

UPGRADE OF THE HSI-RFQ AT GSI TO FULFILL THE FAIR REQUIREMENTS

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Abstract

In Darmstadt/Germany the existing accelerator facility 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-accelerator and therefore need to be upgraded. In a first step the 36 MHz-HSI-RFQ for high current beams will obtain new electrodes to fulfill the FAIR requirements. First simulation results for capacity and multipole components will be presented.

INTRODUCTION

The existing HSI-RFQ is part of the linear accelerator UNILAC at GSI which has a length of 120 m and consists of the RFQ (up to 120 keV/u), two IH-DTL (up to 1.395 MeV/u), four Alvarez cavities (up to 11.4 MeV/u) and 15 shiftable single gap resonators [1].

The facility is expanding with the FAIR project to one of the biggest joint research projects worldwide. With the physics at FAIR questions of the evolution of the universe, the structure of matter and its constituent parts will be approached [2]. Therefore the existing site should be used as pre-injector. To fulfill the requirements (i.e. a huge range of beam intensities and energies, highest beam quality) a lot of modifications and updates are needed.

The RFQ was built in 1996 [3] and modified in the past years. With the actual structure the emittance is too high for the following IH-DTL which leads to unwanted beam losses and a low brilliance. The planned upgrade of the electrodes should result in an increase of the brilliance.

THE RFQ STRUCTURE

The RFQ is designed as an IH-RFQ, it has a length of nearly 10 m and consists of 10 modules with 10 stems each (see Fig. 1). The electrodes are mounted on rings where only two of them are at the same ring on one stem (like in every RFQ). To tune the RFQ and to get a better voltage distribution it is possible to change every single ring to vary the capacity by adding correction rings (see Fig. 2). The parameters for the existing RFQ are listed in Table 1 (where \bar{A} is the average aperture to the beam axis along the complete electrodes).

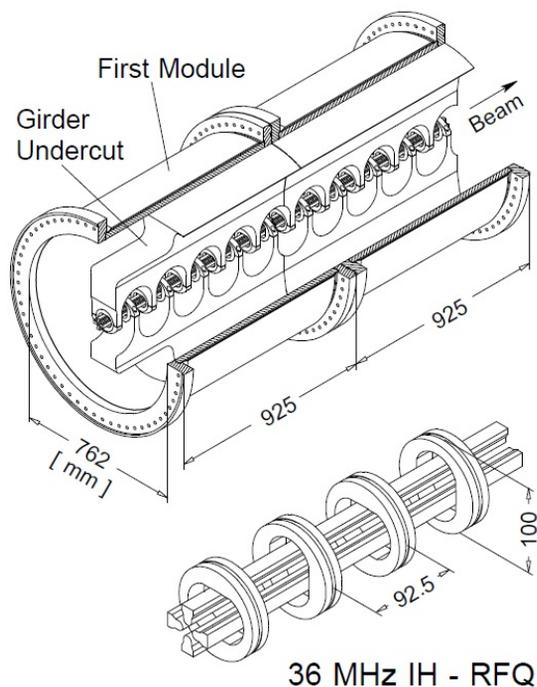


Figure 1: The IH-RFQ. [3]

Table 1: RFQ Parameters

parameter	value
\bar{A}	9.4 mm
R_0	4.2 mm
h	7 mm
L	14.8 mm

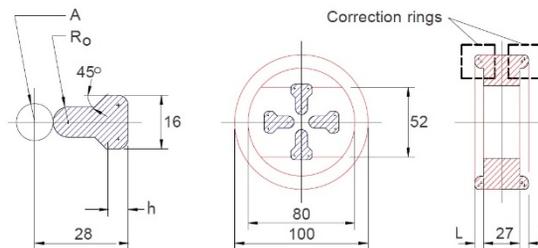


Figure 2: The electrodes with carrier and correction rings. [4]

SIMULATIONS

All simulations were done with the CST software Microwave Studio. At first simplified models are used before simulating the complete detailed RFQ. In a first step only one RF-cell with the average aperture $\bar{A} = 10.4$ mm of the 5th module was simulated (see Fig. 3). To calculate the capacity the lumped circuit model is used [5]. The capacity of the RFQ therefor is calculated to ~ 170 pF/m.

