

On-line test of the Ion Catcher setup at the FRS

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The FRS Ion Catcher [1] was tested in a first on-line experiment. The system is designed to efficiently stop in-flight separated exotic nuclei from the FRS in a helium-filled gas-cell and to provide them as cooled, low-energy (a few 10 eV) beams for different experimental setups. It is a prototype for an ion catcher system at the Low-Energy Branch of the Super-FRS. The primary goal of the experiment was a proof-of-principle with relativistic exotic nuclei. Besides that, stopping and extraction efficiency, extraction times and possible conceptual limitations should be studied.

A schematic view of the setup placed at the final focal plane of the FRS is shown in figure 1. In the experiment,

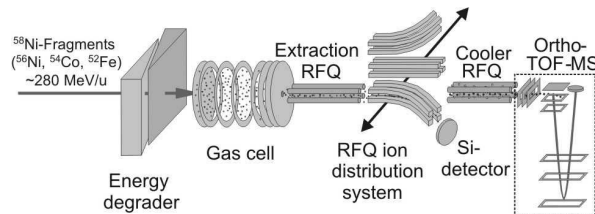


Figure 1: Schematic view of the experimental setup. Detectors placed in front of the energy degrader for particle identification of the incoming secondary beams are not shown.

exotic nuclei were produced by projectile fragmentation of a ⁵⁸Ni primary beam of 10 ms spill length in an Al target. Fragments with N=Z were separated with the FRS and energy-focused [2] with the second stage and a wedge-shaped degrader at its exit. This led to the mono-energetic secondary nuclides indicated in figure 1 with approximately 280 MeV/u. The various N=Z-fragments have different ranges. Due to the energy focusing, the range differences exceed the range straggling. This imposes an additional separation and thus, varying the degrader thickness allows to stop isotopically pure beams in the gas cell. This cell, developed at ANL [3], is the key component of the setup. It has a length of 1.25 m and works with a sophisticated configuration of DC and RF fields, which guide and extract the stopped ions. A longitudinal DC potential drop is applied to swiftly transport the ions close to the exit nozzle where they are extracted, dragged by the gas flow. An additional RF field applied to the extraction cone repels the ions from the gas-cell surface. In the experiment, the gas cell was filled with helium and mostly operated at a pressure of 100 mbar, cor-

responding to an areal weight of 2,3 mg/cm². The extracted radioactive ions were separated from the gas by two differential pumping stages. Using a newly developed RFQ-based beam-distribution system [4], the radioactive ions extracted from the gas cell could be alternatively guided to a Si-detector and a high-resolution time-of-flight mass spectrometer (Ortho-TOF-MS). The beam-distribution system ensures that the extracted, cooled ion beams are guided throughout by the pseudo potential created by an RF field and transmission losses are thus minimized. The Si-detector was used to count the α -decays from the stopped radioactive ions and with the Ortho-TOF mass spectrometer it was possible to detect and identify the created molecular ions and adducts. It also allowed to study the time-scale of ion extraction.

The most important result of the experiment is the fact, that relativistic exotic nuclei can be stopped in and extracted from the cell. The total transmission time is of the order of several 10 ms thus allowing for experiments with short-lived nuclei. This is confirmed by our measurement of the half-life of isomeric state ^{54m}Co with the result (202±5)ms, in agreement with the literature value 198 ms. The extraction times increase, as expected, with increasing mass number. The overall efficiency of the setup, defined as the ratio of decays of ⁵⁴Co measured with the Si detector and the number of incoming ions of the same species, is depicted in figure 2 as a function of the cone RF voltage. A detailed analysis is in progress.

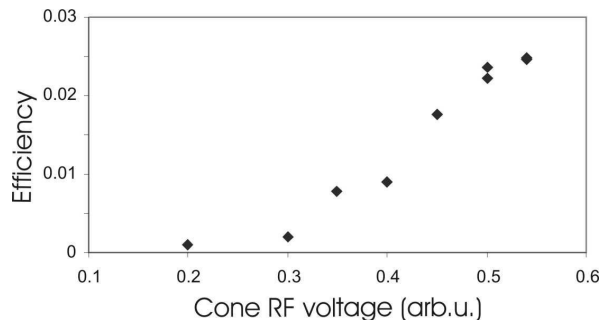


Figure 2: Preliminary data of the overall efficiency of the setup as a function of the cone RF voltage (see text for details).

- [1] M. Maier et al., GSI Report 2005-1, 331 (2005).
 [2] C. Scheidenberger et al., N.Instr.Meth. B204, 119 (2003)
 [3] G. Savard et al., Nucl. Instr. Meth. B204, 582 (2003).
 [4] M. Petrick et al., GSI Report 2005-1, 330 (2005).