FACET
The New User Facility at SLAC

Christine Clarke
7th September 2011

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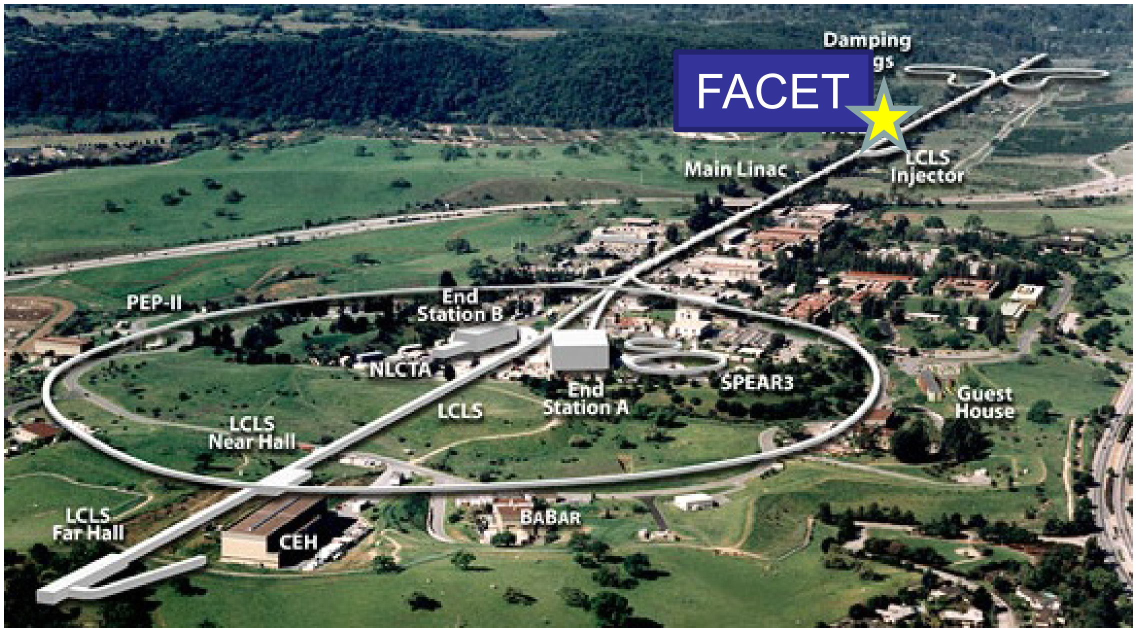
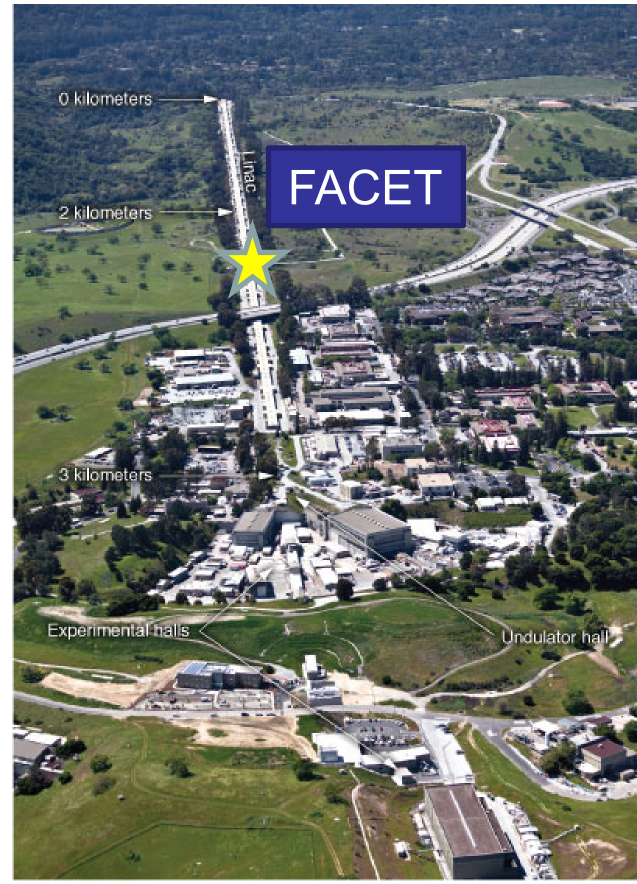
Introduction

- Facility for Advanced Accelerator Experimental Tests
- Goal to study plasma acceleration (short, intense electron and positron bunches)
- Unique facility for other experiments:
  - Dielectric/Metallic wakefield structures
  - Instrumentation
  - Materials in high E fields
  - THz light source

