Cosmic Background suppression for a NuMI electron-neutrino cross-section measurement in MicroBooNE

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New Perspectives

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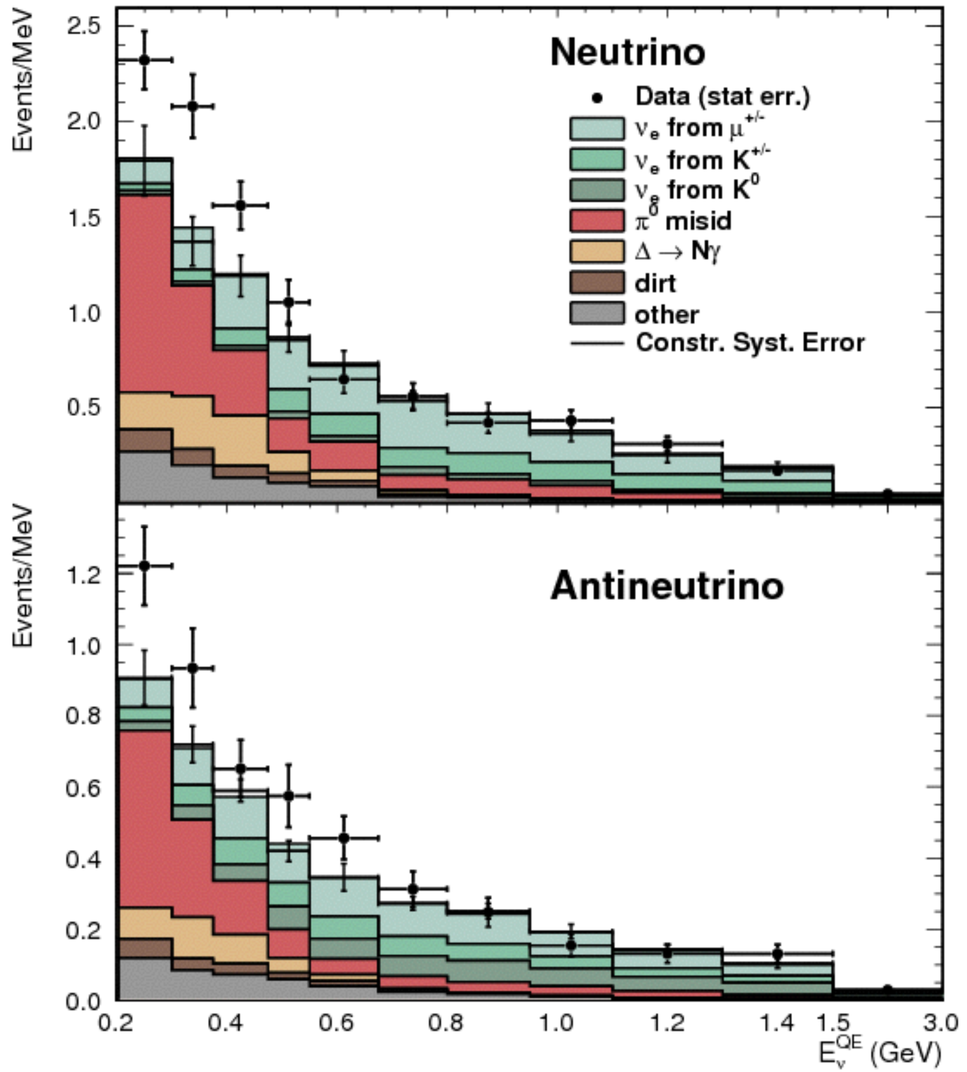
MANCHESTER 1824
The University of Manchester

μBooNE

Motivation - Why do we care about ν_e?

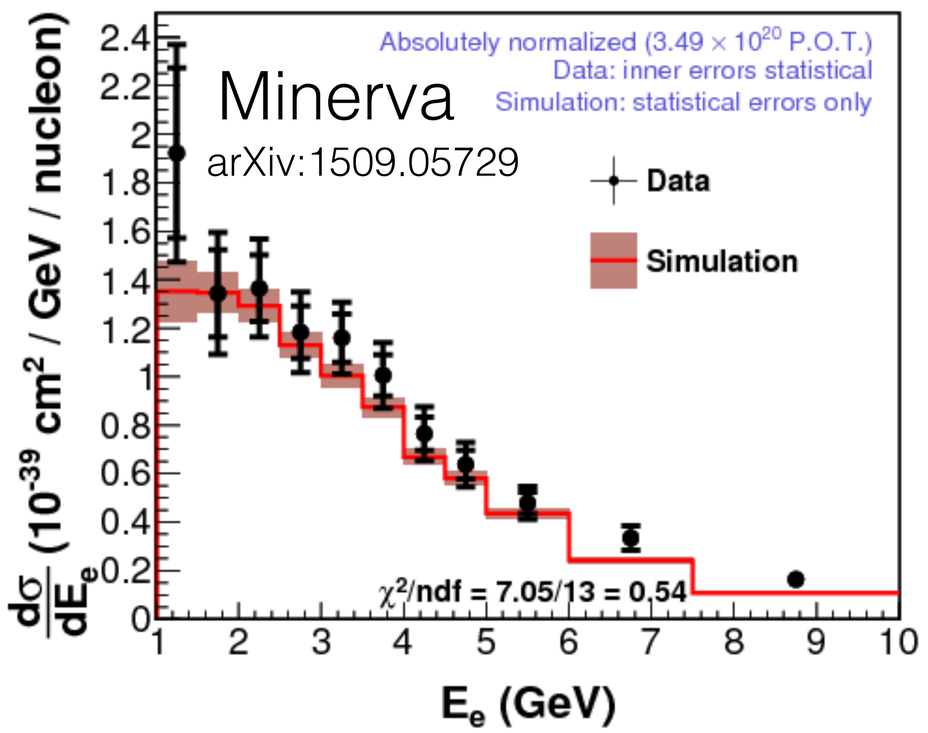
- Two key motivations:
  - LSND/MiniBooNE ν_e-like excess - MiniBooNE was limited by the π^0 backgrounds.
  - We have limited data on ν_e interactions around 1 GeV.
- ν_e cross section also critical for DUNE.

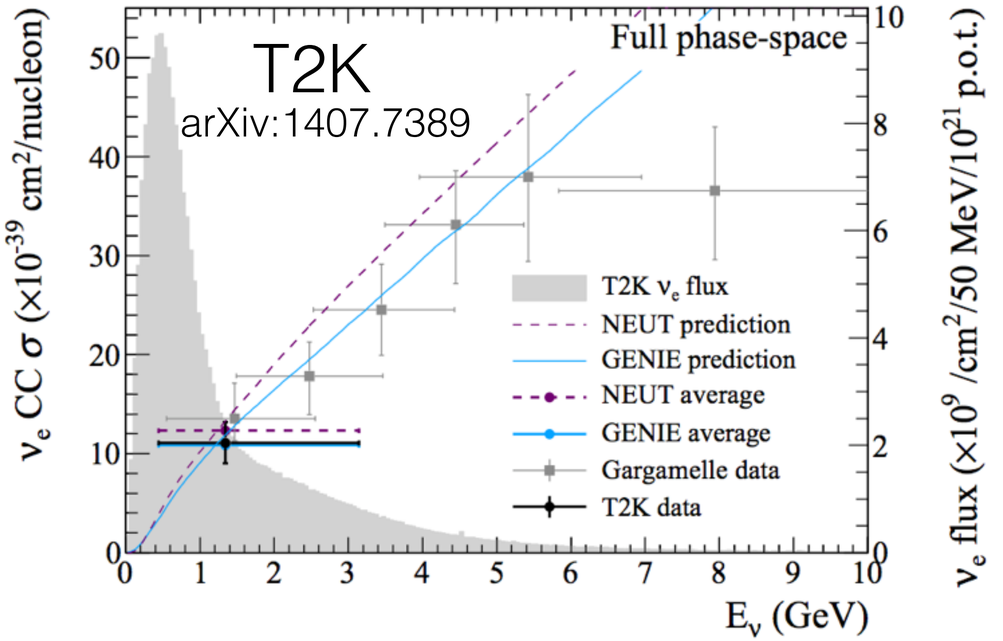
MiniBooNE "Low Energy Excess"



ν_e Cross Section Measurements

- The few measurements of ν_e CC cross-section were made by the Gargamelle, Minerva and T2K experiments.
- MicroBooNE is also well-equipped to measure the ν_e CC cross section given its excellent spatial resolution and calorimetric capabilities.
- MicroBooNE's energy range is around 1 GeV.

