A RFQ-DECELERATOR FOR HITRAP*

B. Hofmann, A. Schempp, IAP, J. W. Göthe-Universität, Frankfurt, Germany
O. Kester, GSI, Darmstadt, Germany

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-Linca of a IH-structure, which decelerates down to 500 keV/u and a 4-Rod RFQ, decelerating to 6 keV/u. The properties of the RFQ decelerator and the status of the project will be discussed.

INTRODUCTION

The HITRAP RFQ has to decelerate ions from the IH from 500 keV/u down to 6 keV/u. The operation frequency is 108.408 MHz and the duty factor < 1%. Fig. 1 shows the arrangement in the reinjection channel from the ESR to the SIS18.

The HITRAP 4-rod-RFQ is related to the design of the 108 MHz structure of the GSI-HLI RFQ, part of the GSI-LINAC, the high-charge state injector to the UNILAC.

Due to the low A/q ratio the length of the structure is only 1.9m. A maximum electrode voltage of 77.5 kV is required. The mean aperture radius is 4 mm which reduces the peak fields to safe values.

The ion bunches extracted from the IH-structure have a phase spread of 45° which needs to be reduced to 20° for the RFQ acceptance. Thus, in the matching section between IH-structure and RFQ a two gap - 108 MHz spiral Rebuncher will be installed (Fig. 1).

Microwave Studio (MWS) calculations have been done to optimize the rf-structure to the drift tube geometry (Fig. 2). At 0.5 MeV/u the cell length $\beta\lambda/2$ is 45.3 mm.

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 transformations.

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.

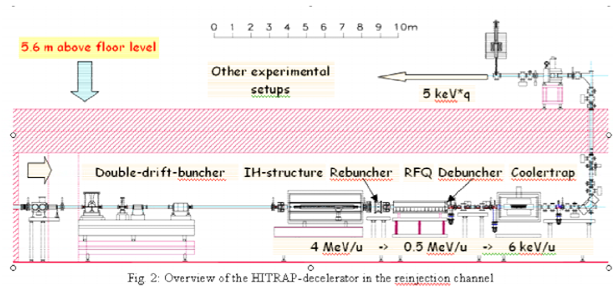

Figure 1: Overview of the RFQ section of the HITRAP decelerator.

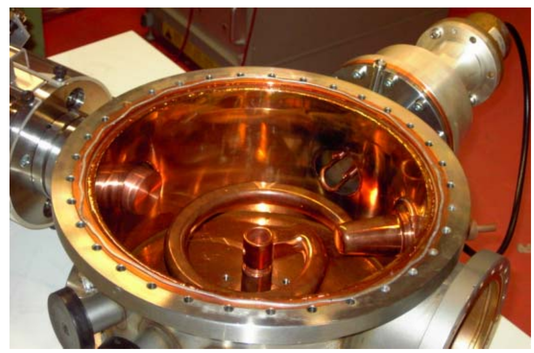

Figure 2: The Rebuncher-spiral-resonator with mounted plunger and coupling loop.

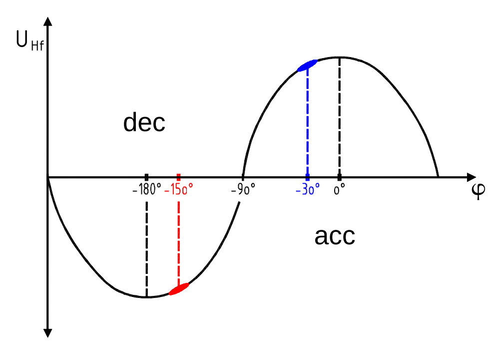

Figure 3: synchronous phases of a bunch leaving the accelerating structure and of a bunch that is injected into a decelerator.

Important parameters for the 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 especially 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.

* supported by the BMBF

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 $\epsilon = 0.24\ \pi$ mm mrad been used for input.

The RFQ has been built, the electrodes have been aligned within ± 0.02mm of the design value.

