MILO VERMEULEN 14-2-2019 ❤

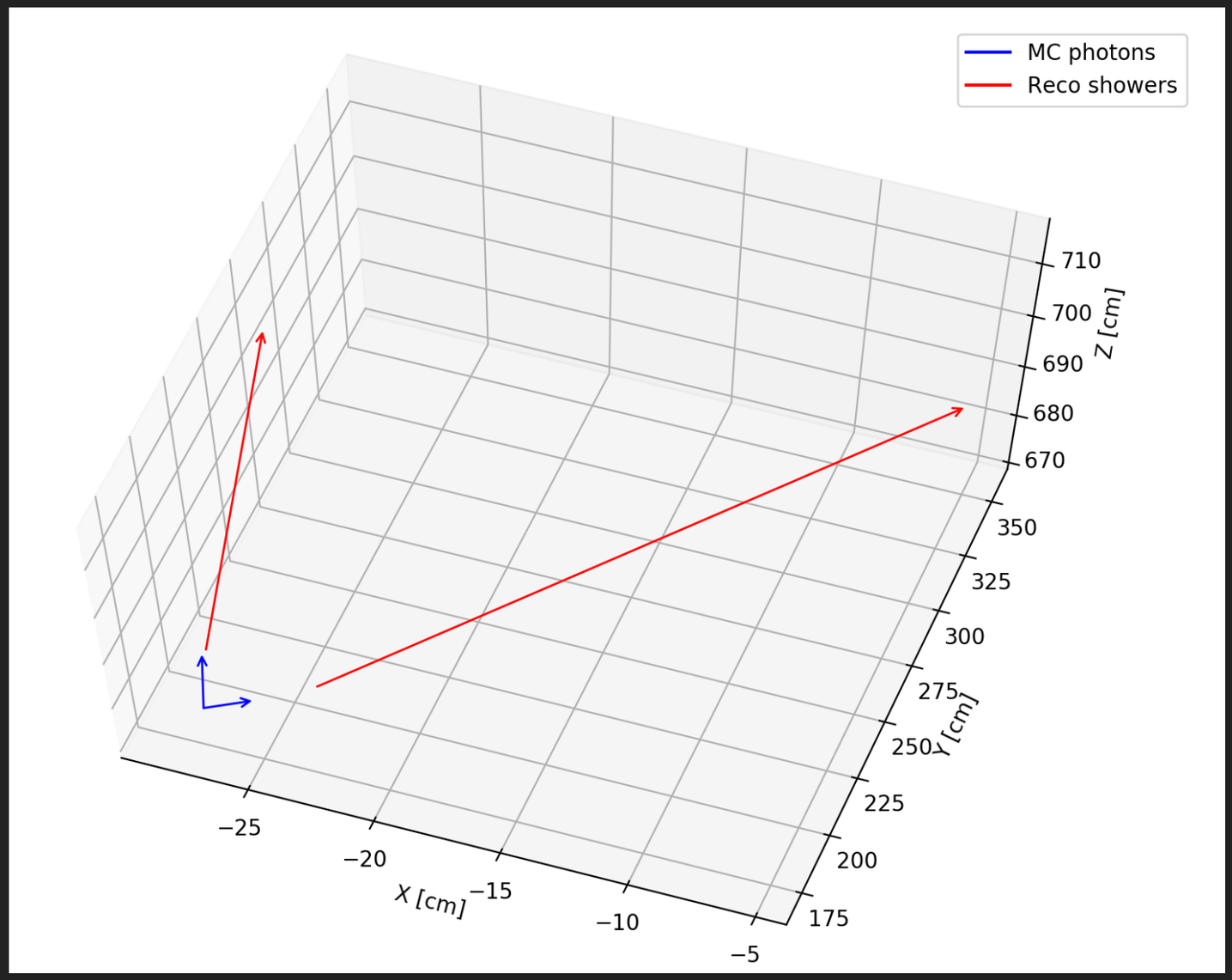
SHOWER RECONSTRUCTION FROM AN ANALYST'S PERSPECTIVE

BACKSTORY

- Search for π^0 particles (major DUNE background)
  - Look for $\pi^0 \rightarrow \gamma\gamma$ showers coming from the same vertex
  - Compare reconstruction with Monte Carlo
- Need to extract (Pandora) shower information
  - Position, length, direction, energy, best_plane, opening angle, etc. etc.

