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Single-Neutron Transfer to 50Ti

Jessica Nebel-Crosson

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Abstract

This project is a continuation on the analysis of the data that was collected in 2019 through a neutron-transfer reaction with ^{50}Ti via the use of the Super-Enge Split Pole Spectrograph at Florida State University. We will be using the measured angular distributions of protons from the reaction to make angular momentum assignments to excited states of ^{51}Ti. The excitation energies will be determined from the momentum of the outgoing protons and from these, we will be able to deduce the single-neutron energies beyond the N=28 neutron shell. These single-neutron energies may then shed light on discrepancies that have arisen from previous studies between theoretical predictions and experimental measurements of the behavior of exotic nuclei beyond ^{48}Ca.

1 Experiment

The measurement of neutron-transfer to ^{50}Ti spectra data was collected at the John D. Fox Accelerator Lab at Florida State University in the summer of 2019. A beam of deuterium with the total kinetic energy of 16 MeV was sent from a 9 Megavolt Super-FN Tandem Van de Graaf accelerator and towards a target of enriched ^{50}Ti with a 0.425 mg/cm^3 thickness that was housed within the Super-Enge Split-Pole Spectrograph (SPS). This was done at angles from 10 to 50 degrees, increasing with increments of five where magnetic fields guide the particles through the rest of the spectrograph. The remaining protons from the (d,p) reaction would continue through to the focal-plane detector, passing through a gas-volume where they cause ionization. The ionized electrons move upwards towards a Frisch-Grid which is followed by two proportional-counter anodes and then a set of position pads on top of those. The Frisch-Grid picks up the signal from the ionization as soon as the particle enters the focal-plane. The anode wires measure the charge from the ionized gas that each wire collects, proportional to the energy lost by the passing particle. The set of pads, which are connected with a delay line between each pads, generate time signals at either end of the focal plane via the detection of the induced charge arriving at the anode wires. These timing signals give us the position in the focal plane which is proportional to the momentum of the proton.

2 Analysis

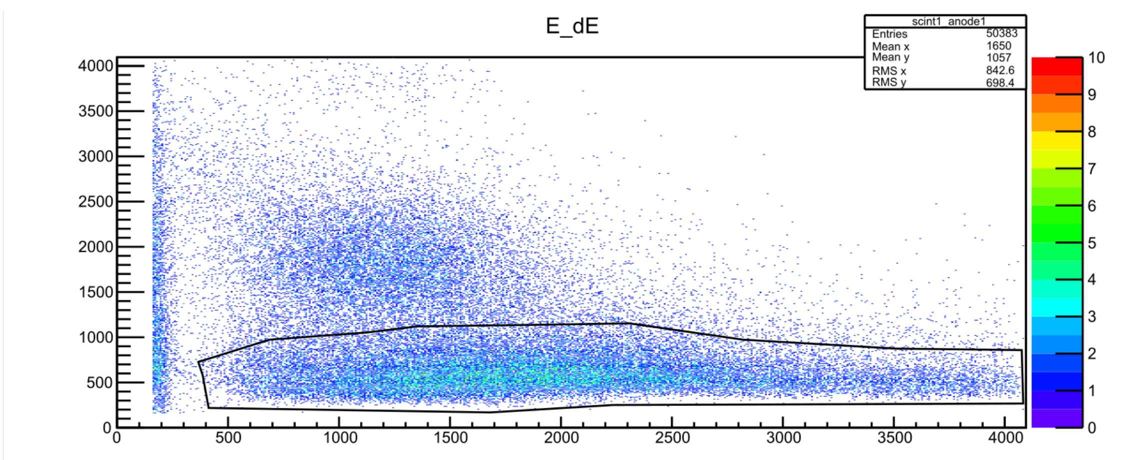

Figure 1: The particle identification spectrum at 35° including the cut that is isolating the protons from the deuterons in the rest of the plot. Deuterons deposit more energy in the scintillator; thus they are concentrated to higher parts of the graph than the protons.

