STATUS OF SUPERCONDUCTING RF TEST FACILITY (STF)

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Abstract

The superconducting RF test facility (STF) in KEK is the facility to promote R&D of the International Linear Collider (ILC) cavities and cryomodule. The surface treatment and field test of 9-cell cavities are performed in daily bases. The second electro-chemical polishing facility was completed its construction, and became operational. As an international project; S1-Global cryomodule test is now conducted at STF. The cool down experiment and RF performance test are under execution towards end of December 2010. In parallel, modification of STF phase-2 plan was discussed and the plan was changed. In order to accommodate efficient R&D and effective accelerator demonstration with limited budget, the new RF powering scheme; DRFS (Distributed RF System) was adopted. All of the STF development and modified plan done in 2009-2010 are summarized in this paper.

1 INTRODUCTION

The reference design report (RDR) of the ILC was completed and published in 2007[1]. In order to develop more cost effective ILC design, SB2009 (Strawman Baseline 2009) design modification for acceleration unit design and other accelerator scheme is under discussion in ILC-GDE [2]. For the single tunnel design of the ILC main linac in SB2009, KEK proposed the DRFS using 750kW small klystron powering two cavities stand next to the cryomodule in the accelerator tunnel. The demonstration of this new RF scheme is come to the milestone of the STF phase-2 construction. During phase-2 unit construction, we will conduct several experiments, such as cryomodule thermal test, S1-Global experiment, compact X-ray generation experiment [3]. In the S1-Global experiment, we will demonstrate ILC-like cryomodule built by the international collaboration. In the compact X-ray generation experiment referred as 'quantum beam project' which is founded by the MEXT, the electron beam source and beam capture cryomodule are demonstrated. The new infrastructure, such as the second electro-polishing facility to be used for KEKB cavities, and automated cavity tuning machine are also introduced. As an industrialization study of cavity fabrication, the new cavity fabrication facility is under commissioning.

2 CRYOMODULE THERMAL PERFORMANCE TEST

After completing the STF phase-1 cryomodule experiments, a separate performance study on the STF cryomodules was conducted using Cryomodule-B in 2009. First, the magnetic field at the cavity position was measured by creating a dummy space with the magnetic shield surrounding it, as shown in Fig. 1. The measured magnetic field was approximately 2 mG and was found to be consistent with the design simulation.

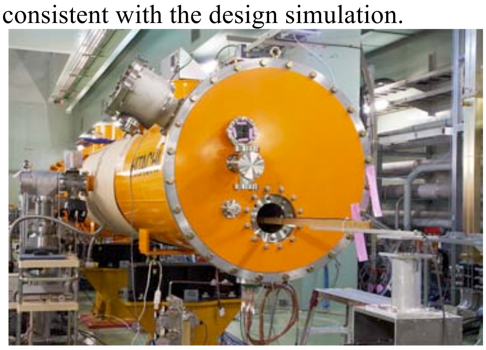

Figure 1: Cryomodule performance test with magnetic field measurement.

Second, to study the displacement of the cold mass during the cool-down and warm-up processes, a set of laser sensors were added to monitor the vertical locations of the gas return pipe (GRP). It was observed that the GRP has a banana-like deformation on the order of a few mm during cool-down and warm-up. However, when the cavity temperature stabilizes at 2 K, the GRP returns to its room-temperature shape, within about 0.5 mm. In the third cool-down experiment, dummy cavity tanks filled with liquid helium and without the 5K thermal shield were installed and the heat insulation characteristics of the cryomodule were measured. The measured heat performance was in good agreement with the design performance. The removal of the 5K shields is one of the proposed measures to reduce the cost of ILC cryomodules.

