

THE FRANKFURT FUNNELING EXPERIMENT *

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Abstract

Funneling is a procedure to multiply beam currents at low energies in several stages. The Frankfurt Funneling Experiment is a prototype of such a stage. Our experiment consists of two ion sources, a Two-Beam RFQ accelerator, a funneling deflector and a beam diagnostic system. The two beams from the ion sources are injected into two RFQ beam lines. These two beams are accelerated in a Two-Beam RFQ and combined to one beam axis with a funneling deflector. The last parts of the RFQ electrodes have been replaced to achieve a 3d focus at the crossing point of the two beam axis. The newly designed multigap deflector is adapted to the optimized funneling section. First results and measurements with the new setup will be presented.

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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 is making use of the higher current limits at higher beam energies by

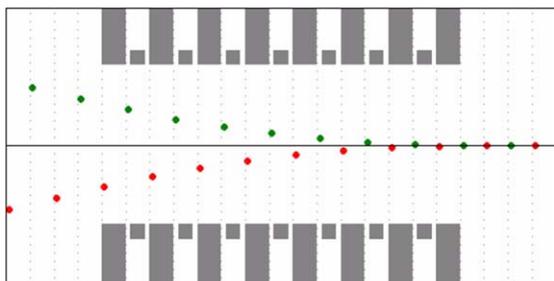


Fig. 1: Bunch trace through the funneling deflector in top view.

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 figure 1. Ideally the beam emittance could be staying 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.

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EXPERIMENTAL SETUP

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

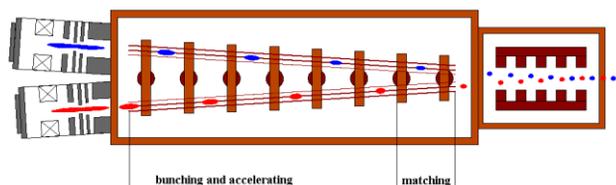


Fig. 2: Scheme of the experimental setup.

The two-beam RFQ accelerator consists of two sets of quadrupole electrodes arranged with an angle of 75 mrad in one common resonant structure (fig. 2) [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 center of the deflector with low acceleration to 179keV.

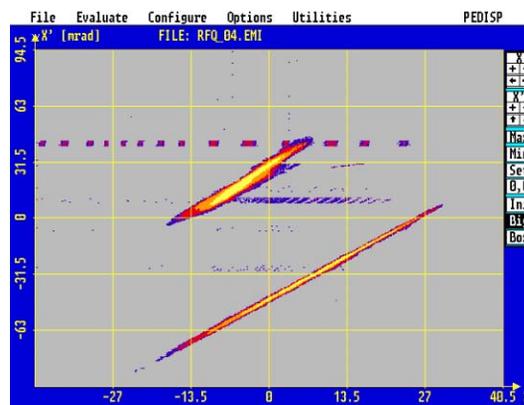


Fig. 3: Emittance measurement with one beam line upgraded.

The new matching section reduces the beam size of about 60% [3]. Figure 3 shows the comparison of the new (top) and old (bottom) electrode section.

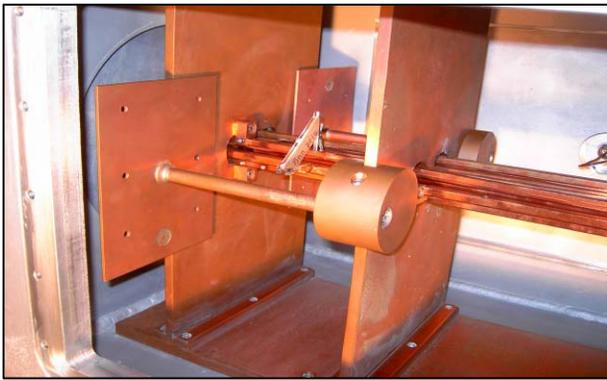


Fig. 4: Photo of the new matching section with additional capacity.

