

SBND SPINE Space Points

SBND Wirecell Meeting

Feb 20, 2025

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SPINE



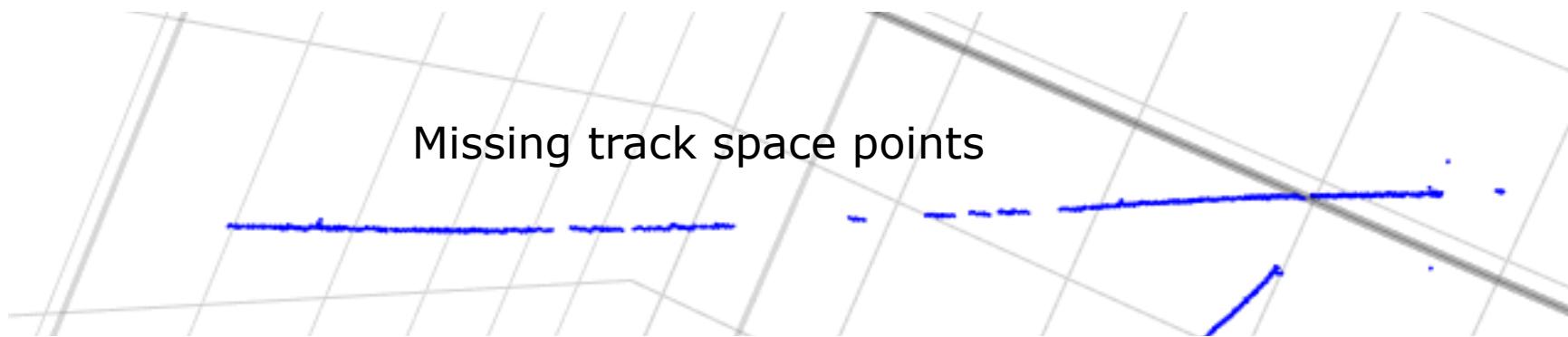
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FLORIDA

Space Points

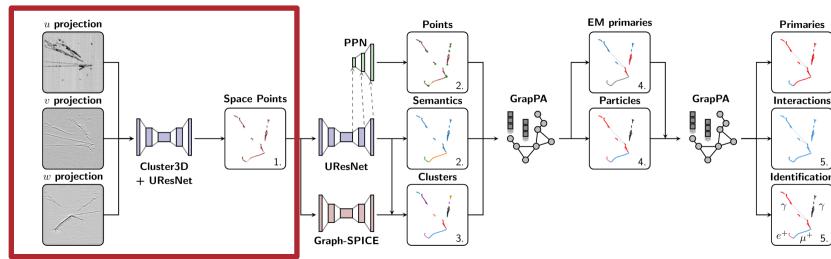
docDB [39799](#)



- Recent versions have large fractions of track missing
- Solution?

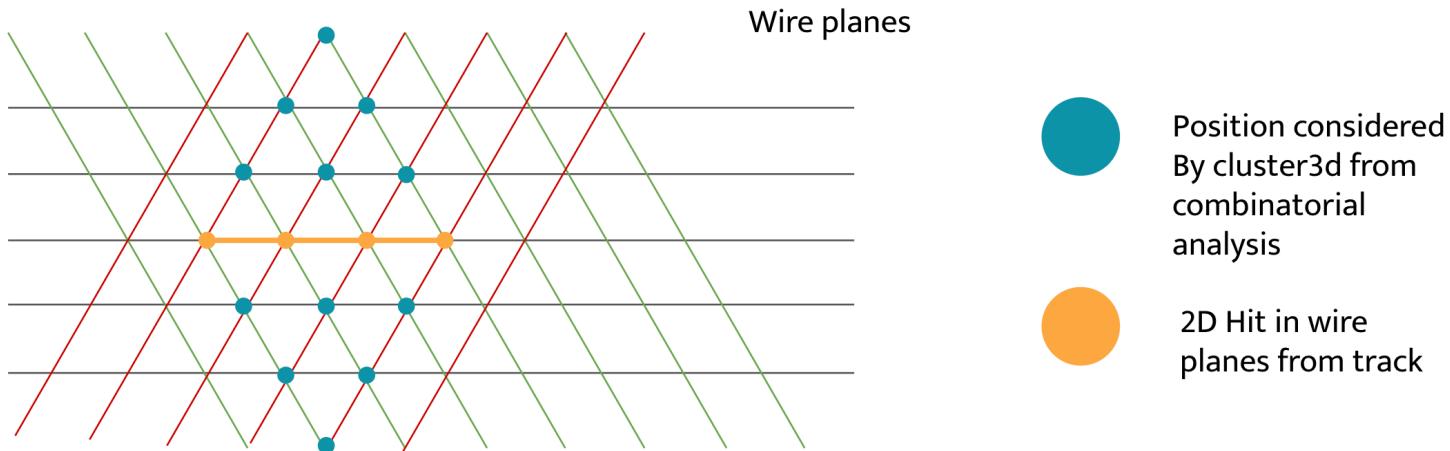


Cluster3D



Cluster3D consumes 2D hits in each of 3 projections

- Finds pairs of hits compatible within a time threshold
- Forms a **triplet (doublet)** point from 3 wires where 3 (2) hits are compatible in time to form candidate space-points



- False hits create ghost points, which are de-ghosted using a UResNet CNN



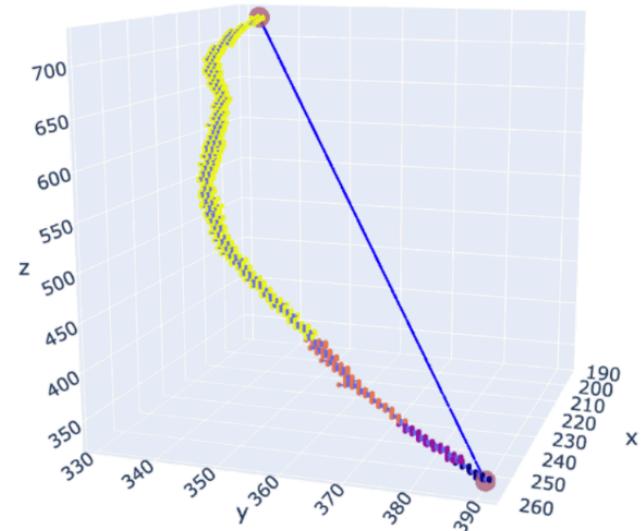
Calculating Track Completeness

1. Cluster voxels with Chebyshev metric ($\epsilon=1.1$)
2. Order clusters along track
3. Calculate inter-cluster distance $d_{i,i+1}$ between consecutive clusters
4. Find $G = \text{sum of gaps in track}$

$$G = \sum_{i=0}^{n-1} (d_{i,i+1} - \delta), \delta = 1/\max_i |\vec{v}|$$

Track direction

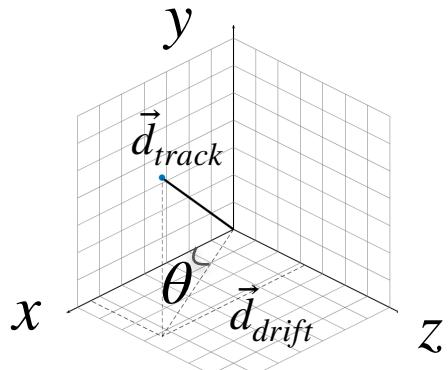
5. Lower G (gap length) / L (track length)
means better track completeness



Space Points

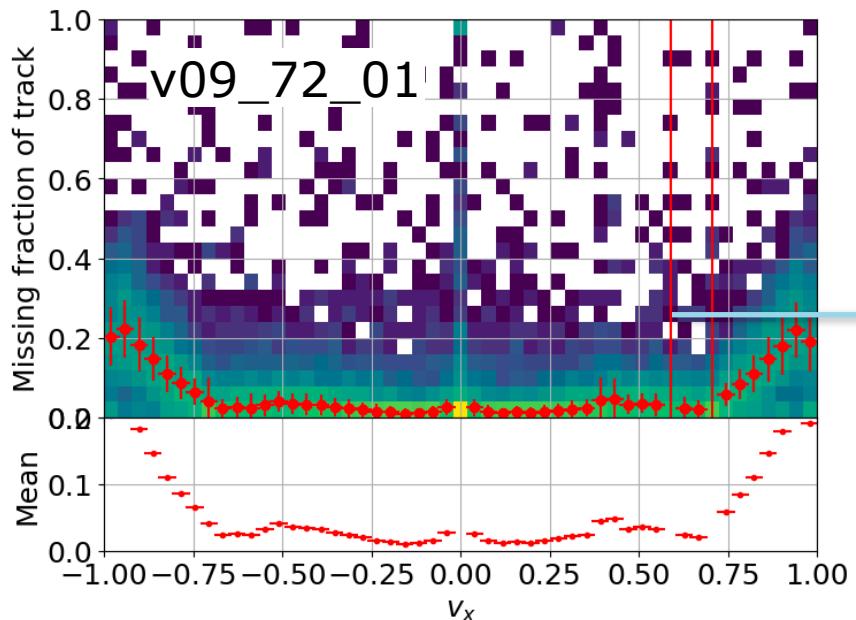
- Recent version has large fraction of track missing

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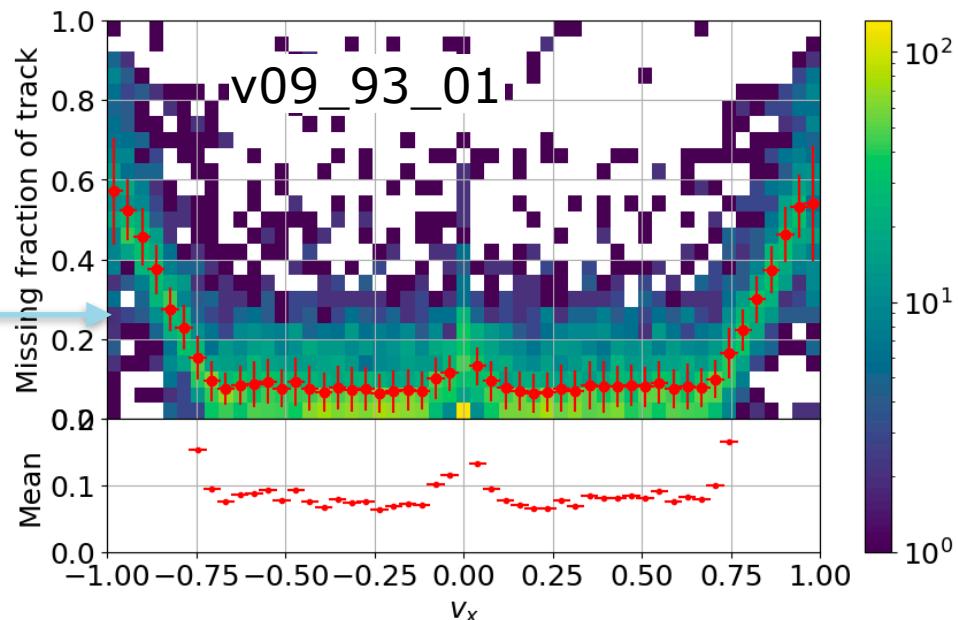


