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

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Introduction

- ICARUS is a LArTPC detector operating at the surface.
- It is prone to a flux of cosmic background radiation.
- Cosmic Ray Tagging (CRT) system is setup around the ICARUS detector to tag cosmic muons.
- CRT's are plastic scintillators, through which scintillation light is read out by silicon photomultipliers and digitalized by CAEN front end boards.
- CRT's are fully installed and are taking data at ICARUS.
- 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.

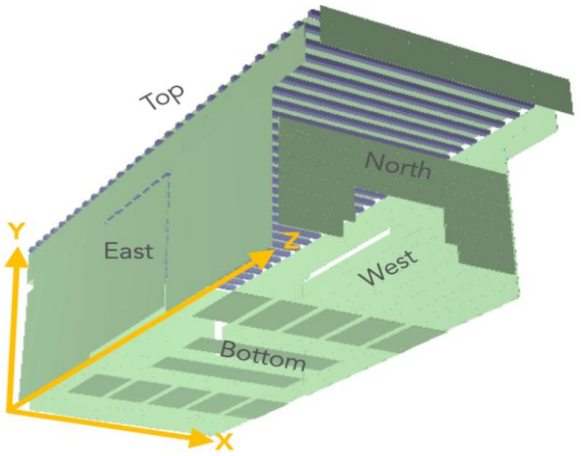


Figure 1: CRT System Geometry with coordinates

CRT Track Reconstruction

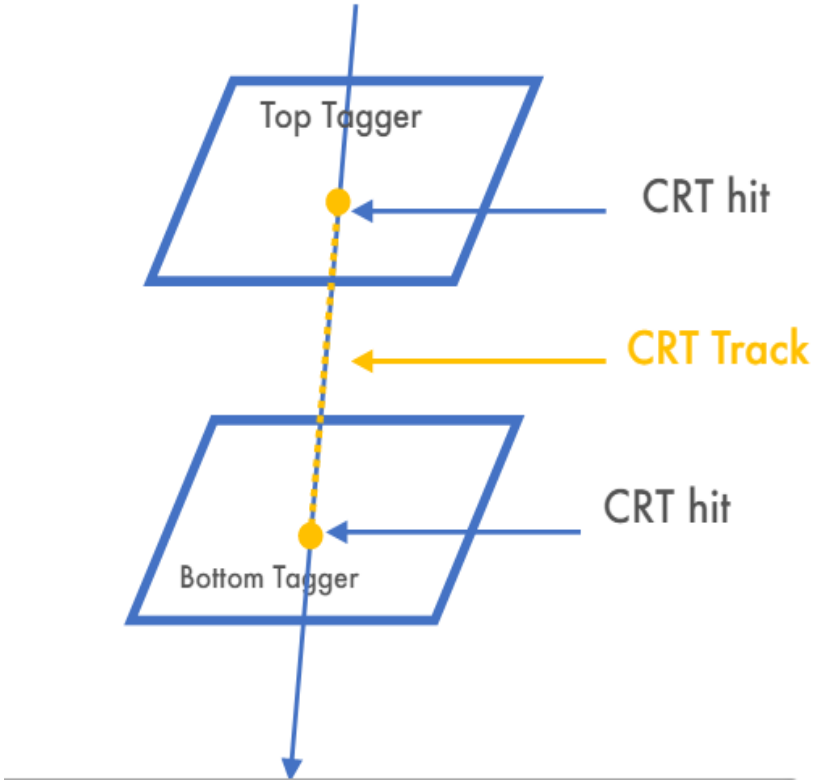
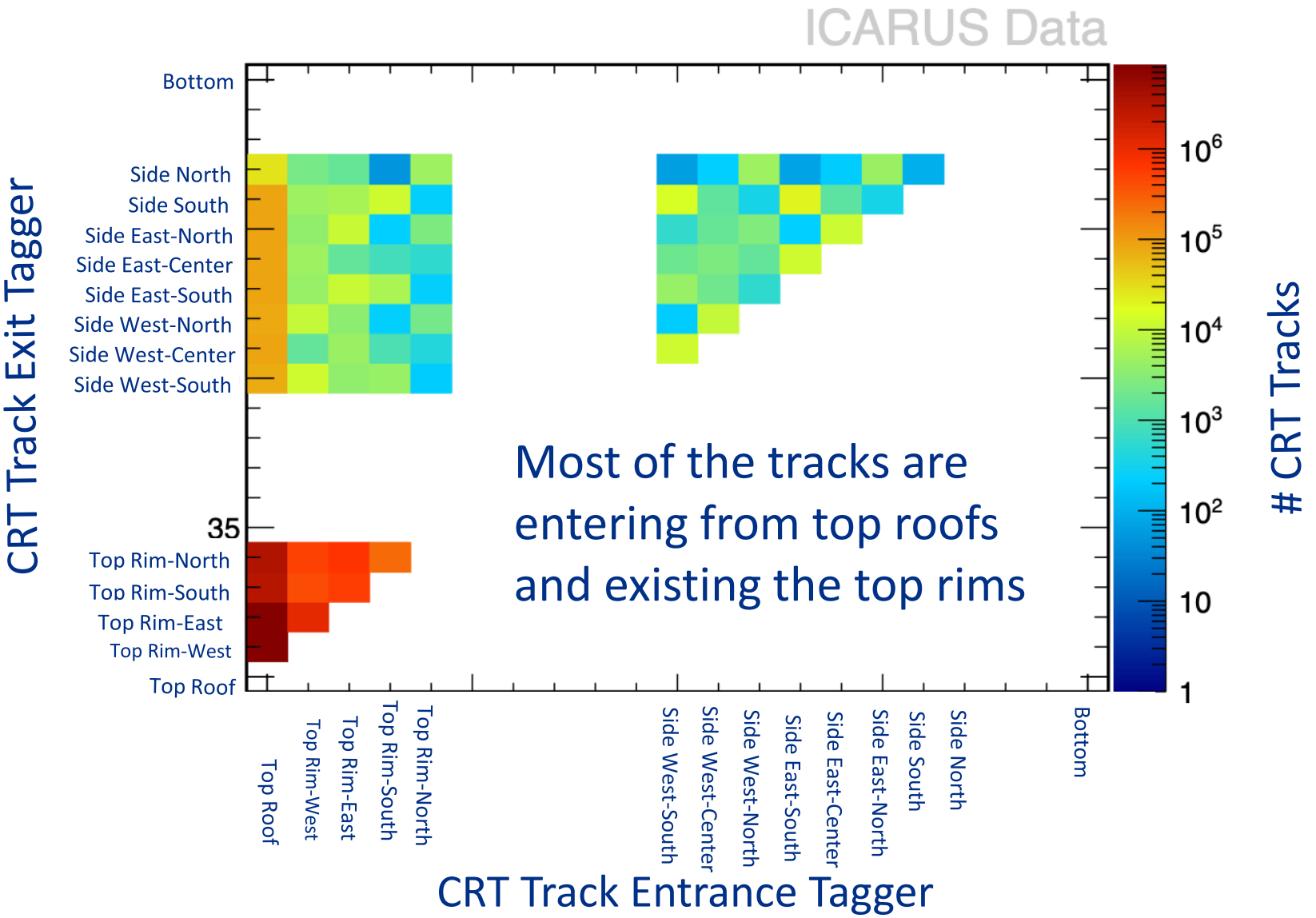


Figure 2: CRT Track reconstruction

- The cosmic muons enter and exit the CRT structure from any 2 surfaces.
- The entry and exit are the 2 hits which are recorded.
- The tracks that the muons take is unknown in the TPC LAr volume.
- The track is reconstructed using a track reconstruction algorithm in CERN ROOT.

