. Wang (SLAC)*

The Cornell Electron Storage Ring Test Accelerator (CesrTA) program has included extensive measurements of coherent tune shifts for a variety of electron and positron beam energies, bunch current levels, and bunch train configurations. The tune shifts have been shown to result primarily from the interaction of the beam with the space-charge field of the beam-induced low-energy electron cloud in the vacuum chamber. Comparison to several advanced electron cloud simulation program packages has allowed determination of the sensitivity of these measurements to physical parameters such as the synchrotron radiation flux, its interaction with the vacuum chamber wall, the beam emittance and lattice optics, as well as to those of the various contributions to the electron secondary yield model. We report on progress in understanding the cloud buildup and decay mechanisms in magnetic fields and in field-free regions, addressing quantitatively the precise determination of the physical parameters of the modelling. Validation of these models will serve as essential input in the design of damping rings for future high-energy linear colliders.

TUPD025 **Resistive Impedance of Oscillating Electron Beam in Undulator Vacuum Chamber** – *A. Grigoryan (YSU) M. Ivanyan, V.M. Tsakanov (CANDLE)*

The resistive impedance of oscillating electron beam in undulator vacuum chamber is studied. The results are compared with the classical straight-forward moving relativistic beam in resistive tube. The impact of the real trajectory impedance to the beam parameter performance in advanced light sources is discussed.

TUPD026 **Impedance Effects in the Australian Synchrotron Storage Ring** – *R.T. Dowd, M.J. Boland, Y.E. Tan (ASCo) D.J. Peake (Melbourne)*

The Australian Synchrotron storage ring must maintain a stable electron beam for user operations. The impedance characteristics of the storage ring can give rise to instabilities that adversely affect the beam quality and need to be well understood. Collective effects driven by the resistive wall impedance are particularly relevant at the Australian synchrotron and their strengths are enhanced by small gap insertion devices, such as IVUs. This study will explore the impedance issues identified in the Australian Synchrotron storage ring and current mitigation techniques.

TUPD027 **Beam Coupling Impedance Measurements at the ANKA Electron Storage Ring** – *P.F. Tavares (Karlsruhe Institute of Technology (KIT)) M. Fitterer, N. Hiller, A. Hofmann, V. Judin, M. Klein, S. Marsching, N.J. Smale, K.G. Sonnad (KIT) E. Huttel, A.-S. Müller (FZK) P.F. Tavares (LNLS)*

We present results of a series of measurements aimed at characterizing the beam coupling impedances in the ANKA electron storage ring. The measurements include transverse coherent tune shifts, bunch lengthening and synchronous phase shift as a function of single bunch current. and were performed under a variety of conditions in the ANKA ring, including injection energy (500 MeV), nominal operating energy (2.5 GeV) as well as at 1.3 GeV in the low alpha optics mode and with different RF voltages. This allowed us to cover a wide range of bunch lengths and thus probe the impedance over a wide frequency range. Special attention is given to the effect of the narrow gap insertion device chambers.

TUPD028 **Fast Beam-ion Instability Studies at SOLEIL** – *R. Nagaoka, L. Cassinari, M.D. Diop, M.-P. Level, C. Mariette, R. Sreedharan (SOLEIL)*

Ever since the commissioning times, transverse instabilities, which now have been identified as the so called Fast Beam-Ion Instability (FBII), have existed in the SOLEIL storage ring. Though along with the improvement of the vacuum level with increasing beam dose its relative importance has decreased to a large extent as compared to the classical instabilities due to the coupling impedance, the FBII still exists persistently at high current, making it difficult to attain a stable beam at the final goal of 500 mA. In particular, sudden beam losses are frequently encountered after keeping the beam stable over a certain time with transverse feedback at the final current, which raised a question as to whether the observed phenomena are compatible with the saturating effect of the FBII. Experimental analysis using the bunch by bunch feedback diagnostics as well as theoretical and numerical analysis using multibunch tracking have been carried out to understand the instability quantitatively and to elucidate the mechanism of the beam losses.

TUPD029 **Coherent Instability Thresholds and Dynamic Aperture with Octupoles and Nonlinear Space-Charge in the SIS100 Synchrotron** – *V. Kornilov, O. Boine-Frankenheim (GSI) V.V. Kapin (ITEP)*

Octupole magnets can be used as a passive cure against transverse collective instabilities. The octupole field creates a betatron frequency spread due to amplitude-dependent tune shift and thus enhances Landau damping. The drawback is the reduction of the dynamic aperture (DA). Ultimately, a balance between collective damping and DA must be found.

Here we analyse the transverse coherent instability thresholds in SIS100 with octupoles and nonlinear space-charge taken into account. As the major impedance sources at low frequencies, the resistive wall and the kickers are considered. A coasting beam is assumed, which results in a conservative stability estimation. On the other hand, we simulate the DA of the SIS100 lattice using the MADX code, with systematic multipole errors, random multipole errors, and closed-orbit errors taken into account.

TUPD030 **Simulation of the Fast Ion Instability in SSRF Storage Ring** – *G.X. Xia (MPI-P) B.C. Jiang (SINAP) L.G. Liu (SSRF)*

Fast ion instability has been observed in the early commissioning and operation of the Shanghai Synchrotron Radiation Facility (SSRF) storage ring. In this paper, a weak-strong code is used to simulate the fast ion instability in SSRF storage ring. Various fill patterns and gas pressures are investigated. The results show that the mini-train fill patterns are very effective to suppress the growth of the fast ion instability. By employing a fast feedback system, it is possible to damp the growth of beam oscillation amplitude below the beam size.

TUPD031 **Dynamics of the Electron Cloud in the Vicinity of Wiggler's Zero Vertical Field** – *L. Schächter (Technion)*

Electron cloud confined to move in the vertical direction by either the wiggler field or a dipole field has been investigated extensively. We present results of an analysis demonstrating that electrons may be trapped in the region of zero vertical field of a wiggler. Their characteristic frequency and life-time are established and some of the implications are discussed.

TUPD032 **Single Bunch Wakefields in the CERN-PSI-ELETTRA X-band Linear Accelerator** – *M.M. El-Ashmawy (ELETTRA)*

PSI-XFEL and FERMI@ELETTRA are 4th Generation Light Sources that require high quality electron beam at the entrance of the undulator chains. In this context, a specially developed X-band structure with integrated alignment monitors will be used to mitigate the nonlinearities in the longitudinal phase space before the beam compression process. The knowledge of the transverse and longitudinal short range wakefields in the X-band structure is essential to evaluate the beam quality in terms of longitudinal energy spread and transverse kick spread. We have used the ABCI code to numerically evaluate the transverse and longitudinal wake potentials for short bunches in this structure. Furthermore approximate analytical models for longitudinal and transverse wake function have been deduced to calculate the relevant wakes integrals.

TUPD033 **Short Range Wakefields Studies of Step-out and Taper-out Transitions Adjacent to X-band Linac in FERMI@elettra** – *M.M. El-Ashmawy (ELETTRA)*

FERMI@ELETTRA is a single pass FEL Facility in construction at the ELETTRA Laboratory in Trieste. To linearize the beam longitudinal phase space, it is planned to use a short X-band accelerating structure installed before the first bunch compressor. Since both the end tubes of the structure have a reduced radius of 5.0 mm, much smaller than the 13.5 mm radius of the beam pipes before and after the structure, a transition, either stepped or tapered, will be necessary between the two components. Using the ABCI code, we have investigated the short range wake fields at such transitions and we have compared them with some conventional analytical models. We have developed specific ABCI-based analytical models that simulate accurately the short range wake field for a wide range of rms bunch lengths (sigma = 25-1000μmeter).

TUPD034 **The Short Range Wakefields of the Traveling Wave and Standing Wave X-band Linearizer of FERMI@ELETTRA FEL: A Comparative Study** – *M.M. El-Ashmawy (ELETTRA)*

In most of the Linac based 4th Generation Light Sources now under development (i.e. FERMI@ELETTRA), to linearize the beam longitudinal phase space, a short accelerating structure, operating at higher harmonics (i.e. X-band, 12 GHz), is adopted. This structure could be either traveling wave or standing wave type. As it is well known, each one of such structures has its own advantages and drawbacks in terms of RF properties. In this paper an overall comparison, from the wakefields point of view, of two different X-band structures will be carried out. The purpose is to evaluate quantitatively the longitudinal and transverse wake functions of the structures, determining their relevant wake integrals, such as the average value of energy loss, rms energy spread, kick factor and kick spread.

TUPD035 **ABCI-based Analytical Model for Plotting and Calculating the Transverse Wakefield in Axi-symmetric Step-out Transition** – *M.M. El-Ashmawy (ELETTRA)*

Step-out transition is one of the most frequent component, commonly used on the new generation light source facilities where very short and dense electron bunches are involved. The numerical calculation of the short-range wake at this type of transition requires a spatial mesh size equal to a fraction of bunch length. This calculation, for a very short bunch lengths, e.g. sigma = 25μmeter, becomes very time consuming due to the large number of mesh points required. On the other hand, the available analytical models that calculate the transverse wake field are applicable only on a narrow range of bunch lengths. We developed an ABCI-based analytical model that can simulate accurately the transverse wake filed and relevant loss integrals. The advantage of this model is quick, accurate and covers wide range of rms bunch lengths (up to sigma =1000μmeter). The model also covers a wide range of beam pipe ratio b/a.

TUPD036 **Electron Cloud Build up and Instability in DAΦNE** – *T. Demma, D. Alesini, P. Raimondi, M. Zobov (INFN/LNF)*

A strong horizontal instability limiting the positron current has been observed at DAΦNE since the installation of the FINUDA detector in 2003. Experiments and simulations seem to provide an evidence that the electron cloud build-up in the wigglers and bending magnets of the DAΦNE positron ring induces a coupled bunch instability with features compatible with observations*. To better understand the electron cloud effects and possibly to find a remedy, a detailed simulation study is undergoing. In this communication we present recent simulation results relative to the build up of the electron cloud taking into account the effect of clearing electrodes in the dipoles and wigglers of the DAΦNE positron ring. The resulting electron cloud distribution is used to study both coupled and single bunch induced instabilities.

TUPD037 **The Quadratic Coefficient of the Electron Cloud Mapping** – *T. Demma (INFN/LNF) S. Petracca, A. Stabile (U. Sannio)*

The bunch-to-bunch evolution of the electron cloud density can be modeled using a cubic map. The map approach has been proved reliable for RHIC* and LHC**. The coefficients that parameterize the map may be obtained by fitting from time consuming numerical simulations. In this communication we derive a simple approximate formula for the quadratic coefficient, which determines the saturation of the cloud due to space charge, in the electron cloud density map, under the assumptions of round chambers and free-field motion of the elctrons in the cloud. Results are compared with simulations for a wide range of parameters governing the evolution of the elctron cloud.

TUPD038 **Collective Effects in the SuperB Collider** – *T. Demma (INFN/LNF) M.T.F. Pivi (SLAC)*

Some collective effects have been studied for the SuperB* high luminosity collider. Estimates of the effect of Intra Beam Scattering on the emittance and energy spread growths have been carried up for both the High Energy (HER, positrons) and the Low Energy (LER, electrons) rings. Electron cloud build up simulations for HER were performed with the ECLOUD code, developed at CERN**, to predict the cloud formation in the arcs, taking into account possible remediation techniques such as clearing electrodes. The new code CMAD, developed at SLAC***, has been used to study the effect of this electron cloud on the beam and assess the thresholds above which the electron cloud instability would set in.

TUPD039 **The Stretched Wire Method: A Comparative Analysis Performed by means of the Mode Matching Technique** – *V.G. Vaccaro, F. Galluccio, M. Panniello (Naples University Federico II and INFN)*

The Wire Method for Coupling Impedance evaluations is quite appealing for the possibility to make bench measurements on the Device Under Test (DUT). However, it is not entirely reliable because the stretched wire perturbs the boundary conditions, introducing a TEM wave that has a zero cut off frequency. We expect that, for frequencies smaller than the cutoff one, this behaviour produces an additional power loss which drastically lowers the high Q resonances of DUT. Above cutoff frequency, the impact of the stretched wire is not as dramatic as below cutoff. The Mode Matching Technique will be used to simulate the measurement with the Wire

Method. In this way one may get a result which is not affected by the errors intrinsic of experimental measurements. The same method will be used to get, according to its standard definition, the Coupling Impedance of the real structure. The two results will be compared in order to define the frequency ranges in which they agree or disagree. As expected large discrepancies appear below cutoff frequency, while above cutoff, for certain ranges of parameters, an agreement is found.

TUPD040 **Streak Camera Observations of KEKB LER Positron Bunches in the Presence of Electron Clouds** – *J.W. Flanagan, H. Fukuma, H. Ikeda (KEK)*

We present streak camera measurements of longitudinal and transverse beam profiles taken at the KEKB LER (positron ring) with the electron-cloud suppression solenoids turned off. Bunch spectral data were also taken in parallel to confirm the presence of electron-cloud-induced instability in the ring.

TUPD041 **Measurement of the Electron Cloud Density in a Solenoid Coil and a Quadrupole Magnet at KEKB LER** – *K. Kanazawa, H. Fukuma (KEK)*

The near beam electron cloud density in a magnetic field was estimated with a simple electron current detector at KEKB LER. The estimation is based on the assumption that high energy electrons which hit a chamber wall come directly from the region around the beam after the interaction with a circulating bunch. The first successful application of this idea for a drift space was reported at PAC05 by the authors. In a solenoid field of 50 G, the near beam cloud density is reduced by about four orders of magnitude compared to the no field case. In a quadruple magnet, the density around the beam is by two orders of magnitude lower than the density in a typical drift space, as most simulations show.

TUPD042 **Loss Factor and Impedance of IR Beam Ducts for SuperKEKB and KEKB** – *K. Shibata, K. Kanazawa (KEK)*

As part of the design works of the interaction region (IR) of SuperKEKB (the upgrade of KEKB B-factory (KEKB)), the loss factor and impedance of beam ducts for the interaction point (IP duct) were calculated by GdfiedL. The IP duct is round and connected to beam ducts for electron and positron beams with a diameter of 20 mm via Y-shaped crotch ducts at both ends. The lengths of the straight section and crotch section are about 200 mm, respectively. The beam crossing angle is 83 mrad. Calculations for two types of IP duct were performed. Both ducts are almost same in design except for the diameter of the straight section (20 mm and 30 mm). The loss factors were about 0.001 V/pC in both cases when the bunch length was 6 mm. The longitudinal impedances showed that there were no modes trapped longitudinally in IP duct. However, from the results of the transverse impedance and eigenmode calculation, it was found that many TE modes can be trapped at the crotch section if the beam is off-center of the beam duct. For comparison, the loss factor and impedance of the IR beam duct of KEKB are also being calculated now. Full details of the calculation results will be provided in this report.

TUPD043 **Experimental Studies on Grooved Surfaces to Suppress Secondary Electron Emission** – *Y. Suetsugu, H. Fukuma, K. Shibata (KEK) M.T.F. Pivi, L. Wang (SLAC)*

Grooved surfaces are effective to suppress the secondary electron emission, and can be a possible technique to mitigate the electron cloud instability (ECI) in positron/proton storage rings. Various types of triangular grooved surfaces have been studied in a laboratory, and also using an intense positron beam of the KEKB B-factory. The grooves have vertex angles of 20 ~ 30 degrees, and depths of 2.5 mm. In the laboratory, the secondary electron yield (SEY) of sample pieces were measured using an electron beam in a magnetic-free condition. The maximum SEY well below 1.0 was obtained after some extent of electron bombardment for most of grooved surfaces. To test he groove efficacy in magnetic field regions of particle accelerators, insertions with several types of grooved surfaces were installed into a test chamber in a wiggler magnet of KEKB positron ring. In a dipole-like chamber wit magnetic field (0.78 T), the reduction in the electron density around the beam was observed for a grooved section when compared to the case of a flat surface with TiN coating. An R&D effort is underway to optimize and manufacture the grooved surface in accelerator beam pipes for practical use.

TUPD044 **Coupling Impedance of the Kicker Magnet of RCS at J-PARC** – *Y. Shobuda, J. Kamiya, M. Watanabe (JAEA/J-PARC) T. Toyama (J-PARC, KEK & JAEA)*
The impedances of the kicker magnet of RCS at J-PARC was measured. The measurement was done for the kicker with several terminal impedances. The measurement and theoretical results are in good agreement.

TUPD045 **Beam-RF Cavity Interaction and Acceleration Stability in Energy Recovery Accelerator** – *V.G. Kurakin, A.V. Koltsov (LPI)*
In energy recovery accelerators, used electron beam is directed back to the same accelerator in decelerating phase and gives the main portion of kinetic energy back to rf field. In this technique, loading beam current is close to zero, and total rf power consumption is due to useful effects plus cavity walls losses. A feed back in the system electron beam - rf cavity may take place. The energy change of accelerated beam may result in the decelerated beam phase shift that in turn leads to the total cavity voltage and, in general, accelerated beam energy change. Depending on relation between beams phases, magnet system dispersion sign and value, beams currents etc, the feedback just described may be positive or negative, resulting in positive case in instability, if the total gain in the feedback closed loop exceed unity. In this paper stability analysis in the system beam-rf cavity is undertaken. The equations for induced fields are derived and the expressions for small deviations from the steady state are obtained. This is followed by stability analysis. The results of this are presented in the form of approximate expressions and plots.

TUPD046 **Effects of Direct Space Charge on the Transverse Mode Coupling Instability** – *D. Quatraro, G. Rumolo (CERN)*
The effects of direct space charge forces on the Transverse Mode Coupling Instability (TMCI) are studied using numerical techniques. We have implemented a third order symplectic integrator for the equation of motion, taking into account non linear space charge forces coming from a Gaussian shaped bunch. We performed numerical simulation for the Super Proton Synchrotron (SPS) bunch at 26 GeV of kinetic energy, using either resistive wall or broad band transverse wake fields. In both cases the result of applying direct space charge, leads to an intensity threshold increase by almost 20% before the TMCI appears. Far above the TMCI intensity threshold, the growth rate is almost 10% higher if no space charge forces are applied.

TUPD047 **Head Tail Instability Observations and Studies at the Proton Synchrotron Booster** – *D. Quatraro, A. Findlay, B. Mikulec, G. Rumolo (CERN)*
Since many years the Proton Synchrotron Booster (PSB) high intensity beams have shown head-tail instabilities in all of the four rings at around 100 ms after the injection. In this paper we present the latest observations together with the evaluation of the instability rise time and its dependence on the bunch intensity. The acquired head-tail modes and the growth rates are compared with HEADTAIL numerical simulations, which together with the Sacherer theory points at the resistive wall impedance as a possible source of the instability.

TUPD048 **Amorphous Carbon Coatings for the Mitigation of Electron Cloud in the CERN SPS** – *C. Yin Vallgren, G. Arduini, J. Bauche, S. Calatroni, P. Chiggiato, K. Cornelis, P. Costa Pinto, E. Métral, G. Rumolo, E.N. Shaposhnikova, M. Taborelli, G. Vandoni (CERN)*
Amorphous carbon coatings with low secondary electron yield have been applied to the liners in the electron cloud monitors and to vacuum chambers of three dipole magnets in the SPS. The electron cloud is completely suppressed for LHC type beams in these monitors even after 3 months air venting and no performance deterioration is observed after more than one year of SPS operation. Upon variation of the magnetic field in the monitors the electron cloud current maintains its intensity down to weak fields of some 40 Gauss, where fast conditioning is observed. This is in agreement with dark traces observed on the RF shields between dipoles. The dynamic pressure rise has been used to monitor the behavior of the magnets. It is found to be about the same for coated and uncoated magnets, apart from a weak improvement in the carbon coated ones under conditions of intense electron cloud. Inspection of the coated magnet is foreseen in order to detect potential differences with respect to the coated

monitors. Measurements of the stray fields outside the dipoles show that they are sufficiently strong to induce electron cloud in these regions.

TUPD049 **Transverse Mode Coupling Instability Measurements at Transition Crossing in the CERN PS** – *S. Aumon (EPFL) S. Aumon, M. Delrieux, P. Freyermuth, S.S. Gilardoni, E. Métral, G. Rumolo, B. Salvant, R.R. Steerenberg (CERN)*

Transition crossing in the CERN PS is critical for the stability of high intensity beams, even with the use of a second order gamma jump scheme. The intense single bunch beam used for the neutron Time-of-Flight facility (n-ToF) needs a controlled longitudinal emittance blowup at flat bottom to prevent a fast single-bunch vertical instability from developing near transition. This instability is believed to be of Transverse Mode Coupling (TMCI) type. A series of measurements taken throughout 2008 and 2009 aim at using this TMCI observed on the ToF beam at transition, as a tool for estimating the transverse global impedance of the PS. For this purpose, we compare the measurement results with the predictions of the HEADTAIL code and find the matching parameters. This procedure also allows a better understanding of the different mechanisms involved and can suggest how to improve the gamma jump scheme for a possible intensity upgrade of the n-ToF beam.

TUPD050 **Impedances of an Infinitely Long and Axisymmetric Multilayer Beam Pipe: Matrix Formalism and Multimode Analysis** – *N. Mounet (EPFL) N. Mounet, E. Métral (CERN)*

In the most general Zotter's formalism, the calculation of the beam-coupling impedance created by an offset point charge travelling at any speed in an infinitely long circular multilayer beam pipe still suffers some computational limits, in particular the usual field matching method fails numerically for more than three layers in the pipe for the dipolar mode. Using the same formalism, we present here a novel, efficient and exact matrix method for the field matching determination of all the constants involved in the electromagnetic field components, and in particular in the impedance formula, that improves by a factor of more than one hundred the computational time while allowing the computation for more layers than three. We also generalize our analysis to any azimuthal mode and finally perform summation on all such modes in the impedance formulae. In particular the exact multimode direct space-charge impedances (both longitudinal and transverse) are given, as well as the wall impedance to any order of precision. New quadrupolar terms for the transverse wall impedance are found, which look negligible in the ultrarelativistic case but might be of significance for low-energy beams.

TUPD051 **Generalized Form Factors for the Beam Coupling Impedances in a Flat Chamber** – *N. Mounet (EPFL) N. Mounet, E. Métral (CERN)*

The exact formalism from B. Zotter to compute beam coupling impedances has been fully developed only in the case of an infinitely long circular beam pipe. For other two dimensional geometries, some form factors are known only in the ultrarelativistic case and under certain assumptions of conductivity and frequency of the pipe material. We present here a new and exact formalism to compute the beam coupling impedances in the case of a collimator-like geometry where the jaws are made of two infinite plates of any linear material. In such an idealized geometry it is shown that the impedances can be computed theoretically without any assumptions on the beam speed, material conductivity or frequency range. The final formula involves coefficients in the form of integrals that cannot be computed analytically in the general case but which can be calculated numerically. This way we obtain new generalized form factors between the circular case and the flat chamber case, which eventually reduce to the so-called Yokoya or Laslett factors under certain conditions.

TUPD052 **Electromagnetic Simulations of Simple Models of Ferrite Loaded Kickers** – *C. Zannini, N. Mounet, E. Métral, G. Rumolo (CERN) B. Salvant, C. Zannini (EPFL)*

The kickers are major contributors to the CERN SPS beam coupling impedance. As such, they may represent a limitation to increasing the SPS bunch current in the frame of an intensity upgrade of the LHC. In this paper, CST Particle Studio time domain electromagnetic simulations are performed to obtain the longitudinal and transverse impedances/wake potentials of simplified models of ferrite loaded kickers. The simulation results have been successfully compared with some existing analytical expressions. In the transverse plane, the dipolar and quadrupolar contributions to the wake potentials have been estimated from the results of these simulations. For some cases, simulations have also been benchmarked against measurements on PS kickers. It turns out that the large simulated quadrupolar contributions of these kickers could explain both the negative total (dipolar+quadrupolar) horizontal impedance observed in bench measurements and the positive horizontal tune shift measured with the SPS beam.

TUPD053 **The Six Electromagnetic Field Components at Low Frequency in an Axisymmetric Infinitely Thick Single-Layer Resistive Beam Pipe** – *N. Mounet (EPFL) N. Mounet, E. Métral (CERN)*

In this study Zotter's formalism is applied to a circular infinitely long beam pipe made of a conductor of infinite thickness where an offset point-charge travels at any given speed. Simple formulae are found for the impedances in the low frequency regime where the usual classic thick wall formula does not apply anymore due to the very large skin depth compared to the pipe radius. In addition, new analytical formulae for the six electromagnetic field components in that regime were obtained, which enables us to give a rather complete physical picture at low frequency.

TUPD054 **Multi-bunch Effect of Resistive Wall in the CLIC BDS** – *R. Mutzner, N. Mounet (EPFL) T. Pieloni (PSI) G. Rumolo, R. Tomas (CERN)*

Wake fields in the CLIC Beam Delivery System (BDS) can cause severe single or multi-bunch effects leading to luminosity loss. The main contributors in the BDS are geometric and resistive wall wake fields of the collimators and resistive wall wakes of the beam pipe. The present work focuses only on the multi-bunch effects from resistive wall. Using particle tracking with wake fields through the BDS, we have established the aperture radius, above which the effect of the wake fields becomes negligible. Our simulations were later extended to include a realistic aperture model along the BDS as well as the collimators. The two cases of 3TeV and 500GeV have been examined in this paper.

TUPD055 **Quadrupolar Transverse Impedance of Simple Models of Kickers** – *B. Salvant (EPFL) N. Mounet, E. Métral, G. Rumolo, B. Salvant, C. Zannini (CERN)*

The SPS kickers are major contributors to the SPS transverse beam coupling impedance. The current "flat chamber" impedance model for a kicker is obtained by applying form factors to the theoretical impedance of an axisymmetric ferrite beam pipe. This model was believed to be acceptable for the vertical dipolar impedance, as two-wire measurements on SPS kickers revealed a satisfactory agreement. However, one-wire measurements on PS kickers suggested that this model underestimates the kickers' transverse quadrupolar (detuning) impedance. The longitudinal and transverse dipolar impedances of another kicker model that accounts for the metallic plates on each side of the ferrite were derived in the past by H. Tsutsui. The same formalism is used in this paper to derive the quadrupolar impedance. These formulae were then successfully benchmarked to electromagnetic simulations. Finally, simulating the interaction of an SPS bunch with the improved kickers' model results in a positive horizontal tune shift, which is very close to the tune shift measured with the SPS beam.

TUPD056 **Update of the SPS Impedance Model** – *B. Salvant (EPFL) G. Arduini, O.E. Berrig, F. Caspers, A. Grudiev, N. Mounet, E. Métral, G. Rumolo, B. Salvant, E.N. Shaposhnikova, C. Zannini (CERN) M. Migliorati, B. Spataro (INFN/LNF) B. Zotter (Honorary CERN Staff Member)*

The beam coupling impedance of the CERN SPS is expected to be one of the limitations to an intensity upgrade of the LHC complex. In order to be able to reduce the SPS impedance, its main contributors need to be identified. An impedance model for the SPS has been gathered from theoretical calculations, electromagnetic simulations and bench measurements of single SPS elements. The current model accounts for the longitudinal and transverse impedance of the kickers, the horizontal and vertical electrostatic beam position monitors, the RF cavities and the 6.7 km beam pipe. In order to assess the validity of this model, macroparticle simulations of a bunch interacting with this updated SPS impedance model are compared to measurements performed with the SPS beam.

TUPD057 **Impedance Study for the TPS Storage Ring** – *A. Rusanov (NSRRC)*
Taiwan Photon Source (TPS) is a new third generation synchrotron storage ring which will be built at the present site of the NSRRC. The paper summarizes results of the impedance studies of the storage ring vacuum components for the TPS project. The main goal of this work was to support the design of the vacuum chamber and, at the same time, to get a detailed model of the machine impedance, which can be used later for detail studies of collective effects. Wake potentials and impedances for each component of the storage ring have been simulated with a 3D electromagnetic code GdfidL. Numerically obtained data have been compared to analytical results for simplified geometries of the vacuum chamber components.

TUPD058 **Collective Effects Simulations for the TPS Storage Ring** – *A. Rusanov, P.J. Chou (NSRRC)*
Taiwan Photon Source (TPS) is a new third generation synchrotron storage ring which will be built at the present site of the NSRRC. Collective effects in the TPS storage ring have been simulated with tracking code ELEGANT. Quasi-Green's function for the entire ring and coherent synchrotron radiation (CSR) have been taken into account in the simulations. Thresholds of the longitudinal microwave instability and the CSR induced instability have been estimated. Time-dependent sawtooth oscillations of the bunch length at high bunch currents have been analyzed and compared to the bunch length oscillations observed at the SLC damping ring.

TUPD059 **Characterisation of Single Bunch Instabilities at Diamond** – *R. Bartolini, R.T. Fielder, I.P.S. Martin, G. Rehm, J. Rowland, C.A. Thomas (Diamond)*
The investigation of the single bunch dynamics at Diamond has revealed a rich phenomenology where a number of collective effects limit the available current under various operating conditions. We report here the progress on the classification of the current threshold for the longitudinal and transverse instabilities and the studies of the beam behaviour at and above threshold. A computational activity is also ongoing to model numerically the beam dynamics and to provide a full impedance database. Comparison with the available experimental data will be shown.

TUPD060 **Resistive Wakefields from Rectangular Apertures** – *R.J. Barlow, A.M. Toader (UMAN)*
We describe an accurate theory for the generation of resistive wakefields in a rectangular aperture, using the Leontovich condition applied to solutions of Maxwell's Equations. Comparisons are given with the standard Yokoya factor technique. Implications for simulation programs are explored.

TUPD061 **Simulations of the LHC Collimation System** – *R.J. Barlow, R. Appleby, J. Molson, H.L. Owen, A.M. Toader, S.C. Tygier (UMAN)*
The collimation system of the LHC will be critical to its success, as the halo of high energy (7 TeV) particles must be removed in such a way that they do not deposit energy in the superconducting magnets which would quench them, or showers in the experiments. We study the properties of the LHC collimation system as predicted by the Merlin and Sixtrack/K2 simulation packages, and compare their predictions for efficiency and halo production, and the pattern of beam losses. The sophisticated system includes many collimators, serving different purposes. Both programs include energy loss and multiple Coulomb scattering as well as losses through nuclear scattering. The MERLIN code also includes the effects of wakefields. We compare the results and draw conclusions on the performance that can be achieved.

TUPD062 **Nonlinear Single-particle Effects in Multiparticle Tracking Codes for the Analysis of Collective Instabilities** – *J. Rowland, R.T. Fielder (Diamond) R. Bartolini (JAI) R. Nagaoka (SOLEIL)*
Within the common programme on the analysis of collective instabilities at Diamond and SOLEIL, the numerical codes mbtrack and sbtrack have been extended to include a full description of the nonlinearities in the storage rings by means of the nonlinear one-turn map. We present the details of the map implementation and the recent results on the analysis of the effects of the nonlinear terms of the map on the characteristics of the collective instabilities at the two machines.

TUPD063 **Analysis of FEL Jitter Sources for the NLS Project** – *J. Rowland (Diamond) R. Bartolini, I.P.S. Martin (JAI) D.J. Dunning, N. Thompson (STFC/DL/ASTeC)*

An extensive campaign of numerical simulation has been carried out to assess the FEL performance in the presence of realistic electron beam jitter sources and FEL intrinsic noise source for the various FEL operating modes of the NLS project. These include the nominal operating mode based on a cascade harmonic FEL, the fallback option in SASE mode and the single spike operation. These studies have allowed the definition of the required stability constraints for the various linac subsystems.

TUPD064 **Threshold of Slow Longitudinal Instability of a Bunched Beam** – *A.V. Burov (Fermilab)*

Slow longitudinal instability of bunched beams is discussed. Its threshold is found for arbitrary distribution function, RF potential and wake function.

TUPD065 **Long-range Beam-beam Compensation in RHIC** – *H.J. Kim, T. Sen (Fermilab) W. Fischer (BNL)*

A compensation scheme with current carrying wires has been proposed to mitigate the effects of long-range beam-beam interactions which produce beam blow-up and deteriorate beam life time. Two long-range beam-beam compensators were installed in RHIC in 2006. The effects of the compensators have been experimentally investigated. We observed an indication that the compensators are beneficial to beam life time. In this paper, we report on simulations of beam loss and emittance growth for proton-proton beams at collision. The simulation results are compared with measurements performed in RHIC during 2009.

TUPD066 **Gaussian Electron Lens in Tevatron** – *H.J. Kim, T. Sen (Fermilab)*

Increasing the luminosity requires higher beam intensity and often focusing the beam to smaller sizes at the interaction points. The effects of head-on interactions then become even more significant. The head-on interaction introduces a tune spread and excites resonances. A low energy electron beam (so called electron lens) is expected to improve intensity lifetime and luminosity of the colliding beams by reducing the betatron tune spread and changing the resonance strengths. In this paper we discuss the results of beam simulations with the Gaussian electron lens in the Tevatron.

TUPD067 **Flat Bunch Dynamics with Multiple Harmonic Cavities** – *T. Sen, C.M. Bhat, J.-F. Ostiguy (Fermilab)*

We investigate the dynamics of longitudinally flat bunches created with multiple harmonic cavities in a high energy collider. We examine the choice of frequencies and voltage ratios that lead to optimal flat bunch profiles, using beam stability as a primary criterion. Specifically, we establish cavity parameters that maintain or enhance both local and global Landau damping compared to operation with a single cavity. The results are interpreted in the context of possible application to the LHC.

TUPD068 **Simulations of Head-on Beam-Beam Compensation at RHIC and LHC** – *A. Valishev, V.D. Shiltsev (Fermilab)*

Electron lenses are proposed as a way to mitigate head-on beam-beam effects for the LHC upgrade. An extensive effort was put together within the US LARP in order to develop numerical simulations of beam-beam effects in the presence of electron lenses. In this report the results of beam-beam simulations for RHIC and LHC are presented. The effect of electron lenses is demonstrated and sensitivity of beam-beam compensation to imperfections is discussed.

TUPD069 **Test of Integrable Optics at the Recycler Ring at Fermilab** – *A. Valishev, S. Nagaitsev, A.V. Shemyakin (Fermilab) V.V. Danilov (ORNL)*

An intense electron beam with non-uniform transverse density distribution, interacting (colliding head-on) with proton beam in an accelerator with optics conserving angular momentum, could create large betatron tune spread in the proton beam without generation of strong nonlinear coupling resonances (integrable optics). The idea is based upon the successfully tested round colliding beams approach, with the difference being that in the proposed scheme only one of the colliding beams (protons) is circulating, while the other (electrons) is single-pass. It was demonstrated at VEPP-2000 (BINP, Novosibirsk, Russia) that in a round beam collider the beam-beam space charge tune shift could reach 0.09 without beam emittance blow up or life time degradation. Application of such approach to a proton accelerator would allow to overcome intensity limits caused by coherent instabilities and space charge effects. The Recycler ring at Fermilab with electron cooling can be used to study the feasibility of this proposal. In this report we discuss the possible modification of the Recycler and present the preliminary results of experiments with colliding electron and proton beams.

TUPD070 **Progress with Tevatron Electron Lens Head-on Beam-Beam Compensation** – *A. Valishev, G.F. Kuznetsov, V.D. Shiltsev, G. Stancari, X. Zhang (Fermilab) A.L. Romanov (BINP SB RAS)*

Tevatron electron lenses have been successfully used to mitigate bunch-to-bunch differences caused by long-range beam-beam interactions. For this purpose the electron beam with uniform transverse density distribution was used. Another planned application of the electron lens is the suppression of tune spread due to head-on beam-beam collisions. For this purpose, the transverse distribution of e-beam must be matched to that of the antiproton beam. In 2009, the gaussian profile electron gun was installed in one of the Tevatron electron lenses. We report on the first experiments with non-linear beam-beam compensation. Discussed topics include measurement and control of the betatron tune spread, importance of the beam alignment and stability, and effect of the electron lens on the proton and antiproton beam lifetime.

TUPD071 **Beam-Beam Effect in a High Luminosity Muon Collider** – *A. Valishev, Y. Alexahin, A.V. Netepenko (Fermilab)*

In order to achieve the design peak luminosity of a muon collider in the $10^{35}/\mathrm{cm}^2/\mathrm{s}$ range the number of muons per bunch should be of the order of a few units of 10^{12} rendering the beam-beam parameter of the order of 0.1 per IP. Though tuneshifts higher than 0.1 have already been achieved in e^+e^- colliders, practical absence of the synchrotron radiation and much larger energy spread make achieving such values in a muon collider questionable. In this report we present the results of the weak-strong and strong-strong simulations showing that a muon collider with two IPs and beam-beam parameter about 0.1 per IP is feasible.

TUPD072 **E-cloud Driven Single-bunch Instabilities in PS2** – *M. Venturini, M.A. Furman, G. Penn, J.-L. Vay (LBNL) Y. Papaphilippou, G. Rumolo, R. de Maria (CERN)*

One of the options under consideration for a future upgrade of the LHC injector complex includes the replacement of PS with PS2 (a longer circumference and higher energy ring). Efforts are currently underway to design the new machine and characterize the beam dynamics. Electron cloud effects represent a potentially serious limitation to the achievement of the upgrade goals. We report on ongoing numerical studies aiming at estimating the e-cloud density threshold for the occurrence of single bunch instabilities or significant degradation of the beam emittance. We present selected results obtained in the more familiar quasi-static approximation and/or in the Lorentz-boosted frame.

TUPD073 **Effect of Bunch Shape on Electron-Proton Instability** – *Z. Liu, S.-Y. Lee (IUCF) S.M. Cousineau, V.V. Danilov, J. Galambos, J.A. Holmes, M.A. Plum, A.P. Shishlo (ORNL)*

The instability caused by the electron cloud effect (ECE) may set an upper limit to beam intensity in proton storage rings. This instability is potentially a major obstacle to the full intensity operation, at $1.5{\cdot}10^{14}$ protons per pulse, of the Spallation Neutron Source (SNS). High intensity experiments have been done with different sets of parameters that affect the electron-proton (e-p) instability, of which bunch intensity and bunch shape are considered as two main factors. In the experiment, the phase and amplitude of the second harmonic RF cavity are used to modify the bunch shape. Simulation with the beam dynamics code ORBIT has been carried out to compare with experimental results and to understand the impact of bunch shape on electron cloud build-up and beam stability. We have also attempted to benchmark the e-p model to predict the frequency spectrum and the RF buncher voltage threshold values against experimental results. Details and discussion will be reported in this conference.

TUPD074 **Wakefield Effects and Longitudinal Dynamics in the Fermilab NML Accelerator Test Facility** – *C.R. Prokop, P. Piot (Northern Illinois University)*

Fermilab is currently building an electron accelerator test facility primary dedicated to explore the performance of superconducting cavities and associated subsystems. The accelerator will also support advanced accelerator R&D and incorporate a high-brightness photo-injector. In this paper we investigate the longitudinal dynamics of experiment including the impact of wakefields for different operating scenarios (ILC-type beam parameters, "high-brightness" mode, and "super-short bunch" mode). Our wakefield analysis is performed with ABCI and VORPAL for cylindrically symmetric and three-dimensional structures, respectively. The wakefields are included in particle tracking to explore the deleterious effects and their potential solutions.

TUPD075 **Start-to-end Simulation of a Compact THz Smith-Purcell FEL** – *C.R. Prokop, P. Piot (Northern Illinois University) M.C. Lin, P. Stoltz (Tech-X)*

Terahertz (THz) radiation has generated much recent interest due to its ability to penetrate deep into many organic materials without the damage associated with ionizing radiations. The generation of copious amounts of narrow-band THz radiation using a Smith-Purcell FEL operating as a backward wave oscillator is being pursued by several groups. In this paper we present start-to-end simulations of a Smith-Purcell FEL operating in the superradiant regime. Our concept incorporates a double grating configuration to efficiently bunch the electron beam, followed by a single grating to produce Smith-Purcell radiation. We demonstrate the capabilities and performances of the device, including initial beam properties (emittance and energy spread), with the help of numerical simulations using the conformal finite-difference time-domain electromagnetic solver VORPAL.

TUPD076 **Suppression of CSR Effects on a Train of Electron Bunches** – *P. Muggli (UCLA) A.V. Fedotov, M.G. Fedurin, A. Kayran, V. Litvinenko, V. Yakimenko (BNL)*

It is well known that the emission of coherent synchrotron radiation is dipole magnets leads to increase in beam energy spread and emittance. At the Brookhaven National Laboratory Accelerator Test Facility (ATF) we study the suppression of CSR emission and of its effects on a train of electron bunches when generated in the exit dipole magnet of the beam line dogleg. The bunch train is generated using a masking technique recently demonstrated at the ATF*. The bunches are separated by ~300microns (~1ps) and are ~150microns-long. The CSR can be detected by a LHe-cooled bolometer and its frequency spectrum determined with an interferometer. Horizontal conducting plates with variable spacing (0-14mm) are placed in the vacuum chamber of the dipole magnet. With the plates fully open, an energy spread comparable to the bunch separation (~50kV) is observed, and the bunch train appears not well defined. Preliminary experimental results show that closing the plates strongly reduces the energy spread, demonstrating the suppression of the effect of CSR.

TUPD077 **Current Filamentation Instability Study of an Electron Beam in a Capillary Plasma** – *B.A. Allen, P. Muggli (USC) J.L. Martins (Instituto Superior Tecnico) L.O. Silva (GoLP) V. Yakimenko (BNL)*

Current Filamentation Instability, CFI, is of central importance for the propagation of relativistic electron beams in plasmas and could play an important role in the generation of magnetic fields and of radiation in the after-glow of gamma ray bursts and for energy transport in the fast-igniter inertial confinement fusion concept. Using the particle-in-cell (PIC) code QuickPIC, we simulate the propagation of the electron beam at the Brookhaven National Laboratory - Accelerator Test Facility, BNL-ATF, in a cm-long plasma produced by a capillary discharge. The occurrence of the instability is investigated as a function of electron beam (including charge and emittance) and plasma (density and length) parameters by evaluating the beam density and magnetic energy. Results show that with beam and plasma parameters achievable at the BNL-ATF the CFI should be observed within 2 cm of plasma. Using the OSIRIS PIC code, we evaluate the parameters of the radiation generated by the instability by the BNL-ATF beam. We present simulation results and outline the experiment and diagnostics we will employ to observe and characterize the occurrence of the CFI.

TUPD078 **Comparison of Simulation Codes for Microwave Instability in Bunched Beams** – *K.L.F. Bane, Y. Cai, G.V. Stupakov (SLAC)*

In accelerator design, there is often a need to evaluate the threshold to the (longitudinal) microwave instability for a bunched beam in a storage ring. Several computational tools are available that allow us, once given a wakefield, to numerically find the threshold current and to simulate the development of the instability. In this work, we present the results of computer simulations with codes recently developed at the SLAC National Accelerator Laboratory. Our simulations include the cases of the resonator broadband impedance, the resistive wall impedance and the coherent synchrotron radiation impedance. We compare the accuracy of the threshold prediction and discuss the capabilities and limitations of the codes.

TUPD079 **PEP-X Impedance and Instability Calculations** – *K.L.F. Bane, L. Lee, C.-K. Ng, G.V. Stupakov, L. Wang, L. Xiao (SLAC)*

PEP-X, a next generation, ring-based light source is designed to run with beams of high current and low emittance. Important parameters are: energy 4.5 GeV, circumference 2.2 km, beam current 1.5 A, and horizontal and vertical emittances, 150 pm by 8 pm. In such a machine it is important that impedance driven instabilities not degrade the beam quality. In this report we study the strength of the impedance and its effects in PEP-X. For the present, lacking a detailed knowledge of the vacuum chamber shape, we create a straw man design comprising important vacuum chamber objects to be found in the ring, for which we then compute the wake functions. From the wake functions we generate an impedance budget and a pseudo-Green function wake representing the entire ring, which we, in turn, use for performing instability calculations. In this report we consider in PEP-X the microwave, transverse mode-coupling, multi-bunch transverse, and beam-ion instabilities.

TUPD080 **Study of High-frequency Impedance of Small-angle Tapers and Collimators** – *G.V. Stupakov (SLAC) B. Podobedov (BNL)*

Collimators and other similar accelerator structures usually include small-angle tapering to lower the wakefields generated by the beam. While the low-frequency impedance is well described by Yokoya's formula (for axisymmetric geometry), much less is known about the behavior of the impedance in the high frequency limit. In this paper we develop an analytical approach to the high-frequency regime for round collimators and tapers. Our analytical results are compared with computer simulations using the code ECHO.

TUPD081 **Wake Fields in the Super B Factory Interaction Region** – *S.P. Weathersby, A. Novokhatski (SLAC)*

The geometry of storage ring collider interaction regions present an impedance to beam fields resulting in the generation of additional electromagnetic fields (higher order modes or wake fields) which affect the beam energy and trajectory. These affects are computed for the Super B interaction region by evaluating longitudinal loss factors and averaged transverse kicks for short range wake fields. Results indicate at least a factor of 2 lower wake field power generation in comparison with the interaction region geometry of the PEP-II B-factory collider. Wake field reduction is a consideration in the Super B design. Transverse kicks are consistent with an attractive potential from the crotch nearest the beam trajectory. The longitudinal loss factor scales as the -2.5 power of the bunch length. The Super B interaction region wake field characteristics are compared with those of a generic interaction region composed of two intersecting tubes.

TUPD082 **Measurements and Analysis of the Longitudinal and Transverse Wakefield Effects in the LINAC Coherent Light Source Undulators** – *J. Wu, K.L.F. Bane, A. Brachmann, A. Chao, F.-J. Decker, Y.T. Ding, D. Dowell, S.A. Edstrom, P. Emma, J.C. Frisch, A. Gilevich, G.R. Hays, P. Hering, Z. Huang, R.H. Iverson, H. Loos, A. Miahnahri, H.-D. Nuhn, D.F. Ratner, G.V. Stupakov, J.L. Turner, J.J. Welch, W.E. White, D. Xiang (SLAC)*

The successful free electron laser (FEL) performance in the LINAC Coherent Light Source (LCLS) requires that the relative energy variation induced within the bunch in the undulator region to be within a few times the FEL parameter. Inside the undulator, the longitudinal wakefields (resistive-wall, surface roughness, etc.) can induce an energy variation along the electron bunch and energy loss. This is further complicated by the undulator spontaneous radiation and FEL itself which also change the electron bunch energy profile. Measurements in the LCLS undualtors about the electron bunch centroid energy loss and the energy spread are reported, and compared to calculations. In the post saturation region, the energy loss due to coherent emission from the microbunched electron beam is added to cross check with the undulator taper model. The transverse kick due to the transverse wakefield inside the undulator is also studied. The energy loss induced transverse dispersive kick is contrasted to the transverse wakefield kick. Due to the ultra-short electron bunch, for the first time, the measurement validates the short-range resistive-wall wakefield theoretical results.

TUPD083 **Update on Impedance Calculations of Vacuum Chamber Components for NSLS-II** – *A. Blednykh, L. Doom, M.J. Ferreira, H.-C. Hseuh, B.N. Kosciuk, S. Krinsky, O. Singh, T. Tanabe (BNL)*

We report here results of impedance calculations for: a novel design of the NSLS-II bellows; two different Vat Valve geometries with the special elliptical aperture; high stability BPM support; and other vacuum chamber components, which are going to be installed in the future NSLS-II storage ring.

TUPD084 **High Current Limitations for the NSLS-II Booster** – *A. Blednykh, R.P. Fliller, Y. Kawashima, S. Krinsky, J. Rose, T.V. Shaftan, L.-H. Yu (BNL)*

In this paper, we present an overview of the impact of collective effects upon the performance of the NSLS-II booster.

TUPD085 **Rogue Mode Shielding in NSLS-II Multipole Vacuum Chambers** – *A. Blednykh, B. Bacha, M.J. Ferreira, H.-C. Hseuh, B.N. Kosciuk, S. Krinsky, O. Singh, K. Vetter (BNL)*

Modes with transverse electric field (TE-modes) in the NSLS-II multipole vacuum chamber can be generated at frequencies above 450 MHz due to its geometric dimensions. Since the NSLS-II BPM system is triggered by the RF at 500 MHz, frequencies of higher-order modes (HOMs) can be generated within the transmission band of the band pass filter. In order to avoid systematic errors in the NSLS-II BPM system, we introduced frequency shift of HOMs by using RF metal shielding located in the antechamber slot.

TUPD086 **Loss Factor for Short Bunches in Azimuthally Symmetric Tapered Structures** – *A. Blednykh, S. Krinsky (BNL)*

The short-range wakepotential has been analyzed in azimuthally symmetric tapered structures using the electromagnetic code ECHO. Intensive studies were carried out to determine the dependence of the loss factor on the geometric parameters. Useful parameterizations of the loss factor are presented.

TUPD087 **Calculating Point-Charge Wakefields from Finite Length Bunch Wake-potentials** – *B. Podobedov (BNL) G.V. Stupakov (SLAC)*

Starting from analytical properties of high frequency geometric impedance we show how one can accurately calculate short bunch wake-potentials (and even point-charge wakefields) from time domain calculations performed with a much longer bunch. In many practical instances this drastically reduces the need for computer resources, speeds up the calculations, and improves their accuracy. To illustrate this method we give examples for accelerator structures of various complexities in both 2D and 3D.

TUPD088 **Electron Beam Energy Chirp Effect on Seeded FEL Efficiency** – *B. Podobedov, Y. Hidaka, J.B. Murphy, H.J. Qian, S. Seletskiy, Y. Shen, X.J. Wang, X. Yang (BNL)*

Measurements of FEL efficiency and saturation length dependence on electron beam energy chirp have been performed in a single-pass SASE and seeded free-electron laser at NSLS SDL. We present experimental results and compare them with analytical theory and numerical simulations.

TUPD089 **Status and Future Plan of the Accelerator for Laser Undulator Compact X-ray Source (LUCX)** – *M.K. Fukuda,* *S. Araki, A.S. Aryshev, Y. Honda, N. Terunuma, J. Urakawa (KEK) A. Deshpande (Sokendai) K. Sakaue, M. Washio (RISE) N. Sasao (Okayama University)*

We have developed a compact X-ray source based on inverse Compton scattering of an electron beam and a laser pulse, which is stacked in an optical super-cavity, at LUCX accelerator in KEK. The accelerator consists of a photo-cathode rf-gun and an S-band accelerating tube and produces the multi-bunch electron beam with 100 bunches, 0.5nC bunch charge and 40MeV beam energy. It is planned to upgrade the accelerator and the super-cavity in order to increase the number of X-rays. A new RF gun with high mode separation and high Q value and a new klystron for the gun will be installed to provide good compensation with a high-intensity multi-bunch electron beam. A new optical super-cavity consisting of 4 mirrors is also being developed to increase the stacking power in the cavity and to reduce the laser size at the focal point. The first targets are to produce a multi-bunch electron beam with 1000 bunches, 0.5 nC bunch charge and 5 MeV beam energy in low energy mode and 100bunches, 2 nC and 40 MeV in high energy mode to generate X-rays by inverse Compton scattering. In this paper, the status and future plan of the accelerator will be reported.

TUPD090 **The Development of New Terahertz Generator using Beam Optics and RF Deflector** – *F. Furugohri, H. Hioka, S. Someya (SUT) M. Yoshida (KEK)*

New terahertz(THz) generator using the non-relativistic electron beam was developed based on the beam optics and the RF deflector. The conventional THz generators using the electron beam are almost based on the relativistic beam to utilize the lorentz factor as FELs or the strong magnet to make high electron density like gyrotrons or BWOs. Thus it causes that the total equipment becomes large. New THz generator uses the non-relativistic electron beam. And it consists of the beam optics which makes the sliced beam by using a anode slit to focus at second slit as the THz radiation plane. In this configuration, the RF deflector works to move for the transverse direction matched with the phase velocity of the radiated electromagnetic field. The moving sliced beam separates into a number of bunches through the second slit and the bunches makes the THz coherent radiation in zero time interval. In this new THz generator, no strong magnet is required and the large diameter beam can be utilized to generate the high power THz electromagnetic wave. In this paper, the design of new THz generator and its experimental results are reported.

TUPD091 **Generation of Ultra-Short Gamma-ray Pulses by Laser Compton Scattering in UVSOR-II Electron Storage Ring** – *Y. Taira, M. Hosaka, K. Soda, Y. Takashima, N. Yamamoto (Nagoya University) M. Adachi, M. Katoh, H. Zen (UVSOR) T. Tanikawa (Sokendai - Okazaki)*

We are developing an ultra-short gamma ray pulse source based on laser Compton scattering technology at the 750 MeV electron storage ring UVSOR-II. Ultra-short gamma ray pulses can be generated by injecting femtosecond laser pulses into the electron beam circulating in an electron storage ring from the direction perpendicular to the orbital plane. The energy, intensity, and pulse width of the gamma rays have been estimated to be 6.6 MeV, 2.4×10^3 photons puls$\cdot10^{-1}$, and 288 fs, respectively, for the case of UVSOR-II with a commercially available femtosecond laser. These parameters can be tuned by changing the incident angle of the laser to the electron beam, electron energy, and the size of the laser. A preliminary head-on collision experiment was carried out. The measured spectral shape agreed well with simulation including the detector response calculated by the EGS5 code*, which implied the generation of gamma rays by laser Compton scattering and the validity of the estimation of the gamma ray intensity in the case of 90-degree collisions.

TUPD092 **Coherent Hard X-ray Free-electron Laser based on Echo-enabled Staged Harmonic Generation Scheme** – *C. Feng, Z.T. Zhao (SINAP)*

A novel approach to producing coherent hard x-ray based on the echo-enabled staged harmonic generation (EESHG) scheme is proposed. This scheme is not a simple cascaded EEHG, but consists of an EEHG, a beam shifter and a conventional HGHG like configuration, which also works in the EEHG principle. In the first stage, all over the whole electron beam is energy modulated by a laser beam in the first modulator and then converts into separate energy bands by a very strong dispersion section. In the second modulator, the seed laser is adjusted so that only the tail half part of the e-beam is energy modulated, then this beam is sent through the second dispersion section which converts the energy modulated part into a density modulation. The radiation from the first stage serves as the seed laser of the second stage, the beam shifter is so tuned that the head part of the electron beam can exactly interact with the radiation from the first stage in the modulator of the second stage, so the total harmonic number will be over one thousand. It is shown that fully coherent hard x-ray radiation can be obtained directly from a conventional VUV seed laser.

TUPD093 **Beam Dynamics in Compton Storage Rings with Laser Cooling** – *E.V. Bulyak, P. Gladkikh (NSC/KIPT) T. Omori, J. Urakawa (KEK) L. Rinolfi (CERN)*

Compton sources are capable to produce intense beams of gamma-rays necessary for numerous applications, e.g. production of polarized positrons for ILC/CLIC projects, nuclear waste monitoring. These sources need high current of electron beams of GeV energy. Storage rings are able to accumulate a high average current and keep it circulating for a long time. The dynamics of circulating bunches is affected by large recoils due to emission of energetic photons. We report results of both an analytical study and a simulation on the dynamics of electron bunches circulating in storage rings and interacting with the laser pulses. The steady-state transverse emittances and energy spread, and dependence of these parameters on the laser pulse power and dimensions at the collision point were derived analytically and simulated. It is shown that the transverse and longitudinal dimensions of bunches are dependent on the power of laser pulses and on their dimensions as well. Conditions of the laser cooling were found, under which the electron bunches shrink due to scattering off the laser pulses. The beam behavior in rings with the longitudinal strong focusing lattices is discussed.

TUPD094 **Synchrotron X-ray Radiation from Electron Betatron Motion in Laser Wakefield** – *T. Matsuoka, V. Chvykov, F.J. Dollar, Y. Horovitz, G. Kalintchenko, K.M. Krushelnick, A. Maksimchuk, C.S. McGuffey, A.G.R. Thomas, V. Yanovsky (University of Michigan, FOCUS Center for Ultrafast Optical Science) C. Huntington (University of Michigan, Space Physics Research Lab.) S. Kneip, S. P. D. Mangles, Z. Najmudin, C.A.J. Palmer, J. Schreiber (Imperial College of Science and Technology, Department of Physics) K.T. Phuoc (LOA)*

One attractive application of laser wakefield acceleration (LWFA) is an x-ray synchrotron source due to its compactness. In a LWFA synchrotron source, a gas-jet is used as a medium for the generation and acceleration of the electron beam. This same gas-jet provides a "plasma wiggler"* for x-ray generation. In the "plasma wiggler", high energy electrons execute transverse (betatron) motions during acceleration and produce an x-ray beam. Synchrotron x-ray radiation from LWFA was characterized at the HERCULES laser facility of the University of Michigan**. Angularly resolved electron energy spectra showed electron betatron motion which is consistent with the analytical model*. We observed broad synchrotron x-ray radiation extending up to 30 keV and the spectral shape is well reproduced by the analytical model*. A peak brightness of 10^{22} photons/ $mm^2/mrad^2$/second/0.1% bandwidth, which is comparable to currently existing 3rd generation conventional light sources, was achieved in the experiments. This opens up the possibility of using laser-produced "betatron" sources for many applications that currently require conventional synchrotron sources.

TUPD095 **Longitudinal Beam Dynamics Studies at the A0-photoinjector** – *J.C.T. Thangaraj, M.D. Church, H.T. Edwards, A.S. Johnson, A.H. Lumpkin, P. Piot, J. Ruan, J.K. Santucci, Y.-E. Sun, R. Thurman-Keup (Fermilab)*

Future short wavelength FEL will need a high current beam with very low emittance and a long wiggler. Among other efforts, reducing the wiggler length would make such an FEL economical. Typically, a RF photoinjector for an X-ray FEL generates a beam with much smaller longitudinal emittance compared to transverse emittance. Exchanging the longitudinal emittance with the transverse emittance will substantially reduce the gainlength required for the electron beam and thus reduce the cost of a FEL. A goal of the Fermilab A0 photinjector is to investigate the transverse to longitudinal emittance exchange principle. In this paper, we report on the experimental studies on the longitudinal beam dynamics in the A0 facility. We also report on the coherent synchroton radiation (CSR) studies in the emittance exchange line.

TUPD096 **Experimental Results from a Compton-Scattering Gamma-Ray Source** – *D.J. Gibson, F. Albert, S.G. Anderson, C.P.J. Barty, C. Hagmann, F.V. Hartemann, M. Johnson, R.A. Marsh, D.P. McNabb, M. J. Messerly, M. Shverdin, C. Siders, A.M. Tremaine (LLNL) V. A. Semenov (UCB)*

Recently a Mono-Energetic Gamma-Ray (MEGa-Ray) Compton scattering light source, in which an intense laser beam scatters off a relativistic electron beam producing a beam of gamma rays, has been commissioned at LLNL. Operating at energies from 0.1-0.9 MeV, this system produces upwards of 10^6 photons/sec, with a peak brightness of 10^{15} photons/sec/mm^2/mrad^2/0.1% BW at 0.478 MeV. Initial experiments demonstrate the viability of such sources for nuclear resonance fluorescence (NRF) by detecting the presence of a specific isotope of a shielded, low-density material. Here we present a brief overview of the components that make up this system, discuss details of the gamma ray characterization, and give results from initial NRF demonstration experiments on 7Li.

TUPD097 **Laser Technology for Precision Monoenergetic Gamma-ray Source R&D at LLNL** – *M. Shverdin, F. Albert, S.G. Anderson, C.P.J. Barty, A.J. Bayramian, M. Betts, T.S. Chu, C.A. Ebbers, D.J. Gibson, F.V. Hartemann, R.A. Marsh, D.P. McNabb, M. J. Messerly, H.H. Phan, M.A. Prantil, C. Siders, S.S.Q. Wu (LLNL)*

Generation of mono-energetic, high brightness gamma-rays requires state of the art lasers to both produce a low emittance electron beam in the linac and high intensity, narrow linewidth laser photons for scattering with the relativistic electrons. Here, we overview the laser systems for the 3rd generation Monoenergetic Gamma-ray Source (MEGa-ray) currently under construction at Lawrence Livermore National Lab. We also describe a method for increasing the efficiency of laser Compton scattering through laser pulse recirculation. The fiber-based photoinjector laser will produce 50 uJ temporally and spatially shaped UV pulses at 120 Hz to generate a low emmittance electron beam in the X-band RF photoinjector. The interaction laser generates high intensity photons that focus into the interaction region and scatter off the accelerated electrons. This system utilizes chirped pulse amplification and commercial diode pumped solid state Nd:YAG amplifiers to produce 0.5 J, 10 ps, 120 Hz pulses at 10^{64} nm and up to 0.2 J after frequency doubling. A single passively mode-locked Ytterbium fiber oscillator seeds both laser systems and provides a timing synch with the linac.

TUPD098 **Overview of Mono-energetic Gamma-ray Sources & Applications** – *F.V. Hartemann, F. Albert, S.G. Anderson, C.P.J. Barty, A.J. Bayramian, T.S. Chu, R.R. Cross, C.A. Ebbers, D.J. Gibson, R.A. Marsh, D.P. McNabb, M. J. Messerly, M. Shverdin, C. Siders, S.S.Q. Wu (LLNL) C. Adolphsen, E.N. Jongewaard, T.O. Raubenheimer, S.G. Tantawi, A.E. Vlieks, J.W. Wang (SLAC) V. A. Semenov (UCB)*

Recent progress in accelerator physics and laser technology have enabled the development of a new class of tunable gamma-ray light sources based on Compton scattering between a high-brightness, relativistic electron beam and a high intensity laser pulse produced via chirped-pulse amplification (CPA). A precision, tunable Mono-Energetic Gamma-ray (MEGa-ray) source driven by a compact, high-gradient X-band linac is currently under development and construction at LLNL. High-brightness, relativistic electron bunches produced by an X-band linac designed in collaboration with SLAC will interact with a Joule-class, 10 ps, diode-pumped CPA laser pulse to generate tunable γ-rays in the 0.5-2.5 MeV photon energy range via Compton scattering. This MEGa-ray source will be used to excite nuclear resonance fluorescence in various isotopes. Applications include homeland security, stockpile science and surveillance, nuclear fuel assay, and waste imaging and assay. The source design, key parameters, and current status are presented, along with important applications, including nuclear resonance fluorescence, photo-fission, and medical imaging.

TUPD099 **Steady State Microbunching in Storage Rings for a High Brightness, High Repetition Rate Light Source** – *D.F. Ratner (Stanford University) A. Chao (SLAC)*

Synchrotrons deliver X-ray pulses at high repetition rates and Free Electron Lasers (FELs) can produce X-ray pulses with high peak brightness, but at present no light source is capable of generating both high repetition rate and high brightness. We propose to create a storage ring configuration that will lead to steady state microbunching of the electrons. Two modulation regions separated by dispersive sections, as used in Echo Enhanced Harmonic Generation (EEHG), can trap electrons at steady state in stable islands spaced at high harmonics of the modulation wavelength. For each turn through the storage ring the resulting bunched beam passes through a radiator, producing high brightness pulses at the MHz repetition rates typical of storage rings. We present computer simulations to illustrate this concept.

TUPD100 **Electron Transport and Emission in Diamond** – *J. Smedley, I. Ben-Zvi, X. Chang, J. Rameau, T. Rao, Q. Wu (BNL) J. Bohon (Case Western Reserve University, Center for Synchrotron Biosciences) E.M. Muller (Stony Brook University)*

The diamond amplified photocathode has the potential to dramatically increase the average current available from photoinjectors, perhaps to the amphere-class performance necessary for flux-competitive fourth-generation light sources. Electron emission from a diamond amplifier has been observed from hydrogen-terminated diamond, using both photons and electrons to generate carriers. The diamond electron amplifier has been demonstrated, with an emission gain of 40. Very high average current densities (>10 A/cm^2) have been transported through the diamond using x-ray generated carriers. The device relies on high-purity intrinsic diamond with low crystalline defect density, as well as a negative electron affinity achieved by hydrogen termination. The effects of diamond purity and crystalline defects on charge transport in the material, and emission from the diamond surface have been studied using a number of techniques and the process is now well understood. The electron affinity of diamond has been measured to be -1.1 eV; the fraction of the electrons produced in the material which are emitted from the surface has also been measured.

TUPD101 **Experimental Characterization of the Transverse Mode Evolution for High-gain FELs** – *X.J. Wang, Y. Hidaka, J.B. Murphy, H.J. Qian, Y. Shen (BNL)*

The transverse mode evolution in both exponential gain and saturation regimes were experimentally characterized at the NSLS Source Development Lab (SDL) for the first time. The transverse mode of a light beam is represented by the M2, we experimentally observed M2 decreasing in the linear regime, and growth in the saturation regime. Furthermore, for the first time, we experimentally demonstrated that the FEL transverse mode could be controlled by the tapering of the undulator.

TUPD102 **Magnet Optics and Beam Dynamics of BERLinPro** – *M. Abo-Bakr, B.C. Kuske, A.N. Matveenko (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

The Helmholtz Zentrum Berlin (HZB) is proposing to build an Energy Recovery Linac Prototype, called BERLinPro, at its site in Berlin Adlershof. A gun test stand for a superconducting RF gun is already under construction at HoBiCaT. In this paper we concentrate on the recirculator part of the ERL and discuss the ERL requirements to the magnet optics. The current design of the magnet lattice will be described and main parameters and simulation results introduced. Since BERLinPro aims to demonstrate high current operation at short pulses according optics aspects will be also discussed. The focus here will be on longitudinal phase space manipulations and lattice layout options, suppressing the BBU instability and increasing its threshold currents.

TUPD103 **Merger Considerations for BerlinPro** – *B.C. Kuske, M. Abo-Bakr, A.N. Matveenko, A. Meseck (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

The Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB) proposes to construct an ERL test facility. To provide different operational modes for different scientific applications is one of the advantages of these new, linac-driven radiation sources. In contrast to the linear machine layouts of FELs, new challenges arise from incorporating the linac into a circular machine. One of them is the so called merger, a magnetic chicane that threads the low energy, low emittance, but high current bunch from the gun into the recirculator. The preservation of the ambitious gun parameters, the optimal collimation of dark current and flexibility to suit all user demands are the dominant design goals. Different design criteria and possible layouts are discussed and a preliminary merger design is proposed.

TUPD104 **Development of an Yb-doped Fiber Laser System for an ERL Photocathode Gun** – *I. Ito, T. Kawasaki, N. Nakamura (ISSP/SRL) Y. Honda (KEK) Y. Kobayashi, K. Torizuka, D. Yoshitomi (AIST)*

We are developing an Yb fiber laser system that drives an ERL photocathode gun. An Yb fiber laser is expected to have both high stability and high output power required for the drive laser of an ERL photocathode gun. First we started to develop an Yb fiber laser oscillator with a high repetition rate up to 1.3 GHz that is the RF frequency of a superconducting accelerating cavity and then a 30W preamplifier using an Yb doped photonic crystal fiber. We report our recent progress in this development.

25-May-10 16:00 – 18:00	Poster	Poster Hall E

TUPE — Poster Session

TUPE001 **Undulator Focusing Lattice Residual Errors Impact on the SASE FEL Performance** – *V.G. Khachatryan, V.M. Tsakanov (CANDLE) M. Vogt (DESY)*

The study was conducted aimed at definition of the after correction error orbit influence on the European XFEL radiation parameters. Beam based quadrupole magnets alignment method will be applied in FEL undulator section to correct focusing lattice quadrupole magnets initial alignment errors. High precision movers will be used to correct quadrupole magnets misplacements instead of traditional dipole correctors. Using Beam Position Monitors (BPM) readings dispersion free steering correction algorithm is applied. Due to BPMs finite resolution, BPM misalignments and movers precision, some after correction errors of quadrupole alignment remain. Numerical simulation of the SASE process was conducted in order to evaluate FEL power reduction due to quadrupole alignment residual errors. Efforts have been made trying to minimize further the beam error orbit by optimization of the beam launch parameters.

TUPE002 **The Extreme Low Charge Regime Study for European XFEL** – *V. Sahakyan, V.G. Khachatryan, A. Tarloyan, V.M. Tsakanov (CANDLE)*

The option for extremely low bunch charge regime (< 20 pC) of European XFEL project is studied. The SASE FEL parameters study (saturation length and power) is performed for wide range of the beam normalized emittance, bunch length and energy. The study is based both on the analytical scaling of the SASE FEL performance and numerical simulations.

TUPE003 **Diffusive Radiation in Infrared Region** – *E.M. Sarkisyan, Zh.S. Gevorkian, K.B. Oganesyan (YerPhI)*

We consider generation of diffusive radiation by a charged particle passing through a random stack of plates in the infrared region. Diffusive radiation originates due to multiple scattering of pseudophotons on the plates. To enhance the radiation intensity one needs to make the scattering more effective. For this goal we suggest to use materials with negative dielectric constant .

TUPE004 **FEL User Facility FLASH** – *S. Schreiber, B. Faatz, J. Feldhaus, K. Honkavaara, R. Treusch (DESY)*

The free-electron laser facility FLASH at DESY, Germany finished its second user period scheduled from November 2007 to August 2009. More than 300 days have been devoted for user operation, a large part of beamtime has been allocated for machine studies for further developments, including beamtime for XFEL and ILC R&D. FLASH provides trains of fully coherent 10 to 50 femtosecond long laser pulses in the wavelength range from 40 nm to 6.8 nm. The SASE radiation contains also higher harmonics; several experiments have successfully used the third and fifth harmonics. The smallest wavelength used was 1.59 nm. We will give a summary of the experience from two years of user operation at FLASH.

TUPE005 **FLASH II: a Seeded Future at FLASH** – *B. Faatz, N. Baboi, V. Balandin, W. Decking, S. Düsterer, J. Feldhaus, N. Golubeva, T. Laarmann, T. Limberg, D. Noelle, E. Plönjes, H. Schlarb, S. Schreiber, F. Tavella, K.I. Tiedtke, R. Treusch (DESY) J. Bahrdt, R. Follath, A. Föhlisch, M. Gensch, K. Holldack, A. Meseck, R. Mitzner (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) M. Drescher, V. Miltchev, J. Rossbach (Uni HH)*

FLASH has been a user facility since 2005, delivering radiation in the wavelength range between 7 and 47 nm using the SASE principle. In order to increase user beam time and improve the radiation properties delivered to users, a major extension of the user facility called FLASH II has been proposed by DESY in collaboration with the HZB, which is a seeded FEL over the parameter range of FLASH. As logical continuation, the HHG development program started with sFLASH, will result in direct seeding. Because in the foreseeable future there will probably not be HHG seed lasers available at high repetition rates down to wavelengths of 4 nm, a cascaded HGHG scheme will be used to produce short wavelengths. After a first design report, the project now enters its preparation phase until the decision for funding will be taken. During this time, the FLASH beam parameters after the present upgrade 2009/2010 will be characterized and the present design will be re-evaluated and adjusted. In addition, complete start-to-end simulations will complete the simulations which have been performed so far, including a complete design of the extraction area.

TUPE006 **Photocathode Performance At FLASH** – *S. Lederer, S. Schreiber (DESY) P.M. Michelato, L. Monaco, D. Sertore (INFN/LASA)*

Caesium telluride photocathodes are used as laser driven electron sources at the Free-Electron-Laser Hamburg, FLASH, and will be used at the European XFEL. One concern of the operation of photocathodes in these user facilities is the degradation of the quantum efficiency during operation. After improving vacuum conditions and removing contaminants, the cathode life time increased from a couple of weeks to several months. In this contribution we report on long time operation of Cs2Te cathodes in terms of QE measurements and investigations on the homogeneity of the electron emission. Another concern of electron guns operated with long RF-pulses (0.8 ms at FLASH) is the generation of dark current either from the cathode or from the gun body. During the last years a constant high amount of dark current, emitted from the gun body itself, was observed at FLASH. Caused by that during the shut-down 2009/2010 the RF-gun at FLASH, operated more than five years, was replaced. The improved dark current situation with the new RF-gun is presented in terms of dark current measurements under different operational conditions.

TUPE007 **High Repetition Rate Seeding of a Free-Electron Laser at DESY Hamburg** – *A. Willner, S. Düsterer, B. Faatz, J. Feldhaus, H. Schlarb, F. Tavella (DESY) E. Enrico, S. Hädrich, J. Limpert, J. Rothhardt, A. Tünnermann (Friedrich Schiller Universität) J. Rossbach (Uni HH) T. Tschentscher (European X-ray Free Electron Laser Project Team, c/o DESY)*

The performance of fourth generation light sources is of interest in many fields in nature science. Different seeding schemes for FELs are under investigation to improve timing stability, pulse shape and spectrum of the amplified XUV or X-ray pulses. One of the most promising schemes is direct seeding by high-harmonic generation (HHG) in gas. A seeded free electron laser with a tuneable wavelength range from 10 to 40nm and a bunch frequency of up to 100 kHz (1 MHz upgraded), as proposed for FLASH II (collaboration HZB/DESY), makes high demands on the HHG seed source concerning conversion efficiency and stability. However, the most challenging task is the conception of a laser system with a repetition rate of 100 kHz (1 MHz upgraded). The key parameters for this laser amplifier system are pulse energies of 1-2mJ and sub-10fs pulse duration. We report on the development status of the required laser system for the seed source and give an overview of first concepts for the HHG target setup which can comply with the requirements of a new seeded FEL at DESY.

TUPE008 **Seeding Flash with High Harmonics: Photon Diagnostics and First Commissioning Results** – *F. Curbis, A. Azima, J. Boedewadt, H. Delsim-Hashemi, M. Drescher, Th. Maltezopoulos, V. Miltchev, M. Mittenzwey, J. Rossbach, M. Schulz, R. Tarkeshian, M. Wieland (Uni HH) S. Bajt, S. Düsterer, J. Feldhaus, T. Laarmann, H. Schlarb (DESY) R. Ischebeck (PSI) S. Khan (DELTA) A. Meseck (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

During spring 2010 FLASH will be under commissioning after a major shutdown carried out in order to upgrade the machine. A direct seeding scheme will be explored with the installation of a high-harmonic generation seed laser, a chain of 10 m variable-gap undulators and a dedicated commissioning beamline for photon diagnostics and pilot time-resolved pump-probe experiments. The aim of the sFLASH project is to demonstrate direct seeding at 35 and 13 nm and synchronization for pump-probe experiments in the fs-range. The characterization of the seeded FEL radiation will be performed in a dedicated beamline inside the tunnel. The gain curve of the seeding process will be detected with an MCP-based intensity monitor on a shot-to-shot basis and a XUV-spectrometer will show the spectral narrowing of the radiation. The diagnostics is designed to span several orders of magnitude in flux, i.e. from the spontaneous emission up to the seeded FEL radiation at gigawatt power level.

TUPE009 **Status of sFLASH, the Seeding Experiment at FLASH** – *H. Delsim-Hashemi, A. Azima, J. Boedewadt, F. Curbis, M. Drescher, Th. Maltezopoulos, V. Miltchev, M. Mittenzwey, J. Rossbach, R. Tarkeshian, M. Wieland (Uni HH) S. Bajt, T. Laarmann, H. Schlarb (DESY) R. Ischebeck (PSI) S. Khan (DELTA)*

Recently, the free-electron laser in Hamburg (FLASH) at DESY has been upgraded considerably. Besides increasing the maximum energy to about 1.2 GeV and installation of a third harmonic rf cavity linearizing the longitudinal phase space distribution of the electron bunch, an FEL seeding experiment at wavelengths of about 35 nm has been installed. The goal is to establish direct FEL seeding employing coherent VUV pulses produced from a powerful drive laser by high-harmonic generation (HHG) in a gas cell. The project, called sFLASH, includes generation of the required HHG pulses, transporting it to the undulator entrance of a newly installed FEL-amplifier, controlling spatial, temporal and energy overlap with the electron bunches and setting up a pump-probe pilot experiment. Sophisticated diagnostics is installed to characterize both HHG and seeded FEL pulses, both in time and frequency domain. Compared to SASE-FEL pulses, almost perfect longitudinal coherence and improved synchronization possibilities for the user experiments are expected. In this paper the status of the experiment is presented.

TUPE010 **Status of the Photo Injector Test Facility at DESY, Zeuthen Site (PITZ)** – *G. Asova, J.W. Baehr, A. Donat, U. Gensch, H.-J. Grabosch, L. Hakobyan, M. Hänel, Ye. Ivanisenko, L. Jachmann, S. Khodyachykh, M.A. Khojoyan, W. Koehler, G. Koss, M. Krasilnikov, A. Kretzschmann, H. Leich, H.L. Luedecke, J. Meissner, A. Oppelt, B. Petrosyan, M. Pohl, S. Riemann, S. Rimjaem, M. Sachwitz, B. Schoeneich, T.A. Scholz, J. Schultze, U. Schwendicke, A. Shapovalov, R. Spesyvtsev, L. Staykov, F. Stephan, F. Tonisch, L.V. Vu, S. Weisse, R.W. Wenndorff, M. Winde (DESY Zeuthen) K. Floettmann, S. Lederer, S. Schreiber (DESY) P.M. Michelato, L. Monaco, C. Pagani, D. Sertore (INFN/LASA) R. Richter (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) J. Rönsch-Schulenburg (Uni HH)*

The PITZ facility is established for the development and testing of electron sources for FELs like FLASH and the European XFEL. The facility has been upgraded during the shutdown starting in summer 2007 to extend the capability of the facility to produce and characterize low emittance electron beams. The upgraded setup mainly includes a photo cathode L-band RF gun with solenoid magnets for space charge compensation, a post acceleration booster cavity and several diagnostic systems. The diagnostic systems consist of charge and beam profile monitors, emittance measurement systems and spectrometers with related diagnostics in dispersive arms after the gun and the booster cavities. RF gun operation with an accelerating gradient of 60 MV/m at the cathode is realized with this setup. A new photo cathode laser system with broader spectral bandwidth was installed for optimizing the temporal distribution of the laser pulses regarding to electron beam properties. Experimental results with this setup demonstrated very high electron beam quality as required for the photoinjector source of the European XFEL. In this contribution, the PITZ facility setup in year 2008-2009 will be presented.

TUPE011 **Generating Low Transverse Emittance Beams for Linac Based Light Sources at PITZ** – *S. Rimjaem, J.W. Baehr, H.-J. Grabosch, M. Hänel, Ye. Ivanisenko, G. Klemz, M. Krasilnikov, M. Mahgoub, M. Otevrel, B. Petrosyan, S. Riemann, J. Rönsch-Schulenburg, R. Spesyvtsev, F. Stephan (DESY Zeuthen) G. Asova, L. Staykov (INRNE) K. Floettmann, S. Lederer, S. Schreiber (DESY) L. Hakobyan, M.A. Khojoyan (YerPhI) M.A. Nozdrin (JINR) B. D. O'Shea (UCLA) R. Richter (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) A. Shapovalov (MEPhI) G. Vashchenko (NSC/KIPT) I. Will (MBI)*

At the Photo Injector Test facility at DESY, Zeuthen site (PITZ), high brightness electron sources for linac based Free Electron Lasers (FELs), like

FLASH and the European XFEL are developed and characterized. The electrons are generated via the photoeffect at a cesium telluride (Cs2Te) cathode and are accelerated by a 1.6-cell L-band RF-gun cavity with an accelerating gradient at the cathode of about 60 MV/m. The profile of the cathode laser pulse has been optimized yielding small emittances using laser pulse shaping methods. The transverse projected emittance is measured by a single slit scan technique. The measurement program in the last run period at PITZ concentrated on emittance measurements for the nominal 1 nC beam and emittance optimization for lower bunch charges. The recent results show that normalized projected emittances of about 1 mm-mrad for 1 nC charge and below 0.5 mm-mrad for 250 pC bunch charges can be realized at PITZ. The facility setup and measurement results including the uncertainty of the measured values will be reported and discussed in this contribution.

TUPE012 **Stability of Free-Electron Laser Resonators** – *S.A. Samant (CBS) S. Krishnagopal (BARC)*

The stability of free-electron laser (FEL) resonators differs from that of resonators of conventional lasers, because of the nature of the FEL interaction. Therefore the stability diagram is modified, and near-concentric configurations are preferred to near-confocal. We study the stability of FEL resonators (especially for g1 =/ g2) using simulations, as well as using a simple thin-lens model, and show that the near-concentric configuration is indeed preferable, while the confocal configuration becomes unstable. Also, since FELs can be widely tuned in wavelength, we investigate the stability of the resonator as a function of the wavelength.

TUPE013 **FERMI@Elettra Dipole and Steerer Magnets** – *D. Castronovo, R. Fabris, D. Zangrando (ELETTRA)*

FERMI@Elettra is a single-pass FEL user-facility located next to the third generation synchrotron radiation facility ELETTRA in Trieste, Italy. The FERMI over all time schedules expects the photons creation by 2010. The paper reports on the design, the construction and on the magnetic measurements results of the Dipole and the Steerer Magnets.

TUPE014 **FERMI@Elettra Quadrupole Magnets** – *D. Castronovo, R. Fabris, D. Zangrando (ELETTRA)*

FERMI@Elettra is a single-pass FEL user-facility located next to the third generation synchrotron radiation facility ELETTRA in Trieste, Italy. The FERMI over all time schedules expects the photons creation by 2010. The paper reports on the design, the construction and on the magnetic measurements results of the Quadrupole Magnets.

TUPE015 **The X-band System for the FERMI@ELETTRA FEL Project** – *G. D'Auria (ELETTRA)*

The single pass FEL facility FERMI@ELETTRA, in construction at the ELETTRA Synchrotron Radiation Laboratory in Trieste, requires very short electron bunches with a very high beam quality at the entrance of the undulator chain. To linearize the longitudinal phase space before the bunch compression, mitigating the effects of Coherent Synchrotron Radiation (CSR), a 4th harmonic accelerating section (12 GHz) will be installed before the first magnetic chicane. Here an overall description of the X-band system under development is reported.

TUPE016 **Generation of Ultra-short Coherent Vacuum Ultraviolet Pulses using the Elettra Storage-ring Free-electron laser: First Pump-probe Experiments** – *G. De Ninno, E. Allaria, M.B. Danailov, E. Karantzoulis, C. Spezzani, M. Trovo (ELETTRA) M. Coreno (CNR - IMIP) G. De Ninno (University of Nova Gorica) E. Ferrari (Università degli Studi di Trieste) D. Garzella (CEA) M. Sacchi (CCPMR)*

We have demonstrated that the Elettra storage-ring free-electron laser is well suited for producing intense VUV harmonic radiation in seeded 'single-pass' configuration. After reviewing the experimental setup, we present the temporal and spectral characterization of the harmonic pulse with respect to several adjustable parameters, such as the seed power, repetition rate (10 Hz / 1 kHz) and pulse duration (100 fs and 1ps), the seed-electron temporal detuning and the strength of the dispersive section between undulators. Measured peak power in the working wavelength range (i.e., 260-87 nm for the reported experiments) is orders of magnitude above spontaneous synchrotron radiation. The obtained results allowed us to successfully carry out first two-color pump-probe experiments, using both gas phase and solid state samples. Collected data are presented in the last part of the paper.

TUPE017 **The Design of the FERMI@Elettra Bunch Compressor Chicane** – *D. La Civita, S. Di Mitri, G. Lanfranco, G. Pangon, D. Zangrando (ELETTRA)*

FERMI@Elettra project at the ELETTRA Laboratory of Sincrotrone Trieste (ST), currently under construction, will be comprised of a linear accelerator and two Free-Electron-Laser beamlines (FEL1, FEL2). Two bunch compressor chicanes will be installed in the Linac section. One (BC1) will be placed at 250 MeV and the second (BC2) at 600 MeV. BC1 and BC2 have the same mechanical design. The bunch compressor consists of a 4 bending magnets 8m long chicane. The central bending magnets slide in transversal direction respect to the beam. Since vacuum chambers, vacuum pumps and quadrupole magnets have to accurately accommodate for this displacement, movable supports and a sliding guide system have been designed. Chicane mechanical conceptual design, diagnostic devices design, movable vacuum chambers design and kinematical analysis are presented.

TUPE018 **Requirements for FEL Commissioning at FERMI** – *E. Allaria, G. Penco, C. Spezzani (ELETTRA) G. De Ninno (University of Nova Gorica)*

The commissioning of the first stage (FEL-1) of FERMI@Elettra has started in the summer 2009. During the first year of operation, the efforts will mainly concentrate on the optimization of the gun performance, as well as on electron-beam acceleration and transport through the LINAC. By fall 2010, it is planned to generate out of the LINAC an electron beam that may be injected into the FEL-1 undulator chain and used to get the first FEL light. In this paper, we present the requirements for FEL-1 commissioning, both in terms of hardware and electron beam properties.

TUPE019 **Integration of Elegant Tracking Code into the Tango Server-based High Level Software of FERMI@elettra for Optics Measurements and Modeling** – *C. Scafuri, S. Di Mitri, G. Penco (ELETTRA)*

The electron beam transverse emittance and Twiss parameters have been measured during the commissioning of FERMI@elettra. Matching of the beam optics to the lattice transverse acceptance and beam transport was performed by means of the elegant particle tracking code; this was integrated with the Tango-server based high level software of FERMI@elettra. Matlab scripts were used as an intermediate layer between the code and the server to automate the matching procedure. The software environment, the experimental results and the comparison with the model are described in this paper.

TUPE021 **Electron Beam Conditioning with IR/UV Laser on the Cathode** – *G. Gatti (INFN/LNF)*

Shining a photocathode at the same time with an UV laser able to extract electrons and an IR laser properly tuned could influence the way the electron beam is generated. Such a process is under investigation at SPARC, through direct measurements, as much as through computer codes assessment studies.

TUPE022 **The SPARX-FEL Project** – *L. Palumbo (Rome University La Sapienza) C. Vaccarezza (INFN/LNF)*

The SPARX-FEL project is meant to provide ultra high peak brightness electron beams, with the energy ranging between 1.5 - 2.4 GeV, in order to generate FEL radiation in the 0.6-40 nm range. The construction will start with a 1.5 GeV Linac; besides the basic S-band technology the C-band option is also presently under study. Both RF-compression and magnetic chicane techniques are foreseen to provide the suitable electron beam to each one of the three undulator systems which will generate VUV-EUV, Soft X-Rays and Hard X-rays radiation respectively. Dedicated beamlines will distribute the beam to the downstream undulators for applications in basic science and technology. In this paper we present the status of the project funded by the Italian Department of Research, MIUR, and by the local regional government, Regione Lazio, that foresees the construction of a user facility inside the Tor Vergata campus by collaboration among CNR, ENEA, INFN and the Università di Tor Vergata itself.

TUPE023 **Infra-red Free Electron Laser at Tokyo University of Science** – *T. Imai, K. Tsukiyama (Tokyo University of Science, IR FEL Research Center) K. Hisazumi, M. Morotomi (MELCO SC) T. Shidara, M. Yoshida (KEK)*

IR-FEL research center of Tokyo University of Science (FEL-TUS) is a facility for aiming at the development of high performance FEL device and promotion of photo-science using it. The main part of FEL-TUS is a mid-infrared FEL (MIR FEL) which consists of an S-band linac and an undulator combined with an optical resonance cavity. MIR-FEL provides continuously tunable radiation in the range of 5-14 micron and a variety of experiments are by the use of this photon energy corresponding to the various vibrational modes of molecules are now underway. We also develop far-infrared FEL (FIR FEL) installed an RF-gun with Disk-and-Washer accelerating cavity for high quality electron beam. The current status of FEL-TUS will be presented.

TUPE024 **Construction of a Timing and Low-level RF System for XFEL/SPring-8** – *N. Hosoda, H. Maesaka, S.M. Matsubara, T. Ohshima, Y. Otake, K. Tamasaku (RIKEN/SPring-8) M. Musha (University of electro-communications)*

The intensity of SASE generated by undulators is sensitive to the peak intensity fluctuation of an electron bunch. The bunch is formed by velocity bunching in an injector and magnetic bunching in bunch compressors (BC). The peak intensity is sensitive to rf phase and amplitude of off-crest acceleration at injector cavities and 5712 MHz cavities before the BCs. Thus, demanded stabilities of the rf phase and amplitude for stable SASE generation are very tight. These are 0.6 degree (p-p) and 0.06 % (p-p) at the 5712 MHz cavities, respectively. We are constructing a low-level rf (LLRF) system comprising a master oscillator, an optical rf signal transmission system, and a digital rf control system using IQ modulator/demodulator to drive klystrons. To realize the demands, much attention was paid to temperature stabilization for the system. A water-cooled 19-inch rack and a water-cooled cable ducts are employed for almost all part of the system. Temperature stability of the rack was 0.4 K (p-p) even though outside was 4 K (p-p). The phase and amplitude stabilities of the LLRF modules were measured to be 0.30 degree (p-p) and 0.56 % (p-p). These stabilities are sufficient for our demands.

TUPE025 **Development Status of RF System of Injector Section for XFEL/SPring-8** – *T. Asaka, H. Ego, H. Hanaki, T. Kobayashi, S. Suzuki (JASRI/SPring-8) T. Inagaki, Y. Otake, K. Togawa (RIKEN/SPring-8)*

XFEL/SPring-8 is under construction, which is aiming at generating coherent, high brilliance, ultra-short femto-second X-ray pulse at wavelength of 1Å or shorter. The injector consists of a 500kV thermionic gun (CeB6), a beam deflecting system, multi-stage RF structures and ten magnetic lenses. The multi-stage RF structures (238MHz, 476MHz, 1428MHz) are used for bunching and accelerating the beam gradually to maintain the initial beam emittance. In addition, in order to realize linearizing the energy chirp of the beam bunch at three magnetic bunch compression systems after the injector system, we prepared extra RF structures of 1428MHz and 5712MHz. It is important to stabilize the gap voltage of those RF structures because the intensity of X-ray pulse is more sensitive for a slight variation of the RF system in the injector. We developed some stable amplifiers for those RF structures, and confirmed the amplitude and phase stability of an RF signal outputted from the amplifiers. The measurement results achieved nearly the requirement of design parameters. In this paper, we describe the development status and the achieved performances of RF equipment of the injector section.

TUPE026 **Classical and Quantum Mechanical Analyses on Electromagnetic Wave Emissions in the Planar Cherenkov Free Electron Laser** – *H. Fares, Y. Kuwamura, M. Yamada (Kanazawa University)*

In the Cherenkov free electron laser, the interacted electron with the electromagnetic (EM) wave can be represented as a point particle or as a spatially spreading electron wave in the classical or quantum mechanical framework, respectively. In our previous theoretical analysis for the optical region, the electron is described by a plane wave with finite spreading length. This electron wave model was successfully implied for the optical region whereas the spreading length of the electron wave is greater than the wavelength of the optical wave. In this work, when the EM wavelength is sufficiently greater than the spreading length of the electron wave, such as in the microwave region, the electron is assumed to be a spatially localized point particle. This classical analysis is performed using same parameters used in the quantum electron wave model, such as a coupling coefficient between the electron beam and the EM field and the electron relaxation time. Also, we present analytical expressions to describe the stimulated and spontaneous emissions. We show that the classical treatment is consistent with the quantum analysis applied in the optical regime.

TUPE027 **Target Ionization Dynamics by Irradiation of X-ray Free-electron Laser Light** – *T. Nakamura, Y. Fukuda (JAEA/Kansai) Y. Kishimoto (Kyoto Univeristy)*

Interactions of x-ray free electron laser (XFEL) light with a single cluster target are numerically investigated. The irradiation of XFEL light onto material leads to the ionization of the target by photo-ionization and generation of high energy electrons. This results in the further ionization via Auger effect, collisional ionization, and field ionization. The ionization rate or time scale of each process depends on the condition of XFEL (intensity, duration, photon energy) and target size. In order to understand the ionization dynamics, we used a three-dimensional Particle-in-Cell code which includes the plasma dynamics as well as relevant atomic processes such as photo-ionization, the Auger effect, collisional ionization/relaxation, and field ionization. It is found that as the XFEL intensity increases to as high as roughly 10^{21} photons/pulse/mm^2, the field ionization, which is the dominant ionization process over the other atomic processes, leads to rapid target ionization. The target damage due to the irradiation by XFEL light is numerically evaluated, which gives an estimation of the XFEL intensity so as to suppress the target damage within a tolerable range for imaging.

TUPE028 **Status of the MIR FEL Facility in Kyoto University** – *T. Kii, M. A. Bakr, Y.W. Choi, K. Higashimura, R. Kinjo, K. Masuda, H. Ohgaki, T. Sonobe, M. Takasaki, S. Ueda, K. Yoshida (Kyoto IAE)*

A mid-infrared free electron laser (MIR FEL) facility has been constructed for the basic research on energy materials in the Institute of Advanced Energy, Kyoto University. The MIR FEL saturation at 13.2 μm was observed in May 2008, and the construction of the FEL delivery system from accelerator room to the optical diagnostic station and experimental stations has been finished in Dec. 2009. In the conference, optical properties of the MIR FEL and research program using MIR-FEL will be introduced.

TUPE029 **Spectral Measurement of VUV CHG at UVSOR-II** – *T. Tanikawa (Sokendai - Okazaki) M. Adachi, M. Katoh, J. Yamazaki, H. Zen (UVSOR) M. Hosaka, Y. Taira, N. Yamamoto (Nagoya University)*

Light source technologies based on laser seeding are under development at the UVSOR-II electron storage ring. In the past experiments, we have succeeded in generating coherent DUV (Deep Ultra-Violet) harmonics with various polarizations. A spectrum measurement experiment of CHG (Coherent Harmonic Generation) was carried out by using a spectrometer of from visible to DUV range. In order to diagnose spectra of shorter-wavelength CHG, a spectrometer for VUV (Vacuum Ultra-Violet) has been constructed and the VUV CHG was measured. In addition, we try to use a seeding light source based on not only fundamental of Ti: Sapphire laser and the harmonics generated from non-linear crystals but also HHG (High Harmonic Generation) in a gas for the CHG experiment. Now the HHG system is under development. In this presentation, we introduce the VUV spectral measurement system and the HHG system and also report about comparison between the results of the current CHG experiments and design studies of numerical calculation for them.

TUPE030 **High Power Terahertz FEL at ISIR, Osaka University** – *R. Kato, K. Furuhashi, G. Isoyama, S. Kashiwagi, M. Morio, S. Suemine, N. Sugimoto, Y. Terasawa (ISIR) K. Tsuchiya, S. Yamamoto (KEK)*

We have been developing a Terahertz free electron laser (FEL) based on the 40 MeV, 1.3 GHz L-band electron linac at the Institute of Scientific and Industrial Research (ISIR), Osaka University. After the FEL lasing at the wavelength of 70 um (4.3 THz)*, next targets of the FEL development are to extend the available laser wavelength, to increase the FEL power, and to evaluate characteristics of FEL. Since the lowest energy of the linac was restricted by a fixed-ratio power divider between the acceleration tube and the buncher, we have prepared the new one with a different ratio to extend the wavelength longer side. As a result, the wavelength region is able to be extended to 25 - 147 um (12.5 - 2 THz). The maximum output energy of the FEL macropulse so far obtained is 3.6 mJ at 66 um. The peak macropulse power available to user experiments is estimated to be 1 kW or less, given that the pulse duration is 3 us. Three users groups have begun experiments using the FEL. We will report these recent activities on the Terahertz FEL.

TUPE031 **Recent Progress in Infrared FEL and Compton Backscattering Experiment at the Storage Ring NIJI-IV** – *H. Ogawa, N. Sei, K. Yamada (AIST)*

Recently, an FEL in the near-infrared (IR) region was oscillated at a compact storage ring NIJI-IV whose circumference was 29.6 m. We have been developed a device for the storage ring FEL in the IR region with a 3.6-m optical klystron ETLOK-III, and the first lasing at a wavelength of around 1450 nm was achieved at February 2009. The maximum power of the FEL was 0.3 mW per vacuum window and the relative linewidth was $3{\cdot}10^{-4}$.* Moreover, gamma-ray beam was also produced in the long straight section of NIJI-IV by Compton backscattering of the intra-cavity IR FEL and the stored electron beam with an energy of 310MeV. After the first lasing experiment, we have successfully performed to extend the lasing wavelength region and increase FEL power, and this recent progress will be presented.

TUPE032 **Generation Highbrightness X-ray Pulse via Thomson Scattering in Tsinghua University** – *Y.-C. Du, Q. Du, Hua,,J.F. Hua, W.-H. Huang, C.-X. Tang, L.X. Yan (TUB)*

Tsinghua Thomson scattering X-ray source, based on Thomson scattering of fs-laser pulse by a relativistic electron beam, which aims at an ultra-fast, high flux, monochromatic, and tunable X-ray source for sciences, medical, and industrial applications, has been proposed, designed and constructed since 2001. Some experiments have been taken with the beam from the backward traveling wave linac and photocathode RF gun. Now, the electron beam has been accelerated to 30MeV, and initial experiments to generate and detect the scatted X-ray pulse are in process. In this paper, the upgrading of the system is described, and the initial experimental results are also presented.

TUPE033 **Optimum of Terahertz Smith-Purcell Radiation Generated the Periodical Ultrashort Bunched Beam** – *W. Liu, W.-H. Huang, C.-X. Tang, D. Wu (TUB)*

Smith-Purcell radiation (SPR) is emitted when an electron passes near the surface of a periodic metallic grating. The radiation wavelength λ observed at the angle θ measured from a direction of surface grating is determined by λ=D/|n|(1/β cosθ), Where D is the grating period, βc is the electron velocity, c is the speed of light, and the integer n is the spectral order. This radiation mechanism is widely applicated to THz radiation source, for which can be developed into tunable and compact one. In this paper, the radiation characteristics of terahertz (THz) SPR generated from the ultrashort electron beam are analyzed with the three-dimensional particle-in-cell simulation. For obtaining the intense THz radiation, the grating parameters and that of ultrashort electron beam are optimum. The radiation power and energy are obtained by the PIC simulation. The band width of train bunches is compared with that of single bunch. The formation factors including the longitudinal and transverse are calculated. Through this study, we observe that the radiation power is enhanced and the band width can be adjusted.

TUPE034 **Design of FEL by the EEHG Scheme for Tsinghua University** – *X.L. Xu, C.-X. Tang, Q.Z. Xing (TUB)*

Tsinghua University Thomson X-ray source (TTX) has been proposed at Tsinghua University. With the nominal electron beam parameters (beam energy of 50MeV, slice energy spread of 5keV, peak current of 600A, rms normalized emittance of 2 mm mrad) of the TTX linac , the design of Free Electron Laser (FEL) by the Echo-Enabled Harmonic Generation (EEHG) scheme is presented in this paper. High harmonics of the seeding laser is generated by the EEHG scheme. Parameters of the undulators and seeding lasers are optimized. Simulation results using the GENESIS code are also presented in this paper.

TUPE035 **Conceptual Design of a Compton Back-scattering Gamma-ray Light Source based on Hefei Light Source** – *X.C. Lai, H. Hao, X. Li, X.Q. Wang (USTC/NSRL)*

Compton back scattering light sources could provide highly polarized hard-X ray and gamma-ray with low background and sharp energy resolution, which is appealing for medical and nuclear physics applications. Hefei Light Source (HLS) is a 2nd generation light source with 800 MeV electron beam energy used to provide high flux ultraviolet and soft X-ray for biological, physical and chemical research. To expand the application range of the HLS, we designed an HLS based Compton back-scattering light source which can produce high flux gamma photons with several MeV energy. In this design, the upgraded HLS is able to operate simultaneously in two modes: UV mode and gamma mode.

TUPE036 **The Parameters Study for the Enhanced High Gain Harmonic Generation (EHGHG)** – *Q.K. Jia, H. Geng, H.T. Li (USTC/NSRL)*

An easy-to-implement scheme called Enhanced High Gain Harmonic Generation has been proposed and shown to be able to significantly enhance the performance of traditional HGHG-FEL. In this paper we investigate the effects of the system parameters in EHGHG scheme, such as the electron energy tuning, the energy spread, the dispersive strength, amount of the phase shift, and the power of seed laser. The numerical results are presented, and shown that: the EHGHG scheme has acceptable the parameters tolerance requirements and is not more or even less sensitive to the system parameters than that of the existing scheme.

TUPE037 **Optmization of Injector System for PAL-XFEL** – *J.G. Hwang, E.-S. Kim (Kyungpook National University) I. Hwang (PAL)*

Pohang Accelerator Laboratory (PAL) plans free electron laser (FEL) with 1Å wavelength in 94 m long undulator. It is based on Self-Amplified Spontaneous Emission(SASE) and produces a 10 GeV electron beam with 0.2nC. The injector consists of electron gun, solenoids, two 3 m linac and quadrupoles. The photo-injector produces 6.8 ps long electron bunches of 0.2 nC with a normalized transeverse emittance of less than 0.4 mm mrad at 135 MeV. We investigate sensitivity and optimization of laser pulse, solenoid and linac by using of PARMELA.

TUPE038 **Simulation Study on Emittance Increase due to RF Asymmetry** – *Y.W. Parc (PAL) M.S. Chae, J.H. Hong, I.S. Ko (POSTECH)*

Due the field asymmetry in RF gun due the holes in full cell cavity, the emittance of electron beam can be increased. To generate the low emittance electron beam for XFEL, the elimination of the each field components is very important. The RF field can be decomposed as dipole and quadrupole components. The effect on the emittance increase of each component is studied in this presentation by numerical method. The 3D field map is constructed by MATLAB code as input of PARMELA code with each component distribution of the RF field. In this paper the emittance increase of electron beam by the each component of the RF field will be presented.

TUPE039 **Parameter Study for FEL Project at INFLPR** – *F. Scarlat (INFLPR)*

This paper is a presentation of a parameter study for FEL Project at INFLPR considering recent advances of technologies in the domain of accelerators, lasers, undulators and seeded operation with HHG which in their turn allow the construction of a national user facility based on an intense FEL at VUV wavelengths. The calculations also considered the possibilities for the facility to be upgraded for EUV regime, in a second stage. In the first stage, results were obtained for the FEL subsystem parameters starting from the 1 GeV beam electron energy, a 500 A electron current, a single stage HGHG FEL and VUV regime. Also, the status of the project is briefly sketched herein. On behalf of the RO FEL Design Team.

TUPE040 **FEL Activity Developed at JINR** – *E. Syresin, G.A. Chelkov, E.V. Ivanov, R.S. Makarov, E.A. Matyushevskiy, N.A. Morozov, G. Shirkov, G.V. Trubnikov, M.V. Yurkov (JINR) O.I. Brovko (JINR/LHE)*

Different methods for diagnostic of ultrashort electron bunches are developed at JINR-DESY collaboration within the framework of the FLASH and XFEL projects. Photon diagnostics developed at JINR-DESY collaboration for ultrashort bunches are based on calorimetric measurements and detection of undulator radiation. The MCP based radiation detectors are effectively used at FLASH for pulse energy measurements. The infrared undulator constructed at JINR and installed at FLASH is used for longitudinal bunch shape measurements and for two-color lasing provided by the FIR and VUV undulators. The JINR also participates in development and construction of Hybrid Pixel Array Detector on the basis of GaAs sensors. The special laser source for the KEK photo-cathode gun is developed within the frame of the JINR-IAP-KEK collaboration.

TUPE041 **Status of the New Prototype Modulator for the European XFEL Project in Pulse Step Modulator (PSM) Technology** – *M. Bader, J. Alex, M. Frei, M. Iten, D. Reimann, J. Troxler (Thomson Broadcast & Multimedia AG)*

The European XFEL project at DESY in Germany requires 27 RF stations capable of 10 MW RF power each. Each RF station needs one high voltage modulator that generates pulses up to 12 kV and 2 kA with a duration of 1.7 ms and a nominal repetition rate of 10 Hz. DESY decided to investigate new modulator prototypes and Thomson has been awarded to design and build one of these prototype modulators. The Thomson modulator is based on the pulse step modulator (PSM) principle. This technology allows the regulation of the pulse voltage during the pulses, thus achieving a good flatness. The modulator was delivered to DESY in July 2008 and is under test at the modulator test facility in Zeuthen. In the mean time an additional Thomson modulator of the same kind has been ordered and will be delivered to LAL Orsay in October 2010. This Thomson modulator will be integrated in a RF test bench required to condition and test the power couplers for the XFEL superconducting cavities. The paper will show the test results as taken during the testing at the modulator test facility at the DESY Zeuthen site.

TUPE042 **Results of the PSI Diode-RF Gun Test Stand Operation** – *F. Le Pimpec, B. Beutner, S. Binder, H.-H. Braun, R. Ganter, C.H. Gough, C.P. Hauri, R. Ischebeck, S. Ivkovic, K.B. Li, M. Paraliev, M. Pedrozzi, T. Schietinger, B. Steffen, A. Trisorio (PSI)*

This paper summarizes results obtained using a pulsed diode electron source followed by single stage RF acceleration at 1.5 GHz. The diode has an adjustable gap, across which a pulsed high voltage (up to 500 kV) is applied. The electrons are extracted, via photo-electric effect, from the cathode used as a photo-cathode or from a dedicated photo-source embedded in a hollow cathode. The final goal of this accelerator is to produce a 200pC electron beam with a projected normalized emittance below 0.4 mm.mrad and a bunch length of less than 10 ps. The photo-electrons are produced using two different types of UV laser, including the wavelength tunable Titanium-Sapphire laser foreseen for the SwissFEL project. We present comparisons between beam dynamic simulations and measurements, as well as thermal emittance and quantum efficiency measurements at different laser wavelengths.

TUPE043 **THz-pulse-train photoinjector** – *C.H. Chen, K.Y. Huang, Y.-C. Huang (NTHU) W.K. Lau, A.P. Lee (NSRRC)*

A THz-pulse-train photoinjector is under construction at the High-energy OPtics and Electronics (HOPE) Lab. at National Tsinghua University, Taiwan. This photoinjector is believed to be useful for generating high-power THz radiation, as well as for driving or loading a plasma-wave accelerator. A THz laser beat wave with full tunability in its beat frequency is employed to induce the emission of the THz electron pulses from the photoinjector. We show in our study that such a photoinjector is capable of generating periodically bunched MeV electrons with a bunching factor larger than 0.1 at THz frequencies for a total amount of 1nC charges in a 10-ps time duration. We will also present a driver laser technology that can tune the electron bunch frequency with ease and help the growth of the high harmonics in the bunching spectrum of accelerated electrons. Experimental progress on this photoinjector will be reported in the conference. The authors gratefully acknowledge funding supports from National Scienc Council under Contract NSC 97-2112-M-007-018 -MY2, National Synchrotron Radiation Research Center under Project 955LRF01N, and National Tsinghua University under Project 98N2534·10[1].

TUPE044 **Ultra-compact MW THz Superradiance FEL** – *Y.-C. Huang, C.H. Chen (NTHU)*

We study a desktop MW superradiance free-electron laser (FEL) at THz frequencies. By using some nominal beam parameters from a THz-pulse-train electron gun, we show in theory and simulation that 10-MW-level radiation power at THz frequencies is achievable from a meter long undulator in one single electron transit through the undulator. The proposed THz superradiance FEL is directly attached to the emittance compensating coil of the photoinjector without using any additional beam-fucusing element in between. This compact design allows the construction of a 10-MW FEL at THz frequencies on an ordinary desk. We will also show the usefulness of a tapered undulator for a superradiance FEL. With a 20%

linearly tapered undulator, the FEL radiation power can be increased by more than 30%. This FEL is being constructed at the High-energy OPtics and Electronics (HOPE) Laboratory, National Tsinghua University, Taiwan. Experimental progress of this ultracompact, high-power single-pass superradiance FEL will be reported in the conference.

TUPE045 **The Status of TAC IR FEL & Bremsstrahlung Project** – *S. Ozkorucuklu (SDU) O. Yavas (Ankara University, Faculty of Engineering)*

Turkish Accelerator Center Infrared Free Electron Laser and Bremsstrahlung (TAC IR FEL&rems.) project aims to produce cw mode FEL in 2.5-250 microns range and to produce bremsstrahlung photons using 15-40 MeV electron beam. The project is supported by State Planning Organization (SPO) of Turkey and is proceeded with inter university collaboration under the coordination of Ankara University. It is proposed that the facility will consist of 300 keV thermionic DC gun, two superconducting RF module and two optical resonator systems with 25 and 90 mm period lengths. In this study, the status and road map of the project is presented including some technical details on accelerator and FEL. In addition the research potential of facility is summarized.

TUPE046 **Subpicosecond Bunch Formation by Traveling Wave under Heavy Beam Loading** – *V.V. Mytrochenko, M.I. Ayzatskiy, V.A. Kushnir, A. Opanasenko, S.A. Perezhogin, Z.V. Zhiglo (NSC/KIPT)*

Simulation results of subpicosecond bunch formation due to phase motion of electrons in traveling wave are presented. It has been shown that at satisfying phase conditions of electron injection that are necessary for velocity bunching, relative phase velocity of the total wave excited both by RF generator and particles becomes different from unit increasing bunch compression. Simulation of transportation of obtained 8.5 MeV bunches through undulator with a period of 90.6 mm and estimation of bunch form-factor at 446 harmonic of bunch repetition rate of 2797.15 MHz also was carried out. The data obtained allow to expect coherent radiation from undulator at wave-length of 240 um.

TUPE047 **Possible Way of Tandem Free Electron Laser Realization on Channeling Relativistic Particles** – *M.V. Vysotskyy, V.I. Vysotskii (National Taras Shevchenko University of Kyiv, Radiophysical Faculty)*

In the report the possibilities of FEL optimization and creation of tandem laser are considered. One of the optimal ways of coherent hard radiation generation is connected with the creation of FEL on channeling relativistic particles in perfect crystals [1]. The main role in solution of such problem plays the full Doppler effect [2]. The possibility of creation of tandem FEL, where one particle can radiate multiple times on one transition, is predicted for the first time. For such laser the intensive process of consecutive generation of two types of photons with different frequencies on the same radiating transition is possible and this double photon generation leads to the restoration of the initial state of quantum system. This effect allows to predict the possibility of multiple repeat of radiation cycle. The pumping source for such laser is the kinetic energy of moving particles. In such systems there is no need for inversion and absorption on radiation frequency is totally absent. The main problem of realization of tandem FEL is connected with the need of mediums with positive susceptibility in high frequency range, possible ways to solve this problem are also regarded.

TUPE048 **SRF Cryomodule and Cryogenics Developments for NLS** – *S.M. Pattalwar, R. Bate, R.K. Buckley, B.D. Fell, A.R. Goulden, P.A. McIntosh (STFC/DL/ASTeC)*

The superconducting LINAC for the proposed New Light Source (NLS) project in the UK, will consist of 18 cryomodules operating at 1.8 K, each having 8, 1.3 GHz cavities operating in CW mode. The cryomodule design and cryogenic distribution scheme will be one of the key elements to achieve the desired performance from the superconducting RF (SRF) linac. Around the world, several large scale facilities (based on SRF linacs) are already operating (for example: CEBAF, SNS, FLASH) and several more have been proposed (XFEL, ILC, Cornell ERL, etc.). In this paper we define the requirements for an appropriate cryomodule, adopting proven L-band technology systems and also describe the cryogenic distribution scheme, in order to develop an effective and economic solution for the NLS.

TUPE049 **Optimisation of an HHG-Seeded Harmonic Cascade FEL for the NLS Project** – *D.J. Dunning, N. Thompson (STFC/DL/ASTeC) R. Bartolini (JAI) H. Geng, Z. Huang (SLAC) B.W.J. McNeil (USTRAT/SUPA)*

Optimisation studies of an HHG-seeded harmonic cascade FEL for the UK's proposed New Light Source (NLS) facility are presented. Three separate FELs are planned to meet the requirements for continuous coverage of the photon energy range 50-1000eV with variable polarisation, 20fs pulse widths and good temporal coherence. The design uses an HHG seed source tuneable from 50-100eV to provide direct FEL seeding in this range, and one or two stage harmonic cascades to reach the higher photon energies. Studies have been carried out to optimise a harmonic cascade FEL operating at 1000eV; the topics investigated include modulator configuration, seed power level and undulator tapering. FEL simulations using realistic electron beam distributions are presented and tolerances to seed/electron beam misalignment and wakefield effects are considered.

TUPE050 **Improved Temporal Coherence in SASE FELs** – *N. Thompson (STFC/DL/ASTeC) B.W.J. McNeil (USTRAT/SUPA) N. Thompson (Cockcroft Institute)*

A scheme for the generation of attosecond pulse trains in FEL amplifiers was recently proposed*. The method uses repeated equal temporal delays between the electron bunch and co-propagating radiation to generate a modal structure in the radiation field. The modes may be phase-locked via an energy modulation in the electron beam. As a consequence of the radiation /electron delays, the relative radiation /electron slippage during the interaction is increased and leads to a longer cooperation length with the effect of improving the temporal coherence. In this paper we present simulations demonstrating this effect. In particular, we show that the average spacing between the temporal spikes in a SASE FEL is increased in proportion to the increase in the cooperation length. It may therefore be possible to operate a SASE FEL in single-spike mode with longer, higher charge, electron bunches than previously thought possible.

TUPE051 **CW SRF Linac Development for the New Light Source Project in the UK** – *P.A. McIntosh, C.D. Beard, A.R. Goulden, A.J. Moss, S.M. Pattalwar, A.E. Wheelhouse (STFC/DL/ASTeC)*

A design optimisation has been performed for an L-band, SRF linac adopting cryomodule technology developed as part of the TESLA Technology Collaboration (TTC). A conventional XFEL cryomodule has been adopted as a baseline design and modified to allow for CW operation at a nominally high Qo level. An assessment of appropriate operating gradient, based upon expected sub-system component costs and SRF linac operating costs, has been performed. The associated cryomodule modifications to accommodate such a large dynamic load are also highlighted, along with identifying an appropriate RF control architecture which can achieve the stringent phase and amplitude stability requirements for NLS.

TUPE052 **The ALPHA-X Beam Line: towards a Compact FEL** – *M.P. Anania, E. Brunetti, S. Cipiccia, D. Clark, R.C. Issac, D.A. Jaroszynski, T. McCanny, A. J. W. Reitsma, R.P. Shanks, G.H. Welsh, S.M. Wiggins (USTRAT/SUPA) J.A. Clarke, M.W. Poole, B.J.A. Shepherd (STFC/DL/ASTeC) M.J. de Loos, S.B. van der Geer, C.A.J. van der Geer (Pulsar Physics)*

Recent progress in developing laser-plasma accelerators is raising the possibility of a compact coherent radiation source that could be housed in a medium sized university department. Furthermore, since the duration of electron bunches from laser-plasma wakefield accelerators is determined by the relativistic plasma wavelength, radiation sources based on these accelerators can produce pulses with femtosecond durations. Beam properties from laser-plasma accelerators have been traditionally thought of as not being of sufficient quality to produce amplification. Our work shows that this is not the case. Here we present a study of the beam characteristics of a laser-plasma accelerator and the compact ALPHA-X (Advanced Laser Plasma High-energy Accelerators towards X-rays) FEL. We discuss the implementation of a focussing system consisting of a triplet of permanent magnet quadrupoles and a triplet of electromagnetic quadrupoles*. We will present a study of the influence of beam transport on FEL action in the undulator, paying particular attention to bunch dispersion in the undulator. This is an important step for developing a compact synchrotron source or a SASE free-electron laser.

