STATUS OF SUPERCONDUCTING RF TEST FACILITY(STF)

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Abstract

The superconducting RF test facility (STF) is under construction in KEK, in order to promote R&D of the International Linear Collider (ILC) for regional production capabilities and construction share. The STF construction phase-1 plan for 2005 to 2007 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 development is to construct new cavity surface treatment facilities, such as electro-chemical polishing and clean room to get stable high gradient performance. The schedule of the phase-1 has about 1 year delay, so far, the only one TESLA-shape and one LL-shape cavities are installed in the cryomodule instead 4+4 as a first step.

1 INTRODUCTION

The reference design of the ILC was conducted followed by the BCD (baseline Configulation document), and the reference design report (RDR) was almost completed in this summer 2007. The ILC configuration illustrated in Figure 1 is now becoming the new baseline. 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.

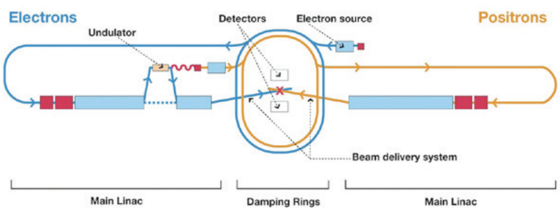

Figure 1 Baseline ILC accelerator configuration

The main linac RF unit has revised after cost reduction design work. 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.

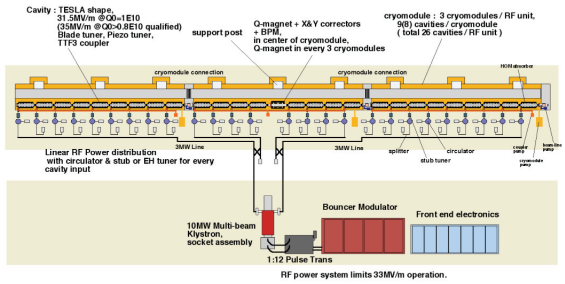

Figure 2 RF unit configuration of ILC main linac.

2 STF PHASE1 CONSTRUCTION PLAN

To promote R&D on these main linac technologies, the construction of the test facility for the ILC which is STF has been started in KEK. The main role of STF is to establish the ILC main linac production capability and the industrial design of them, and to promote Asian and Japanese industrial level towards ILC component production. STF is to be a base of international collaboration for superconducting RF technology in Asian region. The R&D on the cavity operation gradient to achieve more than 31.5MV/m stably is also another urgent issue of ILC.

Based on existing KEK superconducting RF technologies, the new ILC superconducting RF test facility which promote the production of high performance 9-cell cavity and an ILC-like long cryomodule assembly. The first stage (STF Phase 1) is aiming quick start up of 9-cell cavity production, having experience of assembly engineering of half-size cryomodule, and having RF power handling technologies. The infra-structure such as EP facility and clean room are constructed in parallel for preparation of cavity handling capability. The main goal of the second stage (STF Phase 2) is to build one RF unit of ILC main linac (see Figure 2) and to have long-run operation. The timeline of the STF phase-1 is starting at 2005 and completing in 2007. For years 2008 – 2010, STF phase-2 will be conducted.

3 STF PHASE1 STATUS

The movement and installation of He plant (He refrigerator), the modification of klystron modulator with installing bouncer circuit were done in early stage. The RF power source is now used for high-power testing and processing of fundamental mode input couplers. The existing 5MW L-band klystron, TH2105 is re-commissioned with a modulator, which have been provided by PNC laboratory, modified to have bouncer circuit. The klystron is operated with an output pulses of 2MW, 1.5ms width, and the flatness of flattop was less than 1% in the best case (Figure 3).