BACKSTORY

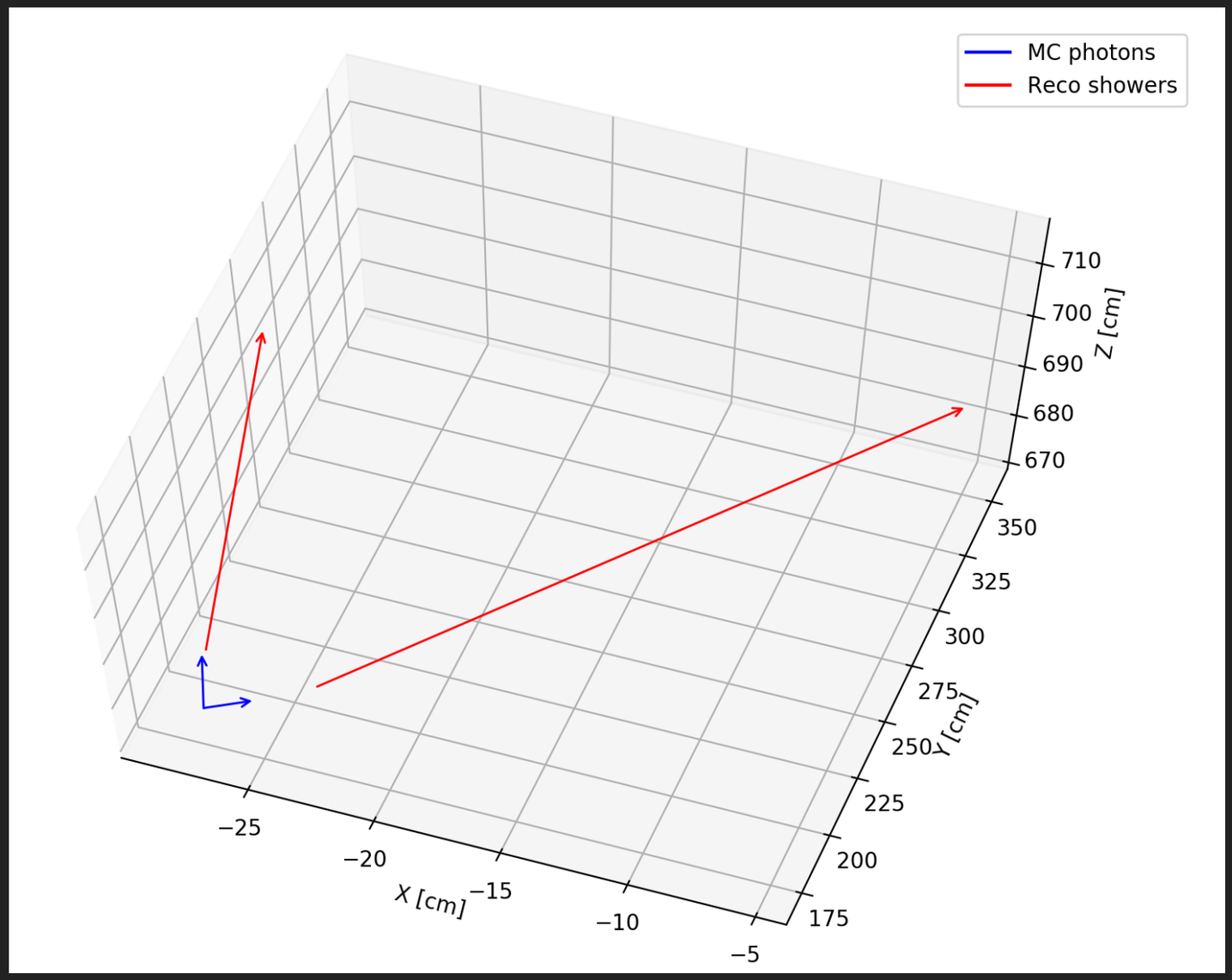
- Score: distance between MC photon endpoint and nearest reco shower start position
- Later incorporate angle, dEdx profile and others



1 GeV π⁰ in DUNE

BACKSTORY

- Main point: good shower reconstruction is needed to reconstruct a π^0
- Thanks to Steve, Leigh and James



