Pandora for non-accelerator neutrinos

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FD Sim/Reco Meeting – 01/03/2021

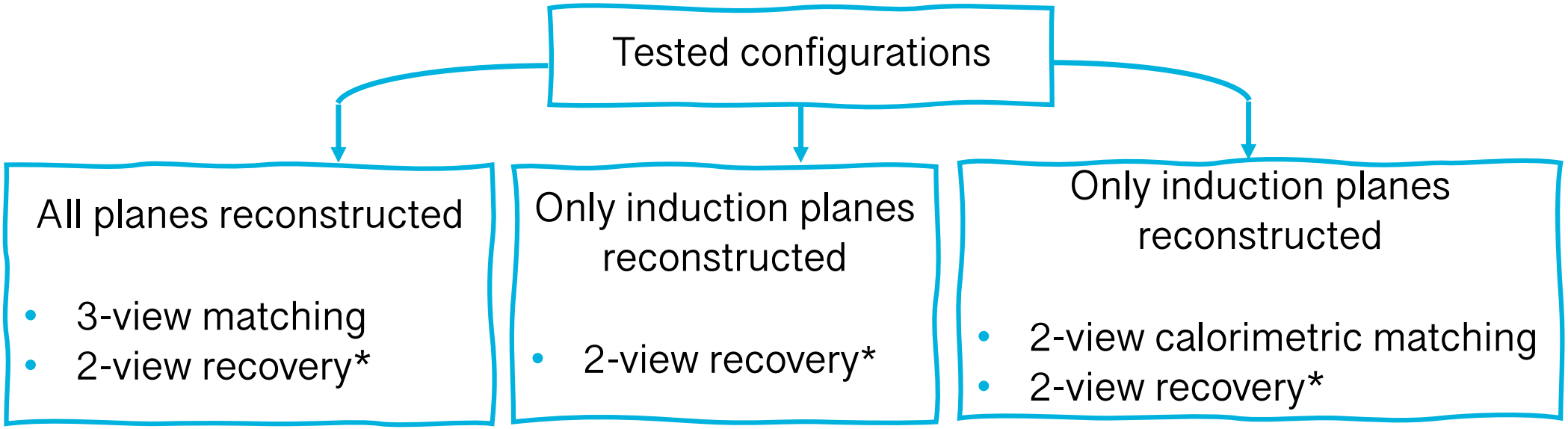
Motivation and Outline

- Work started in the context of the VD design testing
  - Aim: study reconstruction performance for a 2-view vs. a 3-view detector
  - Initially looked at di-muon and 1mu-1e samples with accelerator-like energy spectra
- Pandora reconstruction and non-accelerator neutrinos
- First look at low- and high-energy samples
- Summary and plan of work

2-view vs 3-view comparison study

Using the DUNE-FD 1x2x6 ”45 deg” geometry

- Two induction views making a 90° angle (each making 45° with the vertical)
- One collection view (vertical)



*based on overlap in drift coordinate

High-stats accelerator-motivated samples

- 100K simulated di-muon events
- Fixed starting point near cathode of one of the TPCs
- Flat angular spectrum in θ_{XZ} and θ_{YZ} : [-70°, 70°]
- Flat momentum distribution: [0.2 GeV, 2.5 GeV]

