THE FRANKFURT FUNNELING EXPERIMENT*

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Abstract

The goal of the Frankfurt-Funneling-Experiment is to multiply beam currents of RFQ accelerators at low energies to avoid problems with space charge. The two beams from the ion sources are injected into two RFQ channels. The last part of the RFQ electrodes has been replaced to achieve a 3d focus at the crossing point of the two beam axis where the funneling deflector as a central peace of the experiment is located. The newly designed multigap deflector is adapted to the optimized funneling section. It is mechanicaly solid, easy to tune in and ready for operation. First measurements will be presented.

INTRODUCTION

High beam currents are necessary for heavy ion driven fusion (HIF), XADS or accelerator facilities like IFMIF. Funneling is a possible procedure to achieve these high beam currents. Several ion beams are combined at low energies to one beam using the funneling technique. In each stage a r.f. funneling deflector bunches two accelerated beam lines to a common axis (fig. 1). The Frankfurt Funneling Experiment is a scaled model of the first stage of a HIF driver.

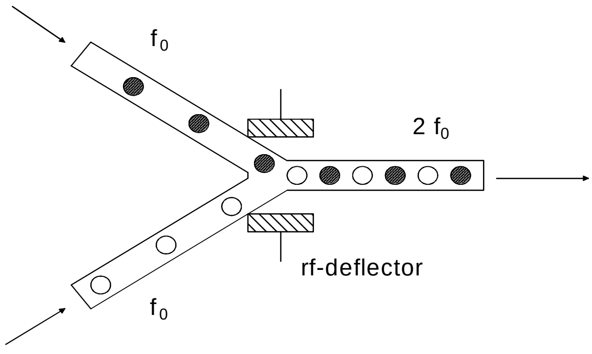

Figure 1: Principle of funneling.

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 LEBT are directly mounted at the front of the RFQ resonator and deliver a He^+ beam at an energy of 4 keV.

The two-beam RFQ accelerator consists of two sets of quadrupole electrodes with an angle of 76 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 179 keV. The new matching section focuses the beam longitudinally and radially to the beam crossing point at the center of the deflector.

The new matching section reduces the beam size of about 65%[2]. Figure 3 shows the comparison of the new (top) and old (bottom) electrode section.

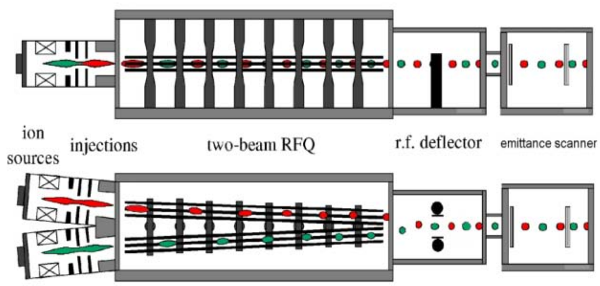

Figure 2: Scheme of the experimental setup.

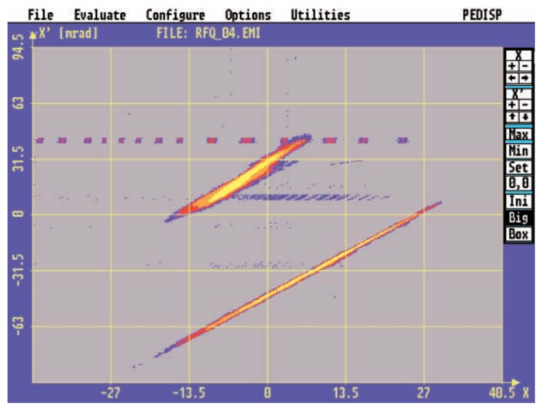

Figure 3: Emittance measurement with one beam line upgraded.

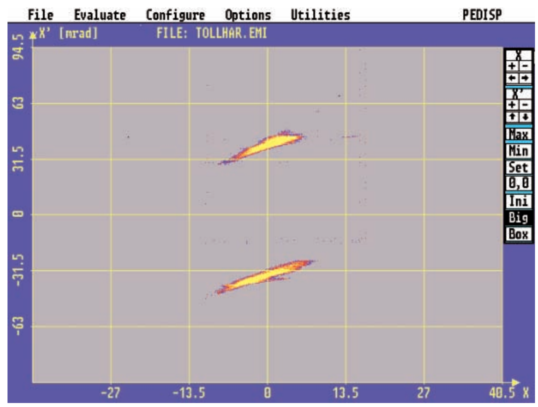

Figure 4: Upgrade of both beam lines.

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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.