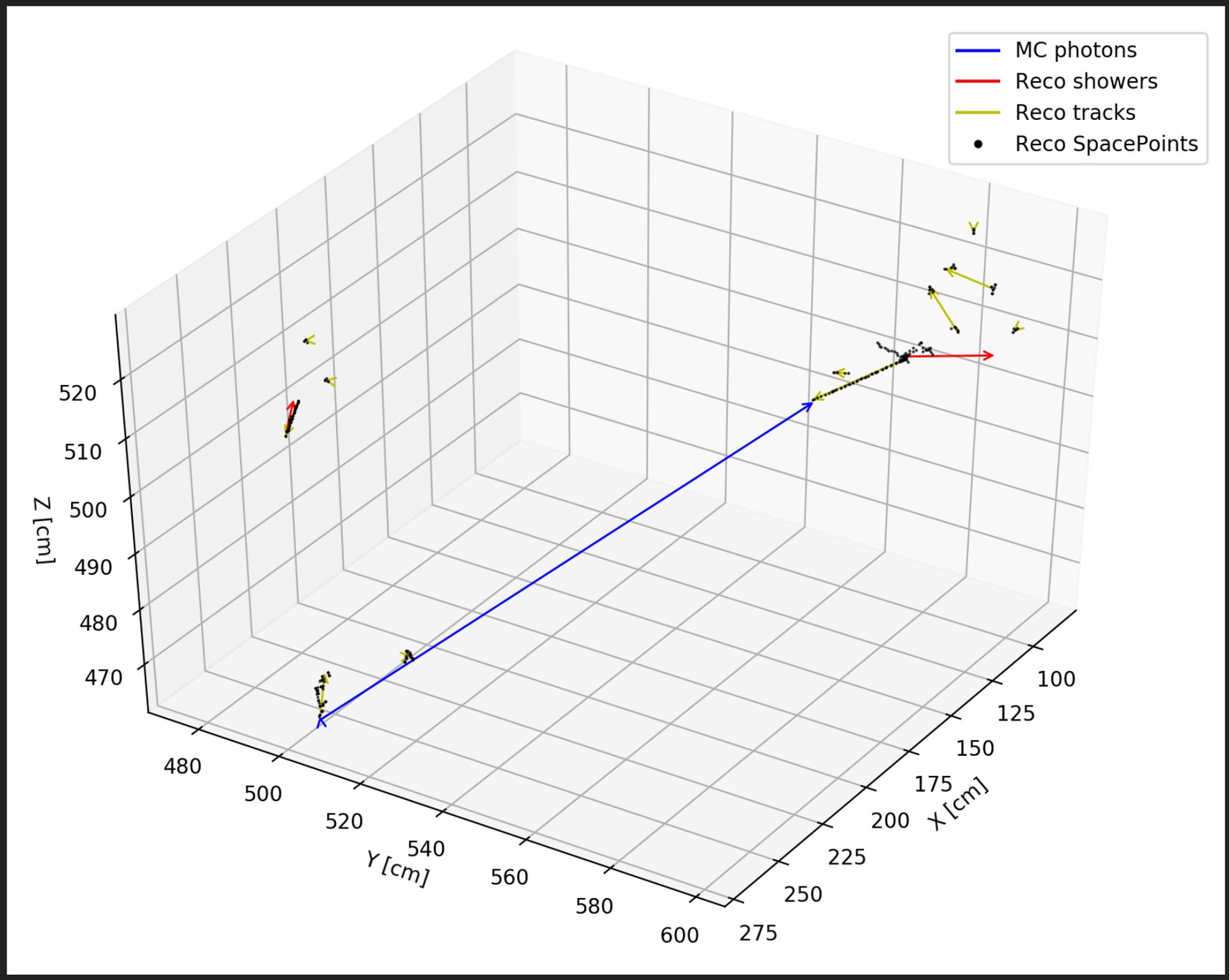
1 GeV π^0 in DUNE

DATA SETS

- ProtoDUNE single π^0 events with standard Geant4 and detector simulation
  - Standard ProtoDUNE reconstruction
  - Modified ProtoDUNE reconstruction
- DUNE single π^0 events with standard FD Geant4 and detector simulation
  - Standard DUNE FD reconstruction

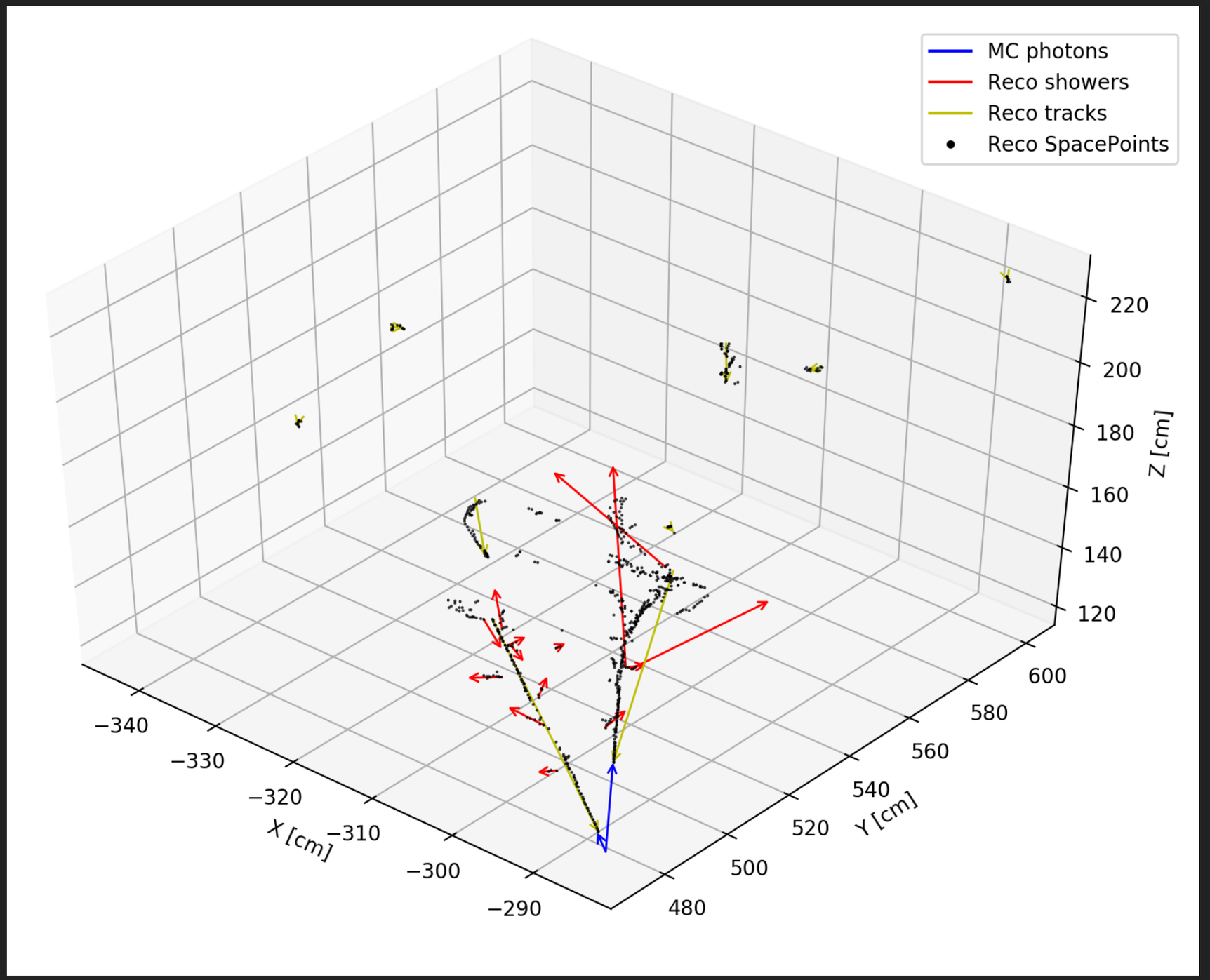
PROTODUNE STANDARD RECONSTRUCTION — 1 GEV Π⁰

- Confusion with tracks
- Tracks going in the wrong direction



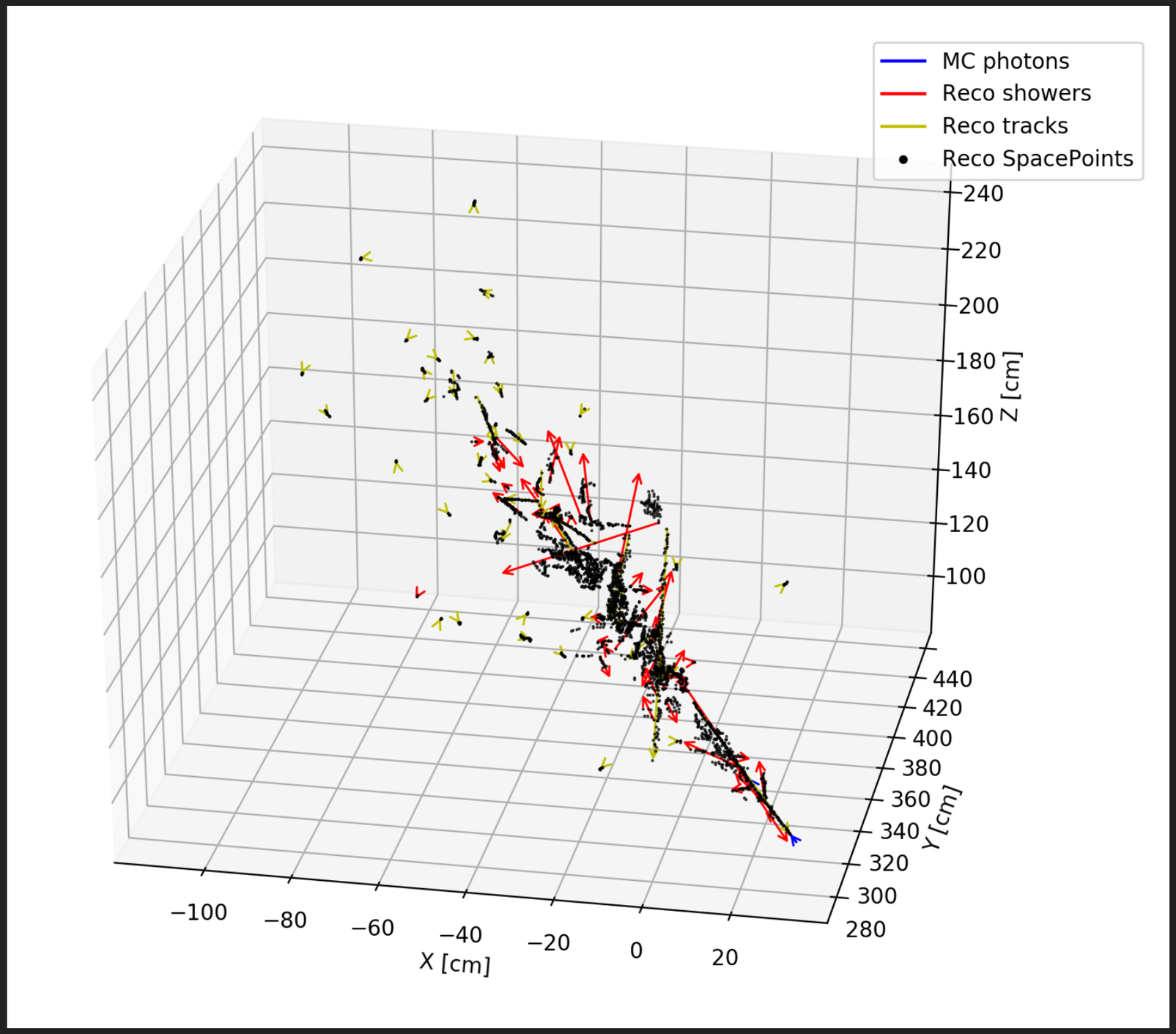
PROTODUNE STANDARD RECONSTRUCTION — 1 GEV Π⁰

- Mixing with tracks
- Segmentation into many smaller tracks and showers



PROTODUNE STANDARD RECONSTRUCTION — 5 GEV Π⁰

- Mixing with tracks
- Segmentation into many smaller tracks and showers



PROTODUNE MODIFIED RECONSTRUCTION

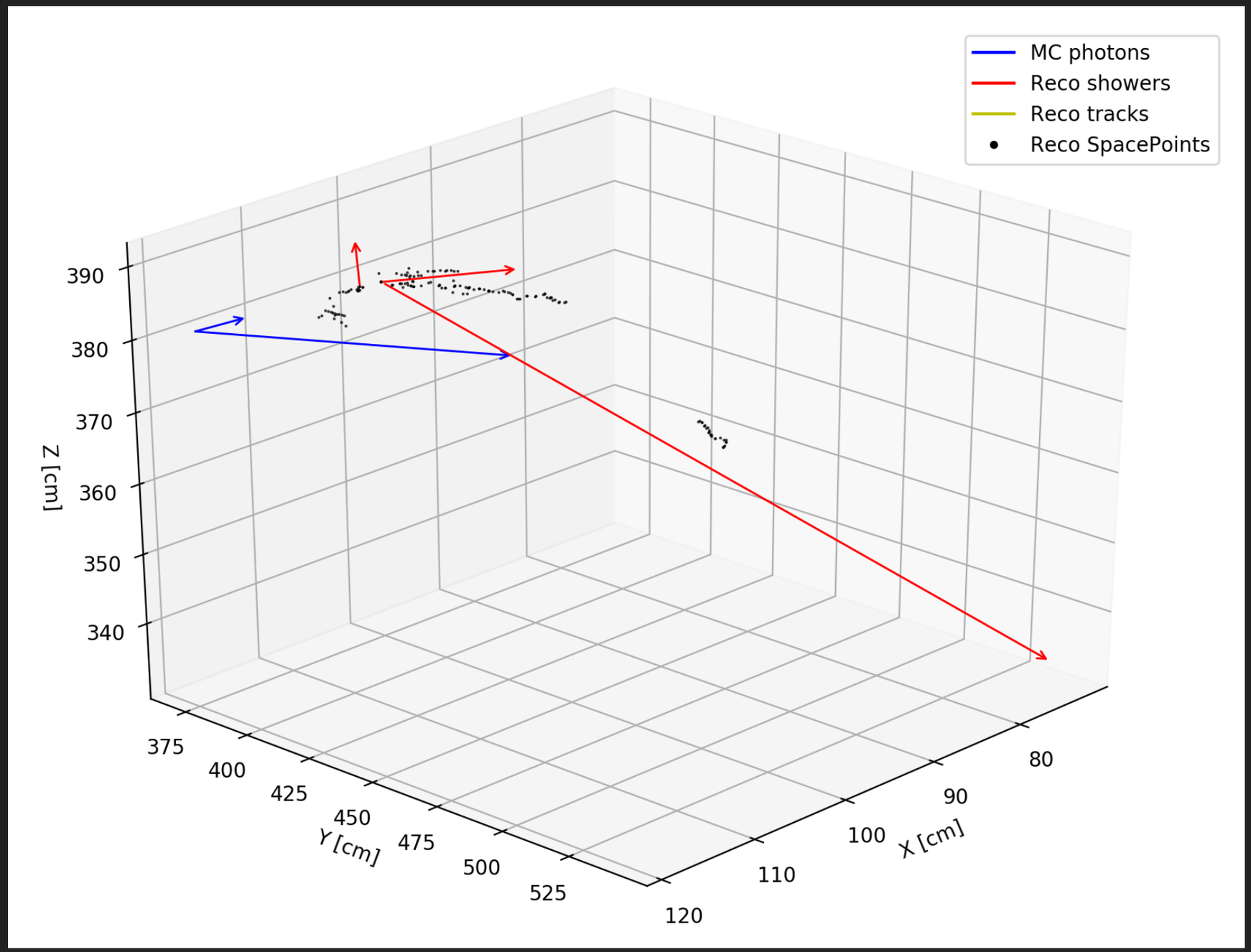
- Standard reco considers π^0 to be cosmic -> tries to split shower into cosmic rays
- Difference from standard reconstruction:

```
> physics.producers.pandora.ShouldRunAllHitsCosmicReco:       false
> physics.producers.pandora.ShouldRunStitching:               false
> physics.producers.pandora.ShouldRunCosmicHitRemoval:        false
> physics.producers.pandora.ShouldRunSlicing:                 false
> physics.producers.pandora.ShouldRunNeutrinoRecoOption:      true
> physics.producers.pandora.ShouldRunCosmicRecoOption:        false
> physics.producers.pandora.ShouldPerformSliceId:             false
```

- ShouldRunNeutrinoRecoOption forces Pandora to consider the π^0 as a test beam particle instead of cosmic

PROTODUNE MODIFIED RECONSTRUCTION — 1 GEV Π⁰

- Much fewer tracks
- Showers in roughly the right spot
- Tend to cross between showers



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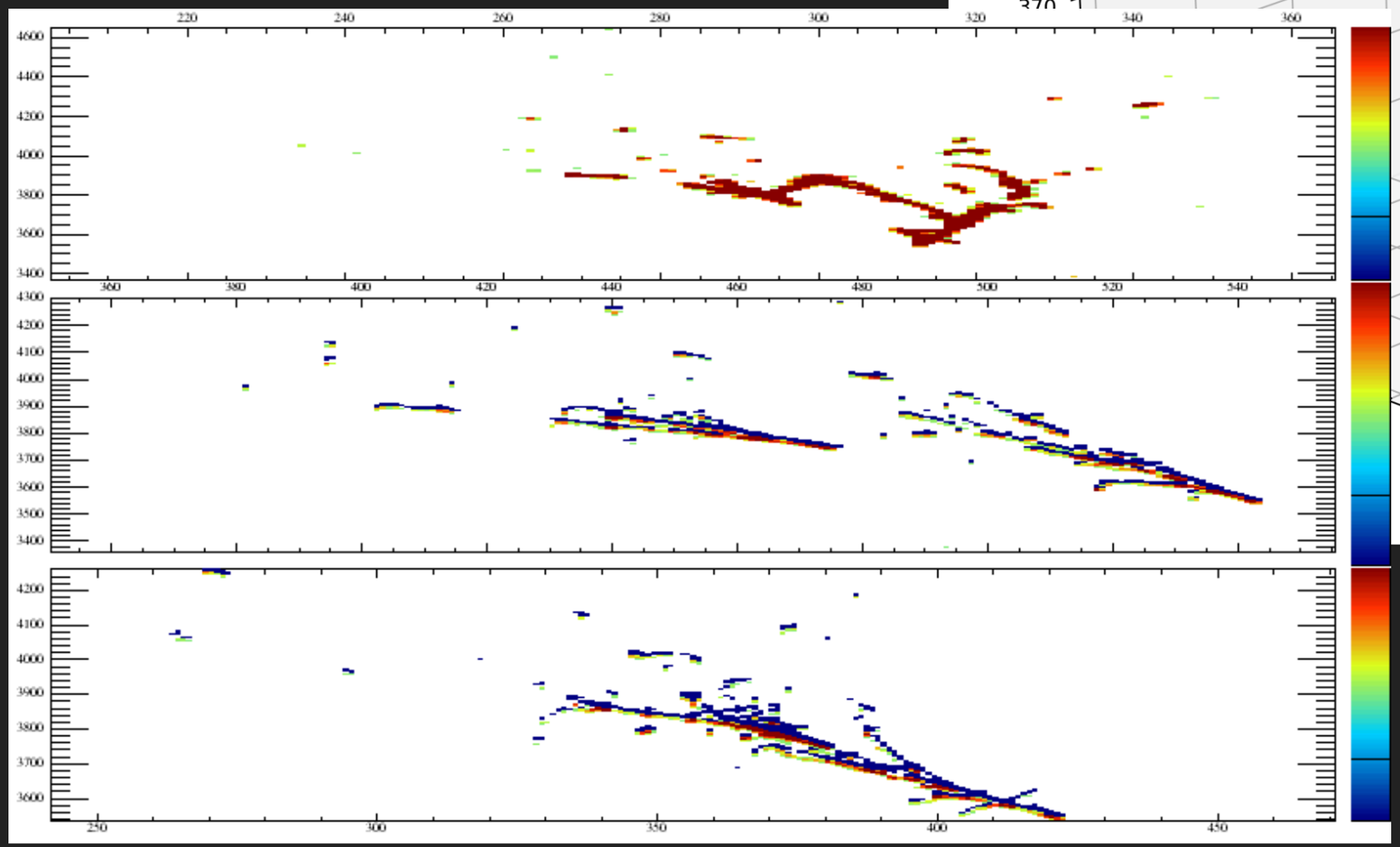

