Constraining the astrophysical $^{23}Mg(p,\gamma)^{24}Al$ reaction rate using the $^{23}Na(d,p)^{24}Na$ reaction

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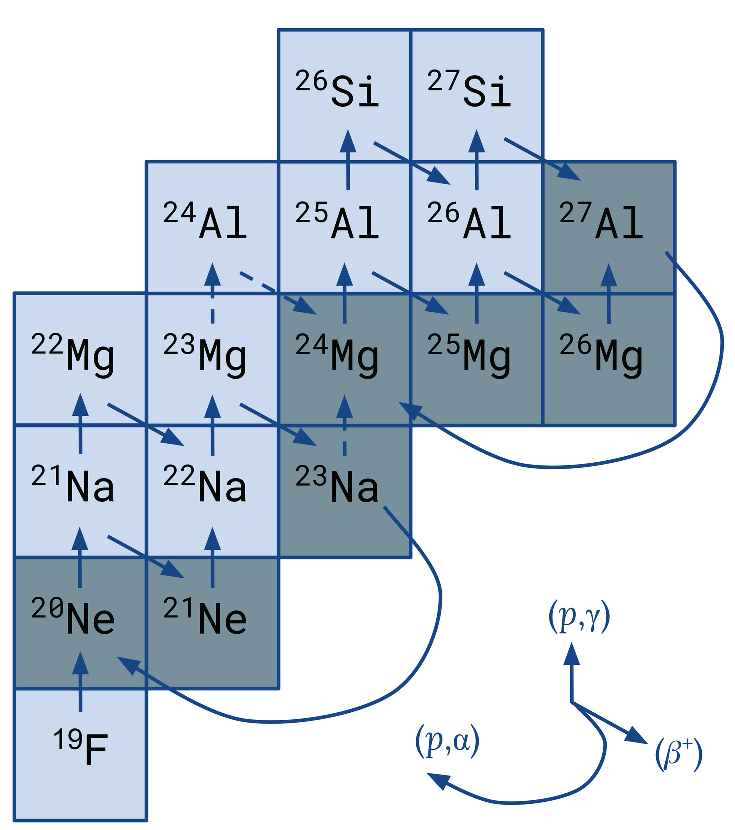
MOTIVATION

