SUPERCONDUCTING RF TEST FACILITY (STF) FOR ILC

Hitoshi Hayano for STF group, High Energy Accelerator research organization (KEK), Tsukuba, Japan

Abstract

A superconducting RF technology was chosen for the main linac of the International Linear Collider (ILC) by the International Technology Recommendation Panel (ITRP). Since KEK has been pursuing the technology of room temperature RF at X-band frequency, the big change in the development direction was indispensable. In order to promote Asian SC-technology for ILC production share, construction of a superconducting RF test facility in KEK was discussed and decided. The role and plan of the superconducting RF test facility (STF) is reported in this paper together with the current status.

1 INTRODUCTION

The development of 1.3GHz superconducting RF system for linear collider main linacs was pioneered by DESY and TESLA collaboration. TESLA collaboration summarized their results into the technical design report of TESLA, and published in 2001[1]. The performance of the TESLA superconducting cavities are well advanced by the electro-polishing (EP) processing as well as chemical etching of the inner surfaces, together with high temperature treatment and high pressure rinsing with ultra-pure water. The TESLA design gradient 23.8 MV/m has been attained on average with cavities of the standard chemical treatment. By application of new EP method to 9-cell cavities, another 6 cavities have reached gradients between 31 and 35 MV/m. Some of them are assembled into the cryomodule in the TESLA Test Facility (TTF). The other components for the main linac have also been developed. Their designs are well advanced and have reasonable performance as construction ready technologies. The ILC main linac design should be based on the TESLA technology. The effort of the main linac design should change the direction toward a design for industrialization and cost reduction.

GLCTA test facility in KEK for the main linac component development was aiming to promote the X-band room temperature RF technology. Now, it will be decrease its facility size and be made tone down the development to the minimum. Instead, the test facility of the ILC superconducting RF technologies (STF) has been discussed about its plan and role after the technology choice.

2 PURPOSE AND PLAN OF STF

The main role of STF is to establish the industrial design of linac unit and to promote Asian and Japanese industrial level towards ILC component production. ATF for linear collider emittance beam generation and instrumentation development is already the base of international collaboration. In the same way, STF will also be a base of international collaboration for superconducting RF technology.

3 STF PHASE 1 PLAN DETAIL

In ILC RF unit which is now under discussion, the bouncer modulator and the pulse transformer generating 120kV, 140A, 1.57ms of width, 5Hz repetition pulse for the multi-beam klystron will be the baseline design of RF power source. Beam is injected after filling time of 500μs from the RF fill into the cavities. The klystron has two RF output. Each of RF output is transported to the linear distribution waveguide system of the cryomodule. RF power branch to each cavity in cryomodule is done by the hybrids, which have different coupling ratio for each cavity input. The circulator of each cavity input ensures the matching condition of waveguide system. There are 10 cavities in each cryomodule. Total 20 cavities are in one RF unit. Assumed gradient for these cavities are 35MV/m, and loaded beam current will be 10.8mA during about 800μs.

There will be three test facilities in the world for the R&D of the ILC main linac RF system. They are TTF at DESY, SMTF at Fermi lab, and STF at KEK. The three regions have test facilities, or will have those. This is natural because each region has superconducting RF technology in the laboratories and enough funding to build test facility for promoting regional production ability in the laboratory or in the industry. So, the role of these facilities is to have an ability of SC-RF technology integration into ILC cryomodule, and to promote regional industry and laboratories for ILC module production. Since the module production will be shared by three regions at the ILC construction, each facility should have a leadership in the production by the basis of module design and production experience. They are not duplication. The RF technology will be shared from the beginning of construction. The experience of design, construction and operation will become three times more and the opportunity of researcher promotion will also be expanded three times.

The KEK activities on superconducting RF for LC were quite small, however several surface treatment and vertical test facilities exist and work inefficiently. Ramping GLCTA down and to start construction of new ILC superconducting RF test facility (STF) were decided. Since KEK does not have experience of a 9-cell cavity production and an ILC like cryomodule assembly, the test facility plan [2] is divided two stages. The first stage

(STF Phase 1) is aiming quick start up of 9-cell cavity production and having experience of assembly engineering of half-size cryomodule. The second stage (STF Phase 2) is to build one RF unit of ILC main linac (see Figure 1 to 3).

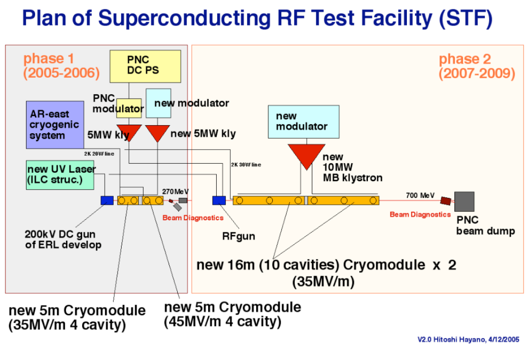


Figure 1 STF accelerator block-diagram. Phase 1 plan and Phase 2 plan are shown in each square block.

