FRS Ion Catcher: A Test Facility for the LEB of the Super-FRS*

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The FRS Ion Catcher experiment consists of three main parts, (i) the FRS, (ii) a cryogenic gas filled stopping cell (CSC) [1] and (iii) the multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) [2]. The exotic nuclei are separated and energy-bunched in the FRS, stopped and thermalized in the CSC and transported in an RFQ beamline to the MR-TOF-MS, which allows for diagnosis and monitoring of the extracted beam, for accurate mass measurements and for isobar separation. The FRS Ion Catcher is an ideal test facility for the LEB of the SuperFRS, as it provides a complete system for the stopping, thermalization, fast extraction, diagnostics, beam preparation, isobar separation, and mass measurement of very short-lived nuclei produced by projectile fission or fragmentation.

The system was successfully commissioned in online experiments in October 2011 and July/August 2012 (Fig. 1) [3, 4]. The stopping and extraction efficiency of the CSC has been measured to be 12% for ^{223}Th. The extraction time of the gas cell, measured with ^{221}Ac (half-life: 52ms), is 24 ms [3]. Also, a first mass measurement with the MR-TOF-MS has been performed using the heavy, short-lived ^{213}Rn (half-life: 20ms) ions [4].

After the first beam time, the cooling of the CSC was changed from LN_2 to cold He provided by a cryocooler-based cooling system. This has the advantage that temperatures as low as 50 K can be achieved and that continuous operation of the system with less user interaction is possible. The CSC has been equipped with a laser ablation ion source, providing the system with an additional offline capability for investigating the performance of the system over a wide mass range, moreover the ion source delivers calibrants for accurate mass measurements.

As part of the FRS Ion Catcher a new detector (alpha tagger) for the FRS has been set up. It comprises a Double-sided Silicon Strip Detector (DSSD) in a vacuum chamber that can be moved in and out of the beam directly in front of the CSC. The ions are implanted in the DSSD and their position, decay energy and decay time are measured. These data are linked to the standard FRS data acquisition. Nuclei can thereby be identified by the energy and life time of their alpha decay offering a fast and efficient way of ensuring that the ion of interest is transmitted to the CSC.

As next steps, the stopping efficiency of the CSC will be doubled. This is possible because at the moment the limitation of the stopping gas density is the pumping speed in the beamline downstream of the CSC. This has recently been improved by more than a factor of 2 due to new turbo pumps. The mass resolving power of the MR-TOF-MS will be further increased by temperature stabilization of the most crucial electronics.

References

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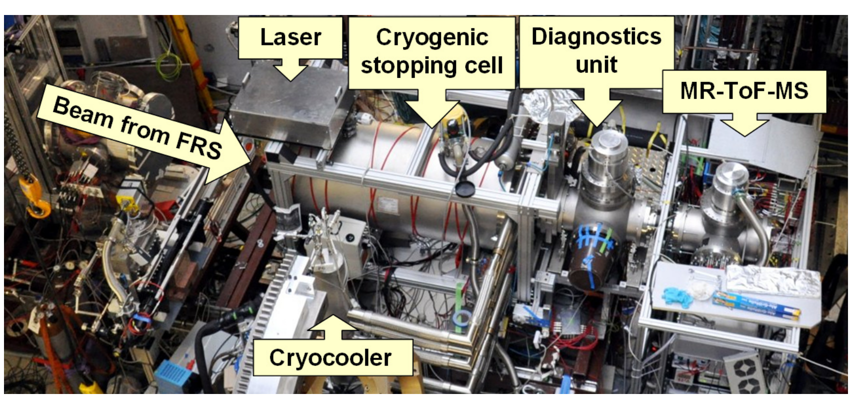

Figure 1: The FRS Ion Catcher at the final focal plane of the FRS during the beamtime in summer 2012.

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