FERMILAB-SLIDES-23-388-STUDENT

Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

Detector Related Uncertainties in ICARUS

Kevin Smith

Supervisor: Harry Hausner

a.This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.
b.This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).

Background

What is ICARUS

- ICARUS stands for "Imaging Cosmic And Rare Underground Signals”
- It is a Time Projection Chamber (TPC) detector, which means that it uses a uniform electric field to drift charged particles through the liquid argon and create a 3D image of the particle tracks
- It is designed to study neutrinos and their interactions with matter

Why Liquid Argon

- It is a dense material, which means that it can stop charged particles effectively
- It is a good scintillator, which means that it produces light when charged particles pass through it. This light can be detected and used to reconstruct the path of the particle
- It is a good insulator, which means that it can be used to create a uniform electric field that can be used to drift the charged particles through the detector
- It is a stable and abundant material, which means that it is relatively easy to obtain and work with

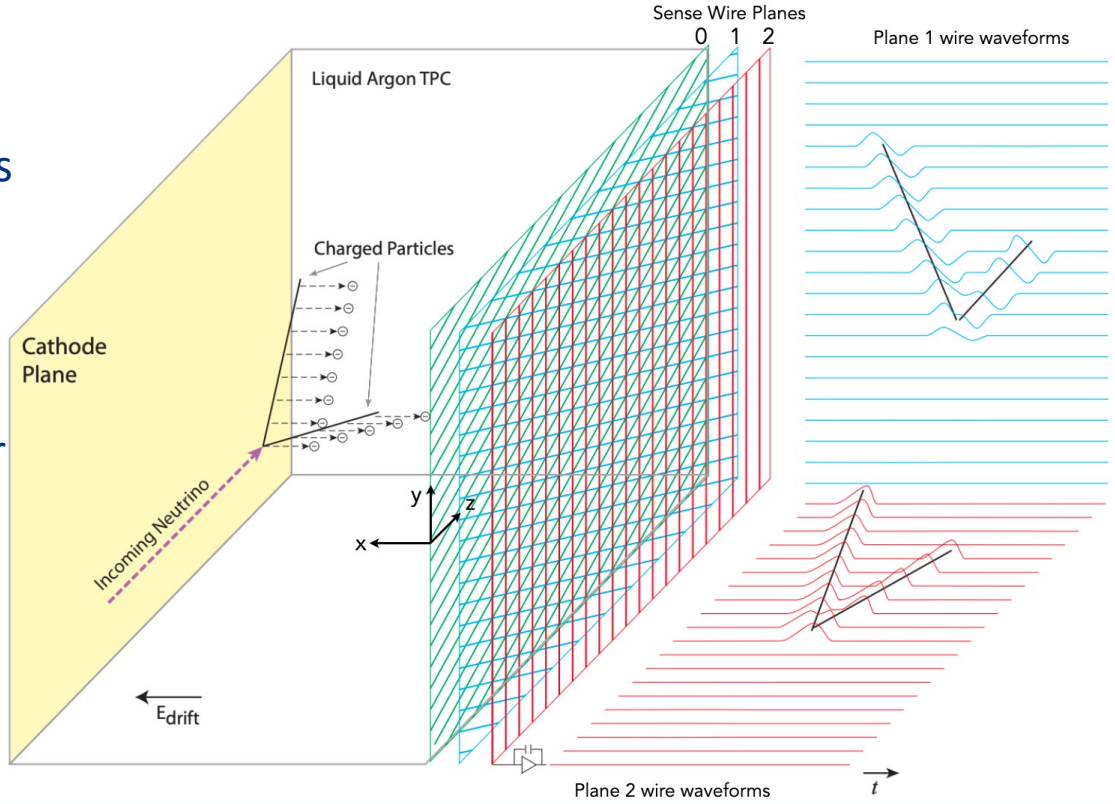
Motivation and Purpose

Purpose

- No detector is perfect, so it is important to quantify this
- There are simulation data and experimental data
- The ratio of these data sets quantifies the differences between the Monte Carlo simulation and the experiment
- This gives insight into detector-related uncertainties

Wire Planes in MicroBooNE

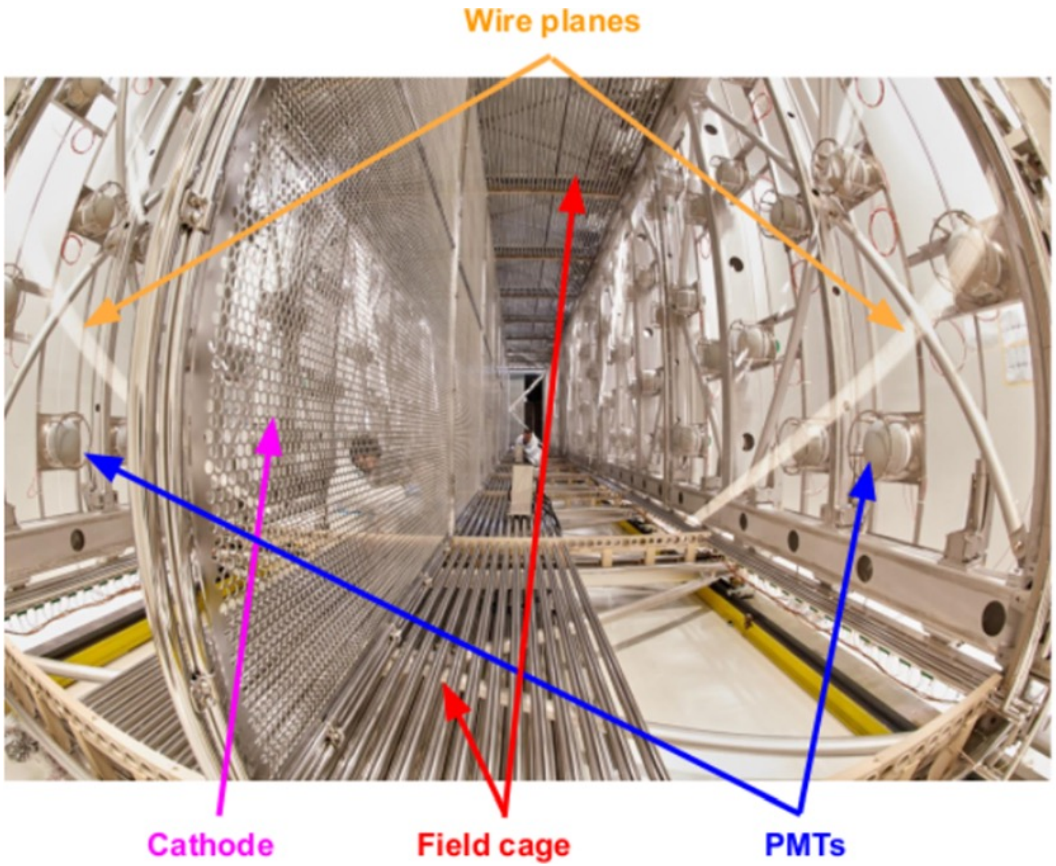
- Ionization electrons drift in the applied electric field until they reach the three sense wire planes located at the anode
- The drifting electrons induce signals on the first two planes, referred to as induction planes or planes 0 and 1, and then directly contribute to the signals in the final plane, referred to as the collection plane or plane 2
- The collection plane wires are aligned vertically, and the induction plane wires are oriented at ±60 degrees from the vertical

