ND-LAr Reconstruction with Pandora

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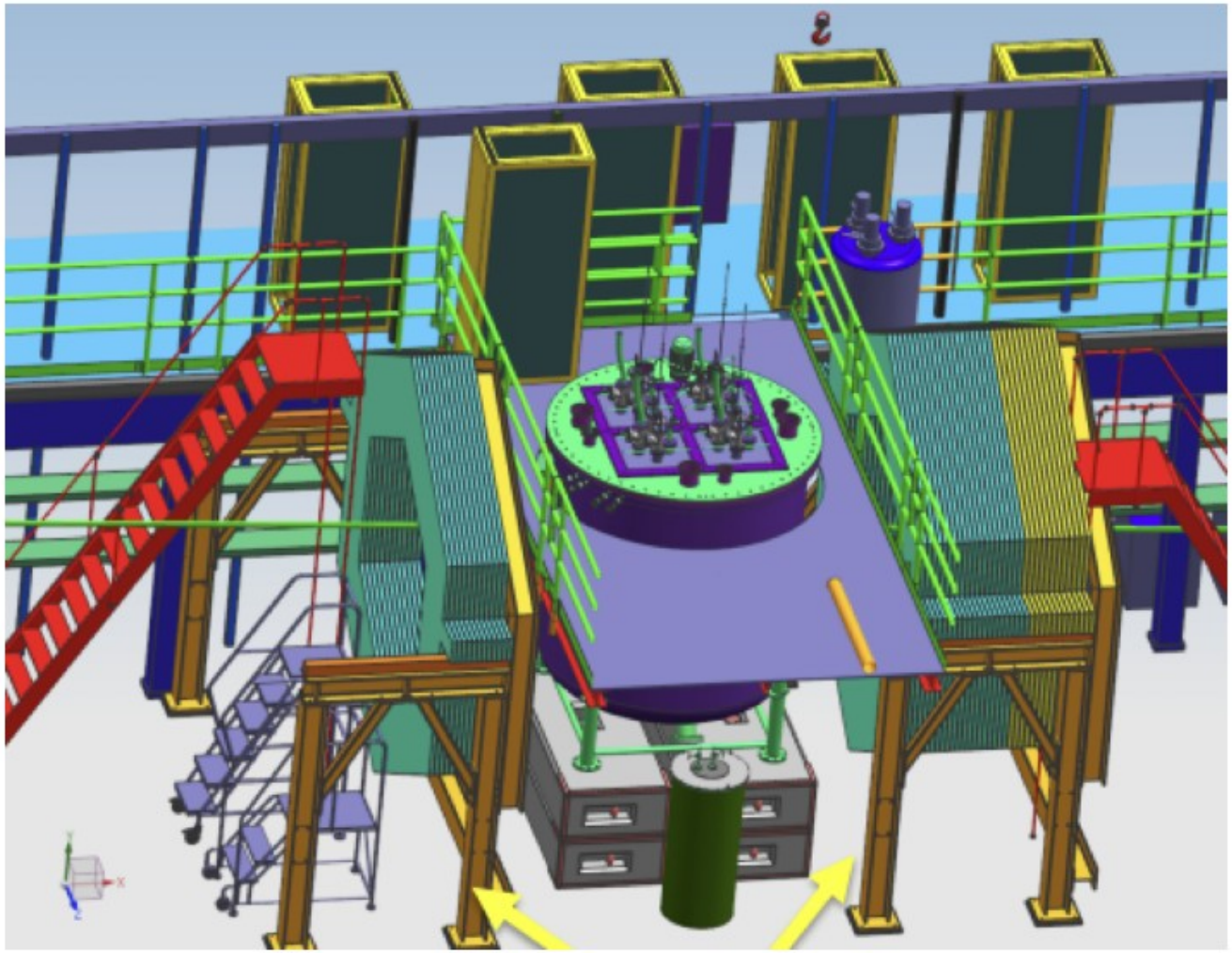
04/06/2023

Introduction

- Using the Pandora reconstruction package for the DUNE liquid argon TPC near detector.
- High neutrino multiplicity gives new challenges to reconstruction.
- Novel pixel readout technology gives us additional power.
  - One 3D TPC view rather than 3 x 2D from wires.
- Huge progress in the last 6 months.
  - Focused on the 2x2 prototype.
    - The LArTPC component of ProtoDUNE-ND.
  - Mostly “plumbing” and infrastructure.
  - Native 3D development.
  - DL for vertexing.
  - All infrastructure and most development common to ND-LAr and the 2x2 prototype.

