Structure of ^{9}C via proton resonance scattering

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Light exotic nuclei provide excellent testing grounds for *ab initio* models that can calculate observables such as the energy levels and electromagnetic moments. ^{9}C is an ideal candidate for testing these models because it is the most neutron deficient nucleus (N/Z = 0.5), besides ^{3}He, to be particle bound and lies next to the proton drip line. The ground state, $3/2^{-}$, and the first excited state, $1/2^{-}$, of ^{9}C were discovered through the transfer reaction ^{12}C (^{3}He, ^{6}He) ^{9}C [1, 2, 3]. The excitation function for p+^{8}B was first measured in [4] using a ^{8}B radioactive beam. R-matrix analysis showed evidence for a broad $5/2^{-}$ state at 3.6 MeV and a possible $3/2^{-}$ state at 4.1 MeV. The experiment was limited to only one angle and the excitation function was measured up to 4.5 MeV. No positive parity states were observed. The study of ^{9}C was chosen as the first commissioning radioactive beam experiment with the Texas Active Target (TexAT) detector partially because the excitation function at low energies is available, and also because ^{8}B is a very clean and intense radioactive beam at the Cyclotron MARS facility. With this new measurement, we have extend the excitation function for p+^{8}B to higher energies and covered wider range of scattering angles. One of the main physics goals of these measurements was to identify positive parity states in ^{9}C, determining location of the sd-shell.

TexAT is a general purpose active target detector to be used for nuclear reaction measurements with rare isotope beams. This study is part of the first commissioning run of the TexAT detector which consisted of stable beam test with ^{12}C, before switching to ^{8}B and ^{8}Li radioactive beams. TexAT uses a highly segmented Micromegas (Micro-MEsh GAseous Structure) plate of 1024 channels. This consists of 768 pads in the central region with 128 chains (running parallel to the beam axis) and 128 strips (running perpendicular to the beam axis) in the side regions. Each pad fired in the central region along with the measured drift time provides a 3D point of the particle while the chains and strips must be matched together to provide a 3D point. These points allow for accurate track reconstruction of both the beam and scattered light recoils (protons in this case) as well as particle ID using their specific energy loss. A total of 15 Silicon detectors backed by CsI(Tl) scintillators were used, 9 in the forward array and 6 in the left wall array (with respect to the beam direction), to measure the total energy of light recoils protons. Because of the large number of channels used in TexAT, the GET (General Electronics for TPCs) data acquisition system was used. The GET system allows for pre-amplification, shaping and digitization of each signal. More details of the TexAT detector and the electronics used can be found in [5, 6, 7].

One of the largest efforts that has been done for this study is the track reconstruction using the Micromegas detector. Prior the commissioning run, an alpha source was placed in the chamber filled with Methane gas at 50 Torr. We have applied various techniques for track reconstruction and determined that the Hough transform works best. The cumulative plot of the tracks from the alpha source in shown in Fig. 1 for the XY plane. There are 5 distinct bands of tracks going to the forward Si array and 3 towards the left Si array corresponding the 5 columns of detectors in the front and 3 in the left. All of these tracks converge behind the Micromegas plate (start of the Micromegas is 0 on the Y-axis) roughly to the size of the source ~5 mm.

The study of ^{9}C was performed on the MARS facility at the Cyclotron Institute at Texas A&M University and was the first radioactive beam measurement using TexAT. A primary beam of ^{6}Li was used to create the ^{8}B beam through the two proton pickup reaction (^{3}He,n). The ^{8}B beam had an energy of 7.5 MeV/A with an intensity of 10^{3} pps. The chamber was filled with methane at 435 Torr to stop the beam before the last 1/8th section of the Micromegas plate in the central region. Protons were identified by their specific energy loss in the Micromegas.

