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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 ^{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. 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. A significant feeding of 3.38\% from ^{31}Cl $\beta\gamma$ 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. This feeding 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 was successfully commissioned with ^{25}Si$(\beta p)^{24}$Mg and ^{23}Al$(\beta p)^{22}$Na in May 2018. We will report on the performance of the detector and present preliminary β-delayed proton spectra.We will all discuss the upgrade of the detector into a TPC by increasing the granularity of the Micromegas pad plane for the measurements of the ^{20}Mg(βp) sequence.

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