



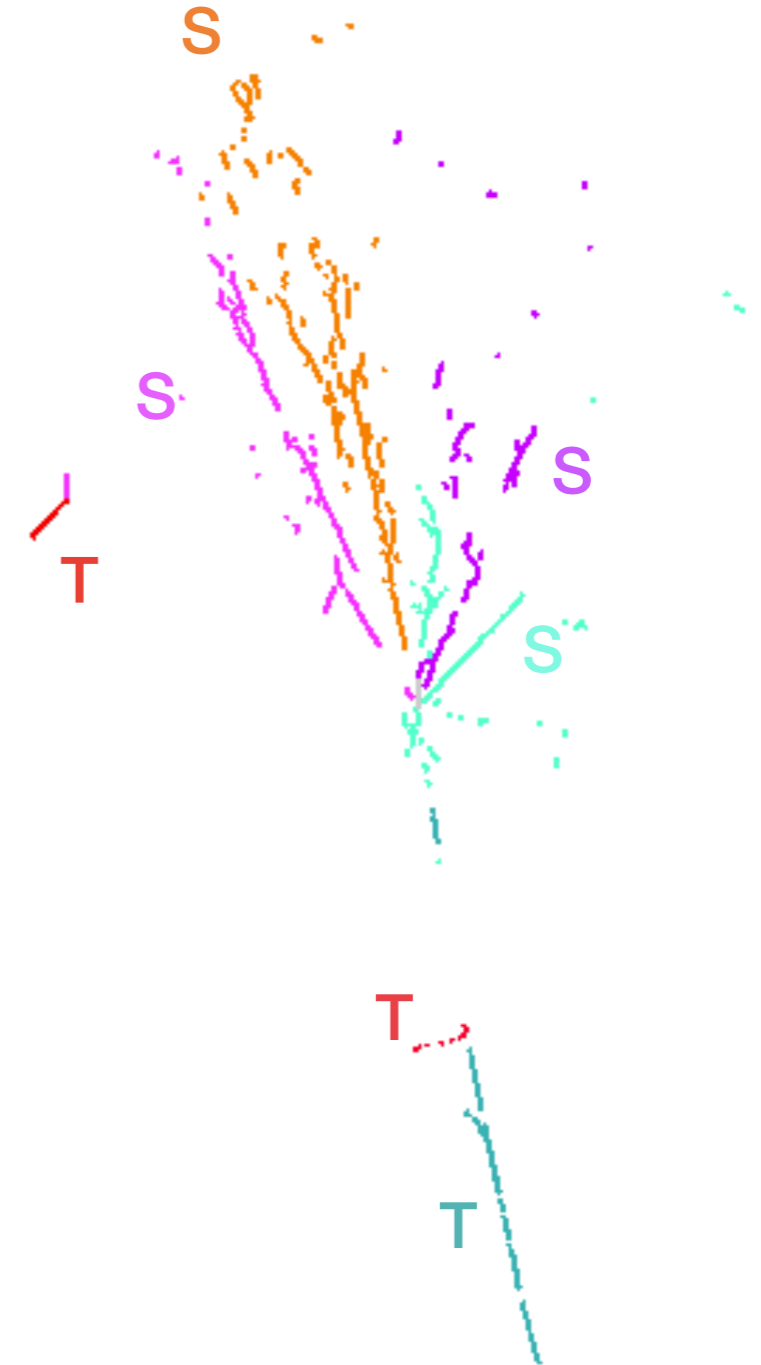
Pandora Reconstruction Metrics For Data

Steven Green on behalf of the Pandora Team

21st November 2018



- Evaluate the performance of the Pandora reconstruction on test beam data.
- Compare the reconstructed output obtained for test beam data to the information produced by the trigger.

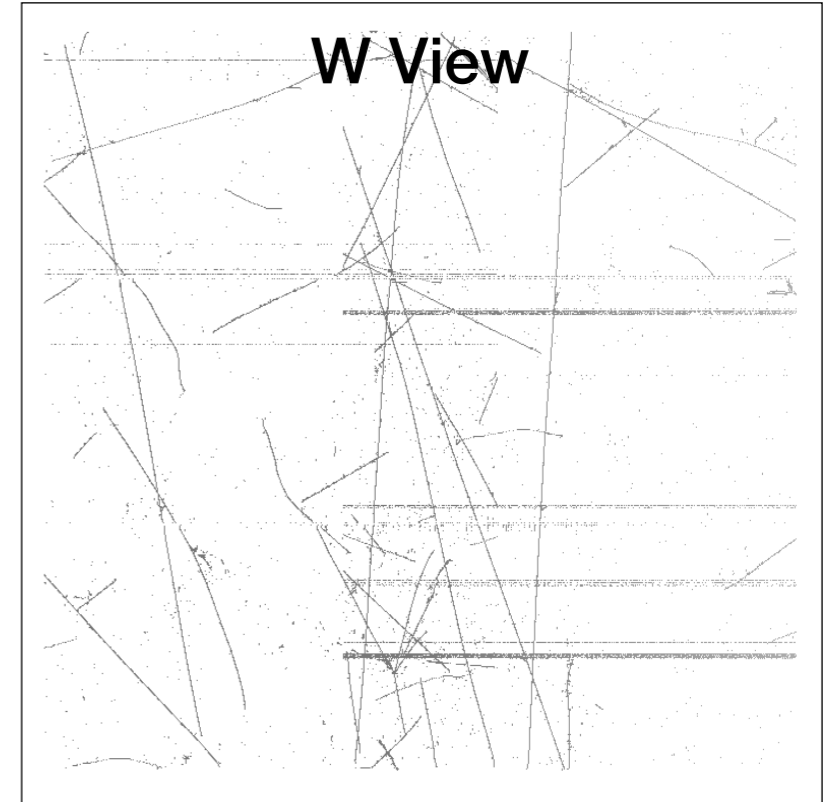
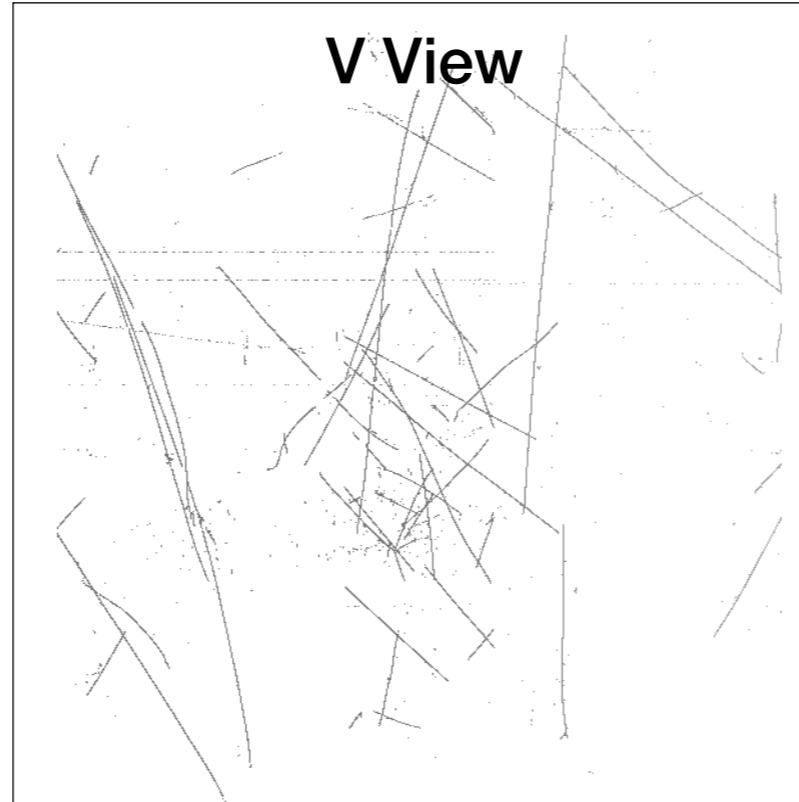
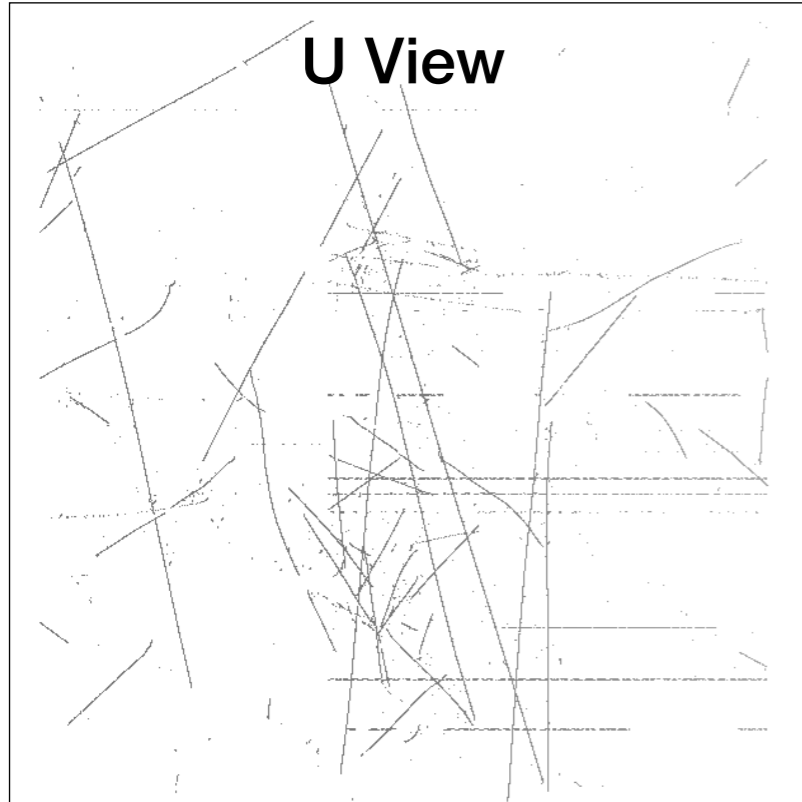


Run Number : 5144
Event Number : 47293
(--nskip 0)
np04_raw_run005144_0038_d15.root

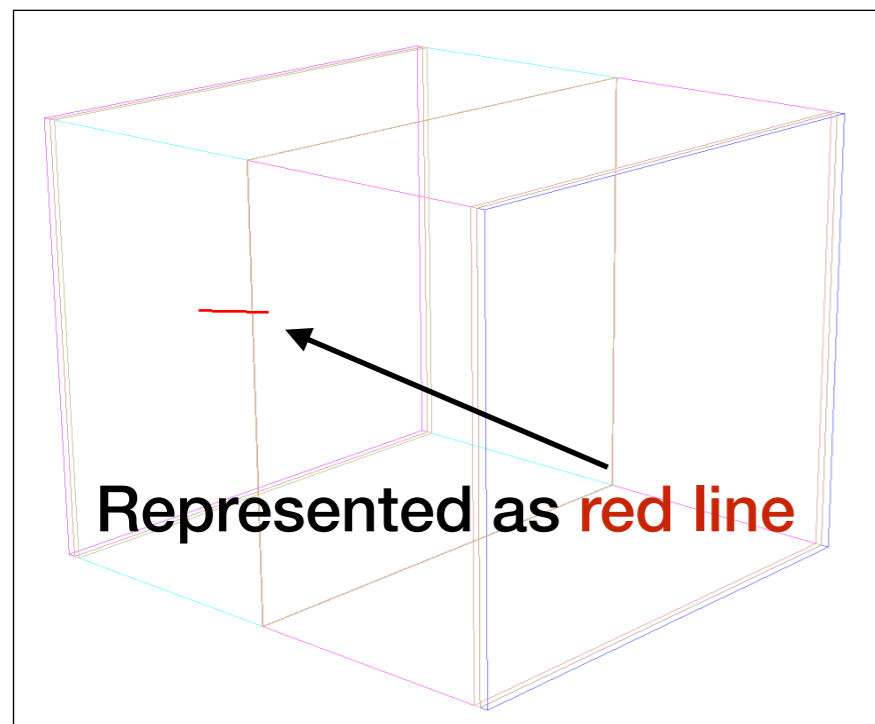


Hits:

Run 5204, Event 57734



Trigger Information:

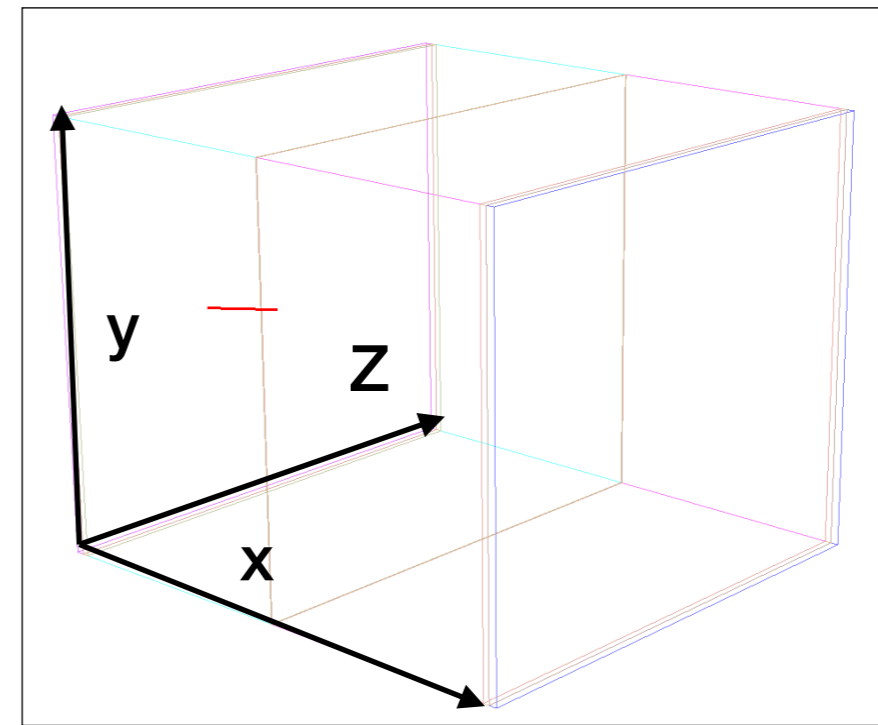
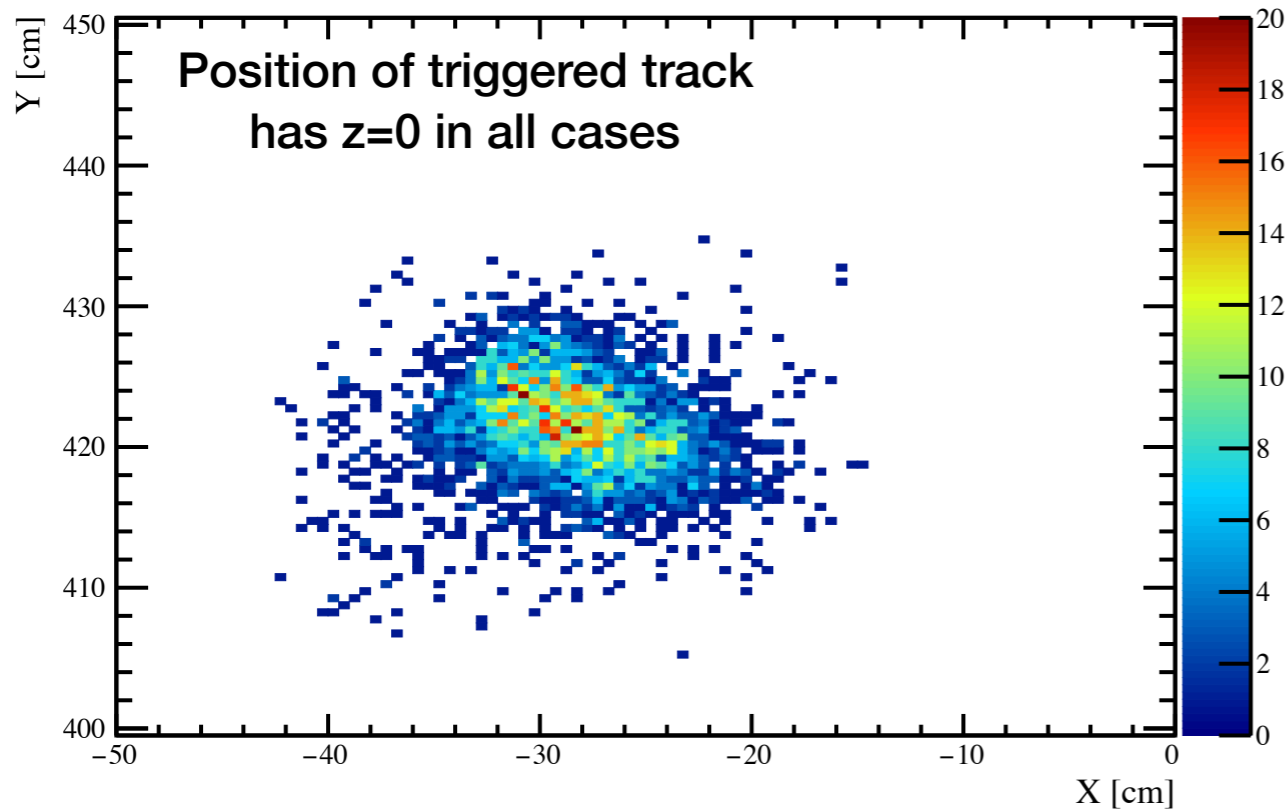


Includes:

- If the trigger was activated.
 - If yes → vector<recob::Tracks> produced by trigger.
 - Select cases where only one recob::Tracks produced to avoid ambiguities, giving:
 - Position
 - Direction
 - Momentum
- + Cherenkov Counter & TOF,
but not used yet.

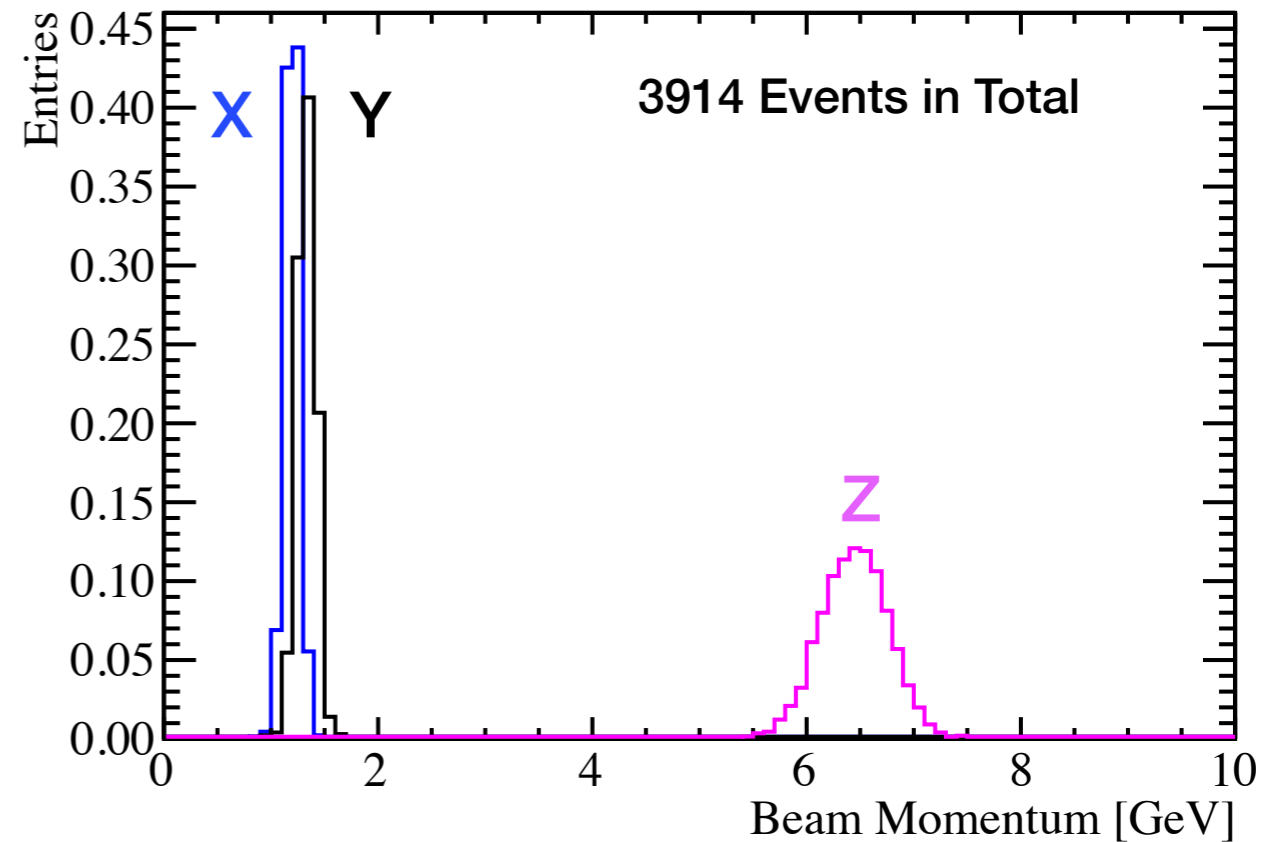
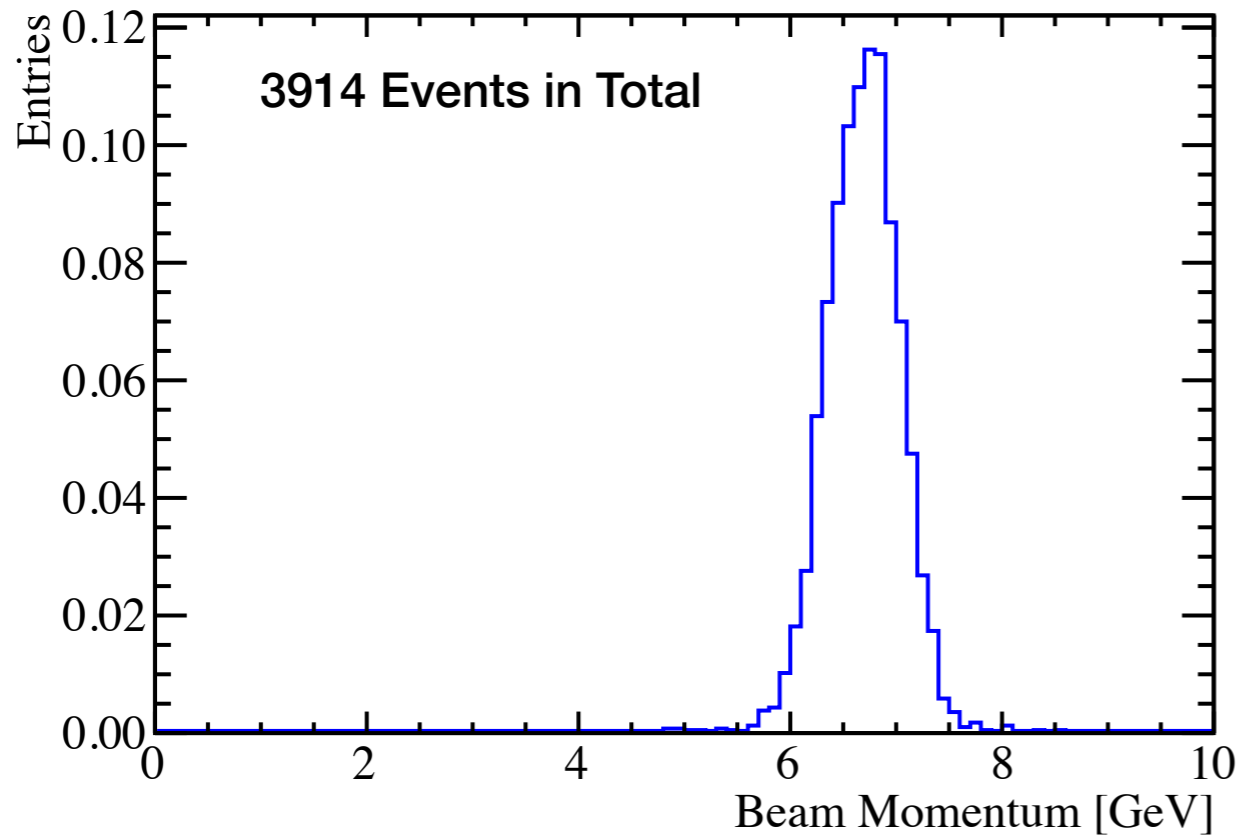


