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

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Abstract

SPIRAL2 is a radioactive beams facility, composed of a superconducting linac driver, delivering deuterons with an energy up to 40 MeV (5 mA) and heavy ions with an energy of 14.5 MeV/u (1 mA). This facility is now fully approved by the French government.

New developments and tests have been carried out, at IPN-Orsay, on high beta 0.12, 88 MHz superconducting Quarter Wave Resonators. These resonators will be installed in the high beta section of the LINAC driver. RF tests results of the prototype cavity are reported. The fabrication of 2 pre-series cavities and their cryomodule is in progress in order to be ready for high power RF tests at 4.2 K at the beginning of 2007.

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, intended for frequency tuning, were successfully tested.

Fabrication of the Helium Tank

End of 2005, we ordered to the ZANON Spa company the helium vessel of the cavity. Manufacturing took 3 months and the cavity was delivered in December 2005 and tested in January 2006 (Figure 1). The helium vessel is in Stainless Steel and do not cover the bottom of the cavity (Figure 3).

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 at IPN Orsay in vertical cryostat at 4.2 K only. During this test, we have 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 4.2 K.

RF performances of the cavity are shown in Figure 2. The intrinsic quality factor is lower than expected: $5.8\ 10^{9}$ instead of $1.0\ 10^{10}$). In fact, as the cavity is not set at the same place inside the cryostat, so, the residual magnetic field, in the top cavity area, is higher than for the previous tests.

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 1: Beta 0.12 QWR before cold test at 4.2 K.

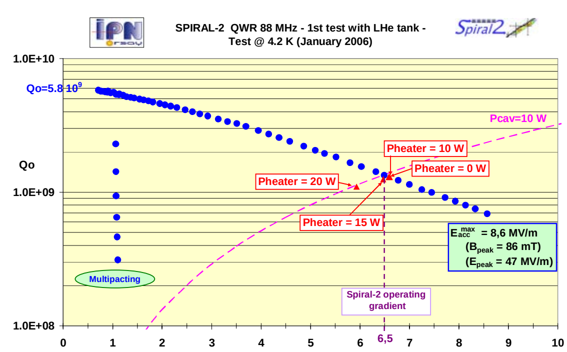

Figure 2: RF results at 4.2 K. Red triangles: Qo measurements with several deposited powers on the RF coupler port.

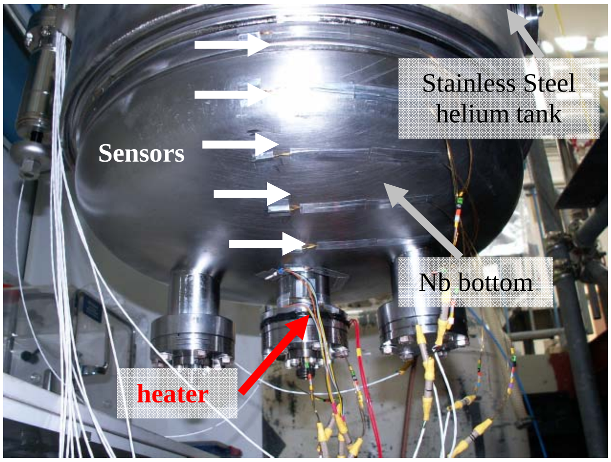

Figure 3: Heater on the cavity bottom.

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 RF performances at the nominal gradient of 6.5 MV/m. The results are represented by the red triangles in Figure 2. The quality factor of the cavity is affected only from 15 W (4% of extra losses). 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.
We tested the cavity with a maximal heating load of 20 W without quenching. One can see on Figure 4 that a large part of the cavity bottom is above 9.2 K.

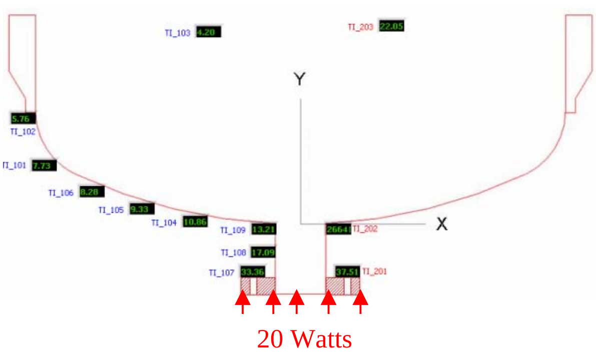

Figure 4: Statement of the temperatures (in Kelvin) along the cavity bottom for a heat load of 20 W. One has to take into account only the values indicated for the blue tags.

Fabrication of the Pre-series Resonators

The two next resonators are being manufactured by the Accel company. The delivery is foreseen in December and the first cold tests in February and March 2007.

These pre-series resonators are designed with a more efficient stiffener (Figure 5) to reduce the frequency shift due to the helium bath pressure variations (i.e. 16 Hz/mbar measured with the prototype). The ring is directly welded on the Helium vessel and the cavity body. This technical solution requires the use of Titanium for the helium vessel instead of Stainless Steel as for the prototype.

But, the main concern for these cavities remains the presence of a multipactor (MP) barrier at a very low gradient, a few tenth of kV/m, which could not be easily processed. That why, the design of the pre-series resonators includes also a new shape in the electrical area in order to reduce this effect.