$$v_x = \vec{d}_{drift} \cdot \vec{d}_{track} = \cos \theta$$

1D Drift / Deconvolution

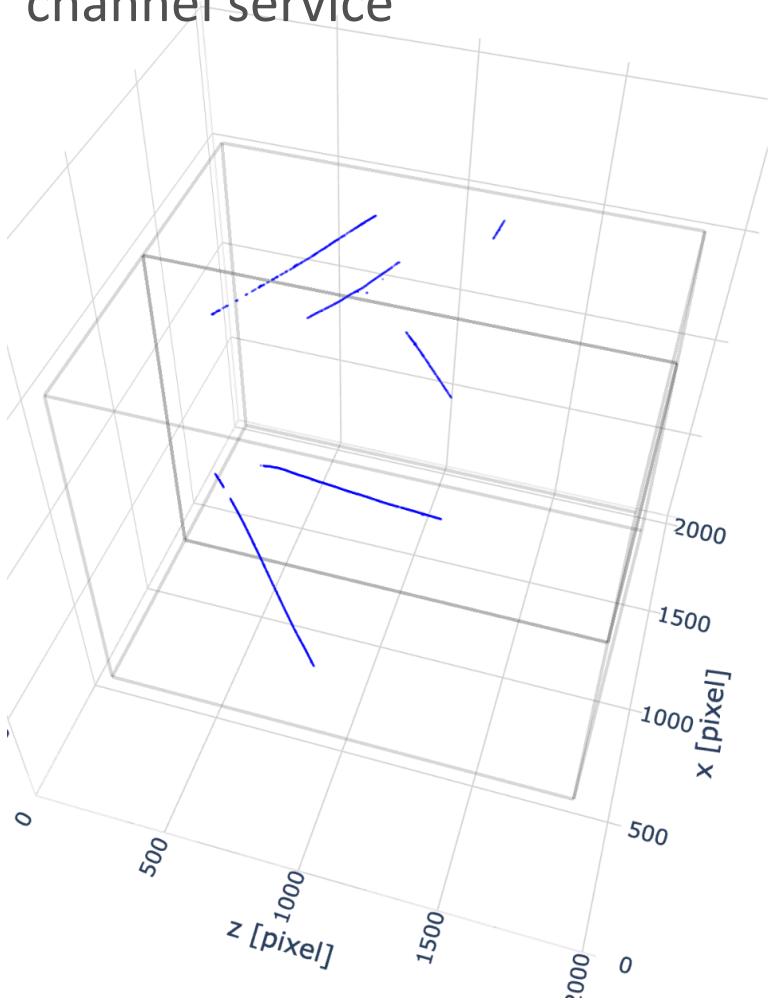


2D Drift / Deconvolution

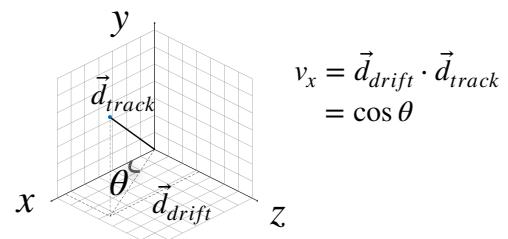


Space Points

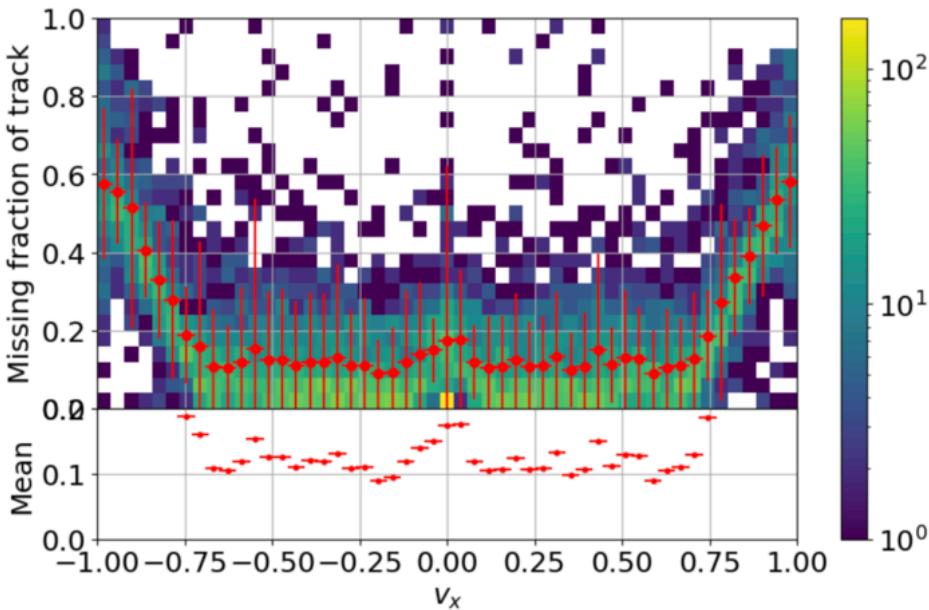
- Make particle gun with 100 events. Start with triplets, no bad channel service



Detector
SED
Cluster3D points (no ghost)
Cluster3D points (ghost)

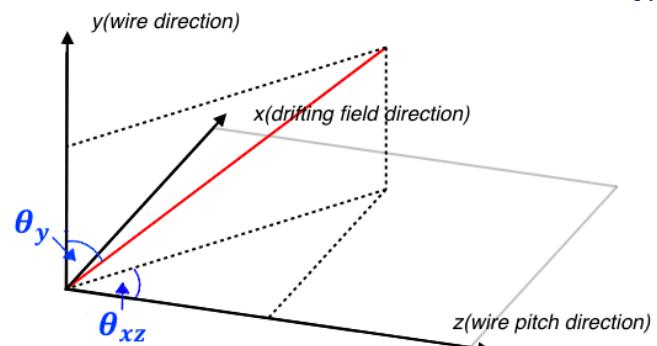


$$v_x = \vec{d}_{drift} \cdot \vec{d}_{track} = \cos \theta$$



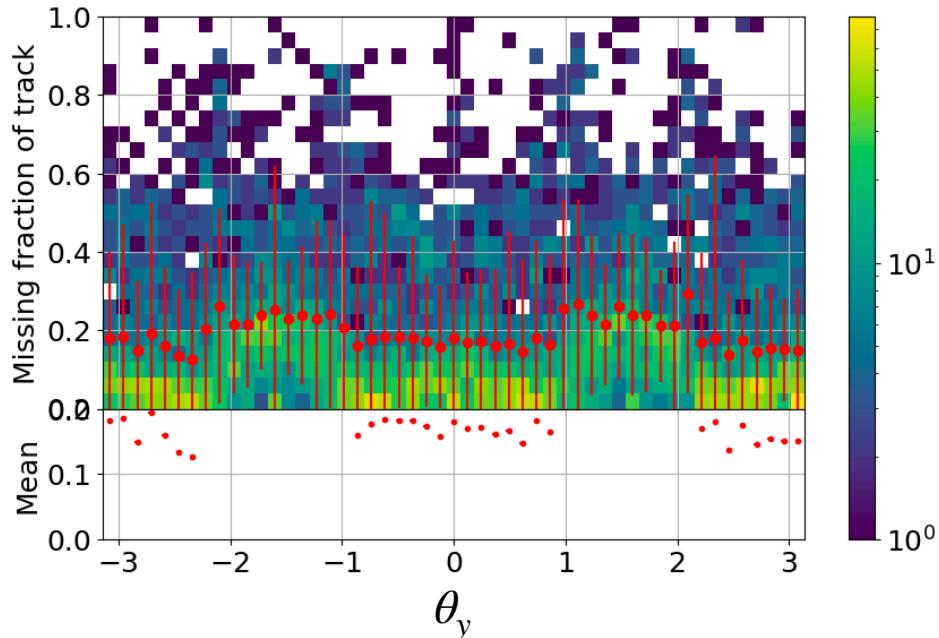
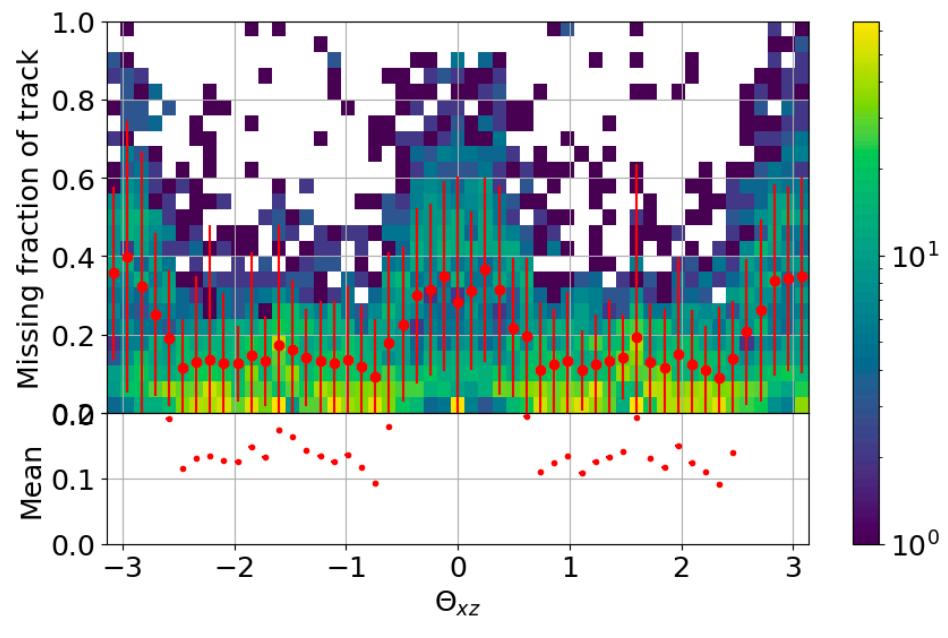
Space Points

- Other projections of incompleteness
- Use triplets and no bad channel service



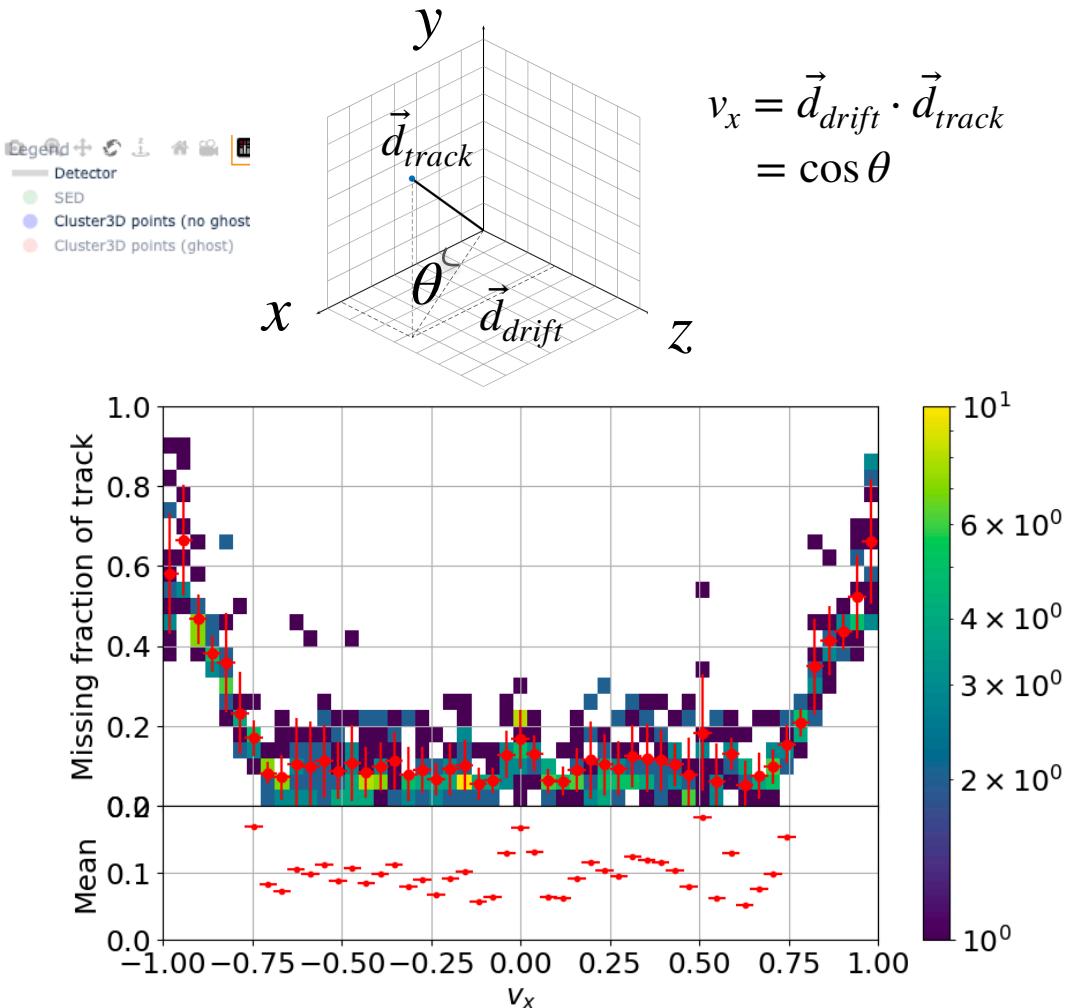
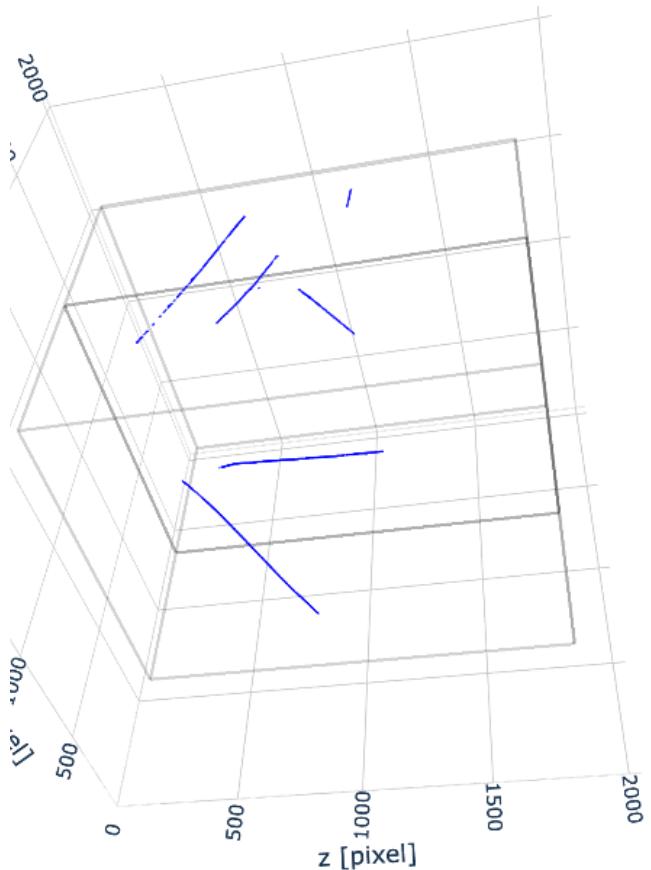
(b) Definition of two angles, θ_{xz} and θ_y .

