THE HITRAP RFQ DECELERATOR AT GSI

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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, provided by the GSI accelerator facility, will be decelerated at first in the existing experimental storage ring (ESR) down to an energy of 5 MeV/u and then injected into a new IH decelerator and decelerated to 500 keV/u.

The following 4-Rod RFQ will decelerate the ion beam from 500 keV to 6 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. 1).

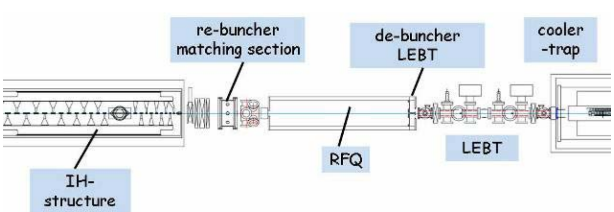

Figure 1: Overview of the RFQ section of the HITRAP decelerator.

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.

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. 2). Faster particles, that come earlier, become more decelerated than particles that are slower than the bunch center.

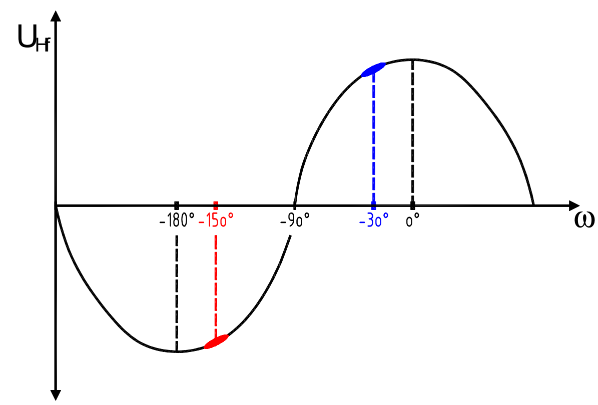

Figure 2: synchronous phases of a bunch leaving the accelerating structure and of a bunch that is injected into a decelerator.

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 $\Delta\varphi < 20°$ 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 $\Delta W/W$ 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 reduce the energy spread of the ion bunch coming from the RFQ from ±6% down to ±4%. A smaller energy spread of the ions is required for high injection efficiency into the HITRAP cooler trap. The buncher cavity, which is directly mounted behind the RFQ, so that both form a short combination, is shown in Fig. 3. Two copperplates ensure rf- separation of the cavities and the Debuncher can also be used as a first differential pumping stage towards the cooler trap.

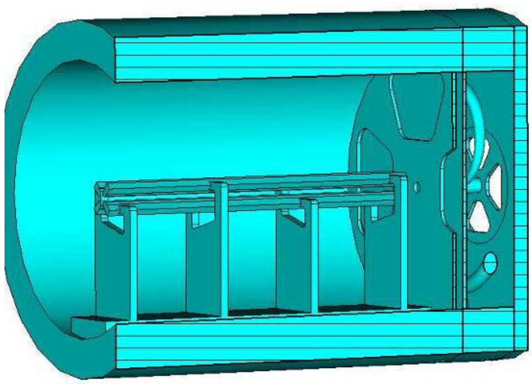

Figure 3: Low energy section of the RFQ and the Debuncher cavity.

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. In Fig. 4 and Fig. 5 the output distribution of the RFQ with and without Debuncher is shown. The beam parameters are, except for the energy spread, nearly unaltered.

CONCLUSIONS

A RFQ-spiral Debuncher combination has been designed for the HITRAP linac at GSI.
The vacuum tank of the RFQ is actually at the copper plating facility 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 Rebuncher cavity will be finished in the 2nd quarter of 2006.

REFERENCES

[1] O. Kester et al., Status of the HITRAP decelerator project.

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

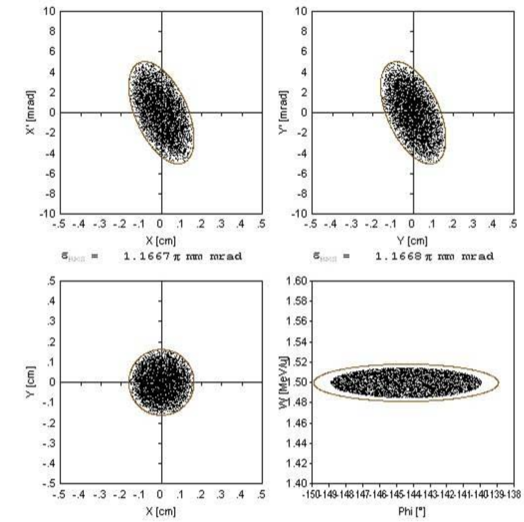

Figure 3: Acceptance of the RFQ and input distribution.

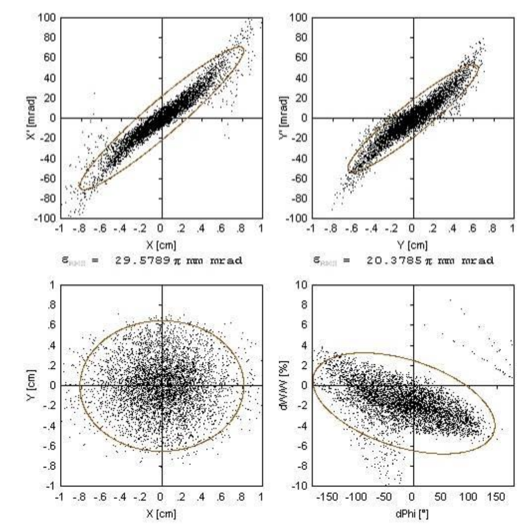

Figure 4: Output distribution with activated Debuncher.

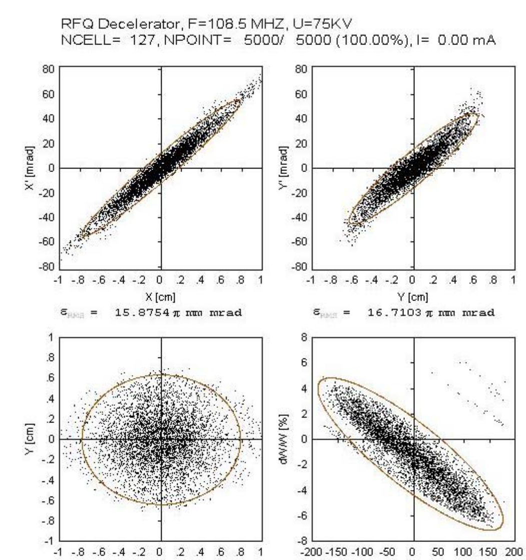

Figure 5: Output distribution with deactivated Debuncher.