Particle Identification techniques -> measuring ν_e appearance in the MicroBooNE LArTPC -> discover New Physics

HARVARD UNIVERSITY

Nicolò Foppiani – Harvard University, for the MicroBooNE collaboration
nicolofoppiani@g.harvard.edu

μBooNE

Follow the flow

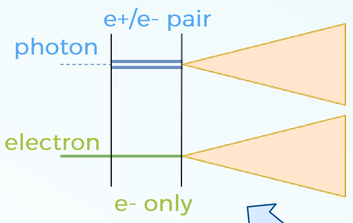
Summary: from the measurement of ν_e interactions to new physics discovery

ν_e interactions in MicroBooNE are rare, as the beam prevalently consists of ν_μ - let's look for them!
1) Tag ν_e events – by identifying the final state particles in the event
2) Measure ν_e appearance – studying sidebands and signal region
3) Test new physics models – motivated by the LSND and MiniBooNE anomalies

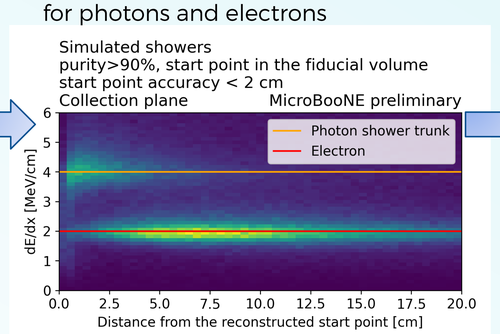
ν_e interactions and how to find them

Shower identification

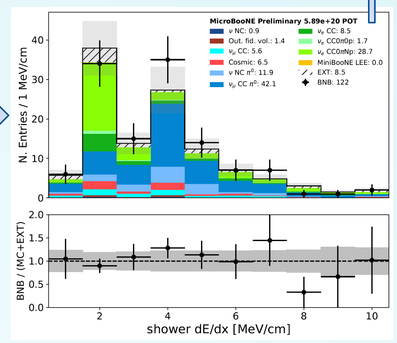
Idea: the trunk of the shower is microscopically different for photons and electrons – e+/e- pair vs e- only



Data: ionization profile in the first few cm – after the showers are the same for photons and electrons



Analysis variable: median of the dE/dx values in the first 4 centimeters



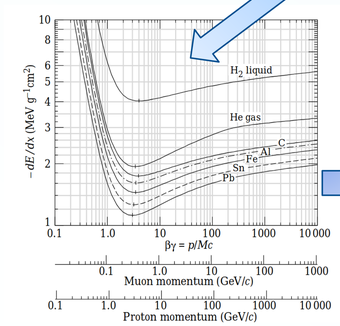
ν_e interactions in MicroBooNE @ ~1 GeV

Summary in 4 points:
- **Type**: charged Current quasi elastic (CCQE)
- **Signature**: electron shower and 1 proton track, reconstructed using Pandora [1]
- **Identification**: tag the electron shower and the proton track.
- **Tool**: calorimetric measurement

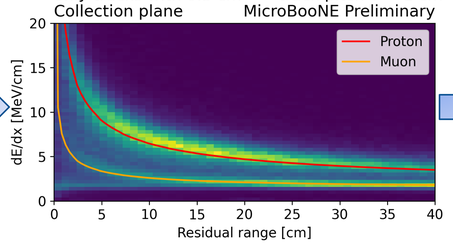
These variables are properly simulated thanks to the accurate calibration work [2, 3, 4]

Track identification

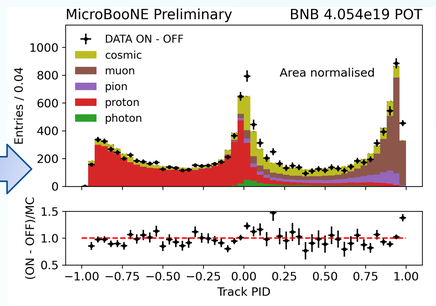
Idea: Bethe-Bloch theory – dE/dx is a universal function of $\beta\gamma$



