

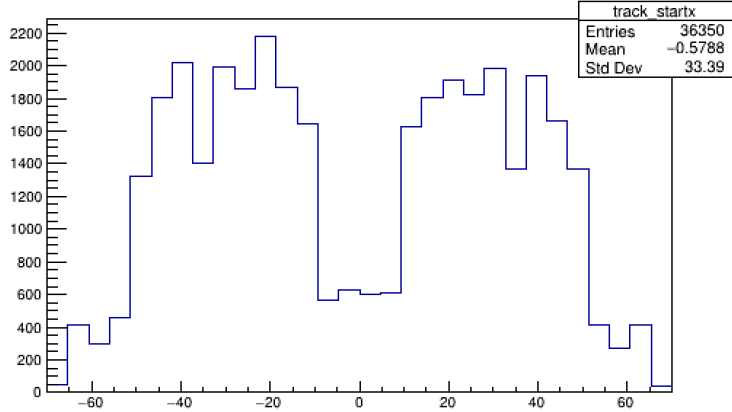
Updates from UniBe+ANL+Kyiv Group (Some Mult., Some General)

Richie for UniBe, ANL, and Kyiv

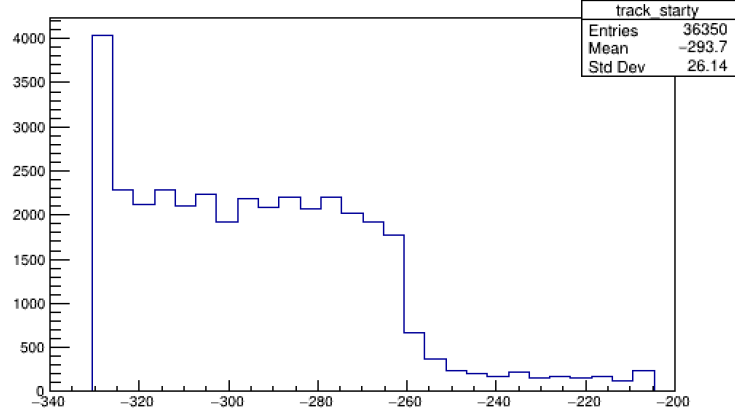
Preliminary Tracking by Position with CAFs (Aleena)

- Plot of the 2D distributions as a function of position (Validates a conservative fid. vol in each module of ~10 cm)

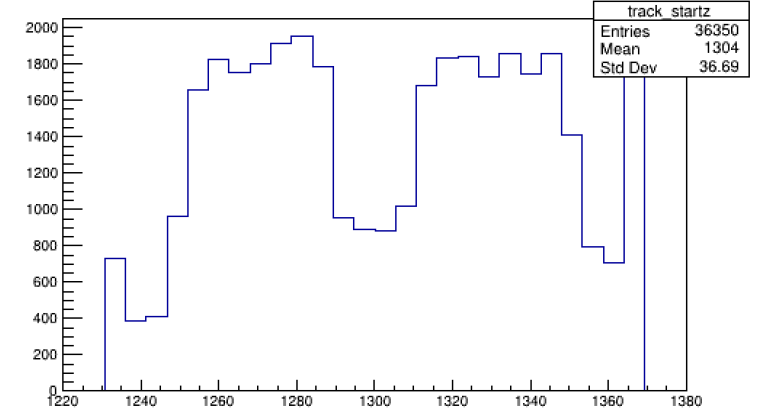
track_startx



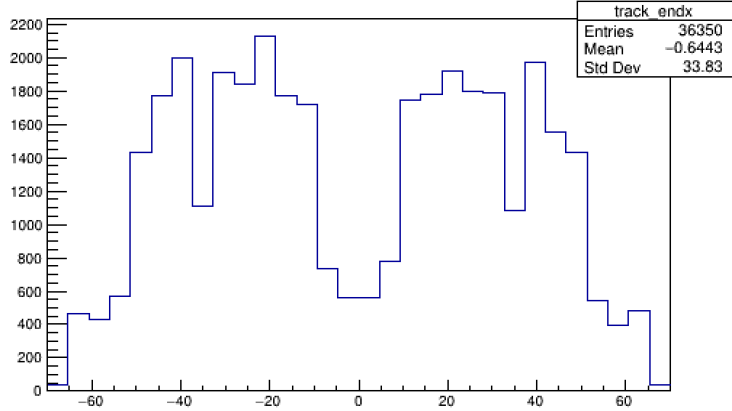
track_starty



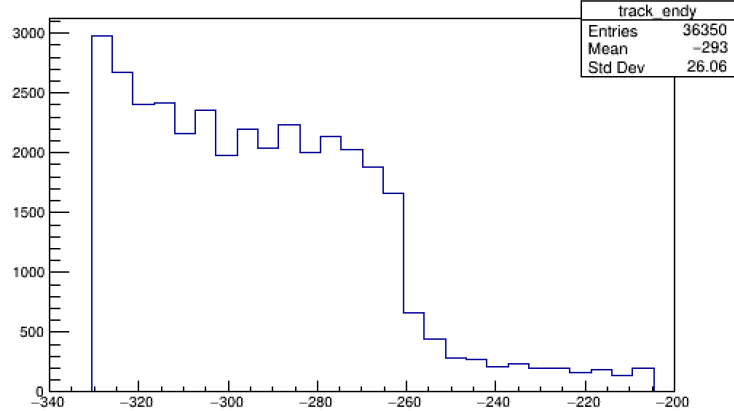
track_startz



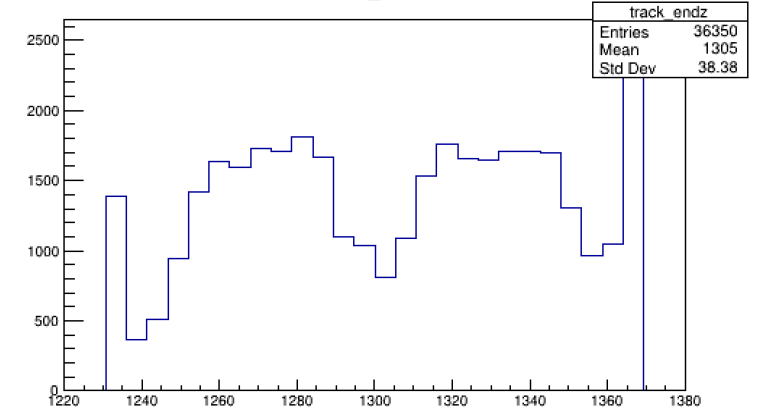
track_endx



track_endy



track_endz



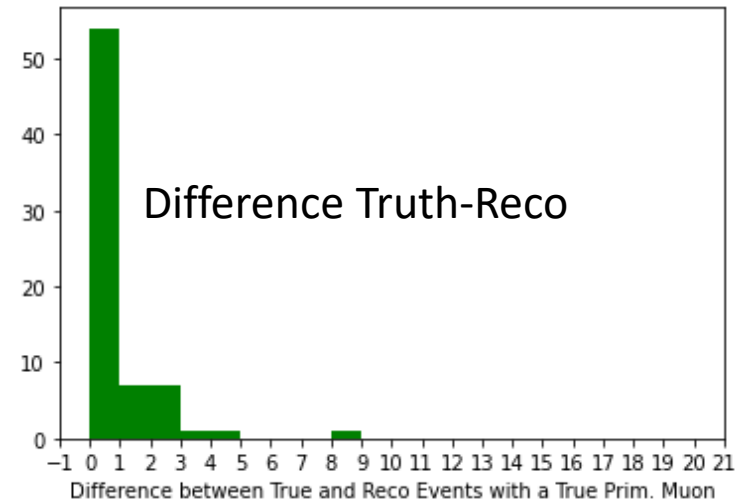
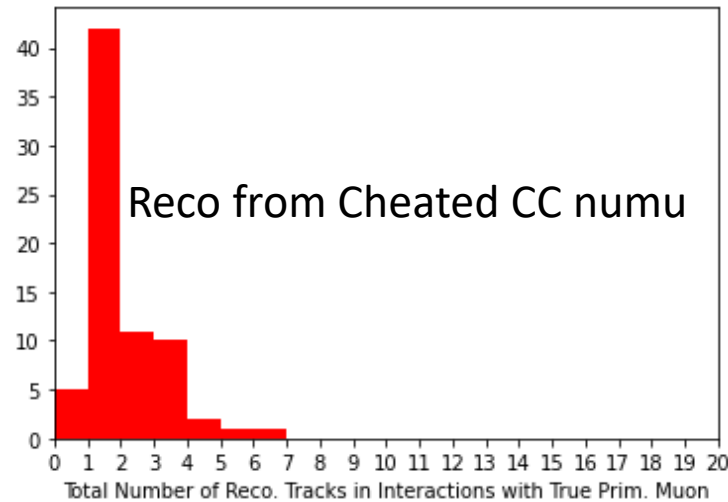
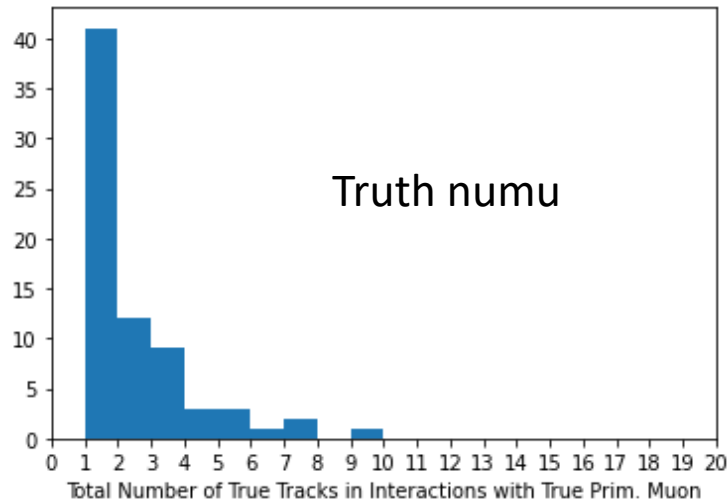
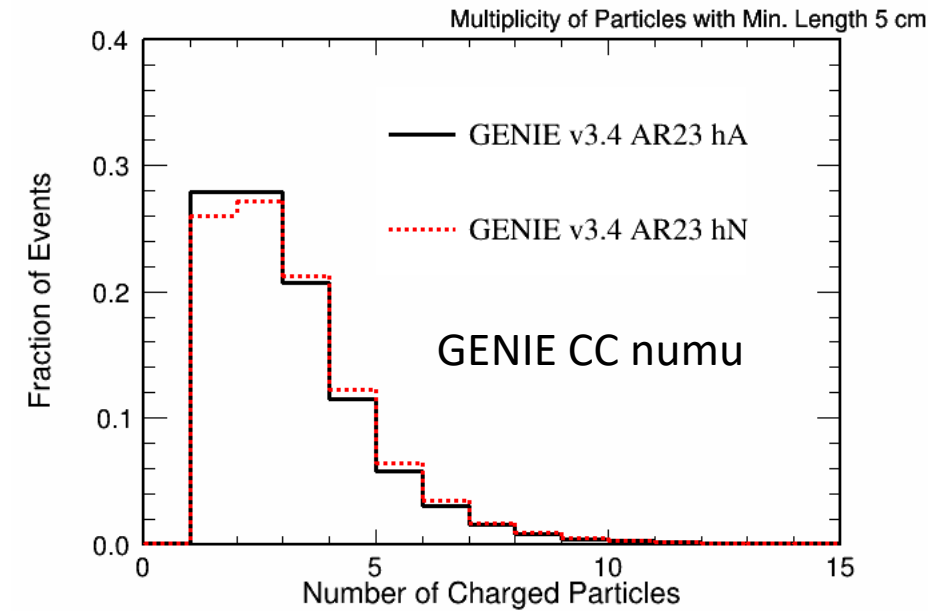
MLReco Files:

Cheated CC Events: Review

Signal Definition: All tracks, primarily consisting of charged muons, pions, protons, and kaons.

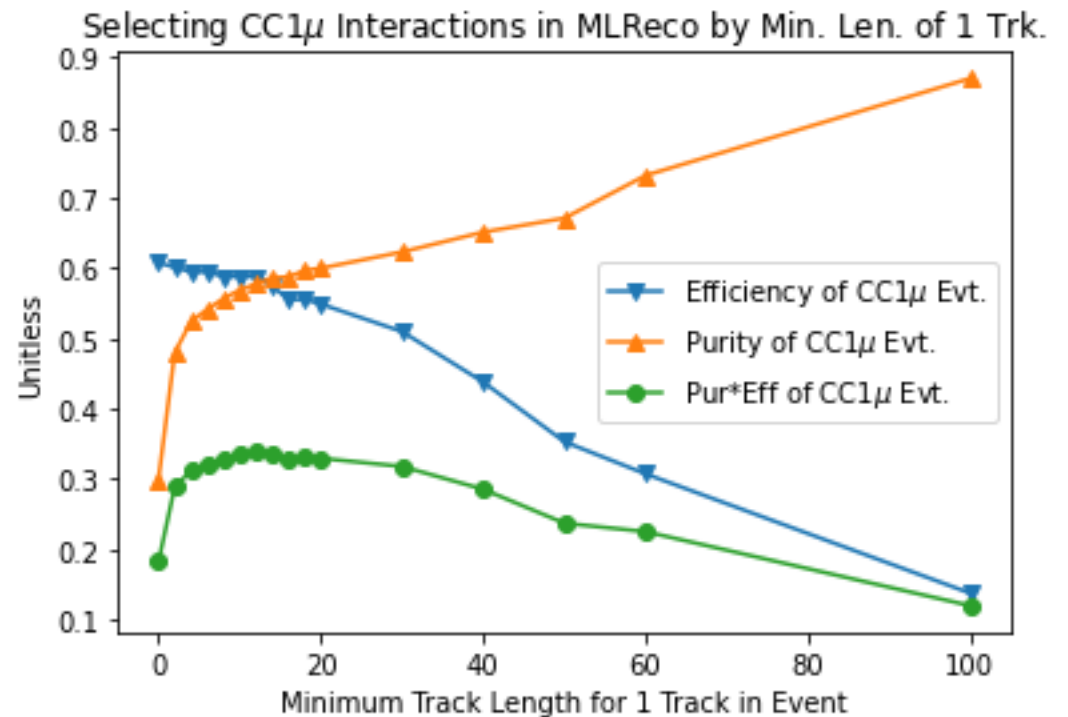
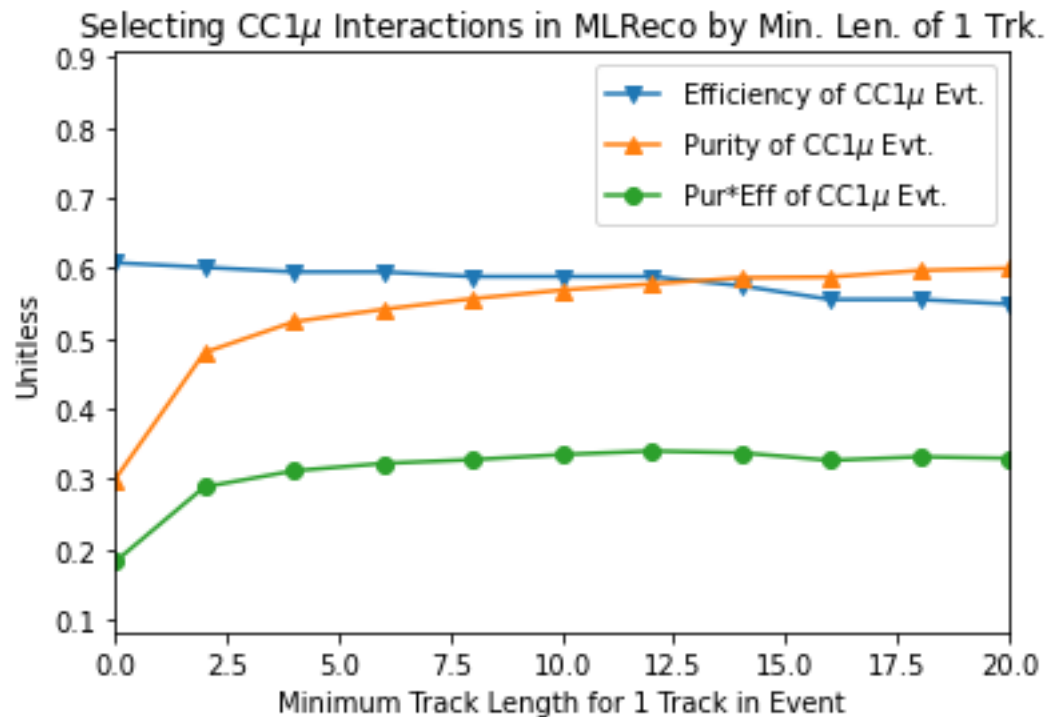
An event with a muon should be a CC event so only select events with a true primary muon.

Tracks must be 5 cm long



Recreating Prelim. ND-LAr Selection

- [Jeremy](#) has studied a preliminary selection by selecting events with at least one track above a threshold (>100 cm).
 - What is the ideal value for 2x2 (length ~ 130 cm)?
 - Ran over 20 MLReco files ($\sim 2,000$ events)
- Optimized the purity and efficiency based on the minimum track cut for the interaction.



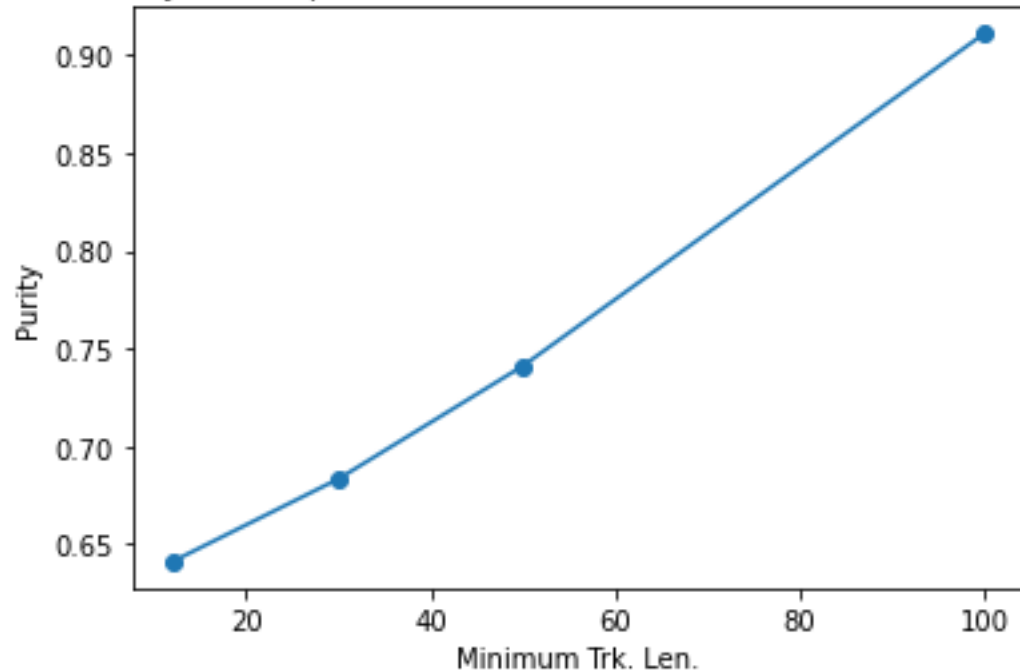
- There is a vertex selection to eliminate MINERvA/rock muons in the backup applied for this study.