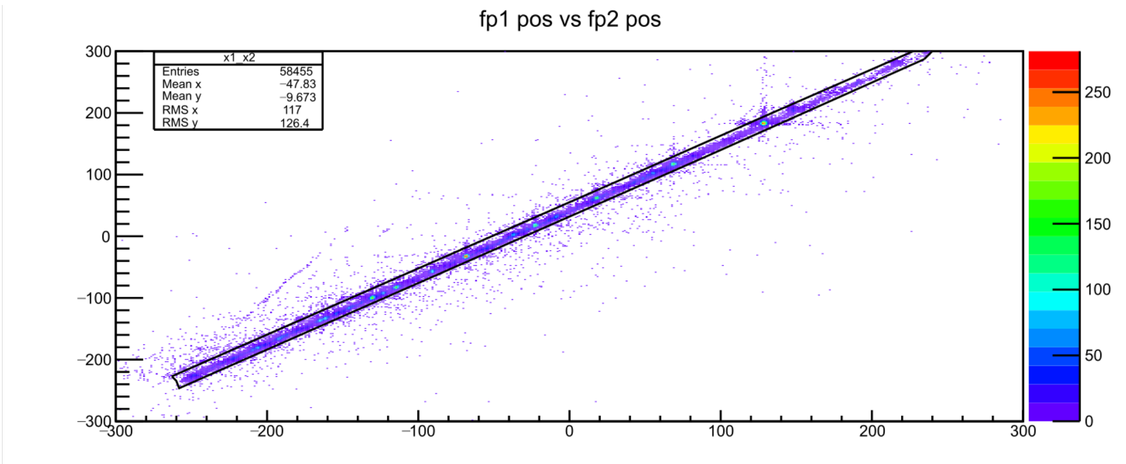

Figure 2: The 2D cut isolates proton trajectories, within the two focal plane positions, from trajectories that stray wildly from the highly concentrated region, as distinguished in the plot by the blue.

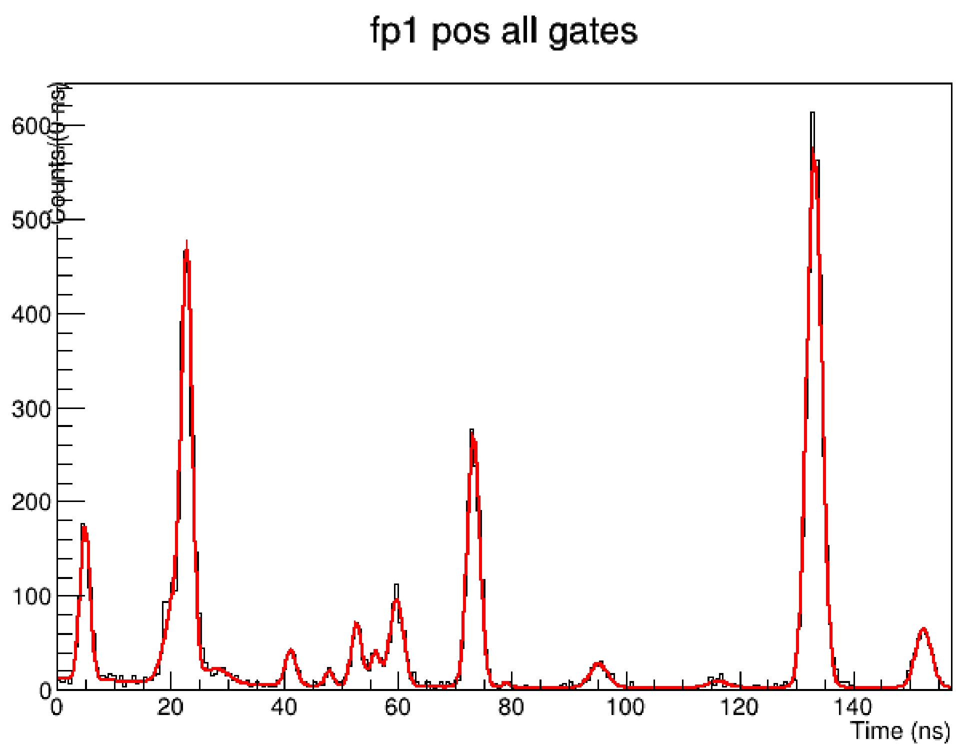

Figure 3: The fitted region of the high energy end of the 25 degree spectrum.