TUPE053 **High Quality, Ultrashort Bunches from a Laser Plasma Wakefield Accelerator: A Suitable Driver of a FEL?** – *D.A. Jaroszynski, M.P. Anania, C. Aniculaesei, E. Brunetti, R.T.L. Burgess, S. Chen, S. Cipiccia, D. Clark, B. Ersfeld, M.R. Islam, R.C. Issac, G.G. Manahan, T. McCanny, G. Raj, A. J. W. Reitsma, R.P. Shanks, G. Vieux, G.H. Welsh, S.M. Wiggins, X. Yang (USTRAT/SUPA) J.A. Clarke, M.W. Poole, B.J.A. Shepherd (Cockcroft Institute) W.A. Gillespie (University of Dundee) A. MacLeod (UAD) M.J. de Loos, S.B. van der Geer (Pulsar Physics)*

The laser plasma wakefield accelerator (LWFA) offers the possibility of reducing the size of accelerators by two or three orders of magnitude, while simultaneously reducing the bunch duration to femtoseconds. The high peak currents possible from these accelerators make them suitable as drivers of radiation sources such as the FEL. We present recent results from the Advanced Laser Plasma High-energy Accelerators towards X-rays (ALPHA-X) project where a compact coherent radiation source based on a LWFA is being developed. We show that the characteristics of electron beams from the LWFA are suitable for driving a FEL* and present latest measurements that indicate femtosecond duration bunches with peak currents in excess of 5 kA. With the measured energy spread and emittance**, the FEL gain parameter rho > 10^{-3}, which should result in saturation of the FEL in the VUV range. We present the latest results in these endeavours. Extension to X-rays should be possible with further acceleration to above a GeV, and a long undulator. A compact FEL would have a large impact on the way science is done by making powerful tools available in medium sized universities and research establishments.

TUPE054 **Short Pulse Options for the UK's New Light Source Project** – *I.P.S. Martin (Diamond) R. Bartolini, I.P.S. Martin (JAI) D.J. Dunning, N. Thompson (STFC/DL/ASTeC)*

The New Light Source project aims to construct a suite of seeded free-electron lasers driven by a 2.25GeV cw super conducting linac. As part of the upgrade path, a number of options are being considered for generating ultra short (<1fs) soft x-ray pulses, with low-charge 'single-spike' operation and bunch slicing like approaches of particular interest, including as a possible extension to echo-enhanced harmonic generation. In this paper we present the status of this work, including recent results from fully start to end simulations.

TUPE055 **Progress with the Design of the UK's New Light Source Facility** – *R.P. Walker (Diamond)*

Considerable progress has been made in recent months with the design of the UK's proposed New Light Source facility. This includes further optimisation of the injector, linac and FEL performance and operating parameters, and full start-to-end tolerance and jitter studies. More detailed engineering considerations for key components such as the cw linac cryomodules, undulator and vacuum chamber have been undertaken, as well as overall layout and outline design of the buildings. In this report we summarise progress in all these areas, the current status and future plans for the project.

TUPE057 **A Tunable Multi-MHz Repetition Rate Soft X-ray FEL** – *P.R. Gandhi, X.W. Gu (UCB) K.-J. Kim, R.R. Lindberg (ANL) G. Penn, J.S. Wurtele, A. Zholents (LBNL)*

A major advantage of FEL radiation sources is the ability, in principle, to tune the radiation output frequency by adjusting either the beam energy or the wiggler amplitude. In practice, this may not be readily achievable for systems that require high repetition rate amplifiers. In our scheme, we envision using two oscillators working at two fixed wavelengths and producing tunable radiation using the echo technique* at much shorter wavelengths. This system avoids the need for seeding lasers and will allow producing narrow bandwidth and high brightness x-ray radiation with a multi-MHz repetition rate using low charge electron bunches provided by a DC or cw rf electron gun and superconducting rf linac. This system is first analyzed using a reduced model** for FEL oscillators, in which the transverse profile of the light beam is expanded using the Gauss-Hermite basis and the FEL equations are integrated over the transverse dimensions. The results are compared with simulations from the GENESIS code***. Studies of the FEL performance will be presented, including its tunability and sensitivity to fluctuations in beam energy.

TUPE058 **Energy Spread Growth in the Laser Undulator based XFELs** – *Y. Kim, Y.C. Jing, S.-Y. Lee, J.A. Musser, P.E. Sokol (IUCF)*

At the Indiana University Cyclotron Facility (IUCF), we are developing a new XFEL concept, which is based on the Compton scattering and the laser undulator instead of the conventional magnetic undulator. Since the period of the laser undulator is only about 500 nm, the coherent hard X-rays can be generated by using a compact electron accelerator with a beam energy of about 50 MeV. In this paper, we report an estimation of the energy spread growths due to the Compton scattering itself and their impacts on the XFEL lasing in the laser undulator based XFEL concept.

TUPE059 **FEL Gain Manipulation using an In-cavity Aperture System** – *J.Y. Li, B. Jia, S.F. Mikhailov, V. Popov, Y.K. Wu (FEL/Duke University) S. Huang (PKU/IHIP)*

The 54 m long free-electron laser resonator at Duke University consists of two concave mirrors with the same radius of curvature. The downstream mirror receives not only the fundamental but also higher-harmonic radiation emitted by relativistic electrons in the wigglers. The ultraviolet and vacuum-ultraviolet power load of wiggler harmonic radiation on this mirror can thermally deform and permanently damage the multi-layer coating of the mirror, which limit the maximum power of FEL. To mitigate these problems, a water-cooled aperture system has been installed inside the FEL resonator. This aperture system has been successfully used to significantly reduce the downstream mirror's power load of the radiation with helical wigglers. This system has also been used to manipulate the FEL net gain by changing FEL beam diffraction loss inside the resonator. In principle, this aperture system can be used as an independent FEL gain control device for stable FEL operation with a fixed beam current and storage ring settings without changing the cavity detuning. This paper reports our study on FEL operation with the active FEL gain control using a water-cooled in-cavity aperture.

TUPE060 **Study of FEL Mirror Degradation at the Duke FEL and HIGS Facility** – *S.F. Mikhailov, J.Y. Li, V. Popov, Y.K. Wu (FEL/Duke University)*

The Duke FEL and High Intensity Gamma-ray Source (HIγS) are operated with a wide range of electron beam energies (0.24 - 1.2 GeV) and photon beam wavelengths (190 - 10^{60} nm). Currently, the HIγS provides users with the gamma beams in the energy range from 1 to about 65 MeV, with a near future extension to about 10^{0} MeV. The maximum total gamma-flux produced at the HIγS facility is up to 10^{10} gammas per second. Production of high level gamma-ray flux, requiring a very high average FEL intra-cavity power and high electron beam current, can cause significant degradation of the FEL mirrors. To ensure the predictability and stability of the HIγS operation for user research program, we have developed a comprehensive program to continuously monitor the performance of the FEL mirrors. This program has enabled us to use a particular set of FEL mirrors for a few hundreds hours of high gamma-flux operation with predictable performance. In this work, we discuss sources and consequences of the mirror degradation for a variety of wavelengths and present our estimates of the mirror life time as a function of the FEL wavelength, gamma-ray polarization, and total gamma-flux.

TUPE061 **Upgrade of the RF Photo-injector for the Duke Storage Ring** – *V. Popov, J.Y. Li, S.F. Mikhailov, P.W. Wallace, P. Wang, Y.K. Wu (FEL/Duke University)*

The accelerator facility for the Duke FEL and High Intensity Gamma-ray Source (HIGS) consists of a linac pre-injector, a top-off booster injector, and the storage ring. The S-band RF gun with the LaB6 cathode was initially operated in the thermionic mode, producing a long electron beam pulse and a large radiation backgroud. In 1997, the thermionic RF gun was converted to a photo-cathode operation using a nitrogen drive laser for single bunch injection into the storage ring. The photo-cathode operation typically delivers 0.1 nC of charge in a 1 ns long pulse to the linac. Since 2006, substantial improvements have been made to the photo-cathode and the linac, including improvements of the nitrogen drive laser, development of driver laser optical transport and beam monitoring system, and optimization of the cathode heater current to minimize the thermionic emission. In addition, two electron beam charge measurement systems using Faraday cup detectors and sample and hold electronics have been developed. In this work, we will present these new developments and discuss the impact of these upgrades on everyday operation of the linac preinjector.

TUPE062 **Simulation Study of a Storage Ring Free-election Laser Oscillator** – *B. Jia, J.Y. Li, Y.K. Wu (FEL/Duke University) J. Wu (SLAC)*

Being a multi-pass process, the simulation study of the storage ring free-electron laser (SRFEL) oscillator requires to develop a proper model system for the electron beam and optical beam. A numerical simulation model has been developed for the Duke storage ring FEL. In this model, we have implemented the most important physics phenomena, including the synchrotron oscillation, radiation damping, FEL interaction, and optical power buildup process. The FEL interaction uses the well-known FEL code GENESIS; storage ring FEL specific codes have been developed to track the recirculation of the electron beam in the storage ring and optical beam in the FEL resonator. Using this model, we have studied the details of the FEL gain process, the growth of the energy spread and bunch length of the electron beam, as well as the impact of the FEL detuning. In this work, we will present this model system and preliminary FEL simulation results and their comparison with experimental data.

TUPE063 **Generation of Optical Orbital Angular Momentum in a Free-electron Laser** – *E. Hemsing, A. Marinelli (UCLA)*

A simple scheme to generate intense light with orbital angular momentum in an FEL is described. The light is generated from a helically prebunched beam created in an upstream modulator. The beam energy is tuned to maximize gain in the higher-order mode which reaches saturation well before the spontaneous modes driven by noise are amplified.

TUPE064 **Simulations of Ion Migration in the LCLS RF Gun and Injector** – *A. Brachmann (SLAC)*

Simulations of ion migration in the LCLS RF gun and injector A. Brachmann On behalf of the LCLS commissioning team The motivation for this work was the observed surface contamination of the first LCLS RF gun copper cathode. We will present the results of simulations in regards to ion migration in the LCLS gun. Ions of residual gases will be created by interaction of molecular gas species with the UV drive laser beam and by the electron beam itself. The larger part of those ionized molecules remain in the vicinity of creation, are transported towards beam line walls or away from the cathode. However a significant fraction gains enough kinetic energy to be focused by RF and magnetic fields, reaching the cathode and producing an undesirable increase of the cathode's surface work function. Although this fraction is small, during long term operation, this effect becomes a significant factor limiting the source performance.

TUPE065 **Surface Characterization of the LCLS RF Gun Cathode** – *A. Brachmann (SLAC)*

Surface characterization of the LCLS RF gun cathode A. Brachmann On behalf of the LCLS commissioning team The first copper cathode installed in the LCLS RF gun was used during LCLS commissioning for more than a year. However, after high charge operation (~ 500 pC), the cathode showed a decline of quantum efficiency due to surface contamination caused by residual ionized gas species present in the vacuum system. We report results of SEM, XPS and XAS studies that were carried out on this cathode after it was removed from the gun. X-ray absorption and X-ray photoelectron spectroscopy reveal surface contamination by various hydrocarbon compounds. In addition we report on the performance of the second installed cathode with emphasis on the spatial distribution of electron emission.

TUPE066 **Femtosecond Operation of the LCLS for User Experiments** – *J.C. Frisch, C. Bostedt, J.D. Bozek, A. Brachmann, R.N. Coffee, F.-J. Decker, Y.T. Ding, D. Dowell, P. Emma, A. Gilevich, G. Haller, G.R. Hays, P. Hering, B.L. Hill, Z. Huang, R.H. Iverson, E.P. Kanter, B. Kraessig, H. Loos, A. Miahnahri, H.-D. Nuhn, A. Perazzo, M. Petree, D.F. Ratner, T.J. Smith, S.H. Southworth, J.L. Turner, J.J. Welch, W.E. White, J. Wu, L. Young (SLAC) R.B. Wilcox (LBNL)*

In addition to its normal operation at 250pC, the LCLS has operated with 20pC bunches delivering X-ray beams to users with energies between 800eV and 2 keV and with bunch lengths below 10 fs FWHM. A bunch arrival time monitor and timing transmission system provide users with sub 100 fs synchronization between a laser and the X-rays for pump / probe experiments. We describe the performance and operational experience of the LCLS for short bunch experiments.

TUPE067 **Operational X-ray Diagnostics for the LCLS** – *J.C. Frisch, J. Arthur, P. Emma, G. Haller, S.A. Lewis, H. Loos, M. Messerschmidt, M. Petree, T.J. Smith, P. Stefan, H. Tompkins, J.L. Turner, J.J. Welch (SLAC) R.M. Bionta, S. Friedrich, S.P. Hau-Riege (LLNL)*

The LCLS has delivered X-ray beams to users with >90% uptime at energies from 780eV to 2 KeV, in both long and short bunch modes. This performance is in part due to a set of non-invasive, and rapid measurement diagnostics which provide information for beam tuning. We describe the X-ray diagnostics used in the day to day operation of the LCLS and their planned upgrades.

TUPE068 **Polarization Control for Seeded FELs in a Crossed-Planar Undulator** – *H. Geng, Y.T. Ding, Z. Huang (SLAC) R. Bartolini (Diamond) D.J. Dunning, N. Thompson (STFC/DL/ASTeC)*

The crossed-planar undulator is a promising scheme for full polarization control in an x-ray FEL*. For SASE FELs, it has been shown a maximum degree of circular polarization of about 80% is achievable**. In this paper, we study the effectiveness of a cross undulator for a seeded x-ray FEL. The degree of circular polarization for both the fundamental and the harmonic radiation are considered.

TUPE069 **A Proof-of-principle Echo-enabled Harmonic Generation FEL Experiment at SLAC** – *C. Hast, E.R. Colby, Y.T. Ding, M.P. Dunning, R.K. Jobe, D.J. McCormick, J. Nelson, T.O. Raubenheimer, G.V. Stupakov, Z.M. Szalata, D.R. Walz, S.P. Weathersby, M. Woodley, D. Xiang (SLAC) J.N. Corlett, J. Qiang, D. Schlueter, M. Venturini, W. Wan (LBNL)*

In this paper we describe the technical design of an on-going proof-of-principle echo-enabled harmonic generation (EEHG) FEL experiment in the Next Linear Collider Test Accelerator (NLCTA) at SLAC. The experiment was designed through late 2009 and built and installed between October 2009 and January 2010. We present the design considerations, the technical realization and the expected performances of the EEHG experiment.

TUPE070 **Second and Third Harmonic Measurements at the Linac Coherent Light Source** – *D.F. Ratner, F.-J. Decker, Y.T. Ding, P. Emma, J.C. Frisch, Z. Huang, R.H. Iverson, H. Loos, M. Messerschmidt, H.-D. Nuhn, T.J. Smith, J.L. Turner, J.J. Welch, J. Wu (SLAC) R.M. Bionta (LLNL)*

The Linac Coherent Light Source (LCLS) is a Free Electron Laser (FEL) operating with a fundamental wavelength ranging from 1.5-0.15 nm. Characterization of the higher harmonics present in the beam is important to users, for whom harder X-rays can either extend the useful operating wavelength range or represent a background to measurements. We present here measurements of the power in both the second and third harmonics. We also compare these power levels to what is expected from theory and simulations.

TUPE071 **Identifying Longitudinal Jitter Sources in the LCLS Linac** – *F.-J. Decker, R. Akre, A. Brachmann, J. Craft, Y.T. Ding, D. Dowell, P. Emma, J.C. Frisch, Z. Huang, R.H. Iverson, A. Krasnykh, H. Loos, H.-D. Nuhn, D.F. Ratner, T.J. Smith, J.L. Turner, J.J. Welch, G.R. White, J. Wu (SLAC)*

The Linac Coherent Light Source (LCLS) at SLAC is an x-ray Free Electron Laser with wavelengths of 0.15 nm to 1.5 nm. The electron beam stability is important for good lasing. While the transverse jitter of the beam is about 10-20% of the rms beam sizes, the jitter in the longitudinal phase space is a multiple of the energy spread and bunch length. At the lower energy of 4.3 GeV (corresponding to the longest wavelength of 1.5 nm) the relative energy jitter can be 0.125%, while the rms energy spread is with 0.025% five times smaller. An even bigger ratio exists for the arrival time jitter of 50 fs and the bunch duration of about 5 fs (rms) in the low charge (20 pC) operating mode. Although the impact to the experiments is reduced by providing pulse-by-pulse data of the measured energy and arrival time, it would be nice to understand and mitigate the root causes of this jitter. The thyratron of the high power supply of the RF klystrons is one of the main contributors. Another suspect is the multi-pacting in the RF loads. Phase measurements down to 0.01 degree (equals 10 fs) along the RF pulse were achieved, giving hints to the impact of the different sources.

TUPE072 **Preliminary Results of the ECHO-7 Experiment at SLAC** – *D. Xiang, E.R. Colby, Y.T. Ding, M.P. Dunning, C. Hast, R.K. Jobe, D.J. McCormick, J. Nelson, T.O. Raubenheimer, G.V. Stupakov, Z.M. Szalata, D.R. Walz, S.P. Weathersby, M. Woodley (SLAC) J.N. Corlett, J. Qiang, D. Schlueter, M. Venturini, W. Wan (LBNL)*
ECHO-7 is a proof-of-principle echo-enabled harmonic generation* FEL experiment in the Next Linear Collider Test Accelerator (NLCTA) at SLAC. The experiment aims to generate coherent radiation at 227 nm, which is the 7th harmonic of the infrared seed laser. In this paper we present the preliminary results from the commissioning run of the completed experimental setup which started in February 2010.

TUPE073 **Laser Assisted Emittance Exchange to Enhance the Single-pass X-ray FEL Performance in a Large Storage Ring** – *D. Xiang, Y. Cai, A. Chao, Y.T. Ding, Z. Huang (SLAC)*
It is generally believed that the high quality electron beam required in an x-ray FEL can only be provided by linear accelerators. In this paper we show that the electron beam from a large storage ring after appropriate manipulation (for instance, laser assisted emittance exchange*) can be used to drive a single-pass x-ray FEL as well. As a representative example, we show that 1 nm FEL can be realized in the proposed PEPX storage ring at SLAC.

TUPE074 **The JLAMP VUV/Soft x-ray User Facility at Jefferson Laboratory** – *F.E. Hannon, S.V. Benson, D. Douglas, P. Evtushenko, K. Jordan, J.M. Klopf, G. Neil, M.D. Shinn, C. Tennant, G.P. Williams, S. Zhang (JLAB)*
Jefferson Lab (JLab) is proposing JLAMP (JLab AMPlifier), a 4th generation light source covering the 10-100 eV range in the fundamental mode with harmonics stretching towards the oxygen k-edge. The new photon science user facility will feature a two-pass superconducting linac to accelerate the electron beam to 600MeV at repetition rates of 4.68MHz continuous wave. The average brightness from a seeded amplifier free electron laser (FEL) will substantially exceed existing light sources in this device's wavelength range, extended by harmonics towards 2 nm. Multiple photon sources will be made available for pump-probe dynamical studies. The status of the machine design and technical challenges associated with the development of the JLAMP are presented here.

TUPE075 **Electrostatic Modeling of the Jefferson Laboratory Inverted Ceramic Gun** – *F.E. Hannon, P. Evtushenko, C. Hernandez-Garcia (JLAB)*
Jefferson Laboratory (JLab) is currently developing a new 500kV DC electron gun for future use with the FEL. The design consists of two inverted ceramics which support a central cathode electrode. This layout allows for a load-lock system to be located behind the gun chamber. The electrostatic geometry of the gun has been designed to minimize surface electric field gradients and also to provide some transverse focusing to the electron beam during transit between the cathode and anode. This paper discusses the electrode design philosophy and presents the results of electrostatic simulations. The electric field information obtained through modeling was used with particle tracking codes to predict the effects on the electron beam.

TUPE077 **Single-spike SASE FEL at the NSLS SDL** – *H.J. Qian, Y. Hidaka, J.B. Murphy, B. Podobedov, S. Seletskiy, Y. Shen, X.J. Wang, X. Yang (BNL) H.J. Qian, C.-X. Tang (TUB)*
With the recent success of the LCLS, there is a growing interest in generating ultra-short electron beam for the single spike SASE operation. Based on the optimization of an electron beam with a charge from 20 to 100 pC and the available optical diagnostics at the 800 nm, a single-spike SASE FEL experiment was initiated at the NSLS source development Lab (SDL). Both temporal and spectral properties of the single-spike SASE will be characterized and both simulation and experimental results will be discussed in this paper.

TUPE079 **Theory of Smith-Purcell Radiation from Rough Surfaces** – *Zh.S. Gevorkian (YerPhI)*

Radiation of a charged particle moving to a rough surface has been considered. Within a common approach periodical and random gratings are examined. A new expression for spectral-angular radiation intensity in periodical case is derived. in the random case it is shown that the main contribution to the radiation intensity give surface polaritons induced by charge on the interface between two media. they are multiply scattered and convert into real photons. The spectral-angular intensity is calculated and its dependence on different parameters is revealed.

TUPE080 **Study of High Harmonic Generation at Synchrotron SOLEIL using an Echo Scheme** – *C. Evain, M.-E. Couprie, J.-M. Filhol, M. Labat, A. Nadji (SOLEIL) A. Zholents (LBNL)*

SOLEIL is presently installing a laser bunch slicing set-up to produce ultra-short X-ray pulses. We propose a method to generate coherent synchrotron radiation at high harmonics in a storage ring using an echo scheme. Like in the method proposed recently for free electron lasers, the echo scheme uses two modulators and two dispersive sections. We show that this can be done at the synchrotron SOLEIL by adapting the classical slicing scheme. In the present study at SOLEIL, the two laser/electrons interactions are planned to occur in two out of vacuum wigglers of period 150 mm, and the high harmonic radiation will be emitted in an APPLE-II type undulator with a period of 44mm or 80 mm in the beamline TEMPO or with a period of 52 mm in the beamline DEIMOS.

TUPE081 **Laser-induced Narrowband Coherent Synchrotron Radiation** – *S. Bielawski, C. Szwaj (PhLAM/CERCLA) M. Adachi, M. Katoh, S.I. Kimura, A. Mochihashi, H. Zen (UVSOR) C. Evain (SOLEIL) T. Hara (RIKEN/SPring-8) M. Hosaka, Y. Takashima, N. Yamamoto (Nagoya University) M. Le Parquier (CERLA) M. Shimada (KEK) T. Takahashi (KURRI)*

Interaction between a laser and a relativistic electron beam provides a way to manipulate the longitudinal charge distribution, and such experiments can lead to a coherent emission of terahertz radiation (Coherent Synchrotron Radiation or CSR). Recently a new method to produce narrow band CSR in the terahertz (THz) region has been developed at the UVSOR-II storage ring [1]. The setup is similar to the one used in femtosecond bunch slicing, but the injected laser pulse has a rather long duration (~300 ps) and is quasi-sinusoidally modulated at a certain THz frequency. The laser-electron interaction inside an undulator induces a fast energy modulation at the optical scale with the modulated amplitude. As the electron bunch pass through a bending magnet, the energy modulation is converted to a longitudinal density modulation which induces strong THz emission. The emission frequency is equal to the modulation frequency. Here, we present a detailed experimental and theoretical study of this effect in the UVSOR-II storage ring, using interaction in the FEL optical klystron. In particular, we show that the bunching can be maintained over more than one full turn in the storage ring.

TUPE082 **Advanced Beam Dynamics Experiments with the SPARC High Brightness Photoinjector** – *M. Ferrario (INFN/LNF)*

The primary goal of the SPARC project is the commissioning of the SASE FEL operating at 500 nm driven by a 150-200 MeV high brightness photoinjector. Additional experiments are foreseen also in the HHG Seeded configuration at 266, 160 and 114 nm. A second beam line hosting a THz source has been recently commissioned. The recent successful operation of the SPARC injector in the Velocity Bunching (VB) mode has opened new perspectives to conduct advanced beam dynamics experiments with ultra-short electron pulses able to extend the THz spectrum and to drive the FEL in the SASE Single Spike mode. Moreover a new technique called Laser Comb, able to generate a train of short pulses with high repetition rate, as the one required to drive coherent plasma wake field excitation, has been tested in the VB configuration. The energy/density modulation produced by an infrared laser pulse interacting with the electron beam near the cathode has been also investigated. In this paper we report the experimental results obtained so far and the comparison with simulations.

TUPE083 **Effects of Alignment Error of Main Superconducting Cavities on ERLs and their Correction** – *N. Nakamura (ISSP/SRL) R. Hajima (JAEA/ERL) K. Harada, Y. Kobayashi, T. Miyajima, S. Sakanaka, M. Shimada (KEK)*

In ERLs, superconducting cavities accelerate low-emittance beams with high-gradient standing-wave RF fields. If alignment error of the cavities is considerable, they can harmfully affect the beam trajectory and quality because the cavities have strong transverse focusing. Achieving high alignment accuracy of the cavities is difficult compared with the other ERL elements such as magnets because the cavities are contained in cryomodules. Therefore we studied effects of the alignment error of main superconducting cavities with analytical approaches and simulations, using a one-loop model of the compact ERL as an example. In this paper, we present the effects of alignment error of main superconducting cavities on ERLs and their correction.

TUPE084 **Tolerance Study on RF Amplitude and Phase of Main Superconducting Cavities and Injection Timing for the Compact ERL** – *N. Nakamura (ISSP/SRL) R. Hajima (JAEA/ERL) Y. Kobayashi, T. Miyajima, S. Sakanaka, M. Shimada (KEK)*

In ERL-based light sources, higher accuracy is expected to be required for RF control and timing, because the ERL beam has much shorter bunch length (less than 100 fs at minimum) compared with that of the existing SR sources. We studied effects of RF amplitude and phase variation of main superconducting cavities and effects of timing jitter of beam injection from an injector, using a simulation code 'elegant'. In this paper, we present the simulation results and discuss tolerances for the RF amplitude and phase and the injection timing.

TUPE085 **Application of the Eigenvector Method with Constraints to Orbit Correction for ERLs** – *N. Nakamura (ISSP/SRL) K. Harada (KEK)*

Orbit correction in an ERL is more complicated than those of an ordinary linac and a transport line, because the ERL beam passes a straight section containing main superconducting cavities at least two times with different energies. A corrector in this section gives a different kick angle to the beam in a different turn. Therefore a sophisticated orbit correction method is required for ERLs and ERL-based light sources. The eigenvector method with constraints (EVC)* can perform global orbit correction under constraint conditions and has been proposed and used for uniting global and exact local orbit corrections mainly in storage-ring based SR sources**. We applied this EVC method to orbit correction in an ERL. In this paper, we present how to use the EVC method for an ERL and simulation results of orbit correction for the compact ERL.

TUPE086 **A Study of Lifetime of NEA-GaAs Photocathode at Various Temperatures** – *H. Iijima, D. Kubo, M. Kuriki, Y. Masumoto, C. Shonaka (HU/AdSM)*

We report that a lifetime of GaAs photocathode activated the surface to negative electron affinity (NEA) at various temperatures. An electron source with the NEA-GaAs photocathode is an important device for high-average-current electron accelerators, such as a next-generation light source based on an energy recovery linac, in which a high power laser is illuminated to the photocathode for generation of the electron beam of 100mA. For example, the laser power of 15W should be needed for the quantum efficiency of 1% and the wavelength of 800nm. Consequently the high power laser causes to rise the GaAs temperature. The degradation of photo emission from the cathode is enhanced by a thermal desorption of Cs due to the temperature rise, even if the beam is not extracted. We have measured the cathode lifetime at various temperatures between room temperature and 100 C.

TUPE087 **Development of a Photocathode Test Bench using a Cryo-pump and a NEG Pump** – *D. Kubo, H. Iijima, K. Ito, M. Kuriki, Y. Masumoto, C. Shonaka (HU/AdSM) N. Nishimori (JAEA/ERL) M. Yamamoto (KEK)*

A NEA-GaAs photocathode is an important component for the next generation light source based on the ERL. Although the NEA-GaAs cathode has high quantum efficiency, deterioration of the NEA surface becomes serious with a high current operation. Therefore improvement of a vacuum in the cathode chamber is essential to get a long lifetime of the NEA-GaAs cathode. We are developing a photocathode test bench consisting of titanium (TP340) chamber, whose outgas rate is 1/10^{00} smaller than one of a SUS chamber, a cryo-pump (4000l/s) and a NEG pump (1900l/s). We report mainly the vacuum performance of the system.

TUPE088 **Light Source based on Multiturn-circulation of Beam of Energy Recovery Linac** – *T. Nakamura (JASRI/SPring-8)*

Multiturn circulation of a beam from an energy recovery linac (ERL) in a light source with bunch-by-bunch switching devices with RF cavities can reduce the output current of the ERL by a factor of the number of turns of the circulation, keeping the average current of the light source*. This scheme eases the requirement of an electron gun and an ERL, and lead to the possibility of cost-effective multi-pass ERL scheme. In previous work*, the scheme to increase the number of circulation with a ring shaped beam transport was proposed. In this work we propose a scheme without ring-shaped transport and it can be applied to various shapes of ERLs and light sources. As an example, we show a nine-turn circulation light source with the combination of newly proposed three-turn circulation system. The detail of the system, the brightness including the growth of emittance and energy spread by radiation excitation, and the effect of round-to-flat beam conversion which is a possible method for the reduction of the growth of the horizontal emittance are discussed.

TUPE089 **Preparation of Start-to-end Simulation for Compact ERL** – *T. Miyajima (KEK)*

Start-to-end (S2E) simulation from electron gun to beam dump is required to estimate light source performance and beam loss, which are essential parts in synchrotron light source based on Energy Recovery Linacs (ERL). Since the beam energy is widely varied from eV to GeV order in the ERL, the S2E simulation have to include many effects, e.g., space charge (SC) effect, coherent synchrotron radiation (CSR), cathode model, wake function, ions and beam break up. In order to carry out the S2E simulation, the preparation of it using General Particle Tracer (GPT), which is a particle tracking code including SC routine, has been started for compact ERL (cERL) beamline. The cERL is a test accelerator to establish accelerator technologies for GeV-class synchrotron light source based on ERL, and consists of an injector with photo cathode DC gun, a merger section, SRF cavities for acceleration and energy recovery, return loops, and a beam dump. In this presentation, the result of the S2E simulation from gun to the middle of return loop with SC and CSR effects, and the results of bench marking for each part in cERL, e.g. injector, merger, SRF cavities and return loop section, are shown.

TUPE090 **Progress in Construction of Gun Test Facility for Compact ERL** – *T. Miyajima, K. Haga, K. Harada, T. Honda, Y. Kobayashi, T.M. Mitsuhashi, S. Nagahashi, E. Nakamura, S. Nozawa, T. Ozaki, S. Sakanaka, K. Satoh, M. Shimada, T. Takahashi, R. Takai, M. Tobiyama, T. Uchiyama, A. Ueda, M. Yamamoto, Y. Yosuke (KEK) S. Matsuba (Hiroshima University, Graduate School of Science) T. Muto (Tohoku University, School of Scinece)*

Compact ERL (cERL) is a test accelerator to establish accelerator technologies for GeV-class synchrotron light source based on ERL (Energy Recovery Linac), and will be constructed in KEK. It consists of an injector with photo cathode 500 kV DC gun, a merger section, super conducting RF cavities for acceleration and energy recovery, return loops, and a beam dump. To operate and test the photo cathode gun before installing it in the cERL injector, Gun Test Facility is constructing in KEK, AR south experimental hall. The Gun Test Facility has two photo cathode guns, 200 kV gun developed by Nagoya University and new 500 kV gun which is being developed, laser system to be emitted electrons from photo cathode surface, beam transport lines, and a beam diagnostics system. The diagnostics system consists of a double slit emittance measurement system, beam position monitors, transverse profile monitors, and a deflecting cavity to measure the bunch length and the longitudinal profile. In this presentation, the progress in the construction of the Gun Test Facility and the beam dynamics simulation will be presented.

TUPE091 **Recent Progress in the Energy Recovery Linac Project in Japan** – *S. Sakanaka, M. Akemoto, T. Aoto, D.A. Arakawa, S. Asaoka, A. Enomoto, S. Fukuda, K. Furukawa, T. Furuya, K. Haga, K. Hara, K. Harada, T. Honda, Y. Honda, H. Honma, T. Honma, K. Hosoyama, M. Isawa, E. Kako, T. Kasuga, H. Katagiri, H. Kawata, Y. Kobayashi, Y. Kojima, T. Matsumoto, H. Matsushita, S. Michizono, T.M. Mitsuhashi, T. Miura, T. Miyajima, H. Miyauchi, S. Nagahashi, H. Nakai, H. Nakajima, E. Nakamura, K. Nakanishi, K. Nakao, T. Nogami, S. Noguchi, S. Nozawa, T. Obina, S. Ohsawa, T. Ozaki, C.O. Pak, H. Sakai, H. Sasaki, Y. Sato, K. Satoh, M. Satoh, T. Shidara, M. Shimada, T. Shioya, T. Shishido, T. Suwada, T. Takahashi, R. Takai, T. Takenaka, Y. Tanimoto, M. Tobiyama, K. Tsuchiya, T. Uchiyama, A. Ueda, K. Umemori, K. Watanabe, M. Yamamoto, S. Yamamoto, Y. Yamamoto, Y. Yano, M. Yoshida (KEK) M. Adachi, M. Katoh (UVSOR) R. Hajima, R. Nagai, N. Nishimori, M. Sawamura (JAEA/ERL) H. Hanaki (JASRI/SPring-8) H. Iijima, M. Kuriki (HU/AdSM) I. Ito, H. Kudoh, N. Nakamura, S. Shibuya, K. Shinoe, H. Takaki (ISSP/SRL) H. Kurisu (Yamaguchi University) M. Kuwahara, T. Nakanishi, S. Okumi (Nagoya University) S. Matsuba (Hiroshima University, Graduate School of Science) T. Muto (Tohoku University, School of Scinece) K. Torizuka, D. Yoshitomi (AIST)*

Future synchrotron light source using a 5-GeV-class energy recovery linac (ERL) is under proposal by our Japanese collaboration team, and we are conducting active R&D efforts for that. We are developing super-brilliant DC photocathode guns, two types of cryomodules for both injector and main superconducting linacs, 1.3 GHz high CW-power rf sources, and other important components. We are also constructing a compact ERL for demonstrating the recirculation of low-emittance, high-current beams using those key components. We present our recent progress in this project.

TUPE092 **Triple Bending Achromat Lattice in 2-Loop Compact Energy Recovery Linac** – *M. Shimada, K. Harada, Y. Kobayashi, A. Ueda (KEK) R. Hajima (JAEA/ERL)*

It is important issue for Energy Recovery Linac (ERL) to preserve the extreme low transverse emittance at the arc section. Two circulating sections in the 2-loop compact ERL include triple bending achromat (TBA) or quasi-TBA. At least, the typical isochronous TBA has an overfocus point, in which the space charge effect becomes serious problem for low emittance beam at the low electron energy. Furthermore, the wake due to the coherent synchrotron radiation at the shorter electron bunch length is also harmful. This presentation shows the optimization of the lattice design and optical function of an isochronous TBA for low emittance beam.

TUPE093 **High-Voltage Test of a 500-kV Photo-Cathode DC Gun for the ERL Light Sources in Japan** – *R. Nagai, R. Hajima, N. Nishimori (JAEA/ERL) Y. Honda, T. Miyajima, T. Muto, M. Yamamoto (KEK) H. Iijima, M. Kuriki (HU/AdSM) M. Kuwahara, T. Nakanishi, S. Okumi (Nagoya University)*

A 500-kV, 10-mA photocathode DC gun has been designed and is now under fabrication by the collaboration efforts of JAEA, KEK, Hiroshima Univ. and Nagoya Univ. The Cockcroft-Walton generator and the ceramic insulator are installed upright in the SF6 tank. We have adopted a multiple-stacked cylindrical ceramic insulator, because this type of ceramic insulator has shown good stability and robustness at the 200-kV Nagoya polarized gun and the 250-kV JAEA FEL gun. The vacuum chamber, the guard-rings and the support-rod electrode are made of titanium alloy with very low out-gassing and robustness to high voltage performances. The Cockcroft-Walton generator, the ceramic insulator, the vacuum chamber and the guard-rings have been assembled and a high-voltage test has been successfully done with up to 550kV. The high-voltage test and up-to-date status of the gun development will be presented in detail.

TUPE094 **Cooling Test of ERL HOM Absorber** – *M. Sawamura (JAEA/ERL) T. Furuya, H. Sakai, K. Umemori (KEK) K. Shinoe (ISSP/SRL)*

HOM absorbers are one of the key components to determine the ERL cavity performance to reduce the HOM problem for the high current operation. When a beam line HOM damper is installed inside the cryomodule, the HOM absorber is cooled down to liquid nitrogen temperature. The RF absorber used for the HOM absorber is required to have good frequency and temperature properties at low temperature. The RF absorber was selected by permittivity and permeability measurement of some ferrites and ceramics from room temperature to 40 K. The HOM absorber is designed by optimizing the parameters such as length, thickness and position with microwave simulation codes. The HOM absorber test model was designed and fabricated to test the RF, mechanical, cooling and temperature properties.

TUPE095 **First Results from III-V Photocathode Preparation Facility for the ALICE ERL Photoinjector** – *B.L. Militsyn, B.D. Fell, L.B. Jones, J.W. McKenzie, K.J. Middleman (STFC/DL/ASTeC) I. Burrows, R.J. Cash (STFC/DL) H.E. Scheibler, A.S. Terekhov (ISP)*

ALICE is an Energy Recovery Linac built at STFC Daresbury Laboratory to investigate the process of energy recovery. The project is an accelerator research facility intended to develop the technology and expertise required to build a New Light Source (NLS) in the UK based on a suite of Free-Electron Lasers. Currently the ALICE gun accommodates only a single photocathode at any one time, and the system must be vented to atmospheric pressure for photocathode replacement. To meet the stringent vacuum demands for good photocathode lifetime, the system then requires baking for up to three weeks. A new load-lock cathode preparation system has been designed as an upgrade to the ALICE gun. The load-lock can accommodate up to six photocathodes, and permits rapid transfer of photocathodes between the load-lock activation chamber and the gun, thus maintaining the vacuum. The photocathode preparation facility was successfully commissioned in spring 2009, and has since permitted a quantum yield of 15% to be achieved at a wavelength of 635 nm. Presently, a new gun vessel and photocathode transport system is under manufacture, with a view to this being fully-installed on ALICE in Spring 2012.

TUPE096 **Recent Developments on ALICE (Accelerators and Lasers In Combined Experiments) at Daresbury Laboratory** – *Y.M. Saveliev, J.A. Clarke, S.P. Jamison, P.A. McIntosh, A.J. Moss, B.D. Muratori, S.L. Smith, N. Thompson (STFC/DL/ASTeC) M. Surman (STFC/DL/SRD) P. Weightman (The University of Liverpool)*

Progress made in ALICE (Accelerators and Lasers In Combined Experiments) commissioning and a summary of the latest experimental results are presented in this paper. After an extensive work on beam loading effects in SC RF linac (booster) and linac cavities conditioning, ALICE can now operate in full energy recovery mode at the bunch charge of 40pC, the beam energy of 30MeV and train lengths of up to 100us. This improved operation of the machine resulted in generation of coherently enhanced broadband THz radiation with the energy of several tens of uJ per pulse and in successful demonstration of the Compton Backscattering x-ray source experiment. The next steps in the ALICE scientific programme are commissioning of the IR FEL and start of the research on the first non-scaling FFAG accelerator EMMA. Results from both projects will be also reported.

TUPE097 **Coherent Synchrotron Radiation Simulations for the Cornell Energy Recovery Linac** – *C.E. Mayes, G.H. Hoffstaetter (CLASSE)*

Coherent Synchrotron Radiation (CSR) can be a detrimental effect on particle bunches with high charge and short bunch lengths. CSR can contribute to an increase in emittance and energy spread, and can limit the process of bunch compression. It is especially important in Energy Recovery Linacs (ERLs), because any energy lost by the particles is energy that cannot be recovered. Here we present CSR simulation results using the particle tracking code BMAD for all of the operating modes in the proposed Cornell ERL, including the bunch compression mode. These simulations consider the effect of CSR shielding, as well as CSR propagation between bends.

TUPE098 **Cornell Energy Recovery Linac Lattice and Layout** – *C.E. Mayes, G.H. Hoffstaetter (CLASSE)*

The current status of the lattice and layout for the proposed Cornell Energy Recovery Linac lightsource is presented. This design is centered about a new hard X-ray user facility to be located on Cornell's campus, and is adapted to the local topography in order to incorporate the existing CESR tunnel and Wilson Laboratory. Nonlinear charged-particle optics for this new machine have been designed and analyzed. The lattice is populated with various components for the appropriate accelerator physics requirenments, including instrumentation for orbit, bunch length and emittance growth, a vacuum system compatible with rest-gas-scattering limits, a collimation system for halo from effects like intra-beam-scattering, correction coils and BPMs for sub-micron beam stabilization, and ion-clearing electrodes at ion-accumulation points to limit emittance growth.

26-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area A

WEPEA — Poster Session

WEPEA001 **The Australian Synchrotron Accelerator Physics Program** – *G. LeBlanc (ASCo)*

The Australian Synchrotron has been running normal operations for beamlines since April 2007. The high degree of beam availability has allowed for an extensive accelerator physics program to be developed. The main points of this program will be presented, including student involvement at different levels and developments being made in anticipation of moving to top-up mode injections.

WEPEA002 **Maximising Beam Availability at the Australian Synchrotron** – *D. Morris, G. LeBlanc, D.C. McGilvery, J. Trewhella (ASCo)*

The Australian Synchrotron has been open to users since April 2007. Beam availability is now consistently above 98%, with a Mean Time Between Failures (MTBF) of approximately 50 hours and a Mean Down Time (MDT) of approximately 1 hour. This paper discusses the program of activities that has been undertaken to improve beam availability, and to maximize the MTBF and reduce the MDT.

WEPEA003 **Time-resolved Tune Measurements and Stability Analysis of the Australian Synchrotron Booster** – *T.K. Charles (Monash University, Faculty of Science) M.J. Boland, R.T. Dowd, M.J. Spencer (ASCo)*

The Australian Synchrotron booster synchrotron accelerates electrons from 100 MeV to 3 GeV in 600 ms. The fractional tune components that were measured are presented in two graphical formats showing the time-resolved measurement of the horizontal and vertical tunes. This experiment demonstrated that the current in the booster was extremely sensitive to the ratio of BF to BD combined-function magnets. Large variations of the fractional tunes were found to follow the differences in the gradients of the BD and BF combined-function magnet ramping curves and with this knowledge, alterations were made to the ramping table increasing the efficiency of the booster by on average 40%. Rapid fluctuation of the tunes meant that it could not be distinguished during the first 80ms of the ramp. Multiple side bands to the revolution harmonic were visible during a minimal sweep time of 2.5ms, during this first 80ms.

WEPEA004 **Large Vacuum Intervention to Install New BPMs and Radiation Absorbers into the LNLS Electron Storage Ring** – *R.M. Seraphim, O.R. Bagnato, F.H. Cardoso, R.H.A. Farias, R.O. Ferraz, H.G. Filho, F. R. Francisco, G.R. Gomes, S.R. Marques, R.T. Neuenschwander, F. Rodrigues, A.L. Rosa, M.B. Silva, M.M. Xavier (LNLS) P.F. Tavares (Karlsruhe Institute of Technology (KIT))*

An upgrade of the beam position monitors (BPMs) of the Brazilian Synchrotron Light Source (LNLS) storage ring was scheduled in the beginning of 2008. It was proposed replace the whole twenty four BPMs installed in the storage ring and install new radiation absorbers. One third of the BPMs were replaced in October 2008 and the remaining BPMs were replaced in October 2009. This large vacuum intervention was focused on having an electron beam orbit measurement system more thermally and mechanically stable. Finally, it will be presented the vacuum conditioning behavior of the machine after each large vacuum intervention.

WEPEA005 **Beam Position Interlock System for the LNLS 4 Tesla Superconducting Wiggler** – *F.H. Cardoso, J.F. Citadini, S.R. Marques, X.R. Resende, R.M. Seraphim (LNLS)*

The main facility of the Brazilian Synchrotron Light Laboratory is a 93 meters circumference, 1.37 GeV storage ring. Recently, the first superconducting insertion device was installed in the machine. This 4 T ID produces powerful beams that can damage the non-cooled parts of the accelerator vessel in the case of a miss-steered beam, even with a relatively large vacuum chamber cross section. In this paper we present the design details and the first operational results of the electronic beam position interlock system. Topics about redundancy engineering will be discussed as well.

WEPEA006 **Design Status of the New Brazilian Light Source** – *L. Liu, R.H.A. Farias, X.R. Resende, A.R.D. Rodrigues (LNLS)*
We report on the status of the new 3 GeV synchrotron light source currently being designed at the Brazilian Synchrotron Light Laboratory (LNLS) in Campinas, Brazil. The light source will consist of a low emittance storage ring based on the use of permanent magnet technology for the dipoles. An innovative approach is adopted to enhance the performance of the storage ring dipoles. The idea is to combine low field ferrite magnets for the main beam deflection and a short slice of NdFeB magnet. This short slice will create a high bending field only over a short longitudinal extent, generating high critical photon energy with modest energy loss from the complete dipole. There are several attractive features in this proposal, including necessity for lower RF power, less heating of the vacuum chambers and possibility to reduce the beam emittance by placing the longitudinal field gradient at a favorable place.

WEPEA007 **Production of Coherent Synchrotron Radiation at the Canadian Light Source** – *L.O. Dallin, W.A. Wurtz (CLS)*
Preliminary observations of coherent synchrotron radiation (CSR) at the Canadian Light Source have been reported earlier. At that time a more suitable operating point was identified based on particle tracking calculations. These calculations showed that a large stable longitudinal phase space can be achieved through adjustment of the chromaticities. With the implementation of these operating conditions CSR has been produced with much improved beam lifetime. CSR has been produced both with multiple bunches at 1.5 GeV and with a single bunch at the nominal 2.9 GeV beam energy. The production of CSR with these new operating points has proven to be reliable and repeatable. Operations at the nominal beam energy allows for setup times of under 20 minutes. With a beam lifetime (1/e) of over 7 hours single shifts dedicated to CSR production are now practical.

WEPEA008 **ASTRID2 - A New Light Source in Denmark** – *S.P. Møller, N. Hertel, J.S. Nielsen (ISA)*
At Aarhus University in Denmark, a new synchrotron radiation source is being built. The 46-m circumference storage ring with 6-fold symmetry will operate at 580 MeV to produce bright UV and soft x-ray radiation. The storage ring will have a horizontal emittance of around 10 nm. Four straight sections will be available for insertion devices including a 12-pole wiggler with a field of 2 Tesla. ASTRID2 will operate in top-up mode with electrons from the present storage ring ASTRID, used as a booster. The insertion devices will have a strong influence on the lattice, and studies of dynamical aperture and compensation of tunes and beta beat will be presented. Also injection simulations will be given. The technical layout with details about magnetic arrangements on girders will be shown, including the vacuum system with extensive use of NEG. A 10^5 MHz RF system is being built together with a new LLRF system. At present, most major components have been ordered, and first injection will take place in the first half of 2011.

WEPEA009 **Beam Dynamics of the 50 MeV Preinjector for the Berlin Synchrotron BESSY II** – *A.S. Setty, J.-L. Pastre (THALES) E. Weihreter (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*
A turn key 50 MeV linac is under construction, in order to inject electrons into the booster of BESSY II synchrotron in replacement of the existing microtron. The linac will deliver electrons according to two operations modes: a Short Pulse Mode (< 1 ns - 0.35 nC) and a Long Pulse Mode (40 to 300 ns - 3 nC). We have calculated the beam dynamics using our in house code, PRODYN *, from the gun to the end of the linac. This code has been previously used for the beam dynamics of the SOLEIL and ALBA linacs. The beam behaviour, such as the radial control, the bunching process, the energy spread and emittance are analysed.

WEPEA010 **Operation and Performance Upgrade of the SOLEIL Storage Ring** – *J.-M. Filhol, J.C. Besson, M.-E. Couprie, J. Denard, C. Herbeaux, P. Lebasque, M.-P. Level, P. Marchand, A. Nadji, R. Nagaoka (SOLEIL)*
The SOLEIL synchrotron light source is now delivering photons to 20 beamlines with a current of 400 mA in top-up mode. The long and short term H and V beam position stabilities are in the range of one micron thanks to the efficient slow and fast orbit feedbacks, and to the improved tunnel temperature regulation. The bunch by bunch transverse feedback

is running with two independent H and V loops. To enable canted undulator implementations, a 3 magnet chicane has been installed in a medium straight whereas an additional triplet of quadrupole was inserted in the middle of a long straight to create a double low vertical beta. 17 insertion devices are now installed in the storage ring, 2 will be added early 2010, 8 are under construction, including a cryogenic undulator. Following the significant progression of the vacuum conditioning, the lifetime is now mainly Touchek limited. An electron bunch slicing set-up is also being installed to provide 100 fs long X-rays pulses to two existing beamlines. ~4500 hours will have been delivered in 2009 to the Beamlines with an availability above 96 % thanks to the very reliable operation of the unique SOLEIL RF system.

WEPEA011 **Double Low Beta Straight Section for Dual Canted Undulators at SOLEIL** – *A. Loulergue, C. Benabderrahmane, F. Bouvet, P. Brunelle, M.-E. Couprie, J. Denard, J.-M. Filhol, C. Herbeaux, P. Lebasque, V. Leroux, A. Lestrade, O. Marcouillé, J.L. Marlats, F. Marteau, T. Moreno, A. Nadji, L.S. Nadolski, F. Polack, A. Somogyi, M.-A. Tordeux (SOLEIL)*

SOLEIL is the French 2.75 GeV high brilliance third generation synchrotron light source delivering photons to 20 beamlines with a current of 400 mA in multibunch or hybrid modes, and 60 mA in 8 bunch mode. There are already 17 insertion devices installed and 9 others are planned in the next 2 coming years. Among them, two canted in vacuum insertion devices are planned, for the Nanoscopium and Tomography beamlines, and will be accommodated in a 12 m long straight section, with a 6.5 mrad separation angle. These ~150 m long beamlines will exploit the high brilliance and coherence characteristics of the X-ray (5-20 keV) beam both for diffraction limited focusing and for contrast formation. To provide low vertical beta functions at each undulator, an extra triplet of quadrupoles was added in the middle of the section. We present here the lattice implementation footprint, the different working point under investigations as well as the first results of the measurements on the machine performances.

WEPEA012 **Status of the SOLEIL Femtosecond X-ray Source** – *A. Nadji, F. Briquez, M.-E. Couprie, J.-M. Filhol, C. Herbeaux, Ph. Hollander, V. Leroux, A. Loulergue, O. Marcouillé, J.L. Marlats, T. Moreno, P. Morin, S. Ravy, F. Sirotti (SOLEIL) O.V. Chubar (BNL) M. Meyer (LIXAM)*

An electron bunch slicing set-up is being installed on the SOLEIL storage ring, based on Zholents and Zolotorev method [1]. This will provide 100 fs long X-ray pulses with reasonable flux to two existing beamlines, working with soft X-rays (TEMPO) and hard X-rays (CRISTAL). The parameters of the laser system and of the wiggler modulator, and the optimisation of the laser focusing optics and beam path, from the laser hutch in the experimental hall to the inside of the storage ring tunnel have been finalised. The construction work will start early 2010, including the ordering of the laser, the construction of the laser hutch, the construction of the wiggler, the installation of a new modified vacuum dipole chamber by which the laser will enter into the ring, and the modifications of some components in the beamlines front-ends to provide the best possible separation of the sliced X-Ray. In this paper, we will report on the status of the installation of the set-up and the expected performances including laser-electron interaction efficiency, halo background effect and the possible operation filling patterns.

WEPEA013 **Operation and Upgrade of the ESRF Synchrotron Light Source.** – *J.-L. Revol, J.C. Biasci, J-F. B. Bouteille, J. Chavanne, P. Elleaume, F. Ewald, L. Farvacque, F. Franchi, L. Goirand, M. Hahn, L. Hardy, J. Jacob, J.M. Koch, M.L. Langlois, G. Lebec, J.M. Mercier, T.P. Perron, E. Plouviez, K.B. Scheidt, V. Serriere (ESRF)*

After 15 years of highly successful user operation, the Council of the ESRF are funding an ambitious 7 year upgrade programme (2009-2015) of the European Synchrotron Radiation Facility. In this context the accelerator complex will benefit from a number of upgrades. Several insertion device straight sections will be lengthened from five to six meters. The beamline scientific capacities will be increased by operating some straight sections in the canting geometry. New insertion devices will be built to fulfill the requirements of the scientific programme. The RF system also faces a major reconstruction with the replacement of some klystron based transmitters by high power solid state amplifiers and the development of HOM damped cavities operating at room temperature. The orbit stabilisation system system will be renovated. This paper reports on the present operation performances of the source, highlighting the recent development, as well as the advancement of the upgrade projects.

WEPEA014 **Optic calibration at the MLS and BESSY II** – *P.O. Schmid, P. Kuske (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) D.B. Engel, J. Feikes, R. Mueller, G. Wuestefeld (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

In this paper we present the results of our studies employing LOCO and MML for optic calibration at the MLS and at the BESSY II storage rings. Both the standard user modes and dedicated low alpha modes were analysed.

WEPEA015 **Coherent THz Measurements at the Metrology Light Source** – *G. Wuestefeld, J. Feikes, M.V. Hartrott (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) A. Hoehl, R. Klein, R. Müller, G. Ulm (PTB) P.O. Schmid (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH)*

The Metrology Light Source* is the first storage ring optimized for THz generation**. It applies a bunch shortening mode, based on a flexible momentum compaction factor 'alpha'. The emitted THz radiation is very sensitive to the machine tuning, its power could vary by many orders of magnitude. We report on coherent THz signal intensities as a function of different machine parameters, such as beam energy, beam current, rf voltage and alpha tuning.

WEPEA016 **Frequency Maps at PETRA III** – *A. Kling, K. Balewski (DESY)*

PETRA III is a 3rd generation synchrotron radiation light source which started commissioning in April 2009. Recently, first frequency map measurements have been made using the turn-by-turn capabilities of the beam position monitors and horizontal as well as vertical kicker magnets. The results are in good agreement with expectations from tracking studies performed with SixTrack.

WEPEA017 **Turn-by-turn Data Analysis for PETRA III** – *A. Kling, K. Balewski (DESY) R. Bartolini (JAI)*

PETRA III is a 3rd generation synchrotron radiation light source which started commissioning in April 2009. Turn-by-turn capabilities are available for all 227 BPMs installed in the storage ring thus providing a powerful diagnostic tool for the characterization of the linear and nonlinear motion of the stored beam. We report on first results of beam dynamics studies using multiturn data acquired at PETRA III and first steps towards a calibration of the linear and nonlinear lattice model of the storage ring.

WEPEA018 **Measurement of the Tune versus Beam Intensity at the Synchrotron Light Source PETRA III** – *R. Wanzenberg, K. Balewski (DESY)*

At DESY the PETRA ring has been converted into a synchrotron radiation facility, called PETRA III. The commissioning with beam started in April 2009. The betatron tune versus beam intensity was measured for different configurations of the wiggler magnets which are installed in PETRA III to achieve the small emittance of 1 nm. These measurements are compared with predictions from the impedance model. The measured tune shift is well within the impedance budget and the design single bunch intensities of up-to 2.5 mA can be stored in PETRA III. The predicted vertical tune shift is about 30 % smaller than the measured one.

WEPEA019 **Beam Studies for TBONE** – *S. Hillenbrand, M. Fitterer, N. Hiller, A. Hofmann, E. Huttel, V. Judin, M. Klein, S. Marsching, A.-S. Müller, K.G. Sonnad, P.F. Tavares (KIT)*

The Karlsruhe Institute of Technology (KIT) proposes to build a new light source called TBONE (THz Beam Optics for New Experiments), which aims at a spectral range from 0.1 to 150 THz with a peak power of several MW and a pulse length of only 5 fs. In order to achieve this, a beam transport system with minimal losses and a high bunch compression is required. In this paper we present first beam dynamic simulations of the superconducting linac as well as the bunch compressor and give a short status report of the TBONE project.

WEPEA020 **Observation of Bunch Deformation at the ANKA Storage Ring** – *N. Hiller, S. Hillenbrand, A. Hofmann, E. Huttel, V. Judin, B. Kehrer, M. Klein, S. Marsching, A.-S. Müller, N.J. Smale, K.G. Sonnad, P.F. Tavares (KIT)*

A dedicated optics with a low momentum compaction factor is used at the ANKA storage ring to reduce the bunch length to generate coherent synchrotron radiation (CSR). A double sweep streak camera is employed to determine the bunch length and shape for different optics and as a function of the beam current. Measurements of the longitudinal bunch profile have been performed for many different momentum compaction factors and various bunch currents. This paper describes the set up of the streak camera experiments and compares the measured bunch lengths to theoretical expectations.

WEPEA021 **Observation of THz-bursts with a Hot Electron Bolometer at the ANKA Storage Ring** – *V. Judin, S. Hillenbrand, N. Hiller, A. Hofmann, E. Huttel, M. Klein, S. Marsching, A.-S. Müller, N.J. Smale, K.G. Sonnad, P.F. Tavares (KIT) H.W. Huebers (Technische Universität Berlin) A. Semenov (DLR)*

Since a few years CSR-Radiation created in low alpha mode is provided by the ANKA light source of the KIT*. Depending on the bunch current, the radiation is emitted in bursts of high intensity. These bursts display a time evolution which can be observed only on long time scales with respect to the revolution period. The intensity of the emitted radiation during a burst is significantly increased w.r.t. steady state emission. Some users of the THz radiation don't require particularly constant emission characteristics and could profit from the higher intensity. A better understanding of the long term behaviour of those bursts could help to improve the conditions for those users. We have investigated THz radiation in multiturn mode with a hot electron bolometer. Its time response of 165ps allowed us to resolve the signals of individual bunches. Using a 6GHz LeCroy oscilloscope for data acquisition, we were able to save up to 1.6ms long signal sequences at a sampling rate of 20GS/s. This amount of data corresponds to over 4000 bunch revolutions and allows turn-by-turn signal tracking of desired bunches. In single bunch mode we are able to take segmented data to avoid a huge overhead.

WEPEA022 **Studies of Polarisaion of Coherent THz Edge Radiation at the ANKA Storage Ring** – *A.-S. Müller, I. Birkel, M. Fitterer, S. Hillenbrand, N. Hiller, A. Hofmann, E. Huttel, V. Judin, M. Klein, S. Marsching, Y.-L. Mathis, P. Rieger, N.J. Smale, K.G. Sonnad, P.F. Tavares (KIT) H.W. Huebers (Technische Universität Berlin) A. Semenov (DLR)*

In synchrotron radiation sources coherent radiation is emitted when the bunch length is comparable to or shorter than the wavelength of the emitted radiation. At the ANKA storage ring this radiation is observed as so-called edge radiation (emitted in the fringe field of a bending magnet). This radiation exhibits a radial polarisation pattern. The observed pattern, however, is influenced by the radiation transport in the beam line. A detector system based on a superconducting NbN ultra-fast bolometer with an intrinsic response time of about 100 ps as well as conventional Si bolometers were used to study the beam polarisaion. This paper reports the observations made during measurements.

WEPEA023 **Proposal for National Iranian Synchrotron Light Source** – *J. Rahighi (IPM) S. Varnasseri (SESAME)*

An overview of the 3 GeV Synchrotron radiation source, which is under design in Iran will be presented with emphasis on site location studies, user demands and general parameters of the machine. The background to the proposed facility and different aspects of the machine design also is reported. Operating this third generation light source with 3 GeV storage ring and beam currents of up to 400mA, will result in a source of very intense light over a broad range of photon energies from the IR to hard X-rays to a community that is expected to exceed 500 users a few years after the start of operation in 2015 .

WEPEA024 **Bunch Lengthening Effects by Utilizing a Third Harmonic Cavity in Conjunction with Crab Cavities in TPS** – *H. Ghasem (IPM) H. Hassanabadi (Shahrood University of Technology) A. Mohammadzadeh (NSTRI)*

The effects of utilizing a third harmonic RF cavity in the lengthening mode have been investigated on quality of the electron beam and the emitted photons in the deflecting RF structures for TPS. For the obtained optimum synchronous and relative harmonic phases and harmonic voltage of 0.7 MV, the equilibrium horizontal and vertical emittances blow up as much as 13% and 97%, respectively. In addition, the intensity of the emitted X-ray pulses with 0.54 ps FWHM reduces by 30%.

WEPEA025 **Utilization of Crab Cavities in the Designed QBA Lattice of the 3 GeV Taiwan Photon Source** – *H. Ghasem (IPM) G.-H. Luo (NSRRC) A. Mohammadzadeh (NSTRI)*

A pair of superconducting crab cavities has been studied in the QBA low emittance lattices of the 3 GeV TPS for generating ultra short X-ray pulses. Three configurations with different locations for the two cavities in a super-period of the TPS ring are investigated. The configuration with positioning the RF deflectors between the QBA cells in each super-period as an optimum arrangement gives rise to better quality electron bunches and radiated photon pulses. The FWHM of the radiated photon pulses of about 540 fs with an acceptable intensity is attained by optimizing the compression optical elements of the TPS photon beam line.

WEPEA026 **On Multipacting-free Waveguide for High Current Light Source** – *M. Mostajeran, M. Lamehi Rachti (IPM)*

Abstract Multipactor discharge is the most serious problem for operation superconducting cavity at high RF power system. We intend to study a multipacting free waveguide for the high RF power couplers of Cornell SRF module. The secondary electron yield of metallic conductor plays a critical role in the development of multipactor discharge. By reducing the secondary yield below unity, multipactor can be eliminated. One way to overcome this difficulty is roughness method such as sawtooth and rectangular surface. Sometimes it is difficult to apply these grooves due to require size. Here sandblasting method is proposed to reducing the secondary yield. Monte-Carlo method is used to investigate the effect of sandblasting on multipactor. The equation of motion particles between parallel plats is used as the basis for numerical simulations within a wide range of parameters such as the angular distribution and spread of initial velocity of secondary electrons.

WEPEA028 **Top-up Implementation and Operation at Elettra** – *E. Karantzoulis, A. Carniel, K. Casarin, S. Ferry, G. Gaio, F. Giacuzzo, S. Krecic, E. Quai, C. Scafuri, G. Tromba, A. Vascotto (ELETTRA)*

Elettra established top-up operations taking full advantage of its new full energy injector. The fact that Elettra operates for users at two different energies namely at 2 and 2.4 GeV adds another degree of difficulty to the involved actions. In the paper the top up implementation, operation and radiation measurements are presented and discussed as well as future plans for rendering the system more transparent to the users.

WEPEA029 **HiSOR-II, Future Plan of Hiroshima Synchrotron Radiation Center** – *A. Miyamoto, K. Goto, S. Sasaki (HSRC) S. Hanada (Hiroshima University, Graduate School of Science) H. Tsutsui (SHI)*

The HiSOR is a synchrotron radiation (SR) source of Hiroshima Synchrotron Radiation Center (HSRC), Hiroshima University, established in 1996. HiSOR is a compact racetrack-type storage ring having 21.95 m circumference, and 400-nmrad natural emittance, which is not so small compared with those of other medium~large storage rings. There are 14 beamlines on HiSOR, but the ring has only two straight sections for undulators which are obviously not compatible with modern SR facilities. Therefore, we are planning to construct a compact storage ring, 'HiSOR-II' in which undulators are dominant light sources. We refer to the electron storage ring MAX-III as the best models to design HiSOR-II lattice. This 700 MeV storage ring is designed that the circumference is equal to or less than 50 m so that it can fit in our existing site. It has several straight sections for undulators, and its natural emittance is about 14nmrad. The booster ring aiming for the top-up injection is constructed on the inside basement of HiSOR-II. This layout brings advantages in radiation shielding and prevention of magnetic field interference between two rings.

WEPEA030 **Improved Stability of the Radiation Intensity at the New-SUBARU Synchrotron Radiation Facility** – *S. Hashimoto, S. Miyamoto (NewSUBARU/SPring-8, Laboratory of Advanced Science and Technology for Industry (LASTI))*

K. Kawata, Y. Minagawa, T. Shinomoto (JASRI/SPring-8)
The periodic fluctuations and drifts in the radiation intensity have been observed at the NewSUBARU synchrotron radiation facility. To clarify the cause of this problem we have measured temperatures of air, cooling water, equipments and building with the network-distributed data logger. And we found that temperature fluctuations in both air in the shielded tunnel and the cooling water mainly affect the stabilities of electron beam orbit and optical axis. To maintain a constant temperature, the large doors for carrying equipment at the experimental hall were covered with insulated curtains, and we optimized PID parameters of temperature controllers for air and water. As results, the periodic fluctuations almost disappeared, but some drifts were still remained, which are due to slow variations of equipment temperature. By realizing the automatic COD correction, the drift in electron beam position could be suppressed and the fluctuations of radiation intensity observed at beam-lines became smaller than they used to be. For further stabilization, we recently introduced a XBPM upstream in a beamline to measure the vertical position of radiation axis precisely.

WEPEA031 **Suppression of Horizontal Beam Oscillation by using Fast Kicker Magnet System in SPring-8 Storage Ring** – *C. Mitsuda, K. Fukami, K. Kobayashi, M. Oishi, Y. Okayasu, M. Shoji, K. Soutome, H. Yonehara (JASRI/SPring-8) T. Nakanishi (SES) T. Ohshima (RIKEN/SPring-8)*
In top-up operation at SPring-8 the horizontal beam oscillation had been excited because the injection bump orbit is not closed perfectly. For this problem, we had made an effort to reduce the residual beam oscillation by the improvement of bump magnet design, reducing the effect due to the nonlinearity of sextupole magnet and introducing pulsed corrector magnet, etc. By these improvements the average amplitude of residual oscillation has now been suppressed to the level of less than 0.1 mm. Still remaining relatively large residual oscillation comes from a non-similarity of a temporal shape of magnetic field of four bump magnets. We then started development fast kicker magnet system to give a counter kick to this part of residual beam oscillation. A key technology in this development is how to generate a large pulsed current in a short period to meet the oscillation characteristic. A newly developed fast pulsed power supply can generate a current of about 300 A, or corresponding magnetic field of 4.61 mT, with a pulse width of 1.2 us. Recently, we succeeded in the reduction of the horizontal beam oscillation at the timing of firing bump magnets by using this kicker system.

WEPEA032 **Design Study of a very Low-emittance Storage Ring for the Future Upgrade Plan of SPring-8** – *K. Soutome, H. Ohkuma, J. Schimizu, Y. Shimosaki, M. Takao (JASRI/SPring-8)*
The SPring-8 storage ring has been operated for more than ten years and provided brilliant hard X-ray radiation to users. In recent years there are some discussions on upgrade plans of existing synchrotron radiation facilities and proposals of new facilities. In these the target brilliance of photons is set to be comparable or even higher, in some energy range, than that of the present value of SPring-8. At SPring-8 a design study of a new storage ring is now in progress for the future upgrade plan. The lattice structure will be changed from the present double-bend type to the multi-bend one, keeping the source position of all insertion devices unchanged. The emittance will be lowered from the present value of 3.4nmrad at 8GeV to 0.4nmrad at 6GeV (or 0.8nmrad at 8GeV) in the case of triple-bend lattice and 0.2nmrad at 6GeV (or 0.3nmrad at 8GeV) in the case of quadruple-bend lattice. We will report the present state of our preliminary work on lattice design. Nonlinear resonance correction to enlarge the dynamic aperture for on- and off-momentum electrons will also be discussed.

WEPEA033 **Ultra-bright and Ultra-low Emittance Light Source Storage Ring with Four Long Straight Sections** – *K. Tsumaki (JASRI/SPring-8)*
We indicated that a storage ring with picometer-order emittance is possible with realistic parameters and is promising as a next generation synchrotron radiation source* and applied it to the SPring-8 storage ring**. The storage ring had the same circumference as that of the SPring-8 storage ring, but had not four long straight sections that SPring-8 storage ring has. Accordingly, the storage ring beam line is slightly different from that

of the SPring-8 and the positions of photon beam lines are also different from the existing one. To avoid this, a storage ring with four long straight sections has been studied and was found that the storage ring with the same beam line positions as the existing one is possible. The storage ring consists of twenty ten-bend achromat cells, four five-bend achromat cells and four long straight sections. The long straight section length is 34.0 m and the short one is 6.6 m. The natural emittance is 10^8 pm-rad. The maximum brightness is 2.5×10^{22} photons/s/mm**2/mrad**2 in 0.1% BW with 200 mA beam current, about 160 times brighter than SPring-8. In the end I mention that this ultra-low emittance storage ring is only a result of personal design study.

WEPEA034 **Development and Operational Status of PF-Ring and PF-AR** – *T. Honda (KEK)*

KEK manages two synchrotron radiation sources, Photon Factory storage ring (PF-ring) of 2.5 GeV and Photon Factory advanced ring (PF-AR) of 6.5 GeV. These rings share an injector linac with the two main rings of KEK B-factory, 8-GeV HER and 3.5-GeV LER. Recently, the linac has succeeded in a pulse by pulse multi-energy acceleration. A top-up operation of PF-ring has been realized as the simultaneous continuous injection to the 3 rings, PF-ring, HER and LER. Development of new injection scheme using a pulsed sextupole magnet continues aiming at practical use in the top-up operation. A rapid-polarization-switching device consisting of tandem two APPLE-II type undulators has been developed at PF-ring. The first undulator was installed in 2008, and the second one will be installed in 2010 summer. PF-AR, operated in a single-bunch mode at all times, has been suffered from sudden lifetime drop phenomena attributed to dust trapping for many years. Using the movable electrodes installed for experiment, we confirmed that the discharge created by the electrode was followed by the dust trapping, and succeeded in a visual observation of luminous dust streaking in front of CCD cameras.

WEPEA035 **Test of Hybrid Fill Mode at the Photon Factory Storage Ring** – *R. Takai, T. Honda, Y. Kobayashi, T.M. Mitsuhashi, T. Obina, M. Shimada, Y. Tanimoto (KEK)*

A hybrid fill mode has been tested at the Photon Factory storage ring (PF-ring). The hybrid fill mode consists of a train of low-current bunches and a high-current single bunch. Since a bunch-by-bunch feedback system was not available because of the high contrast of currents between the bunch train and the single bunch, we suppressed multibunch instabilities in the transverse and longitudinal planes by using the octupole magnets and RF phase modulation, respectively. We also suppressed single-bunch instabilities by controlling ring chromaticity. As a result, we successfully stored a 450 mA current with the hybrid fill mode: 1/2 filling (2.56 mA/bunch × 156) + 1 single bunch opposite to the bunch train (50 mA/bunch). The distribution of vacuum pressures along the ring was similar for the hybrid fill and the typical single-bunch mode. In this conference, we will present the results of this test experiment as well as some future subjects to be solved for the user operation.

WEPEA036 **Accelerators of the Central Japan Synchrotron Radiation Research Facility Project** – *N. Yamamoto, M. Hosaka, H. Morimoto, K. Takami, Y. Takashima (Nagoya University) Y. Hori (KEK) M. Katoh (UVSOR) S. Koda (SAGA) S. Sasaki (JASRI/SPring-8)*

Central Japan Synchrotron Radiation (SR) Research Facility is under construction in the Aichi area, and the service will start from FY2012. Aichi Science & Technology Foundation is responsible for the operation and management, and Nagoya University SR Research Center is responsible to run the facility and support the users technically and scientifically. The accelerators consists of an injector linac, a booster synchrotron and an 1.2 GeV electron storage ring with the circumference of 72 m. To save construction expenses, the 50 MeV linac and the booster with the circumference of 48 m are built at inside of the storage ring. The beam current and natural emittance of the storage ring are 300 mA and 53 nmrad. The magnetic lattice consists of four triple bend cells and four straight sections 4 m long. The bending magnets at the centers of the cells are 5 T super-bends and the critical energy of the SR is 4.8 keV. More than ten hard X-ray beam-line can be constructed. One variable polarization undulator will be installed in the first phase. The electron beam will be injected from the booster with the full energy and the top-up operation will be introduced as early as possible.

WEPEA037 **Study of the Coherent Terahertz Radiation by Laser Bunch Slicing at UVSOR-II Electron Storage Ring** – *N. Yamamoto, M. Hosaka, Y. Taira, Y. Takashima (Nagoya University) M. Adachi, M. Katoh, S.I. Kimura, H. Zen (UVSOR) M. Shimada (KEK) T. Takahashi (KURRI) T. Tanikawa (Sokendai - Okazaki)*

Terahertz (THz) coherent synchrotron radiation (CSR) is emitted not only from shorter electron bunches compared with the radiation wavelength but also from electron bunches with μstructures. Formation of μstructures at sub picosecond scale in electron bunches by a laser slicing technique is experimentally studied through observation of THz CSR. The properties of the THz CSR such as intensity or spectrum depend strongly on the shape and amplitude of the μstructure created in the electron bunches. To study in detail the formation of μstructure in electron bunches using the laser slicing technique, we have performed experiments at the UVSOR-II electron storage ring. THz CSR, which contains information on the μstructure, was observed under various laser conditions. The THz CSR spectrum was found to depend strongly on the intensity and the pulse width of the laser. The results agreed qualitatively with a numerical calculation. It was suggested that the evolution of the μstructure during CSR emission is important under some experimental conditions.

WEPEA038 **Present Status and Upgrade Plan on Coherent Light Source Developments at UVSOR-II** – *M. Adachi, K. Hayashi, M. Katoh, S.I. Kimura, J. Yamazaki, H. Zen (UVSOR) M. Hosaka, Y. Taira, Y. Takashima, N. Yamamoto (Nagoya University) T. Takahashi (KURRI) T. Tanikawa (Sokendai - Okazaki)*

UVSOR, a 750 MeV synchrotron light source of 53m circumference had been operated for more than 20 years. After a major upgrade in 2003, this machine was renamed to UVSOR-II. The ring is now routinely operated with low emittance of 27 nm-rad and with four undulators. By utilizing a part of the existing FEL system and an ultra-short laser system, coherent synchrotron radiation in THz range and coherent harmonic generation in VUV range have been extensively studied under international collaborations. Based on results obtained from previous coherent light source developments, a new five-year research program on the coherent light source developments has been started from FY2008, which includes creation of a new 4-m long straight section by moving the injection point, upgrades of the undulator and the laser system and construction of dedicated beam-lines for these coherent light sources. Present status and upgrade plan on these coherent light sources at UVSOR-II will be presented at the conference.

WEPEA039 **Status of Top-up Operation in UVSOR-II** – *H. Zen, K. Hayashi, J. Yamazaki (UVSOR) M. Adachi, M. Katoh, T. Tanikawa, H. Zen (Sokendai - Okazaki) M. Hosaka, Y. Taira, N. Yamamoto (Nagoya University)*

UVSOR-II is a low emittance, 750 MeV synchrotron light source. Low emittance and low energy synchrotron light sources naturally suffered from short electron lifetime due to Touschek effect. Top-up operation is a solution for overcoming the effect. In the UVSOR-II, trials of multi-bunch top-up operation at the full energy were started from 2008. In the trials, we have succeeded in keeping the stored beam current around 300 mA for 12 hours. From this fiscal year, single bunch injection was started for single bunch user operations and for experiments on advanced light source development such as Free Electron Laser (FEL), Coherent Synchrotron Radiation (CSR), Coherent Harmonic Generation (CHG), which require single bunch or 2-bunch filling operation. We have already performed single bunch top-up operation in user time with the stored beam current of 50 mA. And FEL lasing with top-up operation was also achieved at the laser wavelength of 215 nm with the stored beam current of 130 mA / 2-bunch. In the FEL lasing experiment, we succeeded in keeping the average power of FEL around 130 mW for three hours.

WEPEA040 **Progress and Status of Synchrotron Radiation Facility SAGA-LS** – *S. Koda, Y. Iwasaki, T. Kaneyasu, Y. Takabayashi (SAGA)*

Saga Light Source (SAGA-LS) is a synchrotron radiation facility with a 255 MeV linac and a 1.4 GeV storage ring. The spectral range covers from VUV to hard X ray region of about 23 keV. Improvement and development of the accelerator have been achieved from official opening of the facility. Stored current of the storage ring has been increased from 100 mA to 300 mA in these three years. An APPL·10^{-2} undulator was developed and installed to a long straight section LS3. A field correction system for the undulator was developed to compensate precisely betatron tune shift, dipole kick and skew quadrupole. A superconducting wiggler is under construction. The peak field and critical energy are 4 T and 5.2 keV, respectively. The wiggler will provide synchrotron radiation in the 20-40 keV range. The wiggler consists of a superconducting main pole and two normal conducting side poles. The main pole is directly cooled by a small GM cryocooler and liquid helium is not used. In addition, laser Compton scattering experiment is under progress. A port to introduce CO2 laser light was installed as a beam line BL1. First gamma ray was observed in December 2009.

WEPEA041 **Emittance Growth Estimation due to Intrabeam Scattering in Hefei Advanced Light Source(HALS) Storage Ring** – *W. Fan, G. Feng, D.H. He, W. Li, L. Wang, S.C. Zhang (USTC/NSRL)*

Hefei Advanced Light Source(HALS) will be a high brightness light source with about 0.2nmrad emittance at 1.5GeV and about 400m circumference. To enhance brilliance, very low beam emittance is required. High brightness demand and relative low energy will make emittance a critical issue in ring design. Intra-beam scattering(IBS) is usually thought a fundamental limitation to achieve low emittance. Here we preliminarily estimate the emittance growth due to IBS for the temporary lattice design of HALS based on Piwinski and Bjorken-Mtingwa theories, and discuss the effect of implementation of damping wiggler and harmonic cavity to lower the emittance.

WEPEA042 **Lattice Design and Beam Lifetime Study for HLS Storage Ring Upgrade Project** – *G. Feng (USTC/NSRL)*

HLS (Hefei Light Source) is a dedicated synchrotron radiation research facility,whose emittance is relatively large. In order to improve the performance of HLS,especially getting higher brilliance synchrotron radiation and increasing the number of straight section for insertion devices,an upgrade project will be proceeded soon.a new low emittance lattice,whose circumference is same to that of current storage ring but the focusing structure is different, has been studied and presented in this paper. For the upgrade project,the new ring will be installed on current ground settlement of HLS and all of the magnets will be reconstructed. After optimization,two operation modes has been found for different users. Nonlinear dynamics shows that the dynamic aperture for on-momentum and off-momentum particle is large enough. Beam lifetime has also been studied. Calculation results proves that about 9 hours beam lifetime can be obtained with a fourth harmonic cavity installation.

WEPEA043 **The Hefei Light Source Upgrade Project** – *L. Wang, W. Fan, G. Feng, W.W. Gao, W. Li, H. Xu, S.C. Zhang (USTC/NSRL)*

The Hefei Light Source is composed of an 800 MeV storage ring, a 200 MeV electron linac and transfer line, which was designed and constructed twenty years ago. Several factors limit the performance of HLS, for example, less number of insertion devices and large beam emittance. To meet the requirements of synchrotron radiation users, an upgrade project of HLS will be carried out in the next two years. Several sub-systems will be renewed, such as magnet system, power supply, beam diagnostics, vacuum system, etc. The upgrade scheme is described in this paper, including magnet lattice design, nonlinear performance, collective effects,beam injection, orbit detection and correction, injector, etc.

WEPEA044 **Operating Status of SSRF Booster** – *D.M. Li, H.H. Li, H.P. Yan, W.Z. Zhang, Z.T. Zhao (SINAP)*

The SSRF booster was built for normal injection and top-up injection of SSRF storage ring. Since the completion of beam commissioning in the end of 2007, the SSRF booster has been already served as the injector of storage ring with a very low failure rate for more than two years. The energy save mode of the booster dynamic power supply system has been employed since middle of 2008. With a wonderful result that all main performance indexes are reached into designment, the SSRF booster was passed the formal examination by CAS in April, 2009. In this paper, the performance upgrading, operating status, statistic parameters for the SSRF booster are described.

WEPEA045 **Beam Dynamics in the SSRF Storage Ring** – *H.H. Li, J. Hou, B.C. Jiang, L.G. Liu, X.Y. Sun, S.Q. Tian,*

M.Z. Zhang, W.Z. Zhang (SINAP)
SSRF has reached its specification and commenced routine operation in April 2009. In order to obtain better performance, a series of machine studies were carried out in this year. We describe here the results about these studies, including orbit correction and stability, beam optics, and collective effects. The planes for top-up injection, orbit fast feedback, and dual canted undulators, are summarized as well.

WEPEA046 **Study of the Top-up Operation at SSRF** – *H.H. Li (SINAP)*
SSRF is a third generation light source, with the facility now fully operationl, the next major work in machine operations will be top-up mode. Beam current will oscillate within less than 1% level during top-up operation, that means the injection process will running frequently, mostly once per several minutes, and the users can still do experiment during this period. To achieve a good current stability, the system must have high injection efficiency, sufficient long life time and less distortion of the stored beam, etc. An overview of the top-up simulation and experiment will be given.

WEPEA047 **Operation of SRF in the Strage Ring of SSRF** – *J.F. Liu, H.T. Hou, C. Luo, Zh.G. Zhang, S.J. Zhao (SINAP) Z.Q. Feng, Z. Li, D.Q. Mao, Y.B. Zhao, X. Zheng (Shanghai KEY Laboratory of Cryogenics & Superconducting RF Technology)*
The superconducting RF system has been operated successfully in the storage ring of SSRF since July, 2008. The superconducting RF modules integrated with 310 kW transmitters and digital low level radio frequency (LLRF) control are adopted to provide about 4.5 MV cavity voltages to 3.5GeV electron beam. The operation status of SRF system is mainly reported here, the problems we met are analyzed, and the operation with normal conducting cavity systems is introduced briefly. The challenge for us is to improve the system reliability and machine performance.

WEPEA048 **A Design Approach of the Beam Optics in the Complex Storage Ring** – *S.Q. Tian (SINAP)*
Beam optics design is a crucial issue in modern synchrotron radiation facility. A design approach of the beam optics is presented here. It provides much convenience for effectively exploring achievable linear optics and globally investigating flexibility of a complex lattice with super-periodicity. Low-ϵ optics and low-αC optics are emphasized, and the SSRF storage ring is taken as a test lattice.

WEPEA049 **Commissioning of the Shanghai Synchrotron Radiation Facility (SSRF) 150MeV LINAC** – *M.H. Zhao, Y.Z. Chen, G.Q. Lin, W.M. Zhou (SINAP)*
Commissioning of the linac for The Shanghai Synchrotron Radiation Facility (SSRF) 150MeV LINAC was completed in July 2007. The linac was designed and built by Shanghai Institute of Applied Physics. The beam diagnostics, beam analysis software, control system hardware and standard vacuum components was carried out. Operation of the linac at 150MeV in single-pulse and multi-pulse modes of operation was demonstrated, and all operational parameters were measured to be within specification.

WEPEA050 **Studies on Higher Order Modes Damper for the 3rd Harmonic Superconducting Cavity of SSRF** – *H. Yu (SSRF) M. Chen, Z.Q. Feng, H.T. Hou, J.F. Liu, Z.Y. Ma, D.Q. Mao, X. Zheng (SINAP)*
To investigate the higher order mode(HOM) damping in the higher harmonic cavity for Shanghai Synchrotron Radiation Facility(SSRF) when using HOM absorbers,simulations have been done for changing the position and the length as well as the thickness of ferrite of HOM damper. The best values under which the Q value of HOMs can be greatly lowered and the impedance of harmonic cavity will be trapped in the impedance threshold have been found. Bonding a RF absorber to a heat sink is a key of the aspect of the load. Soldering the ferrite tile to the Elkonite(W and Cu alloy) board is the way of dealing with the problems of a heat sink material with the thermal expansion coefficient different to ferrite. After plating in vacuum brazing furnace, good braze result have been seen. Individual panels test of Elkonite with bonded ferrite have been tested, the panels are mounted on a broad wall of GB-14 waveguide, fed by up to a 500WCW at 1500MHz by a power source. The RF power in the test is typically limited to 300W,with 12 such assemblies per load, the assembled unit is effectively tested up to 4.4kW average HOM power.

WEPEA051 **Performance Improvements of the Pohang Light Source** – *S.J. Park, I. Hwang, C. Kim, K.R. Kim, M. Kim, J.W. Lee, S.H. Nam, C.D. Park (PAL) S. Shin (PLS)*

Much efforts have been devoted to improve the beam performance of the Pohang Light Source (PLS). With careful alignments to flatten the storage ring in the year 2009 summer shutdown, we could obtain much better static orbit resulting in many improvements. We have obtained the emittance coupling ratio ~1% (without any coupling corrections) which was measured by the interferometric beam size monitor and the closest-tune approach method. The revolver in-vacuum undulator installed at the #11 straight is now operating at the full gap 6 mm. In 2010, top-up operation mode will be implemented to the PLS in order to overcome lifetime reductions due to ever-being-reduced vertical beam sizes and installations narrower-gap in-vacuum undulators.

WEPEA052 **A Field Measurement System for the PLS-II Magnet** – *K.-H. Park, H.S. Han, Y.-G. Jung, D.E. Kim, K.R. Kim, H.-G. Lee, H.S. Suh (PAL) B.-K. Kang (POSTECH)*

The PAL (Pohang Accelerator Laboratory) has been carrying out the performance upgrade project, PLS-II. The lattice of the storage ring for PLS-II was changed in whole. The energy was increase from 2.5GeV to 3.0GeV thus many magnets installed in storage ring at present should be replaced with new one or modified. The field of the quadrupole and sextupole magnets will be measured using the rotating coils that are newly fabricated with the engineering ceramic for the first time at PAL. The data acquisition system for the field measurement was also rebuilt to make it simple and to have a good signal to noise ratio. In this presentation, the design parameters of the ceramic rotating coil are described. And various characteristics of the field measurement system are also presented

WEPEA054 **Status of the ALBA project** – *D. Einfeld (CELLS-ALBA Synchrotron)*

The Synchrotron Light source ALBA is entering the commissioning period and beam should be provided to the users by the end of 2010. The installation of the full energy 3 GeV booster is finished, with the commissioning taking place in January 2010. The installation of the storage ring is almost finished and the commissioning should take place in summer 2010. The detailed milestones of the project are presented.

WEPEA055 **General description of IDs initially installed at ALBA** – *J. Campmany, D. Einfeld, J. Marcos, V. Massana (CELLS-ALBA Synchrotron)*

The new 3rd generation synchrotron radiation source ALBA built nearby Barcelona is planned to start operation in 2010 with several different insertion devices installed in the storage ring either from the beginning or within the first year of operation. The list of first insertion devices includes: 2 planar PPM SmCo in-vacuum undulators with the period of 21.6 mm; 2 Apple-II type PPM NdFeB undulators with the periods of 62.36 and 71.36 mm respectively; 1 superconducting planar wiggler with the period of 30 mm and a maximum field of 2.1 T, and a 1 conventional wiggler with the period of 80.0 mm and a maximum field of 1.74 T. The emitted light of these IDs covers wide spectral range extending from hard X-rays to UV. Pre-design of the IDs was done by ALBA, but manufacturing has been outsourced. Production is now finished and they have been tested with magnetic measurements. The paper will present the final as build magnetic designs as well as the main results of magnetic measurements performed on the manufactured devices.

WEPEA056 **First beam optics measurements during the commissioning of the ALBA booster** – *G. Benedetti, D. Einfeld, Z. Martí, M. Munoz (CELLS-ALBA Synchrotron)*

The commissioning of the booster for the synchrotron light source ALBA should take place in the period December 2009-January 2010. In this paper, the beam dynamics aspects of the commissioning are described, including the studies performed, the main problems find during the commissioning and a comparison of the measured beam parameters to the design one. A description of the software tools used and developed for the task is included.

WEPEA057 **RF System of the ALBA Booster: Commissioning and Operation** – *F. Perez, A. Salom, P. Sanchez (CELLS-ALBA Synchrotron)*

The Booster of the ALBA synchrotron light source will inject, in top up mode, up to 2 mA of current at 3Hz into the storage ring. The booster ramps the energy from 100 MeV (Linac) up to the 3 GeV of the storage ring. The RF system of the booster consist of a 80 kW IOT amplifier, a WR1800 waveguide system, a 5-cell Petra cavity and a Digital LLRF system. In this paper we will present a short description of the system, its performance during the commissioning phase and the results of operation with beam.

WEPEA058 **Status of the MAX IV Storage Rings** – *S.C. Leemann, J. Ahlback, Å. Andersson, M. Eriksson, M.A.G. Johansson, L.-J. Lindgren, M. Sjöström, E.J. Wallén (MAX-lab)*
In 2009 the MAX IV facility was granted funding by Swedish authorities. Construction of the facility will begin this summer and user operation is expected by 2015. MAX IV will consist of a 3 GeV linac as a driver for a short-pulse radiation facility (with planned upgrade to a seeded/cascaded FEL) as well as an injector for two storage rings at different energies serving user communities in separate spectral ranges. Thanks to a novel compact multibend-achromat design, the 3 GeV ring will deliver a 500 mA electron beam with a horizontal emittance below 0.3 nm rad to x-ray insertion devices located in 19 dispersion-free 5 m straight sections. When the 3 GeV ring goes into operation in 2015 it is expected to become the highest-brightness storage ring light source worldwide. The 1.5 GeV ring will serve as a replacement for both present-day MAX II and MAX III storage rings. Its below 6 nm rad horizontal emittance electron beam will be delivered to infrared and UV insertion devices in twelve 3.5 m straight sections. We report on design progress for the two new storage rings of the MAX IV facility.

WEPEA059 **Energy Acceptance and Touschek Lifetime for the TPS Storage Ring** – *H.-J. Tsai, H.-P. Chang, M.-S. Chiu, P.J. Chou, C.-C. Kuo, G.-H. Luo, F.H. Tseng, C.H. Yang (NSRRC)*
Touschek scattering is an important beam lifetime limiting effect for the TPS storage ring due to several challenges such as low emittance, small physical aperture and large second-order momentum compaction factor (nonlinear longitudinal motion). The Touschek relevant energy acceptance is determined by these challenges, therefore a reliable estimate of the Touschek lifetime is essential. We obtained Touschek induced betatron oscillation amplitudes in three sections (LS, SS and ARC) and RF bucket acceptance analytically and with simulations. In this paper, we present the energy acceptance and Touschek lifetime calculations for the TPS storage ring in the cases for different chromaticity settings, ID chamber limitations, magnet multipole field errors and optics correction effects.

WEPEA060 **An Update of the Lattice Design of the TAC Proposed Synchrotron Radiation and Insertion Devices** – *K. Zengin, A.K. Ciftci, R. Ciftci (Ankara University, Faculty of Sciences)*
The Turkish Accelerator Center (TAC) is a project for accelerator based fundamental and applied researches supported by Turkish State Planning Organization (TSPO). The proposed synchrotron radiation facility of TAC was consisted of 3.56 GeV positron ring for a third generation light source. In the first study, it was shown that the insertion devices with the proposed parameter sets produce maximal spectral brightness to cover 10 eV - 100 keV photon energy range. Now, in this study it is considered that the electron beam energy will be increased to 4.5 GeV, in order to obtain more brightness light and wide energy spectrum range, also the beam emittance reduced to 1 nm.rad.

WEPEA061 **Comparative Analysis of Compton Scattering Cross Section Derived with Classical Electrodynamics and with use of Quantum Approach** – *I.V. Drebot, Yu.N. Grigor'ev, A.Y. Zelinsky (NSC/KIPT)*
In the paper the expression for cross section of Compton scattering derived with classical electrodynamics approach is presented. The comparative analysis of the Compton cross section value calculated with the presented expression and with expression derived with quantum approach was carried out for the case of head on collision and low photon beam intensity. Results of the analysis show the good agreement of both approaches. It proves legitimacy of classical electromagnetic approach use for analysis of particle beam dynamics and estimation of generated x-ray beam parameters in laser electron storage rings.

WEPEA063 **Status of NESTOR Facility** – *A.Y. Zelinsky (NSC/KIPT)*
The status of X-ray generator NESTOR that is under construction in Kharkov Institute of Physics and Technology is described in the paper.

WEPEA064 **Low Emittance Tuning and Coupling Control at Diamond** – *R. Bartolini, I.P.S. Martin, G. Rehm, J. Rowland, C.A. Thomas (Diamond)*
Diamond operates with the lowest horizontal emittance among medium energy synchrotron light source. The correct implementation of the nominal optics allows the full exploitation of the low emittance design, providing the highest possible brightness for the users. We present the experimental results and the corrections strategies put in place to operate the diamond storage ring at its nominal low emittance and the coupling correction required to achieve the ultimate vertical emittance of 2.2 pm.

WEPEA065 **Beam Dynamics for the NLS Superconducting Linac** – *R. Bartolini, C. Christou, J.H. Han, I.P.S. Martin, J. Rowland (Diamond) D. Angal-Kalinin, D.J. Dunning, F. Jackson, B.D. Muratori, N. Thompson, P.H. Williams (STFC/DL/ASTeC)*
We present the progress with the design of the 2.25 GeV superconducting linac for the NLS project. We discuss the performance achieved, the optimisation strategies, the relevance of microbunching instability and the analysis of the effect of various jitter sources

WEPEA066 **The First Eighteen Months of Top-up at Diamond Light Source** – *C. Christou, R.T. Fielder, I.P.S. Martin, S.J. Singleton (Diamond)*
Diamond Light Source has delivered beam for users exclusively in top-up mode since the end of October 2008. In this mode, a small number of single bunches are injected into specific buckets of the storage ring every ten minutes in order to maintain a constant beam current and fill pattern. During top-up the storage ring current is held within a window of approximately 1.5mA around the target current, generally 250mA, for a variety of fill patterns, including a two-thirds storage ring fill and a hybrid fill in which an intense single bunch is added to the normal fill pattern. Top-up has run continuously for several days on many occasions, with injection efficiency into the storage ring of typically 60%-95% even with 10 in-vacuum insertion device in operation with a permitted minimum gap of 5 mm. The effect of insertion devices, pulsed magnet stability and storage ring beam optics on top-up reliability and performance is examined, and the development of tools for the control of top-up and storage ring fill is detailed.

WEPEA067 **Design Studies for a VUV-Soft X-ray FEL Facility at LBNL** – *J.N. Corlett, K.M. Baptiste, J.M. Byrd, P. Denes, R.W. Falcone, W.M. Fawley, J. Feng, J. Kirz, D. Li, H.A. Padmore, C. F. Papadopoulos, G. Penn, G.J. Portmann, J. Qiang, D. Robin, R.D. Ryne, F. Sannibale, R.W. Schoenlein, J.W. Staples, C. Steier, T. Vecchione, M. Venturini, W. Wan, R.P. Wells, R.B. Wilcox, J.S. Wurtele, A. Zholents (LBNL) A.E. Charman, E. Kur (UCB)*
Recent reports have identified the scientific requirements for a future soft x-ray light source and a high-repetition-rate FEL facility responsive to them is being studied at LBNL. The facility is based on a CW superconducting linear accelerator with beam supplied by a high-brightness, high-repetition-rate photocathode electron gun, and on an array of FELs to which the beam is distributed, each operating at high repetition rate and with even pulse spacing. Dependent on the experimental requirements, the individual FELs may be configured for either SASE, HGHG, EEHG, or oscillator mode of operation, and will produce high peak and average brightness x-rays with a flexible pulse format ranging from sub-femtoseconds to hundreds of femtoseconds. We are developing a design concept for a 10 - beamline, coherent, soft x - ray FEL array powered by a 2.5 GeV superconducting accelerator operating with a 1 MHz bunch repetition rate. Electron bunches are fanned out through a spreader, distributing beams to an array of 10 independently configurable FEL beamlines with nominal bunch rates up to 100 kHz. Additionally, one beamline could be configured to operate at higher repetition rate.

WEPEA068 **Simulation of a Pulsed Multipole Injection Method for the Advanced Light Source** – *D. Robin (LBNL) Z.K. Fisher (MIT)*

We have developed computer models for a pulsed-multipole magnet injection scheme for the Advanced Light Source (ALS) at Lawrence Berkeley National Lab. The multipole kicker injection scheme is further shown to be com- patible with the ALS in combination with a magnet lattice that has a low beta-function in the injection straight. Since traditional injection schemes are not compatible with such optimized low beta lattices, implementing the new injection scheme opens up several new possibilities. For instance, the adoption of a low beta lattice can greatly increase brightness due to the better matching of photon and electron beam emittances. This document explains the principles of the injection and the simulations we performed to show that the concept is sound.

WEPEA069 **Upgrade Plans for the Advanced Light Source Accelerator Complex** – *D. Robin (LBNL)*

Over the next three years the Advanced Light Source is planning major upgrade of the storage ring lattice to reduce the emittance to 2 nmrad. In addition there will be major upgrades of the RF system, the controls and instrumentation. In addition there is a study for future upgrades using pulsed multipole injection. In this paper we present an overview of the upgrade plans.

WEPEA070 **Status of the Low Emittance Upgrade of the Advanced Light Source** – *C. Steier, A. Madur, H. Nishimura, G.J. Portmann, D. Robin, F. Sannibale, T. Scarvie, W. Wan (LBNL)*

The Advanced Light Source is one of the earliest 3rd generation light sources. With an active upgrade program it has remained competitive over the years. The latest in a series of upgrades is a lattice upgrade project that was started in 2009. When it will be completed, the ALS will operate with a horizontal emittance of 2.2 nm and an effective emittance of 2.6 nm. Combined with the high current of 500 mA and the small vertical emittance the ALS already operates at this upgrade will keep it competitive for years to come. The presentation will present the status of the upgrade, including beam dynamics studies and lattice optimizations as well as the magnet design and status.

WEPEA071 **Light Source Development and Accelerator Physics Research at Duke University** – *Y.K. Wu (FEL/Duke University)*

The light source research program at the Duke Free-Electron Laser Laboratory (DFELL) is focused on the development of accelerator-driven light sources, including storage ring based free-electron lasers (FELs) and Compton gamma-ray source, the High Intensity Gamma-ray Source (HIGS). The HIGS is the most intense Compton gamma-ray source currently available with an energy tuning range from 1 to 100 MeV. The accelerator physics program at the DFELL covers a wide range of activities, from nonlinear dynamics research, to the study of beam instability with advanced feedback systems, to FEL research and development. In this paper, we will report our recent progress in accelerator physics research and light source development to meet new challenges of today's and future accelerators.

WEPEA072 **An Extension of Cornell's Energy Recovery Linac for Compressed High-charge Bunches** – *F.A. Laham (Cornell University) G.H. Hoffstaetter, C.E. Mayes (CLASSE)*

The proposed Cornell Energy Recovery Linac (ERL) is designed for bunches of 77pC and 100mA whose energy is recovered. However, the ERL linac can also be used for larger bunch charges of reduced average current whose energy does not have to be recovered. The proposed Cornell ERL lightsource currently uses a split linac arrangement connected by a turnaround arc. In order to avoid the detrimental effects of Coherent Synchrotron Radiation (CSR) in this arc, a high charge (1nC) bunch must remain relatively long (2ps), and be compressed at high energy (5GeV). An appropriate bunch compressor must take second order effects into account, which adds complications for the large energy spread associated with compression to 100fs or less. We have therefore designed a very simple four dipole bunch compressor at high energy, which uses second order time of flight terms in the turnaround arc rather than in the bunch compressor itself. This design is tested using particle tracking simulations incorporating CSR, as well as magnetic field errors and misalignments.

WEPEA073 **Lattice Development for PEP-X High Brightness Light Source** – *Y. Nosochkov, Y. Cai, M.-H. Wang (SLAC)*

Design of PEP-X high brightness light source machine is under development at SLAC. The PEP-X is a proposed replacement of the PEP-II in the existing 2.2 km tunnel. Two of the PEP-X six arcs contain DBA type lattice providing 30 dispersion free straights suitable for 3.5 m long undulators. The lattice contains TME cells in the other four arcs and a 90 m wiggler in a long straight section yielding an ultra low horizontal emittance of ~0.1 nm-rad at 4.5 GeV for a high brightness. The recent lattice modifications further increase the predicted brightness and improve beam dynamic properties. The standard DBA cells are modified into supercells for providing low beta undulator straights. The DBA and TME lattice parameters are better optimized. Harmonic sextupoles are added into the DBA arcs to minimize the sextupole driven resonance effects and amplitude dependent tune shift. Finally, the injection scheme is changed from vertical to horizontal plane in order to avoid large vertical amplitudes of injected beam within small vertical aperture of undulators.

WEPEA074 **A Baseline Design for PEP-X: an Ultra-low Emittance Storage Ring** – *Y. Cai, K.L.F. Bane, K.J. Bertsche, A. Chao, R.O. Hettel, X. Huang, Z. Huang, C.-K. Ng, A. Novokhatski, T. Rabedeau, J.A. Safranek, G.V. Stupakov, L. Wang, M.-H. Wang, L. Xiao (SLAC)*

Over the past year, we have worked out a baseline design for PEP-X, as an ultra-low emittance storage ring that could reside in the existing 2.2-km PEP-II tunnel. The design features a hybrid lattice with double bend achromat cells in two arcs and theoretical minimum emittance cells in the remaining four arcs. Damping wigglers reduce the horizontal emittance to 86 pm-rad at zero current for a 4.5 GeV electron beam. At a design current of 1.5 A, the horizontal emittance increases, due to intra-beam scattering, to 164 pm-rad when the vertical emittance is maintained at a diffraction limited 8 pm-rad. The baseline design will produce photon beams achieving a brightness of 10^{22} (ph/s/mm^2/mrad^2/0.1% BW) at 10 keV in a 3.5-m conventional planar undulator. Our study shows that an optimized lattice has adequate dynamic aperture, while accommodating a conventional off-axis injection system. In this paper, we will present the study of the lattice properties, nonlinear dynamics, intra-beam scattering and Touschek lifetime, and collective instabilities. Finally, we discuss the possibility of partial lasing at soft X-ray wavelengths using a long undulator in a straight section.

WEPEA075 **Booster Synchrotron RF System Upgrade for SPEAR3** – *S. Park, W.J. Corbett (SLAC)*

The recent progress at the SPEAR3 were the increase in stored current from 100 mA to 200 mA maximum and the top-off injection to allow beamlines to stay open during injection. Presently the booster injects 3.0 GeV beam to SPEAR3 three times a day. The stored beam decays to about 150 mA between the injections. The growing user demands are to increase stored current to the design value of 500 mA, and to maintain it at a constant value within a percent or so. To achieve this goal the booster must inject once every few minutes. For improved injection efficiency, all RF systems at the linac, booster and SPEAR3 need to be phase-locked. These requirements entail a booster RF system upgrade to a scaled down version of the SPEAR3 RF system running at 476.3 MHz with a 1.2 MW cw output power capability. The present booster RF system is basically a copy of the SPEAR2 RF system operating at 358.5 MHz with 80 kW peak power to a 5-cell RF cavity for 1.2 MV gap voltage. We will analyze each subsystem option for their merits within budgetary and geometric space constraints. A substantial portion of the system will come from the decommissioned PEP-II RF stations.

WEPEA076 **NSLS-II Lattice Optimization with Non-zero Chromaticity** – *W. Guo (BNL) M. Borland (ANL)*

Chromaticity is usually set to a non-zero value at the third generation light sources in order to mitigate intensity-related instabilities. NSLS-II is a third generation light source under construction at the Brookhaven National laboratory. Even though the intensity goal at commissioning is 25 mA, the designed current is 500 mA. Previously, the lattice was optimized for zero chromaticity. In this paper we study optimization with non-zero chromaticity. Dynamic aperture and momentum aperture will be examined, and simulation results with enhanced Landau damping will be presented.

WEPEA077 **The Approach to NSLS-II Lattice Optimization** – *W. Guo, S.L. Kramer, S. Krinsky, B. Nash, F.J. Willeke (BNL)*

NSLS-II is a third generation 3 GeV light source that is being built at the Brookhaven National Laboratory. A horizontal beam emittance of of 1 pi nmrad will be achieved due to the large circumference (792m), the large number of achromats(30) and by six 3.5m long damping wigglers with a peak magnetic field of 1.8T. The vertical emittance will reach the diffraction limit of an 8keV x-ray beam. The civil construction of the facility started in June 2009 and major components of the accelerator complex are in the production process. This paper will summarize the considerations for the NSLS-II lattice design and will concentrate on specific topics such as the flexibility of the lattice, the effect of multipole errors, the integration of the damping wigglers into the accelerator lattice, the optimization of the chromatic correction scheme, and the approach to the dynamic aperture optimization. The discussion of the solutions will demonstrate that the NSLS-II lattice will provide high flexibility while maintaining a sufficiently large dynamic aperture for injection and Touschek scattering which provides good injection efficiency and beam lifetime.

WEPEA078 **Instabilities related to the RF Cavity in the Booster Synchrotron for NSLS-II** – *Y. Kawashima (BNL)*

The booster synchrotron for NSLS-II accepts beam with 200 MeV from a linac and raises its energy up to 3 GeV. In order to raise beam energy up to 3 GeV, a 7-cell PETRA cavity is installed. Beam instabilities related with the cavity are discussed. In particular, in order to avoid coupled-bunch instability, we consider that cooling water temperature for the cavity should be changed to shift frequencies of higher order modes (HOM) to avoid beam revolution lines. To obtain the relation between the temperature dependence of amount of frequency shift in each HOM and cavity body temperature, we carried out the measurement by changing cavity body temperature. From the measurement data, we calculate the required temperature variation. We summarize the results and describe the system design.

WEPEA080 **Optimization of Injection in VUV Ring at BNL National Synchrotron Light Source** – *S. Seletskiy (BNL)*

Injection into VUV Ring at the National Synchrotron Light Source is accompanied by noticeable radiation losses. Utilizing turn by turn (TBT) beam position monitors installed in the VUV ring allowed us to build a reliable model of VUV injection. In this report we perform detailed comparison of TBT measurements with simulation results, discuss the technique for injection studies and give recommendations on VUV ring injection optimization.

WEPEA081 **ILC RTML Extraction Lines for Single Stage Bunch Compressor** – *S. Seletskiy (BNL)*

The use of single stage bunch compressor (BC) in the Damping Ring to the Main Linac beamline (RTML) requires new design of the extraction line (EL). The EL located downstream the BC can be used both for an emergency abort dumping of the beam and the tune-up continual train-by-train extraction. It must accept both compressed and uncompressed beam with energy spread of 3.5% and 0.15% respectively. In this paper we report a final design that allowed minimizing the length of such extraction line while offsetting the beam dumps from the main line by the 5m distance required for acceptable radiation level in the service tunnel. Proposed extraction line can accommodate beams with different energy spreads at the same time providing the beam size suitable for the aluminum dump window.

WEPEA082 **Status of the NSLS-II Injection System** – *T.V. Shaftan, R. Alforque, A. Blednykh, W.R. Casey, L.R. Dalesio, M.J. Ferreira, R.P. Fliller, G. Ganetis, R. Heese, H.-C. Hseuh, P.K. Job, E.D. Johnson, Y. Kawashima, B.N. Kosciuk, S. Kowalski, S. Krinsky, Y. Li, H. Ma, R. Meier, S. Ozaki, D. Padrazo, B. Parker, I. Pinayev, M. Rehak, J. Rose, S. Sharma, O. Singh, P. Singh, J. Skaritka, C.J. Spataro, G.M. Wang, F.J. Willeke (BNL)*

We discuss status and plans of development of the NSLS-II injector. The injector consists of 200 MeV linac, 3-GeV booster, transport lines and injection straight section. The system design is now nearly completed and the injector development is in the procurement phase. The injector commissioning is planned to take place in 2012.

WEPEA083 **Application of Model Independent Analysis with EPICS-DDS** – *I. Pinayev, N. Malitsky (BNL) R.M. Talman (CLASSE)*

Model Independent Analysis (MIA) is an essential approach for measuring optical properties of accelerators. In the paper, we evaluate its application in the context of the NSLS-II Light Source storage ring. It is the first application of the new high-level application environment based on the EPICS-DDS middle layer. Using a full-scale virtual accelerator, the paper explores the tolerance of the MIA approach against the different conditions such as measurement noise in the beam position monitors, magnet errors, misalignments, etc.

WEPEA084 **Study of Beam Emittance and Energy Spread Measurements using SVD and Multiple Flags in the NSLS-II Booster Extraction Beamline** – *G.M. Wang, R.P. Fliller, W. Guo, R. Heese, T.V. Shaftan, L.-H. Yu (BNL) Y.-C. Chao (TRIUMF)*

The low beam emittance requirement in the NSLS-II storage ring imposes a very tight constraint on its acceptance. This requires the injected beam emittance to be very small, for which a reliable scheme of measurement to determine the phase space and momentum characteristics of the beam coming out the booster is necessary. The original scheme based on the booster-to-dump transport line was hampered by the difficulty in decoupling betatron oscillation from dispersion, due to high concentration of dipoles and limited number of quads after the booster. This paper will describe the alternative method being planned to use the booster extraction line to measure the beam emittance and energy spread, as well as the associated errors.

WEPEA085 **Study of the Application of MIA to NSLS-II Booster for Matrix Measurement** – *G.M. Wang, R.P. Fliller, W. Guo, R. Heese, T.V. Shaftan (BNL) C.-x. Wang (ANL)*

In NSLS-II booster-to-dump transport line, we will measure the beam emittance and energy spread with multiple flags. The accurate modeling of transport matrix is very important for the measurement. Due to high concentration of elements after the booster, it is hard to improve the measured matrix accuracy with limited correctors and space. This paper will describe the possible method of more accuracy matrix measurement by using the excited signals in booster, which are known well with MIA by getting rid of the unknown BPM offset error and BPM noise.

26-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area B

WEPEB — Poster Session

WEPEB001 **Data Archive System for J-PARC Main Ring** – *N. Kamikubota, S. Yamada (KEK) T. Iitsuka, S. Motohashi, M. Takagi, S.Y. Yoshida (Kanto Information Service (KIS), Accelerator Group) H. Nemoto (ACMOS INC.) N. Yamamoto (J-PARC, KEK & JAEA)*

The beam commissioning of the J-PARC Main Ring started in May, 2008. Data archive system has been developed using Channel Archiver, which is a tool developed and maintained in the EPICS community. Various machine parameters and status information of Main Ring have been recorded. The number of records registered extends 17,000 as of December, 2009. The archive data can be retrieved in a form of graphical representation by Web browser. In addition, the mechanism to provide bit-type information, such as interlock and on/off, in time series format is available. They have been used in daily operation of Main Ring. Addition to them, we are trying to develop a new scheme to record large waveform data of beam diagnostic signals. Status and progress of the archive system will be discussed.

WEPEB002 **Prototype of the Ethernet-based Power Supply Interface Controller Module for KEKB** – *T.T. Nakamura, A. Akiyama, K. Furukawa (KEK)*

Most of the magnet power supplies of the KEKB rings and beam transport lines are connected to the local control computers through ARCNET. For this purpose we have developed the Power Supply Interface Controller Module (PSICM), which is designed to be plugged into the power supply. It has a 16-bit microprocessor, ARCNET interface, trigger pulse input interface, and parallel interface to the power supply. According to the upgrade plan of the KEKB accelerators, more power supplies are expected to be installed. Although the PSICMs have worked without serious problem for 11 years, it seems too hard to keep maintenance for the next decade because some of the parts have been discontinued. Thus we decided to develop the next generation of the PSICM. Its major change is the use of the Ethernet instead of the ARCNET. On the other hand the specifications of the interface to the power supply are not changed at all. The new PSICM is named ePSICM (Ethernet-based Power Supply Interface Controller Module). The design of the ePSICM and the development of the prototype modules are in progress.

WEPEB003 **Fully Embedded EPICS-based Control of Low Level RF System for SuperKEKB** – *J.-I. Odagiri, K. Akai, K. Furukawa, S. Michizono, T. Miura, T.T. Nakamura (KEK)*

Gazing at SuperKEKB project, a new control subsystem was designed and implemented to upgrade the low level RF system of the KEKB accelerator based on Experimental and Industrial Control System (EPICS). The new control subsystem comprises a uTCA, a PLC, and an industrial PC. Each card plugged in the uTCA chassis and the PLC function as an embedded Input / Output Controller (IOC) by running the EPICS core program on the Linux operating system. The industrial PC runs Extensible Display Manger on Linux to serve as an Operator Interface (OPI). This paper describes the details of the design and the implementation of the fully embedded EPICS-based low level RF control subsystem for SuperKEKB.

WEPEB004 **A VXI-11 Module for Python Language and its Application to Acclerator Controls** – *N. Yamamoto (KEK)*

VXI-11 is an industrial standard to control equipments through network. A moule to control these equipments through Python scripting Language was developed. This module can be used for quick testing of equipments and for the rapid application development. The implementation of the module will be discussed and some application of the module will be reported.

WEPEB005 **Magnet Pattern Control System of the J-PARC Main Ring** – *J. Takano, T. Koseki, S. Nakamura, T. Toyama, N. Yamamoto (J-PARC, KEK & JAEA) S. Hatakeyama (JAEA/J-PARC) K. Niki, M. Tomizawa, S. Yamada (KEK)*

In the J-PARC Main Ring (MR), the bending, quadrupole, sextupole, and steering magnets can be controlled on the operating interfaces (OPI). The optics parameters for all magnets are calculated by using SAD, and are converted to BL tables (ex: 2000 points for a steering magnet) for each power supplies. The BL tables are made from the parameters of optics, pattern timing, and beam energy at flat bottom and flat top. For MR beam studies, the BL tables are adjustable with offset and factor. This system is useful for COD correction, beta function measurement, aperture survey, and slow extraction. In this proceeding, the structure of the magnet control system and OPIs for beam studies will be shown.

WEPEB006 **Present Status of the Development of MPS and TS for IFMIF/EVEDA Accelerator Prototype Control System** – *H. Takahashi, T. Kojima, S. Maebara, H. Sakaki, K. Shinto, K. Tsutsumi (JAEA)*

Control System for IFMIF accelerators consists of the six subsystems; Central Control System (CCS), Local Area Network (LAN), Personnel Protection System (PPS), Machine Protection System (MPS), Timing System (TS) and Local Control System (LCS). The subsystems have been designed and their test benches been fabricated at JAEA. The IFMIF accelerator prototype provides a deuteron beam with the power more than 1 MW, which is as same as that in cases of J-PARC and SNS. In the control system, MPS and TS with high performance and precision are strongly required to avoid the radio-activation of the accelerator components. The prototypes of the MPS and TS are testing in conjunction with the injector test starting at CEA/Saclay from autumn in 2010. These results will feedback the design and the fabrication of the control components. This paper presents the development status of the TS modules and EPICS drivers for TS and MPS, and the prospects to apply them to the Injector test.

