PREPARATION STATUS OF CRYOMODULE TESTS OF TESLA-LIKE CAVITIES IN S1-GLOBAL PROJECT AT KEK

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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 for cool-down tests and high power rf tests. The current preparation status is reported.

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 cryomodule (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 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 is scheduled in June, 2010. The component test results of the cavities, input couplers and tuners, and the efforts for the cryomodule tests are described in this paper.

TESLA-LIKE SC CAVITIES

Qualification in the vertical tests of five Tesla-like cavities was carried out [3, 4], and the final cavity performance of four cavities selected for S1-Global cryomodule is shown in Fig. 1. The achieved maximum accelerating gradient of four cavities was 28.9 MV/m in average. The Qo values at high fields (> 20 MV/m) show a steep drop due to field emission, and the radiation levels of x-rays were also strong, (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. These tuner performances will be compared in the cryomodule tests.

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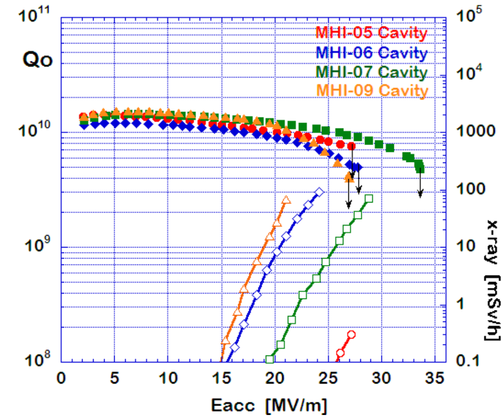

Figure 1: Final cavity performances of four cavities.

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

INPUT COUPLERS

The STF-I input couplers 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. The schematic drawing and the set-up of the high power test stand 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 +/- 30% will be available.
- RF characteristic impedance is 41.5 Ω, 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.
- Doorknob transition was modified to the compact size to reduce the total length to connect with a waveguide system.

RF conditioning of the couplers was carried out at the test stand with a 5-MW pulsed klystron. The conditioning results of two sets of the STF-II couplers are summarised in Table 1. Considerable long conditioning time was needed in a short pulse-width processing.

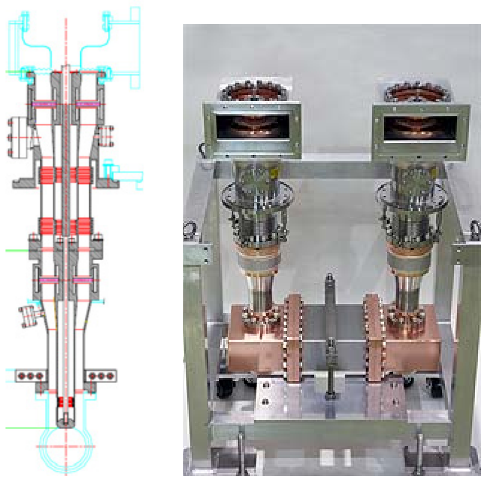

Figure 3: STF-II input couplers for S1-Global.

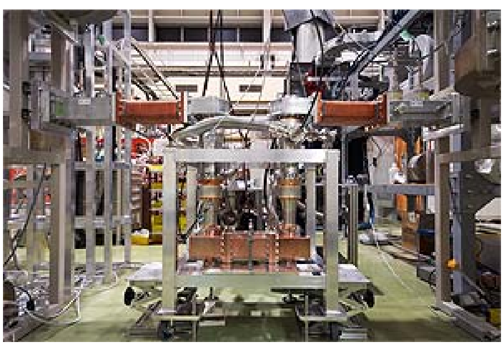

Figure 4: Set-up of high power test stand.

Table 1: RF conditioning of STF-II input couplers

Pulsed operation	#1 & #2 couplers max. Prf,	time	#3 & #4 couplers max. Prf,	time
5 μs, 1-5 Hz	1500 kW,	33 h	--	
10 μs, 1-5 Hz	1230 kW,	47 h	1080 kW,	33 h
20 μs, 5 Hz	--		1140 kW,	1 h
30 μs, 5 Hz	1010 kW,	5 h	1120 kW,	2 h
60 μs, 5 Hz	1060 kW,	4 h	--	
0.1 ms, 5 Hz	950 kW,	6 h	1050 kW,	7 h
0.2 ms, 5Hz	880 kW,	6 h	--	
0.5 ms, 5 Hz	820 kW,	4 h	800 kW,	14 h
1.0 ms, 5 Hz	810 kW,	6 h	--	
1.5 ms, 5 Hz	750 kW,	8 h	270 kW,	6 h
Total time	119 hours		63 hours	

CAVITY STRING ASSEMBLY

Outside surface of four cavities and four 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.

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

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 piezo tuner.

After the attachment of the tuning system, rf measurements of four cavities were carried out to check a cavity resonant frequency and a sensitivity of frequency change by the slide-jack tuner, as summarized in Table 2. The sensitivity ($\Delta f / \Delta L$) of the frequency change was within 314~349 kHz/mm. The resonant frequency was 1297.25±0.1 MHz at room temperature under filling Ar gas at 1 bar in the cavities. Since the resonant frequency changes by pumping both cavities and a vacuum vessel, and cooling-down from room temperature to 2 K, finally, the resonant frequency in cryomodule tests will be set to 1300.000 MHz at 2 K.

Table 2: Cavity resonant frequency and sensitivity of frequency change at room temperature.

Cavity	Resonant frequency (Ar gas at 1 bar)	Frequency change $\Delta f / \Delta L$
MHI-05	1297.174 MHz	317 kHz//mm
MHI-06	1297.184 MHz	321 kHz/mm
MHI-07	1297.288 MHz	314 kHz/mm
MHI-09	1297.338 MHz	349 kHz/mm

CRYOMODULE ASSEMBLY

At a cryomodule assembly area, the string cavities were hung on a helium gas return pipe as shown in Fig. 7, and the 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, as shown in Fig. 8. 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, as shown in Fig. 9. All process of assembling the S1-G cryomodule finished on schedule in the end of May, 2010. The first cool-down and cold tests will be started in June.

Figure 7: String cavities under the gas return pipe.

Figure 8: Installation in the STF tunnel.

Figure 9: Assembly of warm parts for input couplers.

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 cool-down tests of the cryomodule and high power rf tests of the four Tesla-like cavities are scheduled to compare their performances with the TESLA cavities from DESY and FNAL.

REFERENCES

[1] N. Ohuchi, et al., "Construction of the S1-global Cryomodule for ILC", IPAC'10, Kyoto, Japan (2010) WEPE008, 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., "Summary of Vertical Tests for S1-Global Project in KEK-STF", IPAC'10, Kyoto, Japan (2010) WEPE012, in this conference.

[4] K. Watanabe, et al., "Surface Inspection on MHI-01~09 Cavities", IPAC'10, Kyoto, Japan (2010) WEPEC032, in this conference.