THE RFQ-DRIFTTUBE-COMBINATION FOR THE MEDICINE SYNCHROTRON IN HEIDELBERG*

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Abstract

The construction of a heavy ion synchrotron at the Radiologische Universitaetsklinik in Heidelberg has been approved recently. The design and construction of the RFQ section of the LINAC system for the synchrotron is the contribution of IAP to this project [1]. Design studies have been done with respect to beam properties as well as an optimal matching to the following IH-structure and reduced complexity of the machine [2], [5]. An overview of the project will be given, the results of beam dynamics calculations and the status will be presented.

1 INTRODUCTION

The injector consists of two driving units: An RFQ for preaccelaration from 8 keV/u to 400 keV/u followed by an IH type structure for acceleration up to 7 MeV/u - the injection energy of the synchrotron (fig. 1). Because of their focussing properties RFQs are very well adapted to beam transportation and acceleration at low energies. For higher energies the accelerating efficiency decreases and drift tube structures are getting more and more relevant. Drift tubes structures are also used as rebunching units behind the RFQ to match the beam to the acceptance of a following structure longitudinally. A common solution is a separate buncher cavity in a suitable distance between the RFQ and the following DTL structure.

We have developed a new concept: A drift tube is mounted directly on the last RFQ stem at the high energy end, forming a boosting or bunching unit depending on its rf-phase.

2 RFQ DESIGN

The layout of the electrodes has been done with respect to especially small $\Delta\varphi$ at the entrance of the IH and a short cavity length. The following table shows the characteristic parameters:

Table 1: RFQ beam parameters.

Parameter	Value
Input energy	*8 keV/u*
Input emittance	$\varepsilon_{x,y}$=150 π mm mrad
Current limit	max. 2 mA H^+
Output energy	*400 keV/u*
max. beam angle at the exit	±20 mrad (in both planes)
Phase width at IH entrance	$\Delta\varphi \leq \pm 15°$

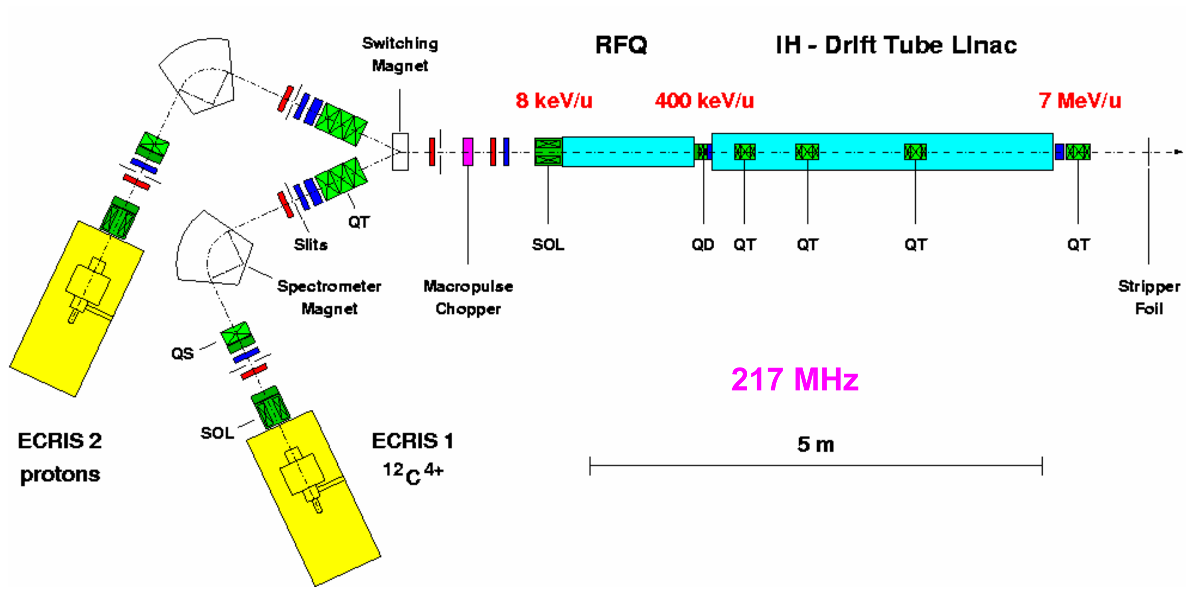

Fig. 1 Injector-linac of the therapy facility in Heidelberg.

