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#dziuba@iap.uni-frankfurt.de

Institute for Applied Physics
Max-von-Laue-Straße 1
D-60438, Frankfurt am Main, Germany

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

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First RF Measurements of the Superconducting 217 MHz CH Cavity for the CW Demonstrator at GSI*

F. Dziuba#,1, M. Amberg[1,3], K. Aulenbacher[3,4], W. Barth[2,3], M. Busch[1], H. Podlech[1], U. Ratzinger[1], S. Mickat[2,3]

[1]IAP University of Frankfurt, 60438 Frankfurt am Main, Germany
[2]GSI Helmholtzzentrum, 64291 Darmstadt, Germany
[3]Helmholtz Institut Mainz (HIM), 55099 Mainz, Germany
[4]KPH Mainz University, 55128 Mainz, Germany

Abstract:

Presently, a superconducting (sc) 217 MHz Crossbar-Hmode (CH) cavity is under construction at Research Instruments (RI), Bergisch Gladbach, Germany. Among the horizontal cryomodule and two sc 9.5 T solenoids the cavity is the key component of the cw demonstrator at GSI. To show the operation ability of sc CH cavity technology under a realistic linear accelerator environment is one major goal of the demonstrator project. A successful beam operation of the demonstrator will be a milestone regarding the continuing advanced sc cw linac project at GSI for a competitive production of Super Heavy Elements (SHE) in the future. The fabrication status as well as first rf measurements at room temperature of the 217 MHz CH cavity are presented.

The Superconducting cw Linac Demonstrator at GSI

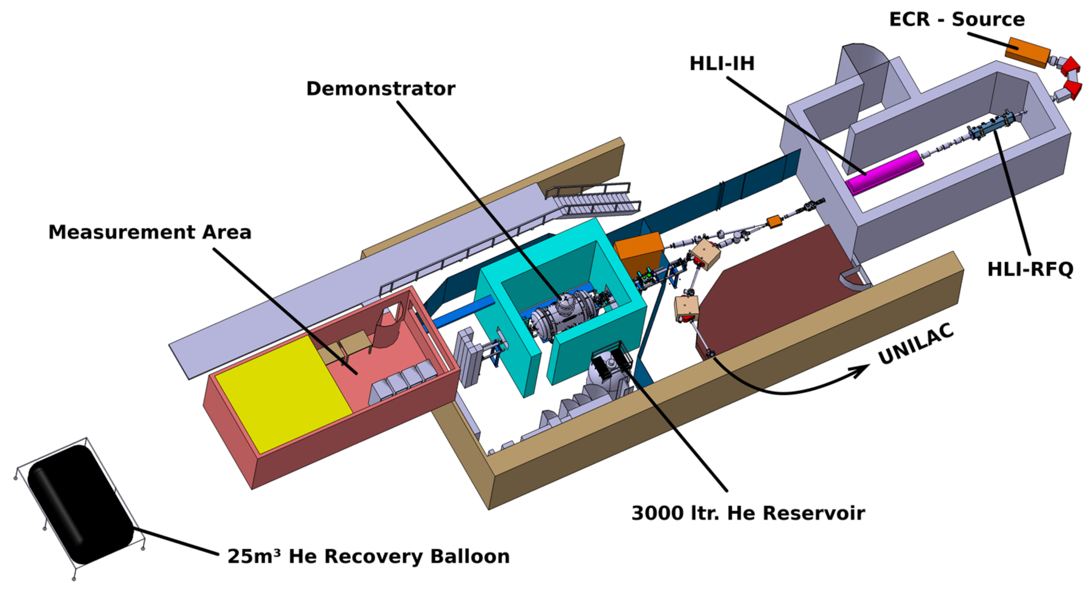

Figure 1: Future test environment at GSI using the existing High Charge State Injector (HLI) asan injector for the cw demonstrator.

Layout of the Cavity

Since June 2012 the sc 217 MHz CH cavity for the cw demonstrator project is under production at Research Instruments (RI) GmbH, Bergisch Gladbach, Germany.

