A RFQ DECELERATOR FOR HITRAP

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Abstract

The HITRAP linac at GSI will decelerate ions from 5 MeV/u to 6 keV/u for experiments with the large GSI Penning trap. The ions are decelerated at first in the existing experimental storage ring (ESR) down to an energy of 5 MeV/u and will be injected into a new Decelerator-Linac consisting of a IH-structure, which decelerates down to 500keV/u, and a 4-Rod RFQ , decelerating to 5 keV/u.

The properties of the RFQ decelerator and the status of the project will be discussed.

INTRODUCTION

The design of the HITRAP 4-rod-RFQ is closely related to the design of the 108 MHz structure of the GSI-HLI LINAC, the high-charge state injector to the UNILAC. The low A/q allows a short structure of 127 cells that is only 1.9 m long. A maximum rod voltage of 77.5 kV is required. The mean aperture radius is about 4 mm which reduces the peak fields to safe values. The 45° phase spread of the ion bunches extracted from the IH-structure needs to be matched to the RFQ acceptance of 20°. Thus, in the matching section between IH-structure and RFQ two gap - 108 MHz spiral Rebuncher from GSI will be installed (Fig. 2).

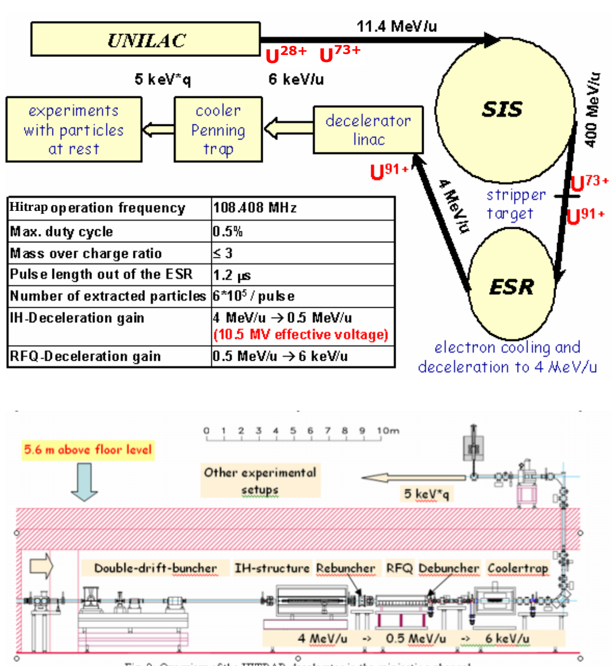

Figure 1: Overview of the HITRAP-decelerator in the reinjection channel

The spiral cavity has been used before at the UNILAC and will be modified to the new synchronous particle velocity by changing its drift tubes. For this purpose Microwave Studio (MWS) calculations have been done to adopt the rf-structure to the new drift tube geometry. At 0.5 MeV/u the cell length $\beta\lambda/2$ is 45.3 mm and so is the distance between the two gap-centers.

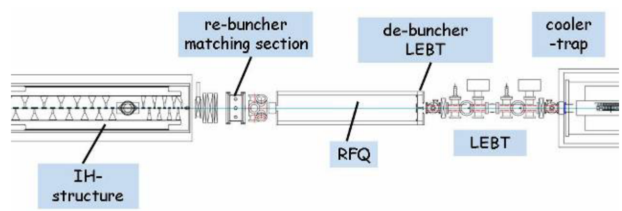

Figure 2: Overview of the RFQ section of the HITRAP decelerator.

RFQ DESIGN

For the layout of the electrodes the RFQSim code had to be modified to allow the deceleration. To do that, first an accelerating structure is generated and saved in inverse order. So the last cell of the structure will be the first in the following particle transformation.

For decelerating the ion beam the synchronous phase has to be in a range of -180° and -90° (Fig. 3). Faster particles, that come earlier, become more decelerated than particles that are slower than the bunch center.

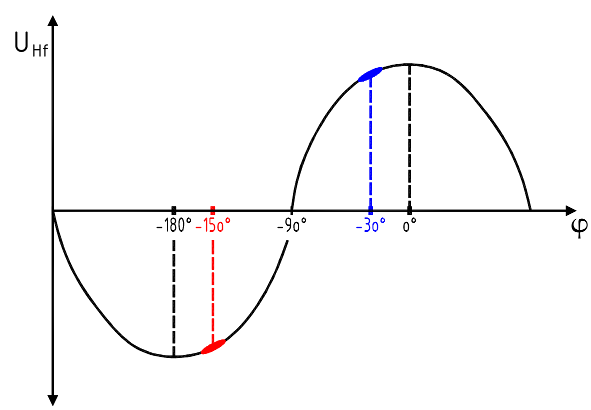

Figure 3: synchronous phases of a bunch leaving the accelerating structure and of a bunch that is injected into a decelerator.

Parameters of essential importance for RFQ design are the longitudinal emittance, the phase width of the beam and the energy spread of the input beam. An energy spread of $\Delta W/W$=0.5% at the high energy input of the RFQ transfers to $\Delta W/W$= 42 % at the low energy end.

