Measurement of Single Electron Events in MicroBooNE[1]

Ivan Caro Terrazas, on behalf of the MicroBooNE Collaboration
icaro@colostate.edu
Colorado State University

MicroBooNE and the Low Energy Excess

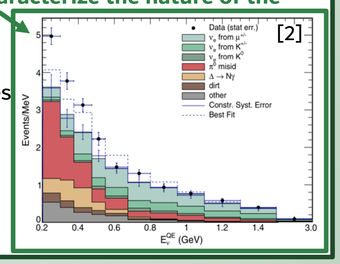
-> **MicroBooNE** is a Liquid Argon Time Projection Chamber (LArTPC) neutrino detector located along the Booster Neutrino Beam at Fermilab

-> Primary physics goal:

- LArTPC R&D
- $\nu - \mathrm{Ar}$ Cross sections
- **Investigate and characterize the nature of the MiniBooNE excess**

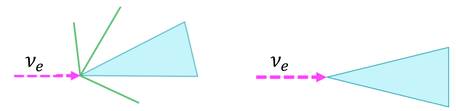
-> MicroBooNE is exploring two hypotheses for the excess of EM events:

- $\boldsymbol{\nu_e}$ **excess**
- Excess of photons



Single Electron Channel

-> The ν_e excess is studied by relying on two exclusive and orthogonal channels:



$\nu_e + Ar \rightarrow 1eNp0\pi$ & $\boldsymbol{\nu_e + Ar \rightarrow 1e0p0\pi}$
where $N > 0$

-> Combined channels match MiniBooNE signal:

$\nu_e + C \rightarrow 1eXp0\pi$ where: $X \geq 0$

-> The $1e0p0\pi$ channel consists of a single electron with no visible protons or pions

-> Single EM shower search

-> Constrain uncertainty related to proton reconstruction, multiplicity and kinematics

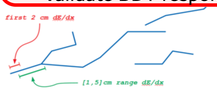
-> Constrain event migration: $1eNp0\pi \leftrightarrow 1e0p0\pi$

Towards the Low Energy Excess

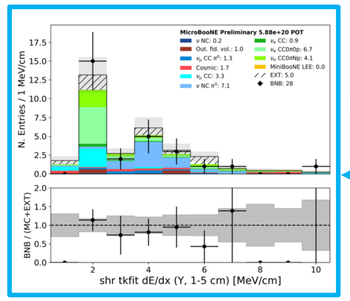
-> Sideband Strategy: opened events having a reconstructed visible energy > 0.9 GeV or a BDT score < 0.4, away from **signal region**

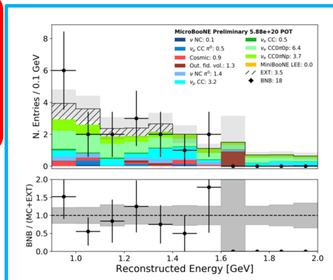
-> Useful for validation studies:

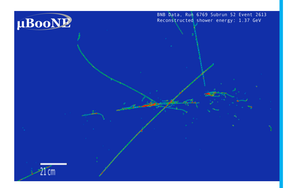
- Validate BDT input variables and BDT score at high energies
- Validate BDT response over energy spectrum



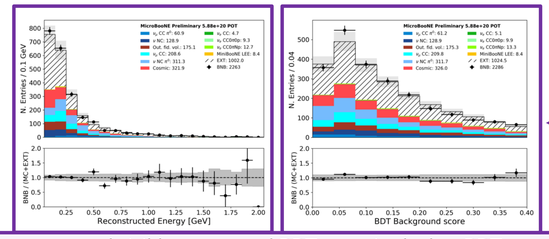
-> Separation of showers of one MIP (mostly $1e0p0\pi$ events) and showers of two MIPs (mostly $NC\pi^0$ events) is observed

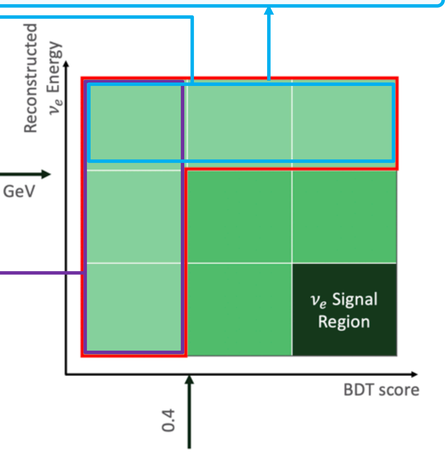






-> Selection of single shower events in the high energy region
-> Display of neutrino induced single shower event