Figure 8. Geometric coordinates and angles for topology description.



Space Points

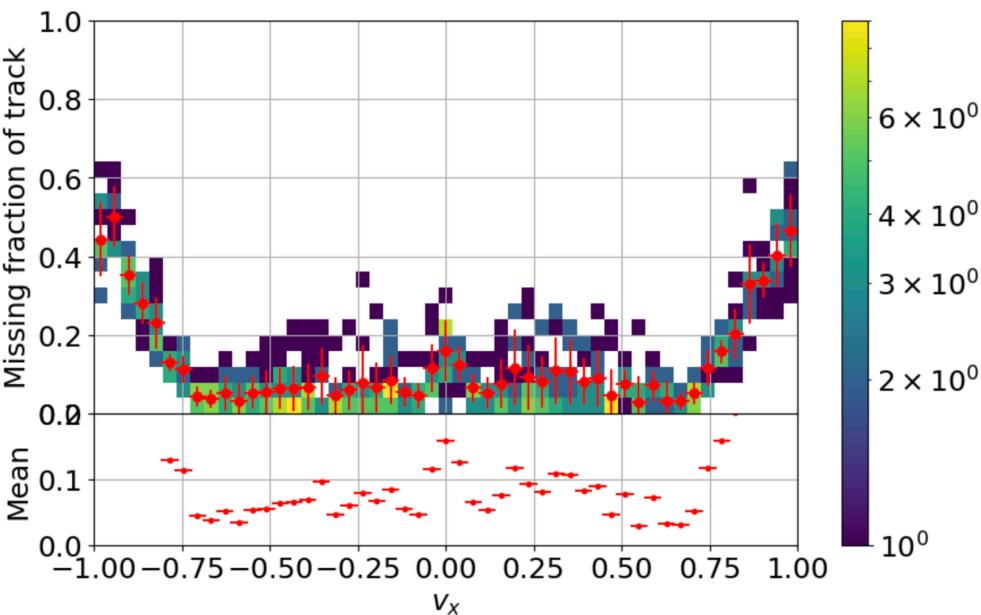
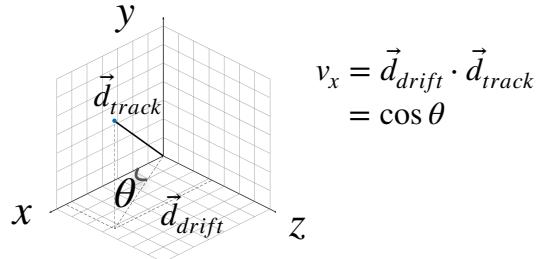
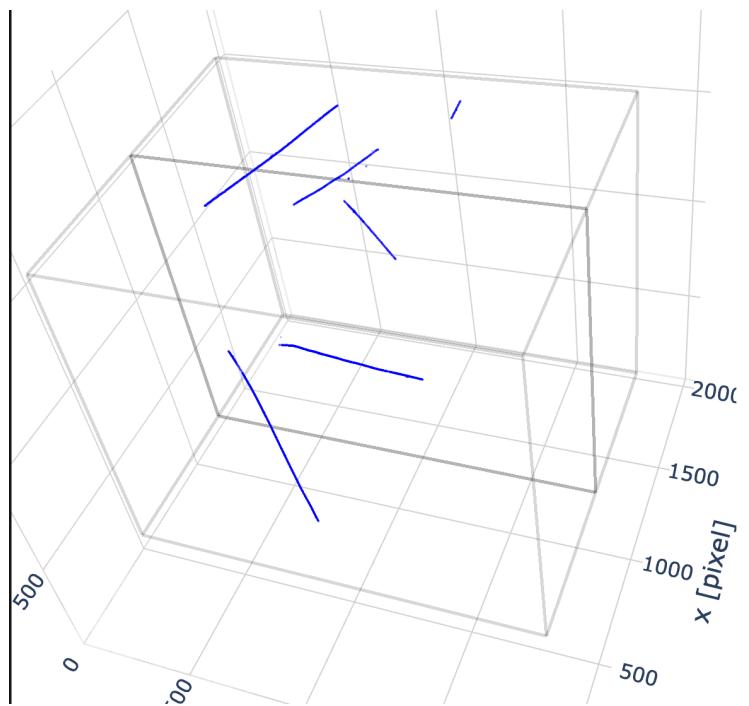
- Introduce service to inform cluster3D where bad channels are





Space Points

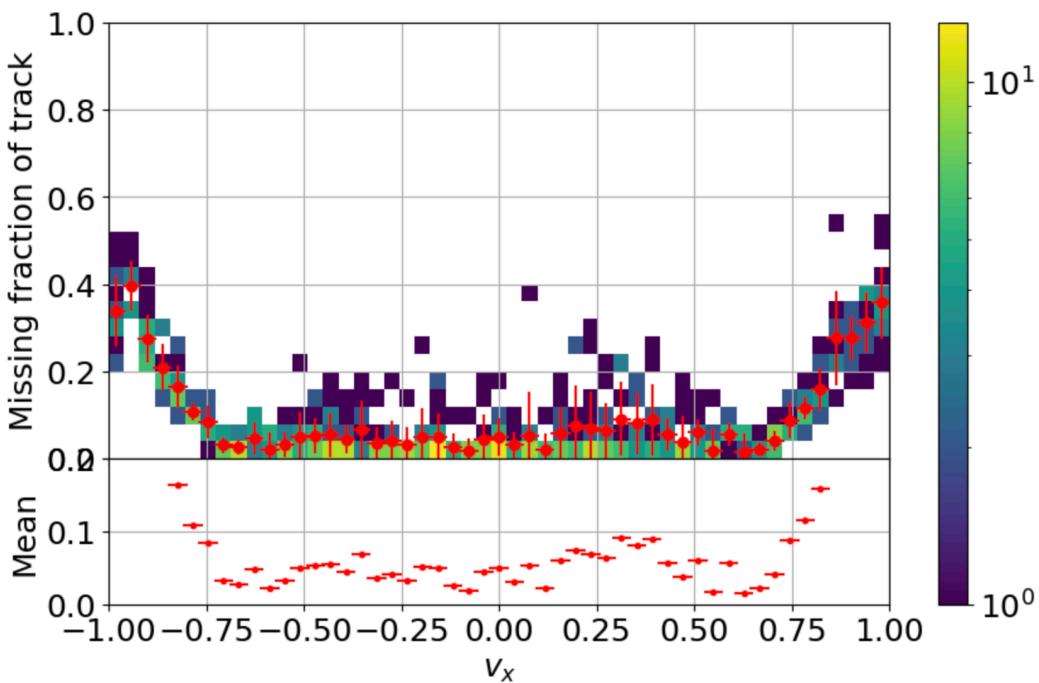
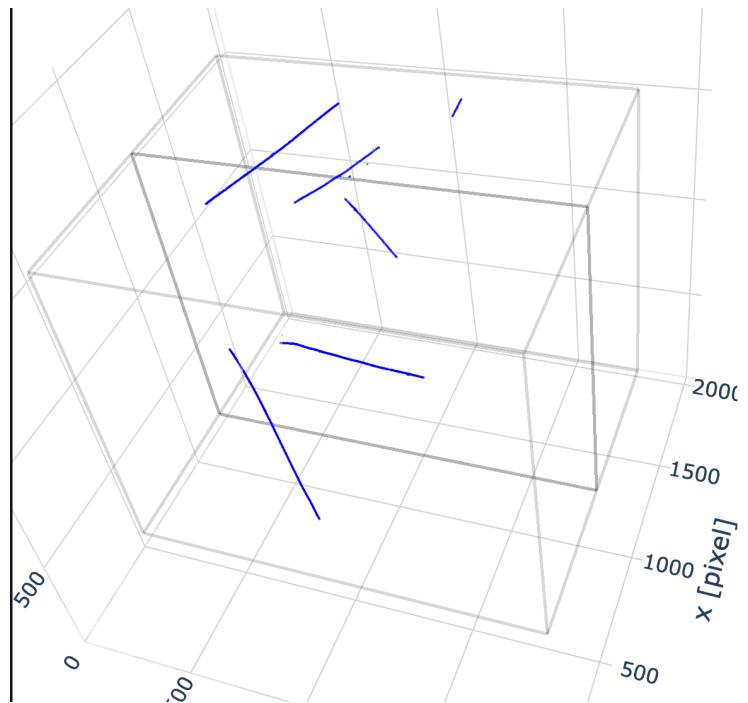
- Introduce service to inform cluster3D where bad channels are
- Use doublets instead of triplets for space points





Space Points

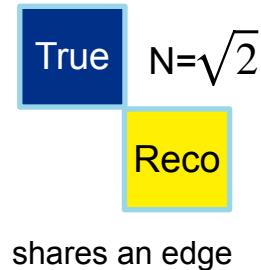
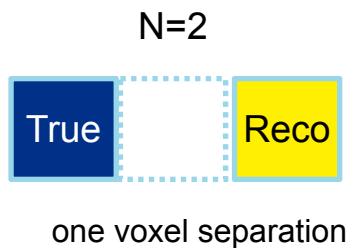
- Introduce service to inform cluster3D where bad channels are
- Use doublets instead of triplets for space points
- Relax parameters that classify points as ghosts (docDB [32034](#))



