Pandora for ND-LAr and 2x2

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Prototype Analysis Workshop
20/05/2023

Introduction

- Today I'll be talking about a few things about Pandora's development in the time since the last meeting.
- Three major thrusts.
  - Development of reconstruction using full 3D information.
  - Integration of the "NDFlow" process, input files and production chain.
  - Move towards user-analysable files.
    - But that's a different talk this afternoon.
- Additionally, Deep Learning vertexing from John Back (Warwick)
  - Promising development.
  - Not going to be in in our first generation of MiniProd files.

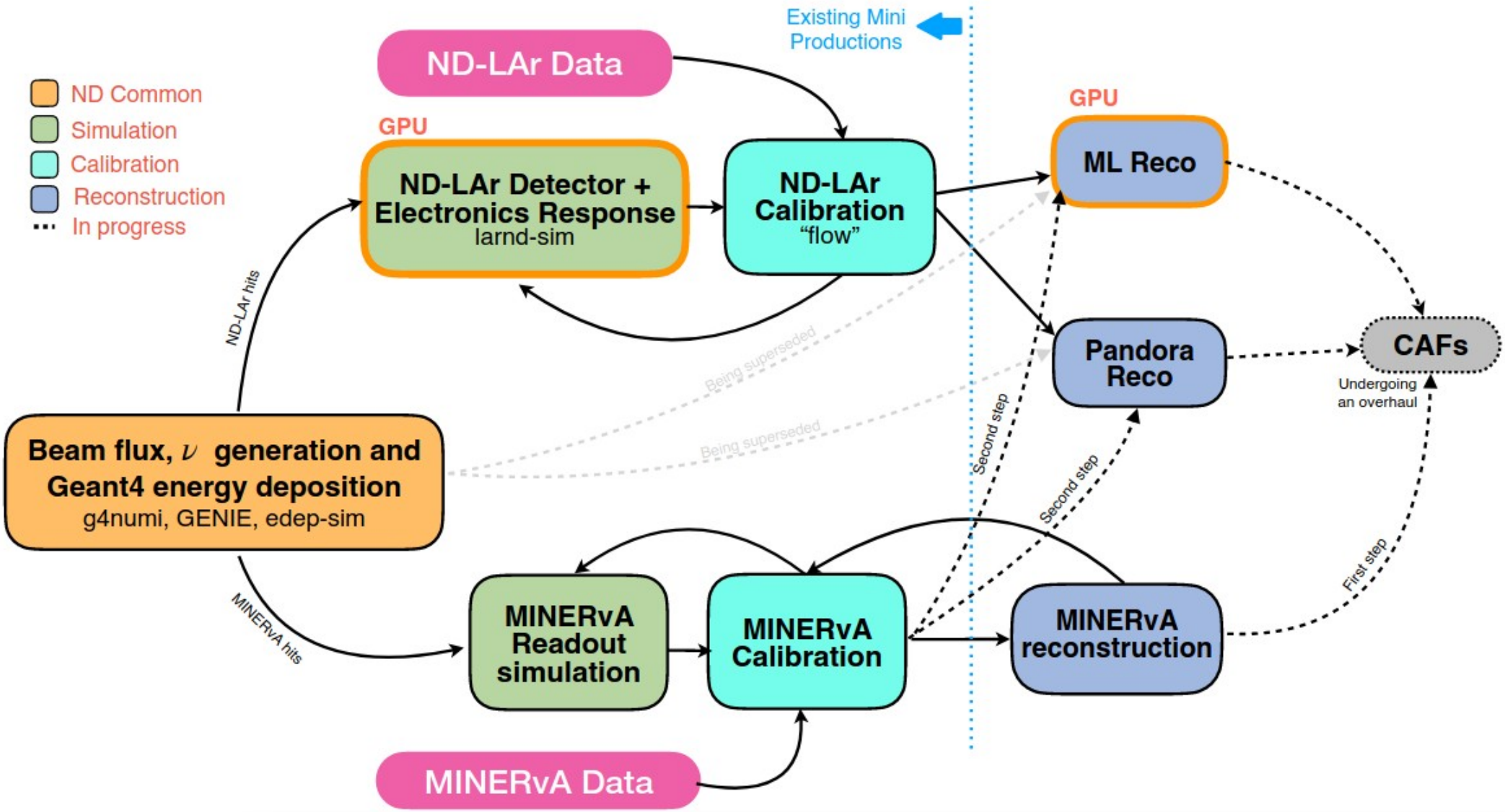
Pandora

- Pandora is a general pattern recognition software framework.
  - Provides reconstruction for many of your favourite LArTPCs.
    - MicroBooNE
    - ProtoDUNE
    - DUNE FD (HD and VD)

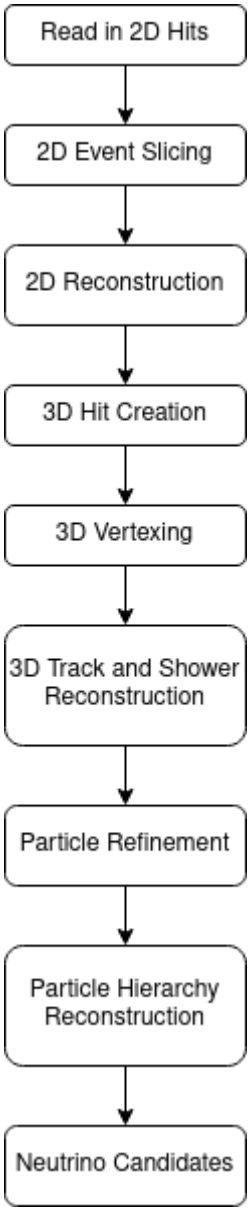
https://github.com/PandoraPFA

- Heavily developed and optimised for 3x2D readout TPCs
  - With low multiplicity.
- Highly active development for ND LAr and the 2x2.

