

# Exploring the key astrophysical reaction $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ with TPCs and $\gamma$ beams.

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Long touted as the “most important nuclear physics uncertainty in astrophysics”, direct measurements of the  $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$  cross section have been a key goal for nuclear astrophysics over the last five decades. It is a difficult cross section to measure, since the reaction is not dominated by a single resonance, but instead by the interference between several bound and unbound states.

Experimental measurements are typically made at higher energies, where the cross section is larger, and an R-matrix extrapolation is used to evaluate its value at stellar conditions. Such an extrapolation relies on accurately determining the E1 and E2 partial cross section and their mixing. The goal is to obtain a 5-10% cross section uncertainty on the extrapolation, which is nowhere near the current precision available from existing capture data.

To circumvent the well-documented challenges with directly measuring the  $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$  reaction, our new experimental approach measures the time reverse photodissociation reaction  $^{16}\text{O}(\gamma,\alpha)^{12}\text{C}$  using an active target Time Projection Chamber (TPC). Accurate measurements of the outgoing charged particles allow detailed angular distributions to be reconstructed. Proof-of-principle measurements using an optical TPC, published in 2021 and 2026, laid the groundwork for the present work using the new electronic Warsaw TPC.

This presentation details experiments run in 2022 using the Warsaw TPC with gamma beams at the H $\gamma$ S facility. Preliminary results on total cross sections and angular distribution analyses are presented.