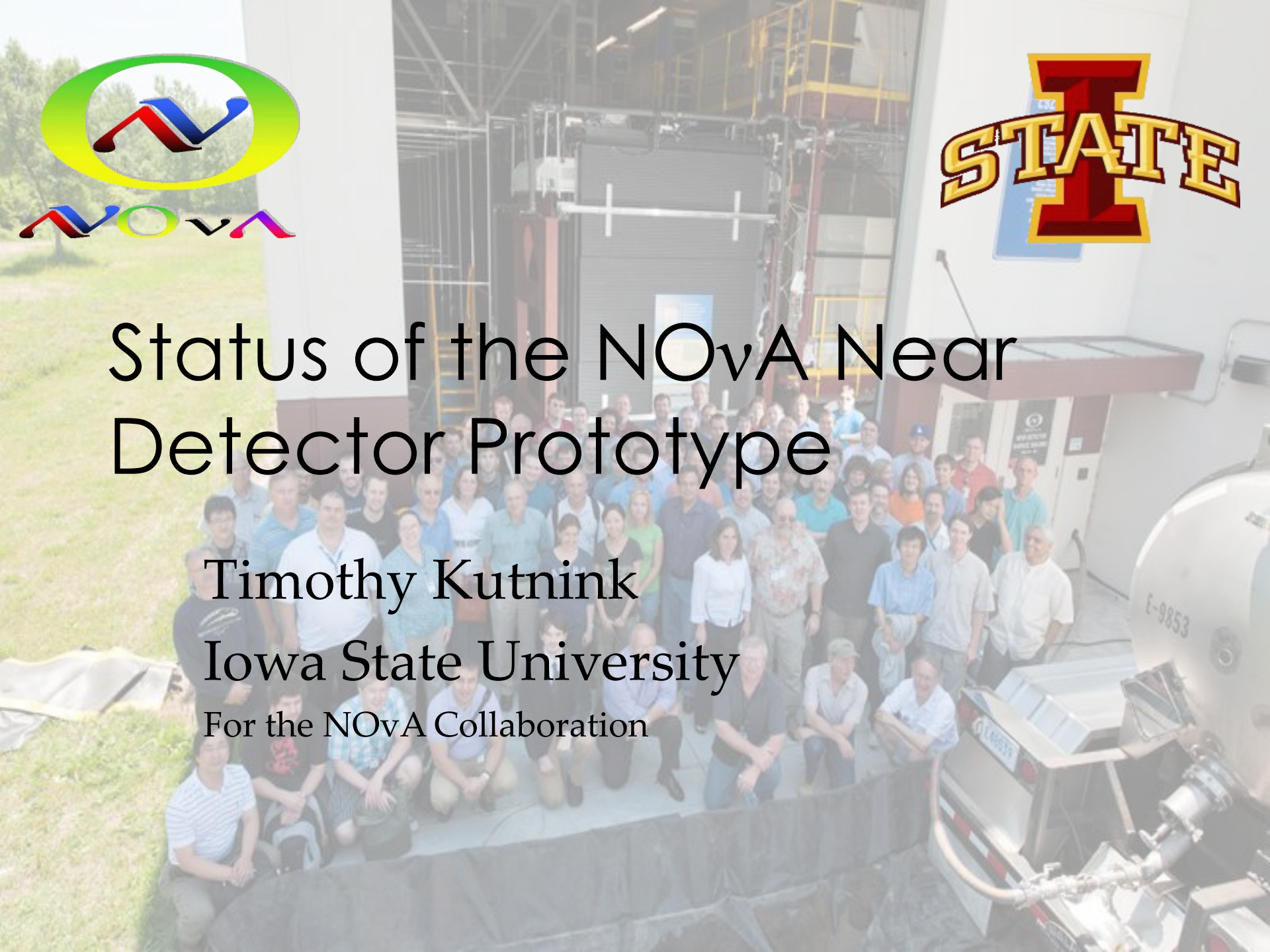


Status of the NOvA Near Detector Prototype

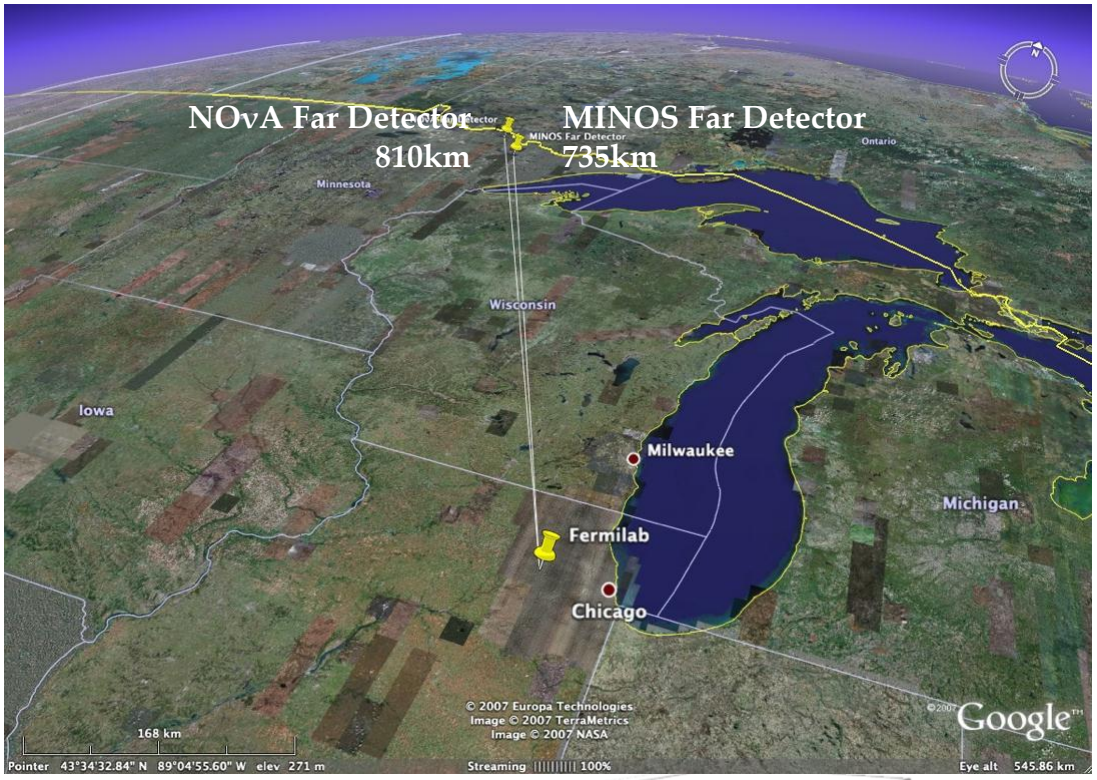
Timothy Kutnink

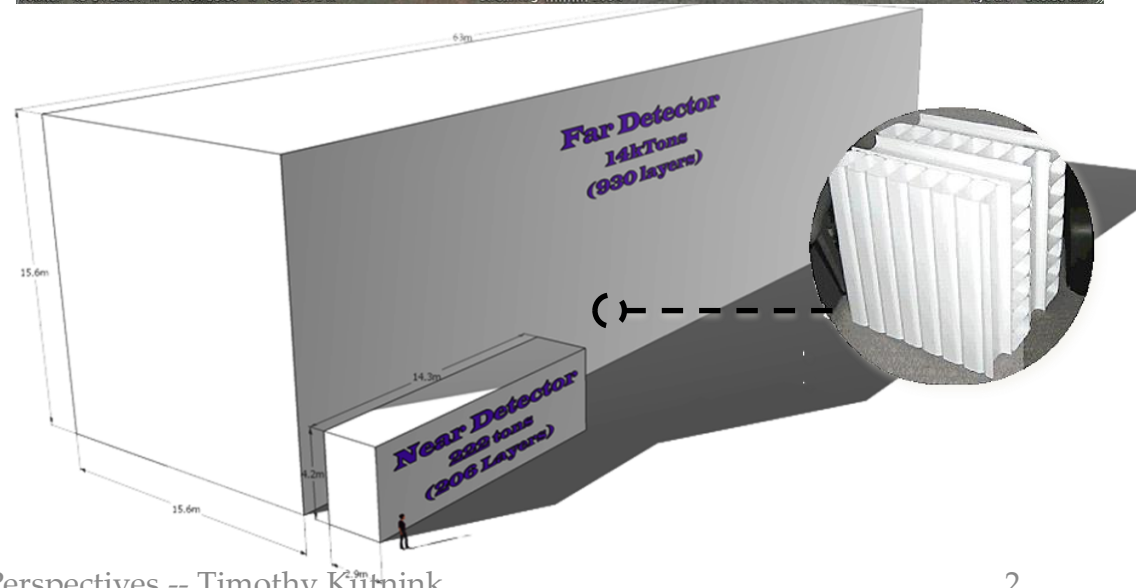
Iowa State University

For the NOvA Collaboration

NOνA

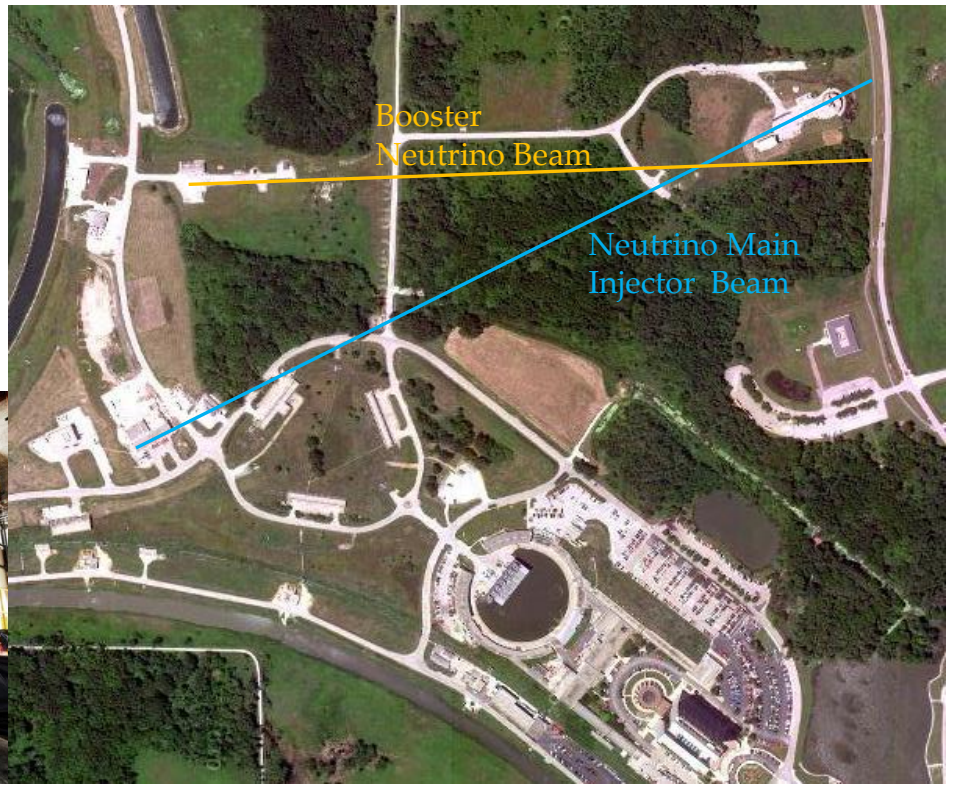
- NuMI Off-axis ν_e Appearance (NOνA)
- NOνA is a long-baseline experiment designed to:
  - Measure θ_{13} and δ_{CP}
  - Determine the mass hierarchy
  - Make precision measurements of θ_{23} and Δm^2_{32}
- NOνA's Near and Far detectors are 14 mrad off-axis of the NuMI beam:
  - PVC extruded into cells filled with liquid scintillator
  - Light is collected by wavelength shifting fibers connected to photo sensor
  - 360000 cells (Far) 16000 cells (Near)

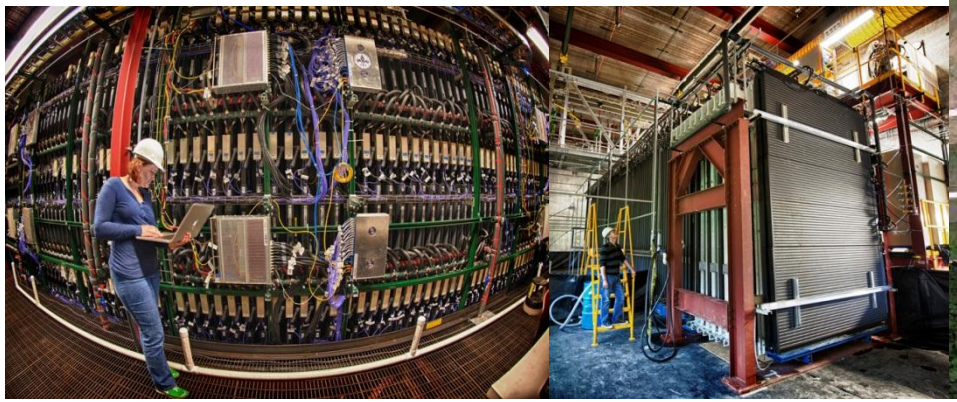




NOvA Near Detector Prototype

- The NOvA Prototype detector (NDOS) located on the surface at Fermilab.
- Uses the same materials and technologies as the Near and Far detectors.
- The NDOS is ~6.1˚ off the NuMI beam axis and on the Booster beam axis.

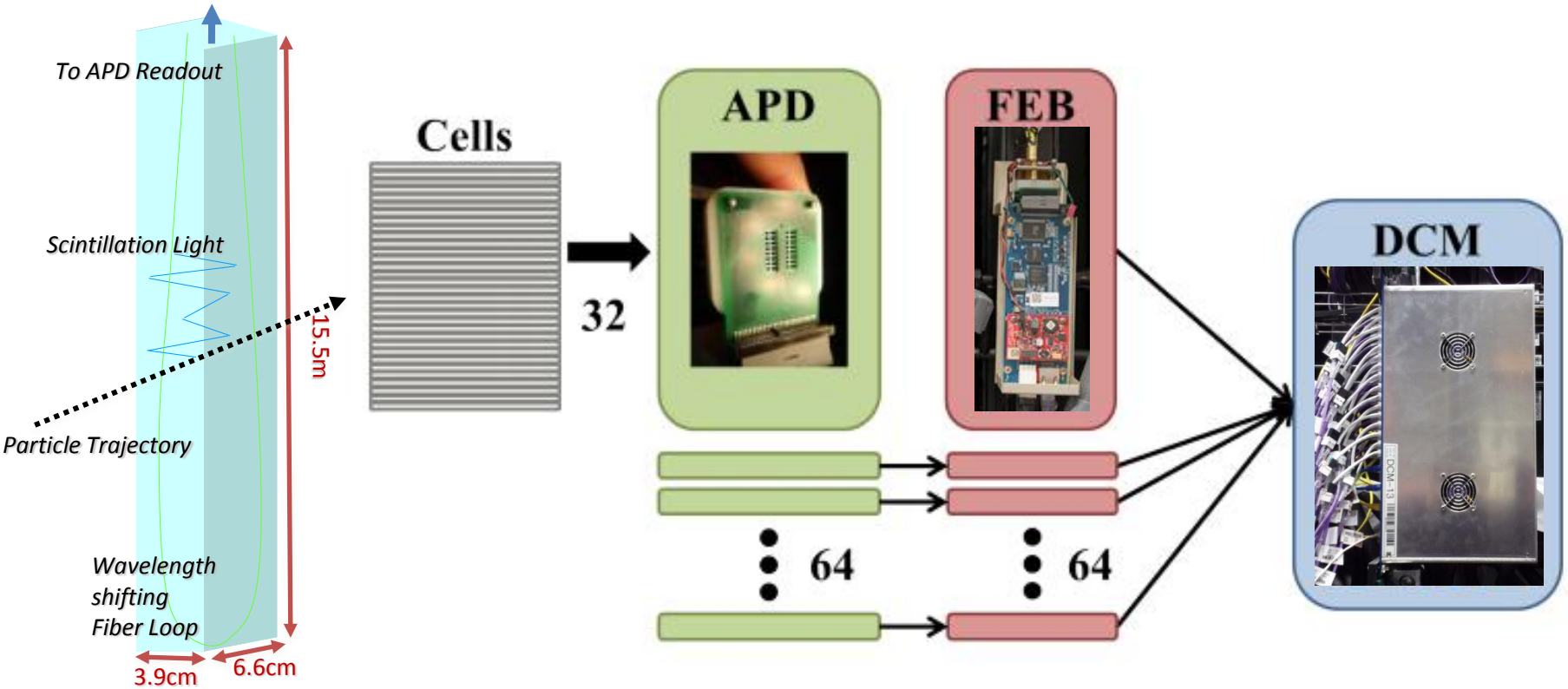




- Goals:
  - Testing assembly techniques for the Near and Far Detectors.
  - Installing, operating, testing the NOvA electronics and DAQ.
  - Developing reconstruction and calibration methods, and physics analyses.

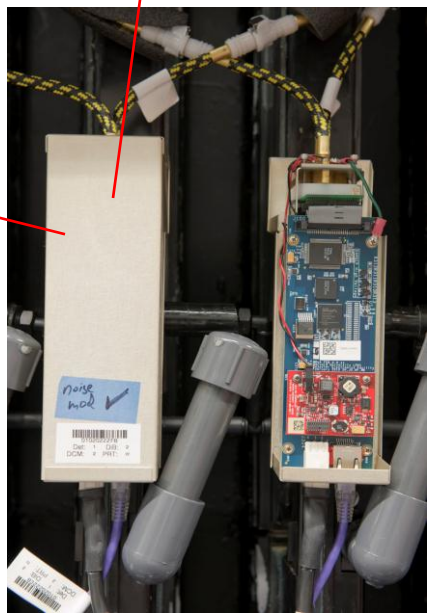
The Detector Technology

- Light is generated by charged particles and collected by wavelength-shifting fiber.
- Each avalanche photodiode (APD) reads out 32 cells.
- Each APD is connected to a Front End Board (FEB).
- The FEB digitizes signal, sends it to a Data Concentrator Module (DCM).
- Each DCM can read 64 FEBs. The NDOS uses 11 DCMs.

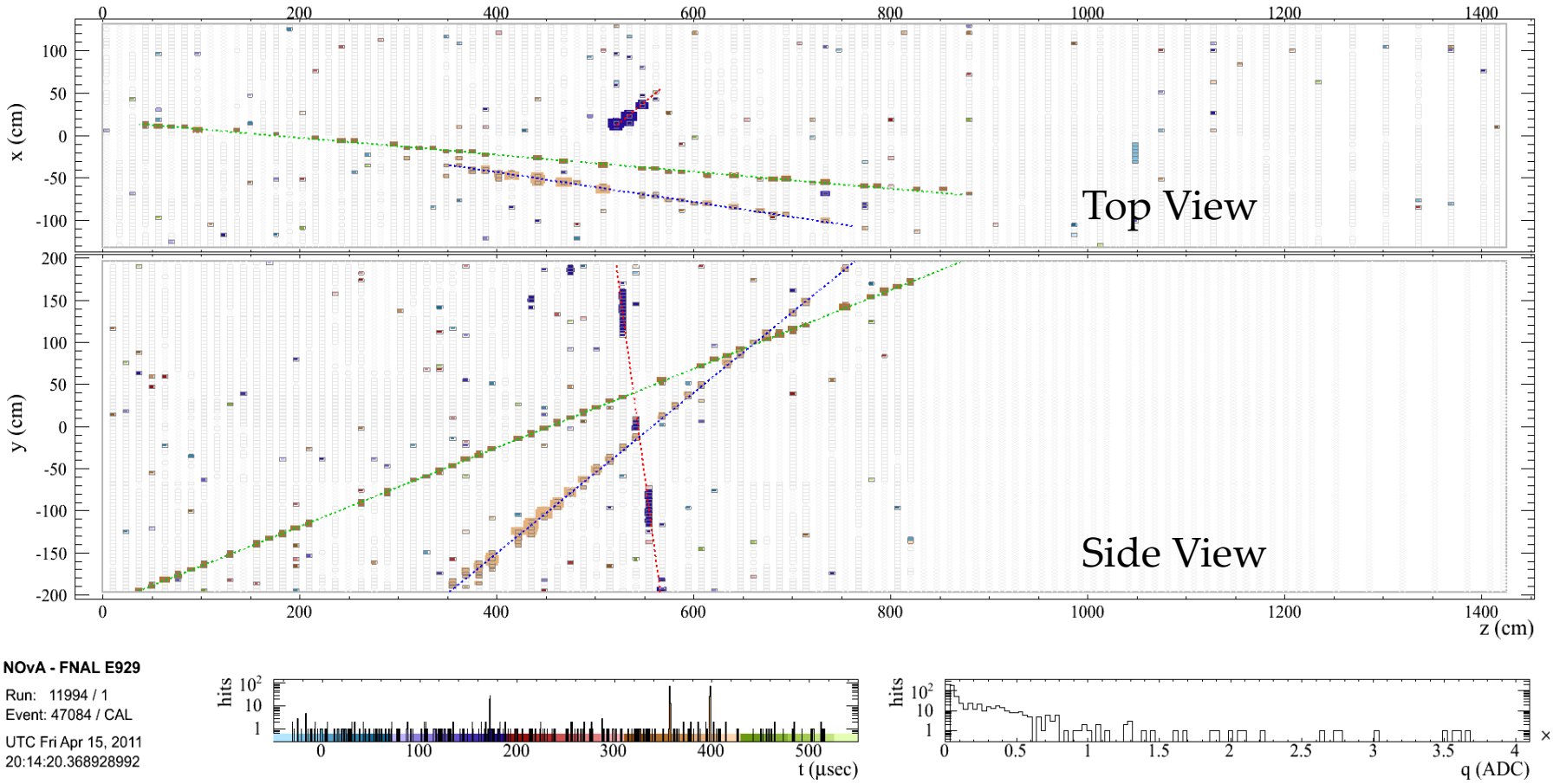


Assembly and Operations

- Used prototype detector to test assembly techniques and detector parts:
  - Redesigned module manifolds and changed module pressure testing procedure to avoid potential cracks.
- Gained experience in qualifying and filling scintillating oil.
- Tested APDs in realistic operating conditions:
  - Developed surface coating for bare APDs to protect the silicon surface from potential contact with contaminants.
  - Added an active air drying system to keep out condensation due to cooling.

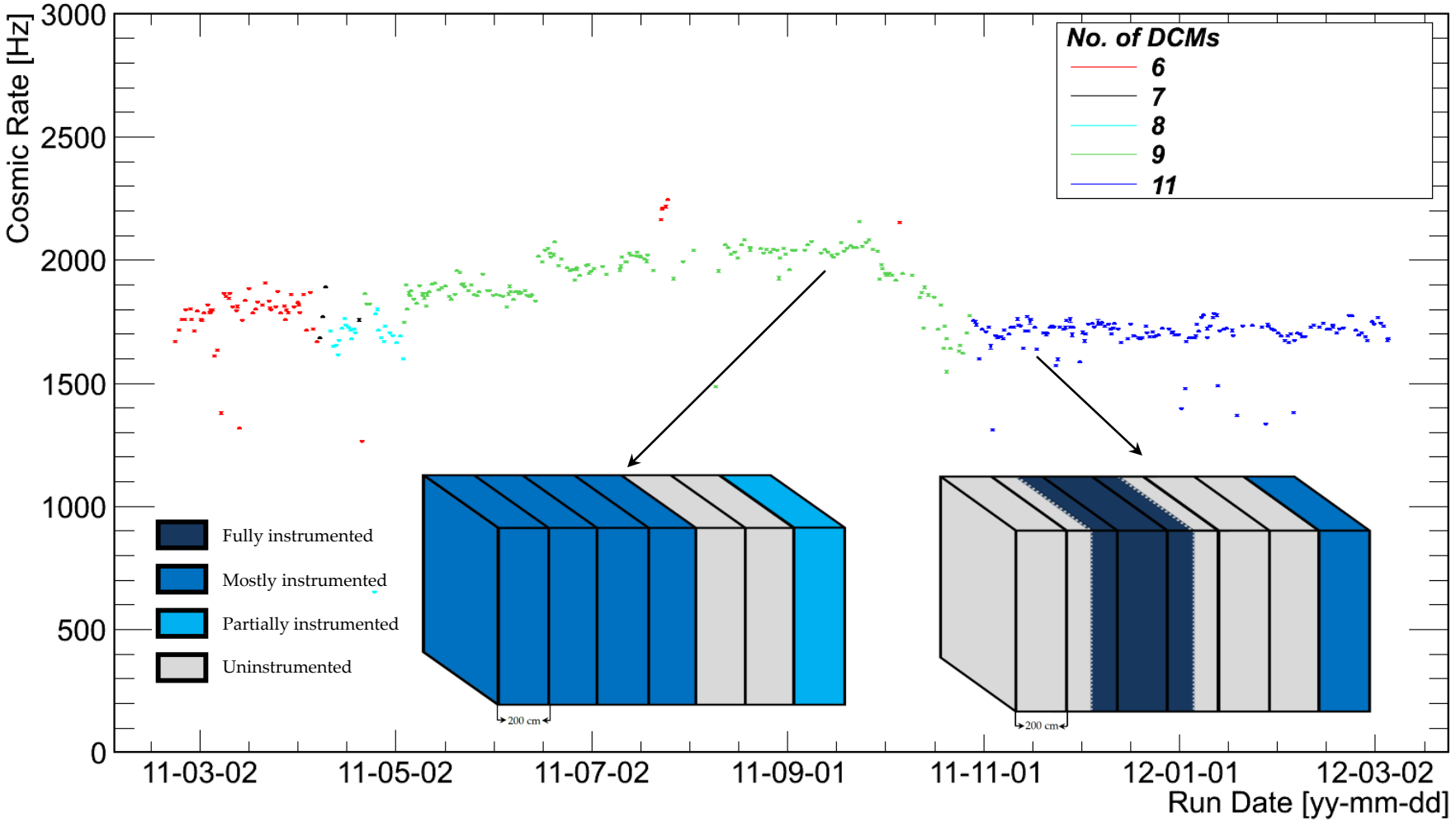


Cosmic Ray Muon Data



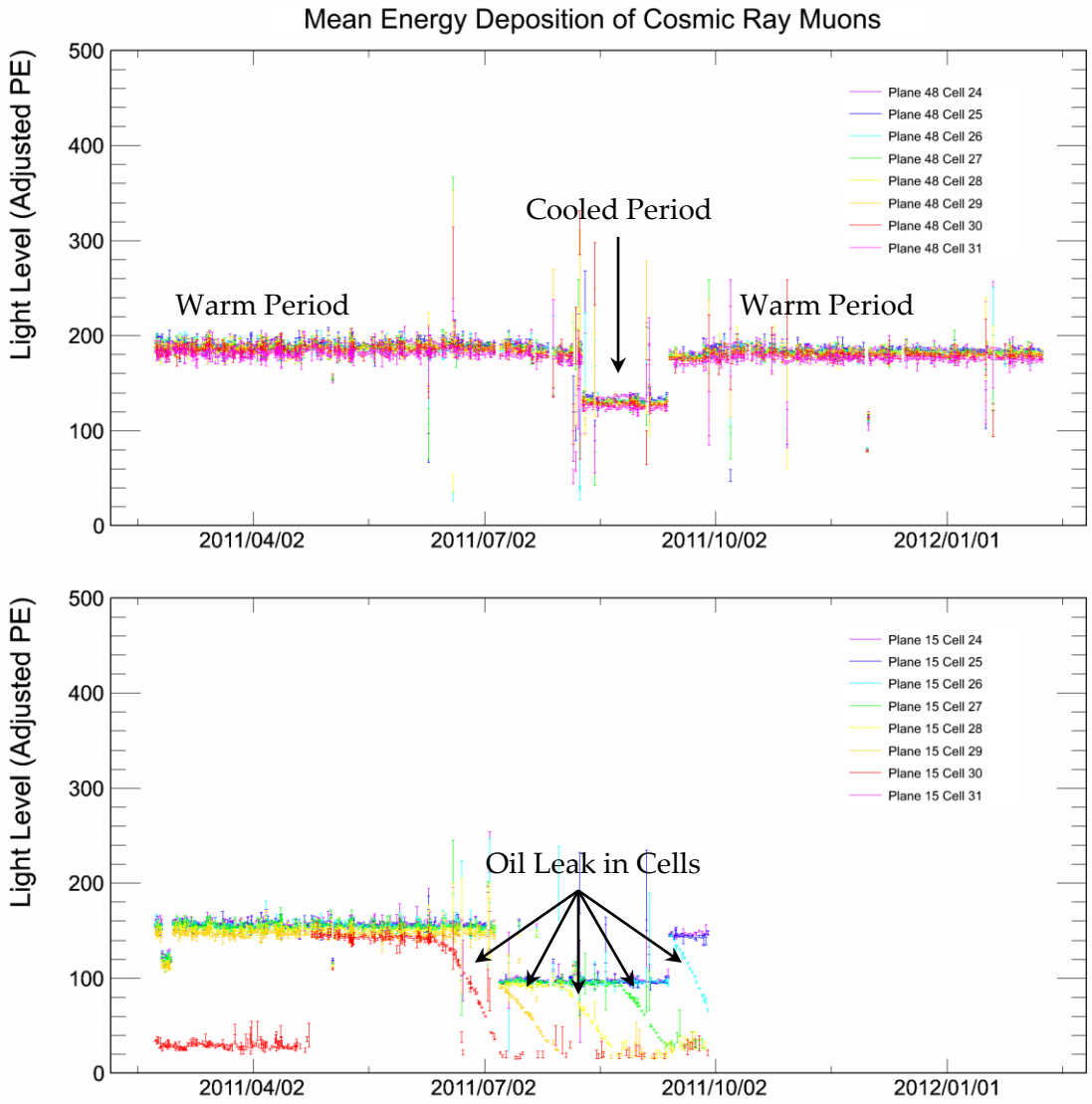
- Reconstructed cosmic ray muons are used for calibration and commissioning.
- Efficiency of cosmic tracker: >98%.

Cosmic Ray Muon Rate



- Raw Expected Rate: 1.95 kHz = 1 $min^{-1}cm^{-2}$ (PDG – expected rate at surface of Earth) x $1.17x10^5$ cm^2.
- Variation in early data reflects changes in the configuration of the detector. Completed configuration results in stable rate.

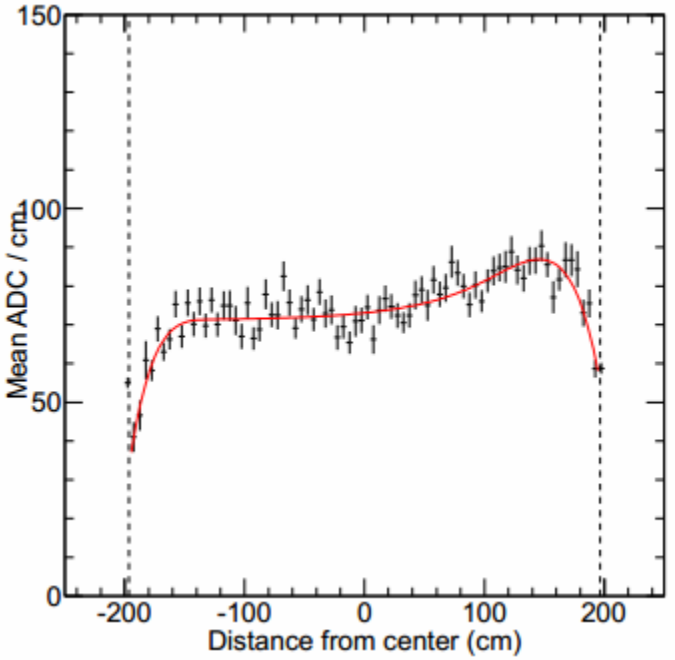
Light Level Stability

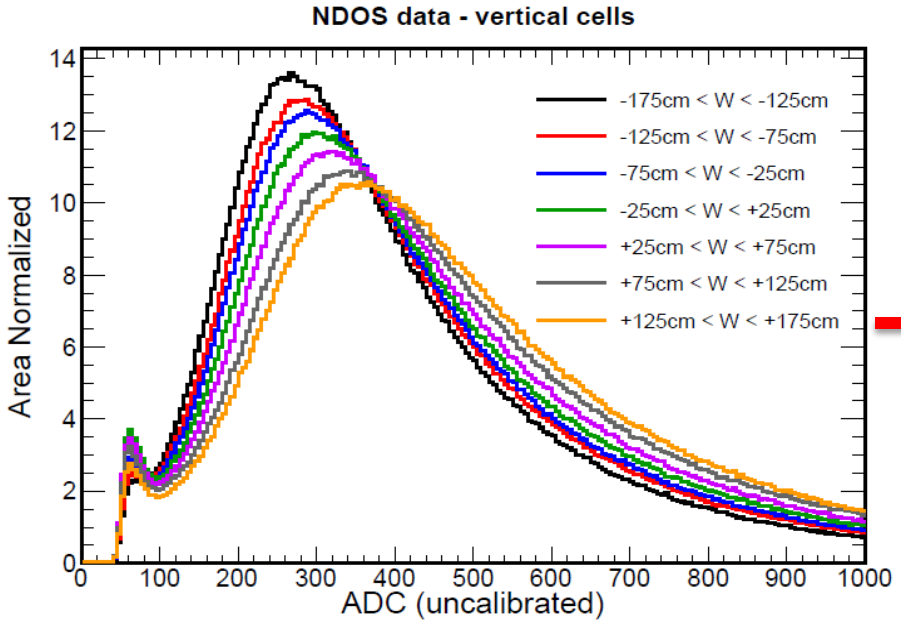


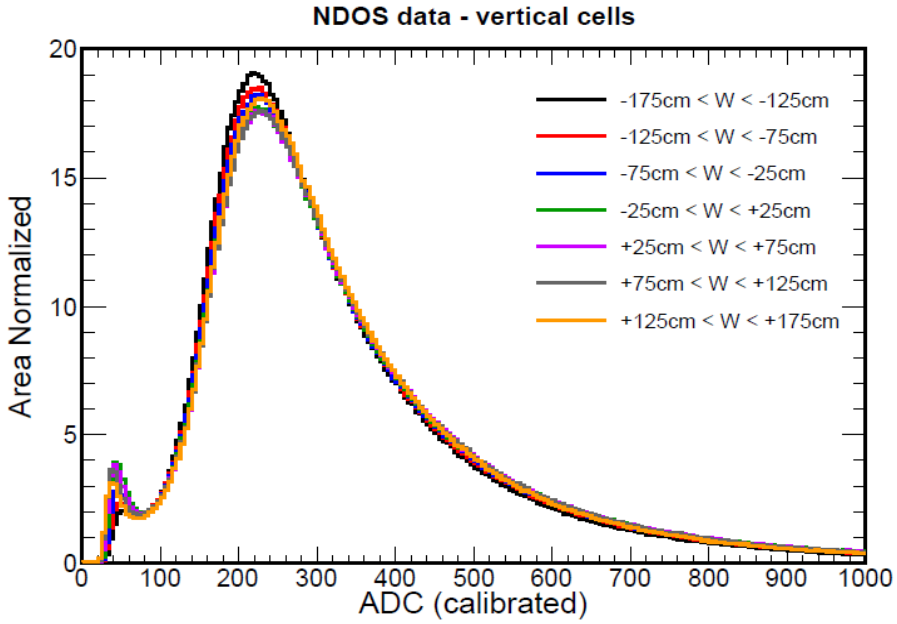
- Mean energy deposition of cosmic ray muons allow us to study the light level stability per cell.
- Light levels are uniform over time.
  - Changes on groups of cells are due to special running conditions with cooled APDs.
  - Cell by cell change shows an oil leak in a plane.
- These studies will be used in commissioning and calibration of the Near and Far Detectors.

Attenuation Calibration

- Position dependence of cell response (light attenuation, etc.).
- W is the position along the cell length.
- Using data from entire run period.

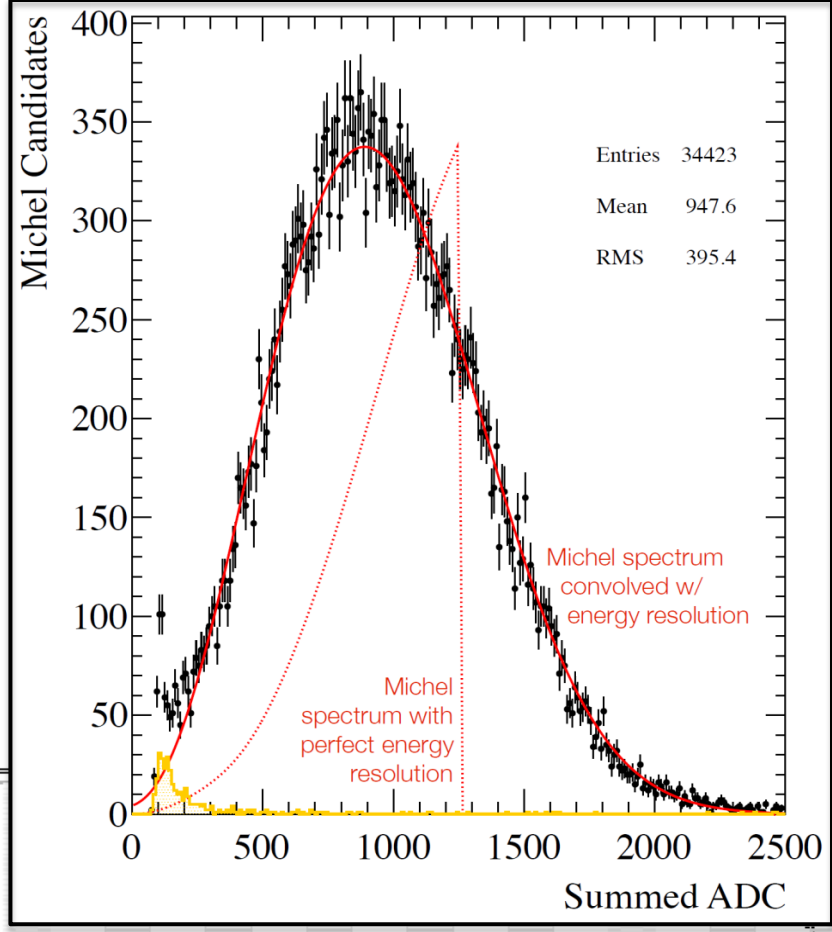


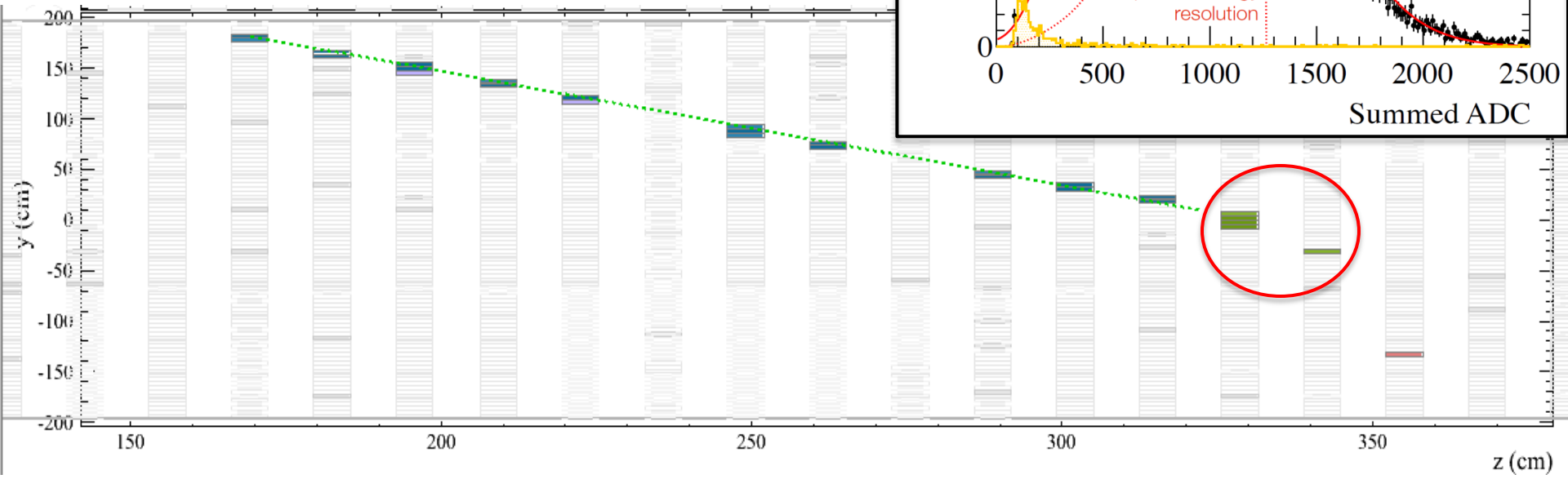




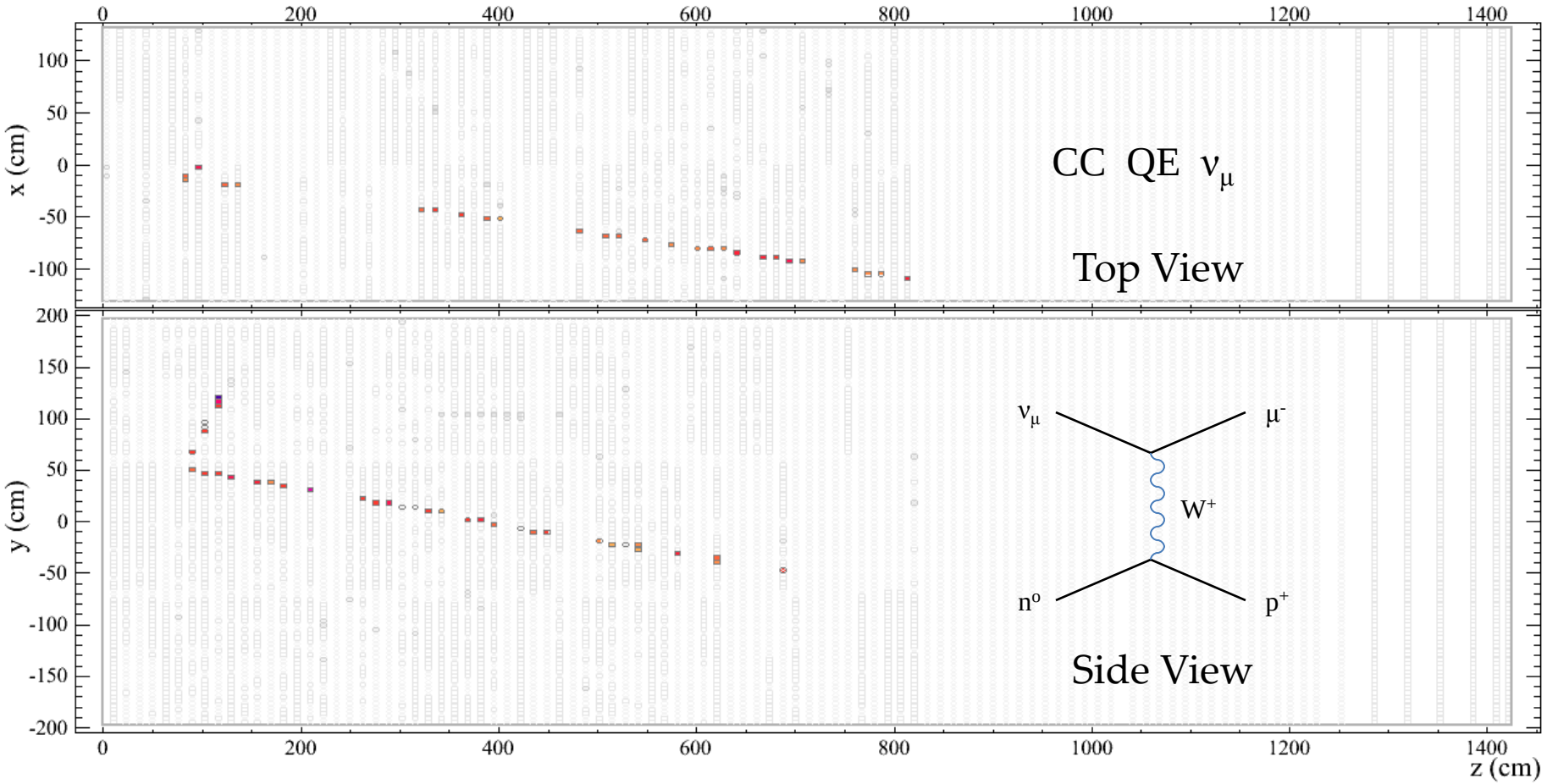
Michel Electrons

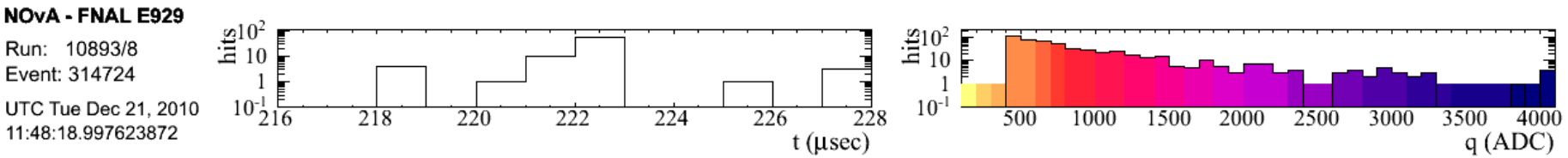
- Used as a part of the energy calibration of the detector.
- Found at the ends of contained muon tracks.
- Typically has about 4 hits in the interaction.



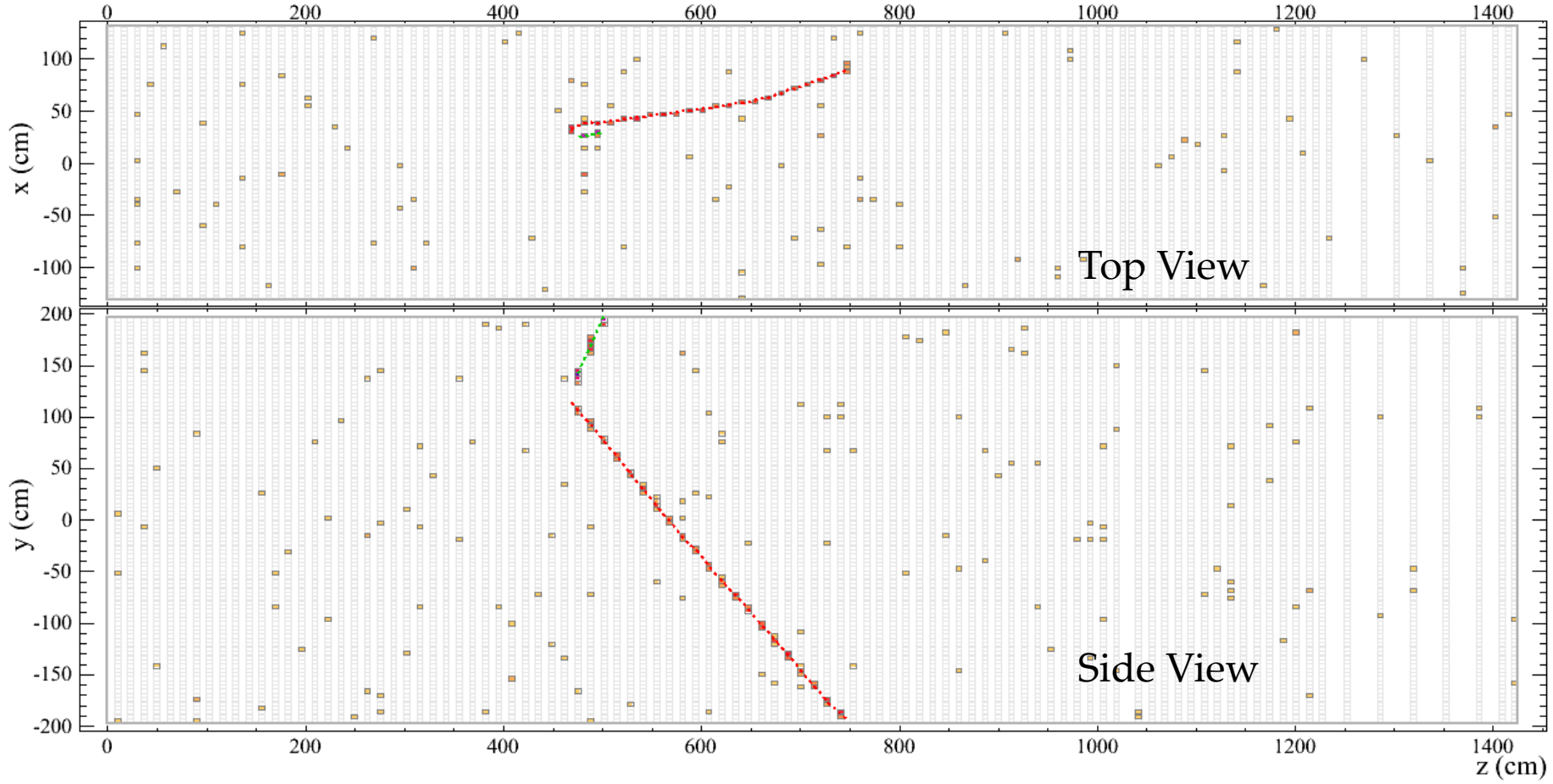


Neutrino Candidate – Data

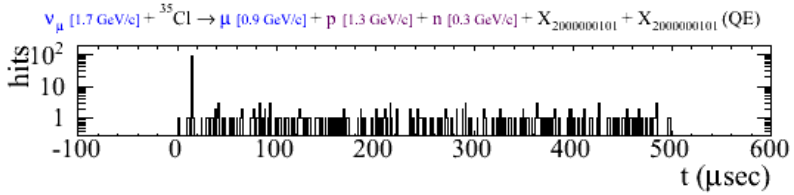


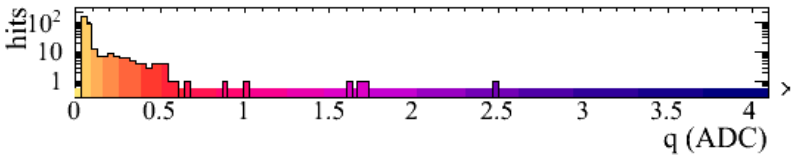


Reconstructed Simulated ν_μ Event

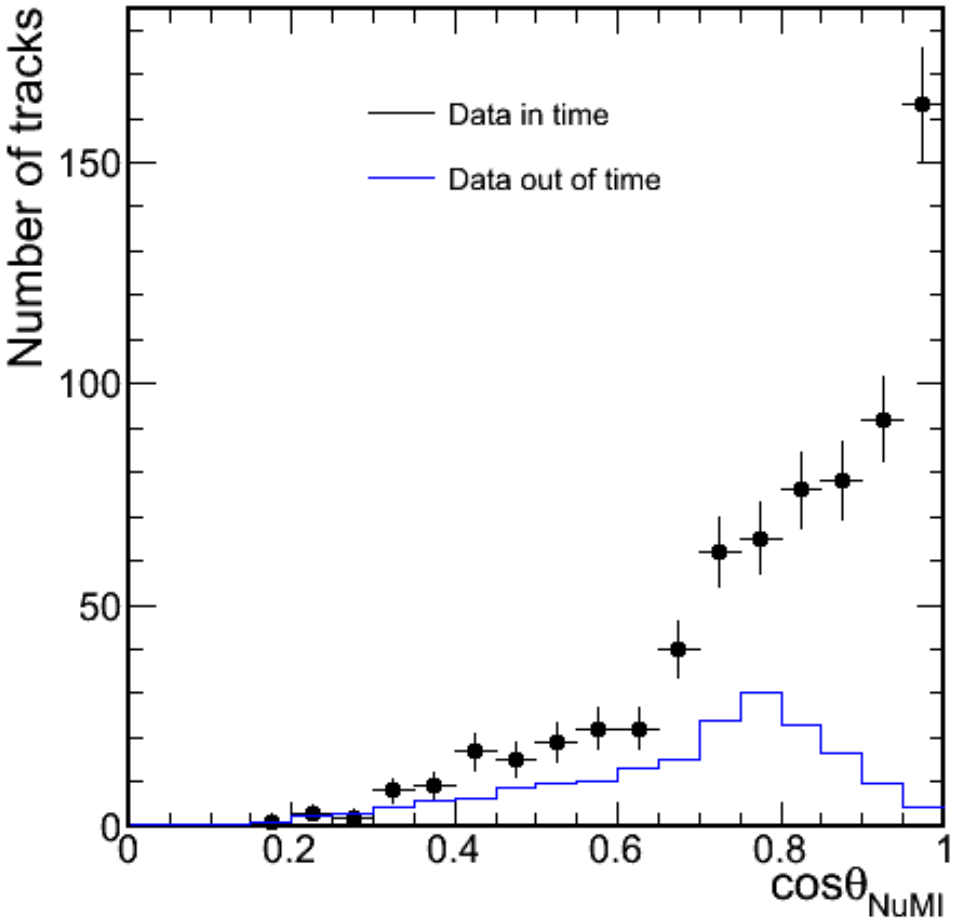


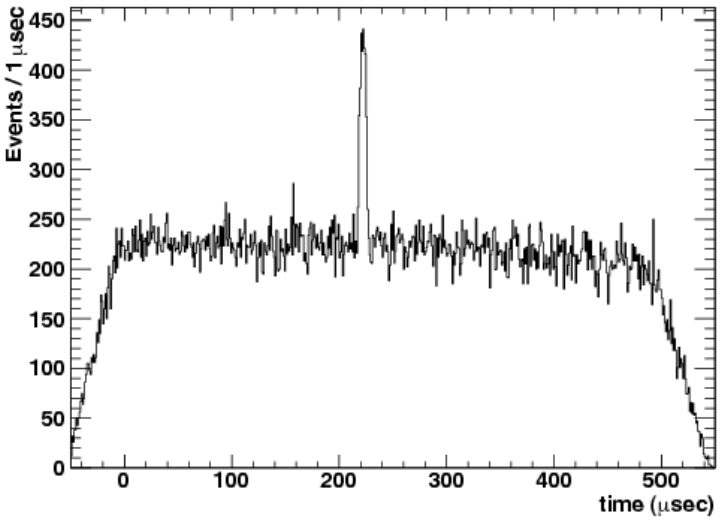
NOvA - FNAL E929
Run: 1 / 0
Event: 1685 / NuMI
UTC Thu Jan 1, 1970
00:00:0.835065408





Neutrino Data from the NuMI Beam

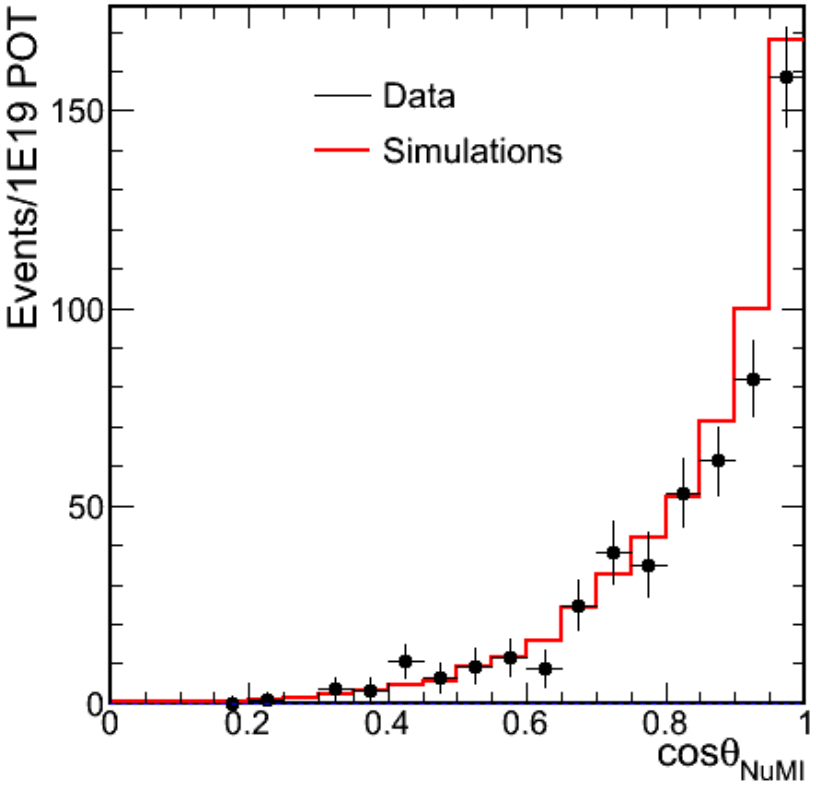


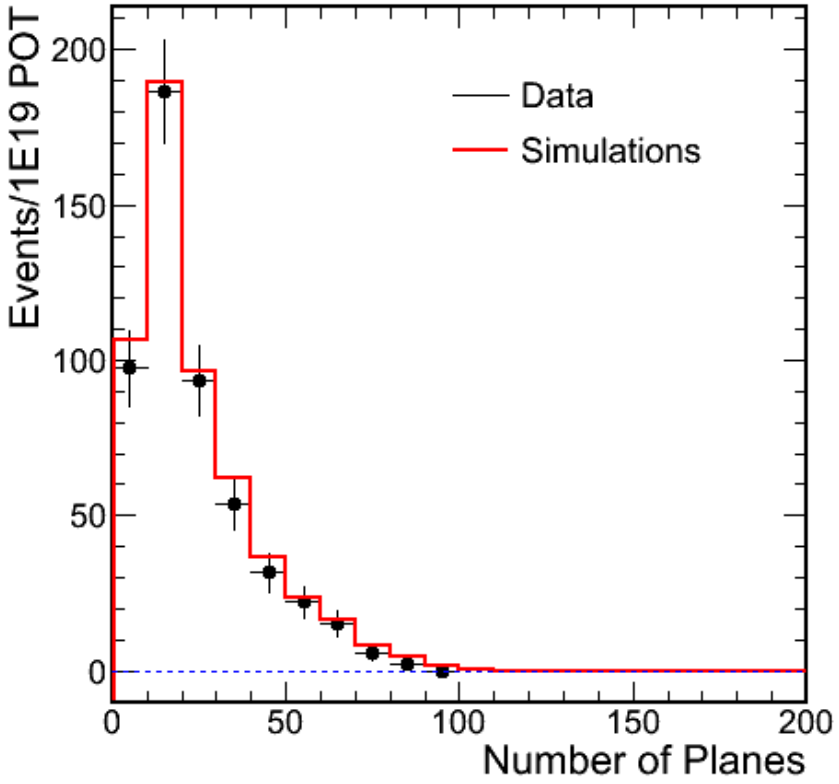


- Data trigger for the NuMI beam is 500 μsec window.
  - The neutrino spill time is 10 μsec.
  - The peak is seen at 222 μsec.
- A time window of 10 μsec is applied to define the data in time.
- The angle between the track and the NuMI beam shows a clear peak for the data in time.
- The data corresponds to 9.6×10^{18} protons on target (POT).

Neutrino Candidates from the NuMI Beam

- After subtracting the background from the in-time data, we obtain neutrino candidate distribution.
- Comparisons to simulated neutrinos matched well in direction and length.





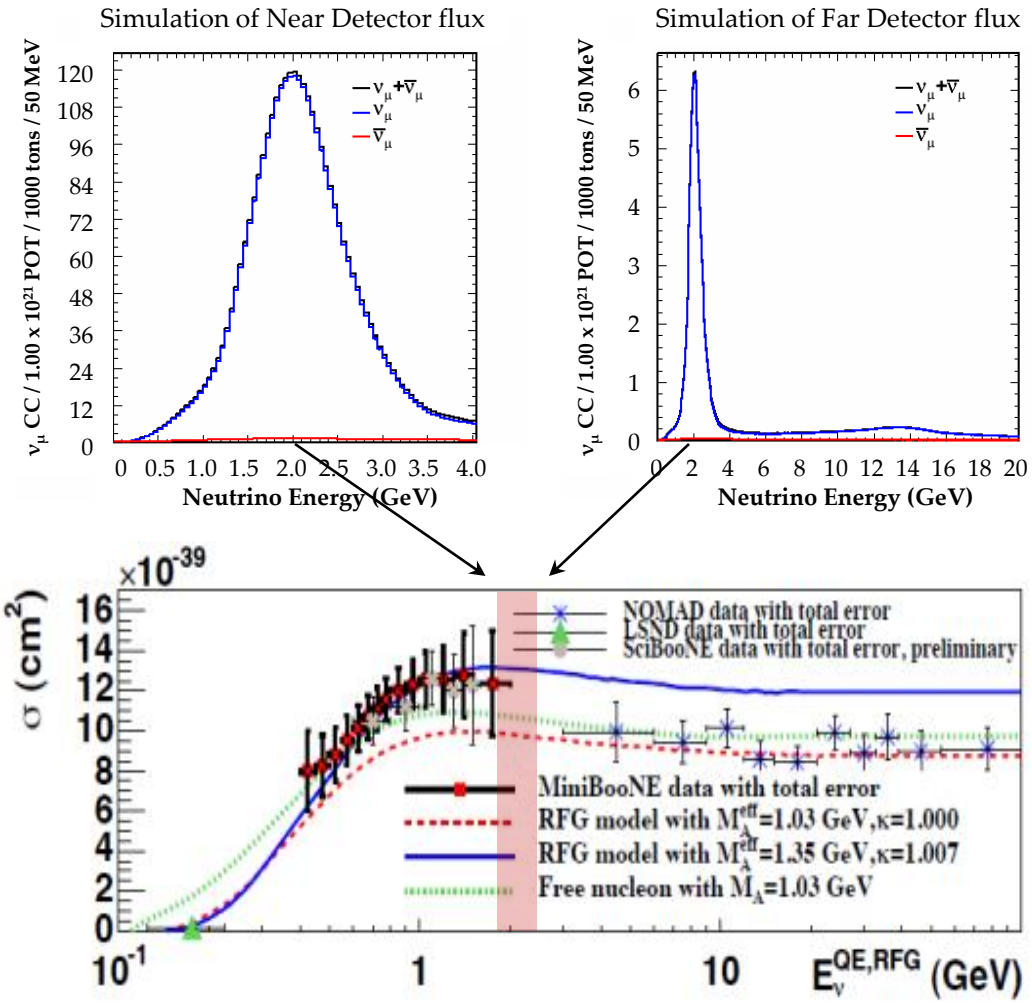
Conclusions

- The NDOS finished collecting neutrino data on 1 May 2012.
- We are continuing to test the stability of operations with cosmic ray muon data.
- We are making progress towards developing calibration and reconstruction methods, as well as physics analyses.
- NOνA will start taking data in April 2013 with 1/3 of the detector constructed.
- We look forward to exciting results!
- Please see: M. Betancourt "**Status of Quasi-elastic Studies in the NOvA Near Detector Prototype**" at 16:30

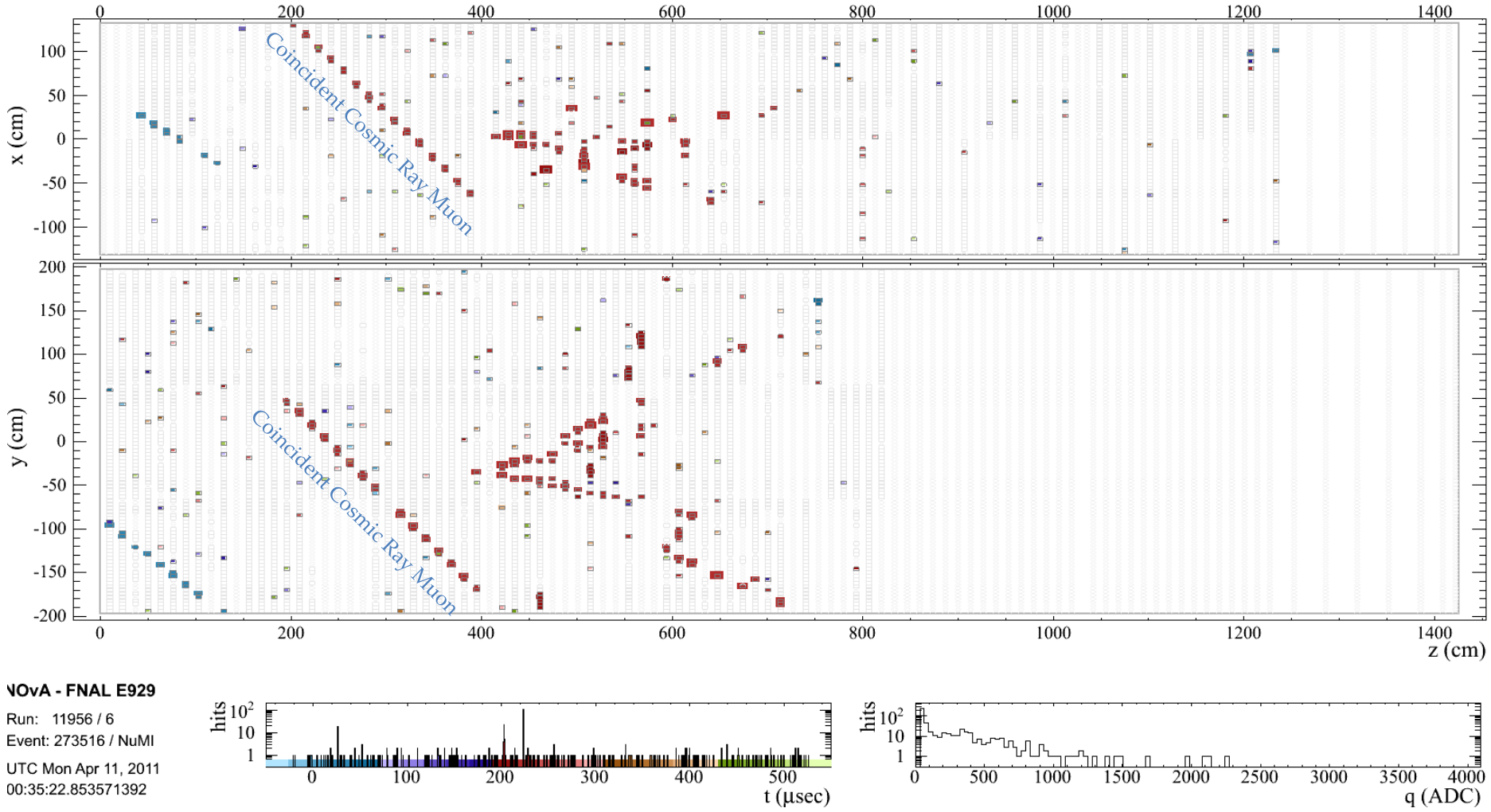
Back-Up

NOvA Quasi-Elastic Studies

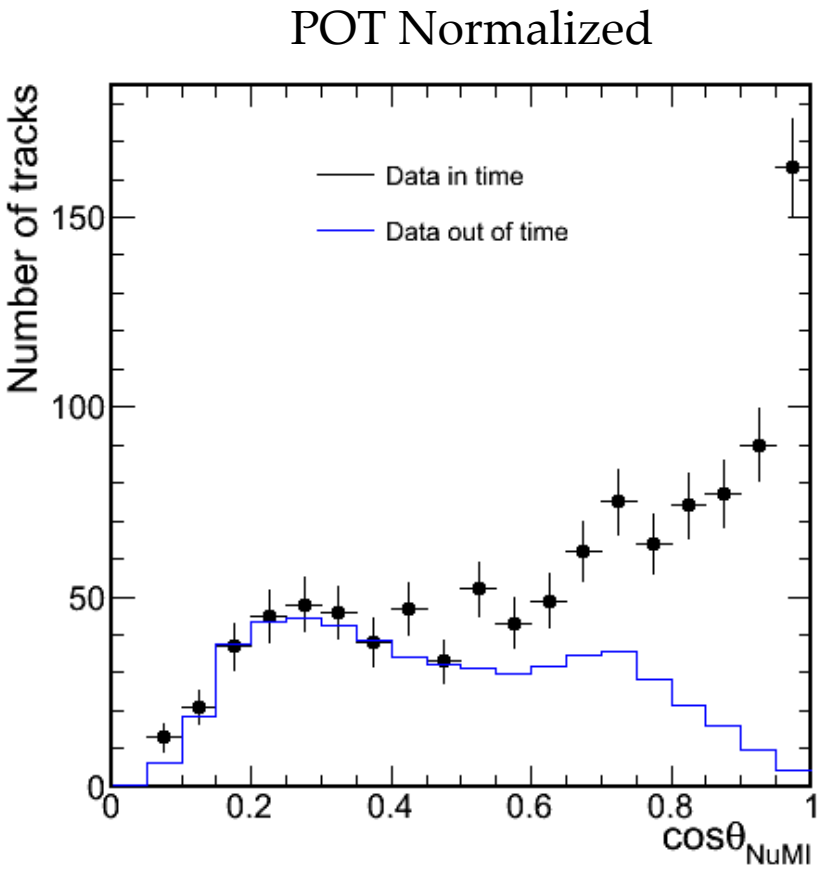
- The neutrino energy spectrum at the NOvA Near and Far Detectors is peaked at 2 GeV.
- The quasi-elastic cross-section at 2 GeV is not well known.
  - Measurements from other experiments disagree in this region.
- We will use the NOvA Near Detector to measure this cross-section.
  - We are using NDOS data to develop this analysis.



