THE FINAL RF DESIGN OF THE 36 MHz HSI RFQ UPGRADE AT GSI

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Abstract

In Darmstadt/Germany the existing accelerator cite GSI is expanding to one of the biggest joint research projects worldwide: FAIR, a new antiproton and ion research facility with so far unmatched intensities and quality. The existing accelerators will be used as pre-accelerators and therefor need to be upgraded to fulfil the requirements with respect for intensity and beam quality. In a first step the 9.2 m long 36 MHz HSI RFQ for high current beams will obtain new electrodes to reach the specific frequency and to allow a higher electric strength. Therefor several simulations with CST MWS have been done. The final RF-design will be presented.

THE NEW RF DESIGN

The existing HSI-RFQ is part of the linear accelerator UNILAC at GSI, which will pass through a lot of modifications and updates during the expansion of the facility with the FAIR project [1]. The resonance structure together with the tank of the existing RFQ will be kept, only the electrodes and its carrier rings should be replaced. Figure 1 shows the first two modules. The blue highlighted parts are the ones to be modified while the rest is taken over from the existing RFQ.

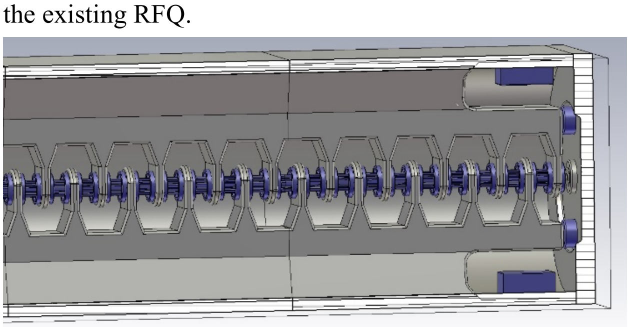

Figure 1: First modules with highlighted parts to be modified: electrodes, its carrier rings, undercut tuners (at the top and the bottom respectively in the first and the last module) and flange tuners (two at the front cover, two at the rear end cover).

The RFQ was separated in ten modules (each 92.5 cm long). Based on average values for aperture and electrode tip radius taken from last beam dynamic simulations by C. Zhang [2] several simulations were done [3].

Finally, the modules have been merged (see Fig. 2) and simulations with modified tuning elements (undercut tuners and flange tuners) were done to evaluate their influence and to reach the correct frequency.

COMPARISON OF OLD AND NEW DESIGN

Simulations with the old design have been done to verify the advantage of the new rf-design and to compare them with each other. Because the variations in the structure are small no big advantages were expected. But the results also show no disadvantage with the new design compared to previous values. Table 1 shows the main parameters for both designs. The peak values for the E-field in brackets come from the beam dynamic simulation [2].

Table 1: Accelerator Parameters

	New design 2017 simulation	**Old design** 2008 simulation
Frequency [MHz]	35.88	36.07
Q-value	15000	14700
R_P-value [kΩm]	865	840
E_{peak} [MV/m]	31 (30.2)	33.8 (31.2)

Furthermore, flatness calculations were done with both designs. The simulations already show the reduced flatness for the new design: While the old one has an unflatness of about ± 7% the new design has only ± 4% (see Fig. 3). Especially in the second half it is already very flat. In this region, the average aperture and tip radius of the electrodes does not change anymore.

After optimization with the existing RFQ a real unflatness of about ± 2.5% was measured [4]. So even if it looks a bit chaotic in the first modules a good alignment for the voltage distribution can be expected.

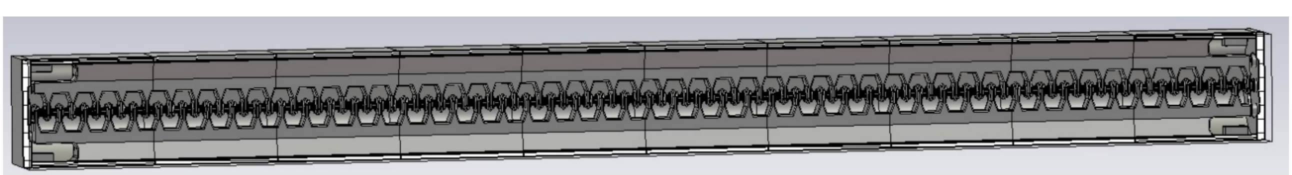

Figure 2: The merged modules for the complete RFQ with static undercut tuners and static flange tuners on both ends of the RFQ.