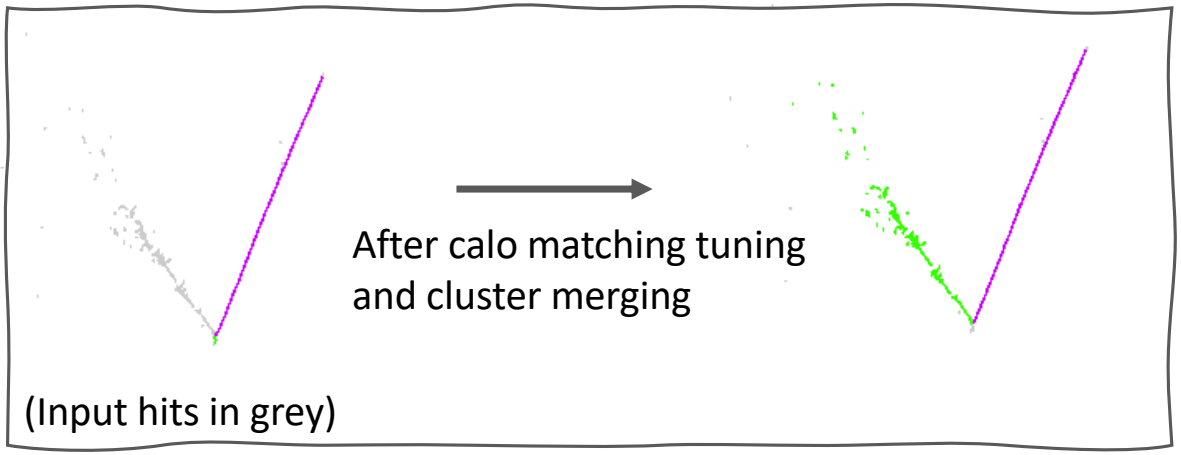
Two tracks

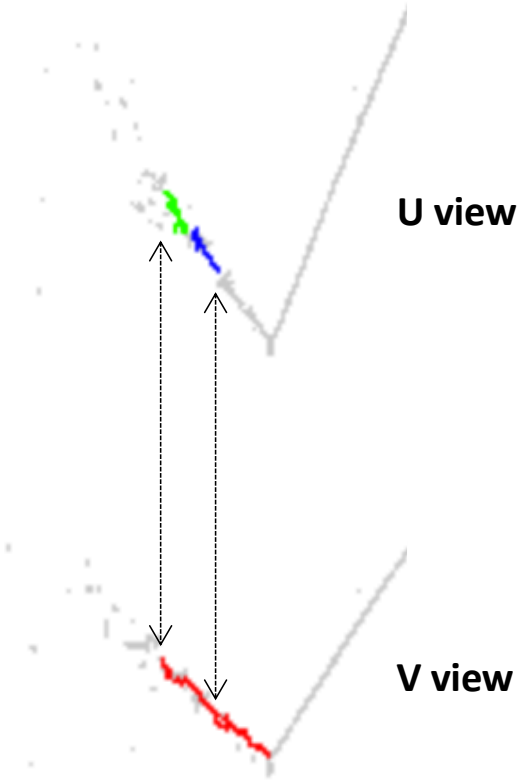
- 250K simulated 1mu-1e events
- Fixed starting point near cathode of one of the TPCs
- Flat angular spectrum in θ_{XZ} and θ_{YZ} : [-70°, 70°]
- Flat momentum distribution: [1 GeV, 3 GeV]

One track and one shower

Shower matching

- Two-view calorimetric matching targeted tracks so far
- We are tuning the matching algorithms for showers
- Splitting/merging tools were added and are being tested