With a special developed design scheme it is possible to reduce this output energy spread to about ± 6%. With an input phase width of Δφ < 20° and asynchronous deceleration the beam pulse emittance can be kept compact.

Table 1: RFQ parameters.

Input energy / output energy	500 keV/u / 6kev/u
Charge-to-mass ratio q/A	> 1/3
Frequency	108.408 MHz
Electrode voltage	77.5 kV
RFQ length	1.9 m
Input emittance (norm.)	0.24 π mm mrad
Radial output emittance (norm.)	0.37 π mm mrad
RF-Power	90 kW

The possible input phase width and energy spread is restricted to the required output emittance so that a ΔW/W of 2 % is the useful upper limit. For the radial emittance a value of 0.24 π mm mrad been used for input.

A Debuncher in the LEBT section is required in order to further reduce the energy spread of the ion bunch coming from the RFQ. A energy spread of the ions as small as possible is required for high injection efficiency into the HITRAP cooler trap. The buncher cavity, which is directly mounted behind the RFQ, as shown in Fig. 4. Two copper plates ensure rf-separation of the two cavities. In addition the Debuncher is a first differential pumping stage towards the cooler trap.

BEAM DYNAMICS

In Fig. 5 and Fig. 6 shows the output distribution of the RFQ with and without Debuncher, by which the energy spread is reduced from ±6% to ±4%. The radial beam parameters are nearly unaltered.

CONCLUSIONS

A RFQ-spiral Debuncher combination has been designed for the HITRAP linac at GSI.

The vacuum tank of the RFQ has been copper plated at GSI, the manufacturing of the electrode structure is nearly finished. The RFQ will be assembled during the 3rd and 4th quarter of 2006. The modification of the Spiral-Rebuncher cavity between IH and RFQ will be finished in the 3rd quarter of 2006.

REFERENCES

[1] O. Kester et al., Status of the HITRAP decelerator project, Proc. EPAC06, Edinburgh,GB

[2] O. Kester et al., Thie HITRAP decelerator project at GSI, Proc. of the HIAT 2005, Port Jefferson, USA.

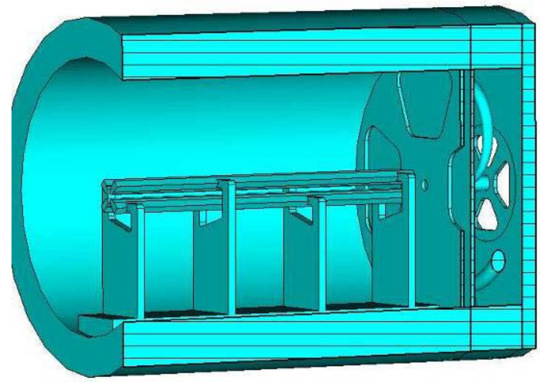

Figure 4: Low energy section of the RFQ and the Debuncher cavity.

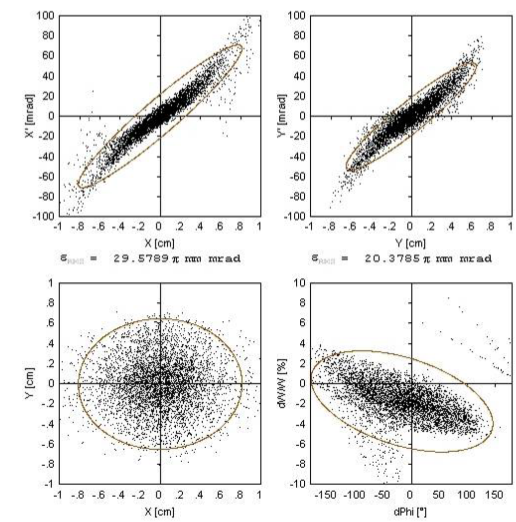

Figure 5: Output distribution with activated Debuncher.

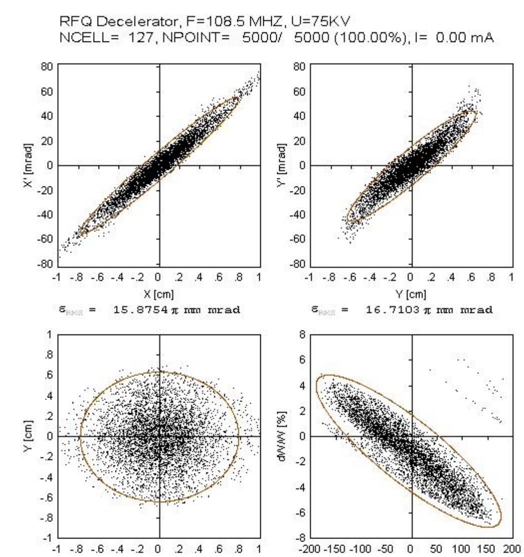

Figure 6: Output distribution with deactivated Debuncher.