

# First Look at Cosmic Ray Tagging (CRT) Track Reconstruction at ICARUS



Krish B Majethia,  
SIST Intern 2022

Supervisors : Minerba Betancourt,  
Biswaranjan Behera

FERMILAB-POSTER-22-139-STUDENT

## Introduction and Motivation

- ICARUS<sup>1</sup> (based on Liquid Argon Time Projection Chamber(LArTPC)) is on the surface at Fermilab exposed to huge cosmic activity. Cosmics are primary background for several physics analysis.
- 4π coverage of the detector with Cosmic Ray Tagger<sup>2</sup> (CRT) to tag the cosmic muons and remove them to identify neutrino interaction.
- The CRT's are plastic scintillators read out by silicon photomultipliers and digitized by CAEN Front End Boards. CRT is fully installed and taking data in the ICARUS detector hall.
- CRT has three sub systems, top, side and bottom and able to tag more than 95% cosmic muons.
- We can use the CRT to analyze dirt muons produced by neutrino interactions in the materials around the ICARUS building.
- CRT tracks provide both position and angle information for particles which cross the CRT volume. Matching TPC track with CRT tracks can provide high purity samples for detector calibrations.

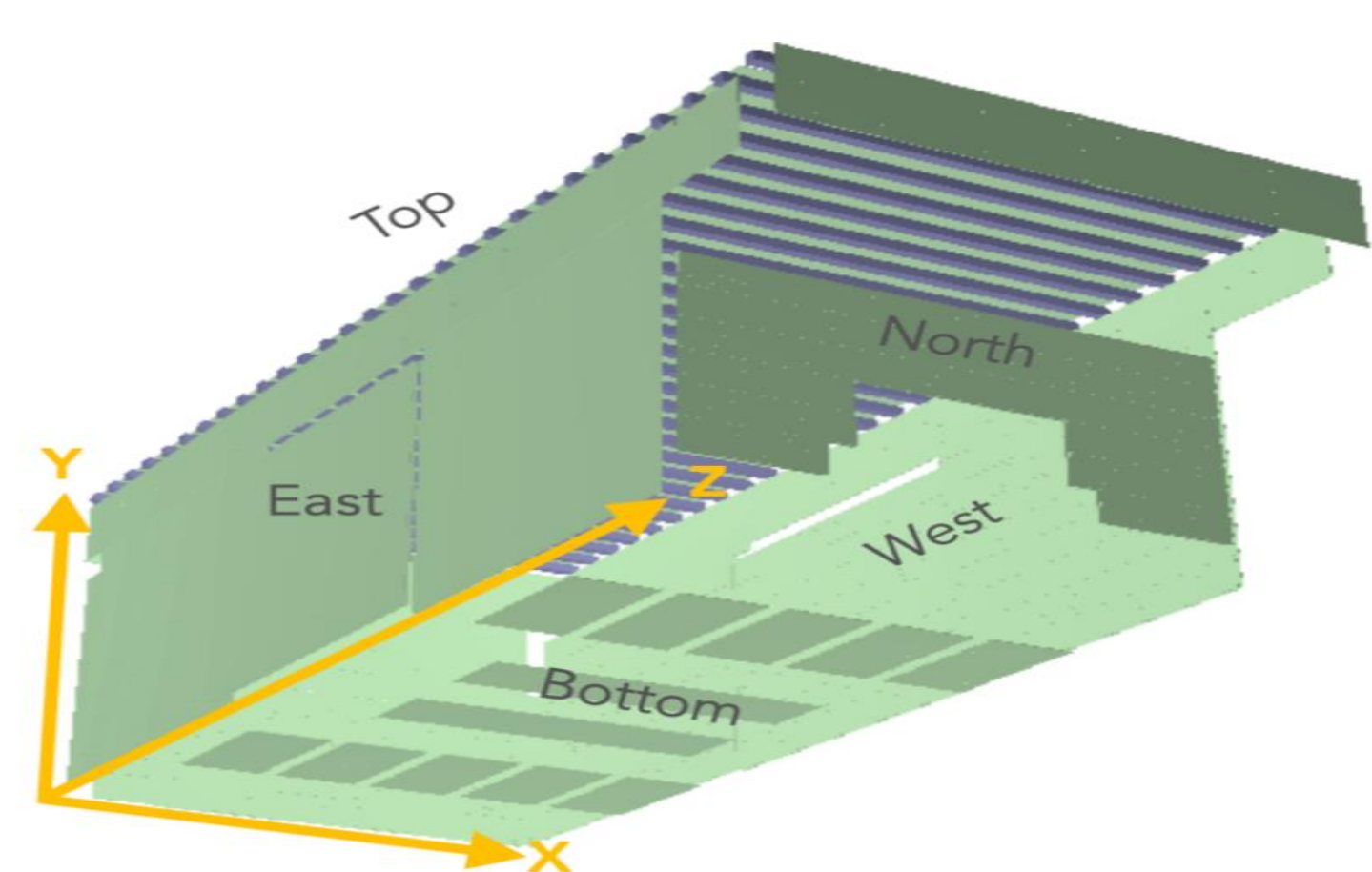


Figure 1: CRT Geometry with Coordinates

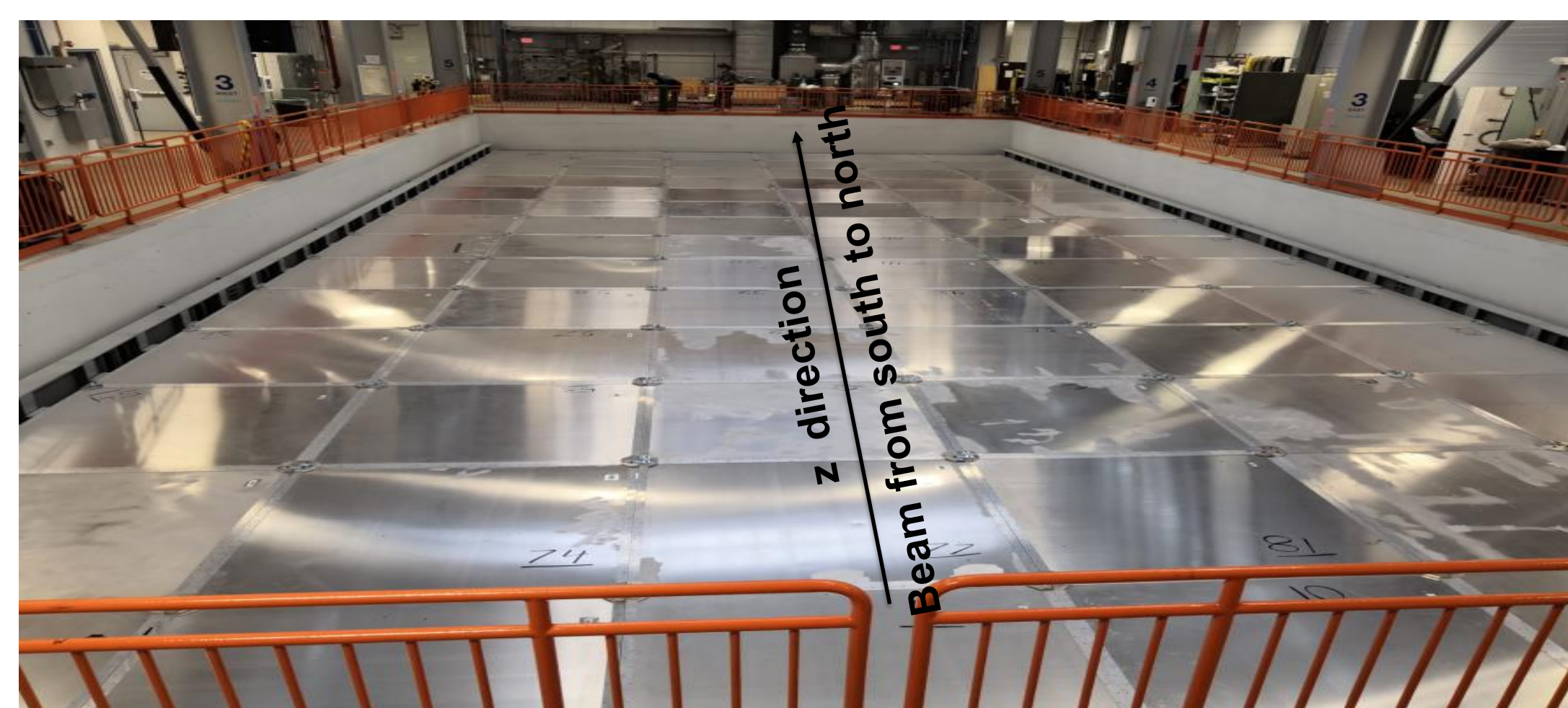


Figure 2: Top CRT installation

## CRT Track Reconstruction Algorithm

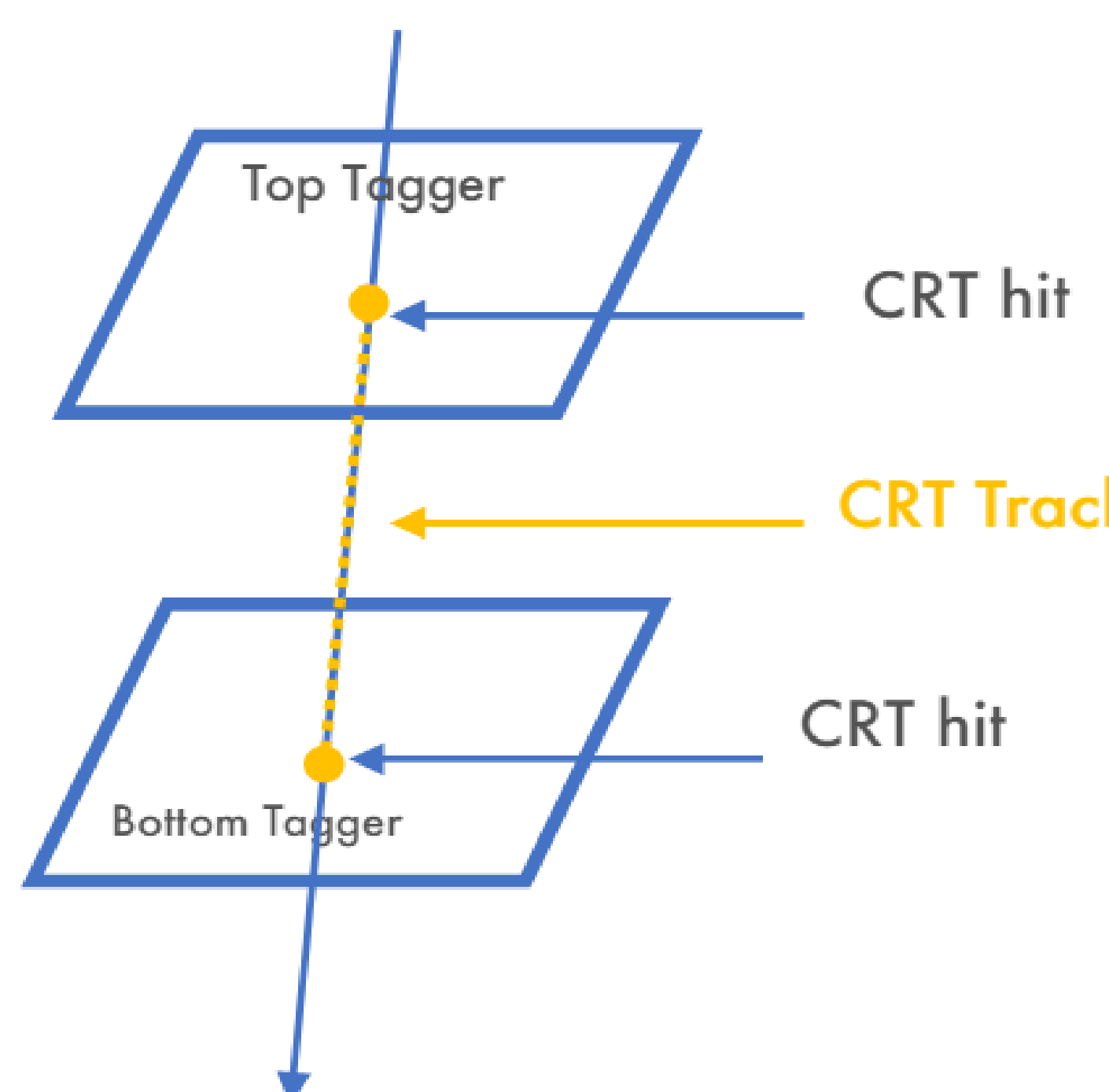
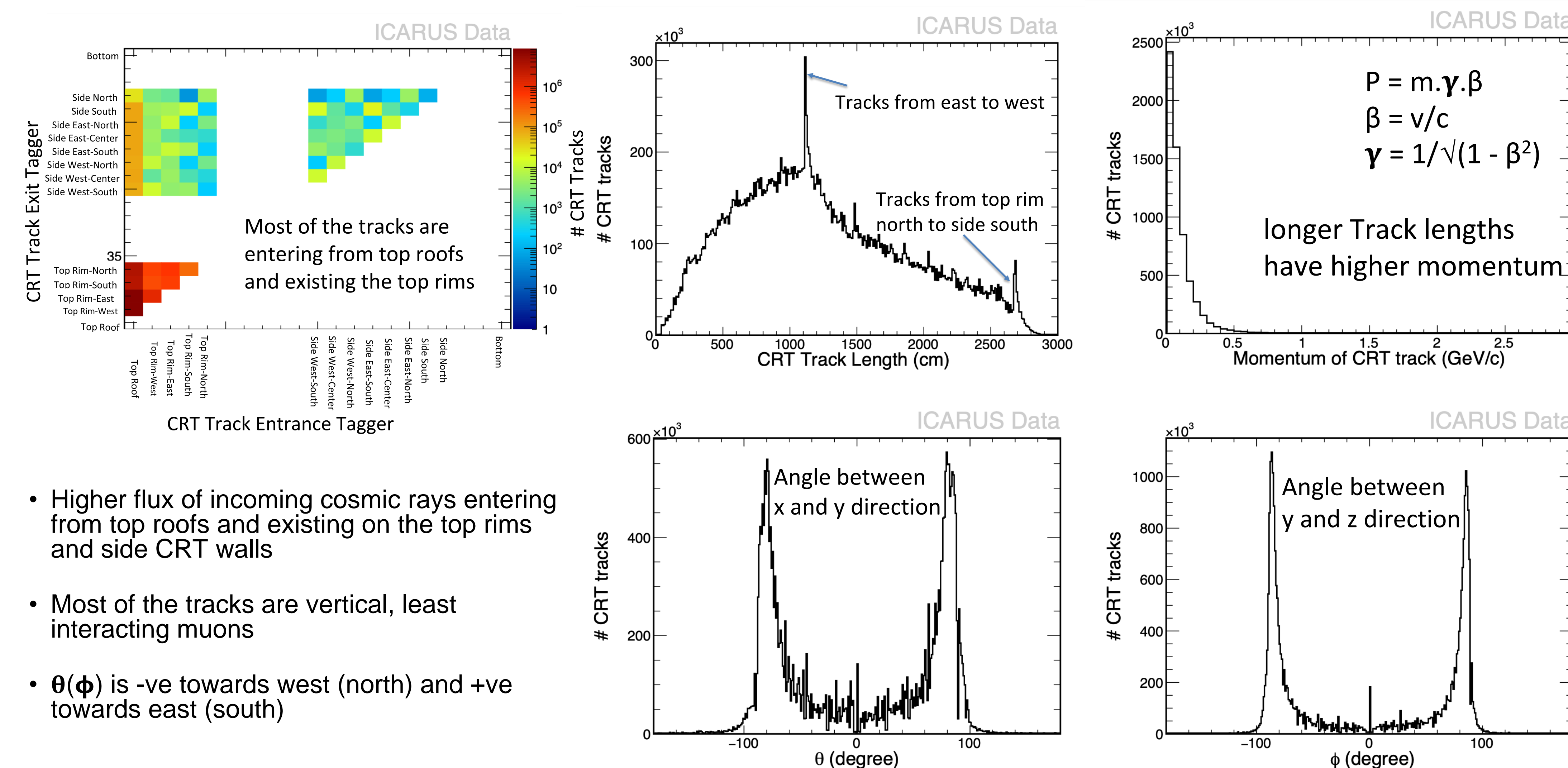


Figure 3: CRT track reconstruction

- Acquire the CRT hit data from the latest run.
- Create t0 collections for hits within 100 ns of each other. For each t0, sort hits by tagger.
- Take the average position and time of all the hits within 60 cm on a tagger.
- Loop over all unique pairs of average hits on different taggers. Draw an infinite track between the 2 hits.
- Do not create tracks with already used hits.

## CRT Track Properties



- Higher flux of incoming cosmic rays entering from top roofs and existing on the top rims and side CRT walls
- Most of the tracks are vertical, least interacting muons
- $\theta(\phi)$  is -ve towards west (north) and +ve towards east (south)

## Summary and Future Work

- Understanding the various properties of cosmic tracks using CRT track.
- First experience on learning and using CERN ROOT<sup>3</sup> data analysis framework used for high energy physics.
- Quantify the amount track crossing the LArTPC which is tagged by the CRT.
- Use the CRT track to calibrate the ICARUS detector.
- Develop an algorithm to match CRT track - TPC track to reject cosmics.

## References

1. C. Rubbia, arXiv:1408.6431 (2014)
2. B. Behera, PoS NuFact2021 (2022) 201
3. <https://root.cern/>

## Acknowledgement

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.