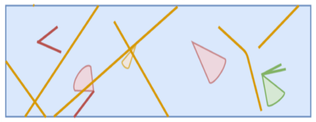




-> Reconstructed visible energy and BDT score in the low BDT score region
-> Simulation in agreement with data measurement

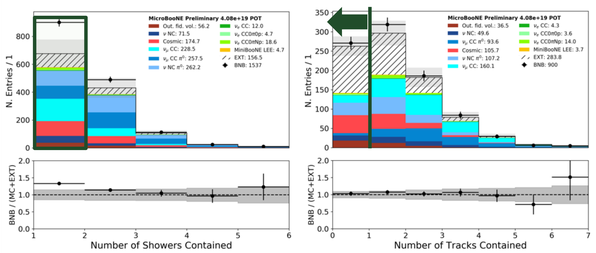
Single Shower Analysis Overview

Cosmic Rejection



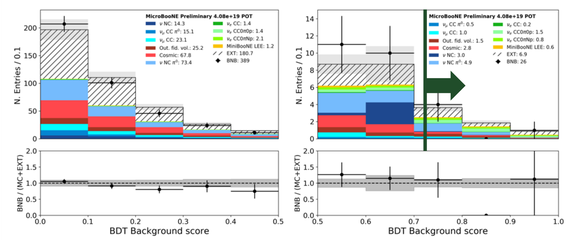
-> Reconstruct event tracks and showers using Pandora [3]
-> Candidate neutrino interactions (green and red) and obvious cosmic activity (orange) are tagged
-> Prompt scintillation light coincident in-time with beam is used to select neutrino (green)

Single Shower Topology



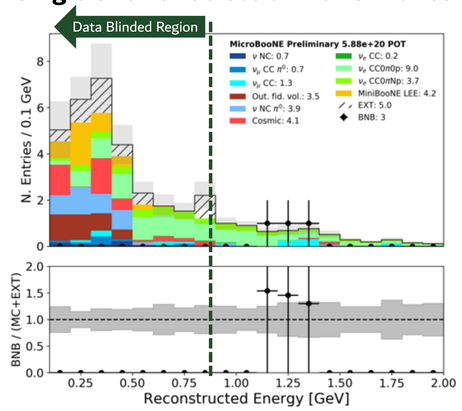
-> Dominated by Cosmic and BNB backgrounds
-> Single shower topology: one contained shower within the fiducial volume with zero contained tracks
-> Other quantities, such as distance or shower angle w.r.t. nearest cosmic, provide further background rejection

BDT Training



-> A single Boosted Decision Tree (BDT) is trained on a dedicated true low energy ν_e sample and a π^0+ cosmic enhanced sample for background events
-> 28 BDT training variables: shower dE/dx most important training variable

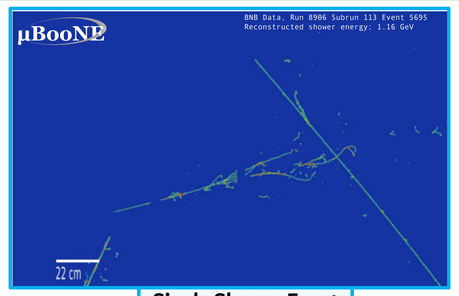
Single Shower Selection Performance



-> Data unblinded for energy above 0.9 GeV
-> Expected **purity of ≈ 47%** for electron neutrinos in the 0-2 GeV reconstructed energy range with an **efficiency of ≈ 10%**
-> Scaling to the full dataset (1.25E21 POT), we expect **19 $1e0p0\pi$ selected events**

Summary

-> Presented ongoing measurement of ν_e single shower events in the Booster Neutrino Beamline with the MicroBooNE detector
-> First measurement of single shower events in a LArTPC
-> 19 single shower events are expected in the full open dataset with a purity ≈ 47% and efficiency ≈ 10% at selecting ν_e events
-> Framework good at selecting truth $1e0p0\pi$ events in the high energy sideband region
-> Validation of analysis on sideband shows good performance
-> Looking forward towards a full dataset unblinding!



Single Shower Event

References:
[1] Search for Electron Neutrinos in Multiple Topologies with the MicroBooNE Experiment (Public Note) MICROBOONE-NOTE-1085-PUB
[2] Significant Excess of Electronlike Events in the MiniBooNE Short-Baseline Neutrino Experiment PRL 121, 221801 (2018)
[3] The Pandora multi-algorithm approach to automated pattern recognition of cosmic-ray muon and neutrino events in the MicroBooNE detector EPJC 78, 182 (2018)

Fermilab · U.S. Department of Energy Office of Science · NSF · FNSNF Swiss National Science Foundation · Science & Technology Facilities Council · The Royal Society