Location

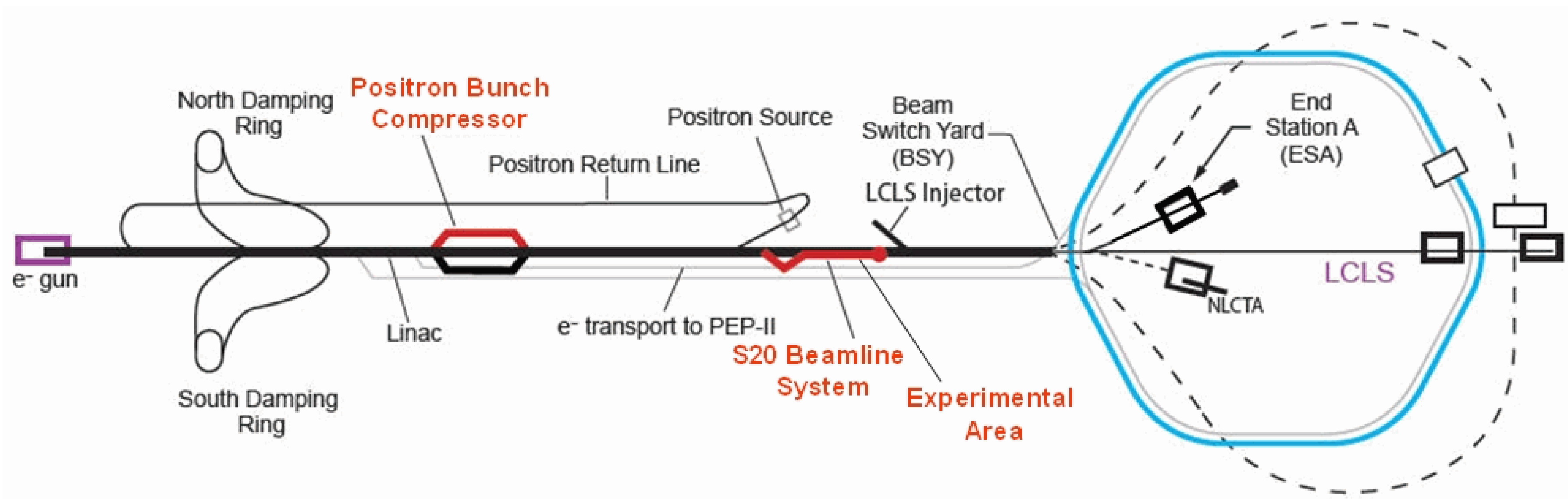
- SLAC National Accelerator Laboratory





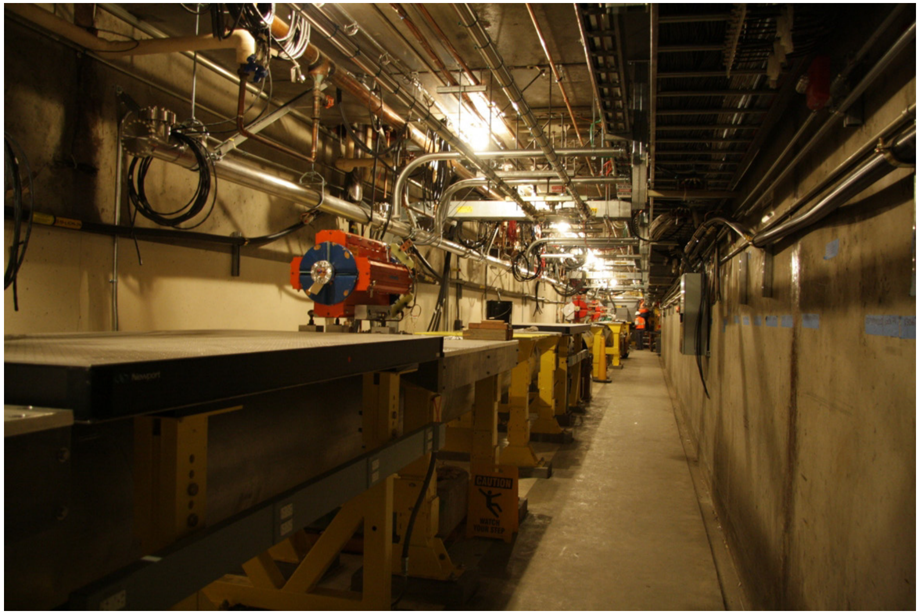
SLAC Site

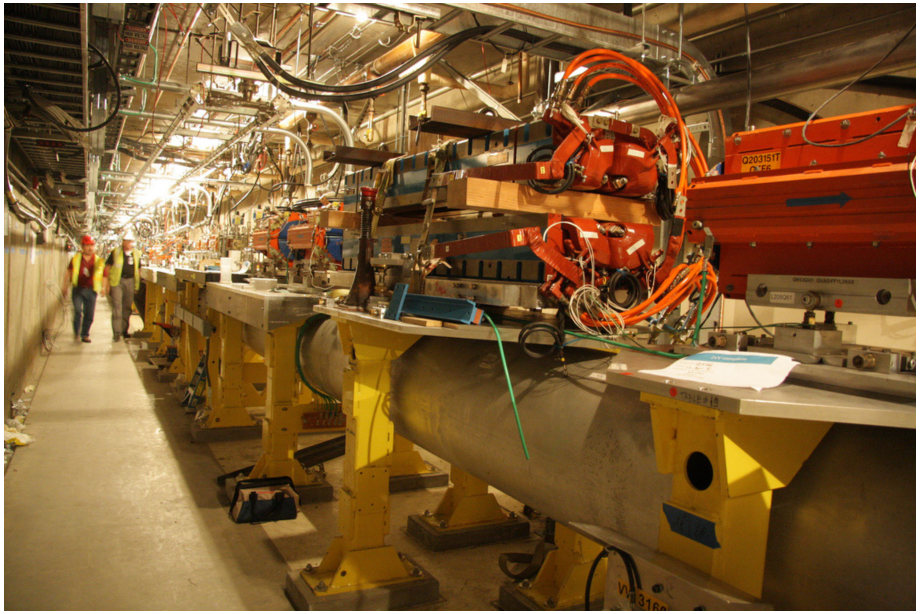
- LCLS uses final third of SLAC linac
- FACET uses the first two-thirds
- New for FACET 2011: S20 Beamline (chicane and final focus) and experimental area



FACET Installation

- FACET project construction completed May 2011
- Next February, we will install the positron bunch compressor in sector 10 to allow to run with compressed positrons
- Currently undergoing electron beam commissioning





Beam Parameters (design)

- At nominal "IP" i.e. where the beam is focused:

Parameter	Value at IP
Energy (GeV)	23 GeV
RMS Energy Spread (%)	1.5
Charge per pulse	2e10 (3.2 nC)
Bunch length (um)	15-40
Beam size (um)	14 x 6
Repetition Rate (Hz)	1-30
Particle	Electrons and positrons

Beam Parameters (design)

- At nominal "IP" i.e. where the beam is focused, and at other locations:

Parameter	Value at IP	THz Table	Dump Table
Energy (GeV)	23 GeV		
RMS Energy Spread (%)	1.5		
Charge per pulse	2e10 (3.2 nC)		
Bunch length (um)	15-40		
Beam size (um)	14 x 6	1100 x 7	55 x 25
Repetition Rate (Hz)	1-30		
Particle	Electrons and positrons		

Beam Parameters (design)

- At nominal "IP" i.e. where the beam is focused:

Parameter	Value at IP	Commissioning so far
Energy (GeV)	23 GeV	✓ (~20 GeV)
RMS Energy Spread (%)	1.5	3
Charge per pulse	2e10 (3.2 nC)	✓
Bunch length (um)	15-40	25
Beam size (um)	14 x 6	30 x 30
Repetition Rate (Hz)	1-30	1-10
Particle	Electrons and positrons	Electrons only