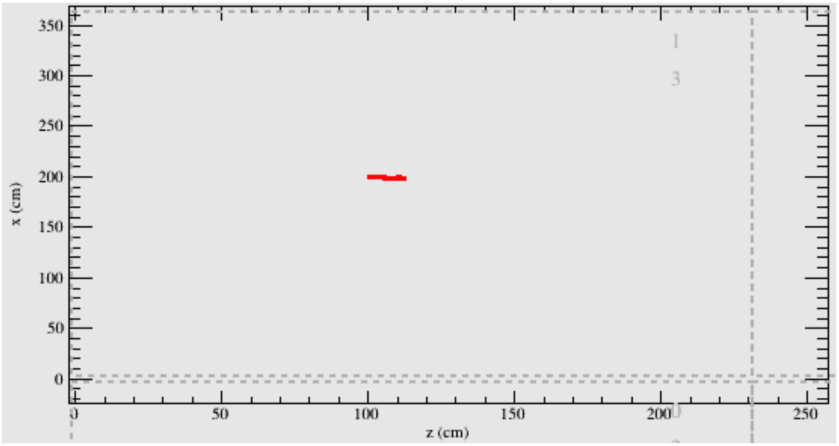


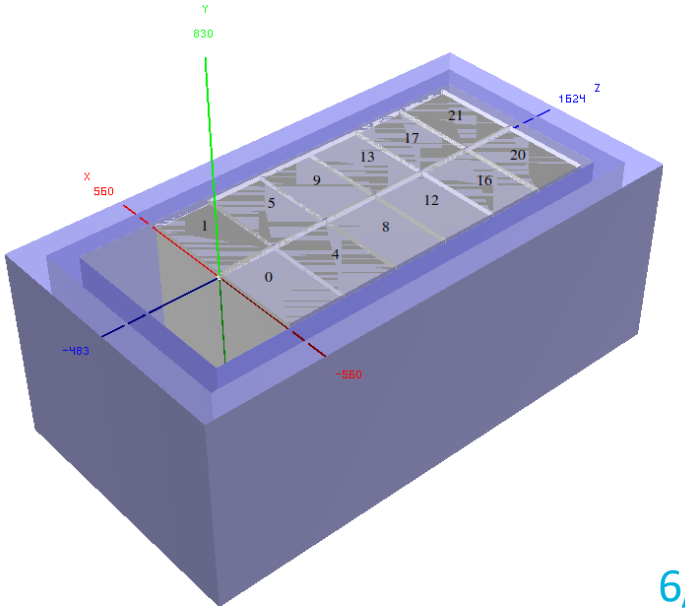
Pandora and non-accelerator neutrinos

- Reconstruction developed targeting accelerator neutrino topologies (GeV scale)
- In particular, the default vertex reconstruction "learns" that the best vertex candidates tend to be at lower z for beam neutrino interactions
- In future, can re-train BDT removing this feature
- On a short time-scale, for VD studies, we decided to cheat the vertex reconstruction using truth information
- We are studying different reconstruction configurations, ranging from additionally cheating some/all 2D reconstruction steps, to using full reconstruction for everything except vertex

Low-energy samples

- Produced 100k electrons in the 1x2x6 geometry
- Flat energy spectrum between 5 MeV and 60 MeV
- Isotropic angles
- Fixed position near the centre of a TPC
- Following discussions with low-energy group, for future samples we will produce electrons homogeneously in the TPC volume and use SN g4 physics list.





Low-energy samples (2)

- Reconstruction files are all located here (courtesy of Dom):

/pnfs/dune/scratch/users/dbrailsf/verticalDriftTesting/pg/A/v09_15_00/
v09_15_00_A_prodsingle_electron_snlike_flatenergy_isotropic_dune10kt_1x2x6_45deg

- There are two text files containing full XROOTD paths to all of the reco files provided for convenience

