NEW DEVELOPMENT OF A RFQ BEAM MATCHING SECTION

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Abstract

Funneling is a method to increase low energy beam currents in multiple stages. The Frankfurt Funneling Experiment is a model of such a stage. The experiment is built up of two ion sources with electrostatic lens systems, a Two-Beam-RFQ accelerator, a funneling deflector and a beam diagnostic system. The two beams are bunched and accelerated in a Two-Beam RFQ. A funneling deflector combines the bunches to a common beam axis. Current work is the construction and beam tests of a new beam transport system between the RFQ accelerator and deflector. With extended RFQ-electrodes the drift between the Two-Beam-RFQ and the rf-deflector will be minimized and therefore unwanted emittance growth reduced. First rf-measurements with the improved Two-Beam-RFQ will be presented.

INTRODUCTION

The maximum beam current of a linac is limited by the beam transport capability at the low energy end of the linac: For a given ion source current and emittance the linac current limit is proportional to $\beta = v/c$ for electric and to β^3 for magnetic focusing channels and ideal emittance conservation. The funneling scheme uses the shift to higher current limits with higher beam energies by doubling the beam current combining two bunched beams preaccelerated at a frequency f_0 with an rf-deflector to a common axis and injecting into another rf-accelerator at frequency $2 \cdot f_0$ as shown in Fig. 1. Ideally the beam emittance could remain as low as for one single beam. Extracting twice the beam from a single ion source would result in at least twice the emittance for the following accelerators.

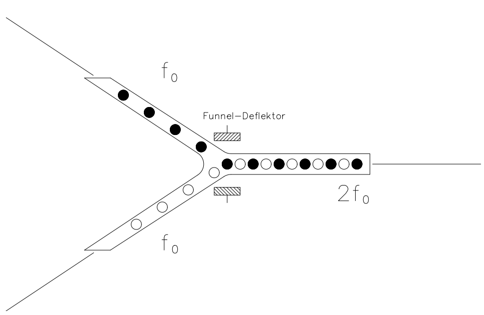

Figure 1: Bunch trace through the funneling deflector in top view.

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EXPERIMENTAL SETUP

The setup of the Frankfurt Funneling Experiment consists of two multicusp ion sources, a two beam RFQ accelerator, a funneling deflector and a beam diagnostic device. Both ion sources with an electrostatic LEBT are directly mounted at the front of the RFQ resonator and deliver a He^+ beam at energy of 4 keV.

Figure 2: Picture of the experimental setup.

The Two-Beam RFQ accelerator consists of two sets of quadrupole electrodes arranged with an angle of 76 mrad in one common resonant structure [1]. The beams are bunched and accelerated with a phase shift of 180°.

The quadrupole sets with a total length of approx. 2 meter are divided into two sections: The first section bunches and accelerates the beam to a final energy of 160 keV. The new matching section focuses the beam longitudinally and radially to the beam crossing point at the centre of the deflector with low acceleration to 180 keV. The matching section reduces the beam size to about 60% of the old value [2]. At the beam crossing point the deflector reduces the angle of the transversal coordinate from x'=38 mrad to x'=0 mrad .

EXTENDED MATCHING ELECTRODES

To reduce beam loss and emittance growth in the deflector the drift between the RFQ and the deflector needs to be shortened (Fig. 3). Therefore the old matching section was replaced by a new one with extended electrodes. The drift is now 5 cm.

The new electrodes are about 20 cm longer. The focus for the bunches is in the middle of the deflector. If the bunches have the smallest possible extent for the deflection, the emittance will less grow.

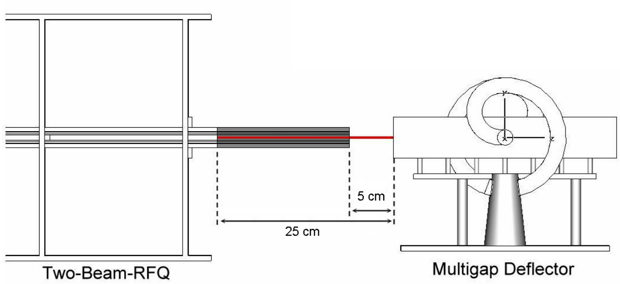

Figure 3: Old drift (without) and new drift (with gray part) between RFQ and deflector.

In Fig. 4 the comparison between old and new electrodes is shown. The old electrodes end with an offset because of the phase shift. In case of higher fields at the end of the extended electrodes because of the smaller distance between the two beam lines, the electrodes of the left beam line (in Fig. 4 the right ones) are about 2.7 cm more extended as the other ones. This is just one more rf-cell at the end without modulation. The electrodes in the middle are in contact with each other. That causes no electrical problem because both are on the same potential.