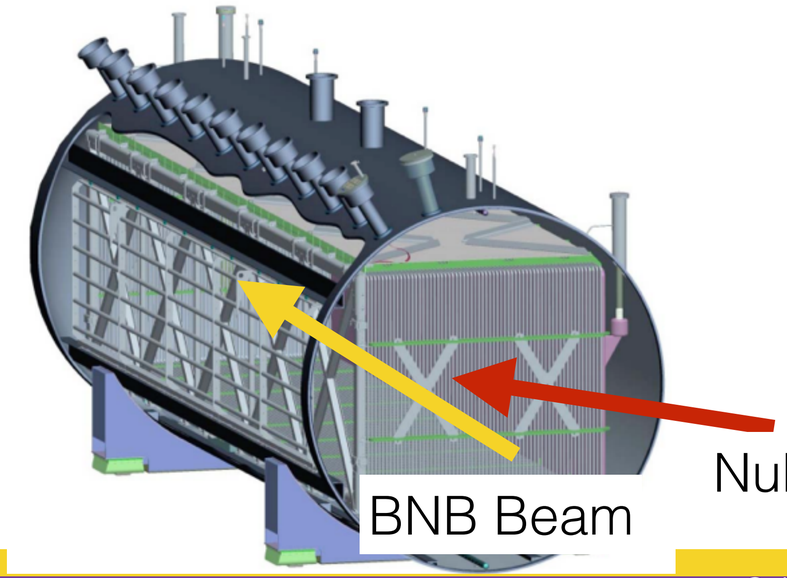


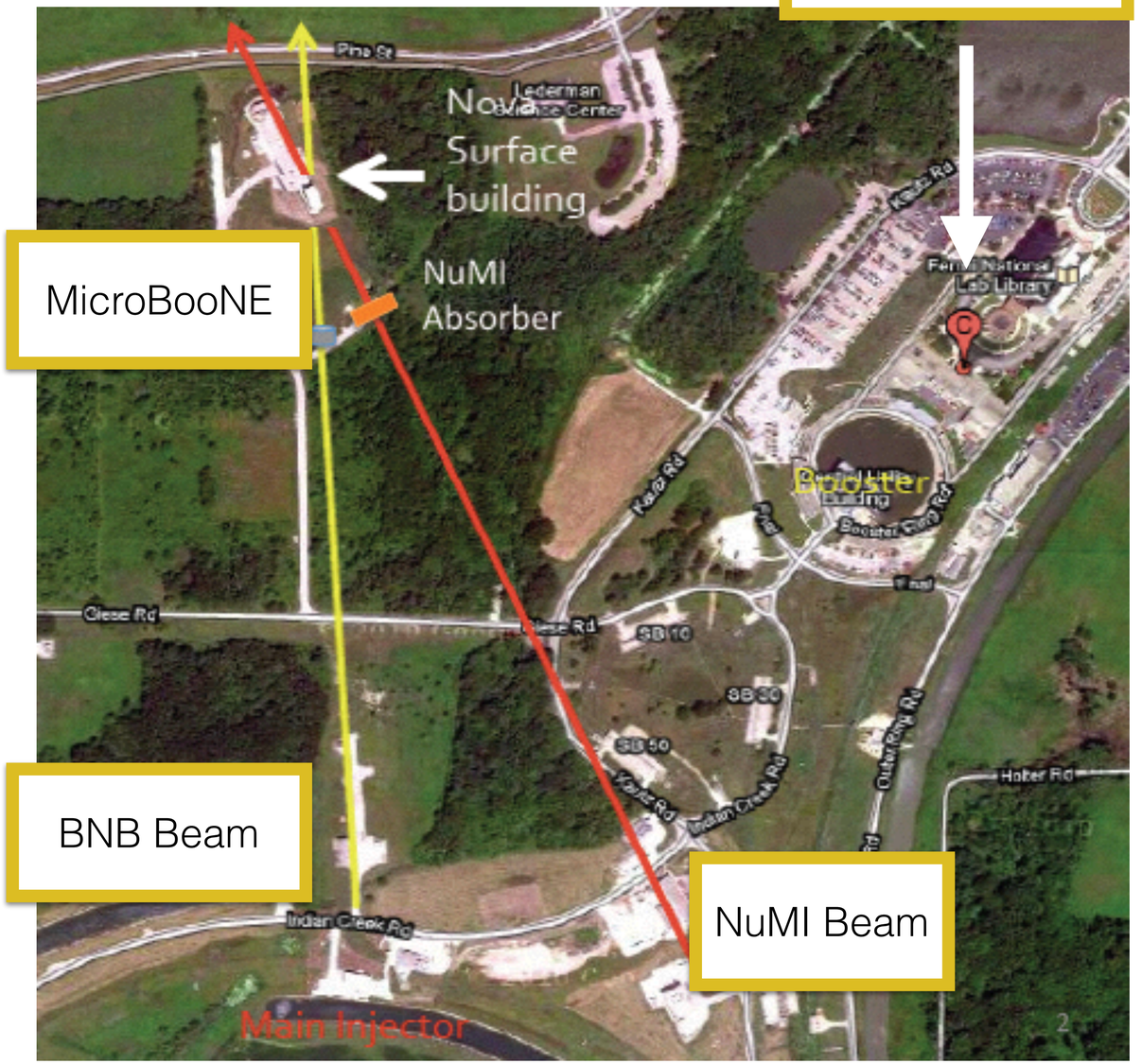


MicroBooNE Detector

- MicroBooNE sits along the BNB and about 8° off-axis from the center of Neutrino Main Injector (NuMI).

