Search for α-Cluster Structure in Exotic Nuclei with the Prototype Active-Target Time-Projection Chamber

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Some exotic nuclei appear to exhibit α-cluster structure, which may impact nucleosynthesis reaction rates. While various theoretical models currently describe such clustering, more experimental data are needed to constrain model predictions. The Prototype Active-Target Time-Projection Chamber (PAT-TPC) has low-energy thresholds for charged-particle decay and a high detection efficiency due to its thick gaseous active target volume, making it well-suited to search for low-energy α-cluster reactions. Radioactive-ion beams produced by the *TwinSol* facility at the University of Notre Dame were delivered to the PAT-TPC to study ^{14}C via α-resonant scattering. Differential cross sections and excitation functions were measured and show evidence of three-body exit channels. Additional data were measured with an updated Micromegas detector more sensitive to three-body decay. Preliminary results are presented.

KEYWORDS: Active targets, Alpha clustering, Radioactive beams, Time-projection chambers

1. Introduction

The description of the internal structure of unstable neutron- and proton-rich nuclei remains a challenge in nuclear physics. Experimental and theoretical studies of the clustering of α particles in light nuclei have helped to shed light on their structures [1–6] These structures can be strongly affected by the presence of nucleons that are valence to the clustering of α particles, such as the two valence neutrons in ^{10}Be [7] and ^{14}C [8–10]. Radioactive ion beams are a useful tool to probe the excited states of these nuclei. While such beams often have low intensities, active targets offer high detection efficiency by way of their thick target material and low energy thresholds due to their gaseous composition; furthermore, time-projection chambers can offer high angular resolution [11–16]. The Prototype Active-Target Time-Projection Chamber (PAT-TPC), a half-scale prototype of the full Active-Target Time-Projection Chamber developed at the National Superconducting Cyclotron Laboratory at Michigan State University [17–19], takes advantage of both of these technologies to provide wide-ranging, continuous excitation functions and angular distributions. In a previous work [10], excited states in ^{14}C were measured via resonant elastic (Fig. 1) and inelastic α scattering of a radioactive ^{10}Be beam at the *TwinSol* facility [20] at the University of Notre Dame and compared to theoretical linear-chain models [21] (Fig. 2). Within the data set, three-body decay channels of $^6\mathrm{He} + \alpha + \alpha$ were also seen, but limited azimuthal sensitivity prevented further analysis of the decays. A second ex-