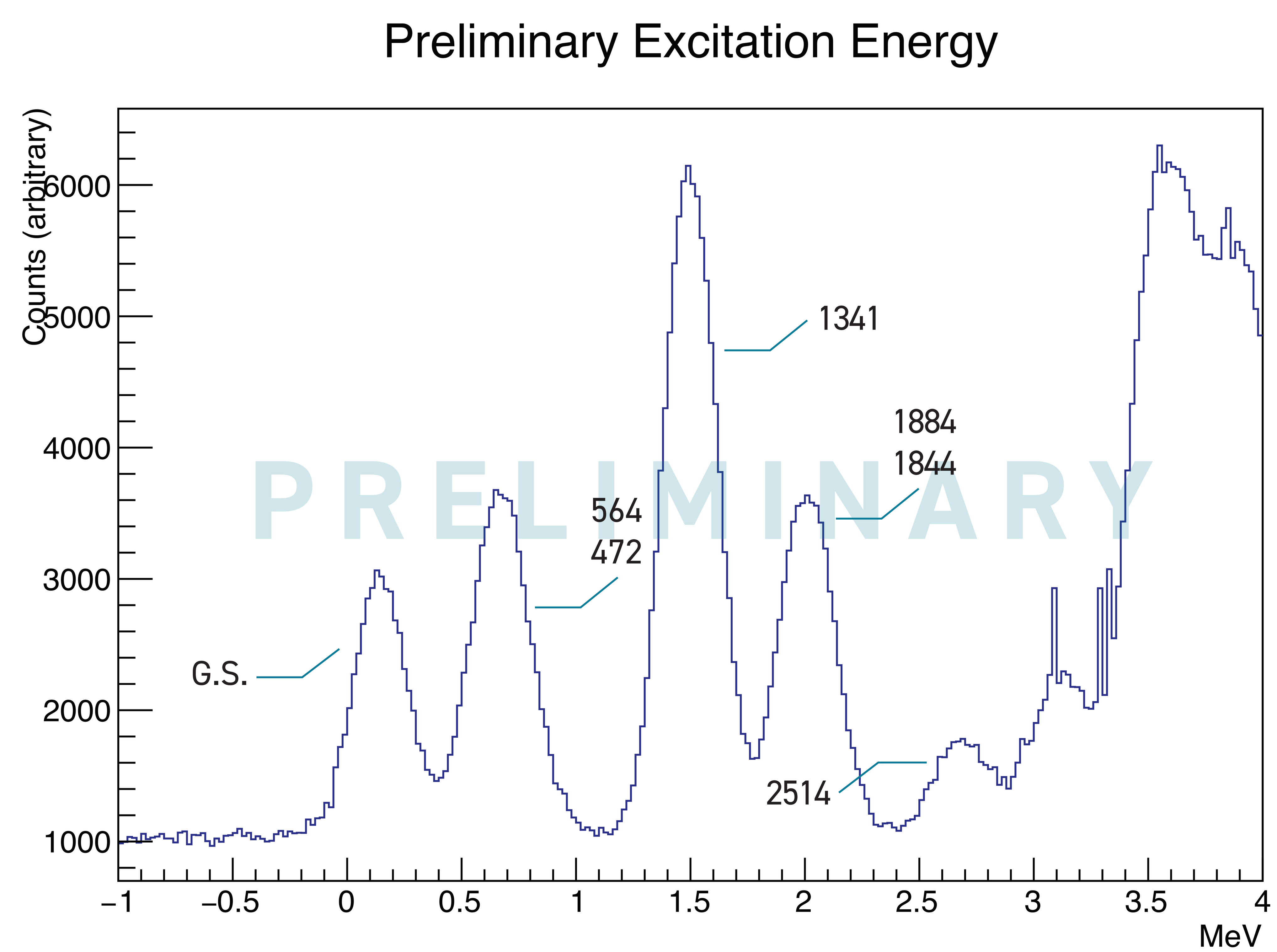
In classical novae, the $^{23}Mg(p,\gamma)^{24}Al$ reaction provides an escape from the Ne-Na cycle and is therefore important in understanding nucleosynthesis in the A>20 mass range. Classical novae occur in binary star systems when a white dwarf's companion main sequence star sheds its matter and the white dwarf begins to accrete hydrogen-rich materials on its surface. The burning of the materials raises the white dwarf's temperature and runaway nuclear reactions begin. It is at these increased temperatures that the proton capture reaction on 23Mg outpaces the decay reaction favored at lower temperatures [1,2]. The ^{24}Al generated by this proton capture reaction quickly decays into ^{24}Mg and allows entrance into the Mg-Al cycle [3].