CRT Track distribution data



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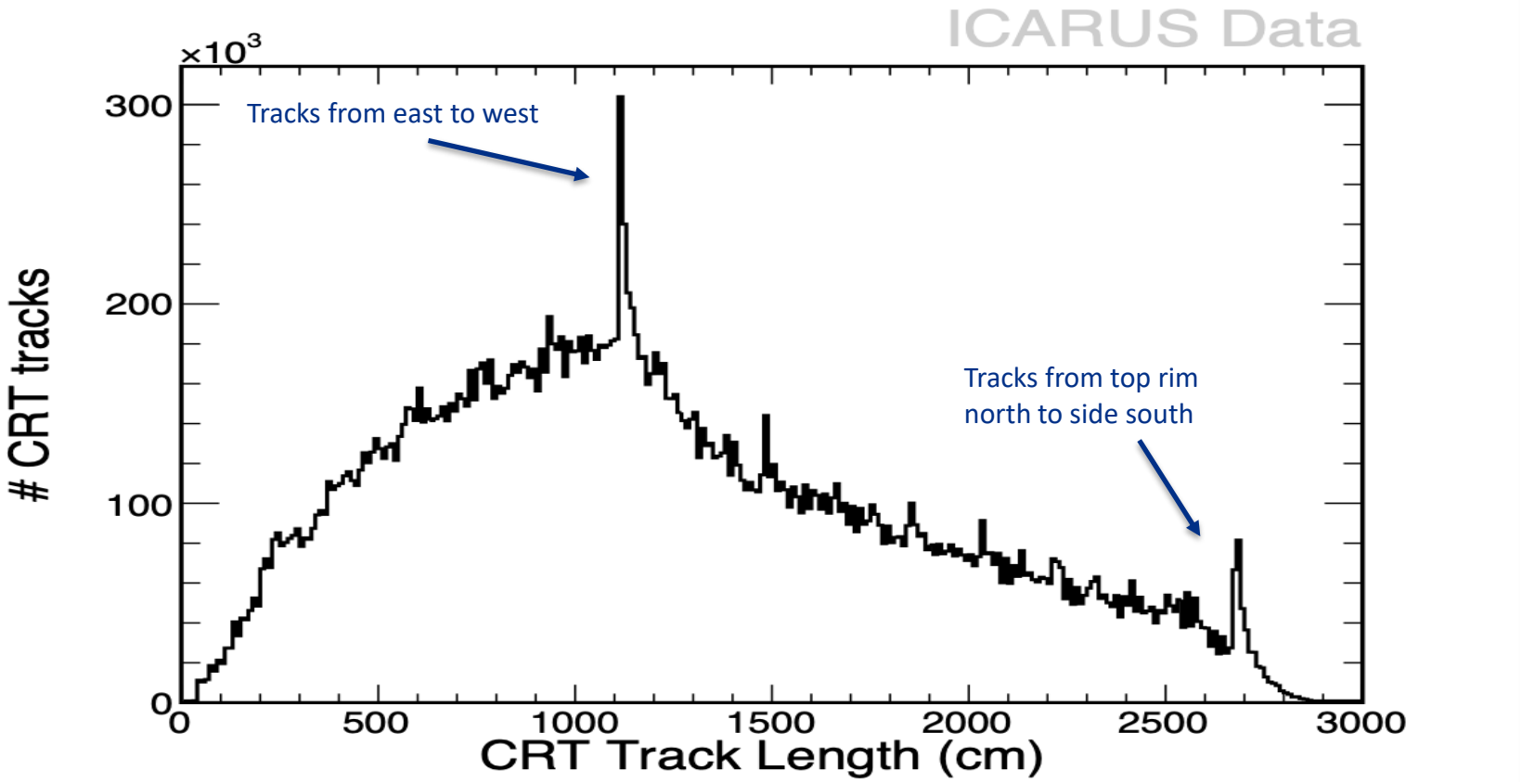
CRT Track Properties

After the reconstruction of the CRT tracks we can use them to study the properties of the cosmic particles.