WEPEB007 **The Data Acquisition System of Beam Position Monitors in J-PARC Main Ring** – *S. Hatakeyama, N. Hayashi, K. Satou (JAEA/J-PARC) D.A. Arakawa, Y. Hashimoto, S. Hiramatsu, J.-I. Odagiri, M. Tejima, M. Tobiyama, T. Toyama, N. Yamamoto (KEK) K. Hanamura (MELCO SC)*

The Data Acquisition System of Beam Position Monitors(BPMs) in J-PARC Main Ring are consist of 186 Linux-based Data Processing Cirquits (BPMCs) and 12 EPICS IOCs. They are important tool to see the COD and turn-by-turn beam positions. This report describes the process of the data reconstruction which include how the various calibration constants are applied.

WEPEB008 **PLC Control System of the Deuteron Injector** – *Q.F. Zhou, J.E. Chen, Z.Y. Guo, Y.R. Lu, S.X. Peng, J. Zhao (PKU/IHIP)*

A compact remote PLC control system with S7-300 is being designed for PKUNIFTY (Peking University Neutron Imaging FaciliTY). At present stage, the front part for the deuteron injector, consisting of the electron cyclotron resonance (ECR) D^+ ion source and the low energy beam transport (LEBT) system, is finished. The Human Machine Interface (HMI) is developed by the Siemens WinCC software to monitor and control the system, with the SQL2000 database to acquire and archive data. A Software-Redundant framework including two 315-2DPs enhances the system's safety for fear of CPU failure, and some other unstable environment factors are taken into account. Experiments proved its stability.

WEPEB009 **The SSRF Control System** – *L.R. Shen, D.K. Liu (SINAP)*

SSRF control system is a hierarchical standard accelerator control system based on EPICS. The VME 64X system, special embedded controller and PLCs are used for low level devices control or interlocks system. Using a uniform 1000Base-T backbone redundancy control network instead of field bus for mostly device controller with VLAN technique adopted, and integrate with EPICS using soft IOC. Digital technology such as digital power supply control system, new event timing system and digital phase control system are used and also integrated with some embedded EPICS IOC. An uniform System development and run time environment of hardware and software is adopted at the whole process. The high level physical application environment using MatLab 2007a with Accelerator Toolbox (AT) & middle layer with MatLab CA (Channel Access) connected component MCA/LabCA. The high level physical application can be integrated with the control system easily and conveniently. With the SSRF centre database, an enhanced distributed archive engine based on RDBS with native XML data type is been testing.

WEPEB010 **Soft IOC Application in SSRF Beam Diagnostics System** – *Y.B. Yan, Y.B. Leng (SINAP)*

Soft IOC is an ideal solution for high level global application of accelerator control and beam diagnostics due to easy online modification and rebooting. SSRF beam diagnostics system employees two soft IOCs to handle global tasks such as BPMs group access, orbit performance analyze and online data reliability analyze, which are hardly performed in bottom level IOC side and OPI side. This paper introduces the current status and future upgrade plan.

WEPEB011 **Study on LabVIEW-Based Control System of Compact Cyclotron** – *X. Hu, M. Fan, T. Hu, D. Li, B. Qin, Y.Q. Xiong, J. Yang, T. Yu (HUST)*

The main outcome of this paper is the complete establishment of the compact cyclotron control system in the LabVIEW platform. With the introduction of virtual instrument concept to the virtual prototyping technology, a control system including a friendly human-machine interface and full control logic is developed and can be directly used in scientific research and engineering practice. The paper also proposes an object-modeling method in LabVIEW which provides further support for the virtual control technology.

WEPEB012 **Development for PLS HLS Control System and Web Service** – *J.M. Kim, H. J. Choi, H.-S. Kang, J.H. Kim, E.H. Lee, J.W. Lee (PAL)*

In the third generation synchrotron radiation accelerator that realizes to the smallest emittance, The small ground movement influences performance of 3rd accelerator, and we need to analyze what observes moving of ground movement of PLS storage ring. This paper describes the HLS data acquisition and monitoring system that exactly measures detailed movement of PLS storage ring ground. The HLS sensor Data store to database. The HLS control system was implementation as using LabVIEW and EPICS tool-kit. Stored HLS Data service of database with easy access, and sample monitoring through web.

WEPEB013 **IFC to FESA Gateway: Smooth Transition from GSI to FAIR Control System** – *G. Jansa, I. Kriznar, G. Pajor, I. Verstovsek (Cosylab) R. Baer, L. Hechler, U. Krause (GSI)*

Present GSI control system uses an in-house developed CORBA based middleware called IFC. For FAIR project that will be build on the GSI site, a new control system is foreseen. New devices that are being integrated into the control system preferably will be developed in FESA. In this article, an IFC to FESA gateway will be presented. The gateway provides an intermediate layer that is able to talk to FESA device servers on one side and provide their functionality to existing IFC clients. The gateway will allow coexistence of FESA front-end implementations and existing GSI device servers, providing a smooth transition path to the future FAIR front-end environment. New GSI and FAIR devices that will be implemented in FESA will have to match GSI standards for nomenclature and device modeling. Exact match of new devices is not possible due to different hardware and software architecture of the new system, therefore a gateway solution is required. The gateway can translate the complete device model, including conversion from FESA to GSI data types. In the process of gateway design and implementation, valuable input was collected for the design of the future FAIR control system.

WEPEB014 **Networked Control System Over an EPICS based Environment** – *M. Eguiraun (Fundación TEKNIKER) I. Arredondo, J. Jugo (University of the Basque Country, Faculty of Science and Technology) I. Badillo (ESS-Bilbao)*

The use of distributed control systems for improving control system's performance is a hot research topic. Thus, the importance of developing control systems across networked environment is rising, a lot of research is focused on developing middleware based solutions. On the other hand, EPICS is an extended control system middleware, which is based on TCP/UDP protocol. This protocol has non-deterministic characteristics, limiting its use for networked control systems. Despite of these characteristics, the interest on TCP based networks in industrial field has been increasing due to its advantages in cost and easy integration. In this work, EPICS as a networked control system is analyzed in order to develop strategies to improve its performance. For this purpose, an EPICS based networked control scheme is presented, where control loop is closed over the net. As opposed to usual way of working with EPICS, two IOCs are used located in different hosts. The first one performs data acquisition, while the second one calculates the control signal. The analysis and control performance study of such scheme is presented by using periodic sampling, as well as event based sampling approach.

WEPEB015 **Recent Improvements of the RF Beam Control for LHC-type Beams in the CERN PS** – *H. Damerau, S. Hancock, M. Schokker (CERN)*

To cope with the large variety of different beams for the LHC, the RF beam control in the CERN PS has evolved continuously to improve its flexibility and reliability. Single-bunch beams, several different multi-bunch beams with 25, 50 or 75 ns bunch spacing at ejection for LHC filling, as well as two lead-ion beam variants are now regularly produced in pulse-to-pulse operation. The multi-bunch beam control for protons can be easily re-adjusted from $0.25{\cdot}10^{11}$ to $1.3{\cdot}10^{11}$ particles per ejected bunch. Depending on the number of bunches injected from the PS Booster, the length of the ejected bunch train may vary from 8 to 72 bunches. This paper summarizes recent improvements in the low-level RF systems and gives an outlook on the future consolidation.

WEPEB016 **Application of Modbus-TCP in TPS Control System** – *Y.K. Chen, J. Chen, Y.-S. Cheng, K.T. Hsu, C.H. Kuo (NSRRC)*

Modbus-TCP is a widely used in industry for a long time and accelerator control system recently. Modbus protocol over Ethernet has advantages for non real-time applications due to its maturity. The TPS (Taiwan Photon Source) project will have many Modbus-TCP enable devices which distributed in utility system and accelerator system. The accelerator control environment of TPS project is an EPICS toolkit based system. Modbus-TCP might adopt for some subsystems. There are several possible Modbus-TCP devices including the prototype power supply for magnet field mapping application equip with Modbus-TCP interface, vacuum system local controller, front-end controller, and some monitoring devices. In this paper, we will summarise preparation efforts to accommodate the Modbus-TCP support in the TPS control system.

WEPEB017 **Waveform and Spectrum Acquisition for the TLS** – *Y.-S. Cheng, J. Chen, Y.K. Chen, K.T. Hsu, K.H. Hu, C.H. Kuo, C.Y. Wu (NSRRC)*

To enhance waveform and spectrum remote access supports in Taiwan Light Source (TLS), develop the EPICS support of Ethernet-based oscilloscope and spectrum analyzer for the TLS in under way. On EPICS platform access the waveform and spectrum through the PV (Process Variable) channel access. By using remote operations of waveform and spectrum acquisition, eliminate long distance cabling and improve signal quality. The EDM (Extensible Display Manager) tool is used to implement the operation interface of control console and provide waveform display. According to specific purpose use, build different graphical user interfaces to integrate waveform and spectrum acquisition. This project is the preparation for future control room integration with the Taiwan Photon Source control room. The efforts will be described at this report.

WEPEB018 **Development of the TPS Control System** – *K.T. Hsu, Y.-T. Chang, J. Chen, Y.K. Chen, Y.-S. Cheng, P.C. Chiu, S.Y. Hsu, K.H. Hu, C.H. Kuo, D. Lee, C.-J. Wang, C.Y. Wu (NSRRC)*

Implementation of the Control system for the Taiwan Photon Source (TPS) is on going. The TPS control system will provide versatile environments for machine commissioning, operation, and to do accelerator experiments. The control system is based on EPICS toolkits. Test-bed has set up for various developments. The open architecture will facilitate machine upgrade, modification easily and minimize efforts for machine maintenance. Performance and reliability of the control system will be guaranteed from the design phase. Development status will be summary in this report.

WEPEB019 **Virtual Accelerator Development for the TPS** – *P.C. Chiu, J. Chen, Y.-S. Cheng, K.T. Hsu, C.H. Kuo, C.Y. Wu (NSRRC)*

In order to help early development of TPS control system and user interface, a virtual accelerator model is constructed. The virtual accelerator has been created by AT toolbox and simulated beam behavior; the Middle Layer providing high level accelerator application is also used. LabCA interfaces between Matlab and EPICS (Experimental Physics and Industrial Control System). Such a system could speed development of commissioning required software and examine the correction of all procedures.

WEPEB020 **Control of the Pulse Magnet Power Supply by PLC Embedded EPICS IOC** – *C.Y. Wu, J. Chen, Y.-S. Cheng, C.-S. Fann, K.T. Hsu, S.Y. Hsu, K.H. Hu, C.H. Kuo, D. Lee, K.-K. Lin (NSRRC) K. Furukawa, J.-I. Odagiri (KEK)*

The Programmable Logic Controller (PLC) embedded EPICS IOC has been developed based on F3RP61-2L, a CPU module runs Linux of FA-M3 PLC. The F3RP61-2L module running EPICS IOC core program which can access registers of sequence PLC modules and I/O modules of FA-M3 PLC. The embedded EPICS PLC will apply for pulse magnet power supply control. The system comprises of ADC, DAC, DI, DO modules and a CPU module, which has a built-in Ethernet interface. The control information (status of the pulse magnet power supply, ON, OFF, warn up, reset, read/write current, etc.) is handled remotely over the network using EPICS records. The trigger signal is by an external trigger pulse for pulse magnet power supply. EDM, one of the standard tools of EPICS, has been used to develop GUI applications for pulse magnet power supply. The efforts will be described at this report.

WEPEB021 **Completion of a New High Level Control System for the ALS** – *G.J. Portmann, M.J. Beaudrow, W.E. Byrne, C.M. Ikami, H. Mahic, H. Nishimura, P. Pace, CA. Timossi (LBNL)*

The ALS started operations in 1993. Although the high level software control of an accelerator continually evolves with time, there comes a time to start over. For the ALS this was driven by many factors. The most important was to support a future low level controls upgrade. Aging low level hardware has reached an unacceptable risk level for stable operations and will be replaced. The ALS has also been slowly migrating to EPICS so this was an opportunity to use more EPICS tools in the high level control. Lastly, it was an opportunity to modernize our control with modern computer and software programming tools. Over the last 2 years the ALS has completely changed the high level controls. This involved writing and training operators on 50+ new applications for 3 accelerators (linac, booster, and storage ring) and two transport lines without any interruptions to regular machine operations. As will be presented in this paper, this effort involved combining three very different programming methods 'C#, Matlab, and EPICS tools' to create a completely new control room for the ALS.

WEPEB022 **Online Virtual Accelerator for the Cornell ERL Injector** – *C.M. Gulliford, I.V. Bazarov, J. Dobbins, R.M. Talman (CLASSE) N. Malitsky (BNL)*

Commissioning of the high brightness photo-injector for the Energy Recovery Linac at Cornell University continues. In this effort the need for a software tool that provides the beam physicist with an online high-level physics description of the machine has been identified. Such a tool should provide the ability to retrieve and visualize the current machine settings and relevant beam data from the EPICS control system, the ability to independently compute and visualize simulation data based on a user defined model of the relevant beam dynamics in the injector, and the ability to change the physical machine settings as desired. EPICS-DDS, a middle-layer software based on the OMG Data Distribution Service (DDS) data-centric publish/subscribe model, provides a homogeneous interface between the EPICS IOC and high level physics and visualization applications via EPICS Channel Access. We present the results of work in creating an online accelerator control and simulation application based on EPICS-DDS and incorporating a linear optics model called Numerical Transfer Matrix (NTMAT) developed at Cornell.

WEPEB023 **Logscore – an IRMIS Aware General Purpose PV Logging System** – *G.B. Shen, D. Dohan (BNL)*

An IRMIS based pv logging system is under design and development. It is a general purpose system, and provides the capability for taking snapshots of machine status, restoring the accelerator from a specified snapshot and providing modeling codes with archived lattice element strengths. The system is configured from the IRMIS* relational database, which also captures meta-data associated with each log file. The detailed design and latest progress is described in this paper.

WEPEB024 **Design of Accelerator Online Simulator Server using Structured Data** – *G.B. Shen (BNL) M.R. Kraimer (ANL)*

A modular environment for beam commissioning and operation is under development, which is based on the client/server model. The service oriented architecture consists of a server for each supported service. At NSLS-II, a so-called "virtual accelerator" has been developed, which wraps simulator engines such as Tracy and Elegant onto an EPICS system. However, with the current solution, access to data is not flexible. We are designing a new online simulator server using structured data to provide a flexible method for accessing the simulation data. This paper describes recent results of the simulator server development.

WEPEB025 **Design and Prototype of Lattice Service using IRMIS** – *G.B. Shen, D. Dohan (BNL)*

A modular client/server architecture for beam commissioning and operation is under development at NSLS2. It is a service oriented architecture, replacing the more traditional monolithic high level application approach with a set of commissioning and operational services. Under development is a generic lattice service which provides lattice information (lattice families, element properties, associated run-time process variables, etc) for use by modeling programs. The IRMIS* relational database provides the management of this lattice information, including archived lattice save-sets. Generators have been written which use these services to create formatted input streams to feed different simulators like Tracy, and/or Elegant. This paper describes a detailed design and latest progress for the lattice service.

WEPEB026 **Prototype of Beam Commissioning Environment and its Applications for NSLS-II** – *G.B. Shen, L. Yang (BNL)*

A fundamental infrastructure of software framework for beam commissioning for NSLS-II storage ring is in development. It adopts client/server model, and consists of various servers for data communication and management. Based on this structure, some physics applications are developed to satisfy the requirements of day-1 beam commissioning. This paper describes our status of infrastructure development and its applications.

WEPEB027 **Preliminary Operational Experiences of a Bunch-by-bunch Transverse Feedback System at the Australian Synchrotron** – *D.J. Peake, R.P. Rassool (Melbourne) M.J. Boland, R.T. Dowd (ASCo)*

The Australian Synchrotron storage ring has a resistive wall instability in the vertical plane. Presently this instability is being controlled by increasing the vertical chromaticity. However new in-vacuum insertion devices that significantly increase the ring impedance may demand chromatic corrections beyond the capabilities of the sextupole magnets. A transverse bunch-by-bunch feedback system has been commissioned to combat the vertical instability* and provide beam diagnostics**. A high frequency narrow band mode that could not be damped was initial encountered with IVUs at minimum gap preventing the system from being implemented during user beam. Tuning of the bunch fill pattern, the digital filters and mapping out the system response lead to a configuration for user mode operations.

WEPEB028 **Study of Synchrotron Radiation in an Undulator by means of PIC Simulation and Radiation Formula** – *D. Zhu, M.J. Boland, R.T. Dowd, G. LeBlanc, Y.E. Tan (ASCo)*

In this work, relativistic electron beam radiation in the X-Ray fluorescence microprobe beamline undulator is simulated by means of a PIC code and radiation formula. PIC code is used to simulate the movement of electrons in the undulator, radiation formula is used to calculate the radiation field and hence determine the radiation spectrum and photon flux density distribution. Electron beam distribution and its space charge effect are considered in the analysis. Comparing with experiment result, the result from this analytical method is reasonable.

WEPEB029 **Operational Status of the Transverse Bunch by Bunch Feedback System at SOLEIL** – *R. Nagaoka, L. Cassinari, M.D. Diop, M.-P. Level, C. Mariette, R. Sreedharan (SOLEIL) T. Nakamura (JASRI/SPring-8)*

In this paper we introduce and discuss the recent developments made in our digital transverse bunch by bunch feedback system at SOLEIL, which is routinely in service since the first user operation in both the high average current and high bunch current modes. The above includes installation of a third chain with a dedicated 4-electrode stripline intended to operate in the horizontal plane, an attempt to sample the BPM signal directly at the RF frequency without down-converting to the baseband following the success at SPring-8, a refined tuning procedure by measuring the feedback damping times as a function of the band frequency, as well as exploration of different digital filters ensuring a larger working range in terms of betatron tunes or a faster response against single bunch instabilities. The achieved performance and results are described. The observed evolution of the machine impedance and instabilities shall also be presented.

WEPEB030 **Installing a Fast Orbit Feedback at BESSY** – *R. Mueller, B. Franksen, R. Goergen, R. Lange, I. Mueller, J. Rahn, T. Schneegans (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) P. Kuske (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH)*

In view of increased processing bandwidth at demanding experiments and the need for rapid compensation of noise spikes and new, yet unknown excitations a fast orbit feedback aiming at noise suppression in the 1Hz-50Hz range has become mandatory for the 3rd generation light source BESSY II. As a first step the fast setpoint transmission plus the replacement of all corrector power supplies is foreseen. Later - in combination with top-up operation - orbit stability can be further improved by replacing today's multiplexed analog beam position monitors by parallel processing fast digital units. This paper describes how the pilot installation of a small subset of fast corrector power supplies already allows to tune performance and study the benefits for today's most sensible experiments.

WEPEB031 **Fast Orbit Feedback for DELTA and FAIR** – *P. Hartmann, S. Khan, D. Schirmer, G. Schuenemann, P. Towalski, T. Weis (DELTA)*

A stable beam orbit is essential for safe operation of particle accelerators. This applies to electron machines and even more to hadron machines running high beam currents. Based on developments at DELTA, basic designs of fast orbit feedbacks systems for the FAIR rings SIS18 and HESR (planned) and COSY at the Forschungszentrum Jülich are presented.

WEPEB032 **Studies and Control of Coupled-bunch Instabilities at DELTA** – *S. Khan, J. Fuersch, P. Hartmann, T. Weis (DELTA) D. Teytelman (Dimtel)*

DELTA is a 1.5-GeV synchrotron radiation source at the TU Dortmund University with 2 ns bunch spacing. At nominal operating currents, the beam exhibits significant longitudinal centroid motion due to coupled-bunch instabilities. Two techniques were successfully used at DELTA to damp such instabilities: RF phase modulation, which also improves the beam lifetime, and bunch-by-bunch feedback. Using diagnostic data from the bunch-by-bunch feedback system, modal spectra and growth rates of the longitudinal instabilities were characterized. We also present a preliminary characterization of transverse coupled-bunch oscillations observed at the highest beam currents.

WEPEB033 **Beam-based Feedbacks for the FERMI@Elettra Free Electron Laser** – *M. Lonza, S. Cleva, S. Di Mitri, O. Ferrando, G. Gaio, L. Pivetta, G. Scalamera (ELETTRA)*

FERMI@Elettra is a new 4th-generation light source based on a single pass free electron laser. It consists of a 1.5-GeV normal-conducting linac working at 50 Hz repetition rate and two chains of undulators where the photon beams are produced with a seeded laser multistage mechanism. A number of control loops, some of them working on a shot by shot basis, are required to stabilize the crucial parameters of the beams. For this purpose, a generalized real-time framework integrated in the control system has been designed to flexibly and easily implement feedback loops using several monitoring and control variables. The paper discusses the requirements of the control loops and the implementation of the feedback framework. The first closed loop results and the experience gained in the operation of the feedbacks during the first phase of the machine commissioning will also be presented.

WEPEB034 **Superb Bunch-by-bunch Feedback R&D** – *A. Drago, M.M. Beretta, M.E. Biagini, A. Bocci, C. Milardi, P. Raimondi (INFN/LNF) K.J. Bertsche, A. Novokhatski (SLAC) D. Teytelman (Dimtel)*

The SuperB project has the goal to build in the Frascati or Tor Vergata area, an asymmetric $e+/e^-$ Super Flavor Factory to achieve a peak luminosity > 10^{36} cm^{-2} s^{-1}. The SuperB design is based on collisions with extremely low vertical emittance beams. A source of emittance growth comes from the bunch by bunch feedback systems producing high power correction signals to damp the beams. To limit any undesirable effect, a large R&D program is in progress, partially funded by the INFN Fifth National Scientific Committee through the SFEED (SuperB feedback) project approved within the 2010 budget. One of the first steps of the R&D program consists in the upgrade and test of new 12-bit feedback systems in the vertical plane of the DAΦNE main rings. The systems are the direct evolution of the previous 8-bit system design by a KEK/SLAC/LNF collaboration, yielding a good compatibility with the powerful diagnostics and analysis programs developed in the past. Studies on their effects in the longitudinal plane are also in progress.

WEPEB035 **The Clic Drive Beam Phase Monitor Design** – *F. Marcellini (INFN/LNF) I. Syratchev (CERN)*
In the two beam acceleration scheme the Main Beam must be precisely synchronized with respect to the RF power produced by the Drive Beam. Timing errors would have an impact on the collider performances. The Drive Beam phase errors should be controlled, by means of a feed forward system, within 0.1^{o} (23fs @ 12GHz) to avoid a luminosity reduction larger than 2%. A beam phase arrival monitor is an essential component of the system. Its design has been based on the following main requirements: resolution of the order of 20fs, very low coupling impedance due to the very high beam current and integrated filtering elements to reject RF noise and weak fields in the beam pipe that could otherwise affect the measurements.

WEPEB036 **Bunch by Bunch Feedback Systems for J-PARC MR** – *M. Tobiyama, Y.H. Chin, Y. Kurimoto, T. Obina, M. Tejima, T. Toyama (KEK) Y. Shobuda (JAEA/J-PARC)*
Transverse bunch by bunch feedback systems for J-PARC MR accelerator has been designed and tested. Bunch positions are detected by Log-ratio position detection systems with center frequency of 12 MHz. The digital filter which consists of two LLRF4 boards samples the position signal with 64 times of RF frequency. Up to four sets of 16 tap FIR filter with one-turn delay and digital shift gain can be used. Preliminary results of beam test of the system are also shown.

WEPEB037 **An Energy Feedback System using BPM for KU-FEL** – *Y.W. Choi, M. A. Bakr, K. Higashimura, T. Kii, R. Kinjo, K. Masuda, H. Ohgaki, T. Sonobe, M. Takasaki, S. Ueda, K. Yoshida (Kyoto IAE)*
Free electron laser (FEL) is considered as the next generation of light source. Because high brightness electron beams are crucial for the FELs, stabilization of the electron beam is very important for stable FEL operation. Instability of the FEL power comes from instability of the electron beam energy due to body temperature of the thermionic RF gun, surface temperature of the cathode, and body temperature accelerator tube etc. For these reasons, the electron beam position and energy should be monitored precisely to realize the highly stable electron beam and high current. We are going to develop an energy feedback system using beam position monitor (BPM) for Kyoto University FEL (KU-FEL) to generate a stable FEL. We have installed BPM accuracy of 10 um for nondestructive energy measurement for the KU-FEL linear accelerator and an energy feedback system using BPM is under development. In this conference, we will report on the configuration of the energy feedback system based on the BPM signal as well as experiment results on basic performance of the BPM.

WEPEB038 **The Spill Feedback Control Unit for J-PARC Slow Extraction** – *S. Onuma, K. Mochiki (Tokyo City University) T. Adachi, A. Kiyomichi, R. Muto, H. Nakagawa, H. Someya, M. Tomizawa (KEK) T. Kimura (Miyazaki University) K. Noda (NIRS) H. Sato (Tsukuba University)*
J-PARC is a new accelerator facility to produce MW-class high power proton beams. From the main ring (MR) high energy protons are extracted in a slow extracted mode for hadron experiments. The beam is required with as small ripple as possible to prevent pileup events in particle detectors or data acquisition systems. We took beam tests at HIMAC using a prototype signal processing unit. In these beam tests we had recognized the improvement of the extracted beam structure by using the feedback algorithm whose parameters were changed according to the beam characteristics. We have developed a new signal processing unit for the spill feedback control of J-PARC. The unit consists of three signal input ports (gate, spill intensity and residual beam intensity), three signal output ports (spill control magnets), two DSPs (power spectrum analysis and spill feedback control), dual port memories, FPGAs and a LAN interface (remote control with SUZAKU-EPICS). From October 2009, this unit is being used in the beam study of J-PARC MR to check the performance of digital filtering, phase-shift processing, servo feedback control, real-time power spectrum analysis and adoptive control.

WEPEB039 **Simulation Study of Intra-train Feedback Systems for Nanometer Beam Stabilization at ATF2** – *J. Resta-López, R. Apsimon, P. Burrows, G.B. Christian, B. Constance (JAI) J. Alabau-Gonzalvo (IFIC)*

The commissioning of the ATF2 final focus test beam line facility is currently progressing towards the achievement of its first goal: to demonstrate a transverse beam size of about 40 nm at the focal point. In parallel, studies and R&D activities have already started towards the second goal of ATF2, which is the demonstration of nanometer level beam orbit stabilization. These two goals are important to achieve the luminosity required at future linear colliders. Beam-based intra-train feedback systems will play a crucial role in the stabilization of multi-bunch trains at such facilities. In this paper we present the design and simulation results of beam-based intra-train feedback systems at the ATF2: one system located in the extraction line at the entrance to the final focus, and another at the interaction point. The requirements and limitations of these systems are also discussed.

WEPEB040 **Adaptive Scheme for the CLIC Orbit Feedback** – *J. Pfingstner, H. Schmickler, D. Schulte (CERN) M. Hofbaur (UMIT)*

The main challenge of the CLIC main linac optics is the preservation of the ultra-low beam emittance, despite the very strong wakefield and dispersive effects. Dynamic effects, which would lead to a rapid emittance increase, have to be counteracted by using feedback (FB) systems. These FBs have to optimally attenuate ground motion (disturbances), in spite of drift of accelerator parameters (imperfect system knowledge). This paper presents a new FB strategy for the main linac of CLIC. It addresses the mentioned issues separately, with the help of an adaptive control scheme. The first part of this system is a system identification unit. It delivers an estimate of the time varying system behavior. The second part is a control algorithm, which uses the most recent system estimate of the identification unit. It uses H2 control theory to deliver an optimal prediction of the ground motion. This approach takes into account the frequency and space domain properties of the ground motion, as well as their impact on the emittance growth.

WEPEB041 **Commissioning and Initial Performance of the LHC Beam Based Feedback Systems** – *R.J. Steinhagen, A. Boccardi, A.C. Butterworth, E. Calvo Giraldo, M. Gasior, J.L. Gonzalez, S. Jackson, L.K. Jensen, O.R. Jones, Q. King, G. Kruk, S.T. Page (CERN)*

The LHC deploys a comprehensive suite of beam-based feedbacks for safe and reliable machine operation. This contribution summarises the commissioning and early results of the LHC feedback control systems on orbit, tune, chromaticity, and energy. Their performance – strongly linked to the associated beam instrumentation, external beam perturbation sources and optics uncertainties – is evaluated and compared with the feedback design assumptions.

WEPEB042 **Optimization of the Position of the Radial Loop Pickups in the CERN PS** – *S. Aumon (EPFL) S. Aumon, H. Damerau, S.S. Gilardoni (CERN)*

A part of the beam losses at transition crossing of high intensity beams in the CERN PS have been attributed to an excursion of the closed orbit. The orbit jump occurs simultaneously with the jump of the transition energy triggered by pulsed quadrupoles. Investigations showed that the position of the pickups used for the radial loop system was not optimized with respect to the dispersion change caused by the fast change of the transition energy. Thanks to new electronics of the orbit measurement system, turn-by-turn orbit data could be recorded around transition crossing. Their analysis, together with calculations of the transverse optics, allowed determining a new choice of pickup positions for the radial loop. In comparison to the previous pickup configuration, the new configuration improves the mean radial position not only during transition crossing, but all along the acceleration cycle.

WEPEB043 **The Integrated Orbit Feedback System Design in the TPS** – *C.H. Kuo, P.C. Chiu, K.T. Hsu, K.H. Hu (NSRRC)*

As the latest generation light source, TPS (Taiwan Photon Source) has stringent requirements to perform submicron beam stability with low emittance. The slow and fast correctors of integrated orbit feedback system have been designed for TPS project, therefore some feedback system designed based on them an operation experiences from TLS. This report will present performance simulation and the initial design of system infrastructure for large scale calculation and wide bandwidth communication. To perform this requirement, FPGA-based platform will be implemented to achieve low latency and fast computation. Some studies of integrated feedback loop, communication structure, devices control such as BPM electronics and corrector power supplies are also described.

WEPEB044 **Latest Beam Test Results from ATF2 with the Font ILC Prototype Intra-train Beam Feedback Systems** – *P. Burrows, R. Apsimon, D.R. Bett, G.B. Christian, B. Constance, H. Dabiri Khah, C. Perry, J. Resta-López, C. Swinson (JAI)*

We present the design and beam test results of a prototype beam-based digital feedback system for the Interaction Point of the International Linear Collider. A custom analogue front-end signal processor, FPGA-based digital signal processing boards, and kicker drive amplifier have been designed, built, deployed and tested with beam in the extraction line of the KEK Accelerator Test Facility (ATF2). The system was used to provide orbit correction to the train of bunches extracted from the ATF damping ring. The latency was measured to be approximately 140 ns.

WEPEB045 **The Beam-based Intra-train Feedback System of CLIC** – *J. Resta-López, P. Burrows (JAI)*

The design luminosity of the future linear colliders requires transverse beam size at the nanometre level at the interaction point (IP), as well as stabilisation of the beams at the sub-nanometre level. Different imperfections, for example ground motion, can generate relative vertical offsets of the two colliding beams at the IP which significantly degrade the luminosity. In principle, a beam-based intra-train feedback system in the interaction region can correct the relative beam-beam offset and steer the beams back into collision. In addition, this feedback system might considerably help to relax the required tight stability tolerances of the final doublet magnets. For CLIC, with bunch separations of 0.5 ns and train length of 156 ns intra-train feedback corrections are specially challenging. In this paper we describe the design and simulation of an intra-train feedback system for CLIC. Results of luminosity performance simulation are presented and discussed.

WEPEB046 **Optimization of the CLIC Baseline Collimation System** – *J. Resta-López (JAI) D. Angal-Kalinin, J.-L. Fernandez-Hernando, F. Jackson (STFC/DL/ASTeC) B. Dalena, D. Schulte, R. Tomas (CERN) A. Seryi (SLAC)*

Important efforts have recently been dedicated to the improvement of the design of the baseline collimation system of the Compact Linear Collider (CLIC). Different aspects of the design have been optimized: the transverse collimation depths have been recalculated in order to reduce the collimator wakefield effects while maintaining a good efficiency in cleaning the undesired beam halo; the geometric design of the spoilers have also been reviewed to minimize wakefields; in addition, the optics design have been polished to improve the collimation efficiency. This paper describes the current status of the CLIC collimation system after this optimization.

WEPEB047 **Observation and Improvement of the Long Term Beam Stability using X-ray Beam Position Monitors at DLS** – *C. Bloomer, G. Rehm, C.A. Thomas (Diamond)*

We present our observations of the medium term and long term stability of the photon beams at Diamond Light Source. Drift of the Electron Beam Position Monitors results in real X-ray beam movements, observed by both Front End X-ray Beam Position Monitors and beamline scintillator screens on some beamlines. We discuss how we are using these diagnostics tools to measure and characterise the drift. Medium term movements related to top-up cycles are seen, believed to be caused by changes to single bunch charge, and the long term drift of the electron beam position over several days and weeks is examined. A slow feedback system using X-ray Beam Position Monitors has been shown to successfully correct this drift. The results of these trials are presented.

WEPEB048 **Fault Diagnosis of the APS Real-time Orbit Feedback System Based on FTA*** – *S. Xu, R. Laird, F. Lenkszus, H. Shang (ANL)*

The Advanced Photon Source (APS) real-time orbit feedback system is complex and faults are difficult to diagnose. This paper presents a diagnostic method based on fault tree analysis (FTA). The fault tree is created based on more than ten years operating experience of the system. The method is described to analyze the fault tree. The operator interface to the diagnostic tool is discussed.

WEPEB049 **Recent Progress of the Bunch-by-bunch Feedback System at the Advanced Photon Source** – *C. Yao, N.P. Di Monte, V. Sajaev (ANL)*

A bunch-by-bunch feedback system was installed at the APS in 2008. Close-loop tests were conducted and improvements have been made to the system that include two 500-watt amplifiers, a new location for the horizontal drive stripline, a two-blade new horizontal stripline, and upgrade of front-end electronics. With these improvements we are able to stabilize beam with a reduced chromaticity of 0.45 in the horizontal plane and 2.5 in the vertical plane for the 24-singlet bunch pattern. Beam lifetime has increased from 8.5 hours to 15 hours. We did not observe any obvious increase in the effective beam emittance and rms beam motion. More studies will be performed to explore the potential of improving beam performance of the hybrids fill pattern, which has a 16-mA leading bunch. We report the system improvements and the results of our test results.

WEPEB050 **Scaling of Longitudinal Beam Instability Growth Rate in the Storage Ring** – *W. Wu, J.Y. Li, S.F. Mikhailov, V. Popov, P. Wang, Y.K. Wu (FEL/Duke University) D. Teytelman (Dimtel) W. Xu (USTC/NSRL)*

Employing a Giga-sample field-programmable gate array (FPGA) based processor, a bunch-by-bunch longitudinal feedback (LFB) system has been developed to stabilize the electron beam in the Duke storage ring. Since 2008, this LFB system has been used routinely for the operation of storage ring based free-electron lasers (FELs) and the FEL-driven Compton gamma source, the High Intensity Gamma-ray Source (HIGS) at Duke University. The understanding of the longitudinal instability is critical for operation of low-energy storage rings with a high beam current. Using the LFB system, we have performed detailed studies of the onset of the longitudinal dipole instability. In particular, we have explored the instability growth rate as a function of the beam current, beam energy, as well as bunch patterns. We have also investigated the connection between the instability growth rate at the zero current and natural radiation damping rate of the electron beam in the storage ring.

WEPEB051 **Feedback Systems for the Cornell ERL High Current Injector** – *F. Loehl (CLASSE)*

As a prototype for the proposed Cornell ERL, a low emittance injector, designed to deliver up to 100 mA of beam current at an energy of 5 MeV, is being commissioned at Cornell. This paper gives an overview of the monitors and feedback systems that are being implemented to ensure a stable injector operation. This includes measurement and stabilization of power, timing, and beam orbit of the photo cathode laser. We are further implementing a beam-based feedback loop to stabilize the electron bunch charge by acting on an electro-optic modulator in the laser path. A time-of-flight measurement will be used for the stabilization of the high voltage in the DC gun. For the control and stabilization of the electron beam orbit we developed a DOOCS based global orbit feedback which uses all available corrector magnets and BPMs. This orbit feedback was successfully tested at Cornell as well as at FLASH, DESY, where we implemented it for the 9 mA experiment.

WEPEB052 **SPS Ecloud Instabilities - Analysis of Machine Studies and Implications for Ecloud Feedback** – *J.D. Fox, T. Mastorides, G. Ndabashimiye, C.H. Rivetta, D. Van Winkle (SLAC) J.M. Byrd, M.A. Furman, J.-L. Vay (LBNL) W. Höfle, G. Rumolo (CERN) R. de Maria (BNL)*

The SPS at high intensities exhibits transverse single-bunch instabilities with signatures consistent with an Ecloud driven instability. We present recent MD data from the SPS, details of the instrument technique and spectral analysis methods which help reveal complex vertical motion that develops within a subset of the injected bunch trains. The beam motion is detected via wide-band exponential taper striplines and delta-sigma hybrids. The raw sum and difference data is sampled at 50 GHz with 1.8 GHz bandwidth. Sliding window FFT techniques and RMS motion techniques show the development of large vertical tune shifts on portions of the bunch of nearly 0.025 from the base tune of 0.185. Results are presented via spectrograms and rms bunch slice trajectories to illustrate development of the unstable beam and time scale of development along the injected bunch train. The study shows that the growing unstable motion occupies a very broad frequency band of 1.2 GHz. These measurements are compared to numerical simulation results, and the system parameter implications for an Ecloud feedback system are outlined.

WEPEB053 **Experimental Tests of a Prototype System for Active Damping of the e-p Instability in the ORNL SNS Accumulator Ring** – *R.A. Hardin (ORNL RAD) V.V. Danilov, C. Deibele (ORNL)*

The prototype of an analog transverse (vertical and horizontal) feedback system to actively damp the electron-proton (e-p) instability has been developed and tested on the ORNL Spallation Neutron Source (SNS). We will describe the principle components, system configuration, and review several experimental studies geared towards understanding the current performance and limitations of the system.

WEPEB054 **Analysis of the Performance of the SPS Exponential Coupler Striplines using Beam Measurements and Simulation Data** – *R. de Maria (BNL) C. Boccard, W. Höfle, G. Kotzian, C. Palau Montava, B. Salvant (CERN)*

The SPS exponential coupler stripline are used to study single bunch instabilities. An accurate description of the response of the pickup is required to obtain high resolution measurements of the bunch vertical motion along the longitudinal axis. In this study we present the results of the comparison between dedicated beam experiments and electromagnetic simulations of a geometrical model of the stripline.

WEPEB055 **Straightness Alignment of Linac by Detecting Slope Angle** – *T. Kume, K. Furukawa, M. Satoh, T. Suwada (KEK) E. Okuyama (Akita University)*

Profile shape measurements detecting profile slope angle, which corresponds to the differential of the profile shape, have been used for evaluating profile shapes highly precisely. They are hardly affected by scanning error in measurement and considered to have advantages for long distance measurements. Here, profile measurement using a level was adopted for straightness alignment of the KEK e-/e^+ injector linac, considering the straightness alignment as a profile shape measurement. The slope angles between the alignment base plates of the linac could be detected with reproducibility of 10 micro-rad (sigma) by sequential measurement interval of 1 to 2 m. The reproducibility of the straightness derived from the angle measurements was 42 micrometer (sigma) for 69 m of the measurement distance and agreed well with the estimated value based on our error propagation model. These results show that straightness reproducibility of better than 1 mm (2-sigma) can be achieved for 500 m of the KEK e-/e^+ injector linac by sampling interval of 2m, and for 10 km of the ILC linac by sampling interval of 20 cm.

WEPEB056 **Experiments on laser-based alignment at the KEKB injector linac** – *M. Satoh, E. Kadokura, T. Suwada (KEK)*

A new laser-based alignment system is under development in order to precisely align accelerator components along an ideal straight line at the KEKB injector linac. The new alignment system is strongly required in order to stably accelerate high-brightness electron and positron beams with high bunch charges and also to keep the beam stability with higher quality towards the next generation of B-factories. A new laser optics with Airy pattern (so-called Airy beam) has been developed and the laser propagation characteristics in vacuum has been systematically investigated at a 82-m-long straight section of a beam line of the injector linac. The laser-based alignment measurement based on the new laser optics has been carried out with a measurement resolution of ±0.1 mm level by using a previously-used laser detection system. The experimental results are reported along with the basic design of the new laser-based alignment system.

WEPEB057 **New Laser-Based Alignment System for the 500-m-long KEK Electron/Positron Injector Linac** – *T. Suwada, M. Satoh (KEK)*

A new laser-based alignment system is under development at the KEKB injector linac. We are revisiting our alignment system because the previous alignment system has become obsolete. The new alignment system is again required to increase the stability of the electron- and positron-beam injection towards next-generation of B-factories. It is similar to the previous one, which comprises a laser-diode system and quadrant photodetectors installed in vacuum light pipes. A displacement of a girder unit of the accelerating structure can be precisely measured in the direction of the laser-ray trace, where the laser light must stably propagate up to 500-m-long downstream without any orbital and beam-size fluctuation. A novel approach in which a two-beam-interference laser-light propagates in the vacuum light pipe, has been designed to increase the alignment precision based on the quadrant photodetector measurement. The propagating laser spot sizes can be narrowed due to the two-beam interference over the Rayleigh-range limit. The design of the new laser-based alignment system is summarized along with some experimental results in this report.

WEPEB058 **Compatibility and Integration of a CLIC Quadrupole Nanometre-stabilization and Positioning System in a Large Accelerator Environment** – *K. Artoos, C.G.R.L. Collette, M. Guinchard, C. Hauviller, S.M. Janssens, A.M. Kuzmin, M.V. Sylte (CERN)*

A prerequisite for a successful nanometre level magnet stabilization and pointing system is a low background vibration level. This paper will summarize and compare the ground motion measurements made recently in different accelerator environments at e.g. CERN, CESRTA and PSI. Furthermore the paper will give the beginning of an inventory and characterization of some technical noise sources, and their propagation and influence in an accelerator environment. The importance of the magnet support is also mentioned. Finally, some advances in the characterization of the nanometre vibration measurement techniques will be given.

WEPEB059 **A Wire Position Monitor System for Superconducting Cryomodules in Fermilab** – *D.H. Zhang, N. Eddy, B.J. Fellenz, J. Fitzgerald, P.S. Prieto, A. Saewert, A. Semenov, D.C. Voy, M. Wendt (Fermilab)*

Fermilab is jointly developing capabilities in high gradient and high Q superconducting accelerator structures based on the 1.3 GHz TESLA technology. A wire-position-monitor (WPM) system, based on the INFN/TESLA design, is integrated to monitor cavity alignment and cold mass vibrations. The system consists of a reference wire carrying a 325 MHz signal, 7 stripline pickups (per cryomodule), and read-out electronics based on direct digital signal down-conversion techniques. We present technical details of the system, and preliminary results on resolution and stability measured at a mock-up test stand.

WEPEB060 **System Design of Accelerator Safety Interlock for the XFEL/SPring-8** – *M. Kago, T. Matsushita, N. Nariyama, C. Saji, R. Tanaka, A. Yamashita (JASRI/SPring-8) Y. Asano, T. Fukui, T. Itoga (RIKEN/SPring-8)*

The accelerator safety interlock system (ASIS) for the XFEL/SPring-8 protects personnel from radiation hazard. We designed the ASIS consisting of three independent systems; a central interlock system, an emergency interlock system and a beam route interlock system. The central interlock system monitors the machine tunnel security, status of beam line interlock system and radiation monitoring system. The emergency interlock system monitors status of emergency stop buttons. The beam route interlock system monitors electron beam route by inputting the current of the bending magnets at the electron-beam switching points. If any system trips, or if any system detects unsafe status, the permission signal for the accelerator operation from the system is off and the electron beam is inhibited. In addition, it is demanded that the permission signals must be transmitted within 16.6 ms. Therefore, the stability and fast response are required for the XFEL safety interlock system. We adopted programmable logic controllers (PLC) for the stability, and developed optical modules for the fast signal transmission. This paper describes system design of the ASIS.

WEPEB061 **A Fiber Beam Loss Monitor for the SPring-8 X-FEL: Test Operation at the SPring-8 250 MeV Compact SASE Source** – *X.-M. Maréchal (JASRI/SPring-8) Y. Asano, T. Itoga (RIKEN/SPring-8)*

Fiber-based beam loss monitors (BLM) have attracted much attention in recent years. Among them, systems using the detection of the Cerenkov light generated by the secondary charged particles hitting an optical fiber set along the vacuum chamber, offer the possibility to detect beam losses with a very fast response time (less than a few ms) over long distances, good position accuracy and sensitivity at a reasonable cost. For the undulator section of the SPring-8 X-FEL, radiation safety considerations set the desirable detection limit at 1 pC (corresponding to a 0.1% beam loss of the initial 1 nC/pulse) over more than a hundred meter. We report on a the test operation of a fiber-based BLM carried out at the 250 MeV SPring-8 Compact SASE Source (SCSS), a 1/16th model of the future X-FEL. The expected detection limit of the BLM based on a large (400 μm) core multimode fiber is below 2 pC over 120 m (for a corresponding 10 mV signal) while the position accuracy is expected to be better than one meter.

WEPEB062 **A Fiber Beam Loss Monitor for the SPring-8 X-FEL: A Numerical Study of its Design and Performance** – *T. Itoga, Y. Asano (RIKEN/SPring-8) X.-M. Maréchal (JASRI/SPring-8)*

A fiber-based beam loss monitors (BLM) is under development for the undulator section of the SPring-8 X-FEL: the system is based on the detection of the Cerenkov light generated by the secondary charged particles hitting an optical fiber set along the vacuum chamber. Various parameters come into account in the final performance of the system, such as the impact angle and energy of the lost electrons, the fiber position (angular and radial) with respect to the point of impact, fiber characteristics (numerical aperture, index, diameter), etc. Thorough numerical studies have been carried out to investigate the performances of the system. Comparison with the experimental results obtained at the SPring-8 Compact SASE Source (SCSS), a 1/16th model of the future X-FEL are also given.

WEPEB063 **Concept of Radiation Monitoring and Safety Interlock Systems for XFEL/SPring-8** – *N. Nariyama, H. Aoyagi, M. Kago, T. Matsushita, C. Saji, R. Tanaka (JASRI/SPring-8) Y. Asano, T. Itoga (RIKEN/SPring-8)*

The accelerator safety interlock system of XFEL/SPring-8 was designed to fulfill the requirement of matching with the safety interlock system of SPring-8 because both safety systems are planning to be unified in near future to deal with the electron beam injection from XFEL to SPring-8. At XFEL, however, additional requirements for the system also existed; the designed radiation shielding requires when the electrons are not injected into the dump core properly, the beam has to be terminated within 16 msec, which corresponds to 60 Hz operation, to avoid the next bunch coming. An outline of such different design criteria is presented together with the concept of the safety interlock system. The radiation monitoring system, which was also the same as that of SPring-8, was installed by reinforcing the redundancy and response time. Gamma and neutron monitors are set at 14 positions near the assumed loss points in the accessible place of the controlled area. The dose equivalent data are sent to the radiation monitoring systems of XFEL and SPring-8, respectively, and when the measured dose exceeds the preset level, an alarm signal is sent to the safety interlock promptly.

WEPEB064 **Electricity Generation from Scattered Secondary Particles Induced by Synchrotron Radiation** – *Y. Shimosaki, K. Kobayashi (JASRI/SPring-8)*

Electricity generation from scattered secondary particles has been examined for a kind of energy-recovery by using a beam loss monitor at the SPring-8 storage ring, in which PIN photodiodes are utilized without a reversed bias voltage in similar to a solar cell. The system and results will be reported.

WEPEB065 **Beam Loss of J-PARC Rapid Cycling Synchrotron at Several Hundred kW Operation** – *K. Yamamoto (JAEA/J-PARC)*

We successfully accelerated 300kW beam for one hour. We report the beam loss and the residual dose in such high intensity operation.

WEPEB066 **Shielding Analyses and Procedures for the SNS** – *I.I. Popova, P.D. Ferguson, F. X. Gallmeier (ORNL)*

All stages of the SNS development require significant research and development work in the field of radiological shielding design to assure safety from a radiation-protection point of view for facility operation and to optimize accelerator and target performance. Here we present an overview of on-going shielding work and associated with it procedures and regulations. In the present time, the most of the shielding work is focused on the neutron beam lines and their instrument enclosures in order to commission and provide save operation in the future. This effort is performed according to the guidelines for shielding calculations of SNS neutron beam lines, which sets standards for the analyses and helps to prepare for the Instrument Readiness Review (IRR). The IRR ascertains that the instruments has been design, constructed, and installed to allow safe operation and maintenance. In addition, there is still support for the accelerator facility to redesign parts of the accelerator structures, to design shielding for removed components and test stands for accelerator structures, and for radiation protection analyses for evaluations of accelerator and target safety systems.

WEPEB067 **Beam Containment System for NSLS-II** – *S.L. Kramer, W.R. Casey, P.K. Job (BNL)*

The shielding design for the NSLS-II will provide adequate protection for the full injected beam loss in two periods of the ring around the injection point, but the remainder of the ring is shielded for lower losses of <10% full beam loss. This will require a system to insure that beam losses don't exceed these levels for a period of time that could cause levels outside the shield walls. This beam containment system will measure, provide a level of control and alarm indication of the beam power losses along the beam path from the source (e-gun, linac) thru the injection system and the storage ring. This system will consist of collimators that will provide limits to (an potentially measure) the beam miss-steering and control the loss points of the charge and monitors that will measure the average beam current losses along the beam path and alarm when this beam power loss exceeds the level set by the shielding specifications. This will require some new ideas in beam loss detection capability and collimation. The initial planning and R&D program will be presented.

WEPEB068 **Feasibility Tests of the Beam Halo Monitoring System for Protecting Undulator Permanent Magnets against Radiation Damage at XFEL/SPring-8** – *H. Aoyagi, T. Bizen, N. Nariyama (JASRI/SPring-8) Y. Asano, T. Itoga, H. Kitamura, T. Tanaka (RIKEN/SPring-8)*

A beam halo region of an electron beam at a linear accelerator might hit the undulator magnets and degrade undulator permanent magnets. An interlock sensor is indispensable to protect the magnets against radiation damage. We have been developing an electron beam halo monitor using diamond detectors for an interlock sensor at the X-ray free electron laser facility at SPring-8 (XFEL/SPring-8). The diamond detectors are operated in photoconductive mode. Pulse-by-pulse measurements are adopted to suppress the background noise efficiently. The feasibility tests of this monitor have been performed at the SPring-8 compact SASE source (SCSS) test accelerator for XFEL/SPring-8, and the results will be summarized.

WEPEB069 **LHC Beam Loss Measurements and Quench Level Abort Threshold Accuracy** – *B. Dehning, E. Effinger, J. Emery, E.B. Holzer, S. Jackson, C. Kurfuerst, A. Marsili, A. Nordt, J. Perez, C. Zamantzas (CERN) D. Bocian (Fermilab) V. Grishin (IHEP Protvino) H. Ikeda (KEK)*

The LHC beam loss measurement system is mainly used to trigger the beam abort in case a magnet coil quench level is approached. The predicted heat deposition in the superconducting coils of the magnets have been determined by particle shower simulation codes, while the liquid helium cooling capacity of the system has been both simulated and measured. The results have been combined to determine the abort thresholds. Measurements of the energy depositions of lost protons from the initial beams in the LHC are used to determine the accuracy of the beam abort threshold settings. The simulation predictions are reviewed and compared with the measurement results. An optimisation strategy for improving these settings will be discussed.

WEPEB070 **Particle Shower Simulations and Loss Measurements in the LHC Magnet Interconnection Regions** – *C. Kurfuerst, B. Dehning, E.B. Holzer, A. Nordt, M. Sapinski (CERN)*

Particle losses in the LHC arcs are mainly expected in the interconnection region between a dipole and quadrupole magnet. The maximal beam size, the maximal orbit excursion and aperture changes cause the enhancement of losses at this location. Extensive Geant4 simulations have been performed to characterise this particular region to establish beam abort settings for the beam loss monitors in these areas. Data from first LHC beam loss measurements have been used to check and determine the most likely proton impact locations. This input has been used to optimise the simulations used for the definition of thresholds settings. The accuracy of these settings is investigated by comparing the simulations with actual loss measurements.

WEPEB071 **The CLIC Machine Protection** – *M. Jonker, E.B. Holzer, S. Mallows, D. Manglunki, G. Morpurgo, Th. Otto, M. Sapinski, F. Tecker, J.A. Uythoven (CERN)*

The proposed Compact Linear Collider (CLIC) is based on a two-beam acceleration scheme. The energy of high intensity, low energy drive beams is extracted and transferred to low intensity, high energy main beams. Direct ionization loss by the beam particles is the principal damage mechanism. The total charge gives a single drive beam-train a damage potential that is two orders of magnitude above the level causing structural damage in copper. For the main beam, it is the extreme charge density due to the microscopic beam size that gives it a damage potential of four orders of magnitude above the safe level. The machine protection system has to cope with a wide variety of failures, from real time failures (RF breakdowns, kickers misfiring), to slow equipment failures, to beam instabilities (caused by e.g. temperature drifts, slow ground motions). This paper discusses the baseline for the CLIC machine protection system which is based on passive, active and permit based protection. As the permit based protection depends on the measured performance of the previous pulse, the bootstrap procedure with safe beams and stepwise increase in beam intensities, is also discussed.

WEPEB072 **First Operation of the Abort Gap Monitor for LHC** – *T. Lefevre, S. Bart Pedersen, A. Boccardi, E. Bravin, A. Jeff, A. Rabiller (CERN) A.S. Fisher (SLAC)*

The LHC beam dump system relies on extraction kickers that need 3 microseconds to rise up to their nominal field. As a consequence, particles crossing the kickers during this rise time will not be dumped properly. The proton population during this time should remain below quench and damage limits at all times. A specific monitor has been designed to measure the particle population in this gap. It is based on the detection of Synchrotron radiation using a gated photomultiplier. Since the quench and damage limits change with the beam energy, the acceptable population in the abort gap and the settings of the monitor must be adapted accordingly. This paper presents the design of the monitor, the calibration procedure and the detector performance with beam.

WEPEB073 **The CERN Beam Interlock System: Principle and Operational Experience** – *B. Puccio, A. Castaneda, M. Kwiatkowski, I. Romera, B. Todd (CERN)*

A complex Machine Protection System has been designed to protect the LHC machine from an accidental release of the beam energy, with about 20 subsystems providing status information to the Beam Interlock System (BIS). Only if the subsystems are in the correct state for beam operation, the BIS receives a status flag and beam can be injected into LHC. The BIS also relays commands from the connected subsystems in case of failure for emergency extraction of beam to the LHC Beam Dump Block. To maintain the required level of safety of the BIS, the performance of the key components is verified before every fill of the machine and validated after every emergency beam dump before beam operation is allowed to continue. This includes all critical paths, starting from the inputs from connected system triggering a beam dump request, followed by the correct interruption and propagation sequence of the two redundant beam permit loops until the final extraction of the beam via the LHC beam dumping system. In this paper we report about the experience with the BIS that has been deployed for some years in the SPS (as LHC injector), in the transfer lines between SPS and LHC and recently in LHC.

WEPEB074 **Requirements of CLIC Beam Loss Monitoring System** – *M. Sapinski, E.B. Holzer, M. Jonker, S. Mallows, Th. Otto (CERN) C.P. Welsch (Cockcroft Institute)*

The Compact Linear Collider (CLIC) is a proposed multi-TeV linear electron-positron collider being designed by a world-wide collaboration. It is based on a novel two-beam acceleration scheme in which two beams (drive and main beam) are placed in parallel to each other and energy is transferred from the drive beam to the main one. Beam losses on either of them can have catastrophic consequences for the machine because of high intensity (drive beam) or high energy and small emittance (main beam). In the framework of machine protection, a Beam Loss Monitoring system has to be put in place. This paper discusses the requirements for the beam loss system in terms of detector sensitivity, resolution, dynamic range and ability to distinguish losses originating from various sources. A particular attention is given to the two-beam module where the protection from beam losses is particularly challenging and important.

WEPEB075 **Beam Halo Studies for CTF3** – *S.T. Artikova (MPI-K) C.P. Welsch (Cockcroft Institute)*

Beam halo can have severe effects on the performance of high energy accelerators. It reduces the experimental throughput, may lead to noise in the experiments, or even damaging of accelerator components. In order to understand and ideally control the formation and evolution of beam halo, detailed simulation studies are required. In this contribution halo generation mechanisms and the underlying physical principles are first presented, before the particular case of the CLIC Test Facility (CTF3) is discussed in detail. Analytical, numerical and simulation studies are combined to estimate the relevant sources of halo formation and to study halo propagation in the different CTF3 sections.

WEPEB076 **Precision Synchronization of the FLASH Photoinjector Laser** – *S. Schulz (Uni HH) V. R. Arsov (PSI) M.K. Bock, M. Felber, P. Gessler, K.E. Hacker, H. Schlarb, B. Schmidt, J. Zemella (DESY)*

After its upgrade, the free-electron laser in Hamburg (FLASH) will start operating with an exchanged RF-gun driven by an improved photoinjector laser. Since the SASE FEL process is very sensitive to the RF gun phase it is highly desirable to implement phase stabilization feedback, which, in turn, requires an arrival-time stabilization of the photoinjector laser pulses. In this paper we report on the synchronization of the photoinjector laser system to the optical timing reference using an optical cross-correlation scheme. This enables not only the measurement of the timing jitter, but also the stabilization using adaptive feed-forward algorithms acting on an EOM incorporated in the laser's pulse train oscillator. First results from the commissioning and future plans for a feedback system are discussed.

WEPEB077 **Status of the Upgraded Optical Synchronization System at FLASH** – *S. Schulz, L.-G. Wissmann (Uni HH) V. R. Arsov (PSI) M.K. Bock, M. Felber, P. Gessler, K.E. Hacker, H. Schlarb, B. Schmidt, J. Zemella (DESY) F. Loehl (CLASSE) A. Winter (ITER)*

The free-electron laser in Hamburg (FLASH) has been upgraded recently by a phase-space linearizing third harmonic RF-cavity, the laser-driven seeding experiment (sFLASH) and to achieve a maximum energy of 1.2 GeV. In this paper, we report on the accompanying upgrades and the commissioning of the optical synchronization system which is not only crucial for the commissioning of the accelerator after its shutdown but also an important prerequisite for the sFLASH operation. Furthermore, it should now serve as a basis for a longitudinal feedback to stabilize the electron bunch arrival-time for user operation. The upgrade comprises a much improved infrastructure, the installation of a new master laser oscillator, additional and replaced bunch arrival-time monitors, the required fiber links, two large horizontal aperture BPMs, the synchronization of the seed- and the pump-probe laser as well as the stabilization of the photoinjector laser.

WEPEB078 **Investigation of Drift Compensated Fiber for the Pulsed Optical Synchronization System at FLASH** – *H. Schlarb (DESY)*

Optical pulses with 100fs duration are distributed in actively length stabilized fiber links to remote end-stations for femtosecond synchronization at FLASH. The active link stabilization is labor and cost intensive. To bridge short distances of a few 10m only, the approach is not justified and a passive solution would be desirable. For this purpose, the temperature dependent delay of a short commercial available drift compensated optical fiber has been investigated for the FLASH synchronization system. In this paper, the optical setup and experimental results of the speciallity fiber is presented. For short distances, the drift compensated fiber has shown an excellent performance over the relevant temperature range and outranges RF cables an order of magnitude.

WEPEB079 **Final Design and Features of the B-train System of CNAO**

– *G. Franzini, O. Coiro, D. Pellegrini, M. Serio, A. Stella (INFN/LNF) M. Pezzetta, M. Pullia (CNAO Foundation)*

CNAO, the Italian Centre of Oncological Hadrontherapy located in Pavia, is under commissioning and will be soon fully operational. It is based on a synchrotron that can accelerate carbon ions up to 400 MeV/u and protons up to 250 MeV for the treatment of patients. In this paper we present the subsystem, called B-Train, which has the purpose of measuring the magnetic field in a dedicated dipole connected in series with the sixteen dipoles of the synchrotron and to provide instantaneous values of the synchrotron field to the dipole power supply, to the RF, diagnostics and dump bumpers control systems, via optical lines, using a custom communication protocol. In order to measure the magnetic field with the specified precision (0.1G over 1.5T @ 3 T/s), a different approach has been taken with respect to previous versions of the system. The field is obtained by digitizing the voltage induced on a pick-up coil inserted in the gap of the dedicated dipole through a 18 bit, 1.25 Msamples/s ADC and integrating it by numerical methods. This paper describes the final design and features of the B-Train system, as well as the results obtained on the magnetic field readings precision.

WEPEB080 **Femtosecond Electro-Optical Synchronization System**

– *P.L. Lemut (I-Tech) B. Batagelj, L. Pavlovic, J. Tratnik, M. Vidmar (University of Ljubljana, Faculty of Electrical Engineering)*

The new generation of accelerators requires timing distribution and RF synchronization with femtosecond precision in terms of jitter and long-term stability. The proposed electro-optical synchronization system makes use of commercial telecom single-mode optical fibre operating at 1550 nm.. It operates on over 300 m distance. It consists of a transmitter, located near a low-jitter master oscillator, and receiver, located at the remote location. The field experiments have been done in the accelerator environment with the fibre pair in the tunnel. The prototype units were installed at the same location to make phase difference measurement simple. Temperature in various installation points, phase difference and both units internal operational parameters were continuously monitored and stored. Data was post-analysed and conclusions were used for hardware changes and mostly the long-term stability improvement. A dedicated phase detector was designed to monitor less than 20 fs changes. Results are showing 80 fs RMS and 30 fs stability over 20 and 8 hours respectively. The prototype is being redesigned for manufacturing with some new features for improved long-term stability.

26-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area C

WEPEC — Poster Session

WEPEC001 **Cryogenic Tests of a 704 MHZ 1MW Power Coupler** – *G. Devanz, D. Braud, J.-P. Charrier, S. Chel, M. Desmons, A. Hamdi, D. Roudier, P. Sahuquet (CEA)*

Coaxial power couplers capable of handling 1MW peak power have been developped for high intensity superconducting proton linacs. They have been conditioned in travelling wave up to the maximum power available on the Saclay test bench, 1.2 MW forward peak power, up to 10% duty cycle. One coupler has been assembled on a 5-cell medium beta cavity in the class 10 area of the clean room, and installed in our horizontal test cryostat CryHoLab. This paper focusses on the RF operation of the coupler in this cryogenic environment and thermal aspects.

WEPEC002 **Titanium Nitride Coating as a Multipactor Suppressor** – *W. Kaabi, A. Variola (LAL) A. Brinkmann (DESY) G. Keppel, V. Palmieri (INFN/LNL) I. Montero (CSIC)*

LAL-Orsay is developing an important effort on R&D and technology studies on RF power couplers for superconductive cavities. One of the most critical components of those devices is the ceramic RF window that allows the power flux to be injected in the coaxial line. The presence of a dielectric window on a high power RF line has a strong influence on the multipactor phenomena. The most important method to reduce the multipactor is to decrease the secondary emission yield of the ceramic window. Due to its low Secondary electron Emission Yield (SEY), TiN thin film is used as a multipactor suppressor coating on RF ceramic coupler windows. In this frame work, TiN deposition was made by magnetron reactive sputtering. XPS and XRD analysis were performed to control the film composition and stoechiometry. Coating thickness was optimized so that the TiN coating effectively reduces the SEY but does not cause excessive heating, due to ohmic loss. For this purpose, SEY measurements on covered and uncovered TiN Alumina substrates, multipactor level breakdown on TiN coated Cupper substrates and RRR measurements were performed for different deposit thicknesses.

WEPEC003 **Industrial Production and Delivery of 800 Fundamental Power Couplers for the XFEL Linac** – *L. Lukovac, E. Genesseau (LAL)*

Within the XFEL project Laboratoire d'Accélérateur Linéaire (LAL) is engaged to deliver 800 fundamental power couplers operating at 1.3 GHz at nominal power of 120 kW for the superconducting linac. This paper presents the strategies chosen for industrial production along with that of conditioning so as to deliver couplers at the rate of 8 per week.

WEPEC004 **Recent Activities at HoBiCaT** – *O. Kugeler (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

The HoBiCaT facility at HZB-Berlin for CW testing of superconducting cavities has been up and running for several years now. Recent activities and results are being presented.

WEPEC005 **Optical Inspection of SRF Cavities at DESY** – *S. Aderhold (DESY)*

The prototype of a camera system developed at KEK/Kyoto University for the optical inspection of the inner surface of cavities is in operation at DESY since September 2008. More than 20 prototype nine-cell cavities for the European XFEL have been inspected. The unique illumination system combined with the optical sensors allows for the in-situ search of surface defects in high resolution. Such defects may limit the gradient when causing a breakdown of the superconducting state (quench). The comparison of features detected in the optical inspection and hotspots from the temperature mapping during RF-measurements give evidence for correlations. Consecutive inspections of cavities in different stages of the surface preparation process monitor the evolution of surface defects. There are examples for defects traced from the untreated surface condition to the RF-test with temperature map, which identify the defect as the quench location.

WEPEC006 **Towards PLM-based Quality Assurance in the Fabrication of the Superconducting Cavities for the European XFEL** – *L. Hagge, J.A. Dammann, J. Iversen, J. Kreutzkamp, W. Singer (DESY)*

For the series production of s.c. cavities for European XFEL, thorough quality assurance procedures are under preparation to ensure that all cavities satisfy their performance requirements. Each cavity needs to pass a number of quality gates at different levels of completion. At each quality gate, the so-far available manufacturing data and documentation is reviewed and approved by the XFEL cavity production team. To ensure reliable and repeatable procedures with timely responses, the QA efforts are supported by the DESY Product Lifecycle Management (PLM) System, aka DESY EDMS. The EDMS manages fabrication data, coordinates acceptance tests, manages signoffs and provides fabrication progress monitoring. In particular, the EDMS tracks the entire history of all individual cavities, their parts and their semi-finished products. The setup benefits from experience which has been gained at DESY in the cavity production for FLASH. The poster explains the planned QA procedures and customization of the EDMS, and reports inital experience.

WEPEC007 **Surface Investigation of Prototype Cavities for the European XFEL** – *X. Singer, S. Aderhold, A. Ermakov, W. Singer, K. Twarowski (DESY) M. Hoss, B. Spaniol (W.C. Heraeus GmbH, Materials Technology Dept.) F. Schoelz (W.C. Heraeus GmbH COPY, Materials Technology Dept.)*

Performance of XFEL prototype cavities fabricated at the industry and treated at DESY demonstrates big scattering from 15 to 41 MV/m. Most cavities satisfy the XFEL specification. Few cavities with low performance (15-17 MV/m) are limited by thermal break down without field emission. The T-map analysis detected the quench areas mainly close to the equator. Optical control by high resolution camera has been applied and allowed to monitor the defects in some cases with good correlation to T-map data. In order to understand the cause of reduced performance and get more detailed information of defects origin some samples have been extracted from two cavities and investigated by light microscope, 3D- microscope, SEM, EDX and Auger spectroscopy. Several surface flaws with sizes from few μm to hundreds of μm were detected by microscopy. The defects can be separated in two categories. The first category of defects indicates foreign elements (often increased content of carbon). Inclusions with increased content of carbon adhered on the surface and presumably have a hydrocarbon nature. Deviation from smooth surface profile characterizes the second type of defects (holes, bumps and pits).

WEPEC008 **HOM Spectrum and Q-factor Estimations of the High-Beta CERN-SPL-Cavities** – *H.-W. Glock, T. Galek, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering)*

Beam energy deposited in Higher-Order-Modes may affect both beam stability and cryo power requirements of the planned CERN Superconducting Proton Linac SPL. We report on numerical studies of the high-beta cavity type, analyzing it's HOM spectrum. The most dangerous modes are identified and different possibilities of appropriate damping are discussed.

WEPEC009 **Designing of 9 Cell Reduced Beta Elliptical Cavity for High Intensity Proton Linac** – *A. Saini (University of Delhi) C.S. Mishra, K. Ranjan, N. Solyak, V.P. Yakovlev (Fermilab)*

A superconducting rf cavity is designed for acceleration of particles travelling at 81% the speed of light. The cavity will operate at 1.3 GHz & is to be used in SILC section of the proposed high intensity proton linac at Fermilab. At present cavity will serve to accelerate the particles for energy range 466 MeV to 1.2 GeV. The cavity will be shorter than 9 cell beta =1 cavity but nearly same ratio of surface magnetic field to surface electric field. Cell to cell coupling coefficient is also optimized to get the good field flatness. The cavity is studied for monopole modes and higher order modes. The shapes of end cells are optimized to avoid dangerous modes with keeping same field flatness & same operating frequency.

WEPEC010 **Optimization of End Cells for 11 Cell Beta 0.81 Cavity** – *A. Saini (University of Delhi) A. Lunin, C.S. Mishra, K. Ranjan, N. Solyak, V.P. Yakovlev (Fermilab)*

Eleven cell elliptical cavity is designed for acceleration of particles traveling at 81 % of the speed of light. It will operate at 1.3 GHz and will be used to accelerate the particles from 0.4 GeV to 1.2 GeV. The cavity is studied for higher order mode (HOM) and trapped modes. The shapes of end cells of cavity is optimized to increase the field amplitude in end cells so that coupling of trapped modes may increase with HOM coupler and they can be extracted easily but keeping the field flatness & operating frequency undisturbed.

WEPEC011 **Multipacting Analysis of Superconducting RF Cavities using a Finite Element-based Code employing Leap Frog Scheme** – *S. Ghatak, A.S. Dhavale, K.C. Mittal, J. Mondal (BARC)*

BARC is involved in the development of superconducting cavities for Accelerator Driven Sub-critical System (ADSS). The performance of superconducting RF structure can be greatly affected due to multipacting. Hence 2D and 3D multipaction simulation studies have been carried out for a medium velocity (β=0.49) elliptical Niobium cavity operating at 10^{50} MHz. An in-house code has been developed which uses finite element method based software to calculate electromagnetic field of the structure. Leap frog method algorithm has been used to solve Lorenz force equation for trajectory tracking of electrons which are launched inside from different initial positions. Electron trajectories are tracked until they hit the surface. An interpolation function is used to calculate SEY at different impact energies. By repeating the process at different field level for different primary electrons multipacting field levels are identified. The study revealed that the cavity structure is not multipacting prone up to 17 MV/m average accelerating field. Two point first order multipacting is observed at the equatorial region of the cavity when the accelerating field is between 18 MV/m and 28 MV/m.

WEPEC012 **Study of Multipacting in a Coaxial Coupler** – *A.S. Dhavale (BARC) K.C. Mittal (BARC-EBC)*

The performance of superconducting cavity, couplers and ceramic windows is greatly affected due to multipacting. The present paper describes the multipacting simulations carried out on the co-axial coupler. The equation of motion of electron in RF field is calculated numerically. The enhanced counter function (ECF) is calculated to find out whether a particular electron will give rise to the multipacting. The simulation was carried out for a co-axial coupler having the inner conductor diameter of 34.78 mm and outer conductor diameter of 80 mm at a RF frequency of 350MHz, 700MHz and 1050MHz.

WEPEC013 **Phase Locking of Superconducting Quarter Wave Resonator by Piezoelectric Actuator** – *B.K. Sahu, R. Ahuja, G.K. Chowdhury, R.N. Dutt, S. Ghosh, D. Kanjilal, D.S. Mathuria, A. Pandey, P. Patra, A. Rai, A. Roy, K. Singh (IUAC)*

The existing phase locking scheme of the quarter wave resonators(QWR) in the first operational module of the superconducting heavy ion linear accelerator of Inter University Accelerator Centre consists of a fast (electronic) and a slow time scale control. Helium gas operated slow tuner turns out to be a complicated, somewhat unreliable and expensive for long term operation of the linac. In an alternate scheme to handle the slow time part of the phase control, the tuner plate is deflected by using a combination of a stepper motor for course adjustments and a piezoelectric crystal for fine adjustment of the frequency. The piezoelectric actuator is used in closed loop along with dynamic I-Q based electronic tuner to phase lock the superconducting cavities. During a recent cold test of a QWR, the frequency range of the resonator by the piezoelectric tuner was measured to be 1 kHz. In this test, the fundamental frequency of the QWR was first brought to 97.000 MHz by the mechanical course tuner. The resonator was then locked at a field of 3.8 MV/m at 6 W of helium power and 40 W of forward power from the RF amplifier using the resonator controller along with the piezoelectric tuner.

WEPEC014 **Analysis of the Niobium Surface Evolution during BCP and EP Treatments** – *L. Monaco, P.M. Michelato, C. Pagani, D. Sertore (INFN/LASA)*

The continuous request of higher and reliable accelerating gradient for the SC niobium cavities of the new large accelerator facilities, like XFEL and the ILC, is pushing to improve the niobium surface quality during all the production steps (forming, machining, welding, handling, chemical and electrochemical treatments, HPR, etc.). Furthermore, the more and wider use of specialized equipments for the visual inspections of the inner surface of the cavities has given hints relative to the kind of defects that can be found and that could limit the final accelerating gradients of the SC cavity. In this paper we summarize the experimental results relative to the surface evolution of several niobium samples, welded and not, treated with BCP and EP in our laboratory. In particular, the evolution of artificial defects produced "ad hoc" in different location on the niobium samples surfaces (weld area, heat affected zone), with dimensions and geometries similar to the ones revealed during the cavity visual inspections, is presented and discussed.

WEPEC015 **Development of a Prototype Module for the ERL Superconducting Main Linac at KEK** – *T. Furuya, K. Hara, K. Hosoyama, Y. Kojima, H. Nakai, K. Nakanishi, H. Sakai, K. Umemori (KEK) M. Sawamura (JAEA/ERL) K. Shinoe (ISSP/SRL)*

A prototype module including a couple of 1.3 GHz superconducting 9-cell cavities has been designed as the main linac of cERL which is the test facility to establish the basic ERL technology at KEK. The shape of 9-cell Nb structure has been optimized to accelerate a CW beam of 100 mA with sufficiently damped higher order modes (HOM) which is achieved by adopting an eccentric fluted beam pipe and a cylindrical beam pipe of a large diameter of 123 mm. Extracted HOMs are absorbed by the ferrite cylinders bonded on the copper beam pipes by HIP process. A power coupler with double disk-ceramics has been developed to transfer an RF of 20 kW CW to the cavity in full reflection. The test results of fabrication, cooling and RF performance for these components are integrated as the prototype module of the main linac for cERL facility.

WEPEC016 **Preparation Status of Cryomodule Tests of Tesla-like Cavities in S1-Global Project at KEK** – *E. Kako, H. Hayano, S. Noguchi, N. Ohuchi, M. Satoh, T. Shishido, K. Watanabe, Y. Yamamoto (KEK)*

Cryomodule tests of four Tesla-like cavities is under preparation for S1-global project at KEK. An average maximum accelerating gradient (Eacc,max) of four cavities in the vertical tests at 2 K was reached to approximately 25 MV/m. Conditioning of four STF-2 input couplers was carried out at a high power test stand with a 5MW-pulsed klystron. Two types of frequency tuning system with a slide-jack tuner and a piezo tuner is installed at the center or end position of the He jacket. String asssembly of the four cavities will be started in March, and the first cool-down test of the cryomodule is scheduled in June, 2010.

WEPEC017 **Development of UHV Field Emission Scanner for Surface Study of Niobium SRF Cavity** – *S. Kato, M. Nishiwaki (KEK) V. Chouhan (GUAS) T. Noguchi (KAKEN Inc.) P.V. Tyagi (Sokendai)*

It is mandatory to investigate field emission on Nb SRF cavity systematically since strong field emission often limits the cavity performance. The field emission strength and the number of emission sites strongly depend on Nb surface properties which are determined by its surface treatment and handling. Field emission scanner developed allows us to measure a distribution of the field emitting sites over a sample surface at a given field strength along with its FE-SEM (field emission scanning electron microscope) observation and energy dispersive x-ray analysis. The field emission scanner consists of a sample stage driven by piezo actuators and an anode needle driven by precise 3D stepping motors. In addition, this system was newly equipped with a sample load-lock system for existing UHV suitcases. The compact scanner was installed into the space between the object lens and the SEM sample holder. The UHV pumps were additionally installed in order to improve the base pressure down to UHV to reduce adsorbates during the measurement. This article describes development of the field emission scanner and its preliminary results of the application to niobium samples.

WEPEC018 **Application of Electrochemical Buffing onto Niobium SRF Cavity** – *S. Kato, M. Nishiwaki (KEK) S. Azuma, F. Yamamoto (Ultra Finish Technology Co., Ltd.) P.V. Tyagi (Sokendai)*

Niobium electropolishing for SRF cavities are generally considered to be the best technology today. However, hydrofluoric and sulphuric acid mixture usually used in the EP process is harmful and requires us carefully controlled handling of it and the many additional facilities. In this article, we propose a new application of electrochemical buffing onto niobium SRF cavity. In the method of electrochemical buffing, a rotating disk with abrasive fine particles where electrolyte is supplied is pressed against the workpiece. The disk and the work function as a cathode and an anode, respectively and an aqueous solution of sodium nitrate is used for the electrolyte. This technique brings us a couple of advantages like high etching rate, ultra small surface roughness, cost-effective and environment-compatible polishing.

WEPEC019 **Defect-Induced Local Heating and Transient Thermal Behavior of Superconducting Cavity Surface** – *Y. Morozumi (KEK)*

Surface defects are suspects responsible for thermal breakdown of superconducting RF cavities. Evaluation of local heating at surface defects and analysis of thermal behavior will be discussed in comparison with experimental evidences.

WEPEC020 **Realistic Evaluation of Local Field Enhancement based on Precision Profilometry of Surface Defects** – *Y. Morozumi (KEK)*

The limitation of the accelerating gradient is one of the current major issues in the development of 1.3 GHz superconducting RF accelerator structures. While some of single-cell cavities and a few of 9-cell structures have occasionally seen accelerating gradients over 50 MV/m and 40 MV/m respectively, the reproducibility of high gradient performance is still poor. Field emission and thermal breakdown due to surface imperfections are supposed to limit the gradient. Magnetic field enhancement at small surface defects can give rise to thermal breakdown through local heating ending up with low gradients. Simulations with idealized primitive models are totally unrealistic since real existing defects have complicated and irregular shapes. Profilometry-based realistic high-fidelity modelling of field enhancement will be presented.

WEPEC021 **Measurement of Hydrogen Absorbed in Niobium** – *K. Nakanishi, K. Hara, K. Hosoyama, A. Kabe, Y. Kojima (KEK)*

Hydrogen absorbed in niobium was measured using effect of hydrogen Q-degradation. A niobium cavity was designed and manufactured for this experiment. Hydrogen was introduced from outside of the cavity by electrolysis of diluted sulfuric acid on the outer surface of the cavity with an anode made by stainless steel. The Q-factor is one of the most unstable property of superconducting cavities. Especially, the reproducibility of Q-factor cannot be so expected after disassembled and reassembled it. In this experiment, the Q-factor was measured without disassembling, because hydrogen was introduced from outside of the cavity. The Q-degradation was observed successfully. And the Q-factor becomes worse and worse, when hydrogen was introduced more and more. To estimate the amount of hydrogen which is absorbed in niobium, small and thin niobium samples were prepared. They were warmed by the energizing heating in vacuum after having introduced hydrogen. The out-gas was analyzed by QMS, and the amount of hydrogen was estimated. This method can be applied to measure the absorbed hydrogen during electro or chemical polishing of cavities without some influence of changing the surface morphology.

WEPEC022 **Beam Behavior due to Crab Cavities Break down** – *K. Nakanishi, Y. Funakoshi, M. Tobiyama (KEK)*

Crab cavities were installed in KEKB in 2007. The function of the cavity is to tilt the bunch of the beam in the longitudinal direction. But if the RF phase gets out of control, the cavity kicks the beam like a steering magnet. To avoid this unwanted kick, the RF phase must be controlled well. In beam operation, some disturbances may occur such as a discharge, a quench, etc. When such disturbances occur, it is very difficult to control the RF phase precisely. We can't trust measured RF phase at that time. In KEKB, beam is aborted quickly when a disturbance is detected. Beam behavior before detect the disturbances has been investigated. We discuss following items. (1)How fast should the beam be aborted after detecting disturbances? (2)How fast should RF be turned off after detecting disturbances? (3)What a kind of disturbance is harmful? (4)Is the beam abort necessary at all? (Is just to turn RF off OK?)

WEPEC023 **Surface Study on Niobium Stain after Electro-polishing for Super-conducting RF Cavity** – *M. Nishiwaki, H. Hayano, S. Kato, T. Saeki, M. Sawabe (KEK) P.V. Tyagi (Sokendai)*

In development of superconducting radio-frequency niobium cavities, there are problems in low performances of electro-polished (EP) cavities with a fresh EP solution due to stains on the surfaces with discoloration. Although the stain problems have been known from the past researches, the detailed study with surface analysis has not been carried out. In this study, the stains on the niobium surfaces were observed with x-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy and scanning electron microscope. According to results of XPS, there are some differences in atomic components at the stained and non-stained surfaces, ex, a little amount of fluorine and no metal oxide were found only at the stained surface. In this article, we will describe the detail of the XPS results.

WEPEC024 **Present Status of Superconducting Cavity System in cERL Injector Linac at KEK** – *S. Noguchi, E. Kako, M. Satoh, T. Shishido, K. Watanabe, Y. Yamamoto (KEK)*

A superconducting cavity system has been developing for cERL injector Linac at KEK. Two prototype 2-cell niobium cavities and two prototype input couplers were fabricated. The vertical tests of the cavities at 2 K were carried out to qualify their performance. The rf conditioning of the input couplers were carried out at a high power test stand with a cw-300kW klystron. The results of the cavity performances at high gradients and the conditioning of the input couplers will be presented in this paper.

WEPEC025 **Studies on the Production of Brown Stains in Electro-polishing Process with Nb Sample Plates at KEK** – *T. Saeki, H. Hayano, S. Kato, M. Nishiwaki, M. Sawabe (KEK) R.L. Geng, A.T. Wu (JLAB) P.V. Tyagi (Sokendai)*

In June 2008, some 9-cell cavities were Electro-polishied (EP'ed) with new EP electrolyte at KEK and the performance of these cavities were limited by heavy field emissions. On the inner surface of these cavities, brown stains were observed. We made an effort to reproduce the brown stains on Nb sample plates with an EP setup in laboratory with varying the concentration of Niobium in the EP electrolyte. We found that the brown stains would appear only when processed with new EP electrolyte. This article describes these series EP-tests with Nb sample plates at KEK.

WEPEC026 **Study on the Electro-Polishing of Nb Sample with Artificial Pits** – *T. Saeki, H. Hayano, S. Kato, M. Nishiwaki, M. Sawabe. (KEK) W.A. Clemens, R.L. Geng, R. Manus (JLAB) P.V. Tyagi (Sokendai)*

The Electro-polishing (EP) process is the best candidate of final surface-treatment for the production of ILC cavities. Nevertheless, the development of defects on the inner-surface of the Superconducting RF cavity during EP process has not been studied by experimental method. We made artificial pits on the surface of a Nb sample-plate and observed the development of the pits after each step of 30um-EP process where 120um was removed by EP in total. This article describes the results of this Nb sample EP-test with artificial pits.

WEPEC027 **Long-period Monitoring of Electro-polishing Electrolyte in EP Facility at KEK** – *M. Sawabe., H. Hayano, S. Kato, M. Nishiwaki, T. Saeki (KEK) P.V. Tyagi (Sokendai)*

We have constructed an Electro-polishing (EP) Facility in the Superconducting RF Test Facility (STF) at KEK in 2008. The EP facility has been used for the EP process of Superconducting RF (SRF) 9-cell cavities for more than one year. In the EP facility, the capacity of the EP-electrolyte reservoir tank is 2,000 L. This size is relatively large if compared with EP facilities in other laboratories. It means that the quality control of EP electrolyte is more difficult because the status of EP-electrolyte changes as the aging of EP-electrolyte proceeds. In the real EP-process operations, we circulated the EP electrolyte of 1,100 L which was firstly delivered into the tank in January 2008 and was disposed in May 2009. During this period, we performed the EP processes 40 times and periodically measured the concentration of Nb ,Al ,HF in the EP electrolyte. In this article, we report the detailed results of the EP-electrolyte monitoring as well as the observation of changing electronic current oscillation in the EP processes during this period in the EP facility at STF/KEK.

WEPEC028 **Cavity Diagnostics using Rotating Mapping System for 1.3GHz ERL 9-Cell Superconducting Cavity** – *H. Sakai, T. Furuya, S. Sakanaka, T. Takahashi, K. Umemori (KEK) M. Sawamura (JAEA/ERL) K. Shinoe (ISSP/SRL)*

We are developing the superconducting (SC) cavity for Energy Recovery Linac (ERL) in Japan. In order to survey the electron emission and the heating spot of the cavity inner surface in detail, cavity diagnostics with the rotating mapping system was applied. Two types of sensors, one of which is the carbon resistor and the other is the Si PIN photo diode, were set to detect the temperature rise and electron emission. By rotating the sensor arrays around the cavity axis, a lot of information is obtained all over the cavity surface in detail. This paper reports the results of vertical tests by using this rotating mapping system with Nb 9-cell ERL cavity.

WEPEC029 **Power Coupler Development for ERL Main LINAC in Japan** – *H. Sakai, T. Furuya, S. Sakanaka, T. Takahashi, K. Umemori (KEK) A. Ishii, N. Nakamura, K. Shinoe (ISSP/SRL) M. Sawamura (JAEA/ERL)*

We started to develop an input power coupler for a 1.3GHz ERL superconducting cavity for ERL main linac. Required input power is about 20kW for the cavity acceleration field of 20MV/m and the beam current of 100mA in energy recovery operation. The input coupler is designed based on the STF-BL input coupler, especially choke-mode type ceramic window was applied. After that some modifications are applied for the CW 20kW power operation. We fabricated input coupler components such as ceramic windows and bellows and carried out the high-power test of the components by using a 30kW IOT power source and a test stand constructed.

WEPEC030 **Results of Vertical Tests for KEK-ERL 9-cell Superconducting Cavity** – *K. Umemori, T. Furuya, H. Sakai, T. Takahashi (KEK) M. Sawamura (JAEA/ERL) K. Shinoe (ISSP/SRL)*

In order to verify the technology needed for ERL main linac cavities, we fabricated a prototype of L-band 9-cell KEK-ERL superconducting cavity. For the ERL, along with high gradient and high Q-value, strong HOM damping is required. Its cell shape is optimized for the HOM damping. The cavity has large irises of 80 mm diameter, large beampipes of 120 mm and 100 mm diameter and the eccentric fluted beampipe. After a series of surface treatment, such as annealing, electro-polishing, high-pressure-rinsing and baking, several vertical tests have been performed. As for cavity diagnostics, a rotating X-ray and temperature mapping system was constructed. The cavity performance was limited to less than 20 MV/m by the field emissions. The X-ray distributions caused by field emission were clearly observed by X-ray mapping system. In this report, we summarize the recent results of the vertical tests.

WEPEC031 **Observation of Resonance Mode in Coaxial-type Input Coupler** – *K. Umemori, T. Furuya, H. Sakai (KEK) M. Sawamura (JAEA/ERL) K. Shinoe (ISSP/SRL)*

The coaxial-type input couplers are frequently used for accelerators, since it can successfully propagate high power of RF. Thus we have been developing the coaxial-type input coupler for ERL main linac, operated at 1.3 GHz. When performing high power test of its component, however, we suffered from the heat load due to unexpected loss. A resonance just around 1.3 GHz was found from the low-level measurement. In order to investigate the cause of that resonance, precise calculation was done with MW-studio and HFSS codes. Both codes showed one of dipole modes exists at around 1.3 GHz, near coaxial ceramic window. Details of the mode were further investigated. It showed that the resonant frequency of it depends on, for example, the thickness of the ceramic, the permittivity of the ceramic, and the sizes of inner and outer conductors. In this report, we summarize the experimental observations and the some results from the calculations.

WEPEC032 **Surface Inspection on MHI-01~09 Cavities** – *K. Watanabe, H. Hayano, E. Kako, S. Noguchi, T. Shishido, Y. Yamamoto (KEK) Y. Iwashita (Kyoto ICR) Y. Kikuchi (Tohoku Gakuin University)*

Nine 1.3 GHz 9-cell superconducting cavities (MHI-01 ~ 09) for International Linear Collider (ILC) project were fabricated from 2005 to 2009 at KEK-STF. The vertical test (with temperature and X-ray mapping) and optical inspection using by high resolution camera system for nine cavities were carried out from 2006 to 2009 for STF Phase-I project and S1-Global project at KEK. The cavities were separated to three series. The first series is MHI-01 ~ 04 (fabricated at 2005). They were made the Centrifugal barrel polishing (CBP) at initial surface treatment. The second series is MHI-05 and 06 (fabricated 2008). The third series is MHI-07 ~ 09 (fabricated at 2009). The surface treatments of second and third series cavity were made only Electro Polishing (EP) process (without CBP), because of the EBW seams of equator and iris were improved by the feedback of optical inspection method. A good correlation has been so far observed between the hot spots localized by thermometry measurements in the vertical test and the positions of surface defects found by this system. The result of optical inspection will be reported in this paper.

WEPEC033 **Repair Techniques of Superconducting Cavity for Improvement Cavity Performance at KEK-STF** – *K. Watanabe, H. Hayano, E. Kako, S. Noguchi, T. Shishido, Y. Yamamoto (KEK) Y. Iwashita (Kyoto ICR)*

The repair techniques of superconducting cavity is important to obtain better yield of accelerating gradient of superconducting 1.3 GHz 9-cell cavities. The techniques for repair of the cavity are combination of the optical inspection, make a replica of defect, the local grinding and the result of temperature mapping in vertical test. The pit type defect (size: 0.7 mm x 0.5 mm, depth: about 115 um) was found at the quench location of MHI-08 cavity at 16 MV/m by optical inspection after 1st vertical test at June 2009. The location of defect is boundary between EBW seam and heat affected zone at 172 degree of 2-cell equator. If a cause of field limitation for MHI-08 is really this pit type defect, then the cavity can repair to remove the defect by mechanical grinding method. The defect was removed completely by the special grinding machine. After grinding, Electric polishing process and optical inspection were carried out to check the surface condition at grinding area. The 2nd vertical test of MHI-08 was carried out at October 2009. The accelerating field was improved from 16 MV/m to 27 MV/m. The result of repair of MHI-08 will be reported in this paper.

WEPEC034 **Various Rinsing Effects to Mitigate Contaminants Brought by BCP on Niobium SRF Cavity Surface** – *P.V. Tyagi (Sokendai) H. Hayano, S. Kato, M. Nishiwaki, T. Saeki, M. Sawabe (KEK)*

Buffered chemical polishing (BCP) has been widely used as a final recipe of the surface treatment for niobium cavities and there is still much room to improve this technology since it is environment friendly, cheaper and simpler than electro-polishing. To examine BCPed surface in detail, we carried out BCP experiment followed by various rinsing methods on a series of niobium samples at KEK. As a result of the BCP process some contaminants like fluorine, carbon, etc. have been detected at the surfaces which may be the prominent cause of limiting the performance of SRF cavities. To remove these contaminants, various rinsing processes such as ultra pure water rinse, ultrasonic pure water rinse, alcoholic rinse, detergent rinse, high pressure water rinse (HPR) had been tested after the BCP. The preliminary results show that, only HPR had potential to mitigate these contaminants. In this article, we describe the surface analysis results using X-ray photo electron spectroscopy etc and a comparative study of niobium BCPed samples followed by above mentioned rinsing processes.

WEPEC035 **Multipoint T-maps for Vertical Test of the Superconducting Accelerator Cavities** – *H. Tongu, H. Fujisawa, M. Ichikawa, Y. Iwashita (Kyoto ICR) H. Hayano, K. Watanabe, Y. Yamamoto (KEK)*

The vertical test is a performance trial done by cooling the superconducting cavity, and injecting the high-frequency electricity. The temperature mapping (T-map) system is developed for the vertical test. T-map system can find heat sources that may be caused by defects on inner surfaces of superconducting cavities. The purpose of our studies on T-map is to realize a high spacial resolution and easy installation of the sensors. CMOS analog multiplexers in the cryogenic temperature can manage about thousand sensors per 9 cells to send their signals with fewer lines. Inspection efficiencies to raise the production yield of the cavities would be improved by using such a high resolution T-map system. The preliminary test of the cryogenic temperature by the T-map system is reported.

WEPEC036 **A Preliminary Method to Measure Large Grain Nb Sheet Thickness and Grain Direction by Ultrasonic Microscopy** – *J. Yu, J. Gao, J.Y. Zhai (IHEP Beijing)*

The effort to improve cavity performance to reach high accelerating gradient Eacc has shown large scattering among cavities with almost some fabrication processes. Some of the variability in cavity performance may be traceable to the variability of grain orientation on the surface. Up to now the standard inspection technologies for quality assurance of high purity fine grain Nb sheet are based on electromagnetic techniques, e.g. eddy current, mainly purposed to detect iron inclusion. Recent progress has come to high purity large grain Nb sheet decade. The key point is not iron anymore, but grain orientation difference. Ultrasonic microscopy is a well-established and economic technique for non-destructive surface inspection. It can not only gives surface inspection but also shows clear grain boundary line and grain crystal direction difference on a sheet. This paper focus on the information we can get from a common ultrasonic microscopy inspection result on large grain Nb sheet, large grain substructure and how it affects cavity manufacturing and performance. A method to measure Nb sheet depth and large grain direction by a common ultrasonic microscopy will be introduced.

WEPEC037 **Pre-design Main Points on Optical-laser Inspection System and Temperature-mapping System for IHEP Low-Loss 9 Cell Cavities** – *J. Yu, J. Gao, J.Y. Zhai, J.R. Zhang (IHEP Beijing)*

The continuing effort to improve cavity performance to attain a high accelerating gradient has shown that the theoretical limit for the maximum field is within reach for SRF cavities. As this limit is approached, identification of factors accounting for sub-theoretical performance becomes increasingly important in order to reduce variability in performance. A number of reasons have been concluded, many of which are linked to the hot spots found by t-mapping system and correlated interior surface defects inspected by high resolution camera system. Interior surface inspection system, search defects and measure the shape of them, is adopted in labs all around the world, because this method is useful tool to understand field limitation of a cavity by combination of T-mapping system. This contribution will first summary recent experimental results of the co-working of interior surface inspection system and T-mapping system, conclude the advantages and shortages of methods, and then give a pre-design main points on optical-laser inspection system and Temperature-mapping system for IHEP Low-Loss 9 cell cavities.

WEPEC039 **IHEP Low-loss Large Grain 9-cell Cavity Fabrication and Processing** – *J.Y. Zhai, J. Gao, Z.Q. Li, J. Yu, J.R. Zhang (IHEP Beijing) T.X. Zhao (IHEP Beiing)*

The combination of the low-loss shape and large grain niobium material is expected to be the possible way to achieve higher gradient and lower cost for ILC 9-cell cavities. As the key component of the "IHEP 1.3 GHz SRF Accelerating Unit and Horizontal Test Stand Project", a low-loss shape 9-cell cavity using Ningxia large grain niobium has been fabricated, surface treated at IHEP and will be tested at KEK. The fabrication and tuning procedure, surface treatment recipes are presented in this paper.

WEPEC040 **HOM Analysis and HOM Coupler Design of the IHEP 9-cell Low Loss Cavity** – *T.X. Zhao (Graduate School of the Chinese Academy of Sciences) J. Gao, J.Y. Zhai (IHEP Beijing) L.Q. Liu, T.X. Zhao (TIPC)*

A low loss shape bare tube 9-cell cavity is being fabricated at IHEP, the next one will be a cavity with full end group, and one of the most import parts is higher order mode coupler. We have calculated the monopoles, dipoles, quadrupoles in the cavity, and their R/Q values. The trapped modes have been considered. A HOM coupler base on the Tesla-type HOM coupler has been designed for our cavity. With this HOM coupler, the HOM's Qext is lower than 10^4 for the highest R/Q mode. This paper presents the HOM analysis of the cavity, structure of the HOM coupler, coupler filter characteristics, electro-magnetic field distribution and fabrication considerations.

WEPEC041 **Manufacturing of the First Main Accelerator with TESLA-like 9-cell SRF Cavities at Peking University** – *F.S. He, J. Dai, J.K. Hao, S. Jin, Y.M. Li, K.X. Liu, S.W. Quan, B.C. Zhang, K. Zhao, F. Zhu (PKU/IHIP) W. Xu (BNL)*

The main accelerator for the PKU-FEL project, which is under construction, has been manufactured, while the beam commissioning will be done after the power source and the LHe system are ready. In this poster, some technical issues in the manufacturing progress are reported, including:

the TIG welding of the LHe vessel made of Ti and the superconducting cavity made of Nb in a glove box filled with argon; the demagnetization of the vacuum vessel made of Fe, to decrease the residual magnetic field in the cavity region, which is caused by the magnetization of the vessel during machining and geomagnetism, under 20 mGs; the manufacturing and low power testing of the main power coupler.

WEPEC042 **Tuning for the First 9-cell TESLA Cavity of PKU** – *L. Yang (Peking University, School of Physics)*

A method based on circuit model is used to tune the first home-made 9-cell TESLA type superconducting niobium cavity at Peking University. After tuning, a flat field profile with a final π-mode frequency within 3 kHz of target frequency is achieved. The field flatness is measured by bead-pull method, and the relative electric field is calculated from the frequency shift perturbed by the bead stepping along the axis of the cavity.

WEPEC043 **Design, Fabrication and Testing of a Single Spoke Cavity at Peking University** – *Z.Y. Yao, X.Y. Lu, K. Zhao (PKU/IHIP)*

The design of a 450MHz β=0.2 superconducting single spoke cavity has been finished at Peking University. For most current test results, the performance limitation in a spoke cavity is the thermal-magnetic quench with little or no field emission, the major goal of geometry optimization is minimizing Bpk. In this poster, the optimization of the spoke cavity is described in detail. The RF simulation gives the optimum RF parameters Epk/Eacc=2.65 and Bpk/Eacc=5.22mT/(MV/m). Low Bpk/Eacc will provide a high gradient cavity. The mechanical properties of the cavity are also studied by simulation. Stiff ribs are used to offer a credible mechanical stability. The impacts of mechanical errors on cavity RF performance are analyzed. Conclusion shows that single spoke cavity is robust with respect to mechanical errors, and gives directions on cavity fabrication. Fabrication art has been fixed. Considering reducing welding connections at peak magnetic field area, the art has been improved, and the cross-sections of spoke bar and cavity barrel are formed by deep drawing without welding. The processing is under going now. The post-processing and vertical test will be done at early of 2010.

WEPEC044 **RF Test of Two-cell Prototype for the PEFP Proton Linac Extension** – *H.S. Kim, Y.-S. Cho, H.-J. Kwon (KAERI) S. An (PAL)*

A superconducting RF cavity with a geometrical beta of 0.42 and a resonant frequency of 700 MHz has been under investigation for an extension program of Proton Engineering Frontier Project (PEFP) to accelerate the proton beam above 100 MeV. We developed and tested a two-cell prototype in order to confirm the fabrication procedure and check the RF and mechanical properties of such a low-beta elliptical cavity. The prototype has been fabricated with high RRR niobium sheets (RRR > 250). Double-ring structure was adopted to reduce the Lorentz force detuning effect. For the vertical test of the prototype cavity, a cryostat was designed and fabricated. Operating temperature is 4.2 K, therefore, pumping to reduce the pressure is not required. We applied 40 layers of superinsulation around the helium vessel in addition to the vacuum insulation between the helium vessel and outer chamber. The status of the prototype development and RF test results will be presented in this paper.

WEPEC045 **HOM Damping Effects for Different Taper Shapes of PLS-II SRF Cavities** – *S. An, Y.D. Joo, H.-S. Kang, C.D. Park, I.S. Park, Y.U. Sohn (PAL)*

In the PLS-II storage ring, the available length of a long straight section for RF system is 6.28 m, which is from quadrupole magnet to quadrupole magnet beam-pipe valves with an elliptical transverse cross section. In this room, two beam-pipe transitions from elliptical to circle cross section, two commercial cryomodules with a circle transverse cross section, three bellows for adjusting cryomodule length and four vacuum valves could need to be installed. Two commercial cryomodules are too long to be installed into this section. In order to install two cryomodules into this section, we need to modify the tapers for reducing the total length of these parts. In this paper, the HOM damping effects for different taper shapes has been studied. The beam loss factor influence and broad-band impedance change due to taper shape changes have been estimated.

WEPEC046 **Design of Superconducting RF System for PLS-II Upgrade** – *Y.U. Sohn, S. An, Y.D. Joo, H.-S. Kang, H.-G. Kim, K.R. Kim, C.D. Park, I.S. Park (PAL)*

The RF system for PLS-II upgrade, of which beam current and emittance are 400 mA and 5.6 nmrad at 3 GeV, becomes much more important compared to PLS. To reduce the HOM intensity in RF cavities for stable beam, a superconducting RF cavity is selected for the PLS-II. The RF system has to compensate beam loss power of 663 kW from 24 bending magnets, 20 insertion devices and other losses by RF HOM and broadband losses along vacuum chambers. For sufficient energy acceptance and lifetime the design RF voltage is 4.5 MV. Three 500 MHz superconducting cavities will be operated from October 2012, following successful commissioning with PLS NC cavities from July 2011. For the 3 SRF cryomodules, a 700 W class He cryogenic system will be prepared in 2011. The design of PLS-II SRF system including cryogenic system will be reported in the paper.

WEPEC047 **High-temperature Superconducting Proximity Effect based Materials for Accelerator Applications** – *A.E. Gustafsson, S. Calatroni, W. Vollenberg (CERN) R. Seviour (Cockcroft Institute, Lancaster University)*

Current materials used in accelerator SRF technologies operate at temperatures below 4 K, which require complex cryogenic systems. Researchers have investigated the use of High Temperature Superconductors (HTS) to form RF cavities, with limited success*. We propose a new approach to achieve a high-temperature SRF cavity based on the superconducting 'proximity effect'**. The superconducting proximity effect is the effect through which a superconducting material in close proximity to a non-superconducting material induces a superconducting condensate in the non-superconducting material. Using this effect we hope to overcome the problems that have prevented the use of HTS for accelerating structures so far. We will report the first results on studies of the proximity effect of magnetron sputtered thin films of Cu on Nb as well as Nb on YBCO. In parallel we explore other coating techniques like High Power Impulse Magnetron Sputtering (HiPIMS). The first tests will consist of measurement of the RRR as well as transport mechanism over the interface. In addition we will report on design of a resonator to measure the Q-factor of the samples and the results of these measurements.

WEPEC048 **Darersbury International Cryomodule Coupler Progress** – *A.E. Wheelhouse, C.D. Beard, J.-L. Fernandez-Hernando, P.A. McIntosh, J.F. Orrett (STFC/DL/ASTeC) S.A. Belomestnykh, P. Quigley (CLASSE) M.A. Cordwell, J. Strachan (STFC/DL)*

The Daresbury international Cryomodule Collaboration requires a suitable RF coupler that will fit into the footprint of the ALICE cryomodule, with the ability of transfering potentially up to 30 kW CW of RF power into the cavity whilst maximising the capability for adjusting the coupling. For this a modified Cornell Injector coupler has been used. Modifications to the cold section was carried out. These couplers have now been assembled into a test cavity and conditioned to 30 kW pulsed, 10 kW CW. This paper describes the modifications required to fit inside the cryomodule and details of the tests that were carried out.

WEPEC049 **Novel Geometry for the LHC Crab Cavity** – *B.D.S. Hall, G. Burt, C. Lingwood (Cockcroft Institute, Lancaster University) H. Wang (JLAB)*

The planned luminosity upgrade to LHC is likely to necessitate a large crossing angle and a local crab crossing scheme. For this scheme crab cavities align bunches prior to collision. The scheme requires at least four such cavities, a pair on each beam line either side of the interaction point (IP). Upstream cavities initiate rotation and downstream cavities cancel rotation. Cancellation is usually done at a location where the optics has re-aligned the bunch. The beam line separation near the IP necessitates a more compact design than is possible with elliptical cavities such as those used at KEK. The reduction in size must be achieved without an increase in the operational frequency to maintain compatibility with the long bunch length of the LHC. This paper proposes a suitable superconducting variant of a four rod coaxial deflecting cavity (to be phased as a crab cavity), and presents analytical models and simulations of suitable designs.

WEPEC050 **Design of the Superconducting RF Cavities and Solenoids for the First Muon Linac of the Neutrino Factory** – *C. Bontoiu, M. Aslaninejad, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics)*

The first linac of the Neutrino Factory is designed to accelerate the muon beam from 244 to 900 MeV using standing waves RF cavities and solenoidal focusing. To minimize the operation costs superconducting technologies will be used for both cavities and solenoids mounted in modules containing one solenoids and one, two or four cavities. The superconducting RF cavities working at 201.25 MHz have been modelled in order to achieve the required increase in beam energy by 10 MeV/cavity while the superconducting solenoids have been designed to provide magnetic fields between 2 and 4 T.

WEPEC051 **3D Simulation of the Effects of Surface Defects on Field Emitted Electrons** – *A. Zarrebini, M. Ristic (Imperial College of Science and Technology) K.R. Long (Imperial College of Science and Technology, Department of Physics) R. Seviour (Cockcroft Institute, Lancaster University)*

The ever-growing demand for higher beam energies has dramatically increased the risk of RF breakdown, limiting the maximum achievable accelerating gradient. Field emission is the most frequently encountered RF breakdown where it occurs at regions of locally enhanced electric field. Electrons accelerated across the cavity as they tunnel through the surface in the presence of microscopic defects. Upon Impact, most of the kinetic energy is converted into heat and stress. This can inflict irreversible damage to the surface, creating additional field emission sites. This work aims to investigate, through simulation, the physics involved during both emission and impact of electrons. A newly developed 3D field model of an 805 MHz cavity is generated by COMSOL Multiphysics. Electron tracking is performed using a Matlab based code, calculating the relevant parameters needed by employing fourth Order Runge Kutta integration. By studying such behaviours in 3D, it is possible to identify how the cavity surface can alter the local RF field and lead to breakdown and subsequent damages. The ultimate aim is to introduce new surface standards to ensure better cavity performance.

WEPEC052 **Higher Order Modes in Third Harmonic Cavities for XFEL/FLASH** – *I.R.R. Shinton, R.M. Jones, N. Juntong (UMAN) N. Baboi (DESY) N. Eddy, T.N. Khabiboulline (Fermilab) T. Flisgen, H.-W. Glock, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering)*

We analyse the higher order modes in the 3.9GHz bunch shaping cavities recently installed in the XFEL/FLASH facility at DESY. We report on recent experimental results on the frequency spectrum, both beam and probe based. These are compared to those predicted by finite element computer codes, globalised scattering matrix calculations and a two-band circuit model. This study is focused on the dipole component of the multiband expansion of the wakefield.

WEPEC053 **High Gradient Superconducting Cavity with Low Surface Electromagnetic Fields for The ILC** – *N. Juntong, R.M. Jones (UMAN)*

We present an optimized geometry for a 1.3 GHz superconducting cavity in which the surface electromagnetic fields have been minimized and the bandwidth of the fundamental mode has been maximized. We refer to this design as the New Low Surface Field (NLSF) cavity*. Earlier work* focused the fundamental mode properties. Here we study higher order modes (HOMs), means of damping them, and short range wakefields. A two-band circuit model is employed in order to facilitate rapid characteristic of the HOMs in the cavity.

WEPEC054 **Status of the CLIC RTML Studies** – *F. Stulle, D. Schulte, J. Snuverink (CERN) A. Latina (Fermilab) S. Molloy (Royal Holloway, University of London)*

Over the last months the general layout of the CLIC main beam RTML has stabilized and most important lattices are existing. This allowed us to perform detailed studies of tolerances on magnetic stray fields and on magnet misalignment. Additionally, beam lines could be improved in terms of performance and flexibility. We discuss the overall layout as will be described in the CLIC conceptual design report, highlight the improvements which have been made and show results of tolerance studies.

WEPEC055 **Initial EM Simulations of Proposed Accelerating Cavities for the CERN SPL** – *S. Molloy (Royal Holloway, University of London) F. Gerigk, W. Weingarten (CERN)*

The Superconducting Proton Linac (SPL) is part of the proposed upgrade of the LHC injection chain, intended to significantly improve the characteristics of the beam circulating in the collider. SPL will rely on two classes of superconducting cavities; beta=0.65 and beta=1; each containing 5-cells resonant at 704 MHz. Presented here are the results of some initial simulations of the beta=1 design, performed at the NERSC supercomputing facility with the highly-parallelised ACE3P codes released by the Advanced Computations Department at SLAC National Accelerator Laboratory. The HOM spectrum in the baseline design has been calculated, and dangerous modes identified by their high R/Q value. In addition, perturbations due to the location of the various couplers, and the structure of the beampipes have been investigated, and are presented here.

WEPEC056 **Optimization Studies for Radiation Shielding of a Superconducting RF Cavity Test Facility** – *C.M. Ginsburg, I.L. Rakhno (Fermilab)*

Test facilities for high-gradient superconducting RF cavities must be shielded for particle radiation, which is generated by field emitted electrons in the cavities. A major challenge for the shielding design is associated with uncertainty in modeling the field emission. In this work, a semi-empirical method that allows us to predict the intensity of the generated field emission is described. Spatial, angular and energy distributions of the generated radiation are calculated with the Fishpact code*. The Monte Carlo code MARS** is used for modeling the radiation transport in matter. The detailed distributions of the generated field emission were used for studies with ILC-type superconducting RF cavities with accelerating gradients up to 35 MV/m in the Fermilab Vertical Cavity Test Facility. This approach allows us to minimize the amount of shielding inside cryostat which is an essential operational feature.

WEPEC057 **Single Spoke Cavities for Low-energy Part of CW Linac of Project X.** – *I.G. Gonin, T.N. Khabiboulline, A. Lunin, N. Perunov, N. Solyak, V.P. Yakovlev (Fermilab)*

In the low-energy part of the Project X H-linac there families of 325 MHz SC single spoke cavities will be used, having beta = 0.11, 0.22 and 0.4. Two versions of the beta = 0.11 cavity were considered: low-beta single-spoke cavity and half-wave cavity. Results of detailed optimization of both versions are presented. Single spoke cavity was selected for the linac because of higher r/Q. Results of the beam dynamics optimization for initial stage of the linac with beta=0.11 single spoke cavity are presented as well.

WEPEC059 **The Beam Splitter for the Project X** – *N. Solyak, I.G. Gonin, S. Nagaitsev, V.P. Yakovlev (Fermilab)*

In the Project X facility a 2.6 GeV, H^- CW beam is delivered to three users simultaneously by way of selectively filling appropriate RF buckets at the front end of the linac and then RF splitting them to three different target halls. With the desire to split the H^- beam three ways, an RF separator directs two quarters of the beam to one user (Mu2e), one quarter to another user (Kaon), and one quarter to the third (unidentified) user. The natural way is to use a SC structure with the deflecting TM110 mode. Basic requirements to the deflecting RF structure are formulated and design of the deflecting SC cavities is presented.

WEPEC060 **Beam Pipe HOM Absorber for 750 MHz RF Cavities** – *M.L. Neubauer, A. Dudas, R. Sah (Muons, Inc) G.H. Hoffstaetter, M. Liepe, H. Padamsee, V. Shemeli (CLASSE)*

Superconducting RF (SRF) systems typically contain unwanted frequencies or higher order modes (HOM). For storage ring and linac applications, these higher modes must be damped by absorbing them in ferrite and other lossy ceramic materials. Typically, these absorbers are brazed to substrates that are strategically located, often in the drift tubes adjacent to the SRF cavity. These HOM loads must have broadband microwave loss characteristics and be robust both thermally and mechanically, but the ferrites and their attachments are weak under tensile and thermal stresses and tend to crack. Based on existing work on HOM loads for high current storage rings and for an ERL injector cryomodule, a HOM absorber with improved materials and design will be developed for high-gradient 750 MHz superconducting cavity systems for storage ring and linac radiation sources. This work will build on novel construction techniques to maintain the ferrite in mechanical compression without brazing. 750 MHz RF system designs will be numerically modeled to determine the optimum ferrite load required to meet broadband loss specifications.

WEPEC061 **Novel Crab Cavity RF Design** – *M.L. Neubauer, A. Dudas, R. Sah (Muons, Inc) S. Ahmed (Illinois Institute of Technology) G.A. Krafft, R.A. Rimmer (JLAB)*

The design and construction of electron-ion colliders will be facilitated by the development of an SRF "crab crossing" cavity with 0.5 to 1.5 GHz frequency and 20 to 50 MV integrated voltage. These RF cavities provide a transverse kick to the particle beam. Current state of the art crab cavities provide 2-5 MV of integrated voltage, and most of the existing designs require complex schemes to damp unwanted RF modes. We propose a novel system for implementing TEM-like two-bar structures. Two phase-locked sources 180^o out of phase each drive a half-wavelength coax antenna inside of a cavity designed for the fewest possible unwanted modes. The cavity design will required a high-Q system composed of coax windows designed for maximizing the shunt impedance of the structure. A series of cavities could be installed in a beam line, and individual phase adjustment for each module will accommodate their longitudinal spacing and will provide the required integrated voltage.

WEPEC062 **High Power Coax Window** – *M.L. Neubauer, A. Dudas (Muons, Inc) T.S. Elliott, R.A. Rimmer, M. Stirbet (JLAB)*

A superconducting RF (SRF) power coupler capable of handling 500 kW CW RF power is required for present and future storage rings and linacs. There are over 35 coupler designs for SRF cavities ranging in frequency from 325 to 1500 MHz. Coupler windows vary from cylinders to cones to disks, and RF power couplers are limited by the ability of ceramic windows to withstand the stresses due to heating and mechanical flexure. We propose a novel robust co-axial SRF coupler design which uses compressed window technology. This technology will allow the use of highly thermally conductive materials for cryogenic windows. Using compressed window techniques on disk co-axial windows will make significant improvements in the power handling of SRF couplers. We present the bench test results of two window assemblies back to back, as well as individual window VSWR in EIA3.125 coax. A vacuum test assembly was made and the windows baked out at 155C. The processes used to build windows is scalable to larger diameter coax and to higher power levels.

WEPEC063 **Usage of a Resistive Material for an HOM Load** – *V.D. Shemelin (Private Address) S.A. Belomestnykh (CLASSE)*

Ferrites and lossy ceramics used in HOM load for superconducting accelerators have some shortcomings such as unstable electromagnetic properties, low conductivity at cryogenic temperatures, brittleness causing lossy dust in the nearby SRF cavities, etc. An attempt to use a resistive material free of these shortcomings is presented.

