SIMULATION FOR A BEAM MATCHING SECTION WITH RFQSIM*

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Abstract

The goal of the Frankfurt Funneling Experiment is to multiply beam currents by merging two low energy ion beams. In an ideal case this would be done without any emittance growth. Our setup consists of two ion sources, a Two-Beam-RFQ accelerator and a multi cell deflector which bends the beams to one common beam axis. The end sections of the RFQ electrodes are designed to achieve a 3d focus at the crossing point of the two beam axis. New simulations with the RFQSim-Code for a matching system with extended electrodes 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.

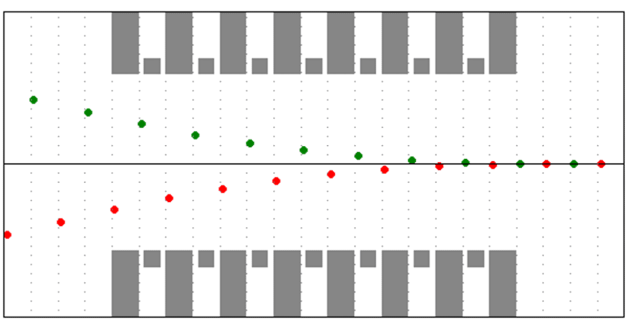

Figure 1: Bunch trace through the funneling deflector in top view.

The funneling scheme is making use of the higher current limits at 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 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.

MOTIVATION

Between the Two-Beam-RFQ accelerator and the deflector, the ion beams are in a drift section for about 25 cm caused in space charge effects. In this drift section and at low energies like 180 keV the beam diameter increases. This results in beam losses at the entrance of the deflectors and throughout the deflector. A shorter drift could be realized with extended RFQ-electrodes. With this the beams are in the focusing fields of the RFQ until approx. 5 cm before the deflector. The impacts of these extensions of the electrodes on the particle dynamic are topic of this paper.

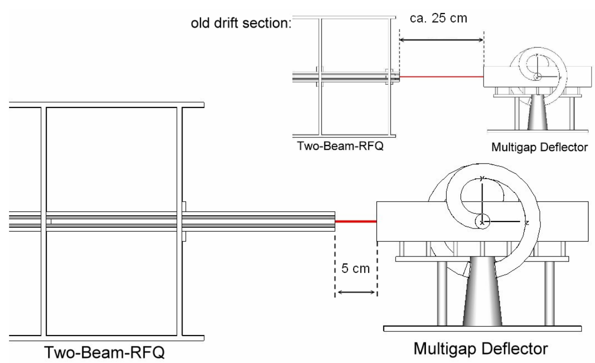

Figure 2: Schematic illustration of the old and new drift section between RFQ and deflector.

Figure 2 shows a schematic arrangement with the two-beam-RFQ and the multigap deflector. The extended electrodes reduce the drift space between the RFQ and the deflector to 5 cm.

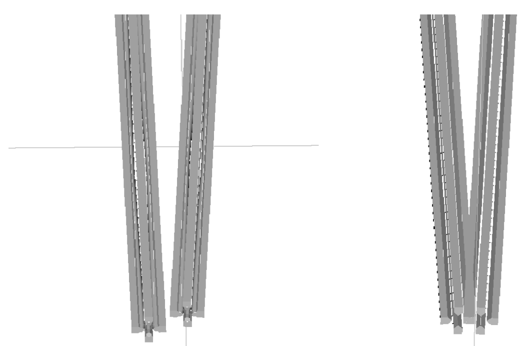

Figure 3: The quadrupole arrangement with short (left) and extended (right) electrodes.

PARTICLE DYNAMIC SIMULATION SOFTWARE

Beam dynamic through the RFQ accelerator is done by RFQSim. RFQSim is a particle simulation program for normal conducting RFQ accelerator structures at low energies. It transports macro particle bunches in the six

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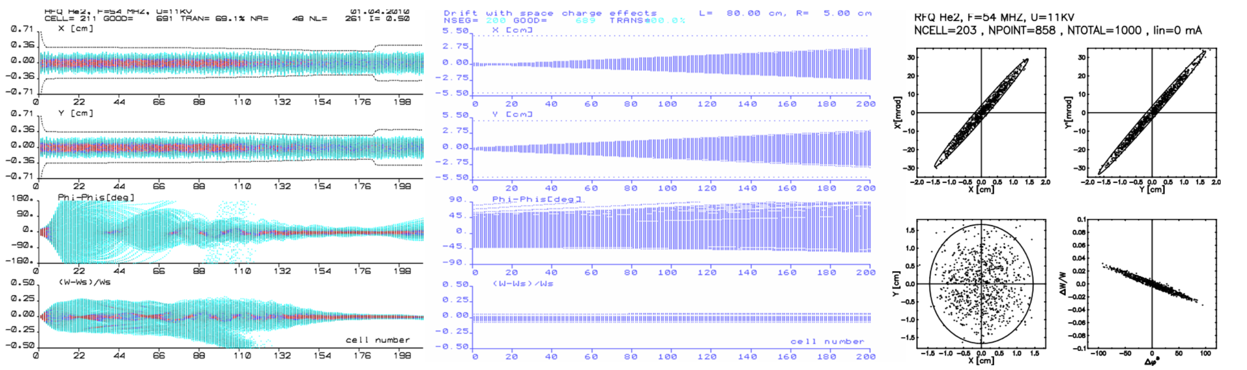

Figure 4: The picture shows a simulation for a beam line without a modulation in the end part of the beam line. This was the design at the first set up of the two beam RFQ accelerator.

dimensional phase space segmentally through the RFQ and more than 15 modules such as bunchers, quadrupoles, lenses and drift tubes. These modules can be placed before and behind the accelerator. Different space charge routines, e.g. method of charge rings, can be chosen [3]. We designed a new matching section for the end part of the two beam funnelling-RFQ with extended end electrodes.

