Structure of ^{10}N via ^{9}C+p resonance scattering

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The new capabilities of rare isotope beams developed three decades ago allowed the discovery of unusually large matter radii in some exotic nuclei by Tanihata *et al.* [1] and opened a new era in nuclear physics. The most famous example is ^{11}Li which has a nuclear matter root mean square radius as large as that of ^{208}Pb. This is due to the two-neutron halo of ^{11}Li where the wave function of two valence neutrons extends far beyond the ^{9}Li core. An important role in explaining the halo structure of ^{11}Li was played by three-particle models that describe ^{11}Li as a ^{9}Li-n-n system. These models rely on accurate knowledge of neutron-^{9}Li interaction, that can be established from the known states in ^{10}Li. However, in spite of much effort (see [2-8] and references therein), uncertainty in spin-parity assignments and excitation energies of some low-lying states in ^{10}Li still remains. Even less is known about the mirror nucleus ^{10}N. Only one experiment that claimed observation of the ground state of ^{10}N has been done. A broad resonance at 2.6(4) MeV with a width of 2.3(16) MeV was identified using the multi-nucleon transfer reaction ^{10}B(^{14}N,^{14}B)^{10}N [9]. The goal of this work is to provide a spin-parity assignment for the ground state and search for the excited states in this exotic, proton drip-line nitrogen isotope - ^{10}N.

States in ^{10}N, including the ground state, were populated in resonance elastic scattering of ^{9}C on protons. The rare isotope beam of ^{9}C was produced by recoil spectrometer MARS using ^{10}B(p,2n) reaction. The excitation function for the ^{9}C+p elastic scattering was measured using a new time projection chamber, which is shown in Fig. 1. Preliminary results of lower excitation energies indicate the presence

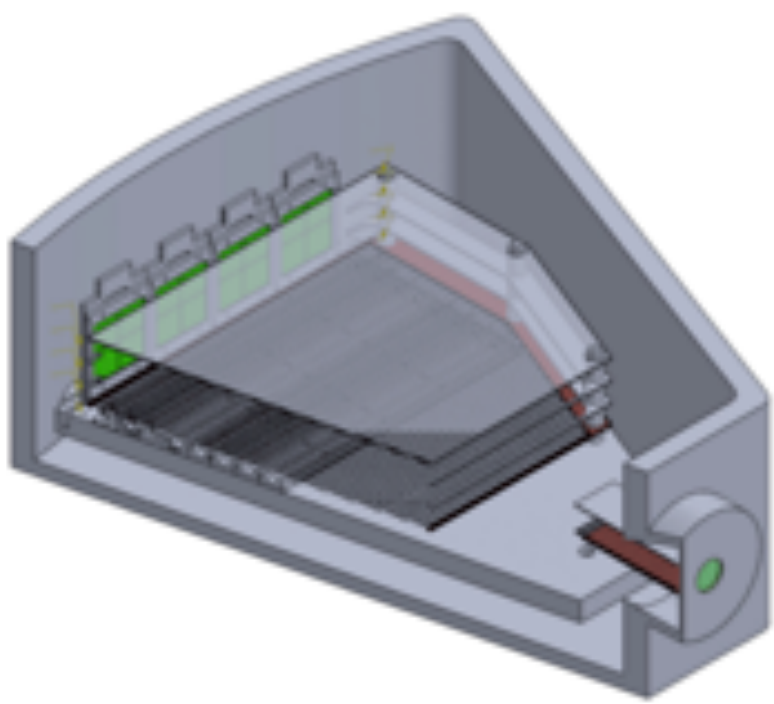

FIG. 1. The layout of the time projection chamber TexAT-P1.

of a broad s-wave state at an energy of 2.25 MeV with a width of 1.5 MeV are were already reported in 2015 Cyclotron Annual Report [10].

The analysis of the higher energy region is complicated by the fact that the high energy protons (>12 MeV) punch through the 1 mm Si detector and do not deposit all of its energy. The difficulty is to distinguishing protons in the spectrum that have 'punch-through' the silicon detectors from those that have not as well as reconstructing all of the 'punch-through' events correctly. The approach we have taken is to develop a realistic simulation in Geant4 (GEometry ANd Tracking) and use these results to aid in our analysis. The simulation includes all components of the experimental setup. Other factors are taken into consideration in the simulation such as the beam energy spread from the velocity filters in MARS and the resolution in both the position and timing, due to drifting of electrons in the gas, for the proportional counter wires.

The first step to using this simulation was to reconstruct the energy of 'punch-through' events. By simulating protons through a silicon detector at many different energies and angles, we are able to safely find the means and standard deviations of the distribution of energies that provide the signals we see in the silicon array. The results of the reconstruction can be found in Fig. 2. As shown in the figure, most events are reconstructed within an error of 1 MeV but improvements can be made.

