NuFact 20|21

The 22nd International Workshop on neutrinos from accelerators

Measurements of Neutrino Interactions with Electrons in the Final State in the NOvA Near Detector

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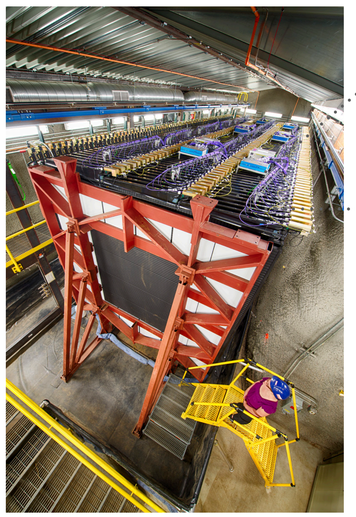
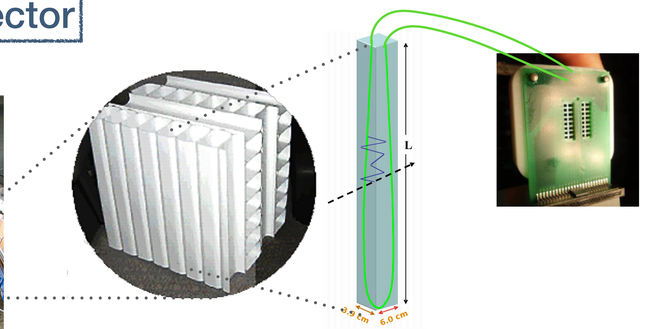
1. NOvA Near Detector





- 193 ton tracking calorimeter
- Extruded PVC cells, filled with liquid scintillator
- Scintillation light captured and routed to APDs via wavelength-shifting fibers
- Fine-grained, low-Z, highly active, X_0 = 38 cm (6 cell depths, 10 cell widths, optimized for EM shower measurement)

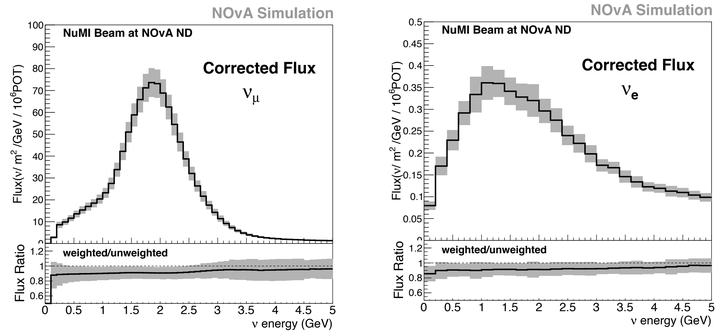
2. Neutrino Interactions with Electrons in the Final State

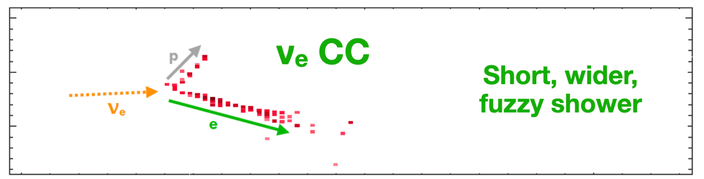
- NOvA flux: **1 and 5 GeV**
- Unique environment for cross-section measurement
  - **Energy range**
  - **Detector technology**
  - **High statistics**
- ν_e **CC inclusive** provides insight and constraints on how all interaction modes fit together

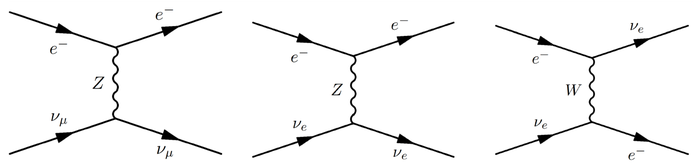
$$\sigma_{\mathrm{CC}}^{\mathrm{inclusive}} = \sigma_{\mathrm{CC}}^{\mathrm{QE}} + \sigma_{\mathrm{CC}}^{\mathrm{MEC}} + \sigma_{\mathrm{CC}}^{\mathrm{Res}} + \sigma_{\mathrm{CC}}^{\mathrm{DIS}} + \cdots$$

- $\nu - e$ **elastic scattering** provides an in-situ constraint on the flux prediction
- Main job - **Find the electron**

