*Work supported by HIM, GSI, BMBF Contr. No. 05P15RFRBA, EU Project MYRTE
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First Performance Test on the Superconducting 217 MHz CH Cavity at 4 K*

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Abstract:

At the Institute for Applied Physics (IAP) of Frankfurt University a superconducting (sc) 217 MHz Crossbar-H-mode (CH) cavity with 15 accelerating cells and a gradient of 5.5 MV/m has been designed. The cavity is the key component of the demonstrator project at GSI which is the first stage to a new sc continuous wave (cw) linac for the production of Super Heavy Elements (SHE) in the future. A successful and reliable beam operation of this first prototype will be a milestone on the way to the proposed linac. After fabrication at Research Instruments (RI) GmbH, Germany, the cavity without helium vessel has been commissioned at the new cryogenic test facility of the IAP with low level rf power at 4.2 K. The results of this first cold test will be presented in this contribution.

Layout of the Cavity

The cavity has a design gradient of 5.5 MV/m which will be achieved by 15 equidistant accelerating cells at an effective length of 612 mm. It is equipped with nine static and three dynamic frequency tuners, a 5 kW cw power coupler and several flanges for surface preparation.

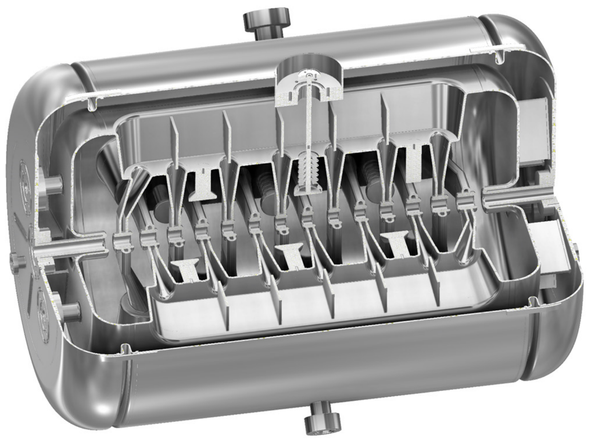


Figure 1: Layout of the sc 217 MHz CH cavity.

Table 1: Parameters of the cavity.

β		0.059
Frequenz	MHz	216.816
Accelerating cells		15
Effective length ($\beta\lambda$)	mm	612
Diameter	mm	409
Tube aperture	mm	18 / 20
Wall thickness	mm	4
Dynamic tuner		3
Static tuner		9
ΔW	AMeV	0.52
G	Ω	52
R_a/Q_0		3240
R_aR_S	kΩ^2	168
E_a	MV/m	5.5
U_a	MV	3.4
E_p	MV/m	34.6
E_p/E_a		6.3
B_p	mT	31.3
B_p/E_a	mT/(MV/m)	5.7

Experimental Setup

The cavity was tested at 4.2 K in a vertical cryostat at the new cryogenic test facility of IAP. During the cold test the helium gas was collected by a recovery system. A 50 W broadband amplifier delivered the forward power to the cavity. Further equipment like the rf generator, the rf control system, scopes, power meter, a network analyzer, a piezo amplifier and a spectrum analyzer was arranged in four racks on top of the radiation cave. The cavity has been provided with seven temperature probes and 60 Thermo-Luminescence-Dosimeter to record field emission. Additionally, a piezo actuator and a piezo sensor was used to analyze the mechanical behavior of the cavity and microphonics, respectively.