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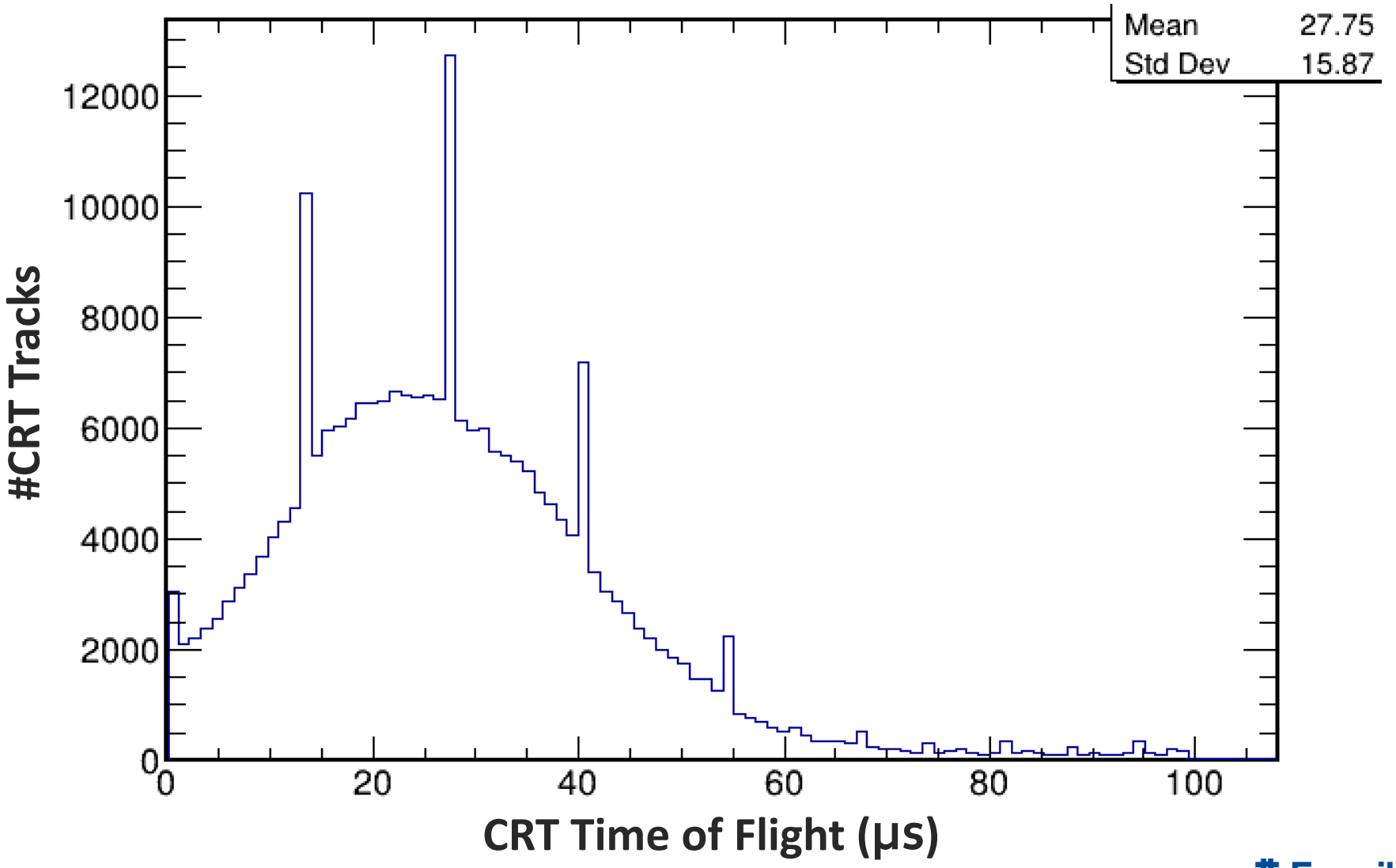
Time of Flight to get the beta distribution for the Momentum



