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

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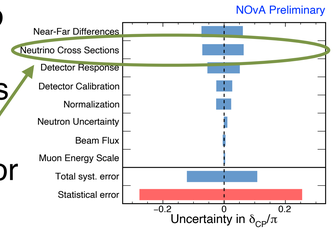
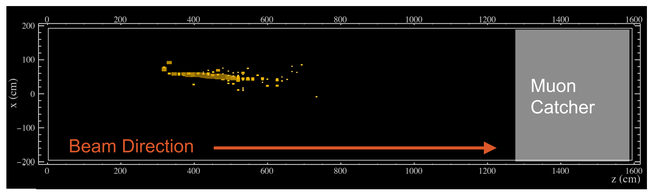
Introduction

- Relatively small number ν_e charged-current (CC) cross section measurements at the few GeV energy scale
- Better understanding is vital to precision measurements of neutrino oscillation parameters
  - Determination of mass hierarchy and CP-violation for long baseline experiments



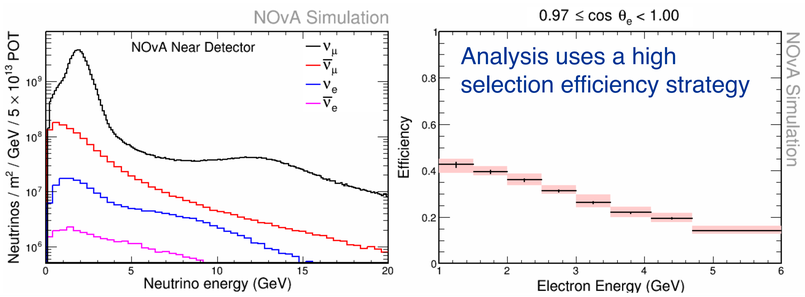
The NOvA Near Detector

- The NOvA near detector (ND) is located at 1km from the production target, ~14 mrad off-axis from the NuMI beam at Fermilab
- Comprised of liquid scintillator filled cells arranged into alternating horizontal and vertical planes
  - Detector geometry **designed to distinguish EM showers** from other particle trajectories
- 300 ton that is 77% CH , 16% Cl and 6% TiO2 by mass



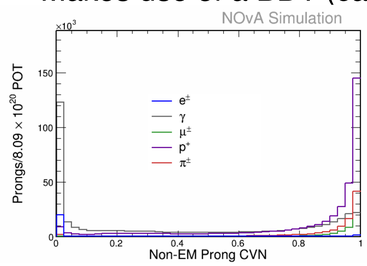
Event Selection

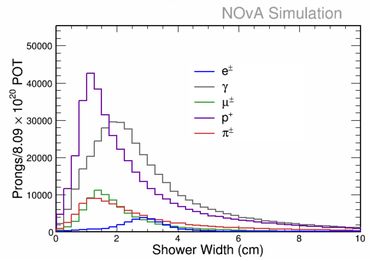
- ν_e make up about 1% of neutrino flux seen at the ND
- **High statistics measurement** ~10k signal events



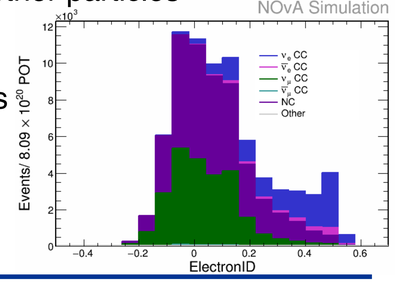
Electron Identification

- Makes use of a BDT (called ElectronID) with several inputs to distinguish electrons from other particles





- Combines:
  - Deep convolution network PIDs
  - Event level information
- ElectronID = highest electron score in an event

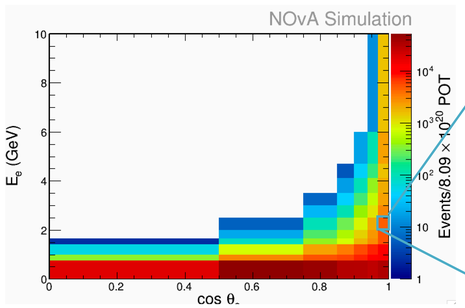


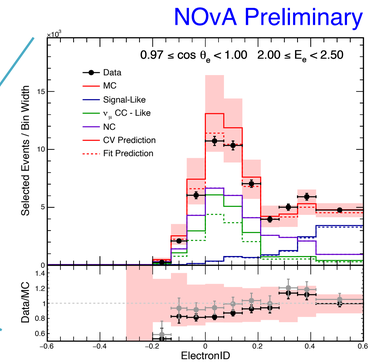
Data Driven Signal and Background Estimation

Signal and background rates are constrained by fitting simulated templates to the observed ElectronID spectrum

Base concept of the analysis:

- As this is a differential analysis simulated templates are generated in each kinematic bin separately
- Procedure assumes the simulated ElectronID shape is correct and allows signal and background normalizations to float





Covariance matrix fit:

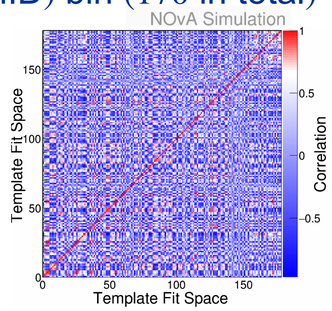
- Uncertainties in template shape are accounted for using a covariance matrix

$$\chi^2 = \left(x_i - \mu_i\right)^T V_{ij}^{-1} \left(x_j - \mu_j\right) \quad V_{ij} = V^{\text{stat}} + V^{\text{syst}}$$

$$\mu_i = a_i N_{sig,i} + b_i N_{NC,i} + c_i N_{\nu_\mu CC,i}$$

$$i = (\cos\theta_e, E_e, \text{ElectronID}) \text{ bin } (170 \text{ in total})$$

- The fit is performed in all kinematic bins simultaneously
- Accounts for the complicated relationships between templates in adjacent kinematic bins



Results

- First double-differential electron neutrino cross section measurement!
  - See all of the results: **Cross-section measurements with NOvA (Neutrino Interactions:II Session)**
- Systematics-limited measurement!
  - 15 - 25% in the double-differential measurement
- Coming soon: inclusive electron- anti-neutrino charged-current cross section measurement