Extraction Beam Line for the Munich Fission Fragment Accelerator

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For the new Munich high-flux reactor FRM-II, which presently is being built, a fission fragment accelerator is under design. Radioactive, very neutron-rich fission products are extracted and roughly mass separated inside the reactor hall. This has the advantage that most of the radioactivity is deposited here and not inside the accelerator hall nearby the reactor, where-to the selected fission fragments are transported and a charge breeding and subsequent acceleration takes place [1,2]. After the acceleration the radioactive beam can be guided to different target stations with magnetic dipole switches, but the main set-up certainly is centered around a target chamber where very heavy ions are produced and detected. The most important instruments of this experimental area are the Munich Online Recoil Residue Ion Separator (MORRIS) [3] and the MINIBALL [4]. In order to optimize the performance of the fission fragment accelerator the design of its components inside the reactor core and inside the reactor hall is done in handshake with the final construction of the reactor itself. This allowed the placement of the ion source in the region of maximum neutron flux ($1.5\times10^{14}\mathrm{cm}^{-2}\mathrm{s}^{-1}$), enlarging the inner diameter of the beam tube there to 155 mm and use a tube with access from both sides. The latter has, among others, the advantage that the ion optical system of the extraction beam line can be mechanically decoupled from the ion source (electrical potential: +30 kV) and to form its grounded top as extraction electrode. This minimizes the danger of carbon vapor deposition on high-voltage insulators between these both components which could result in breakdowns of the extraction voltage. Behind the extraction electrode an Einzel lens is used to collect a significant part of the 30 keV ion beam (Fig. 1), followed by a X/Y steerer to compensate for relative movements of different parts of the beam tube. These are caused by thermal effects or evacuation of other beam tubes and all mechanical parts inside the reactor have to take care of this. At last a quadrupole triplet with additional steering capability is used to focus the ion beam on a diaphragm of 10 mm diameter. This diaphragm is necessary because it is an essential part of the so called 2nd barrier, which is a fundamental safety concept at the FRM-II. All these components are under detailed mechanical and ion optical design.

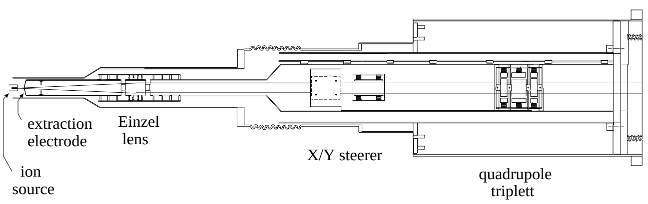

Fig. 1: Beam tube at the FRM-II containing the ion optical elements for the radioactive beam extraction.

After the radioactive beam has passed the diaphragm a mass separation is performed with a achromatic system of two 60°-magnets, an aperture slit and two quadrupole doublets. Single quadrupoles are used to adopt the beam profile to the first magnet and to a second aperture slit. Finally a quadrupole doublet is used to widen the beam for further transport outside the reactor hall. For this set-up a first order ion optics calculation was performed, assuming an energy spread of 60 eV for the ion source and an ion mass of 95 u (Fig. 2). With this a mass resolution $\Delta M/M \approx 1/250$ was achieved, which predominantly is limited by the energy spread of the ions. This can be seen in Fig. 2(c), where the slit diameter had to be set to the relatively big value of 3 mm due to this.

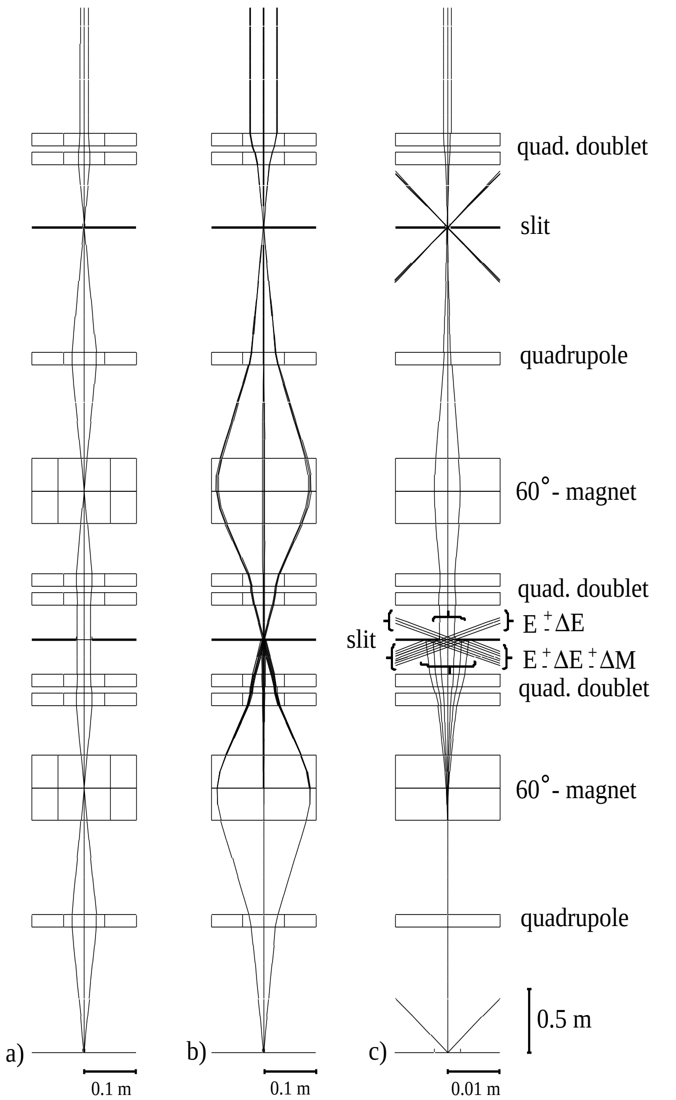

Fig. 2: Results of a first order ion optics calculation for the mass separator beam line. Shown are the center and envelopes of the beam perpendicular (a) and in the dispersive plane (b). In (c) the central part of the latter is shown with a zoom factor of 10.

References

[1] D. Habs *et al.*, Proceedings of RNB 4, Omiya, Japan, 1996, to be published in Nucl. Phys.
[2] D. Habs *et al.*, this report, p. 85
[3] P. G. Thirolf *et al.*, Proceedings of EMIS 13, Bad Dürkheim, Germany, 1996, to be published in Nucl. Instr. and Meth.
[4] D. Habs *et al.*, Proceedings of the Erice Summer School 1996, to be published in Progr. in Part. and Nucl. Phys. ed. A. Faessler