Trigger Information



Data: ~10,000 events from samweb np04_full-reconstructed_v07_08_00_03_physics

- Showing cases where there is **one track from the trigger.**

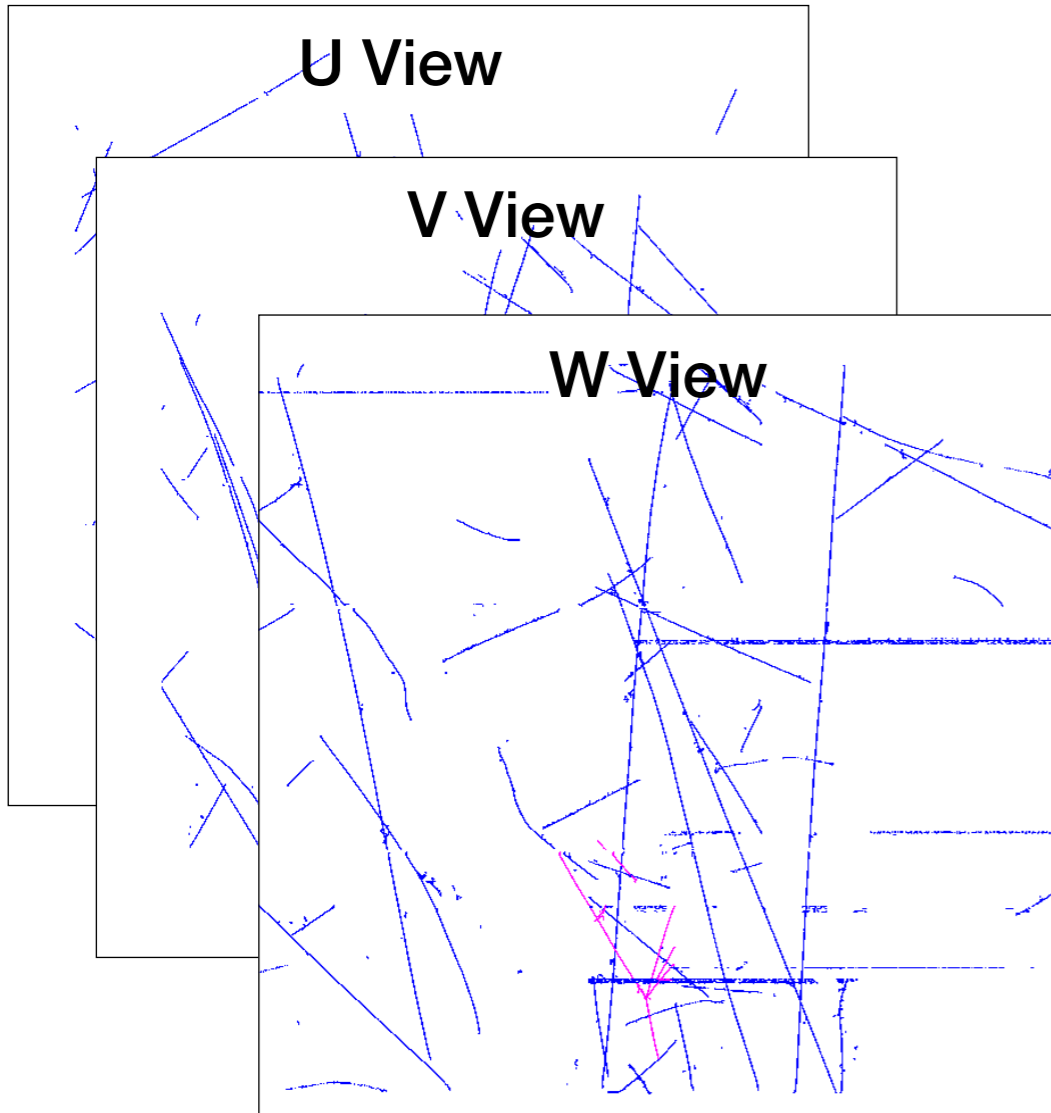




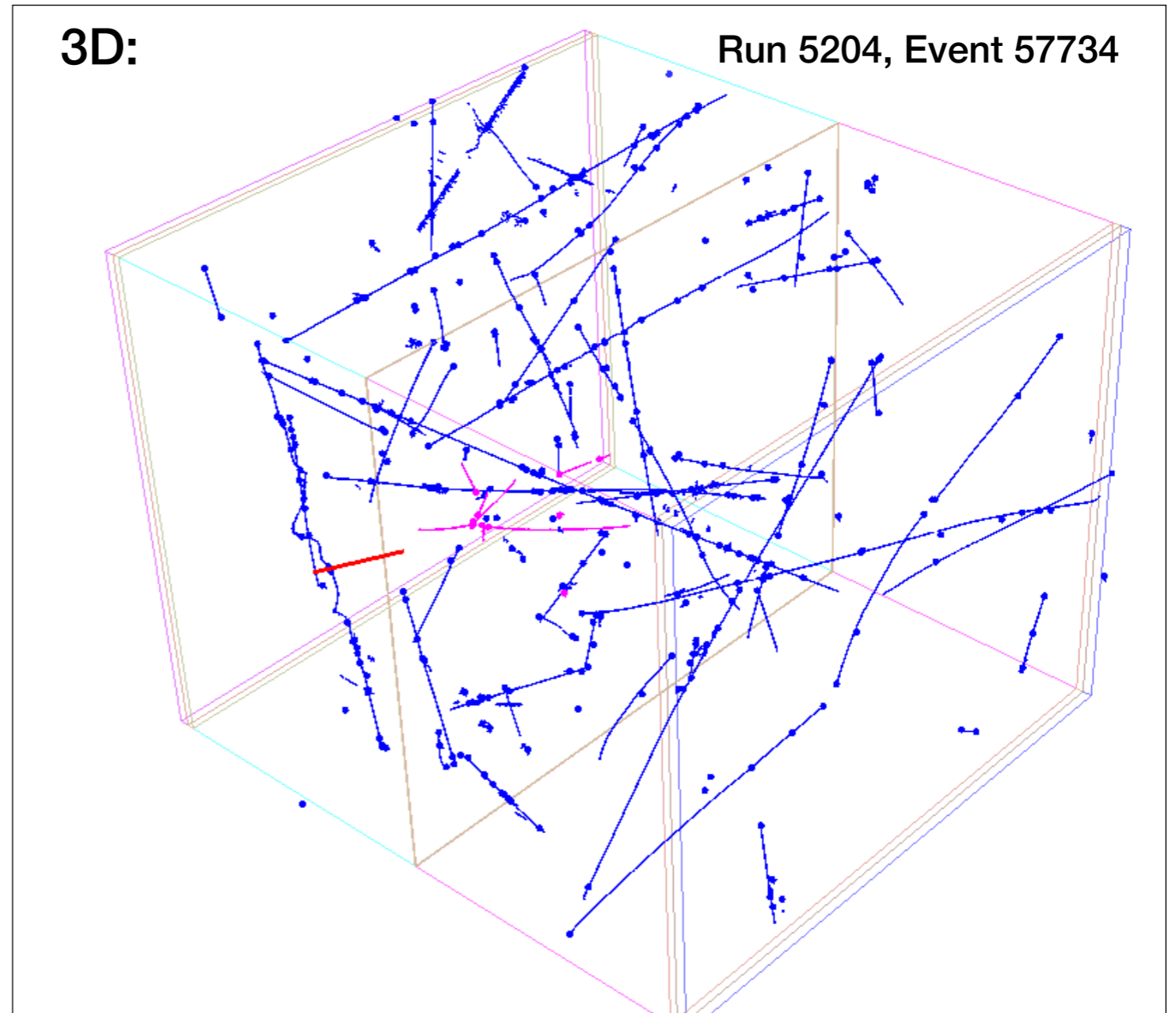
Pandora Outputs



2D:



3D:



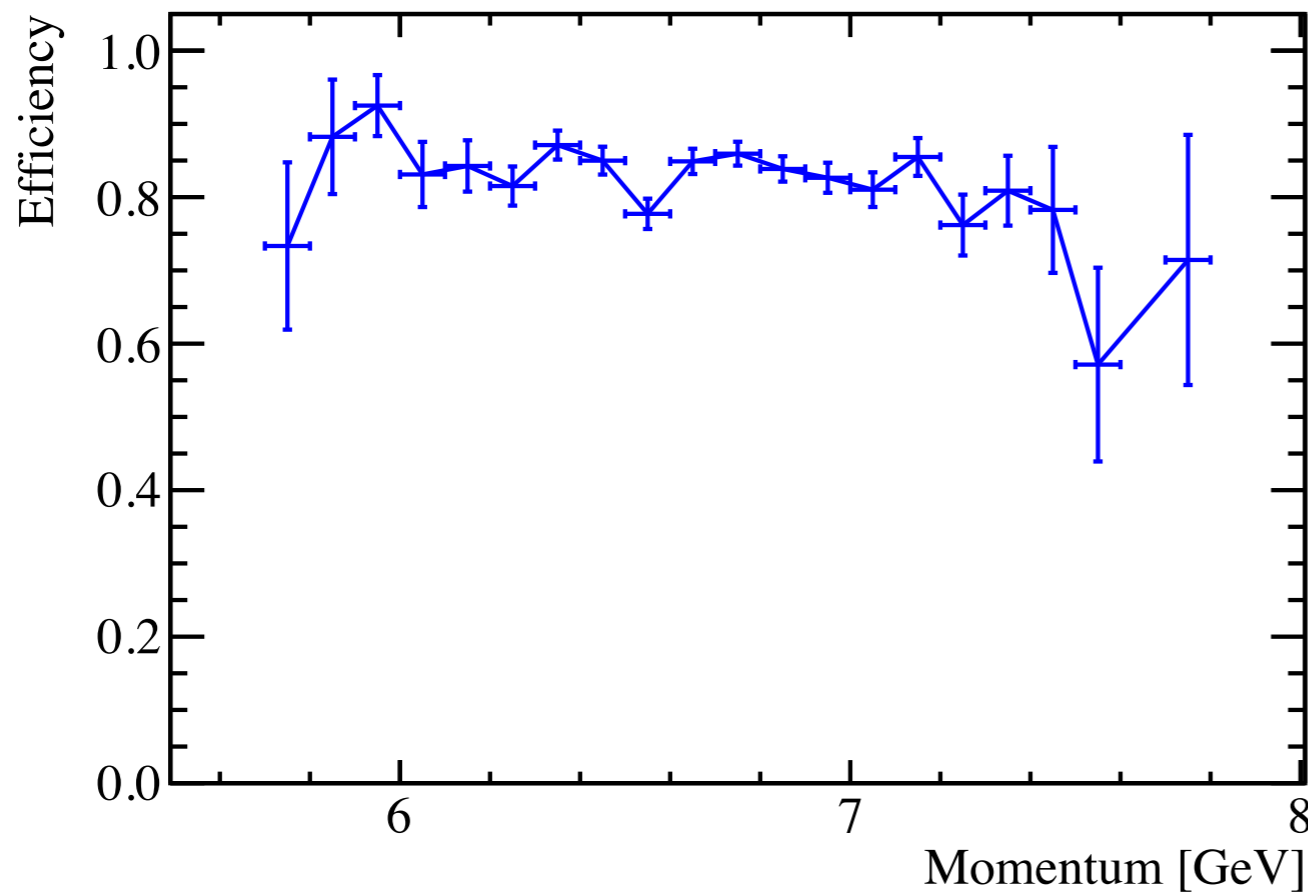
Blue : Cosmic Ray Particles

Purple : Test Beam Particle

Red : Trigger Information

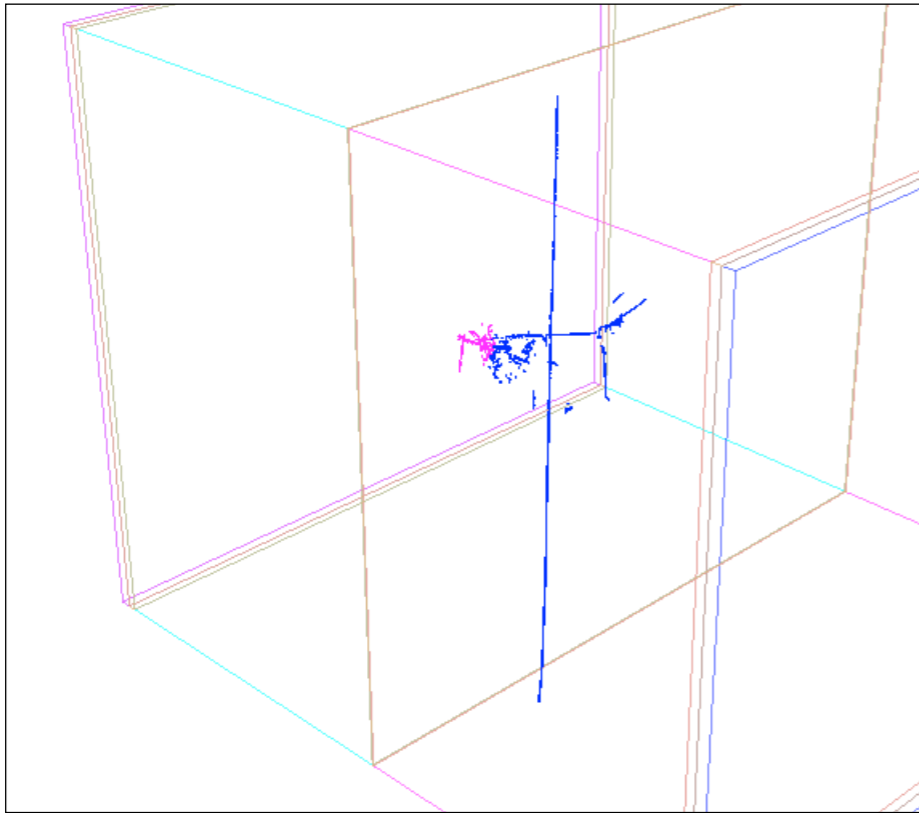


- Efficiency: Fraction of target events where the **trigger is active** and we **reconstruct at least one test beam particle**.
- Plotted as a function of momentum of triggered track.
- Efficiency roughly uniform across momentum range considered. (Slight trend possible, but more statistics needed to verify).
- Performance consistent with studies done by Leigh.

