STATUS OF THE FIRST CH-CAVITIES FOR THE NEW SUPERCONDUCTING CW HEAVY ION LINAC@GSI*

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Abstract

In the field of Super Heavy Elements (SHE) a superconducting (sc) continuous wave (cw) high intensity heavy ion LINAC is highly desirable. Currently a multi-stage R&D program conducted by GSI, HIM and IAP [1] is in progress. The baseline linac design composes a high performance ion source, a new low energy beam transport line, a (cw) upgraded High Charge State Injector (HLI), and a matching line (1.4 MeV/u) followed by the new sc-DTL LINAC for acceleration up to 7.3 MeV/u. The commissioning of the first CH cavity (Demonstrator), in a horizontal cryo module with beam is a major milestone in 2016 [2]. The advanced demonstrator comprises constant-beta sc Crossbar-H-mode (CH) cavities operated at 217 MHz. Presently, the first two sc CH cavities of the advanced demonstrator are under construction at Research Instruments (RI), Bergisch Gladbach, Germany. A string of cavities and focusing elements build from several short CH-cavities with 8 gaps, without girders is recommended. The new design potentially reduces the overall technical risks during the fabrication and the pressure sensitivity through stiffening brackets at the front and end cap. The present status of the first two sc cavities as well as the technical layout of the new cw heavy ion LINAC will be presented.

INTRODUCTION

The construction of cavity 2 and 3 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 entire demonstrator at GSI. The demonstrator cavity has been successfully rf tested at cryo conditions at the University of Frankfurt. The recent design of the sc cw-LINAC comprises the advanced demonstrator as first cryomodule and several additional cryomodules each with two short CH-cavities and one solenoid [1, 3]. The general design of the advanced demonstrator will be reused for all following cavities. The short cavity consisting of 8 accelerating cells is designed for high power applications with 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. Table 1 shows the main parameters of the 217 MHz CH-cavities. In Figure 1 the layout of this cavities is depicted.

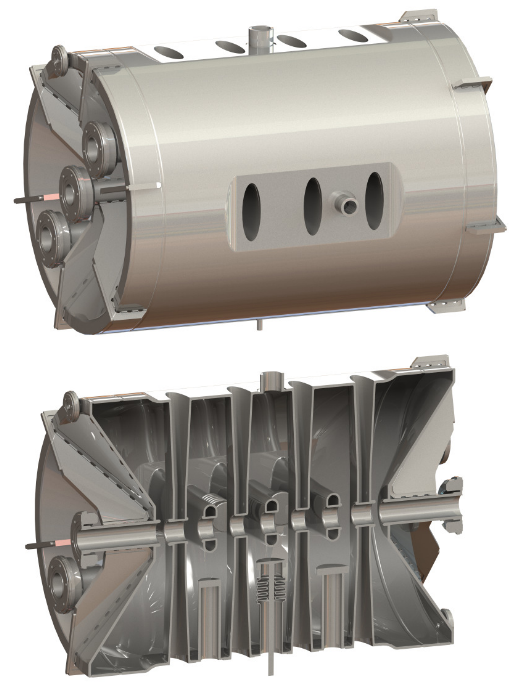

Figure 1: Layout of the sc 217 MHz CH-cavity 2 and 3.

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

Parameter	Unit	
β		0.069
Frequency	MHz	215
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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BELLOWTUNER EIGENMODES

The tuning concept is a crucial point for sc cavities due to their sharp resonance curve. It is important to reach the desired frequency and to keep it constant during operation. In case of the sc CH-cavities for the advanced demonstrator three static tuners ensure the correct frequency of 217 MHz and two dynamic bellow tuners keep the frequency constant during operation. The tuning concept has been designed and optimized with CST Microwave Studio [4]. The dynamic tuners should cover at least a tuning range of 250 kHz, with a tuning stroke of 1 mm, to ensure the right frequency during operation. Due to the high sensitivity of the dynamic tuners several simulations concerning mechanical eigenfrequencies and vibrations through interfering excitations and through tuning operation have been performed with AnsysWB [5]. The height and diameter of the dynamic tuners is determined by the rf specifications like multipacting and the requiered tuning range. The number of fins and their dimensions is determined by the maximum Von-Mises-Stress for a tuning stroke of 1 mm. So only the position of the fins can influence the eigenfrequency of the tuner. Figure 2 shows the layout of the dynamic tuner.