WEPEC064 **Localizing SRF-Cavity Quenches with 2nd Sound** – *Z.A. Conway, D.L. Hartill, G.H. Hoffstaetter, H. Padamsee, E.N. Smith (CLASSE)*

A simple and cost effective defect location scheme, which only requires a single cold test, is reported on. By operating superconducting RF cavities at temperatures below the lambda point the second sound wave emanating from the location where quench occurred can be utilized to triangulate on the quench-spot. Here a method which utilizes a few (e.g. 8) Cornell oscillating superleak transducers (OSTs) to detect the He-II second sound wave is discussed. This technique requires significantly less time and resources than standard temperature mapping techniques, pioneered at Cornell and other labs, used to locate the quench locations in ILC 9-cell cavities. The current standard temperature mapping technique requires several cold tests: one to identify the cell-pair involved via quench field measurements, a second test with numerous fixed thermometers attached to the culprit cell-pair to identify the particular cell, and a third measurement with many localized thermometers to localize the quench spot. Furthermore, the much more costly thermometer technique cannot be applied in-situ in accelerator cryomodules, whereas Cornell-OSTs can easily be added during cryomodule construction.

WEPEC065 **Coupled Electromagnetic-Thermal-Mechanical Simulations of Superconducting RF Cavities** – *S.E. Posen, M. Liepe, N.R.A. Valles (CLASSE)*

The high magnetic and electric radio-frequency fields in superconducting microwave cavities cause heating of the inner cavity surface and generate Lorentz-forces, which deform the shape of the cavity and thereby result in a shift of the fundamental mode frequency. We use 3-dimensional numerical codes for complex coupled simulations of the electromagnetic fields excited in a cavity, of heat dissipation and heat transfer, as well as of mechanical effects. In this paper we summarize our simulation results. These include Lorentz-force detuning in continuous and pulsed cavity operation, mechanical vibration modes, thermal heating and quench simulations, and simulations of the sensitivity to pressure fluctuations in the LHe-bath surrounding the cavity.

WEPEC066 **Latest Results and Test Plans from the 100 mA Cornell ERL Injector SCRF Cryomodule** – *M. Liepe, S.A. Belomestnykh, E.P. Chojnacki, Z.A. Conway, R.P.K. Kaplan, P. Quigley, V. Veshcherevich (CLASSE)*

Cornell University has developed and fabricated a SCRF injector cryomodule for the acceleration of a high current, low emittance beam in the Cornell ERL injector prototype. This cryomodule is based on superconducting rf technology with five 2-cell rf cavities operated in the cw mode, supporting beam currents of up to 100 mA. After a rework of this cryomodule in 2009 to implement several improvements, it is now in beam operation again. In this paper we report on latest results and discuss future test plans.

WEPEC067 **CW Microphonic Control in the Cornell ERL Injector Cryomodule** – *Z.A. Conway, S.A. Belomestnykh, R.P.K. Kaplan, M. Liepe, P. Quigley (CLASSE)*

Microphonic-noise is projected to be the single largest driver of the RF power required to operating the Cornell University ERL main linac cavities in a phase and amplitude stable system. To prepare and compensate for this we have developed a combined piezoelectric/blade-tuner based fast tuning system for the active compensation of cavity microphonic-noise with the cavities in the Cornell ERL injector cryomodule. The Cornell ERL injector cryomodule houses five elliptical 2-cell SCRF cavities developed for the acceleration of a high current (100mA) ultra-low emittance electron beam and is currently undergoing extensive testing and commissioning. All of the cavities are equipped with a blade tuner and each blade tuner incorporates 4 piezoelectric actuators and vibration sensors for the active compensation of cavity detuning. This paper reports of the current status of our active cw phase-stabilization experiments

WEPEC068 **Cavity Optimization for Cornell's Energy Recovery Linac** – *N.R.A. Valles, M. Liepe (CLASSE)*

Cornell University is proposing the construction of an x-ray light source driven by a 5GeV SCRF Energy-Recovery-Linac. The superconducting cavities to be used in the main linac of this accelerator need to be optimized primarily for low cryogenic wall losses of the fundamental mode as well as for supporting stable beam operation at beam currents exceeding 100 mA. We have developed complex optimization routines to achieve these demanding design goals. In this paper we discuss our cavity optimization approach, describe the optimization routines used, and present a cavity design which exceeds the design goals and is stable under small, unavoidable shape perturbations.

WEPEC069 **Microstructural Investigations of Limiting Factors in Niobium Cavities** – *A. Romanenko (CLASSE)*

Investigations at different length scales ranging from atomic to microns with TEM/STEM, EELS, and EBSD of samples from niobium cavities limited either by a high field quench or a high field Q-slope will be presented. Effects of different surface treatments on the microstructure will be reported as well.

WEPEC070 **Critical Magnetic Fields of MgB2, MgB2/Nb and MgB2/I/Nb Systems** – *T. Tajima, G.V. Eremeev (LANL) V.A. Dolgashev, J. Guo, D.W. Martin, S.G. Tantawi, C. Yoneda (SLAC)*

In order to exceed the performance of Nb SRF cavities, the effect of Magnesium diboride (MgB2) coating has been explored. MgB2 has been shown to sustain its RF surface resistance up to relatively high magnetic fields. Using a TE013-like mode hemi-spherical copper cavity and a 11.4 GHz 50 MW Pulsed Klystron to generate short pulses (2 us or less), RF properties, especially RF critical magnetic fields, of MgB2, MgB2/Nb and MgB2/Insulator/Nb systems have been measured under various conditions. An RF critical magnetic field of ~70 mT for MgB2 has been obtained. For the MgB2/Nb and MgB2/I/Nb systems, a reduced RF critical field of 30-40 mT for Nb has been obtained for some reason.

WEPEC071 **SRF Cavity High-Gradient Studies at 805 MHz for Proton and Other Applications** – *T. Tajima, G.V. Eremeev, F.L. Krawczyk, R.J. Roybal (LANL)*

805 MHz elliptical SRF cavities have been used for SNS at ORNL as the first application for protons. At LANL, studies to explore a possibility of getting high-gradient cavities are ongoing, aiming at 40-50 MV/m with Nb alone and higher with cavities coated with another superconductor at this frequency. The future applications at LANL include a proton and muon based active interrogation testing facility that can be added to the LANSCE accelerator and a power upgrade of the LANSCE accelerator for the fission and fusion material test station. Performance results of 3 single-cell prototype cavities and a design of a prototype 6-cell cavity and cryostat will be presented.

WEPEC073 **A Cryogenic RF Material Testing Facility at SLAC** – *J. Guo, S.G. Tantawi (SLAC)*

Superconducting RF is increasingly important for particle accelerators. A lot of effort has been made in the SRF material research recently, aiming to find the superconducting materials with better performance. We developed a testing system using a resonant cavity with high quality factor and an interchangeable wall for the testing of different materials. The system is capable for high power RF cryogenic test to find the critical magnetic field at different temperature. The facility can be also used on testing the low temperature properties of the normal conducting material. Different Cu, Nb and MgB2 samples have been tested. In this paper, we will present the most recent development of the system, along with a discussion on the recent testing results.

WEPEC076 **Recent Progress on High-Current SRF Cavities at JLab** – *R.A. Rimmer, W.A. Clemens, J. Henry, P. Kneisel, K. Macha, F. Marhauser, L. Turlington, H. Wang (JLAB)*

JLab has designed and fabricated several prototype SRF cavities with cell shapes optimized for high current beams and with strong damping of unwanted higher order modes. We report on the latest test results of these cavities and on developments of concepts for new variants optimized for particular applications such as light sources and high-power proton accelerators, including betas less than one. We also report on progress towards a first beam test of this design in the recirculation loop of the JLab ERL based FEL. With growing interest worldwide in applications of SRF for high-average power electron and hadron machines, a practical test of these concepts is highly desirable. We plan to package two prototype cavities in a de-mountable cryomodule for temporary installation into the JLab FEL for testing with RF and beam. This will allow verification of all critical design and operational parameters paving the way to a full-scale prototype cryomodule.

WEPEC077 **RF and Structural Characterization of New Superconducting RF Films** – *A-M. Valente-Feliciano, H.L. Phillips, C.E. Reece, B. Xiao, X. Zhao (JLAB) D.B. Beringer, R.A. Lukaszew, R.A. Outlaw (The College of William and Mary) D. Gu (ODU) K.I. Seo (NSU)*

In the past years, energetic vacuum deposition methods have been developed in different laboratories to improve Nb/Cu technology for superconducting cavities. Jefferson Lab and collaborators are pursuing energetic condensation deposition via Electron Cyclotron Resonance. As part of this study, the influence of the deposition energy, the coating temperature and the substrate's nature on the material and RF properties of the Nb thin film is investigated. The film surface and structure analyses are conducted with various techniques like X-ray diffraction, Transmission Electron Microscopy, Auger Electron Spectroscopy and RHEED. The microwave properties of the films are characterized on 50 mm disk samples with a 7.5 GHz surface impedance characterization system. This paper presents surface impedance measurements in correlation with surface and material characterization for Nb films produced on various substrates with different bias voltages. Emerging opportunities for developing multi-layer superconducting rf films are also highlighted with the commissioning results of a new deposition system.

WEPEC078 **Plasma Etching of Bulk Nb RF Cavity Surfaces** – *S. Popovic, J. Upadhyay, L. Vuskovic (ODU) H.L. Phillips, A-M. Valente-Feliciano (JLAB)*

Plasma based surface modification provides an excellent opportunity to eliminate non-superconductive pollutants in the penetration depth region of the SRF cavity surface and to remove mechanically damaged surface layer improving surface roughness. We have demonstrated on flat samples that plasma etching in Ar/Cl_2 of bulk Nb is a viable alternative surface preparation technique to BCP and EP methods, with comparable etching rates. The geometry of SRF cavities made of bulk Nb defines the use of asymmetric RF discharge configuration for plasma etching. In a specially designed single cell cavity with sample holders, discharge parameters are combined with etched surface diagnostics to obtain optimum combination of etching rates, roughness and homogeneity in a variety of discharge types, conditions, and sequences. The optimized experimental conditions will ultimately be applied to single cell SRF cavities.

WEPEC079 **Design and Prototype toward a Superconducting Crab Cavity Cryomodule for the Advanced Photon Source** – *H. Wang, G. Cheng, G. Ciovati, J. Henry, P. Kneisel, R.A. Rimmer, L. Turlington (JLAB) R. Nassiri, G.J. Waldschmidt (ANL)*

After a successful high power test on a prototype superconducting crab cavity with a waveguide damper on the single-cell equator, the new crab cavity structure design can provide a larger safety margin on the impedance limit imposed by the Advanced Photon Source (APS) as opposed to the previous single-cell design with the waveguide dampers located off the beam pipes. We will report progress on further prototyping activities and component simulations toward the integrated engineering design for the crab cavity cryomodule.

WEPEC080 **Effect of Electrolyte Flow Rate on Surface Finish of Nb SRF Single Cell Cavities Treated by Buffered Electropolishing** – *A.T. Wu, S. Jin, R.A. Rimmer (JLAB) X.Y. Lu, K. Zhao (PKU/IHIP)*

Recent experimental results*,**,*** have indicated that Buffered Electropolishing (BEP) is a promising candidate for the next generation of surface treatment technique for Nb superconducting radio frequency (SRF) cavities to be used in particle accelerators. In order to lay the foundation for using BEP as the next generation surface treatment technique for Nb SRF cavities, some fundamental BEP treatment parameters for the cavities have to be investigated systematically. In this report, a systematic study of the effect of the electrolyte flow rate at room temperature on the surface finish of Nb SRF single cavities treated by BEP for a selected cathode shape is showed. I-V curves will be measured for three locations close to iris, midway, and equator via a demountable Nb SRF single cell cavity at different electrolyte flow rates. Small button samples co-processed with the demountable cavity at the three locations are analyzed by relevant surface instruments to access how the electrolyte flow rate affects Nb surface finish of Nb SRF single cell cavities so that the optimized flow rate can be obtained.

WEPEC081 **Study of Low Temperature Baking Effect on Field Emission on Nb Samples Treated by BEP, EP, and BCP** – *A.T. Wu, S. Jin, R.A. Rimmer (JLAB) X.Y. Lu, K. Zhao (PKU/IHIP)*

Field emission is still one of the major obstacles facing Nb superconducting radio frequency (SRF) community for allowing Nb SRF cavities to reach routinely accelerating gradient of 35 MV/m that is required for the international linear collider. Nowadays, the well know low temperature backing at 120 ^{o}C for 48 hours is a common procedure to improve the high field Q slope. However, some recent experimental observations have showed by the low temperature baking may induce field emission for cavities treated by EP. On the other hand, an earlier study* of field emission on Nb flat samples treated by BCP showed an opposite conclusion. In this report, we study systematically the effect of the low temperature baking on field emission on Nb flat samples treated by BEP, EP, and BCP via our unique home-made scanning field emission microscope. Detected field emitters will be examined by a scanning electron microscope, energy dispersive x-ray, and electron back scatter diffraction to determine the morphology, chemical composition, and possible crystal orientations of the emitters. The possible mechanism responsible for the low temperature backing effect on field emission will be discussed.

WEPEC082 **Computational Modeling of Muons passing through Gas Pressured RF Cavities** – *A.L. Godunov, A. Samolov (ODU)*
Using high-pressure RF cavities for muon colliders would provide higher accelerating gradients, that is crucial for fast acceleration of short-living muons .This approach requires a good evaluation for mechanisms of muon - low-Z gas interaction, including such effects as multiple scattering and space charge effects. Most present simulation tools (GEANT4, G4MICE) for muon beams are based on single particle tracking, where collective effects are not taken into account. We use a modified molecular dynamic simulation technique to study effects of both multiple scattering and space charge screening by the gas on scattering, energy loss, and propagation of muons during both ionization cooling and acceleration.

WEPEC083 **Tomographic Analysis of SRF Cavities as Asymmetric Plasma Reactors** – *S. Popovic, A.L. Godunov, A. Samolov, J. Upadhyay, L. Vuskovic (ODU) H.L. Phillips, A-M. Valente-Feliciano (JLAB)*
The tomographic reconstruction of local plasma parameters for nonequilibrium plasma sources is a developing approach, which has a great potential in understanding the fundamental processes and phenomena during plasma processing of SRF cavity walls. Any type of SRF cavity presents a plasma rector with limited or distorted symmetry and possible presence of high gradients. Development of the tomographic method for SRF plasma analysis consists of several steps. First, we define the method based on the inversion of the Abel integral equation for a hollow spherical reactor. Second step is application of the method for the actual elliptical cavity shape. Third step consists of study of the effects of various shapes of the driven electrode. Final step consists of testing the observed line-integrated optical emission data. We will show the typical results in each step and the final result will be presented in the form of correlation between local plasma parameter distributions and local etching characteristics.

WEPEC084 **Higher Order Mode Properties of Superconducting Parallel-Bar Cavities** – *S.U. De Silva, J.R. Delayen (ODU) S.U. De Silva (JLAB)*
The superconducting parallel-bar cavity* has properties that makes it attractive as a deflecting or crabbing rf structure. For example it is under consideration as an rf separator for the Jefferson Lab 12 GeV upgrade and as a crabbing structure for a possible LHC luminosity upgrade. Initial cavity shape optimization has been performed to obtain a high transverse deflecting voltage with low surface fields. We present here a study of the Higher Order Mode (HOM) properties of this structure. Frequencies, R/Q and field profiles of HOMs have been evaluated and are reported.

WEPEC085 **Simulation of the High-Pass Filter for 56 MHz Cavity for RHIC** – *Q. Wu, I. Ben-Zvi (BNL)*
The damper of 56 MHz cavity is designed to extract all modes to the resistance load outside, including the fundamental mode. Therefore a high-pass filter is required to reflect the fundamental mode back into the cavity. A preliminary design of the filter was previously done. In this paper, we optimize all elements to eliminate the poor filter performance above 1 GHz. The circuit diagram is extracted from microwave lumped elements that reproduce the frequency spectrum of the finalized filter. We also show mode damping results with dampers and filters in the desired configuration, determining the final performance of the cavity.

WEPEC086 **Optimization of Higher Order Mode Dampers in the 56 MHz SRF Cavity for RHIC** – *Q. Wu, I. Ben-Zvi (BNL)*
A 56 MHz cavity was designed for a luminosity upgrade of the Relativistic Heavy Ion Collider (RHIC), including requirements for Higher Order Mode (HOM) damping. A preliminary design of the HOM damper was previously done without optimization. In this paper, we describe our optimization of the damper's performance, and modifications made to its original design. We also show the cavity damper efects with different geometries. Magnetic field enhancement at the ports is reduced to a value less than the highest field in the cavity to eliminate electrical breakdown. All HOMs up to 1 GHz are simulated with their frequencies, mode configurations, R/Qs and shunt impedances, and all modes are well-damped with the optimized design and configuration.

WEPEC087 **New Concept and Design of Band-stop HOM Coupler for High Current Superconducting Cavity at BNL** – *W. Xu, I. Ben-Zvi (BNL)*

Higher-order-mode in RF superconducting cavity is one of the most critical problems for high current SRF facilities, such as eRHIC and MeRHIC at BNL. Due to the overheating effect and high tuning sensitivity of the extant TESLA-type HOM couplers, the TESLA-type HOM couplers with a notch-filter are problematic in high current, CW superconducting cavity. A new band-stop HOM coupler is being designed at BNL for improved performance. The new HOM coupler band-stop filter has a bandwidth of tens of MHZ to reject the fundamental mode, which will avoid overheating due to fundamental frequency shift. In addition, unlike TESLA-type HOM coupler, the S21 parameter of the band-pass filter is nearly flat from first higher order mode to more than 6 times of fundamental frequency. The simulation results showed that the new HOM couplers perform rather well for HOMs damping for BNL cavity with enlarged beam tube diameter. We will present results from a prototype of the newly designed HOM couplers at room temperature and compare the simulation and test results.

26-May-10 16:00 – 18:00	Poster	Poster Hall D
WEPD — Poster Session		

WEPD001 **Calculation Code for Electron Trajectories in Magnetic Fields** – *G. Tosin, J.F. Citadini, R.J.F. Marcondes (LNLS)*
A code was developed for determining the electron trajectories in any kind of magnetic field. It is being used as an auxiliary tool to analyze characteristics of dipoles, quadrupoles, insertion devices and other magnets which are being studied at LNLS. In order to calculate the trajectories, the magnetic field is interpolated inside a tridimensional mesh composed of measured or simulated points. Once the trajectories are known, the field integrals over them are evaluated and multipolar analysis is made. Furthermore, the radiation phase error can be estimated for insertion devices, when it is the case.

WEPD002 **Magnet Blocks Sorting Code for Elliptically Polarized Undulators** – *G. Tosin, J.F. Citadini, R.J.F. Marcondes (LNLS)*
We are reorganizing our software tools for insertion devices assemblies aiming the New Brazilian Synchrotron Light Source. As well known, the quality of synchrotron radiation emitted on elliptically polarized undulator and its disturbance on the orbit can be optimized when it is considered a proper sorting for magnet blocks that compose the device. The code developed deals with previously characterized magnet blocks, taking into account their dimensions and magnetization vectors. Each block placement is randomly chosen and for every generated distribution of blocks, the code calculates the magnetic field and evaluates the electron trajectory, allowing to determine the radiation phase error and the field integrals over the trajectories. The software retains information about the best configuration, according to our criteria for minimization of the merit functions.

WEPD003 **Designs of the Magnet Prototypes of the New Brazilian Light Source** – *G. Tosin, R. Basilio, J.F. Citadini, M. Potye, E.W. Siqueira (LNLS)*
"Green solutions" using permanent magnets are being proposed for the magnetic lattice (dipoles and quadrupoles) of the second Brazilian Synchrotron Light Source. The main purpose is to reduce as much as possible the electrical energy consumption, assuring the reliability of the magnets during several years. Sextupoles will have combined functions in order to reduce the ring circumference.

WEPD004 **Modelling of Elliptically Polarizing Undulators** – *L.O. Dallin (CLS)*
To investigate the effect of an elliptically polarized undulator (EPU) on the dynamic aperture of storage ring a model is required for use in an optics code. An EPU can be modelled as an array of skew dipole magnets. The skew angle ranges from zero to ninety degrees depending on the degree of polarization. Crudely the EPU can be modelled using alternating skew dipole blocks. A model that better reproduces the sinusoidally varying fields can be achieved by slicing blocks into smaller subsets. Field roll-off produced by the limited transverse dimensions of the magnet blocks can be included as skew multipoles. For example the roll-off of the horizontal field in the vertical undulator mode is very nearly a skew sextupole. The model has the advantage of correctly calculating the path length through the EPU which is important for tracking in six dimensions.

WEPD005 **Insertion Device Development at the Canadian Lightsource** – *M.J. Sigrist, D.G. Bilbrough, S. Chen, L.O. Dallin (CLS) K.I. Blomqvist (MAX-lab)*
The Canadian Lightsource is a 2.9 GeV 3rd generation lightsource in Saskatoon, Canada. The latest expansion of operations includes adding 4 insertion devices in 2 straight sections. These devices will include a hybrid permanent magnet wiggler, an in-vacuum undulator and 2 APPLE-II type undulators. The 4 m long elliptical APPLE-II IDs will cover overlapping photon energy ranges of 15-200eV and 200-1000eV. These devices will be installed adjacent to one another in the same straight with the magnet arrays mounted on one support structure and a horizontal translation system to allow users to select one device at a time for use on a single beamline. The 2nd straight will include the hybrid wiggler and in-vacuum undulator in a 3 magnet chicane. The wiggler is designed to supply photons for a center beamline and a side beamline accepting radiation 5 mrad off

of the centerline of the radiation fan. The critical energy of photons emitted of the sideline are >90% of the critical energy on the centerline. An 8 mrad center chicane magnet separates the photons of the undulator from the wiggler beamlines allowing for 3 beamlines operating with 2 IDs in a single straight section.

WEPD006 **Cryogenic In-vacuum Undulator at Danfysik A/S** – *C.W.O. Ostenfeld, M. Pedersen (Danfysik A/S)*

Danfysik A/S has built a cryogenic in-vacuum undulator for Diamond Light Source, with a period length of 17.7 mm and an effective K of 1.7 at cryogenic temperatures. The undulator is hybrid-type, with Vanadium Permendur poles and NdFeB poles. In order to verify the performance of the device under cryogenic conditions, an in-vacuum measuring system is required. We present the magnetic measurements at room temperature and under cryogenic in-vacuum conditions. The magnet assembly cannot be baked, due to a choice of high-remanence, low coercivity magnet grade. We discuss the vacuum performance of the undulator.

WEPD007 **Development of PrFeB Cryogenic Permament Magnet Undulator (CPMU) at SOLEIL** – *C. Benabderrahmane, P. Berteaud, N. Béchu, M.-E. Couprie, J.-M. Filhol, C. Herbeaux, C.A. Kitegi, M. Louvet, J.L. Marlats, K. Tavakoli, M. Valleau, D. Zerbib (SOLEIL)*

The production of hard X rays at SOLEIL, a 2.75 GeV, requires short period and small gap in-vacuum undulators. For shifting further the radiation toward higher energies, the peak magnetic field of the undulators can be further increased by cooling the permanent magnets at cryogenic temperature below 100 K. A R&D programme for the construction of a 2 m long 18 mm period CPMU is launched: the use of PrFeB enables to increase the peak magnetic field at a cryogenic temperature of 77 K. Praseodymium was chosen instead of Neodymium type magnets, because it prevents the appearance of the Spin Reorientation Transition. The magnetic characterisation of different permanent magnet grades at cryogenic temperatures (NdFeB and PrFeB), and the magnetic and thermal measurements on a small 4 period NdFeB cryogenic undulator are presented. The status on the progress of the CPMU conception is given. The magnetic and mechanical design, including the cooling of the girders at 77K, and the thermal budget are described. The designs of the dedicated magnetic measurement benches, which will be required to check the magnetic performance of the undulator at low temperature, are also reported.

WEPD008 **Development of a Short Period High field APPLE-II Undulator at SOLEIL** – *C.A. Kitegi, F. Briquez, M.-E. Couprie, T.K. El Ajjouri, J.-M. Filhol, K. Tavakoli, J. Vétéran (SOLEIL)*

At SOLEIL, the production of high brilliant photon beams with adjustable polarization is achieved by means of Advanced Planar Polarized Light Emitter-II (APPLE-II) undulators. The HU36 is a short period high field APPLE-II type undulator with 36 mm period and 0.8 T peak field at a minimum gap of 11 mm. The HU36 circularly polarized radiation ranges from 2 keV to 5 keV, while the planar one extends up to 10 keV. High harmonic radiation (up to the 13th) is required to reach such high energy; therefore a small RMS phase error is needed. To enable closing the gap at 11 mm, the HU36 is planned to be installed in a short section where the large horizontal beta function imposes constraining tolerances on the integrated field errors. However at low period and high field, the magnet holders, commonly used at SOLEIL to maintain magnets on the girders, experience mechanical deformation due to the large magnetic forces. This results in the variation of field integrals when the shift between girders is changed. Solutions to minimize these errors are discussed and finally the HU36 magnetic performances are reviewed.

WEPD009 **Production of High Flux Hard X-ray Photons at SOLEIL** – *O. Marcouillé, P. Berteaud, P. Brunelle, L. Chapuis, M.-E. Couprie, J.-M. Filhol, C. Herbeaux, J.L. Marlats, A. Mary, M. Massal, K. Tavakoli, M. Valleau, J. Vétéran (SOLEIL)*

The production of high fluxes in the hard X-rays region is a major issue on medium energy storage rings. It requires the installation of Insertion Devices with high magnetic field and a large number of periods. The construction of a superconducting wiggler has been first envisaged but reveals to be maintenance constraining, much more complex and expensive than the permanent magnet technology. A small gap in vacuum wiggler composed of 38 periods of 50 mm has been preferred. The compact magnetic system allows to produce in a limited space a magnetic field of 2.1 T in a small gap of 5.5 mm, whereas an auxiliary counterforce system based on non-magnetic springs compensate the magnetic forces (up to 8.5 Tons) acting between magnet arrays. The gap between jaws and the mechanical deformations have been controlled and corrected. Magic fingers corrections have been also performed to reduce the integrated multipoles and to minimize the 2nd order integrals resulting from the tight width of the wiggler poles. This paper presents the design of the wiggler, the construction, and the results of the measurements after magnetic corrections.

WEPD010 **Upgrade of the Insertion Devices at the ESRF** – *J. Chavanne, L. Goirand, G. Lebec, C. Penel, F. Revol (ESRF)*
An important upgrade of the ESRF is planned from 2009 to 2016. It is mainly driven by the improvement of beamlines performances and capacity. On the storage ring side, the length of the straight sections will be increased from 5 m to 6 m with a possible further extension to 7 m. These long sections will provide a higher photon flux, and it will allow the installation of canted undulators. The length of the insertion devices (ID), such as revolver undulators and in-vacuum undulators, will be modified to fit the first upgraded beamline sections. The resulting implication on the length of new IDs will be presented. The concept of canted undulators is a proposed optional feature. It will rely on novel permanent magnet chicane providing a maximal separation angle of 5.4 mrad while keeping short distance between canted undulators. Magnetic chicane magnets with low fringe field and homogeneous longitudinal field integral have been designed. The developed magnets will be presented.

WEPD011 **Mini-beta Sections in the Storage Ring BESSY II** – *J. Bahrdt, W. Frentrup, A. Gaupp, M. Scheer, F. Schäfers, G. Wuestefeld (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*
At BESSY II photon energies above 2keV can be produced only with bending magnets, a permanent magnet wiggler, superconducting (SC) wavelength shifters and a SC-wiggler. The wiggler brilliance suffers from the depth of field effect and the bending magnets and wavelength shifters produce the X-rays only with a single pole. Experiments such as HIgh Kinetic Energy photoelectron spectroscopy (HIKE) or microspectroscopy on nanostructured materials demand a high brilliance and flux as it is provided by a small period cryogenic undulator. This paper discusses the requirements for the operation of small gap cryogenic devices at BESSY II. A scheme with two adjacent, vertical low beta sections inside of one of the long straight sections is suggested. The straight is divided into two parts by a quadrupole triple in the center. An optic with an increased, vertical beta tune by 0.5 is presently studied. The optics outside of the low beta section and the horizontal tune are kept unchanged.

WEPD012 **Cryogenic Design of a PrFeB-Based Undulator** – *J. Bahrdt, H.-J. Baecker, M. Dirsat, W. Frentrup, A. Gaupp, D. Pflückhahn, M. Scheer, B. Schulz (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) F.J. Gruener, R. Weingartner (LMU) D. Just (Technische Universität Berlin)*
In collaboration with the Ludwig-Maximilian-University Munich a cryogenic PrFeB- based undulator has been built. The 20-period device has a period length of 9mm and a fixed gap of 2.5mm. The undulator has recently been installed at the laser plasma accelerator at the Max-Planck-Institute for Quantenoptik. The operation of a small gap device at a high emittance electron beam requires stable magnetic material. A high coercivity is achieved with PrFeB- material which is cooled down to 50K. This temperature is 100K lower as compared to the temperature of a NdFeB-based cryogenic undulator. In this paper we present the mechanic and cryogenic design and compare the predictions with measured data. The results are extrapolated to a 2m-long variable gap undulator.

WEPD013 **Simulation of Error Influence on the Field Quality of the Superconducting Planar Undulator Mock-up** – *N. Vassiljev (University Erlangen-Nuernberg, Institute of Condensed Matter Physics) Y. Ivanyushenkov (ANL) A.J. Magerl (University Erlangen-Nurnberg, Institute of Condensed Matter Physics)*
Magnetic field profile of a superconducting planar undulator mock-up was simulated with Opera3D software package. The geometry for the

model was chosen in agreement with the SCU currently being developed. The calculations of the 1st, 2nd field integrals and the phase error were carried out with addition of mechanical deviations and alignment uncertainties. Influence of such errors on field quality, the primary goal of this research, is presented in this paper.

WEPD014 **Undulators of the sFLASH Experiment** – *H. Delsim-Hashemi, J. Rossbach (Uni HH) U. Englisch, T. Mueller, A. Schoeps, M. Tischer, P.V. Vagin (DESY) I. Vasserman (ANL)*

A seeded free-electron laser (FEL) experiment at VUV wavelengths, called sFLASH, is being prepared at the existing SASE FEL user facility FLASH. Seed pulses at wavelengths around 35 nm from high harmonic generation (HHG) will interact with the electron beam in sFLASH undulators upstream of the existing SASE undulator section. In this paper the tuning results and performance of the sFLASH undulators are presented.

WEPD015 **Inductive Shimming of Superconductive Undulators** – *P. Peiffer, A. Bernhard, F. Burkart, S. Ehlers, G. Fuchert (KIT) T. Baumbach, A.W. Grau, R. Rossmanith (Karlsruhe Institute of Technology (KIT)) E.M. Mashkina (University Erlangen-Nurnberg, Institute of Condensed Matter Physics) D. Schoerling, D. Wollmann (CERN)*

The monochromaticity and intensity of synchrotron light emitted by undulators strongly depend on the undulator field quality. For the particular case of superconductive undulators it was shown recently that their field quality can be significantly improved by an array of coupled high temperature superconductor loops attached to the surface of the superconductive undulator. Local field errors induce currents in the coupled closed superconducting loops and, as a result, the hereby generated magnetic field minimizes the field errors. In previous papers the concept was described theoretically and a proof-of-principle experiment was reported. This paper reports results of the first quantitative measurement of the phase error reduction in a 12-period short model undulator equipped with a full-scale induction shimming system.

WEPD016 **Reduction of Dynamic Field Errors in Superconductive Undulators** – *P. Peiffer, A. Bernhard, S. Ehlers, G. Fuchert (KIT) T. Baumbach, R. Rossmanith (Karlsruhe Institute of Technology (KIT)) D. Schoerling (CERN)*

In the superconductive undulator SCU14, installed at ANKA, time dependent drifts in the magnetic fields were observed*. Simulations with the software OPERA 3D showed, that the cause of these drifts might be leak and eddy currents in the iron body of the undulator caused by the time-varying currents and fields during current ramps, which slowly decay by ohmic losses. This assumption was crosschecked by measurements at different mockup bodies. This contribution discusses the results of the simulations and measurements and the consequential strategies for avoiding this effect.

WEPD017 **Magnetic Measurements of the 1.5 m Coils of the ANKA Superconducting Undulator** – *S. Casalbuoni, T. Baumbach, S. Gerstl, A.W. Grau, M. Hagelstein, D. Saez de Jauregui (Karlsruhe Institute of Technology (KIT)) C. Boffo, W. Walter (BNG)*

A 1.5 m long superconducting undulator with a period length of 15 mm is planned to be installed in ANKA middle 2010 to be the light source of the new beamline NANO for high resolution X-ray diffraction. The key specifications of the system are an undulator parameter K higher than 2 (for a magnetic gap of 5mm) and a phase error smaller than 3.5 degrees. In order to characterize the magnetic field properties of the superconducting coils local field measurements have been performed by moving a set of Hall probes on a sledge in a liquid helium bath: the results are reported.

WEPD018 **Status of COLDDIAG: a Cold Vacuum Chamber for Diagnostics** – *S. Gerstl, T. Baumbach, S. Casalbuoni, A.W. Grau, M. Hagelstein, D. Saez de Jauregui (Karlsruhe Institute of Technology (KIT)) V. Baglin (CERN) C. Boffo, G. Sikler (BNG) T.W. Bradshaw (STFC/RAL) R. Cimino, M. Commisso, B. Spataro (INFN/LNF) J.A. Clarke, D.J. Scott (STFC/DL/ASTeC) M.P. Cox, J.C. Schouten (Diamond) R.M. Jones, I.R.R. Shinton (UMAN) A. Mostacci (Rome University La*

Sapienza) E.J. Wallén (MAX-lab) R. Weigel (Max-Planck Institute for Metal Research)

One of the still open issues for the development of superconducting insertion devices is the understanding of the beam heat load. With the aim of measuring the beam heat load to a cold bore and the hope to gain a deeper understanding in the beam heat load mechanisms, a cold vacuum chamber for diagnostics is under construction. The following diagnostics will be implemented: i) retarding field analyzers to measure the electron flux, ii) temperature sensors to measure the total heat load, iii) pressure gauges, iv) and mass spectrometers to measure the gas content. The inner vacuum chamber will be removable in order to test different geometries and materials. This will allow the installation of the cryostat in different synchrotron light sources. COLDDIAG will be built to fit in a short straight section at ANKA. A first installation at the synchrotron light source DIAMOND is under discussion. Here we describe the technical design report of this device and the planned measurements with beam.

WEPD019 **Development of Instrumentation for Magnetic Field Measurements of 2m Long Superconducting Undulator Coils** – *A.W. Grau, T. Baumbach, S. Casalbuoni, S. Gerstl, M. Hagelstein, D. Saez de Jauregui (Karlsruhe Institute of Technology (KIT))*

Precise measurements of the magnetic properties of conventional, i.e., permanent magnet based insertion devices has undergone tremendous improvements over the past 10 to 15 years and initiated a new era in synchrotron light sources worldwide. A similar breakthrough is now necessary in the field of superconducting insertion devices. In this contribution we describe the planned instrumentation to perform magnetic measurements of the local field, the field integrals and the multipole components of superconducting undulator coils in a cold invacuum (cryogen free) environment.

WEPD020 **Experimental Demonstration of Period Length Switching for Superconducting Insertion Devices** – *A.W. Grau, T. Baumbach, S. Casalbuoni, S. Gerstl, M. Hagelstein, D. Saez de Jauregui (Karlsruhe Institute of Technology (KIT)) C. Boffo, W. Walter (BNG)*

One of the advantages of superconducting insertion devices (IDs) with respect to permanent magnet IDs is the possibility to enlarge the spectral range by changing the period length by reversing the direction of the current in a part of the windings. In this contribution we report the first experimental test of this principle demonstrated on a 70mm NbTi mock-up coil with period tripling, allowing to switch between a 15mm period length undulator and a 45mm wiggler.

WEPD021 **Fabrication of the New Superconducting Undulator for the ANKA Synchrotron Light Source** – *C. Boffo, W. Walter (BNG) T. Baumbach, S. Casalbuoni, A.W. Grau, M. Hagelstein, D. Saez de Jauregui (FZK)*

Superconducting insertion devices (IDs) are very attractive for synchrotron light sources since they allow increasing the flux and/or the photon energy with respect to permanent magnet IDs. Babcock Noell GmbH (BNG) completed the fabrication of a 1.5 m long unit for ANKA at KIT. The period length of the device is 15 mm for a total of 100.5 full periods plus an additional matching period at each end. The key specifications of the system are: a K value higher than 2 for a magnetic gap of 5 mm, the capability of withstanding a 4 W beam heat load and a phase error smaller than 3.5 degrees. The field performance of the magnets has been qualified with liquid helium in a vertical dewar. As a result of this test the local correction coils have been installed and the magnets inserted in the final cryostat. During the factory acceptance test, the conduction cooling operation has been qualified and at the moment the undulator is ready to be tested at KIT. This paper describes the main features of the system and the results of the factory acceptance tests.

WEPD022 **Fabrication of a Six Period PPM Undulator for Pulsed Wire Method** – *S. Tripathi, M. Gehlot, G. Mishra (Devi Ahilya University) S. Chouksey, V. Kumar (RRCAT) J. Hussain (RGPV)*

In this paper we describe the design and fabrication details of a six period PPM undulator. The undulator period is 5cm. and four NdFeB magnets are used in one period. The geometric size of the magnets is

12.5mm*12.5mm*50mm. This undulator is measured by Hall Probe and first & second field integral are numerically calculated. The algorithm of the field calculation is given and the hall probe results will be compared with the pulsed wire results. The pulsed wire method developed is also briefly described.

WEPD023 **Development of Ultra-high Quality Surface Finish Undulator Vacuum Chambers for the FERMI@Elettra Project** – *G. Lanfranco, P. Craievich, G.L. Loda, A.A. Lutman, S.V. Milton, M. Stefanutti (ELETTRA) M. Canetti, F. Gangini (RIAL VACUUM S.p.A)*

The FERMI@Elettra project at the ELETTRA Laboratory of Sincrotrone Trieste (ST), currently under construction, will be comprised of a linear accelerator and two Free-Electron-Laser beamlines (FEL1, FEL2). In order to deliver high-intensity VUV and soft X-ray pulses, permanent magnet undulators with 9 mm minimum variable gap will be used. The adopted vacuum chambers will have a 7 by 25 mm^2 elliptical internal cross-section. While manufacturing the vacuum chamber in aluminum helps reducing the resistive wall wakefield effects, the chamber inner wall surface quality is strongly correlated to the surface roughness wakefield component. We report on the results of the study to improve the wall surface finish and lower the roughness periodicity. The chamber manufacturing status and its alignment mechanism is also presented.

WEPD024 **New Scheme of Quasi-Periodic Undulators** – *S. Sasaki (HSRC)*

More than a decade has past after the original quasi-periodic undulator (QPU) was proposed.* Until now, much work has been done to improve the QPU performance. One of the first most productive improvements was to introduce the quasi-periodicity in an electron trajectory by partially changing the field strength in a periodic undulator.** Also, a modification of creation theory of one-dimensional quasi-periodicity gave another degree of freedom to build this type of device.*** As the result, many different types of QPUs have been and will be installed in the synchrotron radiation facilities worldwide.**** In this paper, a new scheme of quasi-periodic undulator that has a different magnetic structure is proposed. This new QPU generates a slightly higher intensity radiation with higher harmonics pattern different from those of previous QPUs. This new scheme of QPU is achieved by introducing orthogonal field in each half-period in order to create additional phase delay of electron beam at certain positions predicted by the theory. We discuss about realistic magnetic configurations as well as possibilities and limitations of new-QPUs.

WEPD025 **Theoretical Examination of Radiation Spectrum from the Quasi-periodic Undulator** – *S. Hirata (Hiroshima University, Faculty of Science) S. Sasaki (HSRC)*

Different form conventional periodic undulators, the quasi-periodic undulator (QPU) can radiate irrational harmonics instead of rational harmonics. It suits with experiments that need highly monochromatic light after passing through the monochromator. For this reason, the QPU is used in many synchrotron radiation facilities all over the world. Recently, new type QPUs that generate radiation spectra different from those by conventional type QPU were proposed*,**. In principle, the shape of radiation spectrum from a new QPU is determined by magnetic field distribution having different quasi periodic pattern. However, calculated spectra using a realistic magnetic field are often different from those of theoretical expectation. In this paper, a detailed comparative study is conducted to examine why there are these differences, how to correct magnetic field to get predicted spectra that fit to the theory. In addition, a possibility of modifying the basis of theory is investigated. These results, new generation method of new quasi-periodicity, and magnetic field distribution to achieve the best performance are presented at the conference.

WEPD026 **In-situ Magnetic Measurement and Correction for Cryogenic Undulator Development** – *T. Tanaka, H. Kitamura (RIKEN/SPring-8) A. Anghel, M. Bruegger, W. Bulgheroni, B. Jakob, T. Schmidt (PSI) A. Kagamihata, T. Seike (JASRI/SPring-8)*

The cryogenic permanent magnet undulator (CPMU) is an insertion device in which permanent magnets are cooled down to cryogenic temperature (CT) to improve the magnetic performances. Although CPMUs are realized by a slight modification of in-vacuum undulators (IVUs), we have several technical challenges to be overcome. Among them, the most important one is how to ensure the magnetic performance, in other words, how to measure the magnetic field at CT, and how to correct it if necessary. A new method of the phase-error correction has been proposed at SPring-8, in which the gap variation is corrected by adjusting mechanically the in-vacuum beam. What is important in this method is that the correction can be done at CT without breaking the vacuum, i.e., an 'in-situ' field correction is possible. The correction method has been tested to check the feasibility using the new CPMU with a magnetic period of 14 mm and a magnetic length of 1.7 m constructed for Swiss Light Source. In this paper, the principle and results are described together with the details of the new measurement system SAFALI (self aligned field analyzer with laser instrumentation) for the field measurement of CPMUs.

WEPD027 **Tuning of the Fast Local Bump System for Helicity Switching at the Photon Factory** – *K. Harada, Y. Kobayashi, T. Miyajima, S. Nagahashi, T. Obina, M. Shimada, R. Takai (KEK) S. Matsuba (Hiroshima University, Graduate School of Science)*

The fast local bump system for the helicity switching of variably polarizing undulators has been developed at the Photon Factory ring. The system consists of two APPLE-II type variably polarizing undulators and five identical horizontal kicker magnets for local bump with four small corrector magnets to prevent the leakage of the bump. At present, one undulator and the local bump system with corrector magnets are installed. For beam test, the system was operated with frequency up to 50 Hz with feed forward correction. In this presentation, after brief description of the system configuration, the results of the test operation and fine tunings of the fast local bump system are shown.

WEPD028 **Magnetic Field Adjustment of a Polarizing Undulator (U#16-2) at the Photon Factory** – *K. Tsuchiya, T. Aoto (KEK)*

We have been developing a rapid-polarization-switching source at the B15-16 straight section in the PF 2.5GeV ring. The source consists of tandem two APPLE-II type elliptically polarizing undulators (EPU), namely U#16-1 and U#16-2, and a fast kicker system. These two undulators are designed to obtain the soft x-ray at the energy region from 200eV to 1keV with various polarization states. We have constructed U#16-1 and installed in the PF ring in March 2008. The operation of U#16-1 for the user experiments has been started successfully since April 2008. The construction of the second undulator U#16-2 is underway. U#16-2 will be installed in the PF ring at this summer. We report the result of the magnetic field adjustment of the U#16-2.

WEPD029 **End Field Termination for Bulk HTSC Staggered Array Undulator** – *R. Kinjo, M. A. Bakr, Y.W. Choi, K. Higashimura, T. Kii, K. Masuda, K. Nagasaki, H. Ohgaki, T. Sonobe, M. Takasaki, S. Ueda, K. Yoshida (Kyoto IAE)*

Aiming at realizing a short period undulator with strong magnetic field, we have proposed a Bulk HTSC (high temperature superconductor) Staggered Array Undulator which consists of bulk high temperature superconductor magnets with a staggered array configuration. The experiment with the prototype undulator at 77 K shows this configuration can be applicable to real undulator. We also estimated the magnetic performance of real device by calculations with a loop current model based on Bean model of superconductor. Although end field termination is required for practical use, traditional methods are not applicable for the bulk HTSCs. We found that the end field termination can be realized by controlling the shape and size of bulk HTSCs at the end section by numerical calculation using the loop current model. In the conference, the calculation and experimental result of end field termination will be presented.

WEPD030 **Elimination of Hall Probe Orientation Error in Measured Magnetic Field of the Edge-focusing Wiggler** – *S. Kashiwagi, G. Isoyama, R. Kato (ISIR) K. Tsuchiya, S. Yamamoto (KEK)*

The edge-focusing (EF) wiggler has been fabricated to evaluate its performance rigorously with the magnetic field measurement. It is a 5-period planar wiggler with an edge angle of 2^{o} and a period length of 60 mm. The magnetic field is measured using Hall probes at four different wiggler gaps. It is experimentally confirmed that a high field gradient of 1.0 T/m is realized, as designed, along the beam axis. The magnetic field gradient of the EF wiggler is derived as a function of the magnetic gap. The field gradient decreases with increasing magnet gap more slowly than the peak magnetic field does for the present experimental model. An analytic formula for the field gradient of the EF wiggler is derived and it is shown that the slope of the field gradient with the magnet gap can be changed by varying the magnet width of the EF wiggler. We analyzed the relation between the orientation errors of the measurement system and the measured magnetic field or field gradient using a model magnetic field of the EF wiggle. We corrected the measurement magnetic field based on this analysis and evaluated the performance of the EF wiggler.

WEPD031 **Observation and Correction of Effects of Variably Polarized Undulator on Electron Beam at SAGA-LS** – *T. Kaneyasu, Y. Iwasaki, S. Koda, Y. Takabayashi (SAGA)*

An APPLE-II type variably polarized undulator was installed in the SAGA-LS storage ring in 2008. Following the installation, we have investigated influence of the undulator on the electron beam. Based on the measurements, we have developed a feedforward correction system to minimize the effects of the undulator. The correction system successfully compensates for closed orbit distortion (COD), betatron tune shift and a weak change in the betatron coupling. The standard deviation of the COD variation relative to the reference orbit and the tune shift are suppressed to less than 4 micron and 0.001, respectively, when the pole gap is changed at a fixed phase. The observed tune shift is interpreted in terms of a second order focusing effect evaluated by RADIA code. The simulated tune shift fairly agrees with the measurements. To minimize the effects on the betatron coupling, a wire-type skew quadrupole magnet mounted on the undulator duct is utilized. The skew field required for the coupling compensation is consistent with those predicted by field integral measurements. The feedforward correction reduces the effect to a relative change in the vertical beamsize of 5%.

WEPD032 **Design Consideration of New Insertion Devices of Hefei Light Source** – *Q.K. Jia (USTC/NSRL)*

To meet the requirements of users for higher brilliance and good transverse coherence VUV and soft X-ray synchrotron radiation, Hefei Light Source(HLS) will be upgraded. Now the design is undergoing. After upgrade HLS will have smaller beam emittance and install more insertion devices. In this paper the design considerations of new insertion devices including two undulators and one wiggler are reported.

WEPD033 **Undulator Harmonic Field Enhancement Analysis** – *Q.K. Jia (USTC/NSRL)*

The enhancement of arbitrary odd harmonic field is analyzed for pure permanent magnet undulator. The two dimensional analytical formula is given. It is shown that odd harmonic field can be enhanced by optimal the length ratio of vertical magnetization magnet block and horizontal magnetization magnet block, the 3rd harmonic field can exceeded 20% of the fundamental field and 7th harmonic field can exceeded 3 % of the fundamental field for magnet gap-period ratio equal to 0.1.

WEPD034 **Controller of In-Vacuum Undulator for SSRF** – *M. Gu, Q. Yuan (SINAP)*

The undulator controller based on Siemens S7-300 PLC is mainly consisted of controlling motion of two stepper motor, monitoring real-time gap position of upstream and downstream through position feedback derived from four linear absolute encoders (LAEs) with 0.1μm resolution, monitoring cooling water's temperature and flux (CWTF), monitoring magnet array temperature (MAT), providing remote access for EPICS via Ethernet, as well as MPS and PPS interlock interface to and from upper-level protection system. In addition, the controller is equipped with considerate motion safety protection tactics. As for the gap position protection, besides mechanical hard stop, software limit, photo-interrupter limit and kill switch are available to achieve it. As for the taper protection, software limit is available to achieve it.

WEPD035 **Mechanical Design of the Undulator for Compact THz Radiation Source based on FEL** – *J. Xiong (HUST)*

The compact terahertz (THz) radiation source based on FEL will require undulators with high mechanical precision in order to achieve the magnetic field requirements. A C-type, variable gap, and hybrid undulator will be used. The design requirements and mechanical difficulties for holding, positioning and driving the magnetic arrays are explored. Structural, magnetic and electrical considerations which influenced the design are then analyzed. We describe the mechanical design and features of the undulator, vacuum vessel and support system.

WEPD036 **Magnet Sorting and Shimming for PAL-II In-Vacuum Undulator** – *H.S. Suh, H.S. Han, Y.-G. Jung, D.E. Kim, H.-G. Lee, K.-H. Park (PAL)*

Pohang Light Source (PLS) is planning a major upgrade (PLS-II) for high photon energy and brighter synchrotron radiation with more straight sections for insertion devices. For these purpose, the storage ring will have lower emittance and lower energy spread. Undulator which will be installed on the PLS-II should also have low integrated multipole, lower orbit deviation and optical phase errors. We are developing effective method for sorting and shimming of magnets for the in-vacuum undulator under construction. Magnets with good quality and effective sorting algorithms of magnets will reduce the efforts for the shimming. The resulting undulator will have less impact on the operation of the storage ring.

WEPD037 **Tolerance Study of the 0.1nm PAL XFEL Undulator System** – *J. Lee, M. Yoon (POSTECH)*

A tolerance study of the undulator parameter error for the 0.1 nm X-ray Free Electron Laser at Pohang Accelerator Laboratory (PAL XFEL) has been performed and the results are presented in this paper. Effects of random and periodic errors on the FEL performance have been investigated, especially on the saturation power and saturation length. Periodic errors include sinusoidal and sawtooth forms. The study assumes non-steering error because it can be cured by beam-based alignment technique. As a result, we found that an rms 0.05% random error of undulator K increases the saturation length approximately by 2% and decreases the saturation power by 6%.

WEPD038 **Insertion Devices for the MAX IV Light Source** – *E.J. Wallén (MAX-lab)*

The MAX IV light source, to be constructed at MAX-lab in Lund Sweden, will consist of two separate storage rings and a linac-driven short-pulse facility. The two storage rings are operated at different energies, 3 GeV and 1.5 GeV, to provide radiation of high brightness over a broad spectral range. The 3 GeV linac serves as a full-energy injector for the storage rings as well as the driver of the short-pulse facility delivering intense x-ray pulses. The paper describes the initial set of insertion devices and the expected brilliance, photon flux, and heat loads produced by the insertion devices.

WEPD039 **First Magnetic Tests of a Superconducting Damping Wiggler for the CLIC Damping Rings** – *D. Schoerling, M. Karppinen, R. Maccaferri (CERN) A. Ams (IMFD) A. Bernhard, P. Peiffer (KIT) R. Rossmanith (FZK)*

Two damping rings (e+, e-) are foreseen for the CLIC injection chain. In each damping ring 76 two meter long wigglers will be installed. The short period (40-50 mm), combined with a gap larger than 14 mm and a requested field in the mid-plane BPeak > 2 T requires the usage of superconducting technologies to meet these requirements. To demonstrate the feasibility of this wiggler design a short-model vertical racetrack wiggler (40 mm period; 16 mm gap) was built and successfully tested at CERN. The wiggler carries a current of 730 A and 910 A and reaches a mid-plane peak field of Bpeak = 2 T and Bpeak = 2.5 T at 4.2 K and 1.9 K, respectively. The results show that the wiggler model meets the magnetic requirements of the CLIC damping rings at 1.9 K. The paper will also discuss the improvements we propose to enhance the performance in order to meet the CLIC specifications also at 4.2 K.

WEPD040 **The Spectrum Property Analysis of Wiggler-like Undulator** – *S.D. Chen, T.M. Uen (NCTU) C.-S. Hwang (NSRRC)*

A wiggler with the property of low total radiation power and keeping high photon flux in hard x-ray region, 5-20 keV, which is necessary for the special demand of users, was under investigated for reducing the difficulty of the design of optical components in the beam line and decreasing the load of RF cavity power. Such an insertion devise was called wiggler-like undulator. The spectrum of wiggler-like undulater was investigated with a code, of which the algorithm is based on the compromising between photon flux and radiation power of insertion devices for spectrum optimization. The property of the spectrum of the wiggler-like undulator are discussed herein. Furthermore, the brilliance and the power distribution are somehow also discussed.

WEPD041 **Auto-field Shimming Algorithm for Elliptical Polarized Undulator** – *C.M. Wu, C.-S. Hwang, F.-Y. Lin (NSRRC)*

Shimming magnetic field error on each pole in the Elliptically Polarized Undulator (EPU) is a time-consuming work and highly based on experience without scientific systematic methods. Therefore, an auto-field shimming program is developed to save time on pole shimming process. The program is including two major steps to analyze where the poles is defective or imperfect. Step one is to clarify the magnetic pole quality. If its quality is far away to user-defined standards, we change the pole instead of processing to balance them relatively for uniform magnetic field. The magnetic pole quality is based on deltaB/Bavg and deltaI/Iavg(half period of integral) percentage. The second step is to build the effective field and once integral model of pole and permanent magnet calculation. If we shim the defective pole by moving vertically and transversely, it would surge intrinsic change of the deltaB/Bavg and deltaI/Iavg at defective and surrounded poles. Auto-field shimming algorithm would assist us to plan shimming strategies to deal with magnetic poles.

WEPD042 **Design and Development of a 4-m Long Elliptically Polarized Undulator for TPS** – *C. H. Chang, C.-H. Chang, H.-H. Chen, J.C. Huang, M.-H. Huang, C.-S. Hwang, F.-Y. Lin, C.M. Wu (NSRRC)*

A 4-m long elliptically polarized undulator with 48 mm period length (EPU48) was designed for fulfilling the spin-polarized PES and inelastic scattering experiment in the Taiwan Photon Source (TPS). The EPU48 would be used to produce variously polarized light in the soft X-ray spectral domain of 0.2-1.5 keV. To achieve high mechanical performance and high quality of photon source, a new manufacture method by casting shall be adopted to fabricate a key component of carriage of the undulator at National Synchrotron Radiation Research Center (NSRRC). We expect that this way could take advantages of less assembly error, more rigidity and high precision properties. This work describes details of the magnetic circuit design and mechanical design of the EPU48 based on the new concept of engineering construction.

WEPD043 **The Development of Gradient Damping Wiggler for ALPHA Storage Ring** – *Z.W. Huang, D.J. Huang (NTHU) M.-H. Huang, C.-S. Hwang, C.Y. Kuo (NSRRC) S.-Y. Lee (IUCF)*

A novel gradient damping wiggler (GDW) was developed for the ALPHA storage ring in Indiana University. The GDW will be used to change the momentum compaction factor and the damping partition at ALPHA storage effectively. There is one middle pole and two outer poles that they have gradient field were assembled together on the same girder to be a full set of GDW magnet system. The dipole and gradient field strength of the middle (outer) pole is 0.67 T (-0.67) and 1.273 T/m (1.273 T/m), respectively. The magnet gap of the middle and outer pole is 40 mm and 35.87 mm, respectively, that the three combined function of dipole magnet can be charged by the same power supply. There is a trim coil on the three magnets to adjust the first and second integral field to zero. The good field region of middle pole and outer pole in transverse x-axis (deltaB/B=0.1%) are ±50mm and ±40mm separately. A prototype GDW magnet was fabricated and a Hall probe measurement system was set up to measure the magnet field to verify the magnet design and the magnet construction performance. The field cross-talk and the fringe field are also discussed herein by different methods.

WEPD044 **Modelling Synchrotron Radiation from Realistic and Ideal Long Undulator Systems** – *D. Newton (The University of Liverpool)*

An analytic description of the synchrotron radiation from electrons with short-period helical trajectories is given by the Kincaid equation. A new code is under development which generates an analytical description of an arbitrary magnetic field, including non-linear and higher-order multipole (fringe field) components. The magnetic field map of a short-period undulator was modelled, using a 3-d finite element solver, and it's analytical field description has been used to compare the synchrotron radiation output from electrons with a 'realistic' trajectory in terms of the ideal analytic equations. The results demonstrate how small numerical inaccuracies in the particle tracking can lead to large inaccuracies in the calculated synchrotron output. The affects of the higher order field modes are studied which give additional insights into the radiation output from long undulator systems.

WEPD045 **The Rapid Calculation of Synchrotron Radiation Output from Long Undulator Systems** – *D. Newton (The University of Liverpool)*

Recent designs for third generation light sources commonly call for undulator systems with a total length of several hundreds of metres. Calculating the synchrotron output from bunches of charged particles traversing such a system using numerical techniques takes an unfeasibly long time even on modern multi-node computer clusters. Analytical formulae (i.e. the Kincaid Equation) provide a more rapid solution for an idealised system but necessarily fail to produce the non-ideal response which is under investigation. A new code is described which generates an analytic description of an arbitrary magnetic field and uses differential algebra and Lie methods to describe the particle dynamics in terms of series of transfer maps. The synchrotron output can then be calculated using arbitrarily large step size with no loss of accuracy in the trajectory. The code is easily adapted to perform parallel calculations on multi-core machines. Examples of the radiation output from several long magnet systems are described and the performance is assessed.

WEPD046 **Electron Beam Heating Effects in Superconducting Wigglers at Diamond Light Source** – *E.C.M. Rial, C.P. Bailey, A.F. Rankin, J.C. Schouten, R.P. Walker (Diamond)*

Diamond Light Source is currently operating with two multipole superconducting wigglers, one with 49 poles at 3.5 T and another with 49 poles at 4.2 T. The cryogenic arrangement is similar in both cases; each cryostat contains a liquid helium bath cooled by four cryocoolers. The design goal was to allow up to six months continuous operation in the storage ring between refilling the liquid helium bath. However, the helium boil-off is much higher than expected, necessitating much more frequent refills. As well as having a cost implication, this also currently poses a restriction on the operating beam current. In this report we present the results of measurements carried out under various beam conditions to try to understand the reason for the higher boil-off in terms of heat load seen by the cryostat and effective cryocooler performance. We also present our plans for dealing with the problem in the near and longer term.

WEPD047 **Development Status of a Superconducting Undulator for the APS*** – *E.R. Moog, K.D. Boerste, T.W. Buffington, D. Capatina, R.J. Dejus, C. Doose, Q.B. Hasse, Y. Ivanyushenkov, M.S. Jaski, M. Kasa, S.H. Kim, R. Kustom, E. Trakhtenberg, I. Vasserman, J.Z. Xu (ANL) N.A. Mezentsev, V.M. Syrovatin (BINP SB RAS)*

A number of prototype magnetic structures for a superconducting undulator have been successfully built and tested. The field quality of a test device was measured in a vertical dewar; the phase errors were 7.1 deg. at the maximum design current with no phase shimming. The Advanced Photon Source (APS) specification for overall trajectory was met using the end compensation coils. Several Hall probes have been calibrated at cryogenic temperatures. The design for a cryostat to hold the undulator for installation in the APS storage ring is nearing completion, and a cryogenic measurement facility to measure the magnetic field of the completed undulator is under development.

WEPD048 **A Simple Model-based Magnet Sorting Algorithm for Planar Hybrid Undulators** – *G. Rakowsky (BNL)*

Various magnet sorting strategies have been used to minimize trajectory and phase errors in undulators, ranging from intuitive pairing of stronger and weaker magnets, to full 3D FEM simulation with actual Helmholtz coil magnet data. We present a simpler approach, first deriving trajectory displacement, kick angle and phase error signatures of each component of magnetization error from a 3D Radia* undulator model. Then, for a given sequence of magnets, the trajectory and phase profiles are computed by cumulatively summing the scaled displacements and phase errors. The rms error is then minimized by swapping magnets according to one's favorite optimization method. A fast, simple magnet swapping algorithm, implemented in Mathematica, is described. 100,000 iterations take only minutes, so dozens of solutions can be compared. This approach was applied recently at NSLS to a short in-vacuum undulator, which required no trajectory or phase shimming. We also obtain trajectory and phase error signatures of some mechanical errors, to guide "virtual shimming" and specifying mechanical tolerances. Finally, multipole signatures of some simple inhomogeneities are modeled.

WEPD049 **Progress and Future Plans on Insertion Device Related Activities at the NSLS-II** – *T. Tanabe, T.M. Corwin, D.A. Harder, P. He, G. Rakowsky, J. Rank, C.J. Spataro (BNL)*

National Synchrotron Light Source-II (NSLS-II) project is now in the construction stage. A new insertion device (ID) magnetic measurement facility (MMF) is being set up at Brookhaven National Laboratory in order to satisfy the stringent requirement on the magnetic field measurement of IDs. ISO-Class7 temperature stabilized clean room is being constructed for this purpose. A state-of-the-art Hall probe bench and integrated field measurement system will be installed therein. IDs in the project baseline scope include six damping wigglers, two elliptically polarizing undulators (EPUs), three 3.0m long in-vacuum undulators (IVUs) and one 1.5m long IVU. Three-pole wigglers with peak field over 1 Tesla will be utilized to accommodate the users of bending magnet radiation at the NSLS. Future plan includes: 1) an in-vacuum magnetic measurement system, 2) use of PrFeB magnet for improved cryo undulator, 3) development of advanced optimization program for sorting and shimming of IDs, 4) development of a closed loop He gas refrigerator, 5) switchable quasi-periodic EPU. Design features of the baseline devices, IDMMF and the future plans for NSLS-II ID activities are described.

WEPD050 **Performance Evaluation of Undulator Radiation at CEBAF** – *C. Liu (CASA) G.A. Krafft (JLAB)*

The possibility of producing sub-ps x-ray by putting undulator in CEBAF machine will be discussed. The performance of undulator radiation at CEBAF will be calculated and compared with storage ring light source.

WEPD051 **Ultrashort Electron Bunch Train Production by UV Laser Pulse Stacking** – *L.X. Yan, Q. Du, Y.-C. Du, Hua,,J.F. Hua, W.-H. Huang, C.-X. Tang (TUB)*

Ultrashort relativistic electron beam can be applied to produce high power coherent THz radiation by mechanisms such as FEL, CSR, CTR et al. The THz modulated electron beams, or THz-repetition-rate ultrashort electron bunch trains exhibit further enhancement of coherent THz radiation. This article will report the experimental results on the ultrashort electron bunch train production by copper based photocathode RF gun via direct UV laser pulse stacking using birefringent α-BBO crystal serials at our laboratory. The temporal profile of the electron beam was measured by deflecting cavity. Space charge effect downstream the photocathode is simulated. This shaping method of laser pulse by α-BBO crystals can also be applied to form quasi flattop UV laser pulse for reducing the initial emittance of the electron beam from the photocathode RF gun.

WEPD052 **Wavelength-tunable UV Laser for Electron Beam Generation with Low Intrinsic Emittance** – *C.P. Hauri, B. Beutner, H.-H. Braun, R. Ganter, C.H. Gough, R. Ischebeck, F. Le Pimpec, M. Paraliev, C. Ruchert, T. Schietinger, B. Steffen, A. Trisorio, C. Vicario (PSI)*

In the framework of the SwissFEL activities at PSI we developed a powerful UV laser system delivering wavelength-tunable pulses at a central wavelength varying from 260 to 283 nm. The laser system based on a ultrastable frequency-trippled Ti:sapphire amplifier delivers mJ pulse energy within a duration of 1-10 ps with 1.5 nm spectral width. Temporal flattop pulses are achieved by direct UV shaping with a UV Dazzler and a prism-based stretcher. The system is used to explore thermal emittance and quantum efficiency dependence on photon energy from metallic photocathode (Cu and Mo). With pepperpot techniques we have measured the predicted theoretical limit for thermal emittance (0.4 mm.mrad / mm rms laser spot size at 283 nm and 0.6 mm.mrad / mm at 263 nm) for metallic photocathodes.

WEPD053 **First Results of the Daresbury Compton Backscattering Experiment** – *S.P. Jamison, P.J. Phillips, Y.M. Saveliev, S.L. Smith (STFC/DL/ASTeC) D.M. Graham (The University of Manchester, The Photon Science Institute) D. Laundy (STFC/DL) G. Priebe (MBI) E.A. Seddon (Manchester University)*

Backscattered xrays with an energy of 20keV have been generated from the head-on collision of a multi-TW, 60fs FWHM duration, laser pulse with 30MeV electrons in the ALICE energy recovery linac. The spatial profile of the backscattered xrays was obtained in single shot scintellation screen imaging. The temporal profile of the xray yeild as a function of the time delay between laser and electrons is consistent with that expected from the collision point dependence of the laser-electron beam transverse overlap. Comparison of observed and calculated xray yield is discussed.

WEPD054 **Novel Ultrafast Mid-IR Laser System** – *R. Tikhoplav, A.Y. Murokh (RadiaBeam) I. Jovanovic (Purdue University)*

Of particular interest to X-ray FEL light source facilities is Enhanced Self-Amplified Spontaneous Emission (ESASE) technique. Such a technique requires an ultrafast (20-50 fs) high peak power, high repetition rate reliable laser systems working in the mid-IR range of spectrum (2μm or more). The approach of this proposed work is to design a novel Ultrafast Mid-IR Laser System based on optical parametric chirped-pulse amplification (OPCPA). OPCPA is a technique ideally suited for production of ultrashort laser pulses at the center wavelength of 2 μm. Some of the key features of OPCPA are the wavelength agility, broad spectral bandwidth and negligible thermal load.

WEPD055 **Semi-nondestructive Monitoring System for High-energy Beam Transport Line at HIMAC** – *E. Takeshita, T. Furukawa, T. Inaniwa, Y. Iwata, K. Noda, S. Sato, T. Shirai (NIRS)*

The development of the screen monitor system (SCN) at the Heavy Ion Medical Accelerator in Chiba (HIMAC) comprises the surveillance of the carbon beam. In the three-dimensional scanning system for the carbon therapy, the beam qualities, i.e., position, size and intensity of the beam, play a significant role for the patient's treatment. Therefore, we designed a semi-nondestructive monitoring system located on the the high-energy beam transport line to monitor the beam qualities by using a thin fluorescent screen and a high-speed charge-coupled device. The beam position and profile were obtained from the light emitting distribution of the screen. The SCN was checked on the prototype scanning system at HIMAC and succeeded to monitor the beam real-time in steps of about 10 msec, corresponding to a 100 Hz sampling rate. The developments steps will focus toward a operation at HIMAC's new therapy facility extension, recently. In the conference, we would like to report on details of the automatic beam tuning before starting the treatment and the interlock system during therapy using the SCN.

WEPD056 **Performance of the L-Band Electron Linac for Advanced Beam Sciences at Osaka University** – *G. Isoyama, K. Furuhashi, S. Kashiwagi, R. Kato, M. Morio, J. Shen, S. Suemine, N. Sugimoto, Y. Terasawa (ISIR)*

The 40 MeV L-band electron linac at the Institute of Scientific and Industrial Research, Osaka University is extensively used for various applications on advanced beam sciences including radiation chemistry by means of pulse radiolysis and development of the free electron laser in the THz region. It was constructed in 1975-78 and has been remodeled sometimes for improving its performance. The most recent one was made in 2002-2004 for higher operational stability and reproducibility, resulting in significant advances in the studies. We will report the present status of the linac and results of its performance evaluation.

WEPD057 **Linac Energy Management for LCLS** – *P. Chu, R.H. Iverson, P. Krejcik, D. Rogind, G.R. White, M. Woodley (SLAC)*

Linac Energy Management (LEM) is a control system program which calculates, and optionally implements, magnet setpoint settings (BDESs) following a change in Energy (such as a change in the number, phase, and amplitude of active klystrons). The change is made relative to those magnets' existing BDES setpoints by a factor encoding the change in energy. LEM is necessary because changes in the number, phase, and amplitude of the active klystrons (the so-called "Klystron complement") change the beam's rigidity, and therefore, to maintain constant optics, one has to change focusing gradients and bend fields. This paper describes the basic process and some of the implementation lessons learned for LEM at the LCLS.

WEPD058 **A High Power Fibre Laser for Electron Beam Emittance Measurements** – *L. Corner, L.J. Nevay (OXFORDphysics) L. Corner, R. Walczak (JAI)*

We present the results of the development of a high power fibre laser system for the laserwire project to measure very low emittance electron beams. We use the output of a commercial 1uJ, 6.49MHz laser system and amplify it in rod type photonic crystal fibre. This is a novel form of optical fibre which has a large core diameter (70um) but still supports only a single Gaussian spatial mode, essential for focusing the beam to the smallest spot size and achieving the highest resolution. We amplify the seed pulses in a burst mode suitable for use in a linear accelerator, which has the advantage of decreasing the pump power required and thus reducing the running cost and heat loading of the laser system. The amplified pulses have energies of ~ 100uJ in the near infrared and excellent beam quality, as specified in the original design, and are frequency converted to the green to give sub-micron spatial resolution.

WEPD059 **EMI Noise Suppression in the Klystron Pulse Power Supply for XFEL/SPring-8** – *C. Kondo, K. Shirasawa (JASRI/SPring-8) T. Inagaki, T. Sakurai, T. Shintake (RIKEN/SPring-8)*

Low electro-magnetic noise interference (EMI) is required to the klystron modulator power supply for XFEL/SPring-8 project in order to realize the highly stable beam operation with aid of various feedback loops using high-performance beam monitors. The dominant noise source is the thyratron switching noise, associated with its rapid voltage swing of 50 kV maximum. To suppress the noise leakage, special care was taken to the enclosure design of klystron modulator, i.e., using thick steel plates a monocoque enclosure was fabricated, in which all of the high power circuits was installed. The rapid image current flows on the inner surface, thus EMI was minimized. A special co-axial feed-though was developed for filtering the conducted noise on power line for thyratron and klystron heaters. In this presentation, we will report the details of the devices and the results of the noise suppression.

WEPD060 **Update of PF-AR Main Magnet Power Supplies** – *T. Ozaki, A. Akiyama, K. Harada, T. Kasuga, Y. Kobayashi, T. Miyajima, S. Nagahashi, T.T. Nakamura, M. Ono, T. Sueno (KEK)*

At PF-AR, a bending magnet power supply was updated in 2007. The converter works in the 3 pulsed PWM. A trouble caused by higher harmonics above 40th had occurred. We manufactured filters and installed in 6.6kV ac lines in 2008. Furthermore, a QF magnet power supply was updated in 2009. This paper reports on the update of PF-AR main magnet power supplies.

WEPD061 **Application of Energy Storage System for the Accelerator Magnet Power Supply** – *H. Sato, t.s. Shintomi (KEK) T. Ise, Y. Miura (Osaka University, Graduate School of Engineering) S. Nomura, R. Shimada (RLNR)*

Magnets of the synchrotron accelerator which extracts the accelerated beams are excited by pulse operation power supply, and then the load fluctuation should be a severe problem. An energy storage system, such as SMES, fly-wheel generator so far, will be required for compensating the pulse electric power, and reducing the disturbances of the connected power line. The system is also expected to protect the instantaneous voltage drop and contributes the reliability of the storage ring. Present status of R & D and the features for the energy storage systems are discussed. The application of the energy storage systems to synchrotrons for the medical use is described. The compensation of the typical pulse electric power of the synchrotron for the cancer therapy is studied.

WEPD062 **Magnetic Field Measurement and Ripple Reduction of Quadrupole Magnets of the J-PARC Main Ring** – *H. Someya, S. Igarashi (KEK) S. Nakamura (J-PARC, KEK & JAEA)*

The power supply current ripple of the quadrupole magnets of the J-PARC main ring has been measured to be the order of 10^{-4}. The magnetic field of the quadrupole magnets has been measured and the ripple frequency distribution of each magnet was observed to be depending on where the magnet is in the magnet chain. A transmission line model for the cable and magnets was able to explain the distribution. The field ripple made by the common mode current ripple was reduced by changing the magnet cabling to be symmetrical with respect to the N and S poles of the quadrupole magnets. The common mode ripple was drastically reduced. The normal mode ripple of 600, 1200 and 1800 Hz however remained. The field ripple was further reduced using resistors those are connected in parallel to the magnet coils and bypass the current ripple. It was effective to the higher frequency ripple of 1200 and 1800 Hz and the effect was in a good agreement with an electric circuit simulation program LTspice.

WEPD063 **Suppression Scheme of COD Variation Caused by Switching Ripple in J-PARC 3GeV Dipole Magnet Power Supply** – *Y. Watanabe (JAEA)*

In J-PARC RCS, horizontal closed orbit distortion (COD) which is ±2 or 3mm in amplitude was observed all over the ring. Main component of the horizontal COD is 1kHz, phase variation period about 140 seconds. This paper demonstrates phase variation of the 1kHz horizontal COD caused by switching ripple from dipole magnet power supply. To suppress the phase variation of the horizontal COD, switching timing of the dipole magnet power supply was synchronized J-PARC timing system.

WEPD064 **New Multiconductor Transmission-line Theory and the Origin of Electromagnetic Noise** – *H. Toki, K. Sato (RCNP)*

The ordinary electric circuits produce and receive electromagnetic noise. The noise is a problem for stable operation of synchrotron accelerators. We do not know the origin of the noise generation due to the lack of electric circuit theory, which takes into account the noise sources. The proper treatment of electric circuit together with noise requires a proper knowledge of multiconductor transmission-line theory. We have developed a new multiconductor transmission-line theory in which we are able to describe the performance of multiconductor transmission-line system*. In this theory, it is essential to use the coefficients of potential instead of capacities and the introduction of the normal and common modes. After understanding the multiconductor transmission-line theory, we propose the introduction of the middle line (three lines) and symmetric arrangements of electric loads**. The use of this concept made the J-PARC MR successful in operation.

WEPD065 **Storage Ring Magnet Power Supply System at the PLS-II** – *S.-C. Kim, K.R. Kim, S.H. Nam, C.D. Park, Y.G. Son, C.W. Sung (PAL)*

Lattice of the Storage Ring (SR) is changed from TDB to DBA, and beam energy is enhanced from 2.5 GeV to 3.0 GeV at the Pohang Light Source upgrade (PLS-II). Therefore all magnet specification and number have to change compare with exist PLS SR. At the PLS-II, Magnet Power Supplies (MPS) must be re-designed according to magnet specification of the PLS-II. Newly development MPSs are adopted switching type power conversion technology. High current unipolar MPSs are parallel operation type of unit module buck type power supply, and low current bipolar MPSs are H-bridge type. All MPSs are performed ± 10 ppm output current stability and adopted full digital controller. In this paper, we report on the development and characteristics of the MPS for PLS-II SR.

WEPD066 **ALBA Storage Ring Power Converters** – *M. Pont (CELLS-ALBA Synchrotron)*

ALBA is a 3 GeV third generation synchrotron light source under construction in Spain. The design and performance of the ALBA Storage Ring Power Converters will be described. A total of 122 power converters are required: 1 for the dipoles (all connected in series), 112 for the quadrupoles (each magnets with its own power supply) and 9 for the sextupoles (each family connected in series). All converters are switched mode with full digital regulation and a common control interface. The paper will describe the performance of the power converters and compare it with the design specifications.

WEPD067 **ALBA Booster Power Converters** – *M. Pont (CELLS-ALBA Synchrotron)*

ALBA is a 3 GeV third generation synchrotron light source under construction in Spain. The injection system is composed of a 100 MeV Linac as pre-injector followed by a full energy booster synchrotron. The booster requires AC power converters operating at 3.125 Hz with a sinusoidal current waveform. All converters are switched mode with full digital regulation and a common control interface. The design specifications have been demonstrated and early tests on the Booster commissioning with beam will be presented

WEPD068 **Septum and Kicker Magnets for the ALBA Synchrotron Light Source** – *M. Pont, R. Nunez (CELLS-ALBA Synchrotron) E. Huttel (KIT)*

At the ALBA Booster and Storage Ring 6 kicker and 3 septa magnets are installed for beam injection and extraction. A 100 MeV beam coming from the linac is injected on axis into the ALBA Booster. The full energy (3 GeV) beam is extracted from the booster and injected into the Storage Ring, where 4 kicker magnets bring the stored beam close to the septa.

All septa are direct driven out-of-vacuum magnets with C shape iron laminated yoke and soft iron screen for the stored beam. The magnets are excited by a full sine 330 μs pulse length; the nominal field is 0.15 / 0.84 / 0.9 T (booster injection / extraction /storage ring injection). The stray field seen by the stored beam is less than 1 μT. The booster kicker magnets are in-vacuum magnets with C-ferrite yoke. The magnets are excited by a 0.3 μs flat top pulse; the nominal field is 0.03 / 0.04 T (booster injection / extraction). The charge of a pulse-forming-network is switched by a thyratron. The storage ring kickers have a C-ferrite yoke and a Ti coated ceramic vacuum chamber. The pulse is a 6 μs half sine; the nominal field is 0.13 T. The thickness of the Ti coating is 0.4 μm and had been done by magnetron sputtering.

WEPD069 **Booster of the ALBA Synchrotron Light Source** – *M. Pont (CELLS-ALBA Synchrotron)*

ALBA is a 3 GeV third generation synchrotron light source under construction in Spain. The injection system is composed of a 100 MeV Linac as pre-injector followed by a full energy booster synchrotron which shares the same tunnel as the storage ring. With a circumference of 249.6 m and a magnetic lattice based on combined magnets an emittance of 9 nm.rad has been predicted. At present time we are in an intensive sub-system commissioning testing with the aim to start the commissioning with beam early in January 2010.

WEPD070 **High Precision Current Control for the LHC Main Power Converters** – *H. Thiesen, M.C. Bastos, G. Hudson, Q. King, V. Montabonnet, D. Nisbet, S.T. Page (CERN)*

The LHC was restarted on the 20th of November 2009 after 14 months of shutdown. The machine is composed of 8 powering sectors, each containing a main dipole circuit and two main quadrupole circuits. Each of these main circuits is entirely independent. To operate the LHC, the magnetic fields in the main magnets must be controlled with unprecedented accuracy. Indeed, the current in each power converter must be controlled with an accuracy of a few ppm (parts per million of nominal current) and the currents must be perfectly synchronised between sectors. To achieve the performance required of the LHC power converters, many challenges have been resolved. These include: measuring the power converter currents with an extreme absolute precision, control of these currents without tracking error or overshoot, perfect synchronisation of the current references sent to the power converters of the 24 main circuits. This paper details how these various problems have been resolved to obtain the performance required. Many experimental results are included, in particular the results of the tracking tests performed with the main circuits of the LHC.

WEPD071 **A New Generation of Digital Power Supply Controllers** – *M. Emmenegger, H. Jaeckle, R. Kuenzi, S. Richner (PSI)*

In accelerator applications, high precision high speed power supplies (PSs) for magnets are needed to guarantee the high beam quality. These PSs are the main purpose of the presented second generation of a Digital Power Electronic Control System (DPC) which has been designed and successfully applied at the Paul Scherrer Institute PSI. The main components of the DPC are the controller board ($DPC_C C$) and the high precision analogue to digital converter board ($DPC_A D$). Compared to the first generation the properties such as precision, acquisition rate, processing power and functionality have been improved considerably. This allows faster control cycles and/or more complex control algorithms. The controller board now features 12 standard precision (16 bit) ADC channels and allows the simultaneous control of multiple power supplies. High precision requirements are met by adding the $DPC_A D$ to the system. In conclusion, the modular and flexible design allows well-matched solutions for the typically heterogeneous accelerator power supplies.

WEPD072 **Conductive EMI Test of Magnet Power Supply in NSRRC** – *Y.-H. Liu, J.-C. Chang, J.-R. Chen, C.-Y. Liu (NSRRC)*

The purpose of this paper is to estimate the conductive Electromagnetic Interference (EMI) from magnet power supply in NSRRC. A LISN system was conducted to measure the EMI spectrum of power supply. The different frequency range of conductive EMI was measured. For the future TPS(Taiwan Photon Source) power supply design, the EMI signals must be lower than TLS kicker. Therefore reducing and eliminating the interference of electromagnetic waves will be a very important issue. A filter and shielding method were used to test the effects of reducing EMI. The EMI prevention scheme will be used in the future.

WEPD073 **TPS Corrector Magnet Power Converter** – *K.-B. Liu, K.T. Hsu, Y.D. Li, B.S. Wang (NSRRC) J.C. Hsu (CMS/ITRI)*

Based on the requirement of beam stability for the third-generation synchrotron radiation light source is more stringent, lower ripple and higher bandwidth of output current of corrector magnet power converters should be developed to implement the closed orbit correction of Taiwan Photo Source (TPS). The ±10A/±50V corrector magnet power converter uses a full bridge configuration, the switching frequency of power MOSFET is 40 kHz, in that each bridge leg has its own independent PWM controller and the output current bandwidth is 1 kHz when connected with the corrector magnet load. Using a DCCT as the current feedback component the output current ripple of this converter could be lower than 5 ppm. In this paper, we will describe the hardware structure and control method of the corrector magnet power converter and the test results will be demonstrated.

WEPD074 **Design and Implementation of a Resonant DC Power Bus** – *C.-Y. Liu, Y.D. Li (NSRRC)*

We design and implement a power convert to supply dc power bus for the MCORE 12 correction supply. Its characteristics were variable frequency at heavy and medium/light load. A relaxation oscillator generates a symmetrical triangular waveform, which MOSFETs' switching is locked to. The frequency of this waveform is related to a current that will be modulated by feedback circuitry. As a result, the tank circuit driven by half-bridge will be stimulated at a frequency dictated by the feedback loop to keep the output voltage regulated, thus exploiting its frequency-dependent transfer characteristics. The characteristics of the resonant dc power bus are illustrated in this paper.

WEPD075 **TPS Magnet Power Supply System** – *K.-B. Liu, K.T. Hsu, Y.D. Li, B.S. Wang (NSRRC)*

The Taiwan Photon Source (TPS), a third-generation synchrotron radiation light source, should be installed with 10^{32} sets of magnet power supplies for the storage ring and 152 sets for the injector. All of the power supplies are preferred in PWM switched mode with IGBT or MOSFET. A high precision DC power supply for 48 dipoles of the storage ring; there are 240 quadrupole magnets and 168 sextupole magnets in storage ring, the main winding of quadrupole and 168 sextupole magnets are powered by individual power supplies. In the booster ring, one set of dynamic power supply for the dipole magnets and four sets for quadrupole magnets run at the biased 3Hz quasi sinusoidal wave. There are several hundred corrector (fast and slow) magnets and skew quadrupole magnets in storage ring and injector are powered by the same bipolar power converters.

WEPD077 **The Fully Digital Controlled Corrector Magnet Power Converter** – *B.S. Wang, K.T. Hsu, Y.D. Li, K.-B. Liu (NSRRC)*

This paper presents an implementation of a precision corrector magnet power converter using the digitally controlled pulse width modulation method. The output current precision of this ±10A/±50V corrector magnet power converter is within ±10ppm. The digital control circuit of the power converter is implemented with using a high speed ADS8382 18-bits analog-to-digital converter and a TMS320F28335 digital signal processor. The converter uses a full bridge configuration, the switching frequency of power MOSFET is 40 kHz and the control resolution is 17-bits. Using a DCCT as the current feedback component the output current ripple of this converter could be lower than 5 ppm that is beyond the requirement of TLS corrector power converter and suitable to be used in TPS.

WEPD078 **A Novel Digital Control System to Achieve High-resolution Current Regulation for DC/DC Converters at the APS** – *G. Feng, B. Deriy, T. Fors, J. Wang (ANL)*

The DC/DC converters in the Advanced Photon Source storage ring are more than 15 years old, and an upgrade is underway to resolve the aging and obsolescence issues. In the upgrade, an 18-bit resolution for current regulation is desired. This paper describes a digital control system to achieve this goal. The system uses a serializer chip, TI TLK2541, combined with a Σ-Δ modulator to realize a 21-bit digital pulse width modulation (DPWM). Analog and digital filters are implemented to block the ripple currents and to reduce the EMI noises. Deployed with filter circuits, a digital compensator has been designed to meet the requirements of output current regulation. Furthermore, a voltage feed forward is employed to compensate for input bus voltage variations. A prototype digital controller using a field-programmable-gate-array development board has been developed. The resolution of the current regulation, and the effect of noises into the digital controlled power converter system have been tested and analyzed.

WEPD079 **Comparison among Eligible Topologies for Marx Klystron Modulators** – *G. Busatto, C. Abbate, F. Iannuzzo, C.E. Pagliarone (University of Cassino) F. Bedeschi, G.M. Piacentino (INFN-Pisa)*

A Marx-topology klystron modulator is based on the connection of several capacitive cells for obtaining the required amplitude and duration of the pulses. Each cell includes at least two high-voltage switches to be used one for the precharge of the capacitors and the other one for the fire of the output pulse. The optimal combination between the number of cells and the number of switches per cell, results from a trade-off in terms of reliability/robustness/efficiency/cost constraints. The objective of this poster is to discuss possible issues of each solution, starting from performances' considerations of last-generations Insulated Gate Bipolar Transistors (IGBTs) switches. Experimental and simulation results obtained from two cells Marx prototypes using several solutions, including single device, series connected devices, hard-switched and soft-switched solutions, are presented. Despite the present tendency to use single device per cell, our results indicate that switching and on-state energy losses of the series solution are better and the robustness and reliability performances not worse than the single device solution.

WEPD080 **Compact Klystron Modulator for XFEL/SPring-8** – *T. Shintake, T. Inagaki, C. Kondo, T. Sakurai, K. Shirasawa (RIKEN/SPring-8)*

XFEL/SPring-8 will use 72 line type modulator pulse-power supply for 66 C-band klystrons, 4 S-band, one L-band and pulsed 500 kV electron gun. In order to make the size smaller to fit the space available in the high gradient C-band accelerator, we have developed all in one box design of modulator. Using metal monocok design, filled with oil, it becomes possible to fit all circuitry: PFN, thyratron, pulse transformer, klyston socket, and protection circuit into a metal box of W 1m x L 1.7m x H 1m, which provides strong support for massive klystron and solenoide with lead shield and functions as superior EM shiled. We developed high precission HV charger for PFN, which has stability better than 100 ppm.pp. Modulator and PFN chargers are under mass prodution.

WEPD081 **Long-pulse Modulator Development for the Superconducting RF Test Facility (STF) at KEK** – *M. Akemoto, S. Fukuda, H. Honma, H. Nakajima, T. Shidara (KEK)*

This paper describes a long-pulse 1.3 GHz klystron modulator that was recently developed for the Superconducting RF Test Facility (STF) at High Energy Accelerator Research Organization (KEK). The modulators is a direct-switched-type design with a 1:15 step-up transformer and a bouncer circuit to compensate for the output pulse droop within ±0.5%; it can drive a klystron with up to 10 MW peak power, 1.5 ms rf pulse width, and up to 5 pps repetition rate. The main features of this modulator are the use of four 50 kW switching power supplies in parallel to charge the storage capacitors to 10 kV, self-healing-type capacitor to realize a compact storage capacitor bank, and a highly reliable IGBT switch which enables elimination of a crowbar circuit. Design considerations and its performance are presented. An IEGT (Injection Enhanced Gate Transistor) switch, composed of six series devices with a rating of 4.5 kV and 2100 A-DC, has been also developed and tested for R&D to realize a compact modulator.

WEPD082 **The Kicker System for the Fast Extraction Beamline at the J-PARC Main Ring** – *K. Koseki, T. Sekiguchi (KEK) K. Otsuka (Nippon Advanced Technology Co. Ltd.)*

The fast extraction kicker system which generates pulsed current of 6.5 kA has been developed. A pulse forming network (PFN) with 60 sections are assembled into a blumlein circuit. With this number of PFN sections, parasitic inductance in high voltage capacitors disturbs fast rise time of output current. To avoid this situation, each capacitor is covered with copper plate which forms a coaxial structure. By comparison, 10% faster rise time was obtained with the coaxial structure. Moreover, a set of saturable inductors are put at an input terminal of an electromagnet (kicker magnet) to compress the output current and to get the faster rise time.

WEPD085 **Design of the Pulse Bending Magnet for Switching the Painting Areas of the MLF and MR at 25Hz in J-PARC 3-GeV RCS** – *T. Takayanagi, M. Kinsho, P.K. Saha, T. Togashi, T. Ueno, M. Watanabe, Y. Yamazaki, M. Yoshimoto (JAEA/J-PARC) H. Fujimori (J-PARC, KEK & JAEA) Y. Irie (KEK)*

At the J-PARC 3-GeV injection, the injection painting area is designed to be different for supplying the MLF (Material Life Science Facility) and MR (50GeV Main Ring) beams. Along with the injection system in the ring, pulsed switching magnets which are installed in the injection beam-line should also have a function to control the beam orbit at 25Hz. The deflection angle ranges from 3 to 38 mrad to meet the user operation as well as the beam physics run.

WEPD086 **Operation of Kicker System using Thyratron of the 3 GeV Rapid Cycling Synchrotron of J-PARC** – *M. Watanabe, J. Kamiya, K. Suganuma, T. Takayanagi, N. Tani, T. Togashi, T. Ueno, Y. Watanabe (JAEA/J-PARC)*

3 GeV rapid cycling synchrotron (RCS) of J-PARC accelerates proton beams from the 181 MeV up to 3 GeV. The RCS injects the beam to the Main Ring and transports it to the muon production target and neutron production target in the Materials and Life Science Experimental Hall. Proton beams in the RCS are fast extracted by kicker magnets at the repetition rate of 25 Hz. The rise time of the magnetic field is approximately 260 ns due to the propagation time through the coaxial cable and the kicker magnet itself. The flat-top length of it is required to 840 ns in order to extract two beam bunches. Pulse forming lines (PFL) and thyratrons are used to make the rise time and the flat-top, at the maximum charging voltage of 80 kV. Two thyratrons, which is a CX1193C made by e2V Ltd., are used for a power supply. 16 thyratrons are used in the eight power supplies of the kicker system. Since thyratrons are gaseous discharge switching devices, they often make misfire or self-breakdown in several hours. In this paper, present status of operation and voltage adjustment method of the reservoir and cathode heater power supply of the thyratrons in the kicker system are described.

WEPD087 **Design, Manufacturing and Testing of CTF3 Tail Clipper Kicker** – *I. Rodriguez, F. Toral (CIEMAT) M.J. Barnes, T. Fowler, G. Ravida (CERN)*

The goal of the present CLIC test facility (CTF3) is to demonstrate the technical feasibility of specific key issues of the CLIC scheme. The extracted drive beam from the combiner ring (CR), of 35 A magnitude and 140 ns duration, is sent to the new CLic EXperimental area (CLEX). A Tail Clipper (TC) kicker is required, in the CR to CLEX transfer line, to allow the duration of the beam pulse to be adjusted: the unwanted bunches are kicked into a collimator. The TC must have a fast field rise-time, of not more than 5 ns, in order to minimize uncontrolled beam loss. Striplines are used for the TC: to establish the required fields, the applied pulse wave front must fully propagate along the striplines. To reduce the wave front propagation time, the overall length of the stripline assembly is sub-divided into 4 sections. The TC has been designed with the aid of detailed numerical modelling: the stripline cross section and coaxial to stripline transitions were carefully designed and optimized using a 3D code. The results of simulations and the measured behaviour of the striplines are presented; in addition measured current pulses are shown. Finally, measurements with beam are reported.

WEPD088 **Beam-Based Measurement of the Waveform of the LHC Injection Kickers** – *M.J. Barnes, L. Ducimetière, B. Goddard, C. Hessler, V. Mertens, J.A. Uythoven (CERN)*

Proton and ion beams will be injected into LHC at 450 GeV by two kicker magnet systems, producing magnetic field pulses of up to 7.8 μs flat top duration with rise and fall times of not more than 900 ns and 3 μs, respectively. Both systems are composed of four traveling wave kicker magnets, powered by pulse forming networks. One of the stringent design requirements of these systems is a field flat top and post pulse ripple of less than ±0.5 %. A carefully matched high bandwidth system is required to obtain the stringent pulse response. Screen conductors are placed in the aperture of the kicker magnet to provide a path for the image current of the, high intensity, LHC beam and screen the ferrite against Wake fields: these conductors affect the field pulse response. Recent injection tests provided the opportunity to directly measure the shape of the kick field pulse with high accuracy using a pilot beam. This paper details the measurements and compares the results with predictions and laboratory measurements.

WEPD089 **CLIC Pre-Damping and Damping Ring Kickers: Initial Ideas to Achieve Stability Requirements** – *M.J. Barnes, L. Ducimetière, J.A. Uythoven (CERN)*

The Compact Linear Collider (CLIC) study is exploring the scheme for an electron-positron collider with high luminosity (10^{34} - 10^{35} cm^2/s) and a nominal centre-of-mass energy of 3 TeV: CLIC would complement LHC physics in the multi-TeV range. The CLIC design relies on the presence of Pre-Damping Rings (PDR) and Damping Rings (DR) to achieve the very low emittance, through synchrotron radiation, needed for the luminosity requirements of CLIC. In order to limit the beam emittance blow-up due to oscillations the combined flat-top ripple and droop of the field pulse, for the DR extraction kickers, must be less than 0.015%. In addition, the allowed beam coupling impedance for the kicker systems is also very low: a few Ohms longitudinally and a few MΩ/m transversally. This paper discusses initial ideas for achieving the extremely demanding requirements for the PDR and DR kickers.

WEPD090 **Design Concepts for RF-DC Conversion in Particle Accelerator Systems** – *F. Caspers, A. Grudiev, M.M. Paoluzzi (CERN)*

In many particle accelerators considerable amounts of RF power reaching the megawatt level are converted into heat in dummy loads. After an overview of RF power in the range 200 MHz to 1 GHz dissipated at CERN we discuss several developments that had come up in the past using vacuum tube technology for RF-DC conversion. Amongst those the developments the cyclotron wave converter CWC appears most suitable. With the availability of powerful Schottky diodes the solid state converter aspect has to be addressed as well. One of the biggest problems of Schottky diode based structures is the junction capacity. GaAs and GaN Schottky diodes show a significant reduction of this junction capacity as compared to silicon. Small rectenna type converter units which had been already developed for microwave powered helicopters can be used in waveguides or with coaxial power dividers.

WEPD091 **The Kicker Systems for the PS Multi-turn Extraction** – *L. Sermeus, M.J. Barnes, T. Fowler (CERN)*

A five-turn continuous extraction is currently used to transfer the proton beam from the CERN PS to the SPS. This extraction uses an electrostatic septum to cut the filament beam into five slices, causing losses of about 15 %. These losses would be an even greater drawback when the beam intensity is further increased for the CERN Neutrinos to Gran Sasso facility. To overcome this, a Multi-Turn Extraction (MTE) has been implemented, in which the beam is separated, prior to extraction, into a central beam core and four islands. Each beamlet is extracted using a set of kickers and a magnetic septum. For the kickers two new pulse generators have been built, each containing a lumped element Pulse Forming Network (PFN) of 12.5 Ohms, 80 kV and 10.5 μs. For cost reasons existing 15 Ω transmission line kicker magnets are reused. The PFN characteristic impedance deliberately mismatches that of the magnets to allow a higher maximum kick. The PFN design has been optimised such that undesirable side-effects of the impedance mismatch on kick rise-time and flat-top remain within acceptable limits. The kicker systems put in place for the current first phase of MTE are presented.

WEPD092 **The Beam Dilution Kickers of the LHC Beam Dump System** – *L. Ducimetière, E. Carlier, F. Castronuovo (CERN)*

The LHC beam dump system protects personnel and equipment by reliably and safely extracting and absorbing the circulating beams which can contain an energy of up to 540 MJ per ring. To avoid damaging the absorber material by the high energy density of the beam the incident bunches are swept during the one-turn dumping process across the front of the absorber block, following an "e"-shape figure. This is achieved by a series of 4 horizontal and 6 vertical kicker magnets per ring, excited by sinusoidal pulses with a period of about 75 microseconds. Each magnet is powered by a dedicated pulse generator through coaxial cables. The generator charging voltage is proportional to the beam momentum, from injection to the top energy of 7 TeV/c; the maximum pulse current is 27 kA. All the discharge switches are triggered simultaneously; the generators of the horizontal magnets include additional elements to obtain an automatic phase shift of 90 degrees. Each kicker magnet consists of a window frame housing the cores, wound from Si-Fe tape, and the high voltage insulated coil. Results of measurements on the series systems are presented and measures taken to ensure a high reliability discussed.

WEPD093 **Upgrade of the Super Proton Synchrotron Vertical Beam Dump System** – *V. Senaj, L. Ducimetière, E. Vossenberg (CERN)*

The vertical beam dump system of the CERN Super Proton Synchrotron (SPS) uses two matched magnets with an impedance of 2 Ω and combined kick strength of 1.152 Tm at 60 kV supply voltage. For historical reasons the two magnets are powered from three 3 Ω pulse forming networks (PFN) through three thyratron-ignitron switches. Recently flashovers were observed at the entry of one of the magnets, which lead, because of the electrical coupling between the kickers, to a simultaneous breakdown of the pulse in both magnets. To improve the reliability an upgrade of the system was started. In a first step the radii of surfaces at the entry of the weak magnet were increased, and the PFN voltage was reduced by 4 %; the kick strength could be preserved by reducing the magnet termination resistance by 10 %. The PFNs were protected against negative voltage reflections and their last cells were optimised. In a second step the two magnets will be electrically separated and powered individually by new 2 Ω PFNs with semiconductor switches.

WEPD094 **Performance of a PFN Kicker Power Supply for TPS Project** – *K.L. Tsai, C.-S. Fann, K.T. Hsu, S.Y. Hsu, K.-K. Lin, K.-B. Liu (NSRRC) Y.-C. Liu (National Tsing-Hua University)*

Test unit of a pulse-forming-network (PFN) kicker power supply is designed and fabricated for TPS (Taiwan Photon Source) beam injection and extraction of the booster ring. In order to fulfill the requirements, the performance of the designed unit is bench tested and the results are examined for evaluation purpose. The pulse-to-pulse stability and the flattop specifications are specified according to the beam injection/extraction needs. Effort has been made to enhance the rise/fall time of the delivered pulse current. The engineering evaluation and its application for beam instrumentation are briefly discussed.

WEPD095 **The Development of a Fast Beam Chopper for Next Generation High Power Proton Drivers** – *M.A. Clarke-Gayther (STFC/RAL/ISIS)*

A description is given of the development of slow-wave chopper structures for the 3.0 MeV, 60 mA, H^- MEBT on the RAL Front-End Test Stand (FETS). The development status of a prototype high voltage pulse generator will be presented.

WEPD096 **Solid-State Tetrode Test Stand** – *M.K. Kempkes, M.P.J. Gaudreau, R.A. Phillips, D. Robinson, K. Schrock (Diversified Technologies, Inc.)*

Diversified Technologies, Inc. (DTI) recently delivered a 500 kW CW, 33 kV solid-state test stand for the evaluation and conditioning of high power tetrodes employed in accelerator and radar systems. The test system consists of DTI-manufactured and commercially-sourced power supplies, a DTI high voltage opening switch, and DTI controls. Combining an opening switch and fast responding power supplies allows the hi-potting and high power burn-in to be consolidated in one test stand. Faulty tubes, which would not operate in a crowbar-equipped modulator, and could not be processed to health on a high potter, can be revived to health with this fast opening switch circuitry. By limiting peak fault current and follow-on-current, the total energy in an arc event is greatly minimized, reducing damage inside the tube. If greater energy (or action) is required for initial tube processing, additional load capacitance downstream of the switch can be added into the circuit for 'spot knocking' purposes. This test stand is capable of operation in pulsed mode as well as CW. This paper will address the design and construction of the test stand and discuss results since its installation.

WEPD097 **A Klystron Power System for the ISIS Front End Test Stand** – *M.K. Kempkes, R. Ciprian, M.P.J. Gaudreau, T.H. Hawkey, K. Schrock (Diversified Technologies, Inc.)*

Diversified Technologies, Inc.(DTI) has delivered a fully solid state Klystron Power Supply for the ISIS Front End Test Stand to Rutherford Appleton Laboratory in the UK. The new pulsed power supply drives a Toshiba E3740A klystron in preparation for construction of a system to demonstrate high quality intense chopped beams. DTI's system represents a significant advance in solid-state high power accelerator technology based upon a hard switch developed for the US Department of Energy (DOE) to meet similar requirements for the International Linear

Collider(ILC). The system includes two 220 kW switching power supplies, a 110 kV solid state hard switch pulse modulator, mod anode and filament power supplies, klystron fault protection, and interfaces to the ISIS controls. This paper will address the design and construction of the KPS system, as well as test results from the installation at RAL in May 2009.

WEPD098 **Fast Kickers for the Next Generation Light Source** – *G.C. Pappas (LBNL)*

The Next Generation Light Source (NGLS) at Lawrence Berkeley Laboratory is a 2.4 GeV linear accelerator with up to ten FELs. Each of the FELs require a fast kicker, with the exception of the final one which can use a normal bend magnet. The requirements for the kickers are to deflect the linac beam by an angle of 3 mrad with a magnetic length of 2 m, and an aperture size of 17 by 17 mm. A strip line magnet with an impedance of 50 Ohms being feed from the opposite direction as the beam has been selected for prototyping. The modulator requirements to drive such a magnet are ±15 kV and ±300 A, with rise and fall times of 5 ns and a flat top of 10 ns. The pulse to pulse stability must be better than 0.01% of the peak value. The design of the modulator is an inductive adder with 20 cells, each driven by 12 power MOSFETs. This paper describes details of the design as well as present preliminary test data.

WEPD099 **Secondary Electron Trajectories in High-gradient Vacuum Insulators with Fast High-voltage Pulses** – *Y.-J. Chen, D.T. Blackfield, G.J. Caporaso, S.D. Nelson, B. R. Poole (LLNL)*

Vacuum insulators composed of alternating layers of metal and dielectric, known as high-gradient insulators (HGIs), have been shown to withstand higher electric fields than conventional insulators. Generally, vacuum insulator failure is due to surface flashover, initiated by electrons emitted from the triple junction. These electrons strike the insulator surface and produce secondary electrons, which also strike the insulator surface to create more secondary electrons and lead to avalanche. Magnetic field from the external sources, the high-current electron beam, the conduction current in the transmission line or the displacement current in the insulator can deflect primary and secondary electrons' trajectories either toward to or away from the insulator surface, and hence affect the performance of the high-voltage vacuum insulator. The displacement current effects are particularly interesting for short pulse applications. This paper presents the displacement current effects with various short applied voltage pulses on performance of high-gradient insulators. Optimal HGI configurations will also be discussed.

WEPD100 **Compact, Intelligent, Digitally Controlled IGBT Gate Drivers for a PEBB-based ILC Marx Modulator** – *M.N. Nguyen, C. Burkhart, K.J.P. Macken, J.J. Olsen (SLAC)*

SLAC National Accelerator Laboratory has built and is currently operating a first prototype (P1) Marx klystron modulator to meet ILC specifications*. Under development is a second prototype (P2)**, which will provide improved modulator performance, serviceability and manufacturability compared to the P1. It consists of 32 cells that each operates at 4 kV with internal droop compensation to regulate the output voltage. Due to the uniqueness of this application, high voltage gate drivers needed to be developed for the main 6.5 kV and PWM correction 1.7 kV IGBTs. The gate driver provides vital functions such as protection of the IGBT from over-voltage and over-current, detection of gate-emitter open and short circuit conditions, and monitoring of IGBT degradation (based on collector-emitter saturation voltage). Gate drive control, diagnostic processing capabilities, and communication are digitally implemented using an FPGA. This paper details the design of the gate drive circuitry, component selection, and construction layout. In addition, experimental results are included to illustrate the effectiveness of the protection circuit.

WEPD102 **AGS Tune Jump Power Supply Design and Test** – *J.-L. Mi, W. Fu, J.W. Glenn, H. Huang, C.J. Liaw, W. Meng, P.J. Rosas, J. Sandberg, Y. Tan, W. Zhang (BNL)*

In the presence of two partial Siberian snakes in the AGS, a new type depolarizing resonance called horizontal intrinsic resonance will cause sizable polarization loss. A horizontal tune jump system is proposed to overcome these resonances, which require to jump the horizontal tune 80 times, 40 jumping up and 40 jumping down. The jump time is about 100 microsecond. Two AGS Tune Jump Magnets have been assembled and installed in AGS ring. The magnet peak jump current is about 1400A. Current pulse flat top time is around 4ms. According to this tune jump current specification requirement, two pulse power supplies are designed and assembled. Each pulse power supply mainly consists of two portions. One is a high voltage capacitor bank and discharging circuit. And another is high RMS current and low voltage capacitor bank. This tune jump pulse power supply employees all semiconductor parts as the main switches. During Dump load and magnet testing, the test result showed that the power supply could meet the specification. This article will describe some detail of power supply simulation, design and testing. Some test waveform and pictures will appear.

26-May-10 16:00 – 18:00	Poster	Poster Hall E

WEPE — Poster Session

WEPE001 **Optics Studies for the Interaction Region of the International Linear Collider** – *R. Versteegen, O. Delferriere, O. Napoly, J. Payet, D. Uriot (CEA)*

The International Linear Collider reference design is based on a collision scheme with a 14 mrad crossing angle. Consequently, the detector solenoid and the machine axis do not coincide. It provokes a position offset of the beam at the Interaction Point in addition to a beam size growth. These effects are modified by the insertion of the anti-DID (Detector Integrated Dipole) aiming at reducing background in the detector. Furthermore a crab cavity is necessary to restore a 'head on' like collision, leading to higher luminosity. This introduces new beam distortions. In this paper, optics studies and simulations of beam transport in the Interaction Region taking these elements into account are presented. Correction schemes of the beam offset and beam size growth are exposed and their associated tolerances are evaluated.

WEPE003 **Design of an 18 MW Beam Dump for 500 GeV Electron/ Positron Beams at an ILC** – *P. Satyamurthy, K. Kulkarni, P. Rai, V. Tiwari (BARC) J.W. Amann, R. Arnold, A. Seryi, D.R. Walz (SLAC)*

Significant progress has been made in the design of an 18MW Beam Dump for 500 GeV electron/positron beams at an ILC. The beam dump design is based on circulating water with a vortex-like flow pattern to dissipate and remove the energy deposited by the beam. Multi-dimensional technology issues have been addressed to design the beam dump system. Detailed thermal-hydraulic analysis was carried out in all the critical regions of the beam dump which include, 1) location of highest volumetric power deposition by the beam, 2) location of highest linear power deposition, 3) entrance window region, 4) vessel walls etc. Based on this analysis, the sizing of the beam dump and its components, water flow rate and inlet jet velocity, optimum location of the beam path in the beam dump, beam sweep radius etc have been estimated. In addition, preliminary mechanical design of the beam dump, cooling circuit details, sizing of the hydrogen/ oxygen recombiner system, ion exchange and 7Be removal, prompt and residual radioactivity studies etc have been carried out. Details of this work will be presented.

WEPE004 **High Gradient Behaviors of Large Grain ICHIRO Single Cell Cavity by Chemical Polishing** – *F. Furuta, T. Konomi, K. Saito (KEK)*

We have started high gradient R&D with the combination of ICHIRO shape, sliced large grain niobium, and chemical polishing (CP). We fabricated one large grain ICHIRO single cell cavity that had end cell shape of ICHIRO 9-cell but no end group. We processed this cavity surface by centrifugal barrel polishing (CBP) and CP. This cavity successfully achieved the high gradient of 42MV/m at the first vertical test. We made series test by repeating CP on this cavity. The results of series test will be reported.

WEPE005 **High Field Q-slope Problem in End Group Cavities** – *F. Furuta, T. Konomi, K. Saito (KEK)*

In our high gradient R&D of ICHIRO cavities at KEK, we have found some problems related to HOM coupler and high power RF input coupler port on beam tube: end group. One is the difficulties of rinsing in complex structures like HOM coupler. The other is Q-slope at high filed more than 40MV/m. The cavities without end group did not show such a high field Q-slope. At first step, we tested much stronger and aggressive rinsing method; wiping, brushing, and mega-sonic rinsing, against end group. The details and results of these rinsing effects will be reported.

WEPE006 **Vacuum Evacuation Effect on ICHIRO 9-cell Cavities during Vertical Test** – *F. Furuta, T. Konomi, K. Saito (KEK)*

We have continued high gradient R&D of ICHIRO 9-cell cavities at KEK. The maximum gradient of ICHIRO 9-cell cavity #5 that has no end groups on beam tube was still limited around 36MV/m so far. The 9-cell performances were sometimes limited by triggered field emission (FE) by multipactings. We suspected the residual gas in the cavity might be one of the sources of triggered FE. The cavity was closed during vertical test in our system. Other labs evacuated cavity during vertical test. In order to improve the vacuum of cavity during vertical test, we made evacuation system in our cavity test stand. The comparison of results for vertical test with and without evacuation will be reported.

WEPE007 **Simulation Study of Scale Error Effect of BPM in ILC Main Linac Corrections** – *K. Kubo (KEK)*

For preserving low emittance beam in the ILC (International Linear Collider) main linacs, Dispersion Matching Steering (DMS) is planed to be used as a main correction method. The linacs are following the earth's curvature and the designed vertical dispersion in the linacs should not be zero. For this reason, the orbit difference due to beam energy difference will have to be measured accurately and tolerance of scale error of beam position monitors (BPM) can be tight. Here, the tolerance of the scale error are estimated by tracking simulations. Choice of optics design for relaxing the tolerance is also discussed.

WEPE008 **Construction of the S1-Global Cryomodules for ILC** – *N. Ohuchi, H. Hayano, N. Higashi, E. Kako, Y. Kondou, H. Nakai, S. Noguchi, M. Satoh, T. Shidara, T. Shishido, A. Terashima, K. Tsuchiya, K. Watanabe, A. Yamamoto, Y. Yamamoto (KEK) T.T. Arkan, S. Barbanotti, H. Carter, M.S. Champion, R.D. Kephart, J.S. Kerby, D.V. Mitchell, Y. Orlov, T.J. Peterson, M.C. Ross (Fermilab) A. Bosotti, C. Pagani, P. Pierini (INFN/LASA) D. Kostin, L. Lilje, A. Matheisen, W.-D. Moeller, H. Weise (DESY)*

In an attempt at demonstrating an average field gradient of 31.5 MV/m as per the design accelerating gradient for ILC, a program called S1-Global is in progress as an international research collaboration among KEK, INFN, FNAL, DESY and SLAC. The S1-Global cryomodule will contain eight superconducting cavities from FNAL, DESY and KEK. The cryomodule will be constructed by joining two half-size cryomodules, each 6 m in length. The module containing four cavities from FNAL and DESY has been constructed by INFN. The module for four KEK cavities is being modified at present. The assembly of the cryomodules is scheduled from January 2010, and the operation of the system is scheduled from June 2010 at the KEK-STF. In this paper, the construction of the S1-Global cryomodule will be presented.

WEPE009 **Application of MO Sealing for SRF Cavities** – *K. Saito, F. Furuta, T. Konomi (KEK)*

Dr. Matsumoto in KEK and his colleague have developed the MO flange for vacuum sealing of normal conducting high peak power RF wave-guide. This is impedance free sealing. We have applied this sealing to SRF cavity technology instead of indium sealing. We used pure aluminum gasket for the sealing material. We had a difficulty on the titanium flange but succeeded to establish leak tightness in super-fluid Helium by stainless flange. In this paper, we will report the R&D results.

WEPE010 **Improvements of Cleaning Methods for High Q-slope Problem in Full End Single Cell Cavity** – *K. Saito, F. Furuta, T. Konomi (KEK)*

We are developing LL high gradient SRF cavity for ILC. Recently we have observed a Q-slope problem at higher gradient over 35-40MV/m on the full end single cell cavities, which have a HOM coupler and an input coupler on a beam tube. This problem might be due to poor rinsing in such a complicate structure. We have studied to strengthen cleaning by improvement of the nozzle shape used high pressure water rinsing, inside ultrasonic cleaning, steam cleaning, and so on. In this paper we will report these results.

WEPE011 **Large Grain 9-cell Cavities R&D at KEK** – *K. Saito, F. Furuta, T. Konomi (KEK)*

We are developing large grain/single crystal niobium material for ILC collaborating with Tokyo Denkai. These materials are very much promising to obtain high SRF cavity performance with cost-effective production. We have fabricated two 9-cell cavities from these large grain niobium materials and made cold test to evaluate the SRF performance. In this paper, we will report cavity fabrications and preparations and cold test results.

WEPE012 **Summary of Vertical Tests for S1-Global Project in KEK-STF** – *Y. Yamamoto, H. Hayano, E. Kako, S. Noguchi, M. Sato, T. Shishido, K. Umemori, K. Watanabe (KEK)*

Vertical tests of five 1.3GHz 9-cell cavities (MHI#5-#9) have been done totally 17 times from 2008 to 2009 for S1-Global project in KEK-STF, which is planned in 2010. MHI#7 cavity achieved 33.6MV/m, which was the best result, and the others below 30MV/m. After the exchange for new EP acid on May/2009, many brown stains (niobium oxide) were observed on the interior surface of the cavity, and onset gradient of radiation level measured at the top flange of cryostat was much lower. After several vertical tests, the effect by this phenomenon was gradually relaxed. After four cavities reached above 25MV/m, the gradient suddenly dropped due to the unknown cause at the next vertical test. Two of four cavities were recovered above 25MV/m at the final vertical test again. However, any cavity in KEK-STF did not reach ILC specification (Eacc=35MV/m, Q0=0.8x10^{10}) yet. This means that more improvement for cavity fabrication and surface treatment is necessary. In this presentation, the summary of the vertical tests for S1-Global project in KEK-STF will be reported.

WEPE013 **Summary of Results and Development of Online Monitor for T-mapping/X-ray-mapping in KEK-STF** – *Y. Yamamoto, H. Hayano, E. Kako, S. Noguchi, M. Sato, T. Shishido, K. Umemori, K. Watanabe (KEK)*

Vertical test for 1.3GHz 9-cell cavity has been routinely carried out over one year since 2008 in KEK-STF. Temperature mapping (T-mapping) system using 352 carbon resistors was introduced to identify the heating location at thermal quenching of the cavity. T-mapping system in STF identified perfectly the heating location in every vertical test for S1-Global project. As X-ray-mapping system, 142 PIN diodes were used, and the x-ray emission site was detected under heavy field emission. During the vertical test, it is convenient to display the result of T-mapping and X-ray-mapping by online monitor system. For this purpose, the new online monitor system was developed by using EPICS (Experimental Physics and Industrial Control System) and Java script, and introduced in recent several vertical tests. As a data acquisition system, nine data loggers (MW100, YOKOGAWA) are used, and signals from totally 540 channels are stored every 0.1 sec. The online display for T-mapping and X-ray-mapping is updated automatically every 5 seconds. In this report, the summary of T-mapping/X-ray-mapping result and the online monitor system will be described in detail.

