OPERATION OF THE VE-RFQ INJECTOR FOR THE ISL-CYCLOTRON*

O. Engels, F. Höllering, A. Schempp Institut für Angewante Physik,
Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany
A. Denker, H. Homeyer, W. Pelzer, Hahn-Meitner-Institut, Berlin, Germany
J. Häuser, NTG, Neue Technologien, Gelnhausen-Hailer, Germany

Abstract

The VE-RFQ-injector for the cyclotron at HMI in Berlin is now in operation. The ECR-source together with the RFQ's [1,2] supply heavy ion beams with 90 - 360 keV/u for q/A > 0.15, matched to the isochronous cyclotron. Properties of the new injector and results of rf-measurements, high power tests and beam measurements are presented.

1 INTRODUCTION

The Ionen Strahl Labor (ISL), the former VICKSI-facility, at the Hahn-Meitner-Institut in Berlin has installed a second injector for the separated sector cyclotron. A combination of an ECR-ion source with a two stage 4-Rod-VE-RFQ (VE = variable energy) [3] replaces the former Tandem-injector to meet the demands of solid state physics [4,5] as shown in figure 1.

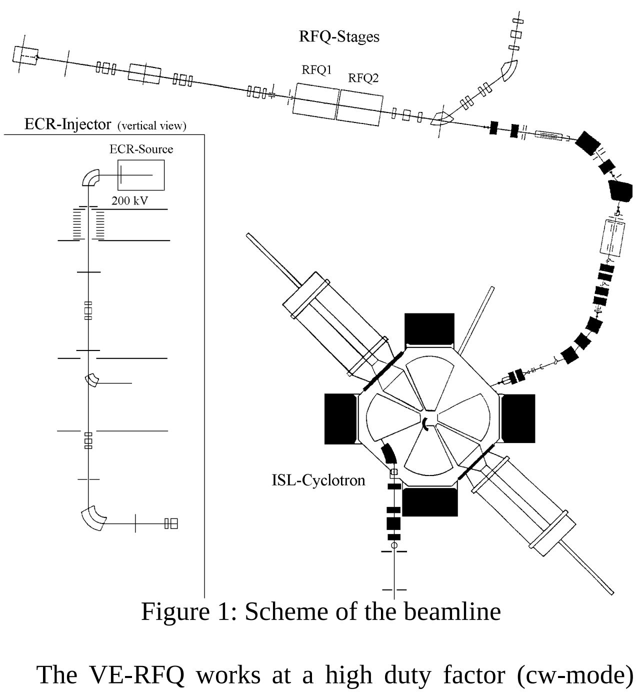

Figure 1: Scheme of the beamline

The VE-RFQ works at a high duty factor (cw-mode) and covers a frequency-range from 85 MHz to 120 MHz. It is designed to accelerate ions with an q/A from 1/8 to 1/2 with input energies from 15 to 30 keV/u to output energies between 90 and 360 keV/u. The final energies out of the cyclotron cover the range between 1.5 and 6 MeV/u [5]. Table 1 gives the parameters of the new injector and figure 2 shows a view of the RFQ.

To achieve this energy variation the RFQ is split into two stages. The second stage is designed to operate either as an accelerator or as an radial focusing transport channel [7,8,9] in an operational mode which has not been tested before with a bunched beam.

Figure 2: View into the two stage RFQ

After the assembly and first high power test at NTG in Gelnhausen the RFQ has been transported to ISL in December 1997 and has been installed at the cyclotron during the first half of 1998.

Length (split into two stages)	[m]	3
diameter	[m]	0.5
number of stems per stage		10
minimum aperture	[mm]	2
min/max Ein	[keV/u]	15.16/29.72
min/max Eout	[keV/u]	178.35/355.09
charge-to-mass-ration		1/8 - 1/2
frequency	[MHz]	85 - 120
duty factor		100% (cw)
max power consumption p. stage	[kW]	20

Table 1: ISL-VE-RFQ parameters

2 GAMMA-SPETROSCOPY

A first set of high power rf-tests was done to check the functionality after transport.

To ensure that the RFQ reaches the necessary electrode voltage and to calibrate the RFQ-probes several high power tests at different frequencies have been made. At a power-consumption of 10 kW the gamma-emission from the cavity has been measured and the results have been extrapolated for a power consumption of 20 kW.

Figure 3 shows the extrapolated electrode voltage and the necessary electrode voltage for minimum q/A proportion of the first RFQ stage.

The bend in the design voltage curve results from the limited preacceleration of 200 kV, so that the necessary injection energy into the RFQ could not be reached for all q/A proportions. The measurements show, that the design voltage can be reached for all frequencies.