THE NEW 15 CELL DEFLECTOR

Because of the new electrode design of the last RFQ section the final energy rises from 160 keV to 179 keV. For this reason the electrode length of the old 17 cell funneling deflector has been adjusted and the numbers of cells have been reduced from 17 to 15. Several improvements have been done. The drift tubes are now mounted on two grounded stems. The separation of mode 1 and mode 2 is now 10 MHz instead of 400 kHz (fig. 5). The deflector is mechanically stable now [3].

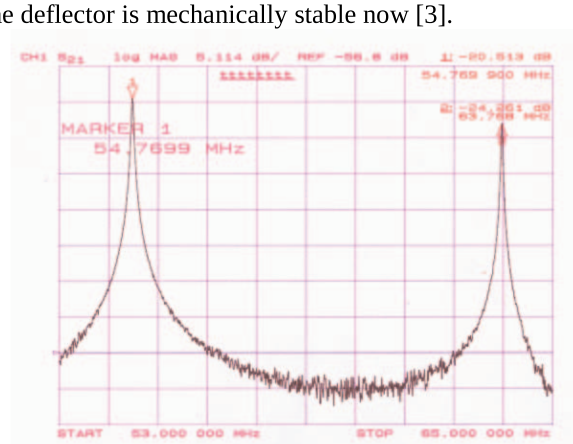

Figure 5: Measured resonance frequencies of the deflector.

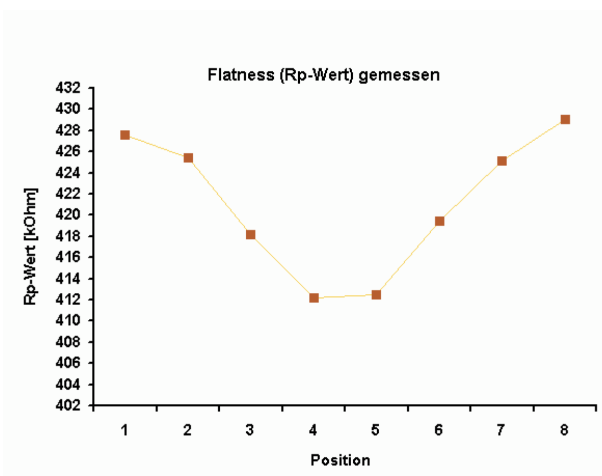

Figure 6: Flatness curve measurement.

The flatness curve of the bead-perturbation measurement delivers a R_p-value of 420 kΩ (fig. 6) 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. 7).

The distribution of the electric field along the beam axis is according to our expectance (Fig. 8). With the drift tubes between the electrodes, the field gets minimized, because they are on ground potential.

To keep the resonance frequency adjusted during operation in vacuum a capacitive tuning device is used (Fig. 9).

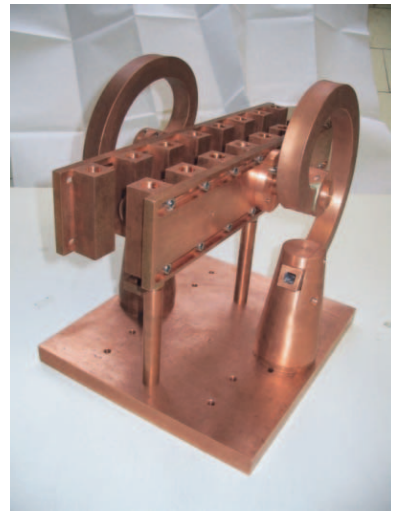

Figure 7: Photo of the new 15 cell funneling deflector.

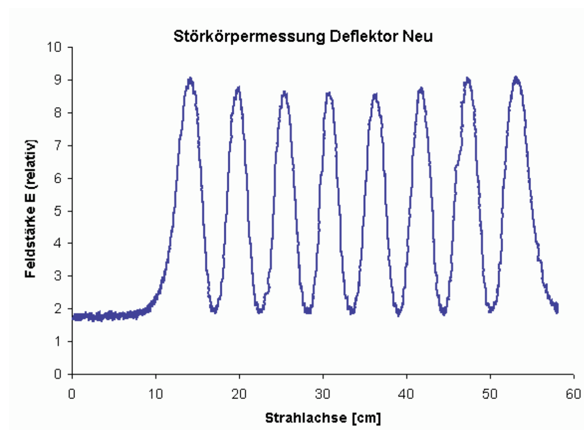

Figure 8: Measured E-field along the beam axis.

