Charged-Current Muon-Neutrino Veto for the Inclusive Electron-Neutrino Analysis in MicroBooNE

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Introduction

This poster presents a method to identify and veto charged-current muon neutrino events in MicroBooNE using Pandora[1] for reconstruction and Wire-Cell generic neutrino selection[2] to remove cosmics.

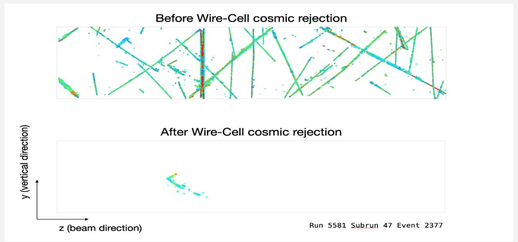
Motivation

Develop a high efficiency, high purity ν_μCC selection with low ν_eCC misID rate that can be used to:

- veto background events to achieve a pure ν_e Low Energy Excess (LEE) signal selection
- constrain the flux and cross-section uncertainties for the low statistic ν_e-like events using the ν_μCC event statistics

Cosmic Rejection

Before event selection, Wire-Cell cosmic rejection and generic neutrino selection[2] are used to remove cosmics. Raises ν:Cosmic ratio from 1:800 to 7.6:1.

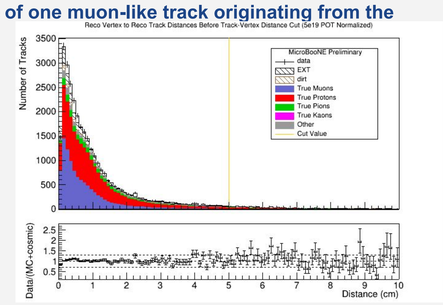


Signal Topology

Inclusive ν_μ charged-current events characterized by the presence of one muon-like track originating from the neutrino vertex.

Event Selection: Basic Cuts

- at least one reconstructed cluster in the TPC compatible with the light signal in time with the beam
- reconstructed neutrino vertex within fiducial volume (<1 cm from TPC boundary)
- at least one track in the event that starts < 5cm from the reconstructed vertex
- the largest cluster is track-like (checked after likelihood cut)

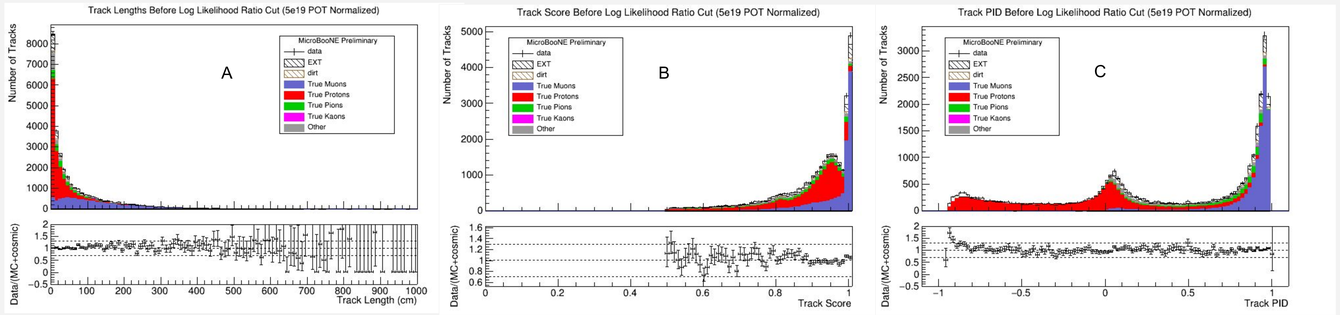


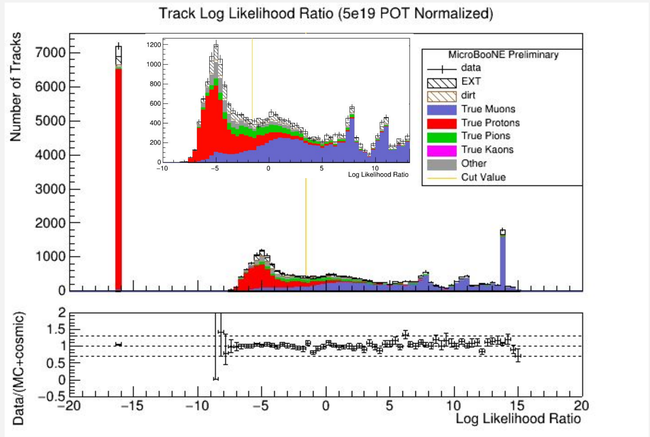
Event Selection: Muon/Proton Log Likelihood Ratio