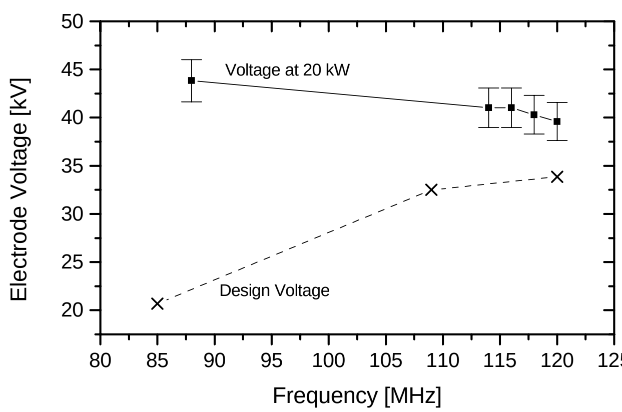

Figure 3: Electrode voltage as a function of RFQ frequency

3 BEAM MEASUREMENTS

The second set of tests were experiments with a beam from the ISL DC-injector. Figure 4 and 5 show the results of O^{4+}- and He^{+}-beams at a frequency of 120 MHz. The second RFQ has been operated in accelerating mode and in transport mode.

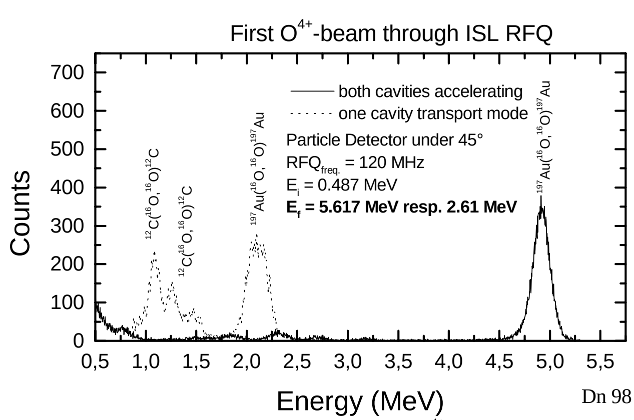

Figure 4: Spectroscopy of O^{4+}-beam

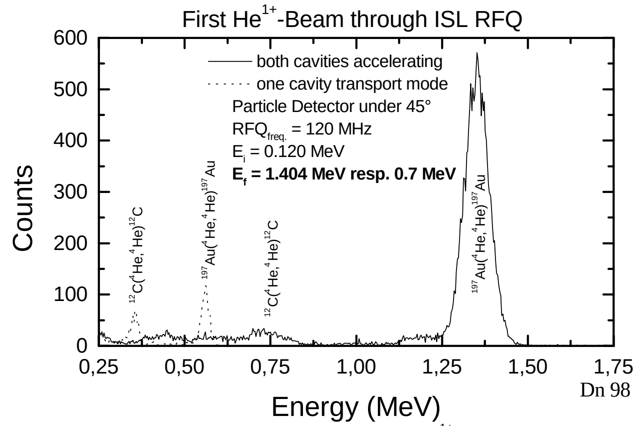

Figure 5: Spectroscopy of He^{1+}-beam

The results of the spectroscopy show that the RFQ works well and provides the calculated energies. It also shows, that the concept of using the second RFQ as a transport channel works, though more efforts on a better coordination between the two stages to improve the transmission in transport mode have to be done.

4 CONCLUSIONS

The series of high power and beam tests showed a good performance of the RFQ. The accelerator provides the correct energies and can be operated in the transport mode. More tests for an optimization of the transport mode have to be done.

At ISL the work is now focused on integrating the RFQ-system in existing controlsystem and on optimizing the rf-systems. In the beginning of September a first injection into the cyclotron is planned.

REFERENCES

[1] I.M. Kapchinskiy and V. Teplyakov, Prib. Tekh. Eksp 119, No. 2 (1970) 17
[2] K.R. Crandall, R.H. Stokes, T.P. Wangler, Linac 79, BNL 51134 (1979) 205
[3] A. Schempp, NIM B40/41 (1989) 937
[4] H. Hohmeyer, K. Ziegler, NIM B64 (1992) 937-942
[5] H. Hohmeyer, W. Pelzer, „Vorschlag zur Realisierung eines Ionenstrahllabors am HMI (ISL-Berlin)“, HMI-Berlin, (1992)
[6] O. Engels et al., NIM B113 (1996), p. 16-20
[7] A. Schempp, O. Engels, F. Marhauser, H. Hohmeyer, W. Pelzer., IEEE PAC 1995, Dallas, TX, p. 914
[8] H. Dehnen, H. Deitinghoff, W. Barth, A. Schempp, „Transport of Ions in a RFQ Accelerator“, EPAC 1992,Ed. Frontiers (1992), p. 967-969
[9] F. Marhauser, diploma thesis, IAP, Frankfurt am Main (1996)