

CRYMODULE TESTS OF TESLA-LIKE CAVITIES IN S1-GLOBAL FOR ILC

E. Kako*, H. Hayano, Y. Kojima, H. Nakai, T. Matsumoto, S. Noguchi, N. Ohuchi, M. Satoh,
T. Shishido, K. Watanabe, Y. Yamamoto
KEK, 1-1, Oho, Tsukuba, Ibaraki, 305-0801, Japan

Abstract

S1-Global project for ILC is an international collaboration for cryomodule tests including eight 9-cell sc cavities from DESY, FNAL and KEK. One of two 6-m cryomodules, Cryomodule-A, contains four Tesla-like cavities with slide-jack tuners and STF-II couplers. The cryomodule was assembled and was installed in the STF tunnel. The first cool-down tests and low power rf tests were carried out in June-July, 2010.

INTRODUCTION

Main purpose of the S1-Global is to demonstrate a stable pulsed operation at 31.5 MV/m in an average accelerating gradient of eight cavities. The S1-Global cryomodule consists of two 6-m cryomodules (Cryomodule-A and Cryomodule-C), which were combined in the STF tunnel at KEK. The Cryomodule-C [1] was newly fabricated by INFN (Italy) and includes four TESLA cavities delivered from DESY (Germany) and FNAL (USA). The Cryomodule-A was constructed for the STF phase-1.0 [2], and new five Tesla-like cavities were fabricated for the S1-Global. Different types of cavity structures, frequency tuners and input couplers were assembled in the S1-Global cryomodule, so that it is possible to directly compare their performance in the cryomodule tests. Assembly of the Cryomodule-A was started in February, 2010, and the first cool down test was carried out in June and July. The component tests of the cavities, input couplers and tuners, and low power rf tests of the cavities in the cryomodule are described.

TESLA-LIKE SC CAVITIES

Qualification in the vertical tests of five Tesla-like cavities was carried out [3], and the final cavity performance of four cavities selected for the S1-Global cryomodule is shown in Fig. 1. The achieved maximum accelerating gradient of four cavities was 28.9 MV/m in average. The Q_0 values at high fields (> 20 MV/m) show a steep drop due to field emission, and strong radiation levels of x-rays were observed, (Limitation of the x-ray sensor is 100 mSv/h). After the qualification, four cavities were covered with a magnetic shield, and they were joined with a titanium helium jacket by TIG-welding, as shown in Fig 2. There are two types of the helium jacket with a different tuner location; one type is at the centre, and another type is at the end. The tuner location at the end was designed in order to avoid the influence of frictions at the supporting tubs for hanging a cavity.

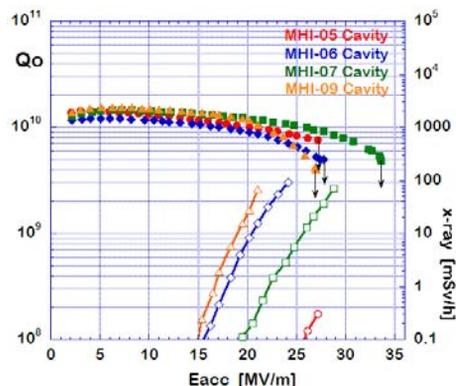


Figure 1: Final cavity performances of four cavities.



Figure 2: Four Tesla-like cavities for S1-Global.

INPUT COUPLERS

The STF-I input couplers [2] used for the STF phase-1.0 had a simple structure with no variable coupling, and Tristan-type coaxial ceramics disks are used for the cold and warm rf windows. Several improvements were made in the STF-II input couplers for the S1-Global cryomodule. Two pairs of the STF-II input couplers consisting of cold and warm parts are shown in Fig. 3. Main features of the STF-II coupler are summarised as follows:

- Bellows were attached at the antenna tip of the inner conductor, so that the variable coupling of $\pm 30\%$ will be available.
- RF characteristic impedance is 41.5Ω , because the diameter of the inner conductor was enlarged in order to insert a mechanism for the variable coupling inside the inner conductor.
- Thermal anchors at 5 K and 80 K were improved to suppress heat losses more efficiently.

* eiji.kako@kek.jp

- Doorknob transition was modified to the compact size to reduce the total length to connect with a waveguide system.

RF conditioning of the STF-II couplers was carried out at the test stand with a 5-MW pulsed klystron, as shown in Fig. 4. Considerable long conditioning time for 30~80 hours was needed for processing up to 1 MW in a short pulse-width of 10 μ s. Finally, conditioning in a long pulsed operation with 1.5 ms and 5 Hz was performed.



Figure 3: STF-II input couplers for S1-Global.

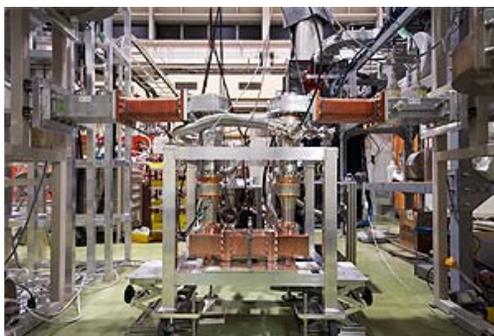


Figure 4: Set-up of high power test stand.



Figure 5: String assembly of four Tesla-like cavities.

CAVITY STRING ASSEMBLY

Outside surface of four cavities and four input couplers were carefully rinsed by a car washer at high water pressure in the entrance of a clean room. Cavity string assembly of four Tesla-like cavities was carried out in the class 10 clean room, as shown in Fig. 5. First of all, alignment of height and rotation of the four cavities was performed. Attachment of input couplers with a cold rf window and HOM pick-up antennas, connection with a bellow duct between two cavities and installation of a gate-valve in an end beam-tube were carried out. After pumping and vacuum leak-check of the string cavities, argon gas was introduced very slowly for approximately 20 hours up to an atmospheric pressure.

