STATUS OF SUPERCONDUCTING RF TEST FACILITY(STF)

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Abstract

The superconducting RF test facility (STF) in KEK is aiming to promote R&D of superconducting linear accelerator to be used in the International Linear Collider (ILC). The STF construction is planned to sub-divided to two parts. They are phase-1 plan and phase-2 plan. The phase-1 plan is aiming to have quick experience on all aspect of 1.3GHz SC cavity and cryomodule technologies by producing 4 TESLA-shape cavities with 5m cryostat and 4 LL-shape cavities with another 5m cryostat, which are powered by 5MW klystron. The other aspect of phase-1 development is to construct new cavity surface treatment facilities, such as electro-chemical polishing and clean room to get stable high gradient performance. The developments of the phase-1 are almost completed in 2008. The results and the developed technology are introduced in this paper.

1 INTRODUCTION

The reference design report (RDR) of the ILC was completed and published in 2007[1]. The baseline ILC configuration is illustrated in Figure 1. They are one polarised electron injector, central 6km damping rings, two 11km main linacs with 31.5MV/m gradient, positron line helical undulator at 150GeV, and 14mrad crossing final focus with single IR (see Fig.1).

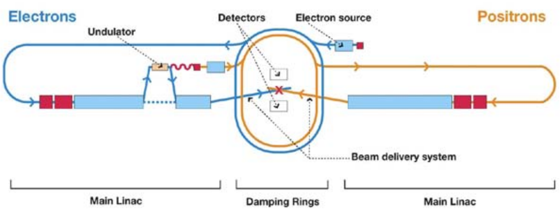

Figure 1 Baseline ILC accelerator in RDR

The main linac RF unit consists of following components. The bouncer modulator and the pulse transformer generating 120kV, 140A, 1.57ms of width, 5Hz repetition pulse for the 10MW multi-beam klystron are the baseline design of RF power source. Beam is injected after filling time of 500µs from the start of RF fill into the cavities. The klystron has two RF output. Each of RF output is transported by the waveguide through the penetration hole to the 4 branch of the linear distribution system of the cryomodule. The circulator of each cavity input ensures the matching condition of waveguide system. There are 9 cavities in the two cryomodules of both side, and 8 cavities and quadrupole magnet are in the central cryomodule. Total 26 cavities are in one RF unit. Operation gradient for these cavities are 31.5MV/m, and loaded beam current is 9mA during about 1ms beam pulse train with 5Hz repetition. The unit configuration is illustrated in Figure 2, below.

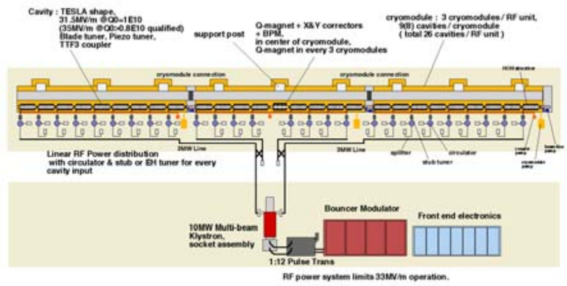

Figure 2 RF unit configuration of ILC main linac.

2 CRYOMODULE TEST OF STF PHASE1

To promote R&D of these main linac technologies and construction of test cryomodules together with superconducting cavity production has been conducted in STF. The R&D on the cavity operation gradient to achieve more than 31.5MV/m, which is an urgent issue of ILC, is also pursued in STF[2].