3 S1-GLOBAL CRYOMODULE EXPERIMENT

The goal of the S1-Global experiment is to build a cryomodule with 8 units of superconducting cavities and to show that the ILC's acceleration technology works with parts assembled from around the world. It consists of two short cryomodules, such as cryomodule-A and cryomodule-C. Cryomodule-A is from STF phase-1 experiment. Cryomodule-C has been designed by INFN Milano-LASA, and its cold-mass components were built by an Italian company, ZANON. Cryomodule-C stores four cavities from FNAL and DESY: AES-004, ACC-011, Z108, and Z109, and the assembly work for its cold-mass at KEK was performed in the early 2009 by a team from INFN Milano-LASA, FNAL, and KEK.

Fig. 2: Researchers from DESY, FNAL, and KEK working in clean room (left), team from INFN, FNAL, and KEK installing frequency tuners (right).

Cryomodule-A stores 4 out of 5 Japanese-made cavities, which have been newly built for this experiment: MHI-05, -06, -07, and -09. The laboratories FNAL, DESY, and KEK contributed their top-performance cavities for this exercise: AES-004 (29.4 MV/m, FNAL), ACC-011 (33.3 MV/m, FNAL), Z108 (31.3 MV/m, DESY), Z109 (30.9 MV/m, DESY), MHI-05 (27.1 MV/m, KEK), MHI-06 (27.7 MV/m, KEK), MHI-07 (33.6 MV/m, KEK), and MHI-09 (27.0 MV/m, KEK). The S1-Global experiment aims to demonstrate the operation of these cavities in their common cryomodules in a pulsed RF environment with an average acceleration gradient of 31.5 MV/m, which is the canonical design value of the ILC. The S1-Global experiment also aims to compare the operation of input couplers and cavity tuners from around the world and to validate their performance. RF operation is scheduled to begin in June 2010 and continue until December 2010.

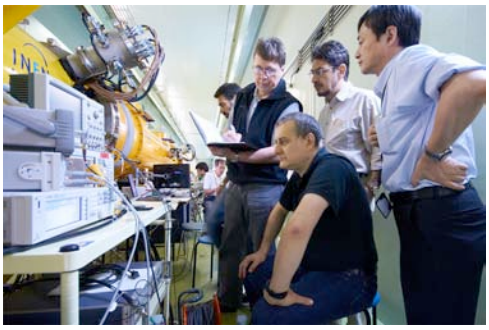

Fig. 3: Cavity performance measurement by the researchers from INFN, FNAL, and KEK.

4 INFRASTRUCTURE DEVELOPMENTS

The electro-chemical polishing (EP) facility at STF came into routine operation in 2009 for ILC cavities. An EP facility at the Nomura Plating Company was for KEKB (508 MHz) accelerating cavities and crab cavities. Because of the age of the components, it was decided to relocate the equipment to the KEK with substantial refurbishing. The relocation work was done in the Fall of 2009. The mechanics of the cavity bed, shower tank, and ultrasonic rinse tank were repaired, and the acid tank, acid pipes, and the control system were replaced with new units. The system is under commissioning by using an old TRISTAN single cell cavity, as shown in Fig. 4, and is expected to become operational in August 2010.

Fig. 4: Second EP system for KEKB cavities, ERL, and ILC cavities.

Since 2007, members of KEK, FNAL, and DESY have engaged in a collaborative effort for the automated cavity tuning machines. The tuning machine is capable of frequency-tuning each of the cells, as well as correcting the alignment of the cells and the straightness of a 9-cell cavity. The commissioning of the control system was completed at FNAL together with operation training sessions, which were conducted in February 2010. Fig. 5 shows a group picture of the participating members. One of complete set of the tuning machines is delivered to STF in August 2010.

Fig. 5: Team members from DESY, FNAL, and KEK in front of tuning machine at FNAL.

5 PHASE-2 DEVELOPMENTS

An illustration of single tunnel design using DRFS system is shown in Fig. 6. Klystrons and its power supplies are installed in the same tunnel of the cryomodules. The demonstration of DRFS instead RDR unit became to have priority, so that STF phase-2 was changed its configuration to DRFS scheme. Fig.7 shows phase-2 diagram accommodating DRFS klystrons in the tunnel.