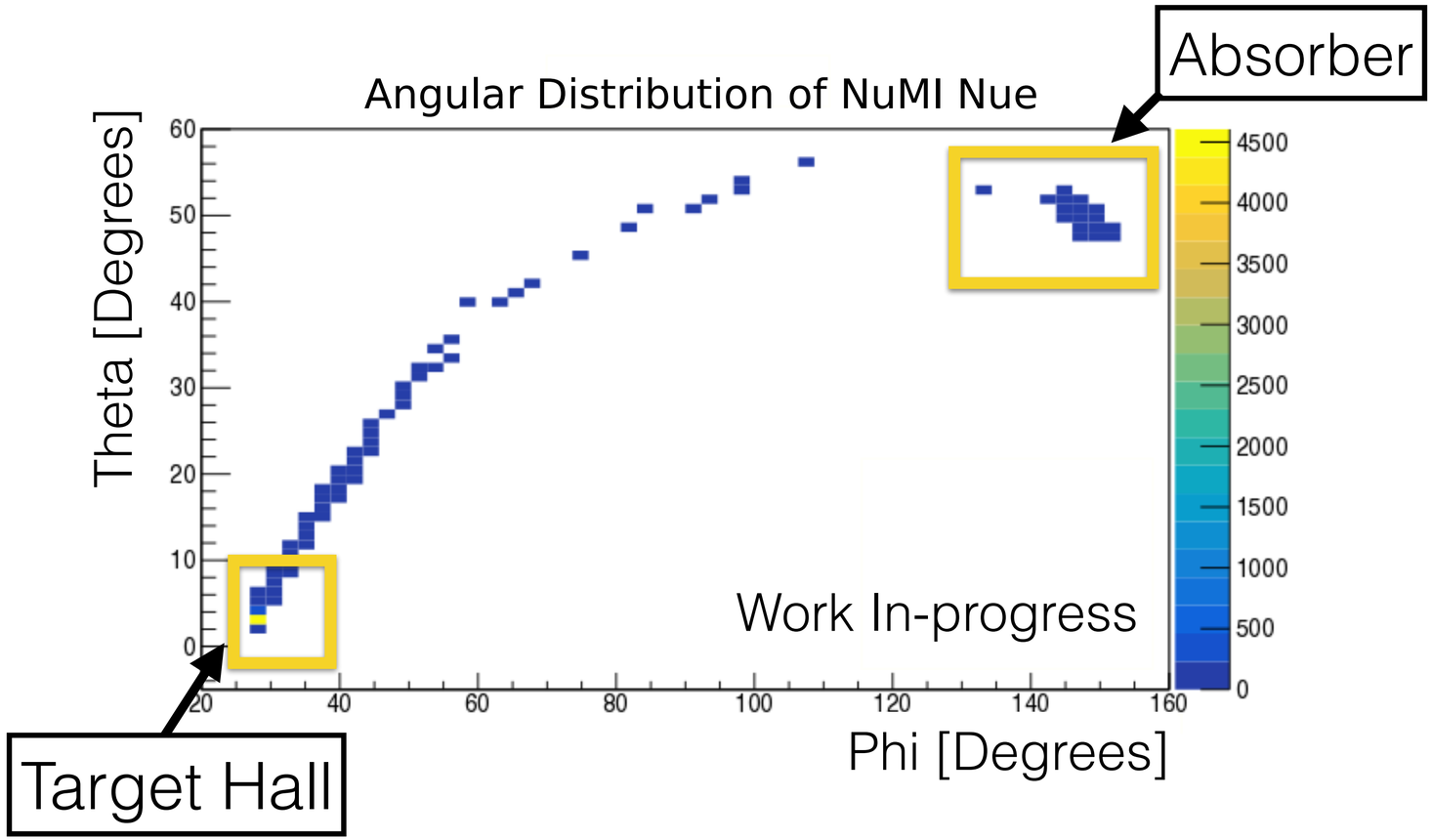
- TPC is “slow” so PMTs behind wire planes are used for triggering.

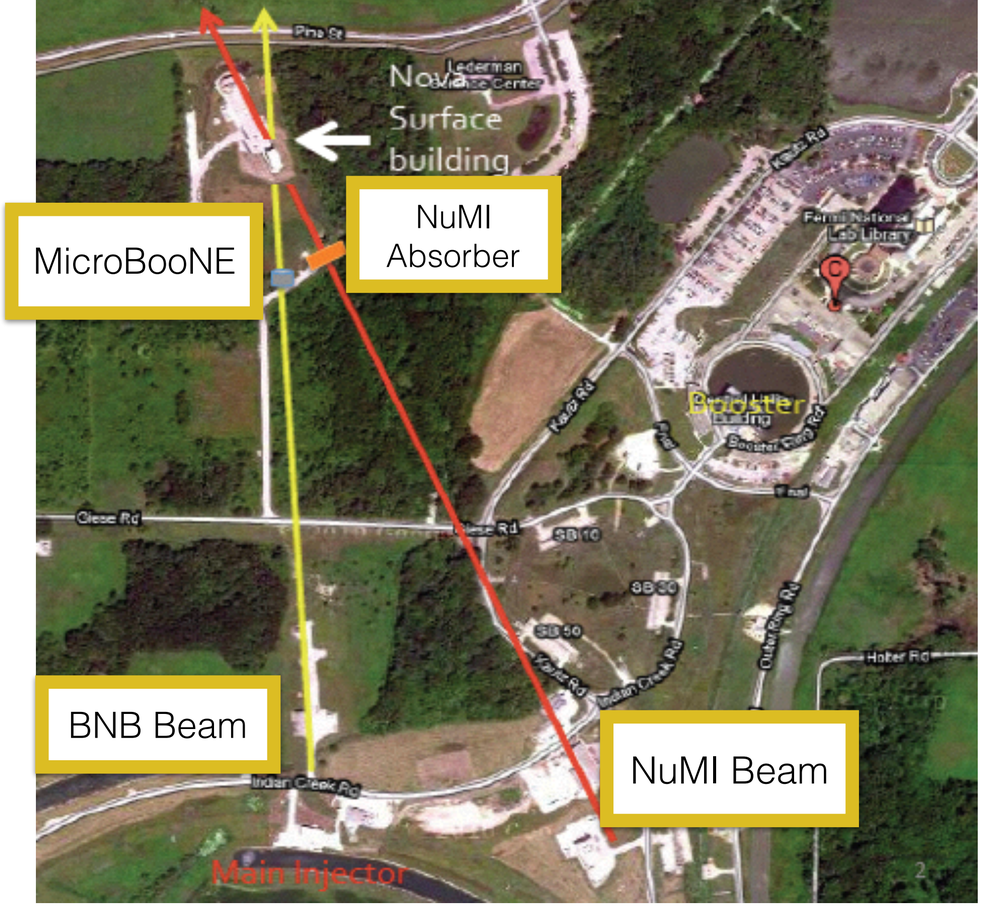


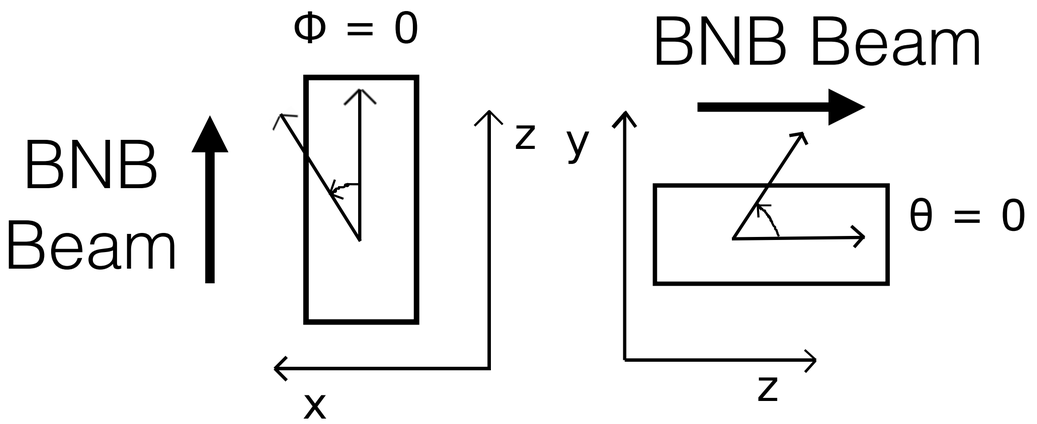


NuMI Beam at MicroBooNE

The GENIE generated ν_e angles tell us from where along the NuMI beamline most of our neutrinos originate.