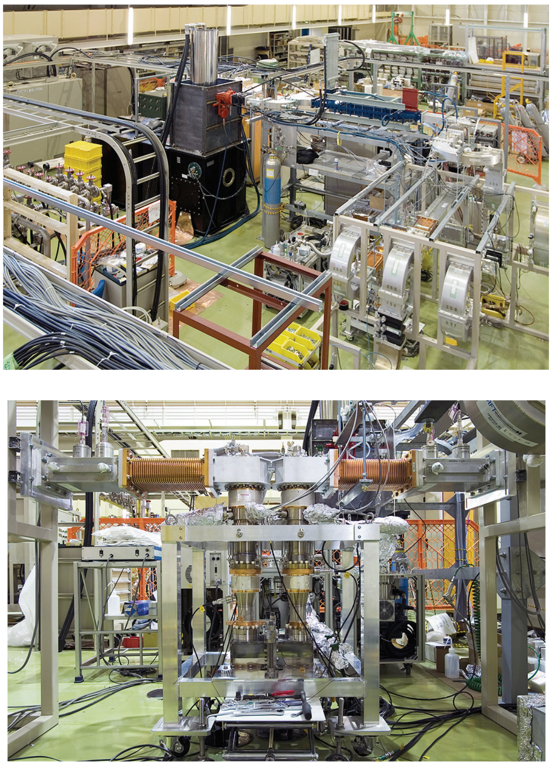

Figure 3 RF power source and input couplers for high power test.

The STF phase-1 cryostat is designed to 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 cryostat is designed for TESLA-style cavities, and the type B 5m cryostat is for LL-design. The interface of cavities, such as coupler holes, holding support, tuner motor interface are different design 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 (STF phase-0.5). The first cool-down test was expected to have in May 2007. However, unfortunately, 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 is delayed, and will be held in October 2007. The installation of 4 cavities of TESLA-style and 2 cavities of LL-design is scheduled in winter of 2007, and cool-down of them is scheduled in May 2008.

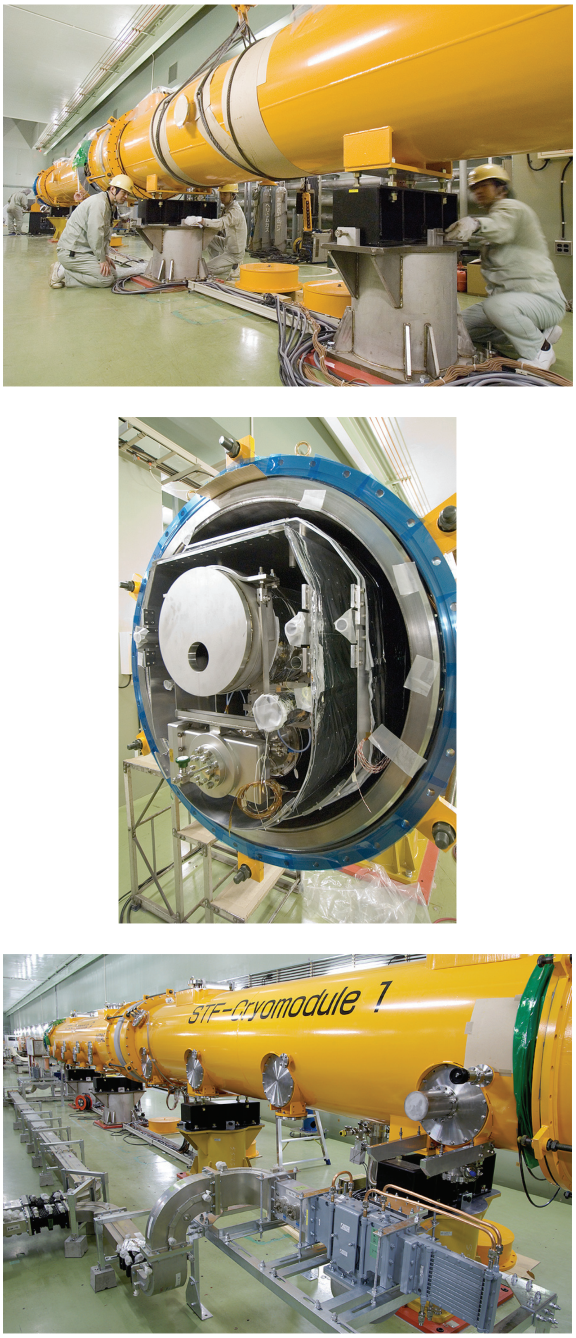

Figure 4 STF Phase 1 cryomodule.
Top is cryostats installation in the tunnel, Middle is the one end of 5m cryostat. And down is the whole view of the connected cryostat, that is cryomodules.