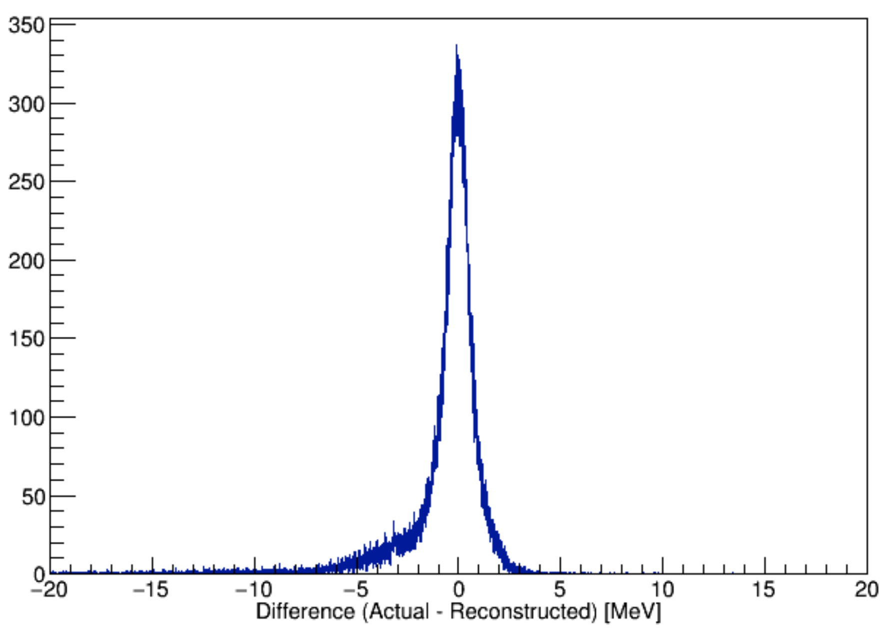

FIG. 2. The difference of the actual proton energy of 'punch-through' events and the reconstructed proton energies using the simulation.

The next step into extracting the full excitation function is to be able to distinguish 'punch-through' events from those that do not. Unfortunately, that cannot be done by only using the energy deposited in the proportional counter cells and the Si detectors. Other means must be used. One of the variables we can extract from our position sensitive wires is the location of the reaction vertex. This is done by tracking of the protons using time projection chamber. Since 'punch-through' events come from a higher C.M. energy of interaction, the vertex should be occurring closer to the entrance of the chamber than those that are low C.M. energy. As shown in Fig. 3., there is a difference in the vertex position for those higher energy events as expected. Of course a small overlap still present and statistical methods have to be implemented for excitation function reconstruction.

Due to complications that are mostly related to the punch-through events analysis of this data is

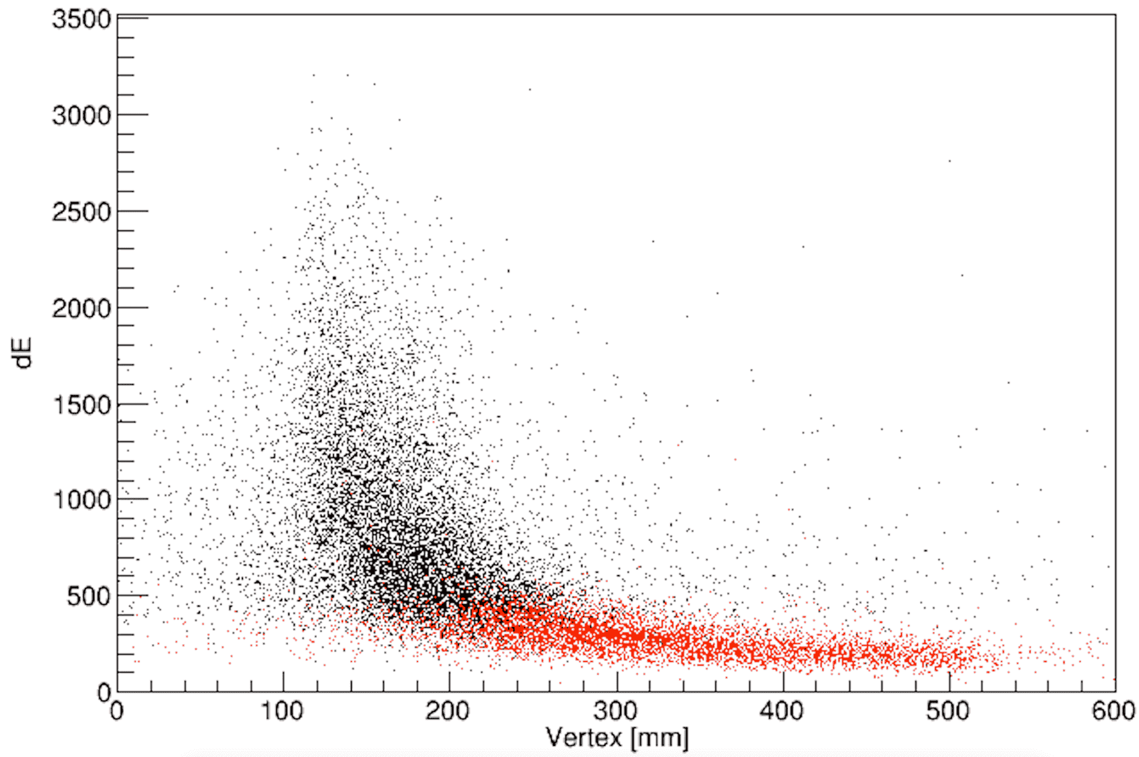

FIG. 3. Energy deposited in the proportional counter wire (dE) vs. the reconstructed vertex position. Black points are events that are not 'punch-through' events and red points are 'punch-through' events.

still in progress, but we expect to finalize the project in the Summer of 2016.

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