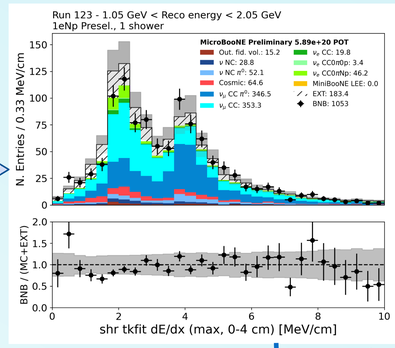
Data: the ionization profile depends on the particle mass



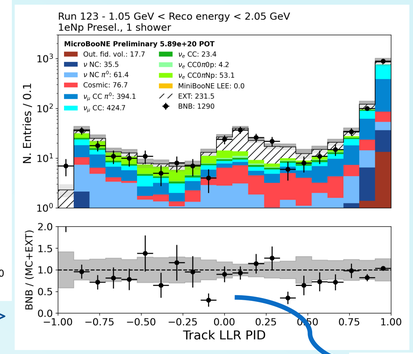
Analysis variable: likelihood method to condense information in one variable



Let's look at some data with the ν_e selection!



First sideband: look for the signal at high energy - E > 1.05 GeV



Target - ν_e CC events
- Electron-like shower: dE/dx ~ 2 MeV/cm
- Proton-like Track: track PID < 0

These variables help separate this signal from the backgrounds!

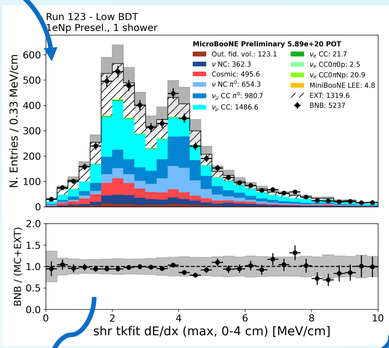
Data and simulation are in good agreement!

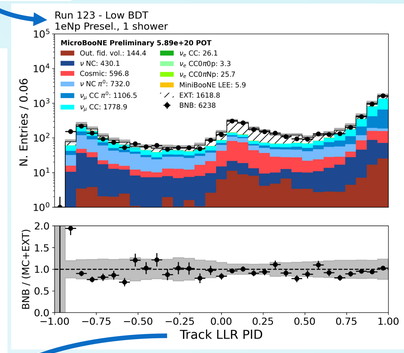
Second sideband: reject the background!

ν_μ and cosmic ray
- Electron-like shower and muon-like track

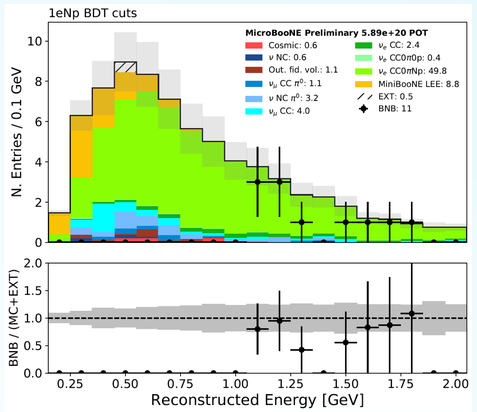
Charged Current π^0
- Photon-like shower and muon-like track

Neutral Current π^0
- Photon-like shower and proton-like track





...and finally test new physics models



Reconstructed ν_e energy spectrum:
- Currently data only from the high energy region
- Forecasted sensitivity to the model of the MiniBooNE Low Energy Excess (LEE)

Median sensitivity = 2.3 (3.0) σ
with 6.9 (12.5) E20 POT of data available

We are almost ready to look at the entire spectrum and find out something new!

And you? Are you ready?
Stay tuned for the next MicroBooNE's result!
Interested in learning more?
You can find more details in our note!

[1] arXiv:1708.03135, Eur. Phys. J. C 78, 82 (2018) [2] arXiv:1802.08709, JINST 13, P07006 (2018) [3] arXiv:1804.02583, JINST 13, P07007 (2018) [4] arXiv:1907.11736, JINST 15, P03022 (2020)

This research is supported by the U.S. Department of Energy, Office of Science, Office of High Energy Physics, under the Award Number DE-SC0007881.