A SUPERCONDUCTING 217 MHz CH CAVITY FOR THE CW DEMONSTRATOR AT GSI*

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Abstract

For a competitive production of new Super Heavy Elements (SHE) in the future a 7.3 AMeV superconducting (sc) continuous wave (cw) LINAC is planned at GSI. Currently, a cw demonstrator is going to be built up. The demonstrator consists of a sc 217 MHz Crossbar-H-mode (CH) [1] cavity and two sc 9.5 T solenoids mounted in a horizontal cryostat. One major goal of the demonstrator project is to show the operation ability of sc CH cavity technology under a realistic accelerator environment. After first rf and cold tests the demonstrator will be tested with beam delivered by the GSI High Charge State Injector (HLI) in 2014.

THE CW DEMONSTRATOR

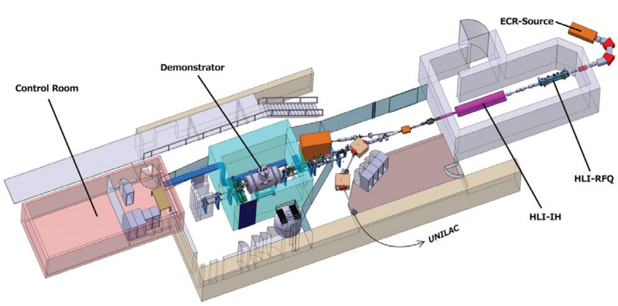

Figure 1: Future test set-up at GSI. The existing HLI will be used as an injector for the cw demonstrator.

Since in the future the existing UNILAC (Universal Linear Accelerator) at GSI will be used as an injector for FAIR (Facility for Antiproton and Ion Research), beam time availability for nuclear chemistry and especially for SHE production will be very limited. Therefore, a new sc cw 7.3 AMeV LINAC at GSI is desired by a broad community of users. For this reason a cw demonstrator, consisting of two sc 9.5 T solenoids and a sc 217 MHz CH cavity mounted in a horizontal cryomodule, is going to be built up. Successful beam tests of the demonstrator will be a milestone on the way to the new LINAC at GSI to keep the SHE program competitive on a high level [2]. For first beam tests the 1.4 AMeV GSI HLI will be used. The whole test set-up at GSI is schematically shown in figure 1.

FABRICATION STATUS OF THE SC 217 MHZ CH CAVITY

The fabrication of the sc 217 MHz CH cavity for the cw LINAC demonstrator [3] (see fig. 2) has started in June 2012 at Research Instruments (RI) GmbH, Bergisch Gladbach, Germany. It is scheduled to be delivered to the IAP in the beginning of 2014 for first cold tests with full rf power. Nevertheless, 15 accelerating cells will provide a maximum gradient of 5.1 MV/m at an inner length of 690 mm. The cavity has a design beta of 0.059 which leads to an effective cell length of 40.8 mm. Regarding the beam dynamics design of the cavity the special EQUUS (EQUidistant mUlti-gap Structure) code was used [4].

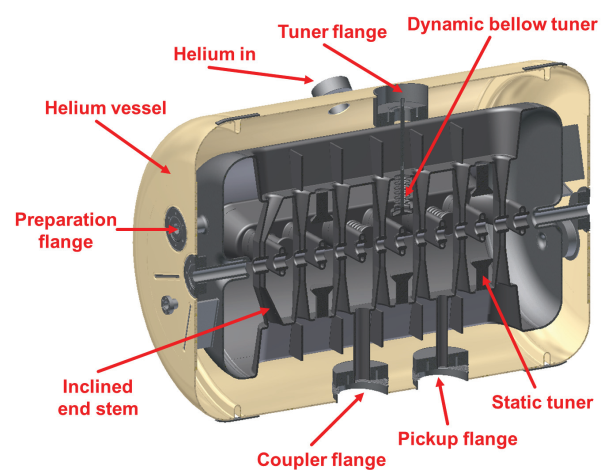

Figure 2: The sc 217 MHz CH cavity.

Table 1 summarizes the main parameters of the cavity. The cavity will be equipped with all necessary auxiliaries: A 10 kW cw coupler with cooled inner conductor to feed the cavity with power, a helium vessel made from titanium, several flanges for surface preparation and a dynamic frequency tuning system with a new tuner drive. In figure 3 the current fabrication status of the cavity is shown.

