TESTS RESULTS OF THE BETA 0.07 & BETA 0.12 QUARTER WAVE RESONATORS FOR THE SPIRAL2 SUPERCONDUCTING LINAC

G. Olry, S. Bousson, T. Junquera, J. Lesrel, G. Martinet, D. Moura, H. Saugnac, P. Szott, CNRS/IN2P3/IPNO, Orsay, France
P. Bosland, P-E. Bernaudin, G. Devanz, CEA/DAPNIA/SACM, Saclay, France

Abstract

New developments and tests have been carried out on low beta (0.07) and high beta (0.12) 88 MHz superconducting Quarter Wave Resonators. These resonators will be installed in the Linac driver of the SPIRAL2 facility, respectively in the low beta section, composed of cryomodules A (developed at CEA-Saclay) and the high beta section composed of cryomodules B (developed at IPN-Orsay). Both resonators' types will be equipped with the power coupler developed at LPSC-Grenoble and designed for a maximum power of 20 kW. RF tests results of the prototype cavities are reported. The fabrication of the 2 cryomodules prototypes, fully equipped, is in progress in order to be ready for high power RF tests at 4.2 K at the beginning of year 2007.

BETA 0.07 QUARTER WAVE RESONATOR

First tests (Figure 2, black dots) of the prototype (Figure 1) have been carried out in 2005 and have been reported in [1]. The cavity achieved Eacc max=9.5 MV/m for 4.5 W dissipated power, largely exceeding the SPIRAL2 requirements, i.e. Eacc=6.5 MV/m for $P_{dissipated}$<10 W (NB: Lacc=βλ=0.24 m).

Nevertheless, the cavity performances were limited by a quench due to a defect located on the NbTi removable bottom plate.

Figure 1: Beta 0.07 QWR inside the clean room during the High Pressure Rinsing process.

New Tests in 2006

Following these good results and in order to improve the performances, a new chemistry of the bottom plate (150 µm instead of 20 µm) was done and the cavity has been baked-out "in situ".

Before the bake-out, the first test (Figure 2, green triangles) showed an improvement of the Eacc max to 10.2 MV/m with no thermal quench (RF power limited to 50 W). A strong multipacting barrier has been observed at very low field, preventing any new measurements. One has to note that this phenomenon was also present during all the beta 0.12 cavity tests. So, the cavity had to be warmed up to 300 K then cooled-down at 4K in order to make this phenomenon disappear (Figure 2, yellow triangles). Another multipacting barrier was clearly identified around 1.2 MV/m and easily processed.

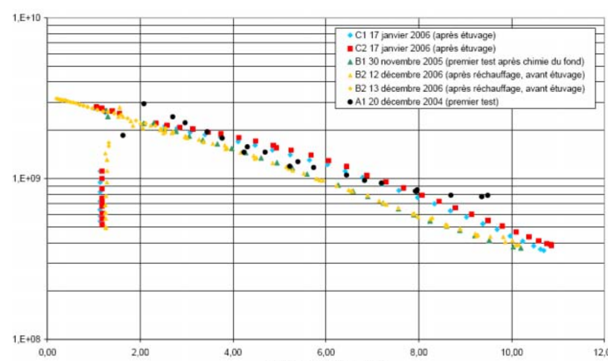

Figure 2: All the RF tests results of the beta 0.07 QWR since 2005.

Last test was done after an "in-situ" bake-out of roughly 100 hours at 110°C. (Figure 2, red squares). RF losses were reduced by 20% at the nominal gradient (3.5 W instead of 4.5 W) and a maximum accelerating field of 10.9 MV/m was reached. The measurements were limited by the RF power.

Pre-Series Cavity Fabrication

A new cavity was ordered this year at ZANON Spa company. Its design is slightly different with respect to the prototype (i.e. a new removable bottom plate shape in copper with sputtered Nb instead of NbTi). The delivery is foreseen in October 2006. Following the tests of this pre-series cavity, the series of 13 cavities should be ordered in March 2007.

The cavity is equipped with its helium vessel and tuning system. It will be tested firstly in vertical cryostat at the end of the year, then in 2007, inside the cryomodule A prototype whose delivery is foreseen in December 2006.

BETA 0.12 QUARTER WAVE RESONATOR

Details on RF and mechanical studies of the prototype have already been presented in, respectively [3] and [4]. The tests results of the prototype have been reported in [1] and [2]. The cavity exceeded the nominal gradient (Eacc max=11 MV/m) and static superconducting plungers were successfully tested.

Figure 2: Beta 0.12 QWR before cold test.

Fabrication of the Helium Tank

End of 2005, we ordered to ZANON Spa company the helium vessel of the cavity. It took 3 months and the cavity was delivered in December 2005 and tested in January 2006 (Figure 2). One has to note that the helium vessel do not cover the bottom of the cavity.

Tests at 4.2 K in 2006

A new preparation was done at CEA/Saclay: a "light" chemistry of 20 µm, followed by a 2-hour rinsing process through the bottom and top ports of the cavity.

The cavity has been tested in vertical cryostat at 4.2 K.

During this test, we have also simulated a heat flux, coming from the 10-kW RF coupler, by sticking a heater directly on the RF port flange (Figure 3). 8 sensors have been set along a cavity bottom radius to record the temperature changes.