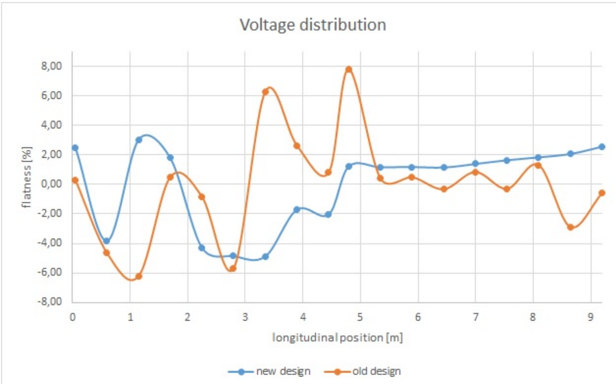

Figure 3: Simulations for the voltage distribution with the old (orange) and new (blue) design.

MULTIPOLE MOMENTUMS OF RADIAL E-FIELD

At different positions along the complete RFQ the electric field was studied on circular curves with different radii in the region between the electrodes (see. Figs. 4 and 5).

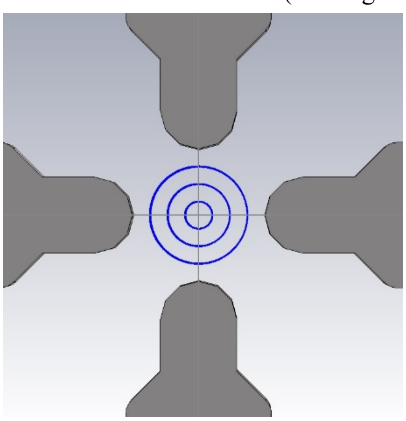

Figure 4: Different curves for evaluation of radial E-field.

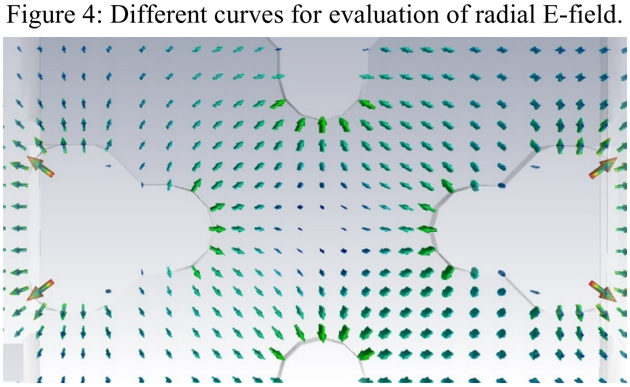

Figure 5: E-field between the electrodes.

Especially the radial component was analysed for multipole momentums. Figure 6 shows a FFT-plot of the first seven momentums relatively to the wanted quadrupole momentum. As one can see the 4-pole momentum is much more present than the other orders. The next highest order is the 12-pole with a mean value of 1.6% of the 4-pole momentum and up to 4% far from the beam axis (close to the electrodes) in the new design (blue curve in Fig. 6). All others are less than 0.5% of the 4-pole.

For the old design (black curve in Fig. 6) the next highest are the 2-pole, 8-pole and 12-pole momentums with mean values of 1.4%, 1.1% and 1.4% up to 3.7%, 2.0% and 3.6% while the others also come over 1%.

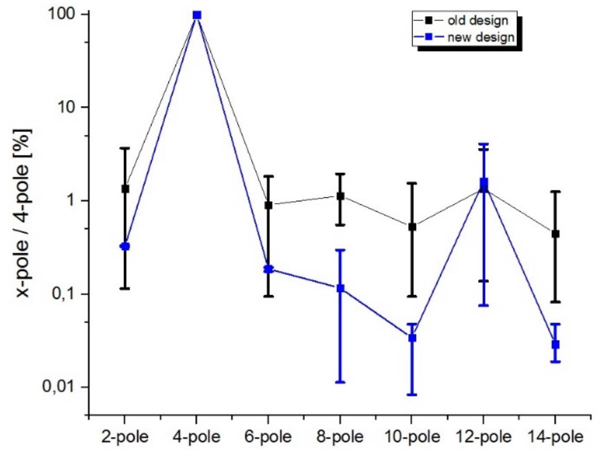

Figure 6: Multipole momentums relatively to the wanted 4-pole momentum at different radii around the beam axis (black: old design; blue: new design).

CONCLUSION

The new modification of electrodes and carrier rings of the HSI RFQ as well as tuning options were simulated. Based on the beam dynamics from C. Zhang [2] a new design was developed. Compared with simulations of the former design not only the beam dynamics were improved but also rf parameters are at least as good as before or were improved by little changes, too.

Next step would be the fabrication of the new parts, installation into and commissioning the modified RFQ.

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