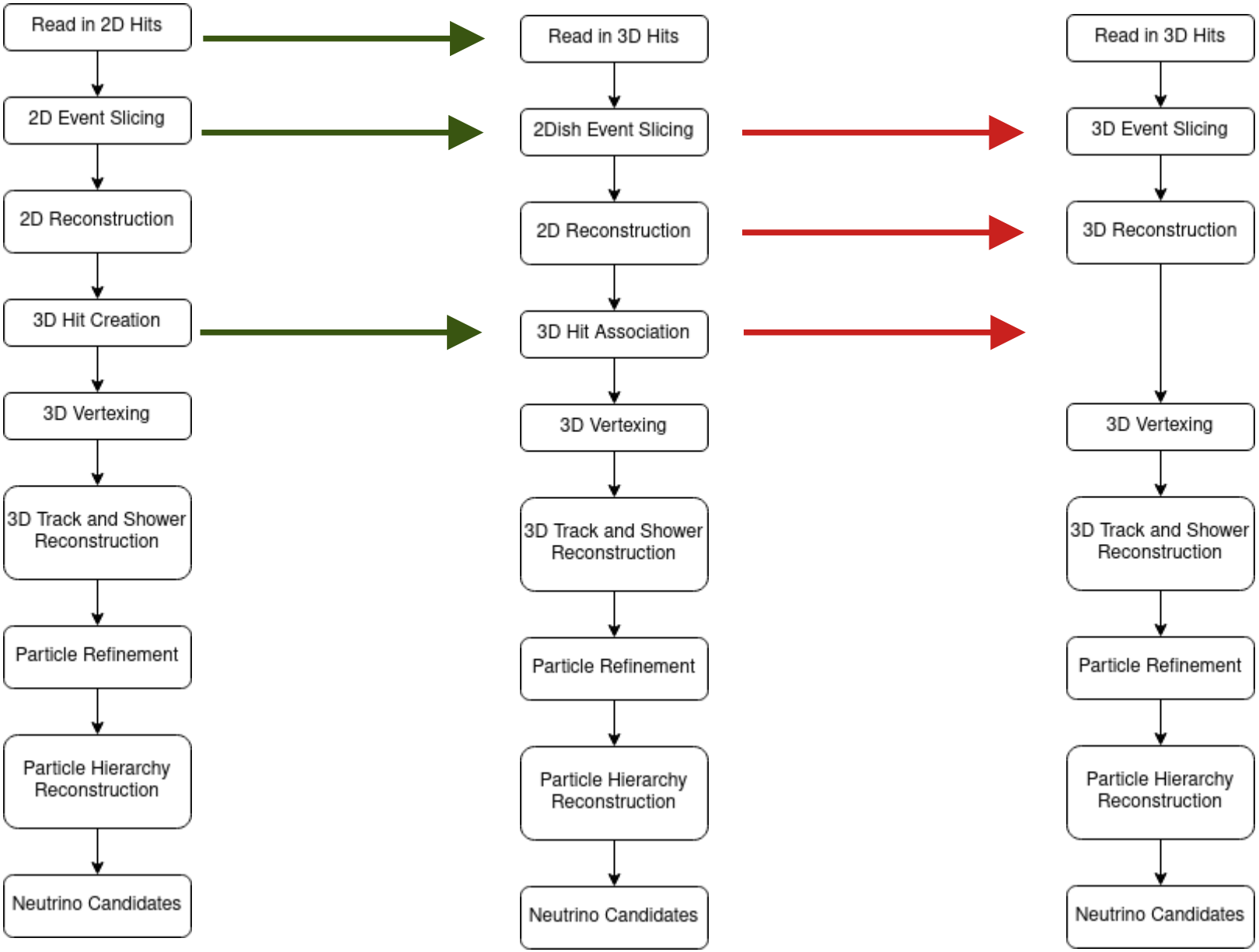
Pandora in the Chain



Where we started (3x2D)



Development of ThreeD reco.

