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Precision Measurement of the 12C(a,g) Reaction With Gamma Beams and a TPC Detector *

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The carbon/oxygen (C/O) ratio at the end of stellar helium burning is the single most important input to stellar evolution theory. However, it is not known with sufficient accuracy, due to large uncertainties in the cross section of the 12C(a,g)16O reaction. We present results based on a new method, which is significantly different from the experimental efforts of the past four decades [1]. With data measured inside one (TPC) detector with vanishingly small background, precise angular distributions of the 12C(a,g)16O reaction were obtained by measuring the inverse 16O(g,a)12C reaction with gamma-beams from the HIgS facility, and an optical readout Time Projection Chamber (O-TPC) detector.

We agree with current world data for the total reaction cross section and further evidence the strength of our method with angular distributions measured at Ecm = 2.0 - 2.6 MeV, where the interference angle of the ell = 1 and ell 2 partial waves (phi_12) varies rapidly. We measure, for the first time over this energy range (2.0 - 2.6 MeV), phi_12 values that agree with fundamental predictions based on the unitarity of the scattering matrix and reconcile these historical disagreement of data with Unitarity. We propose a “Unitarity-Test” of data to elucidate systematic error in measured angular distributions.

postscript note In a recent (April 11 - 15, 2022) measurement at the HIgS facility, our collaboration [2] measured data of the 16O(g,a) reaction using the same method of a TPC operating in gamma beams, but with an improved electronic readout TPC (eTPC) detector constructed at the University of Warsaw. First data measured at Eg > 11 MeV (Ecm > 3.8 MeV) are submitted to this NPA10 meeting [2].

[1] R. Smith, M. Gai, S.R. Stern, D.K. Schweitzer, M.W. Ahmed, Nature Comm. **12**, 5920 (2021), https://www.nature.com/articles/s41467-021-26179-x
[2] M. Cwiok *et al.*, NPA10 conference.

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