Could this be improved (Richie)?

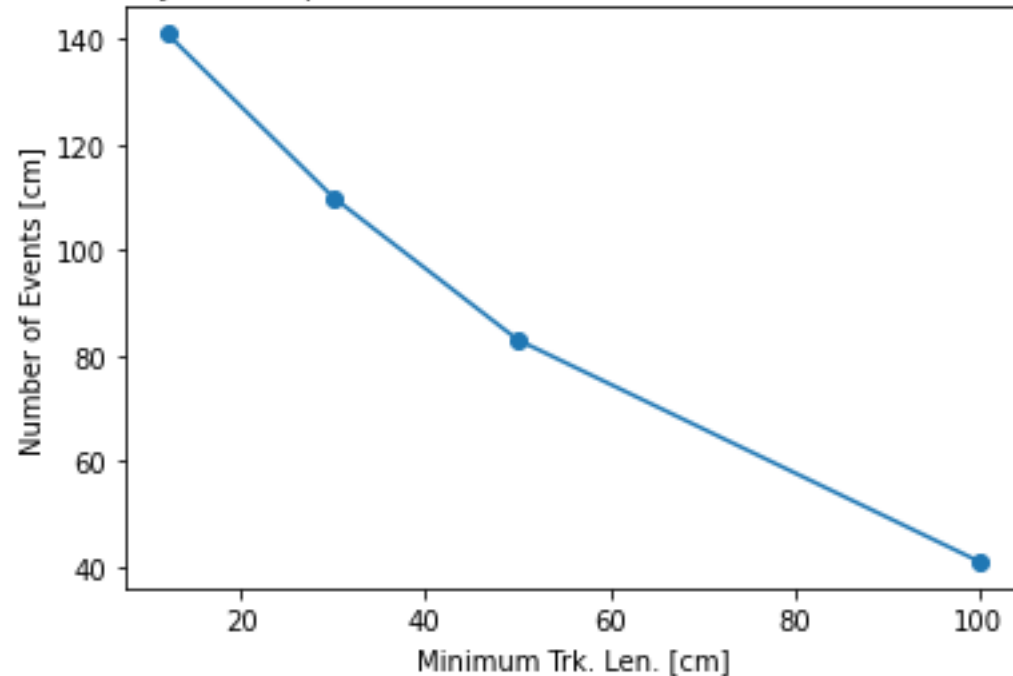
- Muons will be largely forward-going, so what if we select events with a muon that is colinear with the detector length and uncontained.
 - For example, in 717 interactions with primary muons, only 10 have primary stopping muons!
- What if we mandate at least one uncontained particle?

In $\sim 2k$ interactions with the h5 MLReco files:

Purity for CC1 μ for MLReco with Min. Trk. Len.+Uncontained



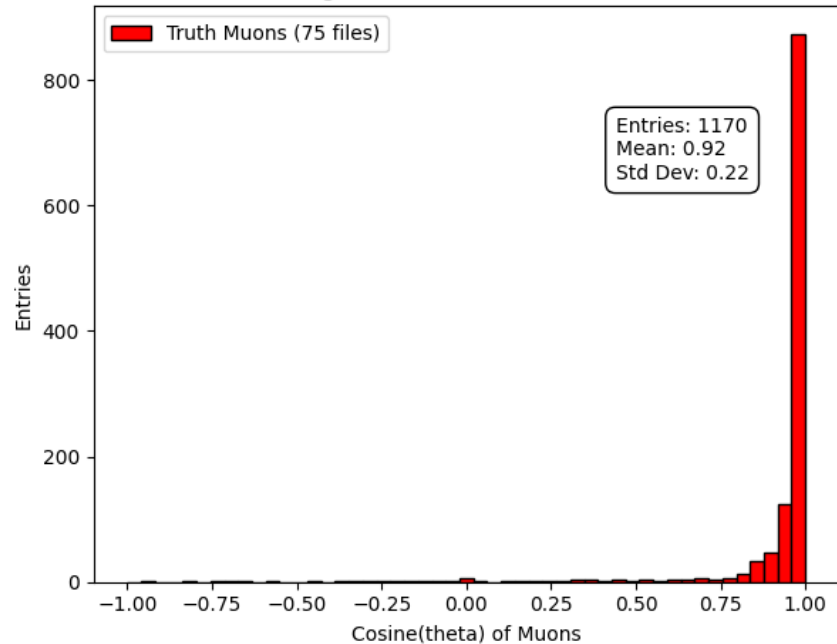
Purity for CC1 μ for MLReco with Min. Trk. Len.+Uncontained



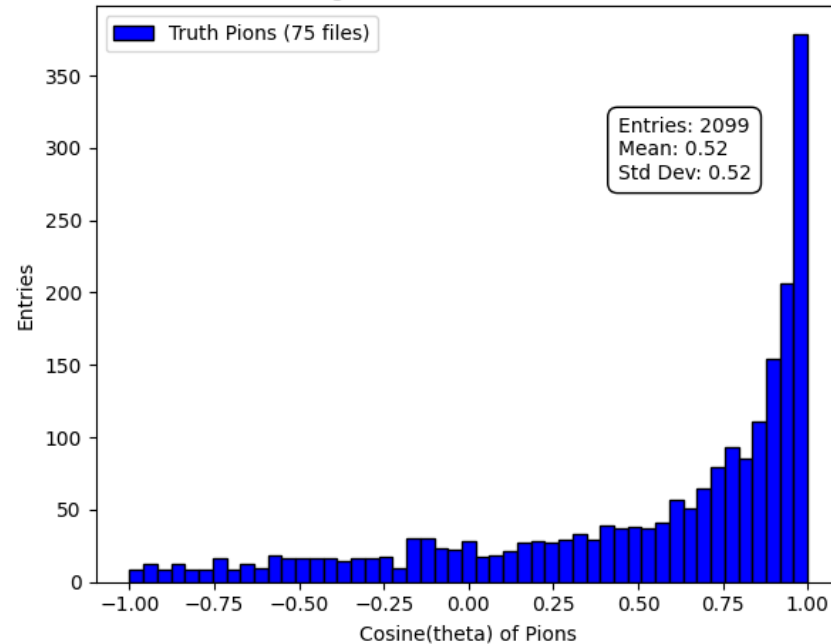
Could this be improved (Bilal)?

- Muons will be largely forward-going, so what if we select events with a muon that is colinear with the detector length and uncontained.
- Can select for muons using the phase space restrictions inherent to the boosted direction of the muons.

