R&D STATUS OF THE NEW SUPERCONDUCTING CW HEAVY ION LINAC@GSI*

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Abstract

For future research in the field of Super Heavy Elements (SHE) a superconducting (sc) continuous wave (cw) ion LINAC with high intensity is highly desirable. Presently a multi-stage R&D program conducted by GSI, HIM and IAP [1] is in progress. The fundamental linac design composes a high performance ion source, a new low energy beam transport line, the High Charge State Injector (HLI) upgraded for cw, and a matching line (1.4 MeV/ u) followed by the new sc-DTL LINAC for acceleration up to 7.3 MeV/ u. The successful commissioning of the first Crossbar-H-mode (CH) cavity (Demonstrator), in a vertical cryo module, was a major milestone in 2015 [2]. The next stage of the new sc cw heavy ion LINAC is the advanced demonstrator comprising a string of cavities and focusing elements build from several short constant-beta sc CH-cavities operated at 217 MHz. Currently the first two sc 8 gap CH-cavities are under construction at Research Instruments (RI), Bergisch Gladbach, Germany. The new design without girders and with stiffening brackets at the front and end cap potentially reduces the overall technical risks during the construction phase and the pressure sensitivity of the cavity. The recent status of the construction phase as well as an outlook for further cavity development of the new cw heavy ion LINAC will be presented.

INTRODUCTION

The construction of cavity 1 and 2 of the advanced demonstrator is the next milestone realizing a new sc heavy ion cw-LINAC at GSI. The first milestone will be the successful beam test of the demonstrator at GSI-HLI. The demonstrator cavity has been successfully rf tested at cryo conditions at Frankfurt University [2]. The recent design of the sc cw-LINAC comprises the demonstrator as first cryomodule and several additional cryomodules each equipped with two short CH-cavities [1, 3]. The overall design of this standard cryomodule will be used for all following cavities. The short cavity with 8 accelerating cells is designed for high power applications at a design gradient of 5 MV/m. Its resonant frequency is the second harmonic of that of the High Charge Injector (HLI) at GSI, Darmstadt. In table 1 the main parameters of the first two 217 MHz CH-cavities are depicted. Figure 1 shows the layout of these cavities.

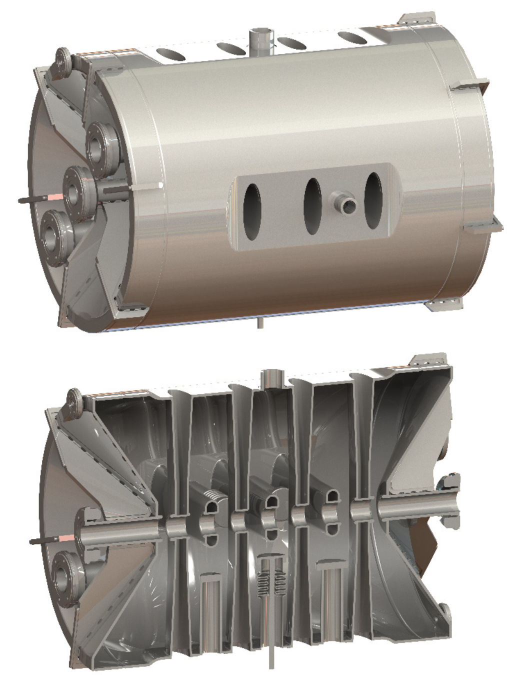

Figure 1: Layout of the sc 217 MHz CH-cavity 2 and 3.

Table 1: Main Parameters of CH-cavity 2 and 3

Parameter	Unit	
β		0.069
Frequency	MHz	216,816
Accelerating cells		8
Length ($\beta\lambda$-definition)	mm	381.6
Cavity diameter (inner)	mm	400
Cell length	mm	47.7
Aperture diameter	mm	30
Static tuner		3
Dynamic bellow tuner		2
Wall thickness	mm	3-4
Accelerating gradient	MV/m	5
E_p/E_a		5.2
B_p/E_a	mT/(MV/m)	<10
G	Ω	50
R_a/Q_0	Ω	1070

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FABRICATION STATUS

The construction of cavity 2 and 3 of the new cw heavy ion LINAC is in progress at Research Instruments (RI), Bergisch Gladbach, Germany. At the moment most of the essential components like stems (see Figure 2) as well as end caps and the cavity body (see Figure 3) have been fabricated.