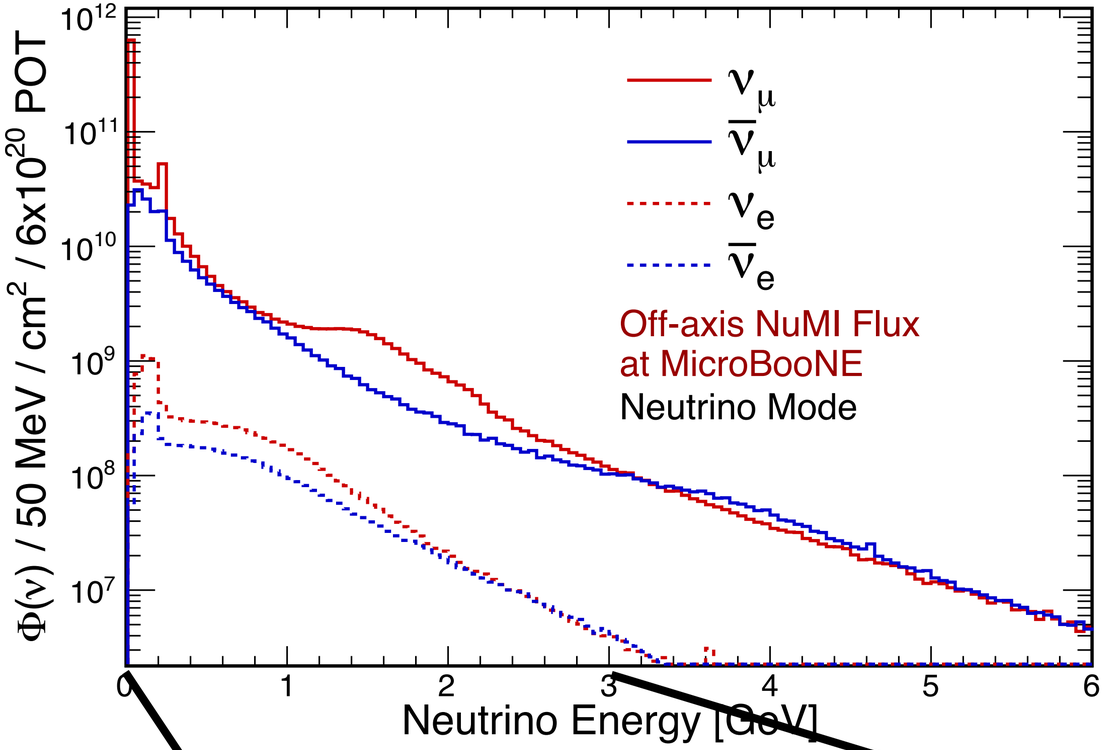


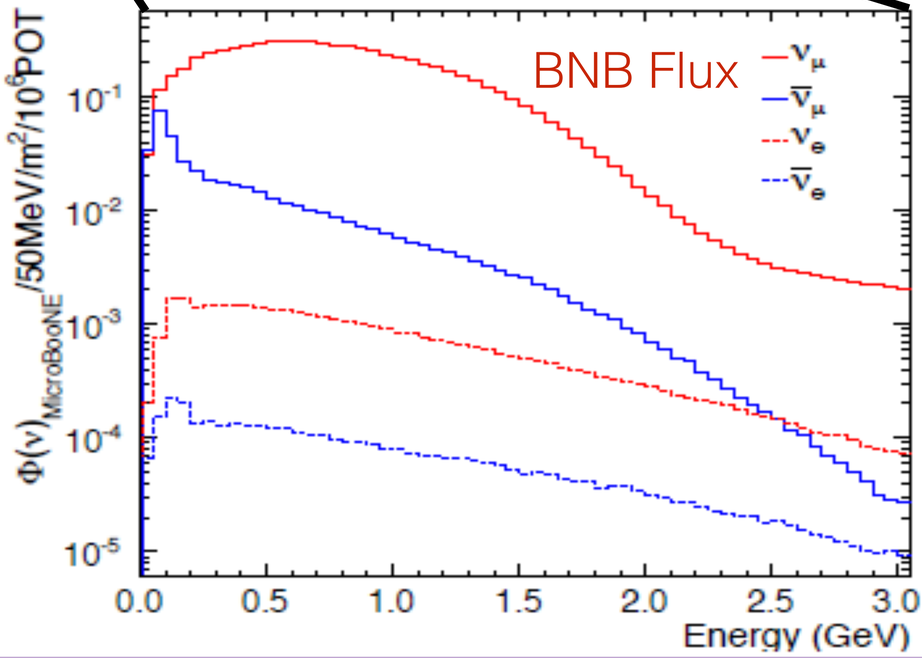


NuMI Beam at MicroBooNE

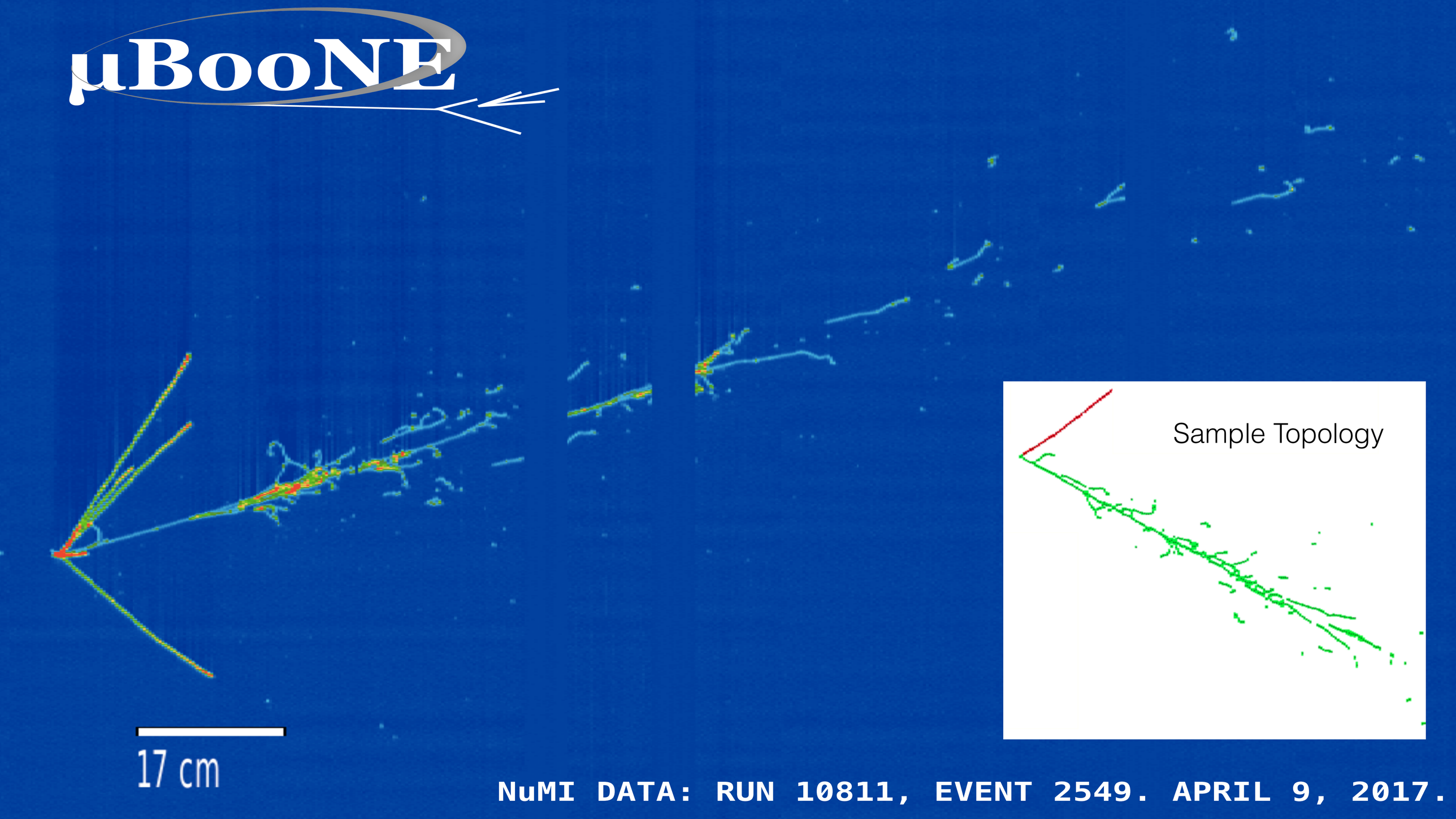
- Measurement from NuMI gives result independent of BNB “low-energy excess”.
- ν_e fraction is larger for NuMI (~5%) vs BNB (~0.6%).