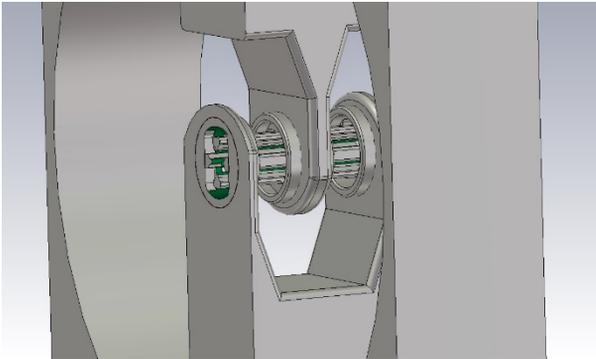


Figure 3: One RF-cell of the simplified IH-RFQ with an average aperture $\bar{A} = 10.4$ mm.

With the model of the complete 5th module and the same parameters the capacity was calculated to ~ 116 pF/m.

Afterwards the multipole components of the radial E-field were studied along nine curves. Three of them are located in the middle of one stem (where the x-electrodes are mounted), three in the middle of the other stem (where the y-electrodes are mounted) and three right in the middle between the two stems (see Fig. 4). In each case the radii of the curves are 1.5 mm, 4.5 mm and 7.5 mm around the beam axis (see Fig. 5).

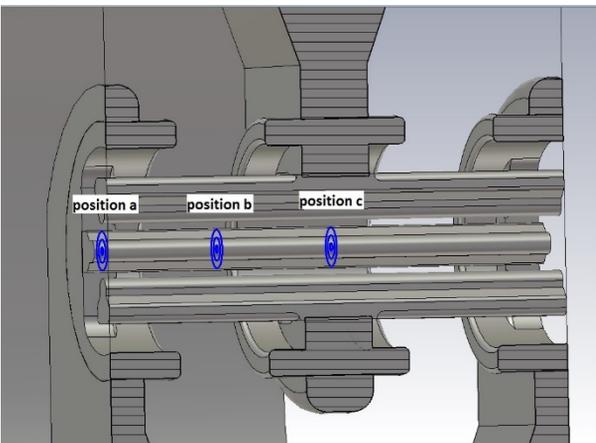


Figure 4: Longitudinal position of the curves for multipole components analyses.

In Figures 6 to 8 some of the results are shown. The amplitudes are not absolute and have different scales.

The expected quadrupole components from the four rods can barely be made out (two oscillations along one curve, see Figs. 6 and 7). But it is covered by a large 8-pole component in every of the curves (four oscillations). The reason why it seems to be there and why it should be that dominant must be further investigated. Maybe it is just an artefact caused by an inadequate mesh. Further simulations are still running. A 16-pole component is also visible but not as dominant as the 8-pole.

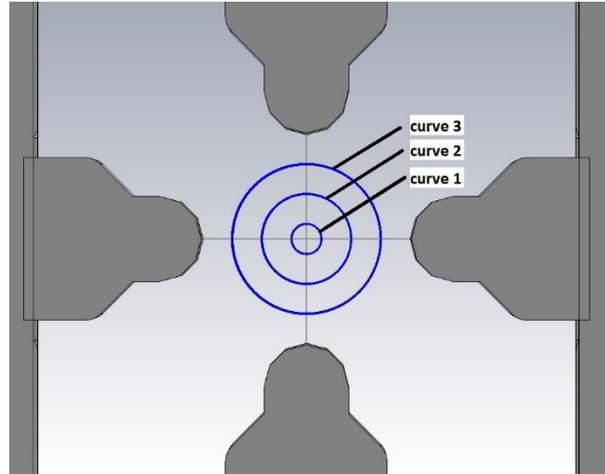


Figure 5: Radial position of the curves for multipole components analyses.

One can also see the 90° shift of the higher and lower peaks in Figures 6 and 7 due to the alternate carried electrodes on the particular stem.

