PERFORMANCES OF THE TWO FIRST SINGLE SPOKE PROTOTYPES FOR THE MYRRHA PROJECT

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MYRRHA Research and Transmutation Endeavour

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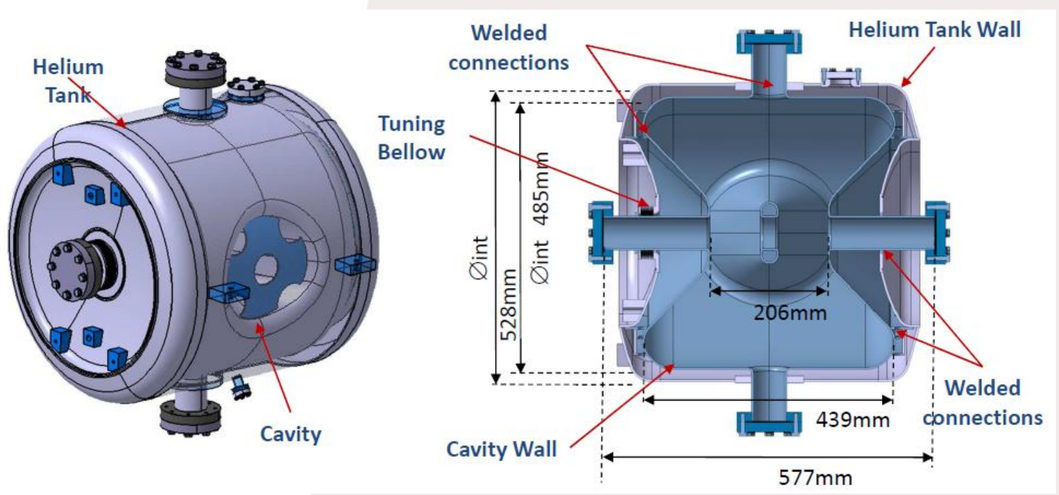
Abstract:

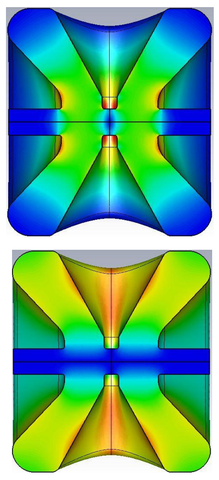
The MYRRHA project aims at the construction of an accelerator driven system (ADS) at MOL (Belgium) for irradiation and transmutation experiment purposes [1]. The facility will feature a superconducting LINAC able to produce a proton flux of 2.4 MW (600 MeV - 4 mA). The first section of the superconducting LINAC will be composed of 352 MHz (beta = 0.37) Single Spoke Resonators (SSR) housed in short cryomodules operating at 2K.
After a brief presentation of the cryomodule design, this paper will aim at presenting the RF performances of the SSR tested in vertical cryostat in the framework of European MYRTE project (MYRRHA Research and Transmutation Endeavour) [2] and compare experimental results (Lorentz forces, pressure sensitivity, multipacting barriers, …) to simulated values.

The SPOKE Resonator design [3]:

- **2 single SPOKE Resonator prototypes built by E. Zanon Spa [4]**



- **RF design made with CST Microwave Studio [5]**

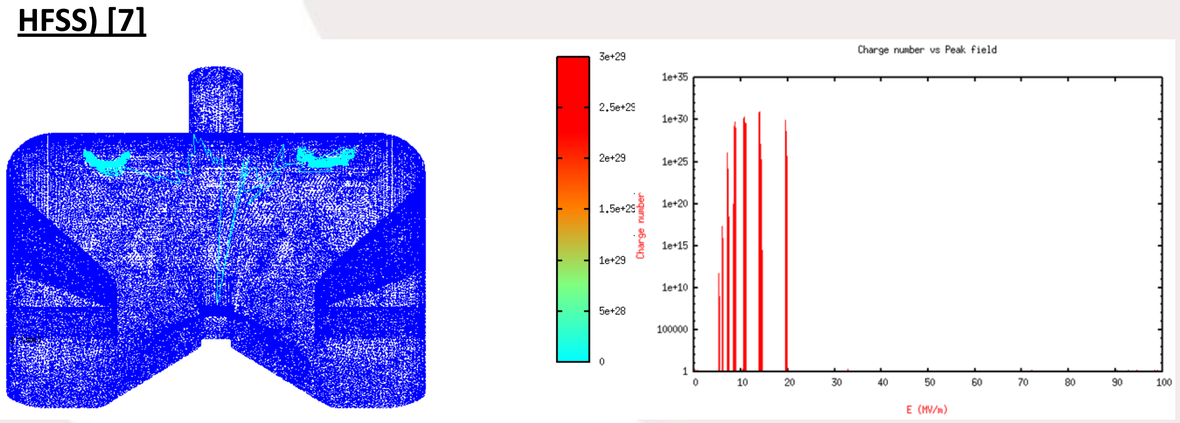


Optimized RF parameters	
Optimal beta	0.37
Vo.T [MV/m] @ 1 Joule & optimal beta	0.693
E_{pk}/E_{acc}	4.29
B_{pk}/E_{acc} [mT/MV/m]	7.32
G [Ohm]	109
r/Q [Ohm]	217
Q_o @ 2K for R_{res}=20 nΩ	5.2 10^9
P_{cav} for Q_o=2 10^9 & 6.4 MV/m [W]	9.35
L_{acc}=0.315m= beta optimal . c . f	

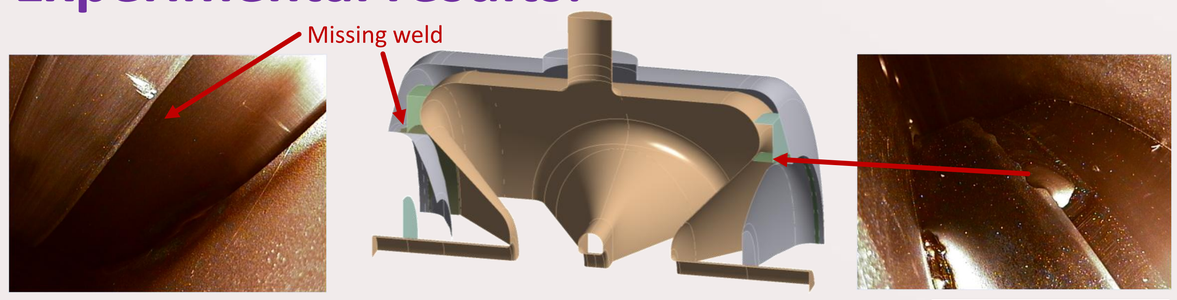
- **Mechanical design [3], [6]**

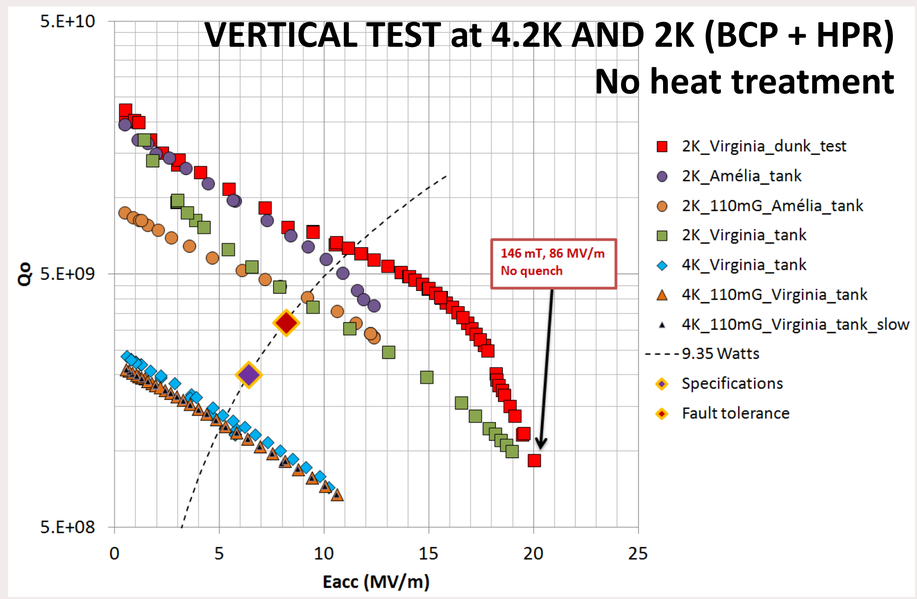
EM/Mechanical parameters	Simulated value	Units
Cavity tuning Stiffness	14.5	kN/mm
Elongation Sensitivity	180	kHz/mm
Sensitivity to pressure (free ends)	+31	Hz/mbar
Sensitivity to pressure (fixed ends)	+23	Hz/mbar
Lorentz force factor (free ends)	-7.7	Hz/(MV/m)^2
Lorentz force factor (fixed ends)	-4.7	Hz/(MV/m)^2
Bandwidth	160	Hz

