β-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 ^{30}P$(p,\gamma)^{31}$S and ^{15}O$(\alpha,\gamma)^{19}$Ne reaction rates has been found to be crucial to the understanding of nucleosynthesis and energy generation in these events [1, 2]. As direct measurements of these reactions are not technically feasible at the present time, indirect measurements of dominant resonance strengths by β-delayed protons and alpha particles are proposed. A previous measurement at NSCL identified a new ^{31}S state at $E_x = 6390$ keV to be a key resonance for ^{30}P proton capture at peak nova temperatures [3]. A significant branching ratio of 3.38% from ^{31}Cl β decay was observed, which enables the determination of the resonance strength by measuring the corresponding 259 keV β-delayed protons. Similarly, a previous measurement at NSCL observed a 0.0156% feeding of the ^{19}Ne state at 4034 keV, a key resonance for the ^{15}O$(\alpha,\gamma)^{19}$Ne reaction, by the ^{20}Mg(βp) sequence [4]. This branching ratio is sufficient to determine the resonance strength by measurement of the proton-α pairs. A gas-filled detector of β-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 γ 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 ^{25}Si$(\beta p)^{24}$Mg and ^{23}Al$(\beta p)^{22}$Na during the first week of May 2018. We will report on the performance of the detector and present preliminary β-delayed proton spectra.

References

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