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beta-Delayed Charged Particle Detector for Studies of Novae and X-ray Bursts

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Classical novae and type I X-ray bursts are energetic and common thermonuclear astrophysical explosions. However, our ability to understand these events is limited by the lack of comprehensive nuclear data on proton-rich nuclei. Specifically, constraining the 30P(p,gamma)31S and 15O(alpha,gamma)19Ne reaction rates has been found to be crucial to the understanding of nucleosynthesis and energy generation in these events. As direct measurements of these reactions are not technically feasible at the present time, indirect measurements of dominant resonance strengths by beta-delayed protons and alpha particles are proposed. A previous measurement at NSCL identified a new 31S state at E_x=6390 keV to be a key resonance for 30P proton capture at peak nova temperatures. A significant branching ratio of 3.38\% from 31Cl beta decay was observed, which enables the determination of the resonance strength by measuring the corresponding 259 keV beta-delayed protons. Similarly, a previous measurement at NSCL observed a 0.0156\% feeding of the 19Ne state at 4034 keV, a key resonance for the 15O(alpha,gamma)19Ne reaction, by the 20Mg(beta p) sequence. This branching ratio is sufficient to determine the resonance strength by measurement of the proton-α pairs.
A gas-filled detector of beta-delayed charged particles has been designed and built to measure the aforementioned decays at NSCL. The detector is coupled with the Segmented Germanium Array (SeGA) to enable coincidence gamma detection as an additional probe of the decay scheme and for normalization purposes. The first phase of the detector functions as a proton calorimeter, and it is scheduled to be commissioned with 25Si(beta p)Mg and 23$Al(beta p)22Na during the first week of May 2018. We will report on the performance of the detector and present preliminary beta-delayed proton spectra.

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