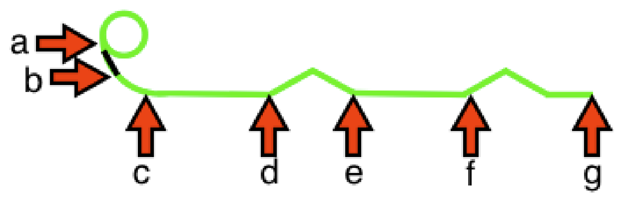
Commissioning still continuing…

Opportunities for Study

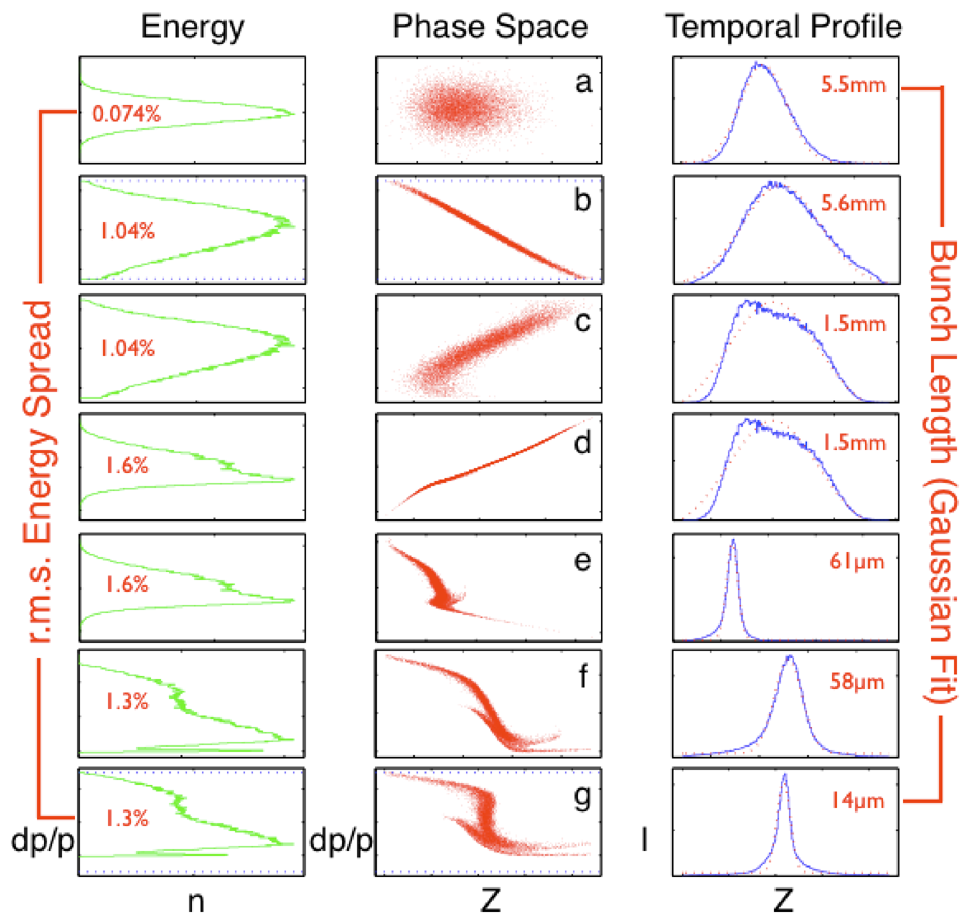
- FACET was designed with novel approaches to acceleration in mind
  - Beam parameters chosen for high power beams
  - Create two bunches (drive and witness)
  - Specialised diagnostics
- Unique facility for testing diagnostics for future accelerators
- High EM fields for materials studies
- Bright source of THz radiation for materials studies

Bunch Compression

- Three-stage bunch compression:

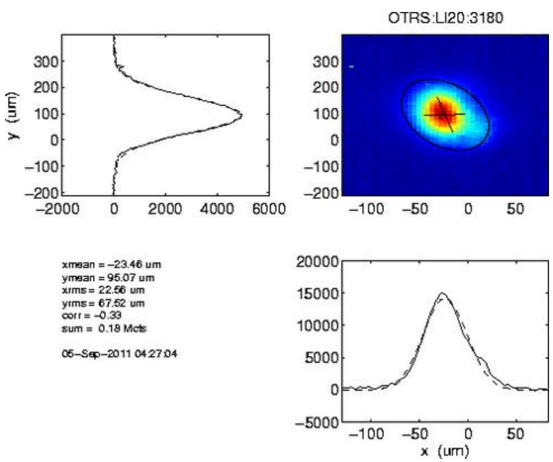


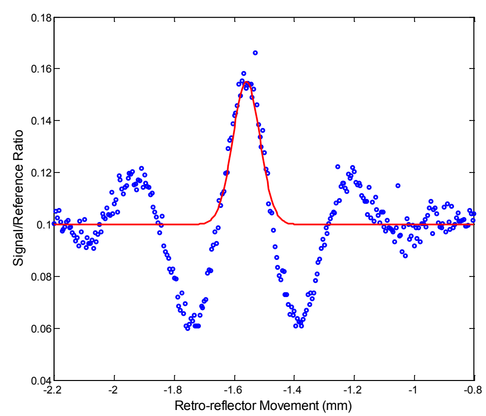
1. On entering linac from damping rings
2. Magnetic chicane in S10
3. Magnetic chicane in S20

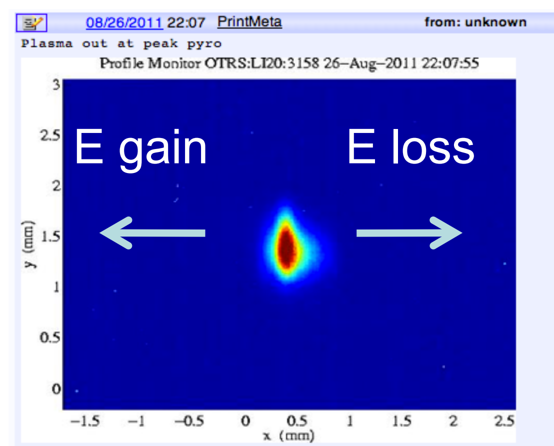


Diagnostics

- Position and beam spot size
  - BPMs
  - Wirescanner
  - OTR screens (left image)
- Charge
  - Toroids
- Energy
  - YAG crystal for x-ray detection
  - Cherenkov radiation from an air-gap (right image)
- Bunch Length
  - CTR Pyro-detector
  - Michelson Interferometer (centre)

