COLD POWER TESTS OF THE SC 325 MHz CH-CAVITY*

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Abstract

At the Institute for Applied Physics (IAP), Frankfurt University, a superconducting 325 MHz CH-Cavity has been designed and built and first tests have successfully been performed. The cavity is determined for a 11.4 AMeV, 10 mA ion beam at the GSI UNILAC. Consisting of 7 gaps this resonator is envisaged to deliver a gradient of 5 MV/m. Novel features of this structure are a compact design, low peak fields, improved surface processing and power coupling. Furthermore a tuner system based on bellow tuners attached inside the resonator and driven by a stepping motor and a piezo actuator will control the frequency. In this contribution measurements executed at 4.2 K and 2.1 K at the cryolab in Frankfurt will be presented.

INTRODUCTION

Various international projects demand high beam power, quality and availability, e.g. MYRRHA (**M**ulti Purpose **HY**brid **R**esearch **R**eactor for **H**igh-Tech **A**pplications) [1] and the planned GSI/ HIM advanced s.c. cw Heavy Ion Linac [2]. For the low-β region of such linacs the superconducting CH-cavity has proved to be an appropiate structure being characterized by a small number of drift spaces between adjacent cavities compared to conventional low-β ion linacs [3]. Additionally the KONUS beam dynamics, which decreases the transverse rf defocusing and allows the development of long lens free sections, yields high real estate gradients with moderate electric and magnetic peak fields. At the Institute for Applied Physics, Frankfurt University, a new cavity operating at 325.224 MHz, consisting of 7 cells, β = 0.16 and an effective length of 505 mm (see table 1) has been designed [4] and measured after fabrication and processing at Research Instruments [5].

Table 1: Specifications of the 325 MHz CH-Cavity

β	0.16
frequency [MHz]	325.224
no. of cells	7
length ($\beta\lambda$-def.) [mm]	505
diameter [mm]	352
E_a (design) [MV/m]	5
E_p/E_a	5
B_p/E_a [mT/(MV/m)]	13
G [Ω]	66
R_a/Q_0	1260
R_aR_s [$k\Omega^2$]	80

MEASUREMENT SETUP

At the cryolab of the IAP a measurement setup comprising a vertical cryostat has been installed for various test purposes (see Fig. 1) allowing power measurements at 4 K and 2 K, respectively. The vaporized Helium can be extracted via a port to a recovery system or the cryostat can be pumped out by a roots pump to achieve 2 K (see Fig. 4). The CH-cavity has been provided with four low-temperature probes, 40 **T**hermo-**L**uminescence-**D**osimeter (see Fig. 2) to record field emission events and two piezos for microphonic excitation and detection. Figure 3 shows the equipment for the measurements particularly the 500 W broadband amplifier (left) and the control system (centered).

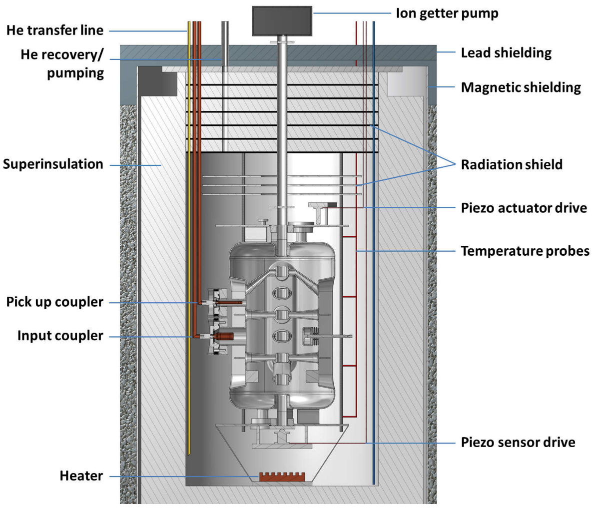

Figure 1: Schematic layout of the vertical croystat setup.

PERFORMANCE RESULTS

After one week of conditioning low multipacting barriers and achieving a pressure of $6 \cdot 10^{-10}$ mbar measurements up to the quench of the cavity have been performed. Figure 4 pictures five different Q vs. E curves beginning with the first test in January 2013 (black curve) [6] with an unprocessed surface and encountering field emission at low fields. The second curve (red) boasts an improvement of the field gradient due to HPR but reveals a Q-value of 10^8 leading to the conjecture of Q-disease. After another thermal cycle with fast cool-down to 4 K ($> 1\,K/min$) the performance improved significantly (blue curve) to gradients up to 8.5 MV/m resulting in voltages of 4.2 MV. Next step was to warm up and bake the cavity at 120°C for 72 h subsequently. The following measurement (purple curve) indi-

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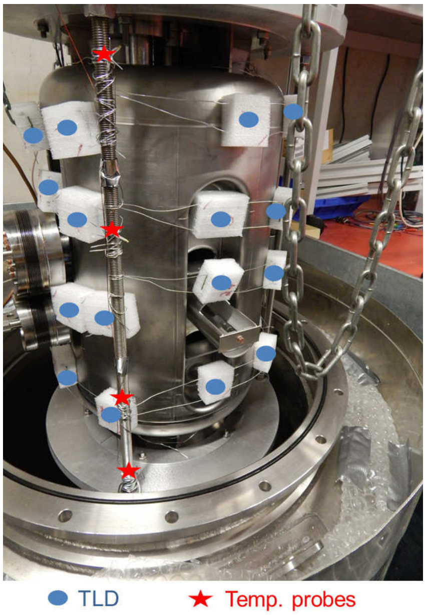

Figure 2: Setup of the cavity with TLDs and temperature probes.