WEPE014 **Design and Model Cavity Test of the Demountable Damped Cavity** – *T. Konomi (Sokendai) F. Furuta, K. Saito (KEK)*

We have designed Demountable Damped Cavity (DDC) for ILC main linac. DDC has two design concepts. One is the coaxial waveguide for HOM damping, which can strongly couple HOM's. Accelerating mode is reflected by a choke filter. The axial symmetry can reduce the beam kick effect. The other concept is demountable structure which can make easy cleaning of end group in order to suppress the Q-slope problem at a high field. In this paper we will report the RF design and measurement results in model cavity.

WEPE015 **Status of the Superconducting Cavity Development for ILC at MHI** – *K. Sennyu, H. Hara, H. Hitomi, K. Kanaoka, M. Matsuoka, T. Yanagisawa (MHI)*

MHI has supplied superconducting cavity for the ILC R&D project to KEK in Japan for the last few years. We are improving the technology to design and fabricate the superconducting cavities. We can present some example of our work that have improved the productivity of the superconducting cavities.

WEPE016 **A 200 keV Polarized Electron Gun System for International Linear Collider** – *T. Nakanishi, M. Kuwahara, S. Okumi, N. Yamamoto (Nagoya University) F. Furuta, H. Matsumoto, M. Yamamoto, M. Yoshioka (KEK) T. Konomi (Sokendai) M. Kuriki (HU/AdSM)*

A newly designed 200-keV polarized electron gun with a GaAs-GaAsP strained super-lattice photocathode was designed and constructed. A high field gradient on the photocathode of 3.0 MV/m was obtained while the dark current between the high voltage electrodes was suppressed to below 1 nA at 200-kV bias voltage using a new type of electrode pair consisting of a Mo cathode and Ti anode. An ultra high vacuum of 2.0x10^{-9} Pa was achieved around a negative electron affinity photocathode using various vacuum technologies. It was demonstrated that the 200-keV gun system almost fulfills the International Linear Collider requirements for bunch charge, spin polarization and continuous beam operation lifetime. A bunch charge of more than 5.7 nC in a 1.2-ns-length bunch could be extracted from the GaAs-GaAsP strained super-lattice photocathode without charge-limit effects and with an electron spin polarization of more than 85%. A dark lifetime of more than several hundred hours was observed and a continuous operational lifetime of 120 hours was achieved for 50-uA CW-beam operation.

WEPE017 **Beam Test Plan of Permanent Magnet Quadrupole LENS at ATF2** – *Y. Iwashita, H. Fujisawa, M. Ichikawa, H. Tongu (Kyoto ICR) M. Masuzawa, T. Tauchi (KEK)*

A prototype of a permanent magnet quadrupole lens for ILC final focus doublet is fabricated. In order to demonstrate the feasibility, it will be tested in a real beam line. Such practical experiences include its shipping, storage, handling, installation, alignment technique, and so on. Because permanent magnets cannot be switched off in contradistinction to electromagnets, they should be evacuated from beam lines when no interference is desired and the process should be quick with enough reproducibility. The magnetic center and strength stability including reproducibility are also important issues during the beam test. In order to reduce interferences with current ongoing testing items at ATF2, the magnet will be installed at a further upstream position of the ATF2 beam line. The installation and test plan will be described.

WEPE018 **ILC Siting in Dubna Region (Russia) and ILC Related Activity at JINR** – *G. Shirkov, Ju. Boudagov, Yu.N. Denisov, A. Dudarev, A.N. Sissakian, G.V. Trubnikov (JINR)*

The investigations on ILC siting in the Dubna region and ILC technical activity at JINR are presented. International intergovernmental status of JINR, stable geological and plain relief conditions, comfortable location and well developed infrastructure create a set of advantages of the JINR site in the neighborhood of Dubna. The shallow layout of accelerator tunnel makes it possible to use a communication gallery at the surface instead of second one. This is an effective way of significant cost reduction of all conventional facilities and explicit labor of the project. The results of the preliminary geological engineering surveys along the supposed route of the ILC in Dubna area of Moscow region are presented.

WEPE019 **The CLIC Post-Collision Line** – *E. Gschwendtner, A. Apyan, K. Elsener, J.A. Uythoven (CERN) R. Appleby, M.D. Salt (UMAN) A. Ferrari, V.G. Ziemann (Uppsala University)*

The 1.5TeV CLIC beams, with a total power of 14MW per beam, are disrupted at the interaction point due to the very strong beam-beam effect. As a result, some 3.5MW reach the main dump in form of beamstrahlung photons. About 0.5MW of e^+e^- pairs with a very broad energy spectrum need to be disposed along the post-collision line. The conceptual design of this beam line will be presented. Emphasis will be on the optimization studies of the CLIC post-collision line design with respect to the energy deposition in windows, dumps and scrapers, on the design of the luminosity monitoring for a fast feedback to the beam steering and on the background conditions for the luminosity monitoring equipment.

WEPE020 **Background in the Interaction Point from the Post-Collision Line** – *E. Gschwendtner, K. Elsener (CERN) R. Appleby, M.D. Salt (UMAN) A. Apyan (Fermilab) A. Ferrari (Uppsala University)*

The 1.5TeV CLIC beams, with a total power of 14MW per beam, are disrupted at the interaction point due to the very strong beam- beam effect. The resulting spent beam products are transported to suitable dumps by the post-IP beam line, which generates beam losses and causes the production of secondary cascades towards the interaction region. In this paper the electromagnetic background at the IP are presented, which were calculated using biased Monte Carlo techniques. Also, a first estimate is made of neutron back-shine from the main beam dump.

WEPE021 **Assessing Risk in Costing High-energy Accelerators: from Existing Projects to the Future Linear Collider** – *P. Lebrun (CERN) P.H. Garbincius (Fermilab)*

High-energy accelerators are large projects funded by public money, developed over the years and constructed via major industrial contracts both in advanced technology and in more conventional domains such as civil engineering and infrastructure, for which they often constitute one-off markets. Assessing their cost, as well as the risk and uncertainty associated with this assessment is therefore an essential part of project preparation and a justified requirement by the funding agencies. Stemming from the experience with large circular colliders at CERN, LEP and LHC, as well as with the Main Injector, the Tevatron Collider Experiments and Accelerator Upgrades, and the NOvA Experiment at Fermilab, we discuss sources of cost variance and derive cost risk assessment methods applicable to the future linear collider, through its two technical approaches for ILC and CLIC. We also address disparities in cost risk assessment imposed by regional differences in regulations, procedures and practices.

WEPE022 **CLIC Energy Scans** – *D. Schulte, R. Corsini, J.-P. Delahaye, S. Doebert, A. Grudiev, J.B. Jeanneret, E. Jensen, P. Lebrun, Y. Papaphilippou, L. Rinolfi, G. Rumolo, H. Schmickler, F. Stulle, I. Syratchev, R. Tomas, W. Wuensch (CERN) E. Adli (University of Oslo)*

The physics experiments at CLIC will require that the machine scans lower than nominal centre-of-mass energy. We present different options to achieve this and discuss the implications for luminosity and the machine design.

WEPE023 **Impact of Dynamic Magnetic Fields on the CLIC Main Beam** – *J. Snuverink, J.B. Jeanneret, D. Schulte, F. Stulle (CERN) C. Jach (Fermilab)*

The Compact Linear Collider (CLIC) accelerator has strong precision requirements on the position of the beam. The beam position will be sensitive to external dynamic magnetic fields (stray fields) in the nano-Tesla regime. The impact of these fields on the CLIC main beam has been studied by performing simulations on the lattices and tolerances have been determined. Several mitigation techniques will be discussed.

WEPE024 **Vacuum Specifications for the CLIC Main Linac** – *G. Rumolo, J.B. Jeanneret, D. Schulte (CERN)*

The maximum tolerable pressure value in the chamber of the CLIC electron Main Linac is determined by the threshold above which the fast ion instability sets in over a bunch train. Instability calculations must take into account that, since the accelerated beam becomes transversely very small, its macroscopic electric field can reach values above the field ionization threshold. In this paper we first discuss threshold values of the electric field for field ionization and the extent of the transverse region that gets fully ionized along the ML. Then, we show the results of the instability simulations from the FASTION code using the new model, and consequently review the pressure requirement in the ML.

WEPE025 **Beam-beam Background in CLIC in Presence of Imperfections** – *B. Dalena, D. Schulte (CERN)*

Beam-Beam background is one of the main issues of the CLIC MDI at 3 TeV CM. The background level have a significant impact on the interaction region design. This paper presents a study of the background expected rates versus luminosity according to different beam parameters and considering different machine conditions, using an integrated simulation of the Main LINAC and BDS sub-systems.

WEPE026 **A New High-power RF Device to Vary the Output Power of CLIC Power Extraction and Transfer Structures (PETS)** – *I. Syratchev, A. Cappelletti (CERN)*

One crucial development for CLIC is an adjustable high-power rf device which controls the output power level of individual Power Extraction and Transfer Structures (PETS) even while fed with a constant drive beam current. The CLIC two-beam rf system is designed to have a low, approximately 10^{-7}, breakdown rate during normal operation and breakdowns will occur in both accelerating structures and the PETS themselves. In order to recover from the breakdowns and reestablish stable operation, it is necessary to have the capability to switch off a single PETS/accelerating structure unit and then gradually ramp generated power up again. The baseline strategy and implementation of such a variable high-power mechanism is described.

WEPE027 **Progress towards the CLIC Feasibility Demonstration in CTF3** – *P.K. Skowronski, S. Bettoni, R. Corsini, S. Doebert, F. Tecker (CERN)*

The objective of the CLIC Test Facility CTF3 is to demonstrate the key feasibility issues of the CLIC two-beam technology: the efficient generation of a very high current drive beam and its stable deceleration in 12 GHz resonant structures, to produce high-power RF pulses and accelerate the main beam with an accelerating gradient of 100 MV/m. The construction and commissioning of CTF3 has taken place in stages from 2003. Many milestones had already been reached, including the first demonstration at the end of 2009 of a factor 2 x 4 re-combination of the initial drive beam pulse, thus reaching a beam current of 25 A. In this paper we summarise the commissioning highlights and the issues already validated at the earlier stages. We then show and discuss the latest results obtained, in view of the completion of the CLIC feasibility demonstration due for the end of 2010.

WEPE028 **CLIC BDS Tuning, Alignment and Feedbacks Integrated Simulations** – *R. Tomas, B. Dalena, E. Marin, J. Pfingstner, D. Schulte, J. Snuverink (CERN) J.K. Jones (Cockcroft Institute) A. Latina (Fermilab) J. Resta-López (JAI) G.R. White (SLAC)*

The CLIC BDS tuning, alignment and feedbacks studies have been typically performed independently and only over particular sections of the BDS. An effort is being put to integrate all these procedures to realistically evaluate the luminosity performance.

WEPE029 **Impact of the Experiment Solenoid on the CLIC Luminosity** – *B. Dalena, D. Schulte, R. Tomas (CERN)*

The main detector solenoid and associated magnets can have an important impact on the CLIC luminosity. These effects are discussed for different solenoid designs. In particular, the luminosity loss due to incoherent synchrotron radiation in the experiment solenoid and QD0 overlap is evaluated. The impact of the AntiDiD (Anti Detector integrated Dipole) on luminosity and compensated techniques on beam optic distortion are also discussed.

WEPE030 **The CLIC Beam Delivery System towards the Conceptual Design Report** – *R. Tomas, B. Dalena, E. Marin, D. Schulte, G. Zamudio (CERN) D. Angal-Kalinin, J.-L. Fernandez-Hernando, F. Jackson (Cockcroft Institute) J. Resta-López (JAI) A. Seryi (SLAC)*

The CLIC Conceptual Design Report must be ready by 2010. This paper aims at addressing all the critical points of the CLIC BDS to be later implemented in the CDR. This includes risk evaluation and possible solutions to a number of selected points. The smooth and practical transition between the 500 GeV CLIC and the design energy of 3 TeV is also studied.

WEPE031 **BDS Dogleg Design and Integration for the International Linear Collider** – *J.K. Jones, D. Angal-Kalinin (STFC/DL/ASTeC)*

It is proposed to investigate the option of moving the positron source to the end of the main linac as a part of the central integration in the International Linear Collider project. The positron source incorporates an undulator at the end of the main linac and the photons generated in the undulator are transported to the target, located at a distance of around 400m. The dogleg design has been optimised to provide the required transverse off-set at the location of the target and to give minimum emittance growth at 500 GeV. The design of the dogleg and the tolerances on beam tuning as a result of locating this dogleg in the beginning of the beam delivery system are presented.

WEPE032 **Recent Progress on Damped and Detuned Wakefield Suppression for CLIC with Minimised Pulsed Surface Temperature Heating** – *V.F. Khan, A. D'Elia, R.M. Jones (UMAN) A. Grudiev, W. Wuensch, R. Zennaro (CERN)*

Our earlier design* for an accelerating structure to suppress the wakefields in the CLIC main accelerating cavities has been modified. This structure combines strong detuning of the cell frequencies with waveguide-like damping by providing the structure with four attached manifolds which loosely couple a portion of the wakefields from each cell. The amended geometry reduces the surface pulse temperature heating by approximately 20%. We report on the overall parameters of the fundamental mode, together with details on damping higher order dipole modes. In order to adequately suppress the wakefield we interleave the frequencies of eight successive structures.

WEPE033 **Considerations of a Dielectric-based Two-beam-accelerator Linear Collider** – *W. Gai, M.E. Conde, J.G. Power (ANL) C.-J. Jing (Euclid TechLabs, LLC)*

In this paper, we present a linear collider concept based on drive beam generation from an RF photoinjector, and employing dielectric structures for power extraction and acceleration. The collider is based on a modular design with each module providing 100 GeV net acceleration. A high current drive beam is produced using a low frequency RF gun (~ 1GHz), and subsequently accelerated to ~1 GeV using conventional standing wave cavities. High frequency (20 GHz) RF power, extracted from the drive beam using a low impedance dielectric structure, is used to power the main linacs, which are based on high impedance high gradient dielectric loaded accelerating structures. We envision this scheme will produce high gradients (300 MeV/m), leading to a very compact design. The modularity of the design will allow a staged construction that will enable extension to multi-TeV energies.

WEPE034 **Final Results on RF Kick and Wake Caused by the RF Couplers** – *A. Lunin, A. Latina, N. Solyak, V.P. Yakovlev (Fermilab)*

In the paper the results are presented for calculation of the transverse wake and RF kick from the power and HOM couplers of the ILC acceleration structure. The RF kick was calculated by HFSS code while the wake was calculated by GdfidL. The calculation precision and convergence for both cases is discussed and compared to the results obtained independently by other group. The beam emittance dilution caused by the couplers is calculated for the main linac and bunch compressor of ILC.

WEPE035 **Development of High Average Power Lasers for the Photon Collider** – *J. Gronberg, B. Stuart (LLNL) A. Seryi (SLAC)*

The realization of a photon collider option at a future TeV scale electron linear collider requires the generation of high average power picosecond laser pulses. Recirculating cavities have been proposed to reduce the amount of laser power that needs to be generated, however, these cavities impose stringent limits on the wavefront quality and stability of the laser architecture. We report on a design study of a high average power laser amplifier architecture which can produce the required laser time structure and stability to drive these recirculating cavities.

WEPE036 **ATF2 Final Focus Optics Tuning Knobs** – *M.-H. Wang, A. Seryi, G.R. White, M. Woodley (SLAC)*

ATF2 is an international project to build and operate a test facility for the final focus system for use in future linear collider. It aims to focus the low emittance beam from the ATF damping ring to a vertical size of about 37 nm at Interaction Point (IP). The primary project goal is to establish the hardware and beam handling technologies to observe and to preserve the designed beam emittance at IP. Compensation of optics errors at the IP is essential for maintaining the emittance. Several tuning knobs have been designed to provide orthogonal compensation of linear and the second order optics aberrations at IP. Quadrupole and sextupole strength and sextupole mover position in the final focusing section are used to develop the knobs. These knobs are integrated into Flight Simulator, an environment for the shared development and implementation of beam dynamics code*. Tuning effects of these knobs are verified using tracking simulations from Flight Simulator.

WEPE037 **Optimization of Dynamic Aperture of PEP-X Storage Ring** – *M.-H. Wang, Y. Cai, Y. Nosochkov (SLAC)*

SLAC is developing a long-range plan to transfer the evolving scientific programs at SSRL from the SPEAR3 light source to a much higher performing photon source that would be housed in the 2.2-km PEP-II tunnel*,**. The proposed PEP-X storage ring is one of the possibilities. The goal of the PEP-X design is to develop an optimal light source design with horizontal emittance less than 100 pm at 4.5 GeV and vertical emittance of 8 pm corresponding to the diffraction limit of 1-Å X-ray. The low emittance design requires a lattice with strong focusing leading to high natural chromaticity and therefore to strong sextupoles. The latter cause reduction of dynamic aperture. The horizontal dynamic aperture required at PEP-X injection point is about 10 mm. In order to achieve the desired dynamic aperture, transverse non-linearities of PEP-X are studied. The program LEGO*** is used for particle tracking simulations. The technique of frequency map is used to analyze the nonlinear behavior. The effects of the non-linearities are tried to minimize. The details and results of dynamic aperture optimization are discussed in this paper.

WEPE038 **Beam-Based Alignment, Orbit Steering and Feedback Design and Operational Experience for ATF2** – *G.R. White (SLAC) Y. Renier (LAL)*

The ATF2 research accelerator project at KEK is testing the novel final focus optics design required by next-generation linear lepton colliders such as ILC and CLIC. ATF2 consists of a 1.3 GeV linac, damping ring providing low-emittance electron beams (<12pm in the vertical plane), extraction line and final focus optics. The primary and secondary goals of the ATF2 are to demonstrate reliable delivery of small (~37nm vertical) beam spot sizes at the IP waist and to maintain the vertical placement of the beam at the IP at the few nm level. These goals require accurate alignment of the beam through the magnetic components of the extraction and final focus beamlines, steering algorithms to achieve the emittance preserving orbits, and feedbacks to maintain the orbit in the presence of ground motion and other vibration sources. We present here the design of these systems and report on their application to the ATF2 accelerator through the 'flight-simulator' simulation and controls interface. ATF2 is currently being commissioned, we present operational experience gained with the alignment, steering and feedback systems discussed.

WEPE039 **A Bunching System for the CLIC Polarized Electron Source** – *F. Zhou, A. Brachmann, J. Sheppard (SLAC)*

Two approaches can be used to provide 312 15-ps-long 2-GHz microbunches for the CLIC source: one is to directly develop a 2-GHz laser pulse train, and the other to develop a 156-ns-long laser pulse and use an RF bunching system to generate 2-GHz microbunches. The former scheme has advantage of easing the RF bunching system but has some disadvantages, for example, the technical difficulty of a 2-GHz mode-locked and amplified laser system providing sufficient peak power, and unproven surface charge behaviour for a 100-ps bunch with 1 nC charge. In the latter scheme, laser technology is mature and the surface charge limit is proven not to be present but a high efficient bunching system is needed to generate a train of 2- GHz microbunches. This paper presents the simulation results of a bunching system consisting of a DC gun, two 2-GHz prebunchers, and a 2-GHz tapered-beta buncher and accelerator for the latter scheme to convert a 156-ps pulse into 312 15-ps 2-GHz microbunches. Initial simulation results show 88% of the electrons from the gun are captured within a window of 30ps x 0.45MeV at 19-MeV, which meets the specifications for the CLIC polarized electron source.

WEPE040 **Polarized Photocathode Developments at SLAC Injector Test Facility** – *F. Zhou, A. Brachmann, T.V.M. Maruyama, J. Sheppard (SLAC)*

SLAC has a worldwide unique Injector Test Facility (ITF) to fully characterize polarized photocathodes including surface charge limit, QE and QE lifetime, and polarization. Currently, this facility is being used to conduct R&D for future linear collider electron sources. A series of recent cathode developments at the ITF are presented in this paper. Measurements on AlInGaAs/AlGaAs show 87% polarization and 0.3% QE are achieved. The QE is expected to recover to 1% with atomic hydrogen cleaning. The correlation of polarization on surface charge limit is notably observed. The dependence of surface doping level on surface charge limit, QE and polarization are measured and analyzed. The ion back-bombardment effects on beam lifetime are measured and integration of both Cs and Li activation technique into ITF to significantly extend beam lifetime is discussed.

WEPE041 **A Superconducting Magnet Upgrade of the ATF2 Final Focus** – *B. Parker, M. Anerella, J. Escallier, P. He, A.K. Jain, A. Marone, P. Wanderer, K.-C. Wu (BNL) P. Bambade (LAL) B. Bolzon, A. Jeremie (IN2P3-LAPP) P.A. Coe, D. Urner (OXFORDphysics) C. Hauviller, E. Marin, R. Tomas, F. Zimmermann (CERN) N. Kimura, K. Kubo, T. Kume, S. Kuroda, T. Okugi, T. Tauchi, N. Terunuma, T. Tomaru, K. Tsuchiya, J. Urakawa, A. Yamamoto (KEK) A. Seryi, C.M. Spencer, G.R. White (SLAC)*

The KEK ATF2 facility, with a well instrumented beam line and Final Focus (FF), is a proving ground for linear collider (LC) technology to demonstrate the extreme beam demagnification and spot stability needed for a LC FF*. ATF2 uses water cooled magnets but the baseline ILC calls for a superconducting FF**. Thus we plan to replace some ATF2 FF magnets with superconducting ones made via direct wind construction as planned for the ILC. With no cryogenic supply at ATF2, we look to cool magnets and current leads with a few cryocoolers. ATF2 FF coil winding is underway at BNL and production warm magnetic measurements indicate good field quality. Having FF magnets with larger aperture and better field quality than present FF might allow reducing the beta function at the FF for study of focusing regimes relevant to CLIC. Our ATF2 magnet cryostat will have laser view ports for cold mass movement measurement and FF support and stabilization requirements under study. We plan to make stability measurements at BNL and KEK to relate ATF2 FF magnet performance to that of a full length ILC R&D prototype at BNL. We want to be able to predict LC FF performance with confidence.

WEPE042 **Status of MICE, the international Muon Ionisation Cooling Experiment** – *V.C. Palladino (INFN-Napoli) A. Alekou (Imperial College of Science and Technology, Department of Physics)*

Muon ionization cooling provides the only practical solution to prepare high brilliance beams necessary for a neutrino factory or muon colliders. The muon ionization cooling experiment (MICE)* is under development at the Rutherford Appleton Laboratory (UK). It comprises a dedicated beam line to generate a range of input emittance and momentum, with time-of-flight and Cherenkov detectors to ensure a pure muon beam. A first measurement of emittance is performed in the upstream magnetic spectrometer with a scintillating fiber tracker. A cooling cell will then follow, alternating energy loss in liquid hydrogen and RF acceleration. A second spectrometer identical to the first one and a particle identification system provide a measurement of the outgoing emittance. In May 2010 it is expected that the beam and most detectors will be commissioned and the time of the first measurement of input beam emittance closely approaching. The plan of steps of measurements of emittance and cooling, that will follow in the rest of 2010 and later, will be reported.

WEPE043 **Study for a Racetrack FFAG based Muon Ring Cooler** – *A. Sato (Osaka University)*

FFAG lattices with racetrack-shape has been studied to cool muon beams. The ring has straight sections with FFAG magnets, which makes enough space to install kicker magnets to inject and extract the muon beam. Wedge absorbers using superfluid helium and RF cavities are installed to the ring. This paper reports progress of the study.

WEPE044 **Demonstration of Phase Rotation using Alpha Particles in the Six-sector PRISM-FFAG** – *A. Sato, M. Aoki, Y. Arimoto, T. Itahashi, Y. Kuno, M.Y. Yoshida (Osaka University) Y. Iwashita (Kyoto ICR) Y. Kuriyama, Y. Mori (KURRI) A. Kurup (Imperial College of Science and Technology, Department of Physics) C. Ohmori (KEK/JAEA)*

An (Fixed Field Alternating Gradient) ring which consists of six PRISM-FFAG magnets was constructed at RCNP, Osaka University. The technique of phase rotation to make a mono-energetic beam has been studied by using this ring and alpha particles. This paper reports the results of this project and its prospect.

WEPE045 **Development of a Superfluid Helium Wedge Absorber** – *A. Sato (Osaka University) S. Ishimoto (KEK)*

The muon cooling is essential to the neutrino factory and muon collider. Most of current design for the cooling channel use liquid hydrogen as an absorber material, since it has a long radiation length. It requires, however, a careful design of the safety system of the liquid hydrogen. We propose to use a safer material, superfluid helium. The high thermal conductivity of superfluid helium is helpful to remove the heat of the absorber material caused by the energy loss of an intense muon beam. An absorber window can be thin due to the low pressure operation. A prototype of the superfluid helium wedge absorber has been build to study a wedge shaped absorber. This paper reports the progress of the development.

WEPE046 **G4beamline Simulation for the COMET Solenoid Channel** – *A. Sato (Osaka University)*

The COMET is an experiment to search for the process of muon to electron conversion in a muonic atom, and is in its design phase to be carried out at J-PARC in near future. The experiment uses a long superconducting solenoid channels from a pion production target to a detector system. In order, to study the solenoid channel the g4beamline is used for the magnetic field calculation and beam tracking. This paper reports the status of the simulation studies.

WEPE047 **Frictional Cooling for a Slow Muon Beam** – *Y. Bao (IHEP Beijing) A. Caldwell, G.X. Xia (MPI-P) D.E. Greenwald (MPI für Physics)*

Low energy muon beams are useful for a wide range of physics experiments. High quality muon beams are also required for muon colliders and neutrino factories. The frictional cooling method holds promise for delivering slow muon beams with narrow energy spreads. With this technology, we consider the production of a cold muon beam from a surface muon source, such as that at the Paul Scherrer Institute. A cooling scheme based on frictional cooling is outlined. Simulation results show that the efficiency of slow muon production can be raised to 1%, which is significantly higher than current schemes.

WEPE048 **Further Study of Muon Ionization Cooling Process** – *T.V. Zolkin, A.N. Skrinsky (BINP SB RAS)*

The LyRICS (Lithium Rod Ionization Cooling Simulation) multi-purpose software have been created for muon beams' final cooling scheme (based on consequent lithium rods) research (*),(**). It can simulate 6-dimensional movement of muon beam through the matter including such effects as non-paraxiality, dissipations and stochastic processes like scattering or energy losses fluctuations. Also LyRICS allows to simulate movement in matching sections based on lithium and plasma lenses, including acceleration in RF cavities with taking into account transversal defocusing due to transversal components of RF-fields and estimate it's technical parameters. The special bending sections for non-dissipative phase-space volume redistribution (needed for all 6 dimensions cooling) can be considered in simulation in this concept type and in regime with full simulation. The analysis of possible cooling limit in dependence of technical parameters and type of phase-space volume redistribution is made. The comparison of possible luminosity with other cooling schemes is given. The cooling process optimized and more quality and deep estimation made.

WEPE049 **Comparison of Physics Reach Between MICE Step V and MICE Step VI** – *C.T. Rogers (STFC/RAL/ASTeC)*

In the Muon Ionisation Cooling Experiment (MICE), muons are passed through absorbers and RF cavities. The muon momentum is reduced in the absorbers but replaced in the longitudinal direction only in the RF cavities. Stochastic processes such as multiple Coulomb scattering and energy straggling negate the effect to some extent. Given a suitably conditioned beam and lattice, the transverse emittance is reduced and longitudinal emittance is increased slightly; overall the 6D emittance is reduced. In the MICE experiment, installation will proceed in steps. In Step V, a half-cell of the focussing lattice will be installed, with two absorbers and a 4-cavity RF linac. In Step VI, the full focussing lattice will be installed including two 4-cavity RF linacs and 3 absorbers. In this paper the performance of Step V and Step VI is compared. The options for magnetic lattices, emittance reduction capability compared with detector resolution, and performance as a system test is assessed.

WEPE050 **Muon Front End for the Neutrino Factory International Design Study** – *C.T. Rogers (STFC/RAL/ASTeC) D.V. Neuffer (Fermilab) G. Prior (CERN) M.S. Zisman (LBNL)*

In the Neutrino Factory muon front end, a high power proton beam is fired onto a liquid Mercury target resulting in the creation of a high emittance pion beam. The pions are captured in an adiabatically tapered solenoidal field where they decay to muons. The muons are bunched into many RF buckets using a variable frequency RF capture scheme before phase rotation and ionisation cooling, resulting in the capture of a muon beam suitable for acceleration. In order to contain the high emittance muon beam and perform bunching, phase rotation and cooling, RF cavities operating near the Kilpatrick limit are placed in intense magnetic fields. However, there are experimental indications that such intense magnetic fields may induce RF breakdown at lower gradients. Several options have been studied to improve on the baseline and mitigate the technical risk due to this magnetically induced breakdown. A hybrid gas-filled/solid-absorber lattice, a lower RF-frequency design, a shielded RF-cavity lattice and a more highly optimised version of the original baseline lattice are considered together in order to provide an optimal solution that significantly improves on the Neutrino Factory baseline.

WEPE051 **Muon Cooling Performance in Various Neutrino Factory Cooling Cell Configurations using G4MICE** – *A. Alekou, J. Pasternak (Imperial College of Science and Technology, Department of Physics) C.T. Rogers (STFC/RAL/ASTeC)*

The Neutrino Factory is a planned particle accelerator complex that will produce an intense, focused neutrino beam, using neutrinos from muon decay. Such high neutrino intensities can only be achieved by reducing the muon beam emittance using an ionization cooling system. The G4MICE software is used to study the performance of various cooling cell configurations. A comparison is drawn between the cooling in the FS2 cells, the baseline Neutrino Factory and doublet cells. The beam dynamics in each of cooling channels are presented. The lattices are compared with respect to the equilibrium emittance, muon transmission, acceptance and evolution of emittance along the channel. Conclusions for a possible optimisation of the future muon cooling channel of the Neutrino Factory are presented.

WEPE052 **The MICE Muon Beamline Optimisation and Emittance Generation** – *M. Apollonio (Imperial College of Science and Technology, Department of Physics) M.A. Rayner (OXFORDphysics)*

In the Muon Ionisation Cooling Experiment (MICE) at RAL muons are produced and transported in a dedicated beamline connecting the production point (target) to the diffuser, a mechanism inside the first spectrometer solenoid designed to inflate the initial normalized emittance up to 10 mm rad in a controlled fashion. In order to match the incoming muons to the downstream experiment, covering all the possible values of the emittance-momentum matrix, an optimisation procedure has been devised which is based upon a genetic algorithm coupled to the tracking code G4Beamline. Details of beamline tuning and initial measurements are discussed.

WEPE053 **Muon Beam Monitoring in a Neutrino Factory Decay Ring** – *M. Apollonio (Imperial College of Science and Technology, Department of Physics) A.P. Blondel (DPNC) D.J. Kelliher (STFC/RAL/ASTeC)*

Monitoring the muon beam properties in the final stage of the Neutrino Factory (the Decay Ring) is important for the understanding of the beam itself and a crucial piece of information for the downstream physics detectors. The main topics to be assessed are: knowledge of the muon beam energy, divergence of the muon beam and muon beam current. In the framework of the International Design Study for the Neutrino Factory (IDS-NF) a Race Track model Decay Ring based on G4beamline has been produced to understand how electrons from muon decays can be used to infer the energy properties of the beam via the spin depolarisation technique. The use of other codes, like Zgoubi, to generate a realistic beam including effects like spin polarisation, are considered. A general discussion on the remaining topics is presented.

WEPE054 **The MICE Muon Beam: Status and Progress** – *A.J. Dobbs, M. Apollonio, J. Pasternak (Imperial College of Science and Technology, Department of Physics) D.J. Adams (STFC/RAL/ISIS)*

The international Muon Ionisation Cooling Experiment (MICE) is designed to provide a proof of principal of the ionisation cooling technique proposed to reduce the muon beam phase space at a future Neutrino Factory or Muon Collider. The pion production target is a titanium cylinder that is dipped into the proton beam of the Rutherford Appleton Laboratory's ISIS 800 MeV synchrotron. Studies of the particle rate in the MICE muon beam are presented as a function of the beam loss induced in ISIS by the MICE target. The implications of the observed beam loss and particle rate on ISIS operation and MICE data taking is discussed.

WEPE055 **The COherent Muon to Electron Transition (COMET) Experiment** – *A. Kurup (Imperial College of Science and Technology, Department of Physics) A. Kurup (Fermilab)*

The COherent Muon to Electron Transition (COMET) experiment aims to measure muon to electron conversion with an unprecedented sensitivity of less than 1 in 10 million billion. The COMET experiment was given stage 1 approval by the J-PARC Program Advisory Committee in July 2009 and work is currently underway towards preparing a technical design report for the whole experiment. The need for this sensitivity places several stringent requirements on the beamline, such as, a pulsed proton beam with an extinction level between pulses of 9 orders of magnitude; a 5T superconducting solenoid operating near a high radiation environment; precise momentum selection of a large emittance muon beam and momentum selection and collimation of a large emittance electron beam. This paper will present the current status of the various components of the COMET beamline.

WEPE056 **Accelerator and Particle Physics Research for the Next Generation Muon to Electron Conversion Experiment - the PRISM Task Force** – *J. Pasternak, L.J. Jenner, Y. Uchida (Imperial College of Science and Technology, Department of Physics) R.J. Barlow (UMAN) K.M. Hock, B.D. Muratori (Cockcroft Institute) D.J. Kelliher, S. Machida, C.R. Prior (STFC/RAL/ASTeC) Y. Kuno, A. Sato (Osaka University) A. Kurup (Fermilab) J.-B. Lagrange, Y. Mori (KURRI) M. Lancaster (UCL) S.A. Martin (FZJ) C. Ohmori (KEK/JAEA) J. Pasternak (STFC/RAL) S.L. Smith (STFC/DL/ASTeC) H. Witte, T. Yokoi (JAI)*

The next generation of lepton flavour violation experiments will use high intensity and high quality muon beams. Such beams can be produced by sending a short proton pulse to the pion production target, capturing pions and performing RF phase rotation on the resulting muon beam in an FFAG ring, which was proposed for the PRISM project. A PRISM task force was created to address the accelerator and detector issues that need to be solved in order to realise the PRISM experiment. The parameters of the initial proton beam required and the PRISM experiment are reviewed. Alternative designs of the PRISM FFAG ring are presented and compared with the reference design. The ring injection/extraction system, matching with the solenoid channel and progress on the ring's main hardware systems like RF and kicker magnet are discussed. The activity on the simulation of a high sensitivity experiment and the impact on physics reach is described. The progress and future directions of the study are presented in this paper.

WEPE057 **Injection/Extraction System of the Muon FFAG for the Neutrino Factory** – *J. Pasternak, M. Aslaninejad (Imperial College of Science and Technology, Department of Physics) J.S. Berg (BNL) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC) J. Pasternak (STFC/RAL) H. Witte (JAI)*

Nonscaling FFAG is required for the muon acceleration in the Neutrino Factory, which baseline design is under investigation in the International Design Study (IDS-NF). In order to inject/extract the muon beam with a very large emittance, several strong kickers with a very large aperture are required distributed in many lattice cells. Once the sufficient orbit separation is obtained by the kickers, the final degree of separation from the lattice is made by the septum, which needs to be superconducting. The geometry of the symmetric solutions allowing to inject/extract both signs of muons is presented. The preliminary design of the kicker and septum magnets is given.

WEPE058 **Effect of Chromaticity Correction, Field Errors and Magnet Misalignments on the Beam Dynamics in the Muon FFAG for the Neutrino Factory** – *J. Pasternak, M. Aslaninejad (Imperial College of Science and Technology, Department of Physics) J.S. Berg (BNL) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC) F. Meot (CEA) J. Pasternak (STFC/RAL) H. Witte (JAI)*

Nonscaling FFAG is a primary candidate for muon accelerator in the Neutrino Factory baseline design under investigation by the International Design Study (IDS-NF). The muon acceleration requires a very large dynamical acceptance and the final energy spread of the beam cannot exceed a few percent. In order to controll the time of flight variation with amplitude (ToF) and the final energy in the FFAG, chromaticity correction is required, which by introduction of nonlinear field components reduces the dynamical acceptance of the machine (DA). Also the injection and extraction systems leads to an unavoidable breaking of the symmetry in the FFAG lattice, which together with the natural field errors and misalignments further limits the DA. The effect of various degree of chromaticity correction and lattice symmetry breakings, introduction of the field errors and misalignment is addressed in tracking studies using quasirealistic field maps of the FFAG magnets. The conclusions on the performance of the machine are drawn.

WEPE059 **Injection and Broadband Matching for the PRISM Muon FFAG** – *J. Pasternak (Imperial College of Science and Technology, Department of Physics) A. Kurup (Fermilab) J. Pasternak (STFC/RAL) A. Sato (Osaka University)*

The next generation of lepton flavour violation experiments requires high intensity and high quality muon beams. Such conditions can be met using phase rotation of short muon pulses in an FFAG ring, as was proposed for the PRISM project. The very large initial momentum spread and transverse emittance of the muon beam poses a significant challenge for the injection system into the PRISM FFAG. Also, the matching optics between the solenoidal transfer channel and the ring needs to create a specific orbit excursion in the horizontal plane, suppress any vertical dispersion and produce good betatron conditions in both planes. Candidate geometries for the matching and injection systems are presented and their performances are tested in tracking studies.

WEPE060 **Investigation of Beam Loading Effects for the Neutrino Factory Muon Accelerator** – *J.K. Pozimski, M. Aslaninejad, C. Bontoiu, J. Pasternak (Imperial College of Science and Technology, Department of Physics) J.S. Berg (BNL) S.A. Bogacz (JLAB) S. Machida (STFC/RAL/ASTeC)*

The IDS study showed that a Neutrino Factory seems to be the most promising candidate for the next phase of high precision neutrino oscillation experiments. A part of the increased precision is due to the fact that in a Neutrino Factory the decay of muons produces a neutrino beam with narrow energy distribution and divergence. The effect of beam loading on the energy distribution of the muon beam in the Neutrino Factory has been investigated numerically. The simulations have been performed using the baseline accelerator design including cavities for different number of bunch trains and bunch train timing. A detailed analysis of the beam energy distribution expected is given together with a discussion of the energy spread produced by the gutter acceleration in the FFAG and the implications for the neutrino oscillation experiments will be presented.

WEPE061 **Measurements of Muon Beam Properties in MICE** – *M.A. Rayner, J.H. Cobb (OXFORDphysics)*

The Muon Ionization Cooling Experiment is one lattice section of a cooling channel suitable for conditioning the muon beam at the front end of a Neutrino Factory or Muon Collider. Scintillating fibre spectrometers and 50 ps resolution timing detectors provide the unprecedented opportunity to measure the initial and final six-dimensional phase space vectors of individual muons. The capability of MICE to study the evolution of muon beams through a solenoidal lattice will be described.

WEPE062 **MICE Target Operation and Monitoring** – *P. Hodgson, C.N. Booth, P.J. Smith (Sheffield University)*

The MICE experiment requires a beam of low energy muons to demonstrate muon cooling. A target mechanism has been developed that inserts a small titanium target into the circulating ISIS beam during the last 2ms before extraction. The target mechanism has been in operation in the ISIS beam during 2009 and a large set of useful data has been obtained describing the target's operational parameters. This has allowed the commissioning of the initial section of the MICE beam line and instrumentation, and the close monitoring of target performance. This work describes these target parameters and presents some of the results from operational shifts.

WEPE063 **The MICE Target** – *P. Hodgson, C.N. Booth, P.J. Smith (Sheffield University) J.S. Tarrant (STFC/RAL)*

The MICE experiment uses a beam of low energy muons to test the feasibility of ionisation cooling. This beam is derived parasitically from the ISIS accelerator at the Rutherford Appleton Laboratory. A target mechanism has been developed and deployed that rapidly inserts a small titanium target into the circulating proton beam immediately prior to extraction without undue disturbance of the primary ISIS beam. The first target drive was installed in ISIS during 2008 and operated successfully for over 100,000 pulses. A second upgraded design was installed in 2009 and is currently in operation. The technical specification for this upgraded design is given and the motivation for many of the improvements is discussed. In addition possible future improvements to the current design are discussed.

WEPE064 **Low-beta FOFO Snake for 6D Ionization Cooling of Muons** – *Y. Alexahin (Fermilab)*

To achieve low emittance of muon beams required for a high-luminosity muon collider it is supposed to use ionization cooling. A technologically simple solution which allows to cool muons in all three degrees of freedom (6D cooling) - called a helical FOFO snake - was proposed in earlier paper*. Here we consider possibilities to lower beta functions at the absorbers so that much lower emittances of the order of 0.5 mm*mrad could be achieved.

WEPE065 **The US Muon Accelerator Program** – *A.D. Bross, S. Geer, V.D. Shiltsev (Fermilab) H.G. Kirk (BNL) M.S. Zisman (LBNL)*

An accelerator complex that can produce ultra-intense beams of muons presents many opportunities to explore new physics. A facility of this type is unique in that, in a relatively straightforward way, it can present a physics program that can be staged and thus move forward incrementally, addressing exciting new physics at each step. At the request of the US Department of Energy's Office of High Energy Physics, the Neutrino Factory and Muon Collider Collaboration and the Fermilab Muon Collider Task Force have recently submitted a proposal to create a Muon Accelerator Program that will have, as a primary goal, to deliver a Design Feasibility Study for an energy-frontier Muon Collider after a 7 year R&D program. This paper presents a description of a Muon Collider facility with a brief physics motivation, gives an overview of the proposal with respect to its organization and timeline and then discusses in some detail its major technical components.

WEPE066 **Beam Test of a High Pressure Cavity for a Muon Collider** – *M. Chung, A. Jansson, A.V. Tollestrup, K. Yonehara (Fermilab) R.P. Johnson (Muons, Inc) A. Kurup (Imperial College of Science and Technology, Department of Physics)*

To demonstrate the feasibility of a high pressure RF cavity for use in the cooling channel of a muon collider, an experimental setup that utilizes 400-MeV Fermilab linac proton beam has been developed. In this paper, we describe the beam diagnostics and the collimator system for the experiment, and report the initial results of the beam commissioning. The transient response of the cavity to the beam is measured by the electric and magnetic pickup probes, and the beam-gas interaction is monitored by the optical diagnostic system composed of a spectrometer and two PMTs.

WEPE067 **Beam-induced Electron Loading Effects in High Pressure Cavities for a Muon Collider** – *M. Chung, A. Jansson, A.V. Tollestrup, K. Yonehara (Fermilab) Z. Insepov (ANL) R.P. Johnson (Muons, Inc)*

Ionization cooling is a critical building block for the realization of a muon collider. To suppress breakdown in the presence of the external magnetic field, an idea of using an RF cavity filled with high pressure hydrogen gas is being considered for the cooling channel design. In the high pressure RF cavity, ionization energy loss and longitudinal momentum recovery can be achieved simultaneously. One possible problem expected in the high pressure RF cavity is, however, the dissipation of significant RF power through the electrons accumulated inside the cavity. The electrons are generated from the beam-induced ionization of the high pressure gas. To characterize this detrimental loading effect, we develop a simplified model that relates the electron density evolution and the observed pickup voltage signal in the cavity, with consideration of several key molecular processes such as the formation of the polyatomic molecules and ions, excitation, recombination and electron attachment. This model is expected to be compared with the actual beam test of the cavity in the MuCool Test Area (MTA) of Fermilab.

WEPE068 **Muon Capture Studies for a Neutrino Factory or Muon Collider** – *D.V. Neuffer (Fermilab) M. Martini, G. Prior (CERN) C.T. Rogers (STFC/RAL/ASTeC) C. Y. Yoshikawa (Muons, Inc)*

We discuss the design of the muon capture front end of a neutrino factory and present studies of variations of its components. In the front end, a proton bunch on a target creates secondary pions that drift into a capture transport channel, decaying into muons. A sequence of rf cavities forms the resulting muon beams into strings of bunches of differing energies, aligns the bunches to (nearly) equal central energies, and initiates ionization cooling. The cooling section uses absorber material (reducing the 3-D muon momenta) alternating with rf cavities (restoring longitudinal momentum) within strong focusing magnetic fields. The design is affected by limitations on accelerating gradients within magnetic fields. The effects of gradient limitations are explored, and mitigation strategies are presented. Variations of the ionization cooling and acceleration scenarios and extensions toward use in a muon collider are discussed.

WEPE069 **Electronegative Dopant Gases in Hydrogen Pressurized RF Cavities** – *K. Yonehara, M. Chung, M. Hu, A. Jansson, A. Moretti, M. Popovic, A.V. Tollestrup (Fermilab) M. Alsharo'a, R.P. Johnson, M.L. Neubauer (Muons, Inc) D. Huang (IIT) Z. Insepov (ANL) D. Rose (Voss Scientific)*

High pressure hydrogen gas filled RF cavities provide both the energy loss and energy regeneration needed for ionization cooling. They also can overcome the reduction in breakdown electric gradients in high magnetic fields that is seen in vacuum cavities. However, one possible problem is that a high intensity muon beam generates an electron swarm by interacting with the dense hydrogen gas, where RF power can be dissipated into the electron swarm. As a result, the quality factor of the RF cavity can be degraded as a function of the electron density. By adding an electronegative dopant gas into the RF cavity, the electron density can be reduced because of attachment of the free electrons to the electronegative dopant gas. The resulting negative ions are each too heavy to move fast or far enough in the RF field to transfer energy to the gas and thereby absorb RF power. We demonstrate this effect in simulation and experiment.

WEPE070 **Stopping Muon Beams** – *C.M. Ankenbrandt, R.J. Abrams, M.A.C. Cummings, R.P. Johnson, C. Y. Yoshikawa (Muons, Inc) D.V. Neuffer, M. Popovic (Fermilab)*

Physics experiments often use low-energy beams of unstable particles that stop in a target in order to provide high sensitivity to rare processes with reduced backgrounds. However, the stopping rate in the target is limited by the dynamics of the production process and by multiple scattering and energy straggling in the material used to slow the particles. As a result the event rates and sensitivity to rare processes are limited. In this project, we have applied new six-dimensional beam cooling inventions, improved capture techniques, and our new simulation tools to develop designs for low-energy beam lines to stop many muons in small volumes. An entirely new concept for reducing the energy spread of the secondary pion beam was invented and is under development to provide better protection from many sources of background that could limit the sensitivity of the experiment and also to provide the possibility for highly polarized stopping muon beams.

WEPE071 **Integrated Low Beta Region Muon Collider Detector Design** – *M.A.C. Cummings (Muons, Inc) D. Hedin (Northern Illinois University)*

Muon Colliders produce high rates of unwanted particles near the beams in the detector regions. Previous designs have used massive shielding to reduce these backgrounds, at a cost of creating dead regions in the detectors. To optimize the physics from the experiments, new ways to instrument these regions are needed. Since the last study of a muon collider detector in the 1990s, new types of detectors, such as solid state photon sensors that are fine-grained, insensitive to magnetic fields, radiation-resistant, fast, and inexpensive have become available. These can be highly segmented to operate in the regions near the beams. We re-evaluate the detector design, based on new sensor technologies. Simulations that incorporate conditions in recent muon collider interaction region designs are used to revise muon collider detector parameters based on particle type and occupancy. Shielding schemes are studied for optimization. Novel schemes for the overall muon collider design, including "split-detectors", are considered.

WEPE072 **Incorporating RF into a Muon Helical Cooling Channel** – *S.A. Kahn, G. Flanagan, R.P. Johnson, M.L. Neubauer (Muons, Inc) V.S. Kashikhin, M.L. Lopes, K. Yonehara, M. Yu, A.V. Zlobin (Fermilab)*

A helical cooling channel (HCC) consisting of a pressurized gas absorber imbedded in a magnetic channel that provides solenoidal, helical dipole and helical quadrupole fields has shown considerable promise in providing six-dimensional cooling for muon beams. The energy lost by muons traversing the gas absorber needs to be replaced by inserting RF cavities into the HCC lattice. Replacing the substantial muon energy losses using RF cavities with reasonable gradients will require a significant fraction of the channel length be devoted to RF. However to provide the maximum phase space cooling and minimum muon losses, the HCC should have a short period and length. In this paper we examine an approach where each HCC cell has an RF cavity imbedded in the aperture with the magnetic coils are split allowing for half of the cell length to be available for the RF coupler and other services.

WEPE073 **Quasi-isochronous Muon Collection Channels** – *C. Y. Yoshikawa, C.M. Ankenbrandt (Muons, Inc) D.V. Neuffer, K. Yonehara (Fermilab)*
Intense muon beams have many potential applications, including neutrino factories and muon colliders. However, muons are produced as tertiary beams, resulting in diffuse phase space distributions. To make useful beams, the muons must be rapidly cooled before they decay. An idea conceived recently for the collection and cooling of muon beams, namely, the use of a Quasi-Isochronous Helical Channel (QIHC) to facilitate capture of muons into RF buckets, has been developed further. The resulting distribution could be cooled quickly and coalesced into a single bunch to optimize the luminosity of a muon collider. After a brief elaboration of the QIHC concept, some recent developments are described.

WEPE074 **A Possible HPRF Linear Cooling Channel for a Neutrino Factory** – *M.S. Zisman (LBNL) J.C. Gallardo (BNL)*
A Neutrino Factory requires an intense and highly cooled (in transverse phase space) muon beam. We discuss a hybrid approach for a linear 4D cooling channel consisting of high-pressure gas-filled RF cavities –potentially allowing high gradients without breakdowns– and discrete LiH absorbers to provide the necessary energy loss that results in the needed muon beam cooling. We report simulations of the channel performance and its comparison with the vacuum case; we also discuss the various technical and safety issues associated with cavities filled with high-pressure hydrogen gas. Even with additional windows that might be needed for safety reasons, the channel performance is comparable to that of the original, all-vacuum Feasibility Study 2a channel on which our design is based. If tests demonstrate that the gas-filled RF cavities can operate properly with an intense beam of ionizing particles passing through them, our approach would be an attractive way of avoiding possible breakdown problems with a vacuum RF channel.

WEPE075 **Large-Acceptance Linac for Accelerating Low-Energy Muons** – *S.S. Kurennoy, A.J. Jason, H.M. Miyadera (LANL)*
We propose a high-gradient linear accelerator for accelerating low-energy muons and pions in a strong solenoidal magnetic field. The acceleration starts immediately after collection of pions from a target by solenoidal magnets and brings muons to a kinetic energy of about 200 MeV over a distance of the order of 10 m. At this energy, both an ionization cooling of the muon beam and its further acceleration in a superconducting linac become feasible. The project presents unique challenges - a very large energy spread in a highly divergent beam, as well as pion and muon decays - requiring large longitudinal and transverse acceptances. One potential solution incorporates a normal-conducting linac consisting of independently fed 0-mode RF cavities with wide apertures closed by thin metal windows or grids. The guiding magnetic field is provided by external superconducting solenoids. The cavity choice, overall linac design considerations, and simulation results of muon acceleration will be presented. While the primary application of such a linac is for muon interrogation, it can provide muon fluxes high enough to be of interest for physics experiments.

WEPE076 **Simulation of Large Acceptance Muon Linac** – *H.M. Miyadera, A.J. Jason, S.S. Kurennoy (LANL)*
Many groups are working on muon accelerators for future neutrino factory and muon colliders. One of the applications of muon accelerator is muon radiography which is a promising method to investigate large objects taking advantage of the long penetration lengths of muons. We propose a compact muon accelerator that has a large energy and a phase acceptance to capture relatively low energy pion/muon of 10 - 100 MeV and accelerates them to 200 MeV without any beam cooling. Like an RFQ, mixed buncher/acceleration mode provides phase bunching during the acceleration. Our current design uses 805 MHz zero-mode normal-conducting cavities with 35 MV/m peak field*. The normal conducting cavities are surrounded by superconducting coils that produce 5 T focusing field. We ran Monte Carlo simulations to optimize linac parameters such as frequency and acceleration gradient. Muon energy loss and scattering effects at the cavity windows are studied, too. The simulation showed that about 10 % of the pion/muon injected into the linac can be accelerated to 200 MeV. Further acceleration is possible with superconducting linac.

WEPE077 **Muon Collider Final Focus with High-gradient Permanent Magnet Quadrupoles** – *G. Andonian (RadiaBeam)*

G. Andonian, F.H. O'Shea, J.B. Rosenzweig (UCLA)

One of the challenges of the proposed muon collider is the beam size at the interaction region. The current target for the beta function (beta-star) is 10mm for the 1.5TeV scenario with a beam emittance of 25mm-mrad. In this paper, we describe the design and development of a final focusing scheme that attempts to reach these parameters. The final focus scheme is based on the use of permanent magnet quadrupoles (PMQ) in a triplet configuration. Initial simulations show that the PMQs reach gradients as high as ~990T/m using Praseodymium based magnets in a Halbach style arrangement. Possible methods for tuning the PMQs at the interaction region, via temperature control and high-resolution movers, are also described.

WEPE078 **The MERIT High-power-target Experiment at CERN** – *K.T. McDonald (PU) J.R.J. Bennett (STFC/RAL/ASTeC) O. Caretta, P. Loveridge (STFC/RAL) A.J. Carroll, V.B. Graves, P.T. Spampinato (ORNL) I. Efthymiopoulos, F. Haug, J. Lettry, M. Palm, H. Pereira (CERN) A. Fabich (EBG MedAustron) H.G. Kirk, H. Park, T. Tsang (BNL) N.V. Mokhov, S.I. Striganov (Fermilab) P.H. Titus (PPPL)*

The MERIT experiment was performed at CERN in Nov. 2007 as a proof-of-principle demonstration of a 4-MW target system for a Muon Collider or Neutrino Factory. We present updated results from this successful demonstration.

WEPE079 **Particle Production in the MICE Beamline** – *L. Coney (UCR)*

The Muon Ionization Cooling Experiment (MICE) is being built at the Rutherford Appleton Laboratory (RAL) to test ionization cooling of a muon beam. Successful demonstration of cooling is a necessary step along the path toward creating future high intensity muon beams in either a Neutrino Factory or Muon Collider. Production of particles in the MICE beamline begins with a titanium target dipping into the ISIS proton beam. The resulting pions are captured, momentum-selected, and fed into a 5T superconducting decay solenoid which contains the pions and their decay muons. Another dipole then selects the final particles for propagation through the rest of the MICE beamline. Within the last year, the MICE target has been redesigned, rebuilt, and has begun operating in ISIS. The decay solenoid has also become operational, dramatically increasing the number of particles in the MICE beamline. In parallel, particle identification detectors have also been installed and commissioned. In this paper, the commissioning of the improved MICE beamline and target will be discussed, including the use of Time-of-Flight detectors to understand the content of the MICE beam between 100 and 480 MeV/c.

WEPE080 **Six-Dimensional Cooling Lattice Studies for the Muon Collider** – *P. Snopok, G.G. Hanson (UCR)*

A significant reduction in the six-dimensional emittance of the initial beam is required in any proposed Muon Collider scheme. Two lattices based on the original RFOFO ring design representing different stages of cooling are considered. One is the so-called open cavity lattice addressing the problem of the 201.25 MHz RF cavities running in a magnetic field, the other one is the 805 MHz RF lattice that is used for smaller emittances. The details of the acceptance analysis and tracking studies of both channels are presented and compared to the independent ICOOL implementation.

WEPE081 **Wedge Absorber Design Approaches and Simulations for MICE** – *P. Snopok, L. Coney (UCR) C.T. Rogers (STFC/RAL/ASTeC)*

In the Muon Ionization Cooling Experiment (MICE), muons are cooled by ionization cooling. Muons are passed through material, reducing the total momentum of the beam. This results in a decrease in transverse emittance and a slight increase in longitudinal emittance, but overall reduction of 6D beam emittance. In emittance exchange, a dispersive beam is passed through wedge-shaped absorbers. Muons with higher energy pass through more material, resulting in a reduction in longitudinal and transverse emittance. Emittance exchange is a vital technology for a Muon Collider and may be of use for a Neutrino Factory. Two ways to demonstrate emittance exchange in the straight solenoidal lattice of MICE are discussed. One is to let a muon beam pass through a wedge shaped absorber; the input beam distribution must be carefully selected to accommodate chromatic aberrations in the solenoid lattice. Another approach is to use the input beam for MICE without beam selection. In this case no polynomial weighting is involved; however, a more sophisticated shape of the absorber is required to reduce longitudinal emittance.

WEPE082 **Final Lattice Design for the Non-scaling FFAG in the International Design Study of the Neutrino Factory** – *J.S. Berg (BNL) M. Aslaninejad, J. Pasternak (Imperial College of Science and Technology, Department of Physics) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC)*

The baseline design for the International Design Study of the Neutrino Factory contains a linear non-scaling fixed-field alternating gradient accelerator (FFAG) as the final stage of acceleration. We give the final choice for the design of that FFAG. We describe the basic lattice cell and the injection and extraction systems, giving their parameters. We justify the choices that were made, indicating their advantages over other possibilities. We propose how the magnets could be designed. Finally, we perform tracking simulations of a realistic beam accelerated in the machine.

WEPE083 **Lattice Design of a Hybrid Lattice of Fast Ramping and Superconducting Magnets for Muon Acceleration** – *J.S. Berg (BNL) A.A. Garren (UCLA) D.J. Summers (UMiss)*

We describe the design of a lattice to accelerate muons to 750 GeV. The lattice contains both superconducting magnets to keep the average bending field high, and ramping magnets to increase the average bending field as the beam accelerates. The ramping rate must be sufficiently fast to keep the level of muon decays reasonable. To reduce the stored energy in the ramped magnets, the variation in the closed orbit during acceleration should be minimized. Since superconducting RF is used, the time of flight per turn should remain constant during acceleration. We compute the time dependence of the ramping magnets that keeps the tunes and time of flight independent of time while minimizing the closed orbit variation. We show how other lattice parameters behave during the acceleration cycle, and study the longitudinal dynamics in the machine.

WEPE084 **Muon Acceleration with RLA and Non-scaling FFAG Arcs** – *V. Morozov (ODU) S.A. Bogacz (JLAB) D. Trbojevic (BNL)*

Recirculating linear accelerators (RLA) are the most likely means to achieve the rapid acceleration of short-lived muons to multi-GeV energies required for Neutrino Factories and TeV energies required for Muon Colliders. In the work described here, a novel arc optics based on a Non Scaling Fixed Field Alternating Gradient (NS-FFAG) lattice is developed, which would provide sufficient momentum acceptance to allow multiple passes (two or more consecutive energies) to be transported in one string of magnets. We present a combination of the non-scaling NS-FFAG RLA placed in a straight section. Orbit offsets of different energy muons are kept small in the NS-FFAG arcs during multiple passes. The NS-FFAG, made of densely packed FODO cells, allows momentum acceptance of $dp/p=\pm60\%$. This solution would reduce overall cost and simplify the operation. Difference in a muon path length for corresponding energies is corrected with a chicane. We will also discuss technical requirements to allow the maximum number of passes by using an adjustable path length to accurately control the returned beam phase to synchronize with the RF.

WEPE085 **Parameter Scan for the CLIC Damping Rings under the Influence of Intrabeam Scattering** – *F. Antoniou (National Technical University of Athens) M. Martini, Y. Papaphilippou, A. Vivoli (CERN)*

Due to the high bunch density, the output emittances of the CLIC Damping Rings (DR) are strongly dominated by the effect of Intrabeam Scattering (IBS). In an attempt to optimize the ring design and using classical IBS formalisms and approximations, the scaling of the extracted emittances and IBS growth rates is being studied, with respect to several ring parameters including energy, bunch charge, optics and wiggler characteristics. Results from the simulations using a multi-particle tracking code are also presented.

WEPE086 **A Low Emittance Lattice for the International Linear Collider 3 km Damping Ring** – *S. Guiducci, M.E. Biagini (INFN/LNF)*

A new baseline parameter set has been proposed for the ILC with a reduction by a factor 2 in the number of bunches. This option will allow for a corresponding factor 2 decrease in the Damping Ring circumference, with significant cost savings. A low emittance lattice for a 3.2 km long damping ring has been designed, with the same racetrack layout of the present reference 6.4 km long lattice and similar straight sections. The technical work done for the longer ring can be easily applied to the shorter one. The lattice is based on an arc cell design adopted for the SuperB collider and allows some flexibility in tuning emittance and momentum compaction.

WEPE087 **RF Accelerating Structure for the Damping Ring of the SuperKEKB Injector** – *T. Abe, T. Kageyama, H. Sakai, Y. Takeuchi, K. Yoshino (KEK)*

A damping ring of positron beams is under consideration for the upgrade of KEKB (SuperKEKB) because low emittance of beams injected to the main rings is required by the SuperKEKB optics in the nano-beam scheme. We present the design of the RF accelerating structure, especially on the higher-order-mode (HOM) damped structure. This structure is based on the normal-conducting accelerating cavity system ARES, which has successful records of the long-term stable operations so far with low trip rates at KEKB. All the HOM absorbers are made of silicon carbide, bullet-shaped, and to be directly water cooled, so that the structure presented in this paper can be also a prototype for accelerating beams of the order of 10A in the SuperKEKB main ring in the high-current scheme.

WEPE088 **A New Design for ILC 3.2 km Damping Ring** – *D. Wang, J. Gao, Y. Wang (IHEP Beijing)*

In this paper, we made a new design for ILC 3.2 km damping ring with 2 arcs based on FODO cell and 2 straight sections which are nearly the same as the new version of the 6.4 km ring DCO4. This new lattice uses less dipoles and quadrupoles than the present SuperB like lattice and has an adequate aperture for the large injected emittance of the positron beam. The work of lattice design and DA optimization will be presented in detail.

WEPE089 **Design Optimisation for the CLIC Damping Rings** – *Y. Papaphilippou, F. Antoniou, M.J. Barnes, S. Bettoni, S. Calatroni, R. Corsini, A. Grudiev, R. Maccaferri, M. Modena, L. Rinolfi, G. Rumolo, D. Schoerling, D. Schulte, A. Vivoli (CERN) E.B. Levichev, S.V. Sinyatkin, P. Vobly, K. Zolotarev (BINP SB RAS)*

The CLIC damping rings should produce the ultra-low emittance necessary for the high luminosity performance of the collider. This combined to the high bunch charge present a number of beam dynamics and technical challenges for the rings. Lattice studies have been focused on low emittance cells with optics that reduce the effect Intra-beam scattering. The final beam emittance is reached with the help of super-conducting damping wigglers. Results from recent simulations and prototype measurements are presented, including a detailed absorption scheme design. Collective effects such as electron cloud and fast ion instability can severely limit the performance and mitigation techniques have been identified and tested. Tolerances for alignment and technical system design such as kickers, RF cavities, magnets and vacuum have been finally established.

WEPE090 **Intra-Beam Scattering in the CLIC Damping Rings** – *A. Vivoli, M. Martini (CERN)*

The CLIC 3 TeV nominal design requires very low emittance of the electron and positron beams to be reached in the damping rings. Due to low energy and to relatively high bunch charge and ultra-low emittance, Intra-Beam Scattering (IBS) effect is very strong and an accurate calculation is needed to check if the required emittance is effectively reached. For this reason it is being developed at CERN a new Software for IBS and Radiation Effects (SIRE), which simulates the evolution of the beam particle distribution in the damping rings, taking into account radiation damping, IBS and quantum excitation. In this paper we present the results of our simulations performed with SIRE on the current lattice of the CLIC damping rings.

WEPE091 **The Swiss Light Source - a "Test-bed" for Damping Ring Optimization** – *M. Böge, M. Aiba, A. Luedeke, N. Milas, A. Streun (PSI)*

The application of various optics correction techniques at the SLS allows to reduce the vertical emittance to <3 pm.rad corresponding to an emittance coupling of <0.05 %. Beam sizes can be measured with a resolution of ~0.5 um allowing to resolve vertical beam sizes close to the quantum radiation limit of 0.55 pm.rad. The application of beam-based alignment/ calibration techniques on magnet girders (remotely controlled), quadrupoles and sextupoles can be used to center the beam in all relevant optical elements at a minimum expense of vertical dipole corrector strength. Furthermore a fast orbit feedback based on a high resolution digital BPM system allows to stabilize the closed orbit up to ~90 Hz and to perform precise orbit manipulations within this bandwidth. Furthermore the top-up operation mode guarantees very stable conditions for the various beam-based measurements. These conditions make the SLS an excellent "test-bed" for future damping ring optimization.

WEPE092 **Mechanical and Vacuum Design of Wiggler Section of ILC DR** – *O.B. Malyshev (STFC/DL/ASTeC) N.A. Collomb, J.M. Lucas, S. Postlethwaite (STFC/DL) M. Korostelev (The University of Liverpool) A. Wolski (Cockcroft Institute) K. Zolotarev (BINP SB RAS)*

A vacuum vessel design of wiggler sections should meet a few challenging specification. The SR power of about 40 kW is generated in each wiggler. Expanding fan of SR radiation reaches the beam vacuum chamber walls in the following wiggler and may cause the following problem: massive power dissipation on vacuum chamber walls inside the cryogenic vessel, radiation damage of superconducting coil, high photo-electron production rate that cause an e-cloud build-up to unacceptable level. Therefore this power should be absorbed in the places where these effects are tolerable or manageable. A few possible solutions for tackling all SR related problems as well as vacuum design are discussed in the paper in details.

WEPE093 **Study of Ion Induced Pressure Instability in the ILC Positron Damping Ring** – *O.B. Malyshev (STFC/DL/ASTeC)*

Ion induced pressure instability is a potential problem for the ILC positron damping ring (DR)if the chosen pumping scheme does not provide sufficient pumping. The ion induced pressure instability effect results from ionisation of residual gas molecules by the beam particles, their acceleration in the field of the beam towards the vacuum chamber walls, causing ion induced gas desorption from vacuum chamber walls; these gas molecules in their turn can also be ionised, accelerated and cause further gas desorption. If the pumping is insufficient, this effect may cause a pressure instability, in which the pressure in the beam chamber grows rapidly to an unacceptable level. To analyse the ion induced pressure instability in the ILC positron DR the energy gained by ions was calculated for the appropriate beam parameters; it was found that the energy gain of ions will be about 300 eV. The ion induced gas desorption was estimated, and pumping solutions to avoid the ion induced pressure instability are suggested. The cheapest and most efficient solution is to use NEG coated vacuum chamber.

WEPE094 **SR Power Distribution along Wiggler Section of ILC DR** – *O.B. Malyshev (STFC/DL/ASTeC) N.A. Collomb, J.M. Lucas, S. Postlethwaite (STFC/DL) M. Korostelev (The University of Liverpool) A. Wolski (Cockcroft Institute) K. Zolotarev (BINP SB RAS)*

A 374-m long wiggler section is a key part of ILC damping ring that should alloy reaching a low beam emittance for the ILC experiment. Synchrotron radiation generated by the beam in the wigglers should be absorbed by different components of vacuum vessel, including specially designed absorbers. The optimisation of the mechanical design, vacuum system and anti-e-cloud mitigation requires accurate calculation of the SR power distribution. The angular power distribution from a single wiggler was calculated with in-house developed software. Then the superposition of SR from all wigglers allows calculating power distribution for all components along the wiggler section and the downstream straight section.

WEPE095 **Impedance and Single-bunch Instabilities in the ILC Damping Ring** – *M. Korostelev, O.B. Malyshev, A. Wolski (Cockcroft Institute) N.A. Collomb, J.M. Lucas, S. Postlethwaite (STFC/DL) A.J.P. Thorley (The University of Liverpool)*

The longitudinal and transverse wakefields have been calculated by using 3D code, CST Particle Studio, for a number of different vacuum chamber components of the 6.4 km ILC damping ring design. Based on the results, studies of bunch lengthening and single-bunch instabilities have been carried out. Bunch lengthening from a particle tracking code are compared with results from numerical solution of the Haissinski equation. The tracking code is used to predict the threshold for single-bunch instabilities.

WEPE096 **Lattice Design of the 6.4 km ILC Damping Ring** – *M. Korostelev, A. Wolski (Cockcroft Institute)*

A new lattice design for the ILC damping ring has been developed since the beginning of 2008 as a lower cost alternative to the previous OCS6 design. The lattices for the electron and positron damping rings are identical, and are designed to provide an intense, 5 GeV beam with low emittance at extraction. The latest design, presented in this paper, provides sufficient dynamic aperture for the large positron beam at injection. The lattice also meets the engineering requirements for arrangement of the positron ring directly above the electron ring in the same tunnel, using common girders for the magnets in the two rings, but with the beams circulating in opposite directions.

WEPE097 **Recommendation for the Feasibility of a 3 km ILC Damping Ring** – *M.T.F. Pivi, L. Wang (SLAC) C.M. Celata, M.A. Furman, M. Venturini (LBNL) J.A. Crittenden, G. Dugan, M.A. Palmer (CLASSE) T. Demma, S. Guiducci (INFN/LNF) K.C. Harkay (ANL) O.B. Malyshev (Cockcroft Institute) K. Ohmi, K. Shibata, Y. Suetsugu (KEK) Y. Papaphilippou, G. Rumolo (CERN)*

As part of the International Linear Collider (ILC) collaboration, we have compared the electron cloud effect for different Damping Ring designs respectively with 6.4 km and 3.2 km circumference and investigated the feasibility of a shorter damping ring with respect to the electron cloud build-up and related beam instability. These studies were carried out with beam parameters of the ILC Low Power option. A reduced damping ring circumference has been proposed for the new ILC baseline design and would allow to considerably reduce the number of components, wiggler magnets and costs. We also briefly discuss the plans for future studies including the luminosity upgrade option with shorter bunch spacing, the evaluation of mitigations and the integration of the CesrTA results into the Damping Ring design.

WEPE098 **Optimal Pion Production Target Shapes for the Neutrino Factory** – *S.J. Brooks (STFC/RAL/ASTeC)*

The neutrino factory requires a source of pions within a momentum window determined by its specific downstream structure. The technique of finding which parts of a large target block are net absorbers or emitters of particles may be adapted with this momentum window in mind. Therefore, analysis of a hadronic production simulation run using MARS15 can provide a candidate target shape in a single pass. This shape will produce the optimal particle yield contingent on certain assumptions about the particle flows, which are also discussed in this paper.

WEPE099 **Thermal and Mechanical Effects of a CLIC Bunch Train Hitting a Beryllium Collimator** – *J.-L. Fernandez-Hernando (STFC/DL/ASTeC)*

Beryllium is being considered as an option material for the CLIC energy collimators in the Beam Delivery System. Its high electrical and thermal conductivity together with a large radiation length compared to other metals makes Beryllium an optimal candidate for a long tapered design collimator that will not generate high wakefields, which might degrade the orbit stability and dilute the beam emittance, and in case of the beam impacting the collimator temperature rises will not be sufficient enough to melt the metal. This paper shows results and conclusions from simulations of the impact of a CLIC bunch train hitting the collimator.

WEPE100 **Dielectric Collimators for Linear Collider Beam Delivery System** – *A. Kanareykin, P. Schoessow (Euclid TechLabs, LLC) R. Tomas (CERN)*

In this presentation, dielectric collimator concepts for the linear collider will be described. Cylindrical and planar dielectric collimator designs for CLIC and ILC parameters will be presented, and results of simulations to minimize the beam impedance will be discussed. The prototype collimator system is planned to be fabricated and experimentally tested at Facilities for Accelerator Science and Experimental Test Beams (FACET) at SLAC.

WEPE101 **A 4MW Target Station for a Muon Colldier** – *H.G. Kirk (BNL) V.B. Graves (ORNL) K.T. McDonald (PU)*

We describe a concept for a target station surrounding a pion production/capture system capable of accepting a 4MW proton beam. The target system consists of a free mercury jet immersed in a high-field solenoid magnet capture system. The shielding required for the protection of the superconducting solenoid coils is a major consideration. Additional infrastructure required for the target system is discussed.

27-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area A

THPEA — Poster Session

THPEA001 **Fabrication and Installation of Radio Frequency System for K500 Superconducting Cyclotron at Kolkata** – *M. Ahammed, R.K. Bhandari, P. Bhattacharyya, J. Chaudhuri, M.K. Dey, A. Dutta Gupta, B.C. Mandal, B. Manna, S. Murali, S. Saha, S.K. Singh, S. Sur (DAE/VECC)*

K500 Superconducting Cyclotron (SCC) is already commissioned successfully at VECC, Kolkata by accelerating Ne^{3+} internal beam with 70 nA beam current at 670 mm extraction radius. The Radio Frequency cavity of SCC is successfully operational since last two years. All these years were very challenging and worthy period from the point of view of gaining experience and knowledge by solving fabrication and assembly problems faced during construction of 10 m tall copper made coaxial RF cavities and tackling RF related commissioning problems. RF system operates within the frequency range of 9 to 27 MHz for generating maximum 100 kV DEE voltage. The construction of the RF system demands making of numerous critical soldering and brazing joints including joints between ceramic and copper along with maintaining close dimensional accuracies, assembly tolerances, mirror symmetricity, surface finish and utmost cleanliness. This paper presents the details of fabrication and installation procedures and their effects on the final performance of the cavities. It also highlights the problems faced during the commissioning process of the RF cavities.

THPEA002 **RF Systems of the VEC-RIB Facility** – *H.K. Pandey, A. Bandyopadhyay, A. Chakrabarti, S. Dechoudhury, D.P. Dutta, T.K. Mandi, V. Naik (DAE/VECC)*

An isotope separator on-line Rare Isotope Beam (RIB) facility is presently under development at VECC, Kolkata around the existing K=130 room temp cyclotron. In first stage the low-energy (1.7 keV/u; q/A ≤ 1/14) RIB will be accelerated to about 470 keV/u in the Radio Frequency Quadrupole (RFQ) linac followed by three IH-LINAC. This consists of seven different rf systems for RFQ, three re-buncher and three IH-Linac cavities each operating in CW mode. The 3.4 meter rod type RFQ and the four gap $\lambda/4$ re-buncher is designed to operate at 37.8 MHz. The RFQ and re-buncher has been installed and successfully operated at CW rf power. The first beam testing for O^{5+} has been done with proper phase locking between rf transmitters. Two DTL accelerator systems consist of IH-mode tank operating at 37.8 MHz and other with 75.6 MHz. The first IH linac has been installed in beam line and tested with nominal RF power. The Second IH-linac cavity has been fabricated and is undergoing low power rf test. Two other buncher cavities are presently under development. The rf systems with low power as well as high power testing for above accelerator cavities will be described in this paper.

THPEA003 **An Analytical Formulation for Prediction of Geometrical Dimensions of a Photocathode Gun for Desired RF Properties** – *S. Lal, K.K. Pant (RRCAT) S. Krishnagopal (BARC)*

Tuning of a photocathode gun for desired RF properties of the pi mode, such as FB ~1, fpi = 2856 MHz, and beta ~1, requires precise tuning of the resonant frequency and beta of its independent cells. In this paper, we present a parametric and analytical formulation to predict geometrical dimensions of independent cells and the coupling slot on the full cell to obtain the desired pi mode RF parameters during operation, taking into account the effect of brazing and vacuum. We also compare results obtained from low power RF measurements on a photocathode gun with those predicted by the above formulation.

THPEA004 **Design of 50 kW, 350 MHz Pulsed Power Coaxial Coupler Assembly** – *R. Kumar, P. Singh (BARC)*

A loop type coaxial coupler has been designed to couple RF power (50 kW, 350 MHz, 1% duty factor) to a RFQ cavity of 400 keV deuteron accelerator at BARC. The coupler assembly consists of 15/8" rigid coaxial line with a disc type alumina window for vacuum to air barrier. The assembly will be mounted to the cavity with a Cu plated SS conflate flange. The connection to 61/8" coaxial line on air side is made by a 61/8" to 15/8" coaxial adapter. The capacitive discontinuity introduced by the alumina disc has been matched by under-cuts of suitable length and depth on both sides of the alumina disc. The dimensions of the under-cuts has been obtained by simulations on EM Solver CST Microwave Studio. The structure has been optimized to obtain better than -30 dB return loss with 1% bandwidth. The design, fabrication and measurement results of this coupler assembly will be reported.

THPEA005 **Operating Experience of the 10 MeV Industrial RF Electron Linac at EBC, Navi Mumbai** – *D. Bhattacharjee, R. Barnwal, S. Chandan, R.B. Chavan, K. Dixit, K.C. Mittal, V.T. Nimje, V. Yadav (BARC-EBC) A.P. Bhagwat, S.Y. Kulkarni (SAMEER) D.P. Chakravarthy, A.R. Chindarkar, L.M. Gantayet, S.R. Ghodke, D. Jayaprakash, M.K. Kumar, A.R. Tillu (BARC)*

An indigenously developed 10 MeV industrial RF Electron accelerator is commissioned at the Electron Beam Centre (EBC), Navi Mumbai, and is delivering a beam power of 3 kW. The Linac is an On-axis coupled cavity bi-periodic structure, which is driven by a 6 MW (pk), 25 kW (avg) klystron at 2856 MHz and with pulse width of 10 microsecs and 0.4 % duty cycle. This paper discusses the various stages of RF conditioning, the beam trials, the problems faced during the commissioning stages and their solutions.

THPEA006 **Beam Energy Upgrade of the Frascati SPARC Photo-Injector with a C-band RF System** – *R. Boni, D. Alesini, M. Bellaveglia, G. Di Pirro, M. Ferrario, L. Ficcadenti, A. Gallo, F. Marcellini, E. Pace, B. Spataro, C. Vaccarezza (INFN/LNF) A. Bacci (Istituto Nazionale di Fisica Nucleare) A. Mostacci, L. Palumbo (Rome University La Sapienza) C. Ronsivalle (ENEA C.R. Frascati)*

In the frame of the SPARC-X project, the energy of the Photo-Injector SPARC, in operation at INFN-LNF, will be upgraded from 180 to 250 MeV by replacing a low gradient S-band traveling wave accelerating section with two C-band units, designed and developed at LNF. The new system will consist of a 50 MW klystron, supplied by a pulsed modulator, to feed the high gradient C-band structures through a RF pulse compressor. This paper deals with the design of the full system, the C-band R&D activity and study of the related beam dynamics.

THPEA007 **The Injection System of the INFN-SuperB Factory Project: Preliminary Design** – *R. Boni, S. Guiducci, M.A. Preger, P. Raimondi (INFN/LNF) A. Chancé (CEA) O. Dadoun, F. Poirier, A. Variola (LAL) J. Seeman (SLAC)*

The ultra high luminosity B-factory (SuperB) project of INFN requires a high performance and reliable injection system, providing electrons at 4 GeV and positrons at 7 GeV, to fulfill the very tight requirements of the collider. Due to the short beam lifetime, continuous injection of electrons and positrons in both HER and LER rings is necessary to keep the average luminosity at a high level. Polarized electrons are required for experiments and must be delivered by the injection system, due to the beam lifetime shorter than the polarization build-up: they will be produced by means of a SLAC-SLC polarized gun. One or two 1 GeV damping rings are used to reduce e^+ and e^- emittances. Two schemes for positron production are under study, one with electron-positron conversion at low energy (<1 Gev), the second at 6 GeV with a recirculation line to bring the positrons back to the damping ring. Acceleration through the Linac is provided by a S-band RF system made of traveling wave, room temperature accelerating structures. An option to use the C-band technology is also presented.

THPEA008 **Experimental Characterization of the RF Gun Prototype for the SPARX-FEL Project** – *L. Faillace, L. Palumbo (Rome University La Sapienza) P. Frigola (RadiaBeam) A. Fukasawa, B. D. O'Shea, J.B. Rosenzweig (UCLA) B. Spataro (INFN/LNF)*

The quest for high brightness beams is a crucial key for the SPARX-FEL Project. In this paper, we present the design (including RF modeling, cooling, thermal and stress analyses as well as frequency detuning) of a single feed S-Band RF Gun capable of running near 500 Hz. An alternative design with dual feed has already been designed. Also, experimental results from the RF characterization of the prototype, including field measurements, are presented. The RF design follows the guidelines of the LCLS Gun, but the approach diverges significantly as far as the management of the cooling and mechanical stress is concerned. Finally, we examine the new proprietary approach of RadiaBeam Technologies for fabricating copper structures with intricate internal cooling geometries that may enable very high repetition rate.

THPEA009 **Construction Status of C-band Main Accelerator for XFEL/SPring-8** – *T. Inagaki, N. Adumi, T. Hasegawa, H. Maesaka, S. Matsui, T. Sakurai, T. Shintake (RIKEN/SPring-8) H. Kimura, C. Kondo, K. Shirasawa (JASRI/SPring-8)*

C-band (5712 MHz) accelerator is used as the main accelerator of the XFEL in SPring-8. Since the C-band generates a high accelerator gradient, as high as 35 MV/m, the total length of the 8-GeV accelerator fits within 400 m, including the injector and three bunch compressors. We use 64 C-band rf units, which consists of 128 accelerating structures, 64 rf pulse compressors, 64 klystrons, waveguide components, etc. Mass-production of these high power rf components has been almost completed. Production quality is confirmed by the high power rf test. Installation of the C-band components started in August 2009. So far, about half of the components have been installed on schedule. The accelerating structures are aligned with about 0.1 mm accuracy. By the date of the IPAC'10 conference, we will almost complete the installation. In this presentation, we will report the construction status.

THPEA010 **High Power RF Test on the Mass-produced C-band RF Components for XFEL/SPring-8.** – *T. Sakurai, T. Inagaki, C. Kondo, T. Shintake, K. Shirasawa (RIKEN/SPring-8) S. Suzuki (JASRI/SPring-8)*

We report the high power rf test results of C-band accelerator system for X-ray free electron laser (XFEL) in SPring-8 site. In XFEL main accelerator, 64 C-band systems will be used in total, whose components are under mass production at several industries in Japan. We performed high power RF test with three sets of the mass-produced components in XFEL test bunker. We operate the C-band components with the accelerating gradient, as high as 40 MV/m. We measured the high voltage breakdown rate and the dark current emission.

THPEA011 **Simulation of Magnetic Alloy Loaded RF Cavity and HOM Analysis** – *K. Hasegawa, K. Hara, C. Ohmori, M. Tada, M. Yoshii (KEK) M. Nomura, A. Schnase, F. Tamura, M. Yamamoto (JAEA/J-PARC)*

The RF cavity using Magnetic Alloy (MA) cores has been developed for achieving the high field gradient in J-PARC. For reducing the beam loading effects, the Q-value of the RF cavities in the Main Ring (MR) is controlled by using the cut-core configuration. In order to check the effect of HOMs between the cut-core gap, a simulation method of MA cores was studied and electromagnetic fields of excitation modes have been calculated by HFSS. We present the detail of the simulation method of MA cores and the HOM analysis of the cavity with the cut-cores.

THPEA012 **Various Observables of TW Accelerator Structures Operating 100MV/m or Higher at X-band Facility, Nextef of KEK** – *T. Higo, T. Abe, M. Akemoto, S. Fukuda, N. Higashi, Y. Higashi, N.K. Kudo, S. Matsumoto, T. Shidara, T. Takatomi, K. Ueno, Y. Watanabe, K. Yokoyama, M. Yoshida (KEK)*

Under the CERN-SLAC-KEK collaboration, we have been developing the high gradient TW accelerator structures. One of the main focuses is the feasibility study of CLIC accelerator structure at X-band. A high power facility, Nextef*, was established at KEK in 2007. A few structures have been tested, including an un-damped disk-loaded structure successfully tested beyond 100 MV/m, a heavily damped structure to be tested from late 2009 and a structure made in a quadrant configuration. These structures follow the same accelerating-mode RF parameter profile, called CLIC-C**, but show different features at high gradient operation. Various observables, such as dark current, vacuum activities, light emission, breakdown rate, and so on, are measured. We discuss the high gradient phenomena related to these observables and the possible improvement for stable operation at a higher gradient.

THPEA013 **Advances in X-band TW Accelerator Structures Operating in the 100 MV/m Regime** – *T. Higo, Y. Higashi, S. Matsumoto, K. Yokoyama (KEK) C. Adolphsen, V.A. Dolgashev, A. Jensen, L. Laurent, S.G. Tantawi, F. Wang, J.W. Wang (SLAC) S. Doebert, A. Grudiev, G. Riddone, W. Wuensch, R. Zennaro (CERN)*

A CERN-SLAC-KEK collaboration on high gradient X-band accelerator structure development for CLIC has been ongoing for three years. The major outcome has been the demonstration of stable 100 MV/m gradient operation of a number of CLIC prototype structures. These structures were fabricated basically using the technology developed from 1994 to 2004 for the GLC/NLC linear collider initiative. One goal has been to refine the essential parameters and fabrication procedures needed to realize such high gradient routinely. Another goal has been to develop structures with stronger dipole mode damping than those for GLC/NLC. The latter requires that surface temperature rise during the pulses be higher, which may increase the breakdown rate. Structures with heavy damping will be tested in late 2009/early 2010, and this paper will present these results together with some of the earlier results from non-damped structures and structures built with a quadrant geometry.

THPEA014 **T·10^{11}/TM11 Mixed-mode Waveguide Valve at X-band** – *S. Kazakov, T. Higo, S. Matsumoto (KEK)*

A waveguide vacuum valve for WR90 waveguide was designed, fabricated and tested. The valve consists of a modified commercial gate valve sandwitched with smooth tapers. The T·10^{10} traveling wave in WR90 waveguide is "transmoded" into TE^{11+}TM11 mode in the taper, going through the gate valve and is tapered back to the normal mode in WR90. The test has been successfully done. The valve stably trasmitted 40MW peak power with 500ns pulse width and this is limited by available RF power source.

THPEA015 **L-band Accelerator System in KEKB Injector Linac** – *S. Matsumoto, M. Akemoto, T. Higo, H. Honma, K. Kakihara, T. Kamitani, H. Nakajima, K. Nakao, Y. Ogawa, Y. Yano, M. Yoshida (KEK)*

In order to improve the capture efficiency of the positron produced at the target in present KEKB Injector linac, a new project has just started to utilize L-band (1298MHz) RF. The present S-band (2856MHz) capture cavities and successive three RF units are to be replaced by those of L-band. The specifications of the L-Band system should fulfill the demands of a positron damping ring downstream which is also to be under study for super KEKB project. Besides the whole design work of the system, our present ongoing work is rather concentrated on establishing L-Band RF source and accelerating structures.

THPEA016 **Developments of Magnetic Alloy Cores with Higher Impedance for J-PARC Upgrade** – *C. Ohmori, K. Hasegawa, A. Takagi (KEK) K. Hara, T. Shimada, H. Suzuki, M. Tada, M. Yoshii (KEK/JAEA) M. Nomura, A. Schnase, F. Tamura, M. Yamamoto (JAEA/J-PARC)*

Magnetic alloy cavities are successfully used for J-PARC synchrotrons. These cavities generate much higher RF voltage than ordinary ferrite cavities. For future upgrades of J-PARC facilities, a higher field gradient is necessary. It was found that the characteristics of magnetic alloy is improved by a new annealing scheme under magnetic field. A large production system using an old cyclotron magnet is under construction for the J-PARC upgrade. The status of core development will be reported.

THPEA017 **A Magnetic Alloy loaded RF Cavity System for EMMA** – *C. Ohmori (KEK) J.S. Berg (BNL)*

An RF system using Magnetic Alloy is considered as an option to study the beam dynamics of a linear non-scaling FFAG. Such an FFAG may have many resonances, which affect the beam more when the beam crosses them slowly. The RF system aims at ordinary RF bucket acceleration with an RF frequency sweep of 3 % in 100 turns. The cavity has only 10 cm length to fit in a short straight section. The required RF voltage is 100 kV per turn and each of the three cavities is designed to generate 50 kV.

THPEA018 **Study of RF Breakdowns with Narrow Waveguide** – *K. Yokoyama, S. Fukuda, Y. Higashi, T. Higo, S. Matsumoto (KEK)*

A basic research of the RF breakdown phenomena in the accelerating structure have been in progress at Nextef (New X-band Test Facility at KEK). To investigate the high-gradient RF breakdown, we have performed high-gradient experiments by using narrow waveguides having a field of around 200 MV/m at a power of 100 MW. A significant difference was found between the characteristics of the two materials: stainless-steel and copper. In this paper we discuss in detail the obtained data of a narrow waveguide made of copper.

THPEA019 **Thermal Deformation of Magnetic Alloy Cores for J-PARC RCS RF Cavities** – *T. Shimada (KEK/JAEA) K. Hara, K. Hasegawa, C. Ohmori, M. Tada, M. Yoshii (KEK) M. Nomura, A. Schnase, H. Suzuki, F. Tamura, M. Yamamoto (JAEA/J-PARC)*

Several magnetic alloy cores of the RF cavities, which are installed in the 3 GeV rapid cycling synchrotron (RCS) of J-PARC have shown buckling after about two years operation. To find the reason, why the local deformation happened, we made a test setup. There we heat up MA cores in air by 500 kHz RF and measure the thermal deformation in order to collect information about the buckling process. The results obtained by comparing the expansion of cores made by different production methods are reported.

THPEA020 **Design of an RF Input coupler for the IFMIF/EVEDA RFQ Linac** – *S. Maebara (JAEA)*

In the design of prototype RFQ linac for the IFMIF/EVEDA Project, a coupled cavity type of RFQ, which has a longitudinal length of 9.78m, was proposed to accelerate deuteron beam up to 5MeV. The operation frequency of 175MHz was selected to accelerate a large current of 125mA in CW mode. The driving RF power of 1.28 MW by 8 RF input couplers has to be injected to the RFQ cavity. As the RF input coupler design, RF losses including RF vacuum windows, based on a 4 1/16 inch and 6 1/8 inch coaxial waveguide as well as RF coupling factor of a loop antenna with varied insertion depths using an RFQ model were calculated. In this conference, these results and thermal analysis results in CW operation mode will be presented in details.

THPEA021 **Development and Mass Production of C-band RF Pulse Compressor** – *K. Okihira, F. Inoue, S. Miura (MHI) T. Inagaki, H. Maesaka, T. Shintake (RIKEN/SPring-8)*

An X-ray free electron laser (XFEL) is under construction in RIKEN/Spring-8. In this project, a C-band accelerator with an RF pulse compressor is employed in order to obtain a high acceleration gradient of more than 35 MeV/m. RF power from klystron is stored in the RF pulse compressor, which provides higher peak output power for an accelerating tube. A high Q value and a precise frequency tuning are required for the pulse compressor. We employed a oxygen-free copper cavity of a TE0,1,15 mode in order to obtain a high Q value. In addition, we designed a precise differential screw for the frequency tuner. As a result, the resonant frequency and Q value became very accurate and stable (f = 5712MHz ± 0.01MHz, Q0 = 185000), and the voltage amplification rate was obtained to be about twice (up to 2.5 times). A high power test was also carried out and the designed performance was confirmed without any troubles (peak output power reached 250MW). We produce 64 units of C-band RF pulse compressors for the XFEL project. As of December 2009, we have completed the fabrication and RF measurements of all units, and 61 units of them were installed.

THPEA022 **Condition of MA Cores in the RF Cavities of J-PARC Synchrotrons after Several Years of Operation** – *M. Nomura, A. Schnase, T. Shimada, H. Suzuki, F. Tamura, M. Yamamoto (JAEA/J-PARC) E. Ezura, K. Hara, C. Ohmori, M. Tada, M. Yoshii (KEK/JAEA) K. Hasegawa, K. Takata (KEK)*

We have been operating the RF cavities loaded with MA cores with a high field gradient of more than 20 kV/m since October 2007. We have been measuring the RF cavity impedance at the shutdown periods, and we detected the impedance reductions of RCS RF cavities on January and June 2009. Taking out the RF cavities from the beam line and opening them, we found that many of cores showed a buckling at the inner radius. Also detachment of the epoxy coating intended to prevent rusting was observed. We report the detail of condition of MA cores and the relation between the impedance reduction and core condition.

THPEA023 **Drift Tube Linac Cavity with Space-saving Amplifier Coupling of New Injector for RI-Beam Factory** – *K. Suda, S. Arai, Y. Chiba, O. Kamigaito, M. Kase, N.S. Sakamoto, K. Yamada (RIKEN Nishina Center)*

A new injector RILAC2 for RIKEN RI-Beam Factory is under construction. The three drift tube linac cavities (DTLs), located downstream of an RFQ linac, are designed to operate at a fixed RF frequency of 36.5 MHz, and to accelerate very heavy ions such as $136Xe^{20+}$ and $238U^{35+}$ from 100 keV/u to 680 keV/u for the injection to the RIKEN Ring Cyclotron. The first two cavities (DTL1 and 2) are newly constructed, and an existing cavity is modified for the last one (DTL3). The structure is based on the quarter-wavelength resonator. The inner diameter ranges from 0.8 to 1.3 m, depending on the beam energy. In order to save the construction cost and space for the equipments, direct coupling scheme has been adopted for the RF amplifier. A decrease of resonant frequency due to this coupling scheme was estimated by lumped-circuit and Microwave Studio (MWS) calculations. The decrease was compensated by the cavity height prior to the construction/modification. A capacitive coupler is also designed by MWS to match the input impedance from a tetrode to the cavity (700 Ohm). High power test is scheduled in December 2009.

THPEA024 **Duct-Shaped SiC Dummy Load of L-band Power Distribution System for XFEL/SPring-8** – *J. Watanabe, S. Kimura, K. Sato (Toshiba) T. Asaka, H. Ego, H. Hanaki (JASRI/SPring-8)*

TOSHIBA is manufacturing the L-band acceleration system for the SPring-8 Joint Project for XFEL. We have developed a new type duct-shaped SiC dummy load for its power distribution system. The load terminates a WR650 waveguide and can absorb the maximum mean power of 10kW. In order to reduce VSWR less than 1.1 in the frequency range of 1.428GHz, we shaped the SiC absorber into a 35cm long tapered cylinder and mounted matching stubs in the waveguide near the inlet of the load. The SiC absorber was fit into a cylindrical copper with efficient water-cooling channels. The design and manufacture and the low-power tests of our original dummy load are described in this paper.

THPEA025 **HOM Characteristics Measurement of Mini-LIA Cavity** – *C. Cheng, J.S. Duo, J. Lv, S.X. Zheng (TUB) J. Li (CAEP/IFP)*

Mini-LIA was a miniature linear induction accelerator designed and manufactured by China Academy of Engineering Physics and Tsinghua University. To investigate the higher order mode (HOM) of Mini-LIA cavity, especially the frequency and quality factor Q of the TM110 and TM120 in it, both numerical simulation and experiments were performed. Several models of the cavity were established and calculated by using E module of MAFIA code. Network analyzer was applied to measure the frequency and Q in cavity. Both the simulation results and the experiment results are presented in this paper. The results of the experiments were coincident with the calculated results. Finally, The HOM characteristic of Mini-LIA cavity with metglass core in it was explored, and some interesting results was obtained.

THPEA026 **Investigation of the Genetic Algorithm in the Diagnosis of the Coupled Cavity Chain** – *Q.Z. Xing, D.C. Tong (TUB)*

The application of the genetic algorithm in the diagnosis of the coupled cavity chain is investigated in this paper. One program named GANL2 has already been developed based on the genetic algorithm at Tsinghua University. The cell frequencies, quality factors, and coupling between the cells can be estimated by GANL2 if the pass-band information S11 is already known. This method has been applied in the diagnosis of the 9-cell superconducting ICHIRO copper cavity model. The comparison of the results of the calculation and measurement are presented.

THPEA027 **Study on Frequency Change by 3D Reconstruction of Deformed Cavities of LINAC Collinear Load** – *Z. Shu, L.G. Shen, Y. Sun, X.C. Wang (USTC/PMPI) Y.J. Pei (USTC/NSRL)*

Thermal deformation of accelerating cavities affects their resonant frequency deeply. While conventional evaluation methodology is usually linear and rough, a new approach of 3D reconstruction was utilized to reconstruct the deformed solid geometry model. Nodal temperature and displacement distribution which is non-uniform were obtained in CAE software I-DEAS. First renewed the FE model by adding the nodal displacements to the coordinates of the corresponding nodes. Then extract and sort the boundary nodal data of the cavities according to which the section curves of the inner surfaces are obtained. Finally the deformed solid model enclosed by the inner surfaces was got and directly saved as IGES files which can be imported into CST Microwave Studio for electromagnetic analysis. The data processing and reconstruction operation is done in self-developed JAVA programs by which the accurate influence of deformation of different shapes on frequency change can be acquired. This method is now applied on a 10kW collinear load of a LINAC on which a symmetrical double helix water jacket is adopted in cooling system. The error of reconstruction is controlled within one micrometers.

THPEA028 **Prelimimary Study of the Higher-harmonic Cavity for the Upgrade Project of Hefei Light Source** – *C.-F. Wu, L. Wang (USTC/NSRL)*

A radio frequency system with a higher-harmonic cavity will be used to increase the beam lifetime and suppress coupled-bunch instabilities of the upgrade Hefei Light Source. In the paper, the simulated results confirm that tuning in the harmonic cavity may suppresses the parasitic coupled-bunch instabilities. The higher-harmonic cavity has been designed and the calculated optimum lifetime increase ratio is 2.58.

THPEA029 **Study of Induction Accelerating Cavity for a Helium Ion FFAG Accelerator** – *Y.C. Xu, H. Hao, H.L. Luo, X.Q. Wang (USTC/NSRL)*

A high current Helium Ion FFAG accelerator dedicated to study the influence of Helium embitterment to fusion reactor envelope material was proposed in National Synchrotron Radiation Laboratory (NSRL) at University of Science and Technology of China (USTC). In this paper, conceptual design of an induction accelerating cavity employed for the FFAG is given. The cavity driven by the solid-state modulator is designed to have a 10 kV output with 900 ns to 300 ns flat-top, 0.5 MHz to 1.5 MHz repetitive frequency, corresponding to the Helium ion beam energy from 0.8 MeV to 10 MeV. Properties of the induction cavity such as inductance, stray capacitance, and resistance representing eddy current loss and core excitation loss are discussed. The electric field distribution in the cavity is obtained using the numerical simulation software OPERA-3D.

THPEA030 **Design and Analysis of RF Cavities for the Cyclotron CYCHU-10** – *T. Hu, X. Hu, D. Li, P. Tan, J. Yang, T. Yu (HUST)*

The design study of a 10Mev compact cyclotron CYCHU-10 has been developed at Huazhong University of Science and Technology (HUST). We developed the basic shapes and dimensions and carried out the simulations for the CYCHU-10 cavities with 3D numerical calculation softwares in this paper. The distributions of electromagnetic field, temperature and displacements in cavities are illustrated as well, by means of the electromagnetic, thermal and structural analysis. In addition, This paper gives the frequency shift results after remodeling the cavities which deformed due to high frequency power dissipation under practical operation condition. This work helps to evaluate the performances of capacitive frequency trimmer design.

THPEA031 **Development of a 13.56MHz RF Implanter at PEFP** – *T.A. Trinh, Y.-S. Cho, I.-S. Hong, J.-H. Jang, H.S. Kim, H.-J. Kwon, H.R. Lee, B.-S. Park (KAERI)*

Due to the increasing interest of the microelectronic industry in the implantation of ions with dose as high as 10^{18} ion/cm^2 at a reasonable price and limitation of space, RF linac is well suited. The RF system is roughly half of the total cost of the linac structure. The 13.56MHz RF generator is cheap and readily available. Therefore, an RF implanter using the cavity operating at 13.56MHz has now been considered and developed at Proton Engineering Frontier Project (PEFP) - Korea. The simulation results show that the quality factor is 2500 at 1kW RF power and this 40cm diameter cavity can accelerate particles up to 32keV/u for charge to mass ratio of 1/4. The accelerator design concept, fabrication, testing and commissioning are presented in this presentation.

THPEA032 **Commissioning of L-band Intense Electron Accelerator for Irradiation Applications** – *S.H. Kim, M.-H. Cho, S.D. Jang, W. Namkung, S.J. Park, H.R. Yang (POSTECH) K.H. Chung, K.O.LEE. Lee (KAPRA) J.-S. Oh (NFRI)*

An intense L-band electron linac is now being commissioned at ACEP (Advanced Center for Electron-beam Processing in Cheorwon, Korea) for irradiation applications in collaboration with POSTECH (Pohang University of Science and Technology) and KAPRA (Korea Accelerator and Plasma Research Association). It is capable of producing 10-MeV electron beams with average 30-kW. For a high-power capability, we adopted the L-band traveling-wave structure operated with a $2\pi/3$ mode. The RF power is supplied by the pulsed 25-MW and average 60-kW klystron with the matched pulse modulator and the inverter power supplies. The accelerating gradient is 4.2 MV/m with the beam current of 1.45 A which is fully beam-loaded condition. The solenoidal magnetic field is 700 Gauss to focus the electron beam and suppress the BBU instability. In this paper, we present commissioning status with details of the accelerator system.

THPEA033 **Commissioning of C-band Standing-wave Accelerator** – *H.R. Yang, M.-H. Cho, S.D. Jang, S.H. Kim, W. Namkung, S.J. Park (POSTECH) K.H. Chung, K.O.LEE. Lee (KAPRA) J.-S. Oh (NFRI)*

A C-band standing-wave electron accelerator for a compact X-ray source is being commissioned at ACEP (Advanced Center for Electron-beam Processing in Cheorwon, Korea). It is capable of producing 4-MeV electron beam with pulsed 50-mA. The RF power is supplied by the 5-GHz magnetron with pulsed 1.5 MW and average 1.2 kW. The accelerating column is a bi-periodic and on-axis-coupled structure operated with $\pi/2$-mode standing-waves. It consists of 3 bunching cells, 6 normal cells and a coupling cell. As a result of cold tests, the resonant frequency of the accelerating column is 4999.17 MHz at the $\pi/2$-mode and the coupling coefficient is 0.92. The field flatness was tuned to be less than 2%. In this paper, we present commissioning status with design details of the accelerator system.

THPEA035 **Multi-cell RF Deflecting System for Formation of Hollow High Energy Heavy Ion Beam** – *A. Sitnikov, N.N. Alexeev, A. Golubev, V.A. Koshelev, T. Kulevoy, S. Minaev, B.Y. Sharkov (ITEP) D.H.H. Hoffmann, N.A. Tahir, D. Varentsov (GSI)*

Terra Watt Accumulator project (ITEP-TWAC) is aiming the accumulation of an ion beam accelerated up to 0.7 GeV/u in a storage ring providing intensity of heavy ions up to 10 power 12 particles per pulse for experiments on heavy ion beam-plasma interaction. For advanced experiments on high energy density physics the hollow cylindrical target is needed. A new method for RF rotation of the ion beam is applied for reliable formation of the hollow cylindrical beam. A principle of fast beam rotation by using a system of the multi-cell RF deflectors is considered in this paper. A four-cell H-mode deflecting cavity operating at the frequency of 298 MHz has been developed; similar 1.5 m long cavities being applied for both x- and y- directions. The shape of the deflecting electrodes has been optimized in order to provide the uniform deflection over the whole aperture taking into account both electric and magnetic components of the RF field. A deflecting system and a focusing quadrupole triplet applied to the beam with the energy of 450 MeV/u and normalized transverse emittance of 10*pi mrad*mm may form the quasi-hollow configuration with the inner radius up to 1.5 mm and thickness of 1 mm.

THPEA036 **Stabilization of the Polarization Plane in Traveling Wave Deflectors** – *N.P. Sobenin, A. Anisimov, I.I.V. Isaev, S.V. Kutsaev, M.V. Lalayan, A.Yu. Smirnov (MEPhI) A.A. Zavadtsev, D.A. Zavadtsev (Nano)*

In this paper the alternative possibilities in order to stabilize the TH11-wave polarization plane used in traveling wave deflectors are considered. Along with a classical structure with two stabilizing holes, the structures with grooves in cells or with oval apertures were proposed. The comparison of mentioned structures designed for European X-FEL project in terms of electrodynamical parameters, thermal regimes and manufacturing technology shows the advantages of the suggested structures. Some of them are better RF modes separation, stronger electrical endurance and simpler cooling. The specifics of such structures tuning are also described.

THPEA039 **Constructions of DC Potential Input into Resonator of Linear Accelerators** – *P.R. Safikanov, S.M. Polozov (MEPhI)*

Nowadays the DC potential using was proposed for ion beam focusing in linear accelerators. It was proposed to use the DC potential for combined beam focusing (electrostatic focusing and focusing by using of higher RF field spatial harmonics) in bunching section of linac *. These accelerators use an IH-type resonator. So-called linear undulator accelerator (UNDULAC) was proposed for ribbon ion beam bunching and acceleration **. One of possible scheme of UNDULAC can be realized using an electrostatic undulator in E-type resonator. In this report the different types of the electrostatic potential inputting into resonator will discussed.

THPEA040 **Characteristics of the Parallel Coupled Accelerating Structure** – *A.E. Levichev, V.M. Pavlov (BINP SB RAS) Y.D. Chernousov (ICKC) V. Ivannikov, I.V. Shebolaev (ICKC SB RAS)*

The prototype of parallel coupled accelerating structure is developed. It consists of five accelerating cavities, common excitation cavity and RF power waveguide feeder. The excitation cavity is a segment of rectangular waveguide loaded by resonance copper pins. The excitation cavity operate mode is TE10[5]. Connection between excitation cavity and accelerating cavities is performed by magnetic field. The theoretical model of the parallel coupled accelerating structure is developed. According to model the tuning and matching of the structure are performed. The electrodynamics characteristics are measured. In storage energy regime the accelerated electron beam is obtained.

THPEA041 **Manufacturing and Testing of a TBL PETS Prototype** – *F. Toral, P. Abramian, J. Calero, D. Carrillo, F.M. De Aragon, L. García-Tabarés, J.L. Gutierrez, A. Lara, E. Rodríguez García, L. Sanchez (CIEMAT) S. Doebert, I. Syratchev (CERN)*

The goal of the present CLIC test facility (CTF3) is to demonstrate the technical feasibility of the CLIC scheme. The Test Beam Line (TBL) is used to study a CLIC decelerator focusing on 12 GHz power production and the stability of the decelerated beam. The extracted CTF3 drive beam from the combiner ring (CR) features a maximum intensity of 28 A and 140 ns pulse duration, where the Test Beam Line consists of 16 cells, each one including a BPM, a quadrupole on top of a micrometer-accuracy mover and a RF power extractor so-called PETS (Power Extraction and Transfer Structure). This paper describes the first prototype fabrication techniques, with particular attention to the production of the long copper rods which induce the RF generation. A special test bench for the characterization of the device with low RF power measurements has been developed. Performed mesurements of the scattering parameters and the electric field profile along the structure are carefully described. Finally, the prototype has been installed at CLEX, and first measurements with beam are also reported.

THPEA042 **Engineering Design of a Multipurpose X-band Accelerating Structure** – *D. Gudkov, G. Riddone, A. Samoshkin, I. Syratchev, R. Zennaro (CERN) M.M. Dehler, J.-Y. Raguin (PSI)*

PSI-XFEL and Elettra-Fermi-require a X-band RF structure. As CLIC is pursuing a program for producing and testing x-band high-gradient RF structures, a collaboration between PSI, Elettra and CERN, has been established to build a multipurpose X-band accelerating structure. This paper focuses on its engineering design which is based on disk-shaped cells bonded together by different technologies (diffusion bonding, vacuum brazing and laser beam welding). The accelerating structure consists of 2 coupler subassemblies and 73 disks, and include wake field monitor waveguides. The engineering study also comprises the external cooling system, consisting of two parallel cooling circuits, and the tuning system, allowing for the fine-tuning by means of cell deformations. The engineering solution for installation and sealing of wake field monitor feed-through devices inside the accelerating structure RF-cavity is also proposed.

THPEA043 **RF Pulse Compression Stabilization at the CTF3 CLIC Test Facility** – *A. Dubrovsky, F. Tecker (CERN)*

In the CTF3 accelerator, the RF produced by each of ten 3 GHz klystrons goes through waveguides, RF pulse compressors and splitters. The RF phase and power transformation of these devices depend on their temperature. The quantitative effect of the room temperature variation on the RF was measured. It is the major source of undesired changes during the CTF3 operation. An RF phase-loop and a compressor temperature stabilization are developed to suppress the phase fluctuation and the power profile change due to the temperature variation. The implementation is transparent for operators it does not limit anyhow the flexibility of RF manipulations. Expected and measured suppression characteristics will be given. As well RF measurement dependence on the temperature will be mentioned.

THPEA044 **Effects of Manufacturing Techniques on Cavity Surface and Breakdown Performance** – *A. Zarrebini, M. Ristic (Imperial College of Science and Technology) A. Kurup, K.R. Long, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics) R. Seviour, M.A. Stables (Cockcroft Institute, Lancaster University)*

To reduce manufacturing and operating costs, the next generation of particle accelerators are required to operate with very high accelerating gradients. Yet, the volume production of high field cavities has proved difficult. RF breakdown is a major limiting factor, where it is believed to be directly dependent on the surface quality. During production, the surface of the cavity is subject to both mechanical and chemical alterations. Production techniques introduce different stress patterns into the molecular structure of the metal. This coupled with the impurities introduced would eventually alter the chemical composition and the quality of the surface. This paper aims to present the preliminary results of a systematic experimental study conduced on several button samples fabricated using various techniques. XPS and Interferometer machinery are used to demonstrate how changes occur during each stage of production. The button design allows for high power RF tests being conducted using MTA's 805 MHz cavity. The evaluation of their performance allows better-suited production techniques to be indentified and ensure greater performance and reliability.

THPEA045 **Development of a Dielectric-loaded Accelerating Structure with Built-in Tunable Absorption Mechanism for High Order Modes** – *S.P. Antipov, W. Gai, O. Poluektov (ANL) C.-J. Jing, A. Kanareykin, P. Schoessow (Euclid TechLabs, LLC)*

As the dimensions of accelerating structures become smaller and beam intensities higher, the transverse wakefields driven by the beam become quite large with even a slight misalignment of the beam. These deflection modes can cause inter-bunch beam breakup and intra-bunch head-tail instabilities along the beam path. We propose a built-in tunable absorption mechanism for damping the parasitic transverse modes without affecting the operational modes in dielectric loaded accelerating (DLA) structures and wakefield power extractors. The new principle for HOM absorption is based on electron paramagnetic resonance. The dielectric tube of the DLA has to be doped with a material exhibiting high EPR, for example ruby, Al2O3 overdoped ~1% with Cr^{3+}. The absorption frequency can be tuned by an external DC magnetic field to match the frequency of the transverse mode. At the resonance imaginary part of permeability becomes significant and the dielectric tube acts as an absorber for the transverse modes. The external DC magnetic field is solenoidal and has to have a magnitude of about 3 kG. This configuration in fact is desirable to focus the beam and provide additional control of beam break up.

THPEA046 **The MuCool RF Program** – *A.D. Bross, M. Chung, A. Jansson, A. Moretti, K. Yonehara (Fermilab) D. Huang, Y. Torun (IIT) D. Li (LBNL) J. Norem (ANL) R. B. Palmer, D. Stratakis (BNL) R.A. Rimmer (JLAB)*

The MuCool RF Program focuses on the study of normal conducting RF structures operating in high magnetic field for applications in muon ionization cooling for Neutrino Factories and Muon Colliders. This talk will give an overview of the program, will include a description of the test facility and its capabilities, the current test program, and the latest results from the program. Results on RF structures utilizing Be will be presented as well as a results with a cavity that can be rotated in the magnetic field which allows for a more detailed study of the maximum stable operating gradient vs. magnetic field strength and angle. Results from tests of a high-pressure Hydrogen gas-filled cavity will also be discussed.

THPEA047 **Dielectric Loaded RF Cavities** – *M. Popovic, A. Moretti (Fermilab) M.A.C. Cummings, M.L. Neubauer (Muons, Inc)*

Alternative RF cavity fabrication techniques for accelerator applications at low frequencies are needed to improve manufacturability, reliability and cost. RF cavities below 800 MHz are large, take a lot of transverse space, increase the cost of installation, are difficult to manufacture, require significant lead times, and are expensive. Novel RF cavities partially loaded with a ceramic for accelerator applications will allow smaller diameter cavities to be designed and built. The manufacturing techniques for partially loaded cavities will be explored. A new 200MHz cavity will be built for the Fermilab Proton Source to improve the longitudinal emittance and energy stability of the linac beam at injection to the Booster. A cavity designed for 400 MHz with a ceramic cylinder will be tested at low power at cryogenic temperatures to test the change in Qo due to the alumina ceramic. Techniques will be explored to determine if it is feasible to change the cavity frequency by replacing an annular ceramic insert without adversely effecting high power cavity performance.

THPEA048 **Compact, Tunable RF Cavities** – *R.P. Johnson, M. Alsharo'a, M.L. Neubauer (Muons, Inc) A. Moretti, M. Popovic (Fermilab)*

New developments in the design of fixed-field alternating gradient (FFAG) synchrotrons have sparked interest in their use as rapid-cycling, high intensity accelerators of ions, protons, muons, and electrons. Compact RF cavities that tune rapidly over various frequency ranges are needed to provide the acceleration in FFAG lattices. An innovative design of a compact RF cavity that uses orthogonally biased ferrite or garnet materials for fast frequency tuning and liquid dielectric to reduce the overall cavity size will be developed using computer models, prototyped, and tested. This type of cavity will be useful in a variety of FFAG accelerators and other scientific and commercial applications. The ferrite and garnet test cavity and the model cavity that were built in a previous STTR project will be used as a basis for developing a complete engineering design. Several important engineering issues will be addressed: a double window will be used between the cavity and beam pipe, an RF input coupler will be designed, and a cooling loop designed to control the temperature of the cavity elements within required limits as it is tuned.

THPEA049 **The Normal Conducting RF Cavity for MICE** – *D. Li, A.J. DeMello, S.P. Virostek, M.S. Zisman (LBNL)*

Normal conducting RF cavities must be used for the cooling section of international Muon Ionization Cooling Experiment (MICE) which is currently under construction at Rutherford Appleton Laboratory (RAL) in UK. Eight 201-MHz cavities are needed for the MICE cooling section; fabrication of the first five cavities is nearly complete. This paper reports the cavity fabrication status that includes the cavity design, fabrication techniques and preliminary low power RF measurements of the first five cavities.

THPEA050 **Normal Conducting RF Cavity R&D for Muon Ionization Cooling** – *D. Li, S.P. Virostek, M.S. Zisman (LBNL) A.D. Bross, A. Moretti, Z. Qian (Fermilab) D. Huang, Y. Torun (IIT) J. Norem (ANL) R. B. Palmer, D. Stratakis (BNL)*

Normal conducting RF cavity is required for muon ionization cooling channels. The cavity must operate in a few-Tesla magnetic fields environment. Cavity surface damage associated with multipactoring and RF breakdown due to the external magnetic fields remains a challenge for operating the cavity in accelerating high gradient. This paper reviews the experimental and theoretical studies conducted in the US Neutrino Factory and Muon Collider Collaboration (NFMCC) and reports current progress and proposed R&D programs.