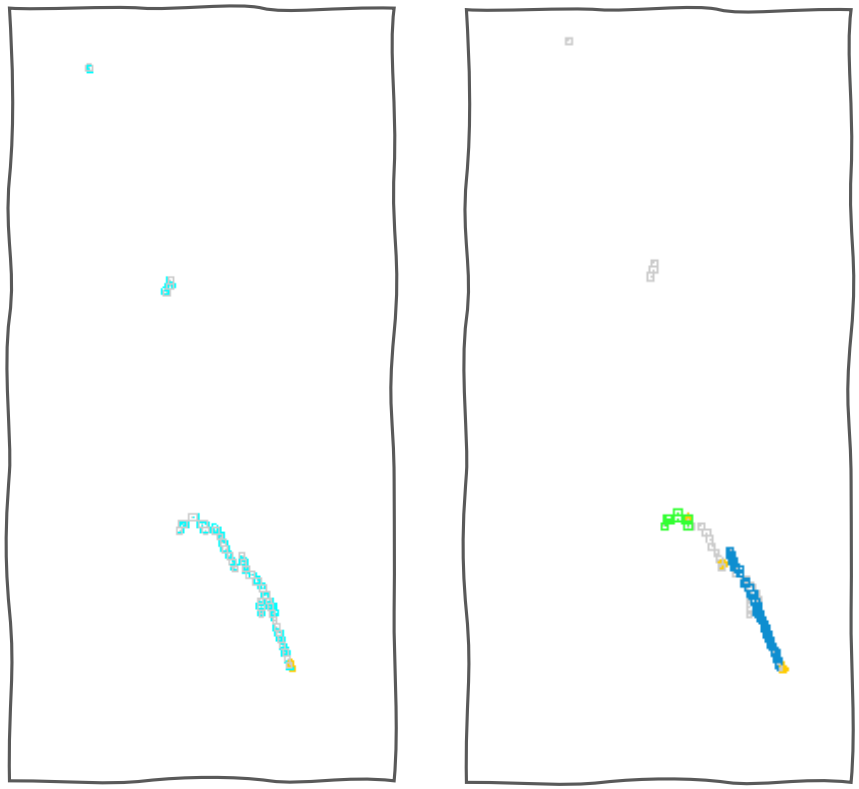
- The original detsim files are located here:

/pnfs/dune/persistent/users/dbrailsf/verticalDriftTesting/pg/A/v09_15_00/
v09_15_00_A_prodsingle_electron_snlike_flatenergy_isotropic_dune10kt_1x2x6_45deg/
detsim

Low-energy samples (2)

- Sample reconstructed cheating both 2D pattern recognition and vertex

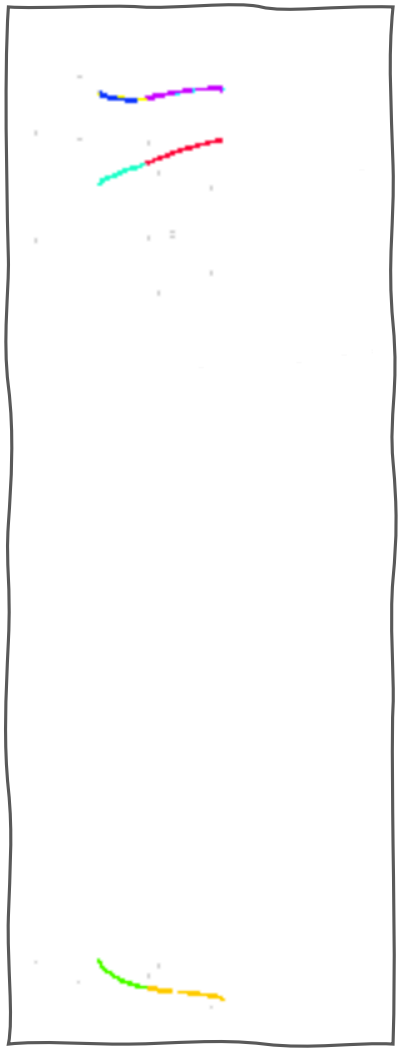
- Cheating 2D patrec leaves us with “perfect” 2D clusters, not allowing for differences in 2D→3D matching to be apparent between the 2-view and 3-view cases



3-view reconstruction: 3D hits in W view
Cheated 2D patrec (left), full 2D patrec (right)

High-energy studies

- Small atmospheric neutrino sample produced (thanks Josh Barrow for pointing us to the relevant fcl files)
- We took a very first look at a small number of events, reconstructed with 3 views
- Only vertex reconstruction cheated
- Plan to make larger samples to study 2-view/3-view performance differences



