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Search for 2p2h Interactions in NOvA

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Introduction

- NOvA is an international collaboration seeking to understand neutrino oscillations.
- Two detectors measure the NUMI neutrino beam at two locations to quantify the ν_e appearance.

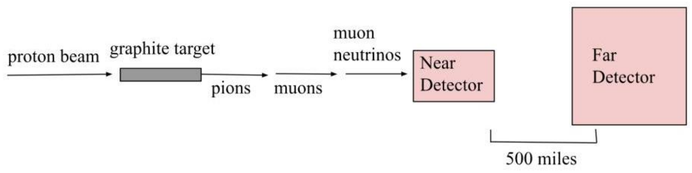


Diagram of the NOvA experimental setup.

- This study focuses on finding 2p2h interactions with two protons and one muon in the final state.
- 2p2h interactions are not well understood, and there are large uncertainties in modeling them.
- A 2p2h interaction includes a neutrino interacting with two nucleons that are coupled by a meson exchange current.

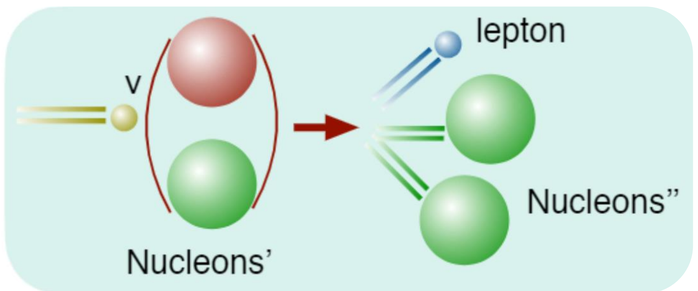
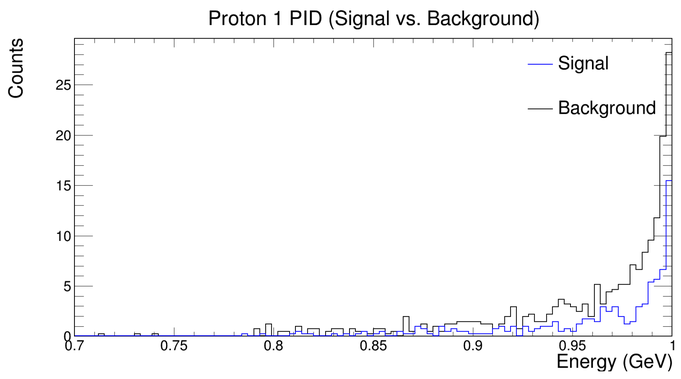


Diagram of a 2p2h interaction. Image courtesy of Linda Cremonesi.

Methods

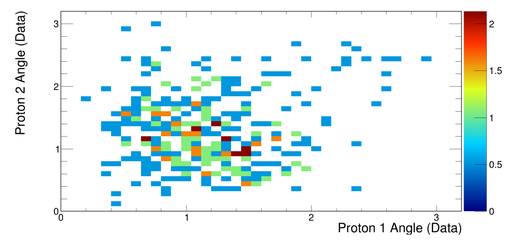
- Event selection is performed to find clean events with two protons and one muon.
- Hits from scintillation light in the detector are grouped as reconstructed prongs which correspond to particles.
- Each prong must be fully within the detector and composed of enough hits to be identifiable.
- Cuts are based on particle CVN (Convolutional Visual Network) classifier information for each prong in an event.



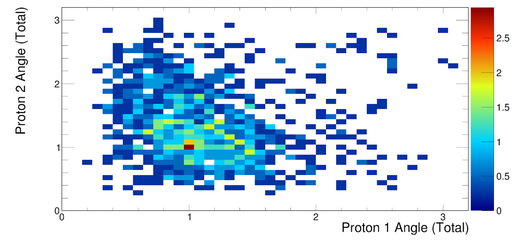
Example plot for proton PID (Particle Identification) values for signal and background. Cuts can be made to optimize the signal to background ratio.

Results

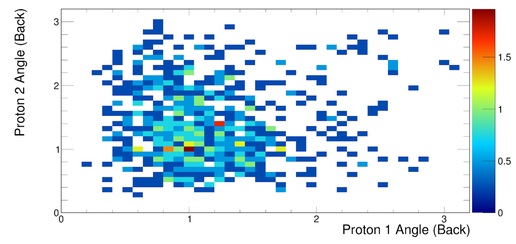
- The best separation from signal and background was found in the angles between the protons and the muons.



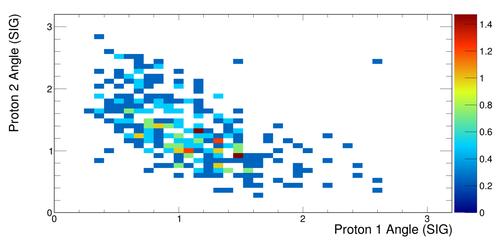
Data



Simulated (Total)



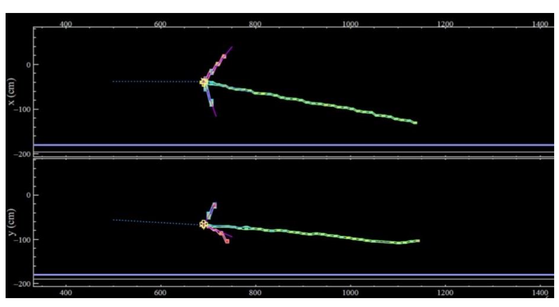
Simulated (Background)



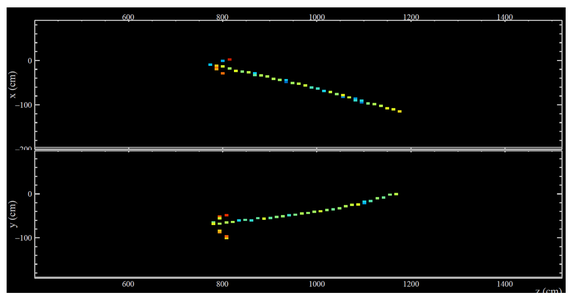
Simulated (Signal)

Plots of the proton angles in the signal region for NOvA data, all simulated data, simulated background, and simulated signal.

- There are a lot of similarities in the shape of the plots, especially between the data and the total simulated plots.
- Using the selection criteria, event displays are found for events in the signal region from the NOvA near detector data and from simulation..



Event display for simulated signal event.



Event display for event in the signal region from data.

Conclusion and Future Studies

- Based on the plots found for the proton angles in the signal region, it can be concluded that the simulated data is a reasonable approximation for the real data.
- 2p2h interactions with two protons and one muon in the final state have been found in the near detector data by comparison with simulated data and through the event display.
- Next steps are to perform a cross-section analysis to estimate the impact the signal has on overall NOvA data.
- Further investigation into the final-state hadronic system's kinematics could lead to increased background reduction.
- The total number of signal events can be estimated by performing a fit of the simulated spectra to the data.

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