DESIGN OF A 352 MHZ-PROTON-RFQ FOR GSI *

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Abstract

Part of the future project of GSI is a new p-linac for the production of Antiprotons. The 4-Rod-RFQ operating at 352 MHz has to accelerate up to 100mA protons from an ECR source. Design studies have been made using the RFQsim- and Microwave Studio codes to optimize beam dynamics properties and the field distribution of the RFQ. Results of the design studies will be presented.

INTRODUCTION

The plan for the future GSI accelerator system is based on the existing UNILAC and SIS18 as injectors to a complex Synchrotron storage ring system, which should be able to deliver unique beams for the study of the structure of matter [1]. A key feature of the facility is the generation of intense, high-quality secondary beams of rare isotopes as well as antiprotons. To serve as an injector, the UNILAC intensity has to be upgraded by a factor of appr. 100. Refering to the experience of CERN the primary proton beam pulse intensity for the production of antiprotons has to be in the order of 50mA, while the maximum proton beam currents from the UNILAC, which is optimized for Uranium beams, are only $I_p < 1$mA. Therefore plans to built a new dedicated P-linac have a high priority.

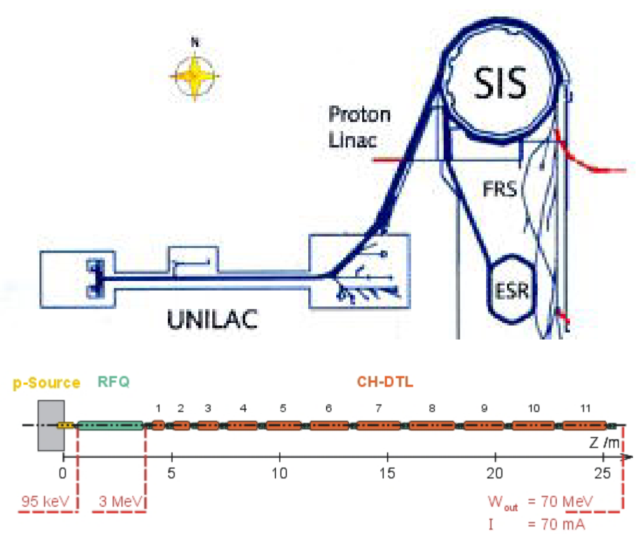

Figure 1: Scheme of the future GSI-p-linac with ECR-source, RFQ and CH-DTL linac.

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Table 1: Basic P-Linac Parameters

Frequency	352 MHz
pulse rate,length	5 Hz, 0.1msec
Output energy	70 MeV
Beam current	70 mA
transv, emittance rms norm.	1.5 π mm mrad
energy spread	± 1%

This new 70 MeV proton linac will directly inject into the SIS18 and should deliver high quality 70 mA beams. It is planned to built a very compact linac, making use of the recent progress in accelerator technology by building an ECR-RFQ-CH linac with a total length of ca. 26 m. The choice of the operating frequency of 352 MHz is set by the availability of LEP-type Klystrons which shall drive the linac [2,3].

RFQ-BEAM DYNAMICS

Preliminary design studies fixed the injection energy of the RFQ to 95 keV and the final energy to 3 MeV. The beam current should be 70 mA, but a current upgrade up to 90mA should be possible without big changes.

Table 2: Basic RFQ Parameters

Frequency	352 MHz
Input energy	95 keV
Output energy	3.0 MeV
Beam current	70/90 mA
output emittance rms norm.	0.4 π mm mrad
energy spread rms	150 deg.keV
Electrode voltage	90 kV
RFQ length	3.22 m
cell number	272
min - max aperture	2.35-3.6 mm

The beam dynamics design is based on the results for the proton RFQs for DESY, RAL and Debtec with adiabatic variation of electrode parameters, it aims at a short structure at low electrode voltage to save rf-power and facilitate rf-tolerances and peak power problems preserve emittance and high transmission.

The beam dynamics design,based on the parameters of Table 1, led to a RFQ with electrode voltage of 90 kV and a length of 3.2 m as summarized in table 2.

The design procedure allows for a transmission of more than 95% even at the high input current of 100 mA, with a very small emittance growth.

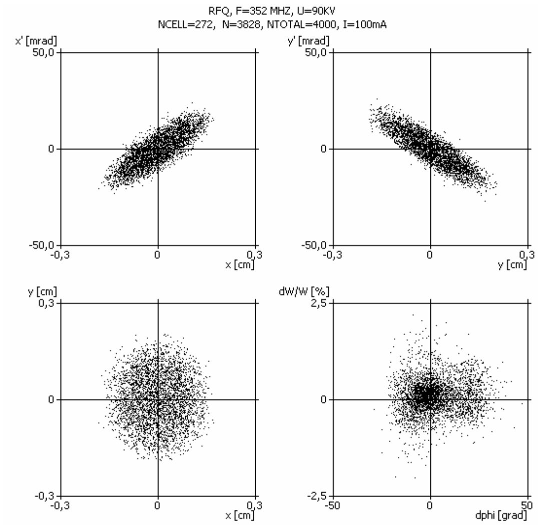

Figure 2: RFQ output distribution. Input beam current 100 mA, output current 95.7 mA, input emittance 0.3 π mm mrad rms n, output emittance 0.27 π mm mrad rms n.