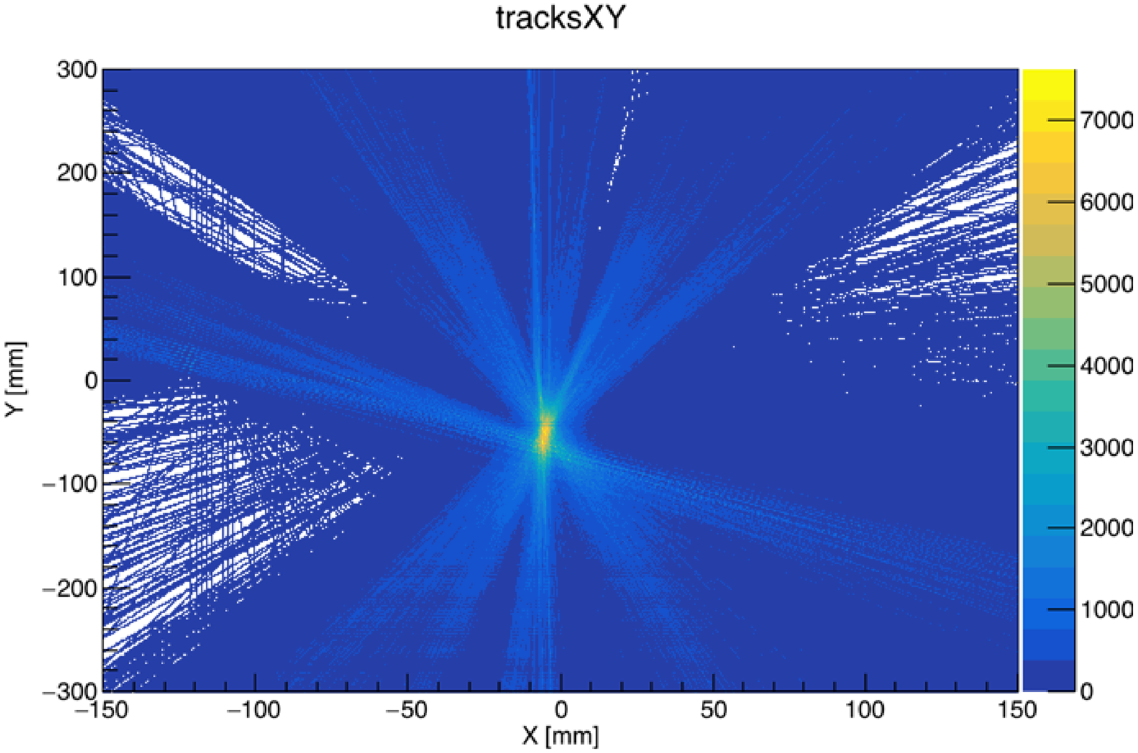

FIG. 1. Cumulative tracks in the XY plane for an α-source in 50 Torr of Methane.

Preliminary partial excitation function for p+^{8}B is shown in Fig. 2. This excitation function is consistent with the excitation function measured in [4]. Analysis is still in progress, but we expect to finalize the project by the end of Summer/beginning of Fall 2018.

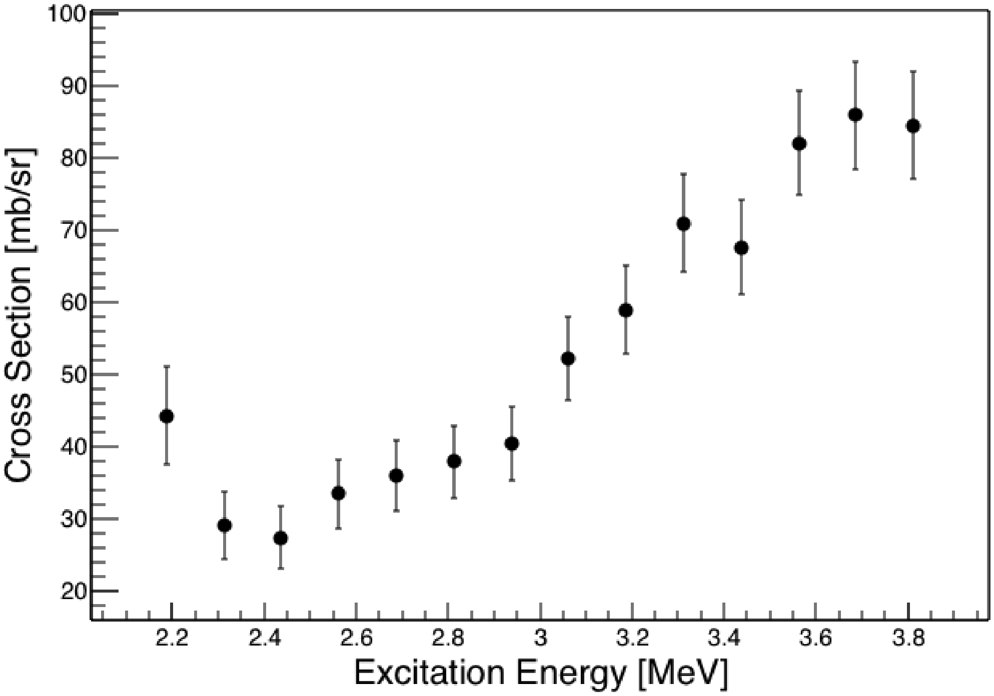

FIG. 2. Preliminary excitation function for one of the central Si detectors.

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