GENIE Parent	NuMI Nue Flux at MicroBooNE (Neutrino Mode)
K^+	57.1%
K^0_L	41.2%
μ^+	1.6%
π^+	0.01%



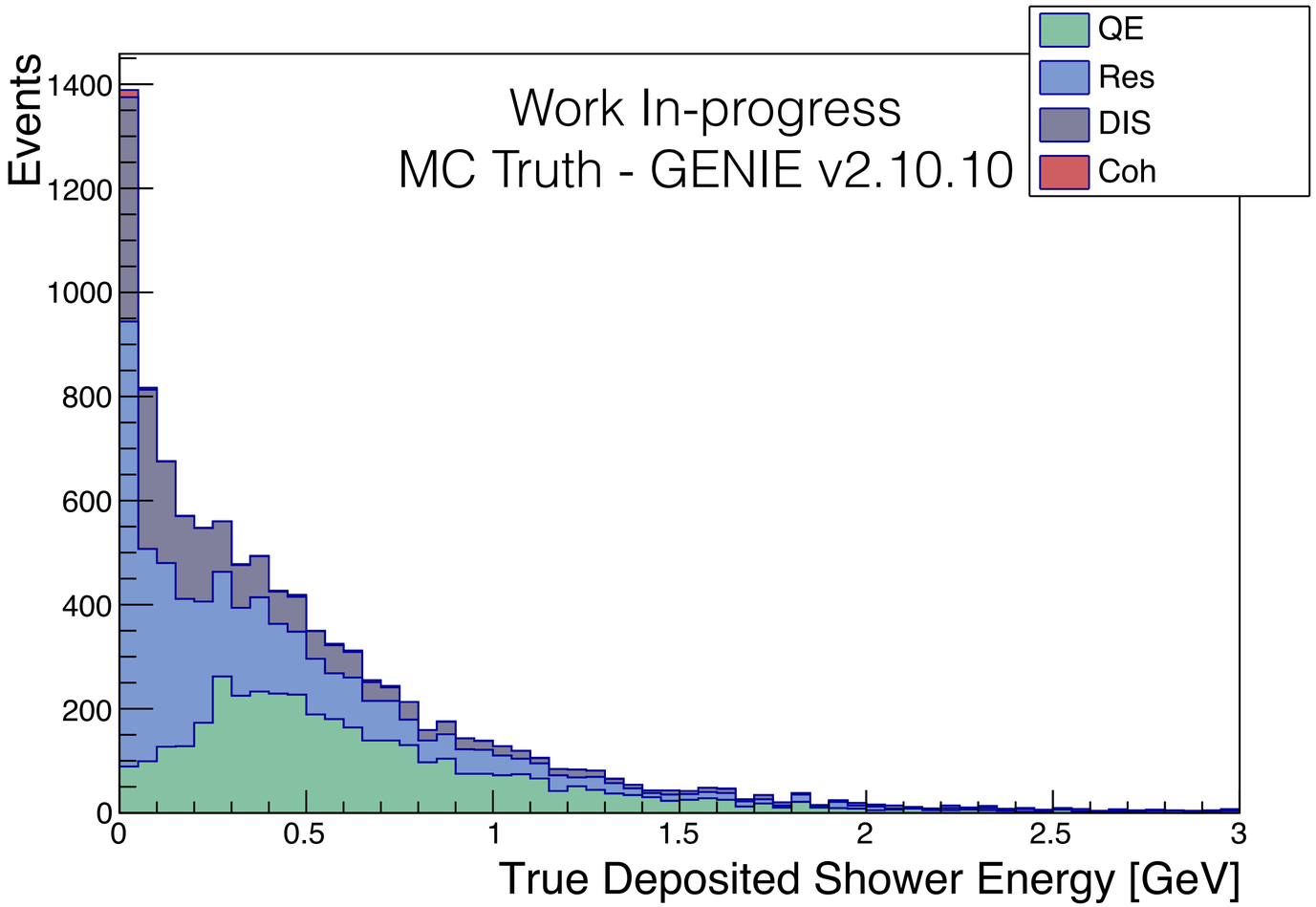


μBooNE



NuMI DATA: RUN 10811, EVENT 2549. APRIL 9, 2017.

True Deposited Shower Energy



- For a cross section measurement we want to measure the shower energy.
- QE events deposit on-average the most energy per shower.
- Other mode's average deposited shower energy peaks below ~200 MeV.

Cosmic Rejection and ν_e Selection

- MicroBooNE sits on the surface - as such cosmic rays are a <u>significant</u> background.

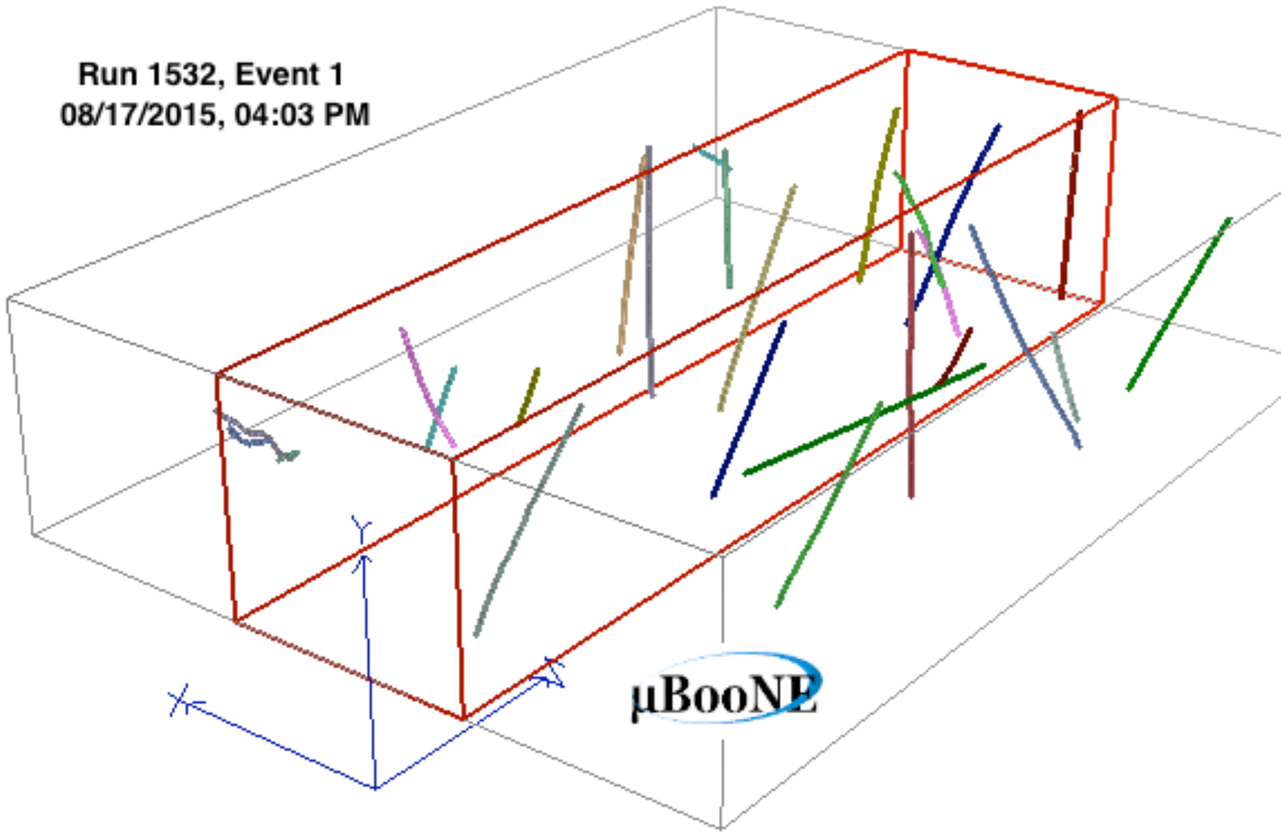
- For every neutrino interaction we expect around 300 cosmic only events.