ProtoDUNE-ND



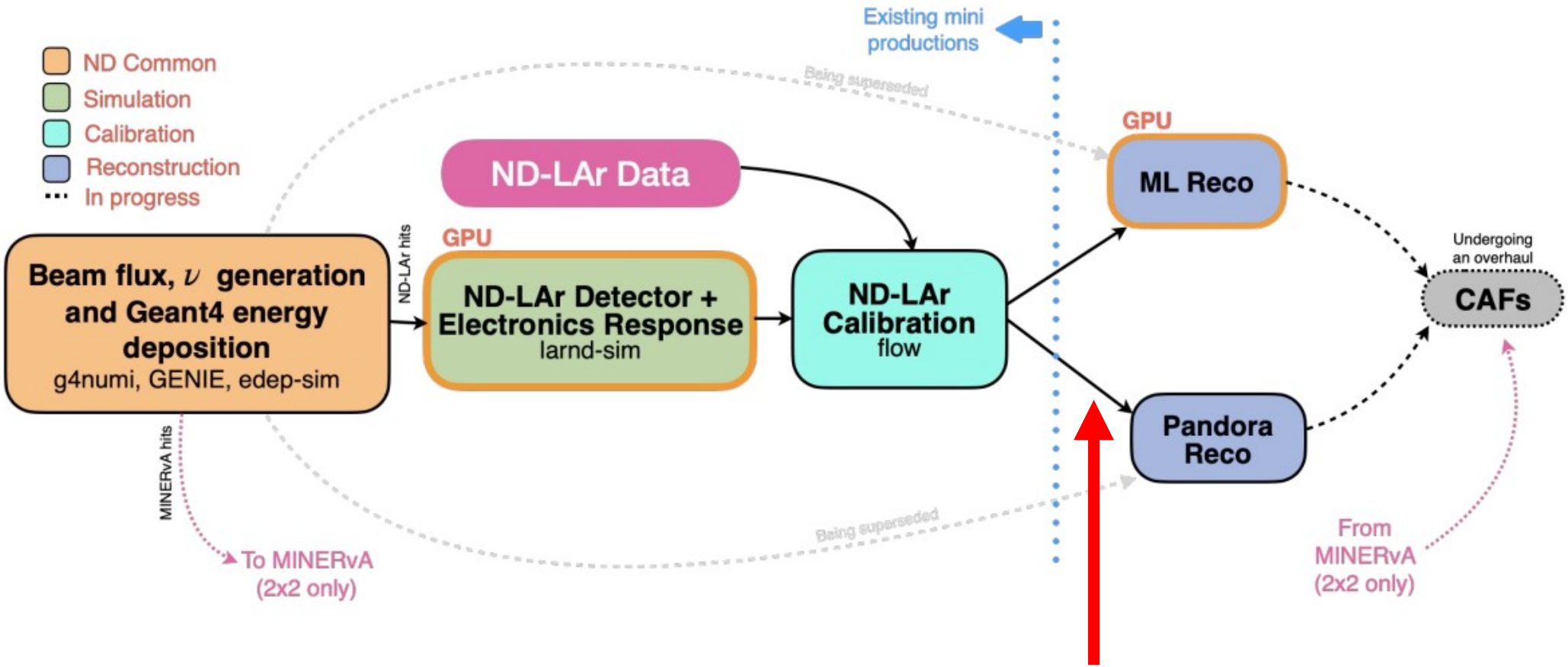
Our group's current focus:
getting ready for data taking with the 2x2+MINERvA demonstrator

- Four ND-LAr prototype modules in a single cryostat
- A forwards & backwards tracker made of repurposed MINERvA modules
- Exposed to the NuMI beam at Fermilab

ProtoDUNE ND Run Plan

- Installation ongoing.
- Commissioning over the summer.
- Will collect RHC (antineutrino mode) NuMI beam data from mid-October.
  - (after summer shutdown)
  - Beam will run antineutrino mode until at least next summer.
  - Run plan determined by NoVA's needs, not ours.
- Very aggressive plan to publish first neutrino data analysis early next year.
  - Software chain needs to be ready when data arrives.