THPEA051 **A Method for Establishing Q-factors of RF Cavities** – *X.D. Ding, S. Boucher (RadiaBeam)*

The distribution of electromagnetic fields in an RF cavity is primarily determined by the geometry of the RF cavity. The quality factor (Q-factor) of an RF cavity characterizes RF losses in the cavity: an RF cavity having a higher Q-factor is a more efficient user of RF power. However, a cavity having a lower Q-factor can operate on a wider range of frequencies, shorter filling time and may be more stable and less sensitive to input power perturbations. A method is discussed in this paper for an RF cavity that provided a desired Q-factor for the cavity while enabling a desired field distribution for electron acceleration within the cavity. The structure forming the inner wall of the RF cavity may be comprised of different types of material(such as copper and steel). Using different materials for different portions of the inner walls forming a cavity will cause different Q-factors for the cavity while the shape of the cavity remains constant.

THPEA052 **The Design of Fast Extraction Kicker for ALPHA** – *T.H. Luo, S.-Y. Lee (IUCF)*

In the accumulation mode of ALPHA, we need to accumulate 10^{00} nC electron beam in the ring and extract them out of ring in one turn. We design a traveling wave fast kicker to finish this extraction task.

THPEA053 **805 MHz Pillbox RF Cavity Upgrade for Muon Cooling** – *Y. Torun, D. Huang (IIT) A.D. Bross, A. Kurup, A. Moretti (Fermilab) D. Li, S.P. Virostek, M.S. Zisman (LBNL) J. Norem (ANL) R. B. Palmer, D. Stratakis (BNL) R.A. Rimmer (JLAB) D.J. Summers (UMiss)*

RF cavities for muon cooling must operate in strong external magnetic fields used for focusing the muon beam in an ionization cooling channel. Since magnetic field increases the probability of surface damage, it is important to study the breakdown resistance of different materials and surface finishes in-situ in a systematic way. An 805-MHz Cu pillbox cavity has been tested at the Fermilab MuCool Test Area with demountable buttons on one side. Using curved buttons, the electric field is enhanced which increases the probability of breakdown on the button surface and allows comparison of different materials. The cavity was recently refurbished. The button holder design was updated for higher field enhancement and support was added for mounting buttons on both sides for a symmetric configuration. The cavity will be tested with Be buttons, a material believed to be superior to Cu for breakdown resistance in high magnetic field.

THPEA054 **Rectangular Box Cavity Tests in Magnetic Field for Muon Cooling** – *Y. Torun, D. Huang (IIT) A.D. Bross, M. Chung, A. Jansson, A. Kurup, J.R. Misek, A. Moretti (Fermilab) J. Norem (ANL)*

Muon cooling requires high-gradient normal conducting cavities operating in multi-Tesla magnetic fields for muon beam focusing in an ionization cooling channel. Recent experience with an 805-MHz pillbox cavity at the Fermilab MuCool Test Area has shown significant drop in accelerating field performance for the case of parallel electric and magnetic fields. It has been suggested that having the magnetic field perpendicular to the electric field should provide magnetic insulation and suppress breakdown. An 805-MHz Cu rectangular box cavity was built for testing with the fields perpendicular. It was mounted on an adjustable support to vary the angle between the rf electric and external magnetic field. We report on design and operation of the rectangular box cavity.

THPEA055 **500 MW X-band RF System of a 0.25 GeV Electron LINAC for Advanced Compton Scattering Source Application** – *T.S. Chu, S.G. Anderson, C.P.J. Barty, D.J. Gibson, F.V. Hartemann, R.A. Marsh, C. Siders (LLNL) E.N. Jongewaard, S.G. Tantawi, A.E. Vlieks, J.W. Wang (SLAC)*

A Mono-Energetic Gamma-Ray Compton scattering light source is being developed at LLNL. The electron beam for the interaction will be generated by a X-band RF gun and LINAC at the frequency of 11.424 GHz. High power RF in excess of 500 MW is needed to accelerate the electrons to energy of 250 MeV or greater. Two high power klystrons, each capable of generating 50 MW, 1.5 msec pulses, will be the main RF sources for the system. These klystrons will be powered by state of the art solid-state high voltage modulators. A RF pulse compressor, similar to the SLED II pulse compressor, will compress the klystron output pulse with a power gain factor of five. For compactness consideration, we are looking at a folded RF line. The goal is to obtain 500 MW at output of the compressor. The compressed pulse will then be distributed to the RF gun and to six traveling wave accelerator sections. Phase shifter and amplitude control are located at the RF gun input and additional control points along the LINAC to allow for parameter control during operation. This high power RF system is being designed and constructed. In this paper, we will present the design, layout, and status of this RF system.

THPEA056 **Advanced X-band Test Accelerator for High Brightness Electron and Gamma Ray Beams** – *R.A. Marsh, S.G. Anderson, C.P.J. Barty, T.S. Chu, C.A. Ebbers, D.J. Gibson, F.V. Hartemann (LLNL) C. Adolphsen, E.N. Jongewaard, T.O. Raubenheimer, S.G. Tantawi, A.E. Vlieks, J.W. Wang (SLAC)*

In support of Compton scattering gamma-ray source efforts at LLNL, a multi-bunch test stand is being developed to investigate accelerator optimization for future upgrades. This test stand will enable work to explore the science and technology paths required to boost the current 10 Hz mono-energetic gamma-ray (MEGa-Ray) technology to an effective repetition rate exceeding 1 kHz, potentially increasing the average gamma-ray brightness by two orders of magnitude. Multiple bunches must be of exceedingly high quality to produce narrow-bandwidth gamma-rays. Modeling efforts will be presented, along with plans for a multi-bunch test stand at LLNL. The test stand will consist of a 5.5 cell X-band rf photoinjector, single accelerator section, and beam diagnostics. The photoinjector will be a high gradient standing wave structure, featuring a dual feed racetrack coupler. The accelerator will increase the electron energy so that the emittance can be measured using quadrupole scanning techniques. Multi-bunch diagnostics will be developed so that the beam quality can be measured and compared with theory. Design will be presented with modeling simulations, and layout plans.

THPEA057 **Development of a CW NCRF Photoinjector using Solid Freeform Fabrication (SFF)** – *P. Frigola, R.B. Agustsson (RadiaBeam) L. Faillace (Rome University La Sapienza) O. Harrysson, K. Knowlson, T. Mahale (NCSU) R.A. Rimmer (JLAB)*

Development of very high duty cycle, high gradient photoinjectors is critical for the next generation of accelerator systems. A key issue for high average power, normal conducting radio frequency (NCRF), photoinjectors is efficient structure cooling. To that end, RadiaBeam has been developing the use of Solid Freeform Fabrication (SFF) for the production of NCRF photoinjectors. In this paper we describe the preliminary design of a high gradient, very high duty cycle, photoinjector combining the cooling efficiency only possible through the use of SFF, and the RF efficiency of a re-entrant gun design. Simulations of the RF and thermal-stress performance will be presented, as well as material testing of SFF prototype components.

THPEA058 **Development of a High Brightness Photoinjector using Solid Freeform Fabrication (SFF)** – *P. Frigola, R.B. Agustsson (RadiaBeam) L. Faillace, A. Fukasawa, B. D. O'Shea, J.B. Rosenzweig (UCLA) O. Harrysson, K. Knowlson, T. Mahale (NCSU) B. Spataro (INFN/LNF)*

Development of high brightness photoinjectors is critical for the next generation of accelerator systems. A key issue limiting the repetition rate of high gradient, normal conducting radio frequency (NCRF), photoinjectors is efficient structure cooling. RadiaBeam Technologies has been developing the use of Solid Freeform Fabrication (SFF) for the production of NCRF photoinjectors. In this paper we describe the preliminary design of a high brightness photoinjector utilizing a cooling scheme only possible through the use of SFF. We also present a preliminary analysis of this technique applied to the S-band hybrid photoinjector currently under development at UCLA and INFN-LNF, in which we show calculations indicating the possibility of >1kHz operation. Simulation of the thermal-stress performance will be presented, as well as material testing of a SFF prototype cathode.

THPEA059 **Ultra-high Gradient Compact S-band Linac for Laboratory and Industrial Applications** – *A.Y. Murokh, R.B. Agustsson, L. Faillace, P. Frigola (RadiaBeam) V.A. Dolgashev (SLAC) J.B. Rosenzweig (UCLA)*

There is growing demand from the industrial and research communities for high gradient, compact RF accelerating structures. The commonly used S-band SLAC-type structure has an operating gradient of only about 20 MV/m; while much higher operating gradients (up to 70 MV/m) have been recently achieved in X-band, as a consequence of the substantial efforts by the Next Linear Collider (NLC) collaboration to push the performance envelope of RF structures towards higher accelerating gradients. Currently however, high power X-band RF sources are not readily available for industrial applications. Therefore, RadiaBeam Technologies is developing a short, standing wave S-band structure which uses frequency scaled NLC design concepts to achieve up to a 50 MV/m operating gradient at 2856 MHz. The design and prototype commissioning plans are presented.

THPEA060 **Status of High Power Tests of Normal Conducting Single-Cell Standing Wave Structures** – *V.A. Dolgashev, S.G. Tantawi, A.D. Yeremian (SLAC) Y. Higashi (KEK) B. Spataro (INFN/LNF)*

We report results of ongoing high power tests of single cell standing wave structures. These tests are part of an experimental and theoretical study of rf breakdown in normal conducting structures at 11.4 GHz. The goal of this study is to determine the accelerating gradient capability of normal-conducting rf powered particle accelerators. The test setup consists of reusable mode-launchers and short test structures powered by SLAC's XL-4 klystron. We have tested structures of different geometries, cell joining techniques, and materials, including hard copper alloys and molybdenum. We found that the behavior of the breakdown rate is reproducible for different structures of the same geometry and material. The breakdown rate dependence on peak magnetic fields is stronger than on peak surface electric fields for structures of different geometries.

THPEA061 **RF Breakdown Studies with a Dual-moded Cavity** – *C.D. Nantista, C. Adolphsen, F. Wang (SLAC)*

The phenomenon of rf breakdown presents a technological limitation in the application of high-gradient particle acceleration in normal conducting rf structures. Attempts to understand the onset of this phenomenon and to study its limits with different materials, cell shapes, and pulse widths has been driven in recent years by linear collider development. One question of interest is the role magnetic field plays relative to electric field. A design is presented for a single, non-accelerating, rf cavity resonant in two modes, which, driven independently, allow the rf magnetic field to be increased on the region of highest electric field without affecting the latter. The design allows for the reuse of the cavity with different samples in the high-field region. Available high-power data will also be presented.

THPEA063 **X-band RF Gun Development** – *A.E. Vlieks, V.A. Dolgashev, S.G. Tantawi (SLAC) S.G. Anderson, F.V. Hartemann, R.A. Marsh (LLNL)*

In support of the T-REX program at LLNL and the High Gradient research program at SLAC, a new X-band multi-cell RF gun is being developed. This gun, similar to an earlier gun developed at SLAC for Compton X-ray source program, will be a standing wave structure made of 5.5 cells operating in the pi mode with copper cathode. This gun was designed following criteria used to build SLAC X-band high gradient accelerating structures. It is anticipated that this gun will operate with surface electric fields on the cathode of 200MeV/m with low breakdown rate. RF will be coupled into the structure through a symmetric final cell with a shape optimized to eliminable both dipole and quadruple field components. In addition, geometry changes to the original gun, operated with Compton X-ray source, will include a wider RF mode separation, reduced surface electric and magnetic fields.

THPEA064 **Fabrication Technologies of the High Gradient Accelerator Structures at 100MV/m Range** – *J.W. Wang, J.R. Lewandowski, J.W. Van Pelt, C. Yoneda (SLAC) B.A. Gudkov, G. Riddone (CERN) T. Higo, T. Takatomi (KEK)*

A CERN-SLAC-KEK collaboration on high gradient X-band structure research has been established in order to demonstrate the feasibility of the CLIC baseline design for the main linac stably operating at more than 100 MV/m loaded accelerating gradient. Several prototype CLIC structures were successfully fabricated and high power tested. They operated at 105 MV/m with a breakdown rate that meets the CLIC linear collider specifications of $< 5\cdot10^{-7}$/pulse/m. This paper summarizes the fabrication technologies including the mechanical design, precision machining, chemical cleaning, diffusion bonding as well as vacuum baking and all related assembly technologies. Also, the tolerances control, tuning and RF characterization will be discussed.

THPEA065 **RF Choke for Standing Wave Structures and Flanges** – *A.D. Yeremian, V.A. Dolgashev, S.G. Tantawi (SLAC)*

SLAC participates in the U.S. High Gradient collaboration whose charter includes basic studies of rf breakdown properties in accelerating structures. These studies include experiments with different materials and construction methods for single cell standing wave accelerating structures. The most commonly used method of joining cells of such structures is the high temperature bonding and/or brazing in hydrogen and/or vacuum. These high temperature processes may not be suitable for some of the new materials that are under consideration. We propose to build structures from cells with an rf choke, taking the cell-to-cell junction out of the electromagnetic field region. These cells will be clamped together in a vacuum enclosure, the choke joint ensuring continuity of rf currents. Next, we propose a structure with a choke joint in a high gradient cell and a view port which may allow us microscopic, in-situ observation of the metal surface during high power tests. And third, we describe the design of a TM01 choke flange for these structures.

THPEA068 **Cryogenic System Design for SPIRAL2 LINAC Project at GANIL (France)** – *S. Crispel, F. Delcayre, F. Ferrand, G. Flavien, D. Grillot, J.-M. bernhardt (Air Liquide, Division Techniques Avancées) C. Commeaux (IPN) P. Dauguet (Air Liquide) M. Souli (GANIL)*

The future superconducting Linear accelerator of the SPIRAL2 project at GANIL (France) will require a complete helium cryogenic system. Air Liquide DTA has been selected to provide around 1300W equivalent refrigeration power at 4.5K with mainly refrigeration load but also helium liquefaction rate and 60K thermal shields feed. The Helium cold box designed and manufactured by Air Liquide DTA will be derived from the standard HELIAL LF product to match the need for the SPIRAL2 project. The cryogenic system also includes a liquid Dewar, cryogenic lines and recovery system for liquefaction rate. Cryogenic distribution line and valves boxes for LINAC Cryomodules are designed and installed by GANIL.

THPEA069 **Runtime Experience and Impurity Investigations at the ELBE Cryogenic Plant** – *Ch. Schneider, P. Michel (FZD) Ch. Haberstroh (TU Dresden)*

The superconducting linear accelerator ELBE at the Forschungszentrum Dresden/Rossendorf has two superconducting accelerator modules and a superconducting photo injector (SRF-Gun). They are operated by a cryogenic Helium plant with a cooling power of 200 W at 1.8 K. Since the commissioning of the plant in 1999 minor and major impurity problems have influenced the operation stability of the plant. The presentation will give an overview of the ELBE cryogenic system and will focus on the different sources of plant contamination and their effects on the plant operation which have been found during the nearly 10 years of plant lifetime. Especially the contamination with residues of oil brake up so as air and water from different sources have limited the run periods of the plant and effected special service and maintenance procedures.

THPEA070 **Performance of Two Additional Cryomodules for Superconducting Linac at IUAC. Delhi** – *T.S. Datta, J. Antony, S. Babu, J. Chacko, A. Choudhury, S. Kar, M. Kumar, A. Roy (IUAC)*

Superconducting Linac at Delhi was partly established and commissioned with one linac cryomodule to house 8 quarter wave niobium cavities along with buncher and rebuncher cryomodule. Two more linac cryomodules are designed, developed and integrated with beam line and cryo distribution line recently. Design of present modules are modified based on the feedback from earlier modules. Present paper will be highlighting the modified design along with thermal and vacuum performance of the present modules w.r.t earlier module.

THPEA071 **Cryogenics for the KEKB Superconducting Crab Cavities** – *H. Nakai, K. Hara, T. Honma, K. Hosoyama, A. Kabe, Y. Kojima, Y. Morita, K. Nakanishi (KEK) T. Kanekiyo (Hitachi Technologies and Services Co., Ltd.)*

Two superconducting crab cavities were successfully installed into the KEKB accelerator in January 2007. Since then the crab cavities have been in stable operation for 3 years up to now, thanks to reliable operation of the cryogenic system of the KEKB including a large-scale helium refrigerator. This means that the cryostat for the crab cavities was well designed and constructed properly, although there are some technical complexities in the cryostat, such as two helium vessels in a cryostat, a movable coaxial coupler which is cooled with liquid helium and so on. The KEKB cryogenic system was also appropriately modified to operate the two crab cavity cryostats stably. This cryogenic system is described in this presentation. A calorimetric method to measure the Q-factors of the crab cavities is suggested, which employs an electric compensation heater in the cryostat, instead of the conventional method, which measures the descending rate of liquid helium level. Measurement results of the Q-factors of crab cavities after being assembled in the cryostat and after being installed into the KEKB accelerator are compared with the vertical test results.

THPEA072 **Model of HeI/HeII Phase Transition for the Superconducting Line Powering LHC Correctors** – *M. Sitko, B. Skoczen (CUT)*

The array of corrector magnets in the LHC is powered by means of a superconducting line attached to the main magnets. The subcooling time of the line has to be minimized in order not to delay the operation of the collider. The corresponding cable-in-conduit problem is formulated in the framework of two-fluid model and the Gorter-Mellink law of heat transport in superfluid helium. A model of lambda front propagation along the narrow channel containing superconductors and liquid helium is presented. The one-dimensional model* adopts plane wave equations to describe lambda front propagation. This approach to normal-to-superfluid phase transition in liquid helium allows to calculate the time of subcooling and the temperature profile on either side of the travelling front in long channels containing superconducting bus-bars. The model has been verified by comparing the analytical solutions with the experimental results obtained in the LHC String 2 experiment. The process of the LHC Dispersion Suppressors subcooling has been optimized by using the presented model. Based on the results, a novel concept of copper heat exchanger for LHC DS operating in superfluid helium is introduced.

THPEA073 **Operational Experience with the LHC Superconducting Links and Evaluation of Possible Cryogenic Schemes for Future Remote Powering of Superconducting Magnets** – *A. Perin, S.D. Claudet, R. van Weelderen (CERN)*

In the LHC, a large number of superconducting magnets are powered remotely by 5 superconducting links at distances of 70 up to 540 m. This innovation allowed to choose more convenient locations for installing the electrical feedboxes and their related equipment. The consolidations performed after the first commissioning campaign and the operational experience with the superconducting links over a period of several months are presented. Based on the successful application of superconducting links in the LHC, such devices can be envisaged for powering future accelerator magnets. Several possible cryogenic configurations for future superconducting links are presented with their respective figures of merit from the cryogenic and practical implementation point of view.

THPEA075 **Installation and Commissioning of the 200-m Flexible Cryogenic Transfer System** – *M.-C. Lin, L.-H. Chang, M.H. Chang, L.J. Chen, W.-S. Chiou, F.-T. Chung, F. Z. Hsiao, H.C. Li, Y.-H. Lin, C.H. Lo, H.H. Tsai, M.H. Tsai, Ch. Wang, T.-T. Yang, M.-S. Yeh, T.-C. Yu (NSRRC) M. Di Palma, S. Lange, H. Lehmann, K. Schippl (NEXANS Deutschland Industries AG & Co. KG)*

The National Synchrotron Radiation Research Center is constructing the Taiwan Photon Source (TPS), a 3-GeV synchroton facility. The superconducting radio frequency (SRF) cavity modules are selected as the accelerating cavities in the electron storage ring. A test area for the SRF modules is established in the RF laboratory, which includes cryogenic environment, RF transmitter, low level RF control system, and radiation shielded space. The liquid helium is transferred from the cryogenic plant in the experimental area of the Taiwan Light Source (TLS), which is not only far from the RF laboratory but also characterized by a complicated route of 205 meters. The main concerns on the cryogenic transfer are the installation difficulty, heat loss, two-phase flow, and pressure loss. Instead of a multi-channel transfer line, which would request a long installation period on radiation-restrict area, flexible cryogenic transfer lines from Nexans were chosen. The installation period was dramatically reduced to one week. With a test Dewar in the RF lab and valve boxes on both ends of the transfer lines, a long distance cryogenic transfer system was completed and proved to work functional.

THPEA076 **The Current Status of the Cryogenic System Design and Construction for TPS** – *H.H. Tsai, J.-C. Chang, S.-H. Chang, W.-S. Chiou, F. Z. Hsiao, H.C. Li, T. F. Lin (NSRRC)*

The TPS is 3 GeV photon source under construction in Taiwan. The electron needs four superconducting RF cavities to maintain the energy. The construction of a new refrigeration/liquefaction helium plant is under way to supply the liquid helium for superconducting RF cavities. This is the third year of the seven years project and part of the design features and parameters is different from the prilimilary design. This paper presents the design of the cryogenic system, which is including the features of the new cryogenic plant, the pressure drop of warm helium pipeline, the distribution valve box and the multichannel line. The design of liquid nitrogen supply line and the phase separator will be also included.

THPEA077 **Cryogenic Refrigeration Equipment for the New Light Source (NLS) Superconducting LINAC** – *A.R. Goulden, R. Bate, R.K. Buckley, P.A. McIntosh, S.M. Pattalwar (STFC/DL/ASTeC)*

The proposed New Light Source (NLS) based on a CW superconducting linear accelerator requires large scale cryogenic refrigeration equipment comparable to some of largest installations around the world (for example CEBAF/SNS and LHC). The maximum refrigeration power requirement is estimated to be 3.4 kW at 1.8 K. The ratio of the dynamic to the static heat load is in excess of 20 and handling such large variations in the refrigeration power is the key issue in the development of the cryogenic system for NLS. In this paper we present our approach to address the issues relating to efficient and reliable operability, operational functionality and capital costs, in order to develop an effective and economic solution for NLS.

THPEA078 **Compact Turbomolecular-Drag Pumps using Spiral Molecular Drag Stage Designed for High Compression Ratio** – *L. Bonmassar, M. Audi, L. Campagna, E. Emelli, S. Giors (VARIAN S.p.A., Vacuum Products)*

Current commercially available turbomolecular-drag pumps for high vacuum systems are based on either Gaede or Holweck molecular drag technology stages, used in series downstream axial bladed stages to extend the maximum compression ratio up to 10 mbar foreline pressure. Modern Gaede molecular drag stages use a disk-shaped impeller, allowing a very compact design and a maximum compression ratio, limited by the leakage effect, of about 10 per stage. Holweck stages are able to supply a higher compression ratio per stage and a high pumping speed, but with the use of a less compact drum-shaped impeller. In this paper a new spiral molecular drag stage design is presented, with the advantages of both high compression ratio and pumping speed per stage and very compact design: a stage occupying the same axial room of one Gaede, can supply comparable compression ratio and pumping speed of a Holweck stage of the same diameter and peripheral speed. The comparison of two turbo-drag pumps with the new spiral design, in the size of 700 l/s and 2000 l/s, with existing Gaede and Holweck based products of the same size is presented, showing the technology advantages of the new design.

THPEA079 **Residual Gas Analysis and Electron Cloud Measurement of DLC and TiN Coated Chambers at KEKB LER** – *M. Nishiwaki, S. Kato (KEK)*

For future high-intensity positron or proton accelerators, beam instability caused by electron cloud is one of the most important problems. Some coatings on inner surface of beam chambers with materials having low secondary emission yields such as titanium nitride (TiN), non-evaporable getter and so on have represented good effects against the electron cloud instability. In this study, diamond like carbon (DLC) and TiN coated chambers, and a copper chamber without coating were installed to an arc section of KEKB LER to make comparisons of total pressure, residual gas components and electron cloud activity during the beam operation under the same condition. Residual gas observation for the DLC coating revealed much higher hydrogen gas desorption because a process gas including hydrogen was used for the film growth. No remarkable hydrocarbon gas desorption was found. On the other hand, a mass peak of amu=14, that is N+ was prominent in the TiN coating. The electron cloud activity in the DLC coating was lower than the TiN coating and the copper chamber.

THPEA080 **Application of Stain-less Steel, Copper Alloy and Aluminum Alloy MO (Matsumoto-Ohtsuka) -type Flanges to Accelerator Beam Pipes** – *Y. Suetsugu, M. Shirai (KEK) M. Ohtsuka (OHTSUKA)*

The MO (Matsumoto-Ohtsuka) -type flange is suitable for connection flanges of beam pipes for accelerators. The flange uses a metal gasket that exactly fits the aperture of the beam pipe, and has a small beam impedance. The flange can be applied to a complicated aperture. We developed a stainless-steel MO-type flange for a copper beam pipe with antechambers. Several beam pipes were installed in the KEKB B-factory positron ring and were tested using beams. No serious problem was observed up to a beam current of 1600 mA (~10 nC/bunch and ~6 ns bunch spacing). Based on experiences in the stain-less steel case, a possibility of employing copper-alloy and aluminum-alloy MO-type flange has been experimentally studied. They can mitigate the heating problems found in the case of stainless-steel flanges, and simplify the manufacturing procedure of beam pipes made of copper or aluminum alloy. Copper-alloy (CrZrCu) flanges show a comparable vacuum sealing property to the stainless-steel one, and several beam pipes with this flange has been successfully installed in the KEKB. The R&D on aluminum-alloy (A2219 and A2024) flanges has recently started, and a promising result was obtained.

THPEA081 **Vacuum Surface Scrubbing by Proton Beam in J-PARC Main Ring** – *M. Uota, Y. Hashimoto, Y. Hori, H. Matsumoto, Y. Saitoh, M. Tomizawa, T. Toyama (KEK)*

In J-PARC 50GeV synchrotron ring, large vacuum pressure rises above 10^{-3} Pa are found at 30GeV acceleration final stage of intensity over 10^{13} protons per pulse in the chambers of the in-vacuum electrostatic septum magnet for the slow-extraction(SX), magnetic septum for SX, and the kicker magnet for the fast-extraction. This pressure rise depends on beam intensity and peak-current, and can be reduced by continuous beam operations, such as scrubbing with proton beam, secondary emission electrons and other cations of remaining gasses or desorptions.

THPEA082 **Vacuum System Design for the PLS-II Storage Ring** – *C.D. Park, T. Ha, M.-S. Hong, C.K. Kim (PAL)*

The PLS-II project, an upgrade at Pohang Accelerator Laboratory, is under way for providing higher beam energy, lower beam emittance as well as more spaces for insertion devices to the synchrotron users. The beam energy will be increased from 2.5 GeV to 3.0 GeV with a doubled beam current of 400 mA. The vacuum system for the storage ring has been designed to have an operation pressure of low 10^{-9} Torr. In this paper, we report the basic design of the PLS-II vacuum system and discuss relevant requirements and considerations on the engineering for the beam stability in terms of outgassing, pumping system, vacuum chamber, independent BPM assembly, TE mode suppression, and synchrotron absorbers, etc.

THPEA083 **The ALBA Vacuum System: Installation and Commissioning** – *E. Al-Dmour, D. Einfeld (CELLS-ALBA Synchrotron)*

The mechanical installation of the booster synchrotron of ALBA started in January 2009 and finished by having the system under vacuum in April 2009. The preparation of the booster vacuum system for the installation (partial assembly with the pumps and instrumentation, bakeout, etc) started already in September 2008. For the storage ring, the main mechanical installation was done from May to September 2009. The average pressure in the booster synchrotron is in the range of low 10^{-9} mbar and in the storage ring is in the low 10^{-10} mbar. The preparation of the installation, the installation and the present performance will be presented in this contribution. The first round of the booster commissioning will take place at the end of 2009 and the beginning of 2010. The first data of the booster vacuum system commissioning are presented as well.

THPEA084 **Summary of Beam Vacuum Activities Held during the LHC 2008-2009 Shutdown** – *V. Baglin, G. Bregliozzi, J.M. Jimenez (CERN)*

At the start of the CERN Large Hadron Collider (LHC) 2008-2009 shutdown, all the LHC experimental vacuum chambers were vented to neon atmosphere. They were later pumped down shortly before beam circulation. In parallel, 2.3 km of vacuum beam pipes with NEG coatings were vented to air and re-activated to allow the installation or repair of several components such as roman pots, kickers, collimators, rupture disks and masks and re-activated thereafter. Beside these standard operations, "fast exchanges" of vacuum components and endoscopies inside cryogenic beam vacuum chambers were performed. This paper presents a summary of all the activities held during this period and the achieved vacuum performances.

THPEA085 **Vacuum Performances of Some LHC Collimators** – *V. Baglin, G. Bregliozzi, J.M. Jimenez (CERN) J. Kamiya (JAEA/J-PARC)*

Pressure increases are observed with the first beams circulating in the CERN Large Hadron Collider (LHC) close to some collimators. This paper describes the vacuum performances of the collimators as measured in the laboratory and also the performances obtained in the machine. Based on these observations, estimations of some operational behavior such as pressure increase and NEG reactivation scenario are given.

THPEA086 **Recovering about 5 km of LHC Beam Vacuum System after Sector 3-4 Incident** – *V. Baglin, B. Henrist, B. Jenninger, J.M. Jimenez, E. Mahner, G. Schneider, A. Sinturel, A. Vidal (CERN)*

During the sector 3-4 incident, the two apertures of the 3 km long cryogenic vacuum sectors of the CERN Large Hadron Collider (LHC) were brutally vented to helium. A systematic visual inspection of the beam pipe revealed the presence of soot, metallic debris and super insulation debris. After four month of cleaning, the beam vacuum system was recovered. This paper describes the tools and methodologies developed during this period, the achieved performances and discusses possible upgrades.

THPEA087 **The Design of TPS Storage Ring Vacuum Interlock System** – *C.Y. Yang, C.K. Chan, C.L. Chen, J.-R. Chen, G.-Y. Hsiung, Z.-D. Tsai (NSRRC)*

Aluminum alloy was chosen for vacuum chamber materials and oil-free manufacturing, ozone water cleaning processes were used to obtain ultrahigh vacuum in TPS vacuum system. The storage ring vacuum system is divided into 24 unit cells and there are 6 ionized gauges, 8 ion pumps and 6 gate valves in one cell. An interlock system is designed to monitor and control the vacuum devices to keep ultrahigh vacuum. Because the vacuum chamber is exposed to the high power synchrotron radiation directly, cooling water and temperature statuses on the vacuum chamber are also monitored. The hardware, software and their associated interlock logic will be described.

27-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area B
THPEB — Poster Session			

THPEB002 **Study on Particle Loss during Slow Extraction from SIS-100** – *S. Sorge, G. Franchetti, A.S. Parfenova (GSI) A. Bolshakov (ITEP)*

The heavy ion synchrotron SIS-100 will play a key role within the future FAIR project underway at GSI. Although this synchrotron is optimized for fast extraction, also slow extraction will be used. Slow extraction is based on beam excitation due to a third order resonance. The spread in the particle momenta generating a tune spread causes particle loss leading to an irradiation of the machine especially in a high-current operation. A major part of the losses is assumed to occur at the electro-static separator. In the present study we apply a tracking method to model the extraction process to predict the losses, where, in a first step, high current effects are not taken into account.

THPEB003 **Determination of the Acceptance of SIS-18 using an RF Voltage** – *S. Sorge, G. Franchetti, A.S. Parfenova (GSI)*

The present heavy ion synchrotron SIS-18 will be upgraded to be used as a booster for further synchrotrons being part of the FAIR project underway at GSI. We present a technique to measure the acceptance of an accelerator based on the extension of a previous method by the measurement of particle loss which we have applied to SIS-18. Here, we used an RF voltage to transversally excite a coasting heavy ion beam. The resulting transverse growth of the beam leads to particle loss when the beam width exceeds the limiting aperture. The acceptance has been determined from the time evolution of the beam current measured after particle have started to hit the aperture.

THPEB004 **Slow Extraction from the Superconducting Synchrotron SIS300 at FAIR: Lattice Design Optimization and Simulations of Beam Dynamics** – *A. Saa Hernandez, N. Pyka, P.J. Spiller (GSI) U. Ratzinger (IAP)*

With the ability to accelerate heavy ions up to an energy of 32 GeV/u, the SIS300 superconducting (sc) synchrotron is a central part of the new FAIR facility at GSI-Darmstadt. SIS300 will provide beams with a 20-fold increase in energy and, by means of a stretcher mode or a fast ramped mode (1 T/s), 100-10000 times higher average intensity. The beam from SIS300 will be extracted towards the experiments using resonant slow extraction, thus SIS300 becomes the first superconducting synchrotron worldwide with this feature. Coupling and persistent currents are the main practical limitation for operation of sc magnets at high ramping rates and long slow extraction plateaus. The effect of the persistent currents, which are time dependent and depend as well on the magnet's history, is especially critical for slow extraction at low energies. These effects determine the tolerances on magnetic components. In order to address this issue, detailed simulations of beam dynamics at slow extraction have been performed. In particular, the optimization of the lattice and its optical parameters for a low-loss extraction in the presence of steady and time-dependent field components will be presented.

THPEB005 **Scaled down Experiments for a Stellarator Type Magnetostatic Storage Ring** – *N.S. Joshi, M. Droba, O. Meusel, U. Ratzinger (IAP)*

The beam transport experiments in toroidal magnets were first described in EPAC08 within the framework of a proposed low energy ion storage ring at Frankfurt University. The experiments with two room temperature 30 degree toroids are needed to design the accumulator ring with closed magnetic fields up to 6~8T. The test setup aims on building an injection system with two beam lines. The primary beam line for the experiments was installed and successfully commissioned in 2009. A special probe for ion beam detection was installed. This modular technique allows online diagnostics of the ion beam along the beam path. In this paper we present new results on beam transport experiments and discuss transport and transverse beam injection properties of that system.

THPEB006 **Optics Measurements and Transfer Line Matching for the SPS Injection of the CERN Multi-turn Extraction Beam** – *E. Benedetto (National Technical University of Athens) G. Arduini, S. Cettour Cave, F. Follin, S.S. Gilardoni, M. Giovannozzi, M. Newman, F. Roncarolo (CERN)*

Dispersion and beam optics measurements were carried out in the transfer line between the CERN PS and SPS for the new Multi-Turn Extraction beam. Since the extraction conditions of the four islands and the core are different and strongly dependent on the non-linear effects used to split the beam in the transverse plane, a special care was taken during the measurement campaigns. Furthermore, an appropriate strategy was devised to minimize the overall optical mismatch at SPS injection. All this led to a new optical configuration that will be presented in detail in the paper.

THPEB007 **RF-knockout Extraction System for the CNAO Synchrotron** – *N. Carmignani, C. Biscari, M. Serio (INFN/LNF) G. Balbinot, E. Bressi, M. Caldara, M. Pullia (CNAO Foundation) J. Bosser (CERN) G. Venchi (University of Pavia)*

The National Centre for Oncological Hadrontherapy (CNAO) is the first Italian centre for the treatment of patients affected by tumours with proton and carbon ions beams. Its status and commissioning results are presented in this conference in several papers. The synchrotron beam extraction is based on the use of a betatron core. The possibility of using the RF-knockout method as alternative system is being investigated, trying to optimise the performances with the already present hardware and minimum upgrades. A multiparticle tracking program has been written to simulate the beam dynamics during the extraction of the synchrotron, and to optimise the parameters of the radio frequency system. Two types of signals have been studied in order to obtain a constant spill with the minimum ripple: a carrier wave with a frequency and amplitude modulation, and a noise at a given range of frequencies modulated in amplitude. The results of the optimisation and the parameters of the proposed system are presented.

THPEB008 **Insensitive Method to Power Supply Ripple in Resonant Slow Extraction** – *K. Mizushima (Chiba University, Graduate School of Science and Technology) T. Furukawa, K. Noda, T. Shirai (NIRS)*

The betatron tune fluctuation due to the current ripple of power supplies brings the beam spill ripple through the stable area variation in resonant slow extraction. The effect becomes dominant especially in the case of the low beam rate extraction. The RF-knockout slow extraction method is insensitive to the tune ripple compared to the ordinary one because it uses the diffusion with the transverse RF field. However, the ripple effect appears even in the beam spill extracted by it. The amount of the separatrix fluctuation due to the tune ripple depends on the difference between the bare and the resonant tune, and the sextupole magnetic strength. We measured the correlation between the beam spill and the tune ripple which was the artificially generated with low and high frequency components of 67 Hz and 1167 Hz near those of the real current ripple. We confirmed the reduction of the beam spill ripple by setting the tune away from the resonance while keeping the separatrix area. The comparison between the experimental results, the analytical calculation and the simulation will be reported.

THPEB009 **Development of H^- Injection of Proton-FFAG at KURRI** – *K. Okabe, R. Nakano, Y. Niwa, I. Sakai (University of Fukui, Faculty of Engineering) Y. Arakida (KEK) M. Inoue, Y. Ishi, Y. Kuriyama, J.-B. Lagrange, Y. Mori, T. Planche, T. Uesugi, E. Yamakawa (KURRI)*

In Kyoto University Research Reactor Institute (KURRI), the FFAG accelerator for accelerator driven sub-critical reactor (ADSR) system has been constructed and world's first ADSR experiments have started in March 2009. In order to upgrade beam intensity, multiturn charge exchange injection system for scaling FFAG accelerator is being studied. The 11MeV H^- beam is injected from linac and is accelerated up to 100MeV in FFAG main ring. In this presentation, the detail of injection system is described and feasibility of such a low energy H^- injection system is discussed.

THPEB010 **Electrostatic Septum for 50GeV Proton Synchrotron in J-PARC** – *Y. Arakaki, S. Murasugi, R. Muto, K. Okamura, Y. Shirakabe, M. Tomizawa (KEK) M. Nishikawa (Nippon Advanced Technology Co. Ltd.) I. Sakai, D. horikawa (University of Fukui, Faculty of Engineering)*

The two electrostatic septa are one of the most important device for the slow extraction in 50GeV proton synchrotron. We have developed the thin ribbon type septum in order to reduce the beam loss. If alignment of ribbons is poor, the effective thickness seen from the beam become large, and it would increase the beam-hitting rate. The alignment of ribbon over 1.5m long septa was measured by a laser-focus displacement meter. The achieved effective thickness of septa is estimated to be 0.075mm and 0.080mm respectively. We will report a high voltage conditioning and a performance under beam commissioning.

THPEB011 **Design and Test of 2-4MHz Sawtooth-wave Pre-buncher for 26MHz-RFQ** – *K. Niki, H. Ishiyama, I. Katayama, H. Miyatake, M. Okada, Y. Watanabe (KEK) S. Arai (RIKEN Nishina Center) H. Makii (JAEA)*

The measurement of 12C(alpha,gamma) reaction is planned at TRIAC(Tokai Radioactive Ion Accelerator Complex). An intense pulsed alpha beam with the width of less 10ns and the interval between 250ns and 500ns is required for this experiment. Because the Split Coaxial RFQ (SCRFQ), which is one of the TRIAC accelerators, has a radio frequency of 26MHz, the bunch interval becomes 38.5ns. In order to make the bunch interval of 250ns or more, the pre-buncher with a frequency of 2-4MHz, is considered to be installed upstream of the SCRFQ. It is designed as the pre-buncher has two gaps with non-Pi mode. In order to make the bunching beam profile like a pseudo sawtooth-wave, the RF voltage synthesized three harmonic frequencies is applied to these gaps. Consequently, the pre-buncher has a compact size and no leakage electric field outside gaps, and can keep the RF voltage low. Recently, the beam test of this pre-buncher with a case of 2MHz-RF and SCRFQ was performed by using $16O^{4+}$ and $12C^{3+}$ beams. The clear bunch structure with a interval of 500ns was obtained by the SSD set downstream of the SCRFQ. The results of the beam test are almost consistent with those of the beam simulation code.

THPEB012 **Beam Test of Sawtooth-wave Pre-Buncher Coupled to a Multilayer Chopper** – *M. Okada, H. Ishiyama, I. Katayama, H. Miyatake, K. Niki, Y. Watanabe (KEK) S. Arai (RIKEN Nishina Center) H. Makii (JAEA)*

In TRIAC (Tokai Radioactive Ion Accelerator Complex), intense bunched beams are planned for measurements of 12C(alpha, gamma) reactions. For 2-4MHz bunching to the 26MHz linac beams, sawtooth-wave pre-buncher has been developed. Since the wave applied to the pre-buncher is pseudo sawtooth shape synthesized from three sine waves, particles in out-of-bunch phase become backgrounds to the bunched beams. In order to remove them, a multilayer chopper has been newly installed upstream the pre-buncher. The multilayer chopper has 20 electrodes (40mm wide, 10mm long, and 0.1mm thick) piled up with gaps of 1.9mm in vertically to the beam direction. And a square-shape electric potential (100V maximum, 2-4 MHz) is applied to each electrodes alternately. The short gap makes it possible to realize sharp beam-chopping with relatively low electric potential and weak leakage electric field, although beam particles could be lost by 5% or more, since this chopper is set on the way of beams. As a result, the ratio of bunched particles to backgrounds has been improved from 3:1 to 99:1 by the chopper. High intensity beam test by $16O^{4+}$ beam will be also reported.

THPEB013 **Lifetime Test of Carbon Stripping Foils by 650keV Intense Pulsed H^- Ion Beam** – *A. Takagi, Y. Irie, I. Sugai, Y. Takeda (KEK)*

Thick carbon foils (>300ug/cm^2) has been used for stripping of H^- ion beam into protons at the injection stage of the 3GeV Rapid Cycling Synchrotron (3GeV-RCS) in J-PARC. The carbon stripping foils with high durability at high temperature >1800K are strongly required. We have recently developed a new irradiation system for lifetime measurement of the stripping foils using the KEK 650keV Cockcroft-Walton type of high voltage accelerator with high current pulsed negative hydrogen ion beam, which can simulate the high energy-depositions upon foils in the RCS. It is found that, by adjusting the peak intensity and the pulse length of the hydrogen ion beams appropriately, the energy deposition becomes equivalent to that exerted by the incoming hydrogen ions and the circulating protons at the injection process of the RCS. The most important factor that affects the foil lifetime is the foil temperature. During lifetime tests by this system, the temperature of foil is measured by a fast thermometer and by using a phototransistor in a pulsed mode (650keV, 10mA, 0.25msec, 25Hz). The new irradiation system and some preliminary results on lifetime of the carbon stripping foil will be presented.

THPEB014 **Status and Upgrade Plan of Slow Extraction from the J-PARC Main Ring** – *M. Tomizawa, T. Adachi, Y. Arakaki, A. Kiyomichi, S. Murasugi, R. Muto, H. Nakagawa, K. Niki, K. Okamura, Y. Sato, S. Sawada, Y. Shirakabe, H. Someya, K.H. Tanaka, E. Yanaoka (KEK) A. Ando, Y. Hashimoto, T. Koseki, J. Takano (J-PARC, KEK & JAEA) K. Mochiki, S. Onuma (Tokyo City University) I. Sakai, D. horikawa (University of Fukui, Faculty of Engineering) H. Sato (Tsukuba University)*

High power protons from the J-PARC main ring is slowly extracted using the third integer resonance and delivered to the experimental hall for various nuclear and particle physics experiments. The slow extraction device comprises two electro static septa (ESS),ten magnetic septa, four bump magnets, eight resonant sextupole magnets and their power supply. One of the critical issue of the slow extraction is radiation caused by the beam loss during the slow extraction. We have developed the electrostatic and magnetic septa with thin septum thickness. A unique scheme with large step size and small angular spread of the extracted beam enables hit rate on the ESS less than 1% level. In January 2009, first 30 GeV proton beam has been successfully delivered to the fixed target. Quadrupole magnets and a DSP feedback control system to obtain a uniform beam spill structure were implemented in 2009 summer shutdown period. We will report the extraction efficiency, extracted beam profiles and spill structure obtained by the beam commissioning so far. We will also mention a upgrade plan based on some new ideas to aim a higher performance.

THPEB015 **Beam Injection Tuning of J-PARC MR** – *G.H. Wei (KEK/JAEA) A. Ando, T. Koseki, J. Takano (J-PARC, KEK & JAEA) S. Igarashi, K. Ishii, M. Tomizawa, M. Uota (KEK) P.K. Saha, K. Satou, M.J. Shirakata (JAEA/J-PARC) J. Tang (IHEP Beijing)*

The beam commissioning of J-PARC/MR has been started from May 2008 and is in good progress*. As usual, injection is in the very first stage and strongly related to other parts. For this function in design, two septa, three kickers and three bump magnets are installed. And For the commissioning at early stage, a simpler injection scheme, which does not use the bump magnets, is adopted. It is named as 'without bump' scheme, whose physical acceptance is smaller than that of the normal 'with bump' scheme, which are 54 π mm-mrad to 81 π mm-mrad. it is applicable to current situation with injection beam emittance of 15 π mm-mrad. For beam tuning online, an injection OPI (Operation Interface) has been made with the SAD code. By it, injection magnets are controlled to modify the beam injection orbit. Finally, The 'Without bump' scheme was got on June 15th 2008, while 'With bump' scheme on February 15th 2009. Beam orbit betatron oscillation to the MR close orbit which cause by injection error is less than 1 mm both in horizontal and vertical direction. Meanwhile, Beam Optics matching for 3 GeV beam from 350BT to MR has been well done too, which is also very important.

THPEB016 **Fast Extraction Study and Beam Tuning of J-PARC MR** – *G.H. Wei (KEK/JAEA) K. Ishii, T. Nakadaira, M. Tomizawa (KEK) T. Koseki, J. Takano (J-PARC, KEK & JAEA)*

The beam commissioning of J-PARC/MR has been started from May 2008 and is in progress*. One key purpose of MR commissioning is the 30 GeV beam fast extraction to Neutrino beam line, which reflect the overall commissioning result. In the MR, the third straight section is assigned for the fast extraction. 5 kickers and 8 septa were installed there, which can give beam a bipolar kick to inside or outside of MR. Inside kick means beam to Neutrino Oscillation Experiment, while outside kick means beam dumped to abort line. However before commissioning, the measured magnetic field distribution of each septa shows non-linear profile along the horizontal direction. In order to find the influence, a simulation with these measured field has been performed. Depends on this study and some OPI (Operation Interface) made by code SAD for orbit modification online, fast extraction of 30 GeV beam to Neutrino line has been achieved on April 23rd 2009. Beam orbit have been tuned to less than 1 mm and 0.1 mrad in both horizontal and vertical at the beginning of Neutrino line, which is also the end of MR fast extraction. And so far, 100 kW continual operation to neutrino line have been achieved, too.

THPEB017 **Beam Loss Study for Downstream of the Charge-exchange Stripping Foil at the 3-GeV RCS of J-PARC** – *H. Harada, H. Hotchi, P.K. Saha, K. Yamamoto (JAEA/J-PARC)*

The beam loss was caused at the downstream of the charge-exchange striping foil at the J-PARC 3-GeV Rapid Cycling Synchrotron. In order to identify the beam loss source, the beam study with both systematic experiment and realistic simulation has been performed. The realistic result of the beam study will be reported.

THPEB018 **Systematic Beam Loss Study due to the Foil Scattering at the 3-GeV RCS of J-PARC** – *P.K. Saha, H. Harada, H. Hotchi, K. Yamamoto, Y. Yamazaki, M. Yoshimoto (JAEA/J-PARC) I. Sugai (KEK)*

The beam loss caused by the nuclear scattering together with the multiple Coulomb scattering at the stripping foil is one of the key issue in RCS (Rapid Cycling Synchrotron) of the J-PARC (Japan Proton Accelerator Research Accelerator). In order to have a very realistic understanding, a systematic study with both experiment and simulation has been carried out recently. A total of seven targets with different thickness were used and the measured beam losses were found to be good in agreement with that in the simulation. A detail and realistic understanding from such a study will be very useful not only to optimize the foil system including the thickness and size at present with the injection beam energy of 181 MeV but also for the near future upgrade with 400 MeV and in addition can be a good example for similar existing and proposing projects.

THPEB019 **Analysis of Hybrid Type Boron-doped Carbon Stripper Foils in J-PARC RCS** – *Y. Yamazaki, M. Kinsho, O. Takeda, M. Yoshimoto (JAEA/J-PARC) I. Sugai (KEK)*

J-PARC requires thick carbon stripper foils to strip electrons from the H^- beam supplied by the linac before injection into the Rapid Cycling Synchrotron (RCS). Foil thickness is about 200 $\mu g/cm^2$ corresponding to conversion efficiency of 99.7% from the primary H^- beams of 181MeV energy to H^+. For this purpose, we have successfully developed hybrid type thick boron-doped carbon (HBC) stripper foils, which showed a drastic improvement not only with respect to the lifetime, but also with respect to thickness reduction and shrinkage at high temperature during long beam irradiation. We started to study carbon stripper foils microscopically why carbon foils have considerable endurance for the beam impact by boron-doped. At first, we made a comparison between nominal carbon and HBC by the electric microscope and ion-induced analysis. In this paper, we will introduce some results for characteristics of HBC foils.

THPEB020 **Beam Study Results with HBC Stripping Foils at the 3GeV RCS in J-PARC** – *M. Yoshimoto (JAEA/J-PARC)*

The hybrid type thick boron-doped carbon (HBC) stripping foils are installed and used for the beam injection at the 3GeV RCS (Rapid Cycling Synchrotron) in J-PARC (Japan Proton Accelerator Research Complex). The HBC foils are developed by Sugai group in KEK, which improved the lifetime drastically. Up to now, the performance deterioration of the stripping foils can not be seen after the long beam irradiation for the 120kW user operation and 300kW high power beam demonstration at the RCS. In order to examine the characteristic of the HBC foils, various beam studies were carried out. The beam-irradiated spot at the foil was measured by scanning the foil setting position, the charge exchange efficiency was evaluated with various thickness foils, and the effect of the SiC fibers supporting the foil mounting was checked with different mounting foils. Beam study results obtained with using the HBC foils will be presented. In addition, the trends of outgas from the stripping foils and the deformations of the foils during the beam irradiation will be reported.

THPEB021 **Improvements of the Charge Exchange System at the 3GeV RCS in J-PARC** – *M. Yoshimoto (JAEA/J-PARC)*

At the 3GeV RCS (Rapid Cycling Synchrotron) in J-PARC (Japan Proton Accelerator Research Complex), the scheme of H^- charge exchange injection using stripping foils is adopted. The charge exchange system is composed of three stripping foil devices. The first stripping foil device, which converts the H^- beam from the 181MeV LINAC into the H^+ beam, can replace the broken foil with new one in vacuum remotely and automatically. In September 2007, mechanical trouble with the first stripping foil device had occurred just before the RCS beam commissioning was started. The magnetic coupling of the transfer rod had been decoupled and the transfer rod had been broken which was caught in the vacuum gate valve. We studied the trouble cause, re-examined the structural design and the selection for the material, and then verified the specification from endurance tests with sample pieces. Then the improved device was installed in the ring in September 2008. In this presentation, we report the mechanical trouble and that countermeasure, including the improvements of the charge exchange system.

THPEB022 **Beam Spill Control for the J-PARC Slow Extraction** – *A. Kiyomichi, T. Adachi, A. Akiyama, S. Murasugi, R. Muto, H. Nakagawa, J.-I. Odagiri, K. Okamura, H. Sato, Y. Sato, S. Sawada, Y. Shirakabe, H. Someya, K.H. Tanaka, M. Tomizawa, A. Toyoda (KEK) T. Kimura (Miyazaki University) K. Mochiki, S. Onuma (Tokyo City University) K. Noda (NIRS)*

The slow extraction beam from the J-PARC Main Ring (MR) to the Hadron Experimental Facility is used in various nuclear and particle physics experiments. A flat structure and low ripple noise are required for the spills of the slow extraction. The spill control system has been developed for the J-PARC slow extraction to make a flat structure and small ripple. It consists of the extraction quadrupole magnets and feedback device. The extraction magnets consist of two kinds of quadrupole magnets, EQ (Extraction Q-magnet) which make flat beam and RQ (Ripple Q-magnet) which reject the high frequent ripple noise. The feedback system, which is using Digital Signal Processor (DSP), makes a ramping pattern for EQ and RQ from spill beam monitor. The extraction magnets and feedback device were installed in September 2009, and spill feedback study were successfully started from the beam time in October 2009. Here we report the operation status of magnets and first study of beam commissioning with spill feedback.

THPEB023 **Design of the Low Energy Beam Transport in RIKEN New Injector** – *Y. Sato, M.K. Fujimaki, N. Fukunishi, A. Goto, Y. Higurashi, E. Ikezawa, O. Kamigaito, M. Kase, T. Nakagawa, J. Ohnishi, H. Okuno, H. Watanabe, Y. Watanabe, S. Yokouchi (RIKEN Nishina Center)*

The RI beam factory at RIKEN Nishina Center needs high intensity of uranium ion beams. We constructed a new injector, RILAC2, which would provide several hundred times higher intensity. As a part of the RILAC2, we designed the low energy beam transport, LEBT, from the superconducting ECR ion source to the RFQ entrance. In this paper we present its requirements and problems, and show our design as the solutions to them. Especially we focus a technique of a pair of two solenoids to treat a rotational operation and a focusing operation independently. Based on this design, the LEBT was completed in March 2010. The RILAC2 will be operational this fall.

THPEB024 **Design of the Medium Energy Beam Transport from High-voltage Terminal as RIKEN Pre-injector** – *Y. Sato, M.K. Fujimaki, N. Fukunishi, A. Goto, Y. Higurashi, E. Ikezawa, O. Kamigaito, M. Kase, T. Nakagawa, J. Ohnishi, H. Okuno, H. Watanabe, Y. Watanabe, S. Yokouchi (RIKEN Nishina Center)*

The RI beam factory at RIKEN Nishina Center needs high intensity of uranium ion beams. We have used so far the RFQ pre-injector upstream of the linac system, in which the extraction voltage of the ECR ion source is as low as 5.7 kV for the uranium beam. However, for much higher intensity beams from a newly developed superconducting ECR ion source, such a low voltage was expected to significantly increase their emittance due to the space charge effect. To reduce this effect, we prepared a new pre-injector line of 127 kV for uranium beams by placing the ion source on a high-voltage terminal. In this paper we present the design of the 127 kV medium energy beam transport, MEBT, and show the measured results through the line.

THPEB025 **Physical Design of the Extraction System with Slow Orbit Bumps at CSNS** – *J. Qiu, N. Huang, J. Tang, S. Wang (IHEP Beijing)*

The extraction system of CSNS (Chinese spallation neutron source) has been totally modified this year because of the ring lattice change at CSNS, which can offer a long straight section of 11 m. After analyzing the beam halo generation in CSNS-I, the acceptance of 250 pi.mm.mrad at the extraction is adopted, but the acceptance at transport line remains 350 pi.mm.mrad in case of beam loss. In the new extraction scheme, 7 kickers and a lambertson are used, using four small DC bump magnets to build inward orbit bump. At the same time, the collimation section also adopts a DC bump.

THPEB026 **Study of Beam Losses at Injection in the CERN PS** – *S. Aumon, S.S. Gilardoni, O. Hans, Y. Papaphilippou (CERN) S. Aumon, M. Juchno (EPFL) R. Bruce (MAX-lab)*
Significant beam losses during injection in the CERN PS give rise to increase radiation levels. This constitutes a limitation on the beam intensity, which becomes problematic as the maximum intensity that the PS has to deliver is continuously increasing. In order to alleviate the losses, we have performed a series of measurements of the matching of the injected beam. Furthermore, a detailed model of a stray field close to the injection septum has been included in the MAD-X model of the injection line. Using this model, we have compared PTC tracking with measured loss patterns and computed a new optics for the injection line with the aim of reducing the losses.

THPEB027 **Transfer Lines to and from PS2** – *C. Hessler, W. Bartmann, M. Benedikt, B. Goddard, M. Meddahi, J.A. Uythoven (CERN)*
Within the scope of the LHC injector upgrade, it is proposed to replace the present injector chain by new accelerators, Linac4, SPL and PS2, for which new beam transfer lines are required. The beam properties and requirements for each of the lines are summarized. The original design of the beam lines has been fully reconsidered due to the very demanding constraints on the beam line layouts at the PS2 injection / extraction regions and a new straight section of the PS2 which led to a much improved beam line geometry. The relevant modifications and optics designs are described and a preliminary specification of the beam line equipment is also given.

THPEB028 **A Doublet-based Injection-extraction Straight Section for PS2** – *W. Bartmann, B. Goddard, C. Hessler (CERN)*
A new design of the injection-extraction straight section for PS2 has been made, motivated by problematic intersections of the PS2 transfer lines, potential gain in drift length for the beam transfer systems and reduction of the total straight section length. The new straight contains two injection systems with separate beam lines and three extraction systems to the SPS sharing a single beam line, together with an extracted "waste" beam from the H^- injection with its line to a beam dump. A symmetric doublet structure was chosen, with a reduced number of cells and quadrupoles. The optics solutions are described and the matching and tuning flexibility investigated. The implications for the different injection and extraction systems and transfer lines will be discussed, together with the specific issues of integration into the overall lattice.

THPEB029 **The Final Beam Line Design for the HiRadMat Test Facility** – *C. Hessler, B. Goddard, M. Meddahi (CERN)*
The High Radiation to Materials facility - thereafter HiRadMat - is designed to allow testing of accelerator components, in particular those of the LHC and its injectors, with the impact of high-intensity pulsed beams. The facility is currently under construction, as an approved CERN project. The installation of the dedicated primary beam line and experimental area is planned during the 2010-2011 CERN accelerator technical shutdown. It will be ready for users after commissioning and some initial running in October 2011. A detailed proton beam line design has been performed in order to fulfill the beam parameter specification, in particular the demanding optics flexibility at the test stand location. The studies presented include trajectory correction and aperture studies as well as specifications of magnetic systems, power converters, beam instrumentation and vacuum systems.

THPEB030 **Stripping Foil Issues for H^- Injection into the CERN PSB at 160 MeV** – *B. Goddard, C. Bracco, C. Carli, M. Meddahi, W.J.M. Weterings (CERN) M. Aiba (PSI)*
Beam physics considerations for the stripping foil of the 160 MeV PSB H^- injection system are described, including the arguments for the foil type, thickness, geometry and positioning. The foil performance considerations are described, including expected stripping efficiency, emittance growth, energy straggling, temperature and lifetime. The different beam

loss mechanisms are quantified and the parameters for the resulting distributions are examined in the context of the aperture limits and collimation requirements for both machines.

THPEB032 **Design and Development of Kickers and Septa for MedAustron** – *J. Borburgh, B. Balhan, M.J. Barnes, T. Fowler, M. Hourican, M. Palm, A. Prost, L. Sermeus, T. Stadlbauer (CERN) F. Hinterschuster (TU Vienna) T. Kramer (EBG MedAustron)*

The MedAustron facility, to be built in Wiener Neustadt (Austria), will provide protons and different types of ions for cancer therapy and research. Ten different types of bumpers, septa and kickers will be used in the low energy beam transfer line, the synchrotron and the high energy extraction lines. They are presently being designed in collaboration with CERN. Both 2D and 3D finite element simulations have been carried out to verify and optimize the field strength and homogeneity for each type of magnet and, where applicable, the transient field response. The detailed designs for the injection and dump bumpers, the magnetic septa and the fast chopper dipoles are presented. A novel design for the electrostatic septa and their high voltage circuits is outlined.

THPEB033 **Injection of Proton and Carbon 6+ into the Non-scaling FFAG** – *M. Aslaninejad, M.J. Easton (Imperial College of Science and Technology, Department of Physics) J. Pasternak, J.K. Pozimski (STFC/RAL) K.J. Peach, T. Yokoi (JAI)*

For the PAMELA medical non-scaling FFAG, carbon 6+ as well as proton particles are required. The general injection layout based on a cyclotron for proton and a Linac for carbon is considered. There are two options for pre-accelerating carbon ions for PAMELA, either accelerating carbon with the charge state 4+ from the ion source and stripping after the pre-accelerator or directly accelerating carbon 6+ ions all the way from the ion source. For both options solution has been investigated. Simulations of beam dynamics for both particle species are presented. The resulting schemes based on either the single turn or multiturn injection into the first FFAG ring are discussed.

THPEB034 **The Design of the MEBT for the PAMELA Medical FFAG** – *M. Aslaninejad, M.J. Easton, J. Pasternak, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics) K.J. Peach, T. Yokoi (JAI)*

The PAMELA medical FFAG complex under design in the UK, aims to operate with both proton and carbon beams for hadron therapy. Medium energy beam transfer(MEBT) of PAMELA consists of the proton beam line coming out of the injector cyclotron, carbon beam transfer from the independent carbon 6+ injector linac, switching dipole when both beam merge and transfer line toward the PAMELA NS-FFAG. The MEBT layout and design, which needs to incorporate the beam chopper for the intensity modulation are discussed. The careful matching of optical functions between various components in the MEBT and beam dynamics simulations are presented.

THPEB035 **Solenoid Fringe Field Effects for the Neutrino Factory Linac - MAD-X Investigation** – *M. Aslaninejad, C. Bontoiu, J. Pasternak, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics) S.A. Bogacz (JLAB)*

International Design Study for the Neutrino Factory (IDS-NF) assumes the first stage of muon acceleration (up to 900 MeV) to be implemented with a solenoid based Linac. The Linac consists of three styles of cryomodules,containing focusing solenoids and varying number of SRF cavities for acceleration. Fringe fields of the solenoids and the focusing effects in the SRF cavities have significant impact on the transverse beam dynamics. Using an analytical formula,the effects of fringe fields and cavities are studied in MAD-X. The resulting betatron functions are compared with the results of beam dynamics simulations using OptiM code.

THPEB036 **Multi-turn Extraction in NS-FFAG** – *T. Yokoi (JAI)*

In an ordinary FFAG accelerator, fast beam extraction with kicker magnet is usually employed. However, in a system with tune drift during acceleration, resonance crossing process can be used for beam extraction. In the resonance extraction in NS-FFAG, by adjusting the main field strength, extraction energy can be varied. In addition, acceleration pattern trimming can adjust the energy distribution of extracted beam. These features provide a possibility of large varieties of applications. In the paper, the overview of the scheme and simulation results are to be presented.

THPEB037 **Kicker and Septum Magnets for PAMELA** – *H. Witte (OXFORDphysics) M. Aslaninejad, J. Pasternak (Imperial College of Science and Technology, Department of Physics) K.J. Peach (JAI)*

PAMELA is a design study of a non-scaling FFAG for charged particle therapy using proton and carbon ions. One of the attractive features of PAMELA is the high repetition rate of 1 kHz. The high repetition rate in combination with the high beam rigidity represent a significant challenge for the kicker and septum magnets. In this paper we discuss this and outline potential solutions.

THPEB038 **Design, Installation, and Initial Commissioning of the MTA Beamline** – *C.D. Moore, J.E. Anderson, F.G. Garcia, M.A. Gerardi, C. Johnstone, T. Kobilarcik, I.L. Rakhno, G.L. Vogel (Fermilab)*

The Mucool Test Area (MTA) beamline is a dual purpose beamline. The primary purpose is to provide beam for Muon cooling experiments and the secondary purpose is to provide an emittance measuring station for the Linac. A description of the optics for the two different uses of the line will be given and the radiation protection aspects will be discussed.

THPEB039 **SNS Stripper Foil Failure Modes and their Cures** – *M.A. Plum, J. Galambos, S.-H. Kim, P. Ladd, R.W. Shaw (ORNL) C.F. Luck, C.C. Peters (ORNL RAD) R.J. Macek (LANL) D. Raparia (BNL)*

The diamond stripper foils in use at the Spallation Neutron Source worked successfully with no failures until May 3, 2009, when we started experiencing a rash of foil failures after increasing the beam power to ~840 kW. The main contributions to foil failure are thought to be 1) convoy electrons, stripped from the incoming H– beam, that strike the foil bracket and may also reflect back from the electron catcher, and 2) vacuum breakdown from the charge developed on the foil by secondary electron emission. In this paper we will detail these and other failure mechanisms, and describe the improvements we have made to mitigate them.

THPEB040 **MeRHIC Interaction Region Design** – *J. Beebe-Wang (BNL)*

RHIC-based high-energy electron-ion collider (eRHIC) is planned to take a staged approach. The first stage is a medium-energy electron-ion collider (MeRHIC), in which a 4GeV electron beam from an energy-recovery linac will be delivered to one of the existing interaction regions (IR) of RHIC. The MeRHIC IR design needs to fulfill a set of very complicated constrains. These constrains include (1) merging and/or separating the electron beam with RHIC ion beams at IP; (2) matching the lattice of IR to the lattices of designed electron transport line and existing RHIC rings; (3) providing large range of tunable ion beam energy for a fixed electron energy; (4) confirming with the technical limitations of magnets and power supplies: (5) in accordance to the detector design and physics measurements; (6) minimizing the detector background due to synchrotron radiations; (7) confirming with space and geometrical conditions based on the installed RHIC hardware and existing tunnel; (8) incorporating vacuum devices required by the further operation. In this paper, we discuss each challenges faced by the MeRHIC design and present how the current IR design addressed these issues.

THPEB041 **Status of the 476 MHz 50 kW Solid State Amplifier for the LNLS Storage Ring** – *R.H.A. Farias, F. Arroyo, E. Hayashi, F.S. Oliveira, L.H. Oliveira, C. Pardine, C. Rodrigues, P.F. Tavares (LNLS)*

In November 2010, LNLS plans to replace the two 50 kW UHF klystron valves which currently provides power to the RF cavities installed in the storage ring. Thanks to a close collaboration with the Syncrotron Soleil started in 1999, LNLS adapted the characteristics of the French project to 476 MHz. The choice of the transistor, the design of the combiners and details on power supplies will be reported, as well as the power tests performed with the two amplifiers using a resistive load.

THPEB042 **Development of Diffusion Bonding Joints between Oxgen Free Copper and AISI 316L Stainless Steel for Accelerator Components** – *R.H.A. Farias, O.R. Bagnato, D.V. Freitas, F.E. Manoel (LNLS)*

Diffusion bonding is a welding process where the main mechanism responsible for the union of the materials is the interdiffusion of atoms across the joint surface, even in solid state. The objective of the present work is to produce bonded joints that could be used in vacuum components for particle accelerator. Is this work was produced a welding joint between two dissimilar materials: oxygen free copper and AISI 316 L stainless steel. Each sample was bonded in vacuum (10-5mbar) at a temperature range between 800 and 900^{o}C, pressure of 12MPa and holding times between 30 and 60min. Optical microscopy, scanning electron microscopy, mechanical testing and helium leak test were used to study the bond quality. The images obtained by optical and electron microscopy revealed good quality interfaces without the presence of defects and pores. All samples are tested through the helium leak test and were approved. The results indicate great potential to use this process in the manufacturing of components suitable for ultra high vacuum, for application in the design of new LNLS storage ring.

THPEB043 **Connection Module for the European X-ray FEL 10MW Horizontal Multibeam Klystron** – *V. Vogel, A. Cherepenko, S. Choroba, J. Hartung (DESY) P.A. Bak, N. Evmenova, A.A. Korepanov (BINP SB RAS)*

For the European XFEL project horizontal multi-beam klystrons will be installed in the XFEL tunnel and will be connected to the double tank pulse transformers. Both, the klystron and pulse transformer need for the normal operation to be filled with oil. To avoid the possible oil leakage during connection of the klystron and transformer tank inside tunnel, the connection module (CM) was proposed. The CM will be mounted on the support platform of the klystron and through the tube socket connected to the guns electrodes outside of the tunnel and will transported to the tunnel together with klystron. The connection to the pulse transformer tank will be done only with HV cable, because the CM has inside it the filament transformer. To reduce the weight and volume of the oil the design of filament transformer was done as high frequency coaxial one with coupling factor of 0.58 and working frequency about 1 kHz. The CM has the built-in current and voltage monitors. In this paper we give an overview about design and test result of the CM together with klystron.

THPEB044 **Development and Operating Experience of S band RF Power Source for 10MeV Industrial Elecrton Linac** – *A.R. Tillu, D.P. Chakravarthy (BARC) A.P. Bhagwat, S.Y. Kulkarni (SAMEER) S. Chandan, R.B. Chavan, K. Dixit, K.C. Mittal, V. Yadav (BARC-EBC)*

At Electron Beam Centre, India, a 10MeV industrial electron linac has been designed, developed and commissioned at ~3kW beam power. The Linac is driven by a 6MW Peak and 25kW average klystron at 2856MHz. The paper describes the development of the RF source, the problems faced and the solutions successfully implemented. The RF source development is described from the very beginning, i.e. the testing of the klystron modulator on the resistive load, impedance matching issues with klystron load, the first-pulse problem, the testing of the klystron on water load and finally the integration of the Linac with the RF Source. The paper also describes the problems faced after prolonged operation, as with respect to HV arcing inside the klystron, and hence replacement of klystron followed by pfn tuning and testing at full peak power.

THPEB045 **Commissioning of S band RF Power Source for 10MeV, Industrial Linear Accelerator and Linac Commissioning Experience** – *S. Chandan, D. Bhattacharjee, R.B. Chavan, K.C. Mittal, V.T. Nimje, R. Tiwari, V. Yadav (BARC-EBC) A.P. Bhagwat, S.Y. Kulkarni (SAMEER) D.P. Chakravarthy, A.R. Chindarkar, L.M. Gantayet, D. Jayaprakash, R.L. Mishra, A.R. Tillu (BARC)*

At Electron Beam Centre, India, a 10MeV, 10kW Industrial Linear accelerator has been designed, developed and commissioned at beam power up to 4kW. The Linac is driven by a 6MW Peak and 25kW average klystron at 2856MHz. The paper describes the commissioning of the RF source, the challenges faced and the solutions successfully implemented. The paper also describes the RF conditioning of the LINAC and the beam trials. This paper describes the testing of the klystron on water load till 5.0MW Peak power and finally the integration of the Linac with the RF Source. Following the integration of the RF source with the Linac, there were a few Problems w.r.t. the RF discontinuity at the window. The paper describes the problem and also the improvised RF continuity gasket used to eliminate the problem. The klystron feeds an indigenously developed S band bi-periodic standing wave structure with unloaded coupling coefficient of 1.8. The structure was conditioned without beam till around 4MW peak power. The indigenously developed 50kV/1A pulsed triode gun injects the beam into the linac. The paper describes the steps in conditioning and hence beams power operation up to 4kW.

THPEB046 **RF Source of Compact ERL in KEK** – *S. Fukuda, M. Akemoto, D.A. Arakawa, H. Honma, H. Katagiri, S. Kazakov, S. Matsumoto, T. Matsumoto, S. Michizono, T. Miura, H. Nakajima, K. Nakao, S. Sakanaka, T. Shidara, T. Takahashi, Y. Yano, M. Yoshida (KEK)*

ERL (Energy Recovery Linac) of 5GeV energy is a future plan in KEK and in order to study the technical feasibility, construction of a compact ERL machine (cERL) is considered. Beam energy and current of cERL are 245MeV and 100mA, respectively. As 1.3 GHz frequency and super conducting cavity are chosen for the RF system, similar technology with KEK STF is employed. From 2008, KEK started the preparation of cERL and one RF unit of injector linac is introduced in this fiscal 2009. A new cw klystron of 300kW out put power, 150kW Y-type circulator and high power water load were developed in FY2009. DC power supply was under manufacturing. Preliminary test of HLRF and the high power couplers are scheduled in the Photon Factory site by making use of the old DC power supply. For main accelerator, we also introduced a 30kW IOT and a 35kW klystron and a DC power supply. At the same time, cERL is determined to be constructed in the East Counter Hall in KEK and the design layout is preceded. In this paper, the recent RF source development of cERL is described. Layout of the east counter hall, where cERL is constructed, is progressed and shown in this report.

THPEB047 **The Development of L-band Inductive Output Tube without Trolly toward Higher Applied Voltage.** – *M. Yoshida, S. Fukuda (KEK) H. Asano, M. Kubosaki, Y. Moriguchi (Mitsubishi Electric Corp., Communication Systems Center)*

The L-band inductive output tube (IOT) without trolly was developed to operate under higher applied voltage. The operation frequency of conventional IOTs is tuned using its trolly. This mechanism is based on the lower frequency IOT. However it causes less insulation voltage of the ceramics since the electric insulation oil is not available for its trolly and the length of the insulation ceramics is limited because it is a part of the resonant cavity. In case of IOTs, it is important to increase the applied voltage for higher output power since the grid gap is very narrow and its area cannot be increased to keep the gain. Thus we developed an IOT which has a longer insulating ceramic and the input cavity is filled with vacuum to use the electric insulation oil. Further the dielectric waveguide can solve to feed the input microwave to the cathode grid without trolly. These new features of the IOT is very effective for the fixed frequency application such as the accelerator, for example the energy recovery linac. The design and the experimental results will be presented in this report.

THPEB048 **Research on RF Synthesize and Amplifier** – *J. Huang, T. Hu, D. Li, B. Qin, J. Yang (HUST)*

The stability and accuracy of frequency synthesize is directly related to the performance of RF system. With the comparison and analysis of different kind of frequency synthesize projects, it comes to the proposal of DDS drive PLL and adapted the DDS chip of AD9850 circuit. The thesis also introduces an introduction of the theoretical basis of linear amplifier, the nonlinearity characteristic of which serves as the basis of linear amplifier design. Then, it is followed by the introduction of the methods to linear amplifier. By combing the theoretical analysis with ADS2005A software, it simulated and designed the 150 watt linear high power amplifier, based on LDMOSFET.

THPEB049 **Beam Optics Calculation and Optimization for a High-voltage Electron Accelerator** – *D. Li, T. Hu, X. Hu, J. Huang, B. Qin, J. Yang (HUST)*

A 350keV high-voltage electron accelerator will be developed in Huazhong University of Science and Technology (HUST). In order to promote the beam extraction efficiency, the beam envelope from the electron gun to the conveyer belt was carried out with TRANSPORT and TRACE-3D. According to results of the optics calculation, we optimized the design of the accelerator to reduce the losing of electron, and some analysis of space-charge effects were also presented in this paper.

THPEB050 **Microwave System for PLS-II 3 GeV Linac at PAL** – *W.H. Hwang, K.R. Kim, S.H. Kim, S.H. Nam, C.D. Park, S.S. Park (PAL)*

The 3.0 GeV linac upgrade plan has already been underway for PLS-II in Pohang Accelerator Laboratory, PAL. The PLS-II 3.0 GeV Linac, to be operated as a full energy injector to the storage ring, is a third generation synchrotron light source. The linac consists of 14 high power klystrons, 13 SLED-type pulse compressors, and 46 constant gradient accelerating sections. The rf design parameters for the PLS-II is tighter than for the present PLS Linac. To meet the tighter design value, the linac rf system needs improvement and modification. The low level rf distribution system must be designed as stable as possible. To prevent long-term energy drift, phase feedback system and energy feedback system is needed. This paper describes the microwave system for PLS-II Linac.

THPEB051 **Observation of an Anomalous Tuning Range of a Doped BST Ferroelectric Material Developed for Accelerator Applications** – *E. Nenasheva (Ceramics Ltd.) A. Kanareykin (Euclid TechLabs, LLC) S. Kazakov (KEK) A.B. Kozyrev (LETI) V.P. Yakovlev (Fermilab)*

The BST based ferroelectric-oxide compounds have been found as suitable materials for a fast electrically-controlled RF switches and phase shifters that are under development for accelerator applications in X, Ka and L - frequency bands. The BST(M) material (BST ferroelectric with Mg-based additives) allows fast switching and tuning in vacuum and in air both; switching time of material samples < 10 ns has been demonstrated*. One of the problems related to accelerator application of BST ferroelectric is its high dielectric constant. Decreasing the permittivity however is usually strongly correlated with a decrease in the tunability ($k(E)=\epsilon(0)/\epsilon(E)$) of ferroelectrics. The use of linear dielectric inclusions in BST ceramics could result in significant suppression of the mentioned k(E) dependence, with the best case being that the tunability vs. ϵ decrease could be unchanged. On the basis of our measurements we report here two unusual phenomena observed**: (i) the increase both the dc and the dynamic tunability with a decrease of the dielectric constant; (ii) the dynamic tunability was observed to exceed the static tunability at specific magnitudes of the applied field.

THPEB052 **IFMIF/EVEDA RF Power System** – *D. Regidor, A. Arriaga, A. Ibarra, I. Kirpitchev, P. Méndez, M. Weber (CIEMAT) M. Desmons, A. Mosnier (CEA) J.M. Forteza, C.R. Isnardi (Indra Sistemas) F. Perez, A. Salom (CELLS-ALBA Synchrotron) D. Vandeplassche (SCK-CEN)*

The IFMIF/EVEDA Accelerator Prototype will be a 9MeV, 125mA CW deuteron accelerator to validate the technical options for the IFMIF accelerator design. The Radiofrequency Quadrupole (RFQ), buncher cavities and Superconducting Radiofrequency Linac (SRF Linac) require continuous wave RF power at 175 MHz with an accuracy of ±1% in amplitude and $\pm 1^{o}$ in phase. Also the IFMIF/EVEDA RF Power System has to work under pulsed mode operation (during the commissioning of the accelerator). The IFMIF/EVEDA RF Power System is composed of 18 RF power generators feeding the eight RFQ couplers (200kW), the two buncher cavities (105kW) and the eight superconducting half wave resonators of the SRF Linac (105kW). The main components of each RF power chain are the Low Level Radio Frequency system (LLRF), three amplification stages and a circulator with its load. For obvious standardization and scale economies reasons, the same topology has been chosen for the 18 RF power chains: all of them use the same main components which can be individually tuned to provide different RF output powers up to 200kW. The studies and the current design of the IFMIF/EVEDA RF Power System are presented.

THPEB053 **A 12 GHz RF Power Source for the CLIC Study** – *K.M. Schirm, S. Curt, S. Doebert, G. McMonagle, I. Syratchev, L. Timeo (CERN) A.A. Haase, D.W. Sprehn (SLAC) A. Hamdi, F. Peauger (CEA) S.V. Kuzikov (IAP/RAS)*

The CLIC RF frequency has been changed in 2008 from the initial 30 GHz to the European X-band 11.9942 GHz permitting beam independent power production using klystrons for CLIC accelerating structure testing. A design and fabrication contract for five klystrons at that frequency has been signed by different parties with SLAC. France (CEA Saclay) is contributing a solid state modulator purchased in industry to the CLIC study. RF pulses over 120 MW peak at 230 ns length will be obtained by using a novel SLED I type pulse compression scheme designed and fabricated in Nizhny Novgorod, Russia. The X-band power test stand has been installed in the CLIC Test Facility CTF3 for independent structure and component testing in a bunker, but allowing, in a later stage, for powering RF components in the CTF3 beam lines. The design of the facility, results from commissioning of the RF power source and the performance of the Test Facility are reported.

THPEB054 **The Development of High Power Solid-state Amplifier in NSRRC** – *T.-C. Yu, L.-H. Chang, M.-C. Lin, Ch. Wang, M.-S. Yeh (NSRRC)*

The RF power source using solid-state amplifier for synchrotron light source has become popular in recent years. The amplifiers array using power dividers and power combiners could obtain equivalent power level as those using klystron of IOT. Such solid-state RF power source also has the advantage of easy maintenance, low cost, low DC power supply voltage and high flexibility. The development of solid-state power amplifier module at 500MHz using the latest power chip has been built that increase the power level of present one power module. The more power that one module can provide, the less number of modules would be required under the same total output power level. Thus, the construction of a transmitter for RF cavity would become less complex.

THPEB055 **Progress on the MICE RF System** – *A.J. Moss, P.A. Corlett, P.A. McIntosh, J.F. Orrett, A.E. Wheelhouse (STFC/DL/ASTeC)*

The Muon Ionisation Cooling Experiment(MICE) is being constructed at Rutherford Appleton Laboratory in the UK. A moun beam will be cooled and then accelerated using 200MHz copper RF cavites. This paper describes the RF power source, testing of the high voltage power supplies and amplifiers to date, progress on the RF distribution scheme to the accelerating cavites and the low level RF control system to be employed.

THPEB056 **Commissioning of the RF System for EMMA at Daresbury Laboratory** – *A.E. Wheelhouse, R.K. Buckley, P.A. McIntosh, A.J. Moss, J.F. Orrett (STFC/DL/ASTeC)*

The RF system on EMMA (Electron Model for Many Applications), the world's first Non-Scaling Fixed Field Alternating Gradient (NS-FFAG) accelerator is presently being installed and commissioned at Daresbury Laboratory. The RF system is required to provide precise amplitude and phase control to each of the 19 identical normal conducting, 1.3 GHz RF cavities which provide the acceleration of the electron beam from 10 MeV to 20 MeV. The system incorporates a high power RF system, which includes a single 100 kW Inductive Output Tube (IOT), a unique RF distribution system and a low level RF (LLRF) control system. The design of the RF system and the commissioning progress to date is presented.

THPEB057 **Design of Photonic Crystal Klystrons** – *Y. Xu (Lancaster University) R. Seviour (Cockcroft Institute, Lancaster University)*

2D Photonic crystals (PC) with defects can act as standing-wave resonators, which offer benefit of high mode selectivity for building novel RF sources. We introduce our work on designing two-cavity single-beam and multi-beam klystrons using triangular lattice metallic PCs. We present the cold test results of the stub-coupled single-beam structure, which show that at resonance a very low reflection can be obtained, and the waves are well confined. We also present bead-pull measurement results of field strengths in the defect, using modified perturbation equation for small unit dielectric cylinder, which are in very good agreement to numerical results. A 6-beam klystron cavity is designed as a 6-coupled-defect structure with a central stub, which only couples to the in-phase mode at the lowest frequency. Finally, we present a feasibility discussion of using this multi-defect PC structure to construct an integrated klystron-accelerator cavity, along with numerical results showing a peak acceleration field of 22MV/m can be achieved.

THPEB058 **Phase and Frequency Locked Magnetrons for SRF Sources** – *M. Popovic, A. Moretti (Fermilab) A. Dudas, R.P. Johnson, M.L. Neubauer, R. Sah (Muons, Inc)*

Typically, high power sources for accelerator applications are multi-megawatt microwave tubes that may be combined together to form ultra-high-power localized power stations. The RF power is then distributed to multiple strings of cavities through high power waveguide systems which are problematic in terms of expense, efficiency, and reliability. Magnetrons are the lowest cost microwave source in dollars/kW, and they have the highest efficiency (typically greater than 85%). However, the frequency stability and phase stability of magnetrons are not adequate, when magnetrons are used as power sources for accelerators. Novel variable frequency cavity techniques have been developed which will be utilized to phase and frequency lock magnetrons, allowing their use for either individual cavities, or cavity strings. Ferrite or YIG (Yttrium Iron Garnet) materials will be attached in the regions of high magnetic field of radial-vaned, π–mode structures of a selected ordinary magnetron. A variable external magnetic field that is orthogonal to the magnetic RF field of the magnetron will surround the magnetron to vary the permeability of the ferrite or YIG material.

THPEB059 **Adjustable High Power Coax RF Coupler with No Moving Parts** – *M.L. Neubauer, A. Dudas, R. Sah (Muons, Inc) M. Borland, R. Nassiri (ANL)*

An extremely low emittance RF gun is being designed for the X-ray Free Electron Laser Oscillator (XFEL-O), which is now being proposed by ANL. An adjustable coupling factor for this gun is very desirable for providing operational flexibility. What is required is a fundamental RF power coupler (FPC), adjustable in situ, that can operate at 100 MHz and 200 kW CW. If rotational motion is used in the adjustable coupler, it is usually necessary to break the vacuum between the coupler and the RF cavity, thereby risking prolonged down-times and the introduction of contaminants into the vacuum system. We propose a novel system for adjusting the coupling coefficient of coaxial couplers to allow for individual control and adjustments to the RF fields under different beam loading scenarios. The RF coupler has no movable parts and relies on a ferrite tuner assembly, coax TEE, and double windows to provide a VSWR of better than 1.05:1 and a bandwidth of at least 8 MHz at 1.15:1. The ferrite tuner assembly on the stub end of the coax TEE uses an applied DC magnetic field to change the Qext and the RF coupling coefficient, β, between the RF input and the cavity.

THPEB060 **Design and Early Commissioning Results of the APEX Project's VHF Gun RF System** – *K.M. Baptiste, L.R. Doolittle, G. Huang, S. Kwiatkowski, F. Sannibale, J.W. Staples (LBNL)*

The Advanced Photoinjector Experiment (APEX) is a Photoinjector and diagnostic beamline being built to address fundamental issues in high average current, high brightness electron beam production for soft x-ray FEL applications. A 186 MHz (VHF-Band) room-temperature CW cavity will generate a gap voltage of 750 kV, accelerating the electrons from various photo-cathode materials under study. In this paper we will present the design of the VHF RF System and early RF system commissioning and test results. The VHF RF system is comprised of a pair of tetrode-based power amplifiers, integrated in a single High Power Amplifier (HPA), each connected via a 4 1/16" coaxial line through a circulator, and an RF window to a loop coupler on the single cell RF cavity. The Low Level RF control system design includes closed-loop controls for the cavity frequency, RF phase and amplitude and photo-cathode laser synchronization.

THPEB061 **CPI's 1.3 GHz, 90 kW Pulsed IOT Transmitter for the EMMA Accelerator** – *M.E. Marks, P. Brown, S. Evans, T.A. Treado (CPI)*

The VIL409 Heatwave IOT-based RF amplifier was designed to meet the requirements of the EMMA accelerator at the Daresbury Laboratory. The VIL409 was successfully commissioned in September 2009. The VIL409 provides up to 90 kW RF output power ver a 5.5 MHz bandwidth centered at 1.3 GHz. It operates at a fixed 1.6 millisecond pulse at up to 20 Hz. Within limits, the user has control of the IOT beam voltage and the IOT grid bias voltage. Normal operation is to achieve smooth control of the output via the LLRF input alone. The IOT grid may be pulsed or operated at a constant voltage; pulsing achieves greatly enhanced energy efficiency. The VIL409 has an embedded processor that controls all internal functions of the amplifier system and interfaces directly to the EPICS control system. The embedded controller provides real-time pulse data to EPICS and operates slow-moving interlocks. Safety and IOT-protective interlocks are hard-wire circuits which operate in the microsecond timeframe. The VIL409 can be operated locally or controlled remotely on the EPICS controls network. This paper describes the VIL409 high power RF amplifier system.

THPEB062 **Design of a New VHF RF Power Amplifier System for LANSCE** – *J.T.M. Lyles, S. Archuletta, N.K. Bultman, Z.C. Chen, J. Davis, A.C. Naranjo, D. Rees, G. M. Sandoval, Jr., D.S. Warren (LANL) D. Baca, R.E. Bratton, R.D. Summers (Compa Industries, Inc.)*

An major upgrade is replacing much of the 40 year-old proton drift tube linac RF system with new components at Los Alamos Neutron Science Center (LANSCE). When installed for the LANSCE-R project, the new system will reduce the total number of electron power tubes from twenty-four to eight in the RF powerplant. A new 200 MHz high power cavity amplifier has been developed at LANSCE. This 3.2 MW final power amplifier (FPA) uses a Thales TH628 Diacrode, a state-of-the-art tetrode that eliminates the large anode modulator of the triode-based FPA that has been in use for four decades. Drive power for the FPA is provided by a new tetrode intermediate power amplifier and a solid-state driver stage. The new system has sufficient duty-factor capability to allow LANSCE to return to 1 MW beam operation. Prototype RF power amplifiers have been designed, fabricated, and assembled and are being tested. High voltage DC power became available through innovative re-engineering of an installed system. Details of the electrical and mechanical design of the FPA and ancillary systems are discussed. Power test results have validated the design and construction of this very high power amplifier system.

THPEB063 **ILC RF System R&D** – *C. Adolphsen (SLAC)*

The Linac Group at SLAC is actively pursuing a broad range of R&D to improve the reliability and reduce the cost of the L-band (1.3 GHz) rf system proposed for the ILC linacs. Current activities include the long-term evaluation of a 120 kV Marx Modulator driving a 10 MW Multi-Beam Klystron, design of a second-generation Marx Modulator, testing of a sheet-beam gun and beam transport system for a klystron, construction of an rf distribution system with remotely-adjustable power tap-offs, redesign of the TTF3 power coupler for ease of manufacturing, and development of a system to combine the power from many klystrons in low-loss circular waveguide where it would be tapped-off periodically to power groups of cavities. This paper surveys the progress during the past few years and notes related L-band R&D at other labs, in particular, that at DESY for the XFEL project.

THPEB065 **A 12 GHz 50MW Klystron for Support of Accelerator Research** – *D.W. Sprehn, A.A. Haase, A. Jensen, E.N. Jongewaard, C.D. Nantista, A.E. Vlieks (SLAC)*

A 12 GHz 50MW X-band klystron is under development at the SLAC National Accelerator Laboratory Klystron Department. The klystron will be fabricated to support programs currently underway at three European Labs; CERN, PSI, and INFN Trieste. The choice of frequency selection was due to the CLIC RF frequency changing from 30 GHz to the European X-band frequency of 11.9942 GHz in 2008. Since the Klystron Department currently builds 50MW klystrons at 11.424 GHz known collectively as the XL4 klystrons, it was deemed cost-effective to utilize many XL4 components by leaving the gun, electron beam transport, solenoid magnet and collector unchanged. To realize the rf parameters required, the rf cavities and rf output hardware were necessarily altered. Some improvements to the rf design have been made to reduce operating gradients and increase reliability. Changes in the multi-cell output structure, waveguide components, and the window will be discussed along with testing of the devices. Five klystrons known as XL5 klystrons are scheduled for production over the next two years.

THPEB066 **Test and Development of a 10 MW 1.3 GHz Sheet Beam Klystron for the ILC** – *D.W. Sprehn, A.A. Haase, A. Jensen, E.N. Jongewaard, D.W. Martin (SLAC)*

The SLAC National Accelerator Laboratory Klystron Department is developing a 10 MW, 5 Hz, 1.6 ms, 1.3 GHz plug-compatible Sheet-Beam Klystron as a less expensive and more compact alternative to the ILC baseline Multiple-Beam Klystron. Earlier this year a beam tester was constructed and began test. Device fabrication issues have complicated the analysis of the data collected from an intercepting cup for making beam quality measurements of the 130 A, 40-to-1 aspect ratio beam. Since the goal of the beam tester is to confirm 3d beam simulations it was necessary to rebuild the device in order to mitigate unwanted effects due to imperfect focusing construction. Measurements are underway to verify the results of this latest incarnation. Measurement will then be made of the beam after transporting through a drift tube and magnetic focusing system. In the klystron design, a TE oscillation was discovered during long simulation runs of the entire device which has since prompted two design changes to eliminate the beam disruption. The general theory of operation, the design choices made, and results of testing of these various devices will be discussed.

THPEB067 **Demonstration Experiment Using a Magnetron to Drive a Superconducting Cavity** – *H. Wang, G.K. Davis, R.A. Rimmer (JLAB) A.C. Dexter, M.I. Tahir (Cockcroft Institute, Lancaster University)*

To demonstrate an economic way of using microwave oven type magnetrons rather than klystrons or IOTs as the RF sources of accelerator cavities, we have experimentally frequency locked a magnetron by using a current-controlled oscillator in a phase-locked loop (PLL) to drive the magnetron anode current. We further demonstrated phase locking to a 2.45GHz copper cavity by a -30dB to -40dB injection signal back to the magnetron output. With a fast feedback digital signal processor (DSP) acting as a PLL, a ±0.6~1.2 deg of phase error has been achieved. We will also report recent experiment results in which a more advanced algorithm is used in the DSP in an attempt to lock a superconducting single-cell cavity, with input coupling Qext=$5 \cdot 10^6$, operated at 2K temperature.

THPEB068 **Building Design for High Beam-power Facilities** – *J.-M. Lagniel (GANIL)*

The buildings and their equipments associated to the nuclear engineering play a crucial role for a successful operation of high beam-power facilities. They also represent the biggest part of the facility total investment cost and are frequently the critical path in the construction planning. The management of the building and conventional facility design and construction is a complex task including many aspects : set up of the functional and technical specifications for buildings, radiation shielding, remote handling, electrical power distribution, cooling system, definition of the interfaces between accelerator and experimental equipments and the buildings, selection of the building prime contractor, task sharing between the accelerator and physicist teams and the building prime contractor, infrastructures optimization up to the final detailed design' These topics will be discussed taking SPIRAL 2 as example.

THPEB069 **Experiments with Viewing Targets for Ion Beams from ECRIS** – *P. Spaedtke, R. Lang, J. Maeder, F. Maimone, J. Rossbach, K. Tinschert (GSI)*

Electron Cyclotron Resonance Ion Sources (ECRIS) are increasingly used as ion source for different types of accelerator because of their high current densities for highly charged ions. To investigate the ion beam quality, normally delivered to the RFQ of the high charge state injector at GSI, we had the chance to install a viewing target close to the position of ion beam injection into the RFQ. The profile visible on the viewing target could be recorded through a regular glass window by a simple camera outside the vacuum. The RFQ itself has been removed for these measurements. We have found a highly structured ion beam distribution at that position. These structures, already caused by the hexapolar field within the ion source have already been observed directly behind the extraction. They are transported through the beam line without becoming homogeneous, which indicates a high degree of space charge compensation for that cw-beam. If the full beam line is mastered by the dipole, all charge states show similar ion beam distribution on the target for a given extraction voltage. This is also a hint, that the structures have been produced within the source already.

THPEB070 **Making Engineering Data Available at the European XFEL** – *L. Hagge, N. Bergel, J. Buerger, J.A. Dammann, S. Eucker, A. Herz, J. Kreutzkamp, S. Panto, S. Suehl, D. Szepielak, P. Tumidajewicz, N. Welle (DESY)*

One of the essential success factors for the European XFEL is up-to-date, complete and consistent engineering data which is readily accessible throughout the project. Such data include for example civil construction drawings of tunnels and buildings; integrated 3D models of accelerator sections; definitions of fabrication processes and test procedures; inspection sheets, test data, standards, contracts and other technical documentation. The data is kept in the DESY Engineering Data Management System (EDMS). The DESY EDMS is the central information platform for the European XFEL and provides procedures for e.g. review & approvals and change management. The poster presents an overview of Engineering Data Management and its benefits at the European XFEL.

THPEB071 **Information Management in the Civil Construction of the European XFEL** – *L. Hagge, N. Bergel, J.A. Dammann, S. Eucker, J. Kreutzkamp, S. Suehl, D. Szepielak, P. Tumidajewicz, N. Welle (DESY)*

Building an accelerator facility brings together civil construction and mechanical engineering, two trades with very different working cultures, practices and tool sets: While construction sites are traditionally paper-based and 2D oriented, the accelerator and its infrastructure are completely modeled in 3D. At the European XFEL, methods and tools known from plant construction were introduced to civil construction to enable efficient collaboration of all trades. Integrated 3D models encompass design models of all technical subsystems. An electronic "XFEL room book" captures requirements and manages assignments of space, infrastructure and equipments in the buildings. The DESY Engineering Data Management System (EDMS) manages and links the information with additional documentation. Electronic workflows coordinate e.g. reviews and change management. 3D models, room book and documentation databases together constitute the so-called "Building Information Model" (BIM). The BIM addresses the entire building lifecycle and is a basis for later facility operation. The poster describes information management procedures, tools and experience in the civil construction of the European XFEL.

THPEB072 **Maximizing the Efficiency of LHC Maintenance during Operation Times using a Mobile Tool** – *P. Martel, Ch. Delamare, S. Mallon Amerigo, L. Pater, S. Petit, D. Widegren (CERN)*

The operation of the LHC imposes minimum maintenance time, when needed corrections to all systems are to be carried out. Today's maintenance management tools at CERN are seen as too slow and cumbersome for such a challenge. The short duration of the technical stops (72 h/month) requires preparation of jobs in advance, and coordination of all involved teams; at the same time, the radio-protection of personnel in the LHC underground areas imposes a strict "As Low As Reasonably Achievable"(ALARA) policy for the works' duration. In order to perform a maximum of tasks in a short time, a mobile tool for the manipulation of job and equipment data has been created. The ability to signal a new job to a team in the field will avoid unnecessary trips to the tunnel; the signaling of a job's completion (and its details) will allow subsequent jobs to start promptly and with more information; finally, the possibility to consult equipment's full manufacturing and installation data "in situ" will help with the investigation of unforeseen situations. In a 27 km environment with scarce Wi-Fi connectivity, an online light tool is now available, covering the essentials of asset maintenance tasks.

THPEB073 **De-ionized Water Supplied System Design of Taiwan Photon Source** – *W.S. Chan, J.-M. Lee, Z.-D. Tsai (NSRRC)*

This work presents overview to the de-ionized water supplied system design of Taiwan Photon Source (TPS). It is important to appreciate that the system design is influenced by three major factors, namely product water quality and quantity, supplied water quality and quantity and the selected process scheme. The system is composed of a pretreatment, make-up, and points-of-use filtration systems. The pretreatment system consists of an active carbon tower, a 5-μm normally cartridge filter and a reversed osmosis (RO) unit. Furthermore, the make-up system consists of a ultraviolent (UV) TOC reduction unit, a degreaser, and a ion-exchange resin unit. Following the water treatment process, the proposed system can provide high quality de-ionized water whose resistivity is better than 10 MΩ-cm at 25$\pm$0.1^{o}C and dissolved oxygen is less than 10 ppb.

THPEB074 **Utility System Design and Construction Status for the 3 GeV TPS Storage Ring** – *J.-C. Chang, J.-R. Chen, Y.-C. Chung, K.C. Kuo, J.-M. Lee, Y.-C. Lin, C.Y. Liu, Y.-H. Liu, Z.-D. Tsai, T.-S. Ueng (NSRRC)*

The design of the utility system for the 3.0 GeV Taiwan Photon Source (TPS) has been finished and the construction engineering has been contracted out in the end of 2009. This paper presents the TPS utility system, including the electrical power, cooling water and air conditioning system, which were designed to meet requirements of high reliability and stability. The TPS construction site is located adjacent to TLS. Even some areas of TPS and TLS are overlapped. The whole utility system construction will be finished in the end of 2012. Therefore, the construction engineering of the TPS utility system is a challenge to finish on a tight schedule and keep the TLS in operation during the construction. Some management schemes of the construction engineering are also presented in this paper.

THPEB075 **Numerical Simulation and Air Conditioning System Study for the Storage Ring of TLS** – *J.-C. Chang, J.-R. Chen, Y.-C. Chung, C.Y. Liu, Z.-D. Tsai (NSRRC) M. Ke (NTUT)*

The stability of air temperature in the storage ring tunnel is one of the most critical factors. Therefore, a series of air conditioning system upgrade studies and projects have been conducted at the Taiwan Light Source (TLS). The global air temperature variation related to time in the storage ring tunnel has been controlled within ±0.1 degree C for years. This study is aimed at more precise temperature control. Some temperature control schemes are applied on this study. We also performed computational fluid dynamics (CFD) to simulate the flow field and the spatial temperature distribution in the storage ring tunnel.

THPEB076 **Utility Cooling System Design for the Taiwan Photon Sourse** – *Z.-D. Tsai, J.-C. Chang, J.-R. Chen, Y.-C. Chung, J.-M. Lee, C.Y. Liu (NSRRC)*

National Synchrotron Radiation Research Center (NSRRC) in Taiwan has finished an open bid about utility system for Taiwan photon source (TPS). The detail design and criteria of the utility cooling system, including cooling water and air conditioning system, have also been considered and confirmed. From controls to facility, all devices were designed and optimized to meet critical requirements of high reliability and stability. Besides, the paper mainly focuses on thermal load evaluation and removes to achieve the best efficiency and performance of system. The brand new system structure and control strategy also be realized.

THPEB077 **Simulation and Design of the High Precision Temperature Control for the De-ionized Cooling Water System** – *Z.-D. Tsai, J.-C. Chang, J.-R. Chen, C.Y. Liu (NSRRC)*

Previously, the Taiwan Light Source (TLS) has proven that the temperature stability of de-ionized cooling water is one of the most critical factors of electron beam stability. A series of efforts were devoted to these studies and promoted the temperature stability of the de-ionized cooling water system within $\pm 0.1^{o}$C. Further, a high precision temperature control $\pm 0.01^{o}$C has been conducted to meet the more critical stability requirement. Using flow mixing mechanism and specified control philosophy can minimize temperature variation effectively. The paper declares the mechanism through simulation and verifies the practical influences. The significant improvement of temperature stability between cooling devices and de-ionized water are also presented.

THPEB078 **Investigation and Analysis of Electric Power System Harmonics in TLS** – *T.-S. Ueng, J.-C. Chang, J.-M. Lee, Y.-C. Lin (NSRRC)*

The electric power system of Taiwan Photon Source (TPS) will be installed during the construction of TPS. Many power electronic devices which produce large nonlinear loads will be used in the new power system and the accelerator facility. The capacitor banks will also be used for the power factor correction. Thus, the excessive harmonic waveform distortion level on the normal waveform will be presented continuously. These excessive harmonic current flows will result in transformer and cable over-heating and many types of circuit faults, and also wasting energy. A project is initiated to study these harmonic effects which will appear in the electric power system of TPS. A computer simulation approach is used to study the harmonic waveform distortion phenomena, and also to investigate an effective approach to reduce it. The harmonic effects of selected section of TLS (Taiwan Light Source) electric power system, and those appear at the mock segment of 1/24 accelerator of TPS system are measured and compared with the simulated results.

THPEB079 **Survey and Alignment Strategy for Compton X-ray Generator NESTOR** – *A.Y. Zelinsky, A. Mytsykov (NSC/KIPT)*

NESTOR facility that is under construction in NSC KIPT (Kharkov, Ukraine) consists of compact 225 MeV electron storage ring, 100 MeV linear accelerator-injector, laser optical system and radiation channel. To provide effective and cheap survey and alignment system for compact facility is crucial task in order to achieve designed X-ray parameters (X-ray intensity up to 1012 phot/s). In the article the survey and alignment strategy of Compton generator NESTOR is described. The system uses traditional triangulation method and provides the accuracy of technological equipment alignment equal to 100 mkm.

27-May-10	16:00 – 18:00	Poster	Event Hall, Poster Area C

THPEC — Poster Session

THPEC001 **Optimization of Nonlinear Wakefield Amplitude in Laser Plasma Interaction** – *A.K. Upadhyay, P. Jha (Lucknow University) S. Krishnagopal (BARC) S.A. Samant, D. Sarkar (CBS)*

Nonlinear, high-amplitude plasma waves are excited in the wake of an intense laser pulse propagating in a cold plasma, providing acceleration gradients up to GeV/m. Linear analytic analyses have shown that the wakefield amplitude is optimal for a certain ratio of the pulse length and plasma wavelength*,**. Here we present results of simulation studies to optimize the nonlinear wakefield amplitudes. Variation in the laser pulse length is considered for maximizing amplitudes of wakefields generated by half-sine and Gaussian pulse profiles. Further, the advantages of using a transversely inhomogeneous plasma for the generation of the nonlinear wakefields are studied and compared with the homogeneous case.

THPEC002 **Simulation of Electron Acceleration by Two Laser Pulses Propagating in a Plasma** – *S. Krishnagopal (BARC) P. Jha, A.K. Upadhyay (Lucknow University) S.A. Samant, D. Sarkar (CBS)*

Simulation studies of electron acceleration by two laser pulses co-propagating one behind the other in a homogeneous plasma, are presented. Such a configuration for generating high amplitude wakefields has been recently proposed and studied in the linear regime*. The trapping and acceleration of electrons is studied and optimized, and the results compared with the single laser pulse case. Further, the effect of a tapered plasma channel is studied. Trapping and acceleration of externally injected electrons is obtained and compared with the homogeneous case.

THPEC003 **Stabilization of Laser Accelerated Electron Bunch by the Ionization-stage Control** – *M. Mori, S.V. Bulanov, K. Kawase, K. Kondo, A. Yokoyama (JAEA) H. Daido, M. Kando (JAEA APRC) H. Kotaki, K. Ogura (JAEA/Kansai) Y. Mizuta, K.A. Tanaka (Osaka University, Graduate School of Engineering) H. Nishimura (ILE Osaka)*

The pointing stability and the divergence of a quasi-monoenergetic electron bunch generated in a self-injected laser-plasma acceleration regime were investigated. Gas-jet targets have been irradiated with focused 40 fs laser pulses at the 4-TW peak power. A pointing stability of 2.4 mrad root-mean-square (RMS) and a beam divergence of 10.6 mrad (RMS) were obtained using argon gas-jet target for 50 sequential shots, while these values were about three times smaller than at the optimum condition using helium. In particular, the peak electron energy was 9 MeV using argon, which is almost three times lower than that using helium. This result implies that the formation of the wake-field is different between argon and helium, and it plays an important role in the generation of a electron bunch. This stabilization scheme is available for another gas material such as nitrogen. At nitrogen gas-jet target, the pointing stability is more improved to 1.4 times smaller (1.7 mrad (RMS)) than that in argon gas-jet target and the peak energy is increased to grater than 40 MeV. These results prove that this method not only stabilize the e-beam but also allows controlling the electron energy.

THPEC004 **All-optical Hard X-ray Sources and their Applications to Nuclear Engineering** – *K. Koyama (University of Tokyo) T. Hosokai (Osaka University) A. Maekawa, H. Masuda, M. Uesaka (The University of Tokyo, Nuclear Professional School) Y. Oishi (Central Research Institute of Electric Power Industry) A. Yamazaki (Nagoya University)*

We are studying the artificial injection of initial electrons into the wakefield for producing stable electron bunch (the charge is 100 pC, the energy stability is better than a few per cent). The objective of our research is to produce 100-keV class monochromatic X-ray pulses for measuring concentrations of nuclear materials in a reprocessing plant. A K-edge densitometry using monochromatic hard x-ray beams is one of the effective technique to measure concentrations of nuclear materials in a reprocessing solutions. An inverse Compton scattering process between an IR-laser beam of 800 nm and high-energy electron bunch of above 80 MeV makes it possible to deliver tunable monochromatic x-rays near K-absorption edges of nuclear materials of 115-129 keV. In order to use in a reprocessing plant, the equipment for the K-edge densitometry must be smaller than a compact car. The only solution to realize the compact system is to use a laser wakefield accelerator instead of a radio frequency linac. An ultra-short ten-TW laser pulse focused on a supersonic jet makes it possible to accelerate electrons up to 100 MeV in a plasma length of 2.5 mm.

THPEC005 **Simulation of Laser WakeField Acceleration based on Typical 100 TW Laser Facilities** – *D.Z. Li, J. Gao, A. He, W.X. Zhu (IHEP Beijing)*

We presented some simulation results from OOPIC program which is developed by tech-X Corporation. All the works are based on typical existed 100 TW laser facilities which are available for Laser WakeField Acceleration (LWFA) in blow-out regime. We analyzed the effects of the plasma density and its distributions on the self-injection process and the electron beam qualities. We also changed laser pulse length and focal spot size for better beams. Meanwhile we observed that the captured bunch executed betatron oscillations during longitudinal acceleration. We compared our simulations with theoretical and experimental results and tried to give a brief explanation. At last we proposed a set of laser plasma parameters for a self-injection LWFA experiment carried on a typical 100 TW, 30fs laser pulse according to these results, and compare our simulations with some experiment results.

THPEC006 **Characterization of Gas Jet Nozzle for Laser-plasma Wakefield Acceleration** – *Hua,,J.F. Hua, L.X. Yan (TUB)*

A high-density gas jets nozzle is designed for laser-plasma acceleration, based on the TW IR laser sytem for Tsinghua Thomson scattering X-ray light source (TTX). The optimization has been made for the long plasma channel production. And the density profile has been measured using interferometry and Abel inversion.

THPEC007 **Density Structure Effect on the Electron Energy in Laser Wakefield Accelerator** – *J. Kim, G. Kim, J. Kim, S.H. Yoo (KERI)*

Using the nonlinear interaction between the high power laser and the plasma, we can generate strong acceleration field, called the laser wake field acceleration. The plasma density is very crucial to generate high energy electron. In this work, we studied the effect of the plasma density structure on the accelerated electron energy. We used 20 TW, 40 fs laser system to generate the plasma wakefield. A gas jet was used as a target. The plasma density was controlled by the back pressure of the gas nozzle and measured by the interferometer. The accelerated electron energy was measured using the electron energy spectrometer with 0.5 T magnet. The bunch charge was measured integrated charge transformer (ICT). When the plasma density is uniform, 2×10^{19} cm^{-3} we can generate 200 MeV electron beam with bunch charge 33 pC. The electron beam divergence was less than 5 degree. If there exists the downward density tramp, the electron energy is only 50 MeV. The PIC simulation also indicates that if there is density ramp structure, the electron is not accelerated well. In this presentation, the overall experimental and simulation results are presented.

THPEC008 **Optimum Plasma Density for the Maximum Photon Flux from the Laser Induced Betatron Oscillation** – *S.H. Yoo, J. Kim, J.-U. Kim (KERI)*

In the laser wakefield accelerator (LWFA), the intense laser pulse generates the ion cavity in the plasma. Inside this cavity, the injected electrons are accelerated and have a betatron oscillatory modtion due to the strong field of the laser pulse.* The ion cavity acts as a wiggler and high harmonics are radiated. The important characteristics of x-ray from this plasma wiggler are the cutoff energy and the photon flux. The photon flux can be peaked for an optimum plasma density.** In this paper, the mechanism of the peaked pattern of the photon flux is investigated through the experiment with a beam profile analysis. The beam ellipticity, which is related to the oscillation amplitude, has a linear relationship with the bunch charge. The peaked patterns of the oscillation amplitude and bunch charge result in the optimum condition of plasma density for the maximum photon flux. Using a Particle-In-Cell simulations, the weaker fields of the laser pulse and multi-cavitation in the modulated regime were investigated. The expected characteristics of the x-ray from the plasma wiggler will be presented.

THPEC009 **A Gas-filled Capillary Plasma Source for Laser-driven Plasma Acceleration** – *H. Suk, D. Jang, D. Jang, M. Kim,* *S. Oh (APRI-GIST)*

In recent years, the laser-driven plasma wakefield acceleration has attracted much attention as it has a much higher acceleration gradient (>100 GeV/m) compared with the RF-based conventional accelerators. In the past, the supersonic gas jet method for plasma wakefield acceleration was widely used, but this method has a limitation in acceleration distance and energy because the focused laser beam is diffracted severely over a very short distance (~ a few mm range). To avoid the diffraction problem, a capillary plasma source can be used, where a high power laser beam can be guided over a long distance (~ a few cm range) by a parabolic plasma density profile in the capillary plasma channel. We have developed a gas-filled capillary plasma source for generation of GeV-level electron beams in collaboration with the University of Oxford team. In this presentation, the detailed test results and the near-future experimental plan for GeV-level e-beam generation are shown.

THPEC011 **Electron Acceleration using the 300 TW HERCULESLaser System at the University of Michigan** – *K.M. Krushelnick, V. Chvykov, F.J. Dollar, G. Kalintchenko, A. Maksimchuk, T. Matsuoka, C.S. McGuffey, W. Schumaker, A.G.R. Thomas, V. Yanovsky (University of Michigan, FOCUS Center for Ultrafast Optical Science)*

Recent experimental results will be discussed with regard to the use of the 300 TW, 30 fsec HERCULES laser system at the Center for Ultrafast Optical Science at Michigan to generate GeV range electron beams using Laser Wakefield Acceleration (LWFA). The electron beam quality is shown to be improved substantially using gas mixtures- causing an increase in beam charge and a decrease in emittance. The dynamics of the acceleration process are also determined by measurements of spatially resolved scattered laser radiation and the use of femtosecond optical probing techniques.

THPEC012 **Laser Wakefield Simulation using a Speed-of-light Frame Envelope Model** – *B.M. Cowan, D.L. Bruhwiler, K. Paul, V.H. Ranjbar, S.W. Sides (Tech-X) E. Cormier-Michel, E. Esarey, C.G.R. Geddes (LBNL)*

Simulation of laser wakefield accelerator (LWFA) experiments is computationally highly intensive due to the disparate length scales involved. Current experiments extend hundreds of laser wavelengths transversely and many thousands in the propagation direction, making explicit FDTD/PIC simulations enormously expensive. The performance of LWFA simulations can be substantially improved by modeling the envelope modulation of the laser field rather than the field itself. This allows for much coarser grids, since we need only resolve the plasma wavelength and not the laser wavelength, and this also allows larger timesteps. Previous work has shown speedup of over 5 orders of magnitude of such a model over explicit FDTD, while having much lower numerical dispersion error and maintaining the property of second-order convergence. Here we describe improvements to the algorithm which allow it to accurately model laser depletion, as well as mesh refinement for efficiently resolving the particle injection process.

THPEC013 **Compact Couplers for Photonic Crystal Laser-driven Accelerator Structures** – *B.M. Cowan, M.C. Lin, B.T. Schwartz (Tech-X) R.L. Byer, C. McGuinness (Stanford University) E.R. Colby, R.J. England, R.J. Noble, J.E. Spencer (SLAC)*

Photonic crystal waveguides are promising candidates for laser-driven accelerator structures because of their ability to confine a speed-of-light mode in an all-dielectric structure. Because of the difference between the group velocity of the waveguide mode and the particle bunch velocity, fields must be coupled into the accelerating waveguide at frequent intervals. Therefore efficient, compact couplers are critical to overall accelerator efficiency. We present designs and simulations of high-efficiency coupling to the accelerating mode in a three-dimensional photonic crystal waveguide from a waveguide adjoining it at 90 degrees. We discuss details of the computation, including an optimization routine to modify the geometric parameters of the coupler for maximum efficiency, the resulting transmission, and estimates of the fabrication tolerance for these devices. We include some background on the accelerator structure and photonic crystal-based optical acceleration in general.

THPEC014 **Resonant Excitation of Plasma Wakefields** – *P. Muggli (UCLA) B.A. Allen (USC) M. Babzien, K. Kusche, J.H. Park, V. Yakimenko (BNL)*

At the Brookhaven National Laboratory Accelerator Test Facility (ATF) we study the excitation of plasma wakefields by a train of electron bunches in a plasma wakefield accelerator (PWFA). The excitation leads to large amplitudes when the plasma density is adjusted such that the plasma wavelength is equal to the period (~1ps or 300microns) of the drive bunches. In addition, a witness bunch following the drive bunches train at a distance of one and a half the drive train period experiences the accelerating wakefield. Driving the wakefield with multiple bunches can lead to acceleration with high transformer ratio and high energy transfer efficiency. We produce this electron bunch train from the ATF beam using a recently demonstrated masking technique*. The electron bunches travel in a capillary discharge with a variable plasma density. The experimental results clearly demonstrate for the first time the resonant excitation of the wakefield with a large energy loss by the drive bunch train and energy gain by the witness bunch. We also observe the PWFA physics associated with the train and the long electron bunch. We will present the latest detailed experimental results.