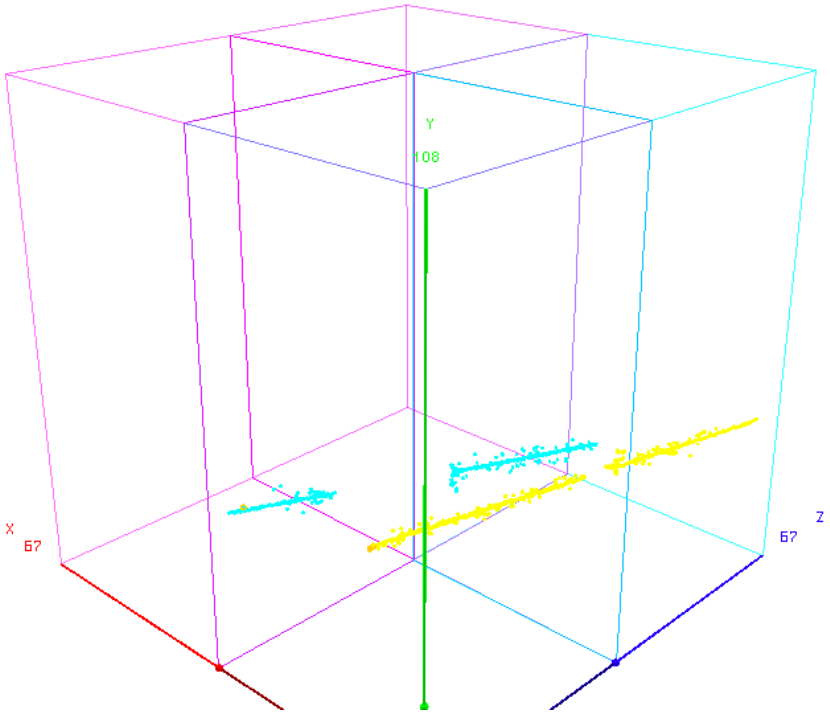


3D Reco Development and Status

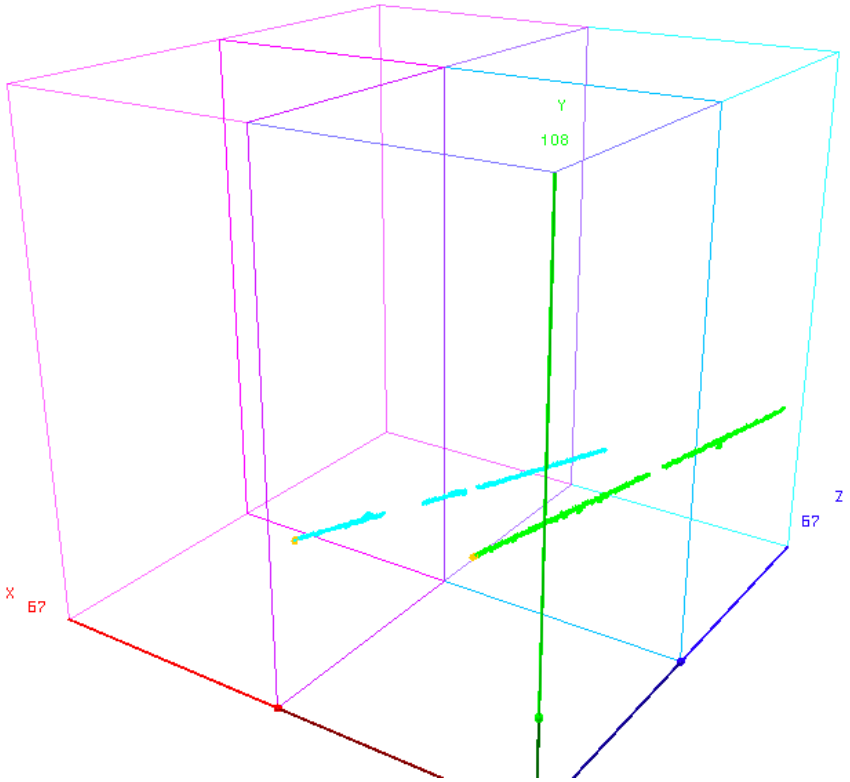
- Significant development in use of full pixel-readout information since January.
- Initial clustering and slicing now performed fully in 3D.
  - All hits and physics objects natively in 3 dimensions.
  - But still use some 2D algorithms for refinement of the 3D objects.
    - Cluster merging algorithms etc.
    - Some Y-axis information missing.
    - “2.8D”
    - Still room for improvement.
- Particle trajectories, tracks and showers all fully built out of 3D hits.
- Development quantitative, more than qualitative.
  - Lacking truth information for full metrics.
- Many thanks to Leigh Whitehead for hard work on this.

Some events.