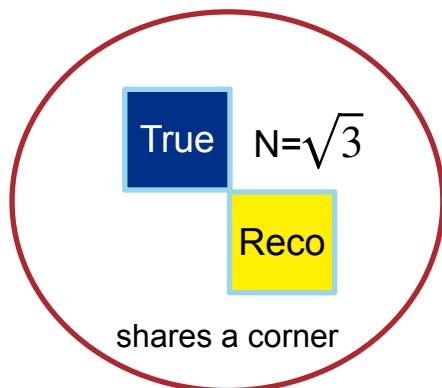


Space Point Parameters

- Investigate matching reco (parse_sparse3d) to true voxels (cluster3d_sed) through voxel coordinates
- Matching threshold (N)- max distance between reco voxel and true voxel to be considered matched
- Used $N^2 = 3$, voxel shares a corner to be considered matched



$$N = |\vec{x}_{\text{true}} - \vec{x}_{\text{reco}}|$$



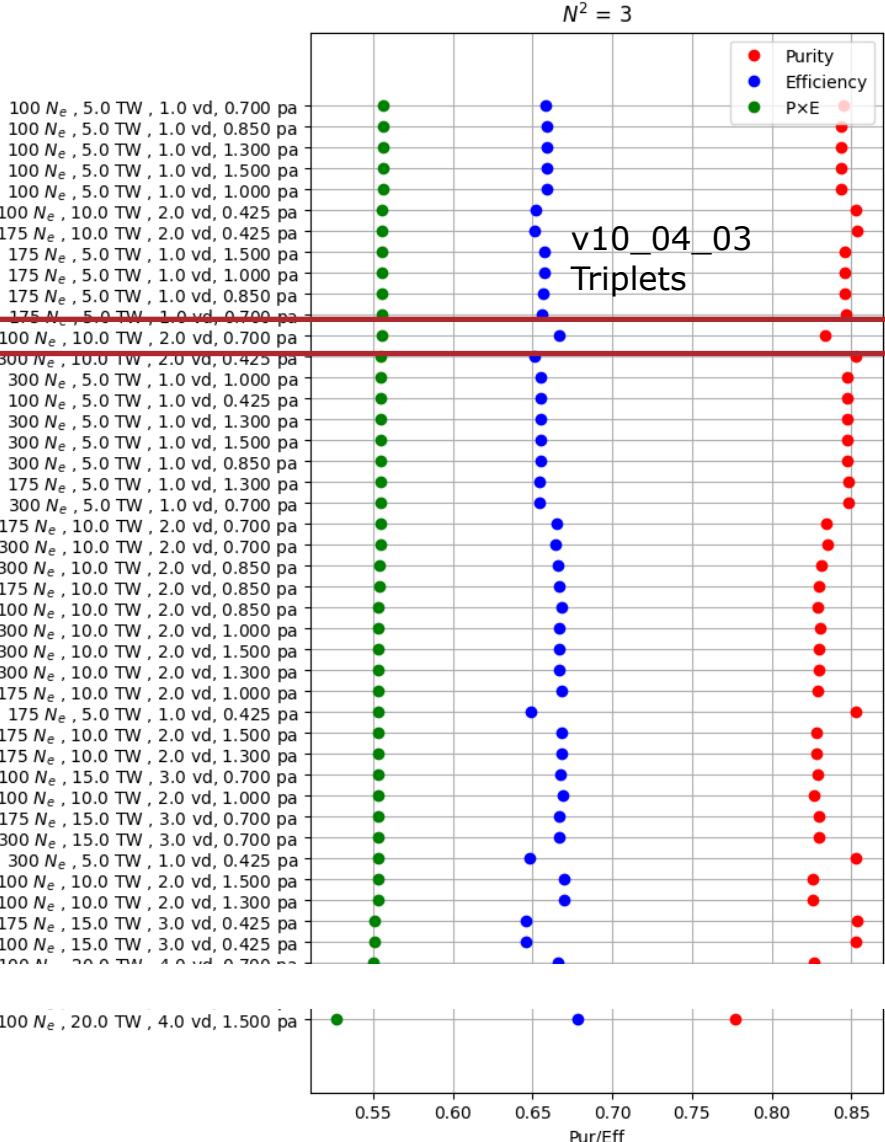
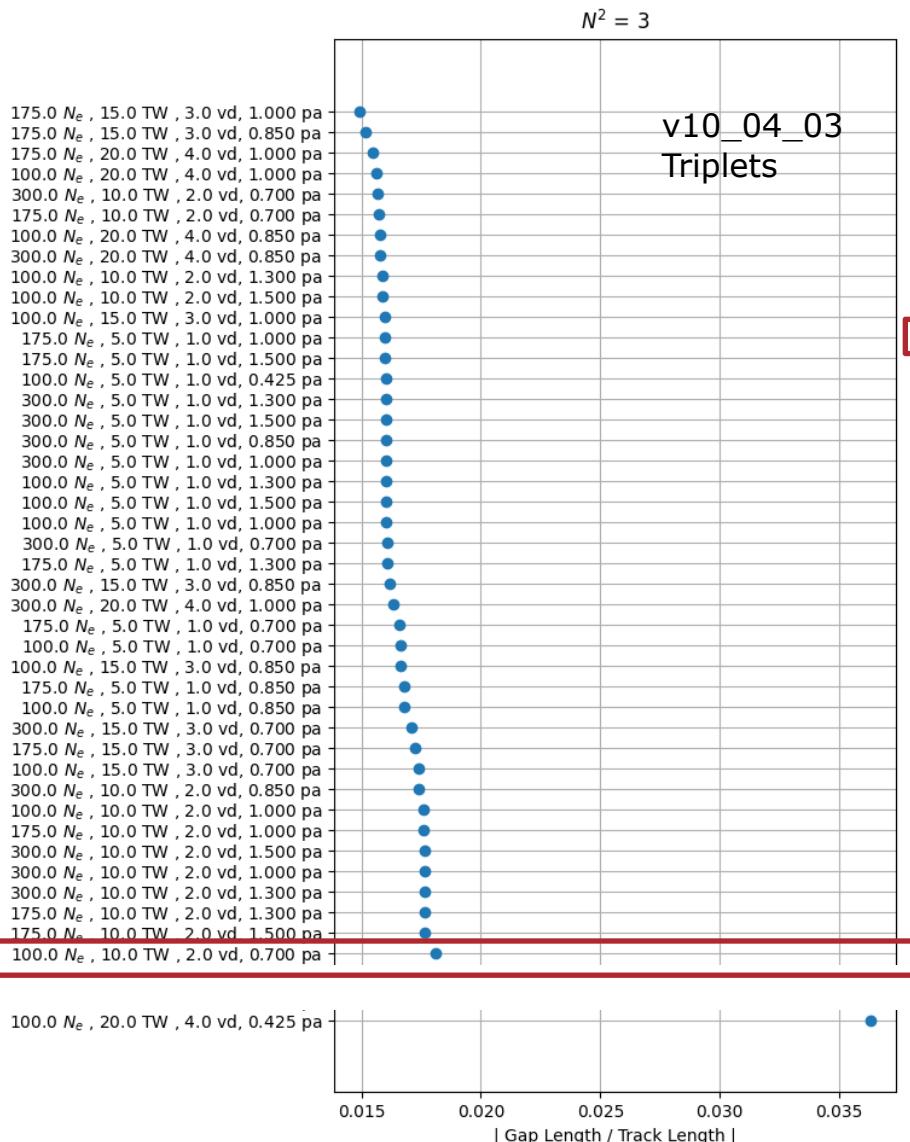


Space Point Parameters

Supera parameters - SuperaTrue2RecoVoxel3D

- Hit Ne (Ne) - Threshold number of electron hits
- Tick window threshold (TW) - Time between true and reco 2d hits to accept hit Ne (500 ns = 1 tick) in ticks
- Voxel distance threshold (VDS) = 1/5 time window due to drift vel. (same in ICARUS and SBND)
- Post averaging threshold (PA) - radius for averaging voxels
- True tagged voxel - True voxel that's matched to a reco voxel $N^2 = 3$
- Reco tagged voxel - Reco voxel that's matched to a true voxel $N^2 = 3$
- Purity - reco tagged voxel count / reco voxels (noghost)
- Efficiency - true tagged voxel count / true voxel count
- Goal - Select parameters that maximize purity/efficiency

Space Points - Triplets



S

13 #today

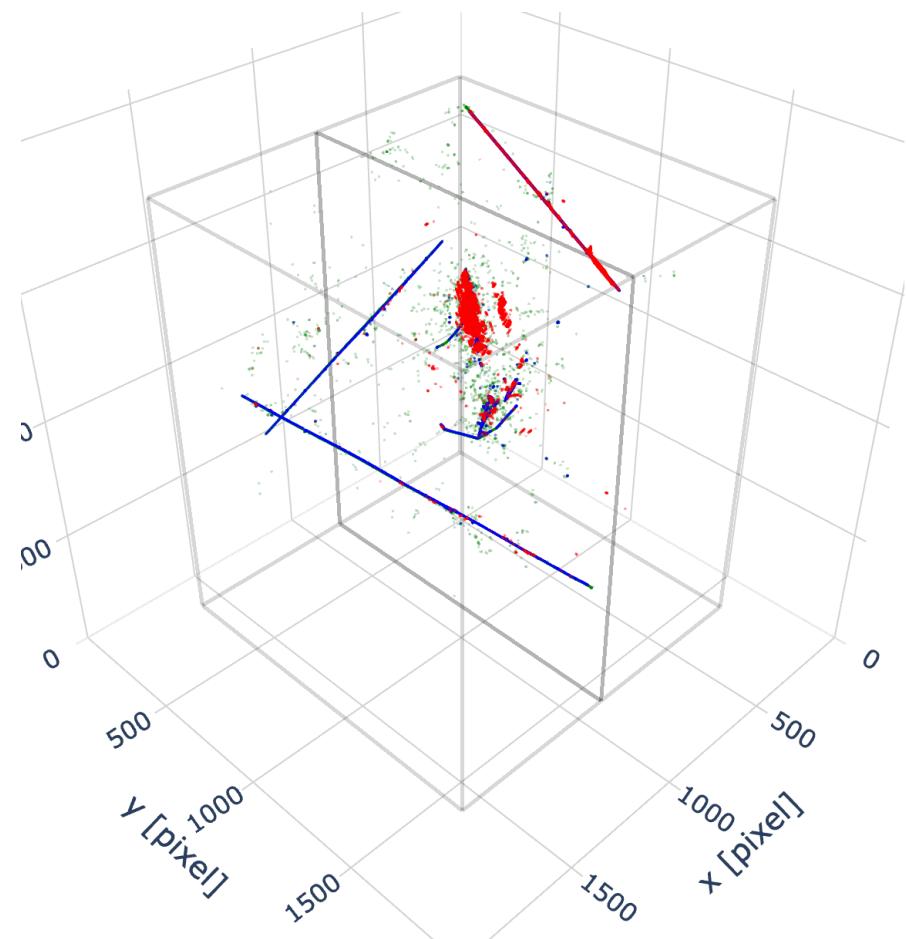
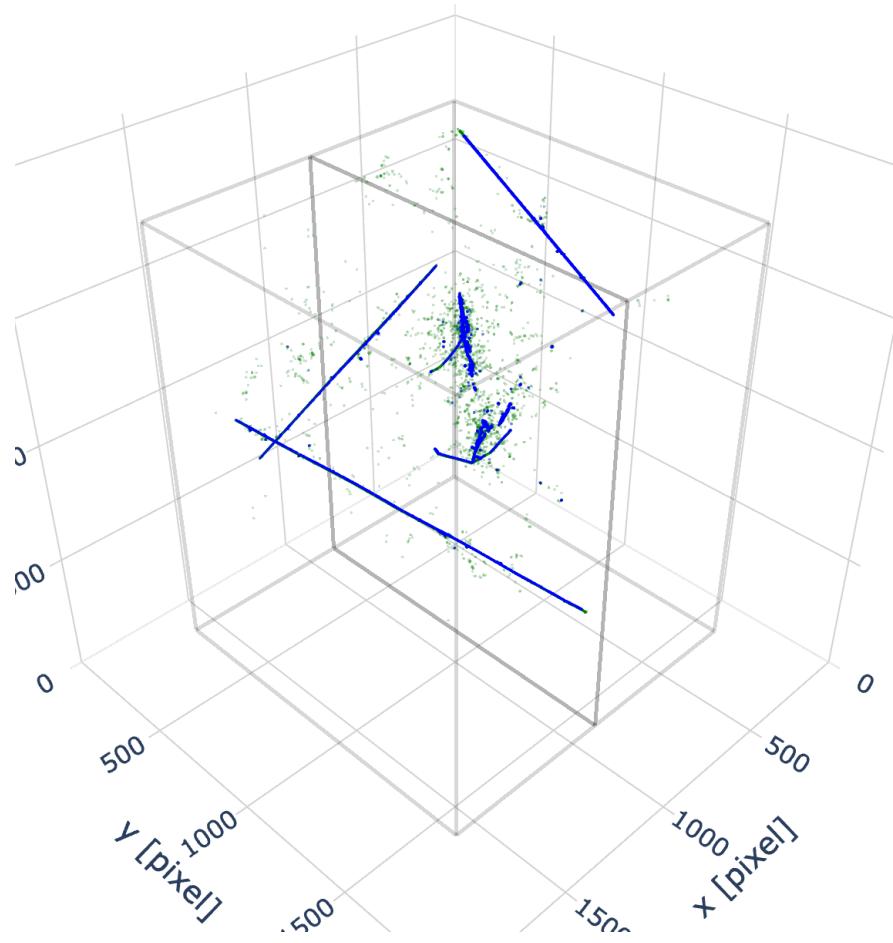
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Space Points - Triplets

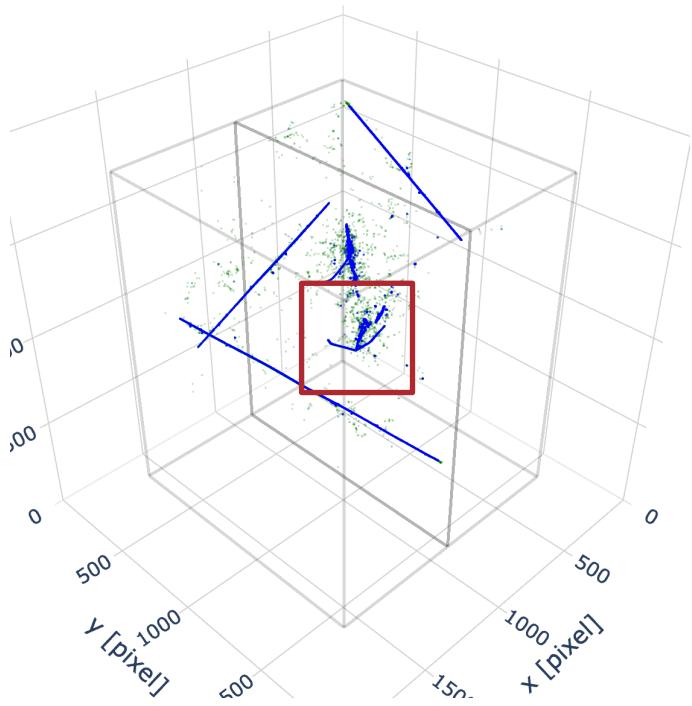


- SED
- Cluster3D points (no ghost)
- Cluster3D points (ghost)

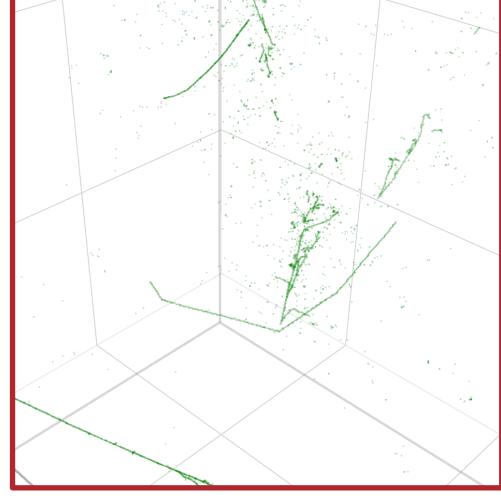
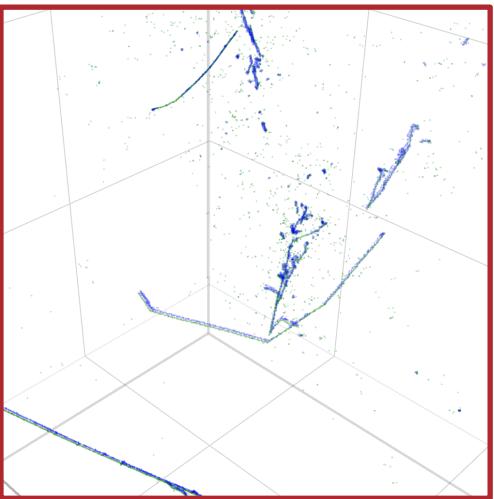
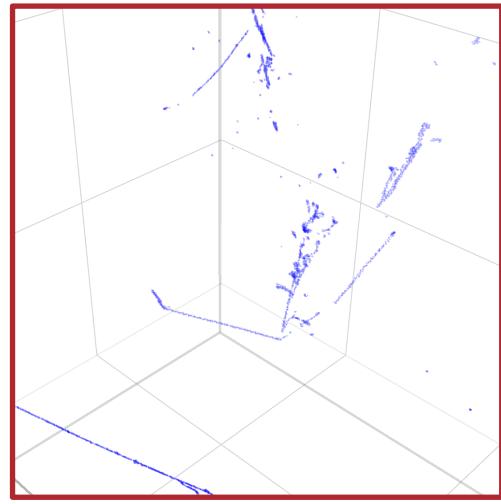
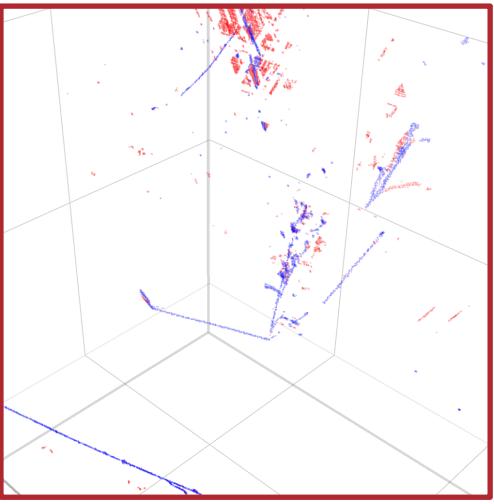


Space Points - Triplets

Missing Cluster3D points in track



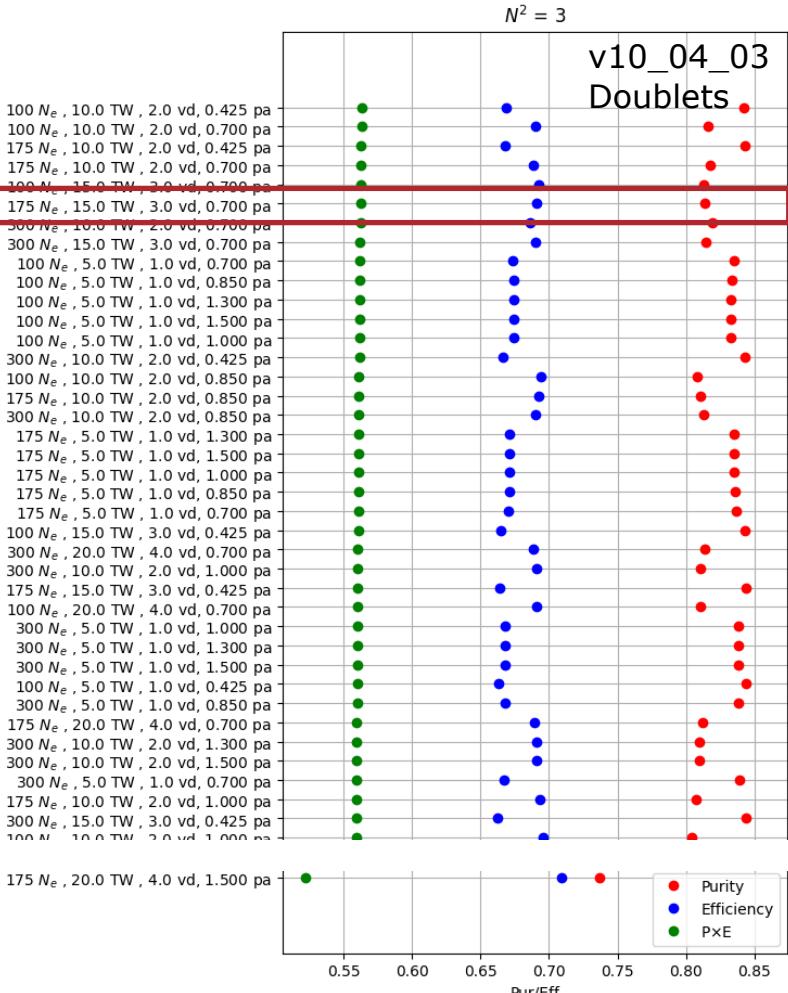
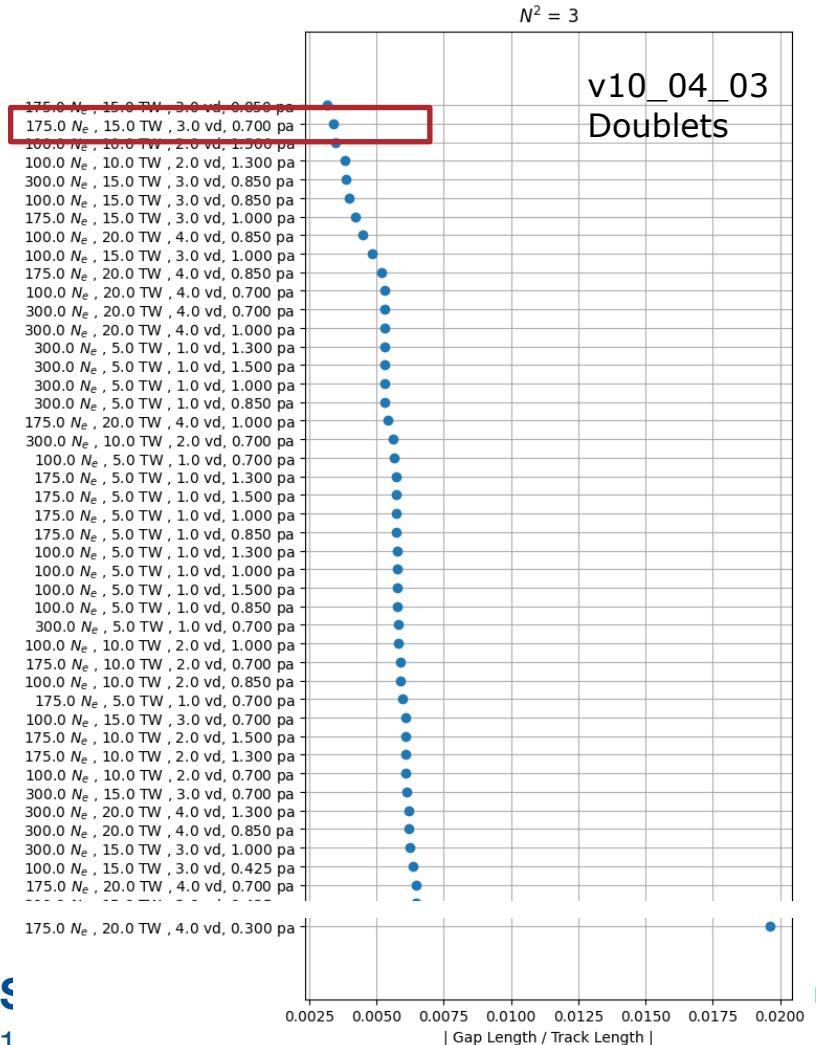
- SED
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Space Points - Doublets

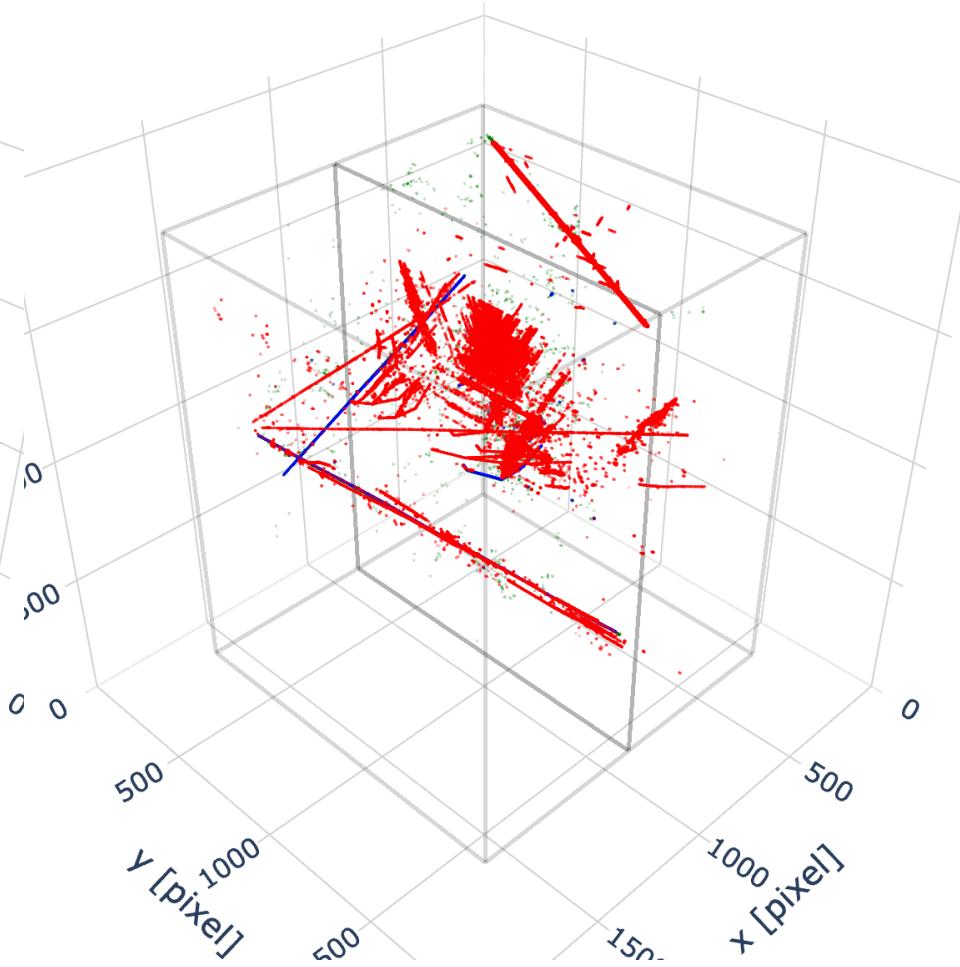
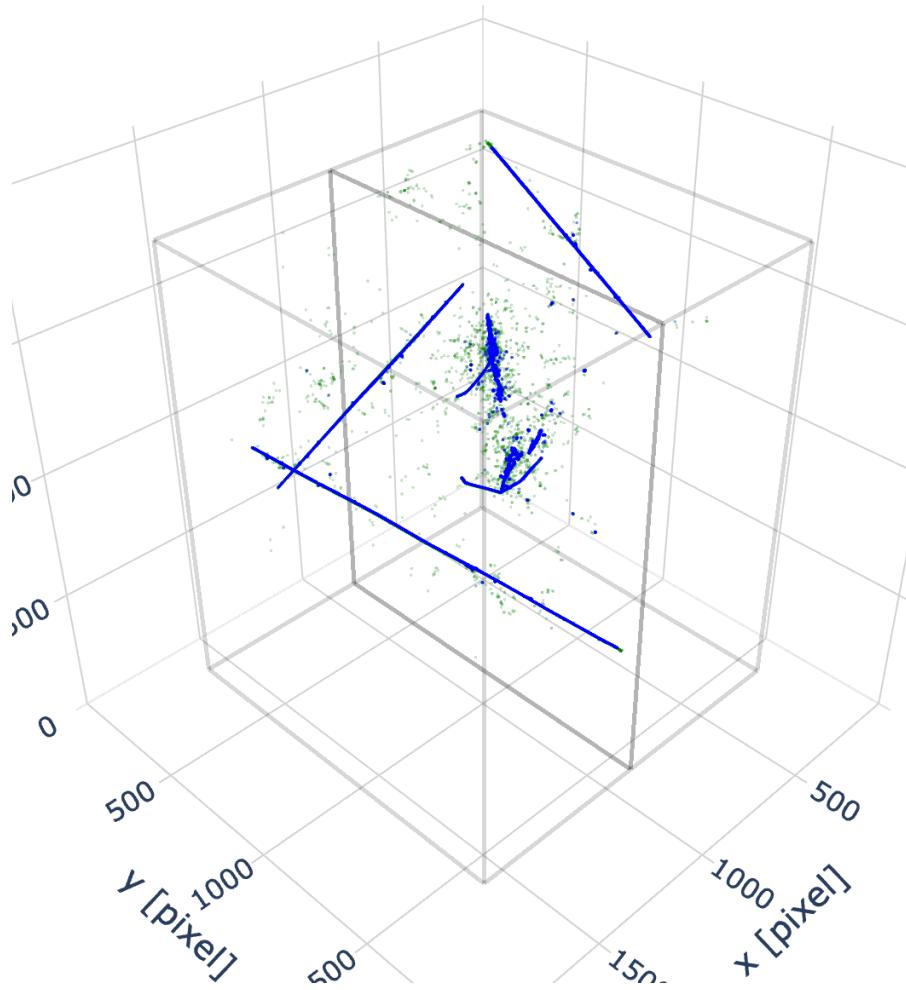
- Optimize Ne, TW, VD, PA (previous slide) according to metrics
- Results for 10 MPVMPR (all in beam window) events shown



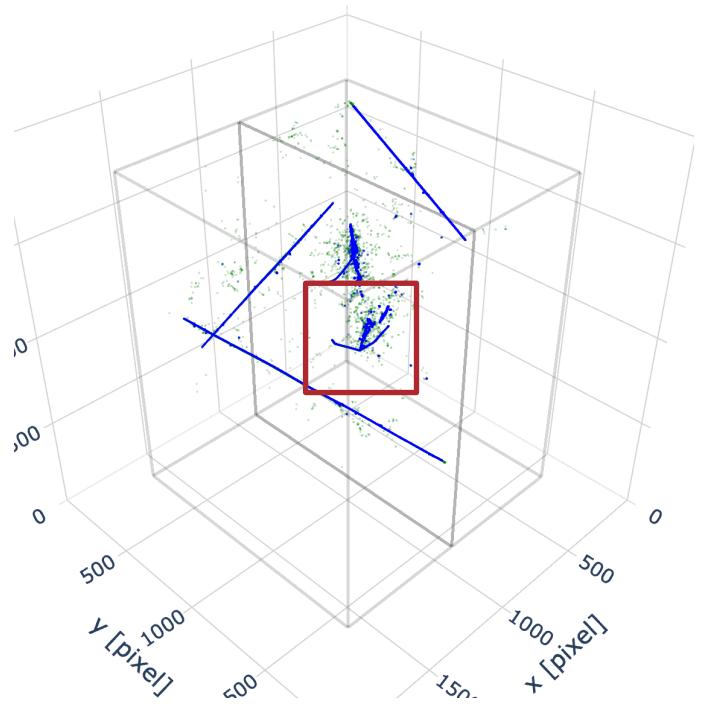
Space Points - Doublets



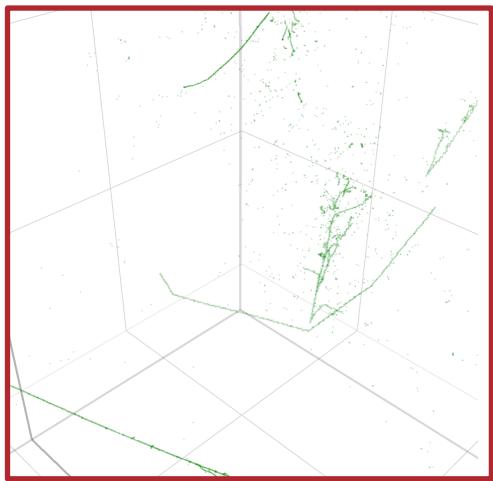
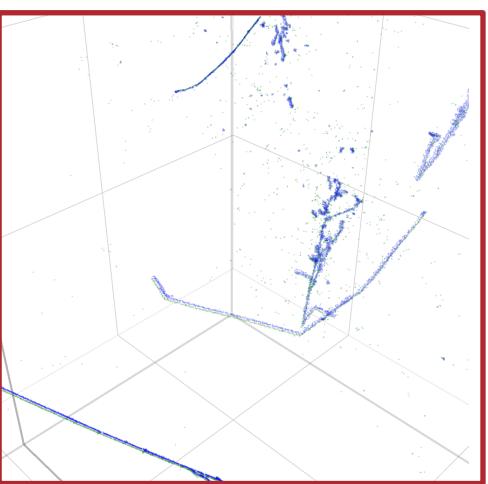
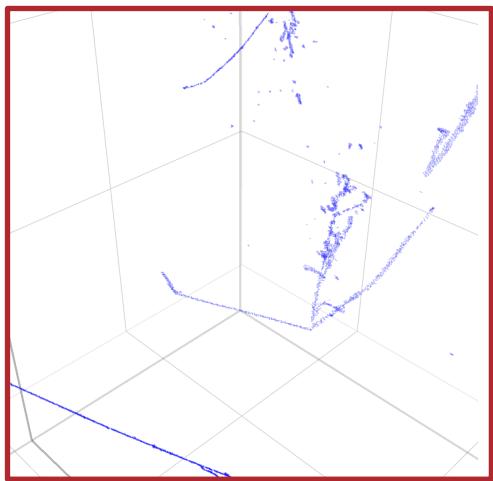
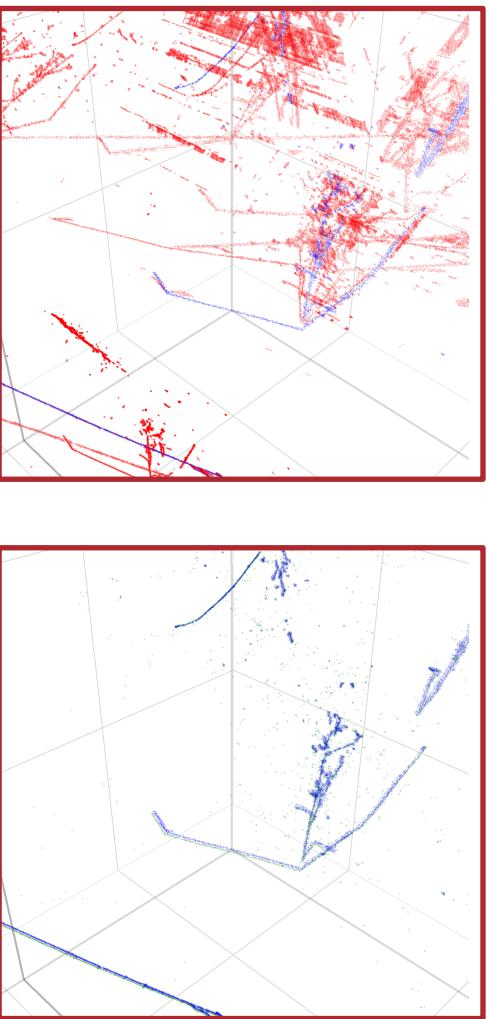
- SED
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Space Points - Doublets



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Conclusion

- Ruled out the channel mapping service
- Find that prolonged tracks are typically the culprit
 - It looks like the hits are only found for the secondary particle in these cases
- Using doublets is an option but...
 - It's not as good as 1D deconv/sim and we'd like to understand why
 - It 4-5x the larcv file size
 - Reduces purity of space points when comparing ghost / non-ghost
 - Increases RAM usage
- Next...
 - Check that Supera v10 labeling still works
 - Train v2 weights with the doublets sample - needed imminently for proof of concept study (we've had outdated weights too long)

Thanks!

