DEEP UNDERGROUND NEUTRINO EXPERIMENT

Recent Pandora Developments

Steven Green on behalf of the Pandora Team

9th January 2019

Introduction

Aim:

- Give a brief overview of recent changes to the Pandora reconstruction.
- Show the latest Pandora reconstruction metrics for data.

Overview of Recent Changes To Pandora Reconstruction

Changes To The Pandora Reconstruction

LArSoft Version (larpandora) : v08_01_00

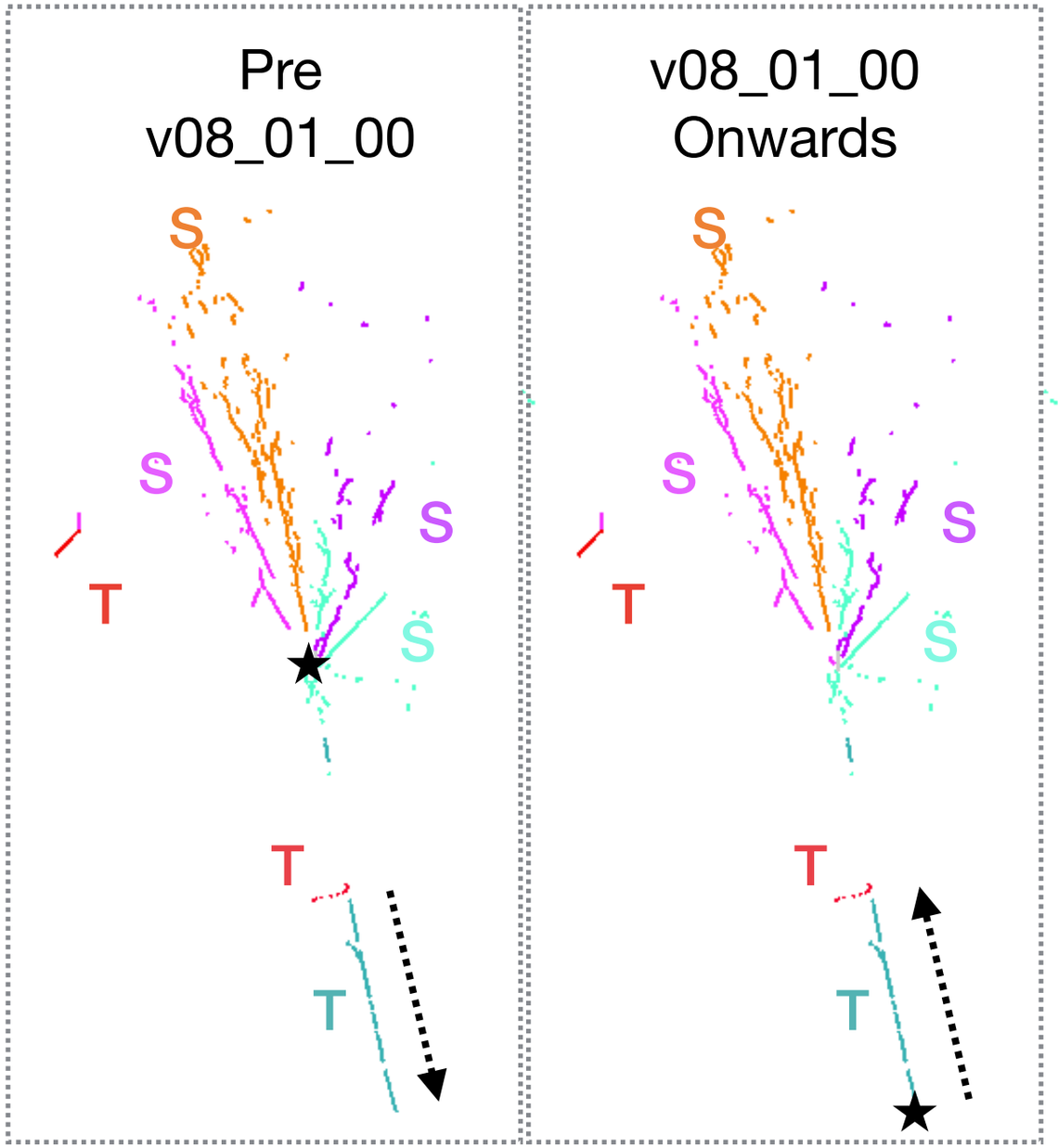
- Added the shower ID index to the recob::Shower object.

LArSoft Version (dunetpc): v08_01_00

- Xml config change : Move the associated vertex to the Parent Test Beam PFParticle from the interaction point, to where the track enters the TPC.
- The direction of track like particles is defined as pointing away from the associated vertex, therefore, the incoming track points in the correct direction.

LArSoft Version (larpandora & larpandoracontent) : v08_03_00*

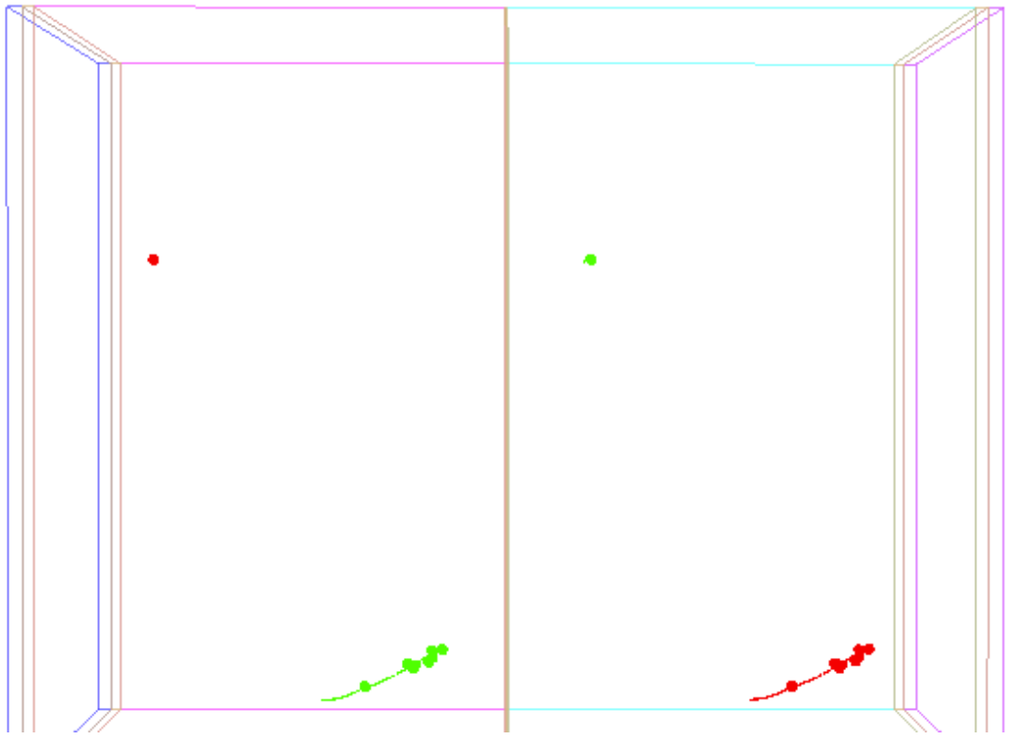
- Alter the cosmic ray stitching (T0 finding) algorithm to allow Pandora to stitch across APA boundaries.



The Dangers of Overstitching

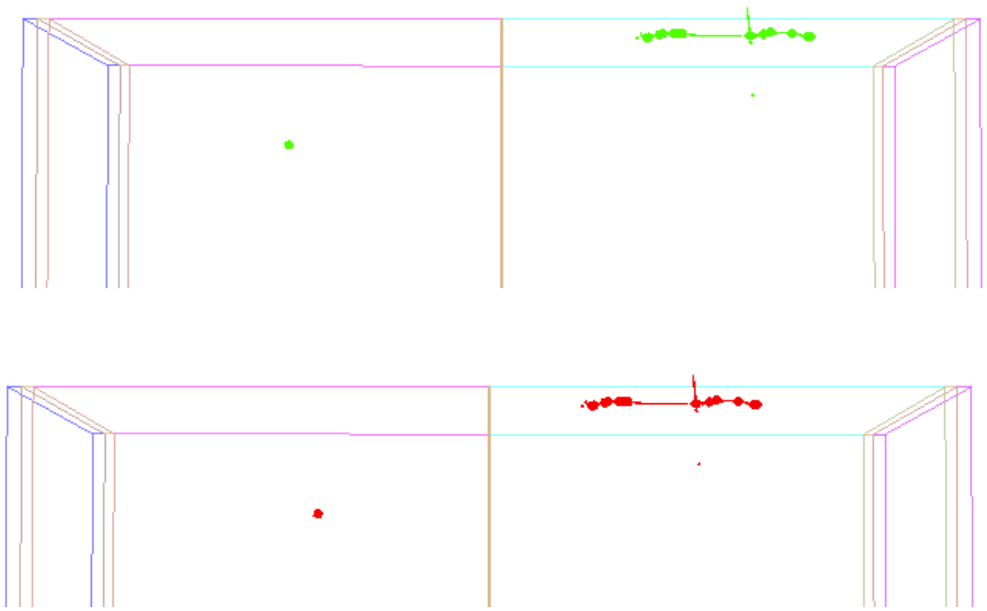
LArSoft Version (larpandora & larpandoracontent) : v08_03_00

- At present the stitching algorithm will not use the cryostat side hits due to the current thresholds.
- Stitching algorithm needs *careful* tuning to act on cryostat side hits to ensure successful stitching without introducing fake T0s. (Ongoing work)
- Examples of failures in stitching if thresholds are lowered too radically.



$T_0 = T_{Beam}$

Corrected T_0



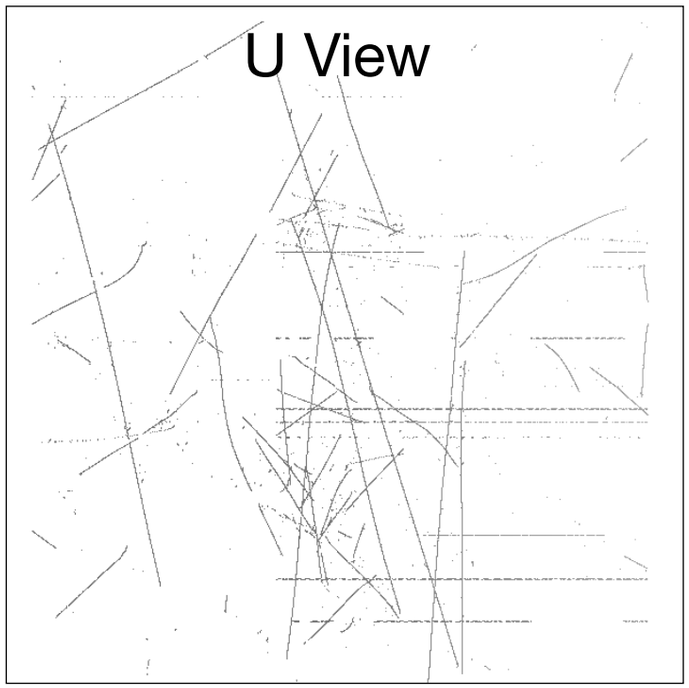
Pandora Reconstruction Metrics for ProtoDUNE Data

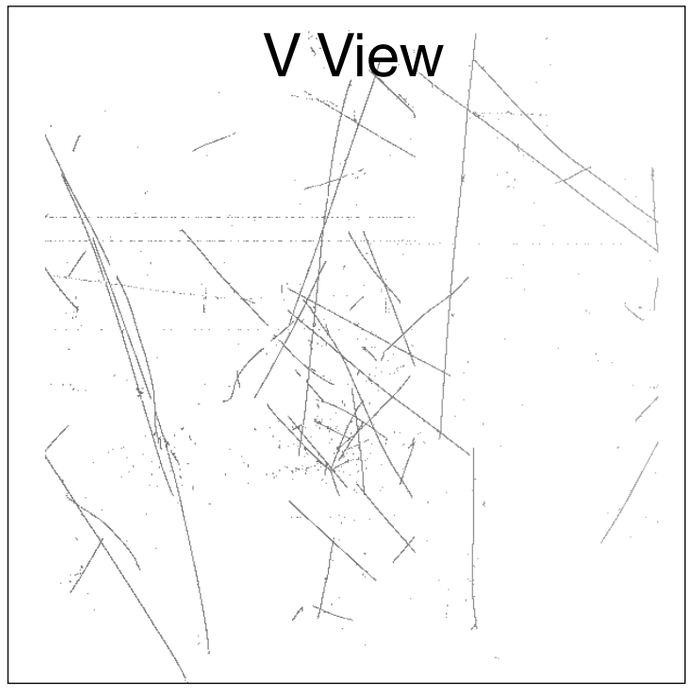
Pandora Reconstruction Metrics

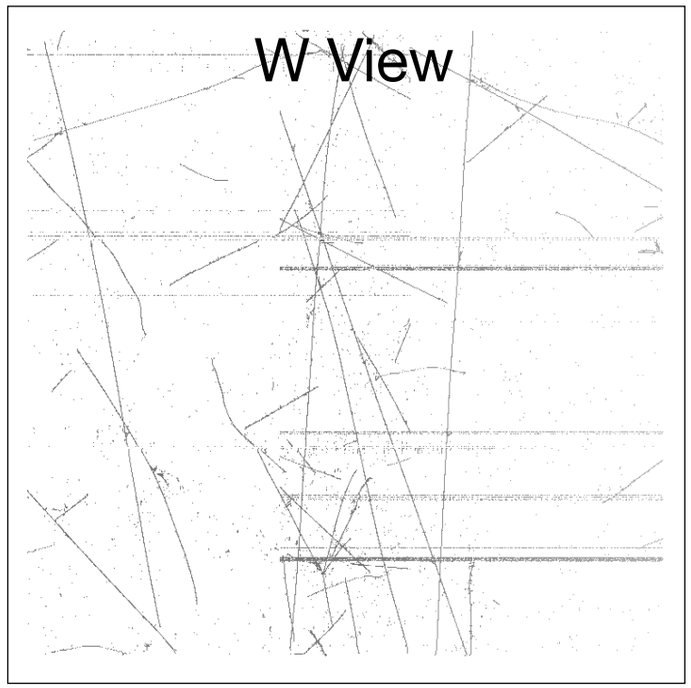
Pandora Inputs

Hits:

Run 5204, Event 57734



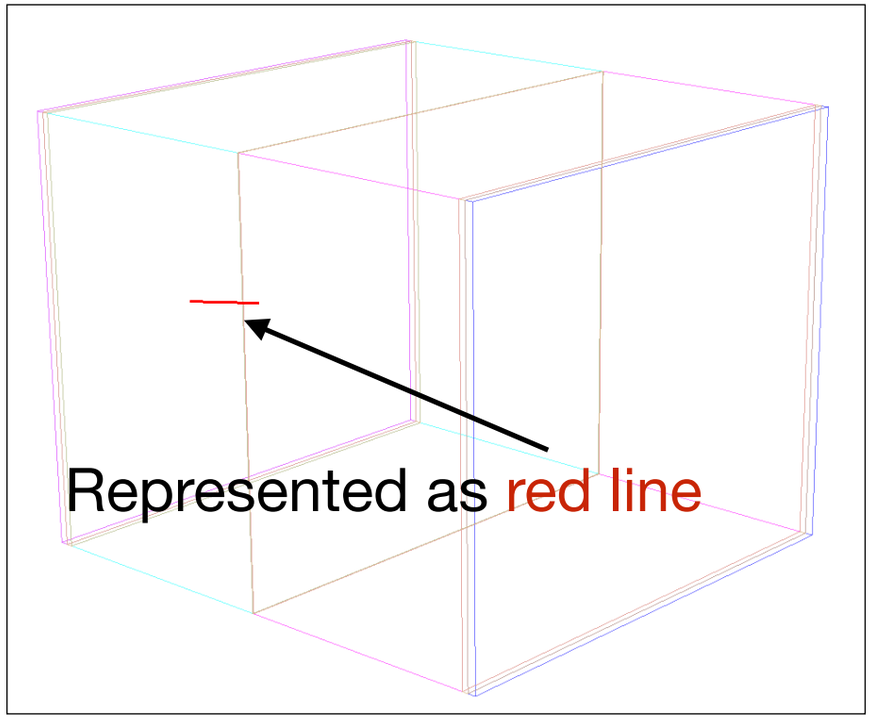




Trigger Information:

- 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

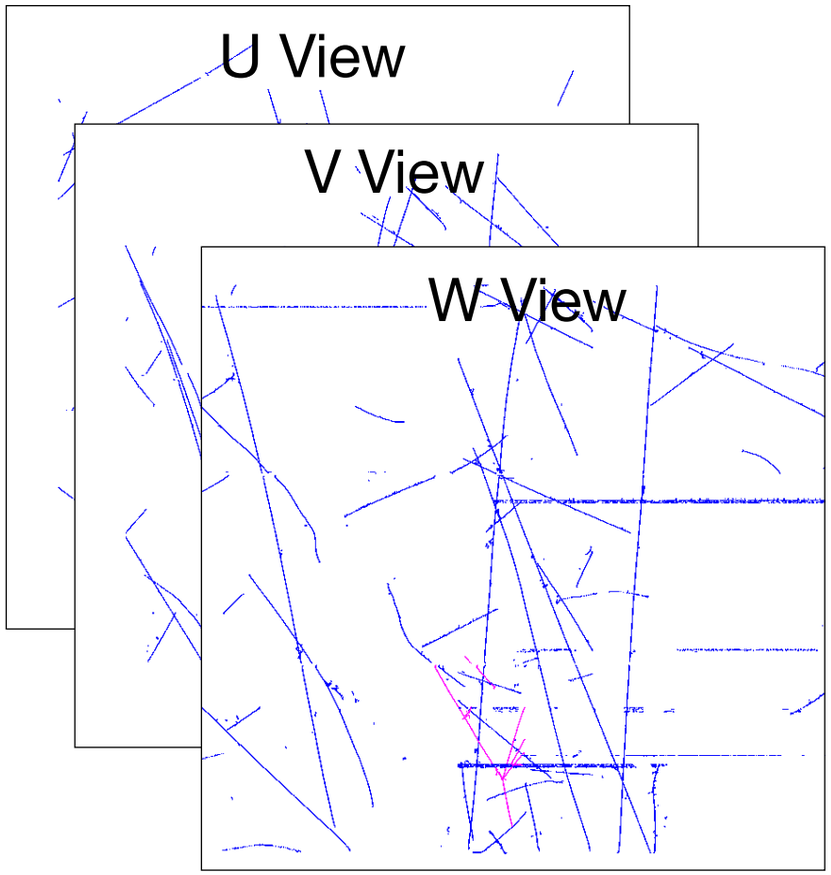
+ Cherenkov Counter & TOF, but not used yet.



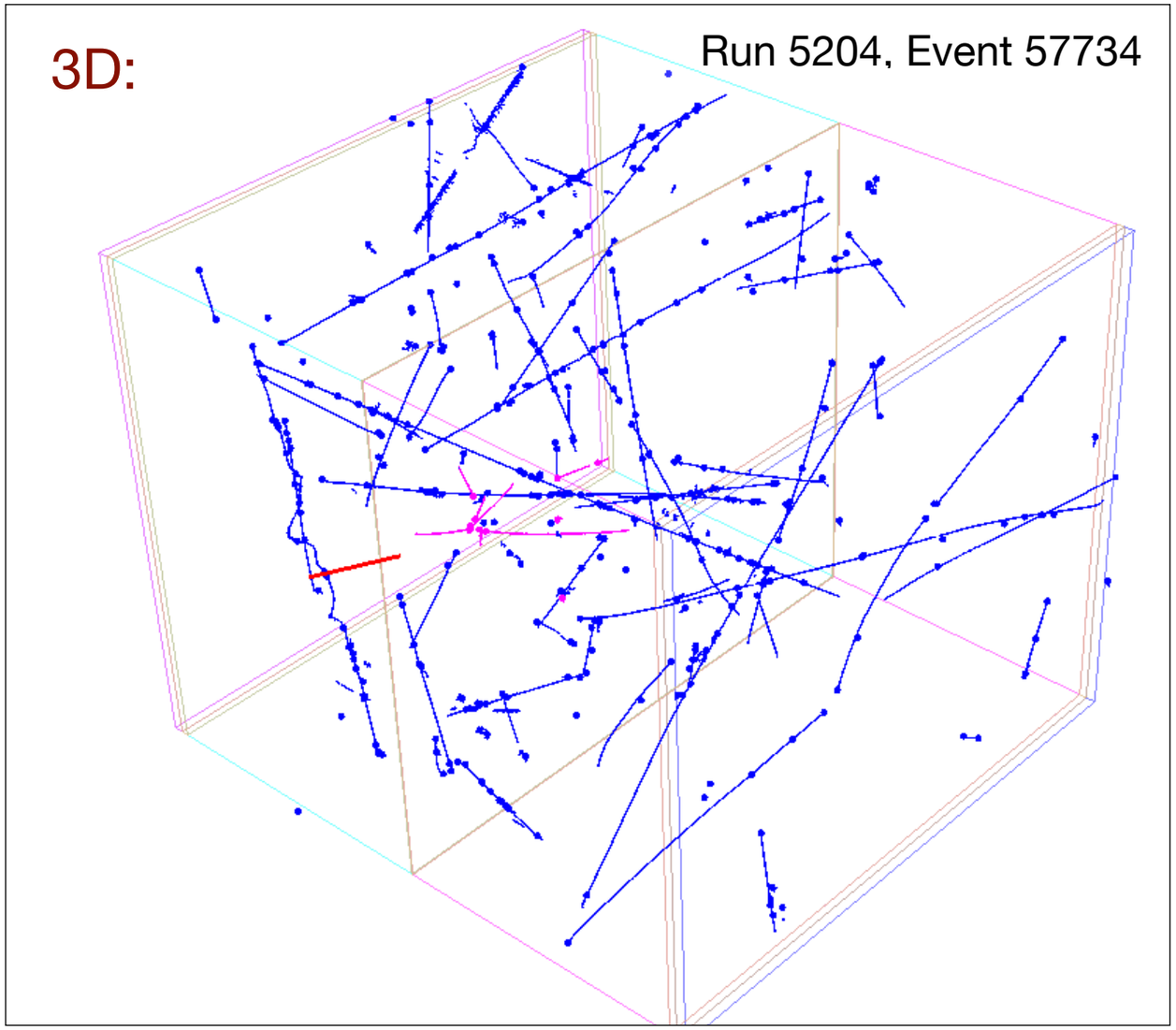
Pandora Reconstruction Metrics

Pandora
Outputs

2D:



3D:



Blue : Cosmic Ray Particles

Purple : Test Beam Particle

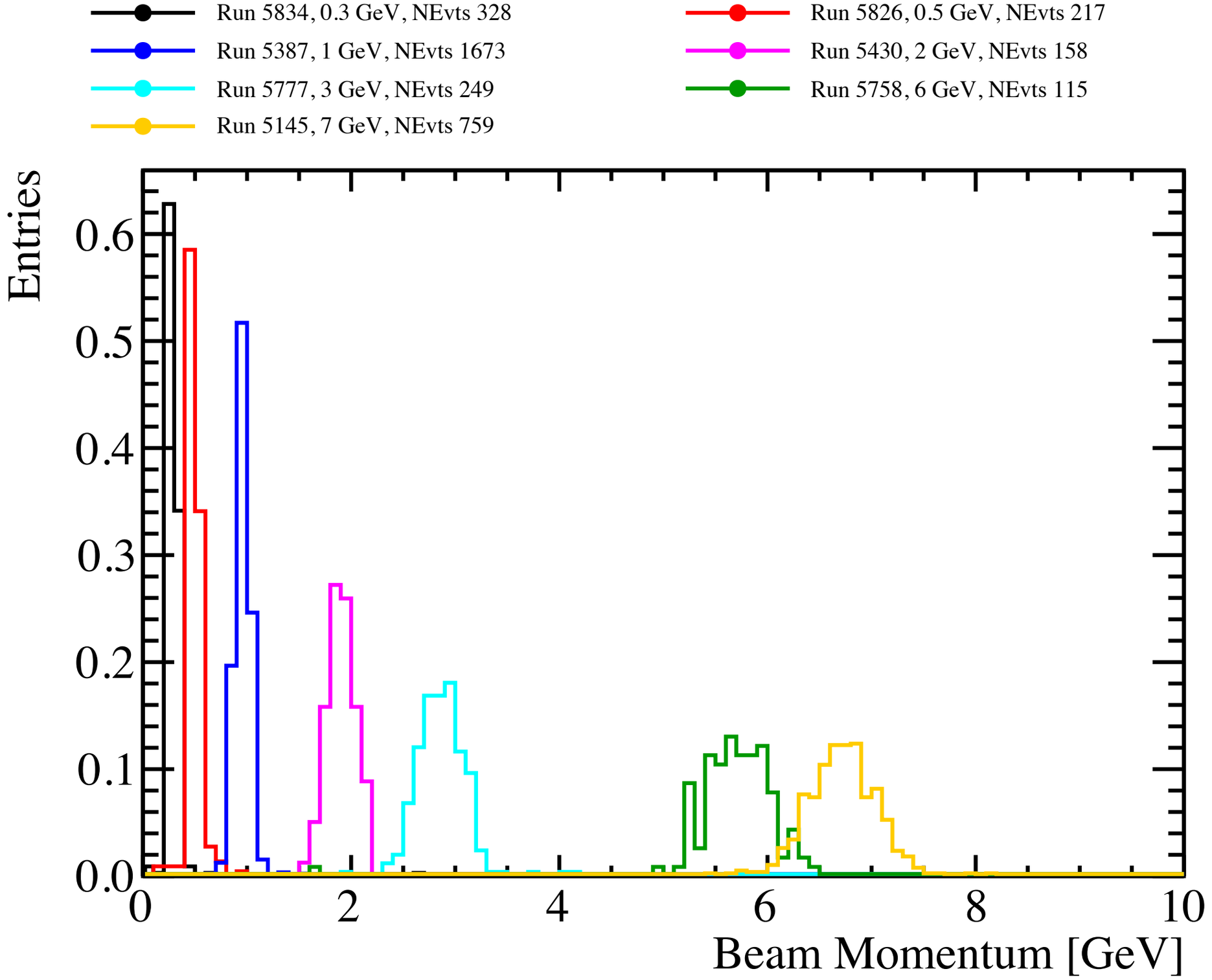
Red : Trigger Information

Efficiency : Fraction of target events where the trigger is active and we reconstruct at least one test beam particle.