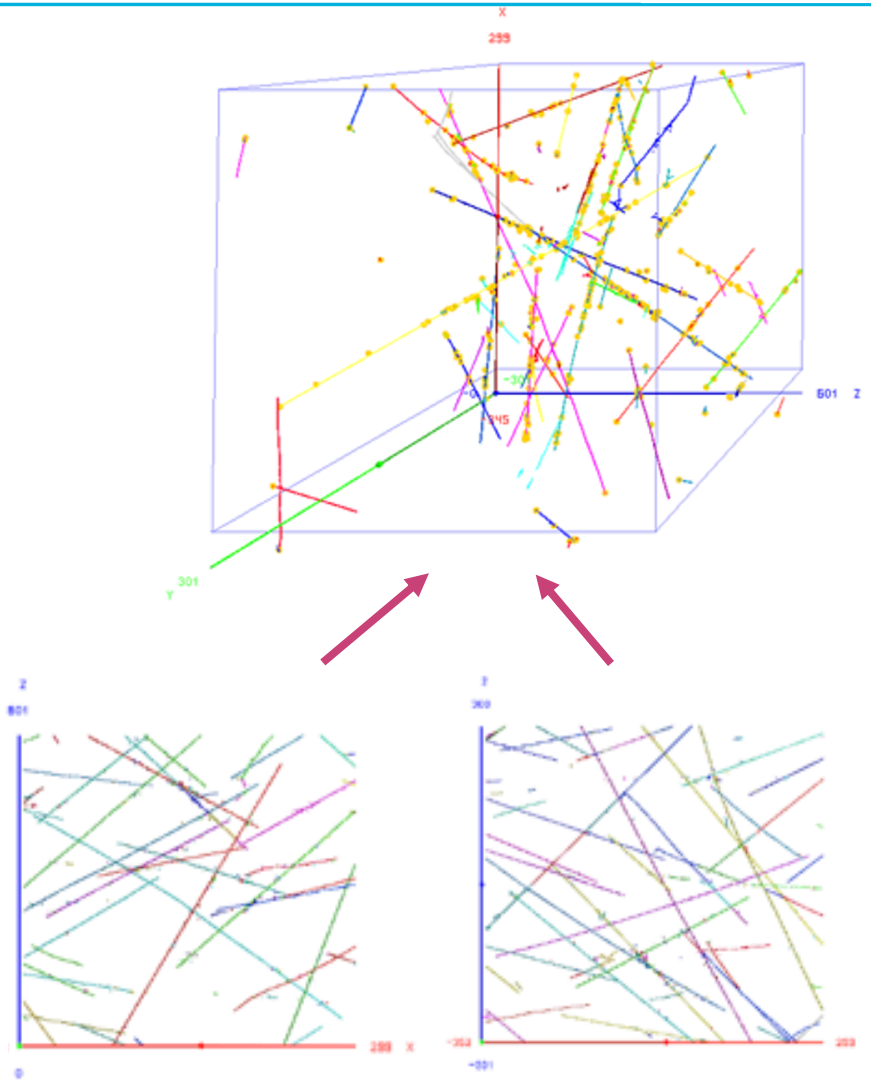
Summary and work plan

- Performance studies for 2-view/3-view reconstruction in 45° 1×2×6 FD geometry ongoing
- Efforts focused on improving 2-view shower matching
- We started to look at non-accelerator neutrino events
  - Suitable sample specifications have been identified, thanks to discussions with low-energy and high-energy groups
  - Production of high-stats samples and 2-view/3-view performance assessment occurring soon