Input: Track Length, Track Straightness Score, Track PID (using energy loss along the trajectory)

$$R_{Likelihood} = \frac{P(Muon)}{P(Proton)} = \frac{A_{Muon} * B_{Muon} * C_{Muon}}{A_{Proton} * B_{Proton} * C_{Proton}}$$

$A_{Muon/Proton}$, $B_{Muon/Proton}$, $C_{Muon/Proton}$: normalized muon/proton A,B,C distributions made from a training sample of Monte Carlo events





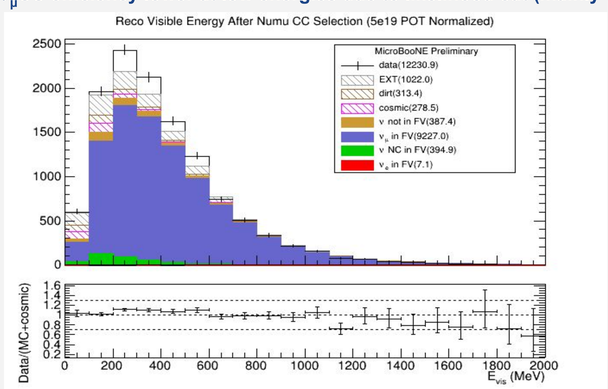
Efficiency and MisID

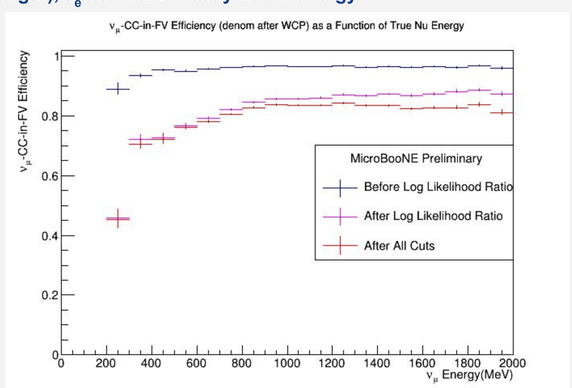
Cuts	ν_μCC Efficiency	ν_eCC MisID
≥1 Cluster	99.98%	100%
Vertex in FV	99.11%	98.94%
≥1 Track <5cm from Vertex	96.01%	78.58%
≥1 Track with Log Likelihood > -1.6	84.26%	24.03%
Cluster is Track-like	81.02%	10.15%

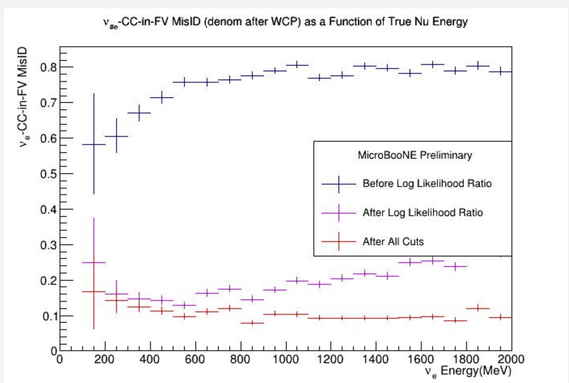
Selection cuts chosen to obtain high ν_μCC efficiency (to suppress background for LEE analysis) and low ν_eCC misID (to achieve high efficiency for LEE analysis)

Performance

- 81.0% ν_μ CC efficiency with 79.7% purity and 10.2% ν_e misID
- efficiency/misID denominator: true ν_μCC/ν_eCC events that have passed Wire-Cell cosmic rejection and have true neutrino vertex in a fiducial volume 3cm inside the TPC boundaries
- ν_μCC efficiency lower at low energies due to likelihood cut (mainly caused by track length), ν_eCC misID mostly flat in energy







Takeaways

- Currently, highest efficiency and purity ν_μCC selection for surface LArTPC neutrino data
- Good selection achievable with optimization using high-performance reconstruction tools
- High efficiency and purity ν_μCC selection is necessary to constrain the flux and cross-section uncertainties for low-statistics ν_e-like events
- Reject overwhelming ν_μCC background in inclusive ν_e selection for low energy excess analysis (see Poster 183 for the LEE analysis using this ν_μCC selection as a veto)
  - Before this selection (Wire-Cell cosmic removal only) ν_μ:ν_e = 129:1
  - After using this selection to veto ν_μCC events ν_μ:ν_e = 31:1

References

[1] Eur. Phys. J. C78, 1, 82 (2018)

[2] MICROBOONE-NOTE-1084-PUB

Supporting Public Note

MICROBOONE-NOTE-1088-PUB

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