Tests status of the SPIRAL 2 Low Beta Cryomodules

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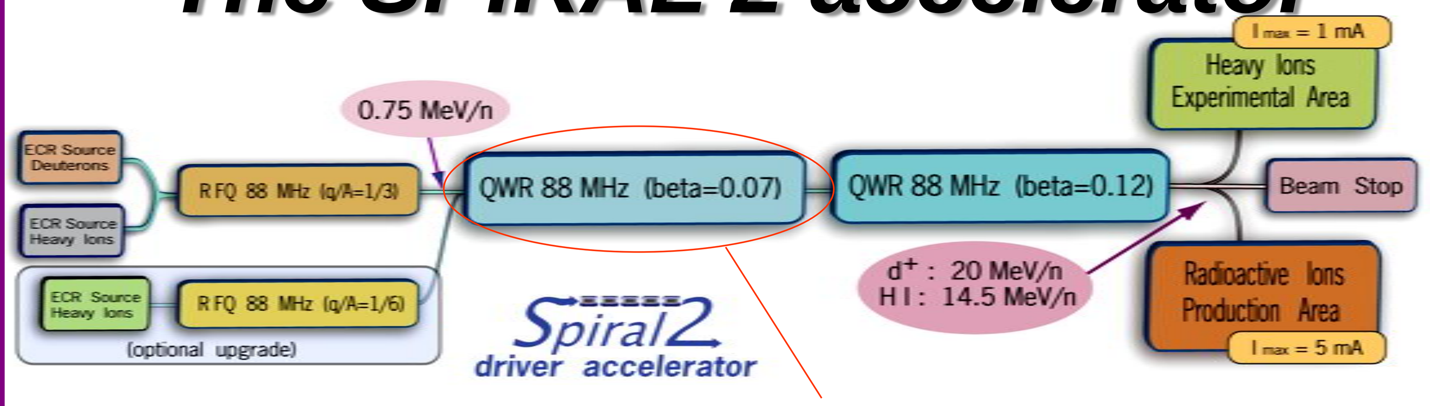
Summary

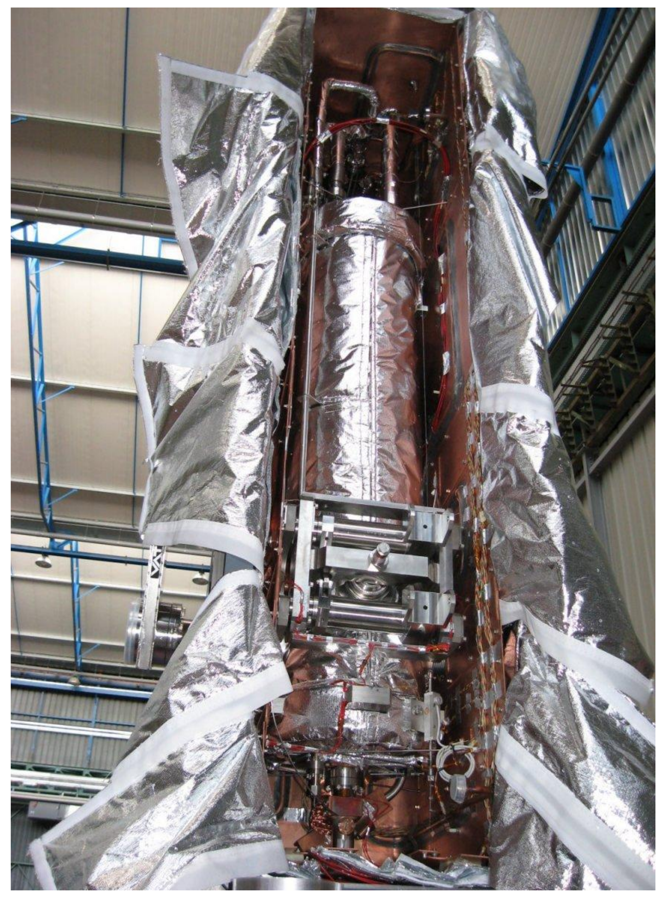
The Irfu institute of CEA Saclay is in charge of the 12 low beta cryomodules that will be installed on the first section of the SPIRAL 2 superconducting LINAC. Each cryomodule houses a single QWR cavity at 88MHz and b=0.07 cooled with liquid helium at 4.4 K. All components of the cryomodules are manufactured by the industry. The power coupler is provided by LPSC Grenoble. The assembling and tests are performed by the CEA. The RF power tests (P_{max} = 10 kW) were performed on the qualifying cryomodule at the end of 2008 before launching the order of the 11 serial cryomodules. The two first cavities of the series were tested in vertical cryostat before the summer 2009. A summary of these tests and the present status of this project are reported.