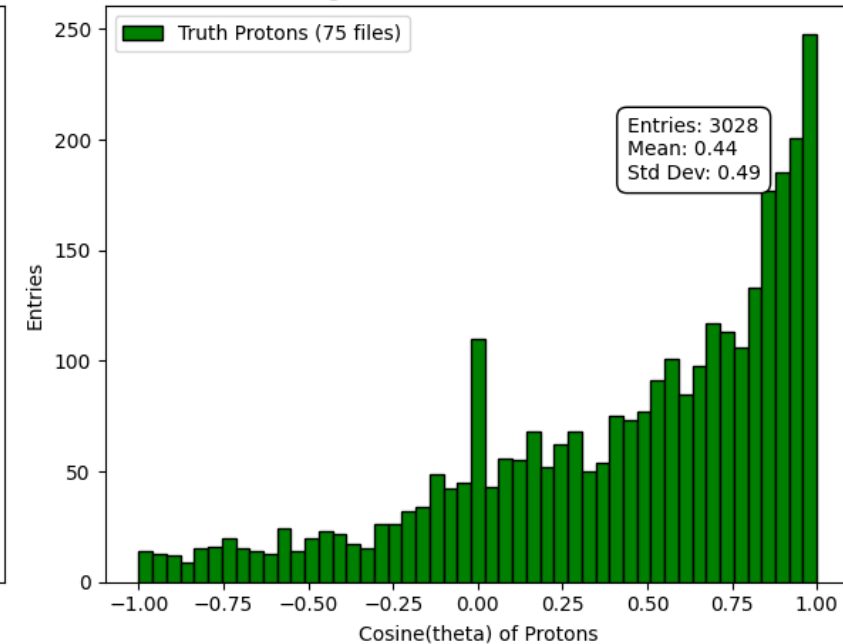
Angular Distribution of Muons



Angular Distribution of Pions



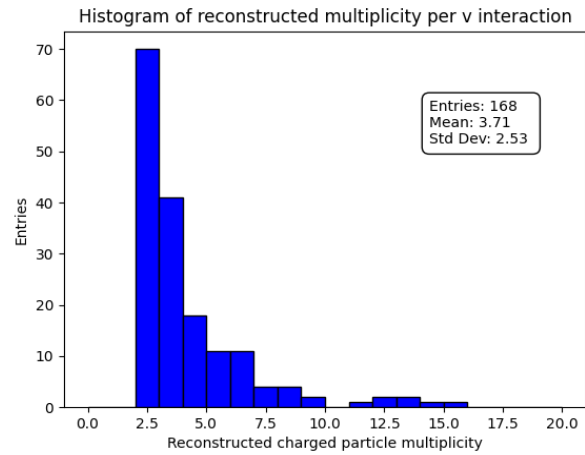
Angular Distribution of Protons



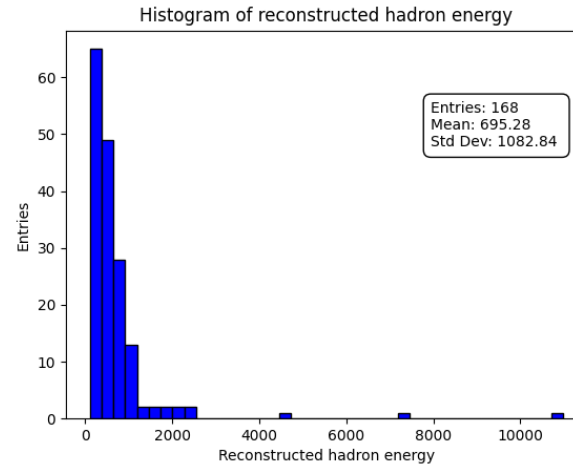
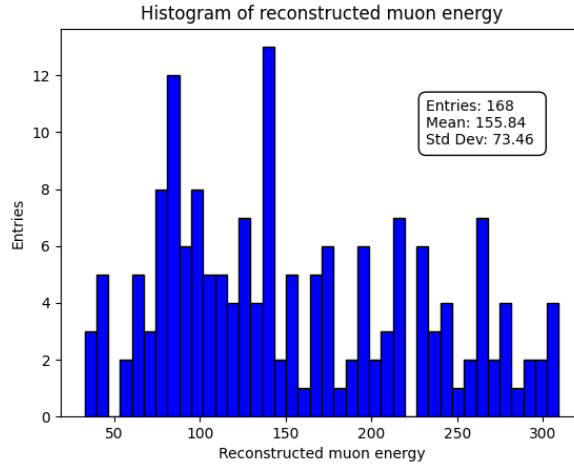
Some of the ongoing multiplicity studies

- ML-reco h5 files, analysis based on python+larcv2 libraries.
- Preliminary cuts: particle track $L > 5$ cm, particle start $x, y, z > 5$ cm away from **outer** boundaries.
 - Require a single muon with other track(s); Muon $\cos \theta > 0$ in this slide

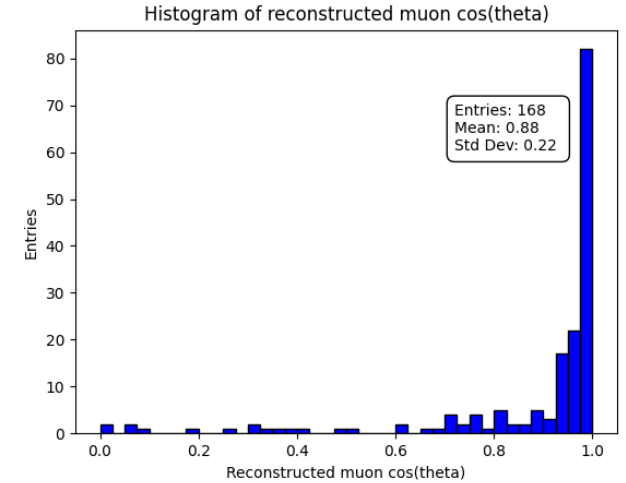
➤ Observed particle multiplicity



➤ Energy deposited in LArTPC



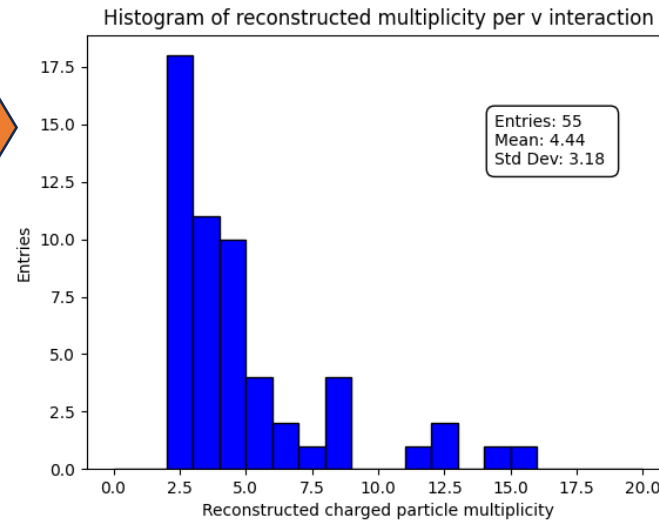
➤ Muon angle ($\cos \theta$)



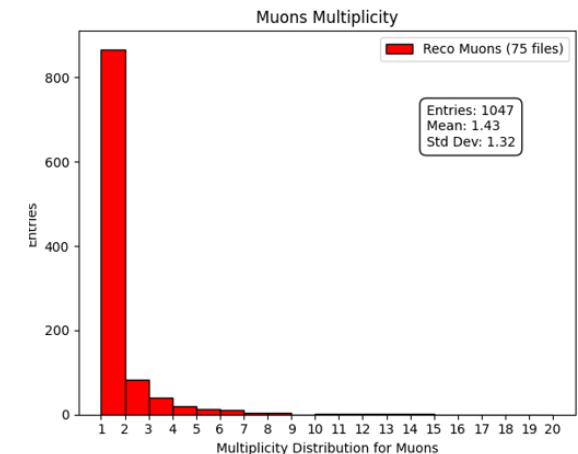
- Multiplicity with Preliminary cuts: particle track $L > 5$ cm, particle start $x, y, z > 5$ cm away from **both inner and outer** boundaries.
 - Require a single muon with other track(s), Muon $-1 < \cos \theta < 1$



- Shape of the multiplicity distribution changes with improved selection; we will continue to investigate the cuts.



➤ Muon count



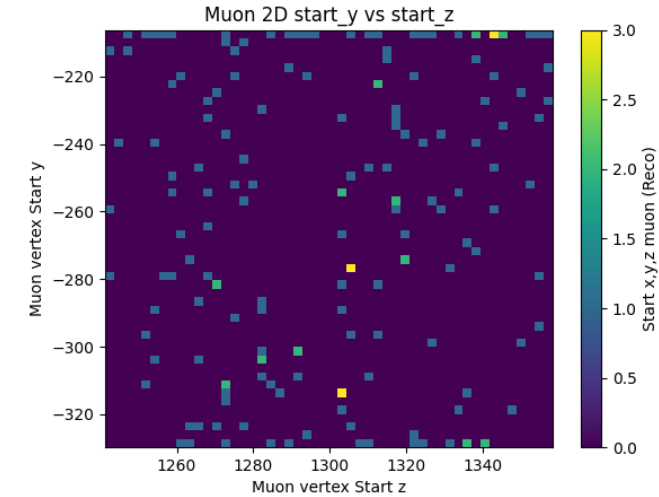
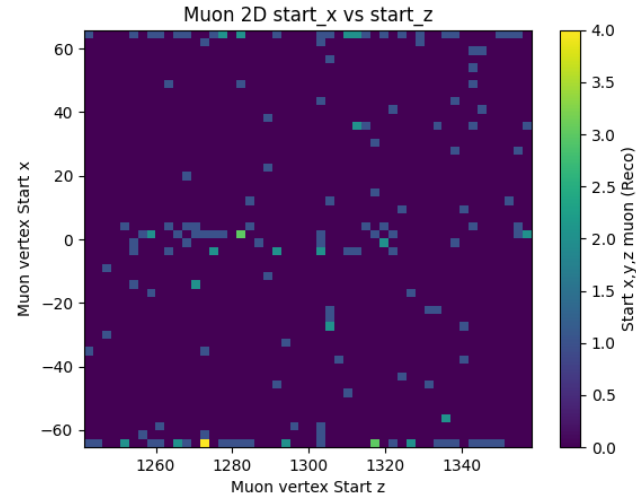
Some of the ongoing multiplicity studies

Zelimir

- ML-reco h5 files, analysis based on python+larcv2 libraries.
- Muon Starting vertex are shown here.

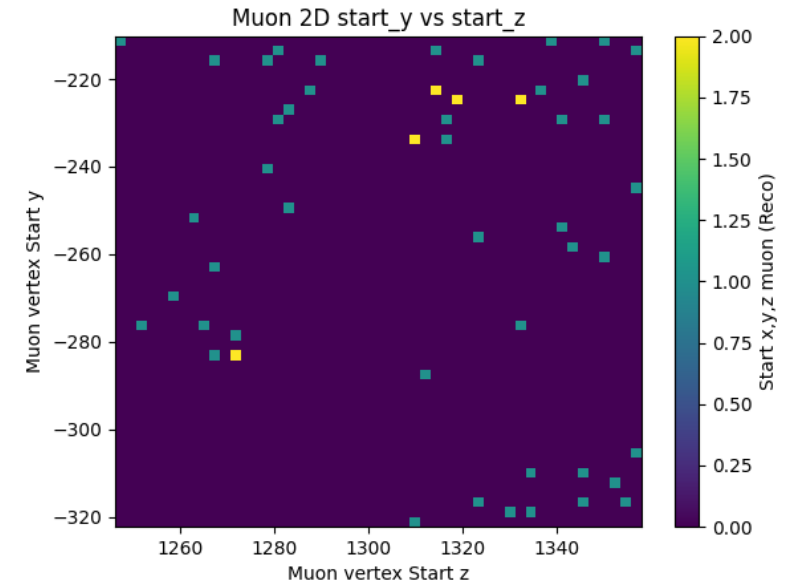
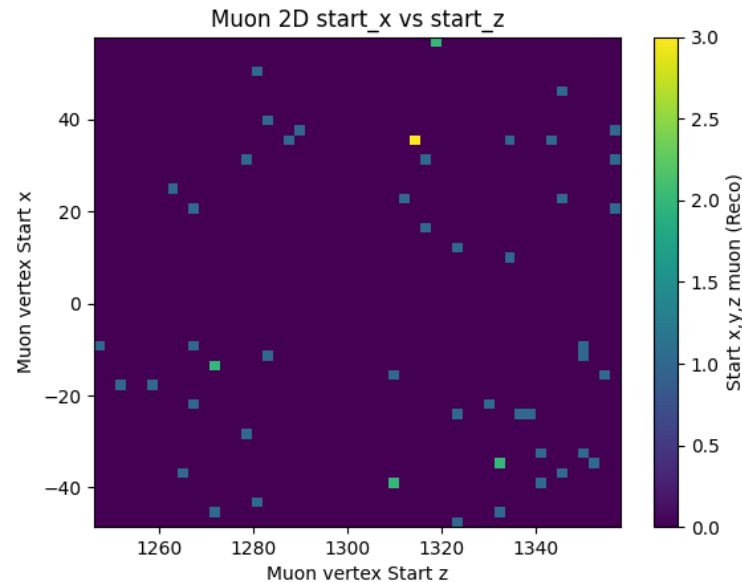
- Preliminary cuts:

- particle track $L > 5$ cm,
- particle start $x, y, z > 5$ cm away from **outer** boundaries.
- Require a single muon with other track(s); Muon $\cos \theta > 0$ in this slide



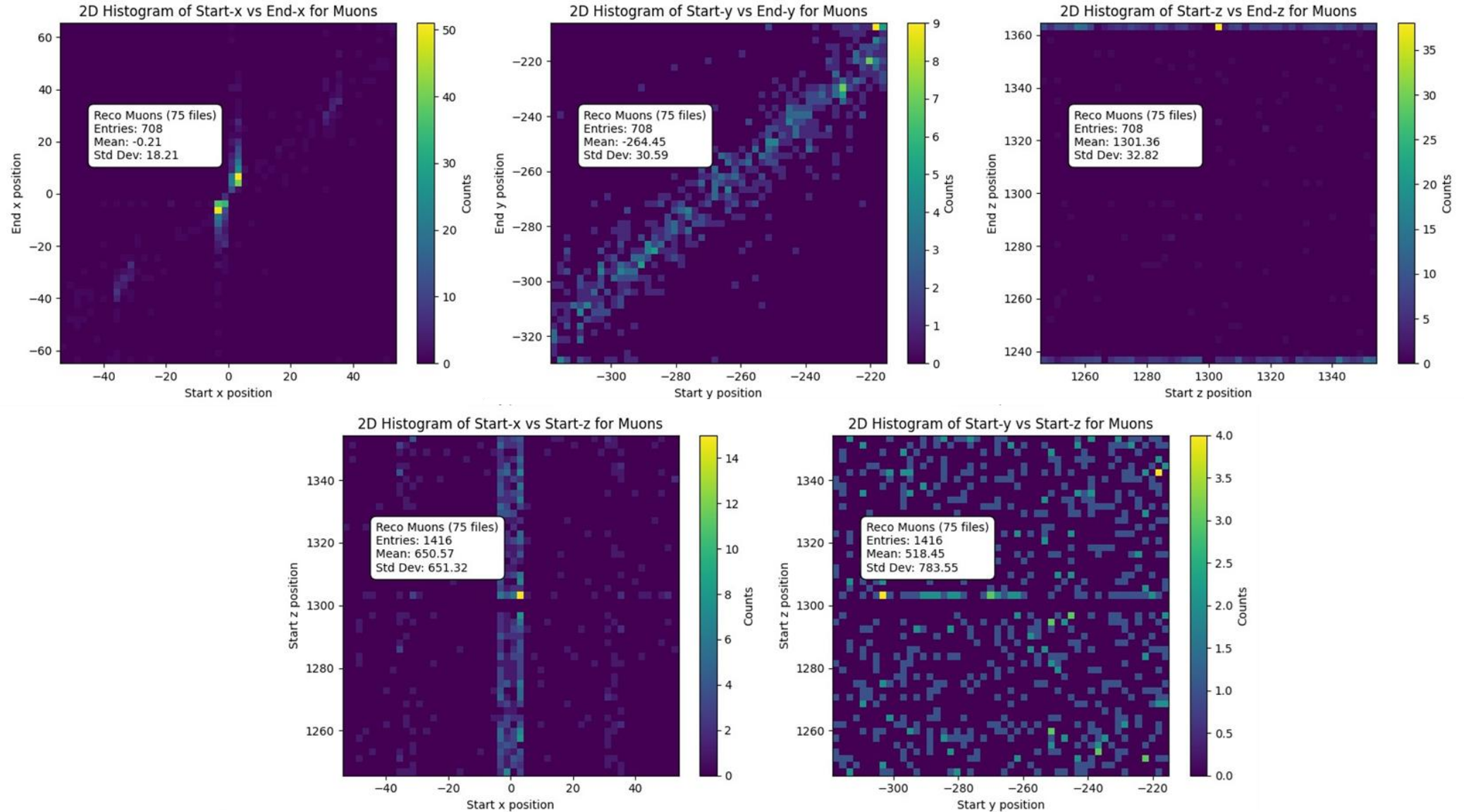
- Preliminary cuts:

- particle track $L > 5$ cm,
- particle start $x, y, z > 5$ cm away from **both inner and outer** boundaries.
- Require a single muon with other track(s), Muon $-1 < \cos \theta < 1$ in this slide



Some of the ongoing multiplicity studies (contd.)

- ML-reco h5 files, analysis based on python+larcv2 libraries.
- Preliminary cuts: not contained, particle track $L > 5$ cm, particle start $x, y, z > 10$ cm away from **outer** boundaries.

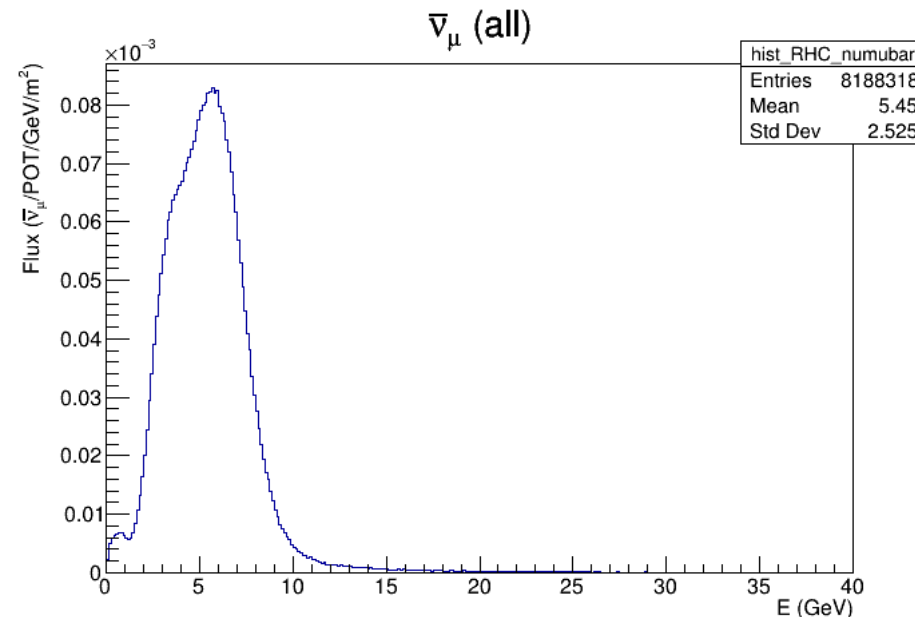


Beam Simulation Summary Histograms

- NuWro, NEUT, GENIE, and GiBUU prefer ROOT histograms to read the flux and simulate events. Huge shoutout to the DUNE and MicroBooNE beamsim group (mostly Deepika) for sending code for dk2nu->ROOT histos.

Full instructions on what to do and the histograms themselves are [here](#), also on 2x2 analysis wiki.

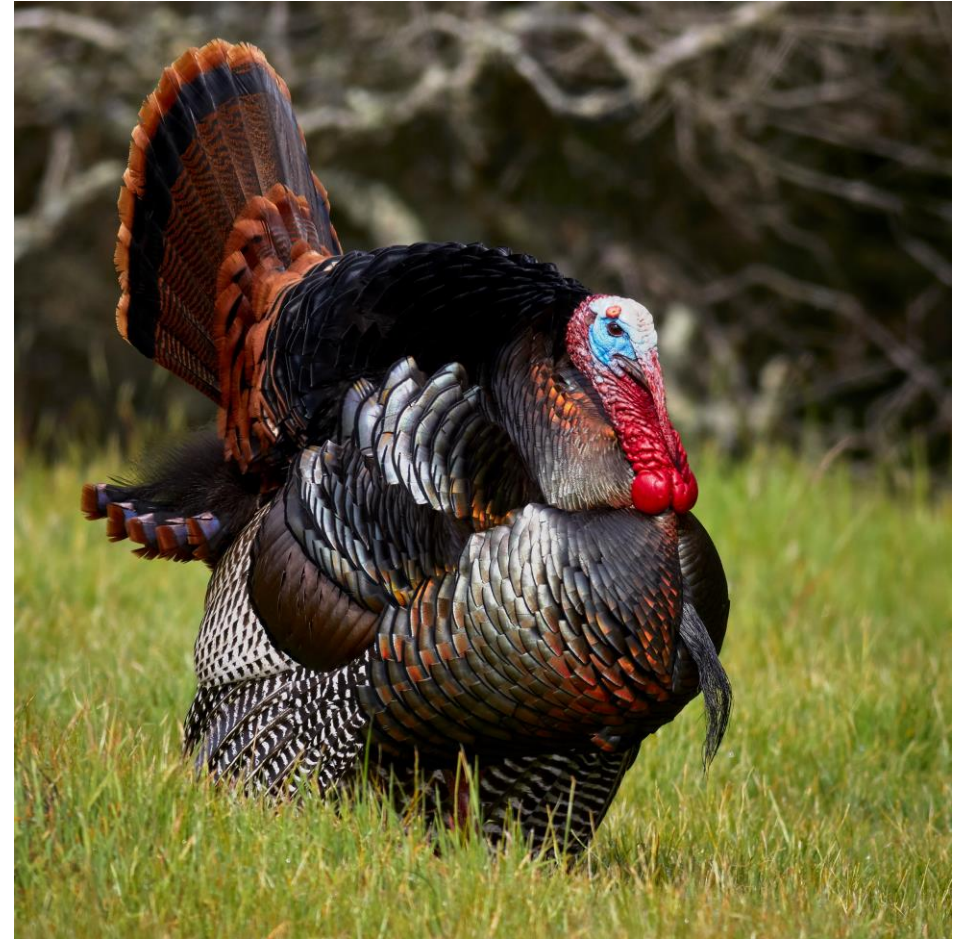
Next steps: Generate events->Convert to HEPMC or Event Libraries->Refeed into GENIE flux driver->det. sim (?)
Opportunity for someone who wants to learn more about event generators!