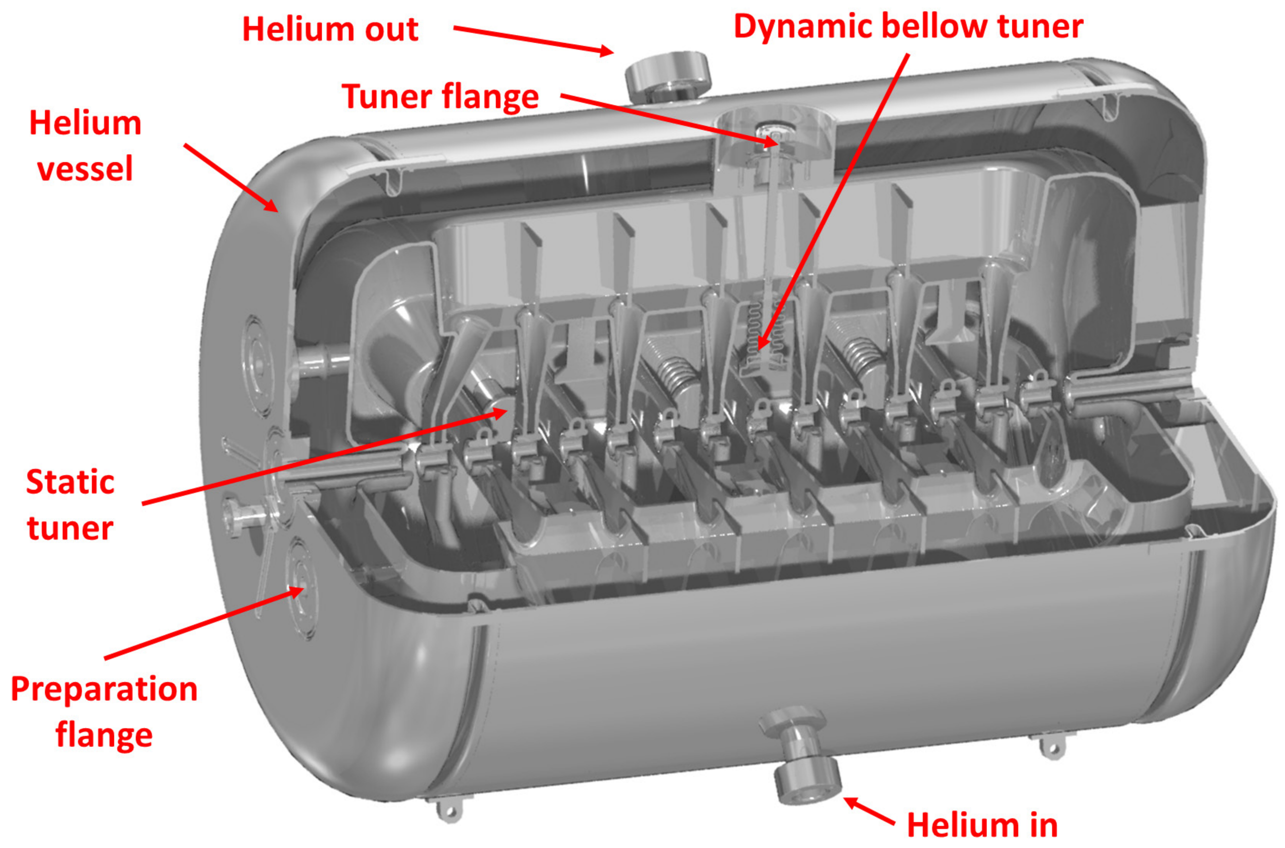

Figure 2: Final design of the sc 217 MHz CH cavity for the cw demonstrator at GSI.

→ The fabrication of the cavity is almost finished. Remaining welding jobs will be completed during the next few months. Recently, the delivery date of the cavity to the IAP is estimated for December 2014. First performance tests and rf conditioning of the cavity are planned at the end of 2014.

Figure 3: Current status of the cavity with temporarily attached end caps (top), measurement setup at Research Instruments (bottom).