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.

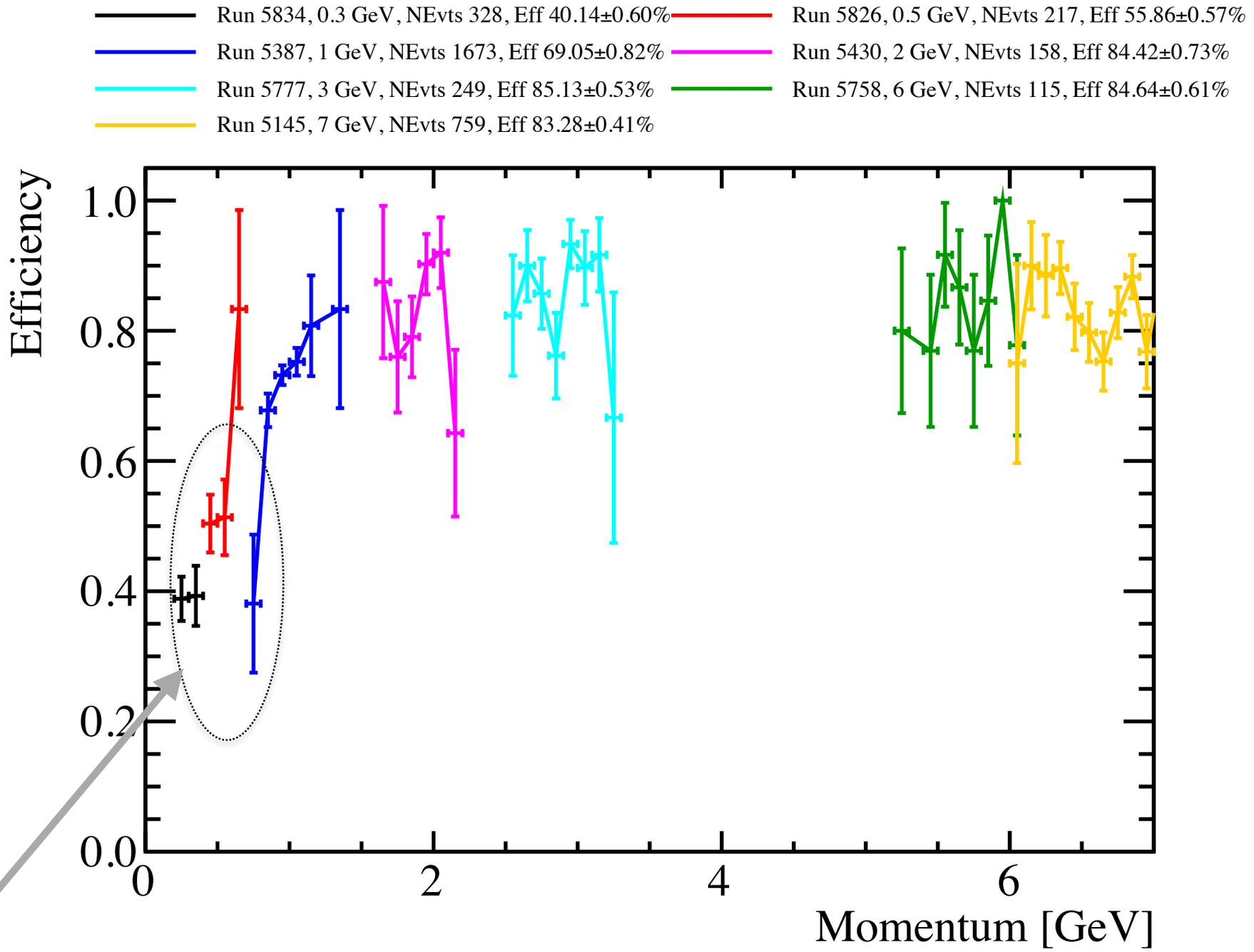
Pandora Reconstruction Metrics

- Distribution of recorded beam momentum from trigger.
- Good to have access to a broad range of momenta in these samples.
- Showing relatively low stats sample, but processing larger sample now.



Pandora Reconstruction Metrics

- Plotting efficiency against the recorded beam momentum.
- Good reconstruction efficiency obtained for high momenta samples : ~85% (c.f. mcc10 ~80%)
- Drop off in reconstruction efficiency at very low momenta.
- Not something we have observed in MC as no samples available with momentum < 1 GeV.
- Let's have a look at some of these events…



Pandora Reconstruction Metrics

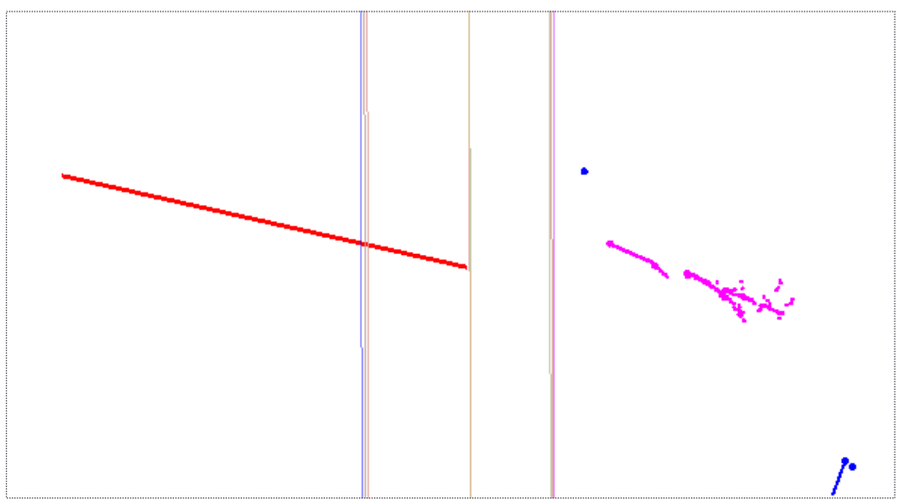
Run 5834, 0.3 GeV

Triggered: ✔

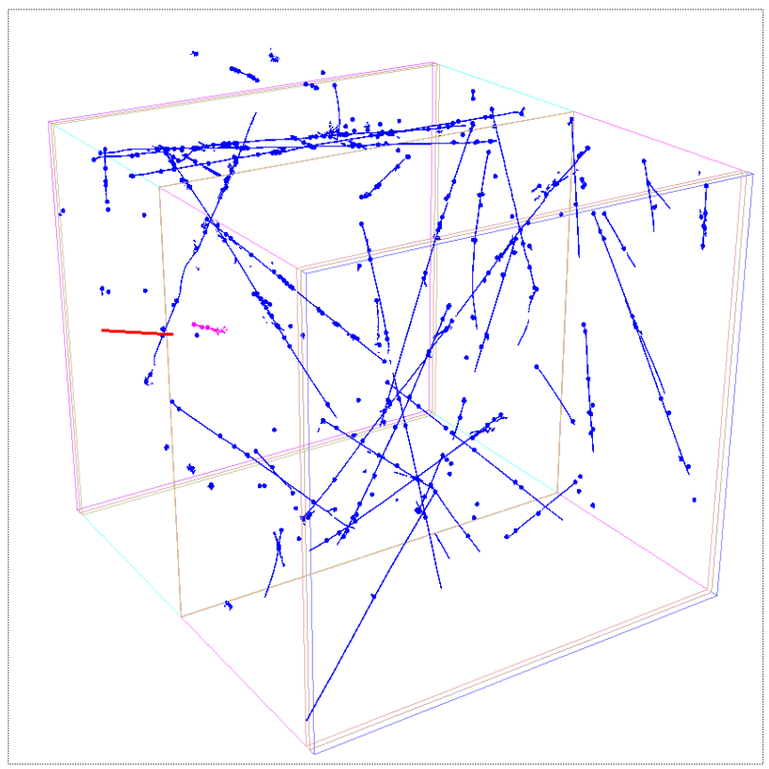
Clear particle: ✔

Correctly identified: ✔

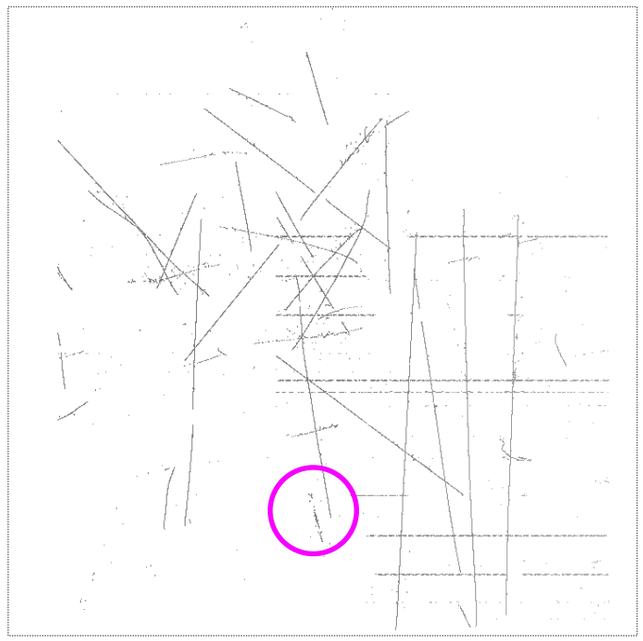
- Good Reconstruction



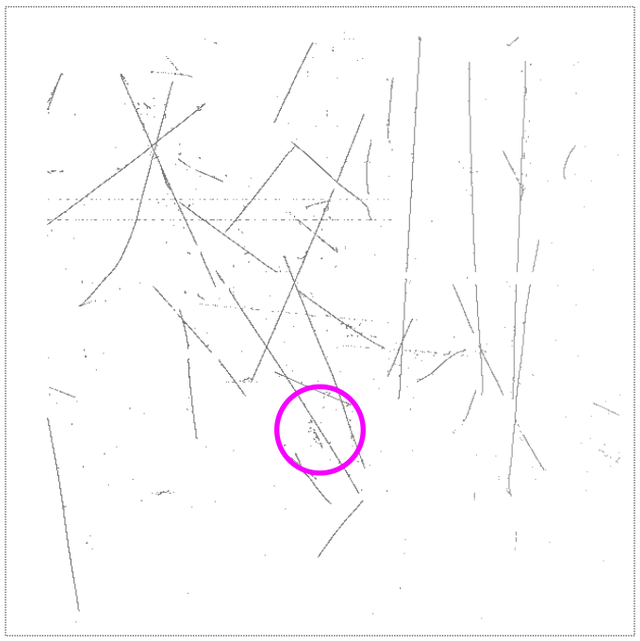
3D:



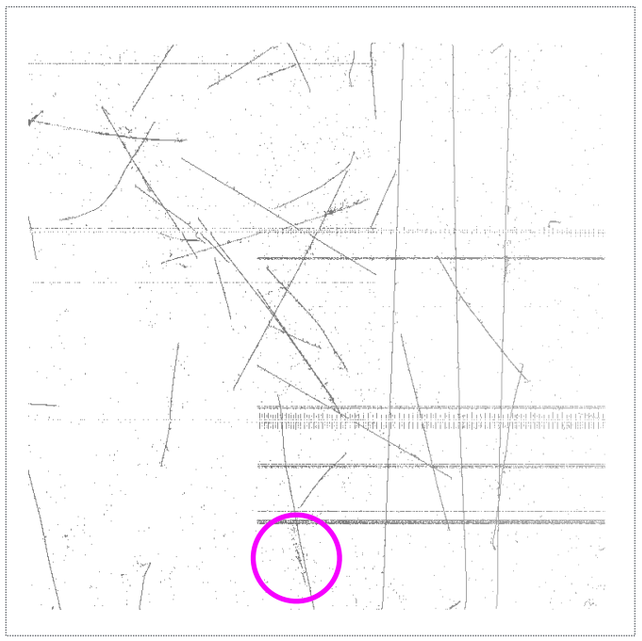
U View



V View



W View



Pandora Reconstruction Metrics

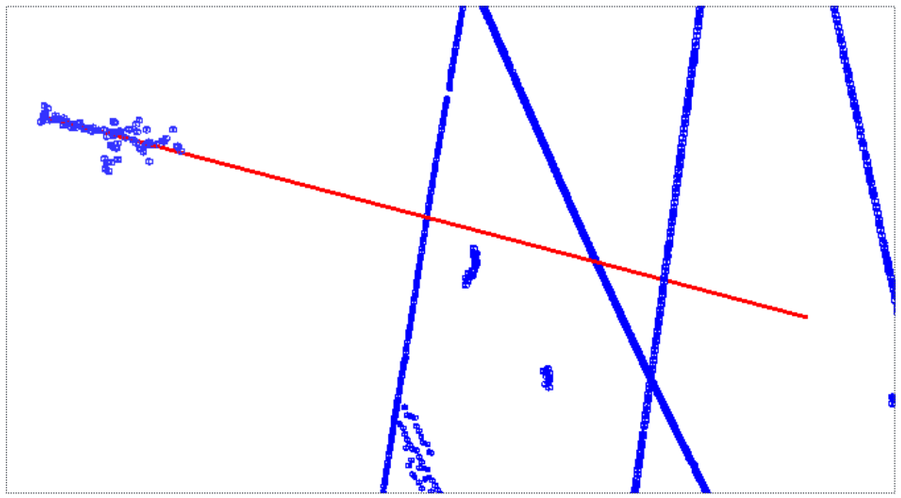
Run 5834, 0.3 GeV

Triggered: ✔

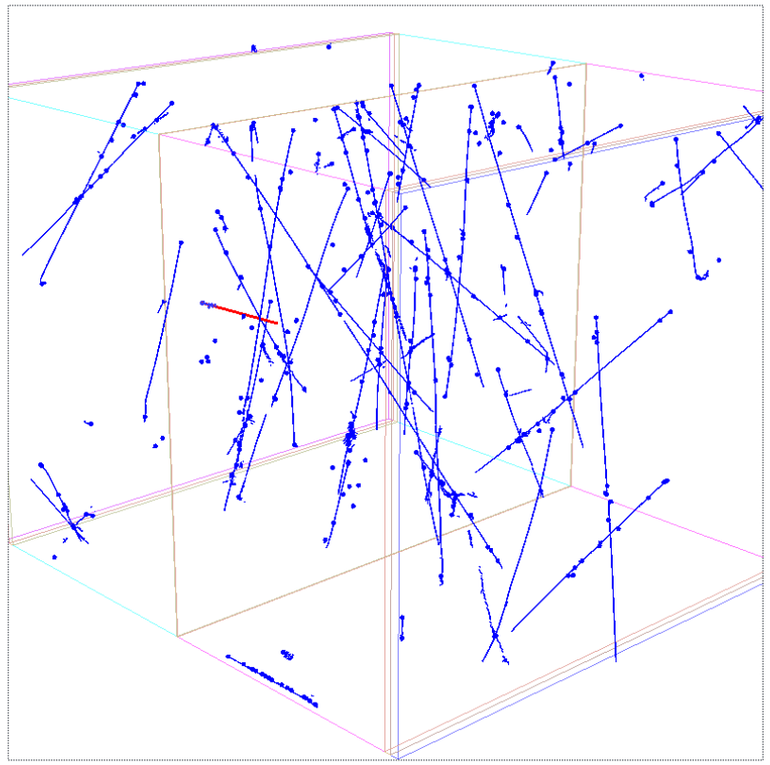
Clear particle: ✔

Correctly identified: ✗

- Genuine Failure Mode



3D:



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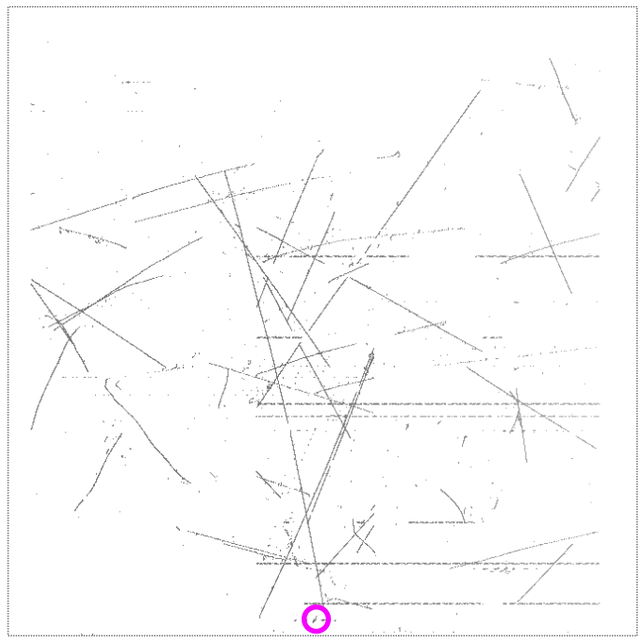
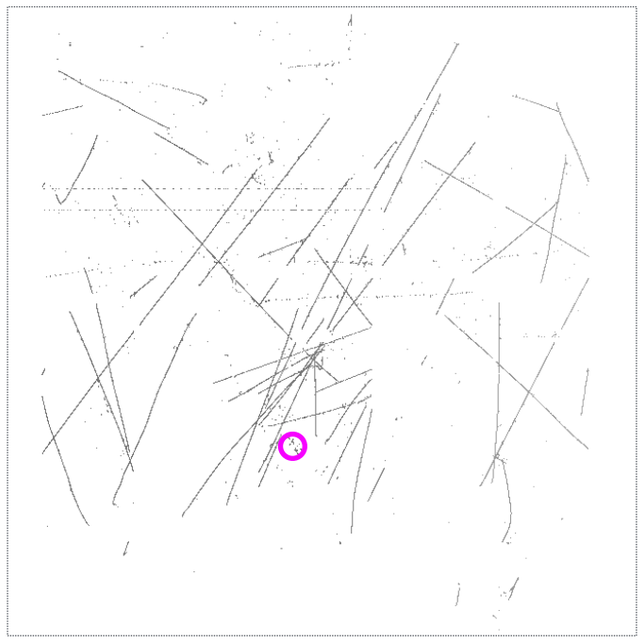
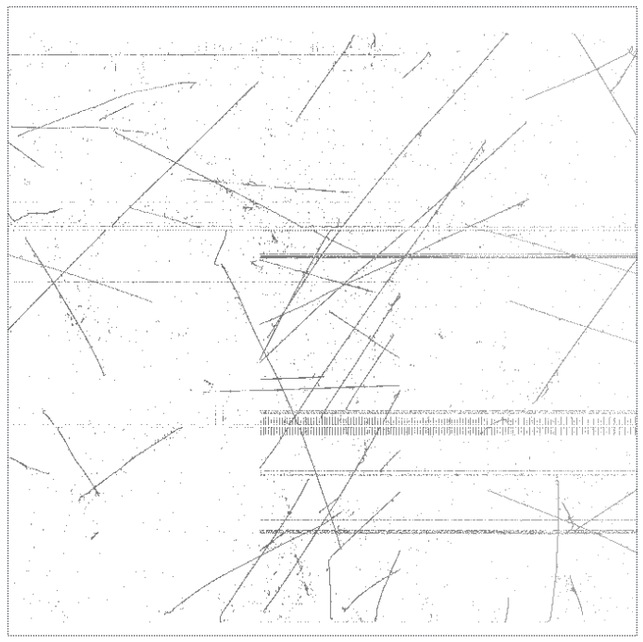


V View



W View



Pandora Reconstruction Metrics

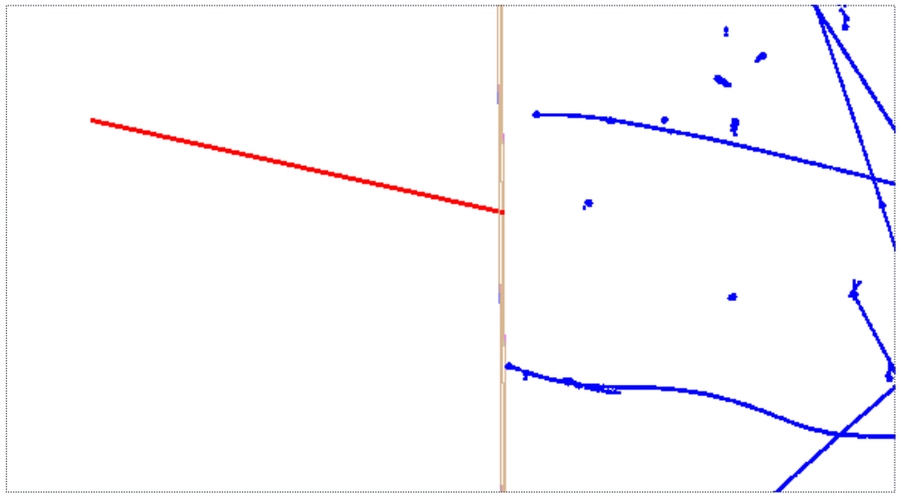
Run 5834, 0.3 GeV

Triggered: ✔

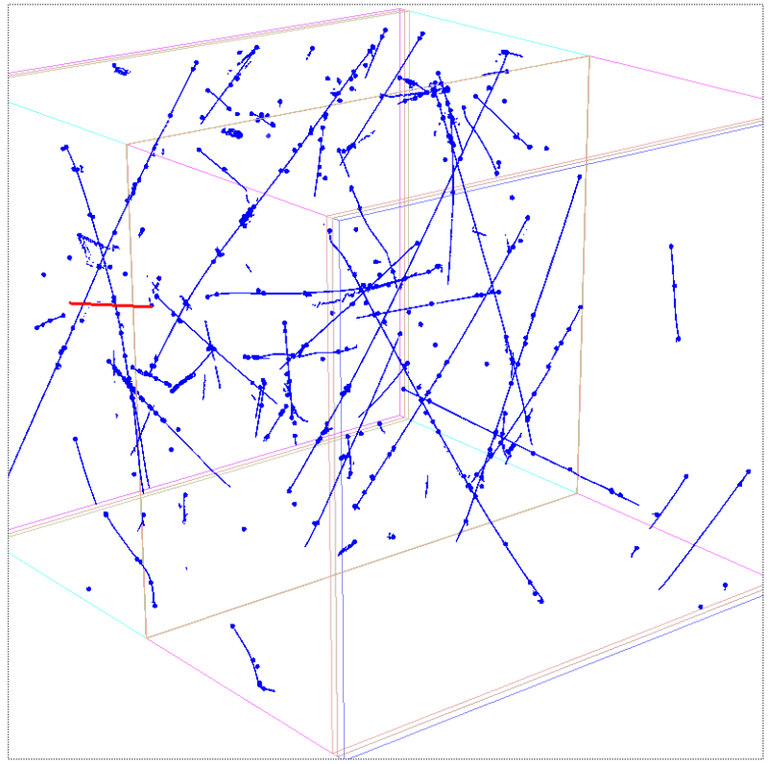
Clear particle: ✗

Correctly identified: N/A

- Fictitious Failure Mode (Makes efficiency seem worse than it really is)



3D:



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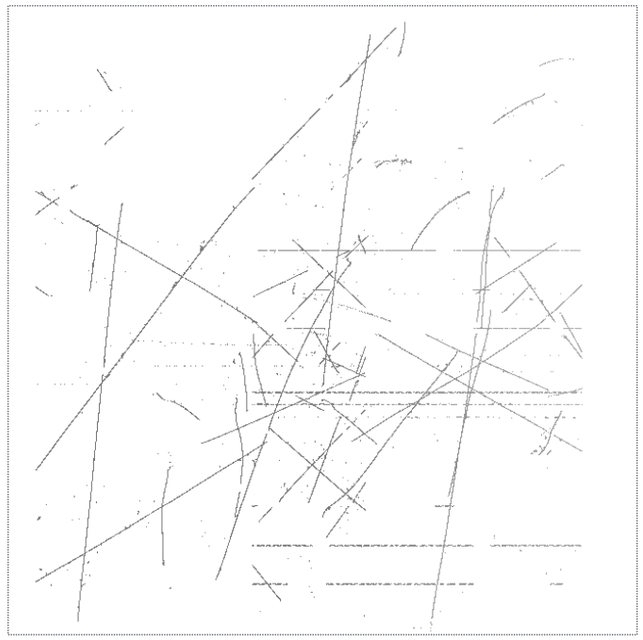
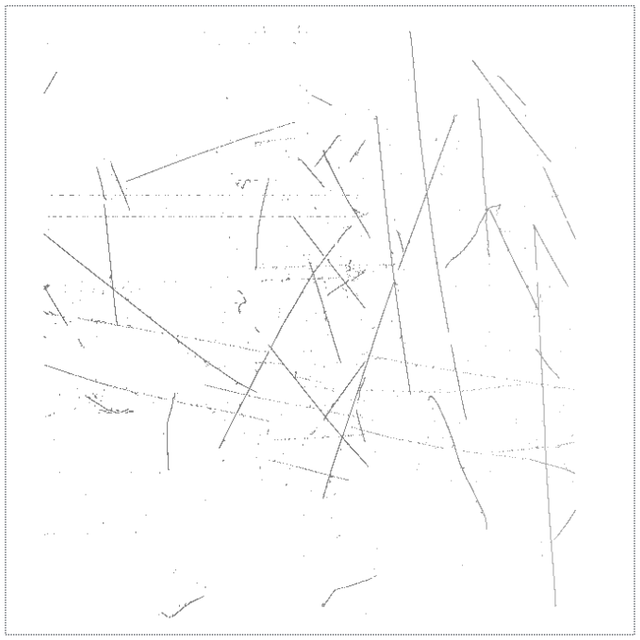
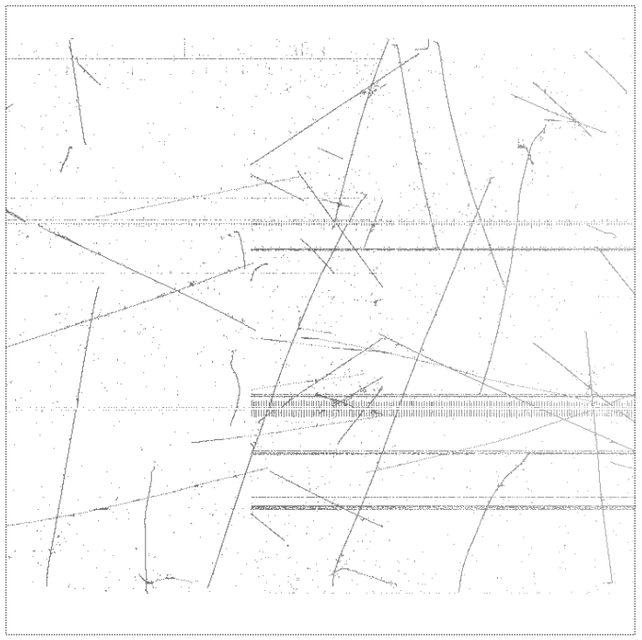