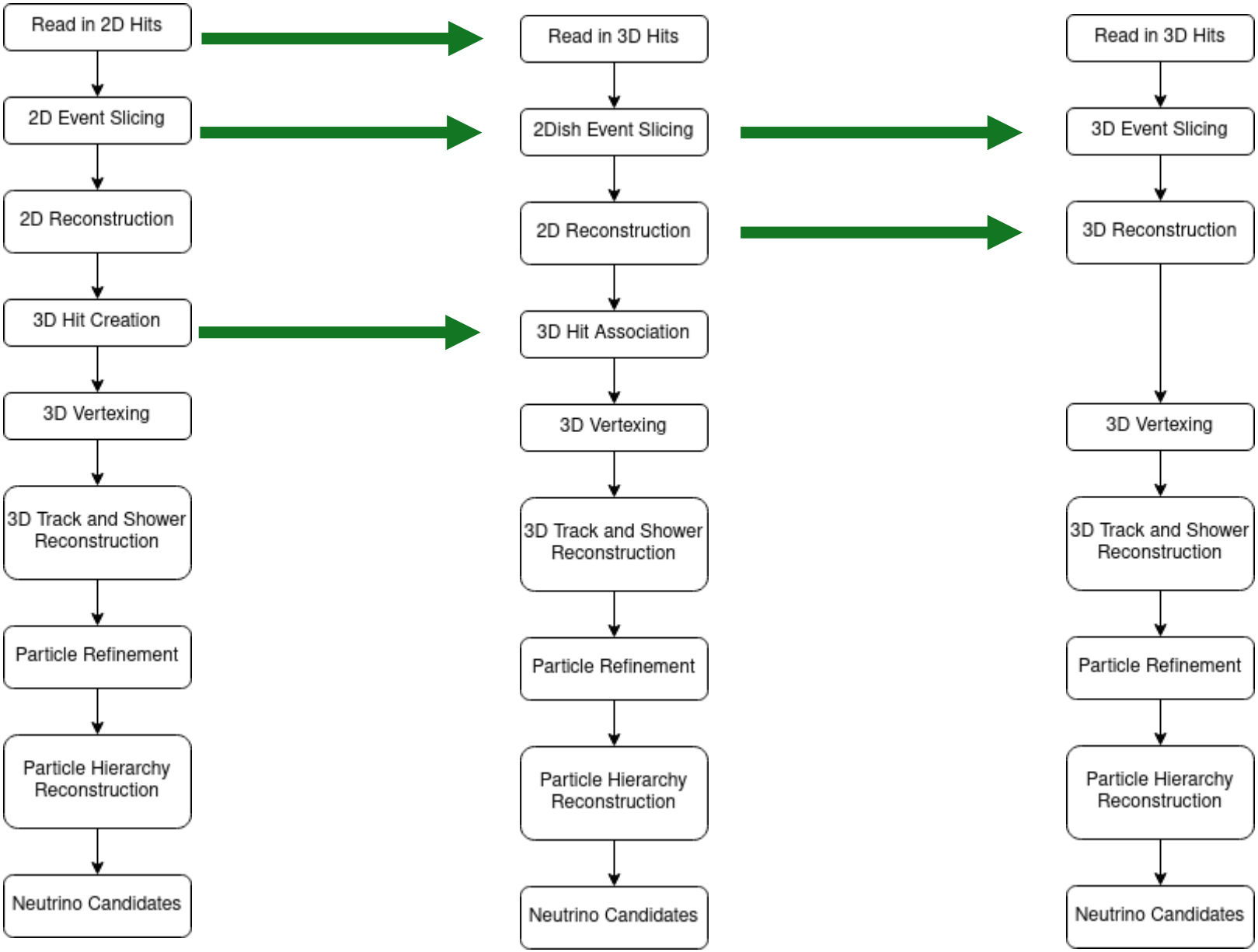
The ND-LAr Analysis Chain



Rapid development at “flow” stage and interface to Pandora.

- We’ve been able to properly interface truth information for… about a week?

Development of 3D Reco



3D Reco Development and Status

- Significant development in use of full pixel-readout information.
- 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.
  - Now we have the relevant truth information.
- Many thanks to Leigh Whitehead for hard work on this.