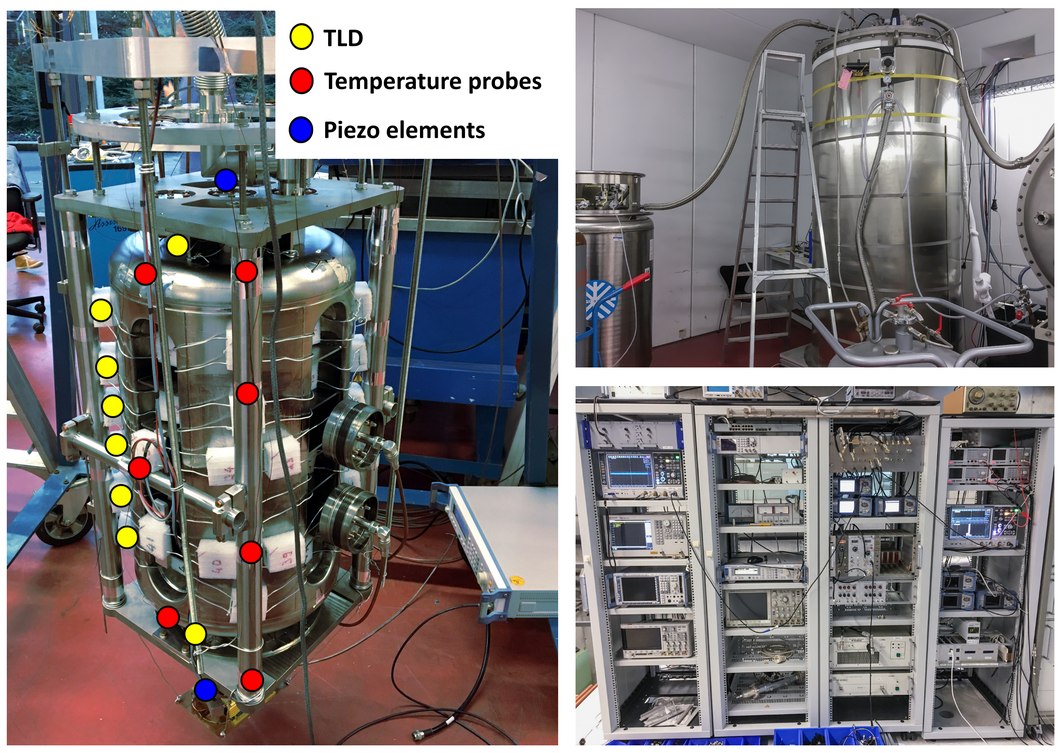


Figure 2: Experimental setup at the new cryogenic test facility of IAP.

Cavity Performance and Long Term Statistics at 4.2 K

Since HPR could only be performed along the beam axis because of technical restrictions by the manufacturer the performance of the cavity is limited by field emission at even low fields. A new HPR installation which is under construction at the moment will allow to rinse each quadrant of the cavity in future. Thereby the performance should be increased significantly. Nevertheless, the design quality factor at 5.5 MV/m could be exceeded by a factor of 2. A maximum gradient of 7 MV/m was reached. Furthermore, the long term VCO measurement at 2 MV/m shows a very stable operation of the cavity.

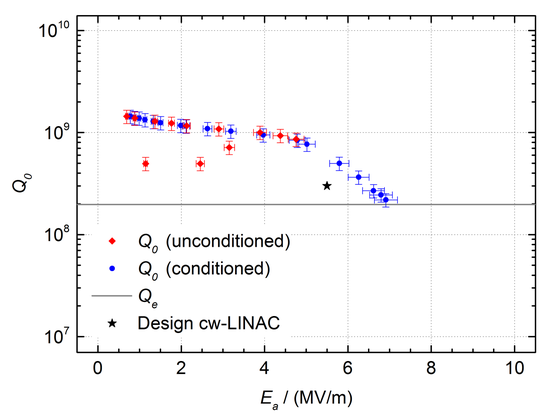


Figure 3: Measurement of Q_0 versus E_a at 4.2 K.