3x2D Reconstruction

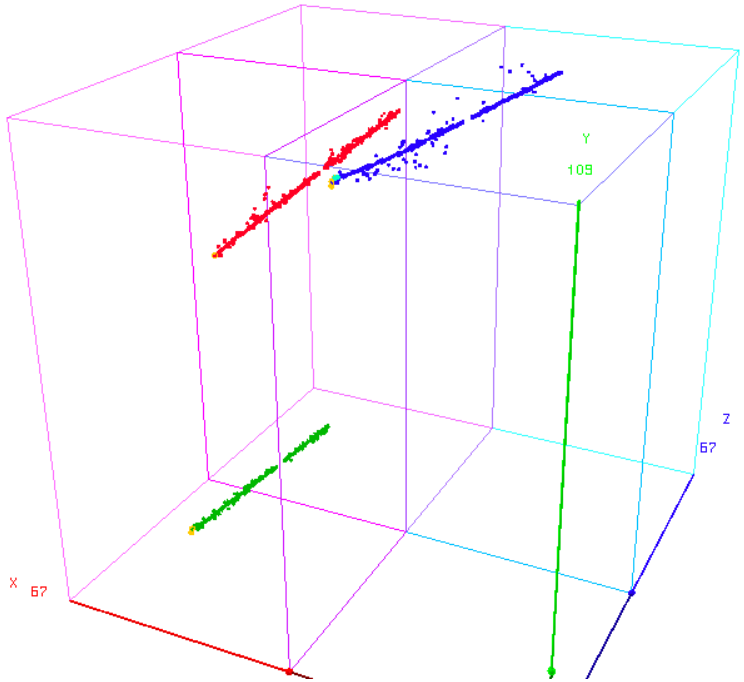


Current 3D reconstruction

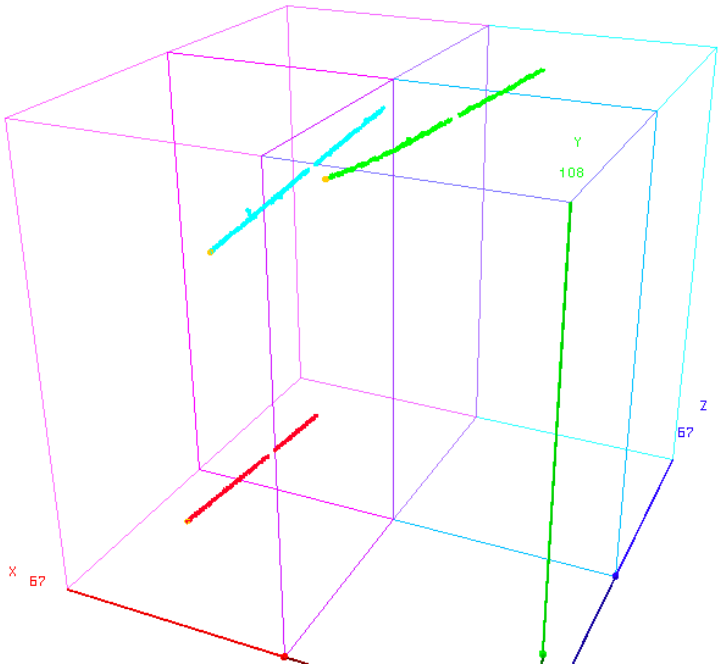


Some events.