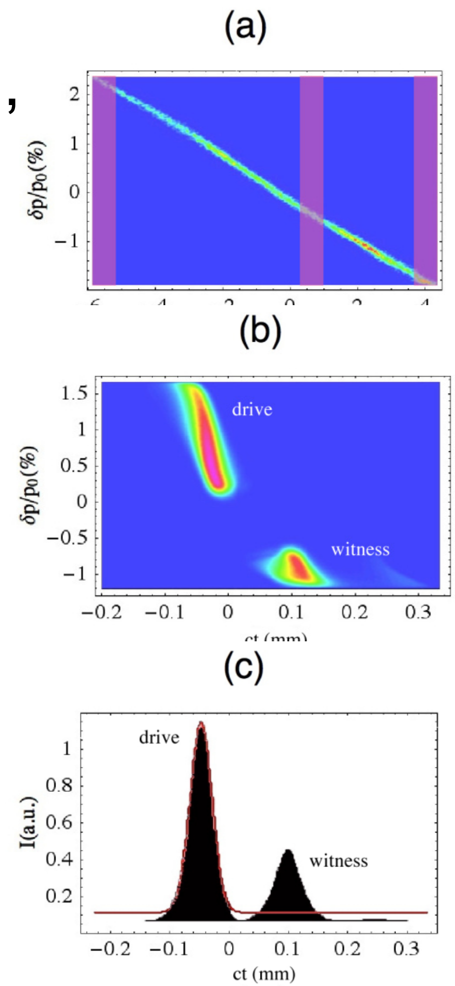


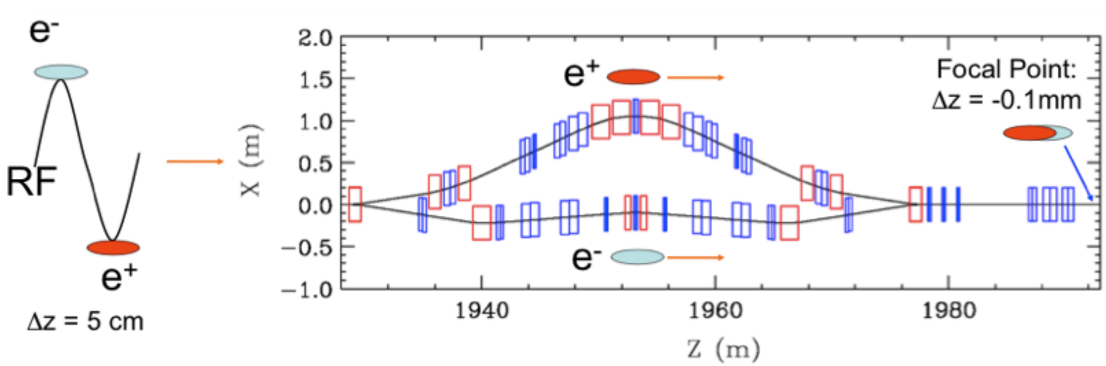




Two bunch production

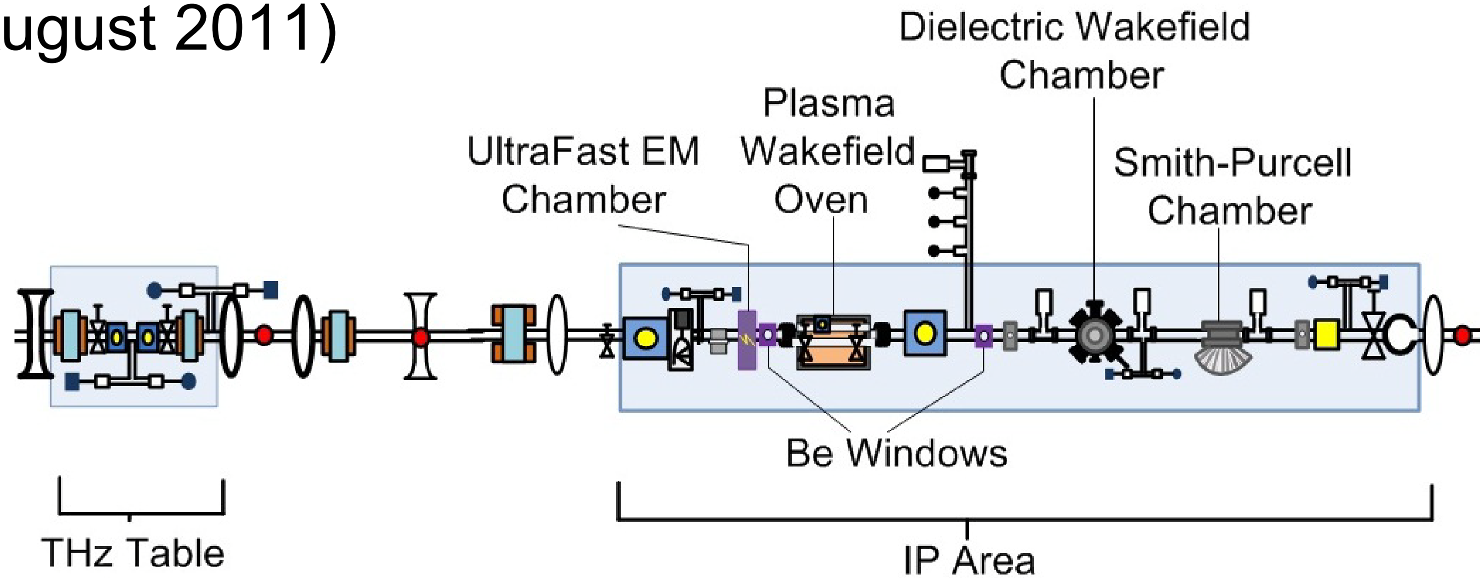
- Notch Collimator – to be installed late 2011, this can split a single bunch into two bunches ~100um separation
- Sailboat Chicane – proposed future installation to allow for one electron bunch and one positron bunch separated by ~100um





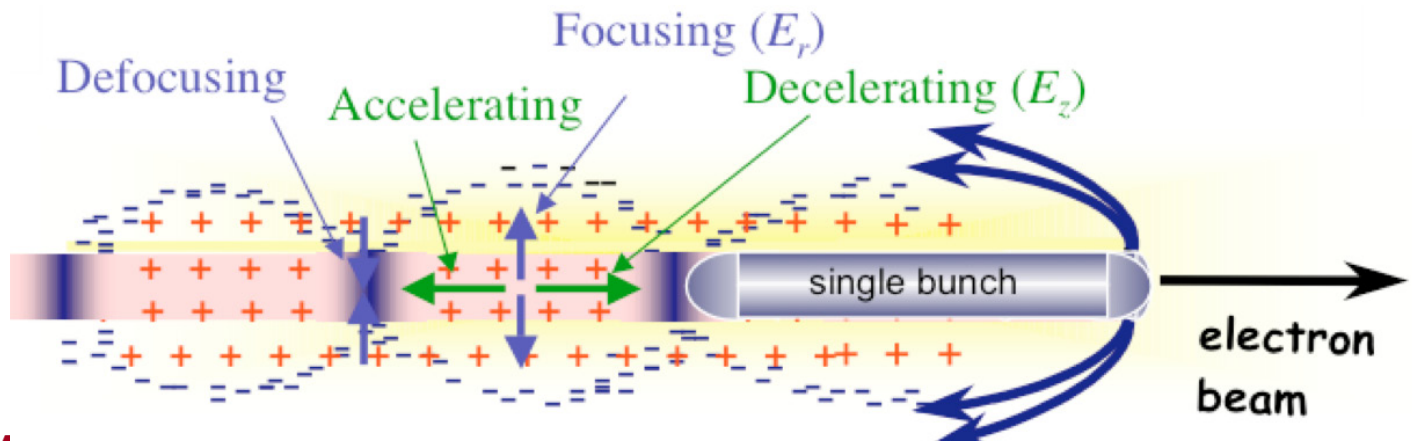
Current Experiments

- 9 proposals for the first FACET run 2012 submitted (in October 2010)
- Peer-review process selected 6 to run with a 7th as a pilot study
- 5 experiments invited for User-Aided Commissioning (August 2011)



Plasma Wakefield Acceleration

- Continuation of very successful experiments at SLAC
  - Single electron bunch in field ionized lithium plasma
  - Single bunch in field ionized caesium plasma
  - Use Notch Collimator
  - Two electron bunches (drive and witness) in field ionized caesium plasma
- Second stage: pre-ionized plasma, positrons and electrons