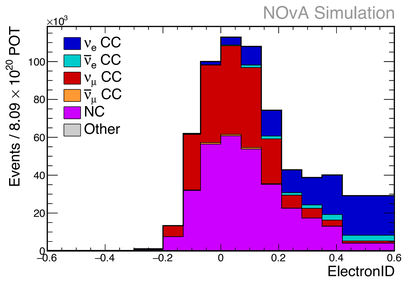
More measurements with electrons see Bryan Ramson's talk on Sept. 7



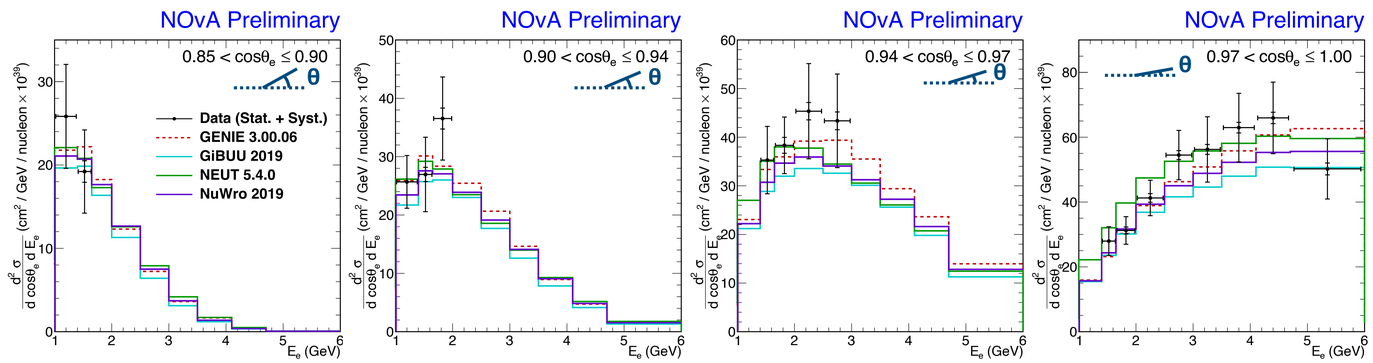




2.1. ν_e CC Double-Differential Measurement

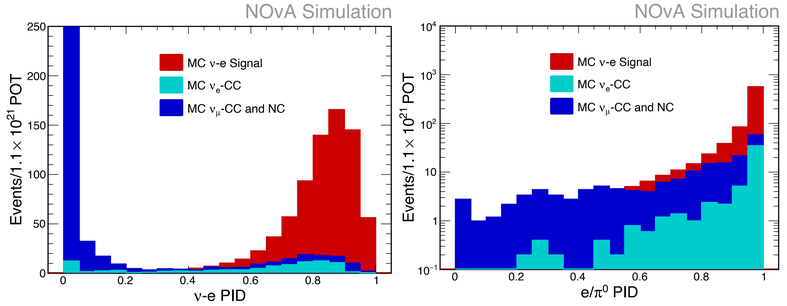


- **ElectronID: Boosted Decision Tree used to distinguish electrons**. Input from
  - Deep convolutional network PIDs based on single particle simulation
  - EM shower candidate information: transverse width, distance between the start point and reconstructed vertex
- **Electron energy and angle (E_e, $\cos\theta_e$)**
- Background estimate in each electron kinematic bin via a template fit of ElectronID
- **9k ν_e CC events, largest sample to date in this energy range, enables the first-ever double-differential cross-section measurement**
- Uncertainties ~15-20% in each bin



2.2. $\nu - e$ Elastic Scattering

- The topology of signal event requires one EM shower with no other particles in the final state
- **Two CNN event classifiers based on the MobileNet_v2 were trained**
  - $\nu - e$ PID: to separate $\nu - e$ scattering events from backgrounds
  - e/π^0 PID: to further rejects backgrounds with π^0 in the final state



- We're looking into data-driven tools to validate the CNNs and study systematic uncertainties
- $\nu - e$ scattering can potentially to constrain the flux normalization uncertainty to ~6%

3. Summary

- Few measurements of ν_e and $\bar{\nu}_e$ CC interactions at the GeV scale. With the high-statistics, NOvA is able to perform the first-ever measurement of a double-differential ν_e CC cross section. Similar analysis for $\bar{\nu}_e$ CC is under way.
- $\nu - e$ elastic scattering can be used to constrain the systematic uncertainty from the flux prediction, which is one of the dominant sources of systematic uncertainties in all neutrino cross-section measurements.
- Stay tuned for further cross-section measurement.

https://novaexperiment.fnal.gov/

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