

# Direct Measurement of Resonance Properties of $^{23}\text{Mg}(p, \gamma)^{24}\text{Al}$ reaction Occurring in Classical Novae using the DRAGON Recoil Separator and an optimized Array of $\text{LaBr}_3$ , $\text{CeBr}_3$ and BGO Gamma Detector Array

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## ABSTRACT

Classical novae are significant contributors to the cosmic abundance of several isotopes, including,  $^{13}\text{C}$ ,  $^{15}\text{N}$ ,  $^{26}\text{Al}$  and the radioactive  $^{22}\text{Na}$ . Observations of these elements in the ejected material help astrophysicists study the processes governing stellar evolution and nucleosynthesis. One particular nucleosynthesis site is classical novae, which are explosions resulting from accretion of hydrogen-rich material onto White Dwarf star are responsible for the formation of a significant number of nuclides lighter than calcium. One of the main reactions that has an observable effect on classical nova nucleosynthesis is the proton capture on radioactive  $^{23}\text{Mg}$ , resulting in  $^{24}\text{Al}$  recoil and a gamma ray. The  $^{23}\text{Mg}(p, \gamma)^{24}\text{Al}$  reaction has been investigated through a variety of experimental and theoretical means in the past. These investigations include a direct measurement of the strength and energy of the dominant resonance in this reaction, using a radioactive  $^{23}\text{Mg}$  beam at the DRAGON facility at TRIUMF in 2010. Although this measurement effectively detected the  $^{24}\text{Al}$  recoils in coincidence with  $\gamma$  rays, the beam energy was slightly too low. Hence it is possible that beam might have reached the resonance energy in non-equilibrium region of the target, invalidating the results. This was evident in 2015, when a high-resolution mass measurement of  $^{24}\text{Al}$  suggested a resonance energy that is inconsistent with the DRAGON result.

Due to the existing inconsistency in resonance energy of the  $^{23}\text{Mg}(p, \gamma)^{24}\text{Al}$  reaction, this research aimed to investigate the resonance properties of the reaction by using a higher  $^{23}\text{Mg}$  beam energy coupled to an array of newly installed hybrid fast timing Lanthanum Bromide ( $\text{LaBr}_3$ ), Cerium Bromide ( $\text{CeBr}_3$ ) and Bismuth Germanate (BGO) detectors for detecting  $\gamma$ - rays. This newly installed detector array allowed a precise measurement of the strength of the resonant state, extracting a value of  $35 \pm 5$  meV, which is in excellent agreement with the Erickson et al., experimental resonance strength of  $38_{-15}^{+12}$  meV. The newly determined reaction rate is incorporated into NuGRID nova simulation code to study its impact on nucleosynthesis and isotopic abundances in classical novae.