TUNER ASSEMBLY

At an outside area of a clean room, attachment of frequency tuning system and alignment of four cavities were carried out. A frequency tuning system as shown in Fig. 6 consists of a slide-jack tuner for a mechanical slow tuning and a piezo tuner for an electrical fast tuning to compensate Lorentz force detuning during an rf pulse.



Figure 6: Attachment of a slide-jack and a piezo tuner.

CRYOMODULE ASSEMBLY

At a cryomodule assembly area, the string cavities were hung on a helium gas return pipe as shown in Fig. 7. Then, the string cavities were covered with 5 K and 80 K thermal shields. An assembled cold mass including four Tesla-like cavities was inserted into a vacuum vessel. The completed Cryomodule-A was installed in the STF tunnel.



Figure 7: String cavities hung on a He gas return pipe.

The Cryomodule-A was combined with the Cryomodule-C including four TESLA cavities from DESY and FNAL with different types of tuning system, [1]. They were connected with a cold box for supplying liquid helium and liquid nitrogen. One of the end beam-tubes in the string cavities was joined with a pumping system. Warm parts of the four STF-II input couplers were assembled in a simple clean-booth. All process of assembling the S1-Global cryomodule completed on schedule in the end of May, 2010, as shown in Fig. 8.



Figure 8: S1-Global cryomodule in the STF tunnel.

LOW POWER RF TESTS

After the first cool-down of the cryomodule, low power RF tests were carried out at 2 K. Variable coupling range of the input couplers was measured as shown in Fig. 9 (left), and the external Q value (Q_{in}) was adjusted to 3×10^6 . Frequency tuning range of the slide-jack tuners was measured as shown in Fig. 9 (right), and the resonant frequency of an accelerating mode was adjusted to 1300.000 MHz. However, a tuning system in the A4/MHI-09 cavity became uncontrollable during the measurement, and the frequency was not able to change at 1299.950 MHz. The cause was due to mechanical trouble of a rotating feed-through connecting with a drive shaft, and this was replaced with new one after warm-up. Characteristics of single pulse response driven by a piezo tuner were measured in four Tesla-like cavities, as shown in Fig. 10. A high voltage type of piezo elements (max. 1000 V) was used for the piezo tuner, and the applied voltage was 470 V in this case. Obtained frequency shift was 270 Hz in two cavities and 450 Hz in two cavities. These values are enough to compensate Lorentz force detuning at 30 MV/m. Mechanical vibration modes were measured as shown in Fig. 11, and the dominant modes were different in each four cavity.

SUMMARY

The S1-Global cryomodule including four Tesla-like cavities with a slide-jack/piezo tuner and a STF-II input coupler was assembled, and then it was installed in the STF tunnel. The first cool-down tests of the cryomodule and low power rf tests of four Tesla-like cavities were successfully carried out.

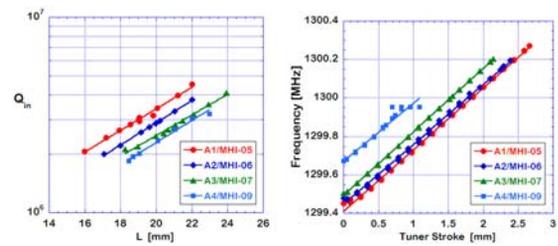


Figure 9: Variable coupling of four STF-II input couplers (left) and tuner stroke of a slide-jack tuners in four Tesla-like cavities (right).

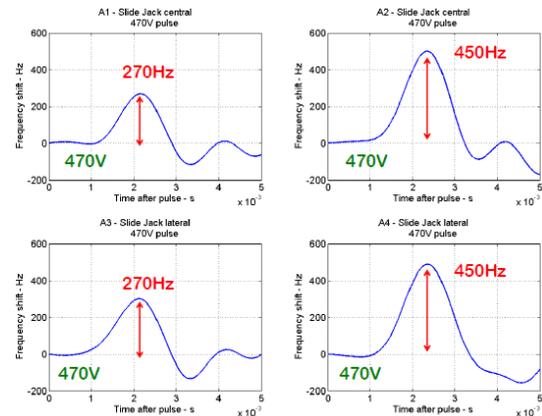


Figure 10: Characteristics of single pulse response driven by a piezo tuner in four Tesla-like cavities.

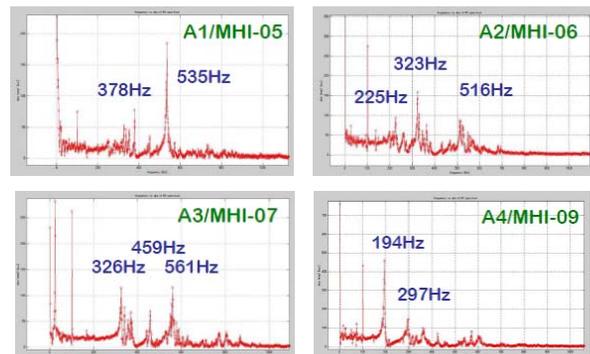


Figure 11: Measurements of mechanical vibration modes in four Tesla-like cavities.

REFERENCES

- [1] N. Ohuchi, et al., "S1-Global Collaborative effort", LINAC'10, Tsukuba, Japan (2010) MO302, in this conference.
- [2] E. Kako, et al., "Cryomodule Tests of Four Tesla-like Cavities in the STF Phase-1.0 for ILC", PAC'09, Vancouver, BC, Canada (2009) TU3RAI04.
- [3] Y. Yamamoto, et al., "Recent results of 1.3 GHz 9-cell Superconducting Cavities in KEK-STF", LINAC'10, Tsukuba, Japan (2010) THP018, in this conference.