Concept of a High Resolution Online Mass Separator for the Munich Fission Fragment Accelerator

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A fission fragment accelerator combined with the Munich high flux reactor FRM-II [1] is under design for the delivery of intense beams of mass separated very neutron rich fission fragments with energies at the Coulomb barrier. They can be used to produce heavy neutron rich nuclei in fusion reactions. The large neutron excess will result in much longer lifetimes of the produced heavy elements, compared to neutron-deficient ones produced in reactions with stable nuclear beams. Thus fast α-chains can no longer be used to identify the heavy reaction products. A new separator will be used consisting of a velocity filter, an ion guide system (IGISOL) and a Penning trap [2]. The velocity filter separates the primary beam and results in a strong background suppression. The IGISOL system improves the emittance and enriches the 1^+-ions in the beam, which will then be efficiently transferred into a Penning trap. In the trap the ions are bunched, stopped and mass separated with high resolving power.

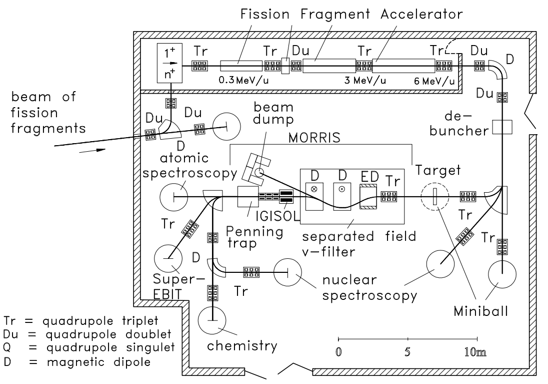

Fig. 1: Layout of the experimental hall at the new Munich reactor FRM-II with the Fission Fragment Accelerator and the recoil mass separator MORRIS.

Fig. 1 shows the layout of the experimental hall of the new Munich reactor FRM-II, including the Fission Fragment Accelerator and the Munich Online Recoil Residue Ion Separator MORRIS. The first stage of MORRIS consists of a velocity filter to separate the evaporation residues from primary beam particles. A filter system with spatially separated electric and magnetic fields of relatively low dispersion and alternating sense of deflection will produce a charge independent velocity distribution [3]. The suppression of background can be estimated to be better than 10^{11} for typical fusion reactions, while a transmission efficiency for heavy reaction products of $\approx$65% is expected with transmission times in the order of a few microseconds. The IGISOL-technique [4] will be used for a fast and efficient formation of a 1^+-beam with good emittance. The evaporation residues will be injected through an entrance foil and stopped within a few millimeters in about 100 mbar of very pure Argon (see fig. 2). The resulting charge state distribution will be dominated by the 1^+-state ($\approx$ 80%). Within a few ms the gas flow will drag the ions through the first skimmer. Cooling by the friction of the gas and the strong focussing field of a Radio Frequency Quadrupole transport channel segmented by skimmer diaphragms will form a high quality 1^+-beam with an efficiency of about 80% [5].

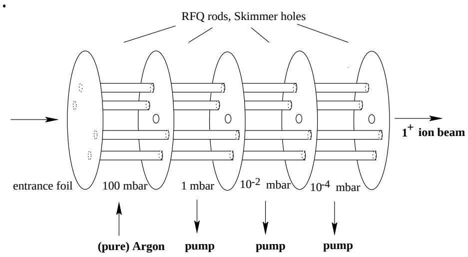

Fig. 2: Sketch of the ion guide system to transport mass separated ions from a stopping gas volume along a differential pumping line into the high vacuum regime.

In a Penning trap a strong homogeneous magnetic field coaxially superimposed by a weak electrostatic quadrupole field is used to confine charged particles into a small volume together with a mass measurement via the determination of their cyclotron frequency $\omega_c = q/m \cdot B$ (fig. 3).

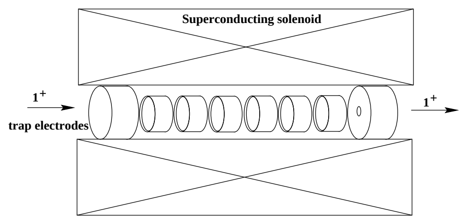

Fig. 3: Schematic view of the cylindrical Penning trap used for bunching, cooling and identification of heavy reaction products.

The continuously injected ions are bunched and mass selectively cooled via collisions with a buffer gas [6]. A broad band excitation with the cyclotron frequency drives all ions off the trap axis. Then a narrow band excitation centers only the masses of interest with high resolution on the trap axis, while all unwanted ion species are lost. With a buffer gas pressure around 10^{-6} mbar a mass resolving power of 10^5 can be reached, thus allowing the separation of (very) heavy isobaric nuclei. A typical storage time of ions in the Penning trap will be $\approx$10 ms, while the capture efficiency of the trap can reach up to 100% [7].

References

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