THE RFQ-INJECTOR FOR COSY-SCL*

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Abstract

For the new sc-linac for COSY at FZ Jülich [1], a combination of an RFQ and a spiral loaded cavity will accelerate H-,D- beams up to 2.5 Mev/u for injection into the sc-linac.

The RFQ is a 3.8 m long four-rod design which accelerates deuterons with an initial energy of 25 keV/u up to 2 MeV/u. Behind the RFQ a compact booster cavity of 300 mm length is mounted. This spiral loaded cavity accelerates the beam to a final energy of 2.5 MeV/u. It uses four accelerating gaps with an effective voltage of 1 MV. An alternative design has gaps with additional electrodes in an rf-quadrupol configuration to add a focussing field in this DTL structure.

The status of the work on this new injector is presented.

1 INTRODUCTION

At the Forschungszentrum Jülich a new injector for the cooler synchrotron COSY is developed. COSY-SCL will be a superconducting linac operating at a frequency of 160 MHz [2]. The low energy part of the injector consists of a conventional room temperature RFQ in combination with a short booster cavity. The ion source delivers polarized protons and deuterons at 25 keV. To accelerate both types of ions ensuring equal beam charcteristics, two RFQs with einzellenses and booster cavities are mounted on a rail system. An overview of the beamline is given in figure 1.

2 RFQ DESIGN

The design of the RFQ electrodes has been done under consideration of the beam parameters listed in Table 1:

Input energy	25 keV/u
Input emittance	0.14 π mm mrad
Current	1.5 mA
Output energy	2 MeV/u
Max. beam angle at the exit	± 15 mrad in both planes
Phase width at the exit	$\Delta\varphi \leq \pm 15°$

Table 1: RFQ beam parameters

In figure 2 the design parameters of the RFQ are shown.

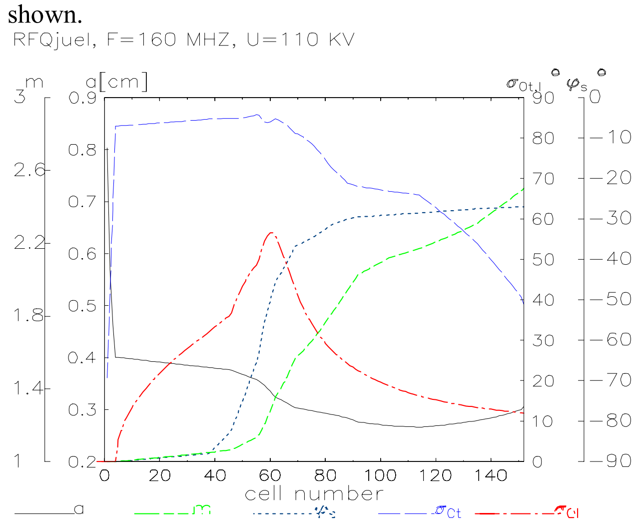

Figure 2: Design parameters of the RFQ

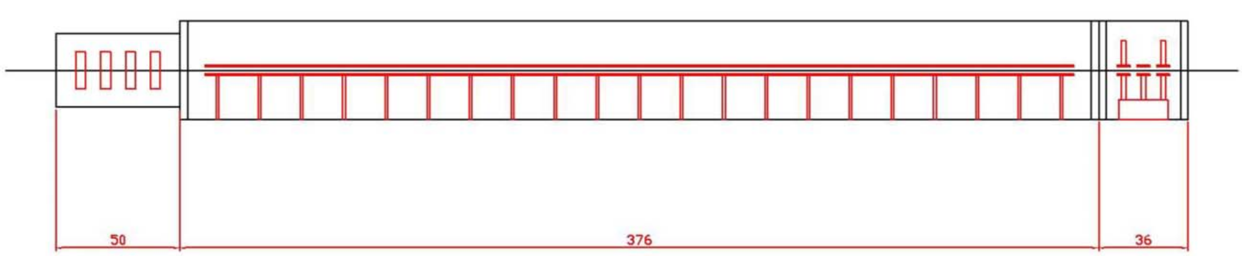

Figure 1: Overview of RFQ and Booster

In the first few cells the aperture decreases from 0.8 cm to 0.4 cm to match the beam radially. After the bunching section the ideal phase is raised to -27° and the aperture decreases furthermore to a minimum of 0.27 cm. The aperture is growing at the end of the electrodes which leads to a decrease of the focusing strength. This is necessary to maintain the beam angle of 15 mrad at the exit of the RFQ.

For the acceleration of the deuteron beam an electrode voltage of 110 kV is necessary. To gain that voltage the power consumption of the RFQ will be about 500 kW at a duty cycle of 1%. To study the thermal evolution in the RFQ the program ISAFEM was used. Figure 3 shows the temperatur distribution in one RFQ stem without cooling.