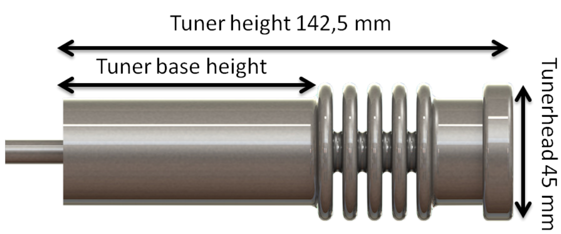

Figure 2: Layout of the dynamic tuner.

To investigate the eigenmode spectrum depending on the position of the fins, the tuner base height was increased from 5 mm to 90 mm. For different tuner base heights the first 6 eigenmodes of the dynamic tuner are shown in figure 3.

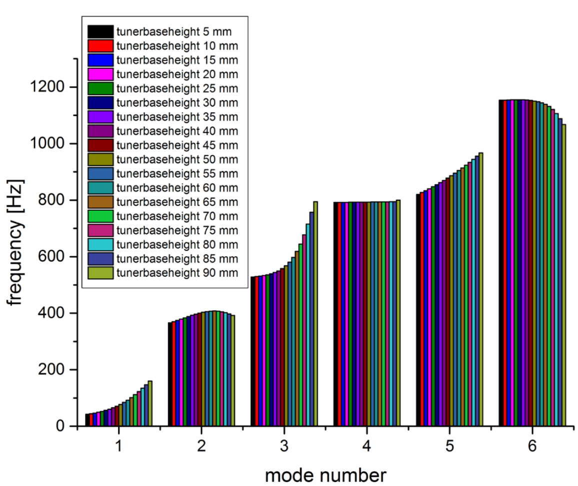

Figure 3: Eigenmode spectrum of the dynamic tuner.

It is expected, that interfering vibrations from vacuum pumps or helium bubbles are below 150 Hz. The first eigenmode could be supressed, by increasing the tuner base height, the eigenfrequency can be raised from ca. 45 Hz up to ca. 160 Hz as shown in figure 4.

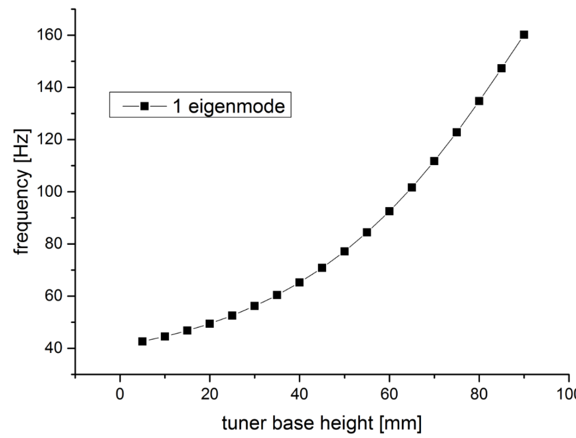

Figure 4: First Eigenmode with increasing tuner base height.

Increasing the tuner base height increases the frequency of the first, third and fifth eigenmode but decreases the frequency of the second and sixth eigenmode. The fourth eigenmode is independent from the tuner base height. In this mode only the fins oscillate among themselves while the tuner itself stays at rest. For operation only the first eigenmode is in the crucial frequency domain for interfering excitations.

BELLOWTUNER RESONANCE SPECTRUM

The resonance oscillations through interfering excitations at the tuner itself and through specific excitations on the tunerrod were investigated by simulations:

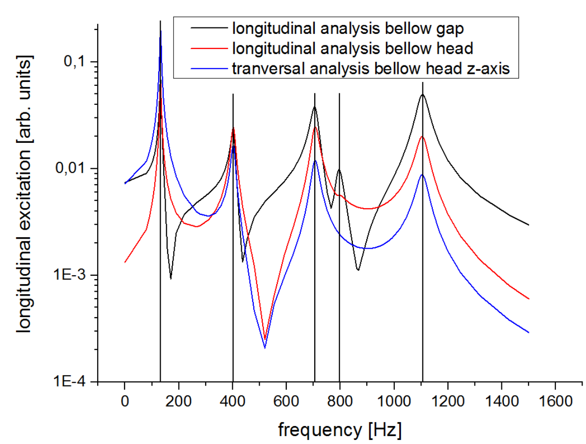

Figure 5: Resonance spectrum for external longitudinal excitations of the tuner.