Spares

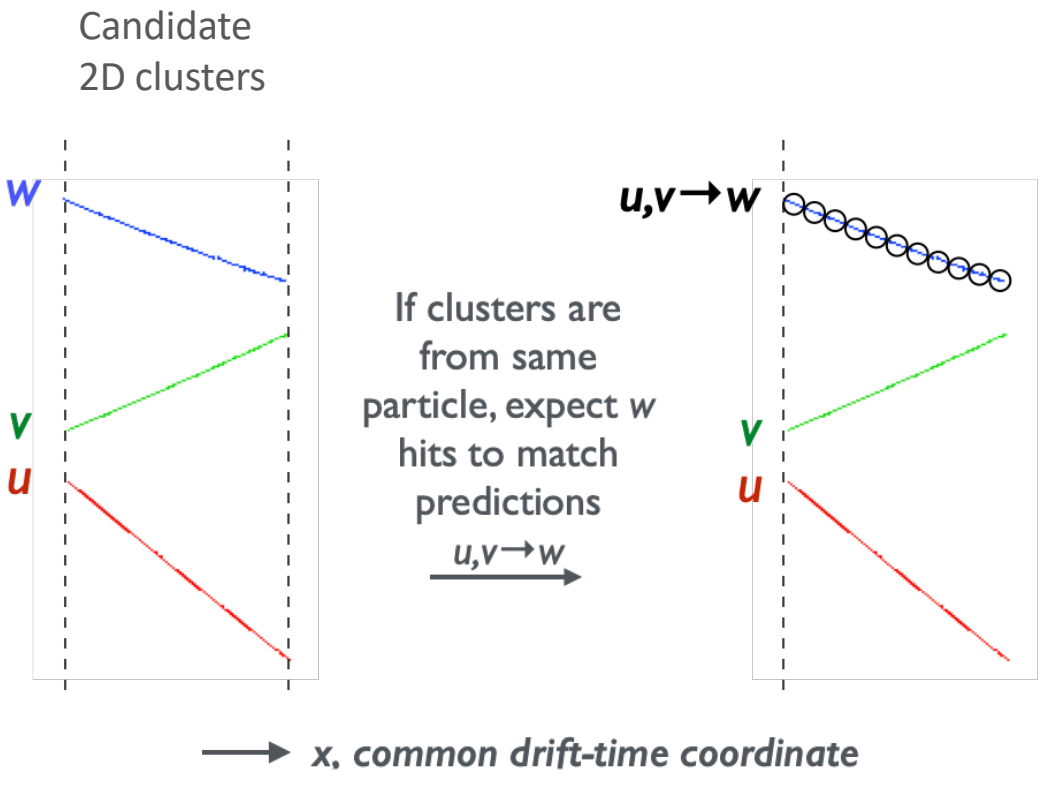
2D → 3D matching

- Key aspect is the 2D → 3D matching procedure: only two views required, but redundant information often necessary to identify correct match
- For 3-view detectors, we exploit 3rd view – if one of the views is unavailable, **recovery algorithms** based on overlap in drift coordinate
- For 2-view detectors, we exploit calorimetric information



2D → 3D matching (3 views)

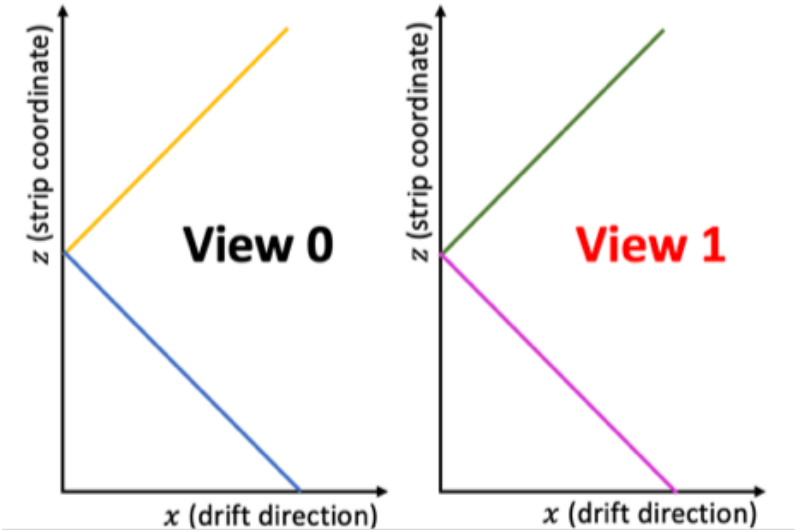
- Three separate 2D clusters for each particle
- Compare 2D clusters from three planes to find those representing same particle
- Exploit common drift-time coordinate and wire plane geometry
- In overlap region, compare predictions with cluster positions $\{u, v \rightarrow w; v, w \rightarrow u; w, u \rightarrow v\}$
- Calculate pseudo-χ^2 and store all results in 3D array, used by matching tools