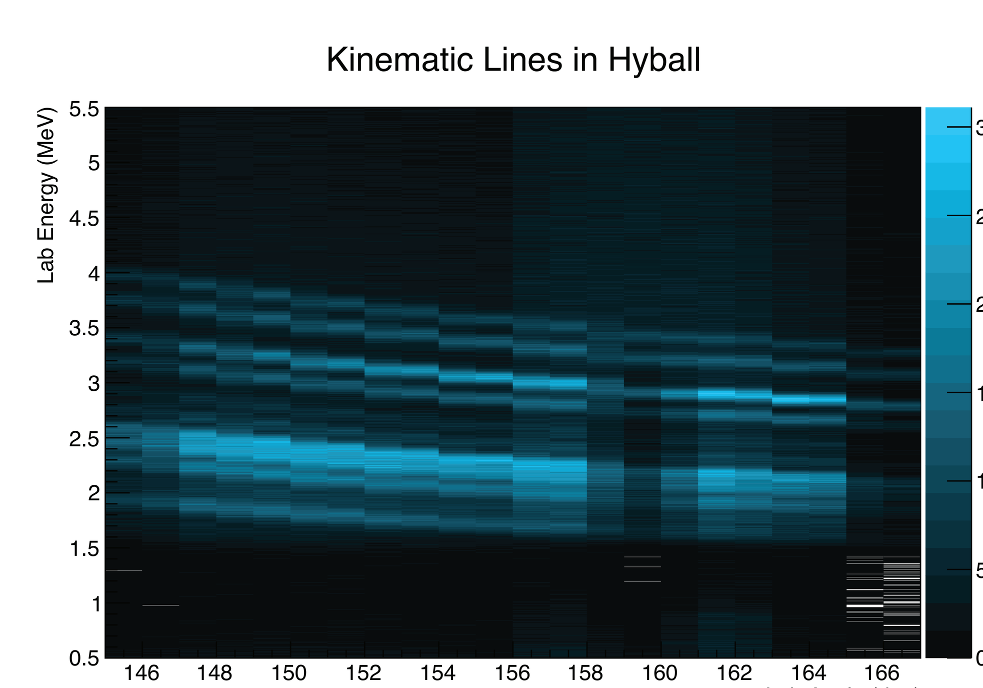


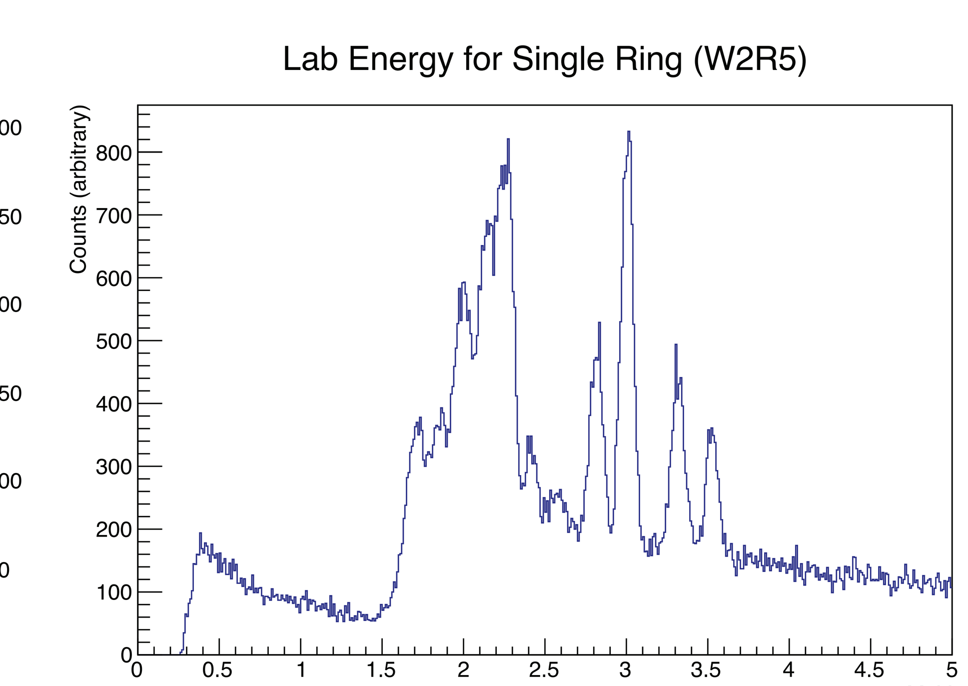
PREVIOUS WORK

Several resonances may be of astrophysical interest, however, at novae temperatures, the lowest resonant energy appears to be the dominant contributor to the reaction rate [2]. Multiple experiments have investigated the excited states in Al that correspond to the resonances of astrophysical interest. A fusion-evaporation experiment at gammasphere found the first resonance energy to be 473 ± 3 keV [4] by performing in-beam γ-ray spectroscopy on the Al nucleus. The first direct measurement of the $^{23}Mg(p,\gamma)^{24}Al$ reaction was performed at DRAGON. Using a ^{23}Mg beam a resonance energy of 485.7 keV and a resonant strength of 38 meV[4] were determined. However, an additional resonance strength higher than initially anticipated was noted upstream of the target position. This observation introduces some uncertainty into the veracity of the results produced.