E-200

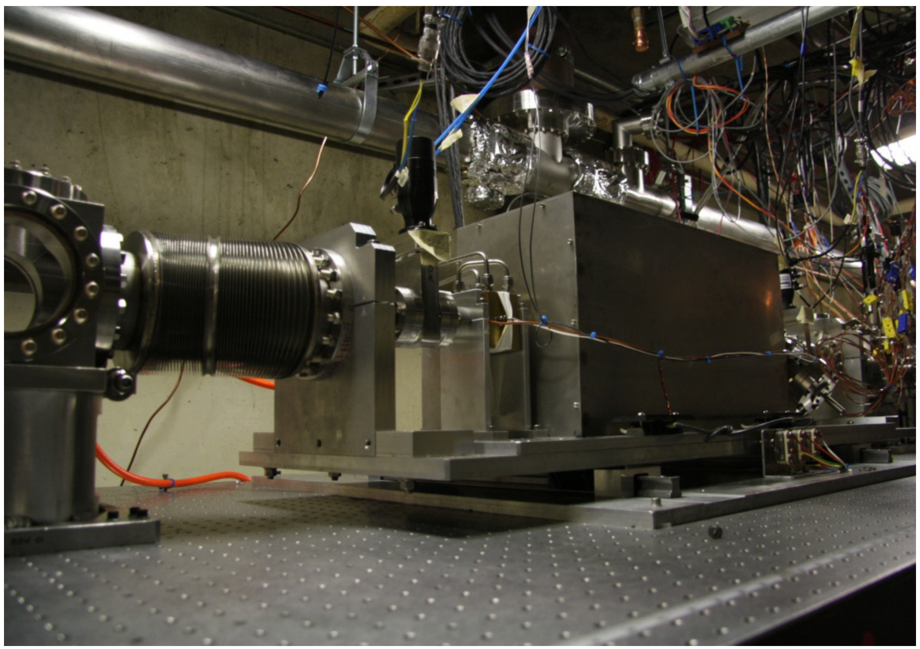
- Multi-GeV Plasma Wakefield Acceleration Experiments
  - Mark Hogan, Joel Frederico, Carsten Hast, Selina Li, Michael Litos, Dieter Walz (SLAC)
  - Chan Joshi, Warren Mori, Weiming An, Chris Clayton, Wei Lu, Ken Marsh, Sergei Tochitsky (UCLA)
  - Patric Muggli (Max Planck)
  - Stephen Pinkerton, Y Shi (USC)

1 Abstract

In the past seven years plasma wakefield accelerators have emerged as a leading advanced accelerator scheme due to progress on a number of fronts (see [1, 2]). The SLAC/UCLA/USC E-162/164/167 collaboration has been arguably the lead group pioneering this research. Accomplishments include the first demonstration that controlled beam propagation and high-gradient acceleration could be extended from the mm scale to meter scales (E-157 and E-162), the first acceleration of positrons (E-162) in a plasma, the first acceleration of electrons by more than one GeV (E-164X) and most recently doubling the energy of some of the electrons from 42 to 85 GeV in just 85cm (E-167). This tremendous progress was enabled by the unique capabilities of the SLAC linac to deliver high energy, high charge, short

Plasma Wakefield Acceleration

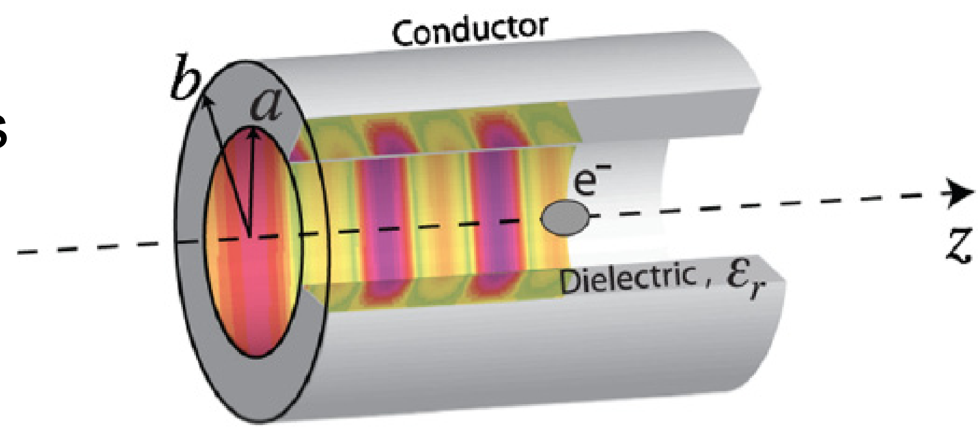
- Lithium Oven was installed in August 2011
- Experiment is fully checked-out and ready for beam



Dielectric Wakefield Acceleration

- GV/m class DWA for use in linear colliders and future light sources
- High gradient regime at FACET! Not available elsewhere!
- Will study parametric breakdown and lifetime effects
- Vary structures (dimensions, materials etc.)

- Use drive and witness bunches to observe acceleration with FACET's two-bunch option
- Next year, use positrons



E-201

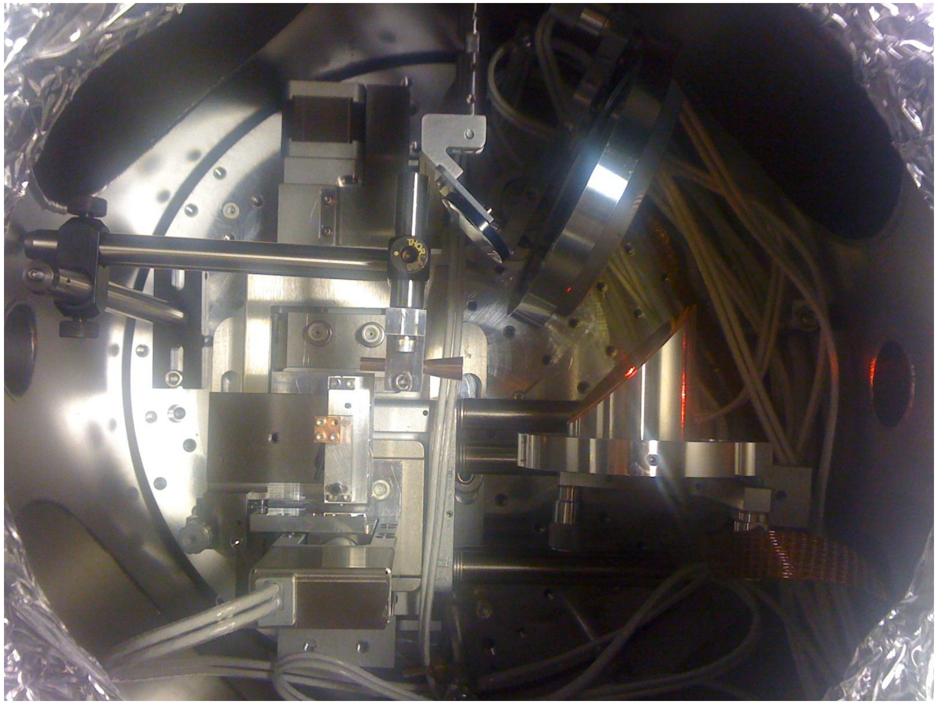
- E-201 Wakefield Acceleration in Dielectric Structures
  - J. B. Rosenzweig, D. Stratakis, G. Travish, O. Williams, G. Andonian, H. Badakov, S. Chen, P. Niknejadi, B. D. O'Shea, X.Wei , J. Zhou (UCLA)
  - A. Kanareykin (Euclid)
  - S. Boucher (RadiaBeam Technologies)
  - A. Cook (MIT)
  - R.J. England, M. J. Hogan, D. Walz
  - P. Muggli (Max Planck)
  - S. Antipov, M. Conde, W. Gai, R. Yoder (Argonne)