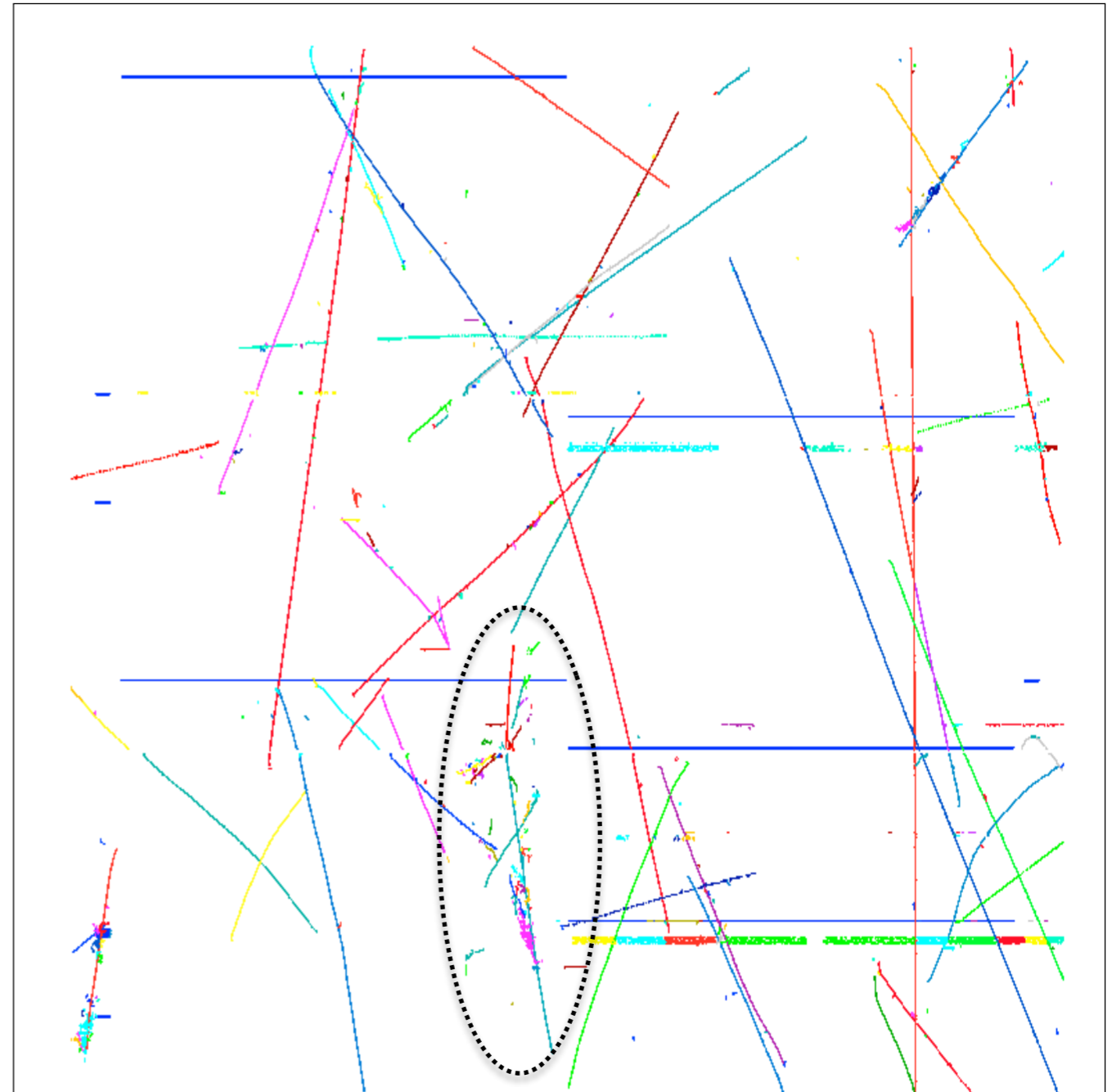


**3914 Events, 3253
Reconstructed With Test
Beam PFParticle
Integrated Efficiency:
 $83.1 \pm 0.6\%$**

Data: ~10,000 events from samweb np04_full-reconstructed_v07_08_00_03_physics

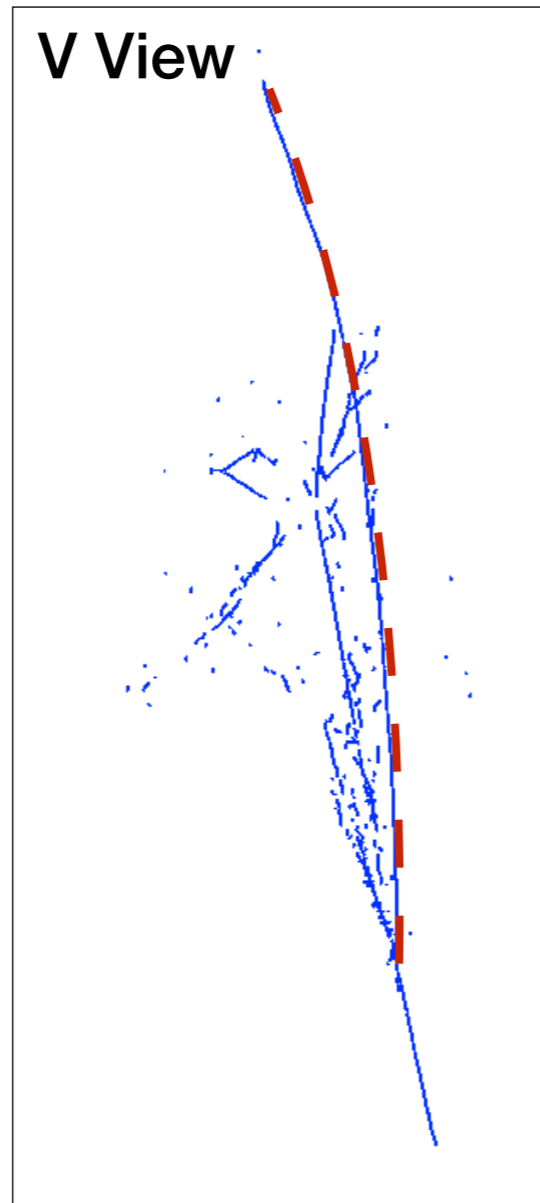
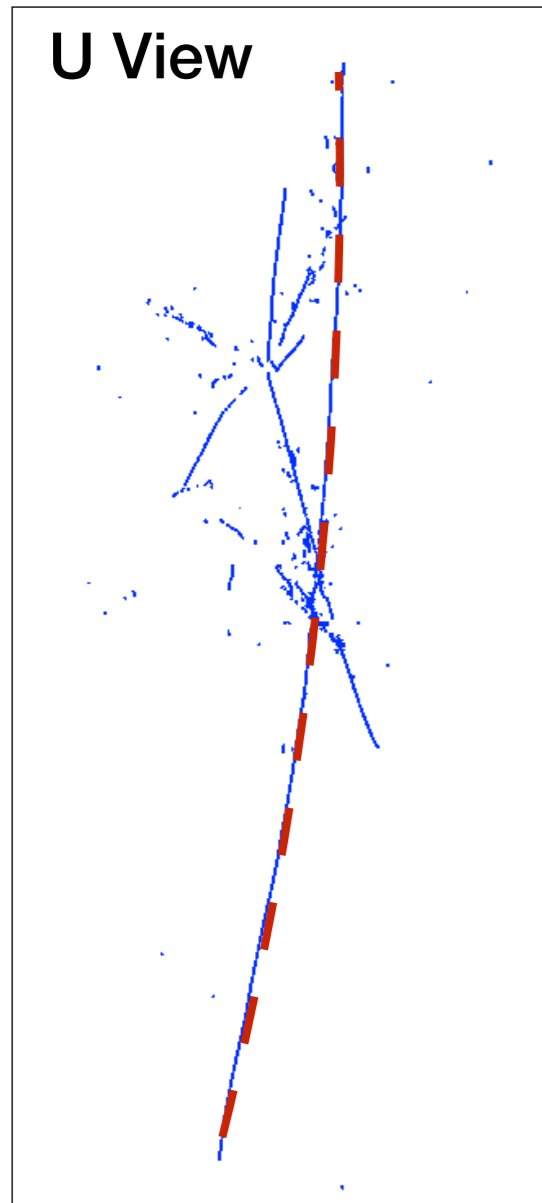


W View



- Test beam particle is visible in 2D and 3D displays.
- But particle fails the test beam ID due to cosmic ray contamination in slicing.

Run 5152, Event 12899



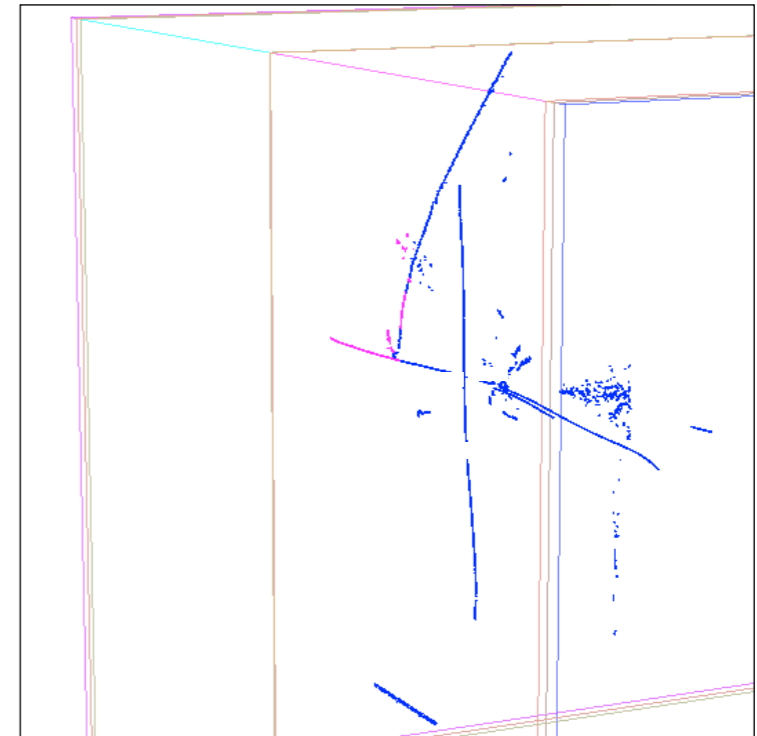
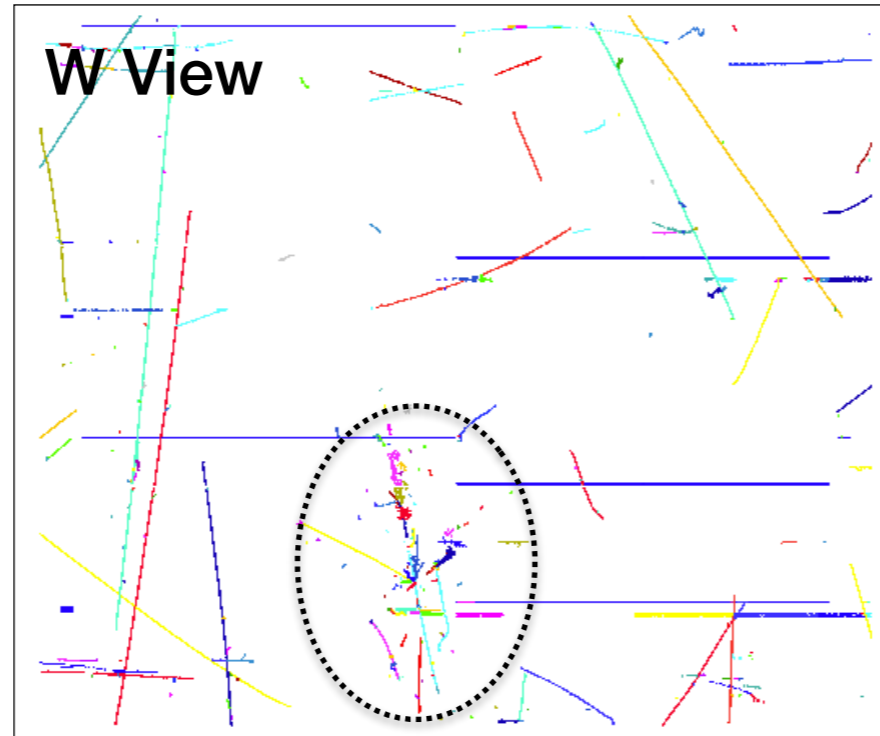
Hits in Test Beam Slice

- Slices containing test beam particle also contains cosmic rays (red dotted lines)

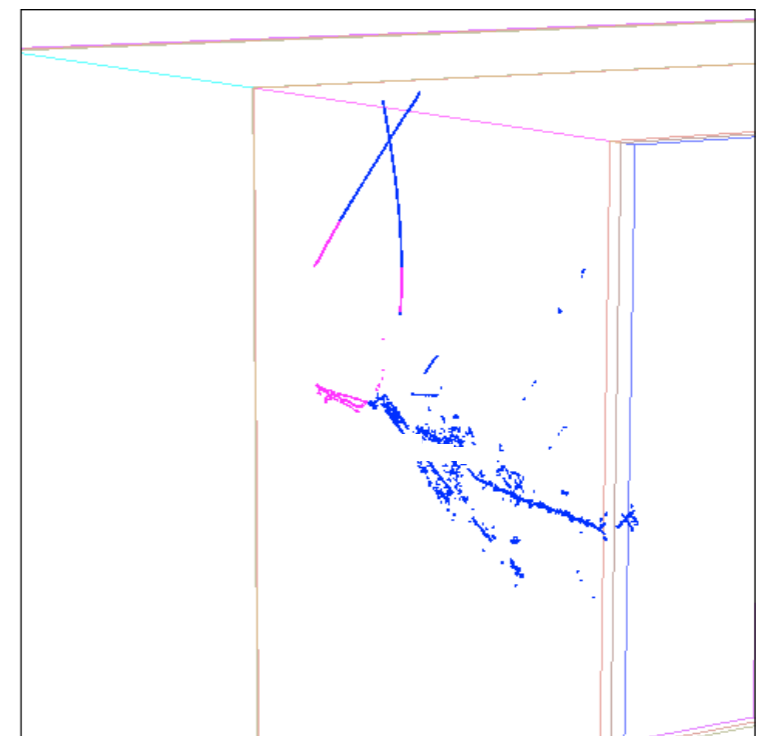
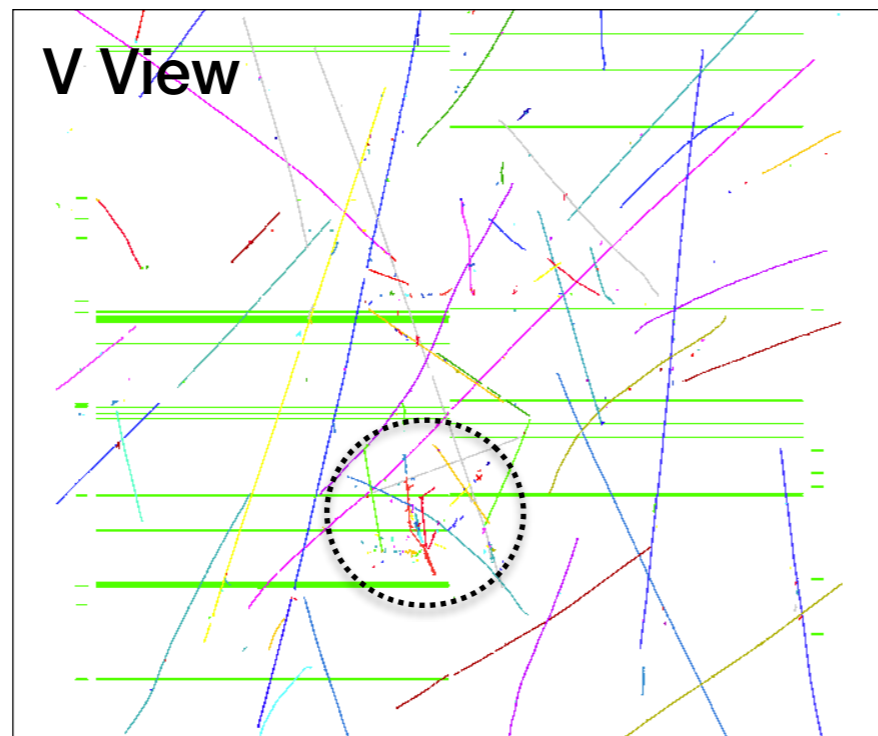
Run 5152, Event 12899



- Cosmic ray contamination seems to be the dominant mechanism for efficiency loss, which is expected based on previous mc studies (see backup for details)



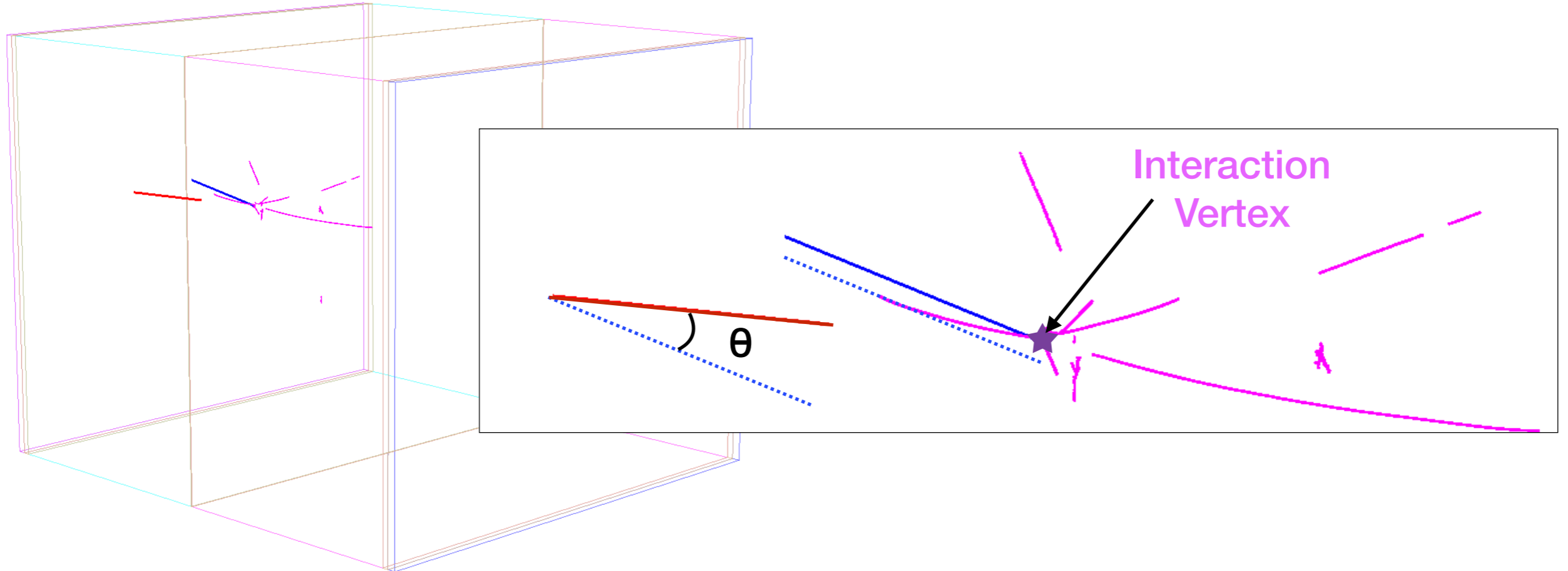
Run 5152, Event 13102



Run 5152, Event 13169



- **Direction:** Compare the relative angle of the reco::Track from the trigger and the direction of a linear fit to the start of the reconstructed test beam particle.



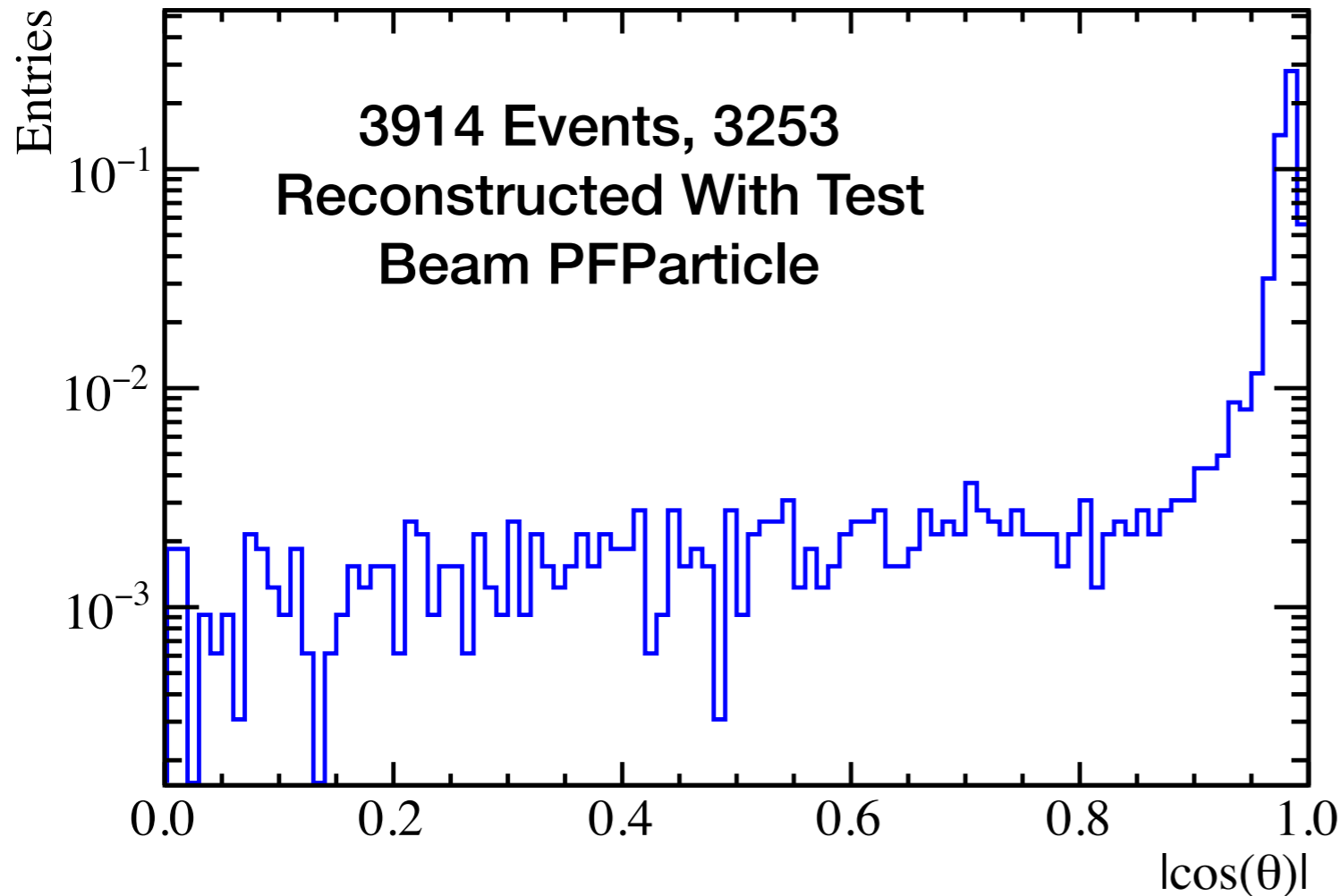
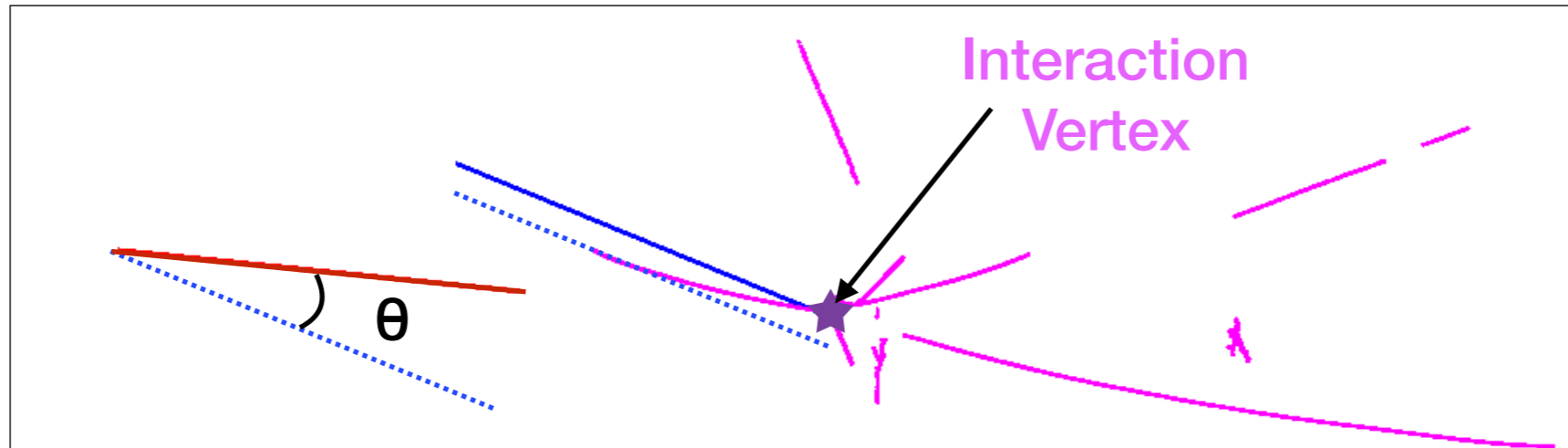
Purple : Test Beam Particle

Blue : Direction when fitting 3D hits at the start of the test beam particle

Red : Trigger Information



Reconstruction Metrics

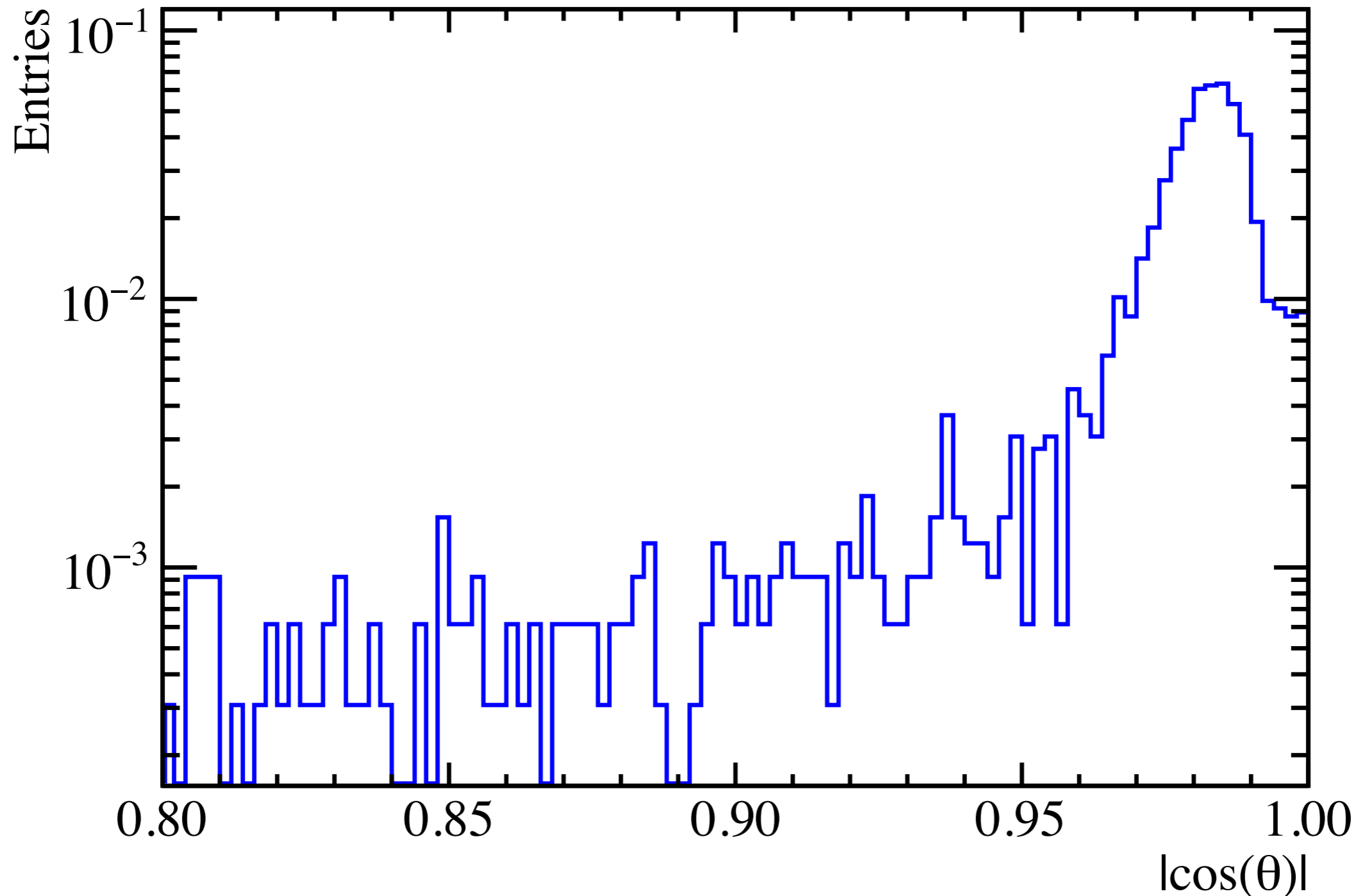


Data: ~10,000 events from samweb np04_full-reconstructed_v07_08_00_03_physics

- Good agreement with peak around $\theta = 0$, indicating that we are reconstructing the test beam particle.
- Values far from $\theta = 0$ are due to cosmic ray overlap skewing the fit.



- When zooming in around peak, non perfect match is visible, but this could be due to space charge causing the track to bow.





- A good efficiency (comparable to that for MC) is being achieved by the Pandora reconstruction on real data.
- The initial direction of the test beam particle reconstructed by Pandora appears to match that produced by the trigger.
- Further studies need to be done that cover a wider range of momenta and examine the particle hierarchy, but the initial results are encouraging.

Thank you for your attention!

Questions? (Or ideas for other metrics to look at?)



Pandora Pattern Recognition



Pandora is an open project and new contributors would be extremely welcome. We'd love to hear from you and we will always try to answer your questions.

Pandora SDK Development

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ProtoDUNE Integration

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MicroBooNE Integration

Andy Smith (asmith@hep.phy.cam.ac.uk)

Other team members

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ProtoDUNE: Stefano Vergani

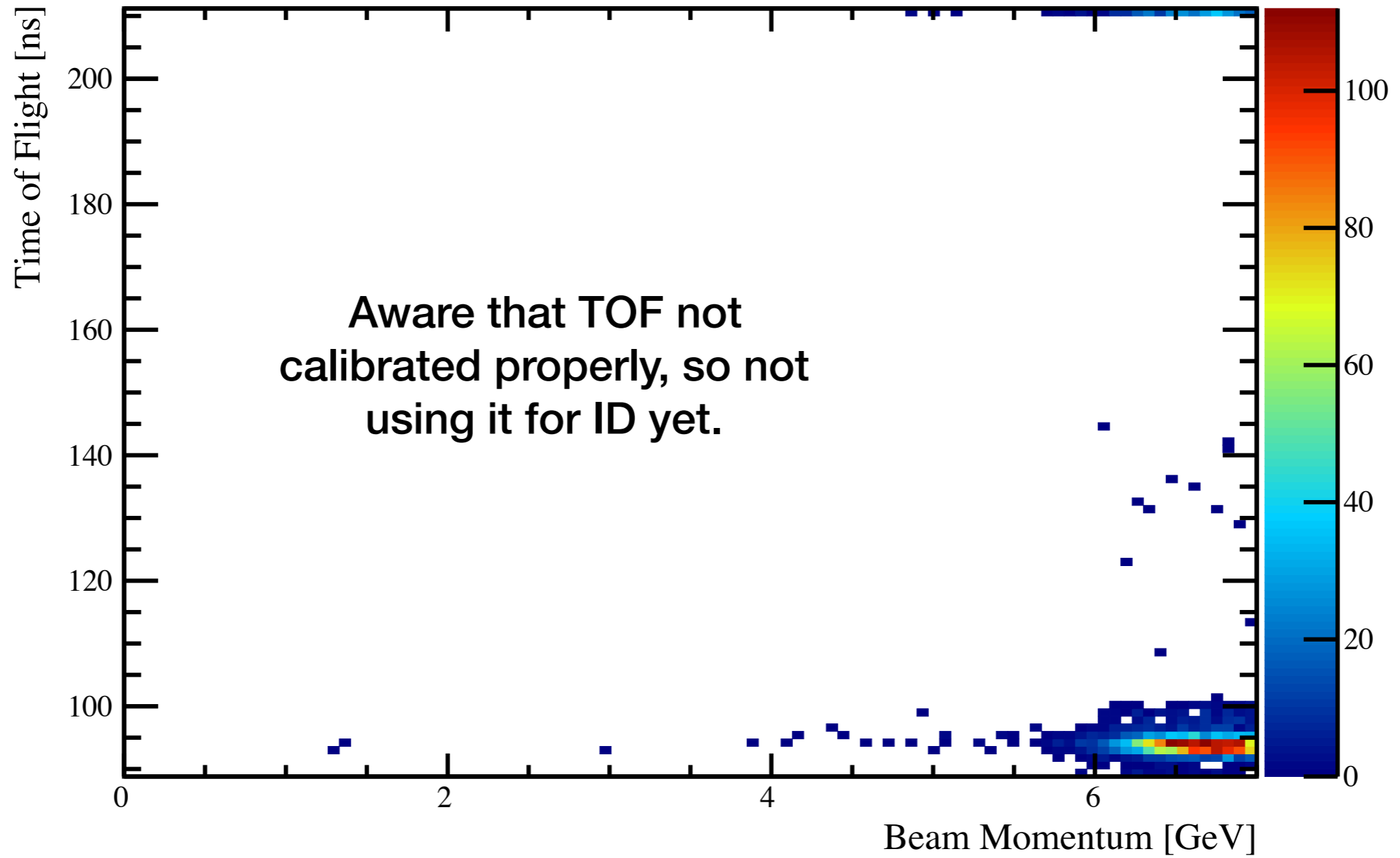


<https://github.com/PandoraPFA>



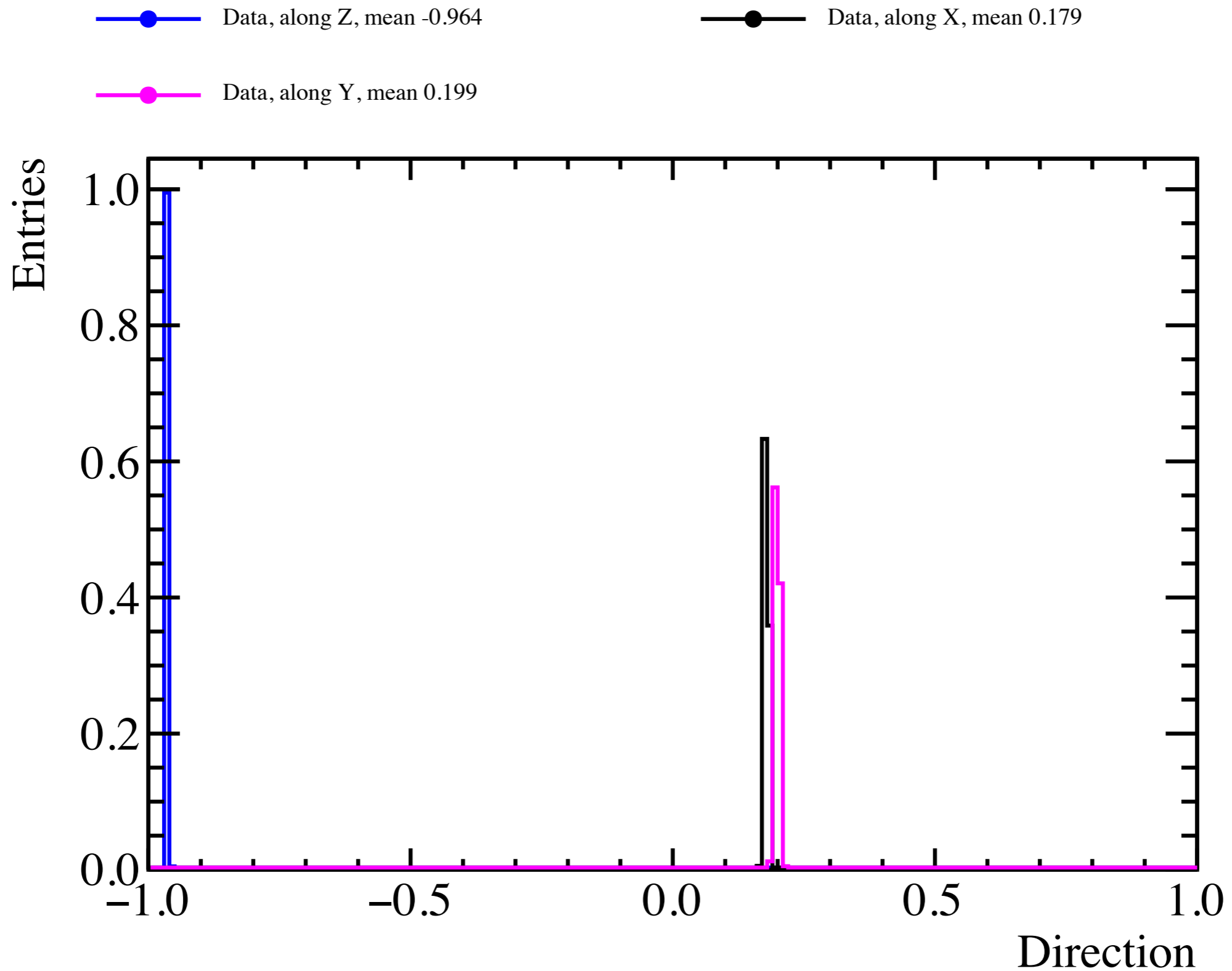
<https://pandorapfa.slack.com>





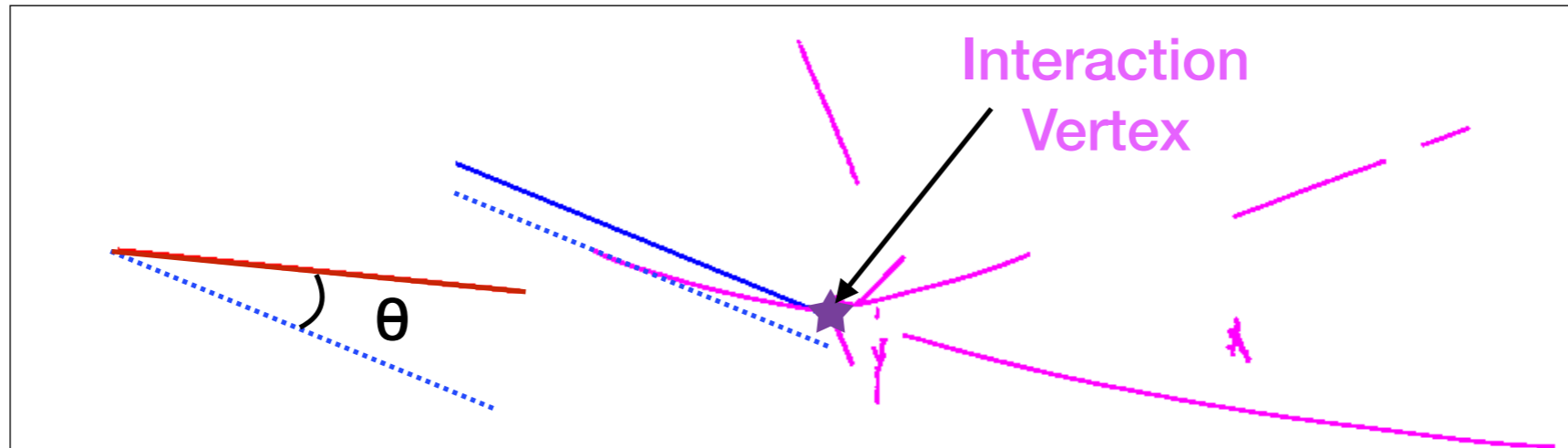


Trigger Information - Direction



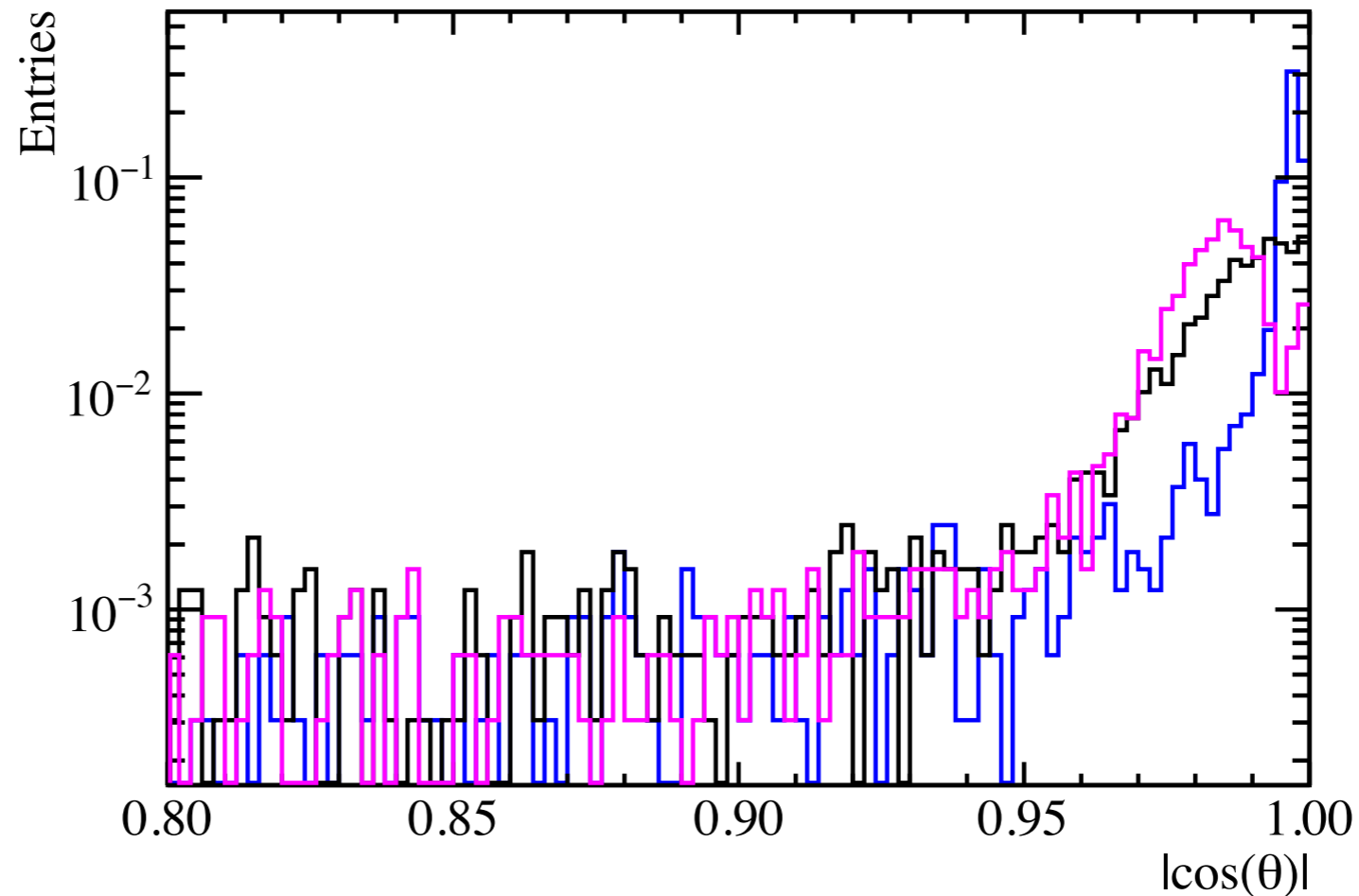


Reconstruction Metrics



- Looking at θ in different 2D projections