V View



W View



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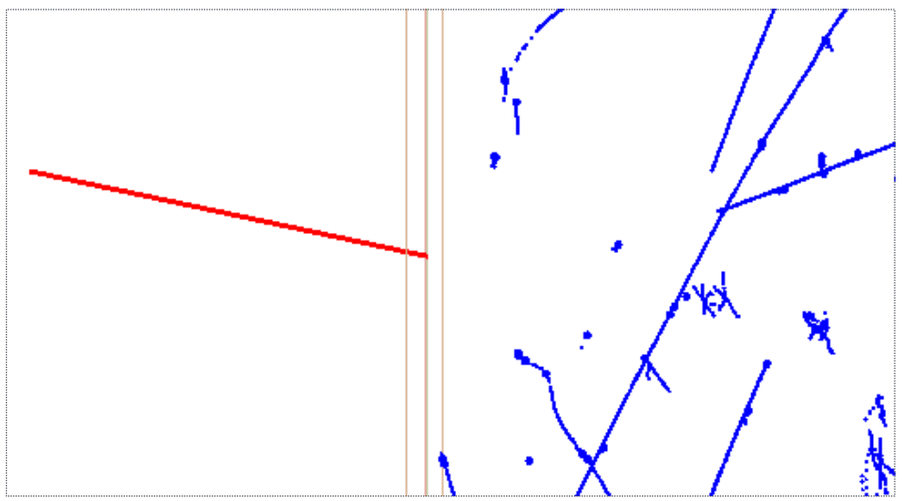
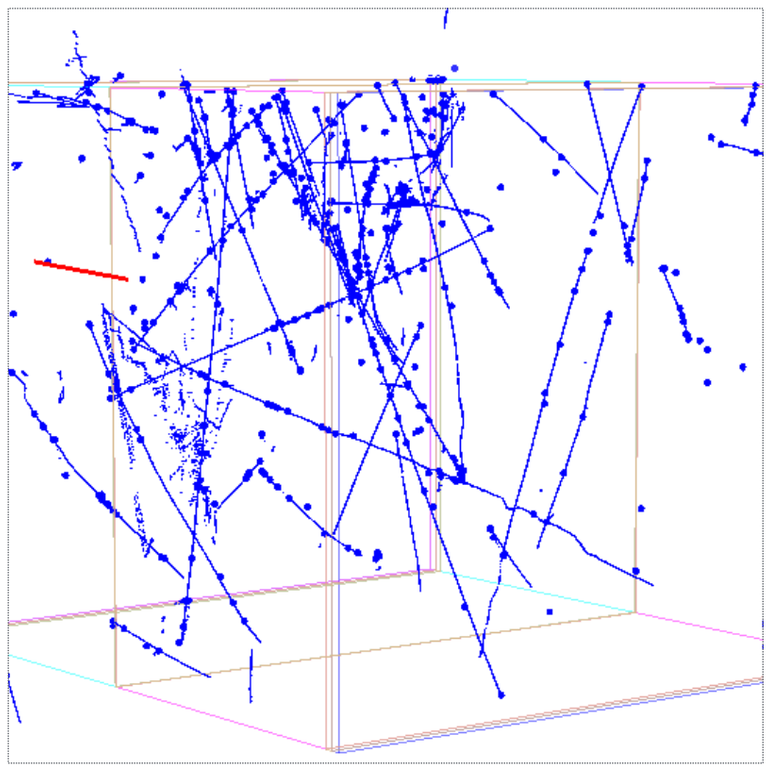
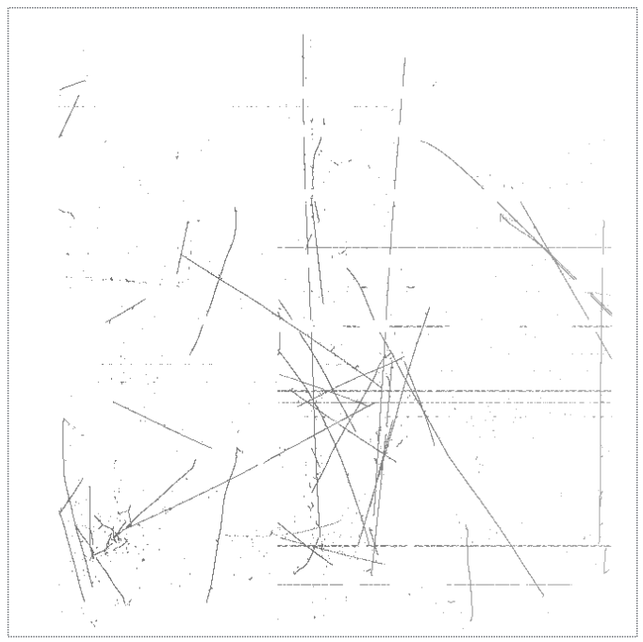


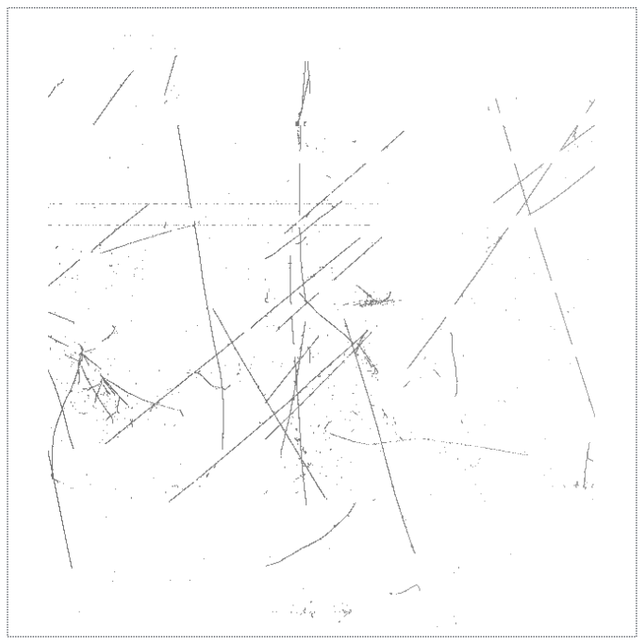
3D:



U View



V View



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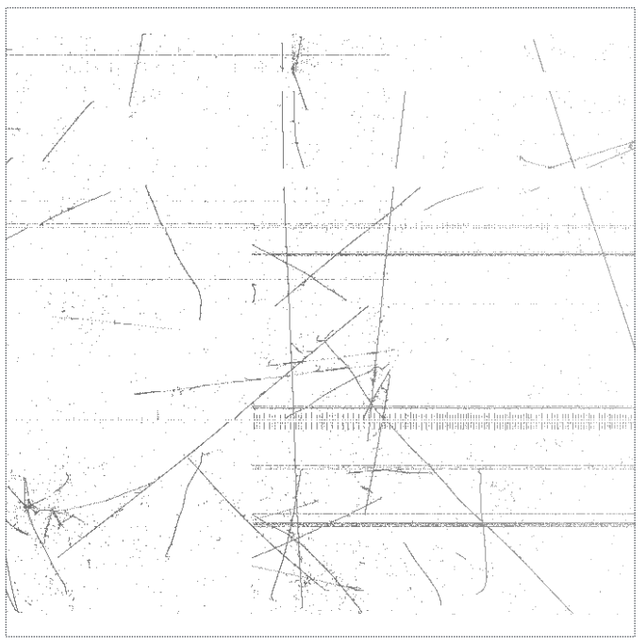


Pandora Reconstruction Metrics

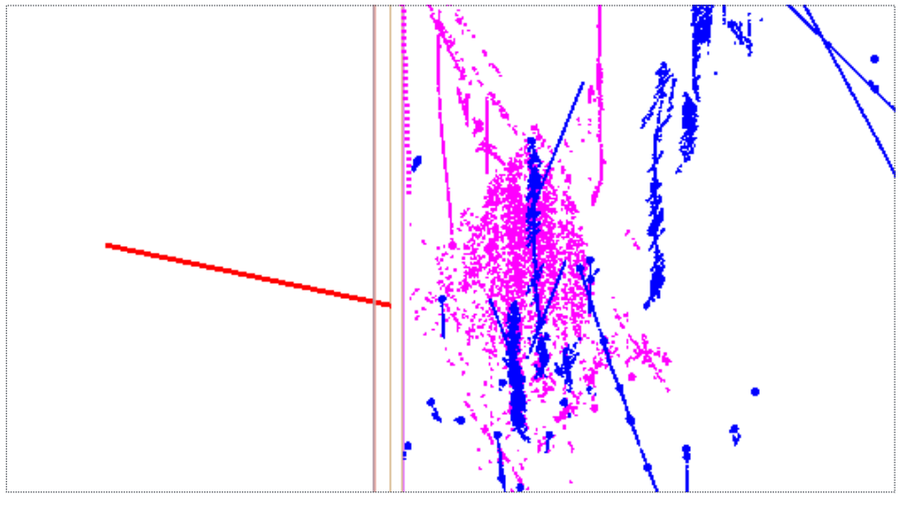
Run 5834, 0.3 GeV

Triggered: ✔

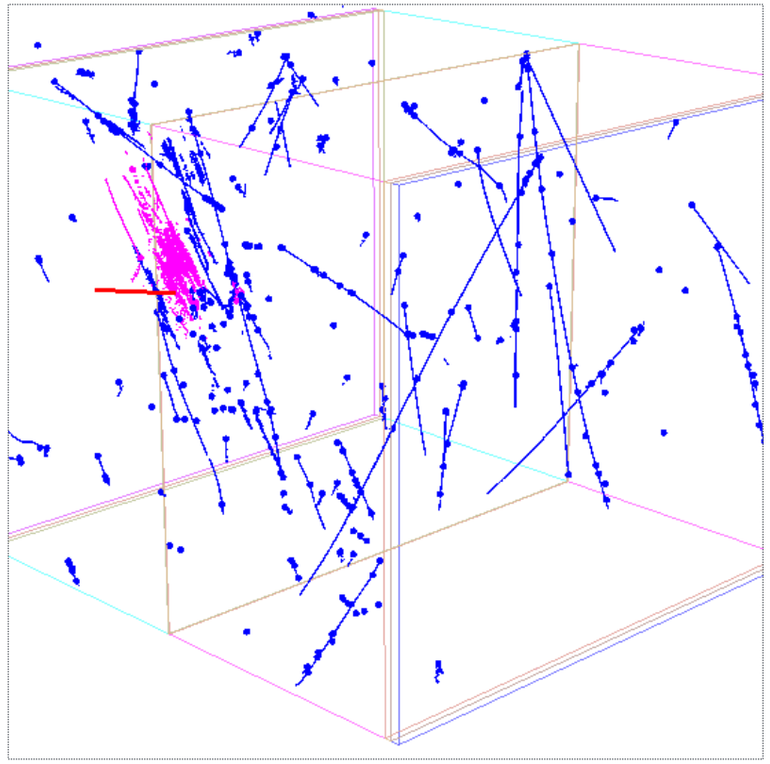
Clear particle: ?

Correctly identified: N/A

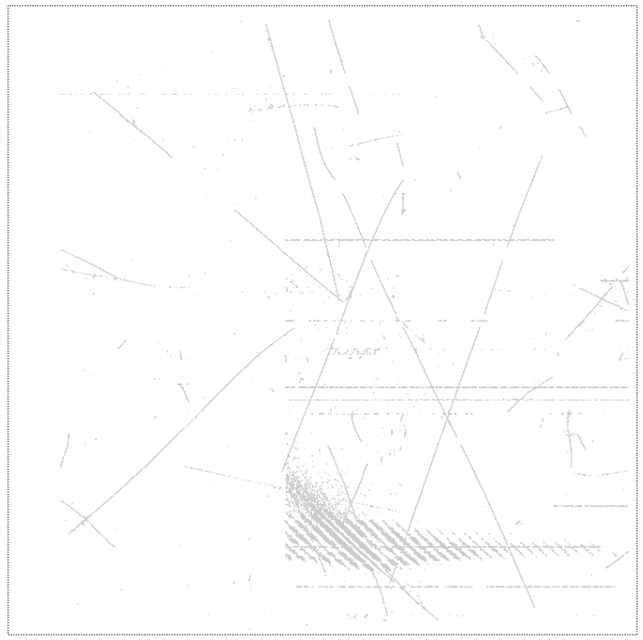
- Fictitious Failure Mode (Makes efficiency seem worse than it really is)



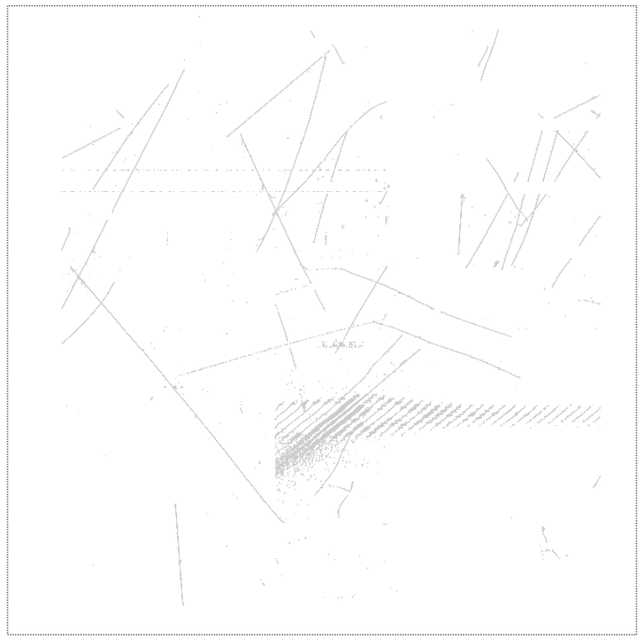
3D:



U View



V View



W View

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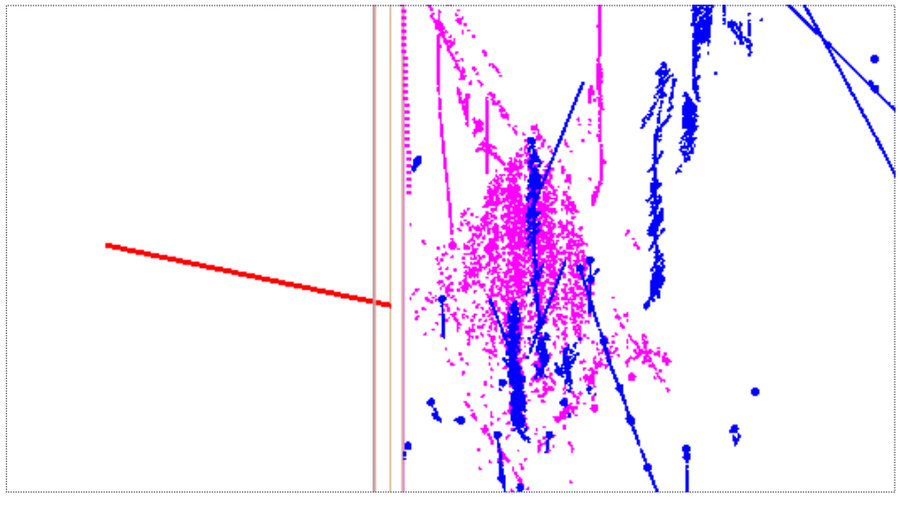
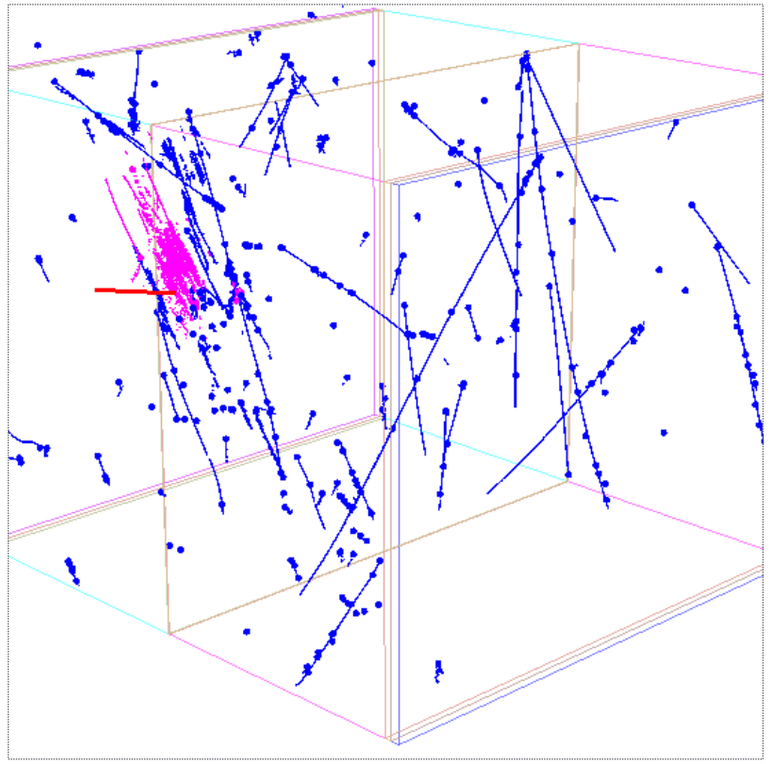
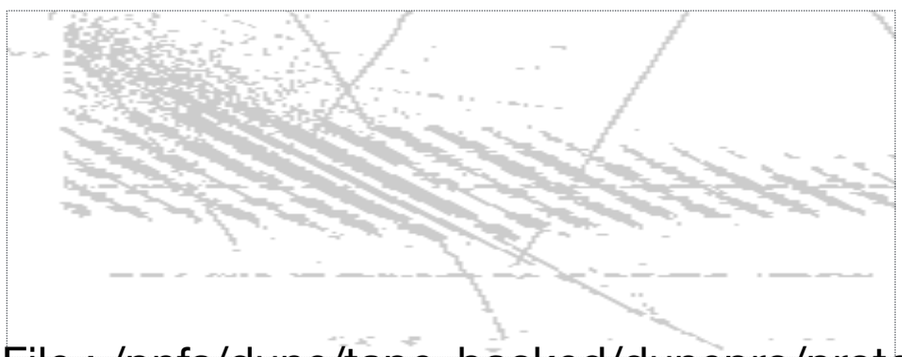


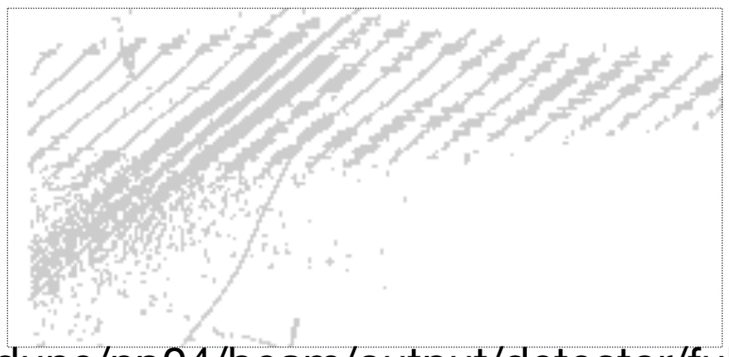
3D:



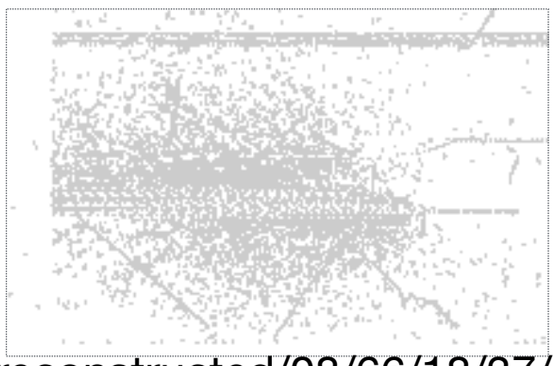
U View



V View



W View



File : /pnfs/dune/tape_backed/dunepro/protodune/np04/beam/output/detector/full-reconstructed/08/66/18/37/np04_raw_run005834_0099_dl1_reco_13640271_0_20181129T034621.root --nskip 9

Event Number : 145736

Conclusions

- Given a brief description of recent Pandora developments.
- A good efficiency (comparable to that for MC) is being achieved by the Pandora reconstruction on real data for beam momenta above 1 GeV.
- Expect higher stats samples to be processes soon, which will allow for a more detailed analysis of the efficiency and to subdivide the reconstruction efficiency into particle type.
- Further examination of the reconstruction on data, particularly at very low beam momentum, is needed to fully understand the performance.

Thank you for your attention!

Questions?

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	John Marshall (John.Marshall@warwick.ac.uk) Mark Thomson (thomson@hep.phy.cam.ac.uk)
LAr TPC algorithm development	John Marshall (John.Marshall@warwick.ac.uk) Andy Blake (a.blake@lancaster.ac.uk)
DUNE FD Integration	Lorena Escudero (escudero@hep.phy.cam.ac.uk)
ProtoDUNE Integration	Steven Green (sg568@hep.phy.cam.ac.uk)
MicroBooNE Integration	Andy Smith (asmith@hep.phy.cam.ac.uk)
Other team members	MicroBooNE: Joris Jan de Vries, Jack Anthony ProtoDUNE: Stefano Vergani

https://github.com/PandoraPFA

https://pandorapfa.slack.com

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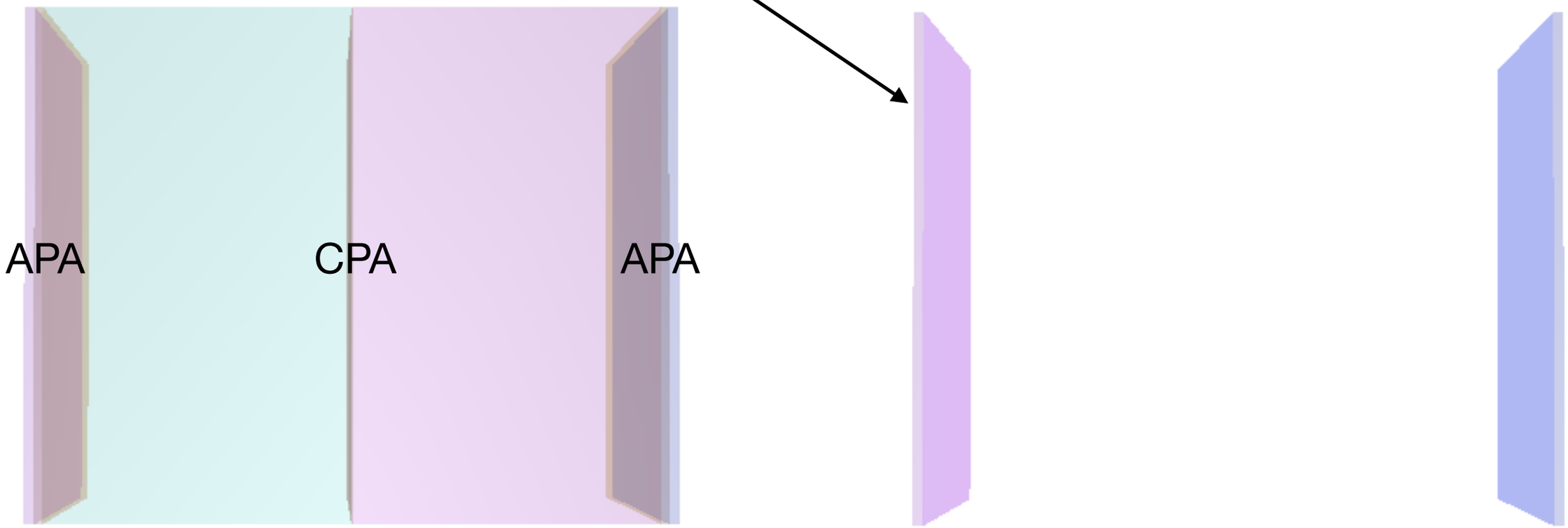
Lancaster University