- Some of these will produce showers, looking like lone ν_e interactions.

- Selection cuts focus on rejecting cosmics:

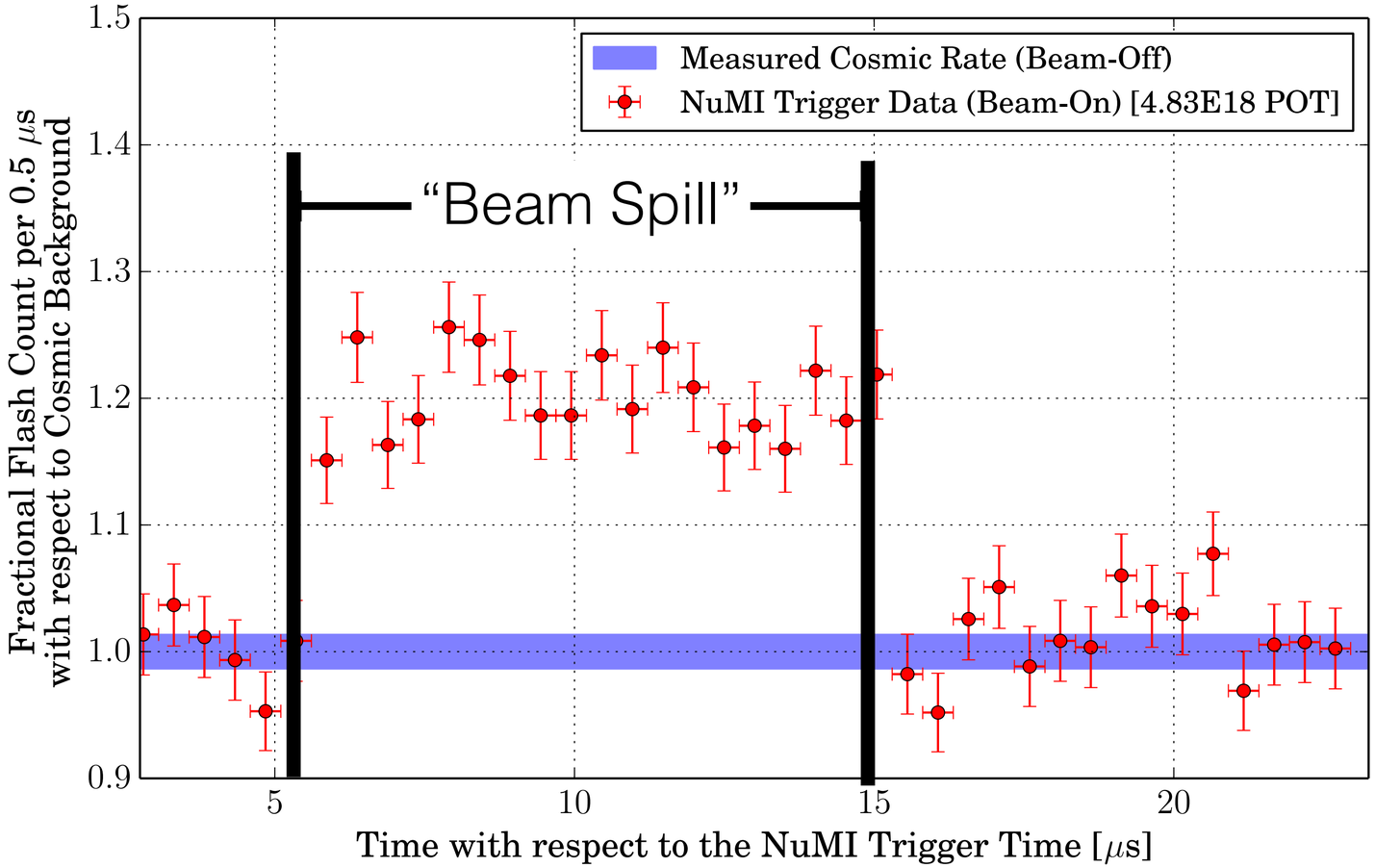
  - Optical Cuts

  - Topological Cuts



Optical Filter

- The optical filter checks for two things:
  - A flash within the beam spill (the time we expect neutrinos to arrive).
  - One flash of at-least 50 photoelectrons.
- This removes cosmic events which are “out of time”.



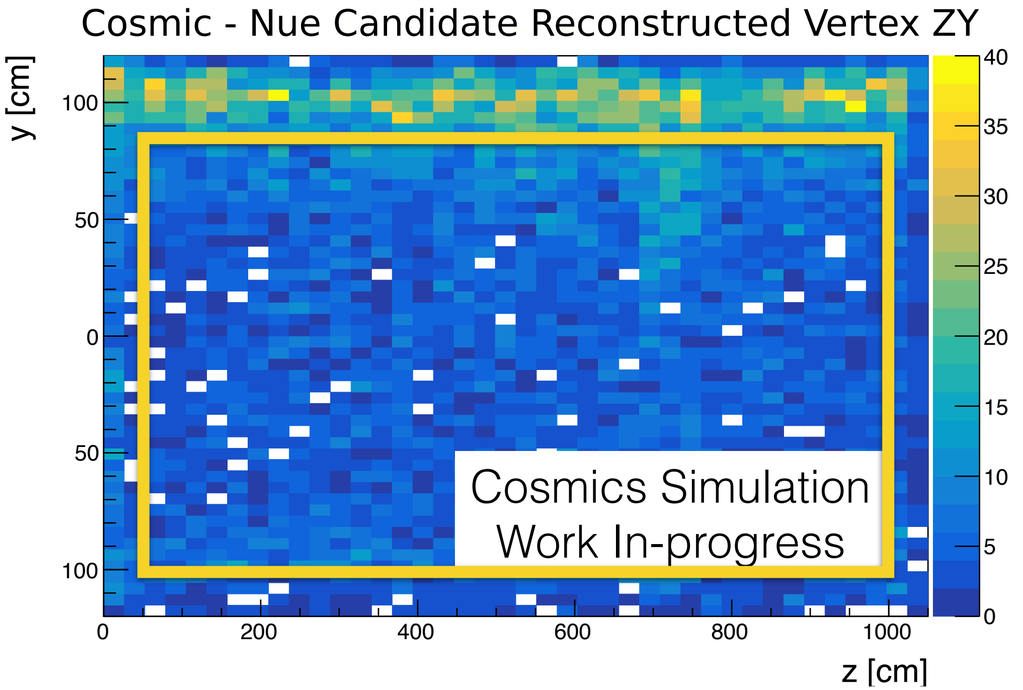
Cut	ν_e *CC* Pass Frac (%)	Cosmic Pass Frac (%)
Op Filter	93.1	7.6