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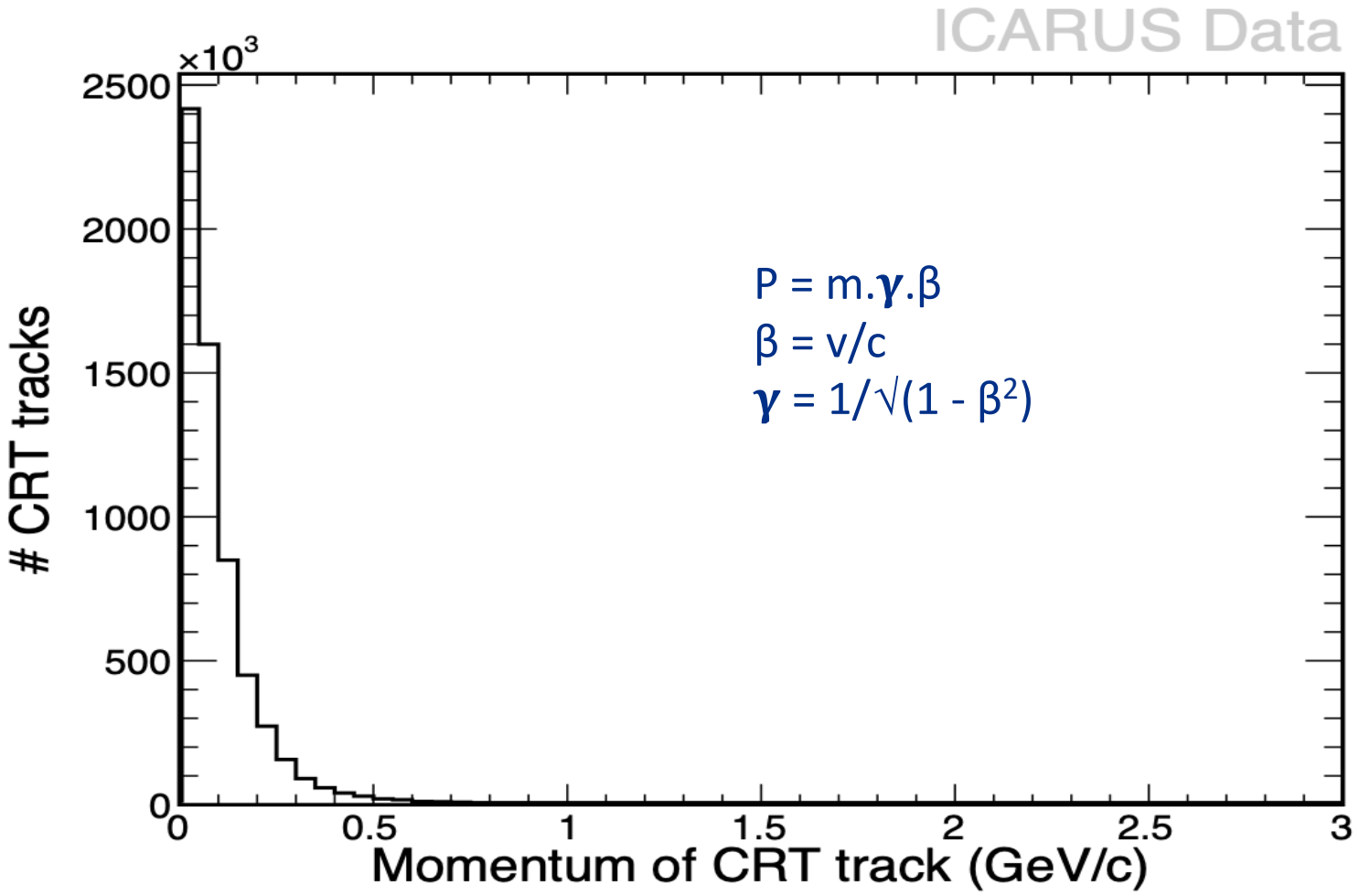
