Sensitivity of Quasi-Elastic Scattering in the LBNE Near Detector

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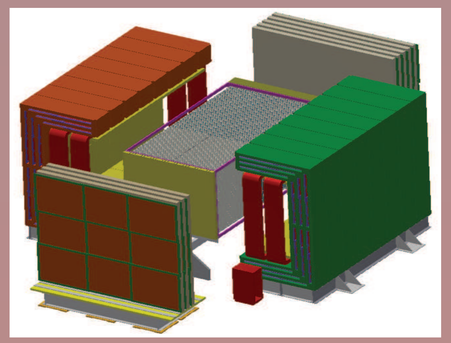
Introduction

We present sensitivity studies of the ν_μ-induced Charged-Current Quasi-Elastic (CCQE) interactions in the Fine-Grained Tracker (FGT) which is the LBNE Near Detector. Efficiency and purity of QE selection is presented in energy bins spanning 0.5 to 25 GeV. Constraints on nuclear effects such as initial state pair wise correlations and final state interactions that can be obtained from the CCQE data are discussed.

The LBNE Near Detector – FGT[1]



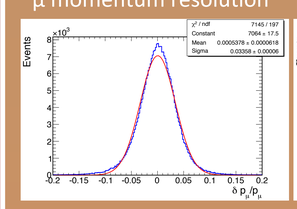
The reference design of the near detector for the LBNE experiment is a Fine-Grained Tracker (FGT) capable of precisely measuring all four species of neutrinos: ν_μ, ν_e, $\bar{\nu}_\mu$, and $\bar{\nu}_e$. The FGT is composed of a Straw-Tube Tracker (STT) with transition-radiation capability surrounded by a high resolution electromagnetic calorimeter (ECAL) and embedded in a dipole magnet. Muon-ID detectors instrument the iron-yoke of the magnet and the downstream and upstream stations outside the magnet.

1. Fine-Grained Tracker as a Near Detector for LBNE - Poster 233

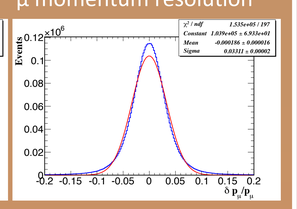
LBNE Near Detector Fast MC[2]

- Parameterized detector response benchmarked NOMAD data and simulation

NOMAD μ momentum resolution



FGT μ momentum resolution

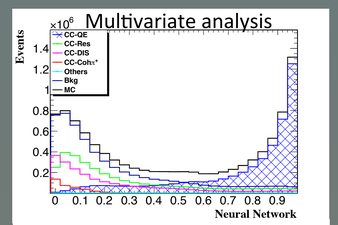


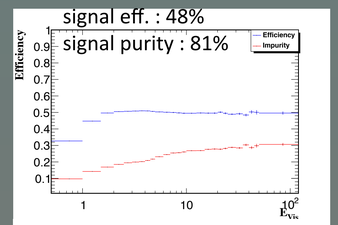
2. The LBNE Fast Monte Carlo- Poster 195

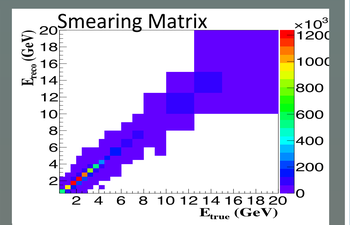
CCQE 2 track (Key to QE)

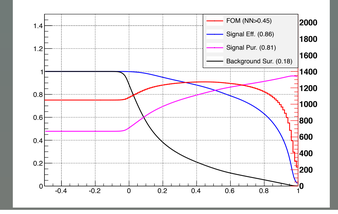
Performed in the way like a pseudo-experiment

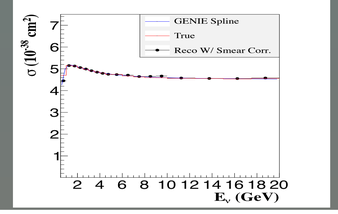
- Preselection
  - Muon momentum & min. #hits
  - Muon ID based on NOMAD experience
  - Neutral veto: $\pi^0/n/K^0$
  - Proton candidate momentum & min. #hits