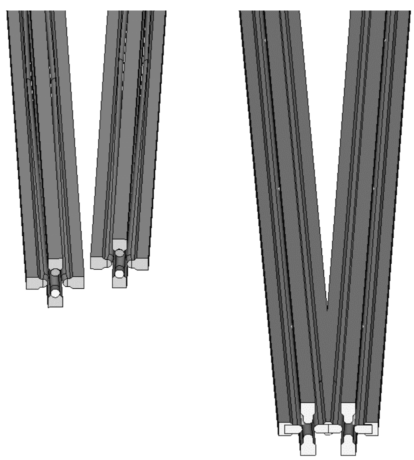

Figure 4: The old (left) and new (right) end of the matching section.

Because the electrodes are about 20 cm longer, a new stem was developed. It is made of Teflon so that it is nonconducting (Fig. 5).

For a better voltage symmetry small tuning angles were build in as additional capacity (Fig. 7). In the old matching section much bigger capacity was needed.

Nevertheless the longitudinal voltage distribution in the RFQ was at ± 23%. Now with the extended electrodes and the small angles at the end the flatness is about ± 8% as it is shown in Fig. 8.

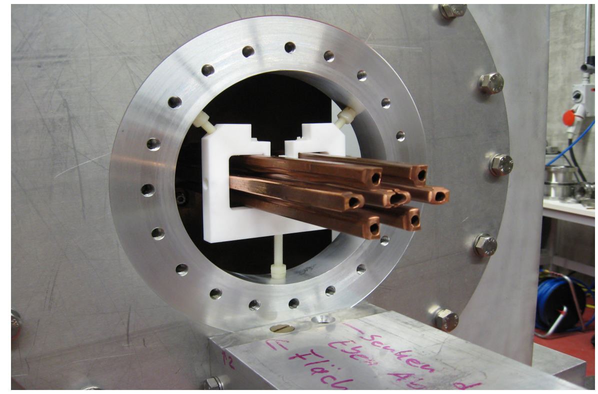

Figure 5: The new matching section with the nonconducting stem.

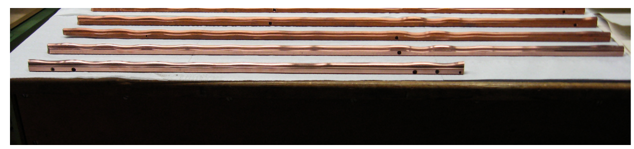

Figure 6: In the front an old short electrode, behind the new extended ones.

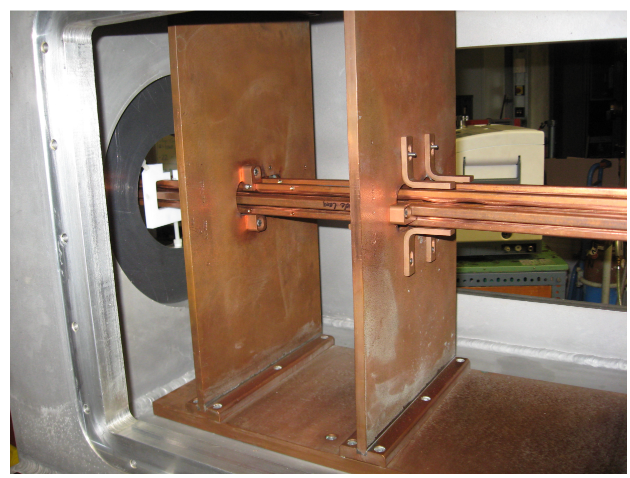

Figure 7: Small tuning angles as additional capacity for a better voltage symmetry.

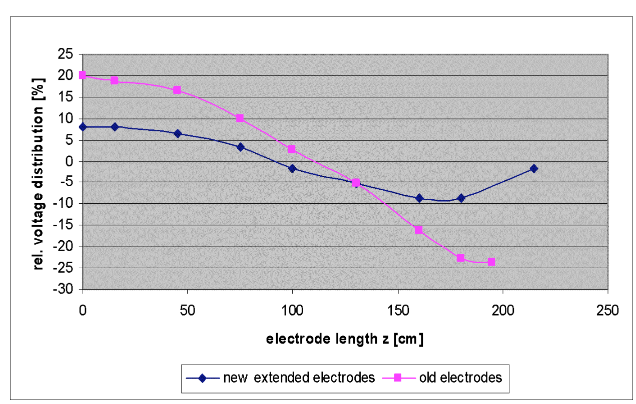

Figure 8: Longitudinal voltage distribution in the RFQ.

CONCLUSIONS

The frequency and energy tuning on the funneling deflectors has been done. First beam measurements have shown a good matching between the RFQ and the deflectors. Faradaycup measurements with the one-gap-deflector have shown the matching end electrodes work fine. Fluorescence screen measurements demonstrate a good beam bending at the new beam axis [3]. In the simulation for the extended electrodes with the beam matching system the beam radius and the phase space are reduced one more time. Moreover, the beam loss in the matching part is minimized, so there is almost no beam loss in the range of the matching section [4]. This is achieved by the smaller field gradients through the extension of the matching section. The extended electrodes have been mounted and first measurements show a considerably reduce of the flatness. Next steps will be beam measurements with this new matching section.

REFERENCES

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