3x2D Reconstruction

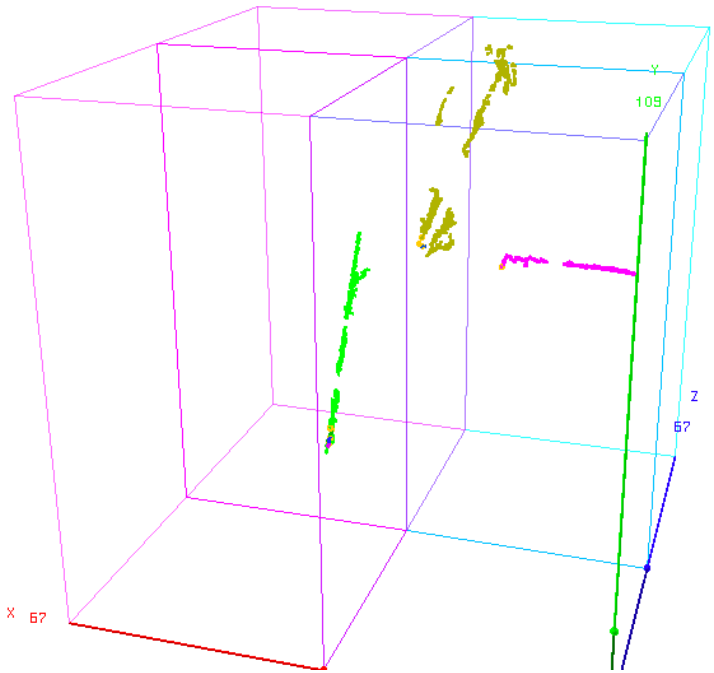


Current 3D reconstruction

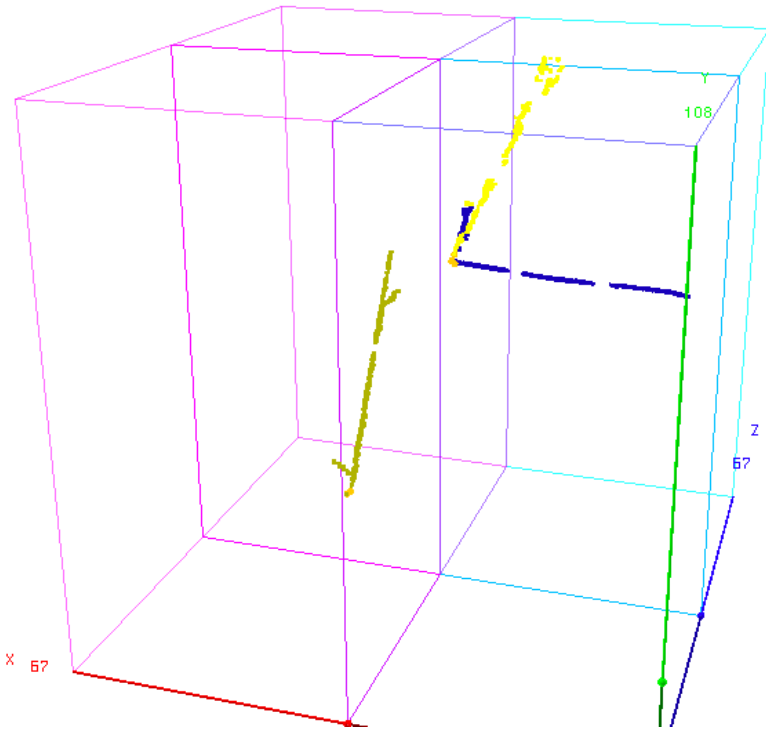


Some events.

3x2D Reconstruction



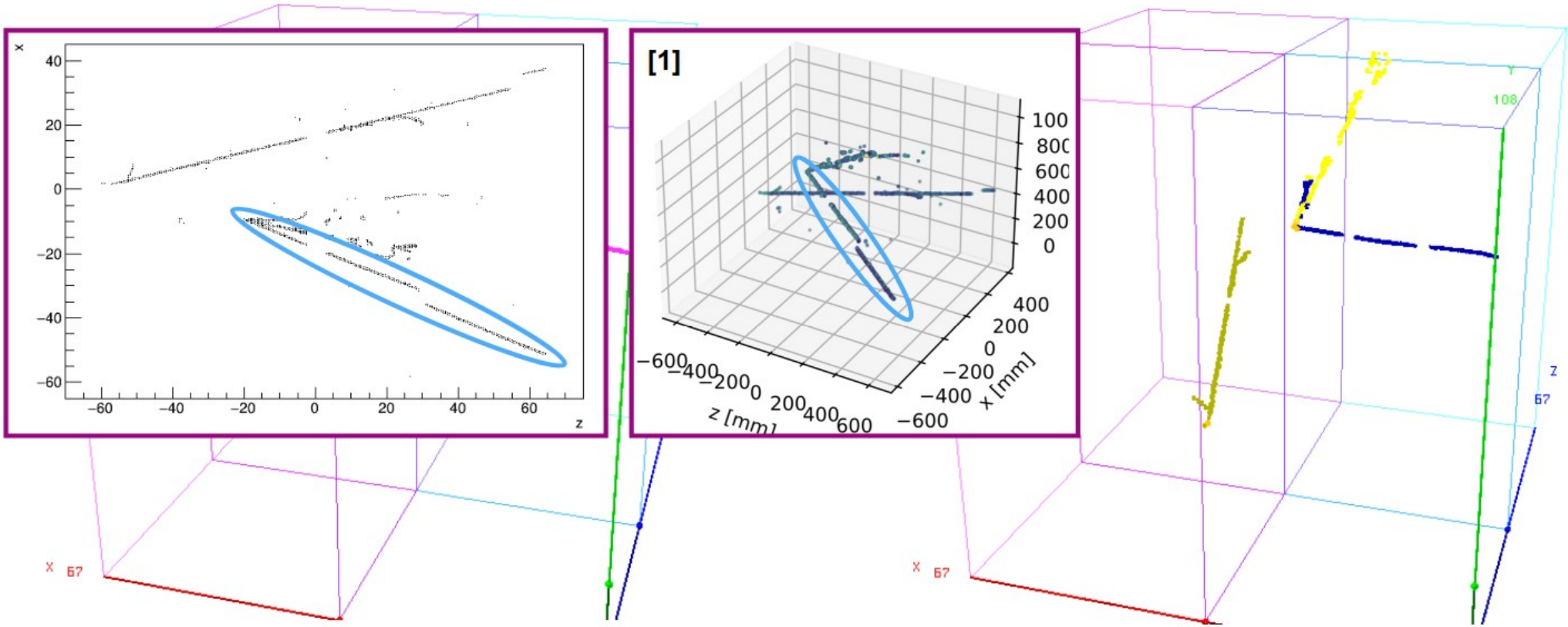
Current 3D reconstruction



Some events.