The STF phase-1 test cryomodule consist from the two units of 5m horizontal cryostats which are the half length of ILC design, and each of them can accommodate 4 cavities. The type A 5m cryomodule is designed to accommodate TESLA-style cavities, and the type B 5m cryomodule is for low-loss (LL) cavity. The interface design of cavities, such as coupler holes, holding support, tuner motor location are different for type-A and type-B. In the middle of 2006, phase-1 plan was modified by the reason of the delay of cavity completion. That is, for the first cool-down test, only one TESLA-style cavity and one LL-design cavity were installed in the cryostats (we call it STF phase-0.5). Unexpectedly, we met several leak trouble, such as leak at cold box (2K refrigerator box), at LL-design cavity helium vessel, and at cold box again. The cool-down test was delayed, and the schedule itself was modified. First, the one TESLA-style cavity was cool-down test in the cryomodule A, in the mean time LL cavity cryomodule B was in leak surveyed. After detailed leak survey, finally we could not find any candidate of leak. The cryomodule B of one LL cavity was reassembled and transported to the tunnel. When a high power experiment and heat load measurement for TESLA-like cavity module were finished, the cryomodule was replaced to the module of LL cavity. During high power test and heat load measurement of LL cavity, four TESLA-like cavities were assembled into the cryomodule A. The installation of cyomodule-A which now involved 4 cavities of TESLA-style was done in May 2008. It was just after the cryomodule-B high power experiments in March 2008.

The surface treatment infra-structure such as EP facility and clean room and the vertical cryostat for cavity test are constructed in parallel.

3 STF PHASE1 EXPERIMENT STATUS

After fixed the cold box leak problem, the high-power test of one TESLA-like cavity in the cryomodule-A was performed in Oct. – Nov. 2007. The installed cavity was BL#3 cavity which reached to 20.5MV/m gradient with 1x10^{10} Q value in the vertical cryostat test. After the rf process of the input coupler and cavity, the gradient reached to 19.3MV/m with 1.5ms pulse width. The limitation of the gradient was quench with high yield of x-ray. The heat load for the cavity package, cryostat and whole cryomodule were measured. They were 1.29W for cavity package, 3.35W for cryostat and 5.6W for whole cryomodule. The study of Lorentz detuning (LD) and its compensation were done by the slide-jack tuner mechanism. The LD compensation by the piezo actuator at 18.2MV/m gradient was successfully performed.

After two months cool-down experiment of TESLA-like cavity module, they were disassembled and moved to the surface for the 4 TESLA-like cavities installation. On the other hands, the LL cavity module was re-assembled and installed into the tunnel instead of them. The cool-down of LL cavity (I9#2) was done in Feb. – Mar. 2008[4]. After rf process of the coupler and the cavity, it reached 22MV/m of gradient field with 1.5ms pulse width. The limitation was caused by quench with very small x-ray emission. LD study was also performed at around 17MV/m field level. The coaxial ball-screw tuner was well performed to compensate LD field slew. The same measurement of heat load were also done. They were 1.79W for the LL cavity package, 3.38W for cryostat and 6.13W for whole cryomodule.

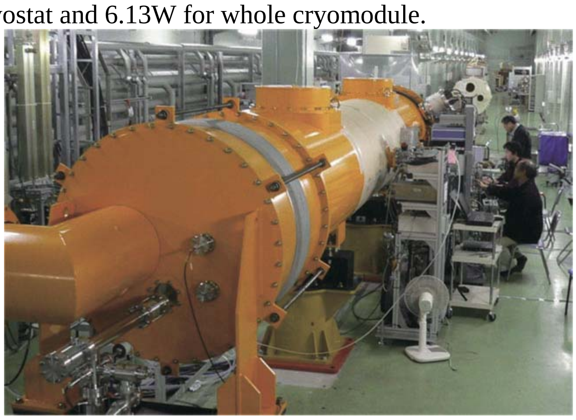

Figure 3 STF test cryomodule-B which contains one LL cavity for cool-down test.

In this January to March during LL cavity cool-down test, the TESLA-like cryomodule was disassembled and the cavity was extracted. Then adding three more TESLA-like cavities to the extracted cavity were re-assembled into the cryomodule again. The rail system in the clean room floor ensured the assembly of the chain of four cavities in line. After careful installation of couplers and connection by the bellows chambers, the cavities chain was taken out from the clean room. The tuner mechanics were installed at outside of clean room. Then cavities were hung on the cold-mass of the cryomodule.

Figure 4 Four TESLA-shape cavity packages assembled in STF clean room (top). They were hung on the cryomodule cold-mass (bottom).