Validation with truth

- We have added some new algorithms to produce validation trees
  - These perform matching between reconstructed and true particles
  - It can also dump information to the screen

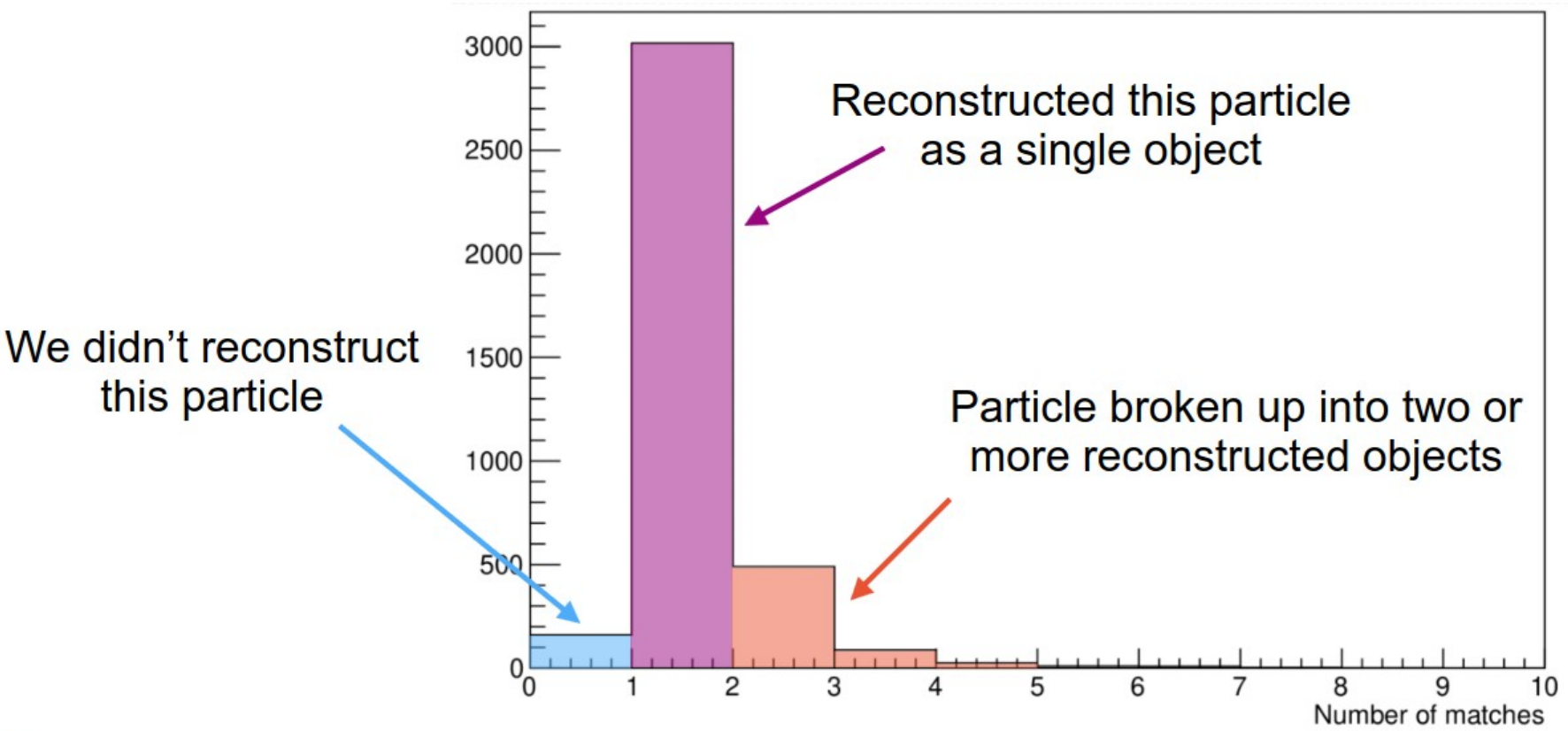
```
===== Matching Information for Neutrino: id = 100000023, pdg = -14, interaction = CC RES =====
  - MC Particle: id = 16605, pdg = -13, nhits = 843, matches 1:
    - Pfo: pdg = 13, hits = 816, shared hits = 771, completeness = 0.914591, purity = 0.944853
  - MC Particle: id = 16608, pdg = 211, nhits = 198, matches 1:
    - Pfo: pdg = 13, hits = 192, shared hits = 192, completeness = 0.969697, purity = 1
```

- In this example we have a CC RES muon antineutrino interaction
  - It produces two reconstructable particles:
    - Antimuon, which is matched to a reconstructed track with decent performance
    - Pi-plus, again, matched well to a reconstructed track

Number of Matches

Very hot off the presses, don't read too much into this.

