Charged-Current Electron Neutrino Measurement with MicroBooNE

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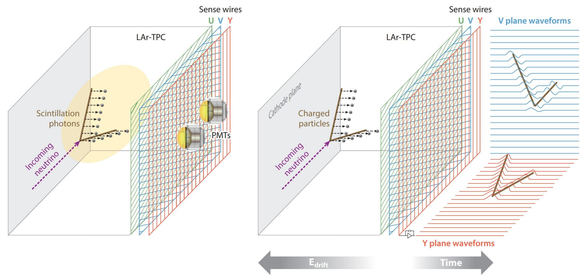
Inclusive ν_e Search in a LArTPC



MicroBooNE

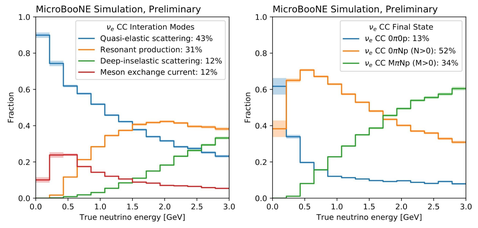
- Investigate the MiniBooNE **low-energy excess**
- **LAr cross-section** measurements
- **R&D** for SBND, ICARUS, and DUNE.

A neutrino interaction produces charged particles, ionising the liquid argon.

1. Fast **Scintillation light** collected by 32 PMT's in nanoseconds.
2. **Ionization charge** collected by 3 anode wire planes with millimeter-scale resolution. The drift time is of the order milliseconds

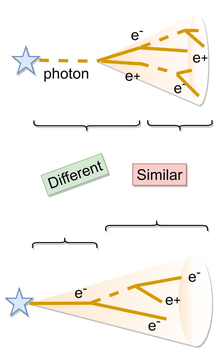
Electron Neutrino Interactions
Are modelled with GENIE v3

- At the energy of the Booster Neutrino Beam around 1GeV several **nuclear processes** are important.
- A large variety of **proton multiplicities** and the possiblilty of **pion production**.

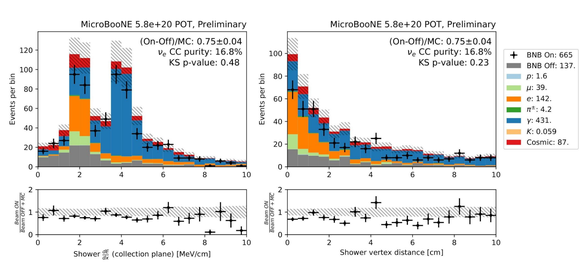


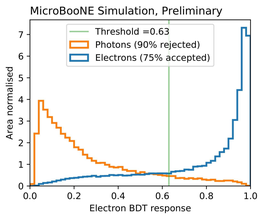
Electron Identification

Photon shower:
displaced vertex and ~4 MeV/cm at start



Electron shower:
vertex at interaction and ~2 MeV/cm at start

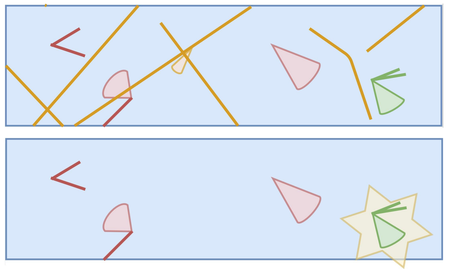




- Threshold of 100 MeV reconstructed shower energy, rejecting the lion share of Michel electrons from muon decay.
- Separation power between pohtons and electrons largely relies on the first few centermeters of the shower.
- Additional variables used to distinguish electrons and low-energy muons from neutrino interactions.
- Additional shower tagging to detect the presence of neutrino induced $\pi^0 \rightarrow \gamma\gamma$ events.

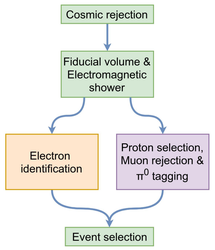
→ **Classification performed with boosted decision tree.**