THPEC015 **Breaking the Attosecond, Angstrom and TV/m Field Barriers with Ultra-fast Electron Beams** – *J.B. Rosenzweig, G. Andonian, A. Fukasawa, E. Hemsing, G. Marcus, A. Marinelli, P. Musumeci, B. D. O'Shea, F.H. O'Shea, C. Pellegrini, D. Schiller, G. Travish (UCLA) P.H. Bucksbaum, M.J. Hogan, P. Krejcik (SLAC) M. Ferrario (INFN/LNF) S.J. Full (Penn State University) P. Muggli (USC)*

Recent initiatives at UCLA concerning ultra-short, GeV electron beam generation have been aimed at achieving sub-fs pulses capable of driving X-ray free-electron lasers (FELs) in single-spike mode. This uses of very low charge beams, which may allow existing FEL injectors to produce few-100 attosecond pulses, with very high brightness. Towards this end, recent experiments at the Stanford X-ray FEL (LCLS, first of its kind, built with essential UCLA leadership) have produced ~2 fs, 20 pC electron pulses. We discuss here extensions of this work, in which we seek to exploit the beam brightness in FELs, in tandem with new developments at UCLA in cryogenic undulator technology, to create compact accelerator/undulator systems that can lase below 0.15 Angstroms, or be used to permit 1.5 Angstrom operation at 4.5 GeV. In addition, we are now developing experiments which use the present LCLS fs pulses to excite plasma wakefields exceeding 1 TV/m, permitting a table-top TeV accelerator for frontier high energy physics applications.

THPEC016 **Propagation and Acceleration of Positron Bunches in Hollow Plasma Channels** – *P. Muggli, X. Li (USC) C. Huang (LANL) S.F. Martins (Instituto Superior Tecnico) W.B. Mori (UCLA)*

The interaction of positron beams with plasma is qualitatively and quantitatively different from that of electron beams with plasmas. In particular, a positron bunch drives a lower accelerating gradient, and its emittance is not preserved in a uniform plasma*. Hollow plasma channels were proposed as an alternative to uniform plasmas to increase the accelerating gradient and preserve the accelerated beam emittance**. We study numerically the possibility of accelerating a positron witness bunch on the wake driven by an electron or a positron drive bunch in a hollow plasma channel. Preliminary results confirm that higher gradient can be driven, and show that the transformer ratio is also larger than in a uniform plasma. However, the positron seems to experiences moderate emittance growth due to plasma electron streaming through the hollow plasma channel. Detailed simulation results will be presented.

THPEC017 **Measurements of the Correlation Between Plasma Bubble Dynamics and Electron Trapping in a Laser Wakefield Accelerator** – *M.H. Helle (Georgetown University) D.F. Gordon, A. Ting (NRL) D. Kaganovich (Icarus Research, Inc.)*

Generation of conically emitted second harmonic radiation has recently been observed in a laser wakefield accelerator experiment at the U.S. Naval Research Laboratory. This second harmonic is the result of frequency mixing within the sheath surrounding a fully cavitated plasma region, "plasma bubble," created by the ponderomotive force of a laser*.

Using this second harmonic signature, we have indirectly studied the dynamics of a plasma bubble. It has been observed that the plasma bubble dynamics are strongly correlated to the generation of electrons. Specifically, the onset of the bubble is connected to the generation of off-axis electrons**, while forward accelerated electrons have been observed when the conical distribution of second harmonic is broken, signifying the disruption of the plasma bubble. Further results on bubble dynamics and its connection to electron beam production will be presented.

THPEC018 **Explosive Field Emission Cathodes** – *M. Caron (CEA)*
Explosive Field Emission Cathodes (EFEC) are used as primary electrons sources in Linear Induction Accelerator (LIA) for flash X-ray radiographic applications. We developped a new set-up to characterise electron emission performances from different velvets and coated thin layers on top of several substrats. In this paper, the set-up is described and first results are reported.

THPEC019 **Implementation of a Polarized Electron Source at the S-DALINAC** – *C. Eckardt, T. Bahlo, P. Bangert, R. Barday, U. Bonnes, M. Brunken, R. Eichhorn, J. Enders, M. Platz, Y. Poltoratska, M. Roth, F. Schneider, M. Wagner, A. Weber, B. Zwicker (TU Darmstadt) W. Ackermann, W.F.O. Müller, T. Weiland (TEMF, TU Darmstadt)*
At the superconducting 130 MeV Darmstadt electron linac S-DALINAC* a source of polarized electrons** is being installed, extending the experimental capabilities with polarized electron and polarized photon probes for nuclear structure studies. This involves disassembling the existing low energy test stand and rebuilding the beam line in the accelerator hall. The beam itself is produced from a GaAs cathode by irradiation with a pulsed laser. The low-energy electron beam line includes diagnostic elements, a Wien filter for spin manipulation, a 100 keV Mott polarimeter for polarization measurement and a chopper-prebuncher section to modulate the time structure of the beam. At higher energies a 5-10 MeV Mott polarimeter and a 50-130 MeV Moeller polarimeter as well as a Compton transmission polarimeter will be installed to measure the beam polarization after acceleration. The Mott polarimeter is working with backscattered electrons under 165^{o} scattering angle while for the Moeller polarimeter a wide-angle (3^{o}-15^{o}) spectrometer magnet was designed. We report on the performance of the test stand, the ongoing implementation, and the polarimeter research and development.

THPEC020 **QE Tests with Nb-Pb SRF Photoinjector and Arc Deposited Cathodes** – *J.K. Sekutowicz (DESY) P. Kneisel (JLAB) R. Nietubyc (The Andrzej Soltan Institute for Nuclear Studies, Centre Swierk) T. Rao, J. Smedley (BNL)*
In this contribution, we report Quantum Efficiency (QE) test results with a hybrid lead/niobium superconducting RF (SRF) photoinjector at 2K and new Pb arc deposited cathodes at 300K. The ultimate goal of our effort is to build a Nb injector with the superconducting cathode made of lead, which, as reported in the past, demonstrated superior QE compared to other metallic superconducting elements. At first, we present the test results obtained with a 1.6-cell high purity Nb cavity with the emitting lead spot in the center of the back plate. The QE test results at room temperature and the SEM surface analysis of eight Pb cathodes, deposited recently under various conditions, are discussed in the second part of this contribution.

THPEC021 **Coaxial Coupling Scheme for TESLA/ILC-type Cavities** – *J.K. Sekutowicz (DESY) P. Kneisel (JLAB)*
This paper reports about our efforts to develop a flangeable coaxial coupler for both HOM and fundamental coupling for 9-cell TESLA/ILC-type cavities. The cavities were designed in early 90's for pulsed operation with a low duty factor, less than 1 %. The proposed design of the coupler has been done in a way, that the magnetic flux B at the flange connection is minimized and only a field of <5 mT would be present at the accelerating field Eacc of ~ 36 MV/m (B =150 mT in the cavity). Even though we achieved reasonably high Q-values at low field, the cavity/coupler combination was limited in the cw mode to only ~ 7 MV/m, where a thermally initiated degradation occurred. We have improved the cooling conditions by initially drilling radial channels every 30 degrees, then every 15 degrees into the shorting plate. The modified prototype performed well up to 9 MV/m in cw mode. This paper reports about our experiences with the further modified coaxial coupler and about test results in cw and low duty cycle pulsed mode, similar to the TESLA/ILC operation conditions.

THPEC022 **Beam Tests of HOM Absorber at FLASH** – *J.K. Sekutowicz, M. Dohlus, A. Goessel, N. Mildner (DESY)*
High frequency Higher Order Modes (HOM) propagating in the beam line of a superconducting linac can carry a substantial fraction of the energy deposited in accelerating structures by the beam. In this contribution, we report test results of the beam line absorber (BLA), which was designed and fabricated at DESY, and installed in the FLASH accelerator to absorb the HOM energy generated by high current beams. Two tests were carried out, in September 2008 and September 2009, during so called high current runs. The experiments confirmed the concept of the BLA design and showed remarkable agreement with computer modeling of the HOM energy absorption.

THPEC023 **Positron Source Simulations using Geant4** – *A. Ushakov, S. Riemann, A. Schaelicke (DESY Zeuthen)*
The development of an intense polarised positron sources provides a challenge for a new generation of linear colliders. The software framework Geant4, a toolkit for simulation of the passage of particles trough matter, features tracking capabilities of charged particles in electromagnetic fields, and also includes the description of polarisation transfer in scattering processes. Based on Geant4 a novel simulation tool, PPS-Sim*, has been developed to optimise the design and to determine polarisation, beam properties, as well as energy deposition in accelerator components. All source components and their parameters can be chosen easily and flexible. Helical undulator, laser-Compton and coherent Bremsstrahlung in crystals are available as positron production schemes. Target materials and geometry can be adjusted. Flux concentrator, quarter wave transformer and lithium lens are implemented as possible capture devices. Geometry, accelerating components and magnetic field configuration can be specified by the user. In this contribution, PPS-Sim will be presented, and selected results for linear collider applications will be discussed.

THPEC024 **Development of a High Average Power Laser Generating Electron Beam in ILC Format for KEK-STF** – *M. Kuriki, H. Iijima (HU/AdSM) H. Hayano, Y. Honda, H. Sugiyama, J. Urakawa (KEK) G. Isoyama, S. Kashiwagi, R. Kato (ISIR) E. Katin, E. Khazanov, V. Lozhkarev, G. Luchinin, A. Poteomkin (IAP/RAS) G. Shirkov, G.V. Trubnikov (JINR)*
Aim of Super-conducting Test Facility (STF) at KEK is demonstrating technologies for International Linear Collider. In STF, one full RF unit will be developed and beam acceleration test will be made. In super-conducting accelerator, precise RF control in phase and power is essential because the input RF power should be balanced to beam accelerating power. To demonstrate the system feasibility, the beam accelerating test is an important step in R&D phase of STF and ILC. To provide ILC format beam for STF, we develop an electron source based on photo-cathode L-band RF gun. To generate ILC format beam, we developed a laser system based on Yb fiber oscillator in 40.6 MHz. The pulse repetition is decreased by picking pulses in 2.7 MHz, which meets ILC bunch spacing, 364 ns. The pulse is then amplified by YLF laser up to 8 uJ per pulse in 1 mm. The light is converted to 266 nm by SHG and FHG. Finally, 1.5 uJ per pulse is obtained and 3.2 nC bunch charge will be made. We report the basic performance of the laser system from the accelerator technology point of a view.

THPEC025 **First Emission of Novel Photocathode Gun Gated by Z-polarized Laser Pulse** – *H. Tomizawa, H. Dewa, H. Hanaki, A. Mizuno, T. Taniuchi (JASRI/SPring-8)*
We have developed a laser-induced Schottky-effect-gated photocathode gun since 2006. This new type of gun utilizes a laser's coherency to realize a compact laser source using Z-polarization of the IR laser on the cathode. This Z-polarization scheme reduces the laser pulse energy by reducing the cathode work function due to Schottky effect. Before this epoch-making scheme, photocathode guns had never utilized laser's coherency. A hollow laser incidence is applied with a hollow convex lens that is focused after passing the beam through a radial polarizer. According to our calculations (convex lens: NA=0.15), a Z-field of 1 GV/m needs 1.26 MW at peak power for the fundamental wavelength (792 nm) and 0.316 MW for the SHG (396 nm). Therefore, we expect that this laser-induced Schottky emission requires just a compact femtosecond laser oscillator as a laser source. Besides, a dichromatic laser scheme (photo-exciting: 780 nm; gating: 30 um) should be applied to polarized electron sources for International Linear Collider (ILC). We report the first feasibility study

of this laser-induced Schottky-effect on several metal photocathodes by comparing radial and azimuthal polarizations.

THPEC026 **Experimental Results of RF Gun and Generation of Multi Bunch Beam** – *A. Deshpande (Sokendai) S. Araki, M.K. Fukuda, N. Terunuma, J. Urakawa (KEK) K. Sakaue, M. Washio (RISE)*

At Accelerator Test Facility (ATF) at KEK, we designed and made a new RF Gun with high mode separation of 8.6 MHz and high Q value as compared to earlier guns. This paper presents fabrication details, low power measurements and tuning procedures followed in making the gun cavity. We also discuss in detail, experimentation done using this gun and show the measurement results. Currently we produce 100 bunch per train but we plan to go for 300 or more bunch per train operation. This will make possible to have higher charge available for laser-beam collisions to generate high flux soft X-rays by Inverse Compton Scattering at our setup.

THPEC027 **Beam Dynamics in Femtosecond Photocathode RF Gun** – *K. Kan, T. Kondoh, T. Kozawa, K. Norizawa, J. Yang, Y. Yoshida (ISIR)*

Time resolution of pulse radiolysis, which is a stroboscopic measurement technique, depends on electron bunch length. In order to improve the time resolution, femtosecond electron bunch generation at photocathode rf gun was investigated. A 1.6-cell S-band photocathode rf gun, similar to the Gun IV type at Brookhaven National Laboratory (BNL), was used. The rf gun consisted of a half cell and a full cell. A copper cathode was located in the half cell. The rf gun was driven by femtosecond UV laser pulse (266 nm), which was generated with third-harmonic-generation (THG) of Ti:Sapphire femtosecond laser (800 nm). The longitudinal and transverse dynamics of the electron bunch generated by the UV laser was investigated. The bunch length was measured with the dependence of energy spread on acceleration phase in a linac, which was set at the downstream of the rf gun. Transverse emittance at the linac exit was also measured with Q-scan method.

THPEC028 **Femtosecond Pulse Radiolysis Study in Radiation Chemistry Using a Photocathode RF Gun LINAC** – *T. Kondoh, K. Kan, T. Kozawa, K. Norizawa, A. Ogata, J. Yang, Y. Yoshida (ISIR)*

Femtosecond electron beam pulse radiolysis which has time resolution of 250 fs was achieved by a Photocathode RF gun LINAC in the ISIR, Osaka University. And geminate ion recombination (charged pair dynamics) in n-dodecane was studied. Kinetics of the Radical cation of n-dodecane was measured. As a result, the existence of the excited-radical cation, and generation of the radical cation via relaxation from the excited-radical cation were suggested. Those new results were obtained in the field of the radiation chemistry by the photocathode RF gun.

THPEC029 **Photocathode Femtosecond Electron Beam Applications: Femtosecond Pulse Radiolysis and Femtosecond Electron Diffraction** – *J. Yang, K. Kan, T. Kondoh, Y. Murooka, N. Naruse, K. Tanimura, Y. Yoshida (ISIR) J. Urakawa (KEK)*

Both ultrafast time-resolved radiolysis and electron diffraction based on photocathode rf electron guns have been developed in Osaka University to reveal the hidden dynamics of intricate molecular and atomic processes in materials. One of the photocathode rf guns has been used successfully to produce a 100-fs high-brightness electron single bunch with a booster linear accelerator and a magnetic bunch compressor. The time resolution of 240 fs was achieved at the first time in the pulse radiolysis. Another photocathode rf gun, which produces directly a near-relativistic 100-fs electron beam, has been developed to construct femtosecond electron diffraction. The megavolt electron diffraction patterns have been observed. The dependences of the emittance, bunch length and energy spread on the radio-frequency (rf) and space charge effects in the rf gun were investigated.

THPEC030 **Design of the COMET Pion Capture Solenoid** – *M.Y. Yoshida, M. Aoki, Y. Kuno, A. Sato (Osaka University) T. Nakamoto, T. Ogitsu, K. Tanaka, A. Yamamoto (KEK)*

An intense muon beam is mandatory for the next-generation experiments to search for lepton flavor violating processes in the muon sector. The COMET experiment, J-PARC $\cdot 10^{21}$, aims to search for muon to electron conversion with an unprecedented sensitivity.. The muon beam is produced from pion decays in a strong magnetic field generated by superconducting solenoid coils. The large-bore superconducting coils enclose the pion-production target to capture pions with a large solid angle. The magnetic field is designed to have a peak of 5T at the target. To avoid severe radiation from the target, thick shielding is inserted in the warm bore of the pion capture solenoid magnet. The proton beam is injected through the gap between the pion capture solenoid and the subsequent transport solenoid magnets. For this purpose, the bore of the pion capture solenoid has to be larger than 1 m. This paper describes the design of the pion capture solenoid magnet for the COMET experiment.

THPEC031 **Multi-bunch Electron Beam Generation based on Cs-Te Photocathode RF-Gun at Waseda University** – *Y. Yokoyama, T. Aoki, K. Sakaue, T. Suzuki, M. Washio, J. Yokose (RISE) H. Hayano, N. Terunuma, J. Urakawa (KEK) S. Kashiwagi (ISIR) R. Kuroda (AIST)*

At Waseda University, we have been studying a high quality electron beam generation and its application experiments with Cs-Te photocathode RF-Gun. We have already succeeded in generating a stable high-charged single-bunch electron beam. To generate more intense electron beam, we designed a multi-bunch electron linac and developed the multi-pulse UV laser which irradiates to the cathode. The target values of the number of electron bunch and bunch charges are 100 bunches/train and 800 pC/bunch, respectively. In addition, we adopted the method of the amplitude modulation of the incident RF pulse to the S-band klystron in order to compensate the energy difference in each bunch because of the slow rise time of acceleration voltage in cavity and beam loading effect in the accelerating structure. In this conference, we will report design properties of our multi-bunch electron linac, the results of the multi-bunch electron beam diagnosis and the energy difference compensation using the RF amplitude modulation method.

THPEC032 **Performance of the CTF3 High Charge Photo Injector** – *M. Petrarca, N. Champault, E. Chevallay, A.E. Dabrowski, M. Divall Csatari, S. Doebert, D. Egger, V. Fedosseev, G. Geschonke, T. Lefevre, R. Losito, O. Mete, L. Rinolfi (CERN)*

The high charge PHIN photo injector is studied at CERN as an electron source for the CLIC Test Facility (CTF3) drive beam as an alternative to the present thermionic gun. The objective of PHIN is to demonstrate the feasibility of a laser-based electron source for CLIC. The photo injector operates with a 2.5 cell, 3 GHz RF gun using a Cs2Te photocathode illuminated by UV laser pulses generated by amplifying and frequency quadrupling the signal from a Nd:YLF oscillator running at 1.5GHz. The challenge is to generate a beam structure of 1908μbunches with 2.33nC perμbunch at 1.5GHz leading to a high integrated train charge of 4446nC and nominal beam energy of 5.5MeV with current stability below 1%. In the present test stand, a segmented beam dump has been implemented allowing a time resolved measurement of the energy and energy spread of the electron beam. In this paper we report and discuss the measured transverse and longitudinal beam parameters for both the full and time gated train of bunches, and the obtained photocathode quantum efficiency. Laser pointing and amplitude stability results are discussed taking into account correlation between laser and electron beam.

THPEC033 **Eddy Current Studies From the Undulator-based Positron Source Target Wheel Prototype** – *I.R. Bailey, J.A. Clarke (Cockcroft Institute) I.R. Bailey (Lancaster University) C.G. Brown, J. Gronberg, L.B. Hagler, W.T. Piggott (LLNL) L.J. Jenner (Imperial College of Science and Technology, Department of Physics) L. Zang (The University of Liverpool)*

The efficiency of future positron sources for the next generation of high-energy particle colliders (e.g. ILC, CLIC, LHeC) can be improved if the positron-production target is immersed in the magnetic field of adjacent capture optics. If the target is also rotating due to heat deposition considerations then eddy currents may be induced and lead to additional heating and stresses. In this paper we present data from a rotating target wheel prototype for the baseline ILC positron source. The wheel has been operated at revolution rates up to 1800rpm in fields of the order of 1 Tesla.

Comparisons are made between torque data obtained from a transducer on the target drive shaft and the results of finite-element simulations. Rotordynamics issues are presented and future experiments on other aspects of the positron source target station are considered.

THPEC034 **Undulator Based Positron Source Optimization for CLIC** – *L. Zang (Cockcroft Institute) I.R. Bailey (Lancaster University) M. Korostelev, A. Wolski (The University of Liverpool)*

CLIC will need of order 10 to the 14 positrons per second to achieve its specified luminosity. For such a challenge, an undulator based scheme has been proposed as one of the options for the positron source. As CLIC may operate over a wide range of energy (from 0.5 TeV to 3 TeV), there is a large margin for us to push the performance of the whole system to be more efficient. We report on the undulator parameters and optimization of components of the source such as conversion target, AMD, solenoid and capture RF for different operational scenarios. In addition to maximizing the positron yield the polarization of the positron beam are also considered.

THPEC035 **An Undulator based Polarized Positron Source for CLIC** – *W. Liu, W. Gai (ANL) L. Rinolfi (CERN) J. Sheppard (SLAC)*

We propose a viable positron source scheme that uses circularly polarized gamma rays generated from the main 250 GeV electron beam. The beam passes through a helical superconducting undulator with a magnetic field of ~ 1 Tesla and a period of a few centimeters. The gamma-rays produced in the undulator in the energy range between ~ 3 MeV ~ 100 MeV will be directed to a titanium target and produces polarized positrons. The positrons are then captured, accelerated and transported to a damping ring. Detailed parameter studies of this scheme including positron yield, undulator parameter dependence and target composition and geometry will be presented. Effects on the 250 GeV drive beam, including emittance, energy spread and energy loss from the beam passing through the undulator will also be discussed.

THPEC036 **Update on the ILC Positron Source Study at ANL** – *W. Liu, W. Gai (ANL)*

We present an update on the ANL ILC positron source study. We examined the impact of different drive beam energies on the positron yield and polarization for the ILC RDR baseline undulator. The e^+ yield is found to drop rapidly as the drive beam energy is reduced. We studied different undulator parameters for their effect on the positron yield and polarization when working at lower drive beam energies. Using a lower K (B field level) can increase the photon energy, but it is still very difficult to bring the yield up for low drive beam energies. For 250 GeV drive beam options, we studied the RDR undulator performance as a function of K. Instead of powering off some sections of the undulator, one can also consider lowering the B field to bring the positron yield back to the desired 1.5 e+/e-. We also studied the liquid lead target option for ILC positron source and the energy deposition in the reference design Ti target wheel.

THPEC037 **Design of a Pulsed Flux Concentrator for the ILC Positron Source** – *J. Gronberg, A. Abbott, C.G. Brown, J.B. Javedani, W.T. Piggott (LLNL) J.A. Clarke (STFC/DL/ASTeC)*

The positron source at a future TeV scale electron linear collider will need to generate positrons at a rate two orders of magnitude larger than have been previously achieved. We report on a design of a 3.5 Tesla pulsed flux concentrator magnet which uses liquid nitrogen cooling of the flux concentrator plates to reduce the electrical resistance leading to reduced energy deposition and the ability to generate the required 1 ms pulse duration. This magnet can double the collection efficiency of positrons emitted from the target.

THPEC038 **The Concept for Antiproton Accumulation in the RESR Storage Ring of the FAIR Project** – *M. Steck, C. Dimopoulou, A. Dolinskyy, T. Katayama, S.A. Litvinov, F. Nolden, C. Peschke (GSI) D. Möhl, L. Thorndahl (CERN)*

In the complex of the accelerators of the FAIR project the RESR storage ring is mainly designed as an accumulator ring for antiprotons. The continuous accumulation of pre-cooled batches with a cycle time of 10 s from the collector ring is essential to achieve the goal of a production rate of 10 million antiprotons per second. The accumulation in the RESR uses a stochastic cooling system which operates in longitudinal phase space, similar as previous antiproton accumulator rings at CERN and FNAL. The ingredients of the accumulation system, the ring lattice functions, the electrode design and the electrical circuits have been studied in detailed simulations. A system has been found which safely provides the required performance and offers the option of upgrades, if higher accumulation rate is required in future. Maximum intensities of 100 billion cooled antiprotons are planned which are expected to stay below the instability threshold.

THPEC039 **Handling of Beam Impurities in Gamma-spectroscopy Experiments at REX-ISOLDE (CERN)** – *T. Bloch, J. Leske, N. Pietralla (TU Darmstadt) J. van de Walle (CERN)*

The REX-ISOLDE facility at CERN delivers a great variety of radioactive ion beams with energies up to 3.0 MeV/u and therefore allows nuclear structure physics experiments far from stability. A crucial point for the experimentalist is the knowledge of possible unwanted beam contaminations, either from the bunching and charge-breeding procedure (residual gas ions) or directly from the ion-production process (isobaric contaminants). The sources of these contaminations will be discussed, as well as possible ways of elimination during the post-acceleration. Methods to analyse the beam composition in the relevant energy range will be presented with an emphasis on the experimental challenges in Gamma-spectroscopy experiments and data analysis.

THPEC040 **Design and Shielding of a Beamline from ELENA to ATRAP using Electrostatic Quadrupole Lenses and Bends** – *Y. Yuri (JAEA/TARRI) E. P. Lee (LBNL)*

The construction of the Extra Low ENergy Antiprotons (ELENA) upgrade to the Antiproton Decelerator (AD) ring has been proposed at CERN to produce a greatly increased current of low energy antiprotons for various experiments including, of course, anti-hydrogen studies. This upgrade involves the addition of a small storage ring and electrostatic beam lines. 5.3 MeV antiproton beams from AD are decelerated down to 100 keV in the compact ring and transported to each experiment apparatus. In this paper, we describe an electrostatic beam line from ELENA to ATRAP and magnetic shielding of the low-energy beam line against the ATRAP solenoid magnet. A possible design of this system is displayed.

THPEC041 **Uniform Beam Distribution by Nonlinear Focusing Forces** – *Y. Yuri, I. Ishibori, T. Ishizaka, S. Okumura, T. Yuyama (JAEA/TARRI)*

To achieve ultra-low-fluence large-area uniform irradiation of ion beams for advanced applications in the field of materials sciences and biotechnology, a uniform-beam irradiation system has been developed using multipole magnets at the Japan Atomic Energy Agency (JAEA) cyclotron facility. The system consists of a beam attenuator for the wide-range intensity control, an electrostatic beam chopper for the control of irradiation time, scattering foils for conditioning of the initial beam distribution, octupole magnets for transverse tail-folding, sextupole magnets for the correction of the beam misalignment, and the diagnostic station of the two-dimensional beam profile. In this paper, recent experimental results are described, especially on the formation of a beam with a uniform transverse distribution by the combination of the sextupole and octupole magnets.

THPEC042 **Thermal and Structual Stability of Medium Energy Target Carrier Assembly for NOvA at Fermilab** – *M.W. McGee, C.R. Ader, K. Anderson, J. Hylen, M.A. Martens (Fermilab)*

The NOνA project will upgrade the existing Neutrino at Main Injector (NuMI) project beamline at Fermilab to accommodate beam power of 700 kW. The Medium Energy (ME) graphite target assembly is provided through an accord with the State Research Center of Russia Institute for High Energy Physics (IHEP) at Protvino, Russia. The effects of proton beam energy deposition within beamline components are considered as thermal stability of the target carrier assembly and alignment budget are critical operational issues. Results of finite element thermal and structural analysis involving the target carrier assembly is provided with detail regarding the target's beryllium windows.

THPEC043 **Mechanical Design of Ceramic Beam Tube Braze Joints for NOvA Kicker Magnets** – *C.R. Ader, R.E. Reilly, J.H. Wilson (Fermilab)*

The NOνA Experiment will construct a detector optimized for electron neutrino detection in the existing Neutrino at Main Injector (NuMI) beamline. The NuMI beamline is capable of operating at 400 kW of primary beam power and the upgrade will allow up to 700 kW. Ceramic beam tubes are utilized in numerous kicker magnets in different accelerator rings at Fermilab. Kovar flanges are brazed onto each beam tube end, since kovar and high alumina ceramic have similar expansion curves. The tube, kovar flange, end piece, and braze foil alloy brazing material are stacked in the furnace and then brazed. The most challenging aspect of fabricating kicker magnets in recent years have been making hermetic vacuum seals on the braze joints between the ceramic and flange. Numerous process variables can influence the robustness of conventional metal/ceramic brazing processes. The ceramic-filler metal interface is normally the weak layer when failure does not occur within the ceramic. Differences between active brazing filler metal and the moly-manganese process will be discussed along with the applicable results of these techniques used for Fermilab production kicker tubes.

THPEC044 **Design Methodology and Considerations for NOνA 53 MHz RF Cavities** – *C.R. Ader, M.P. May, D. Wildman (Fermilab)*

The NOνA Experiment will construct a detector optimized for electron neutrino detection in the existing Neutrino at Main Injector (NuMI) beamline. This beamline is capable of operating at 400 kW of primary beam power and the upgrade will allow up to 700 kW. The cavities will operate at 53 MHz and three of them will be installed in the Recycler beamline. Thermal stability of the cavities is crucial since this affects the tuning. Results of finite element thermal and structural analysis involving the copper RF cavity will be presented.

THPEC045 **Electrostatic Separator and K1.8 Secondary Beamline at the J-PARC Hadron-Hall** – *M. Ieiri, A. Agari, E. Hirose, Y. Katoh, M. Minakawa, R. Muto, M. Naruki, Y. Sato, S. Sawada, Y. Suzuki, H. Takahashi, T. Takahashi, M. Takasaki, K.H. Tanaka, A. Toyoda, H. Watanabe, Y. Yamanoi (KEK) H. Noumi (RCNP)*

In the hadron experimental hall at the 50-GeV Proton Synchrotron (PS) of J-PARC, the secondary beam line K1.8 with double stage separator is expected to provide 1-2 GeV/c kaon beams with less contamination of pions mainly for hadron and nuclear physics experiments with strangeness. An electrostatic (ES) separator is one of key elements of this secondary beam line. The ES separator will generate a 75kV/cm electrostatic field between parallel electrodes of 10cm gap and 6m in length along the beam direction. It is designed so as to be radiation-proof and to lower spark rate at the high intensity proton accelerator facility. The K1.8 line has two 6m ES separators with the intermediate focal point upstream of separators to reduce the pion backgrounds from the production target. The K-/π- ratio of the line is expected to have a larger value than 1 at the experimental target. Beam commissioning of the K1.8 has just started. We will report separator performance, optics design of the K1.8 beam line and the first result of the beam commissioning.

THPEC046 **Performance and Operational Experience of the CNGS Facility** – *E. Gschwendtner, K. Cornelis, I. Efthymiopoulos, A. Ferrari, A. Pardons, H. Vincke, J. Wenninger (CERN) A. Guglielmi (INFN/LNL) P.R. Sala (Istituto Nazionale di Fisica Nucleare)*

The CNGS facility (CERN Neutrinos to Gran Sasso) aims at directly detecting muon to tau neutrino oscillations. An intense muon-neutrino beam (10^{17} muon neutrinos/day) is generated at CERN and directed over 732km towards the Gran Sasso National Laboratory, LNGS, in Italy, where two large and complex detectors, OPERA and ICARUS, are located. CNGS is the first long-baseline neutrino facility in which the measurement of the oscillation parameters is performed by observation of the tau-neutrino appearance. The facility is approved for a physics program of five years with a total of $22.5 \cdot 10^{19}$ protons on target. Having resolved successfully some initial issues that occurred since its commissioning in 2006, the facility had its first complete year of physics in 2008. By the end of the 2009 physics run the facility will have delivered in total more than $5\cdot10^{19}$ protons on target corresponding to ~2-3 tau neutrino events in the OPERA detector. The experiences gained in operating this 500 kW neutrino beam facility along with highlights of the beam performance in 2008 and 2009 are discussed.

THPEC047 **Design and Prototyping of a 400 keV Deuteron RFQ at BARC** – *P. Singh, R.K. Choudhury, P. Jain, S. Kailas, R. Kumar, P.K. Nema, R. Pande, S. Roy, V.L. Sista (BARC)*

A 400 keV, 1 mA (CW) RFQ operating at 350 MHz has been designed to accelerate deuteron beam for generation of neutrons. The beam dynamics simulations consider an input beam of 50 keV with an emittance of 0.02 pi cm.mrad. The length of the RFQ is about 1.1 m and the RF power required, including beam power, is 50 kW. The deuteron beam transmission is calculated to be 98%. We have recently fabricated a prototype of OFHC copper with modulation, beginning and end cells. It has 8 RF tuners, 2 vacuum ports and 2 power couplers. Its resonant frequency and Q-value have been measured. The bead pull tests are in progress. The details of these measurements will be presented in the paper.

THPEC048 **Charge Breeding Test Experiment with a Hollow Gun EBIS** – *V. Variale, T. Clauser, A.C. Rainò, V. Valentino (INFN-Bari) M.A. Batazova, G.I. Kuznetsov, B.A. Skarbo (BINP SB RAS)*

The charge breeding technique is used for Radioactive Ion Beam (RIB) production in the Isotope Separation On Line (ISOL) method in order of optimizing the re-acceleration of the radioactive element ions produced by a primary beam in a thick target. That technique is realized by using a device capable of increase the radioactive ion charge state from +1 to a desired value +n. In some experiments a continuous RIB of a certain energy could be required. The EBIS based charge breeding device cannot reach a real CW operation because the high charge state ions produced are extracted by the same part where the 1+ ions are injected, that is, from the electron collector. In this way, the ions extraction system, placed in the electron beam collector, can be left only to extract the n+ ions, and then the CW operation, at least in principle, could be reached. In this paper, a charge breeding test experiment based on a EBIS which has an e-gun with hollow cathode will be described. Furthermore, the status report of the experiment that is under way at the INFN Laboratori Nazionali di Legnaro (LNL) will be presented.

THPEC049 **New Acceleration Technique by Laser Interaction upon Doped Targets** – *V. Nassisi (INFN-Lecce) G. De Pascali (Laboratorio di Elettronica Applicata e Strumentazione, LEAS,) J. Krasa, A. Velyhan (Czech Republic Academy of Sciences, Institute of Physics) L. Velardi (Bari University, Science Faculty)*

We report characteristics of ion emission from Cu, Sn, Cu/Sn4, Cu/B$\cdot10^2$, Ag/Cu7.5 and Ag/Cu28 plasmas generated by a KrF laser which was operated at wavelength of 248 nm and delivered energy up to 50 mJ. The time-of-flight characteristics of ion beams were determined by using a Faraday cup. Employment an expansion chamber, new part of experimental apparatus, allows to accelerate the created ion beam by HV potential up to 40 kV and to investigate the evolution of ToF signals on distance. The analysis of ion characteristics is the main scope of our contribution. An influence of the dopant admixture, laser pulse energy and accelerating potential on the characteristics of the ion emission is demonstrated.

THPEC050 **Low Emittance Cu Ion Beams by Laser Interaction and Two Accelerating Gap** – *V. Nassisi, M.V. Siciliano (INFN-Lecce) L. Velardi (Bari University, Science Faculty)*

We develop an accelerator having a double acceleration gap system. The ion source was realized by a LIS in order to provide ions of different elements. The LIS consisted of a laser-induced plasma from solid targets, where the plume was made to expand before the action of the first accelerating field. After the first gap action, the ions were undergone a second acceleration. We analyzed the extracted charge from a Cu target as a function of the accelerating voltage at laser fluences values of 1.8, 2.2 and 3.4 J/cm^2. At 60kV of total accelerating voltage, the peak of current density were 2.2 and 5.3 mA corresponding to 1.8 and 2.2 J/cm^2 laser fluences, respectively. At the highest laser fluences, the maximum output current was 11.4 mA with an accelerating voltage of 50 kV and a corresponding ion flux of 10^{12} ions/cm^2. Under the condition of 60 kV accelerating voltage and 5.3 mA output current (ion flux 3.4 10^{11} ions/cm^2) and the normalized emittance of the beam measured by pepper pot method resulted of 0.22 π mm mrad. Under the condition of 160 kV accelerating voltage the ion flux was higher than 1.0 10^{11} ions/cm^2 with the laser energy just 5 mJ to avoid breakdown.

THPEC051 **Low Voltage Electron Beam Bunching, Trapping and Detection** – *M. Cavenago (INFN/LNL) F. Cavaliere, G. Maero, B. Paroli, R. Pozzoli, M. Romé (Universita' degli Studi di Milano e INFN)*

In a Malmberg'Penning trap like ELTRAP an electron beam can be stored or propagated in a space charge dominated condition, due to the low acceleration voltage used; in particular we can test the longitudinal expansion of the electron bunch with several diagnostics, including Thomson scattering. Pulsed electron beams produced by an external photocathode source in the 1'10 keV energy range and with 4 ns length have been measured also by two electrostatic diagnostic systems. A proper software is needed to compensate for the capacitance of the pickup electrodes. Rf can be applied to the sectored electrode to produce a plasma source or to excite or to detect rotational modes; in particular the use of a new 8 sector electrode will allow up to m=3 modes.

THPEC052 **Negative Ion and Electron Plasma Sheath and Beam Extraction** – *M. Cavenago (INFN/LNL)*

In singly charged positive ion sources, the study of beam extraction is greatly simplified by the existence of a well defined place for plasma to beam transition, given by the well known Bohm criterion, where the ion flow speed equals the speed of sonic perturbation, known as Bohm speed. Most of the ion extraction simulation codes are implicity based on the concept of quasi neutrality in the plasma region, as limited by the Bohm criterion. In negative ion source the existence of an electron coextracted beam and of a magnetic filter makes the relevant speed less clear. Moreover there are several scale lengths to be considered: the Debye length, that is typically 0.01 mm, the electron and ion gyroradius, the H^- scattering, absorbtion and production length. In the development of negative ion source for NBI injector for ITER, the production of H^- at wall and the negative sheath so generated is also important. A critical evaluation of these regimes is obtained with 1D (one space dimension) models, mostly restricted to magnetic filter parallel to the extraction wall. Some remarks on 2D simulation codes is also given.

THPEC053 **NIO1 a Versatile Negative Ion Source** – *M. Cavenago, T. Kulevoy, S. Petrenko (INFN/LNL) V. Antoni, G. Serianni, P. Veltri (Consorzio RFX, Associazione Euratom-ENEA sulla Fusione)*

The development of neutral beam injectors (NBI) for tokamak like the ITER project and beyond requires high performance and huge negative ion sources (40 A of D- beam required); it was recently accepted that inductive plasma coupled (ICP) radiofrequency sources are the preferred option. It is therefore useful to have a moderate size source of modular design to test and verify both construction technologies and components and simulation codes; here the NIO1 design (60 kV, 9 beamlets of 15 mA H^- each) and construction status are described. Source is assembled from disk shaped modules, for rapid replacement; the beamlets are arranged in 3 times 3 square matrix so that 90 degree rotation of modules is possible and allows to cross or to align the magnetic filters used in the source. The 2 MHz rf coil and the rf window are a simply replaceable module. Extensive rf absorption and magnetic coil simulations were performed. Related beam simulation and fast emittance scanner development are described elsewhere.

THPEC054 **Angular Distribution of Laser Ablation Plasma** – *T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) R. Dabrowski, M. Okamura (BNL) T. Kanesue (RIKEN Nishina Center) K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology)*

In a laser ion source, a high power pulsed laser shot focused on a solid state target produces laser ablation plasma. This plasma has initial velocity towards the normal direction of the target and simultaneously expands three dimensionally. Since charge state distribution, velocity distribution and plasma temperature strongly depends on laser power density, power density is one of the important parameter to the angular distribution of plasma. Angular distribution of expanding plasma was measured by changing laser power density. Details of the experiment will be shown in the paper.

THPEC055 **DPIS with Solenoid Field** – *T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) R. Dabrowski, M. Okamura (BNL) T. Kanesue (RIKEN Nishina Center) K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology)*

We have been studying a high current and highly charged heavy ion source using a direct plasma injection scheme (DPIS). In DPIS, laser ablation plasma which contains highly charged ions are produced in a biased target chamber. This plasma has initial velocity towards the normal direction of the target and simultaneously expands three dimensionally in a pipe which has same potential as the target chamber. Ions are extracted between the biased pipe and RFQ electrodes. After extraction, ions are captured by RF focusing field and accelerated to the nominal output energy. Since ions are transported as plasma up to the RFQ entrance, space charge effect can be neglected. As plasma expands, ion pulse becomes longer and ion current density decrease rapidly. So there is a limitation on pulse width with adequate ion current. To avoid this problem, solenoid field can be used to confine plasma transversely. A solenoid magnet was installed between the target chamber and the RFQ. The effect of the solenoid on DPIS will be discussed in this paper.

THPEC056 **Recent Development of ECR Ion Souces at RCNP** – *T. Yorita, M. Fukuda, K. Hatanaka, M. Kibayashi, S. Morinobu, H. Okamura, A. Tamii (RCNP)*

The upgrade program of the AVF cyclotron is in progress since 2004 at Research Center for Nuclear Physics (RCNP), Osaka Univ., for improving the quality, stability and intensity of accelerated beams. An 18 GHz superconducting ECRIS has been installed to increase beam currents and to extend the variety of ions, especially for highly charged heavy ions which can be accelerated by RCNP cyclotrons. The production development of several ion like B, C ~ Xe by gas mixing or MIVOC has been performed. In order to extend the variety of ions more, metal viper or spatter system has also been installed to 10GHz NEOMAFIOS with minimum modifications. The details of these recent developments will be presented.

THPEC057 **Acceleration Test of 2-beam Type IH-RFQ Linac** – *T. Ishibashi, T. Hattori, N. Hayashizaki (RLNR)*

High intensity heavy ion beam acceleration in the low energy region is one of the most difficult conditions to achieve, because the space charge effect is extremely strong. In order to generate a high intensity beam using linacs, we have to avoid beam loss by the space charge effect as much as possible. Multibeam acceleration has been proposed as a possible method of reducing the space charge effect. If one cavity could be used to accelerate several beams, a significant gain would be made in installation space and operational cost saving. In this study we look at a multibeam type radio frequency quadrupole (RFQ) linac in order to accelerate several beams using a single cavity. The RFQ electrodes are placed in an IH type cavity; This structure is known as a IH-RFQ linac. GSI in Germany proposed a multibeam type IH-RFQ linac with several beam channels in a single cavity. However, this multibeam type IH-RFQ linac has yet to be manufactured. We manufactured a 2-beam type IH-RFQ linac as a prototype of the multibeam type IH-RFQ. The linac outputs C^{2+} beam of 60 keV/u and 44 mA/channel in the design value. We will report about the beam acceleration test of the linac.

THPEC058 **Development of MUSASHI, a Mono-energetic Ultra-slow Antiproton Beam Source** – *N. Kuroda, Y. Enomoto, H. Imao, C.H. Kim, Y. Matsuda, H.A. Torii, Y. Yamazaki (The University of Tokyo, Institute of Physics) H. Higaki (HU/AdSM) H. Hori (MPQ) Y. Kanai, A. Mohri, Y. Nagata (RIKEN) K. Kira (Hiroshima University, Graduate School of Advanced Sciences of Matter) K. Michishio (Tokyo University of Science) H. Saitoh (University of Tokyo) M. Shibata (KEK)*

The ASACUSA collaboration at CERN has been developed a unique Mono-energetic Ulta-Slow Antiproton beam Source for High-precision Investigation (MUSASHI) for collision studies between antiproton and atoms at

very low energy region, which also used as an intense ultra-low energy antiproton source for the synthesis of antihydrogen atoms in order to test CPT symmetry. MUSASHI consists of a multi-ring electrode trap housed in a bore surrounded by a superconducting solenoid, which works with a sequential combination of the CERN Antiproton Decelerator and the Radio-Frequency Quadrupole Decelerator. GM-type refrigerators were used to cool the solenoid and also the bore at 4K to avoid losses of antiprotons with residual gasses. Up to 1.8 millions of antiprotons per one AD cycle were successfully trapped and cooled. MUSASHI achieved to accumulate more than 12 millions of cold antiprotons by stacking several AD shots. Such cooled antiprotons were extracted as 150 or 250eV beams with various bunch lengths from 2 micoroseconds to 30 seconds long, whose energy width was the order of sub-eV. The beam intensity was enhanced by a radial compression technique for the trapped antiproton cloud.

THPEC060 **Developments of RIKEN New Superconducting ECR Ion Source** – *Y. Higurashi (RIKEN Nishina Center)*

The next generation heavy ion accelerator facility, such as the RIKEN RIBF, requires great variety of high charged heavy ions with a magnitude higher beam intensity than currently achievable. In the last decade, performance of the ECR ion sources has been dramatically improved with increasing the magnetic field and RF frequency to enhance the density and confinement time of plasma. Furthermore, the effects of the key components (magnetic field configuration, gas pressure etc) on the ECR plasma have been revealed. Such basic studies give us how to optimize the ion source structure. Based on these studies and the technology, we successfully constructed the new 28GHz SC-ECRIS which has a flexible magnetic field configuration to enlarge the ECR zone and to optimize the field gradient at ECR point. In the test experiment, we obtained the direct evidence that the field gradient and the zone size strongly affect the beam intensity. It concludes that the gentler field gradient and large ECR zone size gives intense beam of highly charged heavy ions from ECR plasma. In this contribution, we report the systematic study of these effects on the beam intensity of highly charged heavy ions.

THPEC061 **Extraction System and Beam Qualities of the RIKEN Full Superconducting ECR Ion source** – *J. Ohnishi, Y. Higurashi, O. Kamigaito, T. Nakagawa, Y. Sato (RIKEN Nishina Center)*

The superconducting ECR ion source enabled to use a 28 GHz microwave source had been developed to provide intense beam of highly charged heavy ions like U^{35+} to the RIKEN RI-beam factory (RIBF) since 2007. The first plasma was lit in May of 2009 and it was succeeded in providing the uranium beam to the RIBF in December. In this operation, uranium ions were supplied with sputter method and two 18 GHz microwave sources were used. The beam intensity of the uranium ion exceeded 14μAmps, which was more than five times larger than that for 18 GHz ECR ion source of a usual type. The extraction system consists of the accel-decel electrode system, a solenoid coil and a 90 degreeanalyzing magnet. We measured the profiles and emittances of the extracted beams for several ion species and compared with the calculated results with 'OPERA-3d' including space charge effect. And we shall discuss the beam dynamics at the extraction region such as the relationship between the beam emittance and the operating parameters.

THPEC062 **LIS in Low Power Density for RHIC-EBIS** – *K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology) R. Dabrowski, M. Okamura (BNL) T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering)*

The Electron Beam Ion Source (EBIS) project at Brookhaven National Laboratory is a new heavy ion pre-injector for Relativistic Heavy Ion Collider (RHIC) and NASA Space Radiation Laboratory science programs. An important requirement for EBIS is an ion source capable of efficiently providing a variety of heavy ion species to many users within short period of time. In that respect, Laser Ion Source (LIS), which can supply many heavy ion species from solid targets, is a good candidate for RHIC-EBIS, however, LIS has an issue to be resolved. This is the requirement of limited current in low energy beam transport. LIS in the condition that laser power density is low, is expected to provide limited current with long pulse length. The discussions of the experimental results are presented.

THPEC063 **Physics Design of a Photo Fission Ion Source** – *K.O.LEE. Lee, K.H. Chung (KAPRA) H.G. Joo, S.K. Kauh (SNU) S.K. Ko (University of Ulsan)*

The physics design of a Photo Fission Ion Source (PFIS) which will be used in a heavy ion accelerator is introduced. The design variables being considered are asymmetric magnetic field, cooling, neutron reflector and modulator (high density graphite), UCx target, bremsstrahlung power, microwave power and fission fragments (ions). Based on the design studied performed by using Monte Carlo codes and nuclear data, we will present the results, performance, optimization, ion distribution, bremsstrahlung power dependent radiation distribution, and temperature distributions. Finally we will conclude the feasibility of PFIS.

THPEC065 **GEANT-4 Simulations of Secondary Positron Emitted Carbon Ion Beams** – *E. Syresin, V.P. Volnyh (JINR)*

The radioactive ion isotopes $11C^{6+}$, $10C^{6+}$ and others are produced at interaction of primary carbon ion beam with target. These isotopes can be applied for Positron Emission Tomography. The projectile-fragmentation method is used for the production of radioactive isotopes. The intensity of radioactive ion beam is defined by the target optimal thickness, material and by available longitudinal and transverse acceptances of transportation channel. An increase of target thickness permits to improve production rate of radioactive ion beams, however it increase the energy and angle spreads of secondary ions and finally it gives a reduction of number of useful radioactive ions which can be transported to the PET camera. The GEANT 4 simulations related to formation of $11C^{6+}$ secondary ion beams at interaction with different targets are discussed.

THPEC066 **Electron String Ion Source Applied for Formation of Primary Radioactive Carbon Ion Beams** – *E. Syresin, D.E. Donets, E.D. Donets, E.E. Donets, V.V. Salnikov, V.B. Shutov (JINR) T. Honma, M. Kanazawa, K. Noda (NIRS)*

The 11C isotopes are produced in the nitrogen gas target irradiated by a proton beam. If the nitrogen target contains 5% of hydrogen, about $5{\cdot\cdot}10^{12}$ methane molecules can be produced each 20 minutes. The separated methane is loaded into the ion source. The technique used for formation of radioactive carbon beams was developed and tested in the JINR electron string ion source (ESIS) Krion-2. The measured conversion efficiency of methane molecules to carbon ions is rather high; it corresponds to 17 % for C^{4+} ions. The experimentally obtained C^{4+} ion intensity in ESIS was about $2{\cdot\cdot}10^{9}$ ppp. The new ESIS-5T is under construction in JINR now at project ion intensity of $6{\cdot\cdot}10^{9}$ ppp. Accelerated 12C ion beams are effectively used for cancer treatment at HIMAC. The positron emission tomography is the most effective way of tumor diagnostics. The intensive radioactive 11C ion beam could allow both these advantages to be combined. It could be used both for cancer treatment and for on-line PET. Formation of a primary radioactive ion beam at an intensity on the tumor target of $1{\cdot\cdot}10^{8}$ pps allows the cancer treatment by the scanning radiation method and on-line dose verification.

THPEC067 **Design and Construction of Tubular Electron String Ion Source** – *E. Syresin, D.E. Donets, E.D. Donets, E.E. Donets, V.M. Drobin, V.B. Shutov (JINR) A.E. Dubinov, R.M. Garipov, I.V. Makarov (VNIIEF) A.V. Shabunov (JINR/LHE)*

The Electron String Ion Source (ESIS) developed at JINR is effectively used here during the last decade. The Tubular Electron String Ion Source (TESIS) has been put forward recently to obtain a 1-2 orders of magnitude increase in the ion output as compared with ESIS. The project is aimed at creating TESIS and studying the electron string in the tubular geometry. The new tubular source with a superconducting solenoid up to 5 T is under construction now. The method of the off axis TESIS ion extraction will be realized to get TESIS beam emittance comparable with ESIS emittance. It is expected that this new TESIS will meet all rigid conceptual and technological requirements and should provide an ion output approaching 10 mA of Ar^{16+} ions in the pulsed mode and about 10 μA of Ar^{16+} ions in the average current mode. Design, construction and test of separate TESIS systems are discussed in this report.

THPEC068 **First Simulation Tests for the Bilbao Accelerator Ion Source Test Stand** – *I. Bustinduy, D. Fernandez-Cañoto, D. de Cos (ESS Bilbao) J. Alonso, M. Eguiraun,* *R. Enparantza, M. Larrañaga (Fundación TEKNIKER) F.J. Bermejo (Bilbao, Faculty of Science and Technology) V. Etxebarria, J. Portilla (University of the Basque Country, Faculty of Science and Technology) J. Feuchtwanger (ESS-Bilbao)*

The rationale behind the Bilbao Accelerator Ion Source Test Stand (ITUR) project is to perform a comparison between different kinds of hydrogen ion sources using the same beam diagnostics setup. In particular, a direct comparison will be made in terms of the emittance characteristics of Penning-type sources such as those currently being used in ISIS (UK) and those of microwave type such as CEA-Saclay and INFN. The aim here pursued is to build an Ion Source Test Stand where virtually any type of source can be tested and, thus, compared to the results of other sources under the same gauge. It would then be possible to establish a common ground for effectively comparing different ion sources. The work here presented reports on the first simulations for the H-/H^+ extraction system, as well the devices that conform the diagnostic vessel: Faraday Cup, Pepperpot and Retarding Potential Analyzer (RPA), among others.

THPEC069 **Beam Dynamics Studies on the Radio-Frequency Quadrupole for the Bilbao Accelerator** – *I. Bustinduy, D. de Cos (ESS Bilbao) F.J. Bermejo (Bilbao, Faculty of Science and Technology) V. Etxebarria, J. Portilla (University of the Basque Country, Faculty of Science and Technology) J. Feuchtwanger (ESS-Bilbao)*

The main objective of the Bilbao Front End Test Stand (ETORFETS) is to set up a facility to demonstrate experimentally the design ideas for the future ESS LINAC that are being proposed in discussion forums by the technical scientific community. ETORFETS is focused on the first stage of the linear accelerator, namely, that of the Radio-Frequency Quadrupole (RFQ) and its pre and post beam transport systems. The RFQ bunches, focuses transverse and longitudinally, and accelerates charged particles in the low-energy range (up to ~ 3 MeV), thus becoming one of the main components of the accelerating structure. The first RFQ simulations, performed in Superfish and GPT software packages, will be presented in this work.

THPEC070 **Pulse Lengthening Experiments on the FETS Ion Source** – *D.C. Faircloth, S.R. Lawrie, A.P. Letchford (STFC/RAL/ISIS)*

The Front End Test Stand (FETS) under construction at the Rutherford Appleton Laboratory is the UK's contribution to research into the next generation of High Power Proton Accelerators (HPPAs). Running at duty cycles of up 50 Hz with pulse lengths of 2 ms are required. This paper presents initial Hminus beam currents and emittance measurements for long pulse lengths.

THPEC071 **Highly Polarized Ion Sources** – *V.G. Dudnikov, R.P. Johnson (Muons, Inc) Y.S. Derbenev, Y. Zhang (JLAB)*

The operation of the RHIC facility at BNL and the Electron Ion Colliders (EIC) under development at Jefferson Laboratory and BNL need high brightness ion beams with the highest polarization. Charge exchange injection into a storage ring or synchrotron and Siberian snakes have the potential to handle the needed polarized beam currents, but first the ion sources must create beams with the highest possible polarization to maximize collider productivity, which is proportional to a high power of the polarization. We are developing one universal H-/D- ion source design which will synthesize the most advanced developments in the field of polarized ion sources to provide high current, high brightness, ion beams with greater than 90% polarization, good lifetime, high reliability, and good power efficiency. The new source will be an advanced version of an atomic beam polarized ion source (ABPIS) with resonant charge exchange ionization by negative ions. An integrated ABPIS design will be prepared based on new materials and an optimized magnetic focusing system. Polarized atomic and ion beam formation, extraction, and transport for the new source will be computer simulated.

THPEC072 **High Brightness Surface Plasma Sources of Negative Hydrogen Ions** – *V.G. Dudnikov, R.P. Johnson (Muons, Inc) M.P. Stockli, R.F. Welton (ORNL)*

Development of novel modifications of H^- source designs is proposed. The new source will be an advanced version of a Penning DT SPS

(Dudnikov-Type Penning Surface Plasma Source) which will generate brighter beam in noiseless discharge, deliver up to 20 mA average current with better electrode cooling using new materials, and have longer lifetime, fast beam chopping capability, and reduced cesium loss.

THPEC073 **RF H^- Ion Source with Saddle Antenna** – *V.G. Dudnikov, R.P. Johnson (Muons, Inc) G. Dudnikova (UMD) M.P. Stockli, R.F. Welton (ORNL)*

In this project we are developing an RF H^- surface plasma source which will synthesize the most important developments in the field of negative ion sources to provide high pulsed and average current, high brightness, good lifetime, high reliability, and higher power efficiency. We describe two planned modifications to the present SNS external antenna source in order to increase the plasma density near the output aperture: 1) replacing the present 2 MHz plasma-forming solenoid antenna with a 13 MHz saddle-type antenna and 2) replacing the permanent multicusp magnetic system with a weaker electro-magnet. Progress of this development will be presented.

THPEC074 **High Current Density Lithium Ion Source** – *R. Sah, A. Dudas, M.L. Neubauer (Muons, Inc) J.W. Kwan (LBNL)*

Induction linear accelerators are featured in accelerator-based research currently supported by the Office of Fusion Energy Sciences. Over the next few years, the research will concentrate on developing intense ion sources and on studying the physics of spatial compression, neutralized transport, and focusing of the beam. The large diameter of lithium alumino-silicate ion emitters for large currents represents the current state of the art for emission densities of 1-1.5 mA/cm^2. Also, operating temperatures of the surface are limited by the temperature of alumina-potted heater packages. We propose a novel system for increasing the emission of lithium ions from β-eucryptite through modification of the surface morphology by sputter etching with argon plus other gases. The resulting local field enhancement will increase the ion emission over that of a microscopically flat surface. In addition, a free-standing graphite heater assembly will be used to increase the temperature of the surface of the emission source.

THPEC075 **Laser Ion Source with a Static Magnet Field at the Ion Generating Surface** – *R. Dabrowski, M. Okamura (BNL) T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology)*

The Laser Ion Source (LIS) is a proven method for generating ions in heavy ion acceleration. The output produces high current and high charge-state beams from almost any type of elemental species. Using the LIS system, we investigate the effects of applying a static magnetic field at the surface of plasma generation. The inclusion of such a field could increase the likelihood of ionizing interactions that occur during laser irradiation. As previously demonstrated*, the resulting beam is comprised of higher charge-state ions, which yields a higher beam current for acceleration. The static magnetic field is supplied by a permanent magnet positioned behind the target and controlled by varying the distance of the magnet from the target. We will present new results regarding this phenomenon with an improved laser system and show the possible effectiveness of utilizing static magnetic fields for higher charge-state ion development.

THPEC076 **Ion Generation via a Laser Ion Source with Hot Target** – *R. Dabrowski, M. Okamura (BNL) T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology)*

The Laser Ion Source is an efficient method for generating heavy ions for acceleration. The output produces high current and high charge-state beams from almost any type of elemental species. Using the Laser Ion Source apparatus, we consider improving the efficiency of this method by heating the target prior to laser irradiation. Prior deposition of any thermal energy into the target could add with the energy being delivered by the pulsed laser to produce higher current beams. These beams could be composed of higher charge-state ions and/or an increased net number of ions. We investigate by using a retrofitted heater to heat the target to a variety of high temperatures and subsequently analyze the produced beam.

THPEC077 **Confinement of Laser Plasma by Solenoidal Field for Laser Ion Source** – *M. Okamura, R. Dabrowski (BNL)*

A.G. Adeyemi (Holyoke Community College) T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) K. Kondo (Department of Energy Sciences, Tokyo Institute of Technology)

A laser ion source can provide high-current highly-charged ions with a simple structure. Previously we have demonstrated acceleration of >60 mA carbon and aluminum ion beams using a direct plasma injection scheme. However, it was not easy to control the ion pulse width. Especially to provide longer ion pulse, a plasma drift length which is the distance between laser target and extraction point, has to be extended and the plasma is diluted severely. We apply a solenoid field to prevent reduction of ion density at the extraction point. A solenoid field of a few hundred Gauss enhanced the ion density up to 40 times. We present these results, including details of the solenoidal field effects on the expanding laser plasma.

THPEC078 **Cryocatcher for the Control of Ionization Beam Loss in SIS100** – *L.H.J. Bozyk (TU Darmstadt) H. Kollmus, P.J. Spiller (GSI)*

The central accelerator SIS100 of the FAIR-facility will provide high intensity, intermediate charge state heavy ion beams. In order to assure a reliable operation with the intermediate charge states, a special synchrotron design, including ion catcher system had to be developed. Intermediate charge state heavy ions suffer from high cross sections for ionization. Due to the dedicated synchrotron layout, ions which have been further stripped by collisions with residual gas atoms are not lost uncontrolled onto the beam pipe but are caught by the ion catcher system in the cryogenic arcs. The construction and test of a cryo-catcher prototype at GSI is a workpackage of the EU-FP7 project COLMAT. A prototype catcher including cryostat will be set-up at GSI to perform measurements with heavy ion beams of the heavy ion synchrotron SIS18.

THPEC079 **Collimation and Material Science Studies (COLMAT) at GSI** – *J. Stadlmann, H. Kollmus, E. Mustafin, I.J. Petzenhauser, P.J. Spiller, N.A. Tahir, C. Trautmann (GSI) L.H.J. Bozyk, M. Krause (TU Darmstadt) M. Tomut (INFIM)*

Within the frame of the EUCard program, the GSI in Darmstadt is conducting accelerator R&D (Workpackage ColMat). The effort is focussed on materials used for components of the future FAIR facility at GSI as well as the upgrade of LHC at CERN. Numerical simulations have been carried out to study effects (dose deposition, stress, density and temperature profiles) caused by the impact of high intensity beams of LHC and SPS. Tungsten, copper and graphite targets were studied using the hydrodynamic code BIG-2. Experimental studies on radiation damage on materials used in LHC upgrade and the FAIR accelerators are performed at the GSI facilities. The investigations will be complemented by theoretical simulations on activation and irradiation effects of specific FAIR components in 2010. These results will have an impact on the FAIR component specifications. A cryogenic ion-catcher prototype will be constructed and tested. The ion-catcher is an essential part to reach highest heavy ion beam intensities in SIS100. The prototype will be set-up to perform tests with heavy ions from GSI's SIS18. We present an overview of the different workpackages and first results of the R&D performed at GSI.

THPEC080 **Fabrication of Silicon Crystals for CERN UA9 Experiment** – *A. Mazzolari (INFN-Ferrara)*

Channeling in bent crystals is a technique with high potential to steer charged-particle beams for several applications in accelerators physics. Revisited methods of silicon micromachining techniques allowed one to realize a new generation of crystals. Characterizations using x-ray diffraction, atomic force microscopy, high resolution transmission electron microscopy and ion beam analysis techniques, showed high quality of the crystals. A specifically designed holder allowed to mechanically bend a crystal at given curvature and remove unwanted torsion. Characterization of such crystals with 400 GeV at CERN H8 external line highlighted 85% single-pass efficiency. A selected crystal has been installed inside the SPS ring in the environment of the CERN experiment UA9 and successfully employed for collimation of the circulating beam.

THPEC081 **Upgrade of Radiation Shield for BT Collimators** – *M.J. Shirakata, T. Oogoe (KEK)*
The beam transport line between 3GeV Rapid Cycling Synchrotron and Main Ring has a collimator system in order to improve the quality of injected beam in the main ring. The beam power accepted in the collimator is required to be increased for high intensity beam operation. The capacity of radiation shield is insufficient though that of collimator itself is enough. The gate shield system has been preparing in order to satisfy both the radiation shielding and feasibility of maintenance. The development of movable gate shield system is reported which fully covers more than 20 m long collimator system.

THPEC082 **The Collimation System of the CSNS Ring** – *N. Wang, N. Huang, Q. Qin, S. Wang (IHEP Beijing)*
The China Spallation Neutron Source (CSNS) is designed to provide a proton beam with beam power of 120 kW. A two-stage collimation system is designed for the Rapid Cycling Synchrotron (RCS) of the CSNS. The performance goals for the collimators are to minimize the radiation to the ring components, and reduce the uncontrolled beam loss to the level of 1W/m to guarantee hands-on maintenance. The collimators are optimized with the ORBIT code. In this paper, we present the preliminary results of the physical design and the loss distribution around the ring.

THPEC083 **Dump and Current Measurement of Unstripped H^- Ions at the Injection from the CERN LINAC4 into the PS Booster** – *R. Chamizo, J. Borburgh, B. Goddard, A. Mereghetti, R. Versaci, W.J.M. Weterings (CERN)*
Linac4 is the new H^- linear accelerator under construction at CERN aiming to double the brightness of the beam injected to the CERN PS Booster (PSB) for delivering proton beams to experiments or further CERN accelerators, down to the LHC. The injection system in the PSB is based on the H^- charge exchange where the 160 MeV H^- beam is converted into an H^+ beam by stripping the electrons with a carbon foil. A beam dump located inside a pulsed magnet for the injection bump will intercept the unstripped ions (H0 and H-) and measure the collected charge to detect the relative efficiency and degradation of the stripping foil. The challenge of the dump design is to meet the requirements of a beam dump providing a current measurement and at the same time minimizing the perturbation of the magnetic field of the surrounding pulsed magnet. This paper describes all phases of the dump design and the main issues related to its integration in the line.

THPEC084 **Crystal Collimation Efficiency Measured with the Medipix Detector in SPS UA9 Experiment** – *E. Laface, L. Tlustos (CERN) V. Ippolito (INFN-Roma)*
The UA9 experiment was performed in 6 MDs from May to November 2009 with the goal of studying the collimation properties of a crystal in the framework of a future exploitation in the LHC collimation system. An important parameter evaluated for the characterization of the crystal collimation is the efficiency of halo extraction when the crystal is in channeling mode. In this paper it is explained how this efficiency can be measured using a pixel detector, the Medipix, installed in the Roman Pot of UA9. The number of extracted particles counted by the Medipix is compared with the total number of circulating particles measured by the Beam Current Transformers (BCTs): from this comparison the efficiency of the system composed by the crystal, used in channeling mode, and a tungsten absorber is proved to be greater than 85%.

THPEC085 **Beam-beam Effect for the LHC Phase I Luminosity Upgrade** – *E. Laface, S.D. Fartoukh, F. Schmidt (CERN)*
The Phase I Luminosity Upgrade of LHC (SLHC) will be based on a new Nb-Ti inner triplet for the high luminosity region ATLAS and CMS. The new proposed layout aims at pushing beta* down to 30 cm replacing the current LHC inner triplets, with longer ones operating at lower gradient (123 T/m) and therefore offering enough aperture for the beam to reduce beta* to its prescribed value. As a consequence of this new longer interaction region, the number of parasitic encounters will increase from 15 to 21 before the separation dipole D1, with an impact on the dynamic aperture of the machine. In this paper the effect of the beam-beam interaction is evaluated for the SLHC layout and optics, at injection and in collision, evaluating the possible impact of a few additional parasitic collisions inside and beyond the D1 separation dipole till the two beams do no longer occupy the same vacuum chamber. Whenever needed, a comparison with

the nominal LHC will be given. Then a possible backup collision optics will be discussed for the SLHC, offering a much wider crossing angle at an intermediate beta* of 40 cm in order to reach a target dynamic aperture of 7.5 sigma.

THPEC086 **Status of the UA9 Experiment** – *W. Scandale (CERN)*

UA9* was operated in the CERN-SPS for already one year in view of investigating the feasibility of the halo collimation assisted by bent crystals. Two 2 mm long silicon crystals were used with bending angles of about 150 microradians. The crystal collimation process was steadily achieved through channeling with high efficiency. The crystal orientation was easy to be set and optimized, although the installed goniometers suffered of an imperfect angular reproducibility induced by unexpected mechanical damages. The loss profile in the area of the crystal-collimator setup was measured to be close to the simulation expectations, whilst there was no clear evidence of loss in the far- from-collimator areas. The crystal channeling efficiency was also measured to be consistent with simulations and with single pass data collected in the North Area of the SPS. The accumulated observations, shown in this paper, support our expectation that the coherent deflection of the beam halo by a bent crystal should strongly enhance the collimation efficiency in hadron collider.

THPEC087 **Measurement of Nuclear Reaction Rates in Crystals using the CERN-SPS North Area Test Beams** – *W. Scandale (CERN) A.M. Taratin (JINR)*

A number of tests were performed by the UA9 Collaboration* in the North area of the SPS in view of investigating crystal-particles interactions for future application in hadron colliders. The rate of nuclear reactions was measured with 400 GeV proton beams directed into a silicon bent crystal. In this way the background induced by the crystal itself either in amorphous or in channeling orientation was revealed. The results provide fundamental information to put in perspective the use of silicon crystals to assist halo collimation in hadron colliders, whilst minimizing the induced loss. Crystals made of Germanium were also investigated in view of the expected increase of the collimation efficiency respect to silicon. Finally, crystals were tested in axial orientation and with incoming particles of negative charge. The collected results are presented in details.

THPEC088 **Simulation based Optimization of a Collimator System for the Beam Current Upgrade at the PSI Proton Accelerator Facilities** – *Y. Lee, V. Gandel, D.C. Kiselev, D. Reggiani, M. Seidel, S. Teichmann (PSI)*

A simulation based optimization of a collimator system at the 590 MeV PSI proton accelerator is presented, for the planned beam power upgrade from the current 1.2 MW [2 mA] to 1.8 MW [3 mA]. The collimators are located downstream of the 4 cm thick graphite meson production target. These are designed to shape the optimal beam profile for low loss beam transport to the neutron spallation source SINQ. The optimized collimators should withstand 3 mA beam intensity, without sacrificing intended functionalities. The collimator system is under the heavy thermal load generated by a proton beam power deposition approximately of 240 kW at 3 mA, and it needs an active water cooling system. Advanced multiphysics simulations are performed for a set of geometric and material parameters, for the thermo-mechanical optimization of the collimator system. In particular, a FORTRAN subroutine is developed for implementing local beam stopping power in the collimator system into CFD-ACE+. Selected results are then compared with those of full MCNPX simulations. The considered materials are OFHC copper which was used for the present collimators and Glidcop.

THPEC089 **Overview of Solid Target Studies for a Neutrino Factory** – *T.R. Edgecock (STFC/RAL) J.J. Back (University of Warwick) J.R.J. Bennett (STFC/RAL/ISIS) C.N. Booth, G.P. Skoro (Sheffield University) S.J. Brooks (STFC/RAL/ASTeC)*

The UK programme of high power target developments for a Neutrino Factory is centred on the study of high-Z materials (tungsten, tantalum). A description of lifetime shock tests on candidate materials is given as part of the research into a solid target solution. A fast high current pulse is applied to a thin wire of the sample material and the lifetime measured from the number of pulses before failure. These measurements are made at temperatures up to ~2000 K. The stress on the wire is calculated using the LS-DYNA code and compared to the stress expected in the real Neutrino

Factory target. It has been found that tantalum is too weak to sustain prolonged stress at these temperatures but a tungsten wire has reached over 26 million pulses (equivalent to more than ten years of operation at the Neutrino Factory). An account is given of the optimisation of secondary pion production from the target and the issues related to mounting the target in the muon capture solenoid and target station are discussed.

THPEC090 **The EMMA Non-scaling FFAG** – *T.R. Edgecock (STFC/RAL) C.D. Beard, J.A. Clarke, S.A. Griffiths, C. Hill, S.P. Jamison, J.K. Jones, A. Kalinin, K.B. Marinov, N. Marks, P.A. McIntosh, B.D. Muratori, J.F. Orrett, Y.M. Saveliev, B.J.A. Shepherd, R.J. Smith, S.L. Smith, S.I. Tzenov, A.E. Wheelhouse (STFC/DL/ASTeC) J.S. Berg (BNL) N. Bliss, C.J. White (STFC/DL) J.L. Crisp, C. Johnstone (Fermilab) Y. Giboudot (Brunel University) E. Keil (CERN) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC) S.R. Koscielniak (TRIUMF) F. Meot (CEA) J. Pasternak (Imperial College of Science and Technology, Department of Physics) S.L. Sheehy, T. Yokoi (JAI)*

The Electron Model for Many Applications (EMMA) will be the World's first non-scaling FFAG and is under construction at the STFC Daresbury Laboratory in the UK. Construction is due for completion in March 2010 and will be followed by commissioning with beam and a detailed experimental programme to study the functioning of this type of accelerator. This paper will give an overview of the motivation for the project and describe the EMMA design and hardware. The first results from commissioning will be presented in a separate paper.

THPEC091 **Tungsten Behavior at High Temperature and High Stress** – *G.P. Skoro, C.N. Booth (Sheffield University) J.J. Back (University of Warwick) J.R.J. Bennett, S.A. Gray, A.J. McFarland (STFC/RAL/ISIS) T.R. Edgecock (STFC/RAL)*

Recently reported results on the tungsten lifetime/fatigue tests under conditions expected in the Neutrino Factory target have strengthened the case of solid target option for a Neutrino Factory. This paper gives description of the detailed measurements of the tungsten properties at high temperature and high stress. We have performed extensive set of measurements of the surface displacement and velocity of the tungsten wires that were stressed by passing a fast, high current pulse through a thin sample. Radial and longitudinal oscillations of the wire were measured by a Laser Doppler Vibrometer. The wire was operated at temperatures of 300-2500 K by adjusting the pulse repetition rate. In doing so we have tried to simulate the conditions (high stress and temperature) expected at the Neutrino Factory. Most important result of this study is an experimental confirmation that strength of tungsten remains high at high temperature and high stress. The experimental results have been found to agree very well with LS-DYNA modelling results.

THPEC092 **A Pion Production and Capture System for a 4MW Target Station** – *X.P. Ding, D.B. Cline (UCLA) J.S. Berg, H.G. Kirk (BNL)*

A study of a pion production and capture system for a 4MW target station for a neutrino factory or muon collider is presented. Using the MARS code, we simulate the pion production produced by the interaction of a free liquid mercury jet with an intense proton beam. We study the variation of meson production with the direction of the proton beam relative to the target. We also examine the influence on the meson production by the focusing of the proton beam. The energy deposition in the capture system is determined and the shielding required in order to avoid radiation damage is discussed.

27-May-10	16:00 – 18:00	Poster	Poster Hall D
THPD — Poster Session			

THPD001 **Electron Linac Photo-fission Driver for the Rare Isotope Program at TRIUMF** – *S.R. Koscielniak, F. Ames, R.A. Baartman, I.V. Bylinskii, Y.-C. Chao, K. Fong, R.E. Laxdal, M. Marchetto, L. Merminga, A.K. Mitra, I. Sekachev, V.A. Verzilov, V. Zvyagintsev (TRIUMF)*

In July 2009 TRIUMF, in collaboration with the University of Victoria and other partners, was awarded Federal government funds for the construction of an electron linear accelerator in support of its expanding rare isotope program. The project anticipates Provincial funds for the construction of buildings including new target halls in the spring 2010. The science program targets nuclear structure and astrophysics as well as material science. TRIUMF is embarking on the detailed design of the 10 MeV Injector cryomodule and the first of two 20 MeV Accelerator cryomodules, all rated up to 10 mA. The project first stage, ICM and ACM1, providing 25 MeV 5 mA is planned to be completed in 2013. The injector is being fast tracked in a collaboration with the VECC in Kolkata, India. The c.w. linac is based on super-conducting radiofrequency technology at 1.3 GHz & 2K. This paper gives an overview of the facility, and accelerator design progress including beam dynamics, cryogenics, high power RF, machine and beamlines layout. A key feature of the design is compatibility with later installation of return arcs and operation in energy recovery mode for a fourth generation light source.

THPD002 **Compact Solid State Direct Drive RF LINAC** – *O. Heid, T.J.S. Hughes (Siemens AG, Healthcare Technology and Concepts)*

The concept of a compact particle accelerator capable of delivering accelerating fields upto 100MV/m using a direct drive RF LINAC is explored. Such a machine consists of a succession of RF cavities with the RF power being supplied from a ring of solid state RF transistors placed around the cavity circumference. To achieve the required accelerating fields 3 core technologies are presented. (i) The solid-state transistors are used to drive the wall currents in the cavities so achieving a direct drive of the cavity. This allows unprecedented powers to be reached (>GW class) as well as enabling independent phase control of the individual cavities. Central to the implementation is the design of the RF drive consisting of distributed SiC vJFET modules delivering 750kA at 800V per cavity. (ii) A High Gradient Insulator structure is required to hold an electric field of >100MV/m. In contrast to a conventional HGI, the concept utilizes a vacuum insulated grading layer structure. (iii) A chopper and injection system allow the formation of proton bunches with a spatial emissivity <3ns and an injection field of up to 100MV/m.

THPD003 **Test and Commissioning of the Third Harmonic RF System for FLASH** – *E. Vogel, C. Albrecht, N. Baboi, J. Eschke, M.G. Hoffmann, M. Huening, D. Kostin, G. Kreps, W. Maschmann, Ch. Schmidt, J.K. Sekutowicz (DESY) H.T. Edwards, E.R. Harms, A. Hocker, T.N. Khabiboulline (Fermilab)*

Ultra short bunches with high peak current are required for efficient creation of high brilliance coherent light at the free electron laser FLASH. They are obtained by a two stage transverse magnetic chicane bunch compression scheme based on acceleration of the beam off the rf field crest. The deviation of the rf field's sine shape from a straight line leads to long bunch tails and reduces the peak current. This effect will be eliminated by adding the Fermilab-built third harmonic superconducting accelerating module operating at 3.9 GHz to linearize the rf field. The third harmonic module also allows for the creation of uniform intensity bunches of adjustable length that is needed for seeded operation. This paper summarizes the results from the first complete rf system test at the crymodule test bench at DESY and the first experience gained operating the system with beam in FLASH.

THPD004 **Design of the Positron Transport System for SuperKEKB** – *N. Iida, T. Kamitani, M. Kikuchi, Y. Ogawa, K. Oide (KEK)*

SuperKEKB, the upgrade plan of KEKB, aims to boost the luminosity up to $8{\cdot}10^{35}$ /cm^2/s. The beam energy of the Low Energy Ring (LER) is 4 GeV for positrons, and that of the High Energy Ring is 7 GeV for electrons. SuperKEKB is designed to produce low emittance beams. The horizontal and vertical emittances of the injection beams are 4nm and 1nm, respectively, which are one or two orders smaller than those of KEKB. The positron injector system consists of the source, capture system, L-band and S-band linacs, collimators, an energy compression system (ECS), a 1-GeV damping ring, a bunch compression system (BCS), S-band and C-band linacs, and a beam transport line into the LER. This paper reports a design of the positron beam transport system from L-band linacs to SuperKEKB.

THPD006 **Simultaneous Top-up Injection for Three Different Rings in KEK Injector Linac** – *M. Satoh (KEK)*

The KEK injector linac sequentially provides beams, and transfers them to the following four storage rings: a KEKB low-energy ring (LER) (3.5 GeV/ positron), a KEKB high-energy ring (HER) (8 GeV/electron), a Photon Factory ring (PF ring; 2.5 GeV/electron), and an Advanced Ring for Pulse X-rays (PF-AR; 3 GeV/electron). So far, beam injection to the PF ring and PF-AR is carried out twice a day, whereas the KEKB rings are operated in the continuous injection mode (CIM) so that the stored current remains almost constant. The KEK linac upgrade project has been started since 2004 so that the PF top-up and KEKB CIM can be performed at the same time. The aim of this upgrade is to change the linac parameters up to 50 Hz, which is the maximum linac beam repetition rate, by using a multi-energy-linac scheme. This upgrade has been successfully completed. The simultaneous top-up operation for three rings has stably been carried out since this April. We will report the simultaneous top-up injection for the KEKB and PF rings in detail.

THPD007 **The Linac Upgrade Plan for SuperKEKB** – *T. Sugimura (KEK)*

The next generation B-factory 'SuperKEKB' project whose target luminosity is 8×10^{35} cm^{-2}s^{-1} is under consideration. A 'nano-beam scheme' is introduced to the SuperKEKB. In the scheme, an electron beam (Energy = 7 GeV, Charge = 3-4 nC/bunch, Vertical emittance =2.8 x 10^{-5} m) and a positron beam (Energy = 4 GeV, Charge = 4 nC/bunch, Vertical emittance = 1.6 x 10^{-5} m), are required at the end of injector linac. They are quite challenging targets for the present linac. In order to meet the requirements, we will introduce some new components to the linac. They are a photocathode RF gun for an electron beam, a positron capture section using new L-band cavities, a newly designed positron-generation target system and a damping ring for a positron beam. This presentation shows a strategy of our injector upgrade.

THPD008 **Upgrade of Cartridge-type Exchangeable Na2KSb Cathode RF Gun** – *M. Uesaka, Y. Muroya, T. Ueda (The University of Tokyo, Nuclear Professional School) K. Kanbe, K. Miyoshi (University of Tokyo)*

We are commissioning the cathode, Na2KSb at the wavelength of 266, 400 nm with thermo-mechanically modified structure and improved vacuum system ($2 \cdot 10^{-08}$ Pa). We could improve RF reflection waveform and obtain the maximum energy of 22 MeV. We estimate the electrical field of 50 MV at the cathode. So far, we have obtained the quantum efficiencies of 1.1, 0.01% and the maximal charges of 4.6, 1 nC for 266, 400 nm. We are observing and checking carefully individual difference of QE of the cathodes for 266, 400 nm, and we have obtained 22 MeV energy. This new RF photocathode RF gun system has been already used for subpicosecond time-resolved radiation chemistry.

THPD009 **Study on the High Order Modes of the 3.5cell Cavity at Peking University** – *F. Wang, F.S. He, L. Lin, K. Zhao (PKU/IHIP)*

As part of the updated DC-SC injector, a 3.5cell cavity has been fabricated at Peking University, which includes two Coaxial High Order Mode (HOM) couplers. The effect of the HOM couplers has been studied by numerical simulation and measurement. The results are highly uniform and show that the two couplers do effectively damp the HOMs.

THPD010 **Development of an ITC-RF Gun for Compact THz Radiation** – *M. Li, W. Bai (CAEP/IAE)*

An independent tunable cells Thermionic RF gun (ITC-RF Gun) used for compact THz radiation is developed at China Academy of Engineering Physics (CAEP). This RF-gun consists of a single cell and a 3-cells cavity which are powered independently, so the amplitude and phase of the two parts can be easily adjusted. The paper introduces some results of the simulation, cold test and preliminary hot test. The test results agree well with the theoretical design.

THPD011 **Lattice Design for the LHeC Recirculating Linac** – *Y. Sun, A.L. Eide, F. Zimmermann (CERN)*
In this paper, we present the lattice design of the Large Hadron Electron Collider (LHeC) recirculating Linac. The recirculating Linac has one ~3km linac hosting RF accelerating cavities, two arcs and one transfer line for the recirculation.

THPD012 **Emittance Growth in the LHeC Recirculating Linac** – *Y. Sun, F. Zimmermann (CERN)*
In this paper, we study the beta-beating and emittance growth in the LHeC recirculating Linac, which lattice design is presented in another paper of this proceeding. The possible sources for emittance considered are: RF acceleration in the linac, chromatic effects, radiation effects in the recirculating arcs.

THPD013 **Construction of a Thermionic RF Gun Linac System for Ultrashort Electron Beam** – *W.K. Lau, J.H. Chen, J.-Y. Hwang, A.P. Lee, C.C. Liang, T.H. Wu (NSRRC) W.C. Cheng (National Chiao Tung University) N.Y. Huang (NTHU)*
A 25-30 MeV S-band linac system that equipped with thermionic cathode rf gun is being constructed at NSRRC for generation of ultrashort relativistitic electron beam. According to simulation studies, high quality GHz repetition rate electron pulses of about 50 pC as short as few tens fsec can be produced. This injector system will be used as the driver for experiments on fsec head-on inverse Compton scattering X-ray source and high power wake field microwave sources. The progress of our construction work will be presented.

THPD014 **Muon Backgrounds in CLIC** – *H. Burkhardt (CERN) G.A. Blair, L.C. Deacon (Royal Holloway, University of London)*
We report on a study of muon backgrounds in CLIC. For this we combined halo and tail generation using HTGEN with detailed tracking by BDSIM of impacting halo particles and resulting secondaries from the collimation spoilers to the detector.

THPD016 **Upgrade of the Drive LINAC for the AWA Facility Dielectric Two-Beam Accelerator** – *J.G. Power, M.E. Conde, W. Gai (ANL) Z. Li (SLAC) D. Mihalcea (Northern Illinois University)*
We report on the design of a 7 cell, standing wave, 1.3 GHz LINAC cavity and the associated beam dynamics studies for the upgrade of the drive beamline for the Argonne Wakefield Accelerator (AWA) facility. The LINAC design is a compromise between single bunch operation (100 nC @ 75 MeV) and minimizing the energy droop due to beam loadning along the bunch train during bunch train operation. The 1.3 GHz drive bunch train target parameters are: 75 MeV, 10-20 ns macropulse duration, 16x60nC microbunches; this is equivalent to a macropulse current and beam power of 80 Amps and 6 GW, respectively. Each LINAC structure accelerates approximately 1000 nC in 10 ns by a voltage of 11 MV at an RF power of 10 MW. Due to the short bunch train duration desired (~10 ns) and the existing frequency (1.3 GHz), compensation of the energy droop along the bunch train is difficult to accomplish with the two standard techniques: time-domain or frequency-domain beam loading compensation. Therefore, to minimize the energy droop, our design is based on a large stored energy LINACs. In this paper, we present our LINAC optimization method, detailed LINAC design, and beam dynamics studies of the drive beamline.

THPD018 **Generation and Applications of High-brightness Electron Beams at the Fermilab NML Facility** – *P. Piot, M.D. Church, Y.-E. Sun (Fermilab) C.R. Prokop (Northern Illinois University)*
Fermilab is currently constructing a superconducting RF (SRF) test linear accelerator at the New Muon Lab (NML). Besides testing SRF accelerating modules for ILC and Project-X, NML will also eventually support a variety of advanced accelerator R&D experiments by providing a high-brightness electron beam at energies up to 800 MeV to end users. In this paper we explore via numerical simulations the production of high-brightness electron beams with tunable parameters. We especially investigate operating scenarios that could support unique advanced accelerator R&D experiments* by providing tailored emittances partition.

THPD019 **Experimental Generation of Longitudinally-modulated Electron Beams using an Emittance-exchange Technique** – *Y.-E. Sun, H.T. Edwards, A.S. Johnson, A.H. Lumpkin, J. Ruan, J.K. Santucci, J.C.T. Thangaraj, R. Thurman-Keup (Fermilab) P. Piot (Northern Illinois University)*

We report our experimental demonstration of longitudinal phase space modulation using transverse-to-longitudinal emittance exchange technique. The experiment is carried out at the A0 photoinjector at Fermi National Accelerator Lab. A vertical multi-slit plate is inserted into the beamline prior to the emittance exchange, thus introducing beam horizontal profile modulation. After the emittance exchange, the longitudinal phase space coordinates (energy and time structures) of the beam are modulated accordingly. This is a clear demonstration of the transverse-to-longitudinal phase space exchange. In this paper, we present our experimental results on the measurement of energy and time profile of the electron beam, as well as numerical simulations of the experiment.

THPD020 **Beam Dynamics Simulations of the NML Photoinjector at Fermilab** – *Y.-E. Sun, M.D. Church (Fermilab) P. Piot (Northern Illinois University)*

Fermilab is currently constructing a superconducting RF (SRF) test linear accelerator at the New Muon Lab (NML). Besides testing SRF accelerating modules for ILC and Project-X, NML will also eventually support a variety of advanced accelerator R&D experiments. The NML incorporates a 40 MeV photoinjector capable of providing electron bunches with variable parameters. The photoinjector is based on the 1+1/2 cell DESY-type gun followed by two superconducting cavities. It also includes a magnetic bunch compressor, a round-to-flat beam transformer and a low-energy experimental area for beam physics experiments and beam diagnostics R&D. In this paper, we explore, via beam dynamics simulations, the performance of the photoinjector for different operating scenarios.

THPD021 **Distributed Coupling and Optimization of Standing-Wave Linear Accelerators for Ultra High Gradient Applications** – *S.G. Tantawi (SLAC)*

Recently, single cell standing wave accelerator structures have shown potential for ultra-high gradient operation. To make use of that and to limit the effects of degraded performance due to the coupling between accelerator cells we suggest that we feed each cell separately through a distributed coupling system. The cell shape and the coupling system are optimized so that to enhance the shunt impedance of the structure while limiting the peak surface electric and magnetic fields. Also the coupling is designed to allow for wake field damping. We present this novel linac structure architecture and detail the optimization process.

THPD022 **FFAG Tracking with Cyclotron Codes** – *M.K. Craddock (UBC & TRIUMF) Y.-N. Rao (TRIUMF)*

This paper describes tracking studies of non-scaling (NS) FFAGs using cyclotron codes in place of the more conventional lumped-element synchrotron codes. The equilibrium orbit code CYCLOPS determines orbits, tunes and period at fixed energies, while the general orbit code GOBLIN tracks a representative bunch of particles through the acceleration process. Results will be presented for the EMMA linear NS-FFAG under construction at Daresbury (10^{-20} MeV electrons), and for two non-linear NS-FFAG designs: Rees's isochronous IFFAG (8-20 GeV muons) and Johnstone's design for ADSR ($250\text{-}10^{00}$ MeV protons). Our results are compared with those obtained using lumped-element codes. In the case of EMMA, results are presented for both the measured and design fields.

THPD023 **Beam Dynamics Simulations regarding the Experimental FFAG EMMA** – *F. Meot (CEA) Y. Giboudot (Brunel University) D.J. Kelliher (STFC/RAL/ASTeC) T. Yokoi (JAI)*

The Electron Model of a Muon Accelerator (EMMA) FFAG has been the object of extensive beam dynamics numerical simulations, during its design and construction phases, while its commissioning requires further advanced beam dynamics studies as well as on-line and off-line simulations. This contribution will report on the work performed during the last months.

THPD024 **Developements in the EMMA Experimental FFAG On-line Commissioning Code** – *F. Meot (CEA) J.S. Berg (BNL) Y. Giboudot (Brunel University) D.J. Kelliher (STFC/RAL/ASTeC) S.C. Tygier (UMAN)*

In view of design studies and beam dynamics simulations during the construction phase of the experimental FFAG EMMA, the ray-tracing code Zgoubi has been subject to extensive developments. Its use as the on-line code during EMMA commissioning has motivated further evolution of the code and of its capabilities as to the simulation of FFAG rings. It has also motivated extensive work regarding its interfacing to the real world, users and machine. The contribution will report on these code developments and their outcomes.

THPD025 **Recent Status of the MAMI-C Accelerator and First Experience with the Energy Upgrade towards 1.6 GeV** – *R.G. Heine, K. Aulenbacher, M. Dehn, H. Euteneuer, A. Jankowiak, P. Jennewein, H.-J. Kreidel, U. Ludwig-Mertin, O. Ott, G.S. Stephan, V. Tioukine (IKP) O. Chubarov (Siemens AG)*

The university of Mainz institute for nuclear physics is operating the microtron cascade MAMI (Mainzer Mikrotron) since the late 1970ies. The microtron delivers a cw electron beam to users of the hadron physics community. The recent, fourth stage MAMI-C having a design energy of 1.5 GeV is operated since 2006*. This article deals with the recent developments and operational experiences of MAMI-C, as well as with the energy upgardes to 1.56 GeV** and as final step towards 1.6 GeV. The final increase of beam energy was due to user demands, since it is expected to raise the event rate of the eta prime production by an order of magnitude.

THPD026 **Beam Optics and Magnet Design of Helium Ion FFAG Accelerator** – *H.L. Luo, H. Hao, X.Q. Wang, Y.C. Xu (USTC/NSRL)*

Fixed-Field Alternating Gradient (FFAG) accelerator accelerates in smaller costs heavy-ion with higher beam current than conventional circular accelerator, which could be more useful for the study of radioactive material. In this paper, the periodic focusing structure model of a Helium ion FFAG with a few MeV energy, which is contributed to study the impact of Helium embitterment on fusion reactor envelope material is proposed. A large-aperture magnet for Helium ion FFAG synchrotron is designed by using a 3D magnetic field simulation code OPERA-3D. The linear and nonlinear beam dynamics is studied through tracking the particle in the magnetic field generated by OPERA-3D.

THPD027 **Orbit Correction in a non-scaling FFAG** – *D.J. Kelliher, S. Machida (STFC/RAL/ASTeC)*

EMMA - the Electron Model of Many Applications - is to be built at the STFC Daresbury Laboratory in the UK and will be the first non-scaling FFAG ever constructed. The purpose of EMMA is to study beam dynamics in such an accelerator. The EMMA orbit correction scheme must deal with two characteristics of a non-scaling FFAG: i.e. the lack of a well defined reference orbit and the variation with momentum of the phase advance between lattice elements. In this study we present a novel orbit correction scheme that avoids the former problem by instead aiming to maximise both the symmetry of the orbit and the physical aperture of the beam. The latter problem is dealt with by optimising the corrector strengths over the energy range.

THPD028 **First Results from EMMA Commissioning** – *S.L. Smith, B.D. Muratori, Y.M. Saveliev, S.I. Tzenov (STFC/DL/ASTeC) J.S. Berg (BNL) N. Bliss (STFC/DL) T.R. Edgecock (STFC/RAL)*

The first results from commissioning EMMA - the Electron Model of Many Applications- are summarised in this paper. EMMA is a 10 to 20 MeV electron ring designed to test our understanding of beam dynamics in a relativistic linear non-scaling fixed field alternating gradient accelerator (FFAG). EMMA will be the world's first non-scaling FFAG and the paper will outline the characteristics of the beam injected in the to accelerator as well as summarising the results of the extensive EMMA systems commissioning. First beams are expected to be injected into the EMMA ring before the conference. The paper will report on the results of simulations of this commissioning and on the progress made with beam commissioning.

THPD029 **Setting the Beam onto the Reference Orbit in Non Scaling FFAG Accelerators** – *S.I. Tzenov, J.K. Jones, B.D. Muratori (STFC/DL/ASTeC) Y. Giboudot (Brunel University)*

Described in the paper are systematic procedures to inject and keep the beam on the reference trajectory for a fixed energy, as applied to the

EMMA non scaling FFAG accelerator. The notion of accelerated orbits in FFAG accelerators has been introduced and some of their properties have been studies in detail.

THPD030 **Characterisation and Optimisation of the ALICE Accelerator as an Injector for the EMMA NS-FFAG** – *J.M. Garland (UMAN)*

EMMA is the first proof-of-principle non-scaling FFAG accelerator, and is presently under construction at Daresbury Laboratory in the UK. To probe different parts of the bunch phase space during acceleration from 10 MeV and rapid resonance crossing, electron bunches are needed with sufficiently small emittance and energy spread. The purpose of this paper is to study the emittance and energy spread of the beam in ALICE after the main super-conducting Linac in order to optimise the accelerator as an injector into EMMA.

THPD031 **Development of Tomographic Reconstruction Methods for Studies of Transverse Phase Space in the EMMA FFAG Injection and Extraction Lines** – *M.G. Ibison, K.M. Hock, D.J. Holder, M. Korostelev (Cockcroft Institute)*

The EMMA* prototype non-scaling Fixed Field Alternating Gradient (ns-FFAG) electron accelerator is currently being commissioned at Daresbury Laboratory in the UK. One of the key beam diagnostic measurements needed is the characterisation of transverse phase space both before and after acceleration so that the rate of decoherence and other effects may be studied. For this purpose, tomography diagnostic sections have been included in the injection and extraction lines for EMMA, so that beam profile images may be acquired at a range of phase advances and the transverse phase space reconstructed. In addition, the tomography section on the injection line to EMMA also forms a useful diagnostic tool for ALICE operation.

THPD032 **Modern High-Order Description of the Dynamics in FFAGs and Related Accelerators** – *C. Johnstone (Fermilab) M. Berz, K. Makino (MSU) P. Snopok (UCR)*

Innovations in computer techniques and increased sophistication in modeling are required to accurately understand, design and predict the new generation of frontier accelerators for HEP and other applications. A recently identified problem lies in the simulation and optimization of FFAGs and related devices, for which currently available tools provide only approximate and inefficient simulation. For this purpose new tools are being developed within the advanced accelerator code COSY INFINITY to address complex electromagnetic fields, including out of plane fields, high-order fringe fields, edge effects, and general field profiles; tools linked to global optimization techniques that can further accommodate the ultra-large emittances of proposed beams to allow efficient probing of very high dimensional parameter space. This new set of tools based on modern techniques and simulation approaches will be furnished with GUI-based user interfaces. Examples of the performance of the methods for the design of modern high performance FFAG accelerators using transfer maps of orders around 11 including corresponding out of plane expansion and associated symplectic tracking are given.

THPD033 **Nonlinear Propagation of Laser Pulses in Plasmas: a Comparison between Numerical and Analytical Solutions** – *A. Bonatto, R. Pakter, F.B. Rizzato (IF-UFRGS)*

In this work the nonlinear relativistic propagation of intense lasers in plasmas is investigated. It is known that, under appropriate conditions, the ponderomotive force associated with the laser envelope can excite large amplitude electron waves (wakefields), which can be of interest for particle acceleration schemes. Numerical solutions showing some of the possible behaviors of this system are presented and compared to analytical ones, obtained through an effective potential approach using a one-dimensional Lagrangian formalism.

THPD034 **Stable Compact Proton Beam Acceleration from a Two-specie Ultrathin Foil Target** – *T.P. Yu, M. Chen, A.M. Pukhov (HHUD)*

We report on a stable proton beam acceleration from an ultra-thin foil consisting of carbon ions and protons. Numerical simulations show that the radiation pressure leads to a very fast and complete spatial separation of the species. A sharp front dividing the lighter protons and the heavier carbon ions is well defined. In multi-dimensional geometries, the carbon ions are heated and spread in space due to the Rayleigh-Taylor-like (RT) instability. At the same time, protons form a stable thin layer that always rides on the front of the carbon cloud. Finally, a mono-energetic, compact and collimated proton beam forms that has even a better quality as compared with the 1D case. We explain this fact by a significant, or even complete, suppression of the RT instability in the front that separates the species.

THPD035 **Matching the Laser Generated p - bunch into a CH-DTL** – *A. Almomani, M. Droba, U. Ratzinger (IAP) I. Hofmann (GSI)*

The concept of laser acceleration of protons by Target Normal Sheath Acceleration TNSA from thin foils could be used to produce a high intensity proton bunch. This proton bunch could be injected into a linac at energies of ten to several tens MeV. A CH$^-$ structure is suggested as the linac structure because of its high gradient. The motivation for such a combination is to deliver single beam bunches with quite small emittance values of extremely high particle number - in the order of 10 billion protons per bunch. Optimum emittance values for linac injection are compared with available, laser generated beam parameters. Options and simulation tools for beam matching by pulsed solenoid and CH$^-$ structure using LASIN and LORASR codes are presented.

THPD036 **Electron Acceleration by a Whistler Pulse** – *R. Singh (Indian Institute of Technology Delhi, Plasma Physics Group) A.K. Sharma (Indian Institute of Technology Delhi)*

A Gaussian whistler pulse is shown to cause ponderomotive acceleration of electrons in a plasma when the peak whistler amplitude exceeds a threshold value. The threshold amplitude decreases with the ratio of plasma frequency to electron cyclotron frequency ωp / ωc. However above the threshold amplitude the acceleration energy decreases with ωp / ωc. The electrons gain velocities about twice the group velocity of the whistler. For acceleration of electrons one requires a whistler pulse of $\omega > \omega c/2$. It is seen that to enhance the energy gain the value of peak laser amplitude should be above a threshold value.

THPD037 **Studies on Beam Loading in the CLIC RF Deflectors** – *D. Alesini, C. Biscari, A. Ghigo (INFN/LNF)*

After a short description of the Frequency Multiplication Scheme of the CLIC drive beam we present the impact of beam loading in the RF deflectors. First order scaling laws for the beam loading have been obtained to compare the effects in CLIC with those in the Test Facility CTF3. A dedicated tracking code has been written to study the multi-bunch multi-turn beam dynamics and the results are presented. Possible solutions to mitigate the beam loading effects such as the use of multiple RF deflectors are shown.

THPD038 **Hybrid Schemes for the Post-acceleration of Laser Generated Protons** – *A. Mostacci, L. Lampariello, M. Migliorati, L. Palumbo (Rome University La Sapienza) D. Alesini, P. Antici (INFN/LNF) L. Picardi, C. Ronsivalle (ENEA C.R. Frascati)*

Protons generated by the irradiation of a thin metal foil by a high-intensity short-pulse laser have shown to posses interesting characteristics in terms of energy, emittance, current and pulse duration. They might therefore become in the next future a competitive source to conventional proton sources. Previous theoretical and numerical studies already demonstrated the possibility of an efficient coupling between laser-plasma acceleration of protons with traditional RF based beam-line accelerator techniques. This hybrid proton accelerator would therefore benefit from the good properties of the laser-based source and from the flexibility and know-how of beam handling as given from RF based accelerator structure. The proton beam parameters of the source have been obtained from published laser interaction experimental results and are given as input to the numerical study by conventional accelerator design tools. In this paper we discuss recent results in the optimization and design of the such hybrid schemes in the context of proton accelerators for medical treatments.

THPD039 **Proton Generation Driven by a High Intensity Laser Using a Thin-foil Target** – *A. Sagisaka, P.R. Bolton, S.V. Bulanov, H. Daido, T. Esirkepov, T. Hori, S. Kanazawa, H. Kiriyama, K. Kondo, S. Kondo, M. Mori, Y. Nakai, M. Nishiuchi, K. Ogura, H. Okada, S. Orimo, A.S. Pirozhkov, H. Sakaki, F. Sasao, H. Sasao, T. Shimomura, A. Sugiyama, H. Sugiyama, M. Tampo, M. Tanoue, D. Wakai, A. Yogo (JAEA) I.W. Choi, J. Lee (APRI-GIST) H. Nagatomo (ILE Osaka) K. Nemoto, Y. Oishi (Central Research Institute of Electric Power Industry)*

High-intensity laser and thin-foil interactions produce high-energy particles, hard x-ray, high-order harmonics, and terahertz radiation. A proton beam driven by a high-intensity laser has received attention as a compact ion source for medical applications. We have performed the high intensity laser-matter interaction experiments using a thin-foil target irradiated by Ti:sapphire laser (J-KAREN) at JAEA. In this laser system, the pulse duration is 40 fs (FWHM). The laser beam is focused by an off-axis parabolic mirror at the target. The estimated peak intensity is ~$5x10^{19}$ W/cm^2. We have developed on-line real time monitors such as a time-of-flight proton spectrometer which is placed behind the target and interferometer for electron density profile measurement of preformed plasma. We observed the maximum proton energy of ~7 MeV.

THPD040 **Collimated Electron and Proton Beam from Ultra-intense Laser Interaction with a Rear Hole Target** – *X.H. Yang, T.L. Tian, Y. Yin, T.P. Yu (National University of Defense Technology) Y.Q. Gu (Laser Fusion Research Center, China Academy of Engineering Physics) S. Kawata, Y.Y. Ma (Center for Optical Research and Education, Utsunomiya University) F.Q. Shao (National University of Defense Technology, Graduate School) H. Xu (National University of Defense Technology, Parallel and Distributed Processing) M.Y. Yu (Ruhr-Universität Bochum)*

We have proposed a scheme for the generation of collimated proton beams from the interaction of an ultra-intense laser pulse with a rear hole target, which is studied by a 2.5D particle-in-cell (PIC) code PLASIM. When an ultraintense short laser pulse irradiates on such a target, the hot electrons will expand fast into the hole from the inner surfaces of the hole, and strong longitudinal sheath electric field and transverse electric field are produced. However, the plasma in the corners expand slower and be compressed strongly, and then a strong plasma jet is sprayed out from the corner with very high speed, which is just like what happened in armor piercing bullet due to the cumulative energy effect. The two jets extend into the hole and focus along the axis of the hole. At last, a high quality collimated proton beam can be obtained near the end of the hole along the propagation axis. It's found that the beam can propagate over a much longer distance without divergence. The effect of the hole diameter on the collimated proton beam is also investigated. Such target may serve as an important source for collimated proton beam in practical applications.

THPD041 **Evolution of Electron Bunches in a Combined Quasi-static and Laser Electric Field** – *V.A. Papadichev (LPI)*

Short pulses of electrons of femtosecond and attosecond duration are necessary for numerous applications: studying fast processes in physics, chemistry, biology and medicine*. Previous calculations revealed that it is possible to obtain such short bunches by applying quasi-static electric voltage to a needle placed into a laser focus**,***. This paper presents results of computer simulation of the electron bunch evolution for various parameters of the problem (quasi-static and laser electric fields, radius of curvature of the needle, velocity of electron emission etc.). Simple model for analytical calculation of bunch evolution was elaborated to precisely assess its shortening in the case when one can neglect space-charge forces in the bunch. Influence of velocity dispersion in the bunch due to emission process is discussed and the way to optimize the bunching was proposed. Bunch dynamics accounting for space-charge forces was studied using analytical solution of equation of motion.

THPD042 **Dispersion Engineering and Disorder in Photonic Crystals for Accelerator Applications** – *R. Seviour (Lancaster University)*

The possibility of achieving higher accelerating gradients at higher frequencies with the reduction of the effect of HOMs, compared to conventional accelerating structures, is increasing interest in the possible use of Photonic Crystals (PC) for accelerator applications. In this paper we analyze how the properties of the lattice of a PC resonator can be engineered to give a specific band structure, and how by tailoring the properties of the lattice specific EM modes can either be confined or moved into the propagation band of the PC. We further go on to discuss the role of disorder in achieving mode confinement and how this can be used to optimize both the Q and the accelerating gradient of a PC based accelerating structure. We also examine the use of high disorder to give rise to Anderson Localization, which gives rise to exponential localization of an EM mode. Discussing the difference between the extended Bloch wave, which extends over the entire PC, and the Anderson localized mode.

THPD043 **Metamaterial Mediated Inverse Cherenkov Acceleration** – *Y.S. Tan (Lancaster University) R. Seviour (Cockcroft Institute, Lancaster University)*

In this paper we examine the effect of introducing an Electromagnetic metamaterial into a Travelling Wave structure to mediate inverse Cherenkov acceleration. Electromagnetic metamaterials are artificial materials that consist of macroscopic structures that yield an effective permittivity and permeability less than zero. The properties of metamaterials are highly frequency dependent and give rise to very novel dispersion relationships. We show that the introduction of a specifically designed metamaterial into the interaction region gives rise to a novel dispersion curve yielding a unique wave-particle interaction. We demonstrate that this novel wave-particle interaction gives rise energy exchange from wave to beam over an extended interaction regime. We also discuss the benefits and issues that arise from having a metamaterial in a high vacuum high power environment with a specific focus on the issue of loss in metamaterial structures.

THPD044 **Wakefields in Photonic Crystal Accelerator Cavities** – *G.R. Werner, C.A. Bauer, J.R. Cary (CIPS)*

The RF properties of photonic crystals (PhCs) can be exploited to avoid the parasitic higher order modes (HOMs) that degrade beam quality in accelerator cavities and reduce efficiency and power in RF generators. For example, an accelerator cavity can be designed using a PhC structure that traps only modes within a narrow frequency range, so that the cavity has only a single mode. Although the lack of HOMs is perhaps the most drastic difference between PhC cavities and traditional metal cavities, PhC cavities should allow a much wider range of materials and shapes, which could potentially lead to cavities that operate at higher electric fields and at higher frequencies (with lower losses). However, this greater flexibility introduces many challenges for building actual structures. A hybrid cavity that uses a dielectric 2D PhC along with metal plates to trap fields in the third dimension may offer the advantages of a PhC cavity while being relatively easy to construct. Computer simulations show that long-range wake fields can be significantly reduced in such hybrid structures. Optimizing the rod positions can further lower wakefields, while also reducing overall structure size.

THPD045 **Fabrication of a Laser-based Microstructure for Particle Acceleration** – *J. Zhou, G. Travish (UCLA) R.B. Yoder (Manhattanville College)*

The Micro-Accelerator Platform is an optical-wavelength microstructure for laser acceleration of particles, currently under development at UCLA. It is a slab-symmetric structure and can be constructed in layers using existing nanofabrication techniques. We present several possible fabrication techniques and preliminary experimental outcomes for manufacturing this structure.

THPD046 **Initial Results on Electron Beam Generation using Pyroelectric Crystals** – *U.H. Lacroix, D.M. Fong, G. Travish, N. Vartanian (UCLA) E.R. Arab (PBPL) R.B. Yoder (Manhattanville College)*

Pyroelectric crystals, which produce large surface electric fields during heating and cooling, have been proposed as a mechanism for constructing a stand-alone electron beam source. We report on experimental tests of this concept, using a variety of field emission tips combined with a pyroelectric crystal to produce a low-energy electron beam during thermal cycling. The mechanism is suitable for generating very small electron bunches, with energies up to tens of kilovolts, for use in microaccelerator structures.

THPD047 **A Tapered Dielectric Structure for Laser Acceleration at Low Energy** – *J.C. McNeur, J.B. Rosenzweig, G. Travish (UCLA) R.B. Yoder (Manhattanville College)*

This paper extends the physics of the Micro-Accelerator Platform (MAP), which is in development as an optical structure for laser acceleration of relativistic electrons. The MAP is a resonant, optical-scale, slab-symmetric device that is fabricated from dielectric materials using layer-deposition techniques. For stand-alone applications, low-energy electrons (beta ~ 0.3) must be synchronously accelerated to relativistic speeds for injection into the MAP. Even lower energies are desired for other particle species (e.g. protons or muons). In this paper, we present design and simulation studies on a tapered geometry and associated coupling scheme that can produce synchronous acceleration at beta < 1 within a MAP-like structure.

THPD048 **First High-gradient Tests of the Single-cell SC Cavity with the Feedback Waveguide** – *P.V. Avrakhov, A. Kanareykin (Euclid TechLabs, LLC) M. Ge, I.G. Gonin, T.N. Khabiboulline, N. Solyak, G. Wu, V.P. Yakovlev (Fermilab) J. Rathke (AES)*

Use of a superconducting travelling wave accelerating (STWA) structure with a small phase advance per cell rather than a standing wave structure may provide a significant increase in the accelerating gradient in the ILC linac. For the same surface electric and magnetic fields the STWA achieves an accelerating gradient 1.2 larger than TESLA-like standing wave cavities. In addition, the STWA allows longer acceleration cavities, reducing the number of gaps between them. However, the STWA structure requires a SC feedback waveguide to return the few hundreds of MW of circulating RF power from the structure output to the structure input. A test single-cell cavity with feedback was designed and manufactured to demonstrate the possibility of a proper processing to achieve a high accelerating gradient. The first results of high-gradient tests of a prototype 1.3 GHz single-cell cavity with feedback waveguide will be presented.

THPD049 **Controlled Charge Injection for LWFA and Novel Beam Characterization Techniques** – *L. Veisz, C.M.S. Sears (MPQ)*

We present results from recent experiments into controlled charge injection for laser wakefield acceleration. We utilize a novel technique in which a sharp gas density transition is caused by inserting a thin blade into a supersonic gas flow. Improvements in electron energy, injection probability, and charge are observed compared to the self injected regime. We will also present additional results in LWFA beam characterization including shadowgraphy with 2 micron spatial and 8 fs temporal resolution which allows for direct observation of the plasma wakefield structure.

THPD050 **A Proposed Experiment on Proton Driven Plasma Wakefield Acceleration** – *A. Caldwell, G.X. Xia (MPI-P) R.W. Assmann, F. Zimmermann (CERN) K.V. Lotov (BINP SB RAS) A.M. Pukhov (HHUD)*

Proton driven plasma wakefield acceleration holds promise to accelerate a bunch of electrons to the energy frontier in a single acceleration channel. To verify this novel idea, a demonstration experiment is now being planned. The idea is to use the high energy proton bunches from the Super Proton Synchrotron (SPS) at CERN, to shoot them into a plasma cell and drive large amplitude of plasma wake. The interactions between the plasma and protons are simulated and the results are presented in this paper.

THPD051 **Producing Short Proton Bunch for Driving Plasma Wakefield Acceleration** – *G.X. Xia, A. Caldwell (MPI-P)*

A high energy, intense and short proton bunch can be employed to excite an interesting plasma wakefield for the electron beam acceleration. To excite a large amplitude of plasma wave, a short driver is thus required. In this paper, several proton bunch compression scenarios are analyzed. A magnetic bunch compressor is designed to compress the SPS proton beam for the demonstration experiment at CERN. The simulation results of bunch compression are given.

THPD052 **Manipulation of Negatively Charged Beams via Coherent Effects in Bent Crystals** – *V. Guidi, E. Bagli, A. Mazzolari (INFN-Ferrara) A.G. Afonin, Y.A. Chesnokov, V.A. Maisheev, I.A. Yazynin (IHEP Protvino) S. Baricordi, P. Dalpiaz, M. Fiorini, D. Vincenzi (UNIFE) D. Bolognini,*

S. Hasan, M. Prest (Università dell'Insubria & INFN Milano Bicocca) G. Della Mea, R. Milan (INFN/LNL) A.S. Denisov, Yu.A. Gavrikov, Yu.M. Ivanov, L.P. Lapina, L.G. Malyarenko, V. Skorobogatov, V.M. Suvorov, S.A. Vavilov (PNPI) S. Golovatyuk, A.D. Kovalenko, A.M. Taratin (JINR) A. Mattera (INFN MIB) W. Scandale (CERN) S. Shiraishi (Enrico Fermi Institute, University of Chicago) E. Vallazza (INFN-Trieste) A. V. Vomiero (INFM-CNR, Istituto Nazionale di Fisica della Materia - Consiglio Nazionale delle Ricerche)

New results in coherent interaction of negatively-charged particles with bent crystals showed unprecedentedly and significantly high efficiency to manipulate such beams, in the same way as for positively charged particles. Key feature under experimental attainment was the usage of high-quality suitably thin silicon crystals. We experimentally tested crystals Vs. 150 GeV negative pions at external lines of CERN SPS. We observed planar channeling at full deflection angle 30% high single-pass efficiency and large acceptance (about 20μrad). Moreover in the axial case, we reached more than 90% deflection efficiency and larger acceptance (about 60μrad). We also observed volume reflection in a bent crystal, at more than 70% single-pass efficiency with such a wide acceptance as the bending angle. At last, volume reflection by several planes in a single bent crystal was successfully tested with very high efficiency (about 80%). In summary both channeling and volume reflection modes appear to be useful technique for the manipulation of negatively charged beams, e.g. for collimation in the new generation of high intensity accelerators.

THPD053 **Capture and Transport of Electron Beams from Plasma Injectors** – *P. Antici, A. Mostacci (INFN/LNF) C. Benedetti (Bologna University) M. Migliorati, L. Palumbo (Rome University La Sapienza)*

Electron beams produced by laser-plasma interaction are attracting the interest of the conventional accelerator community. In particular Laser-accelerated electrons are particularly interesting as source, considering their high initial energy and their strong beam current. Moreover, the advantages of using laser-plasma electron beam can be expressed in terms of size and cost of the global accelerating infrastructure. However, improvements are still necessary since, currently, the many laser-accelerated beams are characterized by a large energy spread and a high beam divergence that degrades quickly the electron beam properties and makes those sources not suitable as a replacement of conventional accelerators. In this paper, we report on the progress of the study related to capture, shape and transport of laser generated electrons by means of tracking codes. Our study has focused on laser-generated electrons obtained nowadays by conventional multi hundred TW laser systems and on numerical predictions. We analyze different lattice structures, working on the optimization of the capture and transport of laser-accelerated electrons. Results and open problems are shown and discussed.