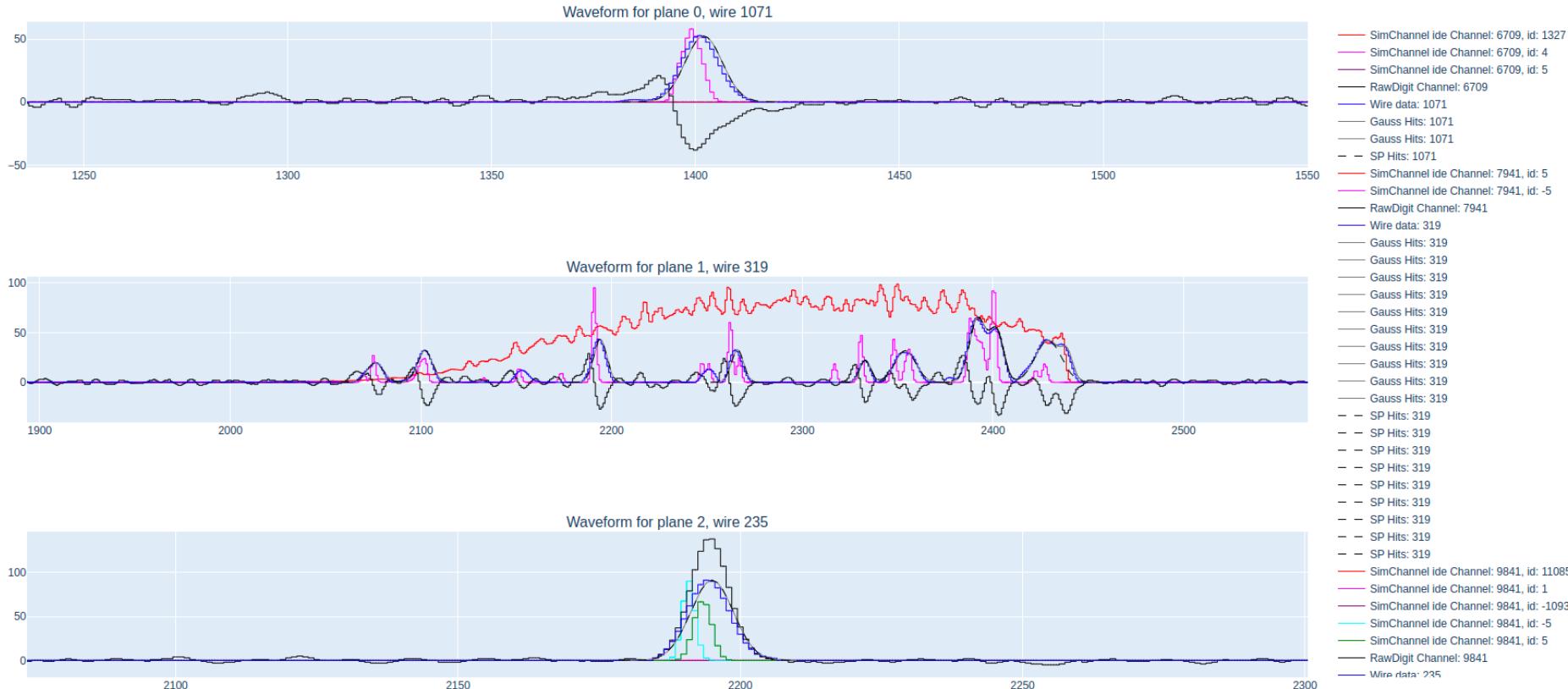


Waveforms for Gappy Tracks



- Plane 1 found hits for track id -5 (pink), but not track id 5 (prolonged track, red)
- Track id -5 is likely a secondary particle from track id 5

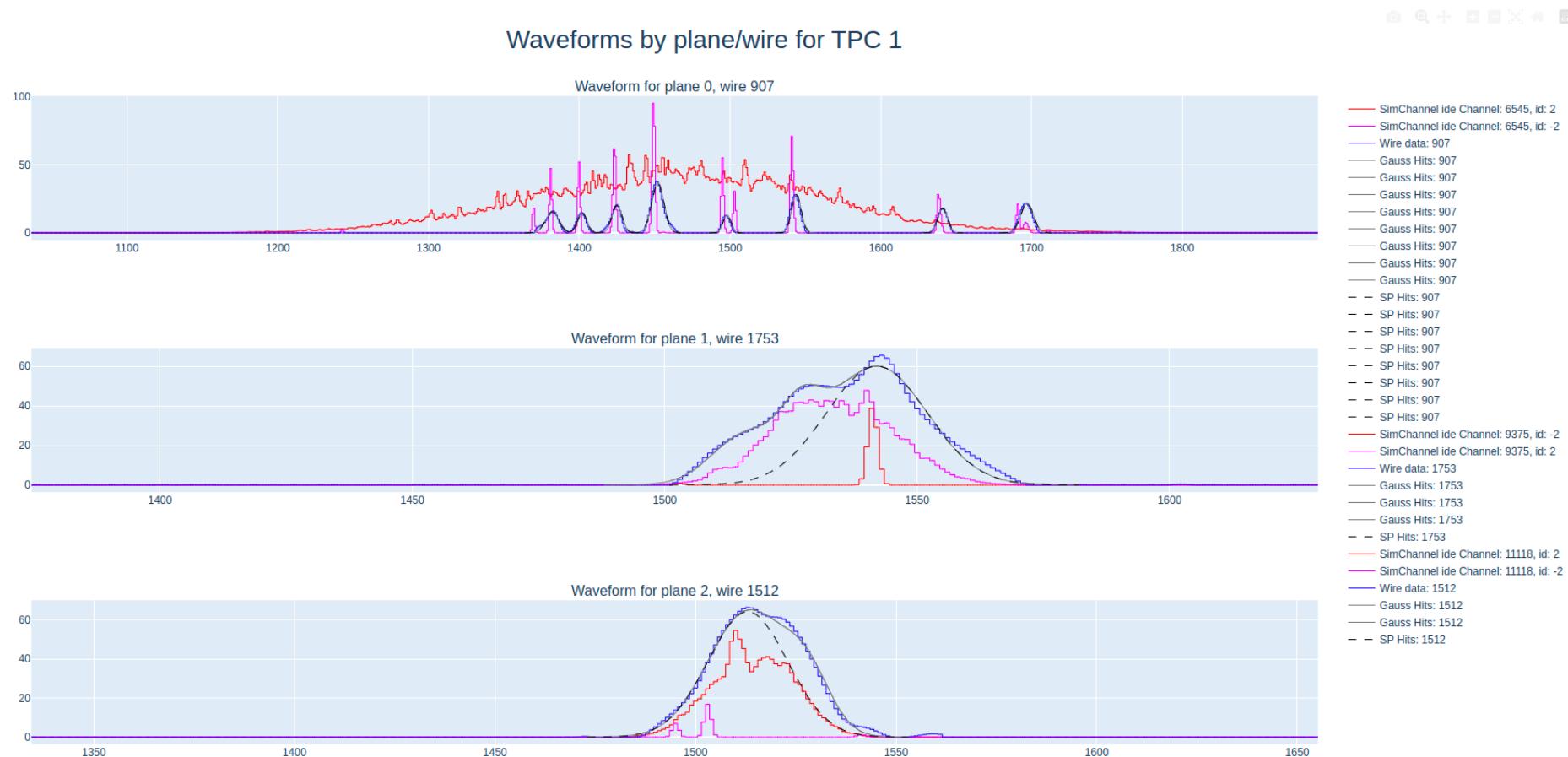
Waveforms by plane/wire for TPC 1





Waveforms for Gappy Tracks

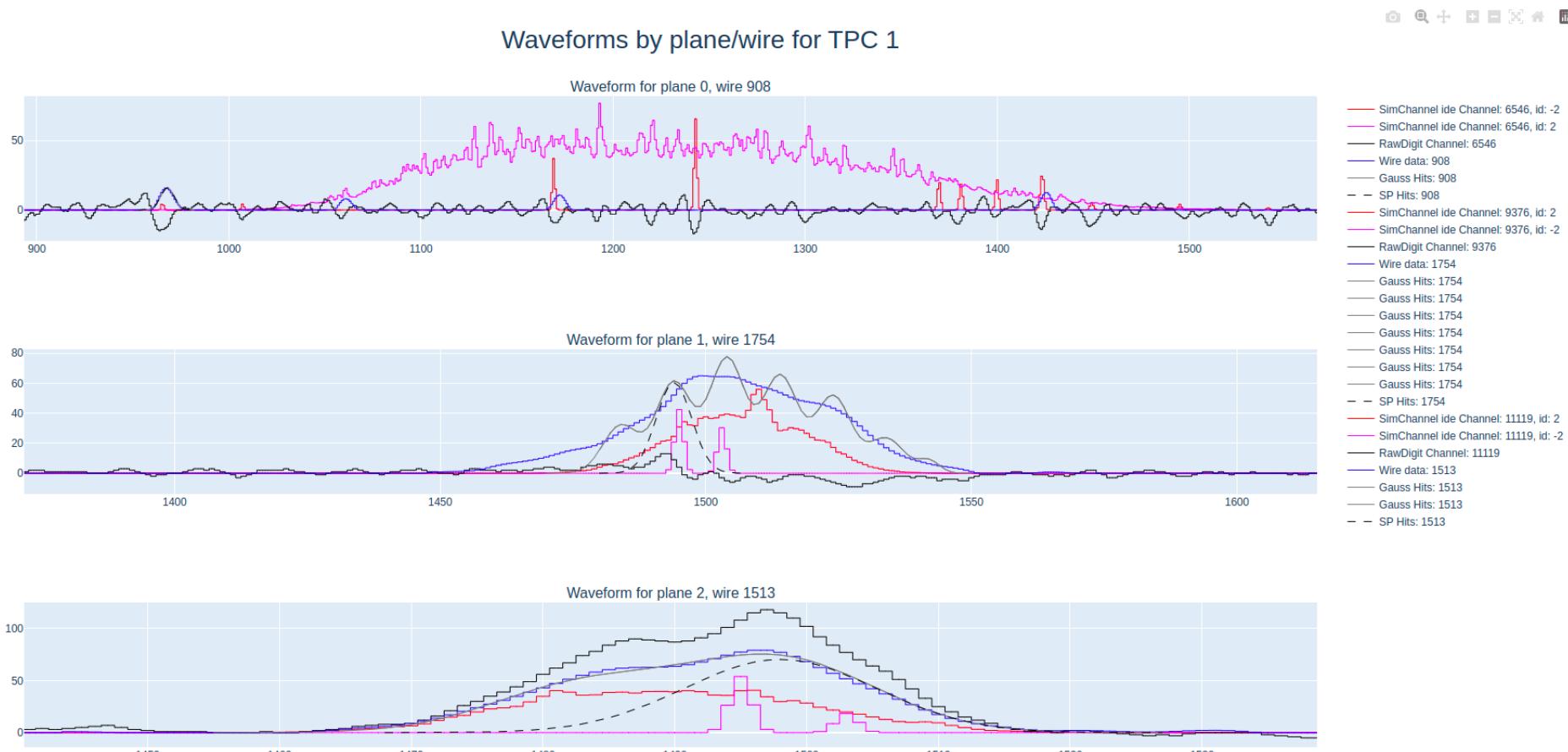
- Plane 0 found hits for track id -2 (pink), but not track id 2 (prolonged track, red)
- Track id -2 is likely a secondary particle from track id 2





Waveforms for Gappy Tracks

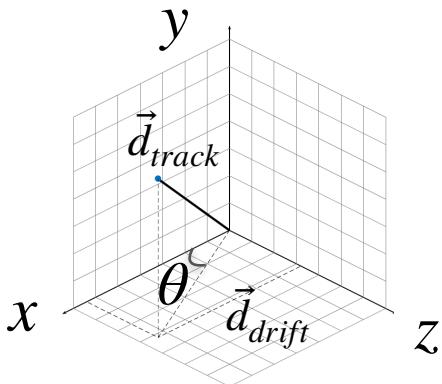
- Plane 0 found hits for track id -2 (pink), but not track id 2 (prolonged track, red)
- Track id -2 is likely a secondary particle from track id 2