Figure 4 shows the measured emittance with the upgrade of both RFQ channels. The emittances are nearly equal.

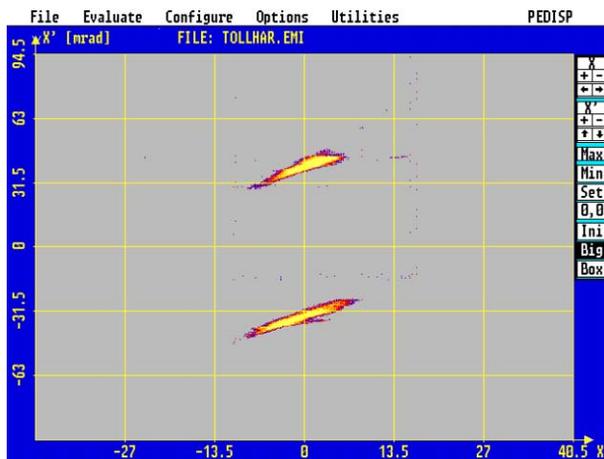


Fig. 5: Upgrade of both beam lines.

At the beam crossing point the deflector reduces the angle of the transversal coordinate from $x'=37.5$ mrad to $x'=0$ mrad in one, with the single cell deflector, or in several steps, with the 15 cell deflector.

DEFLECTOR

Because of the new electrode design of the last RFQ section the final energy rises from 160 keV to 179 keV. Therefore the electrode length of the old 17 cell funneling deflector has been adjusted and the number of cells have been reduced from 17 to 15. The drift tubes are now mounted on two grounded stems. The separation of mode 1 and mode 2 is now 10 MHz instead of only 400 kHz). The deflector is more mechanically stable now [5].

The flatness curve of the bead-perturbation measurement delivers a R_p -value of 420 k Ω . The duty factor determined with the 3dB method is $Q = 2260$. With the help of the mounted and moveable coils the frequency tuning is now very easy (fig. 6).

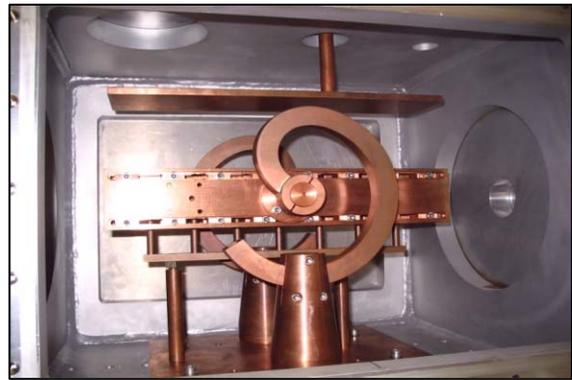


Fig. 6: Photo of the new 15 cell funneling deflector.

PARTICLE DYNAMIC SIMULATION SOFTWARE

RFQSim is a macro particle dynamic program to calculate ion beams in an RFQ accelerator.

The beam through the funneling deflector is simulated with *FUSIONS* (**F**unneling **S**imulation for **I**on **B**eams). It is a newly developed particle dynamic simulation software for funneling deflectors [2, 6]. The 6-dimensional particle distribution from *RFQSim* is transported segmentally through the deflector.

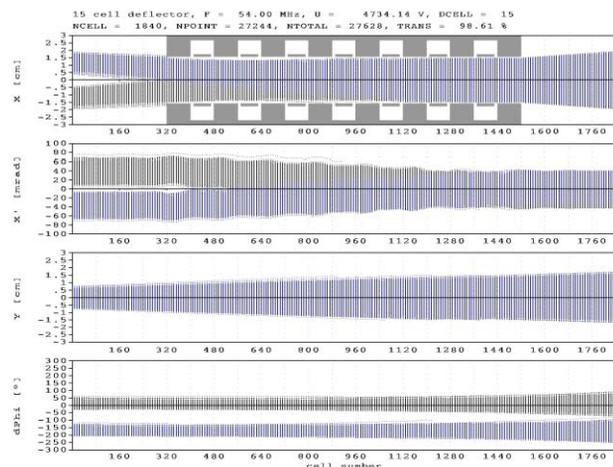


Fig. 7: Beam trace through the 15 cell deflector.