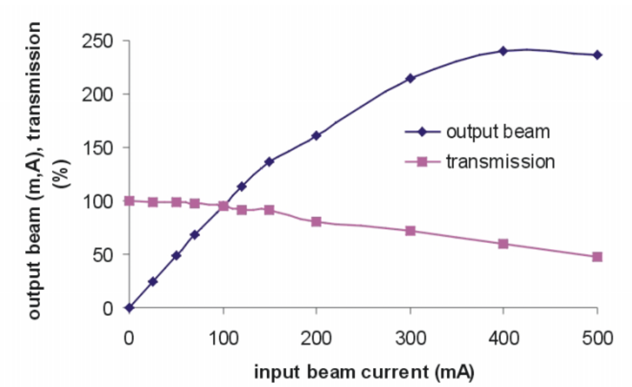

Figure 3: RFQ output proton current as a function of the input proton beam current.
Transmission as function of the input beam current.

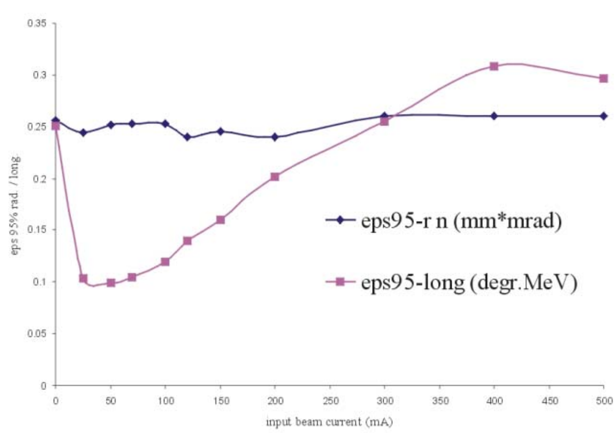

Figure 4: RFQ output emittance (95%) as a function of the input proton beam current.

Fig. 2 shows the output distribution for an input emittance of $\varepsilon_{in} = 0.3\ \pi$ mm mrad rms normalized.

An even higher transmission is possible on cost of structure length. More important seems the behaviour as function of the input current, where one could see in fig. 3 and fig. 4 that the real limit is far above the design value. The radial emittance stays nearly constant even for input currents as high as 500 mA. The output current saturates at appr. 250 mA, the current limit of that design.

RFQ STRUCTURE

A 4-Rod-RFQ structure will drive the RFQ electrodes. The basic cell is a interlaced capacitively loaded λ/2 transmission lines in π0-mode.

Up to now 4-Rod RFQs have been built in the frequency region between 2.5 MHz and 216 MHz for protons, H- and mostly heavy ions up to mass to charge ratios of A/q = 1000.

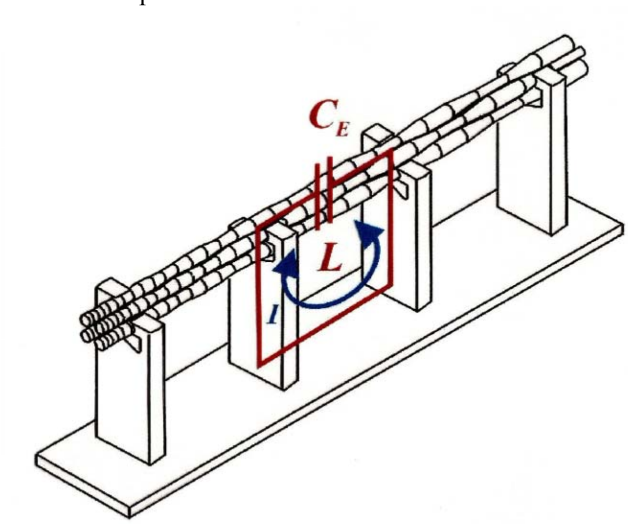

Figure 5: Basic 4-Rod-RFQ Cell.

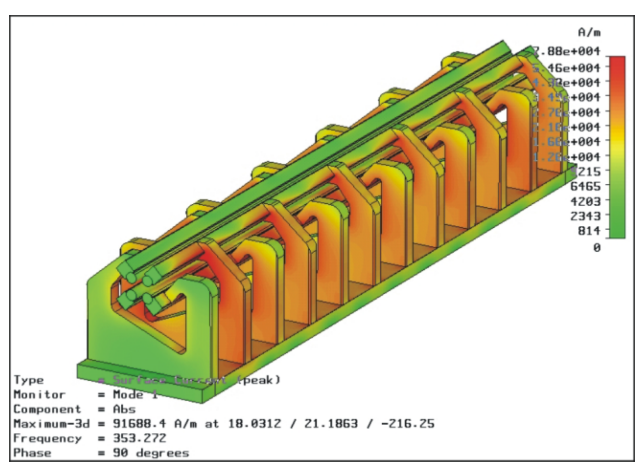

Figure 6: MWS simulation of current densities in the 350 MHz 4-Rod-RFQ structure.