Note: GENIE is/has currently patched its Geant4 and INCL++ FSI giving us a little bit more flexibility.

Conclusion

- We would very much encourage the inclusion of the Geant4 products in the CAFs or a capability to do G4 matching with the events.
 - We believe we are missing information to make a definite answer on where we are missing things.
 - Previous studies in LArSoft G4-only with Pandora were able to recreate the GENIE plot.
- Vertexing and muon event selection explored.
- General histograms for event generation with the dk2nu files created, either investigate HEPMC or event libraries.



Have a happy Thanksgiving to people in the US!

Backup Slides

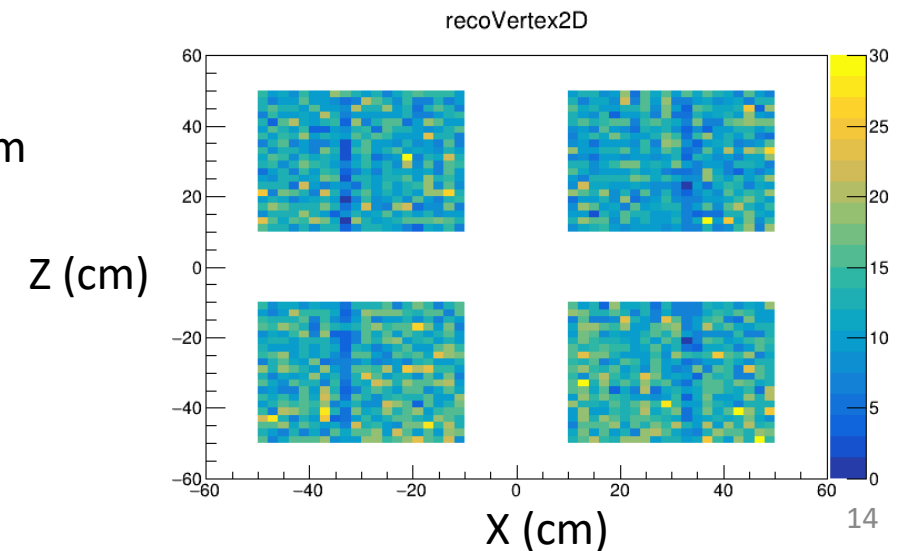
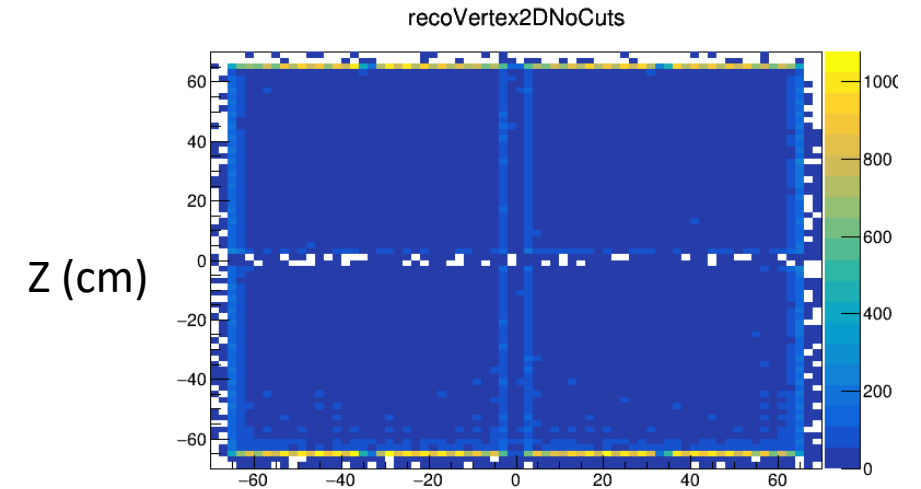
Using CAFs without any Backtracking: Review

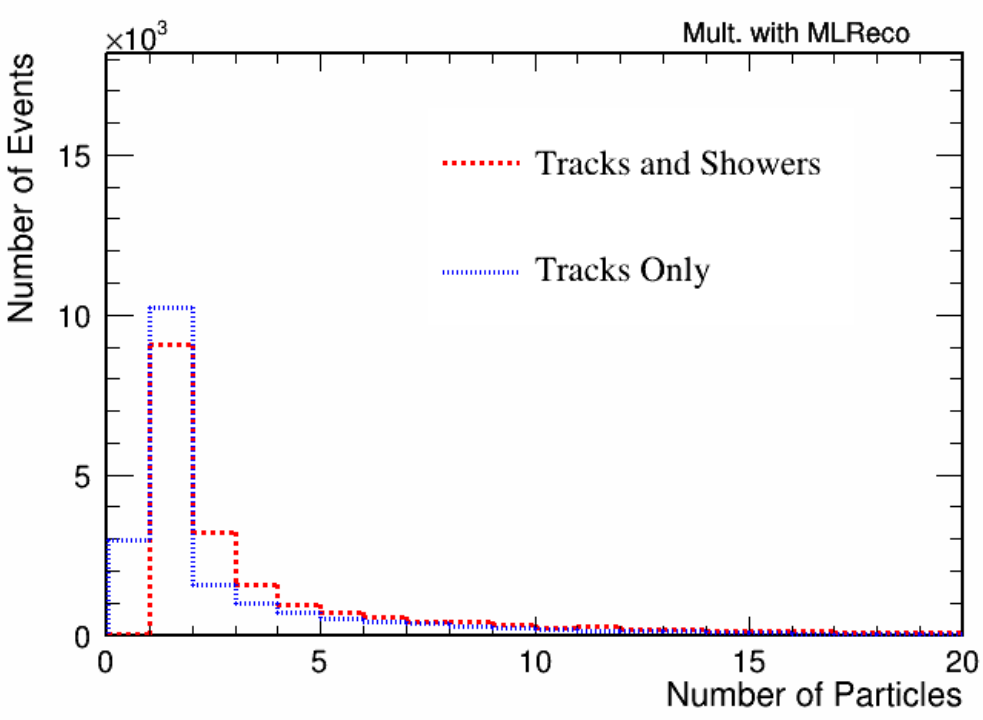
Signal Definition: All tracks, primarily consisting of charged muons, pions, protons, and kaons.

Event Selection:

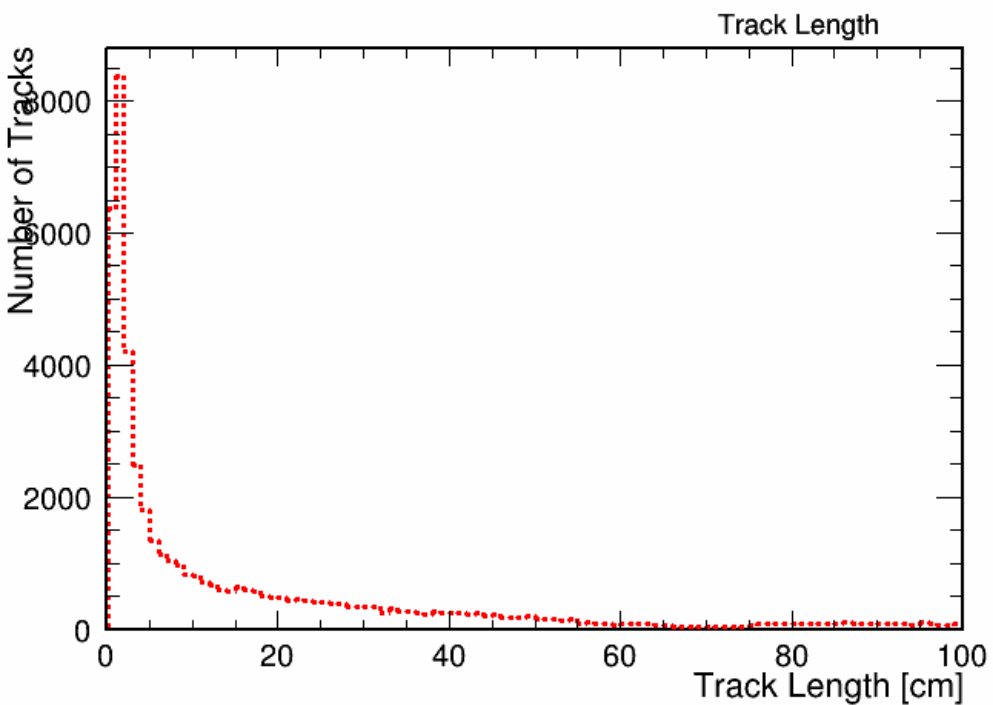
1. Vertex must be at:
 - $10 < |x| < 50$ (Offset 0)
 - $|y| < 50$ (Offset -310)
 - $10 < |z| < 50$ (Offset 1300)
 - Gap between the first pair and the second pair large enough to break tracks.
 - Most tracks are rock/MINERvA muons, so this cut gets rid of most of the data.
2. Vertex must have more than one shower and 0 tracks.
 - Avoid blips and detached showers being picked up as neutrino interactions.