The SPIRAL 2 accelerator



Low beta Linac parameter

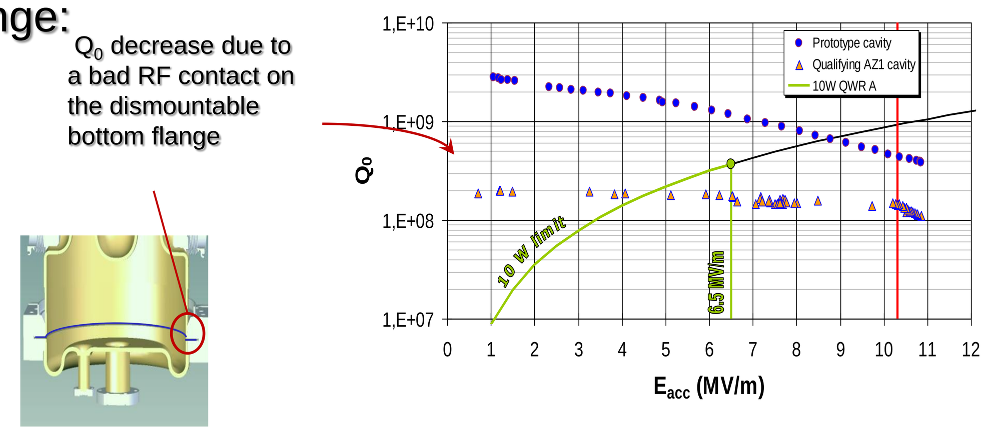
- 12 QWR cavities (β=0.07)
- E_{acc} = 6.5 MV/m
- dynamic losses: 10 W max
- 1 cavity per cryomodule
- 10 kW power coupler
- Mechanical tuning system
- Commissioning schedule: end 2011



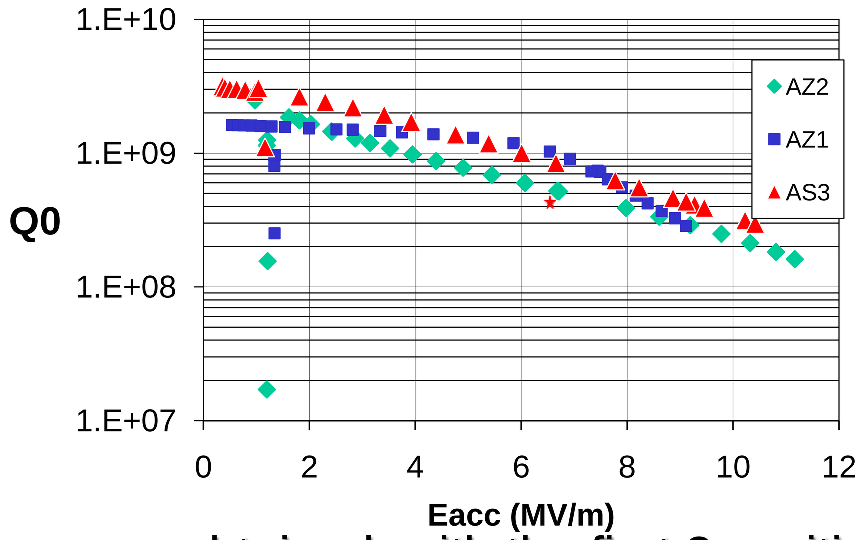
Cryomodule during assembly showing cavity (inside superinsulation), tuning system, thermal shield and outer conductor of the power coupler (at the bottom)