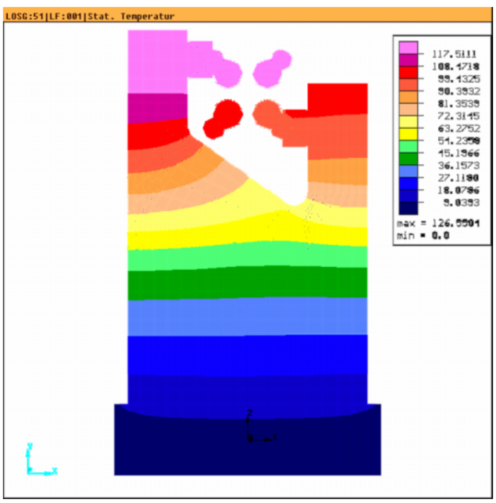

Figure 3: Temperature distribution in an RFQ stem without cooling calculated with ISAFEM.

3 BEAM DYNAMICS

The input distribution has been generated according to the expected beam emmitances at the RFQ entrance. They fit well into the acceptance of the RFQ as shown in figure 4.

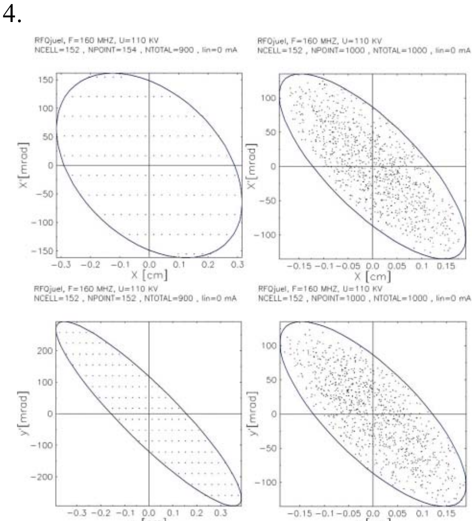

Figure 4: Input distribution and acceptance of the RFQ.

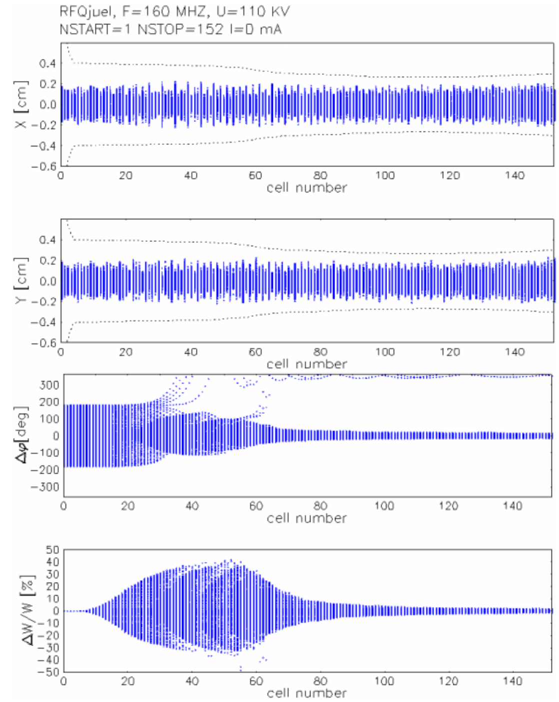

Figure 5: PARMTEQ simulation of the RFQ. The upper two graphs display the transverse beam envelope. The longitudinal evolution of the beam is shown in graphs three and four.

The propagation of the beam through the 152 RFQ cells is displayed in figure 5. The aperture growth at the end of the electrodes corresponds to a decrease of the focusing strength. Therefore the beam radius is rising slightly, but the anglular spread is small and meets the requirements listed in table 1. The energy spread of the beam reaches its minimum at the end of the structure. The output distribution of the RFQ is shown in figure 6.

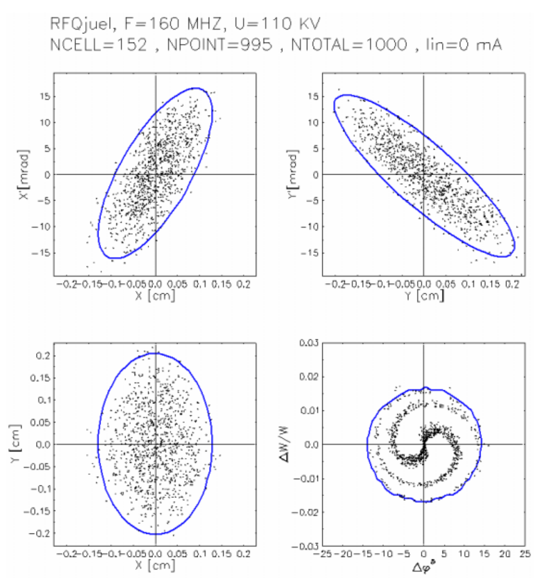

Figure 6: Output distribution of the RFQ.

