NOvA Near Detector Prototype

NOvA is a 14 kton long-baseline neutrino oscillation experiment now being assembled in northern Minnesota. The prototype is a 222 ton detector located on the surface at Fermilab. The prototype collected data for more than one year in the NuMI neutrino beam using a partially instrumented detector, 110 mrad off-axis.

Detector Components
- Detector structure is PVC modules each of which has 32 cells.
- Each cell contains a looped wavelength shifting fiber readout by a pixel of a 32 channel Avalanche Photo-Diode (APD) array.
- Each module is filled with liquid scintillator.

Neutrino Energy and Q^2 Distribution

- Neutrino energy is reconstructed from the length of the track and its angle from the beam direction.
- Neutrino energy for \( \nu_\mu \) CC QE selected events after cosmic background subtraction.

Energy is estimated using

\[
E_n = \frac{2(M^*E_\nu - (M^*)^2 + M_\nu^2 - M_\nu^2)}{2((M^*)^2 - E_\nu + \sqrt{E_\nu^2 - m_\nu^2 \cos \theta_\nu})}
\]

where \( M^* \) is the adjusted neutron mass \( M = M_L - E_\nu \) and \( E_\nu \) is 2.5 MeV.

- Four momentum transfer for \( \nu_\mu \) CC QE selected events after cosmic background subtraction.

Four momentum transfer is estimated using

\[
Q^2 = -m_\nu^2 + 2E_n(E_\nu - \sqrt{E_\nu^2 - m_\nu^2 \cos \theta_\nu})
\]

Study of Background

- Background dominated data with two reconstructed tracks from the interaction is used to cross check the Monte Carlo for background events.
- Each track has a minimum of four hits in each view.
- Longest track used to determine the energy and four momentum transfer.
- Background data agrees with MC simulations.

Quasi-elastic Selection

- Event within 10 microsecond beam spill
- Interaction point 50cm from the edge of the detector
- One and only one reconstructed track
- The slope of the tracks is not near vertical (cosmic rejection)
- Track does not exit the detector

Quasi-elastic interaction identification using a k Neural Network (kNN) algorithm with three input quantities shown below.

**NOvA Preliminary**

Energy around the vertex
- Energy per plane per track length
- Number of planes

Beam candidates after cosmic background subtraction and Monte Carlo simulation for preselected events

- kNN selection: For kNN=0.3, events have 65% purity and 85% efficiency for the partially instrumented detector for both configurations.

**Summary**

- Quasi-elastic studies using the data from the Near Detector Prototype will be limited by statistics.
- We continue to study neutrino data from the Near Detector Prototype to test analysis procedures for NOvA.
- NOvA will begin taking data with a partially constructed Far Detector early in 2013. The detector construction will be completed in early 2014.