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(α, n) reactions at the University of Notre Dame

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(α, n) reactions are needed to model a wide range of physical process ranging from the amount of neutrons available for the astrophysical s-process to the neutron energy spectrum emitted from radioactive fuel storage containers. Yet the cross sections of these reactions often have large, or worse yet uncharacterized, uncertainties that result in inconsistency between model and direct measurement. By evaluating past measurements and through the increased accuracy of modern neutron transport codes, errors in the efficiency determination of many past experiments have been realized. In addition, many applications require not only the total reaction cross section, but the partial cross section to different final states, which could not be determined with the thermalized neutron counters used for the majority of past measurements. To improve on these past measurements, we have developed an efficient measurement technique at the University of Notre Dame Nuclear Science Laboratory using the combination of a high current accelerator, deuterated liquid scintillators, and spectrum unfolding. This has enabled us to obtain partial differential cross sections for the ^{13}C$(\alpha, n)^{16}$O reaction, which extend from laboratory α-particle energies of 0.8 to 6.5~MeV in approximately 10~keV energy steps at 18 angles between 0 and 160°, resulting in over 700 distinct angular distributions. These measurements not only cover a wide energy range but are also the first to extend below 1~MeV. To demonstrate one impact of these data, we use these differential data to augment the previous state-of-the-art R-matrix fit of the low energy ^{13}C$(\alpha, n)^{16}$O reaction and use Bayesian uncertainty estimation to demonstrate that the differential data decreases the uncertainty by a factor of two, from ≈10\% to ≈5\% over the energy region of astrophysical interest.

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