"High-gradient" cavity development and "TESLA-style" cavity development, are performed in parallel. The "high-gradient" cavity development focused on achieving a high accelerating gradient in excess of ~45MV/m with a cavity shape that has been optimized ("low-loss" – LL-design) to reduce the surface current near the "equator" of cavity cell. The surface magnetic field is considered to determine the ultimate gradient performance when the other issues, including dusts and surface contaminations are resolved. On the other hand, TESLA-style cavity was designed to have a ILC operational performance, and was optimized a cavity-jacket system rigidity to reduce the Lorentz detuning deformation, and to have reliability and maintainability. The production of the 9 cell cavities were done. 4 TESLA-shape cavities and 4 LL-type cavities are fabricated, and some of them are processed of their inner surface and made vertical test. Total 16 of surface treatment and vertical test for four TESLA-shape cavities were made, and their gradient performance reached to about 20MV/m for three, and 29MV/m for one. The first production of LL-type cavity which was without input/HOM couplers, was treated repeatedly, and reached to 30MV/m. The second and third LL-type cavity were reached at around 19MV/m by several surface treatments. The last LL-type had leak trouble. The selected cavities of one TESLA-style and one LL-design were installed in the cryostat as mentioned above.

Figure 5 TESLA-shape cavity package hung on the cold mass and the picture of the other three jacketed cavities waiting for installation.

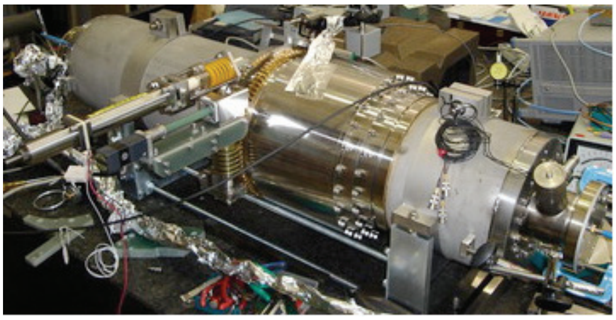

Figure 6 One of the cavity picture of high gradient LL-shape cavity. The test setup of coaxial tuner for LL-shape cavity.

Both "TESLA-style" and "the high-gradient" cavity groups have also built with required active tuners, and jackets, together with fundamental-mode power coupler and HOM absorbers. The power couplers of two design (two-disk window co-axial coupler and capacitive coupling co-axial coupler) were RF processed and proved its high power capabilities. Two type of new tuner mechanism were designed, fabricated, tested and waiting for cool-down test with high power RF input. To identify the problems of high gradient operation of cavity and to resolve them are urgent issue in ILC world-wide.

4 INFRASTRUCTURE

The half of the STF building incorporates an assembly area for the cryomodules associated with a new electro-polishing (EP) facility (Figure 7) and a clean room for the assembling of the cavity. They are utilized for Linear Collider development as well as applications of superconducting cavity technologies in other projects at KEK and in Japan. The new EP facility construction of phase-1 was almost completed, and commissioning will be started soon. The clean room and ultra-high purity water system are in use already. The High Pressure water Rinsing (HPR) will be started its commissioning soon, after resolving the contamination problem of pump.

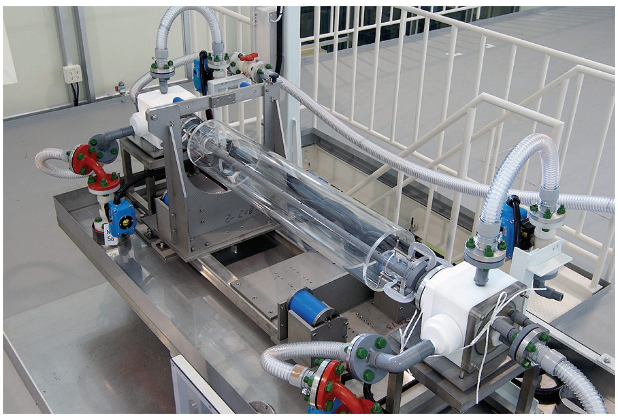

Figure 7 Cavity bed of STF new EP facility. The plastic dummy cavity is mounted for test.