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Figure 3: Fabrication status of the cavity: Assembly of the cavity components (top) and end caps after hydro forming (bottom).

Table 1: Main Parameters of the 217 MHz CH Cavity

β		0.059
Frequency	MHz	216.816
Accelerating cells		15
Inner length	mm	690
Inner diameter	mm	410
Cell length	mm	40.8
Aperture	mm	20 / 18
Accelerating gradient	MV/m	5.1
Energy gain	MeV	2.97
Static tuner		9
Dynamic bellow tuner		3
U_a ($\beta\lambda$ definition)	MV	3.12
E_p/E_a		7.0
B_p/E_a	mT/(MV/m)	5.2
R_a/Q_0	Ω	3320

DYNAMIC TUNER DRIVE

A prototype of the new tuner drive was built at the workshop of the IAP (see fig. 4). This tuner drive system provides slow and fast tuning of sc CH cavities by pushing / pulling a dynamic bellow tuner which acts capacitively. The tuners are welded on the girders between the stems of the cavity. For a coarse match of the frequency at 4 K a stepping motor moves the dynamic bellow tuner with a lever arm around ± 1 mm. Furthermore, a fast reacting piezo element will be driven by a signal bandwidth of up to several hundred Hz to compensate limitations like microphonics and Lorentz-Force-Detuning. The piezo moves the tuner around $\pm 6\ \mu$m. Currently, the system is tested under room temperature conditions. Further tests inside the clean room of the IAP and at 4 K are foreseen during the next months.

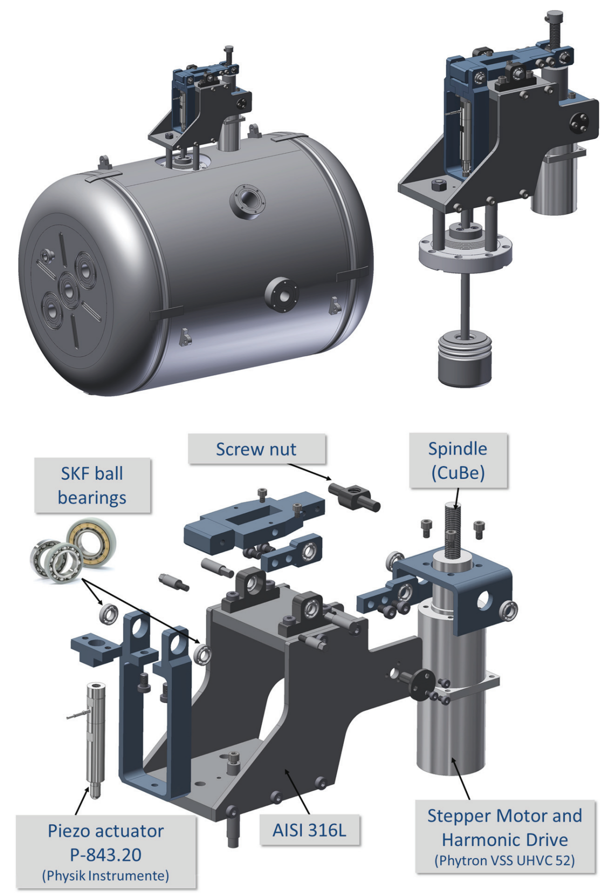

Figure 4: Tuner drive mounted to the helium vessel of a sc CH cavity and frequency tuning system including dynamic bellow tuner (top), exploded view drawing of all single components of the tuner drive (bottom).

HORIZONTAL CRYOMODULE

A new horizontal cryomodule, which houses the two sc solenoids and the sc CH cavity, for the foreseen beam tests at the GSI HLI is required. Regarding this, a layout for the cryostat and the solenoids was worked out together with