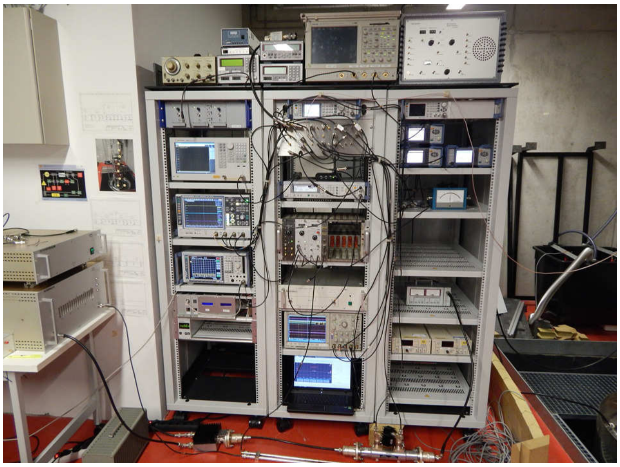

Figure 3: Measurement equipment for the cold tests.

cates a slight decrease in multipacting at higher field levels. By the use of a roots pump Helium temperatures of 3.5 K and 2.1 K, respectively, could be achieved. The corresponding curves (light blue and green) reach a gradient of up to 9.5 MV/m in case of 3.5 K and 14 MV/m at 2.1 K. The quench at the highest field levels is supposedly due to a thermal defect since the degradation of the Q-value is still rather decent. Also the evaluation of the TLDs (see Fig. 6) shows only a small, potential field emitting site located near the bottom area of the cavity.

The VCO voltage has been recorded to accumulate long-term statistics (see. Fig. 7). Thus the frequency variation caused by background noise like pumps, power supplies or helium bubbles could be investigated. The maximum frequency shift compensated by the control system was ±3 Hz.

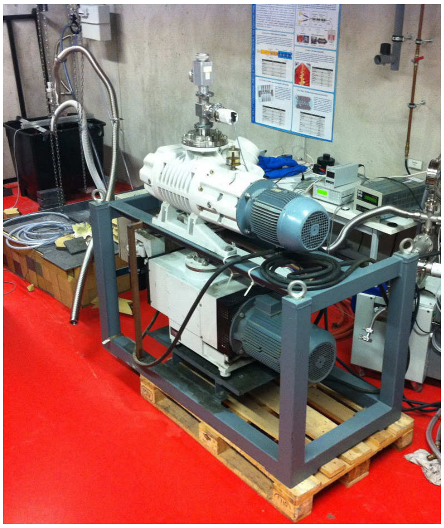

Figure 4: Roots pump for the 2 K setup.

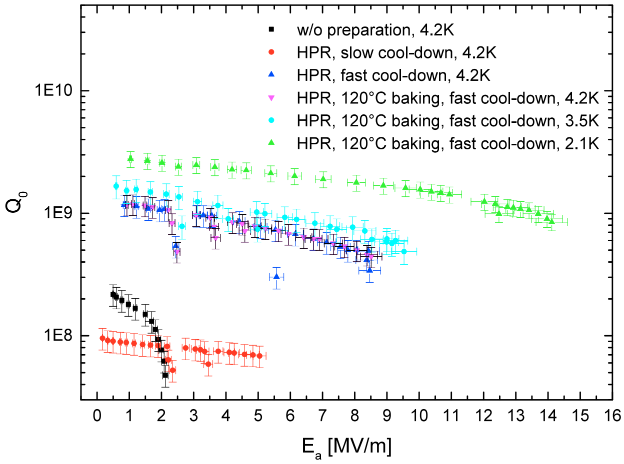

Figure 5: Q vs E curve for various test environments.

Furthermore measurements in pulsed mode have been conducted to study Lorentz-Force-Detuning behaviour. Figure 7 shows an example of the VCO response at a field level of 8.5 MV/m. The according frequency shift compensated by the control system is -435 Hz yielding a LFD factor of -6.1 $Hz/(MV/m)^2$.

CONCLUSION AND OUTLOOK

The cold measurements showed a very promising performance of the CH-cavity with gradients of 8.5 MV/m at 4 K and 14 MV/m at 2 K for a Q of $1 \cdot 10^9$ and $3 \cdot 10^9$, respectively. Next steps are the welding of the helium vessel to the cavity, a final HPR treatment and tests in a large vertical cryostat at the new cryo-bunker at IAP.