3x2D Reconstruction

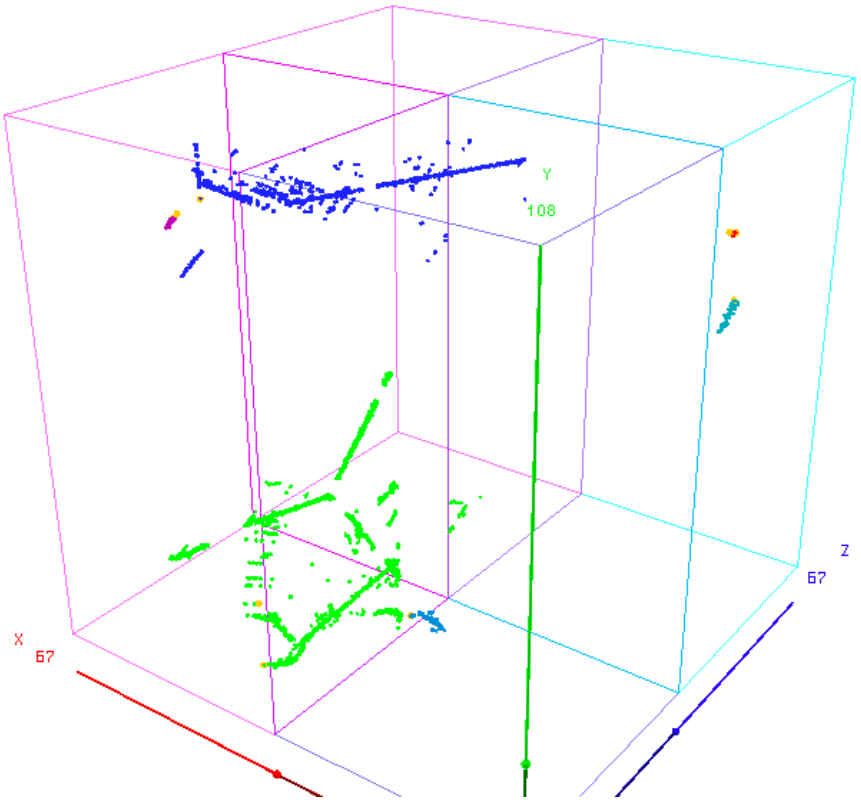
Current 3D reconstruction



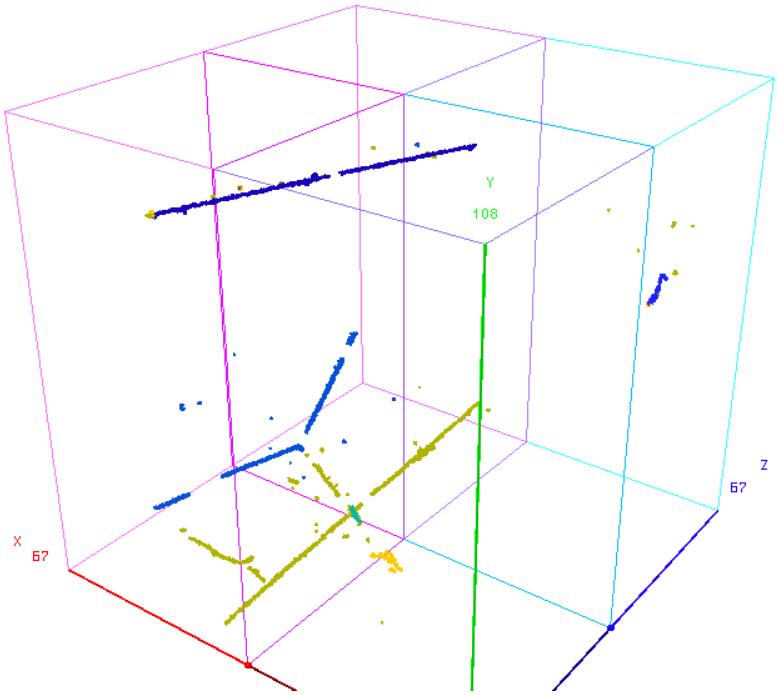
From L. Whitehead.

Some events.

3x2D Reconstruction



Current 3D reconstruction



DL Vertexing

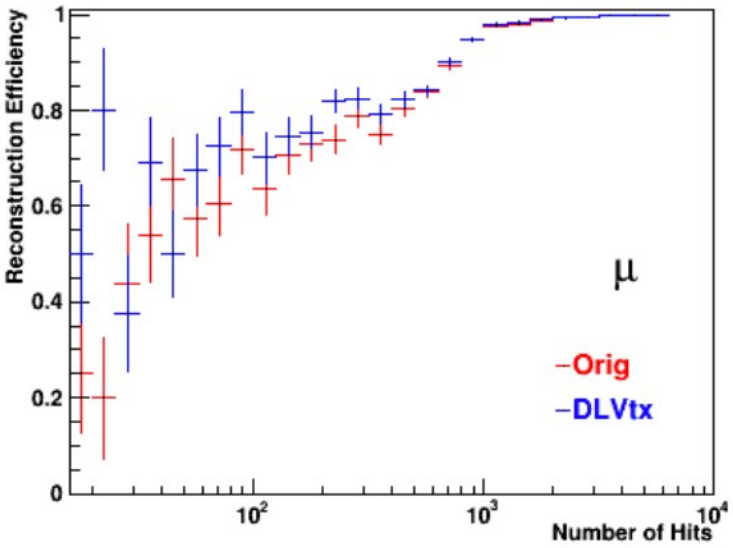
John Back (Warwick) has been adapting the Deep-learning vertexing developed for the far detector.