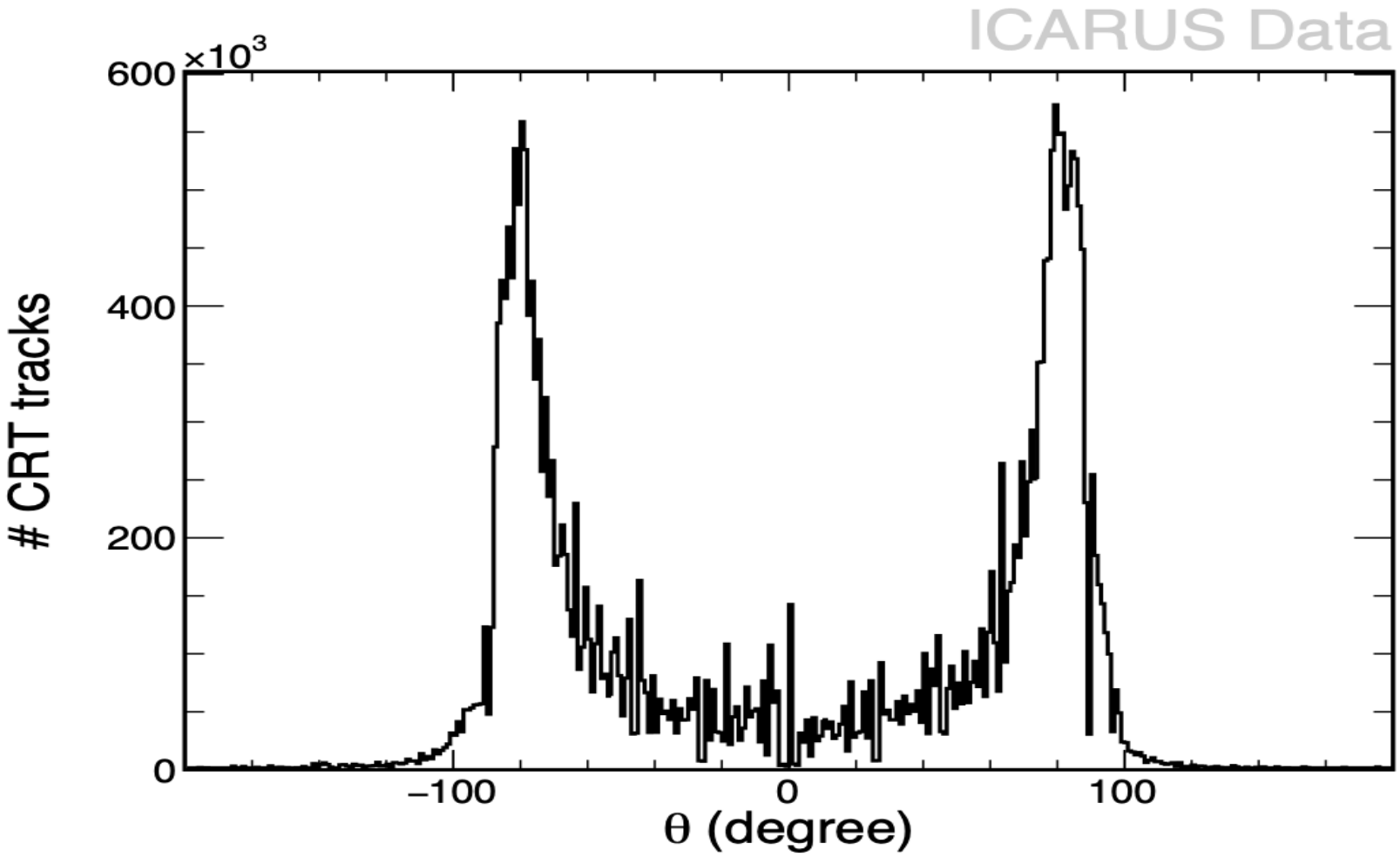
Longer Track lengths have higher momentum