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The very small phase width of ±15° is required at the IH entrance. The latest version of the RFQ design is shown in figure 2 where we have done some modifications to shorten the length of the RFQ and to improve the homogeneity of the output distribution [3].

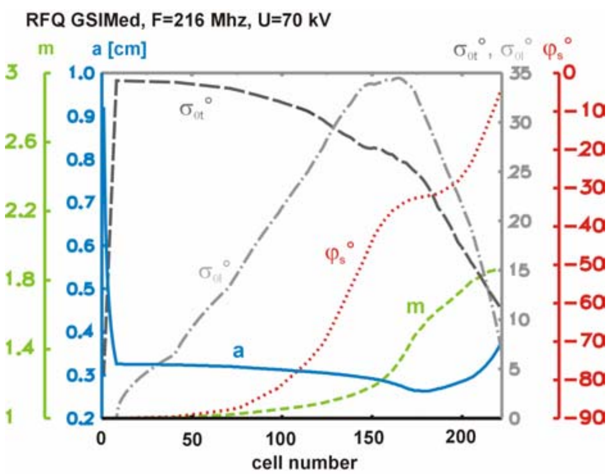

Figure 2: Design parameters of the RFQ.

The growing aperture at the end of the electrodes leads to a decreasing focusing strength, which results in the maximum beam angle of only 20 mrad at the exit of the RFQ. Furthermore there is an unusual increase of the synchronous phase up to nearly 0° corresponding to take a maximum advantage of the rf-voltage for acceleration, but a minimum of longitudinal focusing. This means that the beam is already drifting longitudinally within the RFQ electrodes, which allows the bunching in a distance of only 6 cm behind the last RFQ cell.

3 BEAM DYNAMICS

The input distribution has been generated in accordance with the expected beam emittances from the ECR ion source and fits very well into the acceptance of the RFQ as shown in fig. 3.

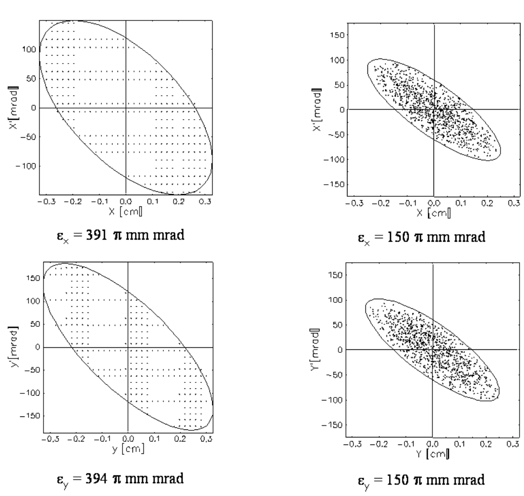

Figure 3: Acceptance of the RFQ and input distribution.

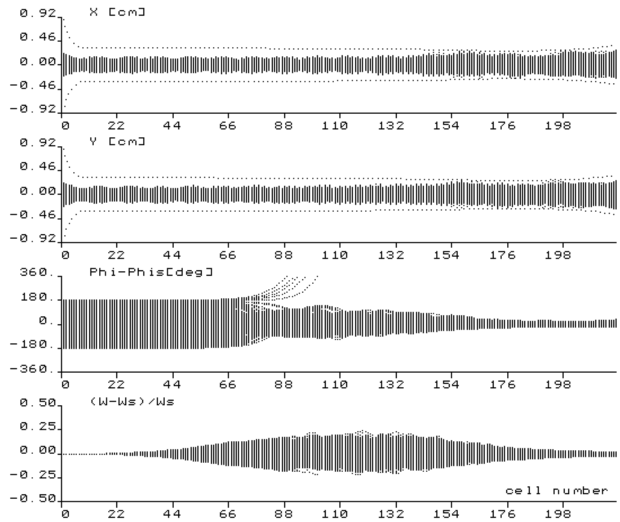

Figure 4: PARMTEQ simulations of the medicine RFQ. The transverse beam envelope is displayed in the upper two graphs. Graphs three and four are displaying the longitudinal evolution of the beam.