Data: ~10,000 events from samweb np04_full-reconstructed_v07_08_00_03_physics



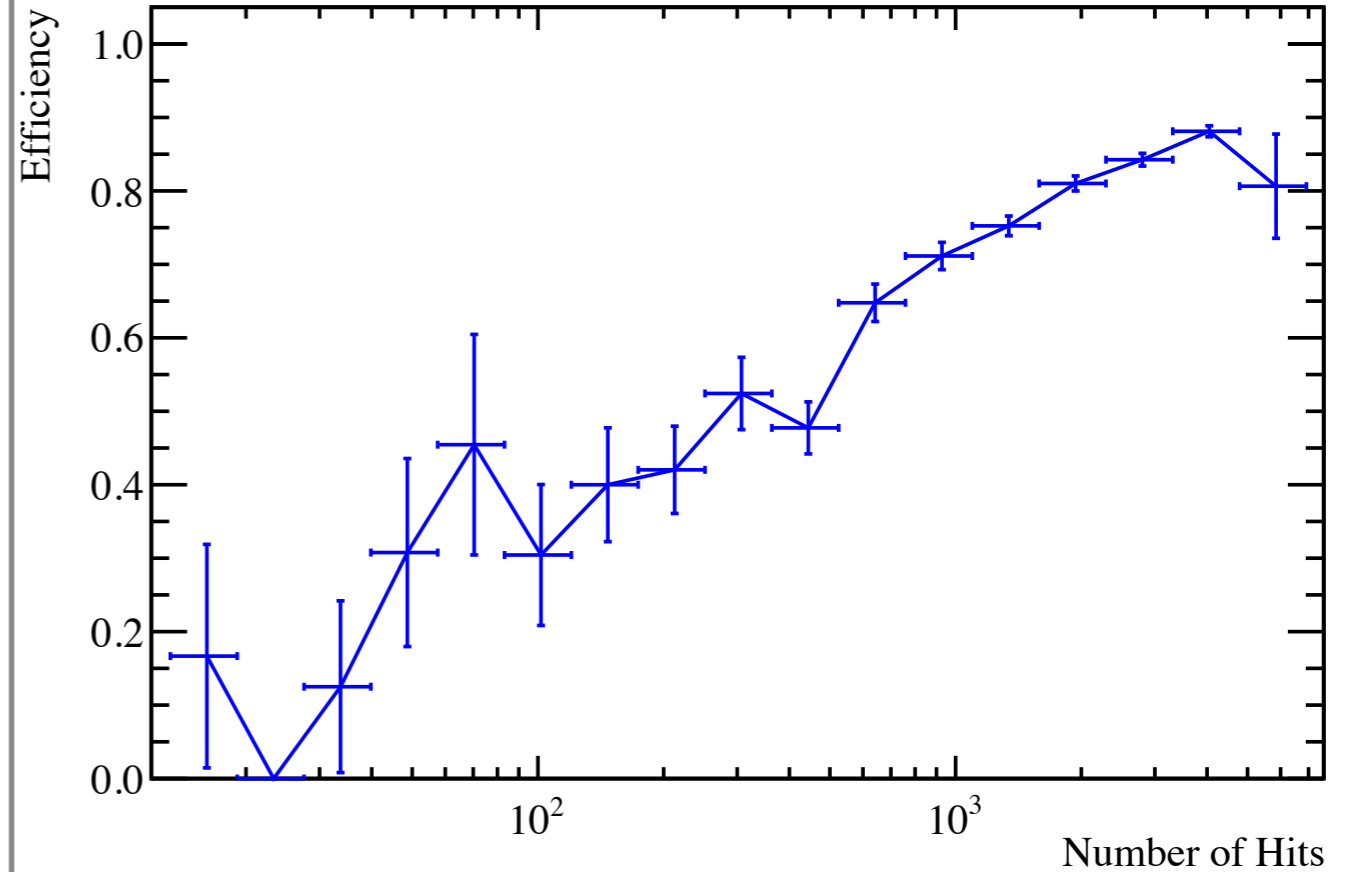
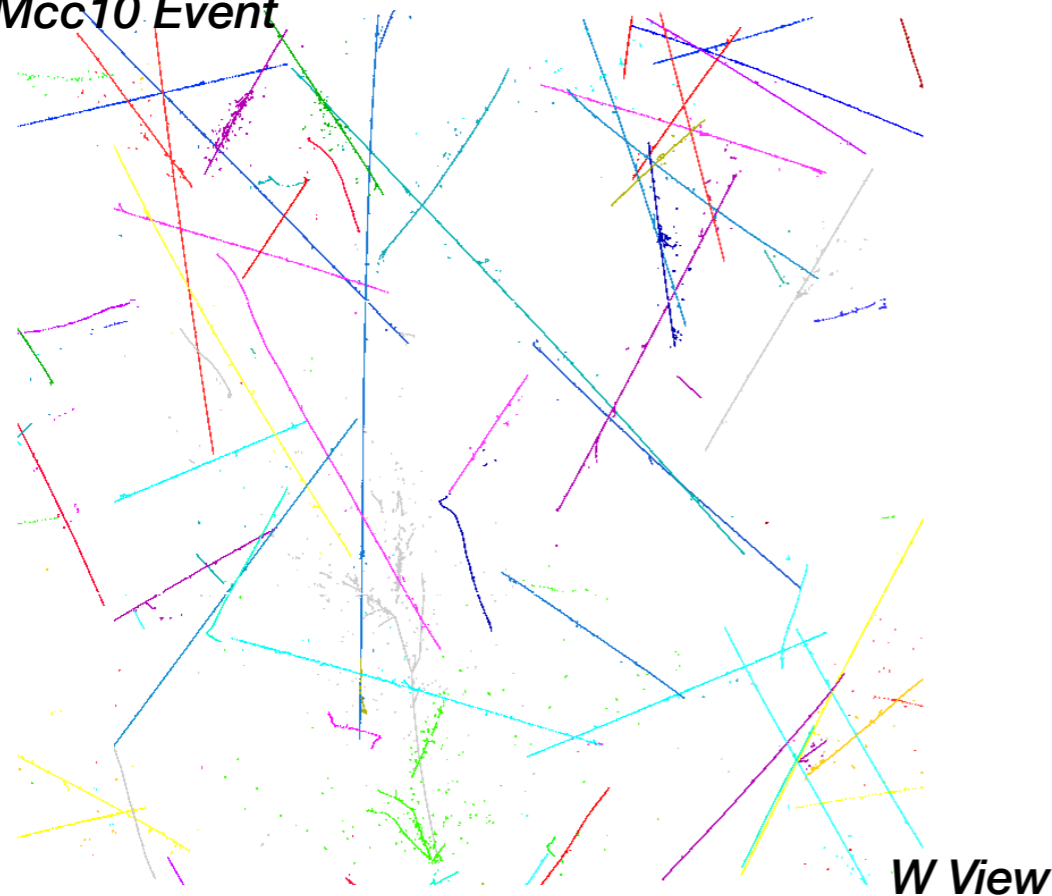


Test Beam Reconstruction Metrics



- The **Pandora test beam reconstruction is good and ready for real data.**
- Inefficiency are primarily due to:

Mcc10 Event



.....
 Beam & Cosmics
 : Integrated Efficiency [%]
 : 78.88±0.47

This metric folds in effects from cosmic-ray pattern recognition, cosmic-ray tagging, slice creation, both the cosmic-ray and neutrino slice reconstructions and test beam particle identification.

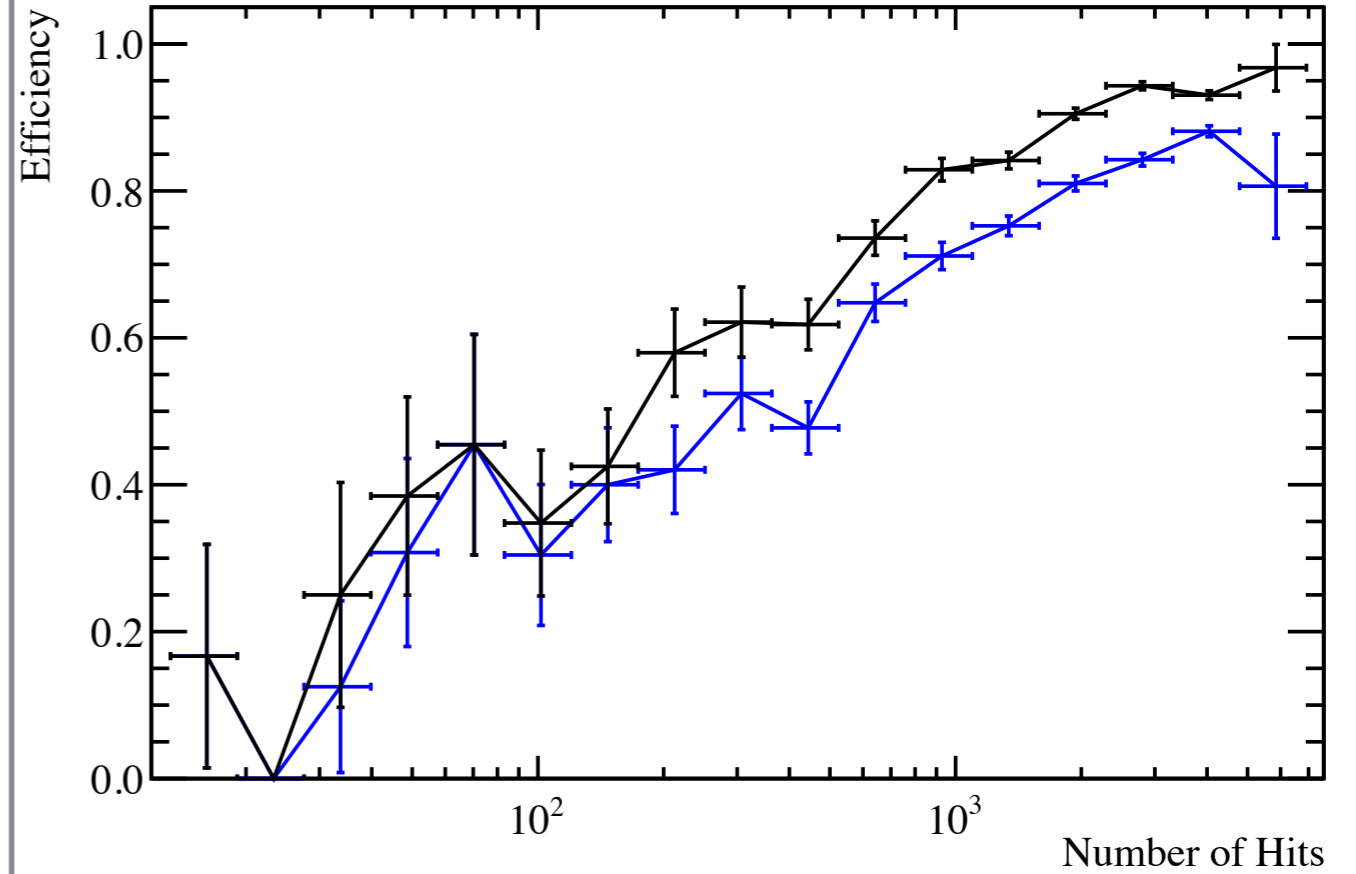
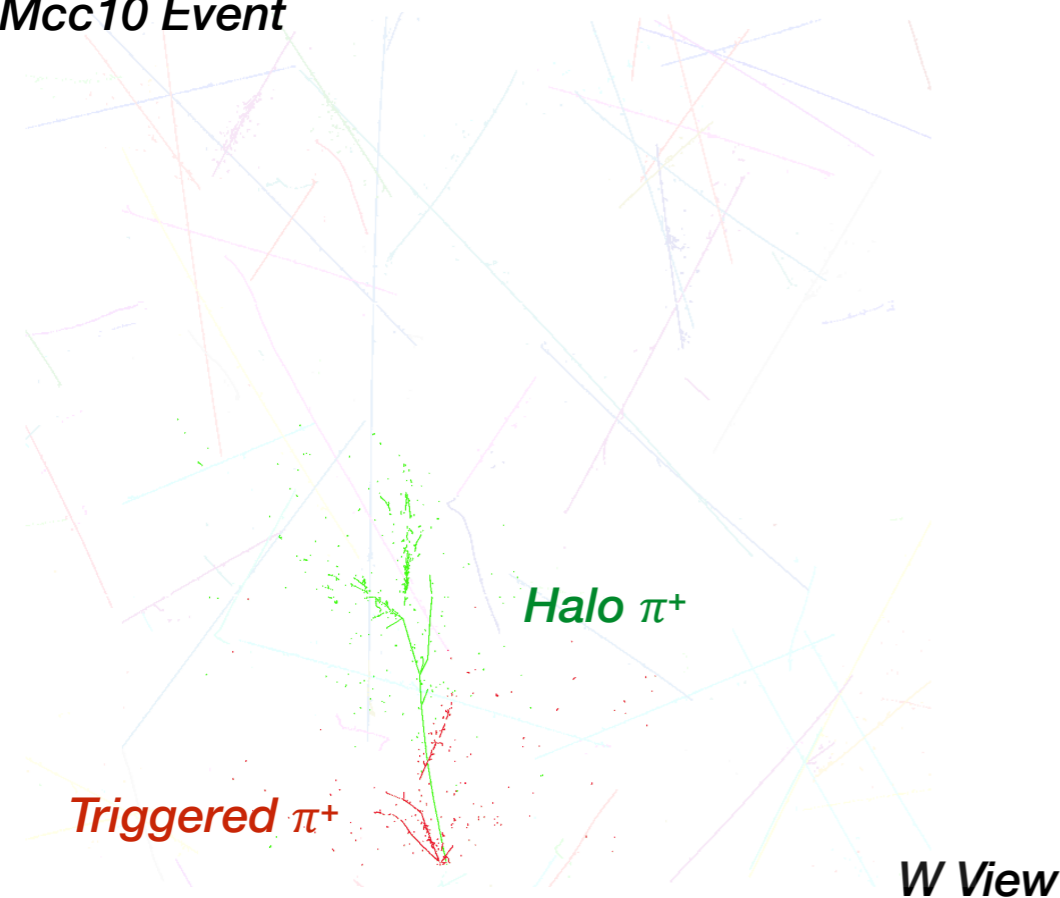