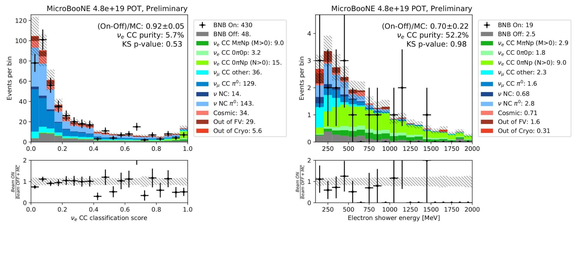
Electron Neutrino Selection

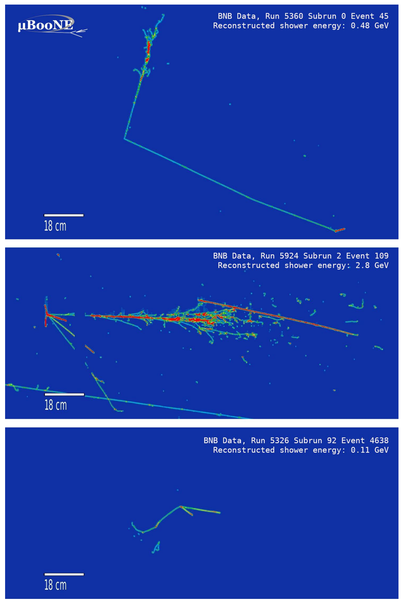


Cosmic Rejection

- Without significant shielding, the **majority of activity** is caused by **atmospheric muons** at a rate of 5kHz.
- **Prompt scintillation light** captured by the PMTs in coincidence with **accelerator triggers** is used.
- The **compatibility** between the **charge and light signal** removes most cosmic activity while selecting neutrinos with 80+% efficiency.







Selection Performance

- **Purity of ≈ 50%** in combination with an **efficiency of ≈ 20%.**
- **Backgrounds** are dominated by neutrino interactions with $\pi^0 \rightarrow \gamma\gamma$, leading to **low-energy electromagnetic showers.**
- Performance evaluated on 4% open data and corresponding event displays.

Inclusive Event Selection

- Staged selection with **gradient boosted decision trees** to identify the electron and reject backgrounds.
- **No assumptions on the interaction mode or the final state topology** are made.
- Electron kinematical variables are not used in the selection to minimise bias.

ν_e Rate & Kinematics Measurement

Understanding electron neutrino interactions

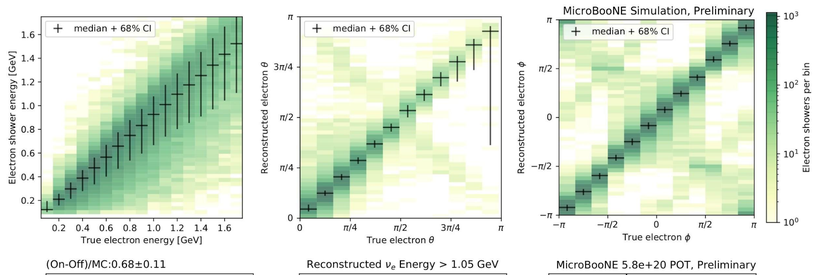
- **Measurement of the charged-current electron neutrino interaction rate** related to the intrinsic beam component.
- **Measurement of the electron shower energy and its orientation for a variety of final states.**
- **Validate the cross-section and flux modelling** of electron neutrinos in MicroBooNE, supporting a wide range of low-energy excess tailored studies.

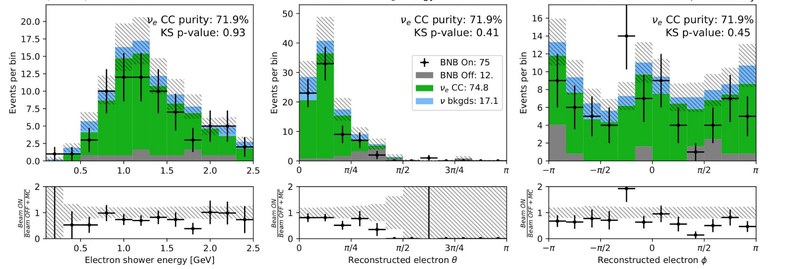
High-Energy Sideband Studies

Important sideband for the low-energy investigation, containing events with a reconstructed neutrino energy above 1 GeV.

Crucial step towards final unblinding of the signal region around 0.5 GeV.

Expect more results soon!





We select and characterise electron neutrino interactions in a muon neutrino beam with the LArTPC detector technology. The Booster Neutrino Beam has an energy peaking around 1 GeV and an electron neutrino content of ≈ 0.5%.

The measurement of the lepton kinematics of electron neutrinos originating from the Booster Neutrino Beam is a crucial component towards understanding the nature of the observed excess of low-energy electromagnetic-like events at MiniBooNE.

MicroBooNE @ Neutrino 2020

Cross-Section talk
By Raquel Castillo
on Tuesday 33 June

Low-Energy Excess talk
By Georgia Karagiorgi
On Thursday July 2

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References

[1] The Short-Baseline Neutrino Program at Fermilab
Annual Review of Nuclear and Particle Science Vol. 69:363-387

[2] The Pandora multi-algorithm approach to automated pattern recognition of cosmic-ray muon and neutrino events in the MicroBooNE detector
arxiv 1708.03135

[3] Significant Excess of ElectronLike Events in the MiniBooNE Short-Baseline Neutrino Experiment
Arxiv 1805.12028

[4] Pandora Low-Energy Excess Public Note
MICROBOONE-NOTE-xxxx-PUB: