Long-Baseline Sterile Neutrino Searches in NOvA

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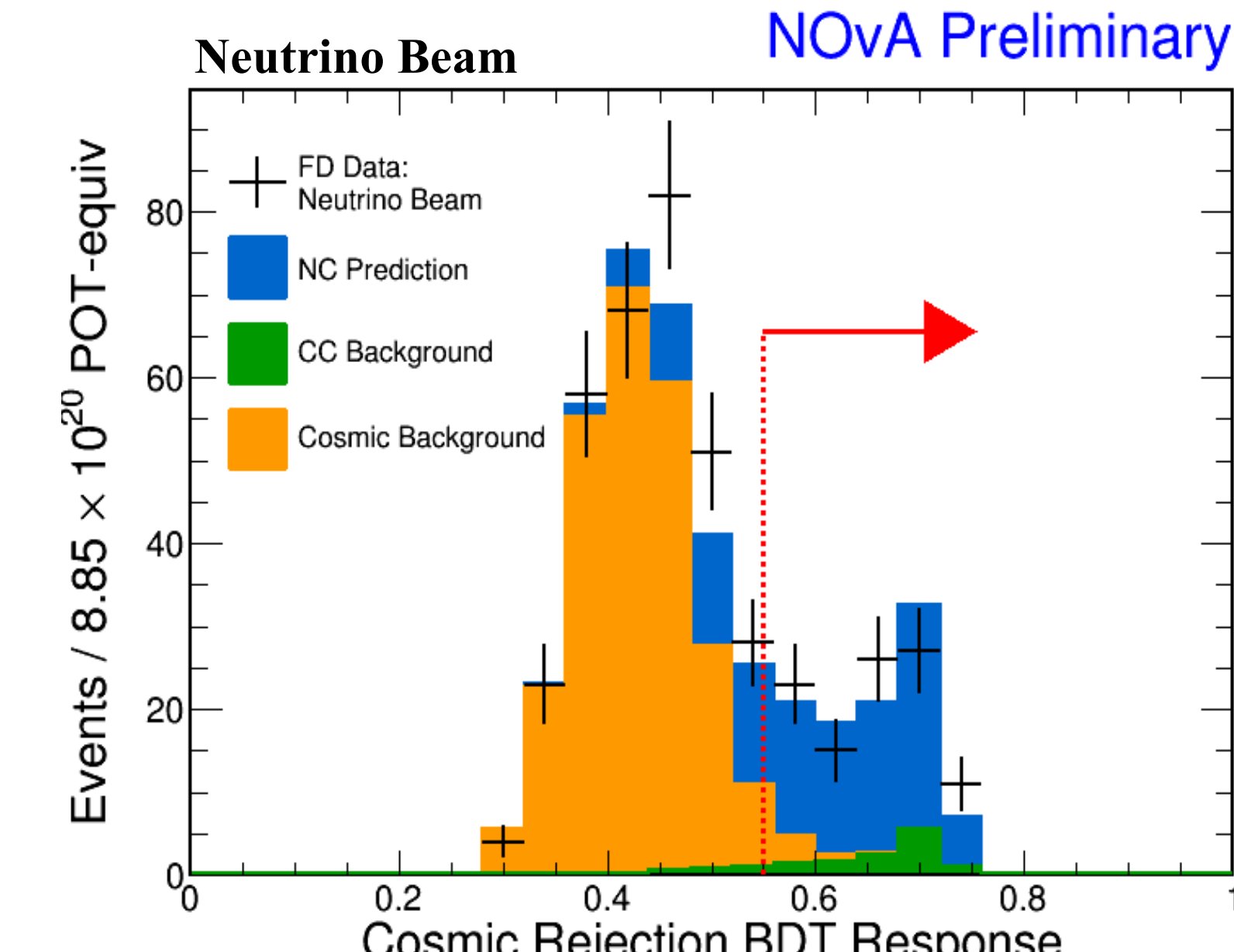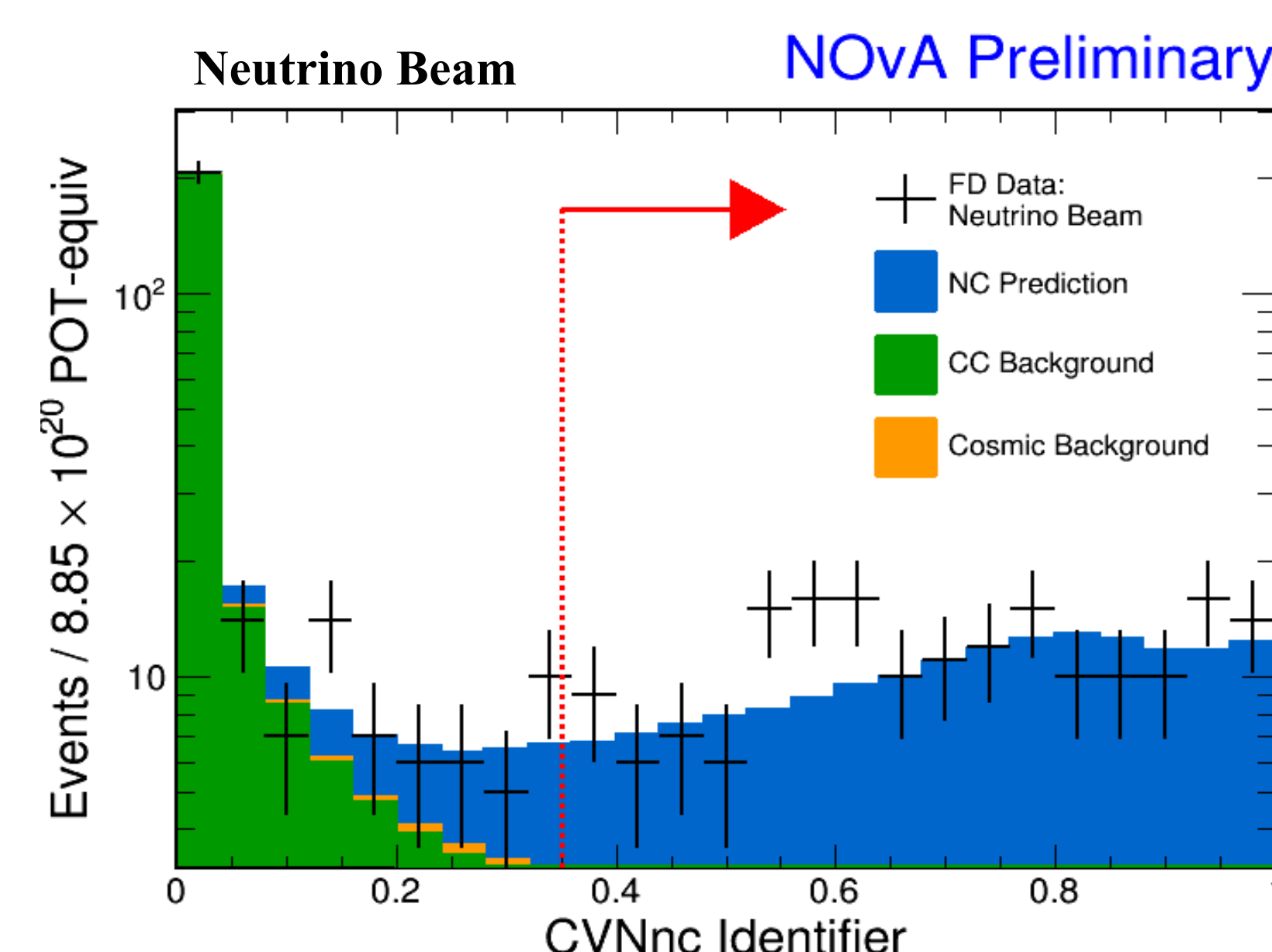
For the NOvA Collaboration

NOvA at a glance

- A long-baseline experiment designed to detect neutrinos from Fermilab's NuMI (Neutrinos at the Main Injector) beam.

- A 14 kt highly active tracking liquid scintillator calorimeter sited 14.6 mrad off the NuMI beam axis at a distance of 810 km in Ash River, Minnesota. which is our Far Detector (FD)

- A functionally identical, 300 ton near detector (ND) sited underground at a distance of 1 km from the NuMI beam source at Fermilab.

- The neutrino flux with energy peak at 2 GeV.

Event display of FD NC neutrino event

Long-baseline sterile neutrino searches in NOvA

- Neutral-Current (NC) interactions are not affected by the three-flavor oscillations.

- Active-Sterile neutrino mixing would reduce the NC interaction rate as sterile neutrinos would not interact in the detector

- **This disappearance of NC events in the detectors is our probe to search for sterile neutrinos.**

We have two analyses,

1. **Neutrino Beam: ND-FD joint fit, using Gaussian statistics based covariance matrix framework with varying Δm^2_{41} considering ND sterile oscillation.**

2. **Antineutrino Beam: Looking for the NC disappearance at the FD, using Near/Far Extrapolation with fixed Δm^2_{41}**

Comparison of a 3-flavor and 4-flavor neutrino hypothesis.

Considering sterile oscillation in the ND enables us to look at wide range of sterile neutrino masses.
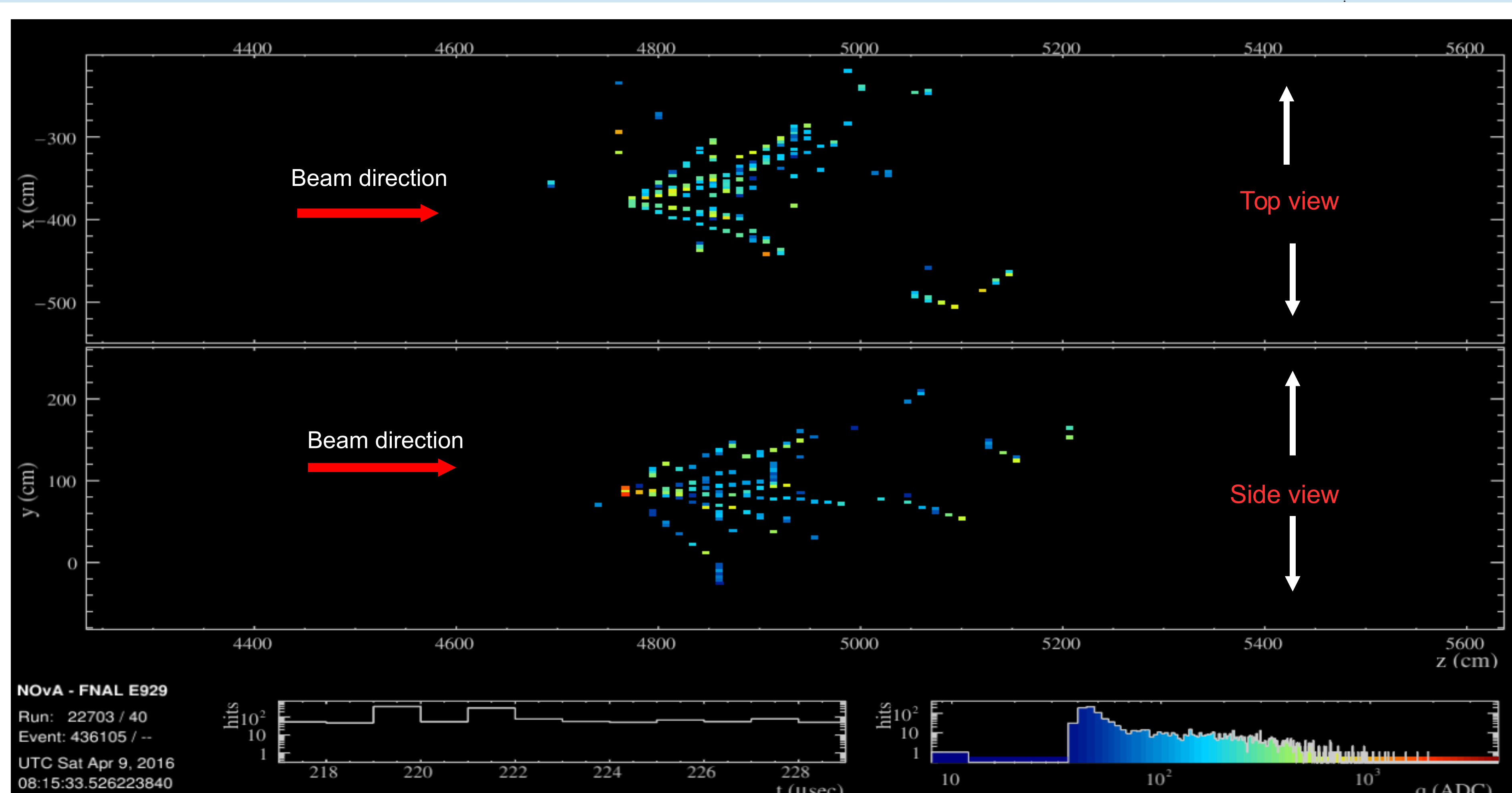
Event selection for the NC disappearance analysis

- In ND, the major background is the charged current (CC) events while at the FD, the major background is the cosmic events that mimic NC events.

- The primary event selector for separating NC events from CC background is the Computer vision based particle identifier CVNnc (Convolutional Visual Network trained for NC events)

- A Cosmic rejection BDT was developed to separate cosmic events. This BDT is trained for varying detector conditions.
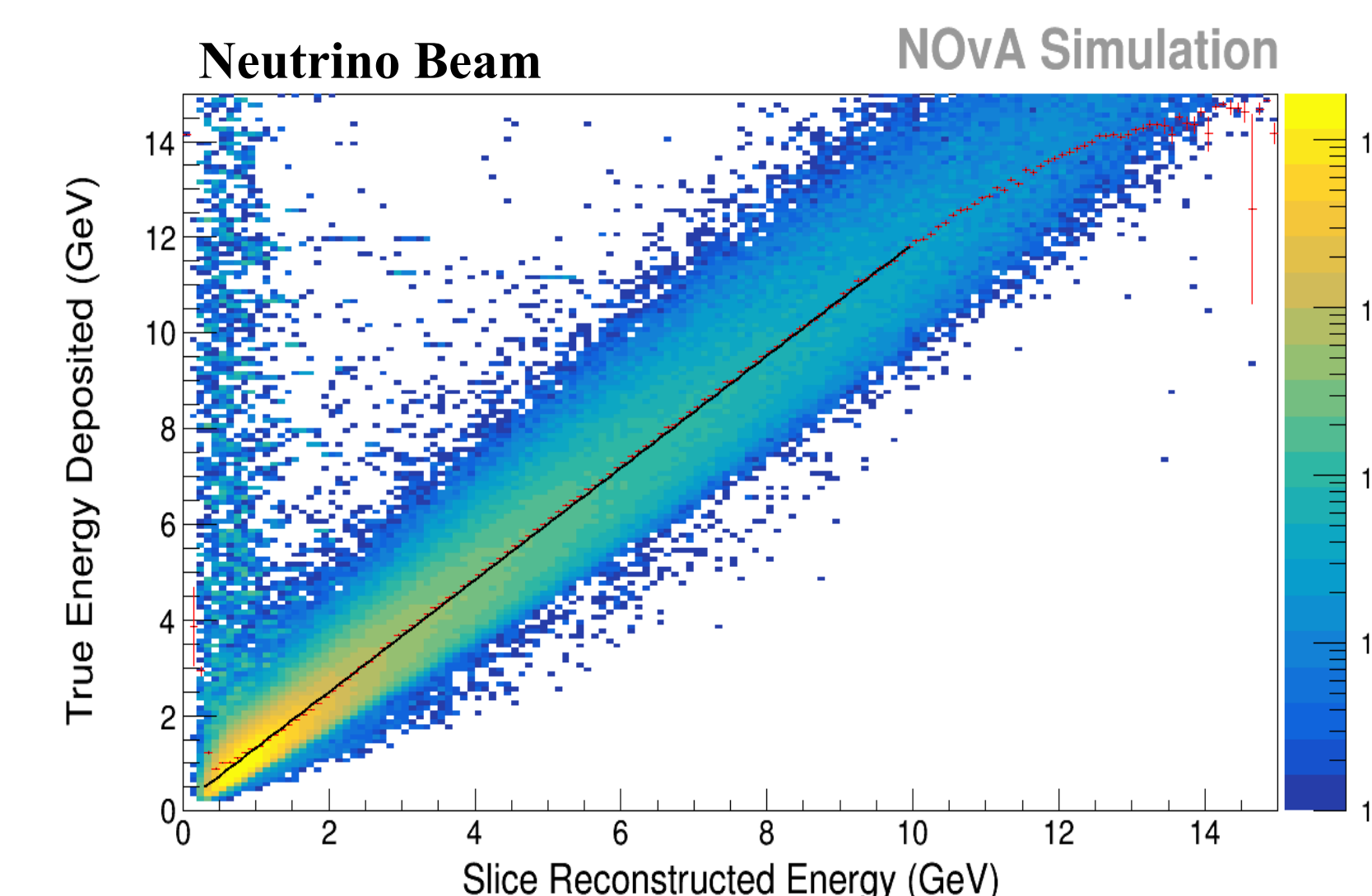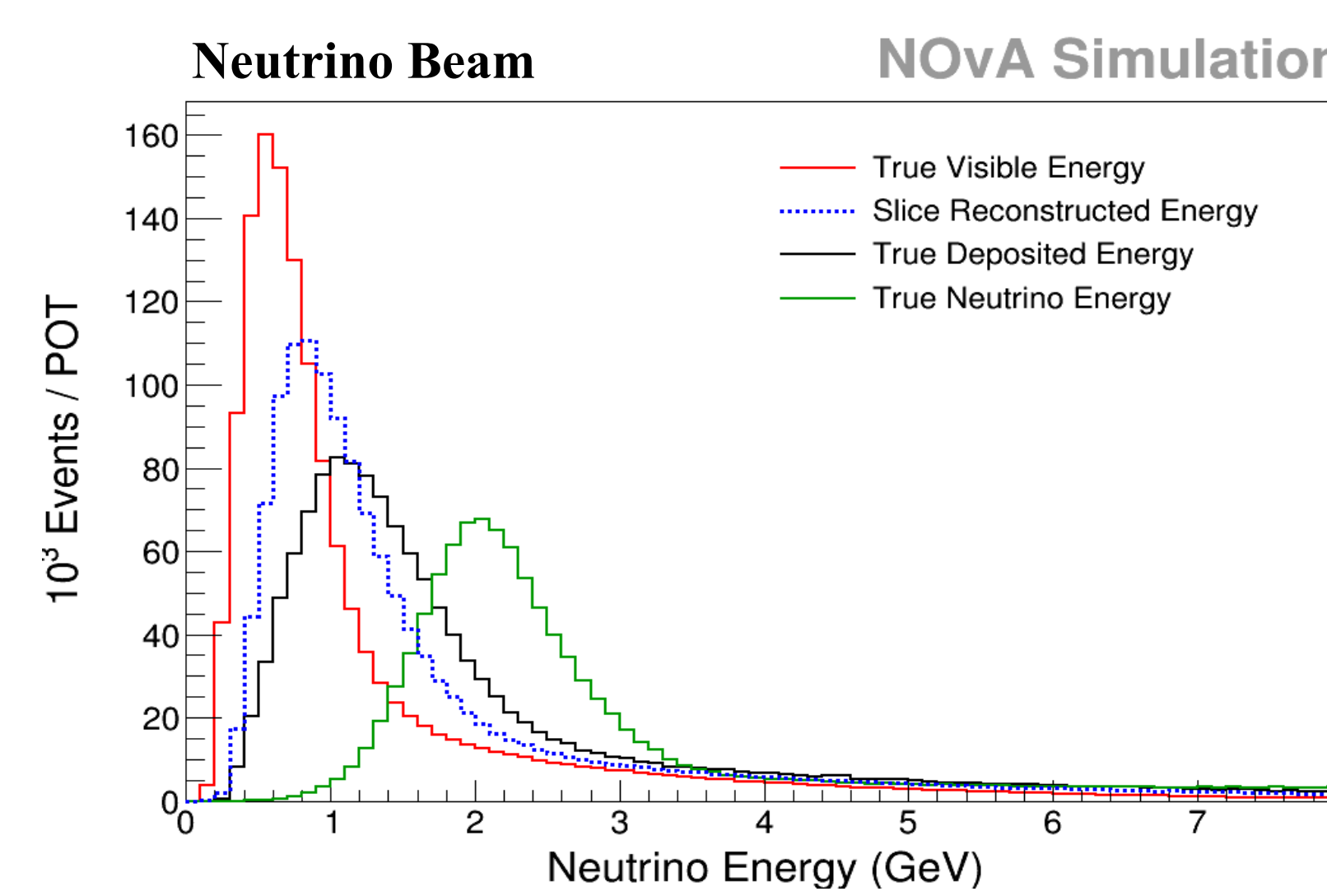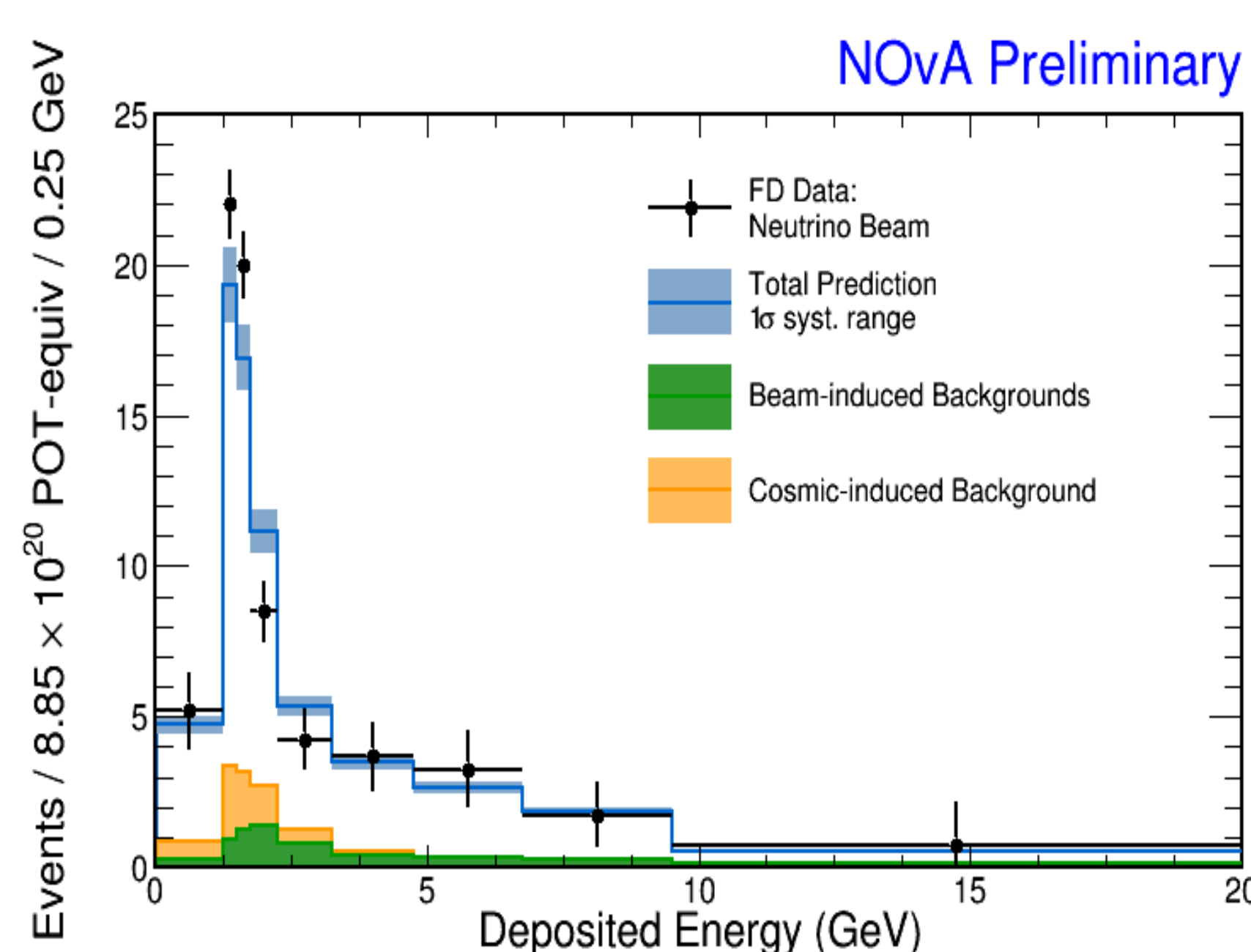

Corrected NC deposited energy estimate

The deposited energy is corrected based on a single parameter linear fit. This is done separately for the FD and ND as well as for the neutrino and antineutrino events.
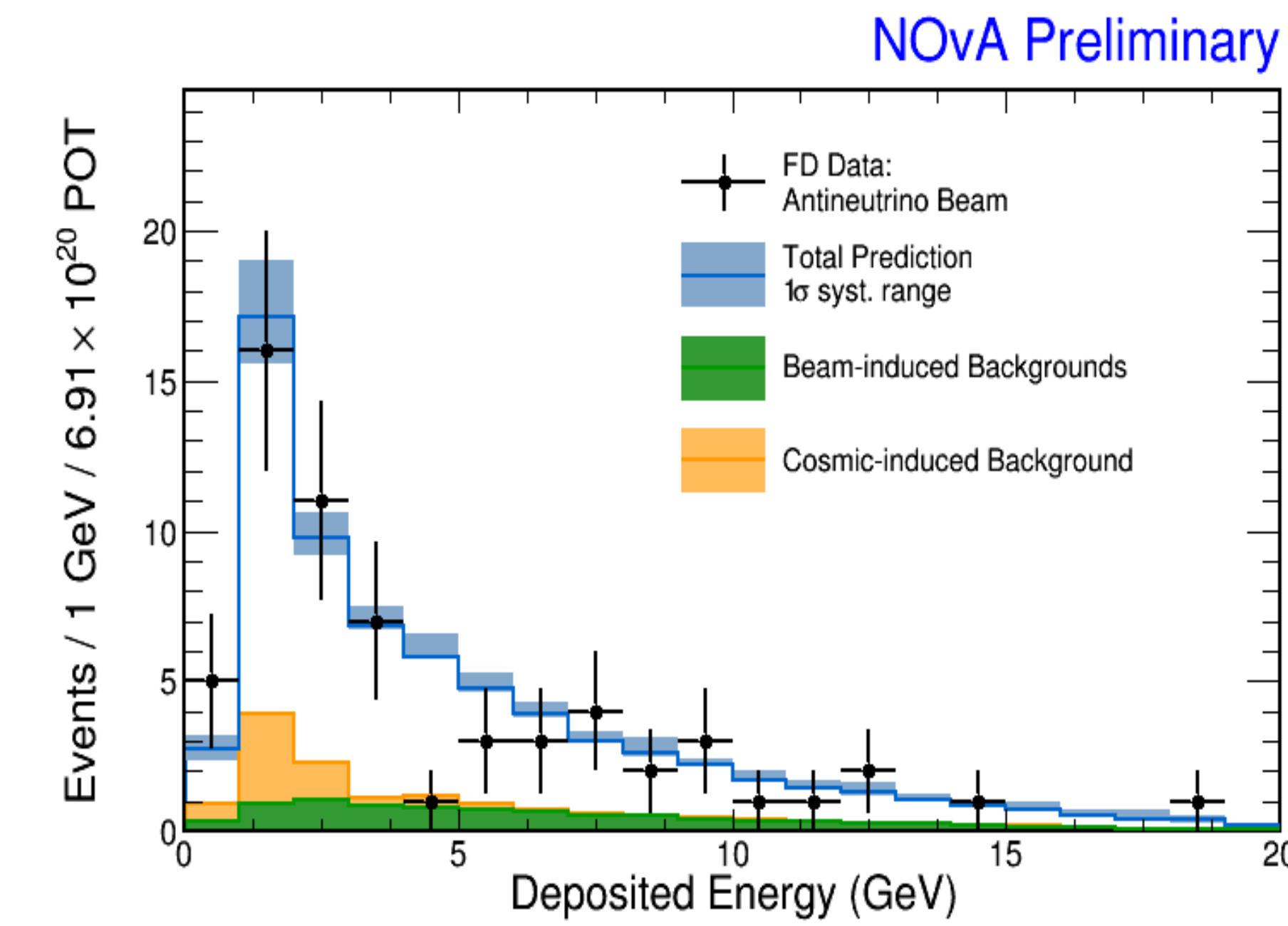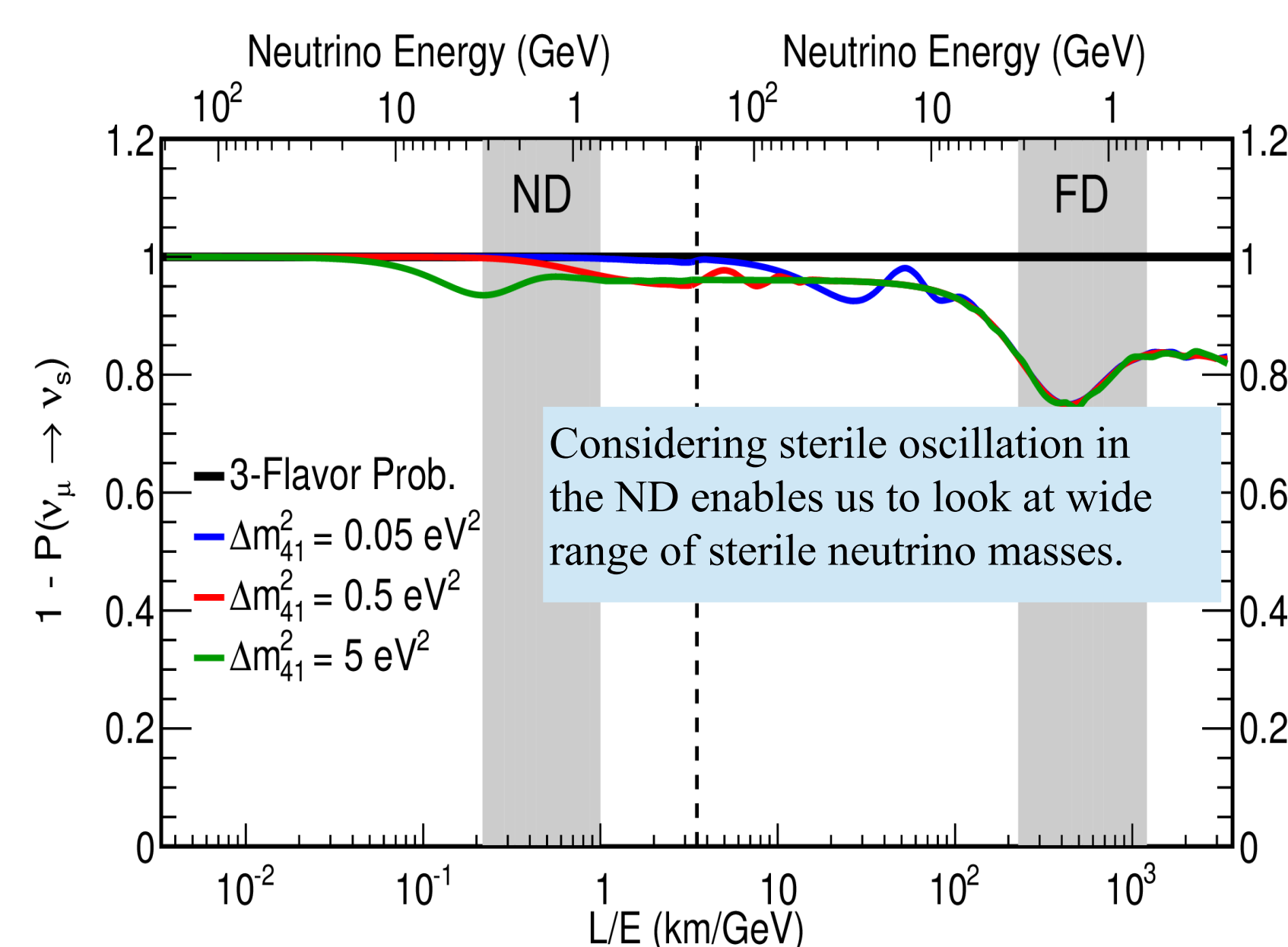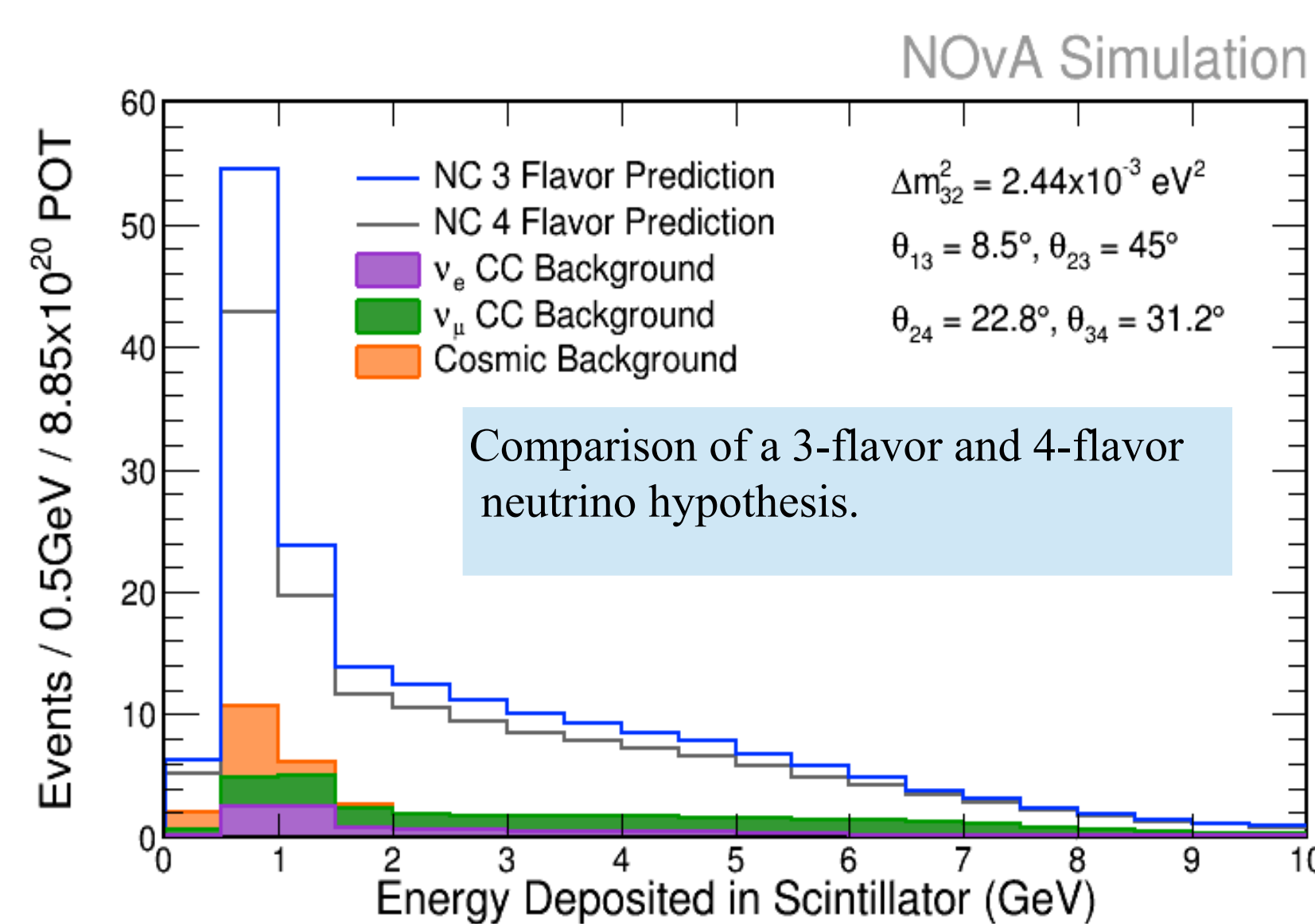

FD Data - MC simulation comparison

Neutrino Beam

Antineutrino Beam

- Observed 201 neutrino NC events.

- Predicted 188.1 events with a statistical uncertainty of 13.7 events.

- The numbers are consistent with the oscillation in the standard 3-flavor framework.

- Observed 61 antineutrino NC events.

- Predicted 68.9 events with a statistical uncertainty of 8.3 events.

- The numbers are consistent with the oscillation in the standard 3-flavor frame-work.

http://novaexperiment.fnal.gov