Test Beam Reconstruction Metrics



- The Pandora test beam reconstruction is good and ready for real data.
- Inefficiency are primarily due to:
 - Cosmic overlay

Mcc10 Event



.....	∴ Integrated Efficiency [%]
Beam & Cosmics	∴ 78.88±0.47
.....	∴ Beam (Triggered + Halo)
	∴ 87.58±0.38

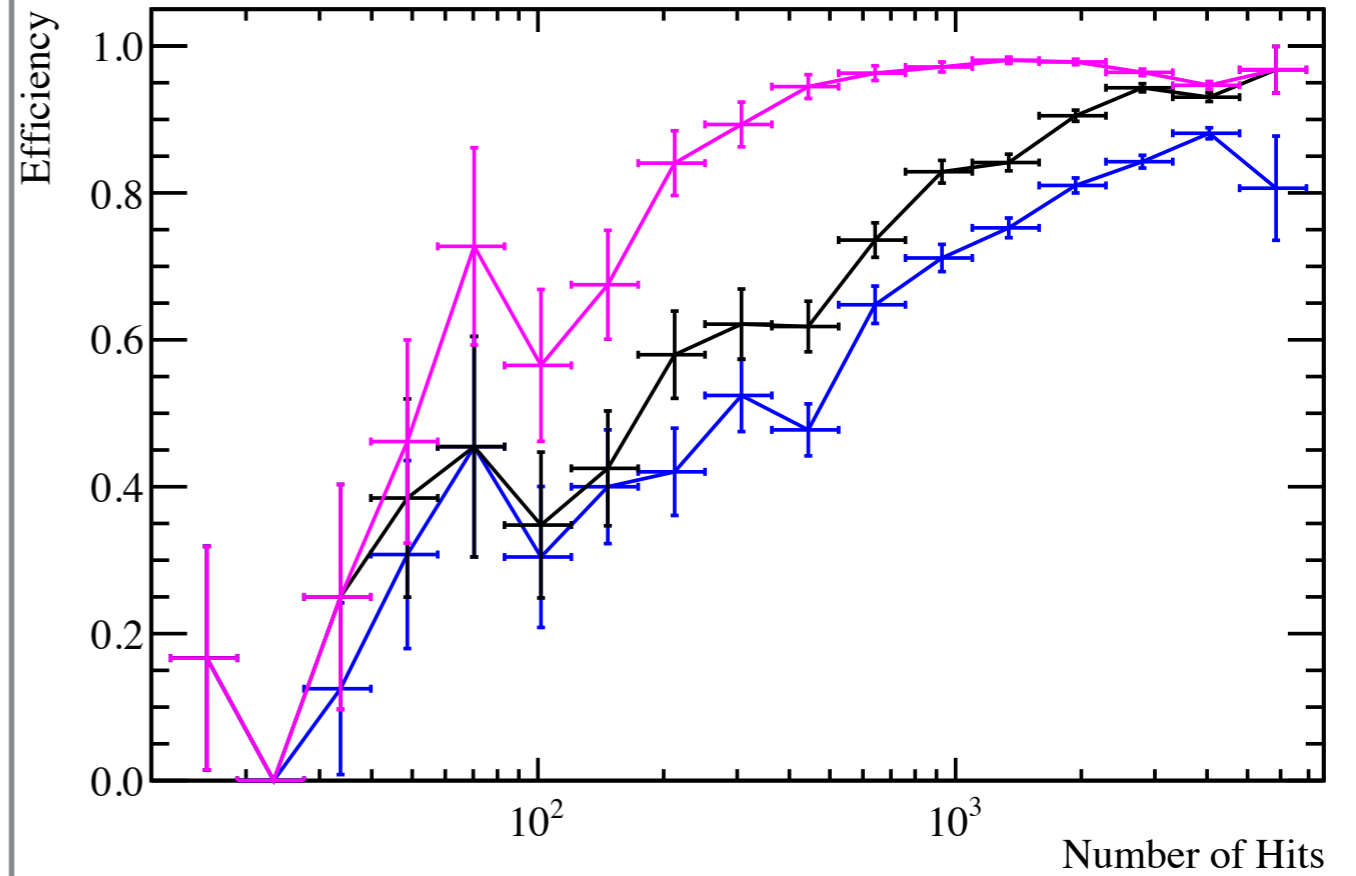
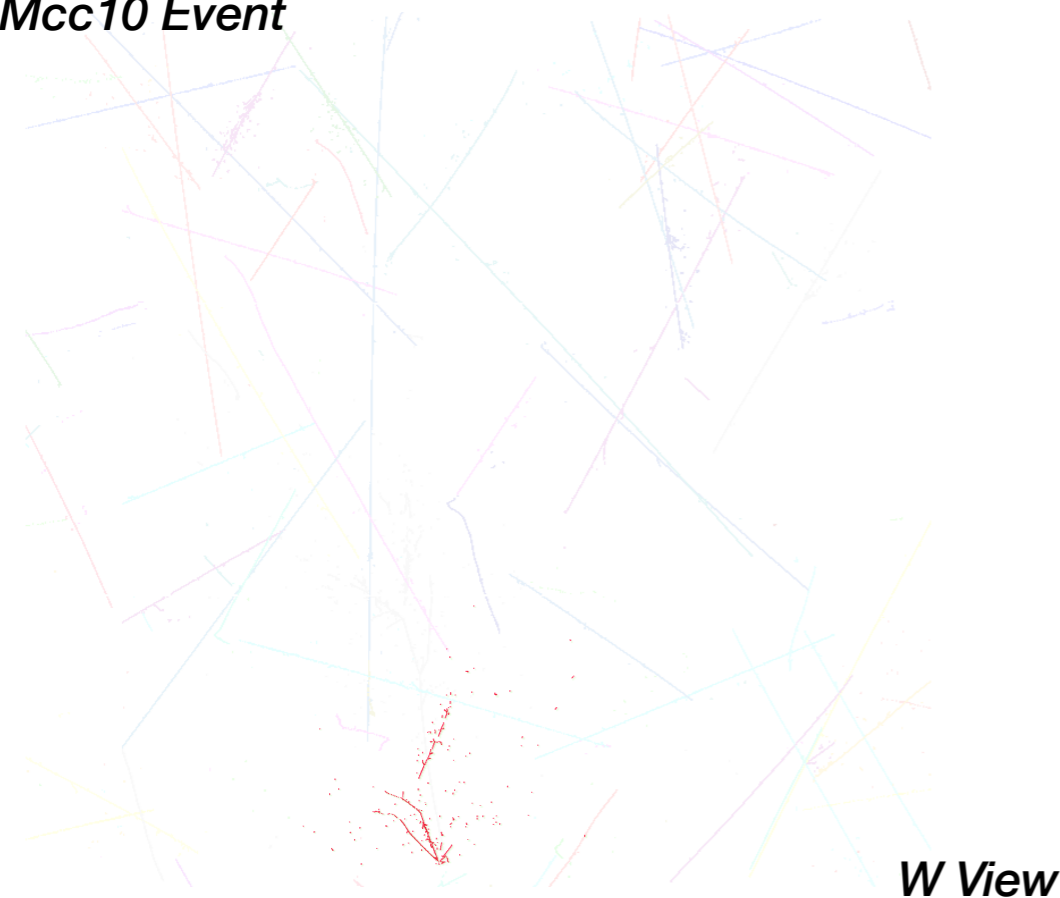


Test Beam Reconstruction Metrics



- The Pandora test beam reconstruction is good and ready for real data.
- Inefficiency are primarily due to:
 - Cosmic overlay
 - The Beam Halo.

Mcc10 Event



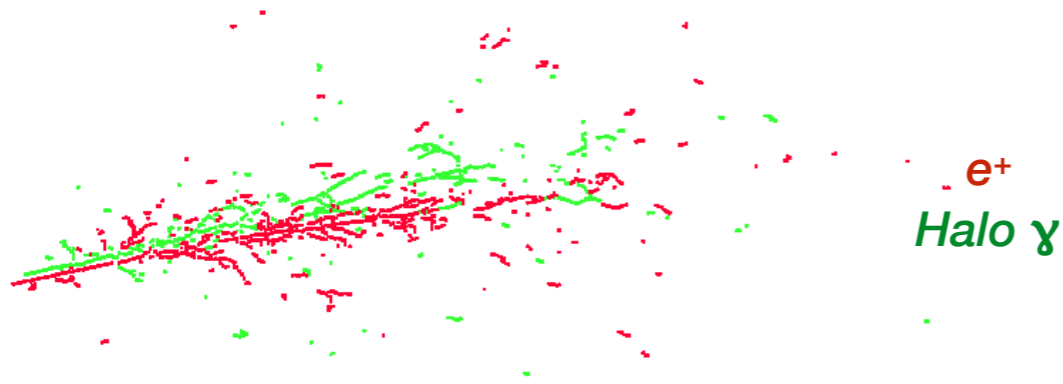
	Integrated Efficiency [%]
Beam & Cosmics	78.88±0.47
Beam (Triggered + Halo)	87.58±0.38
Beam (Triggered)	95.68±0.23



Test Beam Reconstruction Metrics

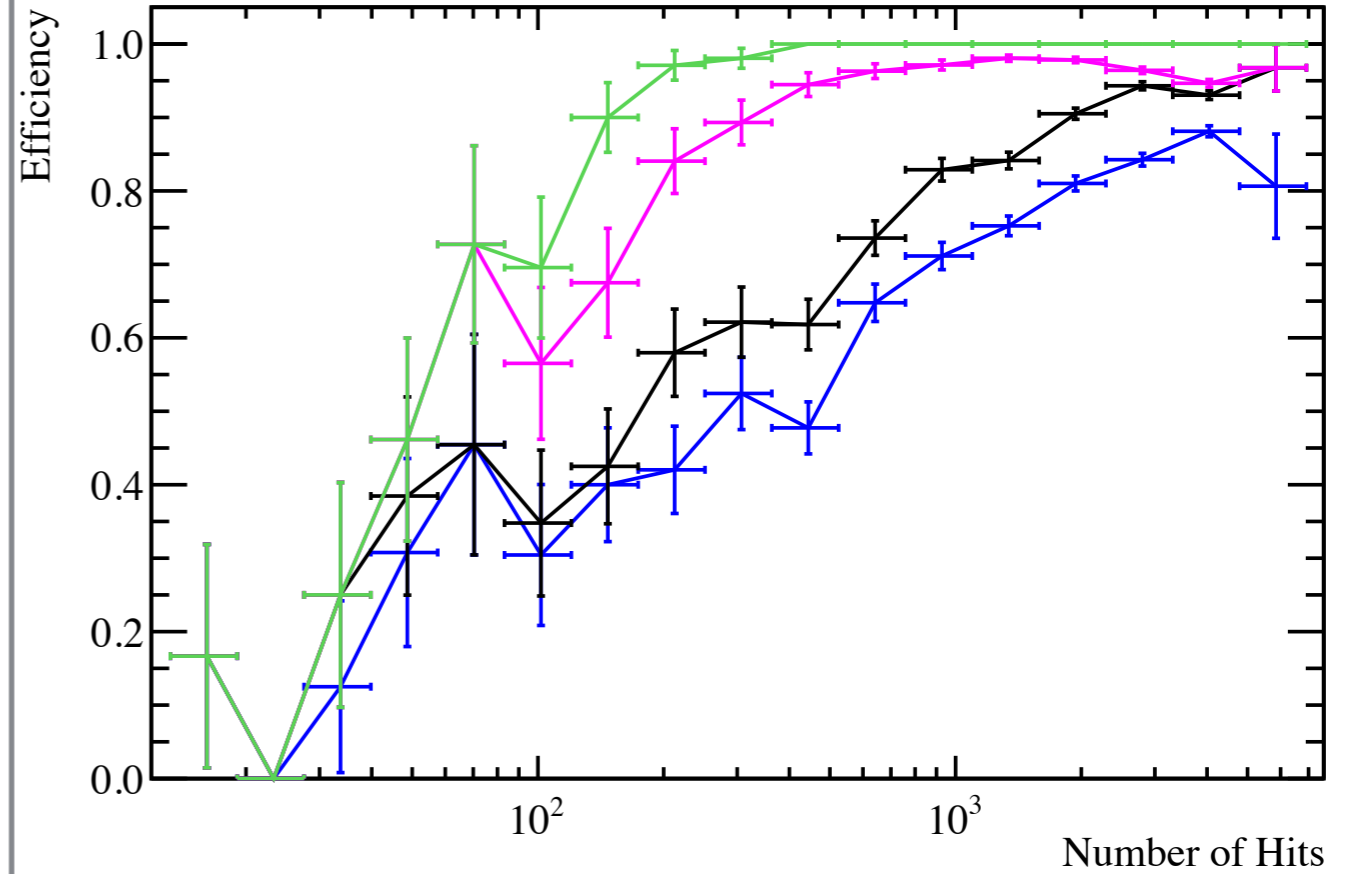


- There is a small inefficiency from the Pandora slicing and test beam particle ID too.
- The e^\pm reconstruction efficiencies suffer from the effect of the halo due to missing MC links to bremsstrahlung photons.



W View

e^+ Beam Only	Integrated Efficiency [%]
Beam (Triggered + Halo)	72.7 ± 0.8293
Beam (Triggered)	90.8 ± 0.5905



	Integrated Efficiency [%]
Beam & Cosmics	78.9 ± 0.5
Beam (Triggered + Halo)	87.6 ± 0.4
Beam (Triggered)	95.7 ± 0.2
Beam (Test Beam Reco, No Slicing)	99.5 ± 0.1