Beta-delayed gamma decay measurements to probe thermonuclear astrophysical explosions

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We describe a program of beta delayed gamma decay measurements to reduce and quantify several of the most important nuclear physics uncertainties associated with nucleosynthesis and energy generation in classical novae and type I x-ray bursts. These measurements employ beams of rare isotopes at the proton drip line produced by projectile fragmentation, and large arrays of high-purity germanium detectors. Using ^{26}P decay, we have observed the first evidence for the exit channel of the key ^{25}Al(p,γ)^{26}Si resonance in novae [1]. This experiment has enabled an estimate of the nova contribution to the Milky Way's ^{26}Al abundance that is effectively free of nuclear-physics uncertainties. We recently collected a high-statistics data set on the beta-delayed gamma decay of ^{31}Cl, which selectively populates L=0 resonances in the ^{30}P(p,γ)^{31}S reaction, in order to identify these resonances with shell-model ones and calculate their strengths. This reaction is a bottleneck whose uncertain rate strongly influences nuclosynthesis in novae on white dwarfs near the Chandrasekhar mass and the identification of candidate presolar nova grains. In the near future, we plan to experimentally test the feasibility of a novel beta-decay method to determine the unknown ^{15}O(α,γ)^{19}Ne reaction rate, which is believed to initiate breakout from the hot CNO cycles in type I x-ray bursts.

[1] M. B. Bennett et al., Phys. Rev. Lett. 111, 232503 (2013)