Informing neutron capture with surrogate (d,p) reactions

J.A. Cizewski[1] and the GODDESS Collaboration

[1]*Rutgers University, New Brunswick, NJ 08901, USA*

Informing neutron capture on rare isotopes is important to understand the synthesis of the elements in stars and their explosions and mergers, as well as nuclear energy and stewardship science. Andrew Ratkiewicz et al., validated neutron transfer (d,p) as a surrogate for (n, γ) reactions. The coupling of an array of γ-ray detectors to the Oak Ridge Rutgers University Barrel Array (ORRUBA) of position sensitive silicon strip detectors forms GODDESS – Gamma-array ORRUBA: Dual Detectors for Experimental Structure Studies. ORRUBA has been coupled to Gammasphere and GRETINA arrays and prepared to couple to GRETA. Ionization chambers or the S800 spectrograph are deployed for heavy recoil detection. Both near Coulomb barrier (at ATLAS) and fast ($\sim$ 40 MeV/u) (at NSCL and FRIB) (d,p) measurements with rare isotope beams have been realized. For a surrogate analysis, the γ-decay probabilities as a function of excitation energy need to be extracted, requiring high efficiency for detecting the γ cascades and good resolution for charged-particle detection. High level density, limited resolution of charged particle detectors, and limited efficiency of γ detector arrays challenges informing (n, γ) cross sections via a surrogate (d,p) reaction. Recently we have demonstrated that measuring the heavy recoil of the (d,p) reaction with the S800 spectrograph can increase the efficiency of deducing the γ-decay probabilities as a function of excitation energy. Therefore, we do not need to understand the complicated decay pattern from discrete γ rays, especially important for nuclei away from closed shells and odd-odd nuclei with high level density. The present talk would summarize the (n, γ) surrogate reaction method with the (d,p) reaction and the realization of GODDESS at NSCL and FRIB with the S800. Preliminary results from recent measurements and proposed experiments to inform (n, γ) rates would be presented. This work is supported in part by the U.S. Department of Energy National Nuclear Security Administrator and Office of Nuclear Physics and the National Science Foundation.