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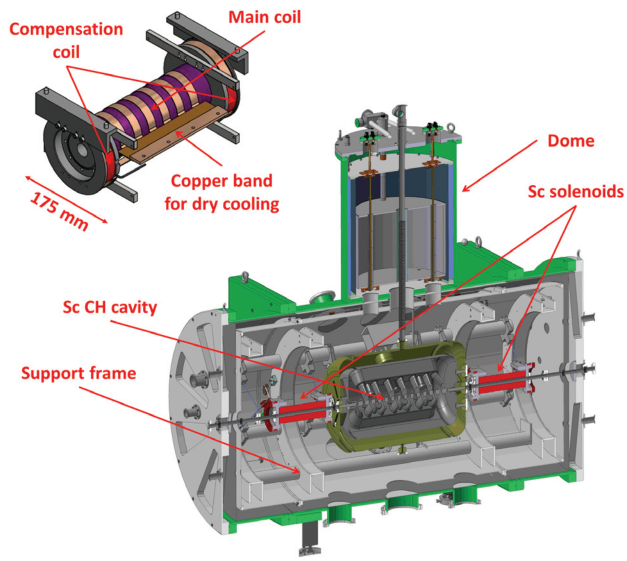

Figure 5: Final layout of the horizontal cryomodule and of the sc 9.6 T solenoid for the cw demonstrator at GSI.

GSI [5]. The design phase is completed. Figure 5 shows the final layout of the horizontal cryomodule and of the sc 9.5 T solenoid for the cw demonstrator. The fabrication of the vacuum vessel as well as of the solenoids has started already at Cryogenic Limited, London, United Kingdom. It is scheduled to be delivered in the middle of 2014. The main design criteria for the new cryostat are [6]:

- modular design, universally usable.
- three part cryostat for easy assembling.
- various flanges for assembling options.
- dome for electrical supplies with a reservoir for cryogenic liquids.
- position measuring system with fiducials.
- support frame adjustable from outside.
- nuclotron suspension with tie rods to all components
- dry cooled solenoids with copper bands.

Table 2 shows the main design parameters of the horizontal cryomodule. Furthermore, the flow rate of the LHe reservoir will be 100 $\mathrm{l/h}$ while the estimated losses of the cryostat are about 2 $\mathrm{l/h}$.

SUMMARY & OUTLOOK

First preparations were done during 2012 to set up the cw demonstrator at the GSI HLI. Within this framework a 3000 l LHe-tank as well as a helium recovery system have been delivered to GSI. In addition to this, the 217 MHz solid state 5 kW rf amplifier for the cavity was delivered to the IAP and successfully tested.

Table 2: Design Parameters of the Cryostat

Inner length	mm	2200
Inner diameter	mm	1180
Material tank		aluminum
Insulating vacuum	mbar	$< 1 \cdot 10^{-5}$
Leaking rate	mbar l/s	$1 \cdot 10^{-9}$
Max. system pressure	bar	< 0.5
Operation temperature	K	4.4
Temperature thermal shield	K	77
Trans. / longit. tolerance	mm	± 0.2 / ± 2
Max. static losses (stand by)	W	< 10

The fabrication of the sc 217 MHz CH cavity has started in June 2012 at Research Instruments. At present, the cavity is scheduled to be delivered to the IAP in the beginning of 2014 for first cold tests with full rf power.

Furthermore, the production of the cryostat and of the sc solenoids has started in August 2013 at Cryogenic Limited.

The delivery of all main components is expected for 2014. In a first step the cold masses will be assembled under clean room conditions and tested at 4 K with full rf power at the IAP. Afterward, a full performance test with beam at the HLI is foreseen in 2014/15. Nevertheless, a successful beam test of the demonstrator will be a big milestone on the way to the proposed sc cw LINAC and consequently to the SHE program at GSI.

ACKNOWLEDGMENT

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REFERENCES

[1] H. Podlech et al., Superconducting CH structure, Phys. Rev. STAB 10, 080101 (2007).

[2] S. Mickat et al., The sc cw-LINAC-Demonstrator - SRF Technology finds the way to GSI, in Proc. of SRF2011, Chicago, USA (2011).

[3] F. Dziuba et al., Development of superconducting crossbar-H-mode cavities for proton and ion accelerators, Phys. Rev. STAB 13, 041302 (2010).

[4] S. Minaev et al., A Superconducting Energy Variable Heavy Ion Linac with Constant Beta, Multi-Cell Cavities of CH-Type, Phys. Rev. STAB 12, 120101 (2009).

[5] V. Gettmann et al., The sc cw-LINAC Demonstrator - an R&D project for SRF technology, in Proc. of SRF2011, Chicago, USA (2011).

[6] F. Dziuba et al., Superconducting CH Cavities for Heavy Ion Acceleration, in Proc. of IPAC2013 (to be published), Shanghai, China (2013).