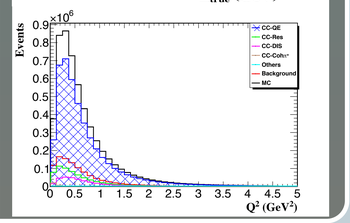








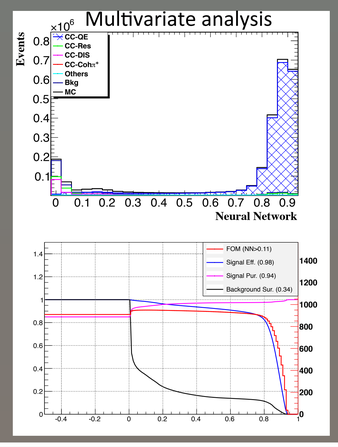


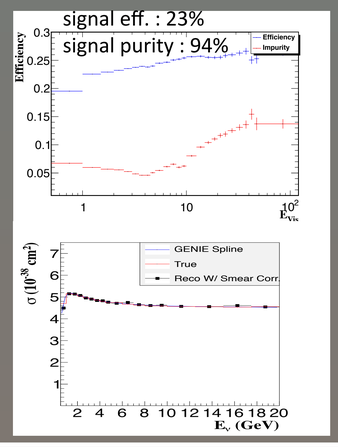


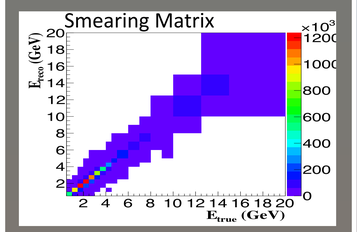
CCQE 1 track (Complementary Channel)

Performed in the way like a pseudo-experiment

- Preselection
  - Muon momentum & min. #hits
  - Muon ID based on NOMAD experience
  - Neutral veto: $\pi^0/n/K^0$
  - No second track

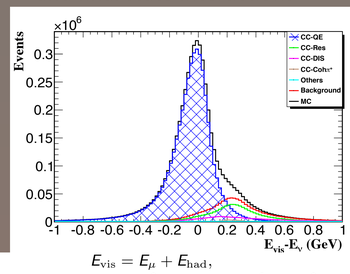






Constraints on nuclear effects

- 2 Track topology.
  - The difference between the E_{vis} and E_ν to constrain initial state pair wise correlations and final state interactions

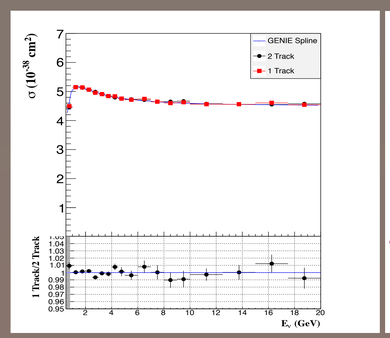


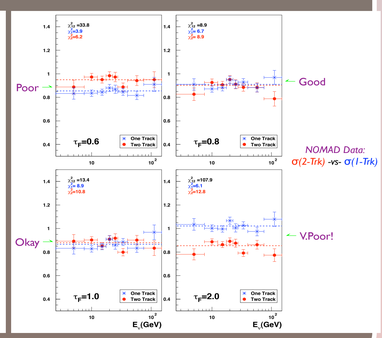
$$E_{\rm vis} = E_\mu + E_{\rm had}, \quad (1)$$

$$E_\nu = \frac{2(M_n - E_B)E_\mu - (E_B^2 - 2M_nE_B + m_\mu^2 + \delta M^2)}{2[(M_n - E_B) - E_\mu + p_\mu \cos\theta_\mu]}, \quad (2)$$

$$\delta M^2 = M_n^2 - M_p^2. \quad (3)$$

- 1 Track + 2 Track
  - Compare 1-track and 2-track cross sections to constrain final state interactions



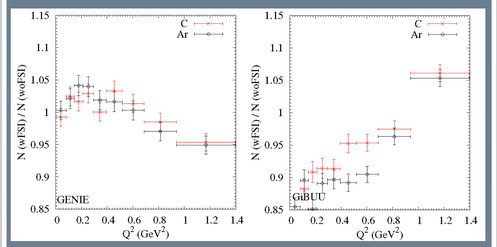


Study of Nuclear Effects using GENIE and GiBUU

(Harish-Chandra Research Institute and Carolina Group)

- Generate CCQE interactions in GENIE and GiBUU
- Compare Q^2, x and y distributions with and without FSI
- Study different nuclear targets: ^{12}C, ^{40}Ar and ^{40}Ca

Generator	GENIE	GiBUU
Nuclear Model	Modified Relativisitc Fermi Gas model & ν+$\mathcal{N}$ Plane Wave Impulse Appr.	
Initial State Pair Wise Correlations	w/ short-range n-n correlations (Bodek-Ritchie)	w/ n-n momentum correlations & density dep. mean-field potential
FSI	$h\mathcal{A}$	BUU transport



Summary

- A preliminary sensitivity study of CCQE interactions in the Fine Grained Tracker using ND Fast MC has been performed
- The high precision, high statistics Near Detector data will provide the strength to constrain the nuclear effects
- Systematic uncertainties evaluation underway
- Propagate constraint to the FD oscillation analyses underway