Angle between x and y direction



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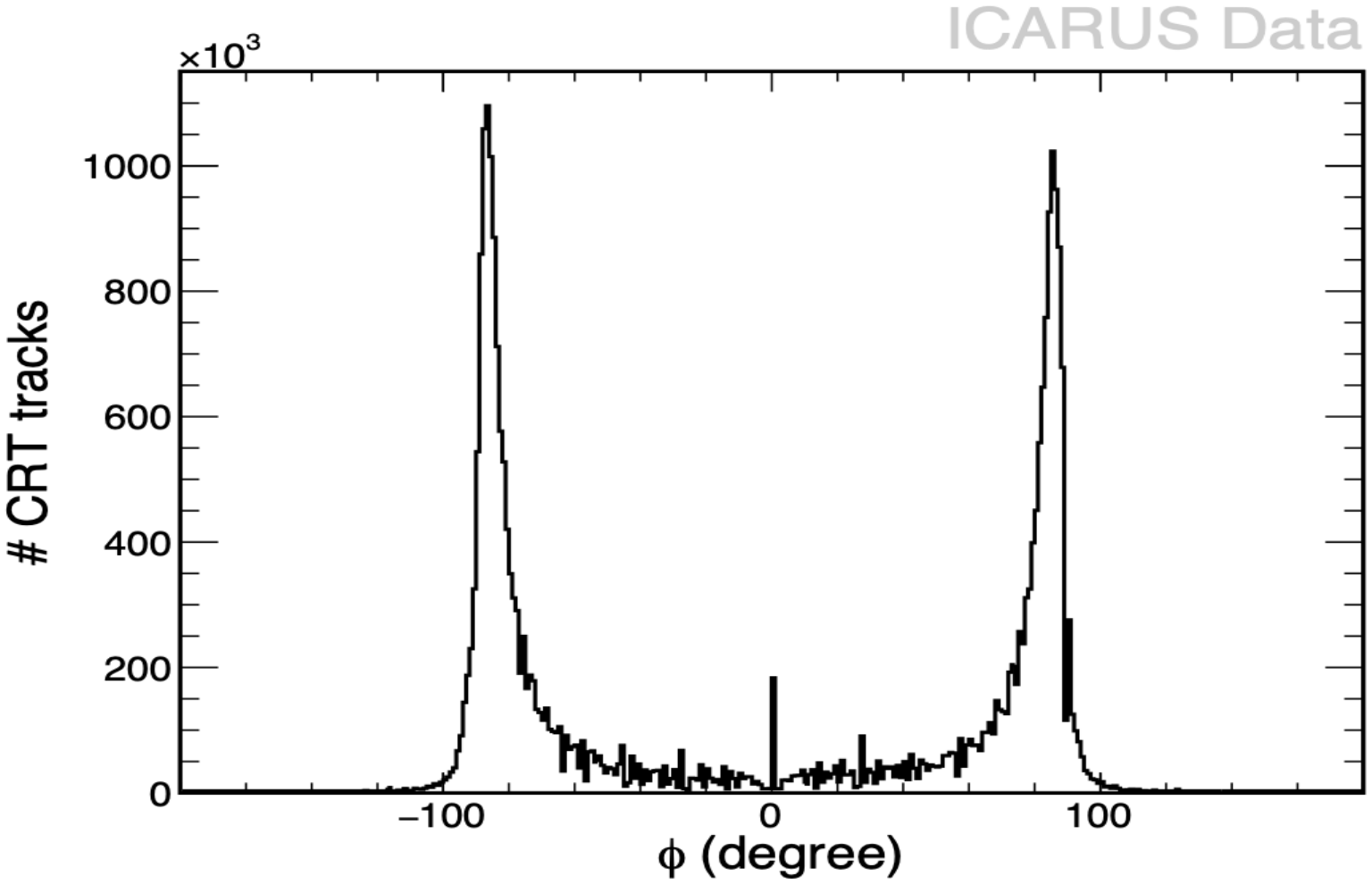
Angle between y and z direction



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Highlights from the Graphs

- Higher flux of incoming cosmic rays entering from top roofs and existing on the top rims and side CRT walls.
- From the angle graphs, most of the tracks are vertical, least interacting muons.
- $\theta(\phi)$ is -ve towards west (north) and +ve towards east (south).
- The spikes in the Length graph are unexpected indicating a need to fine tune the algorithm for precision or some unexplored physical conclusions.

Summary and Future Work

- Understanding the various properties of cosmic tracks using CRT track reconstruction.
- Quantify the amounts of tracks 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.

Collaborations and References

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

Acknowledgement

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