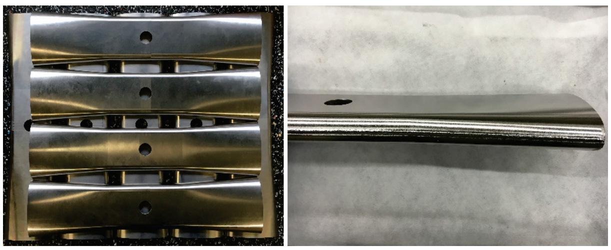

Figure 2: Welded and polished stems.

Figure 3: Cavity body and end caps.

The new cavity design is without girders, resulting in an improved mechanical stability through cylindrical symmetry. Unfortunately RI could not fabricate the cavity completely cylindrical due to the fact that they need a constant welding depth for the electron-beam-welding. So the cylindrical cavity body was flattened in the area of the stems and tuners so that the welding depth is constant for all components. As a consequence of breaking the cylindrical symmetry the pressure sensitivity detoriates. Due to the holding clamps at the end caps, the stability is sufficient to provide for a pressure sensitivity of up to 7 Hz/mbar (see Figure 4) [4].

This value is still much better than the pressure sensitivity of the CH-cavities with girders. To prepare first measurements at the end of 2016 several simulations have been performed with CST Microwave Studio [4] and AnsysWB [5] concerning tuning range, external Q-value for power couplers, mechanical stability and **bu**ffered **c**hemical **p**olishing (BCP) treatment.

TUNING CONCEPT

The tuning concept for cavity 2 and 3 of the cw heavy ion LINAC comprises 3 static tuners and 2 dynamic tuners for each cavity. Two static tuners are designed with a tunerhead for an increased tuning range. The third tuner (without tunerhead) has to be installed from the outside after the end caps and the cavity have been welded together. The simulated tuning range of all 3 static tuners is shown in Figure 5 [4].

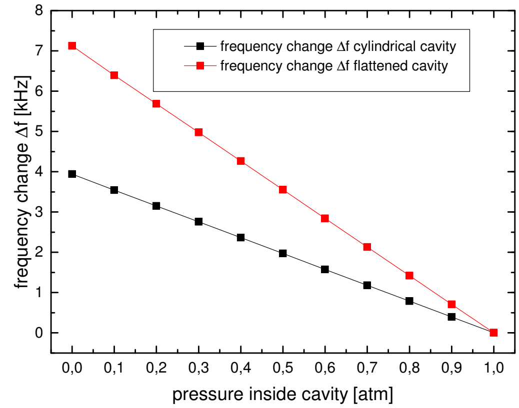

Figure 4: Pressure sensitivity for cylindrical and flattened cavity.

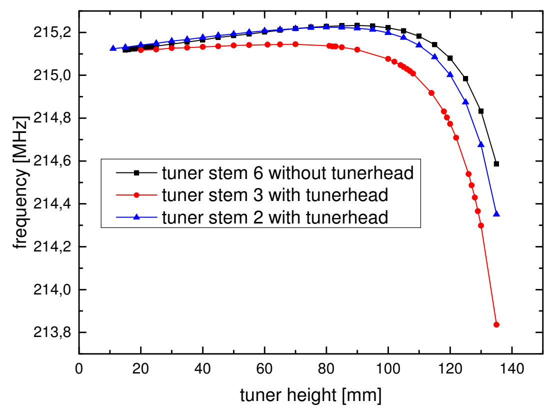

Figure 5: Tuning range static tuner.

3 brass dummy tuner have been fabricated to verify the simulations and to determine the final tuner heights. They are fixated with the cavity body by brass mounts. The brass tuners and mounts are shown in Figure 6.

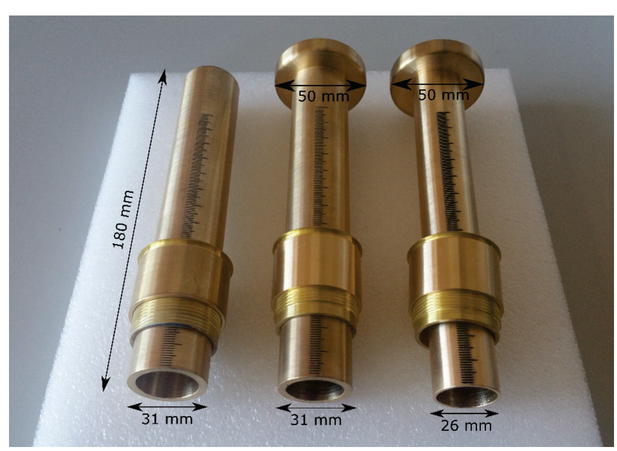

Figure 6: Brass dummy tuner.