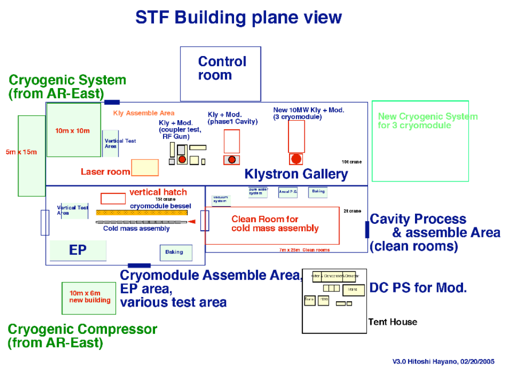


Figure 2 STF plan of building useage

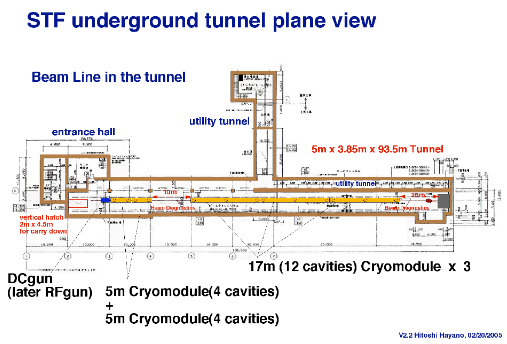


Figure 3 STF tunnel layout plan

Higher gradient greater than 35MV/m is essential for KEK to host ILC in Japan, because of limited length of site candidates. The demonstration of high gradient by changing cavity shape is thought to be high priority. Four of LL-type 9 cell cavity aiming 45MV/m have being fabricated for phase 1 half-sized cryomodule. Another half-sized cryomodule has been fabricated in parallel to accommodate four of TESLA-type cavities aiming 35MV/m. The fabrication of LL-type cavities has being done by deep contribution of KEK scientist, on the other hand, TESLA-type cavities will be done by industry mainly. The cryostat also will be fabricated by industry (see figure 4, 5 and 6). The surface treatment and performance check by the vertical stand will be done by using the existing L-band test facility only for phase 1. STF will be constructed in the building of proton linac facility for J-PARC in KEK. The most of J-PARC linac components in there will be moved to Tokai site till September 2005. The installation of He plant and RF power source will start after moving. The installation of two half-sized cryomodule will begin June 2006. The cool down of cavities are scheduled in October 2006, and turning on beam in December 2006. Other than cryomodule, the new production or the new purchase for phase 1 are one modulator, one 5MW klystron and laser for electron DC gun. All other components are existing one with some modification.

Once the ILC baseline configuration is determined at Snowmass workshop or by the time of BCD, STF phase 2 configuration will follow it. The phase 2 cryomodule construction will be done using the new EP facility, the new assembly clean room and the new cryomodule installation stand. The infrastructure of STF will be one of ILC module assembly facility in the beginning of phase 2 stages. The engineering design of phase 2 will begin in April 2006. The fabrication will begin in April 2007. In November 2008, the ILC RF unit will become operational.

4 STATUS OF STF

Major achievement goals and schedule details of STF are summarized briefly below in figure 7;

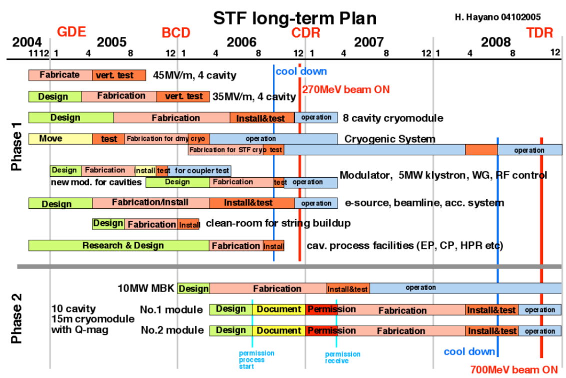
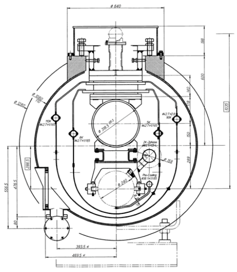


Figure 7 Schedule of STF.

The fabrication of four LL-type 9 cell cavities are underway and will be finished its vertical test in September 2005. Another four TESLA-type cavities will be fabricated by industry within fiscal year 2005. The power input couplers into the cavities will also fabricated 8 of them within fiscal year 2005. As for the RF power source, 5MW reserved klystron is now under testing whether is possible to use or not. Also the reserved modulator is under modification to 1.5ms pulse width to drive 5MW klystron. The reserved waveguide system is also used.

Figure 4 cross-section of STF Phase 1 cryomodule



5 REFERENCES

[1]"TESLA TDR," (March, 2001). http://tesla.desy.de/new_pages/TDR_CD/start.html

[2]Hitoshi Hayano, "KEK-STF Plan & Schedule," 1st ILC-WS 2004.

Figure 5 STF phase 1 connected-cryomodule.

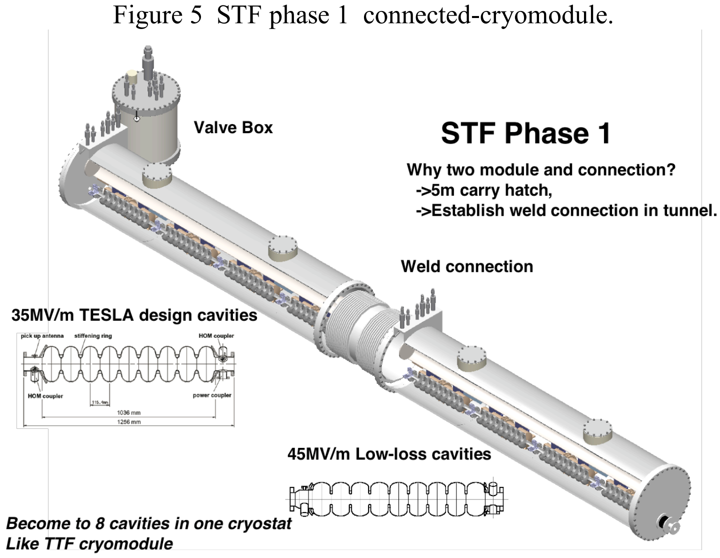


Figure 6 STF Phase 1 beam line configuration