An experimental endstation for the measurement of capture reactions with radioactive ion beams at the HRIBF*

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The fusion of protons with other nuclei provides the energy that powers many astrophysical phenomena and the mechanism for element synthesis. Under extreme conditions, such as are found in accreting binary systems like X-ray pulsars and nova explosions, the rate of proton capture by certain radioactive nuclei may exceed their rate for radioactive decay. Knowledge of proton capture rates by radioactive nuclei is needed in order to understand energy generation and nucleosynthesis in these events. Due to the relatively short half-lives for decay, direct measurement of the proton capture cross sections requires radioactive heavy ion beams on hydrogen targets. The most sensitive technique for measuring these typically small cross sections involves the use of pure hydrogen gas targets with direct detection of the recoiling heavy nuclei in a recoil mass separator [1,2]. An experimental endstation optimized for such measurements is currently being developed at ORNL's Holifield Radioactive Ion Beam Facility (HRIBF) using the Daresbury Recoil Separator (DRS) with a windowless gas target system.

The DRS is a large-acceptance recoil separator that utilizes two 1.2-m-long crossed-field velocity filters and a 50° dipole magnet to separate beam particles from the recoils of interest [3]. Reaction products are detected at the (M/Q) focal plane in a gas ionization chamber. A large-area carbon foil microchannel plate detector is currently being constructed to provide timing and position information. The DRS has been installed at the HRIBF and is being commissioned in a series of measurements using stable ion beams and foil targets. Results of these measurements will be presented.

The use of a pure gas target provides about a factor of 3 increase in yield over plastic targets for the measurement of capture reactions in inverse kinematics. A windowless gas target has been constructed for use with the DRS in measurements of capture reactions. The special compact design of the gas target includes four differential pumping stages on each side of the target. Areal densities of 3×10^{18} /cm^2 of helium have been achieved in the central target region without perceptible increases in the pressure in the fourth pumping stages, located only 0.5 m from the center of the target. Thus a high angular acceptance is achieved while maintaining the base vacuum in the nearby velocity filters. The operating parameters of the target as measured in a series of tests will be presented.

The combination of the DRS with the windowless gas target and large-area focal plane detectors provides a sensitive device for the measurement of capture reactions in inverse kinematics with radioactive beams. Plans for the first measurements with radioactive beams will also be presented.

[1] M. S. Smith, C. E. Rolfs and C. A. Barnes, Nucl. Inst. Meth. Phys. Res. **A306**, 233 (1991).
[2] L. Gialanella *et al.*, Eur. Phys. J. A **7**, 303 (2000).
[3] A. N. James *et al.*, Nucl. Inst. Meth. Phys. Res. **A267**, 144 (1998).

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