Cavity properties:

- equidistant gap centers
- 10 kW power coupler
- frequency tuning system
- titanium helium vessel
- several flanges for surface preparation

Table 1: Parameters of the cavity

PARAMETER	UNIT	
β		0.059
Frequency	MHz	216.816
Gap number		15
Total length	mm	687
Cavity diameter	mm	409
Cell length	mm	40.82
Aperture	mm	20
U_a (βλ definition)	MV	3.4
Accelerating gradient	MV / m	5.1
E_p / E_a		6.4
B_p / E_a	mT / (MV / m)	5.4
R / Q	Ω	3320
Static tuner		9
Dynamic bellow tuner		3

RF Measurements at Room Temperature

Several rf measurements during the production process have been carried out at room temperature to hit the cavity's operation frequency.

→ As one can see, the measurements show a good agreement with the simulation. In terms of the large frequency shift of the static tuners the design frequency of the cavity can be reached easily. The expected behavior of the electric field along the beam axis corresponds to the measurements very well. After removing the oversize and welding the end caps to the cavity the field in the last gaps will be increased and the whole distribution becomes more homogeneous.

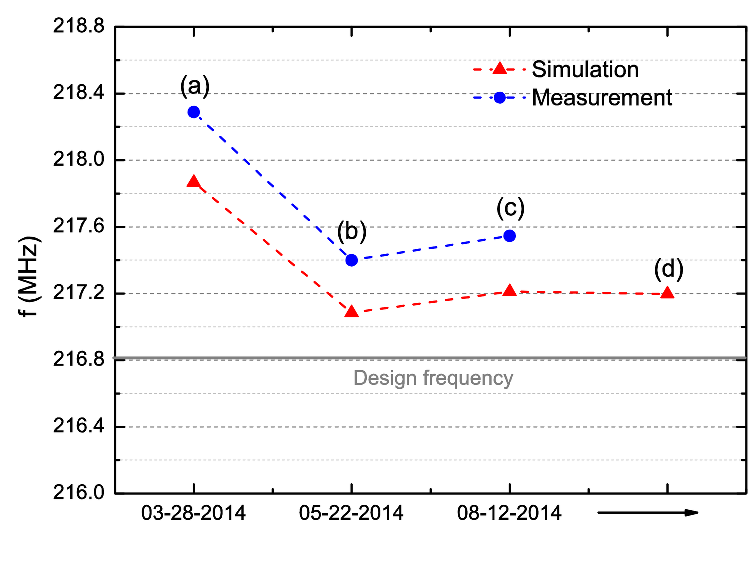

Figure 4: Frequency of the sc 217 MHz CH cavity during the production process: (a) end caps temporarily attached to the cavity, both end caps and end drift tubes with oversize, no static tuners welded into the cavity, (b) four static tuners welded into the cavity, (c) left end cap and drift tube without oversize, both end caps temporarily attached to the cavity, (d) left end cap welded to the cavity, right end cap temporarily attached to the cavity.

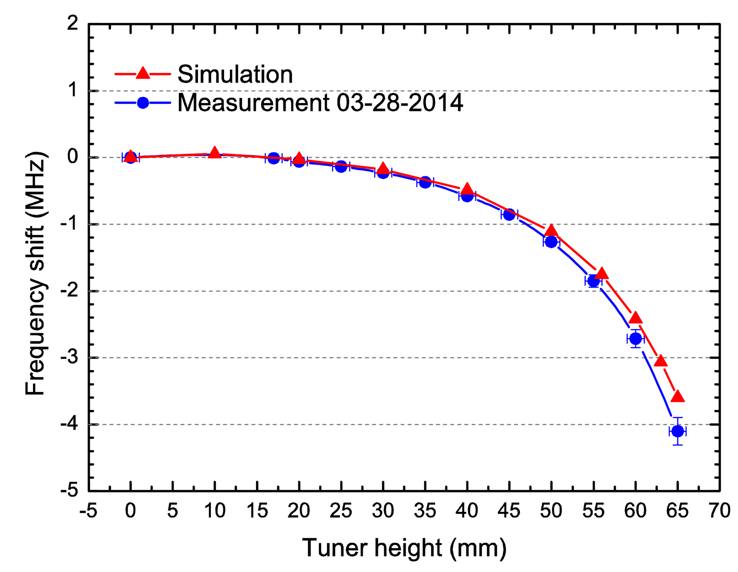

Figure 5: Measured frequency shift of nine static dummy tuners in comparison to the simulation.