WARWICK
THE UNIVERSITY OF WARWICK

Cryostat Side APA Hits

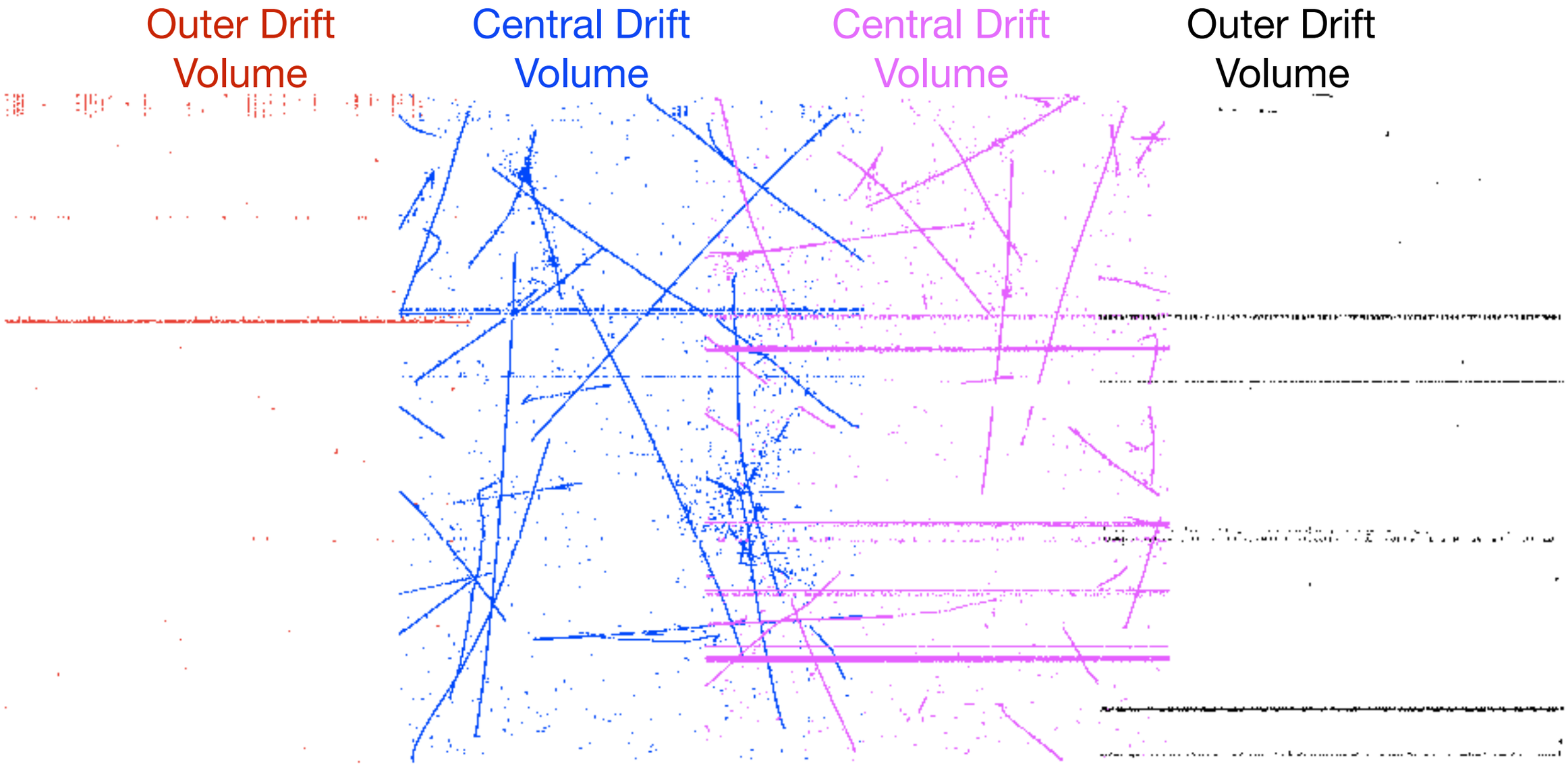
- First step is to make sure Pandora is reading in the cryostat side APA hits.
- For details on code setup to produced these hits c.f. Leigh's talk from last weeks meeting.
  - Since then Leigh has also made a feature branch of dunetpc with these changes in feature/lhw_cryohits
- The Pandora geometry model groups together TPCs with the same drift volume, so in effect there are four drift volumes to consider for ProtoDUNE. The cryostat side APA hits appearing in the external drift volumes.



Pandora Event Display of ProtoDUNE Geometry

Cryostat Side APA Hits

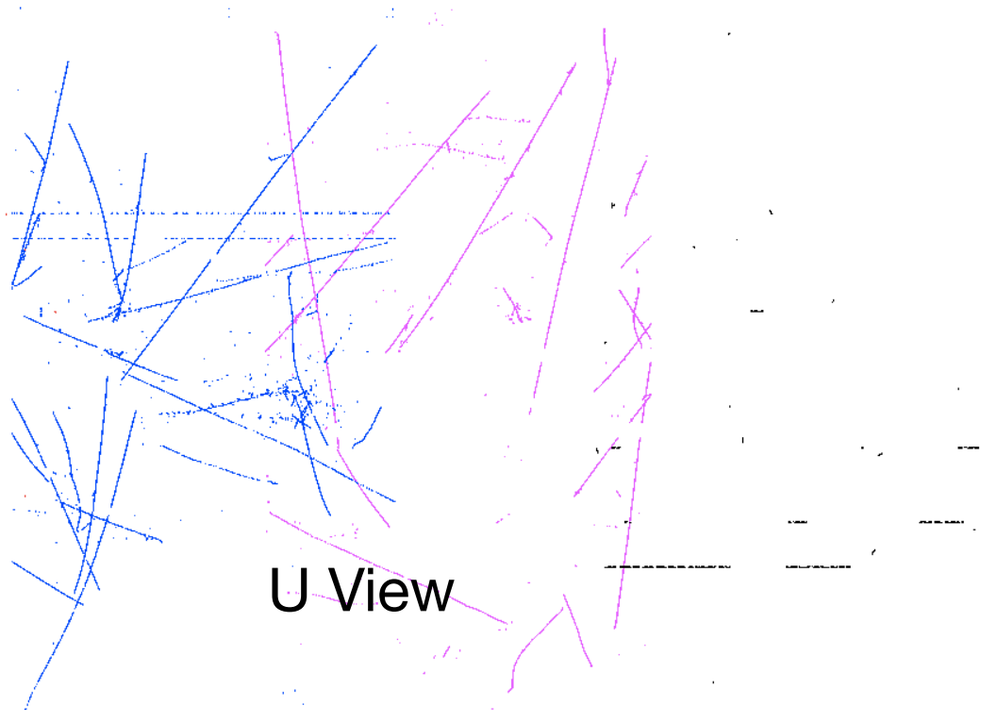
- To demonstrate this I colour coordinated the 2D views based on their drift volume.
- As you can see the outer drift volumes contain hits.

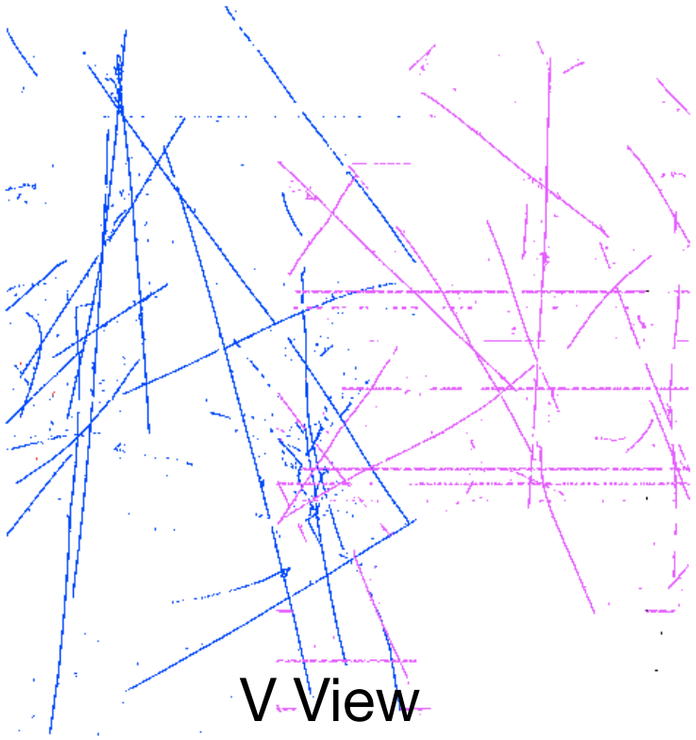


W View

Test Event : Run 5145, Event 271909

Cryostat Side APA Hits

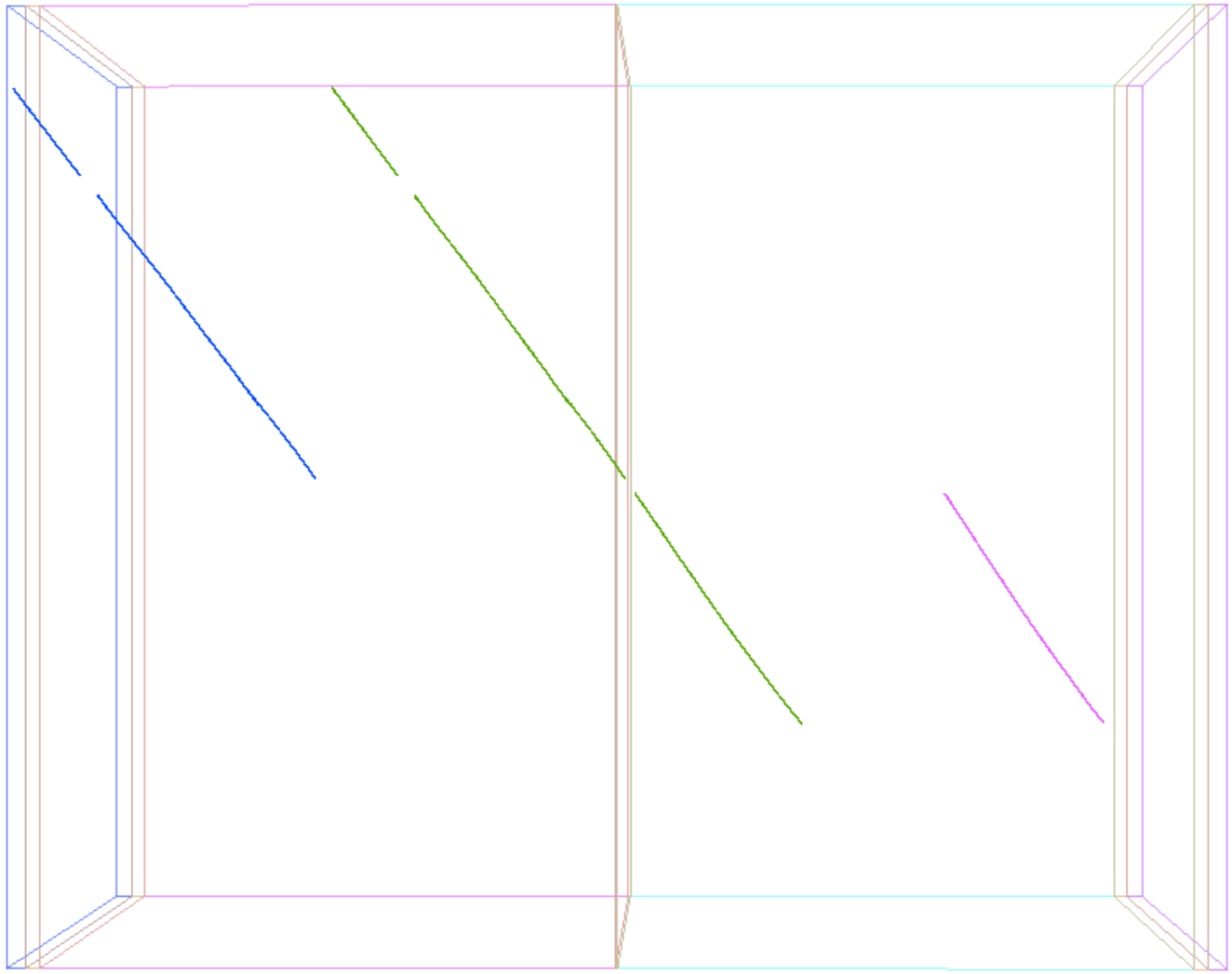




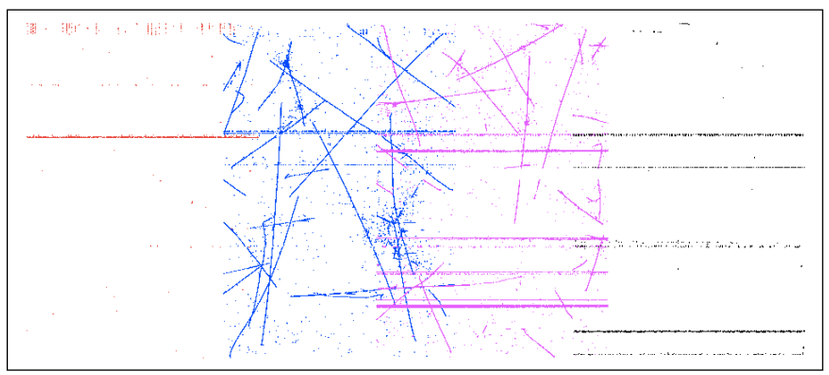
- Additional hits are also present in the U and V views.

Stitching In Pandora

- Brief example showing stitching working between the two central drift volumes.