To reach the overall energy of 2.5 MeV/u a booster cavity is mounted directly at the end of the RFQ. Because

RFQs get less effective at higher energies and the length of the RFQ shouldn't exeed 4 m to ease manufacturing, a spiral loaded cavity with 30 cm length and four accelerating gaps is used. The parameters of the cavity are listed in table 2.

Length:	300 mm
Diameter:	280 mm
Aperture:	20 mm
Gap voltage:	250 kV
Power consumption:	150 KW

Table 2: Parameters of the booster cavity.

DTL cavities thus short feature a high energy acceptance and flexibility [3]. They can be used both as booster or buncher cavities. A drawing of the spiral loaded cavity is pictured in figure 7.

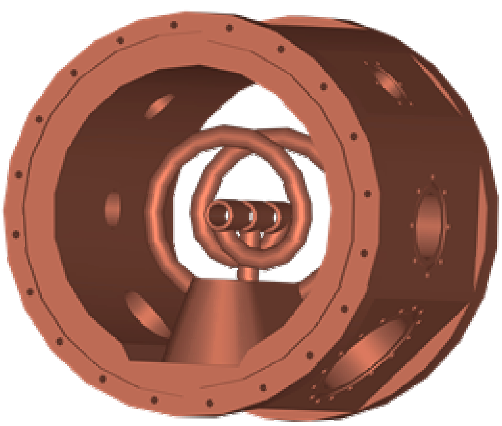

Figure 7: drawing of the spiral loaded cavity.

To match the beam to the following SC linac a matching line consisting of quadrupoles and a buncher is used. The beam distribution after the matching section is pictured in figure 8.

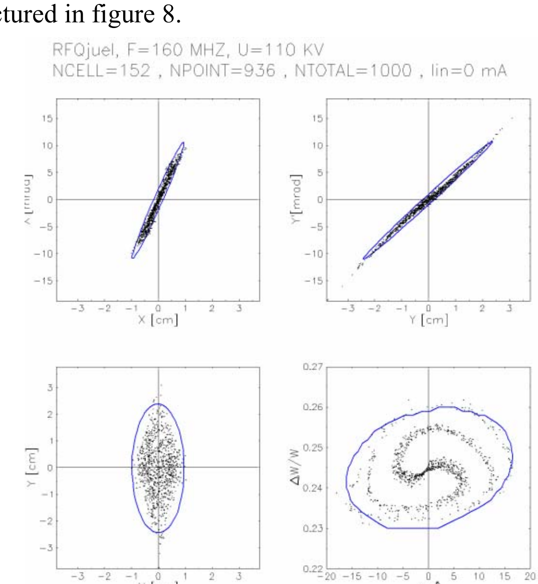

Figure 8: Beam distribution after the matching section.

Optional to the classical DTL booster a DTL cavity with additional quadrupole electrodes could be used to achieve a better focussing a higher energies. This type of cavity is being examined at IAP. Figure 9 shows a schematic drawing of an accelerating gap with quadrupoles. To describe this kind of structure PARMTEQ was used introducing a new transport element which allows to transform the beam through an arbitrary three dimensional potential distribution [5].

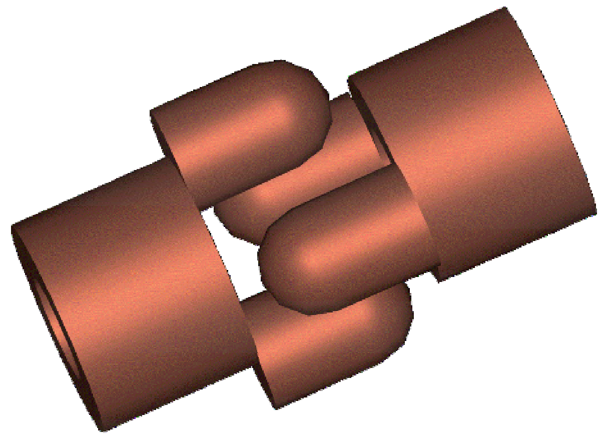

Figure 9: Schematic drawing of an accelerating gap with quadrupoles

4 CURRENT STATUS

At present the vacuum vessel as well as the resonating structure for the RFQ are built at NTG in Gelnhausen. All components for the booster cavity are under construction in Frankfurt

The machining of the vacuum vessels will be finished soon. The alignment of the electrodes as well as RF tuning of both cavities will take place at IAP in Frankfurt.

REFERENCES

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