Neutrino Tridents in the NOvA Near Detector

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The NOvA Detectors

NOvA is a long-baseline neutrino oscillation experiment based at Fermilab that uses the NuMI beam line and two detectors to measure neutrino rates at a near location, and 810 km away at a far location.

The detectors are made from PVC extrusions which segment the volume in to 4x6 cm cells which alternate orientations to provide 3D tracking of particles in the detector.

Neutrino Tridents

Neutrino tridents are a rare Standard Model process in which a neutrino interacts with a nucleus and produces two charged leptons. Dimuon tridents have been observed by multiple collaborations including CHARM-II [1], CCFR [2], and NuTeV [3]. The high neutrino flux at the NOvA Near Detector makes a search viable. The interaction may be mediated by a Z' boson whose addition to the Standard Model could aid the understanding of the anomalous magnetic moment of the muon.

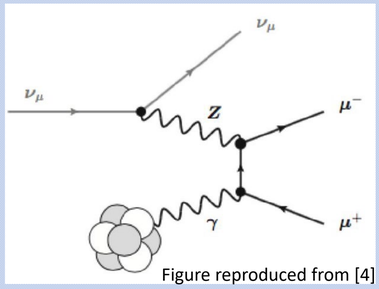
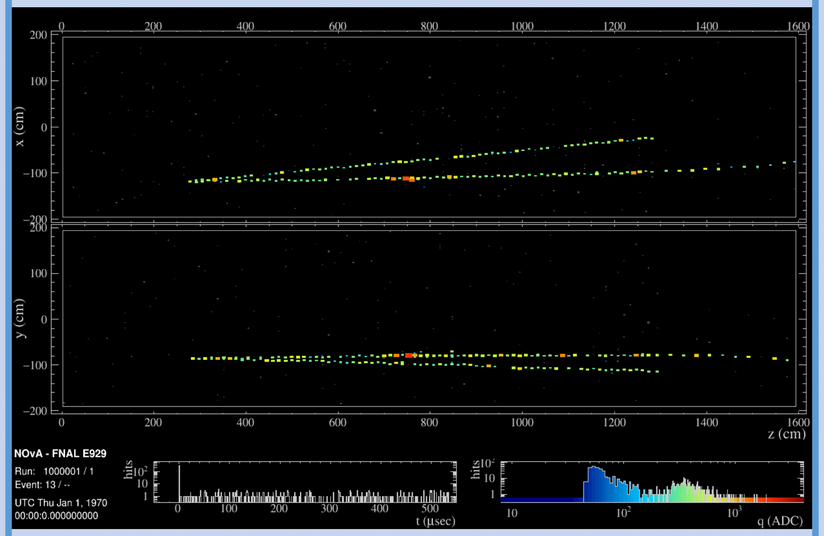


Figure reproduced from [4]

Simulation

To simulate neutrino trident events in the NOvA Near Detector, we adapted the simulation provided by Altmannshofer *et al.* [4] by importing the NOvA beam flux, assigning events a random position, and importing the structure functions for carbon. We estimate that NOvA should see 10-100 trident events per year, somewhat higher than other estimates [5].



An example trident in the NOvA Near Detector is shown above. Dimuon trident events are expected to have two energetic muons and low hadronic energy at the vertex.

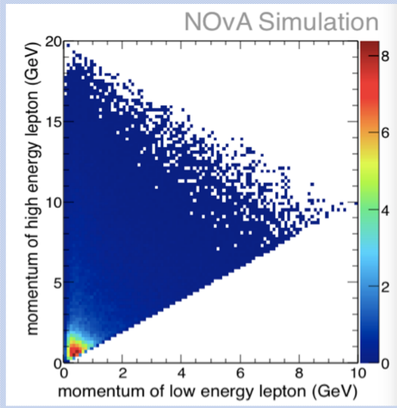
If you're interested in tridents, you may also like:

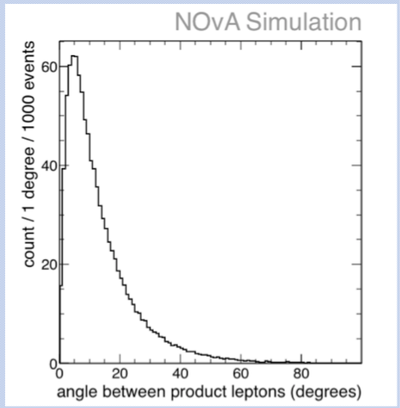
M. Judah, The measurement of the inclusive electron-neutrino charged-current double-differential cross-section using the NOvA near detector

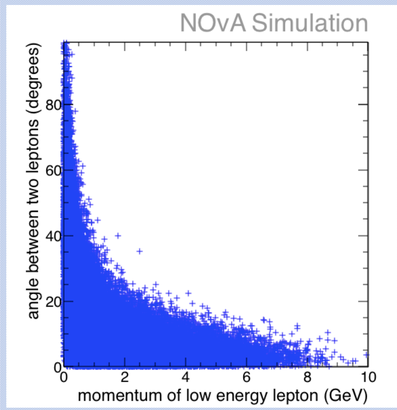
C. Sweeney, Measuring cross sections of neutrino-nucleus interactions with associated charged pions in the NOvA near detector

C. Johnson, Muon-neutrino charged-current inclusive cross-sections using the NOvA near detector

Selection







We expect events where each muon has at least 500 MeV of momentum and the muons have an opening angle of at least 15° to be strong signal candidates in NOvA.

Requirement	Fraction selected
Opening angle > 15°	32%
Lower energy muon p>500 MeV	68%
Selected	11%

A total of 11% of signal events are expected to meet these criteria which yields between 10 and 100 events in the NOvA Near Detector each year. Work is ongoing to understand the backgrounds to this process in NOvA.

[1] D. Geiregat *et al.* (CHARM-II Collaboration), Phys. Lett. B **245** 271, (1990).
[2] S. R. Mishra *et al.* (CCFR Collaboration), Phys. Rev. Lett. **66**, 3117 (1991).
[3] T. Adams *et al.* (NuTeV Collaboration), Phys. Rev. D **61**, 092001 (2000).
[4] W. Altmannshofer *et al.*, Phys. Rev. D **100**, 115029 (2019).
[5] P. Ballett *et al.*, JHEP 01 119 (2019).

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http://novaexperiment.fnal.gov