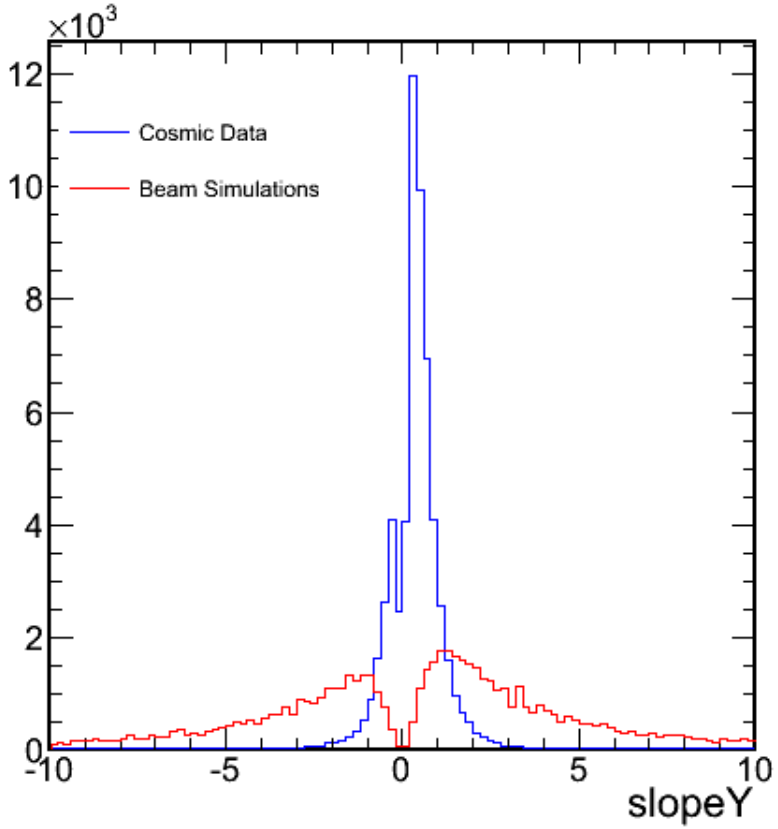
Neutrino Candidate - Data



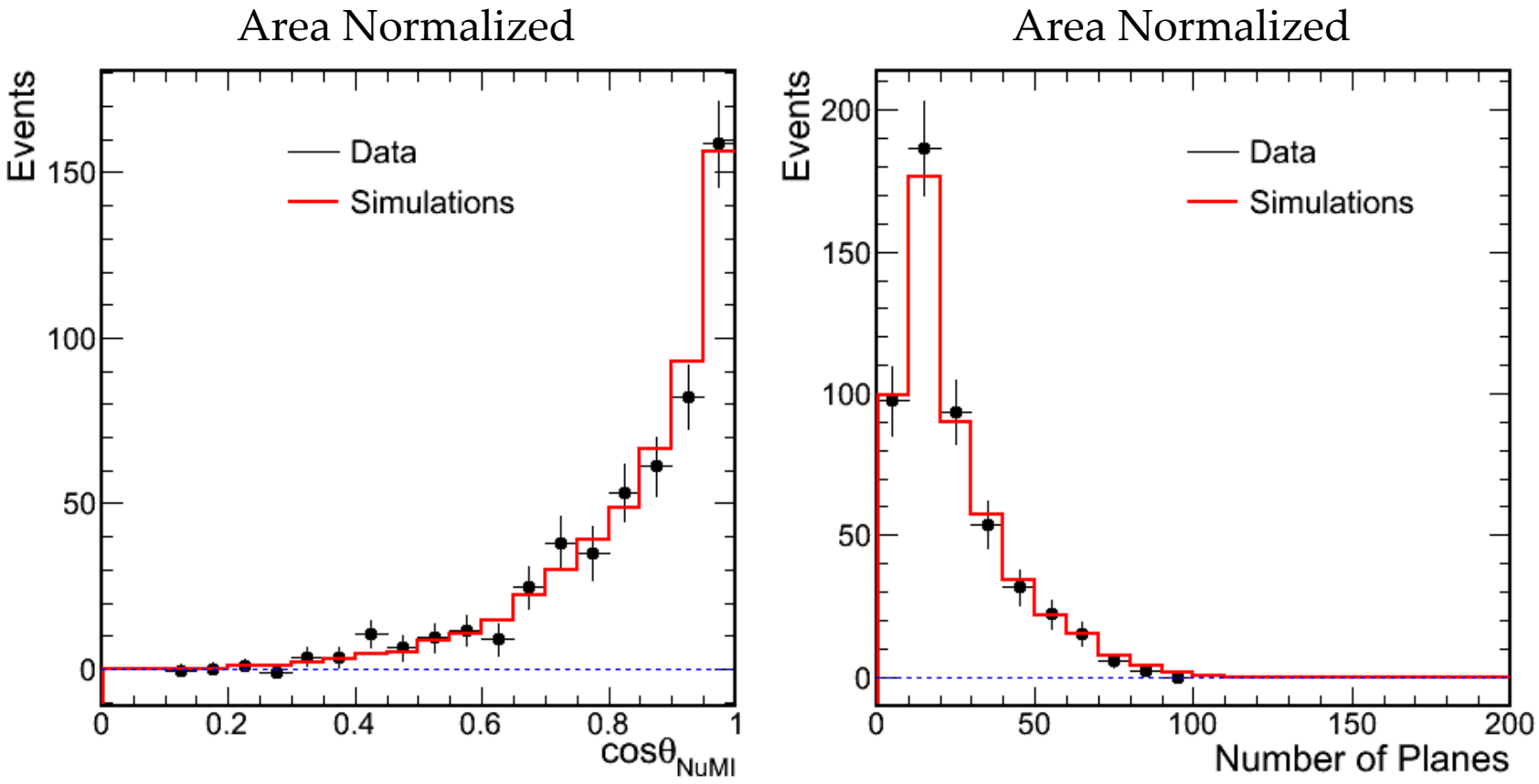
Neutrino Candidates from the NuMI Beam



Neutrino Candidates from the NuMI Beam - Criterion

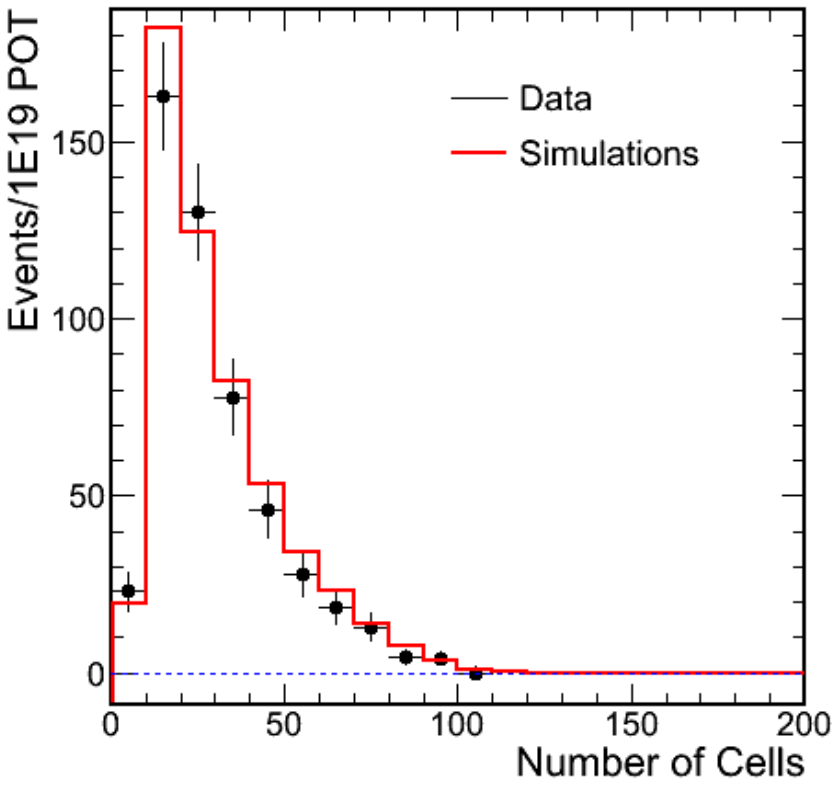


Neutrino Candidates from the NuMI Beam

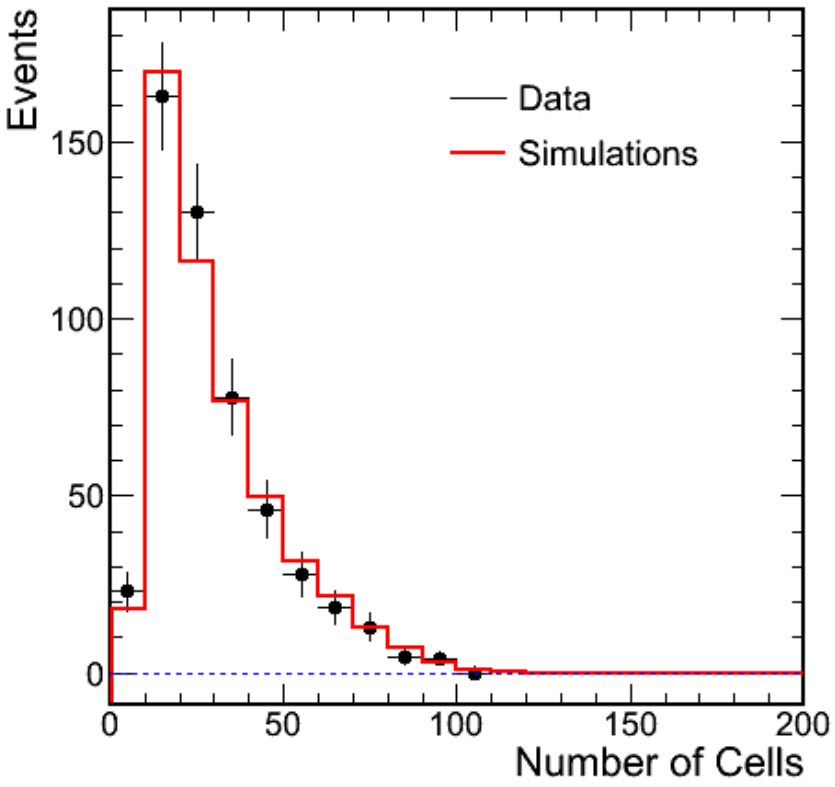


Neutrino Candidates from the NuMI Beam

POT Normalized

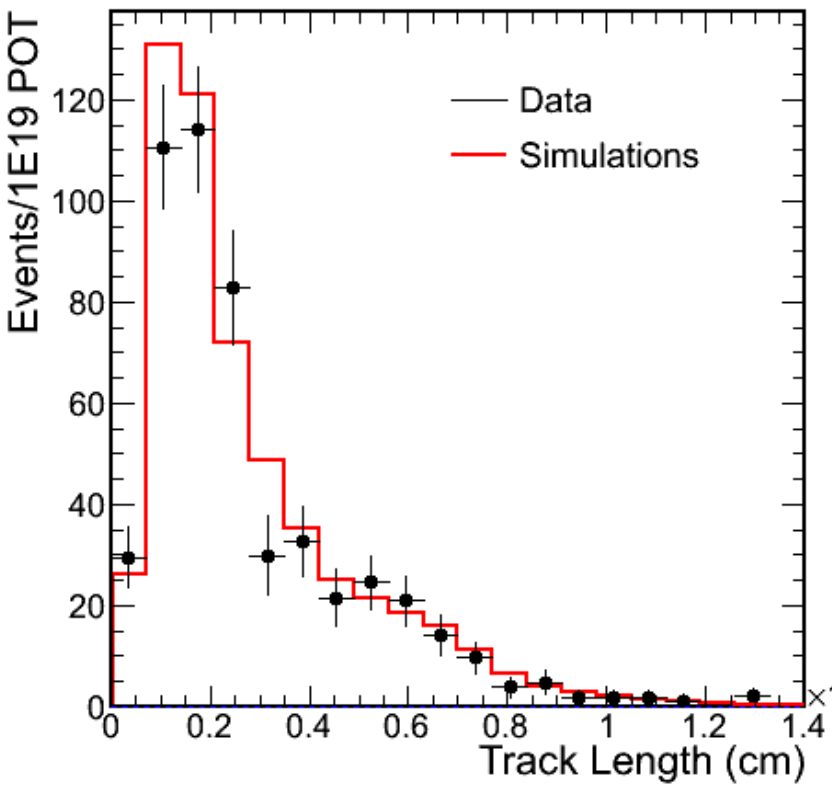


Area Normalized



Neutrino Candidates from the NuMI Beam

POT Normalized



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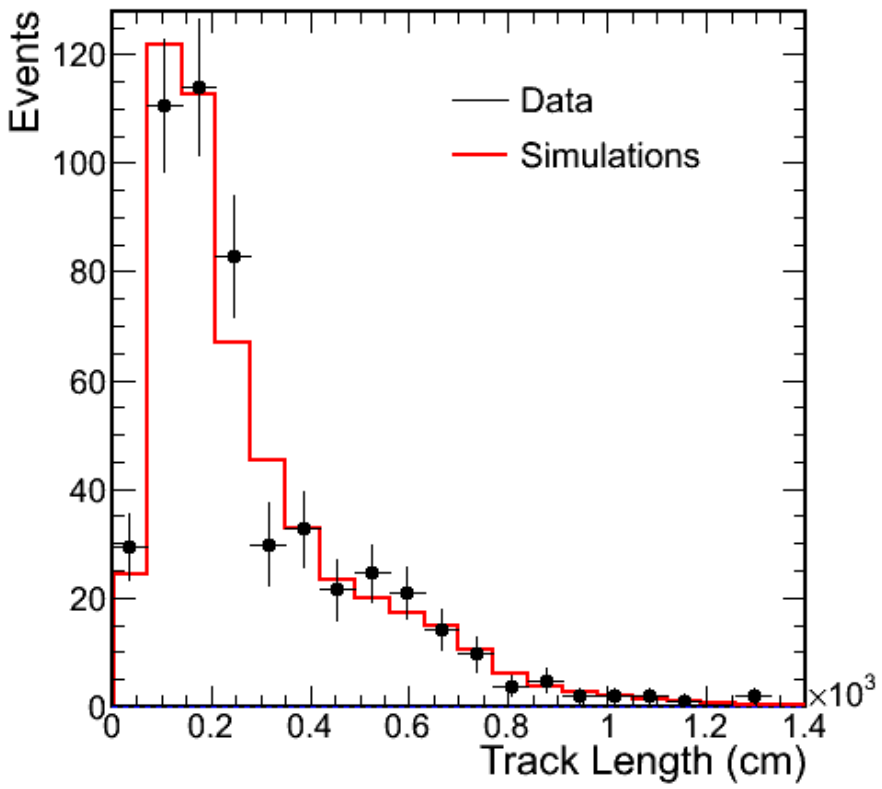
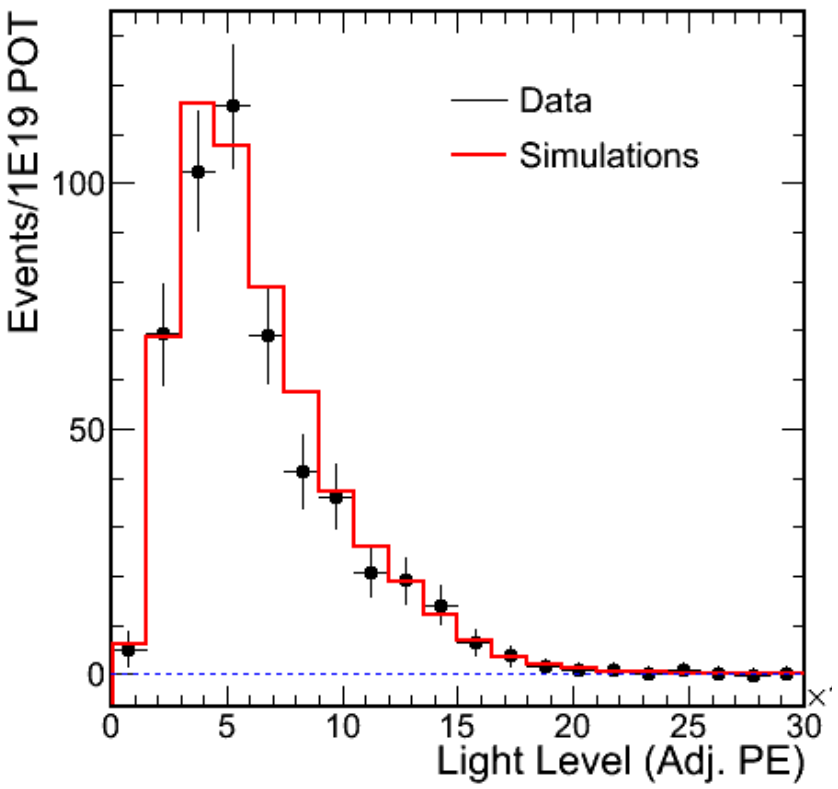
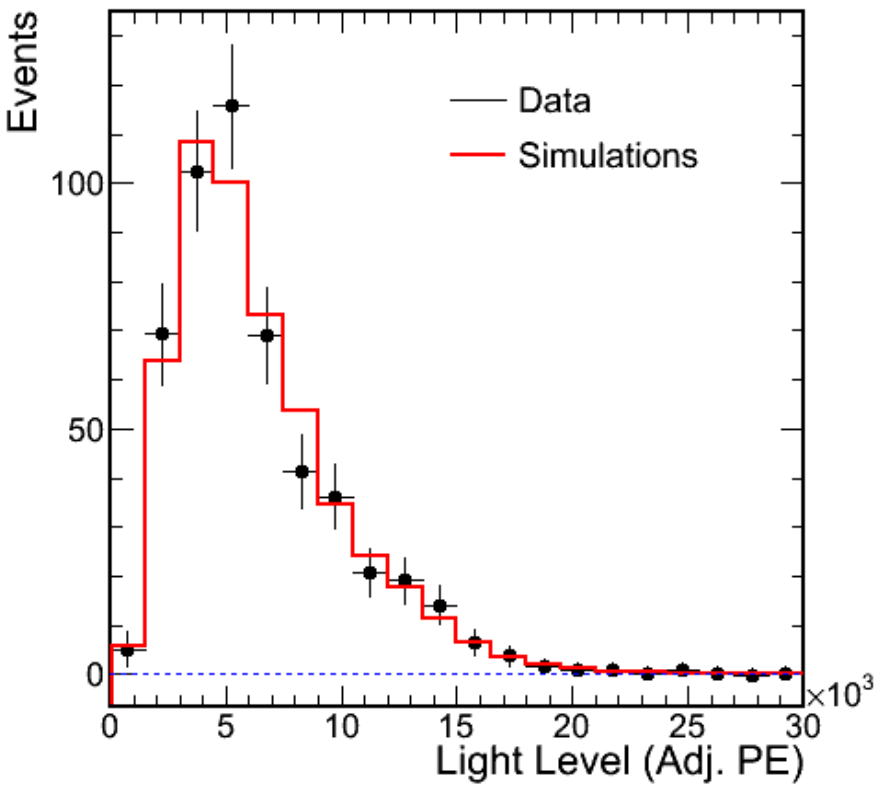


Neutrino Candidates from the NuMI Beam

POT Normalized



Area Normalized



Neutrino Data from the Booster Beam