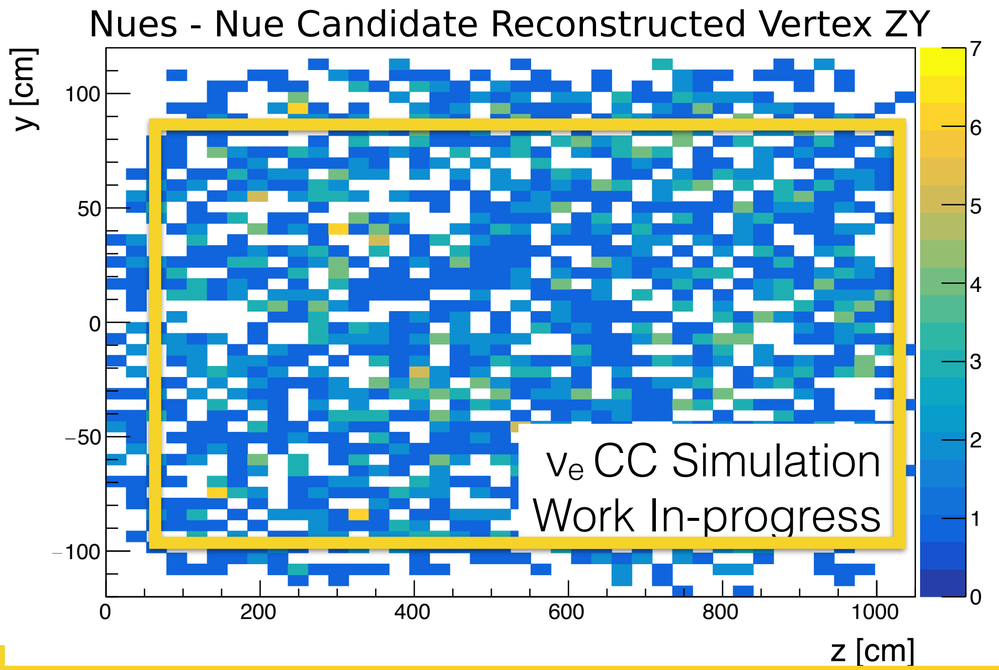
Fiducial Volume Cut

- As expected for the cosmic background, their vertices are concentrated in the top 30 cm of the detector.

- Fiducial Volume: 10 cm from all sides, 30 cm from top.

Cut	ν_e *CC* Pass Frac (%)	Cosmic Pass Frac (%)
Reco in FV	87.6	4.6

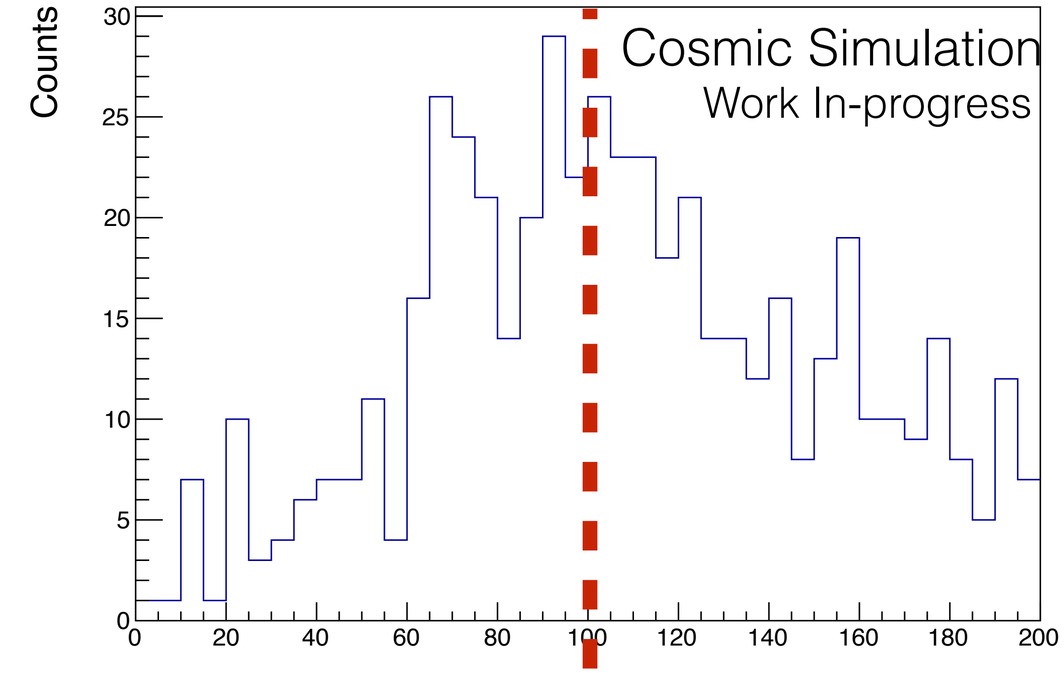


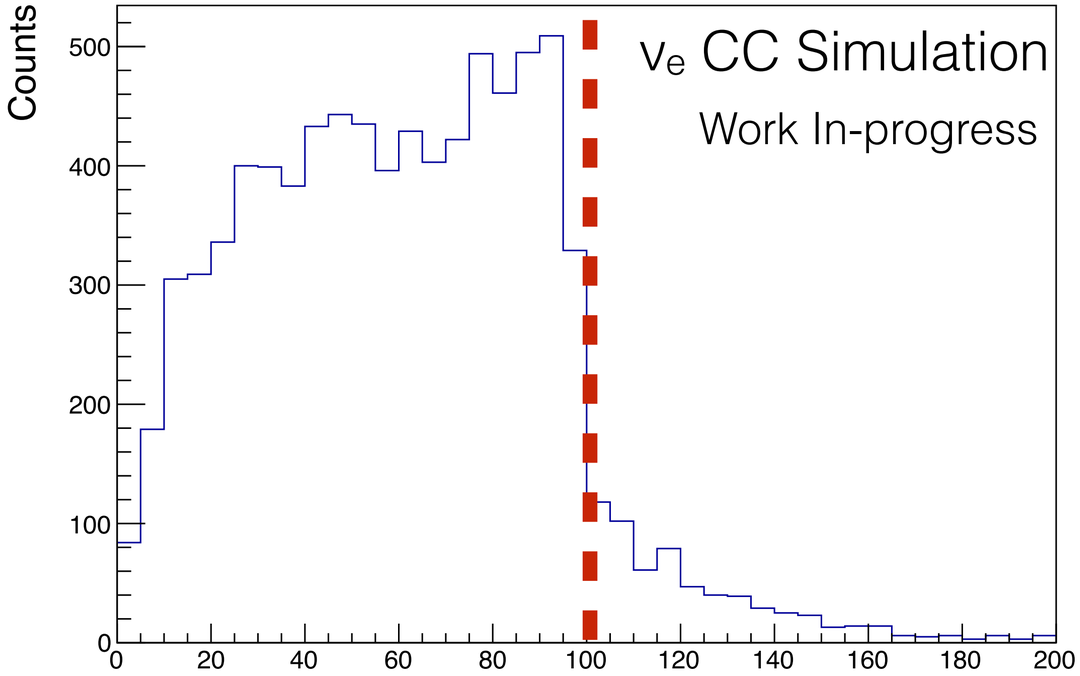


Vertex-to-Flash

- We can combine optical and topological information to place a cut:
  - 2D distance between ν_e shower-vertex and largest flash center - cut at 100 cm.
  - Edge in ν_e spectrum at 100 cm results from PMT coverage granularity, and uncorrelated cosmic events w.r.t. beam flash position.
- This removes events where the shower is reconstructed far away from the largest flash in the event.