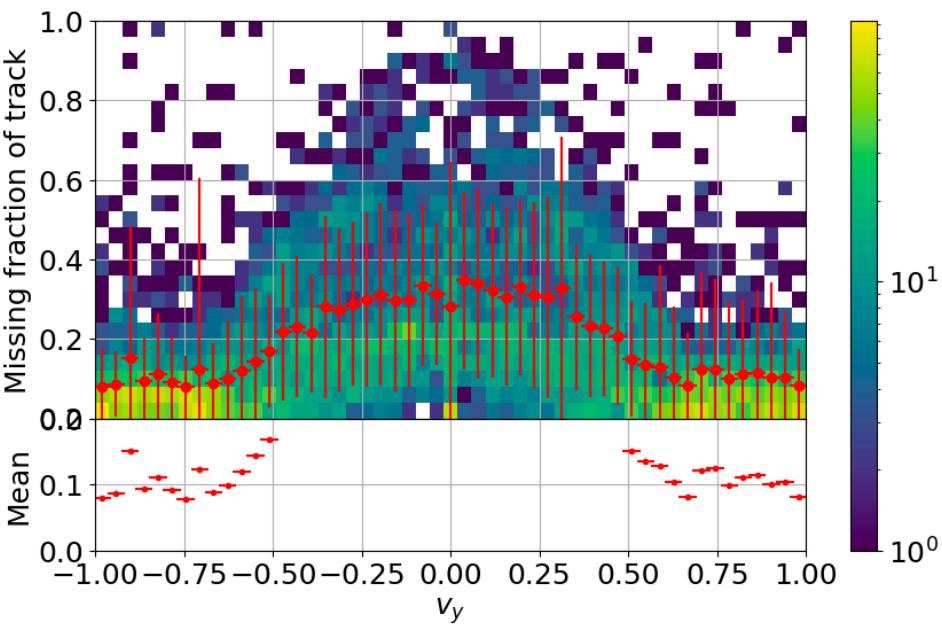
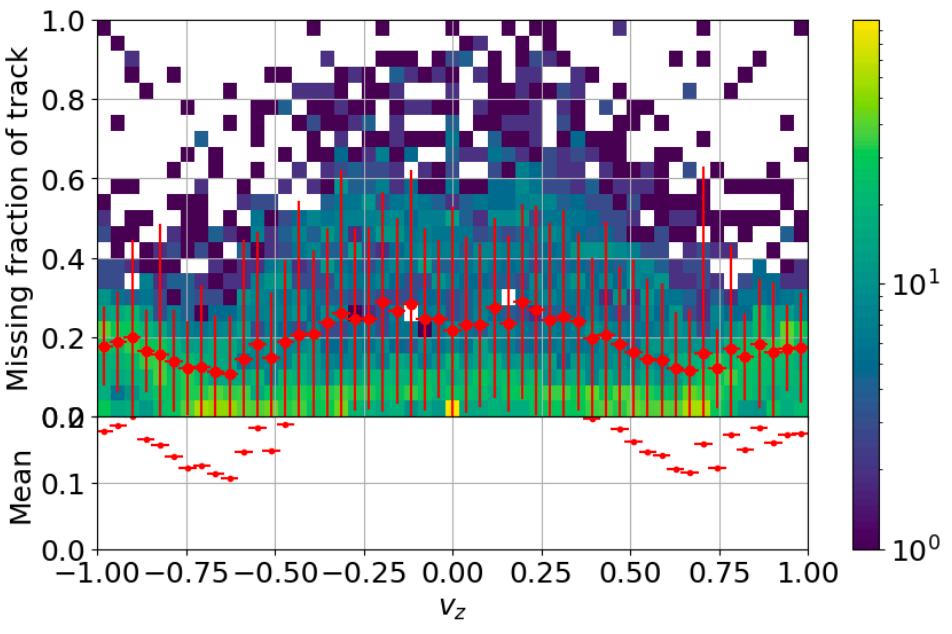


Space Points

- Other projections of incompleteness
- Use triplets and no bad channel service



$$\begin{aligned} v_x &= \vec{d}_{drift} \cdot \vec{d}_{track} \\ &= \cos \theta \end{aligned}$$



Space Points

- Other projections of incompleteness
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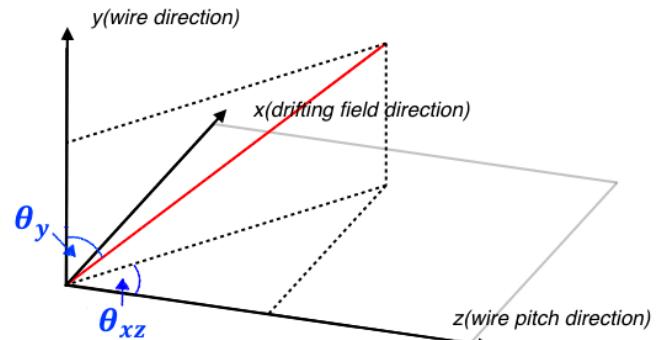
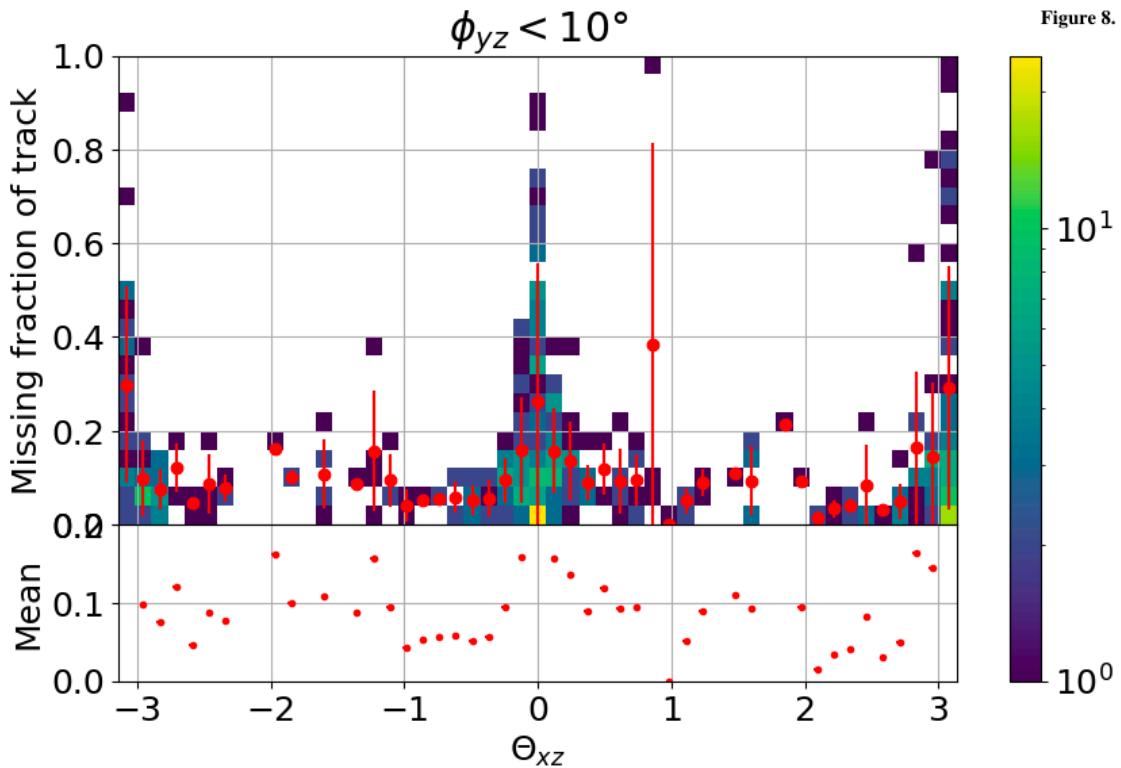
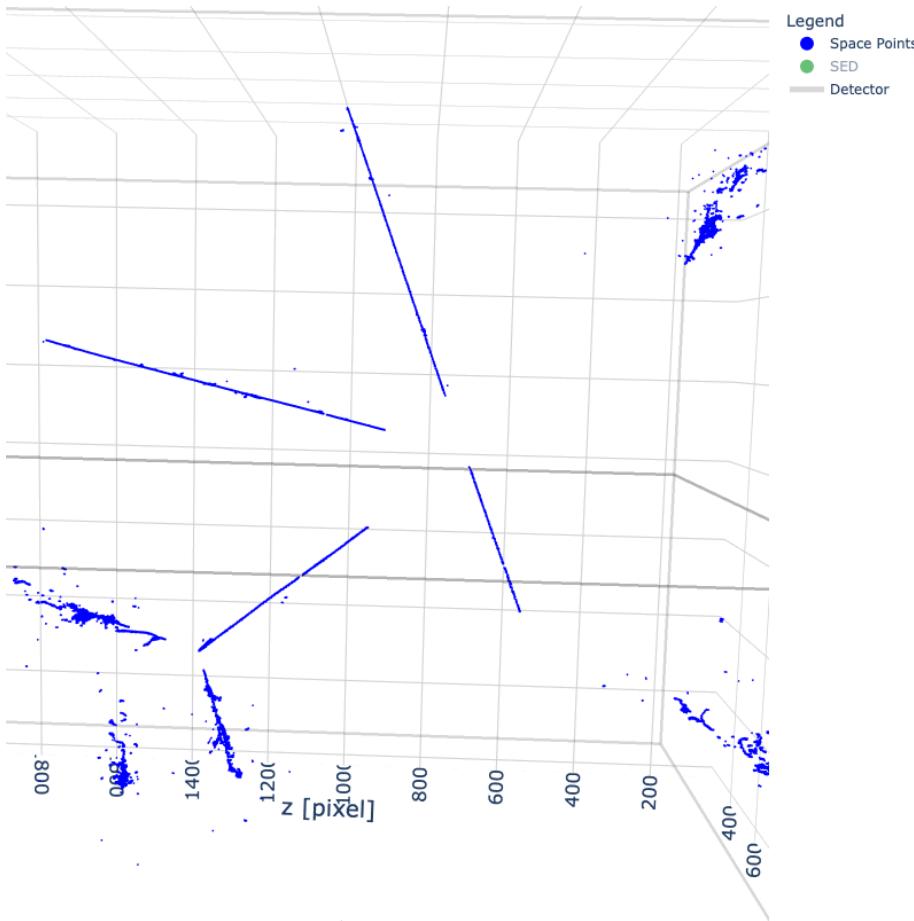
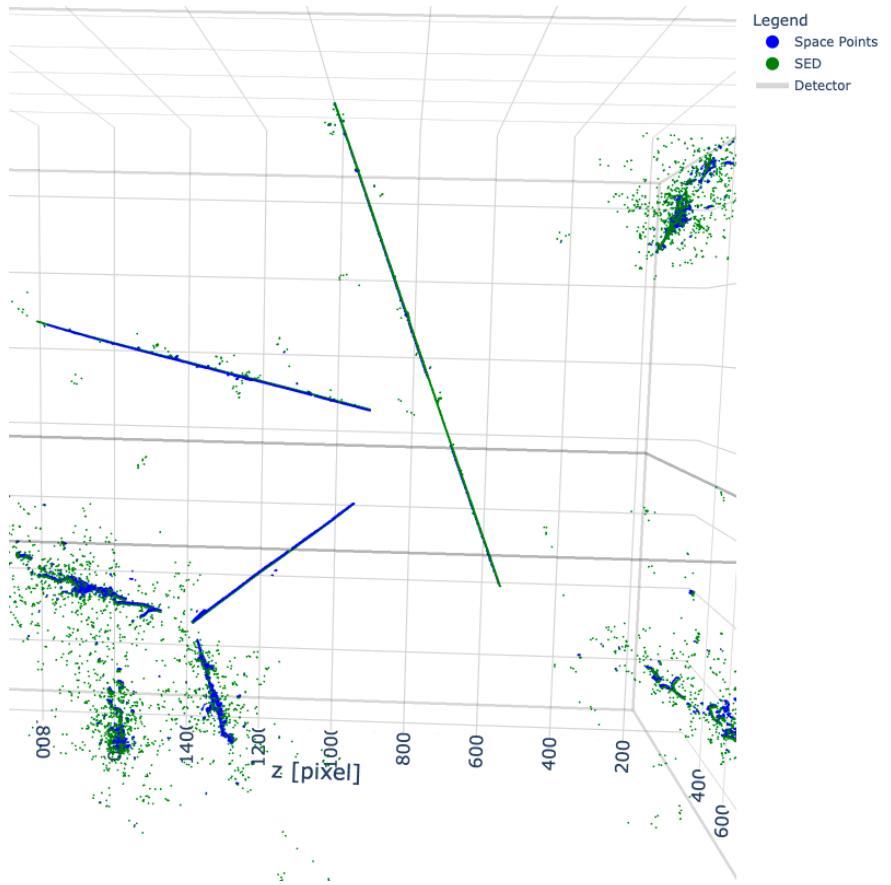


Figure 8. Geometric coordinates and angles for topology description.



Space Point Validation



Space Point Validation



- Recent versions have large fractions of track missing
- Cluster3D [PR](#) to include “bad channel” mapping fix unlikely to solve problem, since both TPCs have identical completeness

