T=3/2 isobaric analog states in ^{9}Be

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Shell evolution with increasing imbalance between protons and neutron is a major question in modern nuclear physics [1,2,3,4]. Experimental information on structure of neutron rich nuclei opens a window into detailed understanding of shell evolution. The study of neutron rich nuclei is currently done with transfer reactions, knock-out reactions and charge exchange experiments. It has been proposed that proton resonance scattering could be used instead by populating isobaric analog states [5]. This would allow for the use of Thick Target Inverse Kinematics and R-Matrix analysis for the study of neutron rich nuclei. However, the higher isospin states in the analogous nuclei tend to be higher energy excited states and at these energies there tend to be many lower isospin states. For complete analysis, the R-Matrix would be used for narrow resonances in the regions of interest while the optical model would be used for the featureless background created by numerous wider T-low states. The A=9, T=3/2 isobaric quartet makes a good test case. ^{9}Li [6] and ^{9}Be have already been studied with transfer reactions and ^{9}C [7] has been studied with resonance scattering. This allows for a comparison of T=3/2 states in ^{9}Be that are above the proton threshold to the analogous states in ^{9}Li and ^{9}C.

In August of 2017 we had the commissioning run of the TexAT [8] active target detector system on the MARS [9] beamline. As part of the commissioning run a 75.5 MeV ^{8}Li beam was produced. TexAT was filled with 470 Torr of iso-butane gas. The goal was to measure the excitation function for ^{8}Li+p to study the T=3/2 states in ^{9}Be. The general view of TexAT detector is shown in Fig 1. In the configuration used for the commissioning run there were fifteen 5x5 cm^2 Si detectors, segmented into

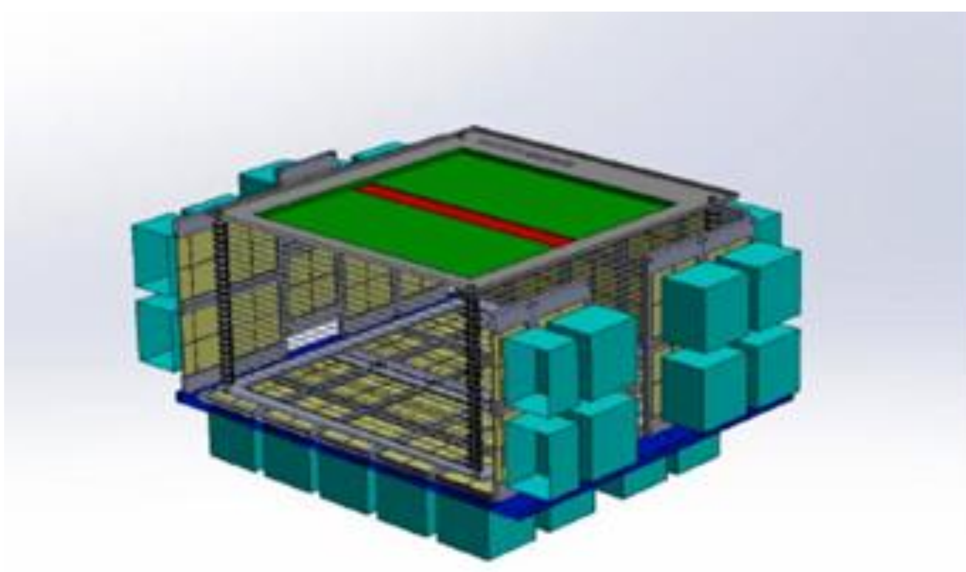

FIG. 1. The general view of TexAT detector.

four quadrants, backed by CsI detectors to measure protons that punch through the 0.7-1 mm thick Si detectors. The forward wall consisted of nine Si detectors and the beam left wall consisted of six detectors. On the top of the chamber was a segmented micromegas plate. The central region was highly segmented with 128 rows of 6 pixels. The side regions were multiplexed, with long strips across the side regions and long chains running the length of the detector. The micromegas, thus, provide particle tracking within the chamber and the Si and CsI detectors measure the energy of the light recoil particles.

TexAT is an active target that allows for the reaction vertex location to be determined. It can be done by tracking of the recoils, but also using information on energy losses along the beam axis. We used the ^{8}Li+p data to explore this second technique, which is particularly useful for the events that correspond to the small scattering angle. Since specific energy losses of the heavy recoil particle (^{8}Li in this case) change suddenly due to scattering a discontinuity in the energy spectrum is expected when plotted against physical location along the beam axis. We normalize energy deposition per micromegas pad to the energy deposited in that pixel by ^{8}Li beam ions that produced no interaction. We then sum up the energy deposited in each row and plot this against the row location and then fit it with a function as in Fig 2. There were some complications involved in using this method. The largest complication comes