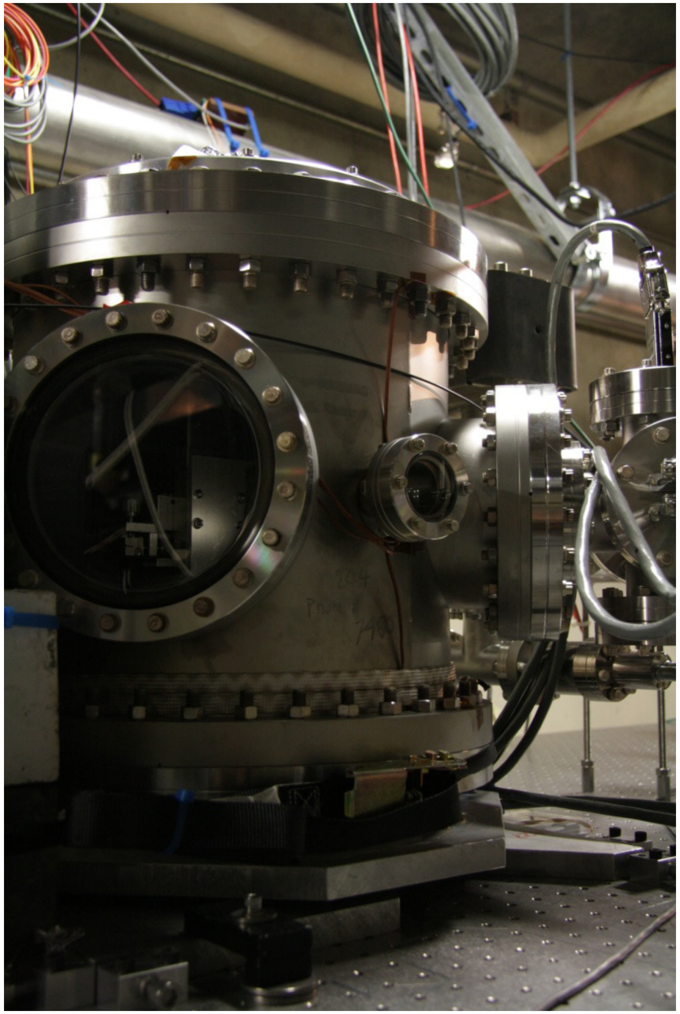
Abstract

This proposal seeks to build upon the path-breaking recent work by this collaboration at the SLAC Final Focus Test Beam (FFTB), the UCLA Neptune Lab, and the BNL Accelerator Test Facility (ATF) on high frequency — mm-THz regime — GV/m-class dielectric wakefield acceleration DWA. The first step in this path has been taken in the FFTB, where >5 GV/m longitudinal field breakdown threshold was observed in DWA experiments in a test-beam run (T481). This was followed by a firset demonstration of coherent Cerenkov radiation production at Neptune, a measurement pointing out the unique role of the DWA scheme in creating new THz sources having a myriad of cutting edge applications. In the past year, there has been increasing emphasis on development of pulse-train driven DWA, as a way to achieve the efficiency needed for linear colliders. This initiative has led to an initial

Facility Provided Sample Chamber

- Vacuum compatible stages for alignment of samples with beam
- Supports samples ~cm





Facility Provided Sample Chamber

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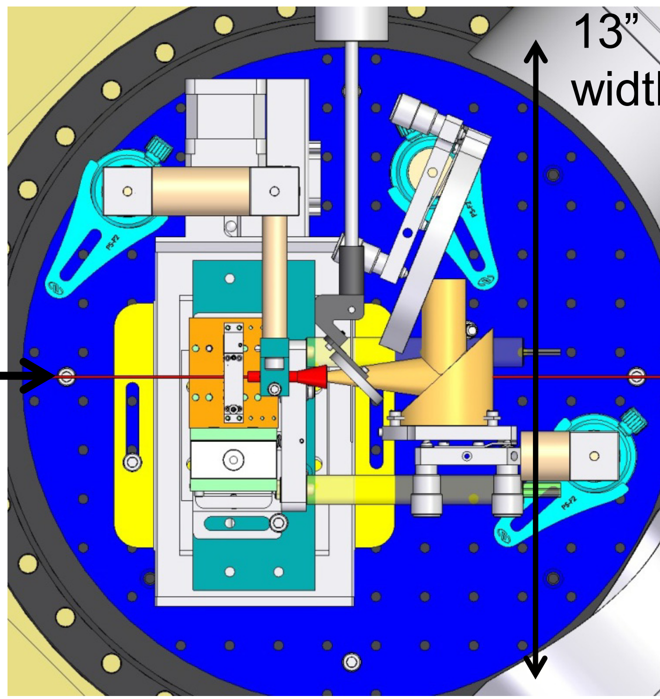
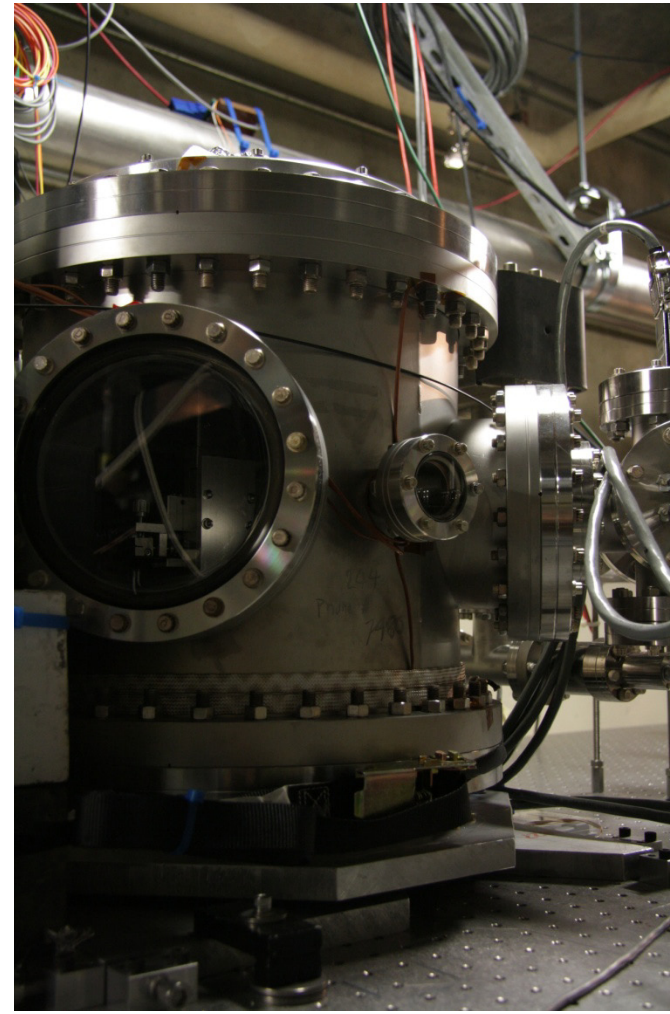




E-204 and E-205

- E-204 Proposal for testing of metallic periodic structures at FACET
  - Valery Dolgashev, Sami Tantawi (SLAC)
- E-205 High Gradient Dielectric Wakefield Measurements at FACET: Applications for Collimating Systems, Energy Compensation and Acceleration
  - Alexei Kanareykin, Paul Schoessow, Chunguang Jing, Sergey Antipov (Euclid Techlabs)