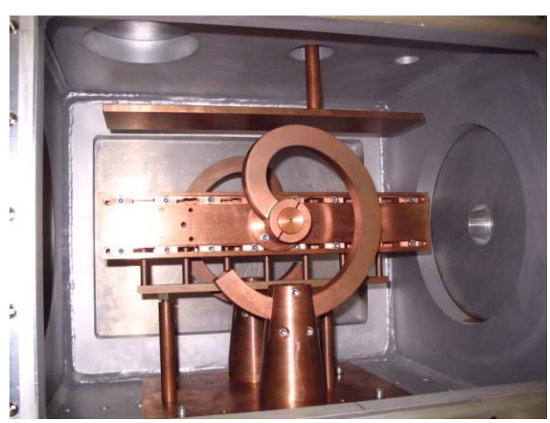

Figure 9: Structure in tank with tuning device.

SIMULATION SOFTWARE

Microwave Studio is a program to simulate HF-resonator structures. After a virtually construction in a 3d-graphic, it solves the Maxwell equations by iteration. The results are very close to reality (fig. 10 and fig. 11).
Microwave Studio has many possibilities for graphical analysis. The electric field is shown in a cutting plan through the deflector model (Fig. 12).
The tuning of the resonance frequency by moving the coils is a linear process as a function of the angle (fig. 13).

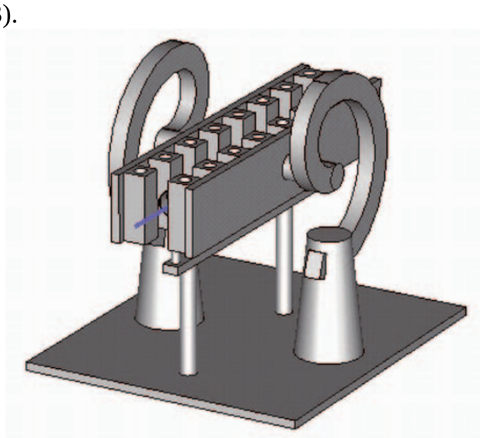

Figure 10: Simulation of the new 15 cell funneling deflector.

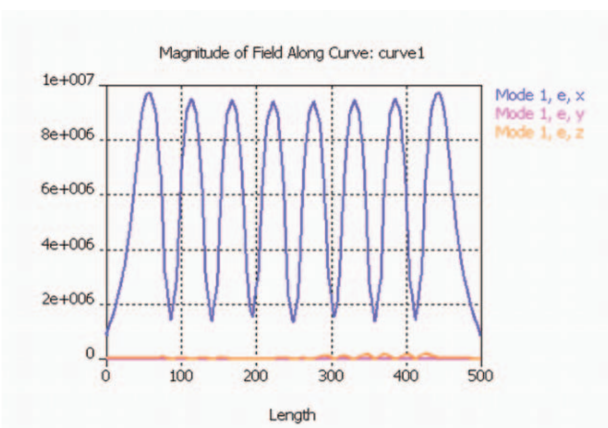

Figure 11: Simulated E-field along the beam axis.

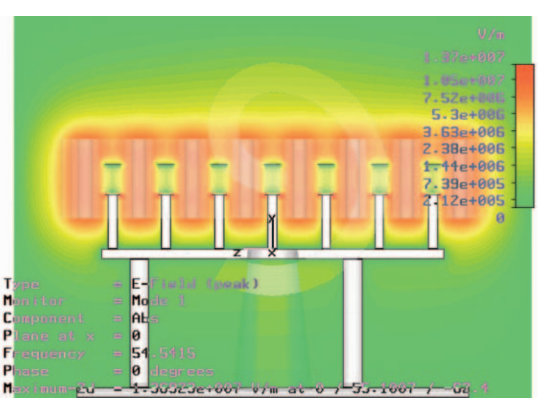

Figure 12: Simulated E-field around the structure.

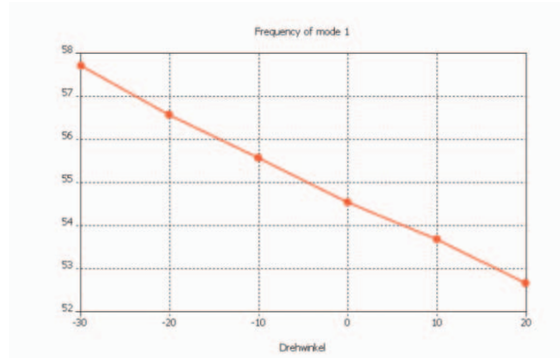

Figure 13: Simulation of the frequency tuning.

CONCLUSIONS

The reinstallation of the experiment in our new experimental hall in Niederursel is still in progress. The upgrade of the both RFQ beamlines is done. Our multi cell deflector has been optimized. Next step will be first experiments with two matched beams and the new funneling deflector.

REFERENCES

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[3] H. Zimmermann et al., “The Frankfurt Funneling Experiment”, Proc. Int’l PAC 2005 Conference, Knoxville, USA (2005), p. 677