Multiplicity of all particles reconstructed from selected vertices.

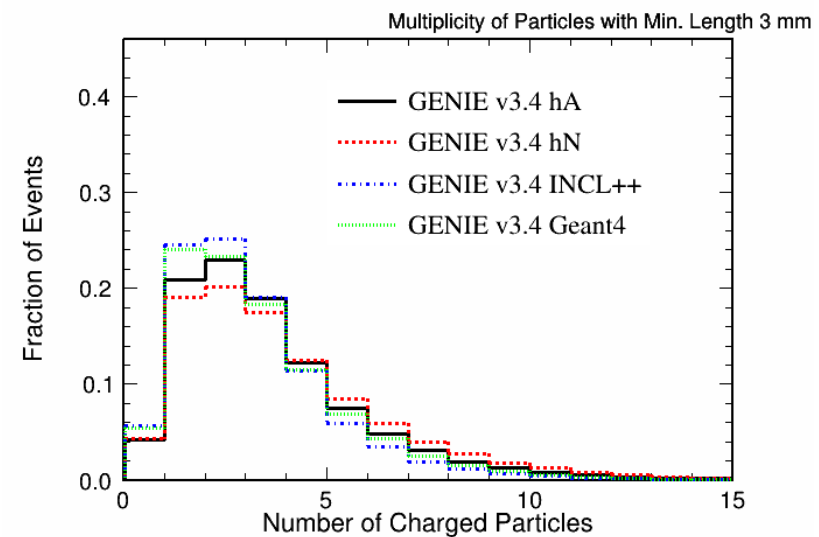




Multiplicity of all particles reconstructed from selected vertices.



Track length of all reconstructed tracks binned in 1 cm bins.

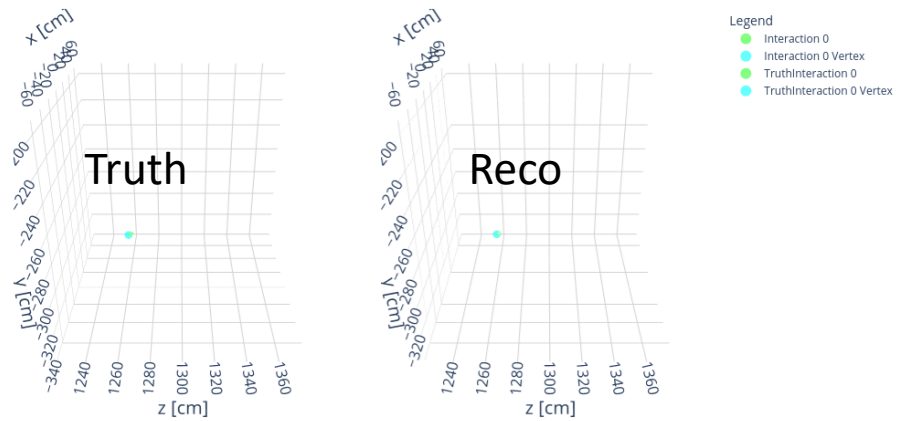
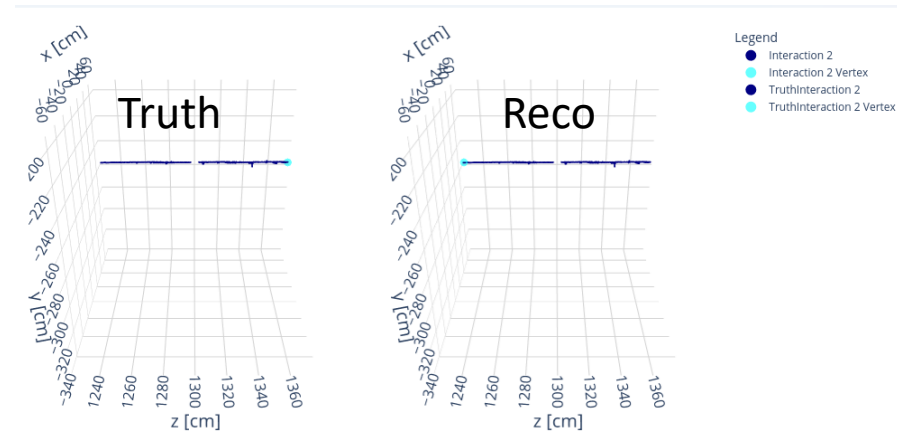
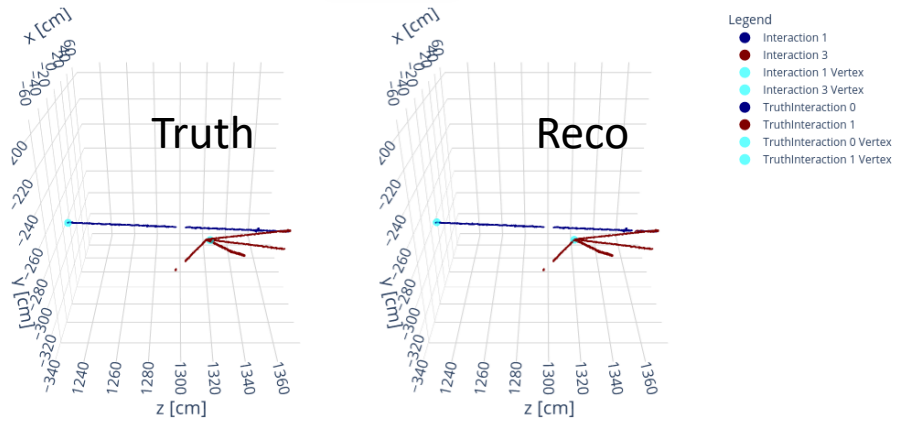


Truth-level distribution using GENIE primaries from self-made file

This is the same result if we combined all the raw GHEP files from MiniRun4.

Event Displays and Move to MLReco Files

- Thank you to Francois for showing us all how to use the MLReco files and their event displays.

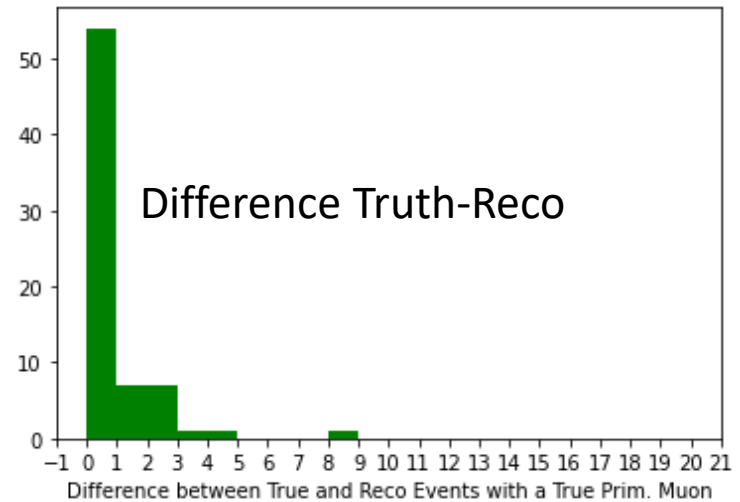
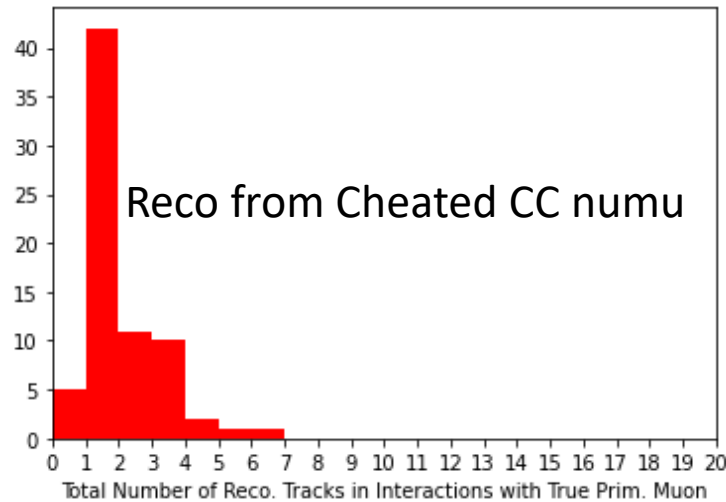
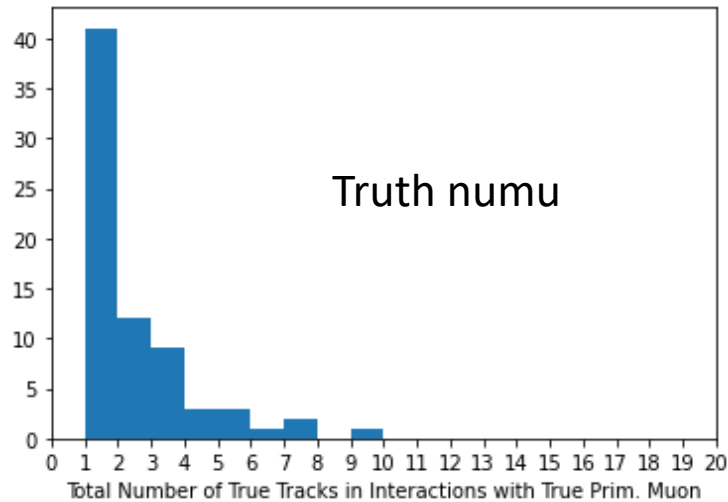
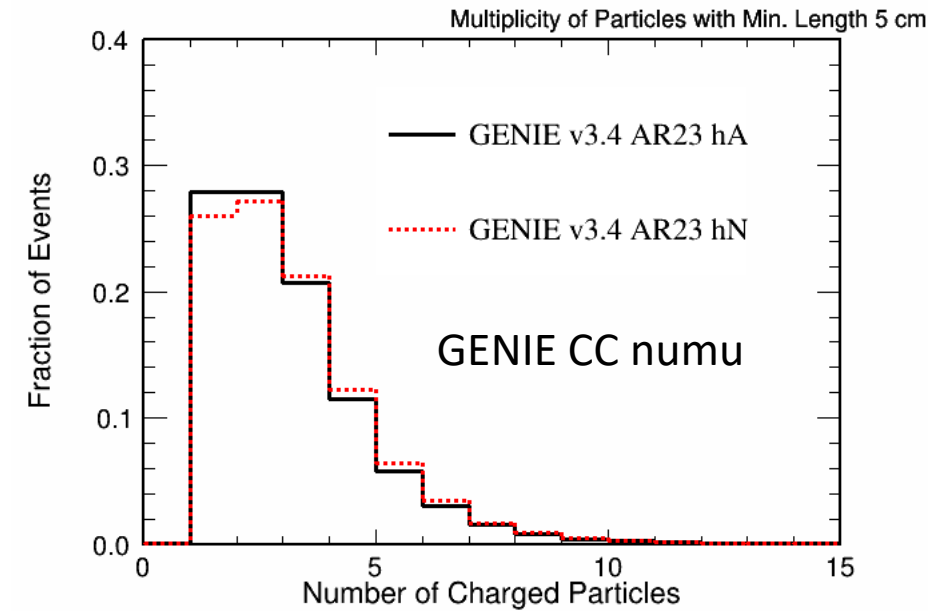