It is important to note that the start of the drift section, in the simulation for the extended electrodes, has a shift of 20 cm compared to the simulation with short electrodes. The drift section between the extended electrodes and the end of the one gap deflector is 40 cm while it is 60 cm with the short electrodes. For the multi gap deflector this means that the bunch drifts 60cm behind the extended and 80 cm behind the short electrodes.

The simulation with beam matching section in the end part of the accelerator shows a smaller beam radius and a smaller longitudinal phase space at the microbunch. The beam radius decreases from 5 cm to 2 cm and the phase length from 180° to 90°. But the beam matching causes approx. 8% beam loss in the end part of the matching section. This beam matching system can provide the beam against beam losses in the deflector but causes beam losses in the matching system.

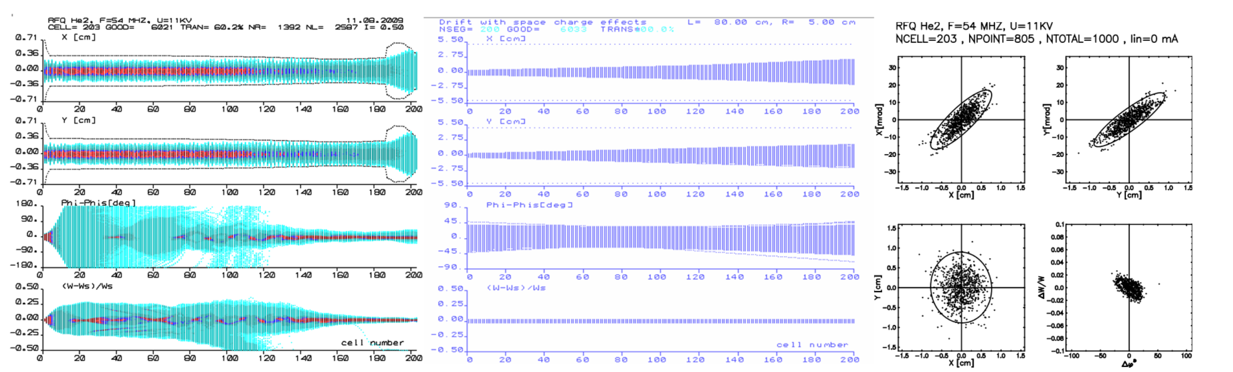

Figure 5: The second simulation shows a beam line with a short matching section in the end of the accelerator.

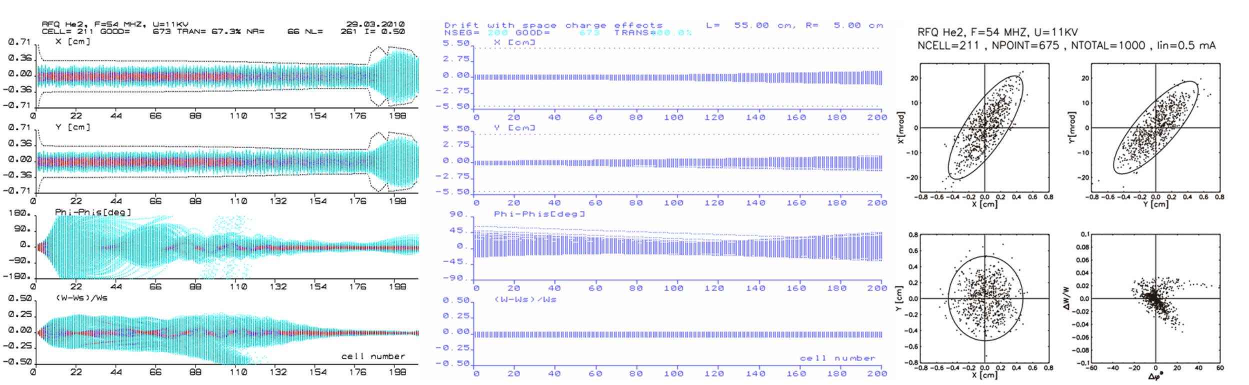

Figure 6: In this simulation the electrodes with about 20 cm extension are used. The matching section is tuned up for maximum transmission.

In the simulation for the extended electrodes with beam matching system we reduce the beam radius and the phase space even more. Moreover the beam loss in the matching part is minimized so there is almost no beam loss in the range of the matching section. This is achieved through the extension of the matching section by the smaller field gradients for the brilliant adaptation needed.

CONCLUSION

The simulation for the new beam matching section with extended electrodes is done. A better transmission and a smaller beam size have been achieved in the simulations. In the next step the new end electrodes are designed and built. Following Hf and beam measurements will be taken.

REFERENCES

[1] A. Schempp, Nucl. Instrum. Methods A 415 (1998) 209.

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[3] J. Thibus, A. Schempp, "Simulations for the Frankfurt Funneling Experiment" Proc. EPAC Conference 2006, Edinburgh, Scotland, 2006, p. 1591.