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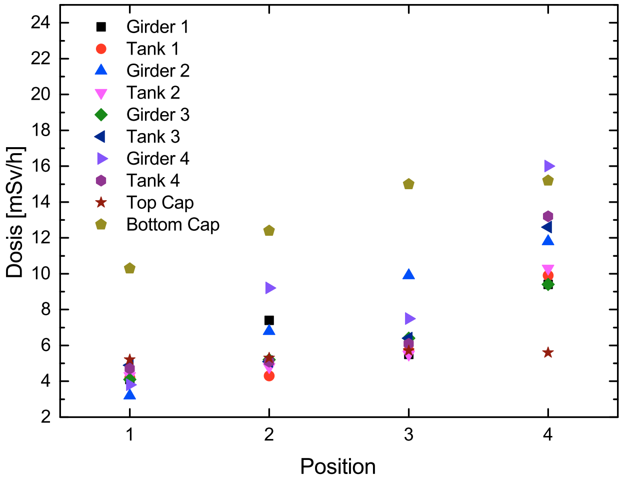


Figure 6: Dosis distribution among the TLDs.

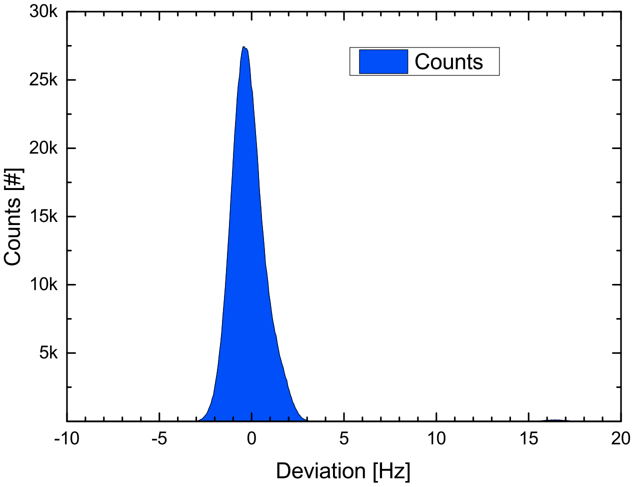
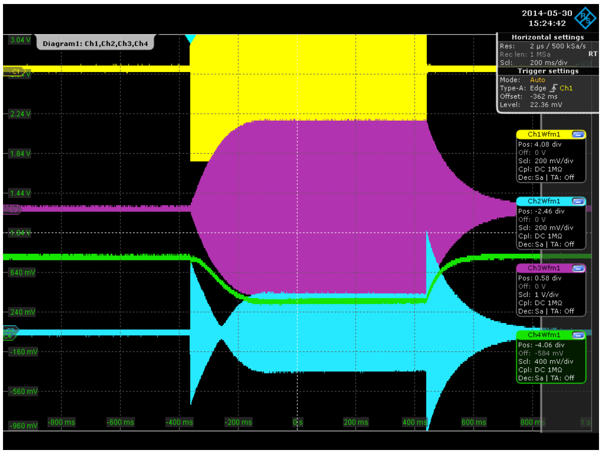


Figure 7: Long-term VCO statistics.



Horizontal settings
Res: 2 µs / 500 kSa/s
Rec len: 1 MSa
Scl: 200 ms/div
Trigger settings
Mode: Auto
Type-A: Edge Ch1
Offset: -362 ms
Level: 22.36 mV

Ch1Wfm1
Pos: 4.08 div
Off: 0 V
Scl: 200 mV/div
Cpl: DC 1MΩ
Dec:Sa | TA: Off

Ch2Wfm1
Pos: -2.46 div
Off: 0 V
Scl: 200 mV/div
Cpl: DC 1MΩ
Dec:Sa | TA: Off

Ch3Wfm1
Pos: 0.58 div
Off: 0 V
Scl: 1 V/div
Cpl: DC 1MΩ
Dec:Sa | TA: Off

Ch4Wfm1
Pos: -4.06 div
Off: -584 mV
Scl: 400 mV/div
Cpl: DC 1MΩ
Dec:Sa | TA: Off

Figure 8: Scope screenshot showing VCO response (green) at 8.5 MV/m pulsed operation.

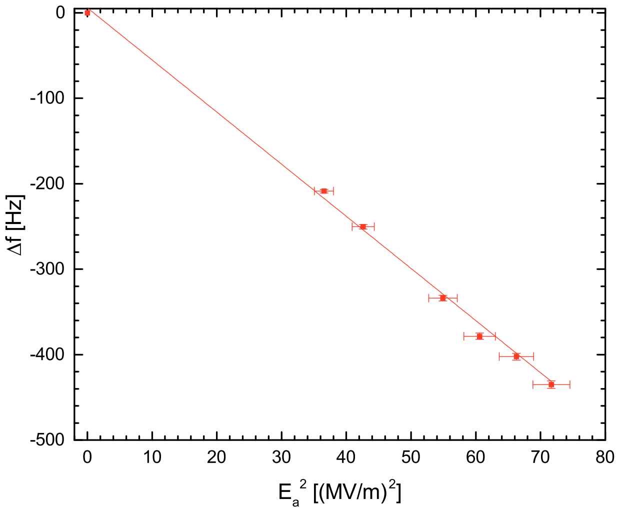


Figure 9: Frequency deviation due to Lorentz-Force-Detuning.

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