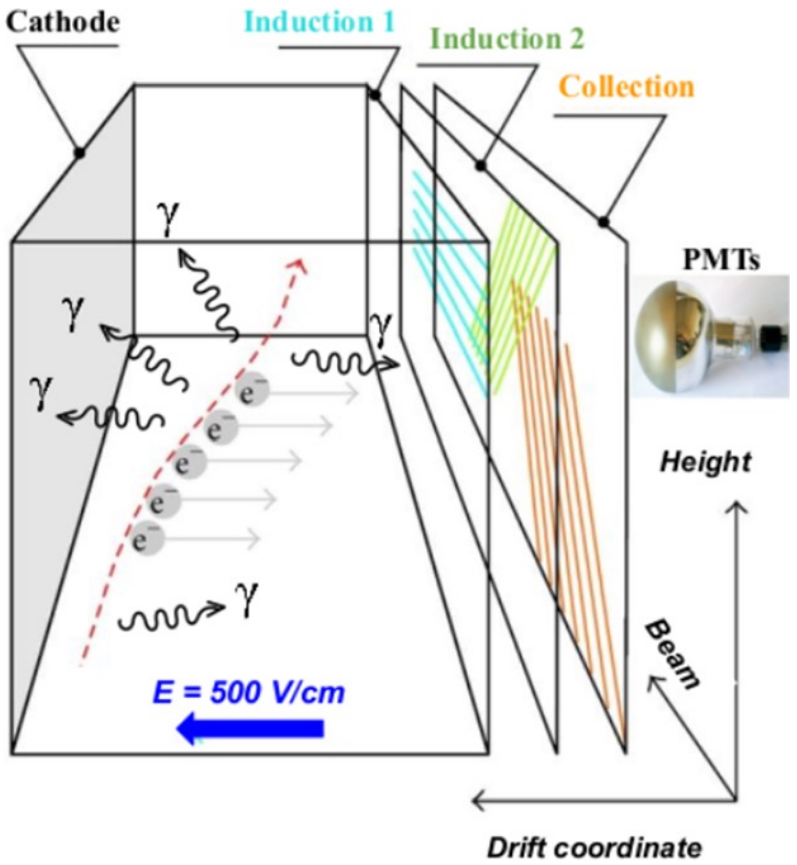


[2] Schematic of MicroBooNE Wire Planes

Fermilab

ICARUS Detector Layout



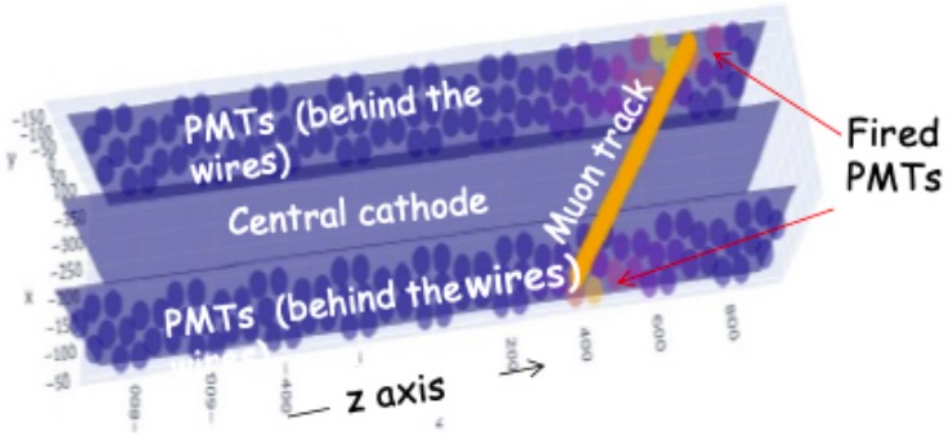


[1] Icarus layout

Fermilab

ICARUS

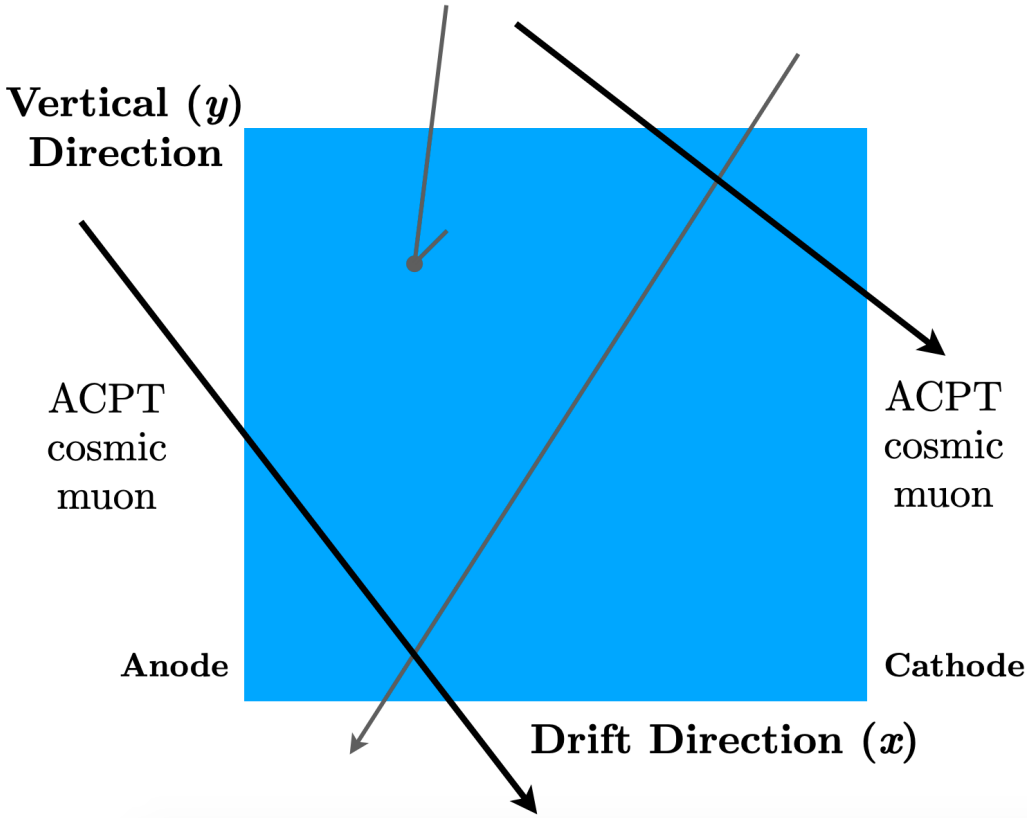
- We want to quantify the differences between the Monte Carlo simulation on the data
- We can look at the data from different parts of the detector and see how the signals differ with the geometry



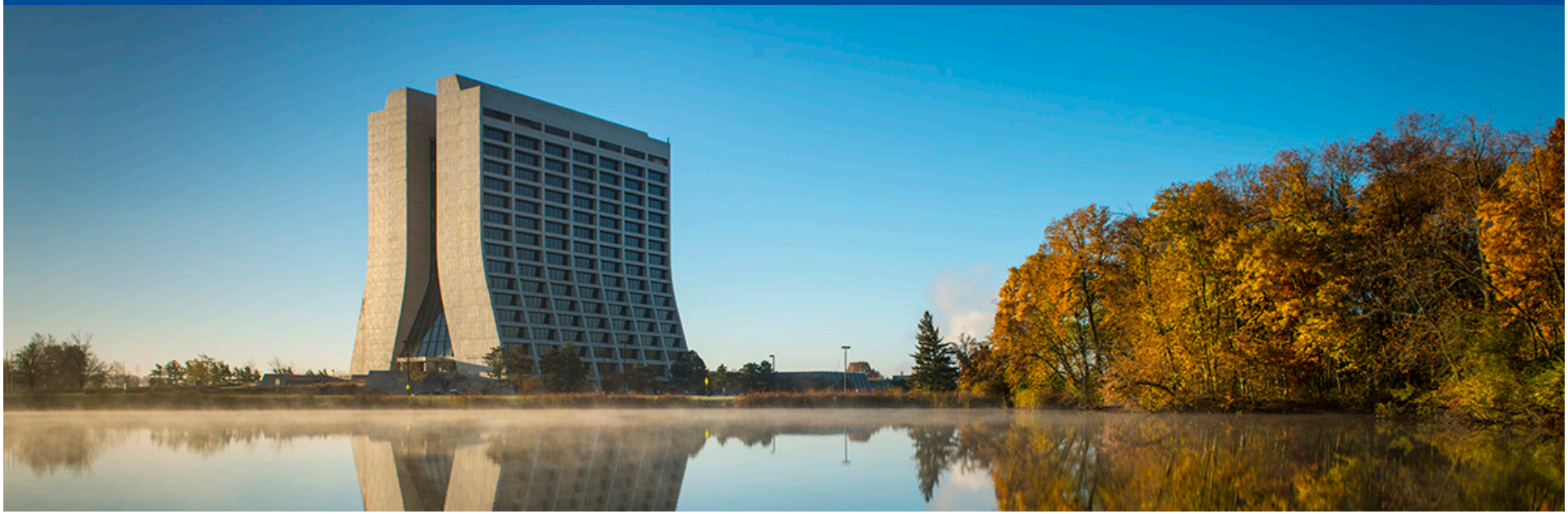
[1] Muon tracks in ICARUS

Using Cosmic Rays

- Neutrinos are hard to detect though, so cosmic ray muons provide a good way to understand the detector



[2] Comic Rays in MicroBooNE

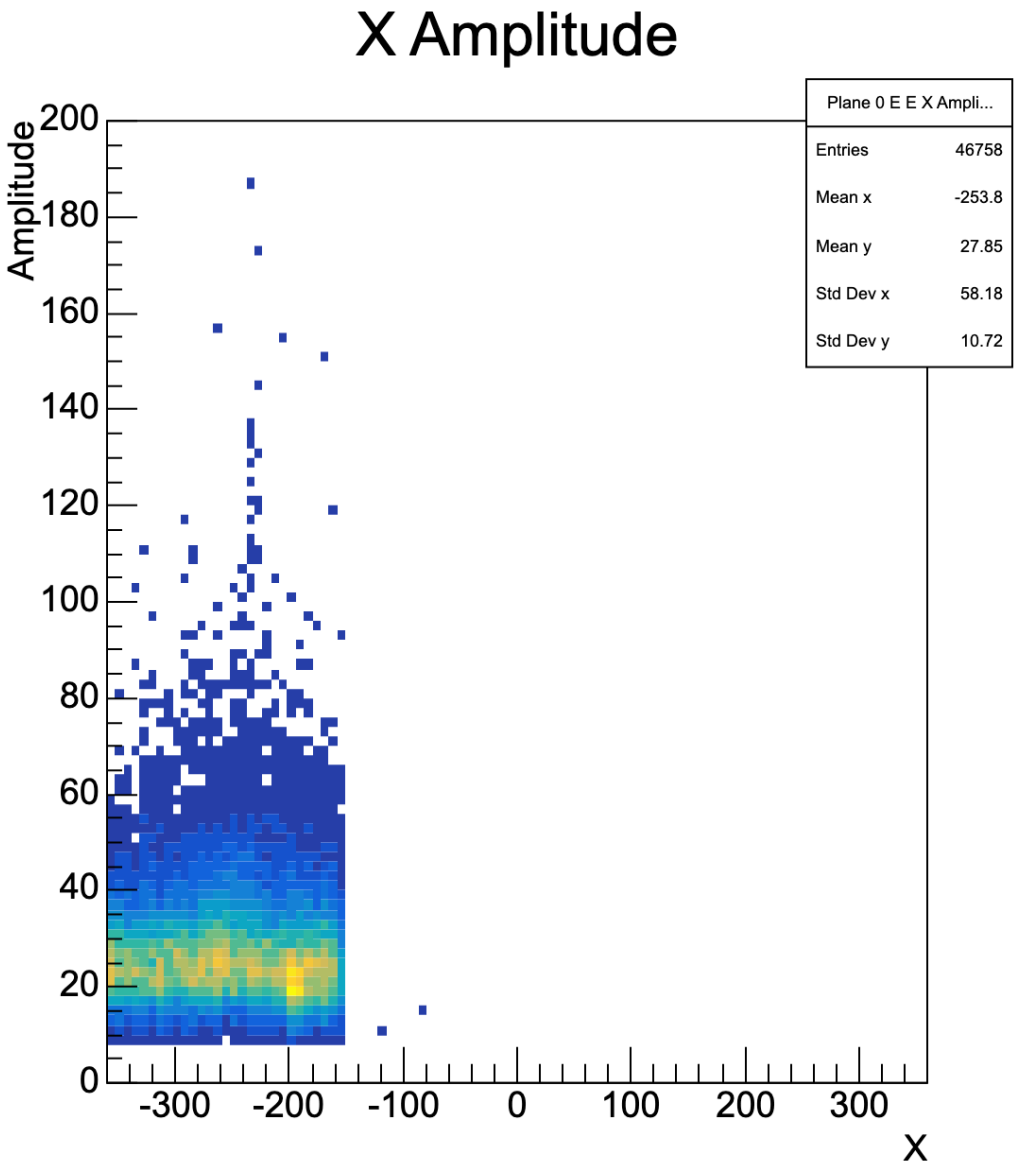


Results

Histograms of Data

The data is organized into different histograms based on:

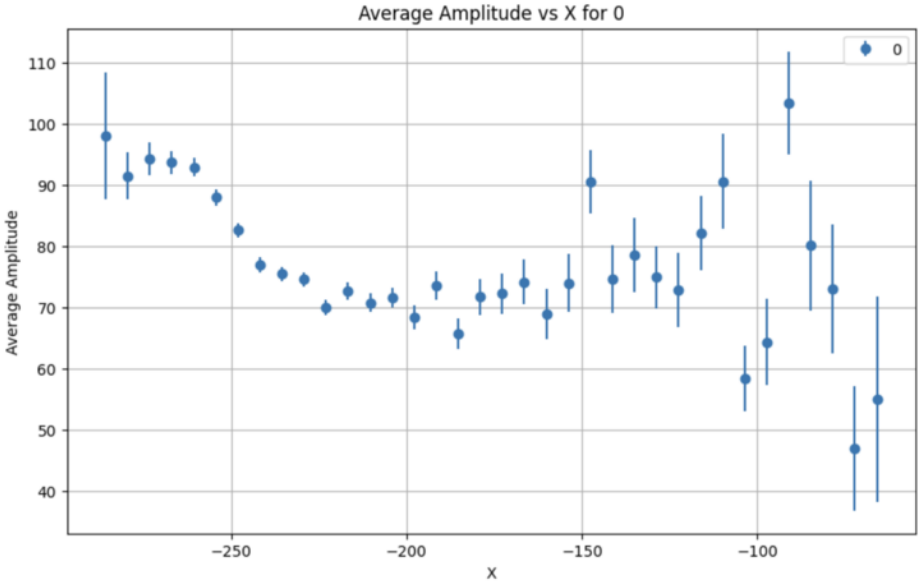
- wire planes
- TPC (East or West)
- Cryostat (also East or West)
- Selected events of particles going through the anode or cathode

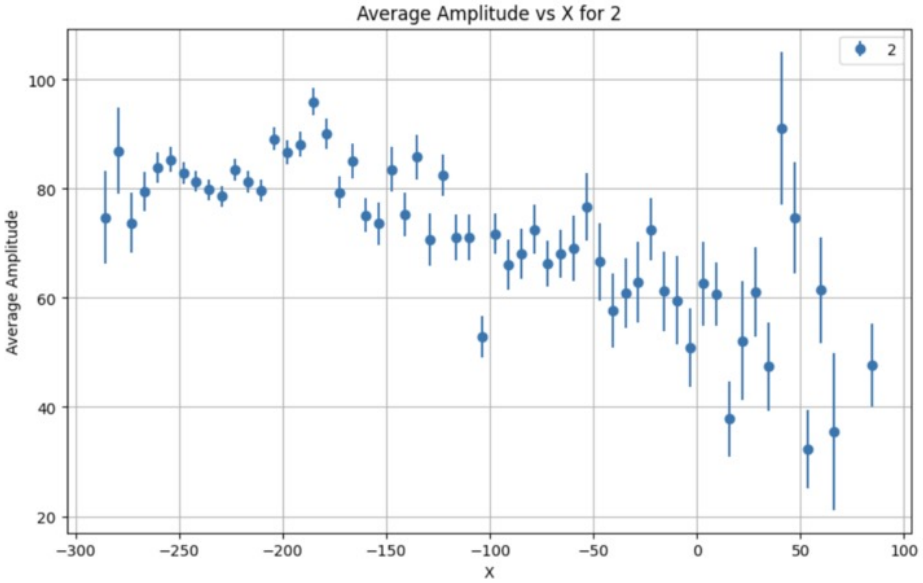


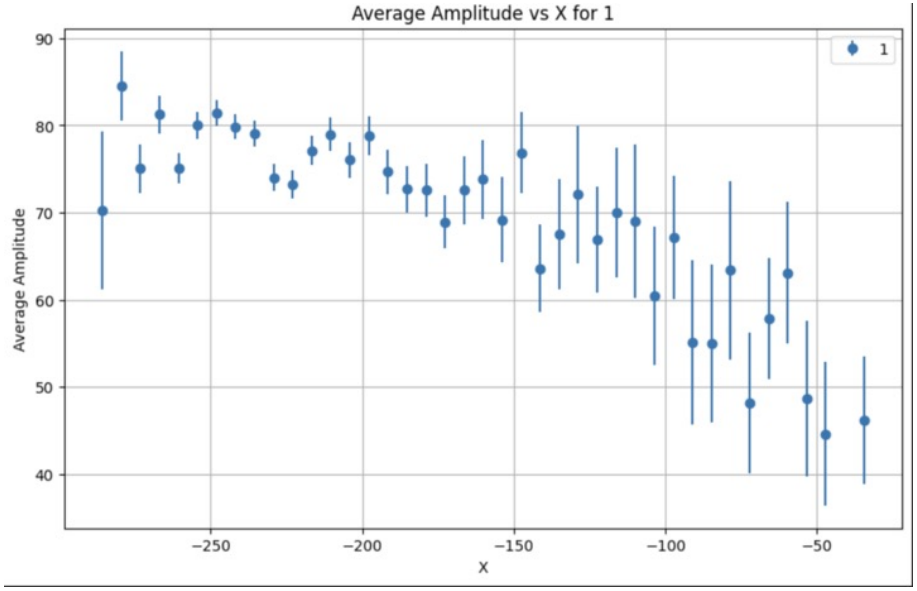
Fermilab

Combing Histograms

- There are quite a few histograms
- Combining all that have the same plane:



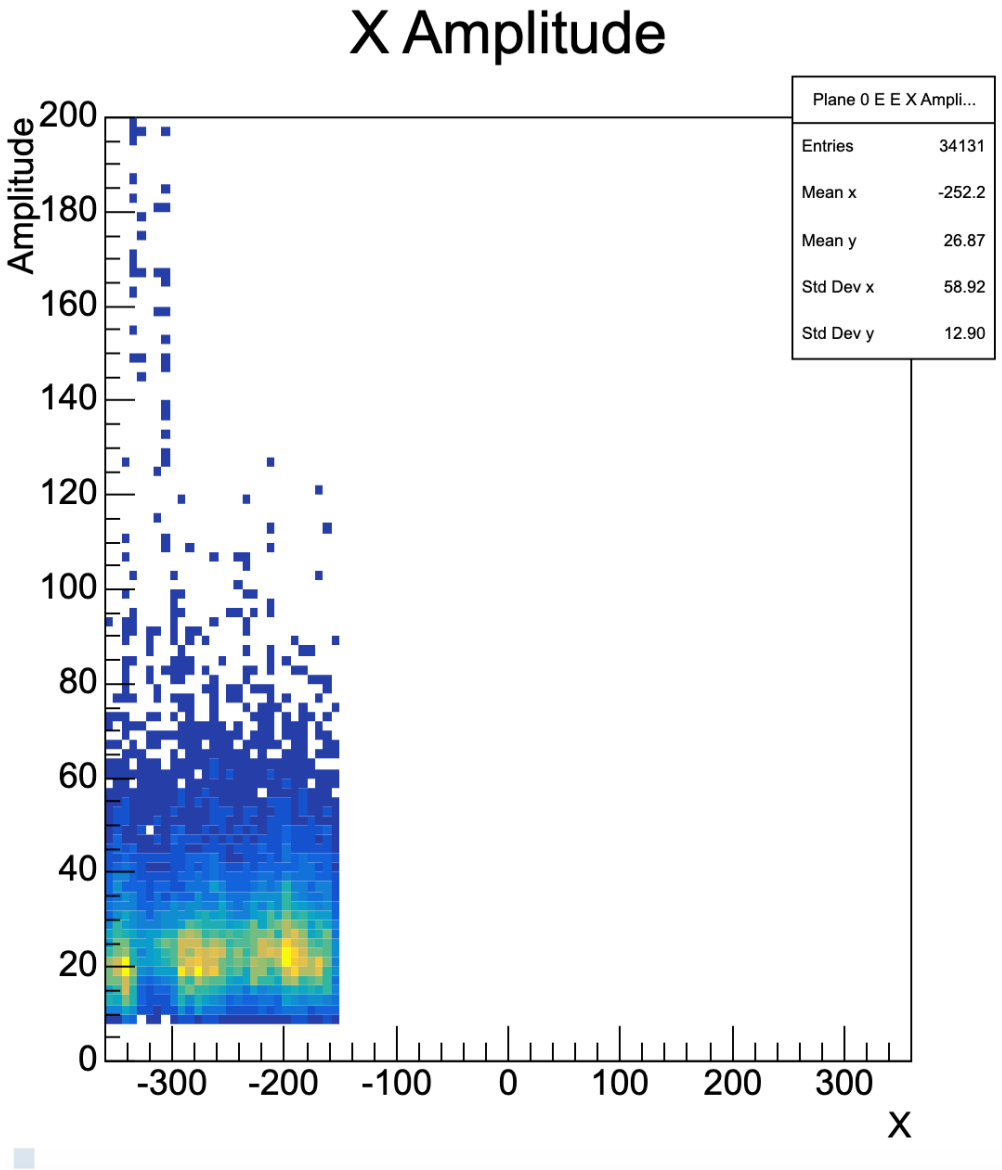




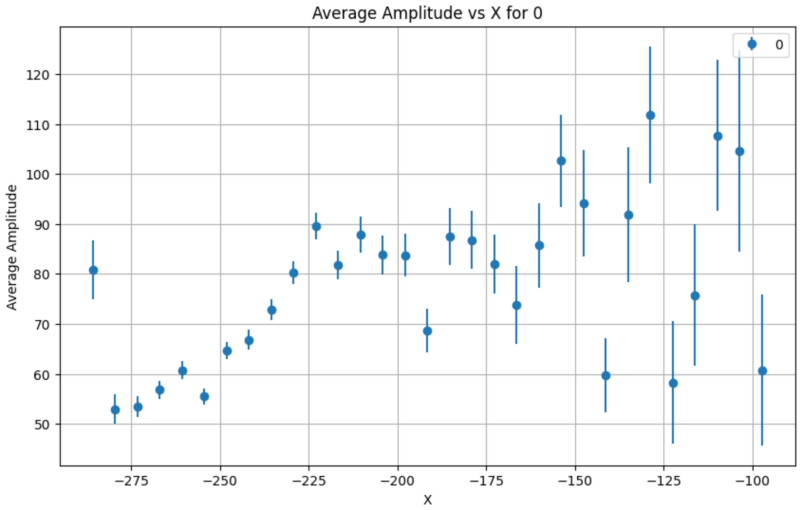
Fermilab

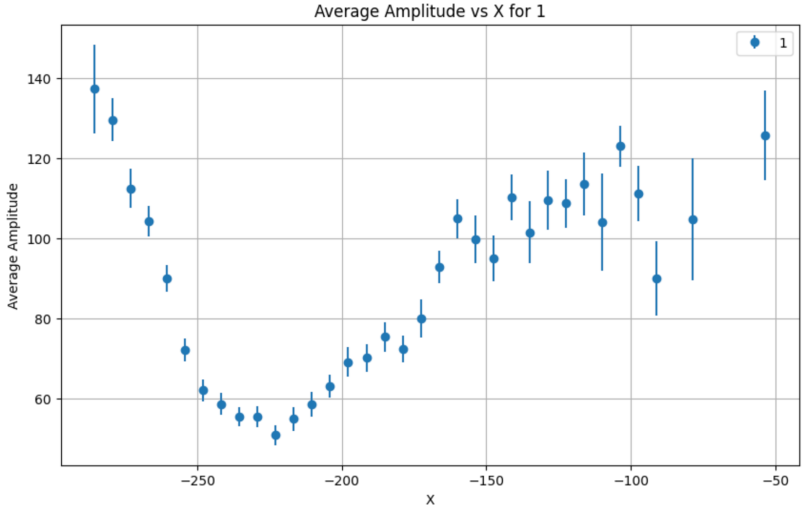
Histograms of MC

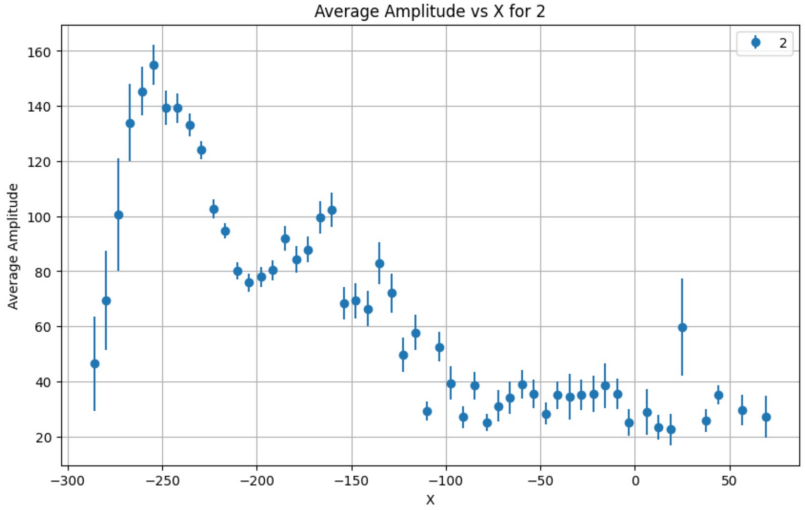
- Results of Monte Carlo simulations so ratios of DATA / MC can be formed



Combining MC Histograms

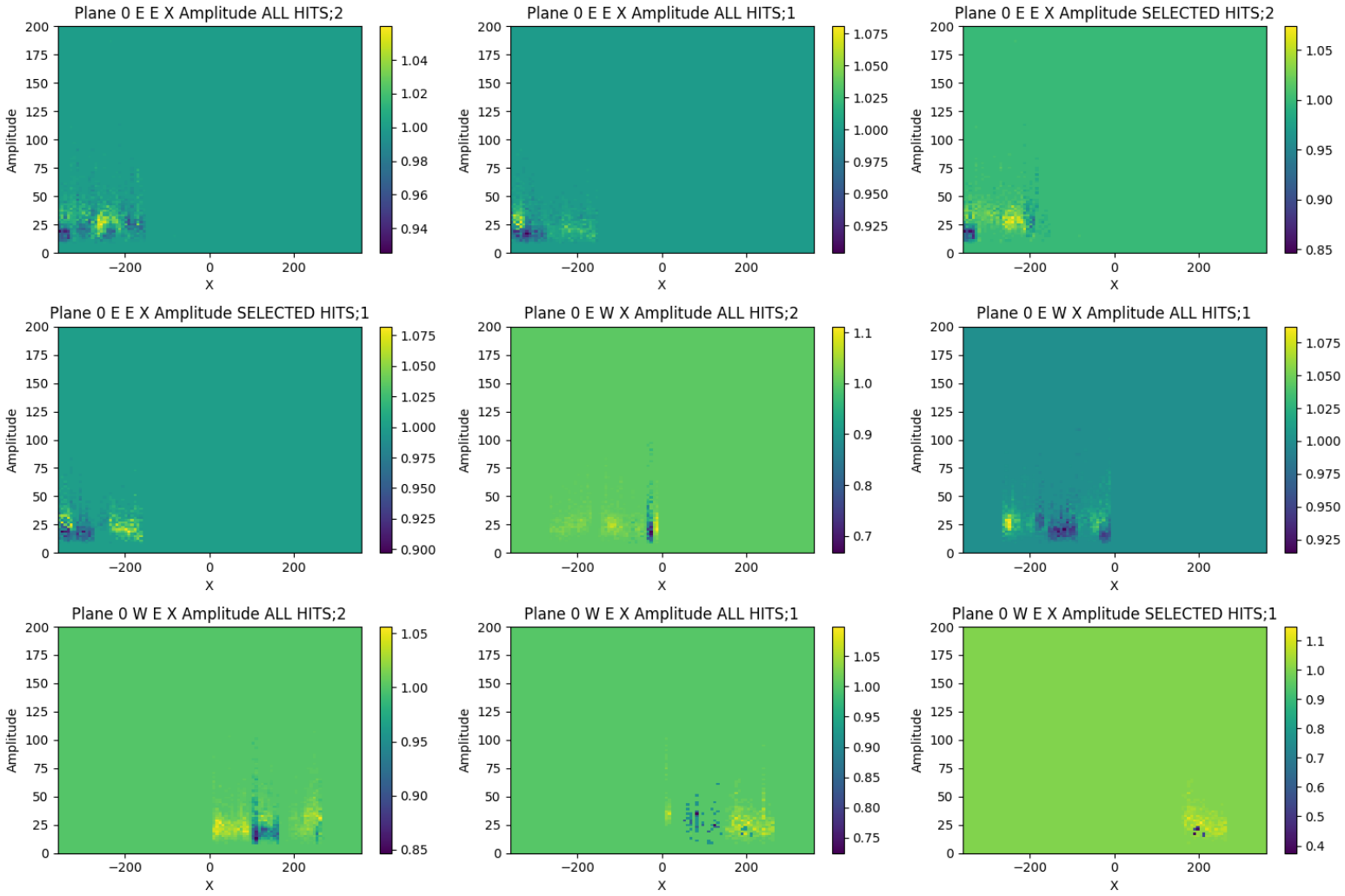




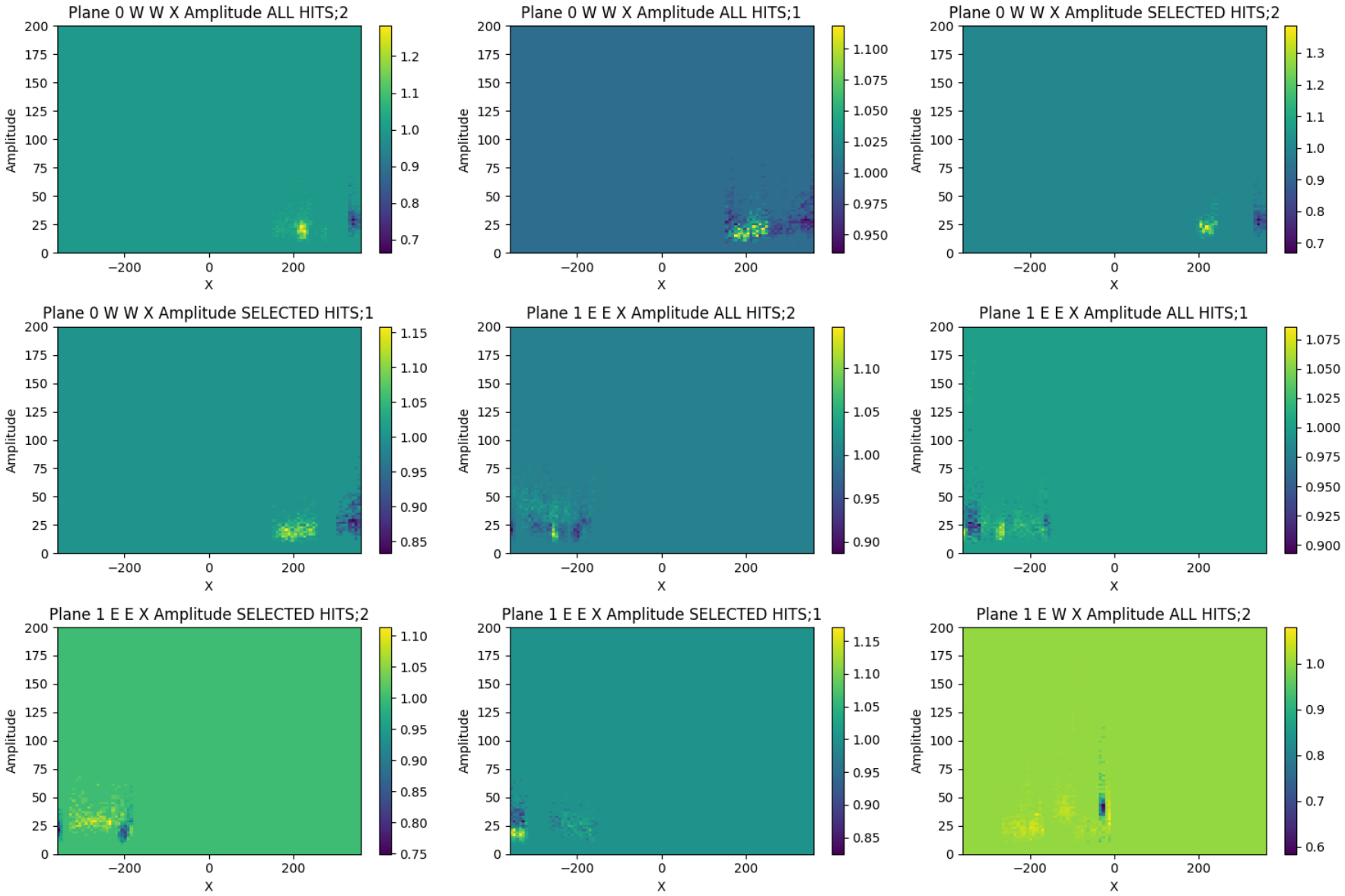


Fermilab

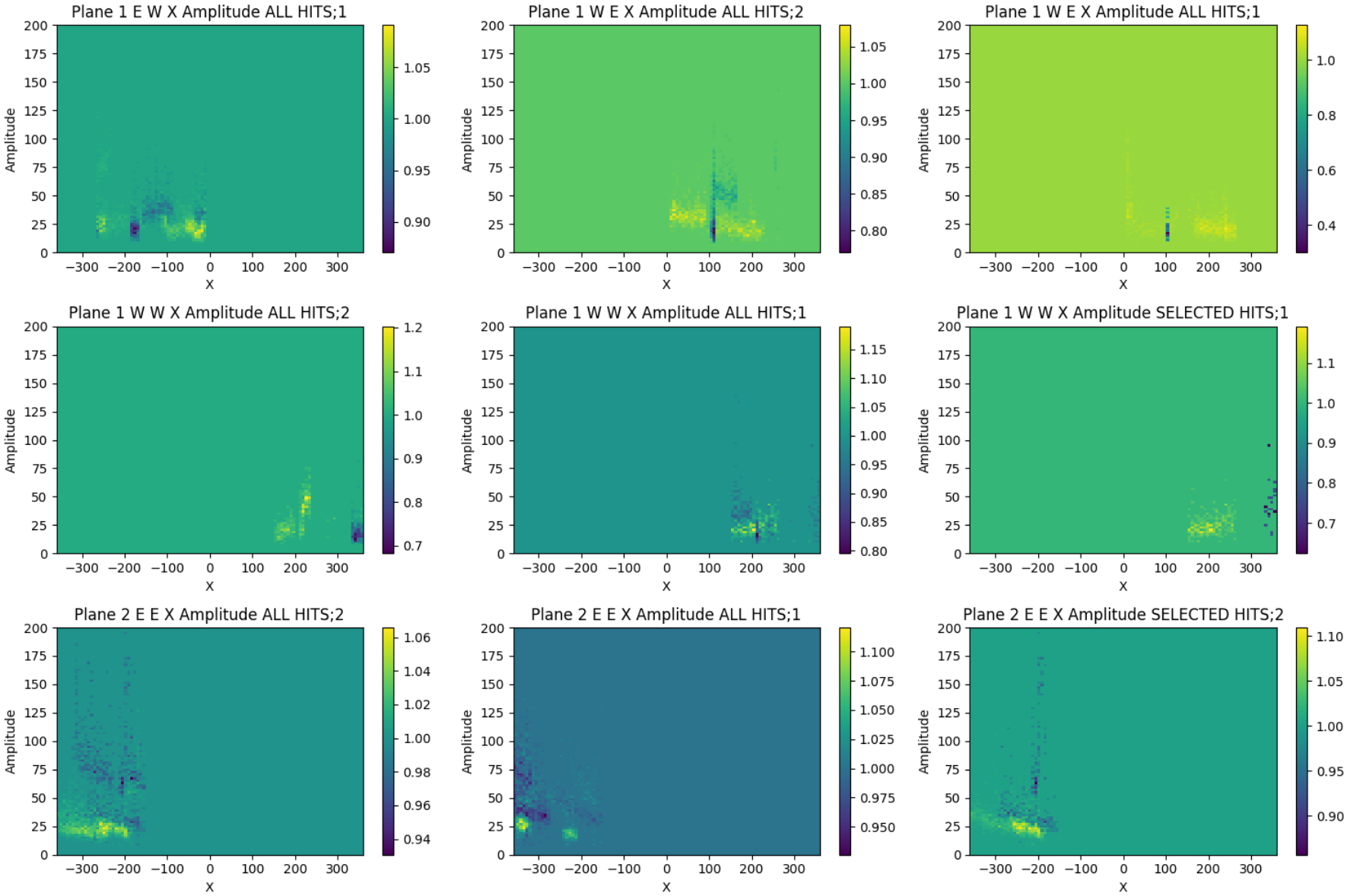
Ratios of Data / MC (X vs. Amplitude)



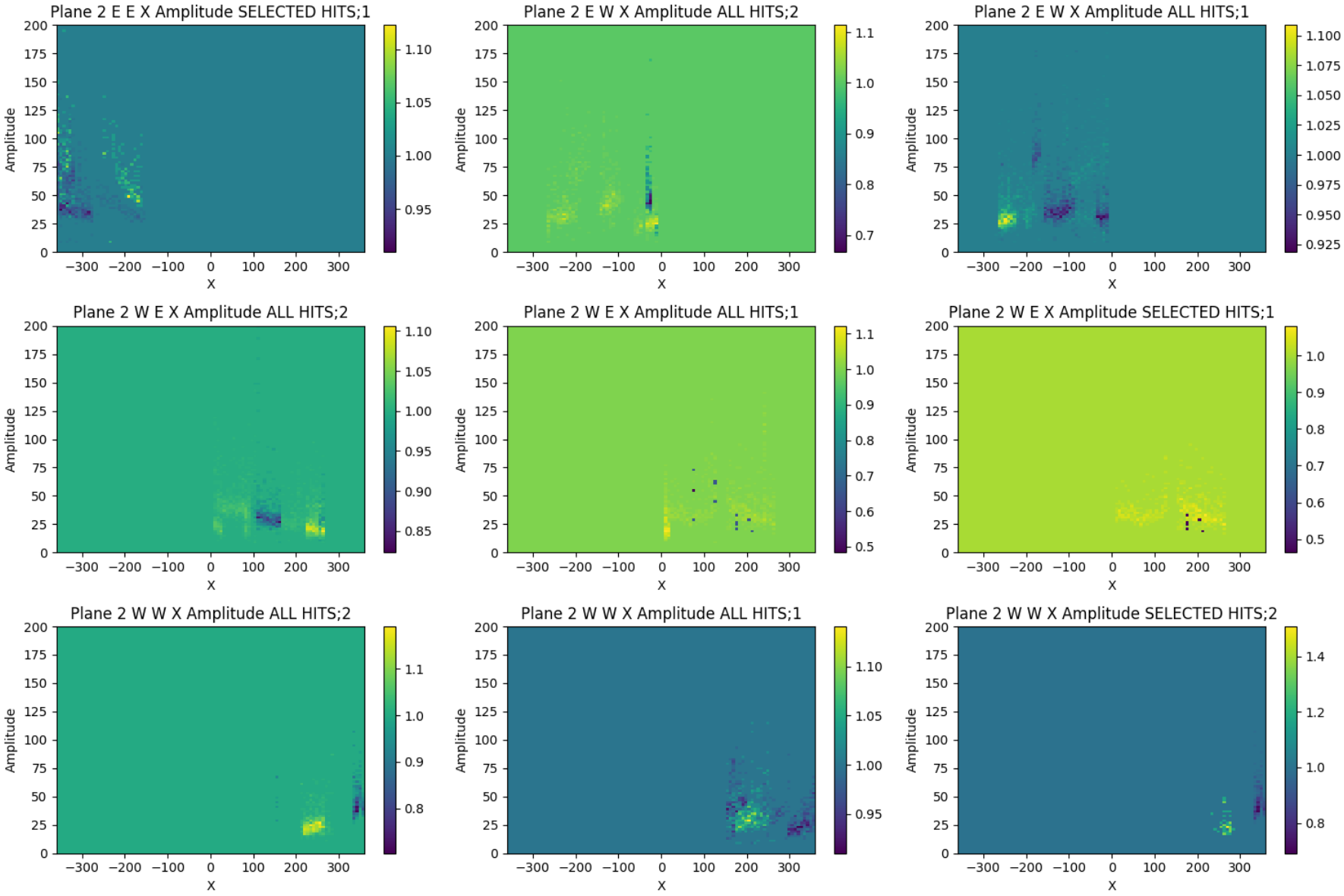
Fermilab


Plane 0 W W X Amplitude ALL HITS;2
Plane 0 W W X Amplitude ALL HITS;1
Plane 0 W W X Amplitude SELECTED HITS;2
Plane 0 W W X Amplitude SELECTED HITS;1
Plane 1 E E X Amplitude ALL HITS;2
Plane 1 E E X Amplitude ALL HITS;1
Plane 1 E E X Amplitude SELECTED HITS;2
Plane 1 E E X Amplitude SELECTED HITS;1
Plane 1 E W X Amplitude ALL HITS;2
Amplitude
X

Fermilab


Plane 1 E W X Amplitude ALL HITS;1
Plane 1 W E X Amplitude ALL HITS;2
Plane 1 W E X Amplitude ALL HITS;1
Plane 1 W W X Amplitude ALL HITS;2
Plane 1 W W X Amplitude ALL HITS;1
Plane 1 W W X Amplitude SELECTED HITS;1
Plane 2 E E X Amplitude ALL HITS;2
Plane 2 E E X Amplitude ALL HITS;1
Plane 2 E E X Amplitude SELECTED HITS;2
Amplitude
X

Fermilab


Plane 2 E E X Amplitude SELECTED HITS;1
Plane 2 E W X Amplitude ALL HITS;2
Plane 2 E W X Amplitude ALL HITS;1
Plane 2 W E X Amplitude ALL HITS;2
Plane 2 W E X Amplitude ALL HITS;1
Plane 2 W E X Amplitude SELECTED HITS;1
Plane 2 W W X Amplitude ALL HITS;2
Plane 2 W W X Amplitude ALL HITS;1
Plane 2 W W X Amplitude SELECTED HITS;2
Amplitude
X

Fermilab

Conclusions

Conclusions

- Neutrinos are hard to study
- Cosmic Rays are easier, so they can be used to understand the detector
- The ratio of the Monte Carlo simulations and the experimental data gives insights into uncertainties stemming from the detector

References

- [1] P Abratenko, A Aduszkiewicz, F Akbar, M Artero Pons, J Asaadi, M Aslin, M Babicz, WF Badgett, LF Bagby, B Baibussinov, et al. Icarus at the fermilab short-baseline neutrino program: initial operation. The European Physical Journal C, 83(6):467, 2023.
- [2] MicroBooNE Collaboration et al. Novel approach for evaluating detector systematics in the microboone lartpc. Technical report, MICROBOONE-NOTE-1075-PUB. https://microboone. fnal. gov/wp-content/uploads . . . , 2020