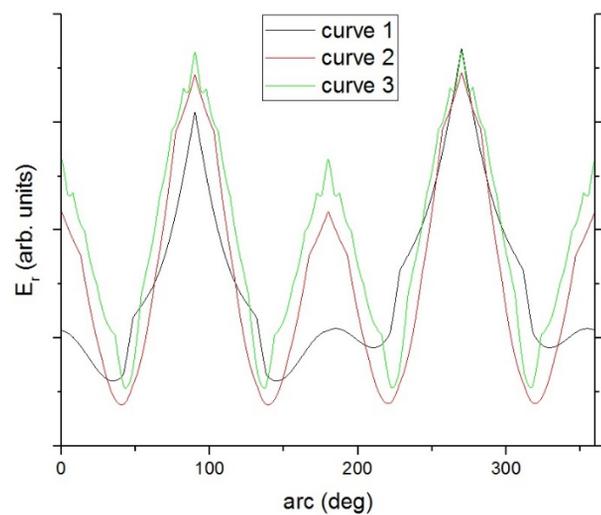


Figure 6: The radial E-field along the curves at the stem for the x-electrodes (position a).

CONCLUSION

Due to long running times for detailed simulations with an adequate mesh and a complex analysis of the data this first results are just superficially. It seems that there are some normally unwanted multipole components. Further analysis and simulations will show more elaborate results for the multipole components and their dependency on the simulation and mesh properties.

REFERENCES

- [1] GSI website: https://www.gsi.de/work/fairgsi/linac_operations/linac/unilac.htm
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- [5] C. Y. Tan et al., *Phys. Rev. ST Accel. Beams* 17, 012002 (2014).

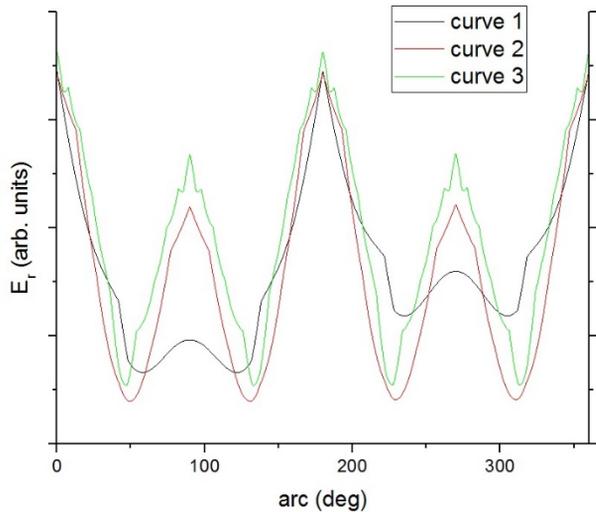


Figure 7: The radial E-field along the curves at the stem for the y-electrodes (position c).

Between the two stems there is also a dipole component (see Fig. 8) resulting from the IH-structure and the asymmetric mounting of the electrodes: in one axis both are parallel orientated at the stem while on the other axis one electrode is mounted on the top and the other on the bottom of the stem (see Fig. 3) so the current and voltage distribution differs.

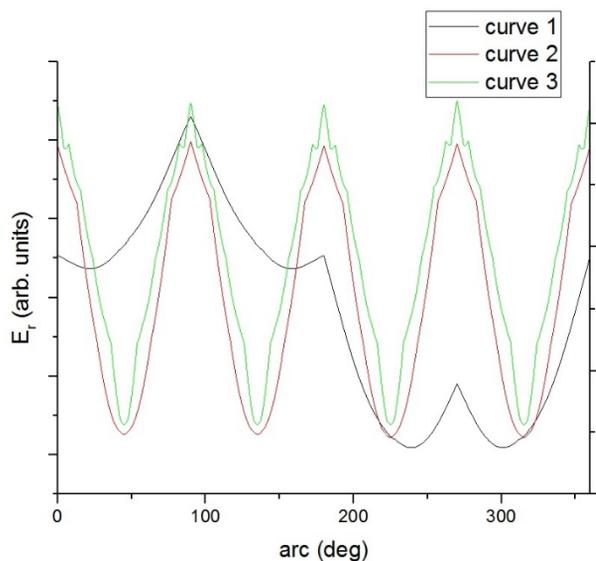


Figure 8: The radial E-field along the curves between two stems (position b).