The evolution of the beam in between the 219 RFQ cells is shown in fig. 4. The growing aperture at the end of the structure leads to a decreasing focussing strength. At this point the beam radius is slightly rising, but the beam angle at the exit is quite small and meets the required values listed in table 1. The slightly growing phase spread up to the end is corresponding to the growing synchronous phase. The output distribution is shown in fig. 5

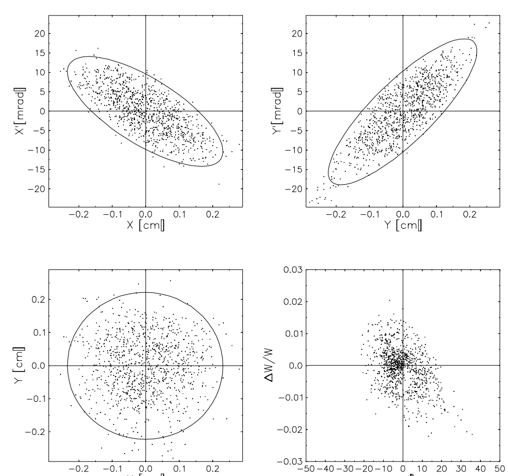

Figure 5: Output distribution of the RFQ.

Further investigations have been done in order to examine the beam dynamics of the transition between RFQ and first Drift tube (fig. 6). The beam simulations have shown very small effects in comparison to calculations, which have been done simply with a field-free drifting [4].

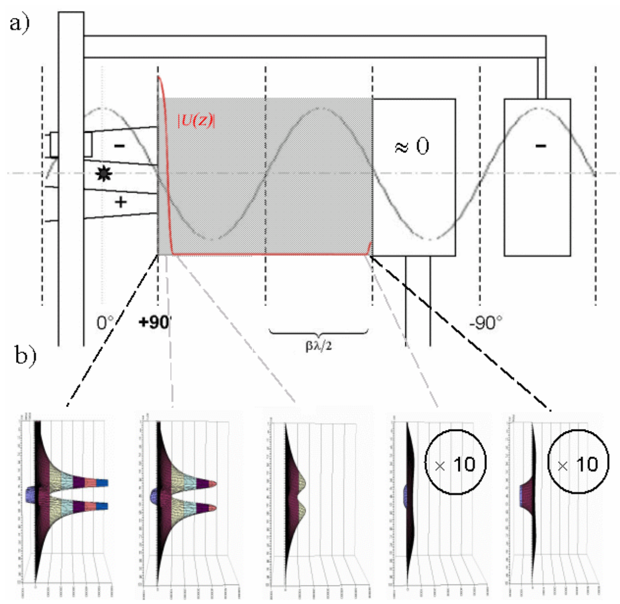

Figure 6: a) Area of interest (shaded) and its boundary conditions: -10 resp. 60 kV electrode voltage, -1.2 kV at the first drift tube (calculated by MAFIA), b) generated static potential in different planes (multiplied by 10 in the last two planes). The red curve shows the potential on beam axis *U(z)*.

4 ALIGNMENT OF THE RFQ

Tank, ground plate, stems and electrodes have been manufactured at NTG in Gelnhausen. Almost all other components like the extra stem in fig. 7, which will support one of the drift tubes, are ready for assembling.

Figure 7: Last stem of the RFQ, which will carry the central drift tube

Presently, we are preparing for the alignment of the RFQ. A first step was the exact measurement of the ground plate position inside the tank with respect to the two end flange centers (fig. 8).

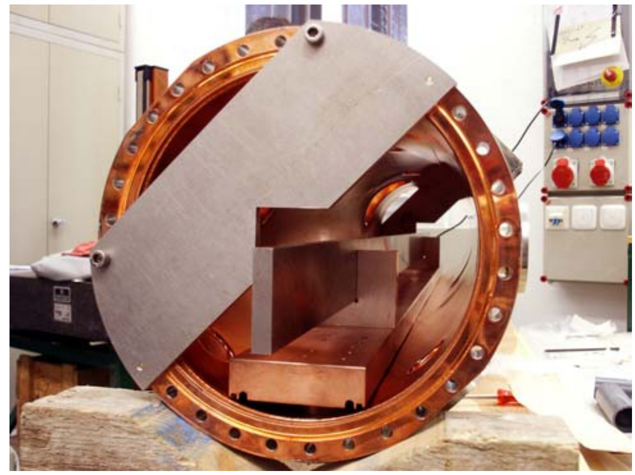

Figure 8: Setup for the ground plate positioning.

The following alignment of the electrodes can be done outside the tank on an optical bank.

5 CONCLUSION

An RFQ-Drifttube-Combination has been designed for the injector complex of the medical therapy synchrotron of Heidelberg.

Almost all components have been manufactured and we are now preparing for assembling and aligning the RFQ. Rf-tuning is planned for the end of 2002, a first beam test will take place next year.

6 REFERENCES

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