First Measurement of Electron Neutrino Scattering Cross Section on Argon

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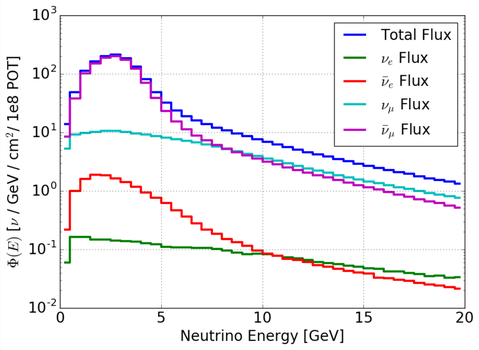
arXiv:2004.01956

Electron Neutrinos in ArgoNeuT

- LArTPC in the NuMI beam at Fermilab.
- Sat directly in front of the MINOS Near Detector.
- 47 (w) x 40 (h) x 90 (l) cm^3 = 0.24 tons.
- 1.25 x 10^{20} POT from low-energy anti-neutrino mode.
- Expect ~100 $\nu_e/\bar{\nu}_e$ charged current events.



Neutrino energy peaks in the few-GeV region.

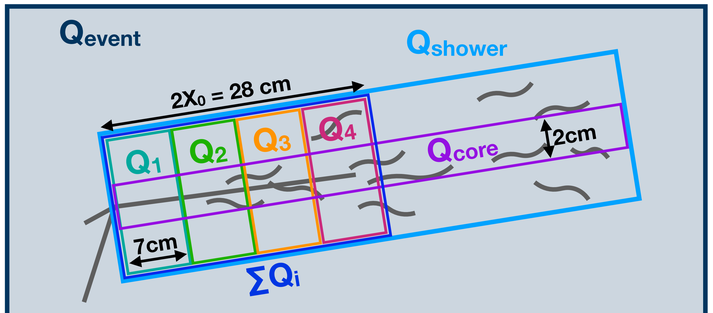
Expect significant contribution from deep inelastic scattering.

R. Acciarri et. al, Phys. Rev. D 95 072005 (2017).

Strategy

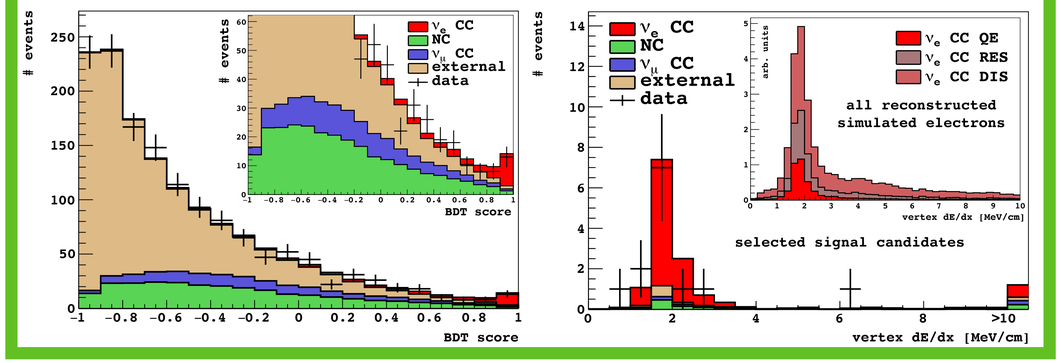
- No expectation of containment given small detector.
- Sizable external background contribution and EM activity with vertex outside the detector.
- High track multiplicity near the neutrino vertex can obscure *dE/dx* and gap information for rejecting photons.
- Define charge ratios motivated by topological features of full EM shower.

not to scale



Inclusive ν_e Charged Current Selection

- Reject ν_μ charged current events with MINOS information.
- Simulation underestimates external backgrounds — only interactions inside the cryostat are simulated.
- Correct external background as a function of BDT score, validated with a hand scan of data and MC at low and mid BDT score.
- Select BDT score > 0.9 to reduce uncertainty associated with external background.