We have developed a design for 352 MHz, which is mainly by reducing the distance between the stems and the shape of the stem [4]. The electrodes have to stay more or less the same as for 200 MHz. Fig. 6 shows current- and power-distribution. Fig 7 and fig. 8 the E-fields in basic mode and the first higher longitudinal mode at 410 MHz.

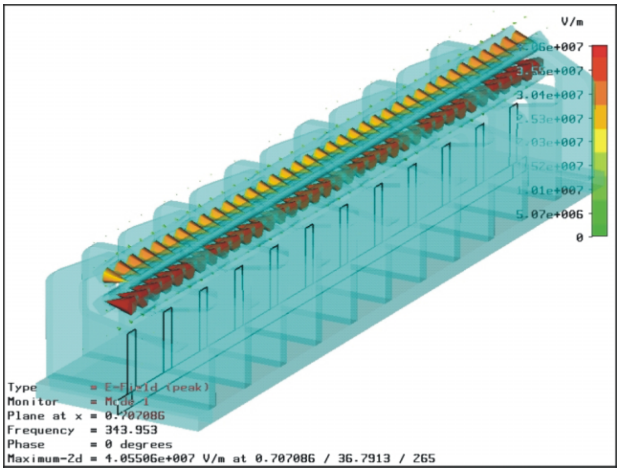

Figure 7: Electric field distribution in the π0-Mode.

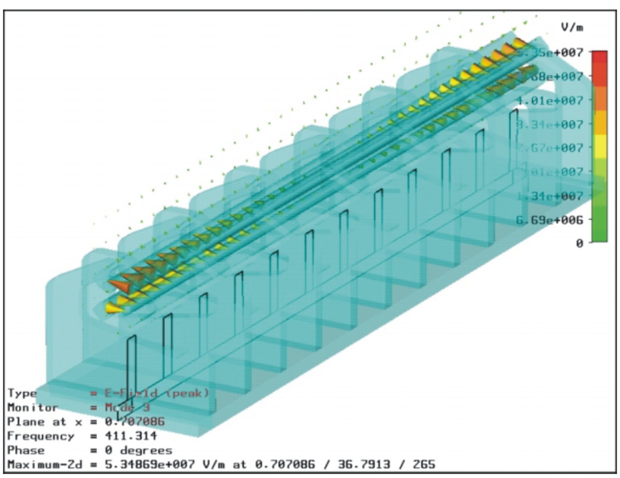

Figure 8: Electric field distribution in the π1-Mode.

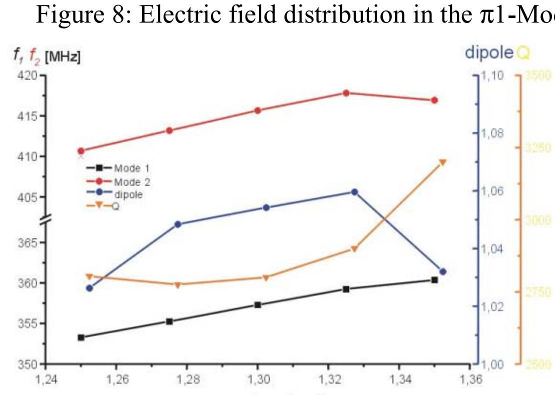

Figure 9: Mode frequencies, Dipoles and Q as function of the aperture radius.

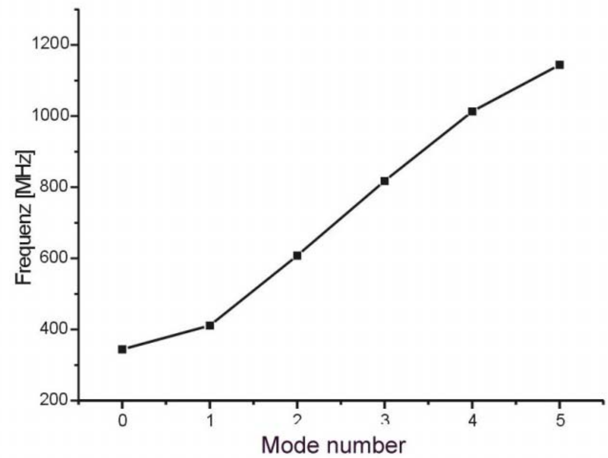

Figure 10: Brillouin diagram for the first 6 modes.

The variation of the aperture to electrode radius does vary the frequency of all modes and in addition influences the dipole mode across the stems and the Q-value of the resonator as shown in fig.9. Fig 10 shows the frequency of the first 6 modes of this 12-stem structure with its big longitudinal coupling.

REFERENCES

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