

An RFQ based beam line and mass filter to improve identification capabilities at the diagnostics unit of the prototype CSC for the LEB *

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In the vicinity of gas-filled stopping cells vacuum pressures are typically too high for operation of conventional electrostatic beam lines. In this high pressure environment radio frequency quadrupoles (RFQ) can provide an efficient ion transport. Advantages of RFQ beam lines are their high transmission efficiencies of nearly 100%, ability to operate at high pressures, compactness (\approx 1m length) and diverse range of applications, e.g. cooling, bunching, mass separation and beam diagnosis.

Such an RFQ based beam line [1] for the prototype cryogenic stopping cell (CSC) [2] has been commissioned successfully at the FRS Ion Catcher at GSI [3]. Recently, the identification of ions in the diagnostics unit (DU) of the RFQ beam line was done by α spectroscopy, but this way of identification is only suitable for α decayed nuclei. In order to improve the identification capabilities of the DU the extraction RFQ of the CSC was modified to operate as an RF-DC mass filter [4]. Thus it is possible to identify ions by their mass-to-charge ratio directly behind the stopping cell. Fig. 1 shows a mass spectrum of ions produced by a discharge ion source mounted inside the CSC. The mass spectrum shows ions from the electrode material of the discharge source (Fe, Cr etc.) and from a ²²³Ra recoil ion source. The mass filter can provide mass-to-charge information of ions between 30 u/e and 250 u/e. This mass spectrum has a resolving power of 10, while achieving a transmission of 80 %. Besides mass identification, the extraction RFQ can be used as a mass filter, transmitting a narrow mass window only and reducing the number of transmitted ions down to the required mass region. As seen in Fig. 1, if the mass filter is tuned for transmission of mass 140 u, the main ion current (mass 65 u) is suppressed by four orders of magnitude.

The mass resolution can be increased further, but as shown in Fig. 2 higher resolving powers lead to reduced transmission. Despite the high pressures the mass-filter provides mass selective ion transport with resolving powers of up to 150 at residual gas pressures of $8.4 \cdot 10^{-2}$ mbar. The performance of the mass filter at high residual gas pressures is of special importance, as the buffer gas emerging from the CSC is pumped away in the extraction region and therefore the areal density of the CSC is determining the residual gas pressure in the DU.

The rough mass identification of ions directly behind the CSC allows systematic investigations of the performance of the CSC. Furthermore the transmission of the downstream

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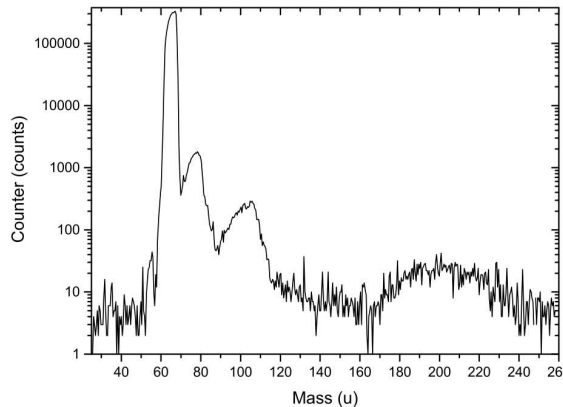


Figure 1: Mass spectrum of ions produced by a discharge ion source inside the CSC measured using the extraction RFQ mass filter

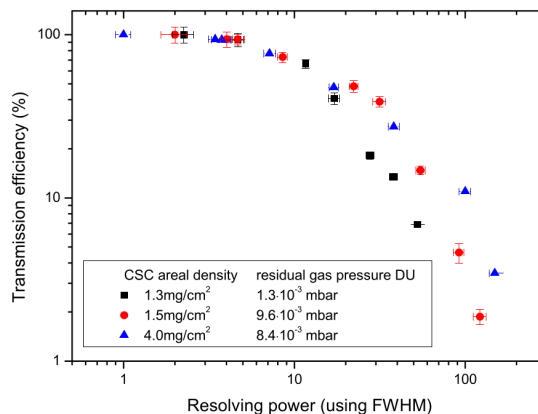


Figure 2: Transmission efficiency vs. mass resolving power of the extraction RFQ mass filter at different residual gas pressures in the DU and the corresponding areal densities inside the CSC.

beam line can be optimized based on the measured mass-to-charge ratio. In addition the mass filter can suppress unwanted ions and decrease space charge effects and contaminations inside the more sensitive parts of the downstream low energy beam line.

References

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