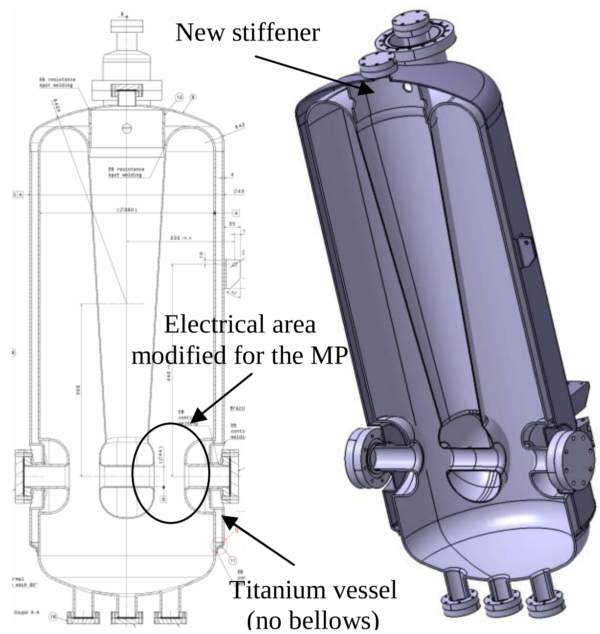

Figure 5: The pre-series Spiral 2 beta 0.12 QWR.

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A first prototype cryostat (Figure 6) is being manufactured on the basis of the general concept defined during the Spiral 2 APD [2].

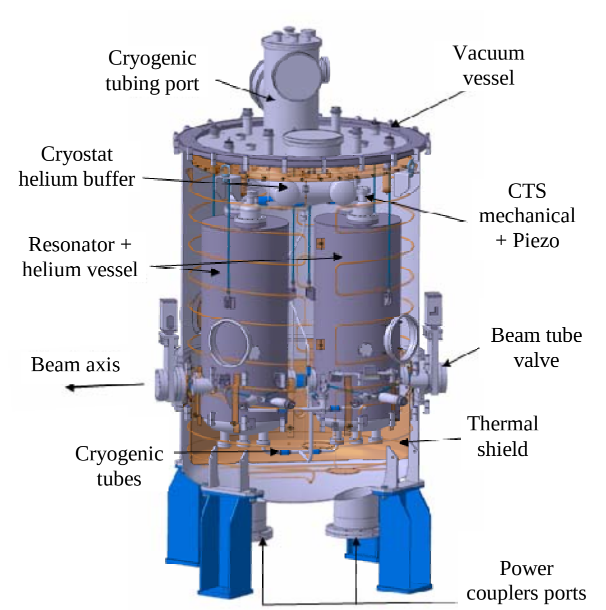

Figure 6: Spiral 2 beta 0.12 prototype cryomodule.

The different sub components are manufactured in several companies and will be assembled at IPN Orsay in the CEA/LAL/IPN common facility, called “Supratech”. The beginning of the assembly is planned for february 2007. The cryogenic validation tests of the fully equiped cryomodule (cavities, power couplers, cold tuning systems, alignement set up…) will be performed from April 2007 to June 2007.

The cryomodule test bench is under fabrication at IPN. It will also allow to validate the 10 kW and 20 kW solid state RF amplifiers prototypes and a Spiral 2 cryogenic cold valves box prototype. The aim of these tests will be to validate the cryomodule as a whole and to determine the mounting and the alignement procedures and the cryogenic and cavity tuning command controls parameters.

The tests and the “supratech” facility for the assembly will be used for the production of the 9 beta 0.12 cryomodules. This facility will be equipped with a 85 m² clean room, featuring an HPR installation in a 45 m² class 10 area (Figure 7). The clean room has been ordered and is planned to be operationnal in december 2006. A chemical etching installation, as well as a 20 l/h liquefier are respectively forseen for the middle of 2007 and the beginning 2008.

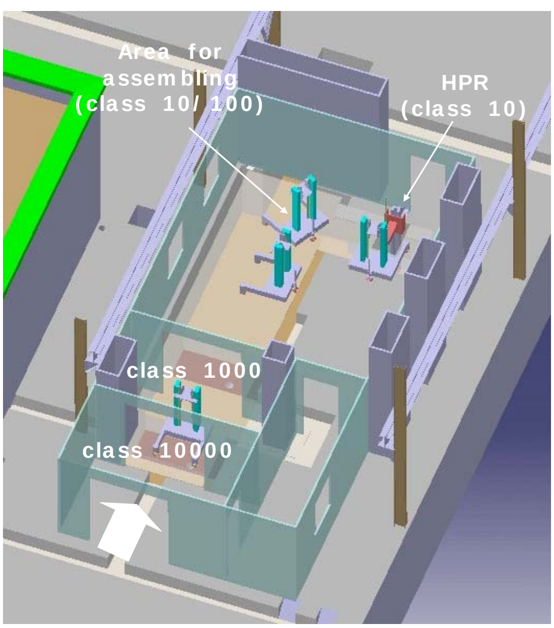

Figure 7: Clean room of the “Supratech” facility, at IPN Orsay.

CONCLUSION

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

Two beta 0.12 pre-series resonators are in construction. They will be tested with their Titanium helium vessel and their own tuning system at the beginning of 2007 in vertical cryostat first then, in the prototype cryomodule.

ACKNOWLEDGMENTS

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