Tests of cavities in vertical cryostat

Low Q_0 value measured during the first tests of the cavity AZ1 due to a poor RF contact on the bottom flange:



After improving the RF contact of the bottom flange, the measured Q curves are as expected



Q curves obtained with the first 3 cavities AZ1, AZ2, AS3

a **copper** bottom flange can be used (see AZ1 curve)

Extra losses @6.5MV/m (nominal gradient):

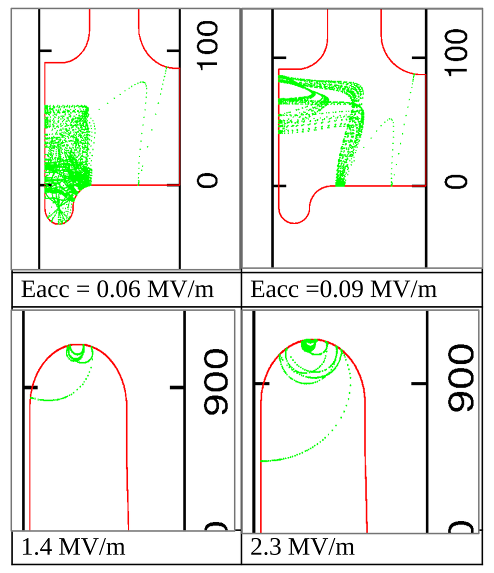
- 0.6W for copper RRR=200
- 1.6 W for normal conducting niobium

P_{cav} ~ 4 W @6.5 MV/m)

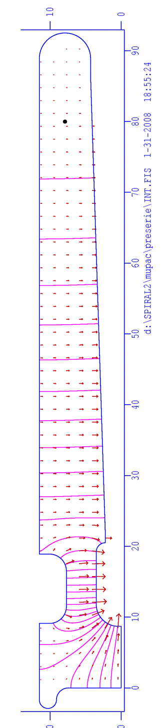
Multipacting

Barriers observed during RF tests:

- *at* very low field: 17 and 53 kV/m => bottom flange no processing -
- at 1.2 and 2.4 MV/m => on the top – processing OK



The MUPAC [5] code was used to compute the MP barriers. The simulation identified 2 barriers on the bottom flange of the cavity at the following gradients: E_{acc}=60 and 90 kV/m.



2D Superfish model of the cavity

__Cavity alignment__:

Movement of the beam axis during cooldown: 1.07 and 1.13 mm measured (1.11 mm estimated)

Future activities

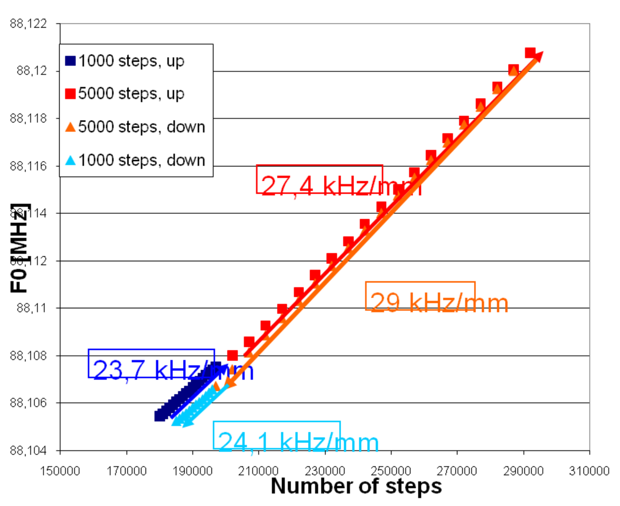
As the first two cavities (AZ2 and AS3) reached the required performances, the following cavities fabrication was shared between the two manufacturer ZANON and SDMS (5 cavities each). Next cavities will be delivered between May and July 2010. They will be tested in vertical cryostat at Saclay after their delivery and before assembly inside the cryomodules.