The tunerbase was longitudinally and transversally excited with frequencies from 0 Hz to 1500 Hz, with the simulation program AnsysWB [5]. The resulting movement of

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the dynamic tuner was monitored at several positions. The longitudinal and transversal movement of the tunerhead was monitored as well as the longitudinal movement of the fins. The resulting resonance spectrums are shown in figure 5 for longitudinal excitations and in figure 6 for transversal excitations of the tuner itself.

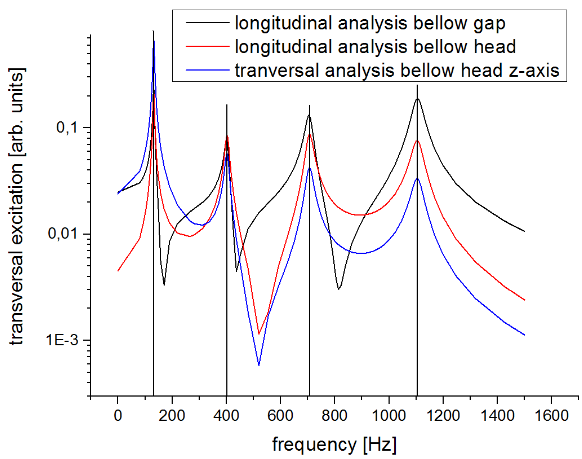

Figure 6: Resonance spectrum for external transversal excitations of the tuner.

The simulation program AnsysWB generates resonance spectra in arbitrary dimensions, so that the different spectra can only be compared qualitatively. The resonance spectrum of both simulations (longitudinal and transversal excitation) show nearly the same spectrum and the same resonances. One mode appears only through longitudinal excitation at ca. 800 Hz. This is a resonance condition where the fins oscillate among themselves and the tuner itself stays at rest (the same mode which is independent from the tuner base height in figure 3).

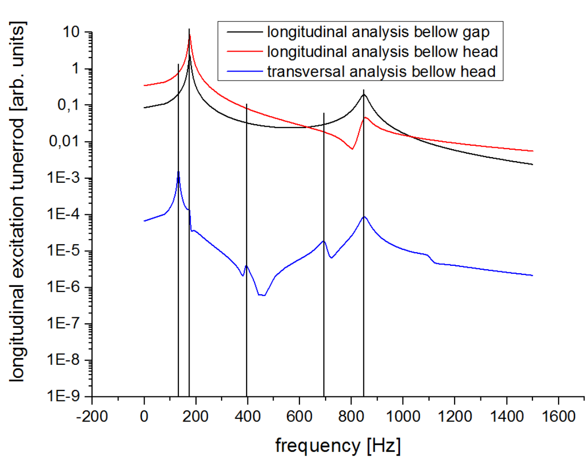

Figure 7: Resonance spectrum for external longitudinal excitations of the tunerrod.

These spectra show the expected oscillations when the interfering signals excite the tuner longitudinally or transversally. To investigate whether the specific tuner elongation for tuning operation itself will cause resonant oscillations at special frequencies, the tunerrod was longitudinal excited from 0 Hz to 1500 Hz. The resulting spectrum is shown in figure 7. Only two dominant resonances remain through excitation along the tunerrod. The resonance at 175 Hz is the main resonance, where the whole tuner oscillates in the tuning direction. To avoid oscillations and frequency changes of the cavity, the tuner should not be operated at this frequency. The other dominant resonance at about 850 Hz is a mode, where again the tuner fins oscillate among themselves and the tuner itself is nearly at rest. This frequency should also be avoided but does not influence the frequency of the cavity directly.

CONCLUSION

The simulations concerning mechanical eigenfrequencies and resonance spectrums show, which specific excitation frequencies during the tuning operation should be avoided and which interfering frequencies can occur. The lowest eigenmode of the dynamic tuner could be increased from 45 Hz up to 160 Hz, avoiding low interfering excitations through helium bubbles or vacuum pumps. The static tuners guarantee the design frequency and both dynamic tuners guarantee the necessary frequency deviation of 250 kHz, per mm per tuner, to keep the frequency at 217 MHz during operation. The dynamic tuners provide a tuner stroke of 1 mm or even more without reaching the limiting Von-Mises-Stress [6]. First measurements during the manufacturing phase will take place in summer 2016.

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