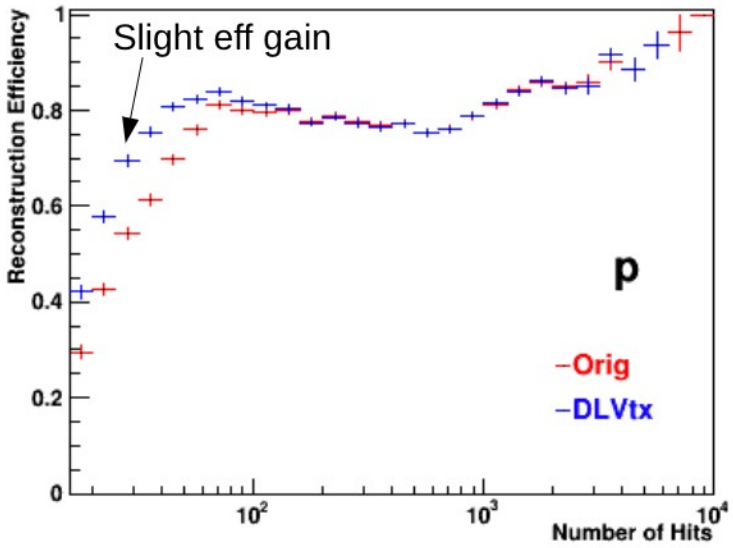
- Trying out **Deep Learning (DL) vertexing** for Near Detector
  - Using **LArContent v4.02.00** & **LibTorch** setup
  - Pandora **MicroBooNE neutrino algorithms**
  - **LArDLVertexing** algorithm: trained for **DUNE Far Detector (A Chappell)**, reused for ND
  - **No retraining done** (yet): no changes to any xml parameter files
- Using 100k single ν_μ interaction GENIE events (no spills)
  - Usual edep-sim ArgonCube simulation & energy hits 4 mm voxelisation
- Comparing LArRecoND performance with/without DL vertexing
  - Original: MicroBooNE neutrino algorithms only
  - DLVtx: MicroBooNE neutrino algorithms with LArDLVertexing (DUNE FD)
  - https://github.com/jback08/LArRecoND/tree/feature/DLVertexing

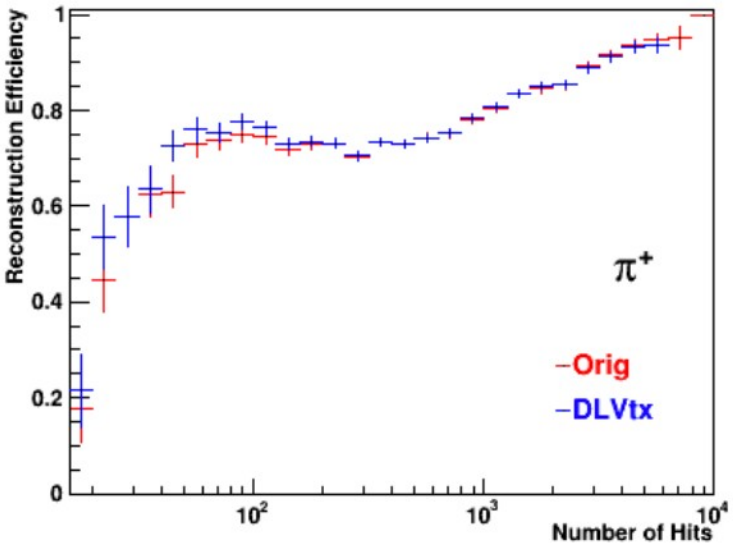
Edep-sim means we can actually quantify these.