The planning of the cryomodules delivery is in phase with that of the cavity delivery. The cryomodules components were ordered to ZANON, except the tuning systems that were ordered to the French company Gavard. The first of the series will be delivered at the beginning of 2010, and the 10 following ones will be delivered between July and December 2010.

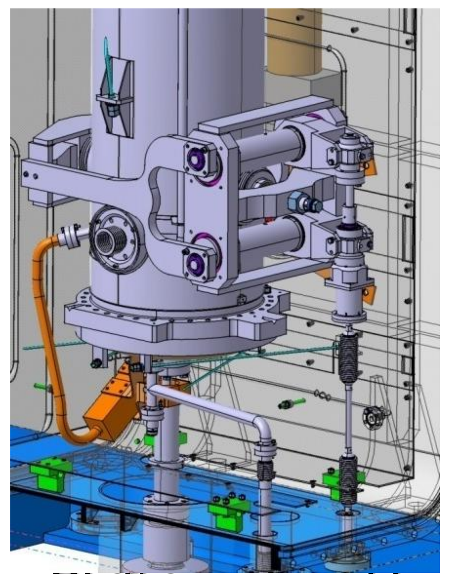
The clean assembling of the cryomodules will be performed in the future large clean room at Saclay that was designed for the assembly of the X-FEL cryomodule (Figure 5).

The qualification cryomodule will be assembled and tested by the end of 2009 and the beginning of 2010. The main upgrade is the new magnetic shield. It consists now in a 1-mm thick foil of Mumetall® placed on the inner face of the cryostat (at room temperature)

Tuning system (CTS) tests



- good linearity: 0.15Hz/motor step
- 29.4 kHz/mm measured for 25 kHz/mm calculated
- small backslash
- tested over a +10kHz amplitude (+25kHz possible)

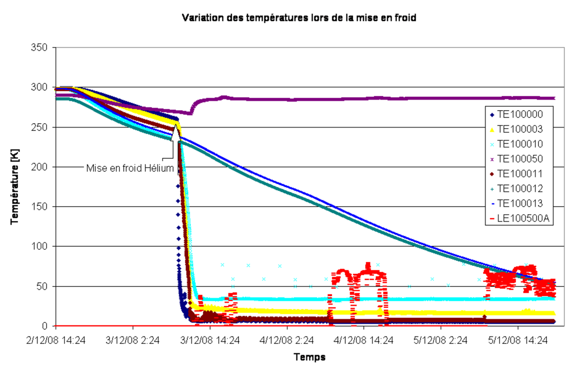


Cavity frequency permanently shifted by 5 kHz during first cooldown. Shift is caused by the differential shrinkage between CTS and cavity => problem solved with a sliding system on one side

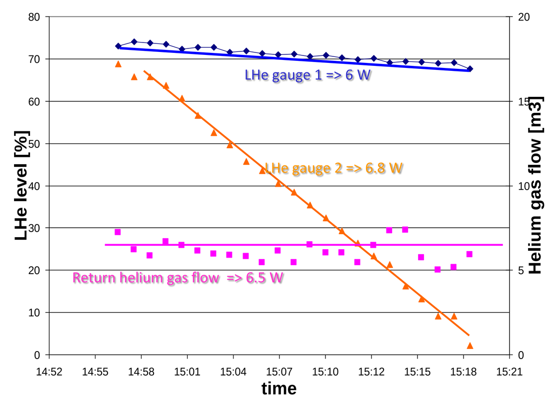
Cryogenic tests

__*Problems:*__

1. Bottom flange of the cavity at T > 14K : cooling system not efficient enough
   => Use of a copper bottom flange (+0.6 W at 6.5 MV/m)
2. LHe level not stable in the helium vessel
   => Modification of the external cryogenic lines
   => Modification of the internal liquid helium inlet



Temperatures during cooling down



Static heat losses at 4K: 6.5 W