The cool down test of the four cavities cryomodule without connection of couplers of the warm side was performed during May 2008[3]. Without connection of the coupler, the heat load of the cavity and cryomodule were measured. In June, connections of the coupler warm side were done and rf power processing were done also. In July, cool down test of the four cavities and cryomodule were performed, however, only one cavity which reached 29MV/m in the vertical test was connected to the klystron for high power test and for LD test at high field [5]. The gradient was reached to 28.1MV/m and got compensated amplitude and phase for pulse top. (Figure 5)

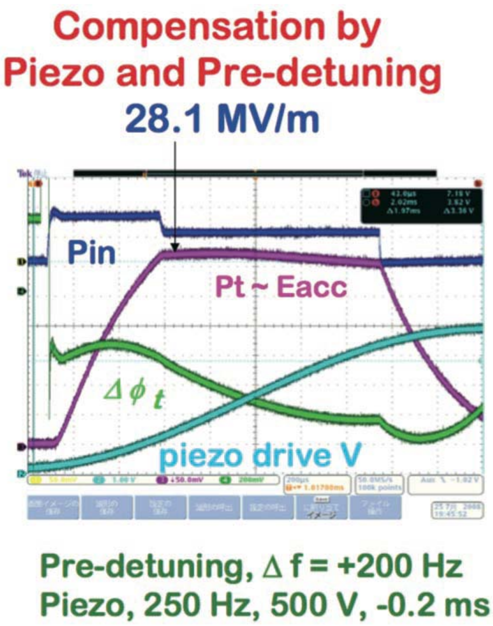

Figure 5 Waveforms at 28.1MV/m with LD compensation in cool-down test of TESLA-like cavity.

4 INFRASTRUCTURE DEVELOPMENTS

The infrastructure constructions for the cavity treatment facility and for the vertical test stand were done in 2007. The new electro-polishing (EP) facility together with Ultra-pure water high pressure rinse (HPR) and the clean room became in operation (Figure 7). Commissioning run using an old TESLA shape 9 cell cavity and a single cell cavity is under going. It is an operator's training of EP system operation, control of surface finish and thickness removal. The EP treatment run is held once in two weeks base[7].

The installation of cryostat in the vertical test stand in STF building was done together with cavity assembly area, rf control room and cavity pre-tuning room[6]. The cryostat was installed into the 6m depth of pit under the floor. It has movable steel shield of 160mm thickness to prevent x-ray radiation from the cavity during rf test. The pumping system for cooling of liquid Helium is also installed. The commissioning of this vertical test stand was successfully done in July 2008 using AES001 cavity borrowed from FNAL.

The development of cavity surface inspection camera is being done by the collaboration with Kyoto University[8]. Combination of high performance CCD camera and special illumination by sheet electro-luminescence (EL), we could find the correlation between the defect on the cavity inner surface and temperature rise in the vertical test. The defect size were around 400-600µm with about 40µm height or depth at around equator weld region. The other defects were many of small pits around 100µm size at near the equator weld region again. We could see the refinement is required for electron beam welding.

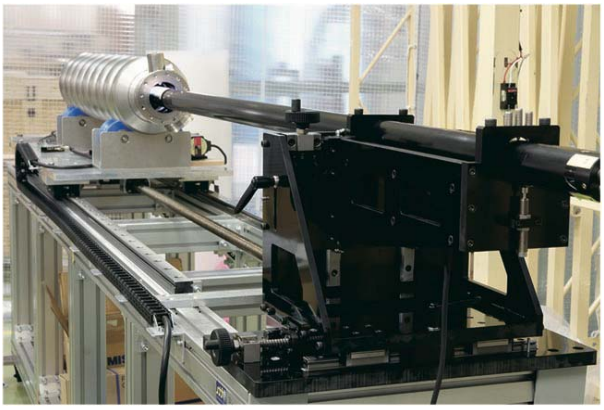

Figure 6 Production model of the cavity surface inspection camera.

5 ACKNOWLEDGEMENT

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6 REFERENCE

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