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They have a length of 180 mm and the tuner diameter for two of them is 31 mm and 26 mm for one tuner with tunerhead (due to revision). The diameter of the tunerhead is 50 mm.

POWER COUPLER

For the first measurements, different power coupler lengths are necessary to validate the simulated external Q-values for the power coupler and pickup. Several coupler tubes made from copper have been fabricated to provide for lengths from 20 mm up to 180 mm in 20 mm steps. The different tubes and front and end caps for both couplers are depicted in Figure 7. The power coupler diameter is 12.2 mm and the pickup diameter is 8.7 mm.

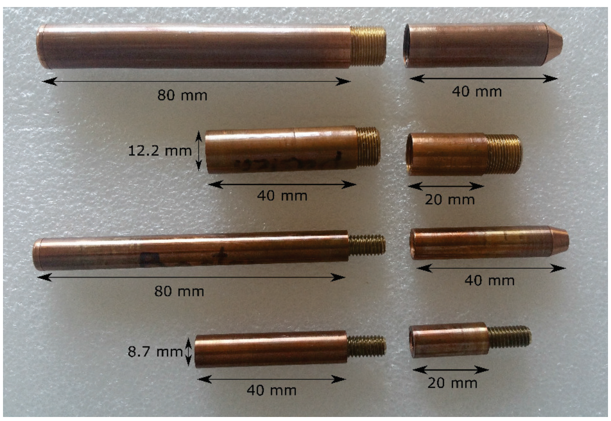

Figure 7: Power coupler and Pickup with tube lengths from 20 mm up to 180 mm.

The estimated length for the pickup should be in the range of 65 mm to 75 mm according to the simulations. The length for the power coupler should be fixed between 90 mm and 120 mm depending on the beam parameters. The simulated external Q-values for the power coupler and pickup are shown in Figure 8 [4].

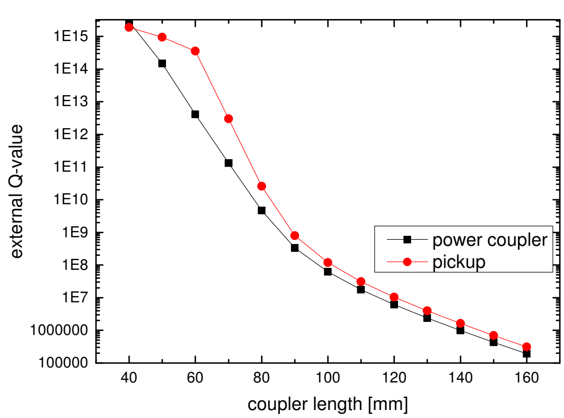

Figure 8: External Q-value for power coupler and pickup.

OUTLOOK

To reduce the construction time between the different CH-cavities, the first layout for the next 2 cavities has been designed and optimized. Both cavities have the same principle design only the cell length is adjusted. The β will rise from 0,069 up to ca. 0,078 while the cell length accordingly increases from 47.7 mm up to ca. 54.5 mm. The basic optimizations concerning RF-performance and mechanical layout have been performed. After finishing final simulation the next step will be the generation of the technical drawings and after that the call for tender.

CONCLUSION

The construction of the first 2 CH-cavities of the advanced demonstrator project started in 2016. All essential components have been fabricated and first measurements during the manufacturing phase will take place at the end of 2016. The first measurements will validate the simulated tuning range, the field distribution as well as the simulated external Q-values for the power coupler and pickup. All required components for the measurements like brass dummy tuners with mounts and copper couplers have been fabrictated in the workshop of the Goethe University Frankfurt am Main and are ready to use. At the moment the flattened parts of the cavity jacket are not within the required tolerances and need to be revised. As soon as the revision is complete the first measurements will take place. The first full power measurements in a cryostat are scheduled for the first half of 2017.

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