2D → 3D matching (2 views)

- **Two views only :** no redundancy to be exploited, can only match end points→ the reconstruction can struggle to make correct matches

- Example: di-muon particle gun Monte Carlo event in ProtoDUNE-DP

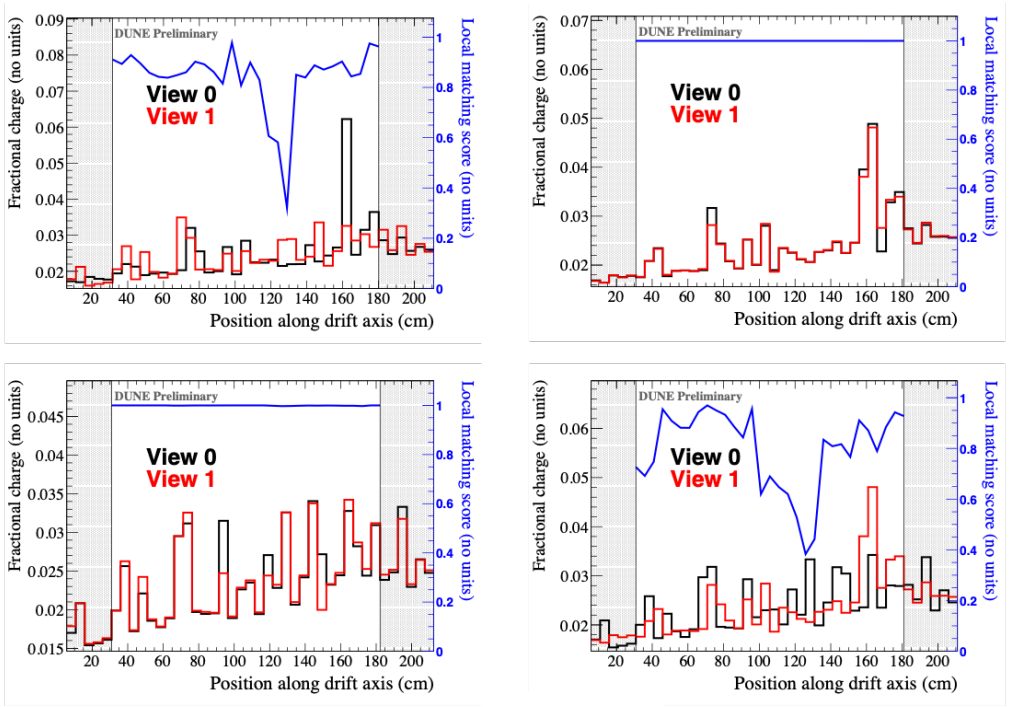


Calorimetric matching procedure

- Identify all cluster combinations
- For each combination, identify overlap region in drift coordinate

2D → 3D matching (2 views)

- For each possible pair, build fractional charge profiles
- Slide an 11-bin wide window across the profiles, and for each calculate **local matching score**: L = 1 - p-value* associated to centre of profile region under window (blue curve)
- If correct match, L consistently close to 1
  If wrong match, L uniform between 0 and 1
- **Locally matched fraction** = fraction of L values above threshold (0.99)



Di-muon particle gun Monte Carlo particle event in ProtoDUNE-DP

Store all results in 2D array with locally matched fraction, n. locally matched points, etc.

*(p-value for measuring a correlation coefficient (r), assuming true r=0)