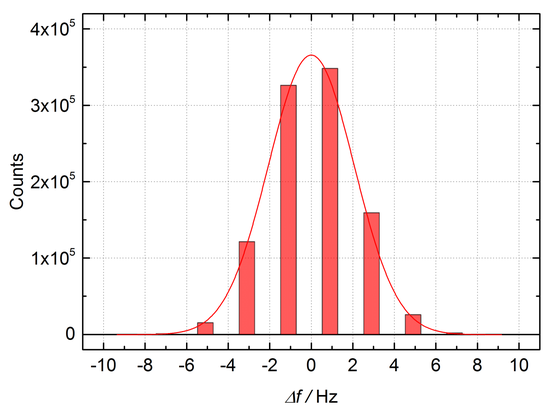
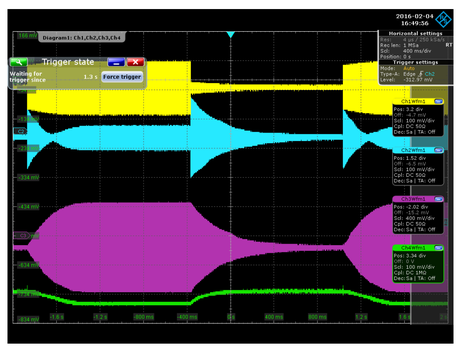


Figure 4: Long term VCO measurement.

Lorentz Force Detuning and Microphonics



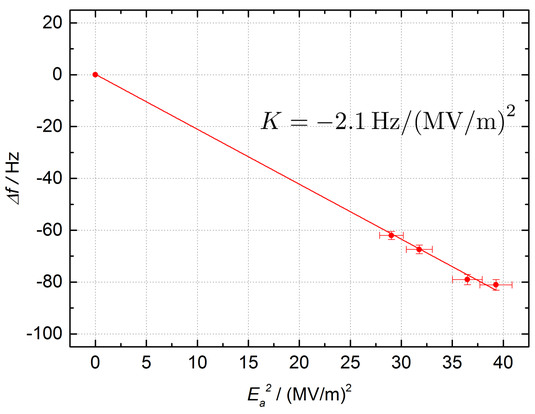


Figure 5: VCO response (green) to LFD at a field level of 5.3 MV/m (left) and corresponding frequency shift (right).

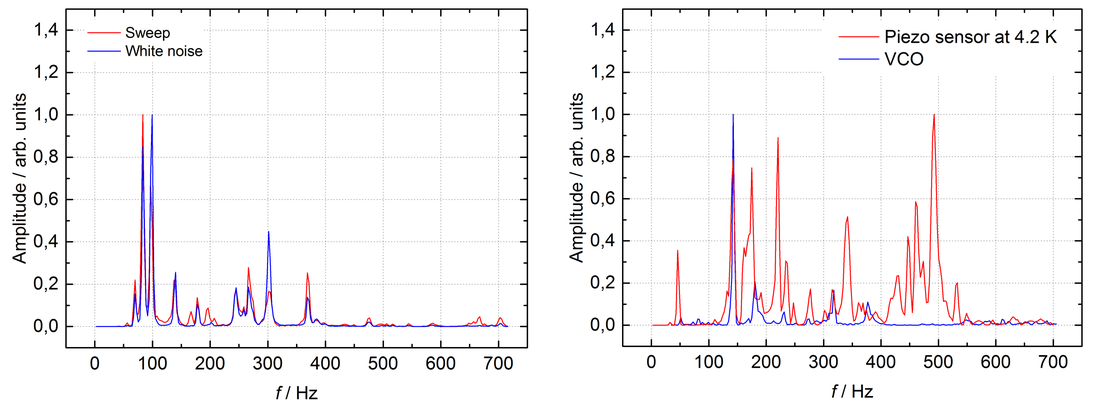


Figure 6: Mechanical modes at room temperature measured with a sprectrum analyzer (left). Mechanical modes and corresponding VCO signal due to an excitation with a harmonic ac voltage at 4.2 K (right).

Summary & Outlook

The sc 217 MHz CH cavity has been successfully tested with low level rf power at 4.2 K. A maximum gradient of 7 MV/m could be reached. Due to insufficient surface preparation because of technical issues the cavity is limited by field emission at even low fields. An optimized HPR installation, which is under construction at the moment, will allow to rinse each part of the cavity. This should lead to a significant increase of the cavity's performance in future.

Nevertheless, in a next step the cavity together with two sc solenoids will be mounted into the new horizontal cryomodule at GSI. A first full performance test of the cavity with beam, which will be provided from the High Charge State Injector, is planned in the 4th quarter of 2016.