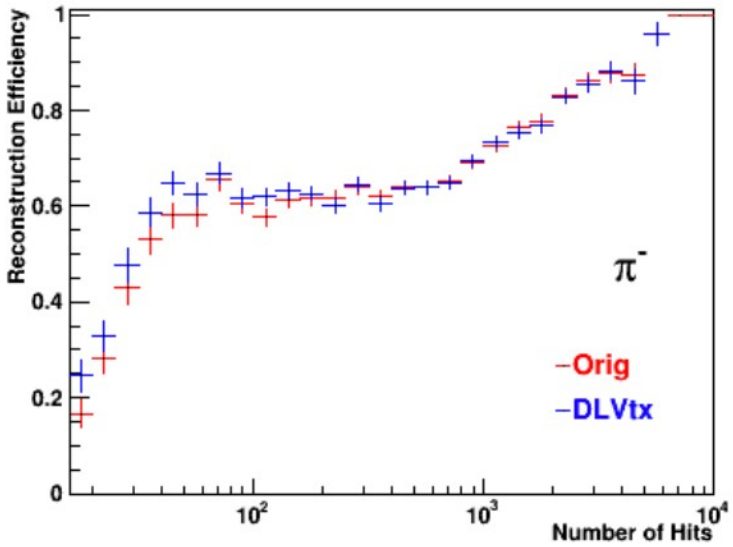
DL Vertexing

ν_μ events: particle reco eff vs number of hits









Original
DLVtx

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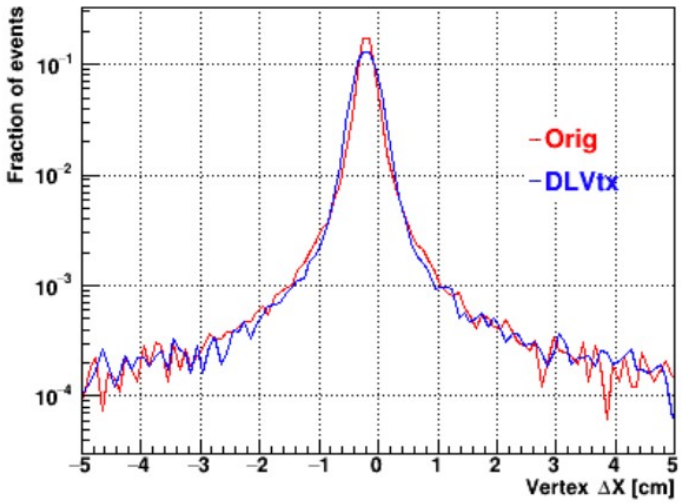
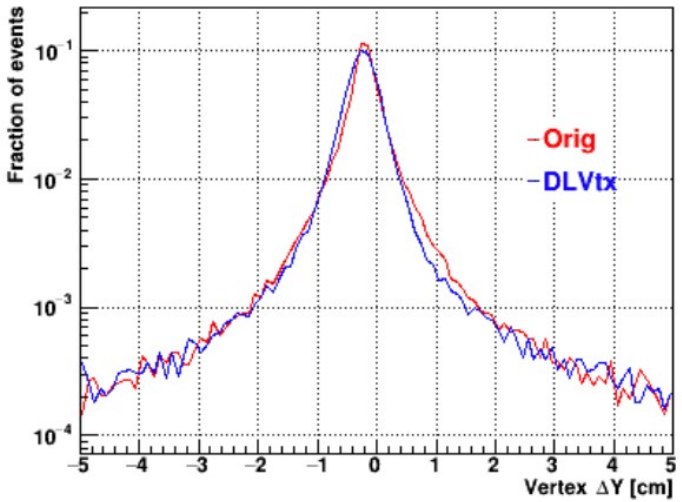
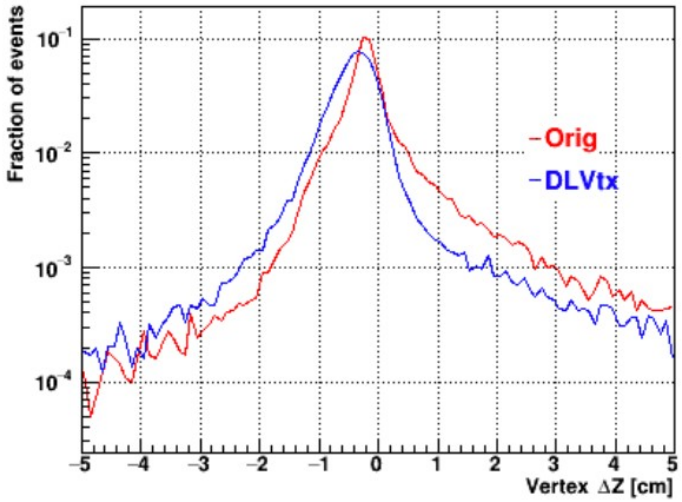
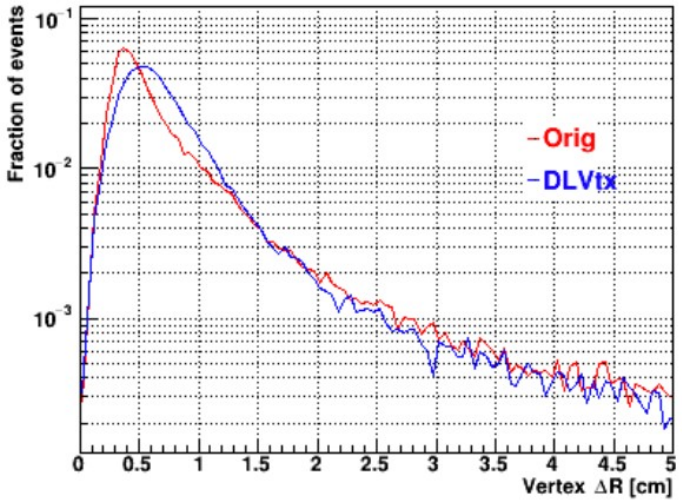
DL Vertexing

ν_μ events: reco – MC vertex residuals (log scale)









Original
DLVtx

Peak ΔR ≈ 4 mm
Peak ΔR ≈ 5 mm

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Updates using Flow

- Significant updates to ND Flow files.
  - Which are our primary input.
  - These are h5 files.
  - We run these through a Python converter to get files that Pandora can ready happily.
  - May well move to full h5 interface at some point.
    - Once file formats are stable.
    - While we're iterating, good to keep flexible python layer.
- Many thanks to the flow team for the rapid development.
  - And Richie Diurba on the Pandora side for his work on updating this.
- Currently rapidly iterating on truth backtracking information.
  - MR 5C has all the truth we need for unmerged hits.
  - But we're still lacking merged hit tracking.

Summary

- Rapid development of 3D capabilities.
- DL vertexing improvements.
  - Probably not in first production.
  - Depending on how long it takes.
- Many updates to input files.
  - We're now very close to having all the information we need.
    - Or at least all the information we know we need right now.
- In the very near feature, we want to combine these two things.
  - So can actually quantify how well our reconstruction works and how the 3D developments have improved it.
  - Rather than just doing "logical" things to the reco, and studying specific event type failures.
  - MR events should be sufficient for this for now.
- Hang in there for updates on our analysis output formats this afternoon.