Another development at STF was the construction of a photocathode RF gun system. The L-band room-temperature cavity for the RF gun and its input coupler were built through a DESY–FNAL–KEK collaboration. This gun was delivered to KEK from

FNAL in November 2009. After making minor modifications to the water jacket and beam pipe flange, vacuum pumps, a solenoid, a waveguide, and a RF window were assembled.

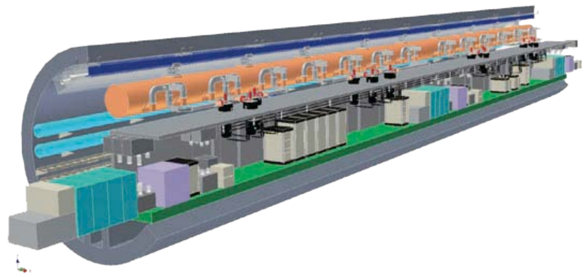

Fig. 6: Illustration of DRFS installation in the single tunnel design.

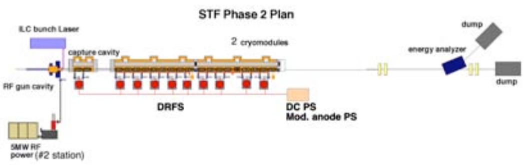

Fig. 7: Schematics of the STF phase-2 demonstration.

Fig. 8 shows the completed assembly. The photocathode of this RF gun is made from Cs_2Te built by KEK. The drive laser for the photocathode was developed in Russia through a KEK–IAP–JINR collaboration that began in 2007. This laser system generates 10ps-long pulsed UV light (266 nm) with a repetition rate of 3 MHz for a 1ms 5Hz RF pulse. The extracted electron charge 3.2 nC corresponds to the specification of the ILC.

Fig. 8: Assembled photocathode RF gun system (left) and drive laser system (right) for beam source of Phase-2.

On the way of the STF phase 2 construction, using the photocathode RF gun and the beam capture cavities, the accelerated beam up to 40MeV is used for the compact X-ray generation experiment. The setup is illustrated in Fig. 9. The beam is bent to laser collision chamber, and collide to the accumulated laser beam in the mirror resonator. The Compton scattered X-ray is generated and detected at the down stream. The experiment is scheduled on the fall of 2011 to the summer of 2012. The phase 2 cryomodule assembly will be started in the summer 2012. The operation will be early 2013.

The cavity fabrication facility was constructed in the utility building of the former proton synchrotron accelerator. It consist of the clean room, chemical room, electron beam welder (EBW), press machine, trimming machine, and instrumentations. The delivery of EBW is scheduled on March 2011, however, the development study was already started for EBW parameter optimization using the same type of EBW at job shop, and press machine optimization together with press-die optimization.

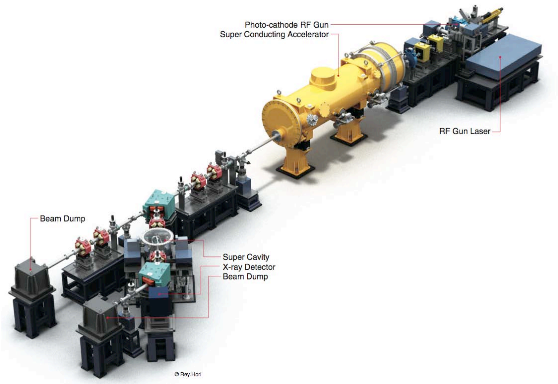

Fig. 9: Illustration of compact X-ray generation experiment setup, and later to be used for STF phase-2 beam source.

Fig. 10: Cavity fabrication pilot plant.

6 ACKNOWLEDGEMENT

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7 REFERENCE

[1] ILC Reference Design Report, ILC-Report-2007-001 (2007); http://www.linearcollider.org/cms/?pid=1000437
[2] R&D plan in TDP-2, release 4 (July, 2010); http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*813385
[3] Hitoshi Hayano, "KEK-STF status," Proc. of the 6th Japanese Accelerator Society meeting, 2009.