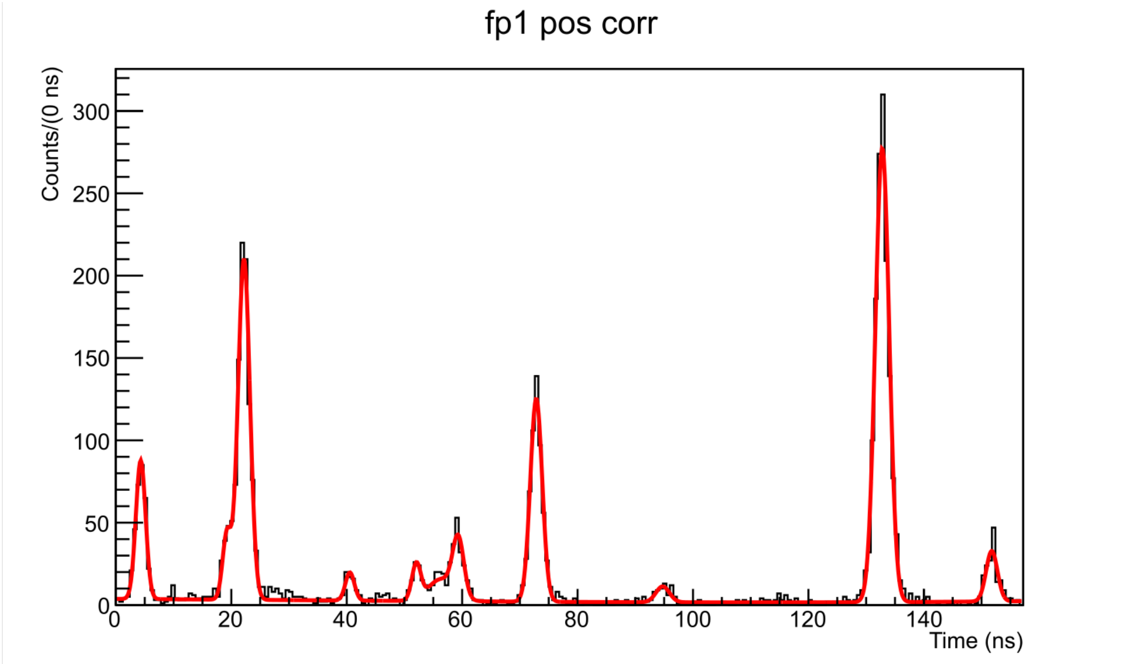

Figure 4: A select, fitted region of the 25° spectrum of counts vs. peak position in nanoseconds. The red lines are the Gaussian fits over the peaks. These fits are necessary to produce information such as the particle count per excitation state. The ground state is the largest peak on the right side of the graph.

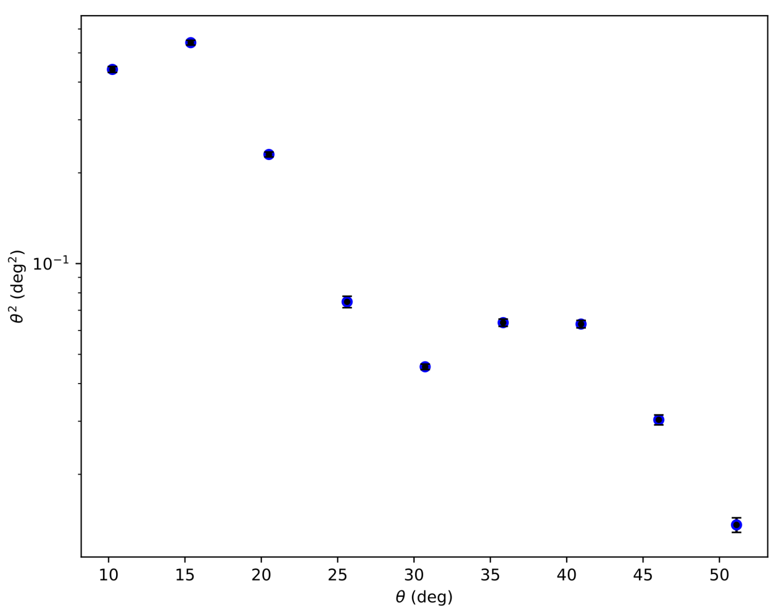

Figure 5: The angular distribution plot for the ground state of ^{51}Ti.

Using a Data AcQuisition (DAQ) code from Florida State University, the raw data was turned into usable spectra after drawing a variety of two-dimensional cuts, allowing us to begin a preliminary analysis on the 25 degree spectrum in Fall 2019 and continuing this summer. Two such cuts can be seen in Figures 1 and 2.

The analysis that took place for this stage of the project was focused on automating the process of calibration, applying Gaussian fits, and plotting angular distributions for each of the nine produced spectra. Conclusions can not yet be drawn at this time.

3 Future Work

Further analysis is needed in order to produce the full range of angular distribution plots for all excited states seen in the measurement. Before any conclusions can be drawn about single-neutron state structures in exotic nuclei, the distribution plots must be compared to reaction theory calculations which will enable us to better identify the angular momentum values of the excited states. At this stage, the analysis will focus on the higher energy end of the spectra and work on confirming states identified by Barnes *et al.*, as well as, looking at possibly new higher energy states. Current data is also using relative cross sections, so the calculation of the absolute differential cross sections will be future work as well. Ultimately, this all will lead us to drawing fundamental information about single-particle states in exotic nuclei beyond ^{48}Ca.

References

[1] P. D. Barnes, C. K. Bockelman, Ole Hansen, and A. Sperduto. Inelastic deuteron scattering and (d, p) reactions from isotopes of ti. i. ${\mathrm{Ti}}^{50}(d, p){\mathrm{Ti}}^{51}$. 136(2):B438–B446.

[2] L. A. Riley, M. L. Agiorgousis, T. R. Baugher, D. Bazin, R. L. Blanchard, M. Bowry, P. D. Cottle, F. G. DeVone, A. Gade, M. T. Glowacki, K. W. Kemper, J. S. Kustina, E. Lunderberg, D. M. McPherson, S. Noji, J. Piekarewicz, F. Recchia, B. V. Sadler, M. Scott, D. Weisshaar, and R. G. T. Zegers. Spectroscopy of $ˆ{54}\mathrm{Ti}$ and the systematic behavior of low-energy octupole states in ca and ti isotopes. 96(6):064315.