No leaks were detected at 300 K and at 4 K.

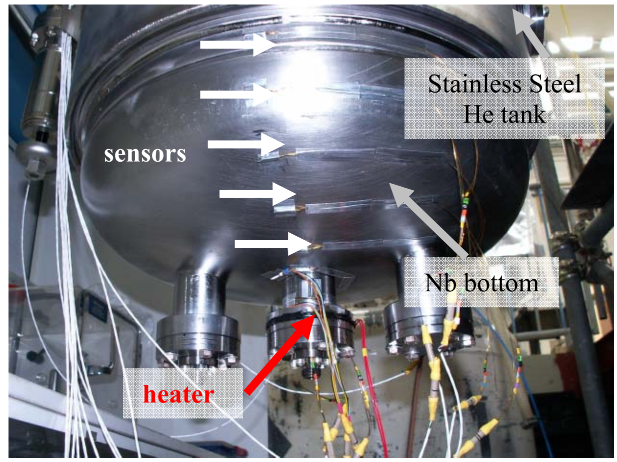

Figure 3: Heater set-up on the cavity bottom.

RF performances of the cavity are shown Figure 4. The intrinsic quality factor is lower than expected: 5.8 10^9 instead of 1.0 10^{10} for the previous tests. As the cavity is not set at the same place inside the cryostat, the residual magnetic field, in the top cavity area, is higher than the last time.

Despite that, Eacc max of 8.6 MV/m was reached, limited by a quench. The SPIRAL2 requirements are still fulfilled with 10 W of dissipated power at 6.5 MV/m.

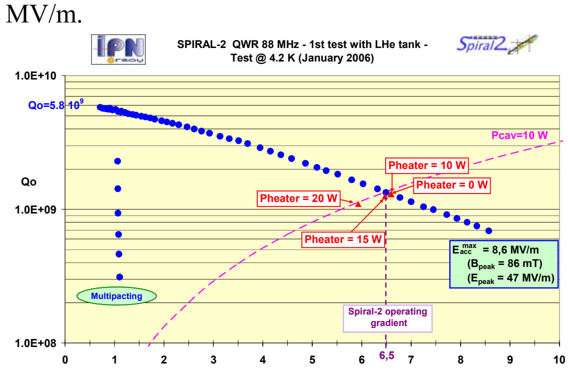

Figure 4: RF results at 4.2 K. Qo measurements with the heater power: red triangles.

After that, we used the heater at 4 different power levels (0, 10, 15 and 20 W) in order to evaluate the consequences on the cavity behaviour at the nominal gradient of 6.5 MV/m. The results are represented by the red triangles in Figure 4. The quality factor of the cavity is affected only from 15 W (4% of extra losses). We tested the cavity up to 20 W of heating without quenching. One can see on Figure 5 that a large part of the cavity bottom is above 9.2 K.

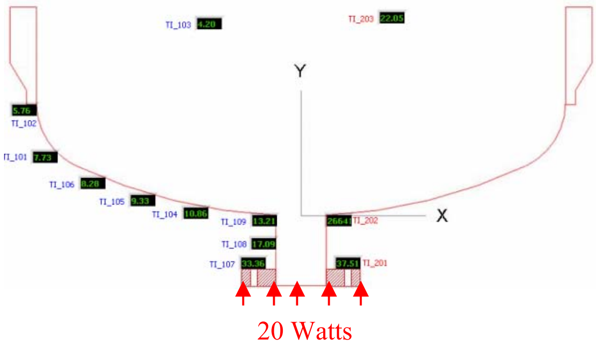

Figure 5: Statement of the temperatures in Kelvin along the cavity bottom for 20 W of heating. One has to consider the values indicated for the blue tags.

This is really a good point because the coupler was designed for less than 1 W of losses at the nominal power of 10 kW. So, we don't need to cool down the bottom of the cavity.

CONCLUSION

The RF designs of the beta 0.07 and beta 0.12 resonators have been validated thanks to excellent performances: 11 MV/m of Eacc max for both cavities and RF dissipated power lower than 10 W at the nominal gradient 6.5 MV/m.

One beta 0.07 cavity and two beta 0.12 pre-series resonators are in construction. They will be tested with their helium tanks and their own tuning system at the beginning of 2007 in their respective cryomodule [5].

ACKNOWLEDGEMENTS

We thank the team of CEA/Saclay for their help during the preparation of the cavity.

REFERENCES

[1] G. Devanz, "SPIRAL2 resonators", SRF 2005, Ithaca, USA, July 2005.

[2] G. Olry et al, "Development of beta 0.12 88 MHz quarter wave resonator and its cryomodule for the SPIRAL 2 project", SRF 2005, Ithaca, USA, July 2005.

[3] T. Junquera et al., "High intensity linac driver for the SPIRAL2 project", EPAC 2004, Lucerne, Switzerland, June 2004.

[4] H. Saugnac et al., "Mechanical stability simulations on a quarter wave resonator for the SPIRAL2 project", LINAC 2004, Lübeck, Germany, August 2004.

[5] H. Saugnac et al, "Status of the beta 0.12 superconducting cryomodule development for the Spiral2 project", these proceedings.