FUNNELING WITH AN TWO BEAM RFQ-ACCELERATOR

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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 a 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 and the last parts of the RFQ electrodes achieve a 3d focus at the crossing point of the two beam axis. A funneling deflector combines the bunches to a common beam axis. The optimized ion sources are adapted to the front end bunching section. Recent beam measurements will be presented.

INDRODUCTION

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

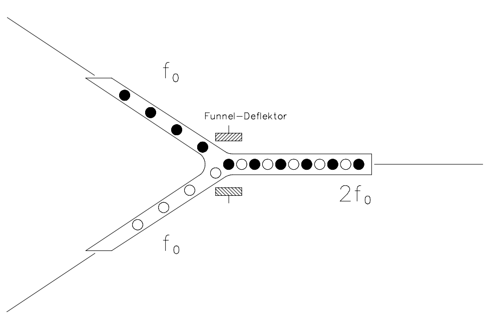

Figure 1: Bunch trace through the funneling deflector in top view.

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.

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 energy of 4 keV.

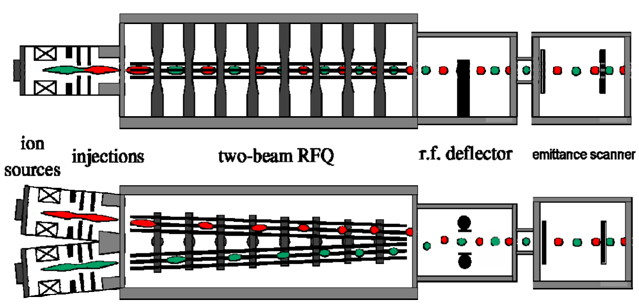

Figure 2: Scheme of the experimental setup.

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 matching section focuses the beam longitudinally and radially to the beam crossing point at the centre of the deflector with low acceleration to 179keV. The matching section reduces the beam size of about 60% [2].

Figure 3 shows the measured emittance with the upgrade of both RFQ channels. The emittances are nearly equal.

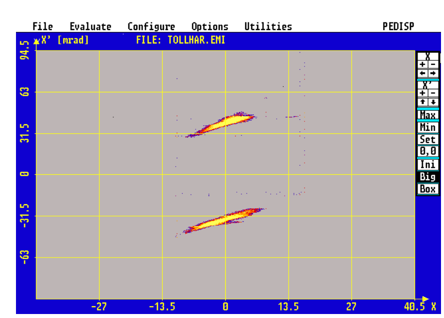

Figure 3: Upgrade of both beam lines.

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

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ONE-GAP DEFLECTOR

For beam bending to a common axis we use a high frequency deflector. The crossing point of the two beams is right in the middle of the deflector, which is 52 cm behind the RFQ. This deflector is like a plate capacitor, oscillating with the same resonant frequency as the RFQ. A photograph of the twin line resonator with the one cell deflector is shown in Figure 4.

Figure 4: Picture of the one cell funnel deflector. The deflector discs are mounted at water-cooled stems. The height is about 2 m.

The angle between the two beam axes is 75 mrad. The one cell funnel deflector bends this angle down to zero by an r.f. voltage of 25 kV. Figure 5 shows a simulated beam bending with the one cell funnel deflector.

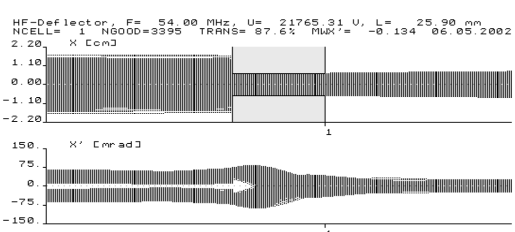

Figure 5: Simulation of the beam bending in the one cell funnel deflector.

Figure 5 shows a funneling simulation [3] of two beams. The angle between the two beams is reduced from 75 mrad down to zero. The rectangles are the deflector plates (top picture), the lower picture shows the beam bending from 37.5 mrad down to zero.

Figures 6 and 7 show two emittance measurements. If the funnel deflector is switched off, the beam drifts through the deflector and we measure the beam-angle of 75 mrad. Figure 7 shows an emittance measurement with the one cell funnel deflector switched on. The two beams are merged into a common beam.