Adjustment of preliminary coupler:

- assumed intrinsic quality factor at 4 K: $Q_0 \approx 8x10^8 – 1x10^9$
- coupling factor: $\beta_e \approx 8 – 10$
- required external quality factor: $Q_e \approx 1x10^8$

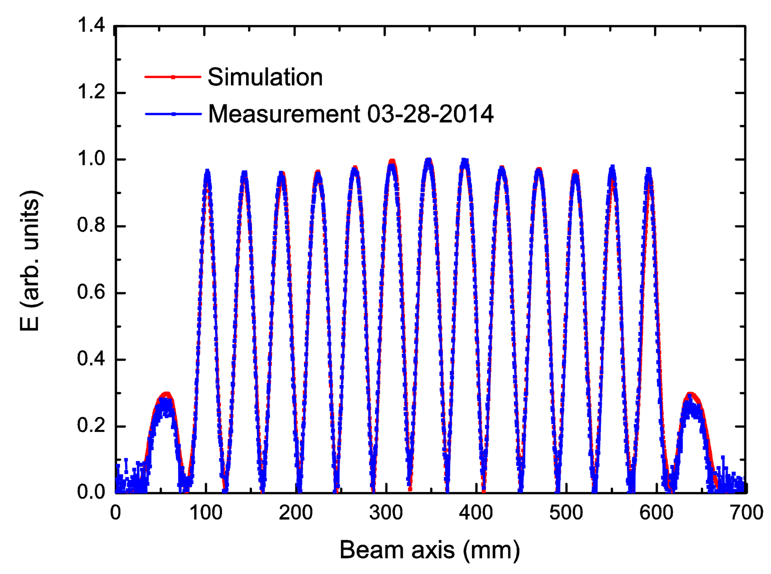

Figure 6: Measured electric field distribution along the beam axis at a dummy tuner height of 60 mm.

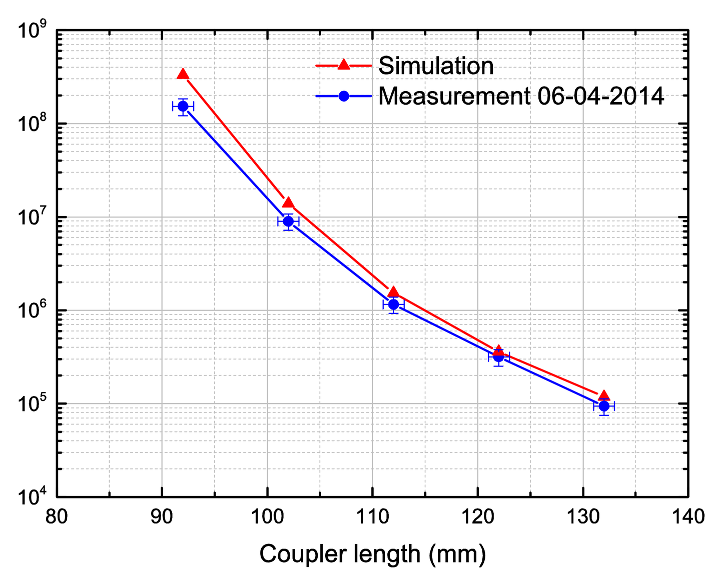

Figure 7: Measurement of the external Q factor depending on the coupler length for a coupler tip of 12.2 mm diameter (measured in transmission).

For first performance tests and especially for rf conditioning at 4 K the cavity should be overcoupled. Therefore, the coupler respectively Q_e has to be adjusted accordingly. A suitable coupling strength can be reached with a short coupler equipped with a coupler tip of 12.2 mm diameter.