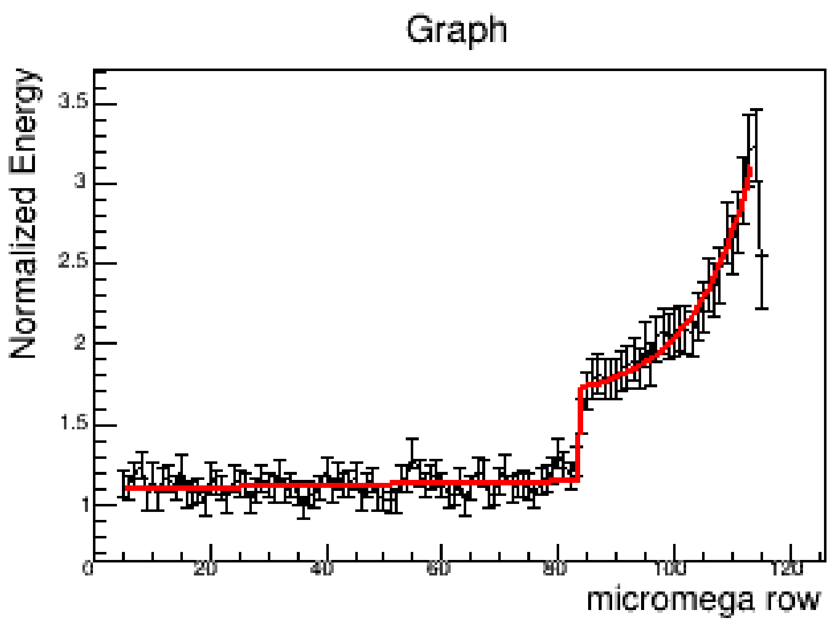

FIG. 2. Plot of Normalized Energy vs micromega row of a single event showing the discontinuity due to a reaction and the fit that calculates the vertex position.

from a threshold in the micromegas that causes not all of the energy deposited to be recorded. This is a problem when the energy is split between two pads in a row. This causes gaps and prevents simple fits to reproduce the correct vertex location. A method was developed to reconstruct the missing energy. First, the energy of the light recoil deposited in the Si-detector is used to determine an approximate reaction vertex location. Second, any points where there is cross over from one column of micromegas to another are set as fixed points. A pair of linear fits are done that are linked through the estimated vertex row and forced through the cross over points identified in the previous step. A normalized Gaussian is placed along the fit using a standard deviation determined by electron drift to the micromegas plate by GARFIELD [10] simulation. We assume the energy deposited across a row is a Gaussian so the amount of overlap of the Gaussian with any pads that have energy in a row is used to scale for the missing energy in those pads. Fig 3 shows the fitting method and results for a typical event. It was found that less than 10% of good events fail to produce a proper vertex and are easily filtered out using χ^2. Development of this analysis procedure is an important step toward better characterization of experimental data produced by TexAT. Analysis of the TexAT ^{8}Li+p data is still in progress.

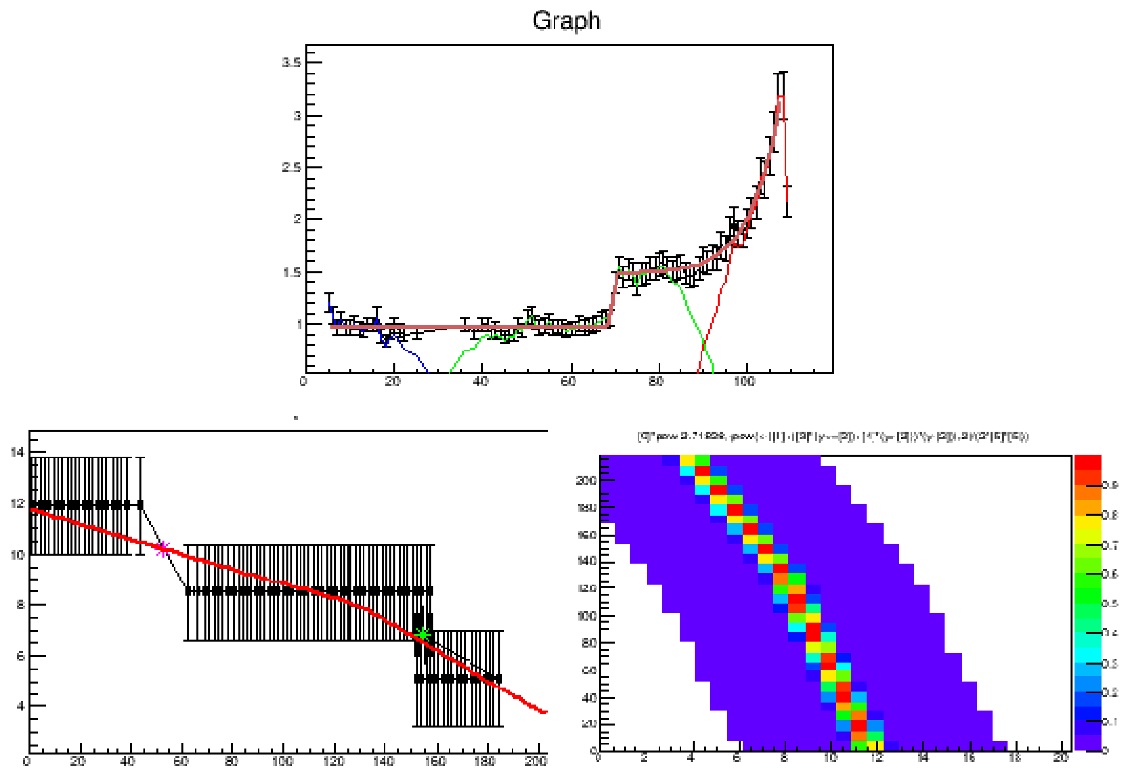

FIG. 3. a) The final reconstructed points and fit on top of the original energy deposited plotted by rows in the micromegas. Note the lower energies on the left side. b) The linear fits over the pads that had energy deposited in them. The stars note the cross over points that were used to constrain the fits. c) The Gaussian with the fit that was used to reconstruct the energy

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