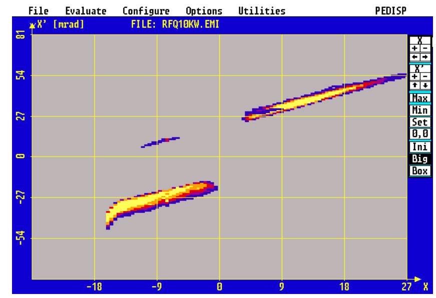

Figure 6: Beam measurement with switched of deflector

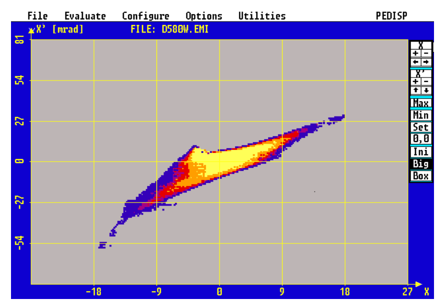

Figure 7: Beam measurement with switched on deflector

BEAM MEASUREMENT

The latest beam measurements with new ion sources [4] and a tuned flatness [5] shows a good matching of the ion sources and the two beam RFQ-accelerator.

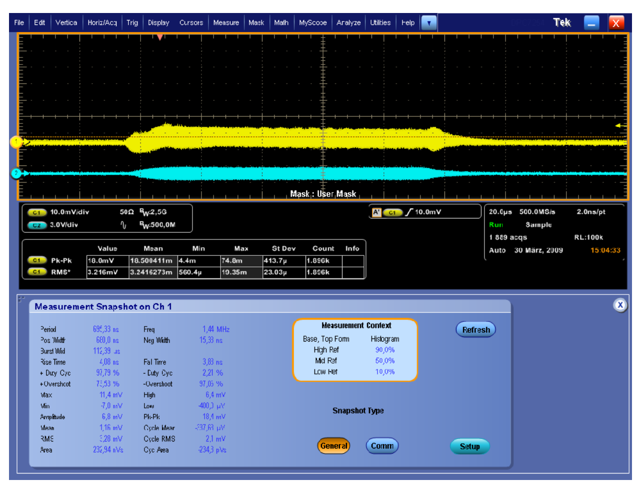

Figure 8: Transported He+ beam

Figure 8 shows a faraday cup measurement of the transported beam behind the RFQ-accelerator in the beam crossing point. The RFQ-accelerator works with an duty Factor of 0.5 %.

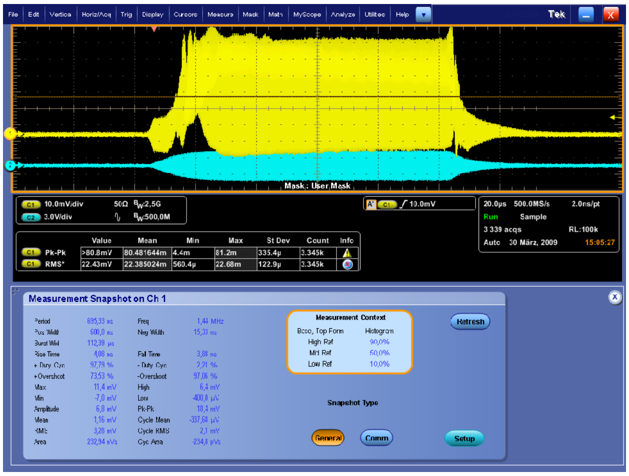

Figure 9: Accelerated He+ beam

In figure 9 the rf-power is increased to 8 kW to accelerate the Helium ions. After the transient oscillation the RFQ-accelerator works stable.

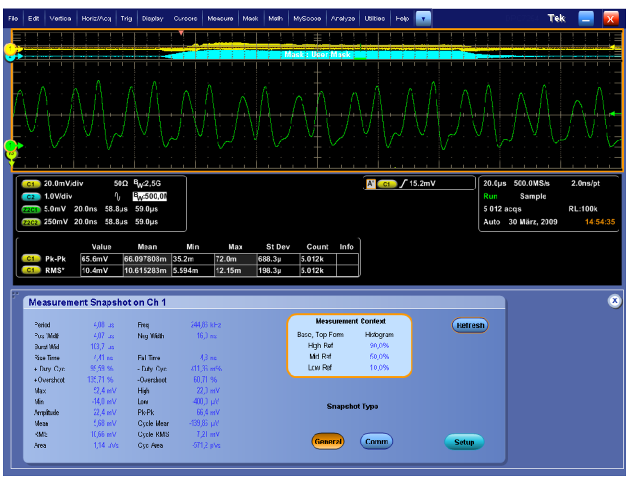

Figure 10: Micropulse measurement with a fast Faraday cup

Figure 10 shows the accelerated micro bunches from the new improved beam lines. The Faraday cup used has only a restricted bandwidth and cannot resolve the pulses with high resolution. But the results clearly show the improvements of the pulse width in comparison with [6]. First measurements with the one gap deflector have shown a good conformance from the new assembling.

Figure 11: Assembling for funneling measurements

CONCLUSIONS

The upgrades of the matching sections of the both RFQ beam lines and the flatness tuning has been done. First beam measurement has shown a good matching between the new ion sources and the RFQ. First funneling test have been done.. Next steps will be funnelling emittance and transmission measurements.

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