THPD054 **Inverse Compton Scattering by Laser Accelerated Electrons and its Application to Standoff Detection of Hidden Objects** – *Y. Kitagawa, K. Fujita, R. Hanayama, K. Ishii, Y. Mori (GPI) T. Kawashima (Hamamatsu Photonics K.K.) H. Kuwabara (IHI)*

A technique for remote detection of hidden objects is an urgent issue, but is not yet realized, because a source and a sensor must be located on the same side of the object. An ultra-intense laser can produce extremely short and directional radiations, that is the inverse Compton scatterings used for the backscattering system. We here demonstrate that the laser-wakefiled-accelerated 10-MeV electrons inversely scatter the same laser light to keV X-ray emissions. A 10 TW OPCPA Ti:sapphire laser BEAT (1J output, wavelength 815 nm, and pulse width 150fs) is divided to two beams. A 0. 8-J beam is focused to an entrance edge of helium gasjet to accelerate electrons via wakefield and the other 0.2-J beam is focused to the exit of the plasma channel from the opposite direction. A second harmonic probe light measured the channel density. To the upstream direction of the latter beam, a CdTe detector analyzed the Compton spectrum under a photon counting mode* in the range of 1 keV to 20 keV, which well agrees with that calculated from the obtained electron spectrum up to a few tens MeV. We also have observed that the emission is strong into the laser axis direction.

THPD055 **Improvement of Quality of Proton Beam during Laser Acceleration and Propagation** – *Y.Y. Ma, S. Kawata, K. Takahashi (Center for Optical Research and Education, Utsunomiya University) Y.Q. Gu, Y.Y. Ma (Laser Fusion Research Center, China Academy of Engineering Physics) F.Q. Shao (National University of Defense Technology, Graduate School) Z.M. Sheng (Shanghai Jiao Tong University) Y. Yin, T.P. Yu, D. F. Zhou (National University of Defense Technology) M.Y. Yu (Ruhr-Universität Bochum) H.B. Zhuo (National University of Defense Technology, Parallel and Distributed Processing)*

Energetic protons of tens MeV or more produced by intense lasers have been observed in recent experiments and numerical simulations. Meanwhile, significant efforts have been made to improve the proton beam quality *,**,***. For most applications, it is important to improve the quality of the proton beam both during the production and during the propagation. Some schemes are proposed to improve the quality of the proton beam both during the production form the laser plasma interaction and during the propagation. The physics is investigated by 2D3V and 3D particle-in-cell codes PLASIM and PLASIM3D. In this paper, we propose to use an umbrella-like target to accelerate, and collimate protons. It is found that high intensity collimated MeV-proton beams can be produced ****. We also propose a scheme to generate quasi-monoenergetic proton beam from the interactions of an ultra-intense laser pulse and a thin tailored hole target. Particle simulation shows that a monoenergetic proton beam is generated from the hole. The propagation of a proton beam both in vacuum and in a plasma is also studied. Compared with the propagation in vacuum, the proton beam quality can be improved obviously.

THPD056 **Experimental Program for the CLIC Test Facility 3 Test Beam Line** – *E. Adli (University of Oslo) A.E. Dabrowski, S. Doebert, M. Olvegaard, D. Schulte, I. Syratchev (CERN) R.L. Lillestol (NTNU)*

The CLIC Test Facility 3 Test Beam Line is the first prototype for the CLIC drive beam decelerator. Stable transport of the drive beam under deceleration is a mandatory component in the CLIC two-beam scheme. In the Test Beam Line more than 50% of the total energy will be extracted from a 150 MeV, 28 A electron drive beam, by the use of 16 Power Extraction and Transfer structures. A number of experiments are foreseen to investigate the drive beam characteristics under deceleration in the Test Beam Line, including beam stability, beam blow up and the efficiency of the power extraction. General benchmarking of decelerator simulation and theory studies will also be performed. Specially designed instrumentation including precision BPMs, loss monitors and a time-resolved spectrometer dump will be used for the experiments. This paper describes the experimental program foreseen for the Test Beam Line, including the relevance of the results for the CLIC decelerator studies.

THPD057 **The Analysis of Tunable Dielectric Loaded Wakefield Accelerating Structure of Rectangular Geometry** – *I.L. Sheynman, A. Altmark, S. Baturin (LETI) A. Kanareykin (Euclid TechLabs, LLC)*

The analysis of Vavilov-Cherenkov radiation generated by wide high current relativistic electronic bunch in a rectangular waveguide with multilayered dielectric filling is carried out. One ceramic layer of the structure possesses ferroelectric properties, which allow the waveguide frequency spectrum to be controlled by varying the permittivity of this ferroelectric layer by external electric field. On the basis of decomposition on orthogonal eigenmodes of a rectangular multilayered waveguide analytical expressions are received and numerical modeling of wakefield electromagnetic fields and the radial forces deflecting the bunch is spent.

THPD058 **Definition of Focusing System Parameters on the Basis of the Analysis of a Transverse Bunch Dynamics in Dielectric Loaded Wakefield Accelerator** – *I.L. Sheynman (LETI) A. Kanareykin (Euclid TechLabs, LLC)*

The strong focusing of high current relativistic electron beams in multibunch wakefield acceleration is investigated. These beams are used for generating wake fields in dielectric loaded accelerating structures. We consider ramped charge distribution in the sequence of high current drive bunch. It is shown that the beam focusing system dumping beam breakup effect and elongating of a maximum distance the high current beam can travel determines the effectiveness of the energy transfer to the accelerated electron bunch. The optimal parameters of the focusing system on the basis of self-consistent transverse dynamics analysis are determined.

THPD059 **The Status of Turkish Accelerator Center Project** – *S. Ozkorucuklu (SDU) O. Yavas (Ankara University, Faculty of Engineering)*

The status and road map of Turkish Accelerator Center (TAC) project is explained. TAC project is in third phase after feasibility and conceptual design phases with support of State Planning Organisation (SPO) of Turkey that the main aim of this phase is to complete of technical design report of TAC and to establish the first (test) facility. The first facility is planned as superconducting electron linac based IR FEL and bremsstrahlung facility. Third phase will be completed in 2013. It is planned that TAC will include a linac on ring type electron positron collider as a super charm factory, third and fourth generation light sources (SR and SASE FEL) and a proton facility. TAC collaboration is an inter-university collaboration of ten Turkish Universities under the coordination of Ankara University and TAC is a national project with international collaboration. In this study, the status of the project and the road map is explained with some results from design and construction studies.

THPD060 **Wakefield Excitation and Electron Energy Gain in Combined Plasma-dielectric Structure** – *I.N. Onishchenko, V. Kiselev, A. Linnik, V. Uskov (NSC/KIPT)*

Increase of wakefield, excited by a train of relativistic electron bunches in the rectangular dielectric structure when it was filled with plasma and electron energy loss and gain was experimentally observed. The train of N=6000 bunches with energy 4.5 MeV and charge 0.16 nC each was produced by the linear resonant accelerator. Frequency of bunch repetition was 2805 MHz, bunch length and radius were 17 mm and 5 mm, correspondingly. As a dielectric structure the standard copper waveguide by cross-section 72.14x34.04 mm2 was used, in which along two wider walls the ceramics plates with permittivity 9 were placed. The thickness 8.8 mm of plates was chosen from the condition of coincidence of the Cherenkov frequency with bunch repetition frequency. The transit channel was filled with air at various pressures. The first part of the train ionized air so that plasma frequency became equal to repetition frequency of bunches and to the frequency of principal mode of the dielectric structure.

THPD061 **Space Charge and Group Velocity Effects at Wakefield Excitation in a Rectangular Multi-zone Dielectric Resonator** – *G.V. Sotnikov, K.V. Galaydych, P.I. Markov (NSC/KIPT)*

To excite intensive accelerating fields a multi-zone dielectric structures can be used*. As have shown already carried out researches, at their excitation by relativistic charged particle bunches the maximal amplitude of an accelerating field significantly depends on group velocity of energized waves. Till now these effects in wakefield multi-zone dielectric accelerators in details are not investigated. In addition the large charge of drive bunches requires the obligatory account of its space charge on bunch dynamics. To account the specified effects we built the nonlinear self-consistent theory of wake field excitation in the multilayered dielectric resonators. Expressions for excited fields, functionally depending on position of bunch particles in the resonator are found analytically. Excited fields are presented in the form of superposition solenoidal (LSE and LSM types) and potential fields. The nonlinear theory built in a general view is valid for any number of dielectric layers. Use of the constructed theory for the account of nonlinear and groups velocity effects is demonstrated on an example of 5-zone dielectric resonator with parameters close to experiment**.

THPD062 **Argonne Wakefield Accelerator Facility (AWA) Upgrades** – *M.E. Conde, S.P. Antipov, W. Gai, R. Konecny, W. Liu, J.G. Power, Z.M. Yusof (ANL) C.-J. Jing (Euclid TechLabs, LLC)*

The AWA Facility is dedicated to the study of advanced accelerator concepts based on electron beam driven wakefields. The facility employs an L-band photocathode RF gun to generate high charge short electron bunches, which are used to drive wakefields in dielectric loaded structures, as well as in metallic structures. Accelerating gradients as high as

100 MV/m have been reached in dielectric structures, and RF pulses of up to 44 MW have been generated at 7.8 GHz. In order to reach higher accelerating gradients and higher RF power levels, several upgrades are underway: (a) a new RF gun with higher QE photocathode will replace the present drive gun; (b) the existing RF gun will generate a witness beam to probe the wakefields; (c) three new 25 MW L-band RF power stations will be added to the facility; (d) five additional linac structures will bring the beam energy up from 15 MeV to 75 MeV. The drive beam will consist of bunch trains of up to 32 bunches, with up to 60 nC per bunch. The goal of future experiments is to reach accelerating gradients of several hundred MV/m and to extract RF pulses with GW power level.

THPD063 **Design and High Power Test of Photonic Bandgap Structures for Accelerator Applications** – *R.J. Temkin, R.A. Marsh, B.J. Munroe, M.A. Shapiro (MIT/PSFC)*

Photonic bandgap (PBG) accelerator structures built of arrays of metallic rods are advantageous for wakefield damping. The operating mode is confined whereas the higher order modes (HOMs) leak out through the PBG structure. The HOMs excited by the electron beam have been tested at MIT using a 17.1 GHz PBG structure. The HOMs were weakly excited, in reasonable agreement with theory. A potential disadvantage of the PBG structure is the increased surface current due to reduced wall area, which leads to relatively higher pulsed surface heating. A new set of PBG structures have been designed at MIT specifically for pulsed heating and breakdown experiments. We finished the first test of an 11.4 GHz PBG structure at SLAC. A similar structure designed at 17.1 GHz will be tested at MIT to study the frequency scaling of pulsed heating and breakdown. We have also designed an improved PBG structure with reduced pulsed heating to be tested at 11.4 GHz at SLAC.

THPD064 **Betatron Radiation from an Off-axis Witness Bunch in a Plasma Wakefield Accelerator** – *P. Muggli, O. Chang, Y. Shi (USC) C. Huang (LANL) W.B. Mori (UCLA)*

In a plasma wakefield the accelerated electrons of the witness bunch oscillate in a pure ion column. They emit strong synchrotron, aka betatron radiation, in the keV to MeV photon range*. In previous experiments with a single electron bunch the oscillating electrons where distributed symmetrically about the beam axis. However, with a drive/witness bunch system, the witness bunch can be injected into the ion column with a transverse momentum component. In this case the witness bunch oscillates about the beam axis. Since the ultra-relativistic bunches do not suffer from dephasing, the energy loss to radiation can be compensated for by the energy gain from the wakefield. We explore the characteristics of the witness bunch oscillations and of the betatron radiation through numerical simulations and calculations. Detailed results will be presented.

THPD065 **Design, Simulations and Experimental Plan of a Proof-of-principle, Laser-powered Dielectric Accelerator for Medical and Industrial Applications** – *S. Boucher, R. Tikhoplav (RadiaBeam) J.B. Rosenzweig, G. Travish (UCLA) R.B. Yoder (Manhattanville College)*

Sources of relativistic electrons, especially for use in generating x-rays, are utilized in applications ranging from cancer therapy to industrial inspection, but such devices are presently large and very expensive. New applications, ranging from research in high-energy physics, to medical uses in advanced imaging and radiosurgery, demand new types of radiation and charged particle sources. Laser-powered dielectric accelerating structures, which have attracted attention in recent years, trade fabrication challenges and extremely small beam apertures for the promise of high gradients and new bunch formats. The slab-symmetric, periodically-coupledμAccelerator Platform (MAP) is one such dielectric accelerator, and has been under development through a RadiaBeam-UCLA collaboration for several years. A relativistic MAP structure has been designed for a proof of principle, external-injection experiment to be performed at the SLAC E163 facility. In this paper we describe the results to date, including design and simulations of the structure, and plans for fabrication and testing.

THPD066 **Observation of Wakefields in a Beam-Driven Photonic Band Gap Accelerating Structure** – *C.-J. Jing (Euclid TechLabs, LLC) S.P. Antipov, M.E. Conde, W. Gai, F. Gao, J.G. Power, Z.M. Yusof (ANL) H. Chen, C.-X. Tang, S.X. Zheng (TUB)*

Wakefield excitation has been experimentally studied in a 3-cell X-band standing wave Photonic Band Gap (PBG) accelerating structure. Major monopole (TM01- and TM02-like) and dipole (TM11- and TM12-like) modes were indentified and characterized by precisely controlling the position of beam injection. The quality factor Q of the dipole modes was measured to be ~10 times smaller than that of the accelerating mode. A charge sweep, up to 80 nC, has been performed, equivalent to ~30 MV/m accelerating field on axis. A variable delay low charge witness bunch following a high charge drive bunch was used to calibrate the gradient in the PBG structure by measuring its maximum energy gain and loss. Experimental results agree well with numerical simulations.

THPD067 **The First Experiment of a 26 GHz Dielectric Based Wakefield Power Extractor** – *C.-J. Jing, F. Gao, A. Kanareykin, P. Schoessow (Euclid TechLabs, LLC) M.E. Conde, W. Gai, R. Konecny, J.G. Power (ANL)*

High frequency, high power rf sources are needed for many applications in particle accelerators, communications, radar, etc. We have developed a 26GHz high power rf source based on the extraction of wakefields from a relativistic electron beam. The extractor is designed to couple out rf power generated from a high charge electron bunch train traversing a dielectric loaded waveguide. The first high beam experiment has been performed at Argonne Wakefield Accelerator facility. The experimental results successfully demonstrate the 15ns 26GHz rf pulse generated from the wakefield extractor with a bunch train of 16 bunches. Meanwhile, ~ 30MW short rf pulse has been achieved with a bunch train of 4 bunches. Beam Breakup has prevented charge transport through the power extractor beyond 10nC. We are doing simulations and developing methods to alleviate the BBU effect.

THPD068 **Experiment on a Tunable Dielectric-Loaded Accelerating Structure** – *C.-J. Jing, A. Kanareykin, P. Schoessow (Euclid TechLabs, LLC) M.E. Conde, W. Gai, J.G. Power (ANL) E. Nenasheva (Ceramics Ltd.)*

Dielectric-Loaded Accelerating (DLA) structures are generally lack of approaches to tune frequency after the fabrication. A tunable DLA structure has been developed by using an extra nonlinear ferroelectric layer. Dielectric constant of the applied ferroelectric material is sensitive to temperature and DC voltage. Bench test shows the +14MHz/^{o}C, and 6MHz frequency tuning range for a 25kV/cm of DC bias field. A beam test is planned at Argonne Wakefield Accelerator facility before the IPAC conference. Detailed results will be reported.

THPD069 **Studies of Nonlinear Media with Accelerator Applications** – *P. Schoessow, A. Kanareykin (Euclid TechLabs, LLC) S. Baturin (LETI) V.P. Yakovlev (Fermilab)*

Materials possessing variations in the permittivity as a function of the electric field exhibit a variety of phenomena for electromagnetic wave propagation such as frequency multiplication, wave steepening and shock formation, solitary waves, and mode mixing. New low loss nonlinear microwave ferroelectric materials present interesting and potentially useful applications for both advanced and conventional particle accelerators. Accelerating structures (either wakefield-based or driven by an external rf source) loaded with a nonlinear dielectric may exhibit significant field enhancements. In this paper we will explore the large signal permittivity of these new materials and applications of nonlinear dielectric devices to high gradient acceleration, rf sources, and beam manipulation. We describe planned measurements using a planar nonlinear transmission line to characterize in detail the electric field dependence of the permittivity of these materials. We will present a concept for a nonlinear transmission line that can be used to generate short, high intensity rf pulses to drive fast rf kickers.

THPD070 **Numerical and Experimental Studies of Dispersive, Active, and Nonlinear Media with Accelerator Applications** – *P. Schoessow, C.-J. Jing, A. Kanareykin (Euclid TechLabs, LLC) S.P. Antipov (ANL)*

Current advanced accelerator modeling applications require a more sophisticated treatment of dielectric and paramagnetic media properties than simply assuming a constant permittivity or permeability. So far active media have been described by a linear, frequency-dependent, single-frequency, scalar dielectric function. We have been developing algorithms to model the high frequency response of dispersive, active, and nonlinear media. The work described also has applications for modeling of other electromagnetic problems involving realistic dielectric and magnetic media. Results to be reported include treatment of multiple Lorentz resonances based on auxiliary differential equation, Fourier, and hybrid approaches. We will also report on recent measurements of paramagnetic active microwave materials using EPR spectroscopy. Comparison of the results to numerical simulations will be presented.

THPD071 **Electron energy recovery linacs for ultra-high energies** – *V. Litvinenko (BNL)*

Using energy recovery linacs (ERLs) for very high-energy colliders, such and LHeC or ILC, could significantly increase their luminosity using high intensity electron beams. Unfortunately traditional ERL schemes do use returning arcs and the resulting synchrotron radiation making any such scheme impractical for energies above 100 GeV. The push-pull scheme, based on two linacs each of which accelerate one beam while decelerate the contra-propagating beam, imposes significant limitation of the beam parameters. This limitations diminish most of the luminosity gains promised by ERLs. In this paper I present the scheme, which has linear scaling for the losses on synchrotron radiation instead of the 'energy in power four' scaling and, in principle, extend applicability of high power ERLs into TeV range of energies.

THPD072 **Laser Energy Conversion to Solitons and Monoenergetic Protons in Near-critical Hydrogen Plasma** – *I. Pogorelsky, M. Babzien, M.N. Polyanskiy, V. Yakimenko (BNL) N. Dover, Z. Najmudin, C.A.J. Palmer, J. Schreiber (Imperial College of Science and Technology, Department of Physics) G. Dudnikova (UMD) M. Ispiryan, P. Shkolnikov (Stony Brook University)*

Recent theoretical and experimental studies point to better efficiency of laser-driven ion acceleration when approaching the critical plasma density regime. Simultaneously, this is the condition for observing solitons: "bubble"-like quasi-stationary plasma formations with laser radiation trapped inside. Exploring this regime with ultra-intense solid state lasers is problematic due to the lack of plasma sources and imaging methods at $\sim 10^2 1$/cc electron density. The terawatt picosecond CO2 laser operated at Brookhaven's Accelerator Test Facility offers a solution to this problem. At 10 um laser wavelength, the CO2 laser shifts the critical plasma density to $10^1 9$/cc which is attainable with gas jets and can be optically probed with visible light. Capitalizing on this approach, we focused a circular-polarized CO2 laser beam with a_0=0.5 onto a hydrogen gas jet and observed monoenergetic proton beams in the 1 MeV range. Simultaneously, the laser/plasma interaction region has been optically probed with a 2nd harmonic picosecond Nd:YAG laser to reveal stationary soliton-like plasma formations. 2D PIC simulations agree with experimental results and aid in their interpretation.

THPD073 **Acceleration Module in Linear Induction Accelerator** – *S. Wang, S. Chen (CAEP/IFP)*

Linear Induction Accelerator (LIA) is a unique type of accelerator, which is capable to accelerate kilo-Ampere beam current to tens of MeV. The LIA acceleration modules, filled with ferrite or ferromagnetic toroid cores, can be conveniently stacked to obtain high energy. During the evolution of LIA, several models for the LIA acceleration module and the function of the cores have been proposed. Authors of this paper surveyed these models and tried to bridged them to form a consistent understanding of the LIA acceleration module. The unified understanding should be helpful in the further development and design of the LIA acceleration module.

THPD074 **Project-X, Neutrino Factories, and Muon Colliders** – *G. Flanagan, R.J. Abrams, C.M. Ankenbrandt, M.A.C. Cummings, R.P. Johnson (Muons, Inc) M. Popovic (Fermilab)*

The designs of accelerator systems that will be needed to transform Fermilab's Project X into a high-power proton driver for a muon collider and/or a neutrino factory are discussed. These applications require several megawatts of beam power delivered in tens or hundreds of short multi-GeV bunches per second, respectively. Project X may require a linac extension to higher energy for this purpose. Other major subsystems that are likely to be needed include storage rings to accumulate and shorten the proton bunches and an external beam combiner to deliver multiple bunches simultaneously to the pion production target.

THPD075 **LOCO based Analysis of CesrTA Emittance Coupling** – *R.T. Dowd (ASCo) D. L. Rubin, J.P. Shanks (CLASSE)*
Achieving a low emittance coupling is an important requirements for the International Linear Collider (ILC) damping rings. The Cornell Electron Storage Ring has been reconfigured as a test accelerator (CesrTA) for the investigation of beam physics issues in such damping rings*. Low emittance tuning has been performed and measurements indicate a vertical emittance of about 35pm has been achieved**. LOCO (Linear Optics from Closed Orbits) is an orbit response matrix based analysis technique which is commonly used in synchrotron light sources for lattice calibration. A low emittance tuning technique based on LOCO has been developed at the Australian synchrotron and used there to achieve extremely low emittance coupling ratios (~0.01%)***. In this study, this technique has been applied to CesrTA to explore the relative merits of a LOCO based approach in low emittance tuning.

THPD076 **Transverse Coupling at the UVX LNLS Storage Ring** – *X.R. Resende, R.H.A. Farias, L. Liu, M.B. Plotegher (LNLS)*
We report the recent studies and developments towards transverse coupling characterization and correction at the 1.37 GeV storage ring in the Brazilian Synchrotron Light Laboratories.

THPD077 **Linear Collider Test Facility: Linear Optics Beam Size Corrections at the IP of ATF2 using Upright and Skew Quadrupoles** – *B. Bolzon, A. Jeremie (IN2P3-LAPP) S. Bai (IHEP Beijing) P. Bambade (KEK) J. Resta-López (JAI) G.R. White (SLAC)*
The optical configuration of ATF2 presently uses enlarged beta functions at the IP of 8 and 1 cm, which will be gradually reduced to their nominal values. A sequence of corrections for the linear optics at the IP has been studied based on final doublet adjustments of the waists, on upright and skew quadrupole adjustments for the spatial dispersion, on skew quadrupole adjustments for residual coupling and on upright quadrupoles to adjust the overall demagnification factors. Coupling and waist corrections at the waist were shown to be close to orthogonal. For large errors in the beam line or at injection, correcting the overall demagnifications was found to be important and an approximate simplified procedure, convenient and empirical, was defined. The full tuning procedure was developed and tested in simulation, allowing to define the maximum errors which can be tolerated in the beam line and at injection. It was also tested and extensively used during the early ATF2 commissioning, using tungsten and carbon wire scanners at and just behind the IP, and using the "Shintake" beam size monitor. In this paper, both the development and initial usage of these tuning methods are described.

THPD078 **A Non Invasive Technique for the Transverse Matching in a Periodic Focusing Channel of a Linac** – *R.D. Duperrier, D. Uriot (CEA)*
A main interest in the high intensity ion linacs is the control of the particle loss in the vacuum chamber. A extremely low fraction of the beam (10^{-4} or 10^{-7}) is sufficient to complicate the hands on maintenance in such accelerator. Beam mismatching being a major source of halo, it is proposed a non invasive technique to adapt the beam to a periodic focusing channel of a linac based on a FDO of FODO lattice. It is demonstrated that only the matched beam can correspond to a particular signature of the quadrupolar moment of the Beam Positions Monitors. This technique allows also to measure the emittance value or evolution along the channel.

THPD079 **Optics Design of the SPIRAL2 Super Separator Spectrometer S3** – *J. Payet, M. Authier, D. Boutin, O. Delferriere, A. Drouart, D. Uriot (CEA) S.L. Manikonda, J.A. Nolen (ANL)*
The S3 spectrometer will be used with the high intensity stable heavy ion beams produced by the superconducting linear accelerator of SPIRAL2. The physics studied by the S3 collaboration requires a separator with a high rejection rate, a large momentum and angular acceptance, and a high mass resolution. This will be achieved with a momentum achromat followed by a mass analyser. In order to meet these unique performances, a design based on symmetric lattices is proposed. That solution naturally cancels several high order aberration terms. We will present the results obtained with theoretical models, and with field maps of multipole magnets calculated with the Opera3D code.

THPD080 **Coupling Measurements in ATF2 Extraction Line** – *C. Rimbault (LAL) S. Kuroda, T. Tauchi, N. Terunuma (KEK) G.R. White, M. Woodley (SLAC)*

The purpose of ATF2 is to deliver a beam with stable very small spotsizes as required for future linear colliders such as ILC or CLIC. To achieve that, precise controls of the aberrations such as dispersion and coupling are necessary. Theoretically, the complete reconstruction of the beam matrix is possible from the measurements of horizontal, vertical and tilted beam sizes, combining skew quadrupole scans at several wire-scanner positions. Such measurements were performed in the extraction line of ATF2 in May 2009. We present analysis results attempting to resolve the 4X4 beam matrix and discuss the experimental limitations of 4D emittance measurements with wire scanners.

THPD081 **Reducing Energy Spread of the Beam by Non-isochronous Recirculation at the S-DALINAC** – *F. Hug, A. Araz, R. Eichhorn, N. Pietralla (TU Darmstadt)*

The Superconducting Linear Accelerator S-DALINAC at the University of Darmstadt/ Germany is a recirculating Linac with two recirculations. Currently acceleration in the Linac is done on crest of the acceleration field using the maximum of the field in every turn. The recirculation of the beam is done isochronous without any longitudinal dispersion. In this recirculation scheme the energy spread of the resulting beam is determined by the stability of the used RF system. In this work we will present a new non-isochronous recirculation scheme, which uses longitudinal dispersion in the recirculations and an acceleration on edge of the accelerating field as it is done in microtrons. We will present beam dynamic calculations which show the usability of this system even in a Linac with only two recirculations and first measurements of longitudinal dispersion using RF monitors.

THPD082 **Beam Simulation Studies for a Stellarator Type Storage Ring** – *M. Droba, N.S. Joshi, O. Meusel, U. Ratzinger (IAP)*

The stellarator-type storage ring for multi- Ampere proton and ion beams with energies in the range of 100 AkeV to 1AMeV was designed. The main idea for beam confinement with high transversal momentum acceptance was presented in EPAC06 and EPAC08. Stable beam transport in opposite directions is possible through the same aperture with two crossing points along the structure. Elsewhere the beams are separated by the RxB drift motion in curved sections. The space charge compensation through the trapped or circulated electrons will be discussed. This ring is typically suited for experiments in atomic and nuclear astrophysics. Here we present the complete simulations for optimization of ring geometry, the stable beam confinement and developments in injection schemes.

THPD083 **Apochromatic Beam Transport in Drift-Quadrupole Systems** – *V. Balandin, R. Brinkmann, W. Decking, N. Golubeva (DESY)*

A straight drift-quadrupole system, though not being an achromat, can transport certain incoming beam ellipses without introducing first-order chromatic distortions. Several examples of such apochromatic beam transport are available in the literature. In this paper we show that the possibility of apochromatic focusing is a general property: For every drift-quadrupole system there exist an unique set of Twiss parameters (apochromatic Twiss parameters), which will be transported through that system without first order chromatic distortions. Moreover, we prove that at the same time the apochromatic Twiss parameters bring the second order effect of the betatron oscillations on the shift of the average bunch path length to the minimal possible value and also minimize the effect of betatron oscillations on bunch lengthening for Gaussian beam. As an example we consider the application of the apochromatic focusing concept to the design of matching sections and phase shifter of the post-linac collimation section of the European XFEL Facility.

THPD084 **Two Cell Repetitive Achromats and Four Cell Mirror Symmetric Achromats** – *V. Balandin, R. Brinkmann, W. Decking, N. Golubeva (DESY)*

An achromat is a focusing system, in which as large a number of higher order aberrations as possible is canceled by symmetries of the linear optics and the rest is corrected by the usage of third and higher order multipoles. The first achromats ever considered were repetitive achromats, in which the cancellation of higher order aberrations relies on appropriate selection of cell tunes. Later on achromats, employing mirror symmetry, were also developed. In this paper we remove one superfluous constraint on the linear optics in the theory of four cell mirror symmetric achromats, make an accurate consideration of two cell repetitive achromats, and compare the number of multipoles required for each of those achromats. Moreover, we contribute a point of view, from which both approaches to the achromat design become identical. As a practical application we consider the design of the arcs of the post-linac collimation section of the European XFEL Facility.

THPD085 **Correction of the Linear Optics at PETRA III** – *J. Keil, K. Balewski (DESY)*

PETRA III is a 6 GeV third generation light source located at DESY/ Hamburg. The former pre-accelerator of HERA has been converted in 2007/2008 into a high brilliance synchrotron light source with an emittance of 1 nm*rad. The commissioning of PETRA III started in 2009. PETRA III is like other third generation light sources very sensitive to errors of the linear optics. Gradient errors reduce the dynamic aperture, increase the emittance and change the beam size. The correction of the optics is based on orbit response matrix data which were analyzed both with the program LOCO and with a fit of the beta-functions and phase-functions at BPMs and correctors. Initial results of the modelling of the machine and the correction of the linear optics functions will be presented.

THPD086 **Measurement and Correction of Transverse Dispersion in PETRA III** – *G.K. Sahoo, K. Balewski, W. Decking, J. Keil (DESY)*

PETRA III is a 6GeV positron light source with a design horizontal beam emittance of 1nm.rad and 1% emittance coupling. This low emittance is achieved with proper correction of horizontal dispersion to its theoretical values in the arcs as well as dispersion free sections. The spurious vertical dispersion, arising due to misalignment and rotational errors of the magnets is also duly corrected as this contributes to the vertical beam size of the photon beam. Here we discuss the method taken to correct the horizontal dispersion using a combined orbit and dispersion correction scheme. In the vertical plane the same procedure can be used as that of horizontal plane or only the dispersion can be corrected using dedicated skew quadrupoles to millimeter level after orbit correction has been done. In this paper we present the methods used and results obtained in correction of dispersions in transverse planes.

THPD087 **Potential Forms for Electrostatic and Magnetic Cylindrical Lens and Tracking of Charged Particle** – *M.H. Rashid, R.K. Bhandari, C. Mallik (DAE/VECC)*

A cylindrical lens is mainly used for focusing and transporting low energy beam. Some analytical forms of scalar potential have been formulated to evaluate electric and magnetic field and its derivatives on the central axis, which help in evaluation of potential and field in the region about the central axis. They are, subsequently, used to analytically find out the optical properties of a lens as well as in tracking of charged particles. It turns into a tool to design an electrostatic or a magnetic cylindrical lens. A section-technique has been developed to evaluate the optical cardinal points of a thick lens very accurately. Smooth profiles of the field and potential along the axis are divided into large number of small stepped profile. Each step represents a weak thin lens as change in radial movement is very small. The effect of the individual weak lenses is evaluated and combined by matrix multiplication method to get optical property of the thick lens. The obtained values are verified by exactly tracking the particles by solving the Lorentz equation of motion of charged particle in electric or magnetic field.

THPD088 **Study of Coupler's Effects in ILC Like Lattice** – *A. Saini (University of Delhi) A. Latina, A. Lunin, K. Ranjan, N. Solyak, V.P. Yakovlev (Fermilab)*

It is well known that insertion of a coupler into a RF cavity breaks the rotational symmetry of the cavity, resulting in an asymmetric field. This asymmetric field results in a transverse RF Kick. This RF kick transversely offsets the bunch from the nominal axis & it depends on the longitudinal position of the particle in the bunch. Also, insertion of coupler generates short range transverse wake field which is independent from the transverse offset of the particle. These effects cause emittance dilution and it is thus important to study their behavior & possible correction mechanisms. These coupler effects, i.e. coupler's RF kick & coupler's wake field are implemented in a beam dynamics program, Lucretia. Simulations are performed for main linac & bunch compressor of International Linear Collider (ILC) like lattices. Results are compared with Placet results & a good agreement has been achieved.

THPD089 **Analytical Formula for the Transient Bunch Lengthening by a Betatron Motion along Bending Sections** – *Y. Shoji (NewSUBARU/SPring-8, Laboratory of Advanced Science and Technology for Industry (LASTI))*

A simple analytical formula for the transient bunch lengthening by betatron motion along bending sections is explained. The formula describes a longitudinal and transverse coupling for a single-pass line, which is obtained as an extension of the formula for a storage ring. The bunch lengthening is expressed by a product of three factors: the square root of horizontal betatron emittance, a betatron phase factor, and the square root of the H-function, in other words, dispersion action. That effect had been calculated in many reports concerning with sub-ps electron bunch generation, such as the laser-bunch slicing, the vertical bunch deflection by a crab cavity, and the beam transport along a quasi-isochronous bending arcs. In these works the transfer matrix elements, R15 and R25, had been calculated for each of various conditions. On the contrary, our simple and general analytical formula gives a good foresight to understand the observed phenomena and for an easy optimization of parameters of bending arcs.

THPD090 **Design of Modified Lattice of Long Straight Section in the SPring-8 Storage Ring** – *K. Soutome, K. Fukami, M. Oishi, Y. Okayasu, J. Schimizu, Y. Shimosaki, M. Shoji, M. Takao, H. Yonehara (JASRI/SPring-8)*

A set of three in-vacuum undulators is going to be installed in one of four long straight sections of the SPring-8 storage ring. In order to make the undulator gap as narrow as possible, we plan to divide this long straight section into three sub-sections and install quadrupole magnets between these sub-sections to lower the vertical betatron function. In the modified lattice, however, the symmetry of the ring is lowered and in general it becomes difficult to keep a sufficient dynamic aperture for on- and off-momentum electrons. The long straight sections were originally introduced in the year 2000 and at that time we developed a method of "quasi-transparent matching of sextupole fields" where two key concepts of betatron phase matching and local chromaticity correction were combined to obtain a sufficient dynamic aperture and momentum acceptance. Then, in the year 2007 "counter-sextupole magnets" were further installed to cancel the effect due to non-linear kick by sextupole magnets used for local chromaticity correction. In designing the new lattice with a modified long straight section, we followed the same line and could recover the dynamic aperture and momentum acceptance.

THPD091 **Explicit Maps for the Fringe Field of a Quadrupole** – *D.M. Zhou (KEK) Y. Chen, J. Tang, N. Wang (IHEP Beijing)*

A perturbation method based on Lie technique, originated by J. Irwin and C.-X. Wang, was extended to calculate the maps for the fringe field of a quadrupole. In our method, the slope of the fringe field is not necessarily antisymmetric with regard to the hard edge position. Both the linear and nonlinear maps were explicitly expressed as function of fringe field integrals. Thus they can be used to assess the influence of the quadrupole fringe fields in beam dynamics.

THPD092 **Applications for Advanced FFAG Accelerator** – *J.-B. Lagrange, Y. Ishi, Y. Kuriyama, Y. Mori, K. Okabe, T. Planche, T. Uesugi, E. Yamakawa (KURRI)*

Until today, scaling FFAG accelerator worked only for the ring type. But a new criteria of the magnetic field configuration satisfying scaling condition even for straight FFAG beam line has been recently found. Various applications based on this criteria such as insertion, matching, dispersion suppressor in the ring and the beam transport systems are here examined.

THPD093 **New Approach for Muon Acceleration with Zero-chromatic FFAGs** – *T. Planche, Y. Ishi, Y. Kuriyama, J.-B. Lagrange, Y. Mori, K. Okabe, T. Uesugi, E. Yamakawa (KURRI)*

The acceleration of intense muon beams up to 25 GeV is the challenge of the international design work for a future neutrino factory. The present baseline scenario for muon acceleration is based on Linac, RLA and non-scaling FFAG. However RLA is one of the most cost driving part. A new approach using zero-chromatic FFAG instead of RLA has been proposed. The details of such a zero-chromatic FFAG lattice and tracking results will be presented.

THPD094 **Production of Femtosecond Electron Pulse using Alpha Magnet together with off-crest Acceleration for Generation of Coherent THz Radiation** – *F. Miyahara, H. Hama, F. Hinode, M. Kawai, T. Muto, K. Nanbu, H. Oohara, Y. Tanaka (Tohoku University, School of Scinece)*

We have studied production of the very short-bunch electron beam to generate intense coherent THz radiation*. The bunch length of 100 fs is required to produce CSR around 1 THz. The beam from the thermionic RF-gun is introduced into the bunch compression system consist of an alpha magnet and a linac. The alpha magnet is often used as a bunch compressor for electron energy of several MeV. However, for our system, the alpha magnet plays a role of the longitudinal phase space rotator and energy filter. The bunch compression is done in the linac employing velocity bunching. The beam is injected on near the zero-cross phase of the RF field in the linac, and then the beam phase slip toward the crest. The longitudinal phase space and beam phase with respect to RF field at the entrance of the linac are optimized so that the bunch length would be minimum. In current analysis using numerical simulation based on the GPT code**, an rms bunch length of 30 fs has been obtained for a bunch charge of 20 pC. We will discuss the bunch compression scheme and the beam dynamics in the system. Prospect of the coherent radiation from the beam will be also reported.

THPD095 **Effects of Magnetic Field Imperfections in the J-PARC 3-GeV RCS** – *H. Hotchi (JAEA/J-PARC)*

In the J-PARC 3-GeV RCS, we evaluated magnetic field imperfections with actual beams; leakage fields from the extraction septa, edge focus caused by the injection bump orbit, and so on. In this paper we will discuss influences of such field imperfections on beams.

THPD096 **Optical Configurations with Variable β* at Different IP Locations in ATF2** – *S. Bai (IHEP Beijing) P. Bambade (KEK) B. Bolzon (IN2P3-LAPP)*

During ATF2 commissioning, measuring the beam size at different IP locations become an important task. Several types of monitors will be placed at different IP locations to measure the beam size. In this paper, a method using optical configurations with variable β* at different IP locations is developed, which can be useful during the ATF2 commissioning.

27-May-10	16:00 – 18:00	Poster	Poster Hall E

THPE — Poster Session

THPE001 **Low Emittance Lattice Optimization Using Multiobjective Genetic Algorithm** – *W.W. Gao, W. Li, L. Wang (USTC/NSRL)*

Low emittance is a desirable performance for high brightness synchrotron light source and damping ring. The work presented in this paper demonstrates that the lattice of a given electron storage ring, which has a fixed circumference and magnet layout, can be optimized to obtain low emittance by using MOGA(Multi-Objective Genetic Algorithm). Both dispersion-free and non-dispersion-free lattices of HLS (Hefei Light Source) upgrade project are computed as an illustration. Simulation result shows that this method is fast and straightforward.

THPE002 **Lattice Compensation for FEL Wigglers at Duke Storage Ring** – *H. Hao (USTC/NSRL)*

In Duke storage ring, two sets of FEL wigglers, the planar OK-4 wigglers and helical OK-5 wigglers, are hosted in a 34 meter long straight section. In addition to the FEL operation, the OK-4 and OK-5 FELs have been used as a photon source to power a Compton gamma-source, the High Intensity Gamma-ray Source (HIGS), at Duke University. To produce gamma-ray beams from 1 MeV to 100 MeV, the OK-4 and OK-5 FELs are operated with a wide range of the wiggler field and electron beam energy, and with a variety of FEL configurations using one, two, or four wigglers. To accommodate this complex set of operation modes, a set of sophisticated wiggler compensation schemes have been developed. The betatron beating compensation and lattice tuning is realized for an under-constrained long straight section lattice with nine families of quadrupoles. In this work, we report our recent work of wiggler compensations for OK-4 and OK-5 FEL operation in a wide range of settings and configurations. These compensation schemes are implemented as feed forward controls to provide transparent operation of the FEL based light sources.

THPE003 **Analysis of theEffect of Environment Temperature on the Magnetic Field in the Heifei Light Source(HLS) storage ring** – *H.Q. Huang, H. Hao, W.W. Li, P.P. Wang, X.Q. Wang, D.R. Xu (USTC/NSRL)*

Shape of the magnet pole face could be affected by the environmental temperature. By analyzing the Hefei Light Source (HLS) storage ring operation data, it is found that there exists a correlation between the environmental temperature and the horizontal electron beam orbit. In this article, temperature effects on main magnets, including dipoles, quadrupoles, as well as on vacuum chamber of the HLS storage ring are calculated using ANSYS, after that corresponding magnetic field deformations are analyzed by OPERA-3D. The simulation results show that higher environment temperature minimizes the horizontal focusing component of the dipole magnet.

THPE004 **Analysis of the Effect of Ambient Temperature on the Beam Orbit of the Hefei Light Source Storage Ring** – *J.J. Tian, H. Hao, X.Q. Wang (USTC/NSRL)*

Ambient temperature could affect the performance of instruments of the storage ring, and eventually changes the orbit. By analyzing the Hefei Light Source (HLS) storage ring operation data, it is found that higher ambient temperature causes defocusing effect on electron beam in horizontal direction. In this article, the effect of the ambient temperature on the electron beam orbit of the HLS storage ring is calculated through analyzing the temperature dependency of focusing strength of main magnets. The numerical simulation results agree with the HLS storage ring operation data.

THPE005 **Beam Polarization Theory and its Application to HLS Storage Ring** – *J.Q. Lan, B. Sun, Y.C. Sun, H. Xu (USTC/NSRL)*

A brief, but clear, review of beam polarization theory is given in the paper. Particularly, the algorithm of spin linear transfer matrix (SLIM) is applied to remark the situation of beam in storage ring, specific to HLS (Hefei Light Source). Theoretical analysis indicates that the beam in HLS, working at 800MeV and 2.58/3.58 transverse tunes, could keep away from a variety of spin resonances, and should be able to build up high polarization.

THPE006 **Closed Orbit Correction Study of HLS II** – *S.C. Zhang (USTC/NSRL)*

In order to meet the increasing requirements of synchrotron radiation users, upgrade of HLS is necessary. The lattice is changed from TBA to DBA, and more straight sections are available for users. The emittance is decreased to 40nmrad. It also require the close orbit distortions (COD) stability is reduced to 5 um. Using orbit response matrix and singular value decomposition method, the distribution of beam position monitors and the location of correctors are reported in the paper. Simulation proves that COD can be corrected down to 50 microns level. The COD stability is maintained to 5 microns. In the same time the corrector strengths are smaller enough in the correction scheme.

THPE007 **A Design of HLS Transport Line with Skew Quadrupoles** – *S.C. Zhang (USTC/NSRL)*

A design of HLS transport line with skew quadrupoles.

THPE008 **Issues on Beam Dynamics in PLS-II** – *S.W. Jang, J.G. Hwang, E.-S. Kim, Y.I. Kim (Kyungpook National University)*

Pohang Light Source-II (PLS-II) is an upgrade project of the existing 2.5 GeV PLS. The circumference, beam current and energy of PLS-II storage ring are 281.82 m, 400 mA and 3 GeV, respectively. The upgrade project has many issues on beam dynamics. We investigated lattice optimization such as lattice corrections, dynamic aperture, selection of optimized tune & emittance and effects of insertion devices. MAD, SAD and Elegant have been used to the lattice optimization. We investigated the effects of machine errors and 20 IDs to the dynamic aperture. PLS-II lattice include twenty insertion devices and their effects on the beam dynamics are investigated. We also investigate possibility to reduce the emittance by increasing horizontal betatron tune and adjusting the dispersion by using of MAD, SAD and Elegant and also examined the required strengths of sextupoles for the various emittances.

THPE009 **Non-linear Beam Dynamics for Sextupole in RCS** – *S.W. Jang, E.-S. Kim (Kyungpook National University)*

Proton Engineering Frontier Project (PEFP) Linac has an upgrade plan of the addition of 1 GeV RCS ring. The lattice of the rapid cycling synchrotron is affected by a non-linear beam dynamics. In this study, we investigated about non-linear dynamics due to sextupoles in PEFP RCS. Notably, we investigated about 3rd integer resonance due to sextupoles. To slowly and continuously extract the proton beam, we utilize the 3rd integer resonance. For the reason, we investigated non linear beam dynamics due to 3rd integer resonance and slow extraction by using of MAD8.

THPE010 **PLS-II Lattice Design and Beam Dynamics** – *S. Shin (PLS) J. Choi, I. Hwang, C. Kim, K.R. Kim, M. Kim, S.H. Nam, S.J. Park (PAL) H. Wiedemann (SLAC)*

Main design goals of the PLSII lattice are to increase beam energy to 3 GeV, to increase number of insertion devices by factor of two, to increase beam current to 400 mA and to reduce beam emittance to below 10 nm with existing PLS tunnel and injection system. Following the desired design criteria, the lattice had been chosen such that the full storage ring includes 12 long straight sections and 12 short straight sections for installation of insertion devices with keeping beam emittance as small as possible. This talk describes the status of a study for PLSII lattice design.

THPE011 **Coupling Diagnostics and Control at PLS Storage Ring** – *I. Hwang, C. Kim, K.R. Kim, M. Kim, S.H. Nam, S.J. Park, S. Shin (PAL) J. Hou, L.G. Liu (SINAP)*

The measurement and the control of the coupling is essential to maximize synchrotron performance. Small coupling is required for small vertical size and high brightness. The Pohang Light Source has a 2.5 GeV storage ring and its coupling constant is measured as about 1%. In addition to errors at quadrupole or sextupole, the condition varying of the insertion device affects the coupling. The coupling for various condition is measured by the resonance and the response matrix and compared with the beam size and the lifetime. The correction and the control of the coupling is presented.

THPE012 **U400 Cyclotron Spiral Inflector with Beam Vertical Focusing Effect** – *I.A. Ivanenko, B. Gikal, G. Gulbekyan (JINR)*

The main losses of the injected beam are localized at the centre region of the cyclotron. One of the problems is the defocusing action of the spiral inflector. At the present work the method of decreasing of the vertical defocusing effect of the spiral inflector is presented. The decreasing of the vertical defocusing is achieved by means of special form of the inflector electric field. At FLNR, JINR, the new type of the inflector was investigated and manufactured. At the present time the inflector is installed and works at the U400 cyclotron. The experiments with the new inflector have shown the increasing of the beam intensity and more tuneble work of the cyclotron.

THPE013 **Invariants of Linear Equations of Motion** – *N.Yu. Kazarinov (JINR)*

Courant-Snyder invariant and Root Mean Square (RMS) beam emittance are well-known invariants of linear equation of motion. They are connected with the second order moments of a beam distribution function. Other invariants of linear equations of motion generated by second and higher order moments are presented in this report.

THPE014 **Round Beam Lattice Correction using Response Matrix at VEPP-2000** – *A.L. Romanov (BINP SB RAS)*

Lattice correction based on orbit responses to dipole correctors and orbit correction based on orbit responses to field gradient variations in quads were successfully implemented on VEPP-2000 for the flat-beam lattice. The round-beam lattice involves the strong coupling of vertical and horizontal motions that requires a full-coupling analysis in the orbit response technique. Used programs were modified to treat this task. Also automation and speed enhancements were done that enable a routine use of this technique at VEPP2000. New experimental results from VEPP-2000 are presented.

THPE015 **Simplified Approach to Evaluation of Beam-beam Tune Spread Compression by Electron Lens** – *A.L. Romanov (BINP SB RAS) V.D. Shiltsev, A. Valishev (Fermilab)*

One of the possible ways to increase luminosity of hadron colliders is the compensation of beam-beam tune-spread with an electron lens (EL). At the same time, EL as an additional nonlinear element in the lattice can increase strength of nonlinear resonances so that its overall effect on the beam lifetime will be negative. Time-consuming numerical simulations are often used to study the effects from the EL. In this report we present a simplified model, which uses analytical formulae derived for certain electron beam profiles. Based on these equations the idealized shapes of the compressed tune spread can be rapidly calculated. Obtained footprints were benchmarked against several reference numerical simulations for the Tevatron and RHIC in order to evaluate the selected configurations. One of the tested criteria was "folding" of the compensated footprint, which occurs when particles with different betatron amplitudes have the same tune shift. Also studied were the effects of imperfections, including misalignment of the electron and proton beams, and mismatch of their shapes.

THPE016 **Quantum Methodologies in Light Beam Optics** – *S.A. Khan (SCOT)*

A unified treatment of light beam optics and polarization, using the standard mathematical machinery of quantum mechanics is presented. Dirac-like form of the Maxwell equations is well known in literature. Starting with the Dirac-like form of the Maxwell's equations a unified treatment of light beam optics and polarization has been obtained. The traditional results (including aberrations) of the scalar optics are modified by the wavelength-dependent contributions. Some of the well-known results in polarization studies are realized as the leading-order limit of a more general framework of our formalism. http://rohelakhan.googlepages.com/

THPE017 **Quantum Aspects of Accelerator Optics** – *S.A. Khan (SCOT)*

Charged-particle optics, or the theory of transport of charged-particle beams through electromagnetic systems, is traditionally dealt with using classical mechanics. Though the classical treatment has been very successful, in designing and working of numerous charged-particle optical devices, it is natural to look for a prescription based on the quantum theory, since any system is quantum mechanical at the fundamental level. With this motivation the quantum theory of charged-particle beam optics, is being developed by Jagannathan et al. It is found that the quantum theory gives rise to interesting additional contributions to the classical paraxial and aberrating behaviour. In the classical limit the quantum formalism reproduces the well-known Lie algebraic formalism. This formalism is further applied to the study of the spin-dynamics of a Dirac particle with anomalous magnetic moment being transported through magnetic optical element. This naturally leads to a unified treatment of both the orbital (the Lorentz and Stern-Gerlach forces) and the spin (Thomas-Bargmann-Michel-Telegdi equation). http://rohelakhan.googlepages.com/

THPE018 **Layout and Optics Solutions for the LHC Insertion Upgrade Phase I** – *S.D. Fartoukh (CERN)*

The main guidelines of the LHC insertion (IR) upgrade Phase I are 1) the development of wider aperture (120 mm) and lower gradient (~120 T/m) quadrupoles using the well-characterized Nb-Ti technology in order to replace the existing inner triplets (IT) equipping the ATLAS and CMS high-luminosity IRs of the LHC, 2) while maximizing the use of the current LHC infrastructure, in particular leaving unchanged the so-called "matching sections" (MS) and "dispersion suppressors" (DS) of these two insertions. One of the initial goals was to be able to squeeze the optics up to a beta* of 25 cm. However, optics solutions with a beta* of 30 cm seems already to be at edge of achievability, both in terms of the IT and MS mechanical acceptance, gradients of the MS and DS quadrupole magnets, and correctability by the LHC arc sextupoles of the huge chromatic aberrations induced by the new inner triplet at ultimate beta*. The layout of the new inner triplet and the corresponding injection and collision optics will be presented and analyzed both in terms of aperture, squeeze-ability and chromatic correction.

THPE019 **CERN Proton Synchrotron Working Point Matrix for Extended Pole Face Winding Powering Scheme** – *P. Freyermuth, D.G. Cotte, M. Delrieux, H. Genoud, S.S. Gilardoni, K. Hanke, O. Hans, S. Mataguez, G. Metral, F.C. Peters, R.R. Steerenberg, B. Vandorpe (CERN)*

The CERN Proton Synchrotron has been continuously improving its beam performances since 1959. The working point parameters of the accelerator are mainly controlled by dedicated windings installed on the poles of the main combined function magnets. In 2007, the power supplies of these windings were renovated and extended from three to five independent groups, allowing exploration of new working point settings. This configuration offers the flexibility of several adjustment strategies such as leaving one current free or to control an additional physical parameter, like Q''_h. A non-linear chromaticity measurement campaign, at different beam energies, resulted in matrices defining the relationship between the five pole face winding currents and the four beam parameters Q_h, Q_v, Xi_h, and Xi_v. Each cell of these matrices was fitted against energy. The final result is a single matrix which is now used by the operational software to trim the working point. This paper summarises this measurement campaign by presenting the resulting matrix with a brief overview of the adjustment tools and strategy. Furthermore a few future possible benefits of this control enhancement will be discussed.

THPE020 **Scenarios for the ATF2 Ultra-Low Betas Proposal** – *E. Marin, R. Tomas (CERN) P. Bambade (KEK) A. Seryi, G.R. White, M. Woodley (SLAC)*

The current ATF2 Ultra-Low beta proposal was designed to achieve 20nm vertical IP beam size without considering the multipolar components of the FD magnets. In this paper we describe different scenarios that avoid the detrimental effect of these multipolar errors in the FD. The simplest approach consists in modifying the optics but other solutions are studied as the introduction of new higher order magnets or the replacement of the FD with SC technology. The practical aspects of such an upgrade are the tuning performance and the compatibility with existing devices and instrumentation. These are fully addressed in the paper.

THPE021 **Comparison of PS2 Lattices with Different Geometries** – *Y. Papaphilippou, W. Bartmann, H. Bartosik, M. Benedikt, B. Goddard (CERN) Y. Senichev (FZJ)*

The PS2 ring is designed with negative momentum compaction arc cells and doublet straights. In this paper, different lattice geometries are considered. In particular, a two-fold symmetric lattice with dispersion suppressors and a 3-fold symmetric one with resonant arc cells are compared with respect to their optics properties, and ability to satisfy space and magnet constraints. The tuning flexibility of rings based on these two options is presented. Finally, the impact of different geometries on resonance excitation and dynamic aperture is evaluated.

THPE022 **Linear Optimization and Tunability of the PS2 Lattice** – *H. Bartosik, W. Bartmann, M. Benedikt, B. Goddard, Y. Papaphilippou (CERN)*

The PS2 lattice, based on Negative Momentum Compaction (NMC) arc cells is being optimized in order to accommodate a new all-doublet long-straight section (LSS) design. Apart from smoothing the optics and enabling different tuning solutions for H^- injection, the optimization focuses on increasing the available magnet-to-magnet drift space and reducing the quadrupole types and strengths. The variation of lattice parameters for a wide range of working points is presented.

THPE023 **Non-Linear Analysis of the PS2 Negative Momentum Compaction Lattice** – *H. Bartosik, M. Benedikt, Y. Papaphilippou (CERN)*

This paper describes a detailed analysis of various non-linear effects of the nominal Negative Momentum Compaction lattice for PS2. Chromaticity and orbit correction schemes together with dynamic aperture studies are presented. The impact of magnet errors is being assessed and tolerances are evaluated. Frequency and diffusion maps are produced and, combined with non-linear driving terms analysis, are used for working point optimization.

THPE024 **Coupling and Vertical Dispersion Correction in the SPS** – *G. Vanbavinckhove, M. Aiba, R. Tomas (CERN) R. Calaga (BNL)*

Consolidation of the coupling correction scheme in the LHC is motivated due to a missing skew quadrupole family in Sector 3-4 at the start-up in 2009. Simultaneous coupling and vertical dispersion correction using vertical orbit bumps at the sextupoles, was studied by analyzing turn-by-turn data. This scheme was tested in SPS where the optical structure of arc cells is quite similar to the LHC. In SPS, horizontal and vertical beam positions are measured separately with single plane BPMs, thus a technique to construct "pseudo double plane BPM" is also discussed.

THPE025 **Coupling and Vertical Dispersion Correction studies for the LHC using Skew Quadrupoles and Vertical Orbit Bumps** – *G. Vanbavinckhove, M. Aiba, R. Tomas (CERN) R. Calaga (BNL)*

After the incident in the LHC in 2008, few skew quadrupoles were damaged and subsequently removed from the tunnel. This could limit the correction of local coupling in the LHC. In order to increase the flexibility in the coupling correction it has been proposed to use of vertical orbit bumps at the sextupoles is studied. Moreover a simultaneous coupling and vertical dispersion can be implemented. Various studies are presented addressing the optimal approach for the correction of the vertical dispersion and the sum and difference coupling resonances.

THPE026 **Software Package for Optics Measurement and Correction in the LHC** – *G. Vanbavinckhove, M. Aiba, R. Tomas (CERN) R. Calaga (BNL)*

A software package has been developed for the LHC on-line optics measurement and correction. This package includes several different algorithms to measure phase advance, beta functions, dispersion, coupling parameters and even some non-linear terms. A Graphical User Interface provides visualization tools to compare measurements to model predictions, fit analytical formula, localize error sources and compute and send corrections to the hardware.

THPE027 **Construction and Performance of IP Optics Tuning Knobs in the LHC** – *S.M. White, R. Tomas, G. Vanbavinckhove, W. Venturini Delsolaro (CERN)*

During the first years of operation of the LHC unknown field errors or misalignments could lead to unmatched optics and discrepancies with respect to the model. This could affect some critical parameters such as the luminosity or the lifetime. It is therefore desirable to implement tools which allow for fine tuning of the IP optics and could be used during the commissioning phase of the LHC. In this paper we report on the implementation the performances and the limitations of these commissioning tools.

THPE028 **LOCO and Alternatives - A Comparison** – *M. Böge, M. Aiba, N. Milas, A. Streun (PSI)*

The storage ring linear optics debugging code LOCO (Linear Optics from Closed Orbits) has helped to improve the performance of many ring based light sources since it allows to identify various sources of linear optics errors (except dipole errors) from a simple measurement of the closed orbit dipole corrector/beam position monitor (BPM) response matrix. In addition alternative techniques can be utilized to get a more direct measurement of the optical functions. Examples are average beta function measurements in quadrupoles from tune measurements and phase/beta measurements from multi-turn BPM data. The effective rotation of BPMs introducing significant artificial betatron coupling and spurious vertical dispersion can also be directly measured by means of closed orbit bumps. A comparison with LOCO reveals the limitations of the various techniques.

THPE029 **Studies of Insertion Device Modeling on TPS Project** – *H.C. Chao, H.-P. Chang, C.-C. Kuo, H.-J. Tsai (NSRRC)*

In this paper, the simulation techniques of insertion device (ID) were discussed. Piecewise hard-edge model was used to estimate the tune shift and changes of emittance and energy spread, while kick map model was used for particle tracking. Optical functions and tune shifts can also be derived by this model. Frequency maps as well as the beta-beating and its correction of Phase I IDs are demonstrated.

THPE030 **Double Mini-Betay Optics for TPS Storage Ring** – *M.-S. Chiu, H.-P. Chang, H.C. Chao, C.-C. Kuo, H.-J. Tsai, C.H. Yang (NSRRC)*

To evaluate the feasibility for installing two insertion devices in the long straight sections (12 m long) of the TPS storage ring, two different kinds of the double mini-betay optics (symmetric and asymmetric configurations) were proposed to fulfill this purpose. In the symmetric case a quadrupole triplet is located at the center of the long straight, while in the asymmetric case a quadrupole doublet is used. The effects on the beam dynamics, such as the dynamic aperture, injection efficiency, and lifetime, etc., are presented.

THPE031 **MATLAB-based Accelerator Physics Applications for the TPS Commissioning and Operation at NSRRC** – *F.H. Tseng, H.-P. Chang, J. Chen, P.C. Chiu, K.T. Hsu, C.-C. Kuo, H.-J. Tsai (NSRRC)*

Taiwan Photon Source (TPS) is the second synchrotron light source in Taiwan which is currently under construction at the NSRRC existing site. With a 3 GeV beam energy, low emittance, 24-DB structure in the storage ring, the TPS can generate higher brilliance and more abundant X-ray sources. TPS is in complementary to the overbooked 1.5 GeV Taiwan Light Source (TLS). The MATLAB-based accelerator physics application programs planned for the TPS commissioning and operation is a high-level software collection including the MML, AT, LOCO, etc., developed at ALS and SLAC. In this report, the testing results by employing this package to the Taiwan Light Source (TLS) are given and the simulations of the TPS virtual machine are also demonstrated.

THPE032 **Calculation of Coupled Lattice Functions from Turn-by-turn Trajectory Data in Storage Rings** – *A. Wolski, M. Korostelev, K.G. Panagiotidis (The University of Liverpool)*

BPMs capable of high resolution turn-by-turn bunch position measurements are becoming increasingly widely used in electron storage rings. Analysis of the data from a set of such BPMs following the excitation of a coherent betatron oscillation can yield useful information for tuning the optics and improving machine performance. This approach to optics measurement has the benefits that the data collection is very fast, and analysis can be local, so that application is as easy for a large ring as for a small one. Here, we describe a technique for using turn-by-turn BPM data to determine lattice functions that describe the local coupling in a storage ring; this may be helpful, for example, for achieving low vertical emittance. We discuss the principles of the technique, give some examples, and discuss possible limitations arising from BPM gain and coupling errors.

THPE033 **Beam Dynamics Studies for the First Muon Linac of the Neutrino Factory** – *C. Bontoiu, M. Aslaninejad, J.K. Pozimski (Imperial College of Science and Technology, Department of Physics) S.A. Bogacz (JLAB)*

Within the Neutrino Factory Project the muon acceleration process involves a complex chain of accelerators including a (single-pass) linac, two recirculating linacs and an FFAG. The linac consists of RF cavities and iron shielded solenoids for transverse focusing and has been previously designed relying on idealized field models. However, to predict accurately the transport and acceleration of a high emittance 30 cm wide beam with 10 % energy spread requires detailed knowledge of fringe field distributions. This article presents results of the front-to-end tracking of the muon beam through numerically simulated realistic field distributions for the shielded solenoids and the RF fields. Real and phase space evolution of the beam has been studied along the linac and the results will be presented and discussed.

THPE034 **A Gantry Design for the PAMELA Project** – *R.J.L. Fenning, A. Khan (Brunel University) T.R. Edgecock (STFC/RAL) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC)*

A gantry is required for the PAMELA project using non-scaling Fixed Field Alternating Gradient (NS-FFAG) magnets. The NS-FFAG principle offers the possibility of a gantry much smaller, lighter and cheaper than conventional designs, with the added ability to accept a wide range of fast changing energies. This paper will build on previous work to investigate a design which could be used for the PAMELA project.

THPE035 **A Non-scaling FFAG Dispersion Suppressor** – *R.J.L. Fenning, A. Khan (Brunel University) T.R. Edgecock (STFC/RAL) D.J. Kelliher, S. Machida (STFC/RAL/ASTeC)*

Purely scaling FFAG dispersion suppressors can never be perfect for all energies. This paper will show that a significant improvement may be possible if the scaling law is relaxed slightly and the multipole components are independently tuned. This will help towards the design of the gantry and transport line for the PAMELA project.

THPE036 **Tune Measurement in Non Scaling FFAG EMMA with Model Independent Analysiss** – *Y. Giboudot (Brunel University) I. Kirkman, A. Wolski (The University of Liverpool)*

The Non Scaling Fixed Field Alternating Gradient (NS-FFAG) EMMA accelerator has a purely linear lattice and thus allows important tune variation. The crossing of resonances during acceleration is a key characteristic of the beam dynamics. An accurate measurement of the tune is therefore mandatory. However commonly used measurement techniques requires the beam to perform an important number of turns in the machine. Simulations have shown that fast decoherence of the beam requires the study of another measurement technique. The model independent analysis (MIA) has been investigated. The singular value decomposition (SVD) of a matrix composed of simulated BPMs reading of various bunches trajectories gives a description of the optics function at each Beam Position Monitor. Including misalignment errors and electronic noise, an accurate value of the tune has been derived from statistical treatment repeating this process few hundreds of time.

THPE037 **Low Alpha Operation of the Diamond Storage Ring** – *I.P.S. Martin, G. Rehm, J. Rowland, C.A. Thomas (Diamond) R. Bartolini, I.P.S. Martin (JAI)*

The Diamond storage ring has been operated in low alpha mode providing short-pulse radiation for pump-probe experiments and coherent radiation for THz/IR measurements. Two lattices have been implemented, with both capable of providing a variable alpha in the range $\pm 2\text{x}10^{-5}$, down to minimum values well below $1\text{x}10^{-6}$. The second lattice additionally provides a low emittance of 4nm.rad, compared to 35nm.rad for the first lattice. An overview of operation in low alpha mode is given, along with first measurements of coherent emission at long wavelengths under a variety of conditions.

THPE038 **Low-emittance Tuning Simulations for the ILC Damping Rings** – *K.G. Panagiotidis, A. Wolski (Cockcroft Institute) K.G. Panagiotidis (The University of Liverpool)*

One of the major challenges for the International Linear Collider (ILC) damping rings is the attainment of the 2 pm vertical emittance specification. To achieve such an ultra-low vertical emittance a highly effective diagnostics and correction system is needed. However, since both BPMs and correctors have also negative impacts on the design (cost, complexity, impedance), it is important to understand how the number and locations of both these components affect the correction. In this paper we present the results of simulations for the Technical Design Phase baseline damping rings lattice (DCO4), aimed at understanding the effectiveness of orbit, dispersion, and coupling correction for different design and operation scenarios.

THPE039 **Investigation of Dipole-field Profiles for Emittance Minimization in Storage Rings** – *C.-x. Wang (ANL) Y.M. Peng,*

G. Xu (IHEP Beijing)
Nonuniform dipoles with bending field variation have been studied for reducing storage ring emittance. In our recently published minimum emittance theory [PRSTAB12, 0610^{01} (2009)], the effects of an arbitrary dipole are characterized by two parameters, i.e., the determinant of the self-correlation matrix of the dispersion-generating vector and the "c"-parameter. To have a better idea of the potentials of nonuniform dipoles, here we numerically explore the values of these two parameters for various field profiles discussed in the literature and beyond.

THPE040 **A Spin Rotator for the Compact Linear Collider** – *A. Latina, N. Solyak (Fermilab) D. Schulte (CERN)*
Polarized positron and electron beams are ideal for searching for new physics at the Compact Linear Collider (CLIC). In order to properly orient and preserve the polarization of the beam at the interaction point, the beam polarization must be manipulated by a spin rotator along the beam line. In this paper a spin rotator design for the CLIC is presented and its integration into the CLIC ring to main linac transport system is discussed.

THPE041 **Beam Dynamics Studies from Damping Rings to Main Linac End for ILC-SB2009** – *A. Latina, N. Solyak (Fermilab)*
One of the critical accelerator design and operation issues for the International Linear Collider is the preservation of the small transverse beam emittances in beam propagation from the Damping Rings to the Interaction Point. In this paper, results of beam dynamics studies in the region from the exit of the Damping Rings to the end of the Main Linac are presented. This system consists of more than 20 km of beamlines including horizontal and vertical doglegs, turnaround, spin rotator, single-stage bunch compressor and the main linac itself. Magnets misalignment, effect of coupler wakefields and RF kick, beam offsets at injection, imperfections in the diagnostics are all considered as well as possible failures of such systems. Advanced techniques of beam-based alignment to counteract the emittance degradation are presented and their effectiveness is studied.

THPE042 **Single-stage Bunch Compressor for ILC-SB2009** – *A. Latina, N. Solyak (Fermilab)*
The Project Management Design Team of the International Linear Collider has recently proposed fundamental changes to the published ILC RDR baseline with the goal of presenting a potential alternate design providing a more cost-effective solution. In this framework a new lattice for the Damping Rings has been presented, shortening the exit bunch length from the RDR value of 9 mm down to 6 mm. The shorter bunch length allowed the adoption of a simpler single-stage bunch compressor, instead of the RDR two-stage compressor. The new single-stage compressor has a compression ratio of 20 and still achieves the nominal RDR value of 0.3 mm bunch length at the Interaction Point. The new design has been optimized to generate the required compression while having a small SR emittance growth, and reduced energy spread. The new lattice and its optimization procedure are presented in this paper.

THPE043 **Demonstration of Transverse-to-longitudinal Emittance Exchange at the Fermilab Photoinjector** – *A.S. Johnson, H.T. Edwards, A.H. Lumpkin, P. Piot, J. Ruan, J.K. Santucci, Y.-E. Sun, J.C.T. Thangaraj, R. Thurman-Keup (Fermilab)*
Phase space manipulation techniques within two degrees of freedom are foreseen to enhance the performances of next generation accelerators such as high-energy physics colliders and accelerator based light sources. At the Fermilab A0 photoinjector, a proof-of-principle experiment to demonstrate the exchange of the transverse and longitudinal emittances is ongoing. The emittance exchange beamline consists of a 3.9 GHz normal conducting deflecting mode cavity flanked by two doglegs. Electron bunches with charges of 250 pC and energy of 14.3 MeV are routinely sent through the exchanger. In this paper, we report our latest results on the demonstration of emittance exchange obtained with significantly improved beam diagnostics. We also compare our experimental results with a simple numerical model and more elaborate tracking simulations.

THPE044 **Injection and Extraction Beam Line Design of ALPHA Storage Ring** – *Y.C. Jing, Y. Kim, S.-Y. Lee (IUCF)*
Beam dynamics of Injection, accumulation, and extraction including nonlinear beam spreading at the target for the ALPHA project are studied and optimized. Beam characteristics at the transport line will be measured, and experimental results will be reported.

THPE045 **Rigorous Global Optimization For Parameter Optimization** – *K. Makino, M. Berz (MSU)*
Recently developed methods for the representation of functional dependencies via Taylor model manifolds will be used to iteratively rigorously eliminate regions from the search space of a global optimization problem, resulting in a progressive pruning of the allowed search space as the optimization progresses. The end result is the rigorous determination of the single or multiple optimal solutions of the parameter optimization, regardless of their location, their number, and the starting values of optimization. The methods are particularly powerful if executed in interplay with genetic optimizers generating their new populations within the currently active unpruned space. Their current best guess provides rigorous upper bounds of the minima, which can then beneficially be used for better pruning. Examples of the method will be presented, including the determination of all operating points of desired tunes or chromaticities etc in storage ring lattices, as well as the determination of all possible configurations achieving the desired resolution in particle spectrographs.

THPE046 **CesrTA Low Emittance Tuning** – *J.P. Shanks, D. L. Rubin, D. Sagan (CLASSE)*
We are developing techniques for measuring and correcting emittance diluting optical and alignment errors in the CesrTA storage ring. Our principle measurement method is to resonantly excite the beam at all three normal mode frequencies and then to extract the amplitude and phase of each mode at all 100 beam position monitors. We reconstruct beta-functions, betatron phase advance, coupling parameters, dispersion, and BPM tilts from the data. A complete characterization including data collection and analysis can be done in a few minutes. To measure the emittance, an x-ray beam size monitor capable of measuring the size of a single bunch on a turn by turn basis provides a real time measure with a resolution on the order of a few microns. This resolution corresponds to a few pm emittance. Our ability to identify alignment and optical errors is limited by systematic measurement errors. We report on the status of our efforts to understand and eliminate systematic errors, the accuracy of our characterization of the machine optics, and our success at reducing sources of emittance dilution.

THPE047 **Lattice Calibration with Turn-by-turn BPM Data** – *X. Huang, J.J. Sebek (SLAC)*
Turn-by-turn beam position monitor (BPM) data from multiple BPMs are fitted with a tracking code to calibrate magnet strengths in similar manner as the well known LOCO code. Simulation shows that this method can be a quick and efficient way for optics calibration. The method is applicable to both linacs and ring accelerators. We also show experimental measurement of the transfer matrix with turn by turn BPM data.

THPE048 **Lattice Modeling for SPEAR3** – *X. Huang, J.A. Safranek (SLAC)*
We use measured or simulated magnetic fields for dipoles and quadrupoles to build a lattice model for SPEAR3. In a non-symplectic approach the phase space coordinate mapping on the fields is based on Runge-Kutta integration of the equation of motion. In a symplectic approach we approximate the fields with proper fringe field models. Complication of the use of rectangular gradient dipoles in SPEAR3 is considered. Results of the model is compared to measurements on the real machine.

THPE049 **Strage Rring Machine Diagnostics and Optimization with a New Nonlinear Program** – *M.J. Lee, W.J. Corbett, X. Huang, P. Lui, J. Wu (SLAC)*
The accuracy of the constructed accelerator beamlines (compared to the designed lattice) directly determines accelerator performance. Therefore, the algorithms to verify and diagnose accelerator optics have long been of interest to accelerator physicists. For example, one uses the measured orbit response matrix to determine normal and skew quadrupole gradients. With a newly developed nonlinear program*, here we report studies for SPEAR3 at Stanford Synchrotron Radiation Lightsource. The performance of the newly developed nonlinear solver is compared to that of the well-known storage ring linear optics debugging code LOCO (Linear Optics from Closed Orbits).

THPE050 **Real Beam Line Optics from a Synthetic Beam** – *R.M. Bodenstein, Y. Roblin, M.G. Tiefenback (JLAB)*
The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab can be described as a series of concatenated beamlines. Methods used

to measure the Twiss parameters in closed orbit machines are not applicable in such open ended systems. We are using properly selected sets of real orbits in the accelerator, as one would for numerical analysis. The evolution of these trajectories along the beamline models the behavior of a synthetic beam which deterministically supplements beam profile-based Twiss parameter measurements and optimizes the efficiency of beamline tuning. Examples will be presented alongside a description of the process.

THPE051 **Magnet Optical and Beam Matching Issues in a Medium Energy Beam Transport line of SNS Linac** – *J. G. Wang, Y. Zhang (ORNL)*

A Medium Energy Beam Transport line (MEBT) is employed in the SNS linac to match the beam from an RFQ to a DTL and to perform other functions. The MEBT lattice consists of fourteen electromagnetic quadrupoles. The quads have very small aspect ratios (steel length over aperture diameter), and they are densely packed in the lattice. Significant fringe fields and magnetic interference cause difficulties in beam matching. We have performed 3D simulations of the magnets, computed their optical properties, and compared their performance with what predicted by simple hard edge models. This paper reports our findings and possible solutions to the problem.

THPE052 **Advanced Numerical Modeling of Collective Final Focus for Intense Ion Beams** – *M. Dorf, R.C. Davidson, I. Kaganovich, E. Startsev (PPPL)*

This paper presents results of advanced numerical simulations demonstrating the feasibility of tight collective focusing of intense ion beams for the Neutralizing Drift Compression Experiment (NDCX-I). In the collective focusing scheme, a weak magnetic lens provides strong focusing of an intense ion beam carrying an equal amount of neutralizing electron background [S. Roberston, Phys. Rev. Lett. 48, 149 (1982)]. For instance, a solenoidal magnetic field of several hundred gauss can focus an intense neutralized ion beam within a short distance of several centimeters. The enhanced focusing is provided by a strong self-electric field, which is produced by the collective electron dynamics. The numerical simulations are performed with the LSP particle-in-cell (PIC) code, and the results of the simulations are found to be in good agreement with analytical predictions. Collective focusing limitations due to possible heating of the co-moving electrons during the transverse compression are also discussed.

THPE053 **Chromatic Beta-beating Measurements at RHIC** – *R. Calaga (BNL) M. Aiba (PSI-LRF) R. Tomas, G. Vanbavinckhove (CERN)*

Measurements of chromatic beta-beating were carried out for the first time in the RHIC accelerator during Run 2009. The analysis package developed for the LHC was used to extract the off-momentum optics for injection and top energy. Results from the beam experiments and comparison to the optics model are presented.

THPE054 **Spin Tune Dependence on Closed Orbit in RHIC** – *V. Ptitsyn, M. Bai, T. Roser (BNL)*

Polarized proton beams are accelerated in RHIC to 250 GeV energy with the help of Siberian Snakes. The pair of Siberian Snakes in each RHIC ring holds the design spin tune at 1/2 to avoid polarization loss during acceleration. However, in the presence of closed orbit errors, the actual spin tune can be shifted from the exact 1/2 value. It leads to corresponding shift of locations of higher-order ("Snake") resonances and limits available betatron tune space. The largest closed orbit effect on the spin tune comes from the horizontal orbit angle between the two snakes. During RHIC Run in 2009 dedicated measurements with polarized proton beams were taken to verify the dependence of the spin tune on the local orbits at the Snakes. The experimental results are presented along with the comparison with analytical predictions.

THPE055 **The Correction of Linear Gradient Errors using Multi-objective Genetic Algorithm** – *G. Wang, M. Bai, L. Yang (BNL)*

We explore the feasibility of using a new optimization algorithm, Multi-objective Genetic Algorithm (MOGA), to correct linear gradient errors. Precise phase advances can be measured by analyzing the turn by turn data of coherent betatron oscillation. An optimizer is then needed in order to derive the correction strengths of a group of selected quadrupoles to minimize the phase beat from the measured optics. Compared with the commonly used SVD algorithm, MOGA has a few advantages. Firstly, as

MOGA is a global optimizer, it does not require the starting point is close to the optima or the objective to be convex. Secondly, adding constraints to the objectives and the variables is much more straightforward in MOGA. Finally, as an multi-objective algorithm, MOGA has the potential to correct multiple optical functions simultaneously. This paper presents both simulation and experimental results for RHIC gradient error corrections.

THPE056 **A New Method of Fine Betatron Tune Measurement Based on Decoherence Signal Analysis** – *A. Sargsyan, G.A. Amatuni, K. Manukyan, V.M. Tsakanov (CANDLE)*

A new method of betatron tune measurement based on the analysis of transverse decoherence signal of kicked beam in storage ring is presented. The method provides the possibility of fine betatron tune measurement with accuracy better than 10^{-4}. The possibility to extract the information on the synchrotron tune and beam energy spread from the resulting signal is discussed.

THPE057 **Relaxation and Emittance Growth of a Thermal Charged-Particle Beam** – *Y. Levin, R. Pakter, T.N. Teles (IF-UFRGS)*

We present a theory*,**, which allows us to accurately calculate the distribution functions and the emittance growth of a thermal charged-particle beam after it relaxes to equilibrium. The theory can be used to obtain the fraction of particles which will evaporate from the beam to form a halo. The calculated emittance growth is found to be in excellent agreement with the simulations.

THPE058 **Relativistic Maps, Acceleration and Chaos in Magnetized Systems** – *F.B. Rizzato, R. Pakter (IF-UFRGS) M.C. Sousa, F.M. Steffens (Univ. Mackenzie)*

The standard map provides a useful tool to investigate a wide range of problems in the nonlinear dynamics of conservative systems. The interaction of charged particles and electrostatic waves is one of these problems. A peculiar characteristic of the standard map is that while one of the canonical variables is coupled to the external wave, the other canonical variable is not. This is why the map can be written in its explicit sympletic form. Our interest here is to describe what happens in relativistic magnetized systems, where the canonical variables appear indiscriminately in the coupled and in the free part of the original Hamiltonian. We construct the fully nonlinear map and show that it becomes similar to the standard map only for small amplitudes of the perturbing waves. We also show how the map parameters can be handled to generate acceleration from very low initial energies.

THPE059 **Dynamical Properties Study of Relativistic Intense Charged Particle Beams in Accelerators and/or Over-dense Plasmas** – *A.C. Piquemal (CEA)*

We investigate the evolution of intense relativistic charged particle beams when transported in accelerators and/or over-dense plasmas. It is generally admitted that in accelerators, when it is badly adapted, a beam goes progressively from a phase space limited distribution function (d.f) at the generation, to a halo profile after some distance of propagation in the machine. If we add an over-dense plasma, the problem is even more complicated because the beam can go to a Bennett-Maxwell d.f. in some situations. For this purpose, we used diagnostics from the chaos mechanics, modified to take into account time-dependent mechanisms, like acceleration or slowing-down due to collisions. With these powerful tools, properties like ergodicity, mixing and self-similarity were studied. Finally, some ideas about the evolution of the beam internal structure and the mechanisms which drive these tranformations, are proposed.

THPE060 **A Compact Ring for the ThomX-ray Source** – *A. Loulergue (SOLEIL) C. Bruni, A. Variola (LAL)*

One advantage of X-ray sources based on Compton Back Scattering (CBS) processes is that such compact machines can produce an intense flux of monochromatic X-rays. CBS results from collisions between laser pulses and relativistic electron bunches. Aiming at high X-ray flux, one possible configuration combining a low emittance linear accelerator with a compact storage ring and a high gain laser cavity has been adopted by the ThomX project. We present here the main ring lattice characteristics in terms of baseline optics, possible other tunings such as low or negative momentum compaction, and orbit correction schemes. In addition, nonlinear beam dynamics aspects including fringe field components as well as higher multipole tolerances are presented.

THPE061 **Non Linear Beam Dynamics Studies at SOLEIL using Experimental Frequency Map Analysis** – *P. Brunelle, A. Loulergue, A. Nadji, L.S. Nadolski, M.-A. Tordeux (SOLEIL)*

SOLEIL, the French 2.75 GeV high brilliance third generation synchrotron light source is delivering photons to 20 beam lines and is presently equipped with 17 insertion devices. Significant reduction of injection efficiency and beam lifetime are observed when using some undulator configurations in daily operation. Measurements on electron beam, such as beam lifetime versus RF voltage, have shown that the energy acceptance is strongly reduced by the combined non linear effects of the four U20 in-vacuum undulators and the HU640 10m long undulator used in linear vertical polarization mode. This paper will present the on and off momentum frequency map measurements that have been performed in order to investigate such effects. The reduction of the on momentum dynamic aperture in the presence of the U20 undulators is confirmed. The off momentum frequency map measurements confirm that the energy acceptance of the bare machine is very large as predicted by tracking calculations, and clearly exhibit the strong energy acceptance reduction due to undulators.

THPE062 **Tilted Sextupoles for Correction of Chromatic Aberrations in Beam Lines with Horizontal and Vertical Dispersions** – *N. Golubeva, V. Balandin, W. Decking (DESY)*

We consider a beam line, in which pure betatron oscillations are transversely uncoupled, but which has nonzero horizontal and vertical dispersions simultaneously. We show that transverse oscillations in such a beam line could be chromatically coupled if the horizontal dispersion is nonzero in the vertical bending magnets and vice versa. We also show that the ability of sextupoles to generate chromatic coupling terms depends on the relation between sextupole tilt angles and the direction of the dispersion vector at the sextupole locations. We discuss different approaches to the setup of sextupole tilt angles depending on chromatic aberrations taken for correction. As a practical application we consider the usage of tilted sextupoles in the design of the beam switchyard at the European XFEL Facility.

THPE063 **Transverse Non-Linear Beam Dynamics in the High-Energy Storage Ring HESR** – *D.M. Welsch, A. Lehrach, B. Lorentz, R. Maier, D. Prasuhn, R. Tölle (FZJ)*

The High-Energy Storage Ring (HESR) is part of the upcoming Facility for Antiproton and Ion Research (FAIR). The HESR will provide antiprotons in the momentum range from 1.5 to 15 GeV/c for the internal target experiment PANDA. The demanding requirements of PANDA in terms of beam quality and luminosity together with a limited production rate of antiprotons call for a long beam life time and a minimum of beam loss. Thus, a sufficiently large dynamic aperture of the HESR is crucial. To provide this, a chromaticity correction scheme for the HESR has been developed to reduce tune spread and thus to minimize the emittance growth caused by betatron resonances. The chromaticity correction scheme has been optimized through dynamic aperture calculations. The estimated field errors of the HESR dipole and quadrupole magnets have been included in the non-linear beam dynamics studies. The ion optical settings of the HESR have been improved using dynamic aperture calculations and frequency map analysis technique. In this presentation comprehensive beam simulations are presented and predictions of long-term stability based on short-term particle tracking and orbit diffusion discussed.

THPE064 **Electron Beam Dynamics in CERN-PSI-ELETTRA 5pi/6 Traveling Wave X-band Linear Accelerator.** – *M.M. El-Ashmawy (ELETTRA)*

The 4th Generation Light Source FERMI@ELETTRA, in construction at the ELETTRA Laboratory in Trieste, requires very short electron bunches at the entrance of the undulator chain. To linearize the longitudinal phase space before the compression process, a 4th harmonic accelerating section (12 GHz) will be installed before the first magnetic chicane. The structure, with integrated alignment monitors, is currently under development in the framework of a collaboration between CERN-PSI-ELETTRA. In this paper we will presents a full longitudinal and transversal beam dynamics of the electron beam along the X-band structure using TStep. The analysis will also consider different types of errors, related to structure machining, cell to cell misalignment, etc. Beam dynamics simulations will also be performed along the whole FERMI linac.

THPE065 **Multipoles Minimization in the DAΦNE Wigglers** – *S. Bettoni (CERN) B. Bolli, S. Ceravolo, S. Guiducci, F. Iungo, M.A. Preger, P. Raimondi, C. Sanelli, F.M. Sardone (INFN/LNF)*

The wigglers of the DAΦNE main rings have been one of the main sources of the non-linearities in the collider. A method to minimize the odd integrated multipoles around the beam trajectory (the even ones tend to vanish due to the periodicity of the device) is described. It consists in displacing the magnetic axis of each pole towards the position of the beam in such a way that the integrated odd multipoles are minimized in each half period of the wiggler. After a study, including multipolar and tracking analysis, has performed to determine the best position of the axes, the wigglers in the DAΦNE main rings have been modified accordingly. To validate this approach magnetic measurements and tests with beam by means of closed orbit bumps have been performed.

THPE066 **Simulation Study on Coherent Resonant Instability of Non-neutral Plasmas Confined in a Linear Paul Trap** – *H. Sugimoto, K. Ito, H. Okamoto (HU/AdSM) S.M. Lund (LLNL)*

Resonant instabilities of ion plasmas confined in a linear Paul trap are studied using the particle-in-cell code WARP. Transverse two-dimensional model is employed to save computing time and perform systematic investigations. Both applied and self-field forces are calculated with a boundary condition assuming a quadrupole electrode structure. A large number of simulations were carried out with rms matched plasmas to clarify characteristics of the instability caused by linear and nonlinear coherent resonances. Stop band distributions produced by the simulation runs are consistent with theoretical prediction. These results are also compared to experimental results obtained from Hiroshima University Paul trap that is developed to study beam dynamics. It is shown that the stop band distributions of both numerical and experimental results are good agreement each other. We confirmed from these results that coherent resonances are excited when one of the coherent tunes is close to a half integer.

THPE067 **Dynamic Aperture Study at the SPring-8 Storage Ring** – *M. Takao, J. Schimizu, Y. Shimosaki, K. Soutome (JASRI/SPring-8)*

The dynamic aperture is of importance for high injection efficiency and long lifetime of a storage ring. At the SPring-8 storage ring, a third generation light source facility, various improvements of the dynamic aperture were developed, e.g. the introduction of supplemental sextupole magnets at long straight sections, and the symmetry restoration of linear lattice. To understand the nonlinear dynamics limiting the aperture, the measurements were performed for the various operation conditions with the improvements. Using injection bump magnets and turn-by-turn beam position monitor system, we measured the horizontal dynamic aperture. The Fourier analysis of the oscillation of the kicked beam shows the resonance excitation influential on the dynamic aperture. The knowledge through the experiments is essential to the further improvements of the dynamic aperture of the present ring and the new storage ring design of the future SPring-8 upgrades.

THPE068 **Effects of the Field Leakage of the Slow Extraction Septum Magnets of the J-PARC Main Ring** – *A.Y. Molodozhentsev, T. Koseki, M. Tomizawa (KEK) A. Ando (J-PARC, KEK & JAEA)*

During the early J-PARC Main Ring commissioning the emittance growth at the injection energy, caused by the field leakage of the slow extraction septums, has been observed. By using the measured field data in the J-PARC Main Ring computational model we perform the analysis of the resonance excitation for the 'bare' working points around the 3rd order horizontal resonance, used for the slow extraction of the accelerated beam. The space charge effects of the low energy beam with the moderate beam power are taken into this analysis. Some possible ways to reduce the transverse emittance dilution and the particle losses during the machine operation for the 'hadron' experiments are discussed.

THPE069 **Simulation of Space Charge Effects in JPARC** – *K. Ohmi (KEK)*

Nonlinear space charge interaction in high intensity proton rings causes beam loss, which limits the performance. Simulations based on particle in cell method has been performed for JPARC-Rapid Cycle Synchrotron and Main Ring. Beam loss estimation during acceleration and resonances analysis are discussed with various simulations using dynamic and frozen models.

THPE070 **Synchro-beta Resonance Simulation using Measured Chromatic Aberrations** – *Y. Seimiya, K. Ohmi (KEK)*
Synchro-beta resonances enhance beam sizes dynamically. For accelerators aimed for high luminosity, the effect can be more serious since a difference between vertical emittance and longitudinal emittance tends to be larger. Therefore, it is necessary to estimate a tune spread of the synchro-beta resonances properly. Synchro-beta effect is caused by chromatic aberrations, which characterize how optics parameters, including tune, Twiss parameter, X-Y coupling parameter, and other parameters, depend on the momentum deviation. The chromatic aberrations are actually defined by coefficients of an optics parameter in is expansion in terms of momentum deviation. The synchro-beta resonances caused by chromatic aberrations are discussed in this conference. We use 6-dimensional symplectic map which is obtained from measured optics parameters in order to simulate beam motion precisely*.

THPE071 **Space Charge Effect for Rotation of Longitudinal Phase Space in Alpha Magnet** – *H. Hama (Tohoku University, School of Scinece) N.Y. Huang (NTHU)*
In compact linac system, alpha magnet seems to be a useful device to manipulate the longitudinal phase space. Particularly combined use with thermionic RF gun has been regarded as a convenient system for bunch compression. The alpha magnet simply acts to rotate the longitudinal phase space of the beam, besides energy selection by an aperture in it. However, by using the alpha magnet, if we like to produce high brilliant electron beam with considerable charge, space charge force has to be carefully taken into account to evaluate the beam property for not only the longitudinal but also the transverse. Since the both transverse motions and the longitudinal one are coupled with each other in the alpha magnet, it is mostly impossible to evaluate the space charge effect analytically. Meanwhile, because energies of the electrons from the thermionic RF gun are ranging from zero to the maximum, a conventional way to count Coulomb force in the rest frame may be not satisfactorily valid in numerical simulations. We will discuss space charge dominated phase spaces derived from 3-D tracking simulations* for the alpha magnet. *GPT (General Particle Tracer) and an FDTD code developed ourselves.

THPE072 **The Simulation Study of the Fringe Field Effect on a Compact Storage Ring** – *D.D. Yang, W.-H. Huang (TUB)*
In compact storage ring design, fringe field effect of the magnets can significantly influence the tune and twiss function of the ring lattice and also the beam stability of the injection. In this paper, we present the simulation study of fringe field effect on particle motion in a compact storage ring proposed for TTX light source. We likewise present the algorithm for the fringe field simulation and utilize some code to test the algorithm.

THPE073 **Experimental Study of Spurious mode in the PLS and PLS-II Storage Ring Vacuum Chamber** – *Y.D. Joo, T. Ha, C. Kim, C.D. Park, S.J. Park (PAL)*
A superconducting RF cavity is used in the storage ring of the Pohang Light Source (PLS) upgrade project (PLS-II) at Pohang Accelerator Laboratory (PAL) for increasing the electron beam current and energy from 2.5GeV/200mA to 3.0GeV/400mA. In order to meet the requirement of lower beam emittance and higher photon energies, as well as more straight sections for insertion devices, the vacuum chambers in the storage ring need to be reconstructed. To control the spurious harmonic resonances' effect to beam position monitors (BPMs) in the PLS and PLS-II storage ring vacuum chamber, the TE mode distribution in vacuum chambers has been analyzed by both numerical simulation and experiment. Based on this analysis, the proper method to control the strength of TE mode at the position of BPMs is suggested.

THPE074 **Beam Envelope Control in Heavy Ion Superconducting Drift Tube Linac** – *V.S. Dyubkov, S.M. Polozov, A.V. Samoshin (MEPhI)*
At present a number of high energy heavy ion linear accelerator projects are discussed. FRIB accelerator is under R&D in Michigan University in USA, GANIL in France etc. The RIA (AEBF) project was designed in ANL, USA some years ago*. The linac should consist of a number of ion sources,

matching system, pre-buncher and high energy sections. Using of independently phased short SC resonators with drift tubes is possible for beam acceleration and SC solenoids or quadruple can be used for focusing. The alternative phase focusing can be also useful**. The beam envelope control is one of the main problems in this linac. The method of analytically beam dynamics investigation will be discussed in the future report. The conditions of beam envelope control will be carried out by using of especially averaging method, discussed in*** initially.

THPE075 **Application of Frequency Map Analysis to Beam-Beam Effects Study in Crab Waist Collision Scheme** – *E.A. Simonov, E.B. Levichev, D.N. Shatilov (BINP SB RAS)*

We applied Frequency Map Analysis (FMA) - a method that is widely used to explore dynamics of Hamiltonian systems - to beam-beam effects study. The method turned out to be rather informative and illustrative in case of a novel Crab Waist collision approach, when "crab" focusing of colliding beams results in significant suppression of betatron coupling resonances. Application of FMA provides visible information about all the working resonances, their widths and locations in the planes of betatron tunes and betatron amplitudes, so the process of resonances suppression due to the beams crabbing is clearly seen.

THPE076 **Effect of the Phase One Insertion Devices in the ALBA Storage Ring** – *Z. Martí, G. Benedetti, D. Einfeld, M. Munoz (CELLS-ALBA Synchrotron)*

The synchrotron light source ALBA incorporates 6 insertion devices (2 Apple-II type undulators, 2 plannar in-vacuum undulators, 1 normal conducting multipole wiggler and 1 superconduction multipole wiggler) at the start of operation. The effect of the different IDs in the performance of the facility is evaluated, using several methods (kick maps, hard edge models, dynamic multipoles, ...), including a comparison of the agreement of the different models and simulation codes. According to the results, and due mainly to the influence of the superconducting wiggler, a new working point has been selected.

THPE077 **Predicted Effect of the Measured High Order Magnetic Multipole in the ALBA Storage Ring** – *M. Munoz, G. Benedetti, D. Einfeld, Z. Martí (CELLS-ALBA Synchrotron)*

The high order magnetic multipole components of all the magnets in the ALBA storage ring have been measured. Previous studies have simulated the effects of the HOMs using statistic methods. The magnets have been installed now in the tunnel, allowing for a better simulation of the future impact of the HOMs in the performance of the light source. In this paper, the effect of the high order multipoles of the dipole, quadrupole and sextupole magnets in the dynamic aperture and the Touschek lifetime are reviewed.

THPE078 **Beam Dynamics Investigation of the 10^1.28 MHz IH Structure as Injector for the HIE-ISOLDE SC Linac** – *M.A. Fraser, M. Pasini, D. Voulot (CERN) M.A. Fraser, R.M. Jones (UMAN)*

The first phase of the HIE-ISOLDE project at CERN consists of a superconducting (SC) linac upgrade in order to increase the energy of post-accelerated radioactive ion beams from 2.8 MeV/u to over 10 MeV/u (for A/q = 4.5). In preparation for the upgrade, we present beam dynamics studies of the booster section of the normal conducting (NC) REX-ISOLDE linac, focused on the longitudinal development of the beam in the 10^1.28 MHz IH cavity, employing a Combined Zero Degree Structure* (KONUS), pulsing at a high gradient of over 3 MV/m. The evolution of the transverse emittance in the superconducting linac depends critically on the injected phase space distribution of particles from the existing linac and, with a better understanding of the longitudinal beam dynamics upstream, the performance of the upgrade can be optimised. Data taken during the commissioning phase of the REX-ISOLDE linac is analysed to understand the properties of the beam in the booster and combined with beam dynamics simulations which include the realistic fields of the IH structure, determined from both simulation and perturbation measurement. The matching of the NC and SC machines is also discussed.

THPE079 **Proposal of a Relationship between Dynamic Aperture and Intensity Evolution in a Storage Ring** – *M. Giovannozzi (CERN)*

A scaling law for the time-dependence of the dynamic aperture, i.e., the region of phase space where stable motion occurs, was proposed in previous papers, about ten years ago. The use of fundamental theorems of the theory of dynamical systems allowed showing that the dynamic aperture has a logarithmic dependence on time. In this paper this result, proven by mean of numerical simulations, is used as a basis for deriving a scaling law for the intensity evolution in a storage ring. The proposed scaling law is also tested against experimental data showing a remarkable agreement.

THPE080 **Dynamic Aperture Computation for the as-built CERN Large Hadron Collider** – *M. Giovannozzi (CERN)*

During the design phase of the CERN Large Hadron Collider the dynamic aperture, i.e., the domain in phase space where stable motion occurs, was used as figure-of-merit to specify the field quality of the various classes of superconducting magnets. The programme of magnetic measurements performed within the framework of the magnets' acceptance process has produced a large amount of information available, which can be used to estimate the value of the dynamic aperture for the actual machine. In this paper the results of massive numerical simulations based on the measured field quality, both for injection and top energy configurations, are presented and discussed in detail.

THPE081 **First Results of Space Charge Simulations for the Novel Multi-turn Injection** – *M. Giovannozzi, M. George (CERN) F. Franchi (ESRF)*

Recently, a novel multi-turn injection technique was proposed. It is based on beam merging via resonance crossing. The various beamlets are successively injected and merged back by crossing a stable resonance generated by non-linear magnetic fields. Space charge is usually a crucial effect at injection in a circular machine and it could have an adverse impact on the phase space topology required for merging the various beamlets. Numerical simulations were performed to assess the stability of the merging process as a function of injected beam charge. The results are presented and discussed in this paper.

THPE082 **Higher Order Mode Analysis of the SPL Cavities** – *M. Schuh, F. Gerigk, J. Tuckmantel (CERN) M. Schuh (MPI-K) C.P. Welsch (Cockcroft Institute)*

Higher Order Modes (HOMs) can severely limit the operation of superconducting cavities in a linac with high beam current, high duty factor and complex pulse structure. The full HOM spectrum has to be analyzed in order to identify potentially dangerous modes already during the design phase and to define their damping requirements. For this purpose a dedicated beam simulation code focused on beam-HOM interaction was developed, taking into account important effects like the HOM frequency spread, beam input jitter, different chopping patterns, as well as klystron and alignment errors. Here this code is used to investigate in detail the HOM properties of the cavities foreseen in the Superconducting Proton Linac (SPL) at CERN and their potential to drive beam instabilities. A special focus is set to HOM excitation by chopped pulses with high repetition rate and on the influence of HOMs on recirculating electron beams in the high-energy part of the SPL. Finally, the HOM characteristics of similar linac designs are presented and compared to the SPL.

THPE083 **Signal Quality of the LHC AC Dipoles and its Impact on Beam Dynamics** – *R. Miyamoto (BNL) M. Cattin, J. Serrano, R. Tomas (CERN)*

The adiabaticity of the AC dipole might be compromised by noise or unwanted frequency components in its signal. An effort has been put to characterize and optimize the signal quality of the LHC AC dipoles. The measured signal is used in realistic simulations in order to evaluate its impact on beam dynamics and to ultimately establish safe margins for the operation of the LHC AC dipoles.

THPE084 **Impact of Filling Patterns in Bunch Length and Lifetime at the SLS** – *N. Milas, L. Stingelin (PSI)*

The filling pattern can have a big impact in the effective bunch lengthening of a passive 3rd harmonic system and as a consequence in the Touschek component of the beam lifetime. Using a longitudinal dynamics tracking code, in which the effects of the accelerating system and the 3rd harmonic system are taken into account, we can calculate the synchronous phase drift caused by the transient beam-loading and thus the effective bunch increase for several different filling patterns. In this paper we present a comparison between simulation and measurements for the SLS.

THPE085 **Applicability of Panofsky-Wenzel Theorem** – *A. Opanasenko (NSC/KIPT)*

In a 1956 article* Panofsky and Wenzel derived the relation for the net transverse kick experienced by a fast charge particle crossing a closed cavity excited in a single rf mode. Later on this relation, usually referred to the Panofsky-Wenzel theorem, was generalized for cavity containing wake field induced by a driving charge. This theorem has played very important role in the accelerator physics. One well-known conclusion of this paper was that in a TE mode the deflecting impulse of the electric field always cancels the impulse of the magnetic fields. In our presentation we more exactly rederive Panofsky and Wenzel's result and obtain correction terms to the transverse kick. We show that in a TE mode the net transverse kick does not zero but is determined by a ponderomotive force. Using the given approach we find correction terms to wake potentials which are inversely proportional to the relativistic factor. Practical implications of our results are discussed.

THPE086 **Non-Linear Parametric Effects and Beam Collapse at Motion of Accelerated Particles in Transversal Focusing Fields** – *M.V. Vysotskyy, V.I. Vysotskii (National Taras Shevchenko University of Kyiv, Radiophysical Faculty)*

The new type of oriental motion, so called parametric channeling of accelerated charged particles with internal energy structure in crystals or transversal focusing fields (TFF) is studied [*,**]. Peculiarities of this motion are connected with parametric coupling of transversal oscillations of fast particle in TFF (e.g. averaged field of crystal plains) and oscillations caused by internal processes in particle. Parametric channeling is investigated for small charged mesomolecules, atomic ions and nuclei with internal resonances, relativistic electrons. It was shown that such parametric coupling leads to the possibility of beam cooling and "collapse": critical decrease of transversal oscillations of moving structured ion in TFF due to energy transfer from this ion to its own internal electron (for atomic ion) or its internal low energy nuclear state (for fast nuclei). Also it was shown that parametric beam cooling with the decrease of transversal energy can take place at axial relativistic electron beams channeling. This process is caused by the parametric coupling between quantized channeling states and electron spin states in effective magnetic field in moving system.

THPE087 **Calibration of the Nonlinear Accelerator Model at Diamond** – *R. Bartolini, G. Rehm, J. Rowland (Diamond) P. Kuske (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH) I.P.S. Martin (JAI) F. Schmidt (CERN)*

The correct implementation of the nonlinear ring model is crucial to achieve the top performance of a synchrotron light source. Several dynamics quantities can be used to compare the real machine with the model and eventually to correct the accelerator. Most of these methods are based on the analysis of turn-by-turn data of excited betatron oscillations. We present the experimental results of the campaign of measurements carried out at the Diamond. A combination of Frequency Map Analysis and resonant driving terms measurements has allowed a precise calibration of the nonlinear model capable of reproducing and then correcting the nonlinear beam dynamics in the storage ring.

THPE088 **Beam Dynamics Effect of Insertion Devices at Diamond** – *B. Singh, R.T. Fielder, J. Rowland (Diamond) R. Bartolini, I.P.S. Martin (JAI)*

Diamond operates with 10 in-vacuum insertion devices at 5 mm gap, two Apple-II, two superconducting and two normal conducting wigglers. We report here the correction of the linear optics of wigglers and measurements of nonlinear effects such as dynamic aperture and frequency maps and their impacts on injection efficiency, lifetime and loss distribution in operation of the storage ring.

THPE089 **Uses of Turn-by-turn Data from FPGA-based BPMs during Operation at the APS Storage** – *V. Sajaev (ANL)*

APS has started a program of upgrading old BPM electronics to new FPGA-based devices. We present here the use of such BPMs for online measurement of betatron tunes during topup operation. In topup injection, the stored beam is kicked and experiences betatron oscillations that can be used for online monitoring of the betatron tunes. Also, due to kicker waveform time dependence, different bunches experience kicks of different amplitude. By collecting data from different bunches one can also monitor tune shift with amplitude. In the case of APS, the matter is complicated by the very fast decoherence of oscillations. We describe methods used to derive tunes and present results of online monitoring.

THPE090 **Optimized Sextupole Configurations for Sextupole Magnet Failure in Topup Operation at APS** – *V. Sajaev (ANL)*
Recently at APS we had a situation when one sextupole power supply failed during topup operation (all magnets at APS have separate power supplies). The beam was not lost but the lifetime decreased significantly to the point where it was hard for the injectors to provide enough charge for topup injections. Luckily, the power supply was able to reset quickly, and the operation was not compromised. One can anticipate similar failures in the future when the power supply would not be possible to reset. In such a case, the APS would need to operate with lower lifetime until the next intervention period. Here we present the optimization of the sextupole distribution in the vicinity of the failed sextupole that allows us to partially recover the lifetime. Genetic optimization algorithm that involves simultaneous optimization of the dynamic and energy apertures was used*. Experimental tests are also presented.

THPE091 **Simultaneous Measurement of all Sextupole Offsets using the Response Matrix Fit** – *V. Sajaev, A. Xiao (ANL)*
APS linear model is defined by the quadrupole and skew quadrupole errors that are determined using the response matrix fit. What was missing until now were the sextupole offsets relative to the beam orbit. At APS the orbit is routinely steered according to user requests, and at some locations the steering has accumulated to rather large values. That is why the usual sextupole changes that are performed during operation mode switches lead to optics and coupling changes. Knowledge of the sextupole offsets would allow us to predict and control those changes. There are a number of ways to measure sextupole offsets but most of them utilize element by element approach. This would take very long time for the 280 sextupoles at APS. Here we describe a method that determines the beam offsets of all sextupoles based on fitted values of local optics and coupling changes at each sextupole. We perform response matrix measurement, fit several lattices with different sextupoles, and derive the sextupole offsets. The results are included in the linear model of the APS storage ring.

THPE092 **Mapping of the Incoherent Synchrotron Tune of Beam Particles in a Barrier Bucket** – *C.M. Bhat (Fermilab)*
The beam particles in a rf bucket with Vrf=0 for an extended region in the center have a large synchrotron spread with fs=0 for particles with dp/p=0 and they increase non-linearly to the bucket boundary. Mapping the synchrotron tune of the beam particles in such a bucket is not a trivial task. Recently developed technique of longitudinal phase space coating* has enabled us to measure the incoherent synchrotron tune of the particles as function of dp/p. In this paper we present the results of first measurements for the beam particles in the Fermilab Recycler rf barrier buckets and compare it with longitudinal beam dynamics simulations.

THPE093 **Crab Cavity in LHC** – *H.J. Kim, T. Sen (Fermilab)*
Beams collide with a crossing angle at the interaction points in the LHC in order to reduce the effects of parasitic collisions which induce emittance growth and beam lifetime deterioration. The crossing angle reduces the luminosity due to a smaller geometrical overlap . A crab cavity is one of the most promising ways to compensate the crossing angle and to realize effective head-on collisions. Moreover, the crab crossing mitigates the synchro-betatron resonances due to the crossing angle. In this paper, we investigate the effects of crab crossing on beam dynamics and beam life time with crab cavities placed locally in IR5 of the LHC.

THPE094 **A Search for Integrable Four-dimensional Nonlinear Accelerator Lattices** – *S. Nagaitsev (Fermilab) V.V. Danilov (ORNL)*
We model an accelerator lattice by a mapping consisting of 4x4 symplectic matrices and thin non-linear lenses of special properties. The lenses are chosen such that they can be created by realistic magnetic fields in vacuum as well as to keep the mapping symplectic. Our goal is to find such non-linear lenses that can eliminate chaotic trajectories in a large volume of the beam phase-space while also having large betatron tune spreads. In this report we present 3 families of integrable nonlinear accelerator lattices with stable nonlinear motion, which can be solved in terms of separable variables.

THPE095 **Quantitative Lattice Optimization using Frequency Map Analysis** – *C. Steier, W. Wan (LBNL)*
Frequency Map Analysis has been used successfully to study accelerator lattices for many years, both in simulations and in experiment. We will present a new application to use the quantitative results of frequency maps (namely the diffusion rates) to optimize the nonlinear properties of lattices. The technique is fairly simple but powerful and has already been used to optimize lattices for example for the NLC and ILC damping rings, as well as the ALS lattice upgrade.

THPE096 **Independent Component Analysis for Nonlienar Beam Measurements** – *X. Pang, S.-Y. Lee (IUCF)*
The independent component analysis (ICA) has been used for data mining in many branches of sciences. In beam physics, the ICA can be applied to analyze turn-by-turn beam position monitor (BPM) data of beam motion. The narrowband filtering of ICA provides us an accurate method to identify and extract information on the linear betatron and synchrotron motion, effects of wake fields, nonlinear elements in accelerators, and other source of perturbations. Numerical simulations are used to demonstrate the ability to obtain sextupole strengths at high precision. The method can be extended to other higher order multiples.

THPE097 **Charged-Particle Dynamics in an Adiabatic Thermal Beam Equilibrium** – *H. Wei, C. Chen (MIT/PSFC)*
The dynamics of charged particles in a recently-discovered adiabatic thermal beam equilibrium* are studied. In particular, test particle motion is analyzed numerically, assuming the beam equilibrium fields are in a periodic solenoidal focusing channel. Poincare surface-of-section maps are generated to examine the behavior of the test particles in phase space such as nonlinear resonances and chaotic regions. Comparisons are made between the adiabatic thermal and rigid-rotor Vlasov beam equilibria**.

THPE098 **Recent Advances in High-Order Map Methods** – *M. Berz, K. Makino (MSU)*
We present methods to not only compute transfer maps, but also rigorously guaranteed bounds for the errors of the expansion. The methods have various interesting applications that will be presented. First, they allow the rigorous detection of chaos by studying crossing properties of stable and unstable manifolds of high-period fixed points, all of which can be found rigorously with the new tools. Second, they allow the construction of symplectic representations with known and guaranteed upper bound of symplectification adjustment, something other symplectification methods can not achieve. Third, they allow the treatment of systems that have such large acceptance that individual maps have poor convergence properties, which arise in the study of FFAGs and muon cooling channels. The availability of rigorous error estimates allow automatic domain decomposition schemes that cover the entire system with a manifold of individual maps, allowing for the effective use of maps for analysis but retaining the flexibility of treatment of arbitrary systems.

THPE099 **RHIC Proton Beam Lifetimes Increase with 10- and 12-pole Correctors** – *W. Fischer, J. Beebe-Wang, Y. Luo, S. Nemesure (BNL) L.K. Rajulapati (SBU)*
The RHIC beam lifetime in polarized proton operation is dominated by the beam-beam effect, parameter modulations, and nonlinear magnet errors in the interaction region magnets. Sextupole and skew sextupole errors have been corrected deterministically for a number of years based on tune shift measurements with orbit bumps in the triplets. During the most recent polarized proton run 10- and 12-pole correctors were set through an iterative procedure, and used for the first time operationally in one of the beams. We report on the procedure to set these high-order multipole correctors and estimate their effect on the integrated luminosity.

THPE100 **Bunch Length Effects in the Beam-beam Compensation with an Electron Lens** – *W. Fischer, Y. Luo, C. Montag (BNL)*
Electron lenses for the head-on beam-beam compensation are under construction at the Relativistic Heavy Ion Collider. The bunch length is of the same order as the beta-function at the interaction point, and a proton passing through another proton bunch experiences a substantial phase shift which modifies the beam-beam interaction. We review the effect of the bunch length in the single pass beam-beam interaction, apply the same analysis to a proton passing through a long electron lens, and study the single pass beam-beam compensation with long bunches.

THPE101 **Extraction of Symplectic Transformation Map from 3D Magnetic Field Map** – *Y. Li, M. Rehak, L. Yang (BNL)*
Precise magnet models are needed for lattice calculation and optimization in the modern storage rings. But the longitudinal dependent magnetic field, like the magnet's fringe field, special elements (like damping wigglers) and the interference of adjacent magnets, cause it to be difficult to use traditional hard edge models to describe magnet's focusing characteristics properly. An algorithm based on differential algebra (DA) and Lie algebra is developed to extract symplectic transformation map up to certain order directly from 3D magnetic field map.

THPE102 **6-D Weak-strong Simulation of Head-on Beam-beam Compensation in the RHIC** – *Y. Luo, W. Fischer (BNL)*
An electron lens was proposed to compensate the head-on beam-beam effect for polarized proton operations in the Relativistic Heady Ion Collider (RHIC). With head-on beam-beam compensation, we plan to reduce the beam-beam tune footprint and increase the beam-beam parameter to increase the luminosity. Here we carry out 6-D weak-strong beam-beam simulations to study the stability of proton particles and the proton beam lifetime in the presence of head-on beam-beam compensation. The effects and tolerances of the errors and noises in the compensation are also calculated.

THPE103 **Sorting Chromatic Sectupoles for Second Order Chromaticity Correction** – *Y. Luo, W. Fischer, G. Robert-Demolaize, S. Tepikian, D. Trbojevic (BNL)*
In this article, based on the contributions of the chromatic sextupole families to the half-integer resonance driving terms, we discuss how to sort the chromatic sextupoles in the arcs of the Relativistic Heavy Ion Collider (RHIC) to easily and effectively correct the second order chromaticities. We propose an online method with 4 knobs or 4 pairs of chromatic sextupole families to correct second order chromaticities. Numerical simulations support this method and shows that it improves the balance of correction strengths among the sextupole families and avoids reversal of sextupole polarities, as well as yielding larger dynamic apertures for the 2009 RHIC 100 GeV polarized proton run.

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Bosco, A.	MOPE069
Boscolo, M.	TUOARA03, TUPEB003, TUPEB006
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Boucher, S.	*MOPEA046*, *MOPEA047*, TUPEA036, THPEA051, *THPD065*
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Bressi, E. MOPEA003, MOPEB004, THPEB007
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Itoga, T.	WEPEB060, WEPEB061, *WEPEB062*, WEPEB063, WEPEB068
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Ivanenko, I.A.	*THPE012*
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Iwamoto, K.	TUPEA023
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Iwasaki, Y.	MOPEB038, WEPEA040, WEPD031
Iwashita, T.	*MOPEC051*, MOPEC052
Iwashita, Y.	MOPEB013, MOPEB067, MOPEC086, WEPEC032, WEPEC033, WEPEC035, *WEPE017*, WEPE044
Iwata, Y.	MOPEA007, *MOPEA008*, MOPEA009, WEPD055
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Kanter, E.P.	TUPE066
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Kapin, V.V.	TUPD029
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Karadeniz, D.	TUPEB065
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Karantzoulis, E.	TUPE016, *WEPEA028*
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Kawakubo, T.	MOPEC050, MOPEC052, MOPEC053
Kawamata, H.	MOPD044, MOPEC039
Kawamoto, T.	TUPEB009
Kawamura, M.	TUPEA046
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Kawase, M.	*MOPEA060*
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Ke, M.	THPEB075
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Kempkes, M.K. *WEPD096*, *WEPD097*
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Kharakh, D. TUPEB003
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Khursheed, M. TUPEC005
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Kil, J.-K.	MOPEA018, *MOPEA069*, MOPEA070
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Kim, D.E.	*MOPEB014*, WEPEA052, WEPD036
Kim, D.G.	*MOPEA019*
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Kim, G.	THPEC007
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Kubosaki, M.	THPEB047
Kubota, C.	MOPEC067, TUPEA046
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Kugeler, O.	TUPEC002, *WEPEC004*
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Kumagai, K.	THOBRA02, MOPD046
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Kuno, Y.	MOPEB065, WEPE044, WEPE056, THPEC030
Kuo, C.-C.	*MOOCMH01*, WEPEA059, THPE029, THPE030, THPE031
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Kuo, C.Y.	MOPEB020, *MOPEB022*, TUPEC033, WEPD043
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O'hira, S.	MOPD042, MOPEC056
Ohkuma, H.	THOBRA02, WEPEA032
Ohmi, K.	*TUPEB012*, *TUPEB013*, TUPEB014, *TUPEB015*, TUPEB017, TUPEB018, TUPEB006, TUPEB016, WEPE097, *THPE069*, THPE070
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Ohnishi, Y.	MOPEB034, TUPEB010, *TUPEB016*, TUPEB019, TUPD008
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Tsai, H.-J.	MOOCMH01, *WEPEA059*, THPE029, THPE030, THPE031
Tsai, K.L.	*TUPEC034*, *WEPD094*
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Tsumori, K.	MOPE018
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