Thermalization and extraction of ^{238}U projectile and fission fragments produced at 1000 MeV/u in the prototype cryogenic stopping cell for the LEB*

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At the Low-Energy-Branch (LEB) of the Super-FRS at FAIR, projectile and fission fragments will be produced at relativistic energies, separated in-flight, range-bunched, slowed-down and thermalized in a cryogenic stopping cell filled with ultra-pure helium gas, featuring enhanced cleanliness and high extraction efficiencies. Using an RF carpet with fine electrode spacing enables operation at high stopping gas densities. After extraction from the CSC the ions will be delivered to the high precision low-energy experiments MATS and LaSpec. A prototype CSC [1] for the LEB has been successfully commissioned at the FRS Ion Catcher at GSI [2].

During several experiments [3] in 2011, 2012 and 2014 up to thirteen ^{238}U projectile and six fission fragments have been produced at 1000 MeV/u, stopped, thermalized and extracted from the CSC. For the first time ^{238}U fission fragments produced at 1000 MeV/u were stopped and extracted from the prototype CSC. Total efficiencies of up to 15 % were reached for projectile fragments, about half of this value for fission fragments. Fig. 1 and 2 show the section of the nuclear chart of all nuclides extracted from the CSC and succesfully identified either by α-spectroscopy or mass measurements using a multiple-reflection time-of-flight mass spectrometer [4]. The fragments were extracted without any significant contribution of adducts or molecular contaminants, demonstrating the excellent cleanliness of the CSC. Furthermore no evidence for a element depended extraction was observed. The rate capability of the CSC has been studied in detail, first analysis shows that the CSC perfromes well under higher rates.

The CSC was operated online at areal densities of up to 6.3 mg/cm^2 helium, which is about two times higher than ever reached before for a stopping cell with RF ion repelling structures (RF Carpet). Despite the high areal density the extraction time of ions from the CSC was about 24 ms, enabling the extraction of short-lived fragments, e.g. ^{220}Ra^{2+} with a half-life of only 17.9 ms. For the future LEB stopping cell the areal density will be increased by a factor of about 5, reaching higher stopping and extraction efficeincies, while decreasing the extraction times down to 5 ms. In addition the extraction of ions in higher charge states will be enhanced. Therefore being perfectly suitable for experiments with exotic nuclei at FAIR.

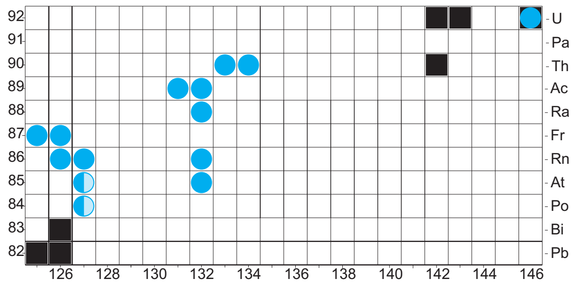

Figure 1: Section of the chart of nuclides showing the projectile fragments produced and measured at the FRS Ion Catcher experiments; half circles indicate the presence of a long lived isomeric state, solid squares indicate stable isotopes.

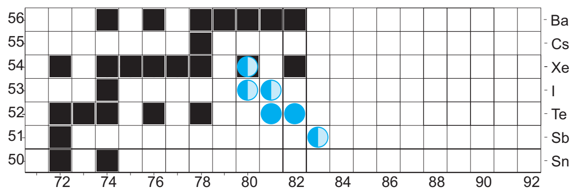

Figure 2: Fission fragments produced and measured at the FRS Ion Catcher experiments; half circles indicate the presence of a long lived isomeric state, solid squares indicate stable isotopes.

References

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