Results

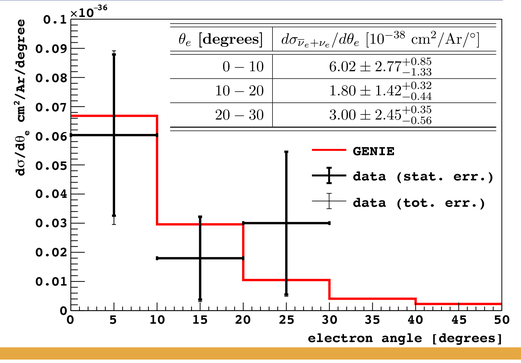
- Combined ν_e + $\bar{\nu}_e$ cross section extracted from 13 events selected.
- Consistent with GENIE expectation.
- Dominant systematic uncertainties are the hadron formation zone used in GENIE and the quantity of external background.

$$\langle \sigma_{\nu_e+\bar{\nu}_e} \rangle = 1.04 \pm 0.38\ (\text{stat.})\ ^{+0.15}_{-0.23}\ (\text{syst.}) \times 10^{-36}\ \text{cm}^2/\text{Ar}$$

$$\sigma_{\text{GENIE}} = 1.17 \times 10^{-36}\ \text{cm}^2/\text{Ar}$$

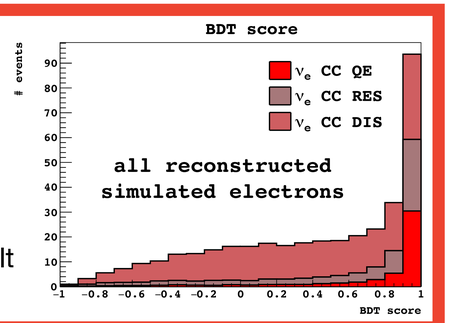
10.5% efficiency, 78.9% purity.

Expect 11.2 $^{+0.4}_{-1.4}$ (syst.) signal and 3.1$^{+2.0}_{-1.3}$ (syst.) background.



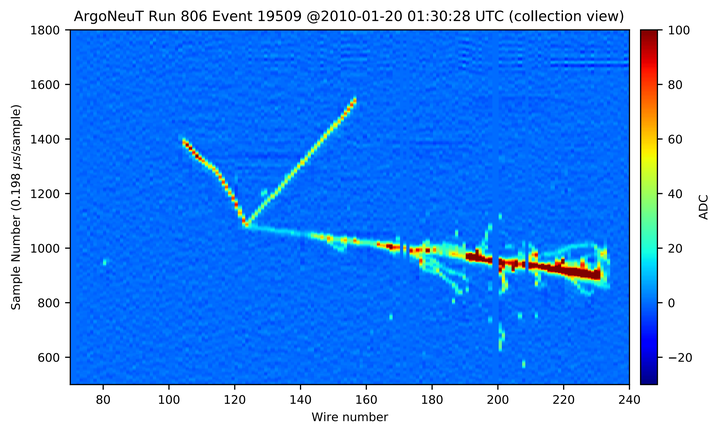
Outlook and Challenges

- Stringent selection is highly efficient for quasi-elastic interactions.
- A subsequent hand scan of a looser selection (BDT score > 0.7) remained consistent with expectation and yielded a larger sample of DIS interactions.
- Bigger detectors will not be overwhelmed by external EM backgrounds.
- Deep inelastic scattering signal and background events are inherently difficult to reconstruct and classify, sometimes impossible even by eye.



Summary

- First end-to-end automated reconstruction and selection of electron neutrinos from GeV-scale neutrino beam data.
- Provides insight into challenges of working with GeV-scale neutrino data.
- Further development of calorimetry-based techniques that use more than traditional vertex *dE/dx* and gap is valuable as a cross check to deep learning-based methods.



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