Proposal for testing of metallic structures periodic structures at FACET

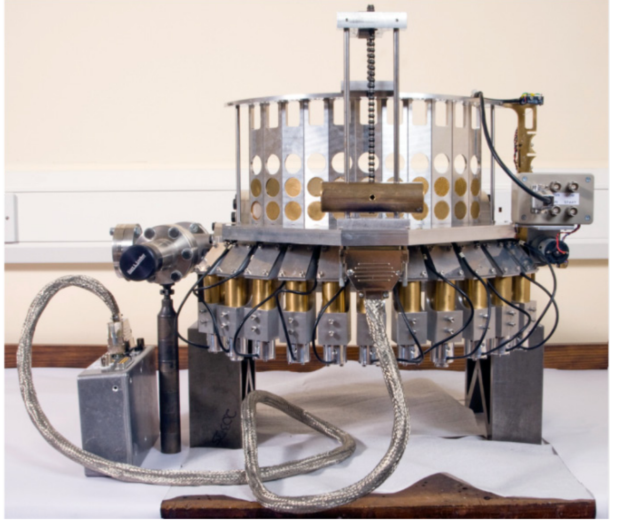
Valery Dolgashev, Sami Tantawi

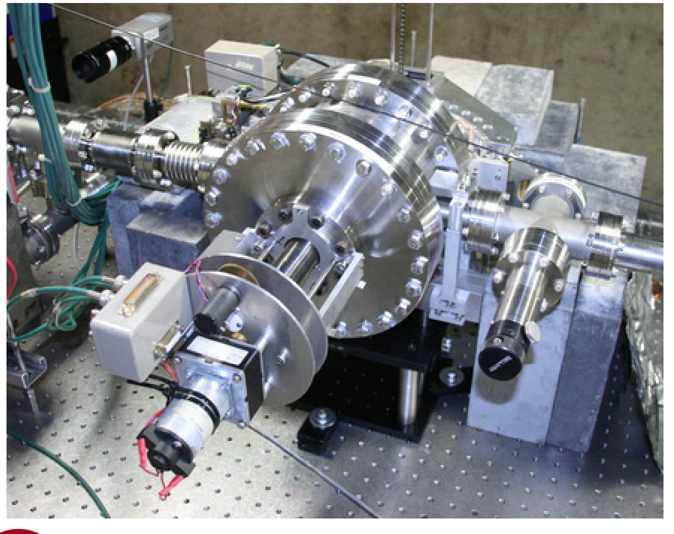
Most the effort on wake-field accelerators is focused on dielectric structures or plasmas. The case for dielectric accelerators is made by observing damage limits using short laser pulses, which shows a favorable scaling for dielectric materials in comparison with metals. However, the response of metallic structures at extremely short pulses in the frequency range between W-band and terahertz is not known. At these frequencies one can construct wake-field accelerators based on metallic periodic guiding structures.

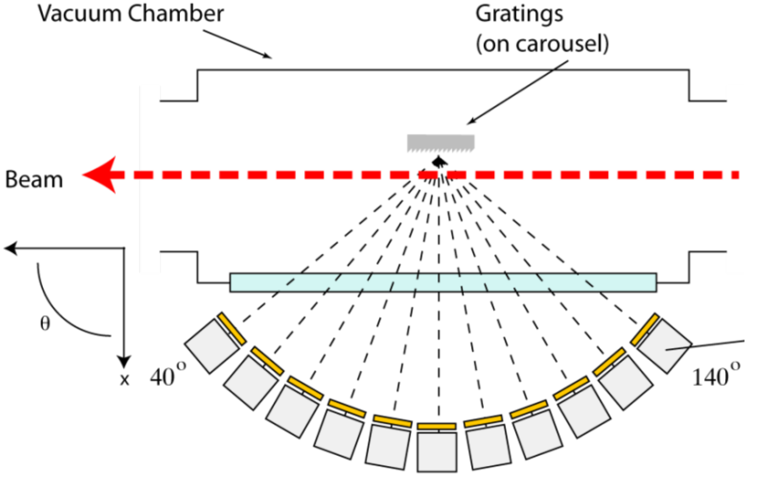
bstract: Euclid Techlabs LLC submits this proposal for experimental measurements and ptimization studies at FACET of wakefields in dielectric based collimating systems. There are ctually three closely related applications of wakefields that we plan to examine. These xperiments are: impedances of cylindrical and planar dielectric structures as prototype LIC/ILC collimators; use of the self-wakefield of a chirped bunch to compensate the energy pread; and a 300-400 MeV/m, 100 GHz dielectric wakefield accelerator. These measurements re closely related and essentially share the same mounting hardware, cooling, and experimental chniques and so it makes sense to combine them into a single set of experiments. An additional de benefit is that we will be able to study the occurrence of breakdown effects in the dielectrics sed to construct the test structures (ceramic, quartz, and CVD diamond) at high gradients and high GHz frequency ranges. The geometries of the prototype cylindrical and planar structures to

Longitudinal Profile Measurements

- Bunch Time Profile measurements with Coherent Smith-Purcell Radiation
- Beam passes by grating which has a dispersive effect
- Non-destructive







E-203

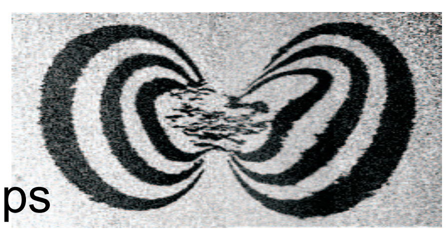
- Determination of the time profile of 50fs long bunches by means of coherent Smith-Purcell radiation
  - Armin Reichold, Riccardo Bartolini, George Doucas, Colin Perry, Nicolas Delerue, Simon Hooker

Abstract

Coherent Smith-Purcell (SP) radiation offers the possibility of determining, in a non-destructive way, the time profile of very short electron bunches like those produced by Laser and Plasma Wakefield Acceleration (PWA). The technique is compact, relatively inexpensive and can operate in single-shot mode. It has already been demonstrated over a broad range of beam energies and with bunches in the 1-3ps range. The present request for beam time aims to demonstrate the validity of the technique with bunch lengths that are about 2 orders of magnitude shorter (~50fs FWHM). If successful, this experiment will open the possibility to extend the method down to ~5fs.