Both space charge routines, a particle-particle and a PIC (particle in cell) routine, are now integrated. At the moment the work of the routines are verified.

MWS-SIMULATION

The rf-structure is a symmetrical RFQ-structure where both sets of electrodes are connected on a common stem extending to the cross-section.

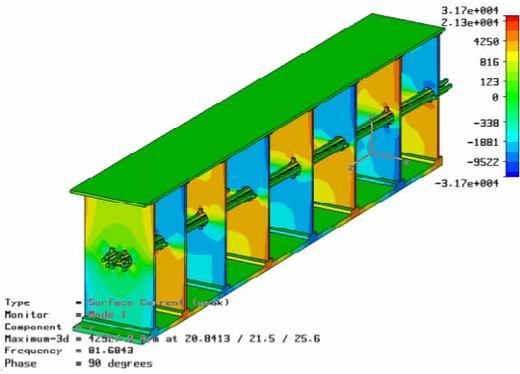


Fig. 8: Two-beam-RFQ microwave studio simulation.

The microwave studio simulations show symmetric current distribution on the RFQ-stems.

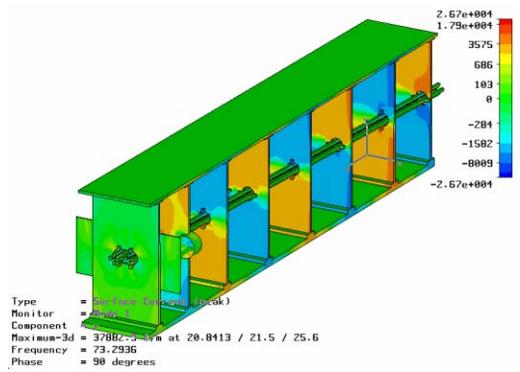


Fig. 9: Simulation with an additional capacity.

The second simulation shows the effect of an additional capacity in the end cell. As expected additional capacity reduce the frequency but also changes the field distribution in the cavity.

FLATNESS MEASUREMENT AND TUNING

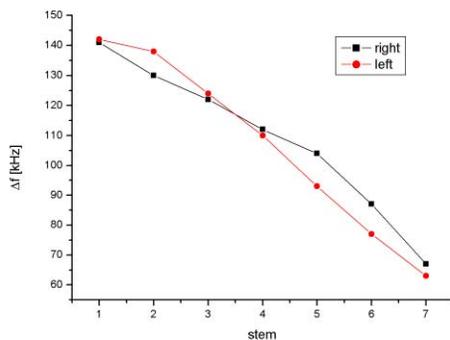


Fig. 10: Flatness measurement with matching section.

On the total length of the two-beam-RFQ there is an unflatness of 50% voltage on the electrodes. The maximum voltage is located on the front end of the RFQ.

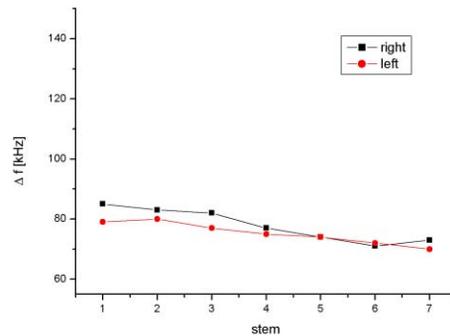


Fig. 11: Flatness measurement with matching section and additional capacity.

An additional capacity reduces the unflatness to less than 12%.

CONCLUSIONS

The reinstallation of the experiment in our new experimental hall in Niederursel is finished. The upgrade of the both RFQ beam lines is done. Our multi cell deflector has been optimized. The flatness tuning has been done. Next step will be first experiments with the new setup and the verification on the matching.

REFERENCES

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