To adjust the longitudinal field distribution (flatness) tuning plates which are mounted in the space between two stems are used. By reducing the inductivity of the local cell the voltage in this area is also reduced. By aranging the plates iteratively it was possible to adjust the voltage to a ± 2% deviation of the average value (Fig. 4)

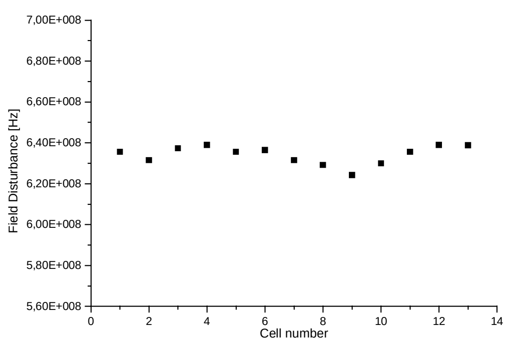

Figure 4: Field flatness of the HITRAP RFQ.

A debuncher in the LEBT section is required as close as possible to the RFQ 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 attached behind the RFQ, is shown in Fig. 3. Two additional copperplates separate the two tanks and ensure rf- separation of the cavities. The debuncher can also be used as a first differential pumping stage towards the cooler trap.

In Fig. 7 the output distribution of the RFQ with Debuncher is shown. The beam parameters are, except for the energy spread, nearly unaltered

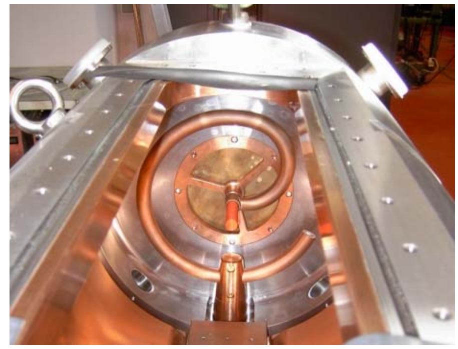

Figure 5: The Debuncher cavity before tuning and copperplating

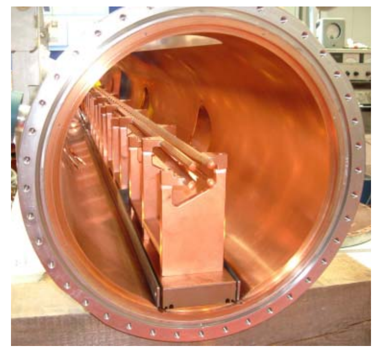

Figure 6: View of the RFQ

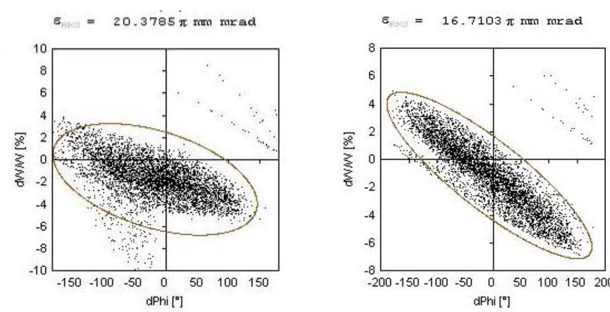

Figure 7: Output distribution with and without Debuncher.

SUMMARY

A RFQ-spiral Debuncher combination has been designed for the HITRAP linac at GSI. The RFQ has been built up, aligned and the flatness has been adjusted so far and mounted inside the vacuum tank. The Rebuncher structure has been also aligned and tuned to the required frequency.

First RF- tests of the system are planned for the end of this year.

REFERENCES

[1] O. Kester et al., Status of the HITRAP decelerator project, EPAC 06, Edinburgh,GB, p. 230
[2] O. Kester et al., The HITRAP decelerator project at GSI, Proc. of the HIAT 2005, Port Jefferson, USA.
[3] B. Hofmann et al, The HITRAP RFQ decelerator at GSI, EPAC 2006, Edinburgh, GB, p.253

 1-4244-0917-9/07/$25.00 ©2007 IEEE