Design of the Radio Frequency Quadrupole (RFQ)-Accelerator for the MAFF Project

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The first accelerator stage of the MAFF (Munich Accelerator for Fission Fragments)-Project [1] is proposed to be an IH (Interdigital H)-RFQ [2]. Generally IH-RFQ's consist of a cavity (excited in the TE_{111}-Mode), in which two opposite girders are mounted. These girders carry equidistant interdigital holders on which the quadrupole electrodes are fixed (see fig. 1). An example for an existing IH-RFQ is the first part of the new GSI high-current injector (diameter=76 cm, f=36 MHz R_p=620 $k\Omega m$, Q=13000) [3]. The motivation to investigate IH-type RFQ's also at higher frequencies (around 100 MHz) is given in several advantages these structures possibly have in comparison to the REX-RFQ [4].

The resonator design of the MAFF-RFQ is done by calculations with the code MAFIA (Solution of MAxwells equations using Finite Integration Algorithms). For a 101 MHz IH-RFQ (length: 3 m) the calculations show, that - due to the larger number of electrode holders (IH1: 42 holders; IH2: 36 holders) - the current and therewith the power dissipation on the quadrupole electrodes is much lower than in the 4-rod RFQ.

	REX-RFQ	IH-RFQ1	IH-RFQ2
tank	7.2%	43.5%	41.1%
stems/holders	59.8%	38.3%	39.1%
plate/frame	7.3%	11.9%	11.6%
electrodes	25.7%	6.3%	8.2%

Table 1: Power dissipation at different accelerator components calculated for the REX-RFQ and for the IH-RFQ with 6 cm (IH 1) and 7 cm (IH 2) holder distance.

The short electrode length between the holders allows on the one hand to cool the electrodes indirectly by the holders and increases on the other hand the Quality Factor and the efficiency (R_p-value) of these accelerators. Table 2 shows - corresponding to table 1 - the result of calculations for 3-ground-cell segments cut out of an infinitely long resonator.

	REX-RFQ	IH-RFQ1	IH-RFQ2
frequency (MHz)	94	92.5	93.5
R_p-value (kΩm)	278	281	288
Quality-factor	7996	11874	11657

Table 2: Resonator parameters of the REX-RFQ and the two IH-RFQ's.

Table 2 shows that the Quality Factor is about 1.5 times higher in the IH-RFQ whereas the calculations show no significant difference in R_p-value. Since the efficiency of a resonator depends on the ratio of its inductances and capacities, in the relative small IH-RFQ cavity at 93 MHz the capacitive load of the numerous holders seems to compensate the short electrode length between the holders (this is also indicated by table 2: larger holder distance - higher R_p-value). Earlier MAFIA-calculations for the REX-RFQ (compared to measurements) have shown, that the MAFIA-values for Q and R_p are always more than a factor two higher than experimental data. At least only the built-up of a 1 m IH-RFQ-model can definitely show if this discrepancy is also valid for cavity resonators and how far a mechanical design of this resonator is feasible.

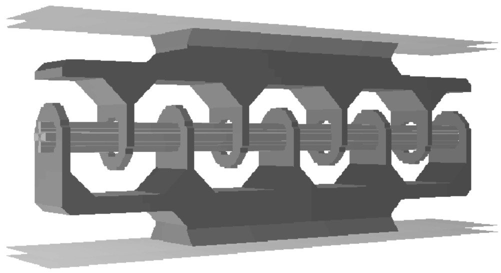

Fig. 1: A possible design for the IH-RFQ model (without half-shells). The parameters are: f=91 MHz, Q=9164, R_p=236 $k\Omega m$, diameter=35 cm, undercuts: length=15 cm, height=4.5 cm.

Concerning the dipole content of the IH-RFQ, fig. 2 shows the voltage distribution for a 3m MAFIA model with 37 holders (holder distance:7 cm) and vertical (respective horizontal) opposite electrodes. The electric field has been numerically integrated between the upper (respective lower) electrode and the middle electrodes. The calculations show, that the average voltage difference is not bigger than 1%. The advantage of a resonator with vertical/horizontal opposite electrodes and an odd number of holders is, that the dipole contribution does not increase at the overhanging electrode segments at the ends of the resonator.

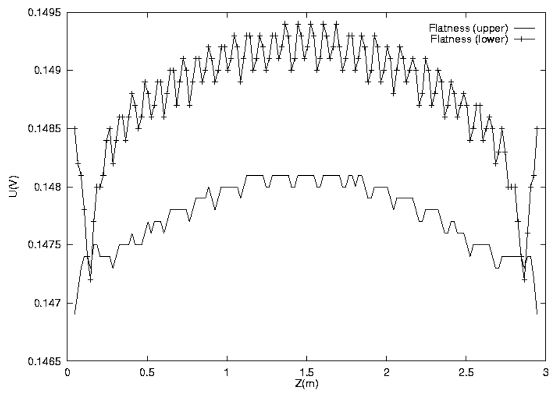

Fig. 2: Differences between the calculated electric potentials of the vertical opposite electrodes (dipole quota).

References

[1] M. Groß *et al.*, The Status of the Munich Fission Fragment Accelerator Project, AIP Conf. Proc. **447** (1998) 126

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[3] U. Ratzinger *et al.*, The 36 MHz High Current IH-Type RFQ and HIIF-relevant Extensions, Nucl. Instr. Meth. **A415** (1998) 281

[4] T. Sieber *et al.*, this report p.76