The Gas Cell and Extraction RFQ for SHIPTRAP ◇

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After the first successful operation of the SHIPTRAP set-up including gas cell and extraction RFQ, developments focussed on optimizing the extraction efficiency. Special attention has been paid to the purity and the ion transporting fields inside the cell. As any impurities inside the cell drastically reduce the extraction efficiency via molecule formation and recombination, UHV-like conditions have to be achieved. Besides an effective oil-free pumping and the usage of only metallic and ceramic components, baking of the set-up is most important. In order to guarantee this, a new PC-controlled baking system based on LabVIEW was installed and successfully operated [1].

As described in [2] the focussing funnel system (40 ring electrodes) is used to guide the ions inside the cell. In the first version of the funnel each ten plates were connected together resulting in a coarse four-fold DC ramp. This has been modified by an individual connection to each of the 40 funnel electrodes. Tests with laser-induced ions showed that the resulting smoother DC ramp allowed to increase the number of extracted ions by at least two orders of magnitude. The tests showed also a good agreement with simulations using a combination of the codes VARJET [3] and SIMION where the results of gas dynamical calculations (VARJET) are incorporated into trajectory calculations for ions in electric fields (SIMION).

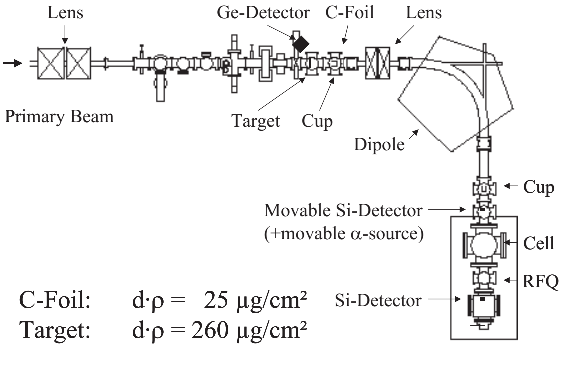

Fig. 1: Schematic view of the Munich test set-up allowing to separate primary beam and secondary ions behind a 90 ° dipole magnet. A C-foil is used to equilibrate the charge states.

Besides the off-line laser tests on-line measurements to study stopping and extraction were performed at Munich. Ag and Au ions from the tandem accelerator were stopped in the cell and mass selectively detected after the extraction with a QMS/MSP (Micro Sphere Plate) [4] system. Due to the low and unknown efficiency of the QMS/MSP combination only a qualitative analysis of the extracted ions was possible. A more effective and definite diagnostics in order to be able to determine the stopping and extraction efficiency is achieved by the usage of radioactive test ions, e.g. α-emitters. Detecting a specific α-decay in front of and behind the cell helps to avoid limitations given by an only mass selective diagnostics.

Therefore (shown in Fig. 1) a large 90 ° dipole magnet and a quadrupole doublet lens were added to the test set-up, allowing to perform nuclear reactions in front of the magnet while separating the primary beam from the secondary reaction products. A thin C-foil placed between target and magnet equilibrates the charge states of the secondary ion in order to compensate for conversion processes following isomeric decays. Detectors in front of the cell (movable) and behind the extraction RFQ allow to analyse the α-energy spectra of injected and extracted ions. A movable α-source close to the first detector allows for an online calibration of the detector.

The ^{121}Sb(^{35}Cl,4n) reaction was used to produce ^{152}Er, an α-emitter (branching ratio 90 %, $t_{1/2}$ = 10.3 s, E(α) = 4.8 MeV) in the rare earth region with the advantage of the absence of competition by the fission decay channel. Thus a high production cross section can be expected. For E(^{35}Cl) = 150 MeV HIVAP calculations expect 55 mb, while PACE4 predicts 110 mb.

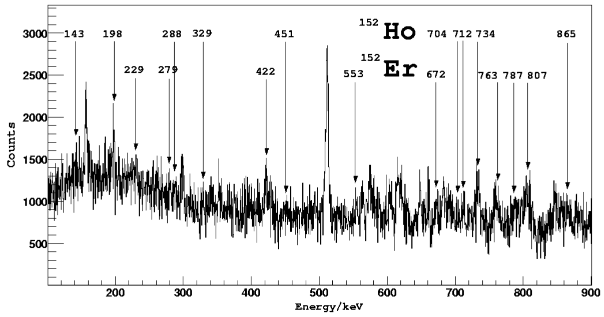

Fig. 2: Spectrum of the emitted γ-rays at a ^{35}Cl-beam energy of 150 MeV after substraction of off-line background. Marked are the levels for ^{152}Er and ^{152}Ho.

In a first step to verify the calculated production cross section a Ge-detector was placed near the target to determine the characteristic γ-rays emitted by the recoil residues. Fig. 2 shows a γ-energy spectrum with the detected γ-levels of ^{152}Er and ^{152}Ho, the two most evaporation residues at 150 MeV beam energy. Although masked by the relatively high background level (which in the meanwhile could be suppressed by an improved detector shielding by a factor of 5) the detected intensity of ^{152}Er amounts to a cross section of 39 mb, in rather good agreement with the HIVAP prediction.

As, due to the low sublimation temperature, the Sb target material easily vaporises, another reaction is discussed. In this case a ^{40}Ca beam will be used with a ^{116}Sn target to produce ^{152}Yb, ^{152}Tm and ^{152}Er with comparable production yields (PACE4). The β-decays of the first two isotopes result in ^{152}Er, thus enriching the amount of this well-detectable α-emitter.

References

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