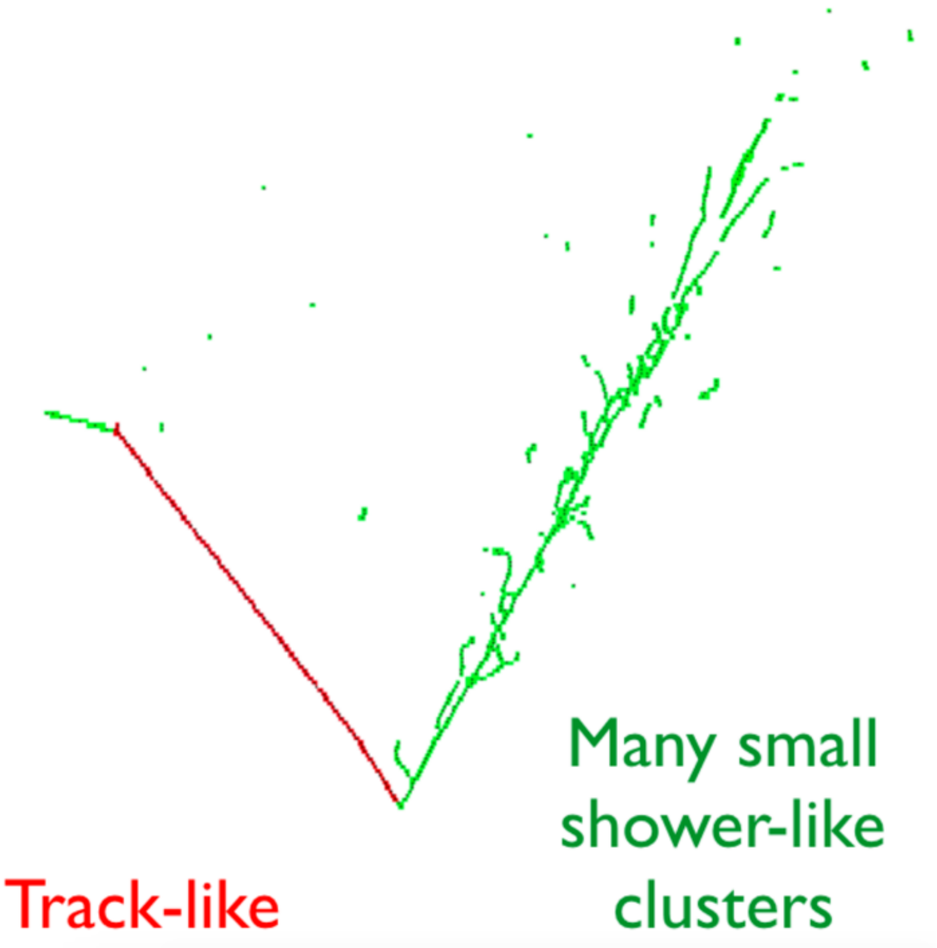
Cut	ν_e *CC* Pass Frac (%)	Cosmic Pass Frac (%)
Vtx to Flash	80.0	0.4





ν_e-like Topology

- This analysis makes use of automated reconstruction algorithms (Pandora).
- Classification of a ν_e-like topology requires:
  - At minimum one reconstructed shower.
  - A shower object associated to a neutrino vertex candidate with the greatest amount of TPC activity.



Pandora - MICROBOONE-NOTE-1015-PUB

Cut	ν_e *CC* Pass Frac (%)	Cosmic Pass Frac (%)
Nue-like	63.4	0.01

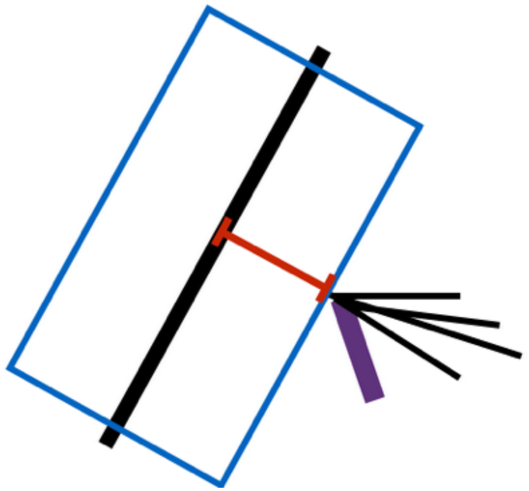
arXiv:1506.05348

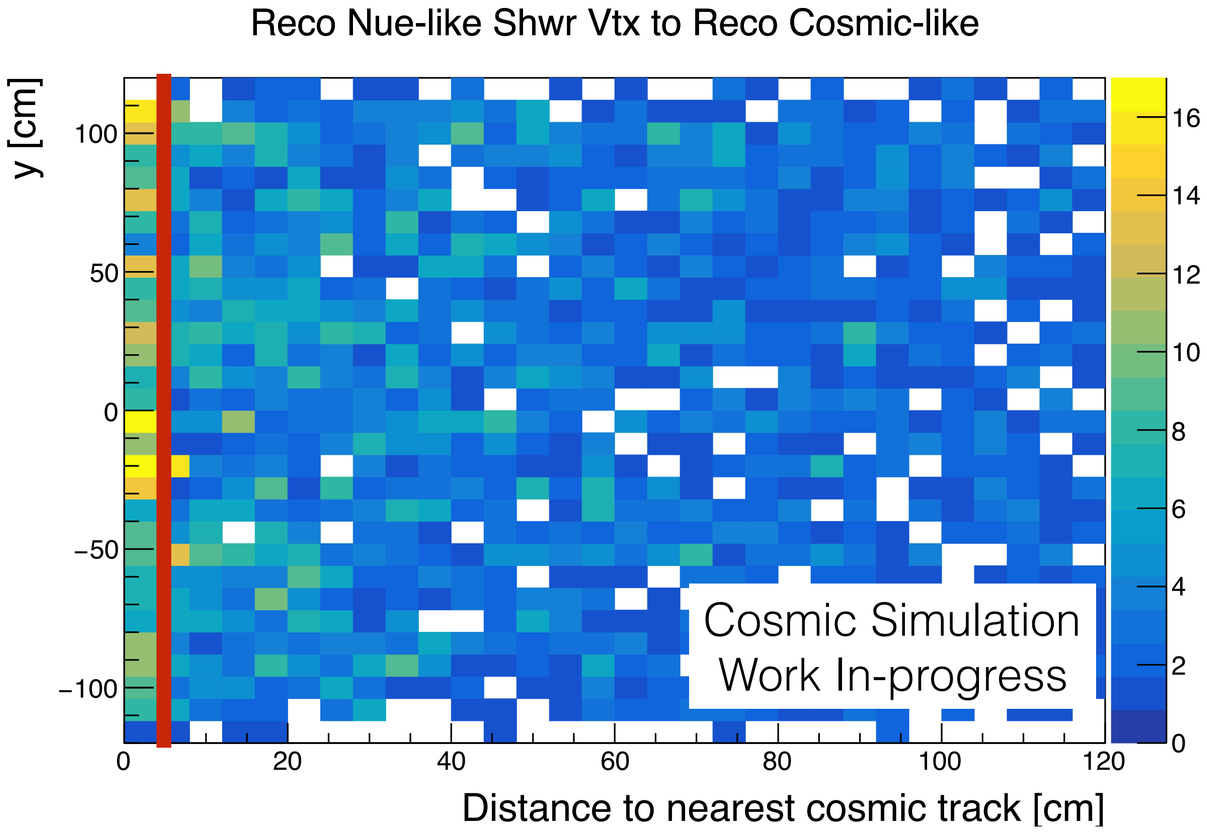
Cosmic Proximity Cut

- This cut attempts to remove showers which result from a cosmic track (gamma / delta rays)

- If a ν_e shower vertex is within a 5 cm radius cylinder, the event is cut.

Cut	ν_e CC Pass Frac (%)	Cosmic Pass Frac (%)
Cosmic Prox	62.5	0.002





Conclusion and Summary

- We demonstrate that the open cosmic background can be reduced by 4 orders of magnitude.
- With these cuts we retain an efficiency of over 60%.
- A number of important backgrounds will soon be included in the analysis (such as NC and muon neutrinos).
- A fully-developed ν_e selection will be useful for further investigating the LSND/ MiniBooNE anomaly and future measurements on DUNE.

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Op Filter	93.1	7.6
Reco in FV	87.6	4.6
Vtx to Flash	80.0	0.4
Nue-like	63.4	0.01
Cosmic Prox	62.5	0.002

In Progress

Backup Slides

T2K Differential Cross Section