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

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The new era of rare isotope beams in nuclear physics started by the discovery of unusually large matter radii in some exotic nuclei by Tanihata, et al. [1]. The most striking example is ^{11}Li which has a nuclear matter radius as large as that of ^{208}Pb. This is due to the two-neutron halo of ^{11}Li - the wave function of two valence neutrons extends far beyond the ^{9}Li core. Important role in explaining the halo structure of ^{11}Li was played by three-particle models that describe ^{11}Li as ^{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. There has been only one experiment that claimed observation of the ground state of ^{10}N as a broad resonance using 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. Intensity of ^{9}C beam was 10^3 pps and total energy after the entrance window was 85 MeV. The ^{9}C beam had purity of 90% with small admixtures of mostly ^{3}He (about 10%). The excitation function for the ^{9}C+p scattering was measured using the new time projection chamber (TexAT-P1). The general design of TexAT-P1 is shown in the Fig. 1. We used planar

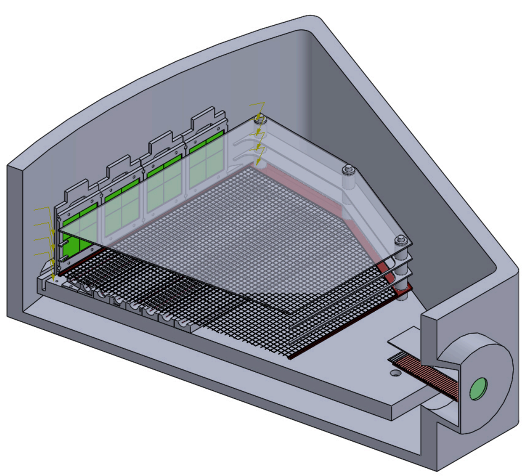

FIG. 1. The layout of the time projection chamber TexAT-P1.

geometry of the field cage to create a uniform electric field for electron drift. In order to achieve high sensitivity in horizontal direction the carbon fiber wires (8 wires in total) were used as anodes for the readout. Due to high resistivity of these wires we were able to achieve 2 mm resolution in the horizontal direction perpendicular to the beam axis. Sensitivity along the vertical axis was achieved by measuring time of electron drift from the location of the track to the anode wire. Resolution of better than 2 mm was achieved in vertical direction. The time projection chamber allowed for accurate proton track reconstruction and particle ID (using specific energy losses). The total energy of protons was measured in the silicon array located at the forward angles (with respect to the beam direction). The scattering chamber was filled with methane gas. Pressure was adjusted to stop the ^{9}C beam ions before the first anode wire. The ionization chamber installed at the entrance of the scattering chamber was used to identify the events associated with ^{9}C ions. Also, the time and energy signal from two PMTs observing the scintillator foil placed in front of the scattering chamber, before the 5 μm Havar entrance window, was used to provide additional selection of ^{9}C related events.

The excitation function for ^{9}C+p elastic scattering at a scattering angle around 165^{o} in c.m.s. is shown in Fig. 2. Only the first half of the measured excitation energies are shown and the analysis of the higher energy region is still in progress. Preliminary R-matrix calculations are shown as a black curve in Fig. 2. These calculations indicate presence of a broad s-wave state at energy of 2.25 MeV with a width of 1.5 MeV. The red curve in Fig. 2 shows the pure Coulomb scattering cross section, which obviously does not describe the data. The s-wave state is needed to reproduce the shape of the excitation function. This is the first high statistics observation of the ^{10}N ground states with definitive assignment of the proton orbital angular momentum. The specific spin-parity assignment will be done after complete excitation function is extracted from the experimental data and the R-matrix analysis is performed for the higher energy range as well.

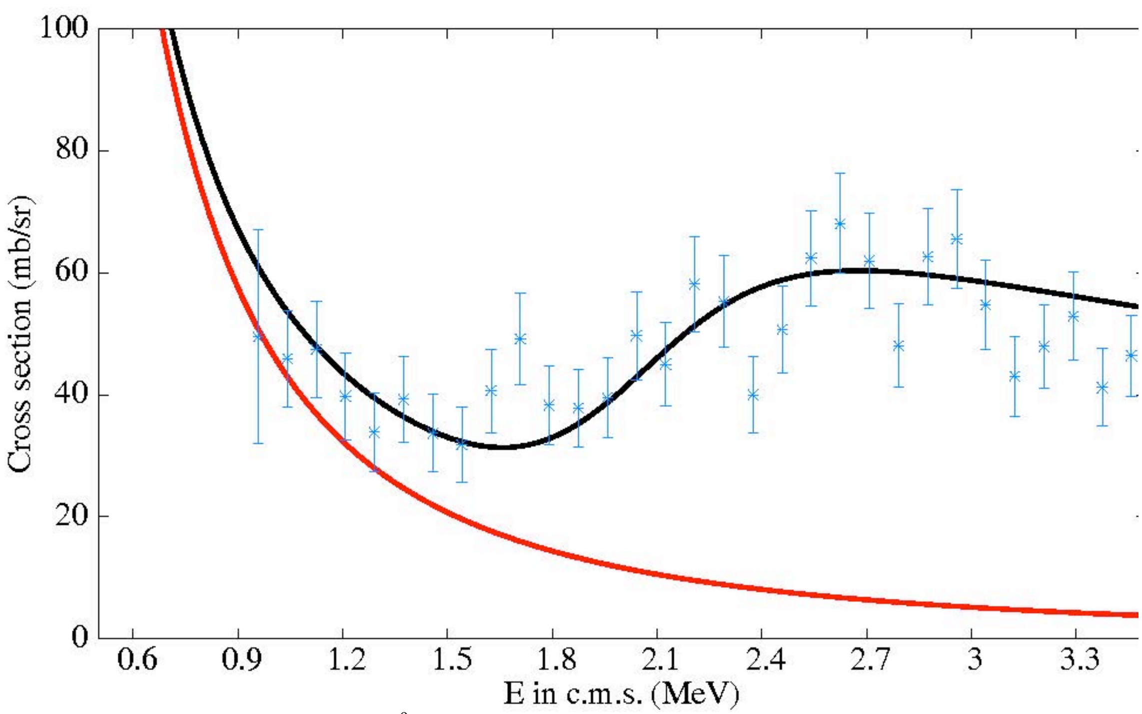

FIG. 2. The excitation function for ^{9}C+p elastic scattering measured at around 165^{o} in c.m.s. The red curve is pure Coulomb scattering cross section. The black curve is a preliminary R-matrix calculation with a single L=0 resonance at 2.25 MeV above the proton separation energy and a width of 1.5 MeV.

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