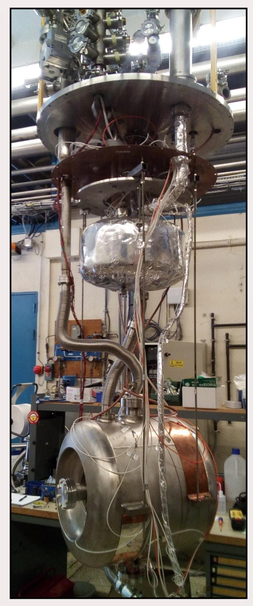
- **Multipacting simulation made with MUSICC3D (EM field map generated by HFSS) [7]**



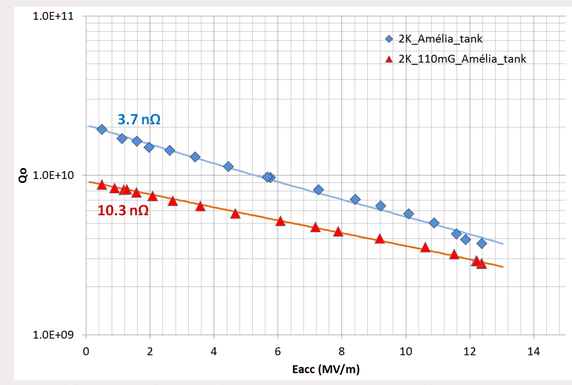
Experimental results:







Cavity	Conf.	T (K)	E_{acc} max (MV/m)	P_c (W)@ 7 MV/m	Sensitivity (Hz/mbar)	Lorentz Factor (Hz/MV/m)	Surface preparation	Field limitation
Amélia	Tank	2	11.9-12.4	3-5	-180	-9.8	BCP (275 µm +HPR) BCP (30 µm + HPR)	Quench
		4	8.2-11.1	30		X		
Virginia	Dunk	2	20.0	3	-236	-8.2	BCP (150 µm +HPR)	Input power
		4	9.1	20		-10.4		
	Tank	2	18.9	5	-155	-7.3	300K thermal cycle (No additional BCP)	Input power
		4	10.5	20		X		



-**Sensitivity to vertical residual magnetic field:**

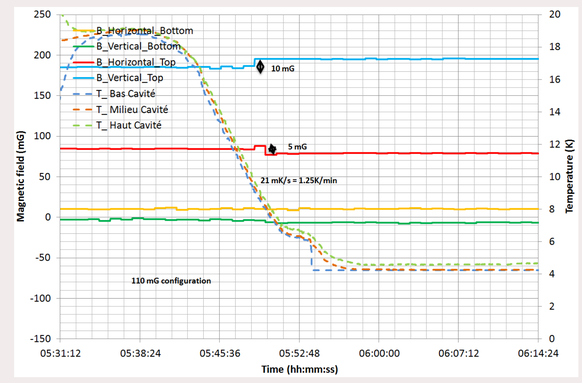
0.045 nΩ/mG (Virginia 4.2K)
0.06 nΩ/mG (Amélia 2K)

- **Theoretical**:

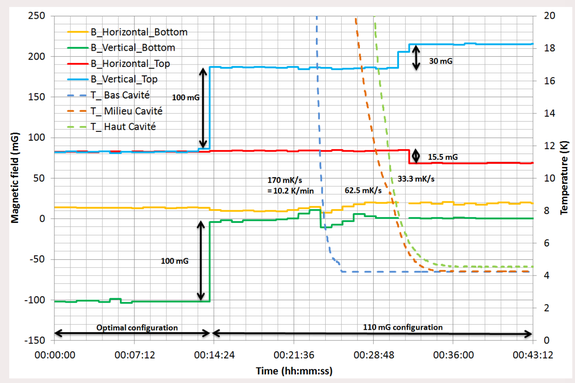
$$R_{res,mag}(2K) = R_n \cdot \frac{H_{ext}}{2 \cdot H_{c2}} = 0.011\, n\Omega/mG$$

- **Effect of cooling speed on flux trapping: visible on magnetic measurement but no effect on Qo.**

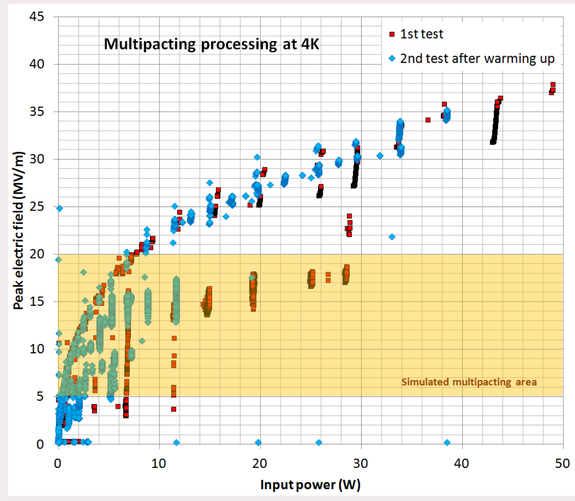
SLOW COOL DOWN

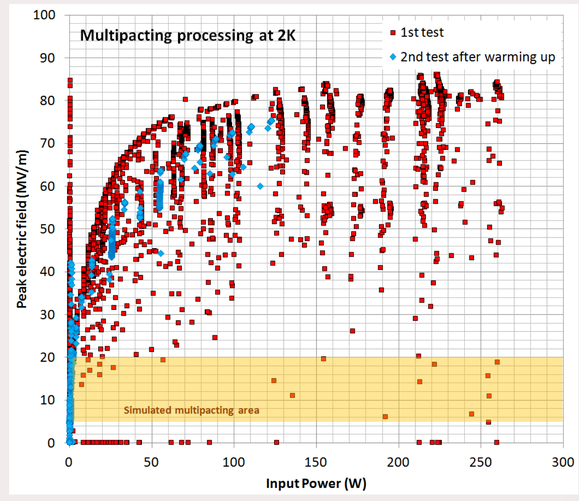


FAST COOL DOWN



- **Multipacting and field emission conditionning**





References:

[1] http://myrrha.sckcen.be
[2] http://myrte.sckcen.be/en
[3] H. Saugnac et al., Spoke cryomodule design , MAX Deliverable number 3.3.
[4] http://www.zanon.com/
[5] https://www.cst.com/products/cstmws
[6] P. Duchesne, internal report.
[7] T. Hamelin, "MUSICC3D : a code for modeling the multipacting", proceedings of the 17th International Conference on RF Superconductivity, Paris, 2013.

Conclusion & perspectives:

Due to missing welds between the cavity and the helium tank, the 2 prototypes show a very high sensitivity to pressure. Frequency regulation and reliability tests foreseen in the future on the cryomodule prototype will not be relevant. 2 new cavities have to be fabricated.
On the other hand, both prototypes show very good RF performances well above specifications with a basic surface preparation (BCP+HPR). As observed, hydrogen degassing will be mandatory to fully recover from Q-disease after a room temperature thermal cycle.
Heat treatment at 650°C of the cavity equipped with its helium tank will be performed in the end of this year in the new furnace recently commissioned at IPNO.