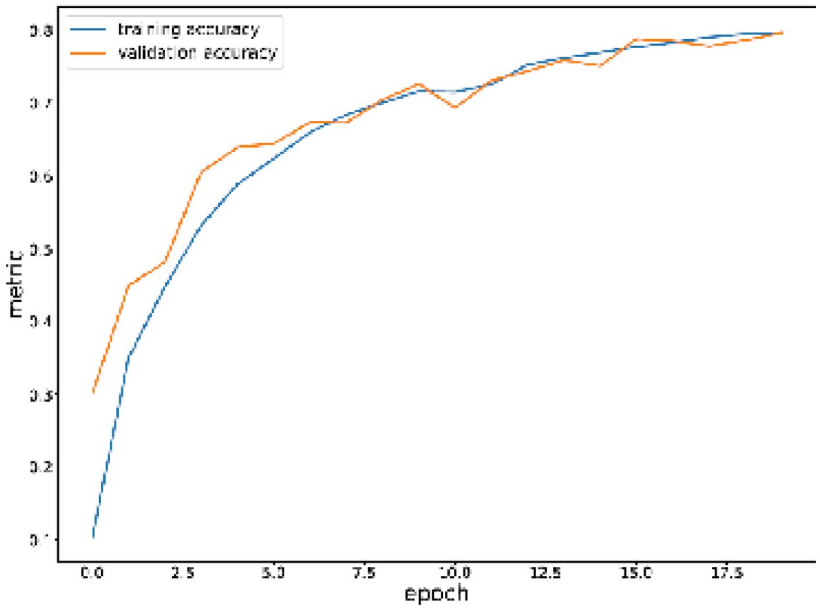
- Number of reconstructed object matches for true muons and antimuons

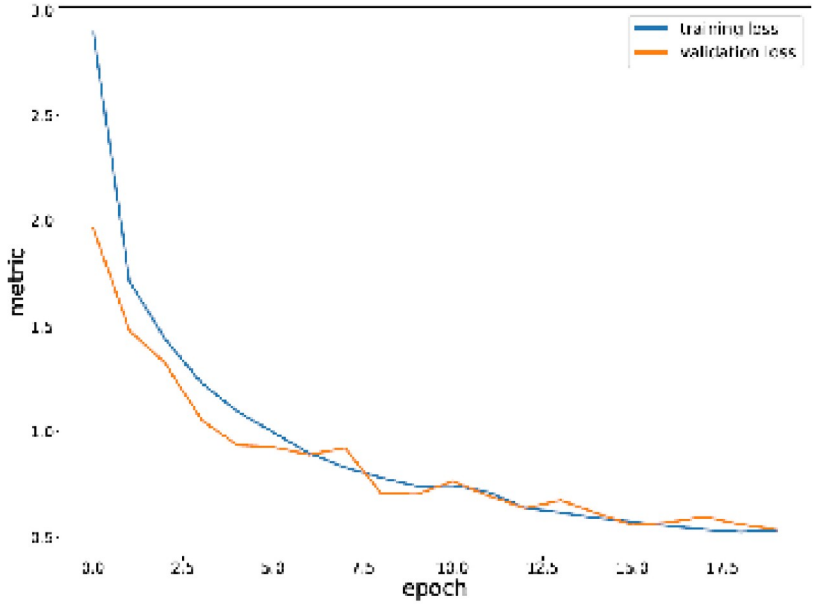


L. Whitehead

ND LAr Vertexing

Deep learning vertexing for ND: pytorch





Recent work-in-progress training metrics

Using "U, V, W" 2D projection views for single-interaction ν_μ training images

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J. Back

Analysis Files

- Working on producing CAF (Common Analysis Format) files for the first analysis teams.
  - I was actually intending to announce today that they're out but I found a bug.
  - So… probably this week.
- CAF format has changed recently.
  - Last week.
- I'll be producing the old-style "flat" CAFs this week.
  - And then the new "hierarchical" CAFs shortly after.
  - Both for "MiniRun 3".
    - For those who care about the prototype analysis group jargon.
  - Will be rapidly followed by MiniRun 4 when it is made.
  - Then, first full production…
    - When it's ready.

Conclusions

- Lots of rapid development.
  - Tonnes of boring plumbing, some interesting reco.
- Data soon.
- Aggressive analysis timeline!
  - Necessitates aggressive production timeline.
- Pandora will be ready for 2x2 physics very soon.
  - And this puts us in great shape for the first set of analysable ND-LAr MC.
- The 2x2 is an exciting place to be right now.