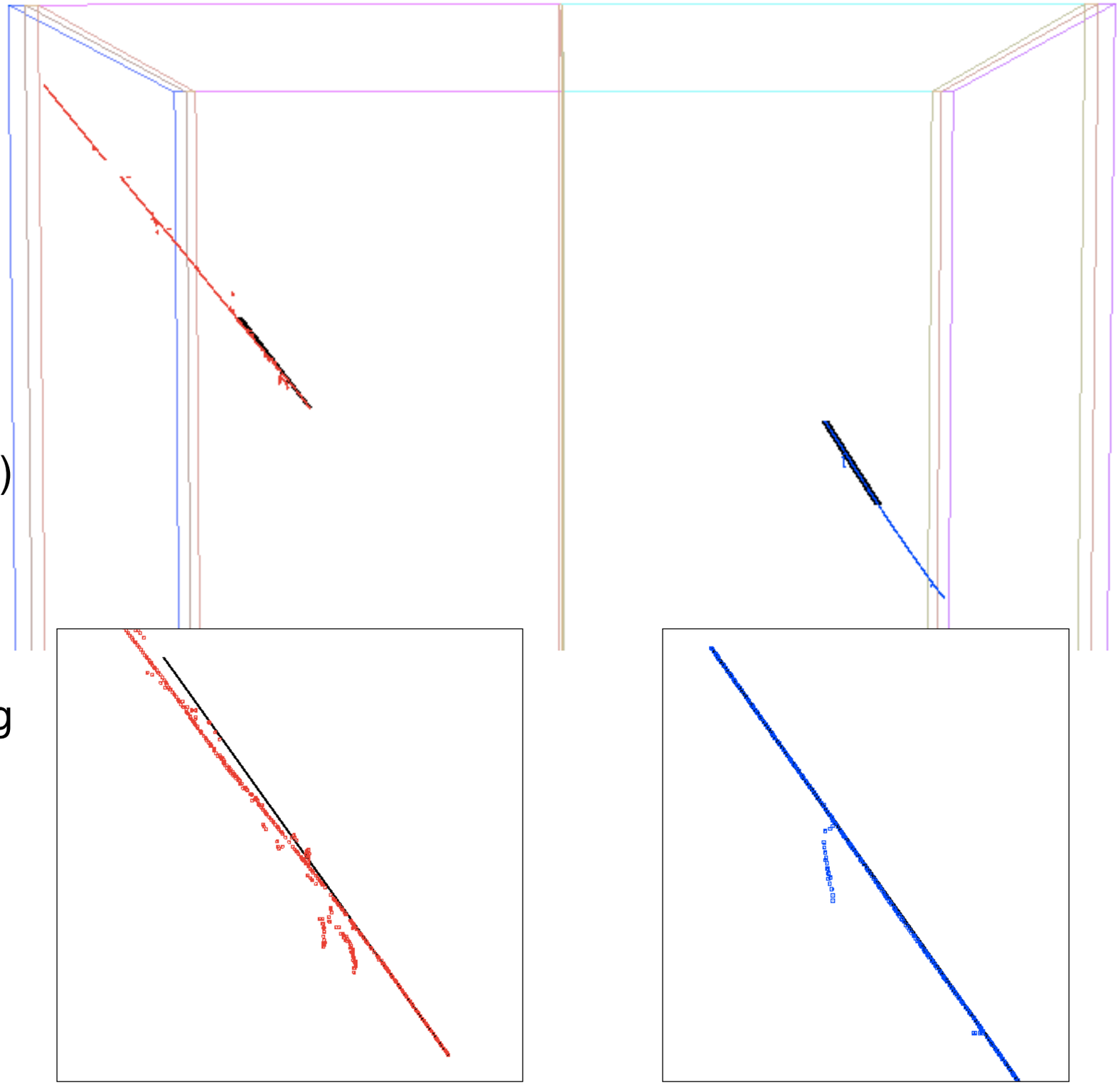


Outer Drift Volume | Central Drift Volume | Central Drift Volume | Outer Drift Volume



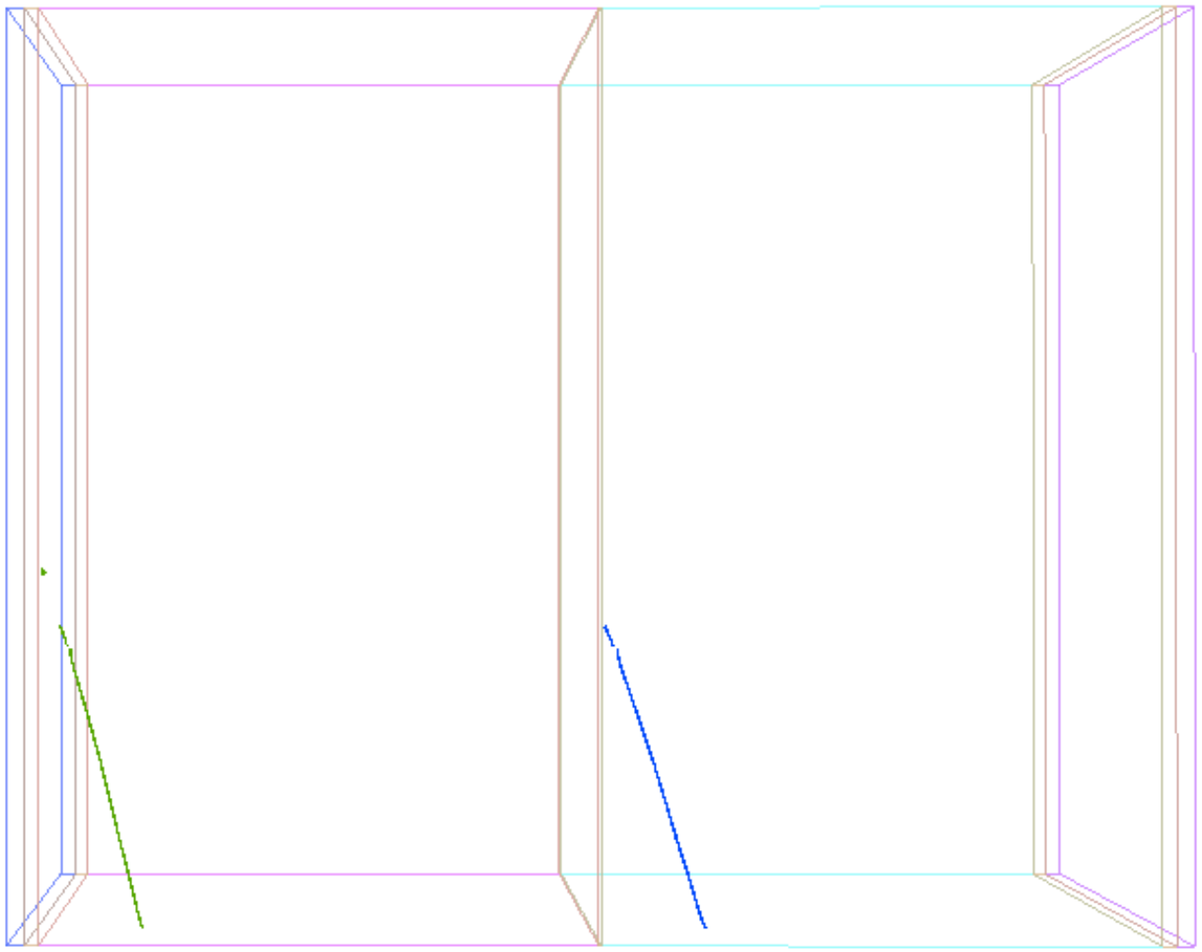
Stitching In Pandora

- Stitching will not work directly out of the box for these side APAs even though the code is setup to stitch adjacent drift volume particles.
- The reason is that to stitch particles Pandora applies a fit to the reconstructed particles from each drift volume (c.f. black lines) to determine whether particles point at each other.
- There is a cut on the minimum particle length to use for stitching to ensure reliability in the fit direction (default 50cm).
- Therefore, I reduced this cut to 5cm to ensure particles in the cryostat side of the APA would be considered.

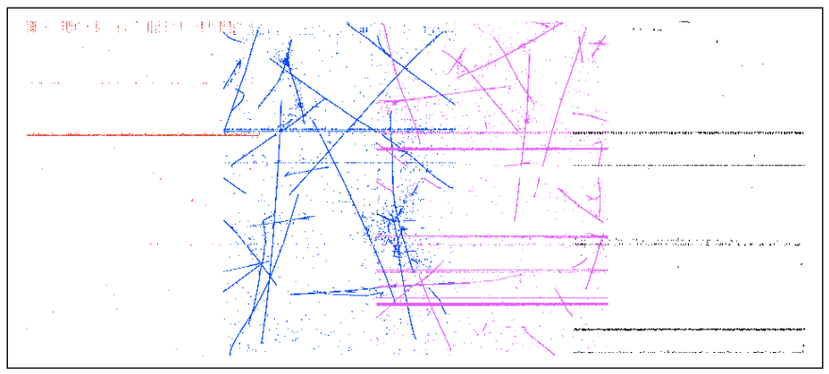


Stitching In Pandora

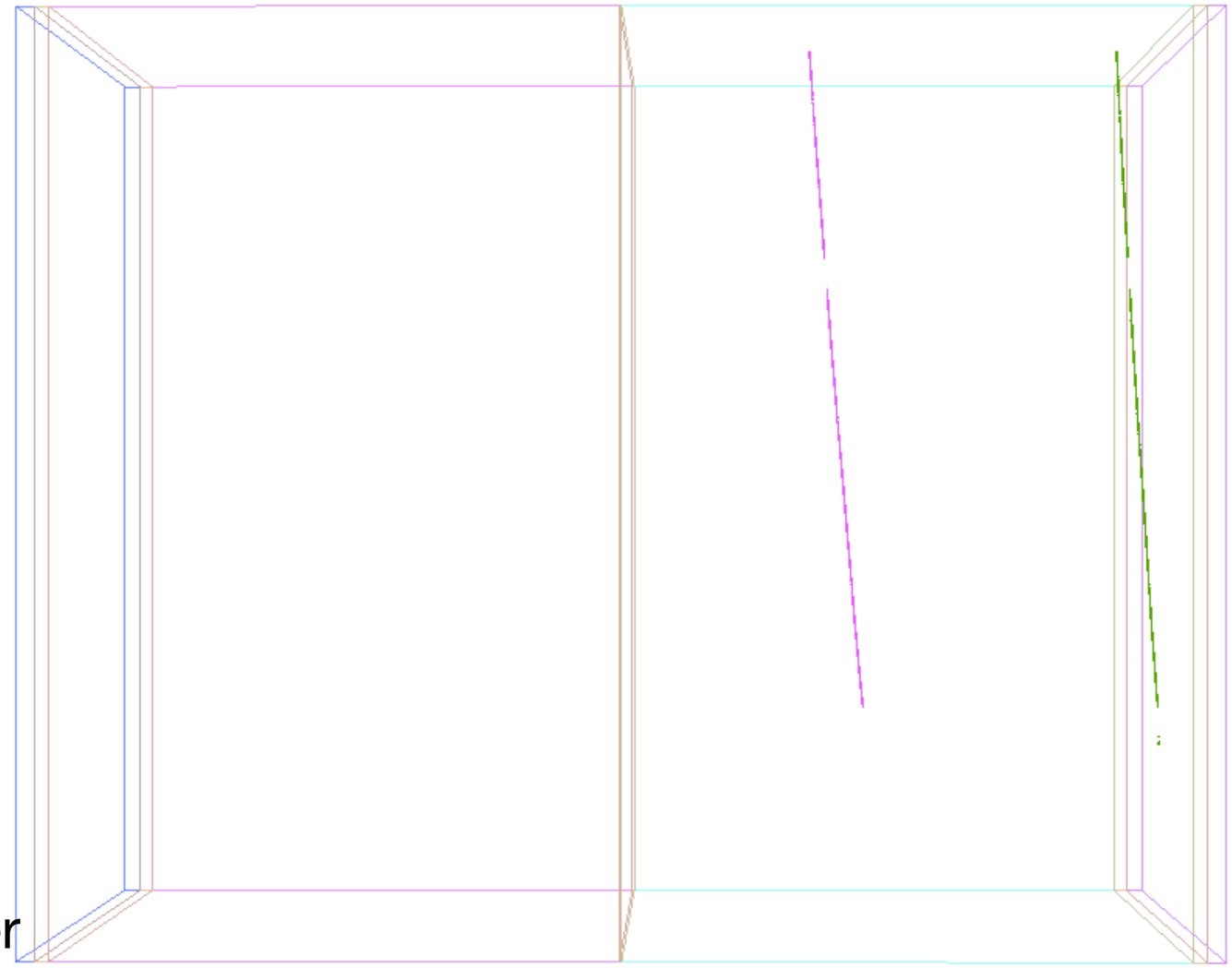
- Then stitching across the APA works (with one minor change to LArContent).
  - As long as Pandora can reconstruct a 3D particle from the cryostat side APA hits.



Outer Drift Volume | Central Drift Volume | Central Drift Volume | Outer Drift Volume



Stitching In Pandora



Outer Drift Volume

Central Drift Volume

Central Drift Volume

Outer Drift Volume