The Mass Separator of REX-ISOLDE

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Physics with accelerated radioactive ions far from stability represents one of the frontiers of nuclear physics. The **R**adioactive Beam **EX**periment (REX) at ISOLDE/CERN makes fully use of the availability of radioisotopes from the online mass separator at the PS-ISOLDE. As described in the project overview the very neutron rich ions are charge breeded in an Electron Beam Ion Source (EBIS) to a charge-to-mass ratio of 1/4.5.

As the intensity of the radioactive ions is much smaller than the intensity of ions from residual gas produced in the EBIS, a mass separator is required. From the known residual gas spectrum of a similar EBIS it is concluded that a mass separation with a q/A-resolution of about 500 is sufficient to select the wanted highly charged rare radioactive ions from other contaminants.

Due to the potential depression of the electron beam, the extracted ions will have an energy spread of ΔE/E $\approx 5 * 10^{-3}$. Thus, a simple magnetic achromat with two 90^0 dipoles is insufficient, because the Δp/p momentum spread results in a corresponding deterioration of the $\frac{\Delta(q/A)}{(q/A)}$-resolution down to 200. We therefore selected a separator similar to a Nier-spectrometer [1]. The layout of the separator is shown in fig. 1. It is designed in a vertical S-shape, displacing the height level from the incoming to the outgoing beam by 3.6 m.

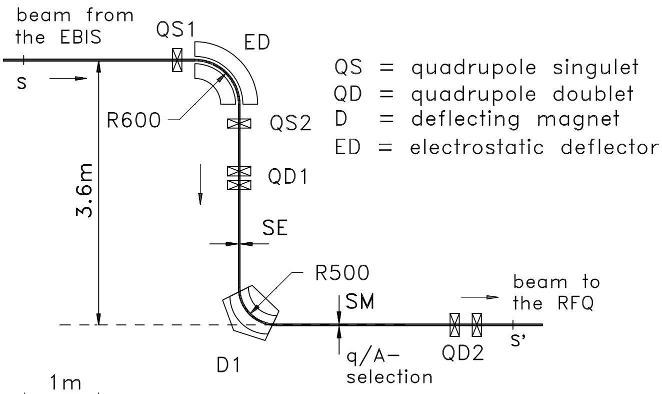

Fig. 1: Lay-out of the REX-ISOLDE mass separator

The first 90^0 downbend is done by an electrostatic cylinder deflector ED, the second bend to the horizontal line by a magnetic 90^0 dipole D1. The optical elements in between (singulet quadrupole magnet QS2 and doublet QD1 and the entrance angle of the dipole) are designed to achieve an achromatic system to first order, concerning an energy deviation. This is shown in beam transport calculations (fig. 2c) where an energy spread of the ion beam of $\pm$0.25% and a maximum angle of $\pm$ 3 mrad have been assumed. The rays are displayed between the starting focus (inside the electrostatic deflector of the trap-EBIS beam line) and the entrance of the RFQ. Due to the difference in the electrical and the magnetical rigidity of a moving ion, the system exhibits a certain mass dispersion at a focus behind the dipole (see fig. 2d). Here, at the slit SM, the mass separation is done. In the bending (y-) direction there are two intermediate foci, one at the end of the electrostatic deflector and one between QD1 and the dipole magnet. Here, at SE, the energy dispersion may be used to limit the energy width (fig. 2c). The first lens QS1 broadens the beam in the bending direction and thus increases the mass resolution. Simultanously it focuses horizontally and helps keeping the beam small in the non bending x-direction.

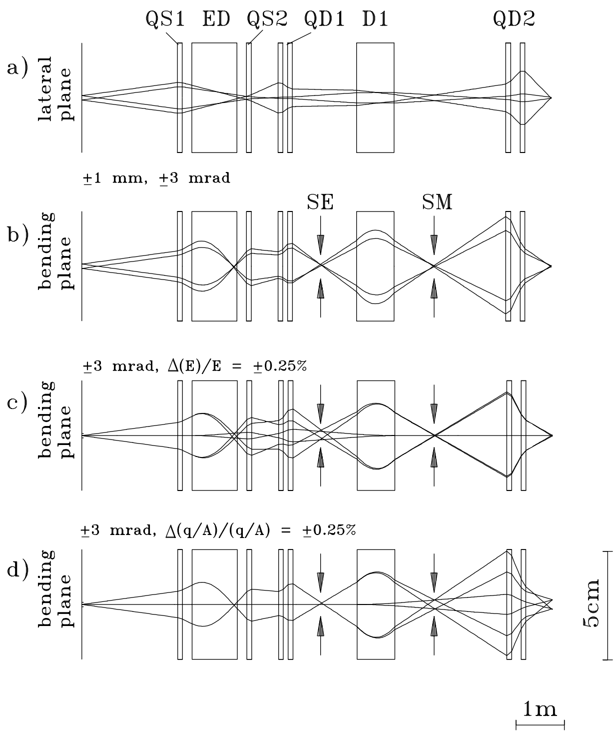

Fig. 2: Beam transport calculation of the REX-ISOLDE mass separator with GIOS. The energy spread of the beam can be limited at the slit position SE, mass separation occurs at position SM.

Figure 2a and 2b display rays with maximum values of the transverse phase space which are matched to the acceptance of the RFQ due to the reduction of the image radius in comparison to the beam radius at the separator entrance by a factor of four. There it is the main aim to match the beam to the entrance acceptance of the RFQ without any additional optical elements.

The system has been calculated to third order with the code GIOS [2]. A concave curvature (506 mm radius) at the entrance and exit pole face of the dipole magnet has been used to correct the main second order contribution. As a result, with the expected phase space at the start ($\pm$ 1 mm, $\pm$ 3 mrad in x and y and dE/E = $\pm$ 0.25%) a q/A resolution of 1460 is calculated at SM. Using start values $\pm$ 2 mm and $\pm$ 6 mrad drops the resolution to 520, partly due to the increasing contribution of the third order. The energy resolution at the slit SE is 550 with the expected transversal phase space at start.

References

[1] A.O. Nier, T.R. Roberts, F.J. Franklin, Phys. Rev. **75** (1949) 346
[2] H. Wollnik, GIOS General ion optic system, Version T4M (1985)