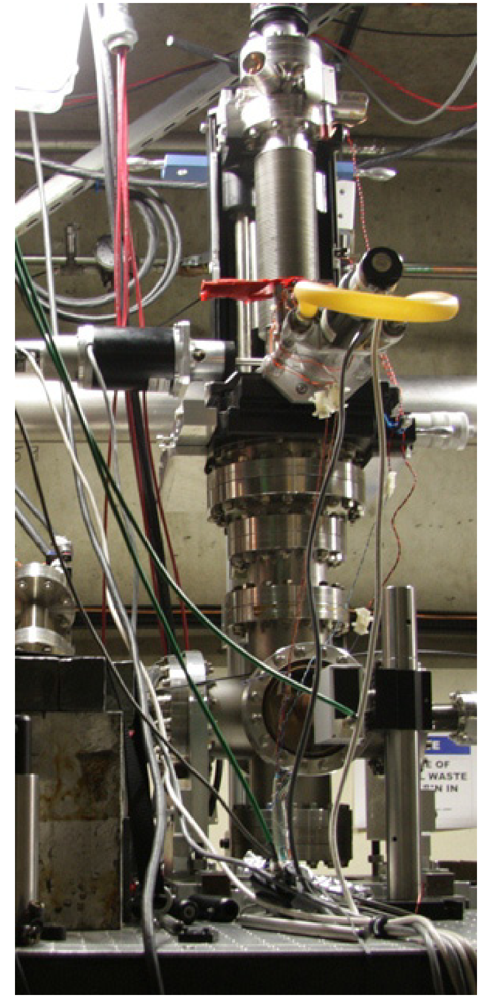
Ultrafast Magnetic Switching

- Magnetic samples in extremely high EM fields
  - 60T and 20 GV/m
- Expose sample to electron bunch
- Then image with spin-sensitive scanning electron microscope.
- Different patterns on same film indicate different physical processes



2.3ps

70fs



E-202

- Study of Ultrafast Processes in Magnetic Solids following Excitations with Electron Beams
  - Hermann Durr, Joachim Stohr, Aaron Lindenberg, Sanne de Jong, Christian Back, Rolf Allenspach, Alexander Kashuba, Mark Hogan, Ziran Wu, Selina Li, Stefan Guenther

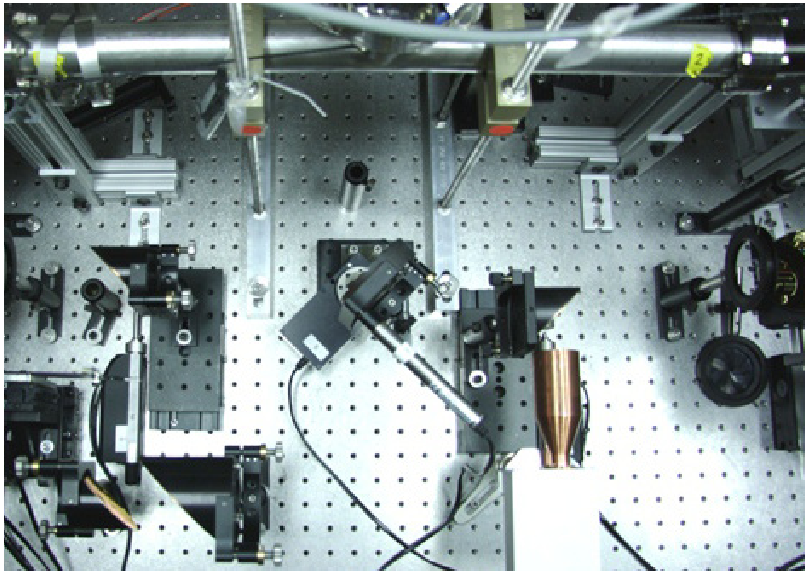
Study of Ultrafast Processes in Magnetic Solids following Excitations with Electron Beams

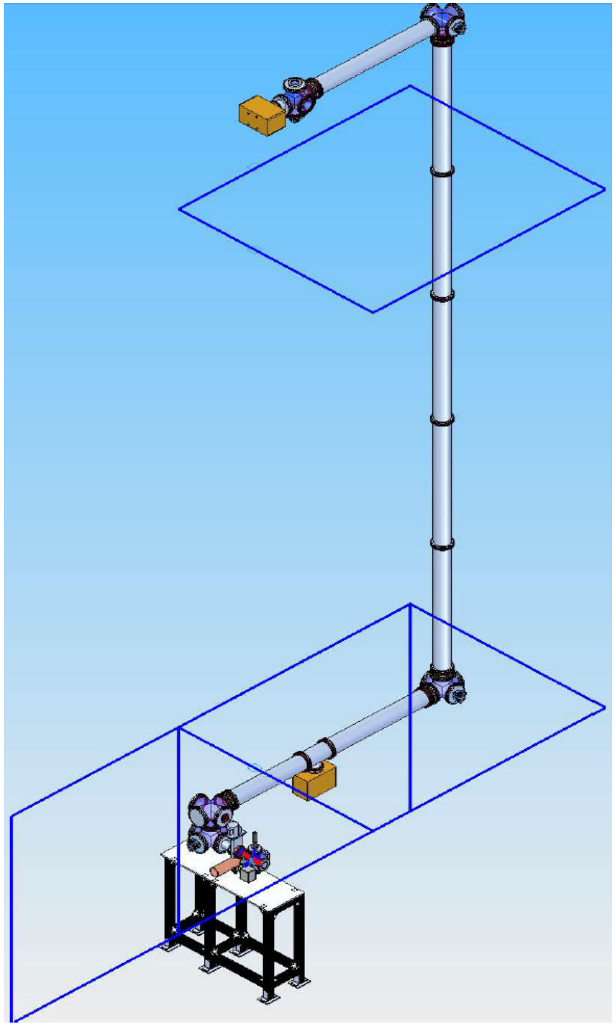
Abstract

We propose to explore the speed limits in switching of the magnetization of magnetic data storage media. So far data storage applications utilize mainly magnetic field pulses to reverse the magnetic moments. However, previous experiments of magnetic switching using 140 fs long electron bunches at the SLAC linac revealed the existence of a novel switching process probably associated with an electrical field induced change of the magneto-crystalline anisotropy of the magnetic material (see Fig. 1). A further surprising new feature was the discovery of negligible sample heating for short (140fs) pulses while several ps long pulses clearly resulted in beam damage of the sample. Here we propose a systematic investigation of these phenomena as a function of electrical field strength and the pulse duration to establish their possibly common microscopic origin. This requires independent

THz Studies

- When focused, Electric fields > 1 GV/m = 0.1 V/Å
- And Magnetic fields > 3 T
- Well above other THz sources
- And “for free”





FACET Schedule

- October 15th – Proposal submission deadline for second half of 2012 run and 2013
- 2nd SAREC review of proposals in January 2012
- Installation of S10 chicane in February 2012
- 1st FACET run (Run 1A) starts in March 2012
- Second half (Run 1B) scheduled for June/July 2012
- Expect 4-5 months of running each year for next five years
- User time arranged with scheduled installation periods in between runs

Thank you

- Please attend related talk…
  - Riccardo Bartolini, today at 12:10 in Chamber Hall on “Electron Bunch Profile Diagnostics in the Few fs Regime through the use of Coherent Smith-Purcell Radiation” WEOBB03
- And posters…
  - “Optics Measurements and Tuning in the FACET Accelerator Complex” WEPC046
  - “First Science from the FACET Facility at SLAC” WEPZ018
  - “Results from Plasma Wakefield Acceleration Experiments at FACET” WEPZ023
  - “Status of Plasma Electron Hose Instability Studies at FACET” WEPZ028
  - “Experimental Studies of a Diamond-based Dielectric Wakefield Accelerator” WEPZ020