Cheated CC Events

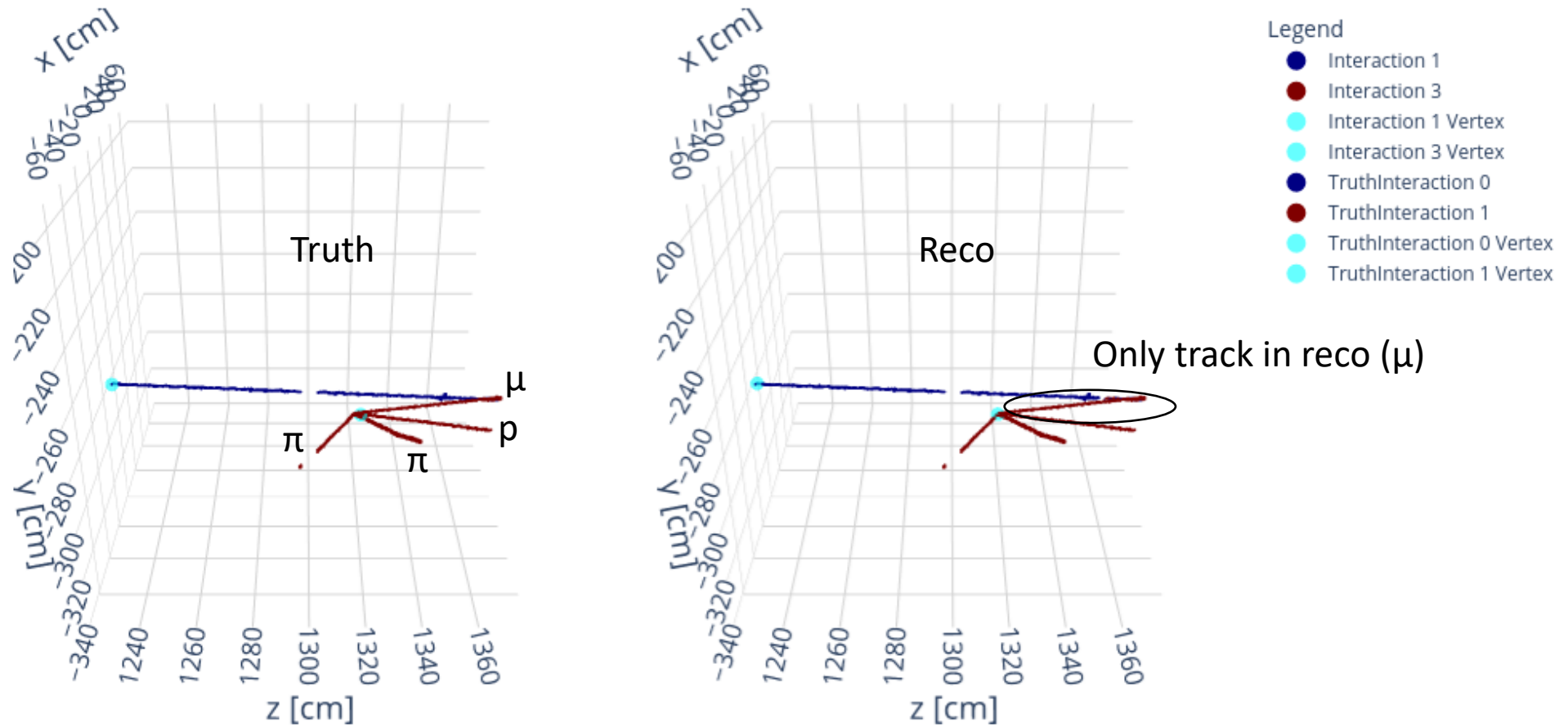
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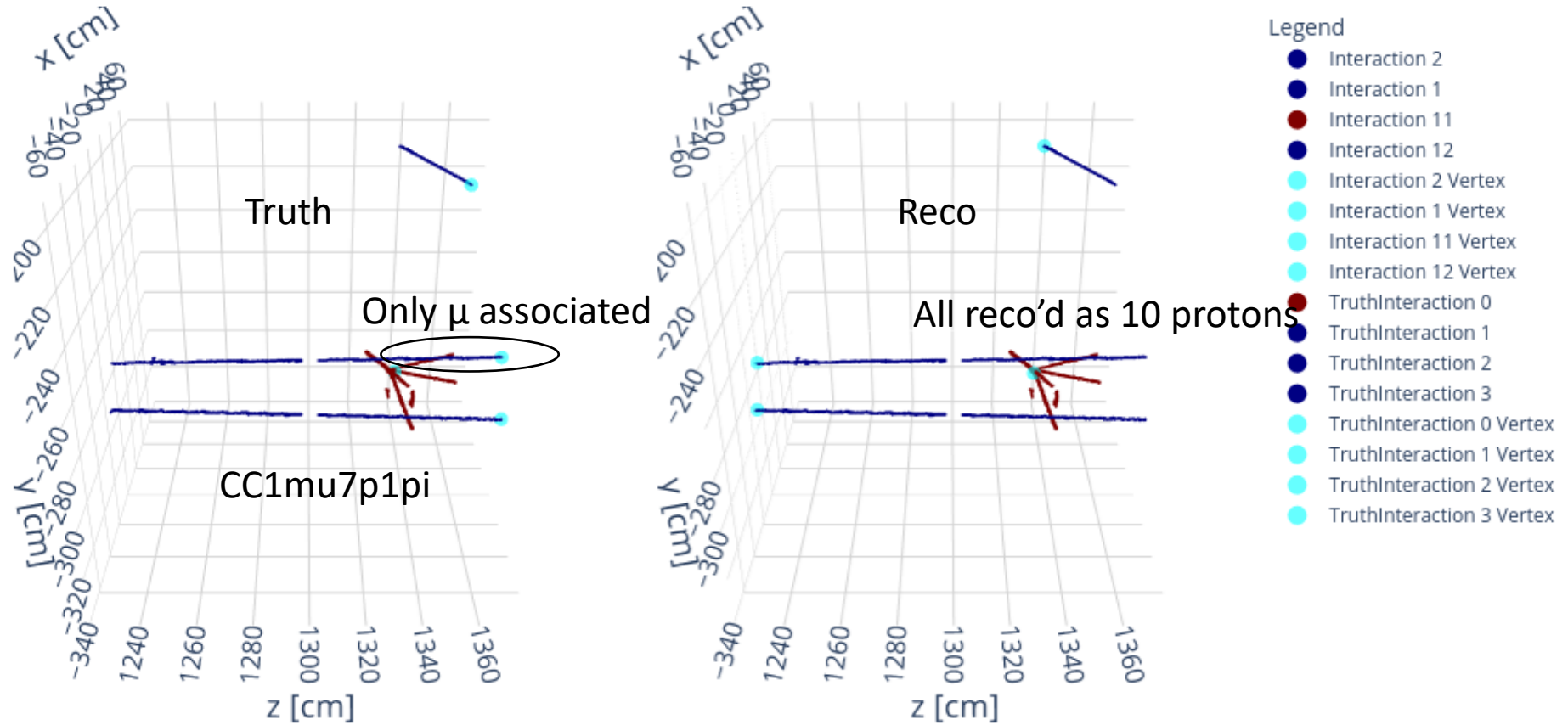


Cheated CC Events



Event 107: /dune/data/users/drielsma/minirun4/output_ana/output_27023276_11-larcv_mlreco_ana.h5

Cheated CC Events



Event 94: /dune/data/users/drielsma/minirun4/output_ana/output_27023276_20-larcv_mlreco_ana.h5