RESULTS

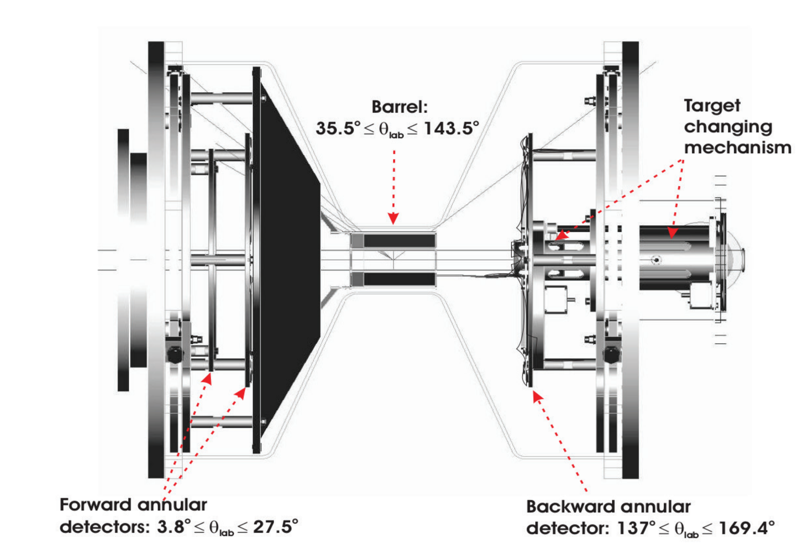


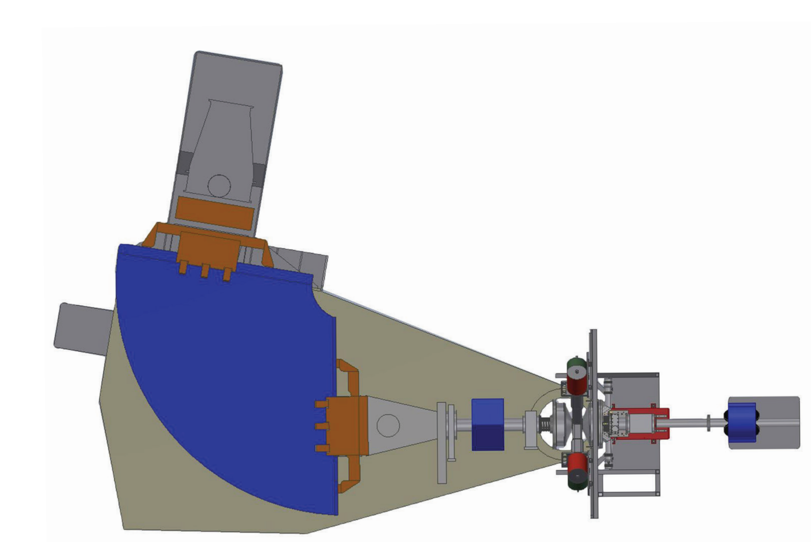




TIARA

The experiment conducted here at the Cyclotron Institute was performed using TIARA, a compact silicon detector array designed to study direct reactions in inverse kinematics. We impinged a 10 AMeV beam of Na on a 500 μg deuterated plastic target mounted in the center of the TIARA chamber. In conjunction with the MDM and Oxford Detector, we are able to look at protons from the $^{23}Na(d,p)^{24}Na$ reaction in the backward angle silicon array with relatively high precision. HPGe detectors mounted around the target position also allow for gamma-ray spectroscopy.





FUTURE WORK

We are continuing to perform offline analysis and verifying the observed results are commensurate with existing literature. Additionally, we are planning a run at DRAGON to repeat a direct measurement of the $^{23}Mg(p,\gamma)^{24}Al$ reaction using the upgraded lanthanum bromide array.

REFERENCES

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[3] L. Erikson, et al., Phys. Rev. C 81 045808 (2010).
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