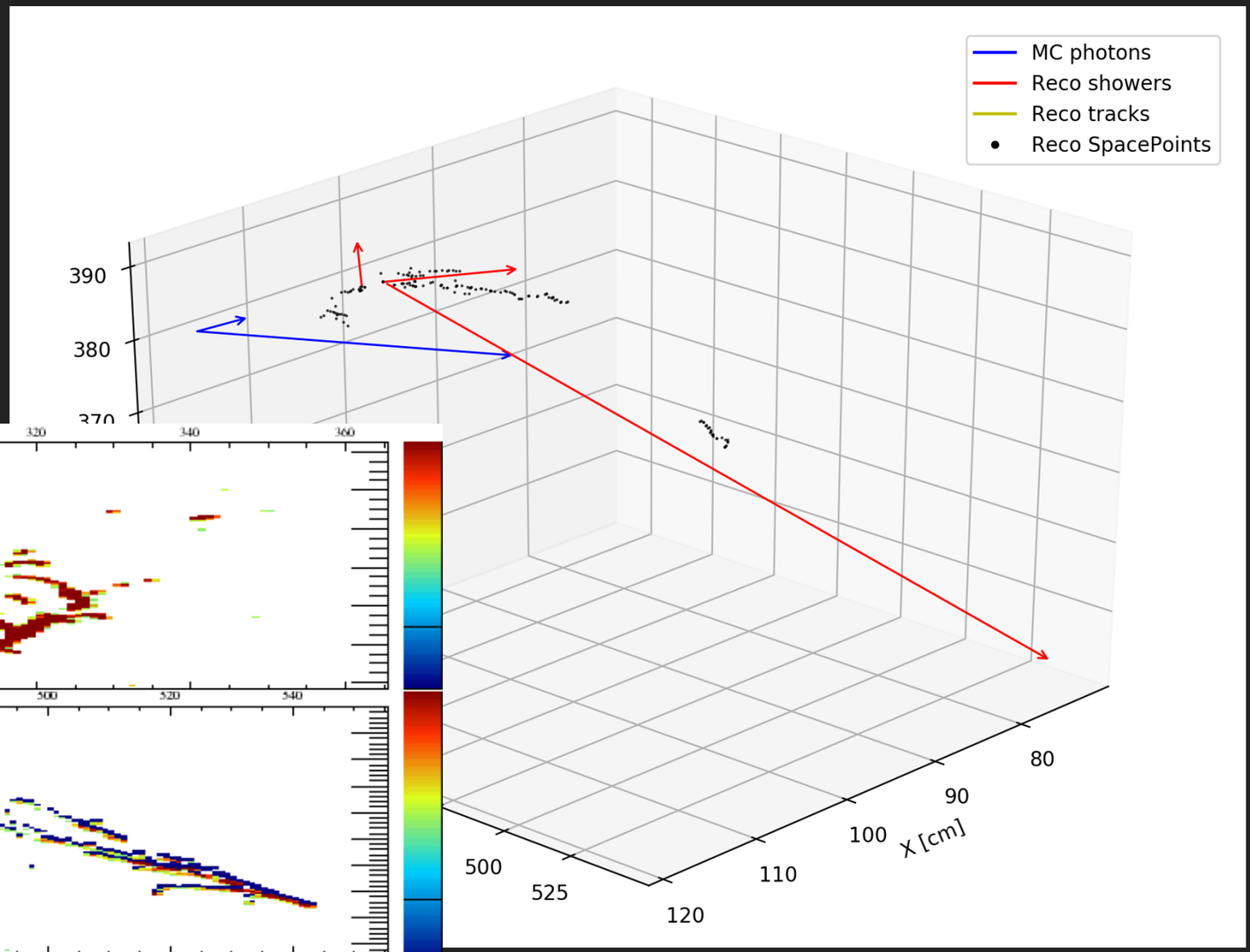

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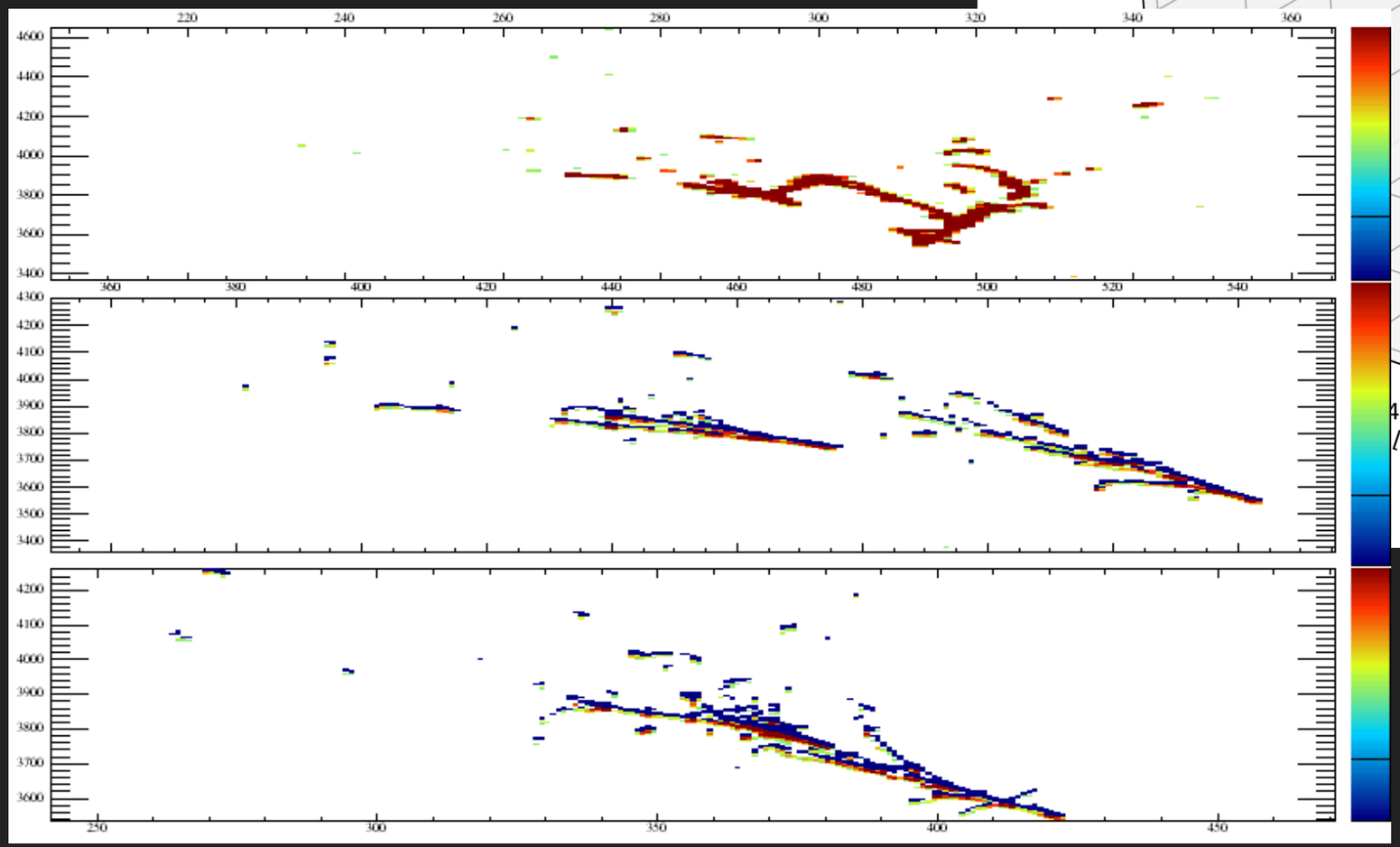

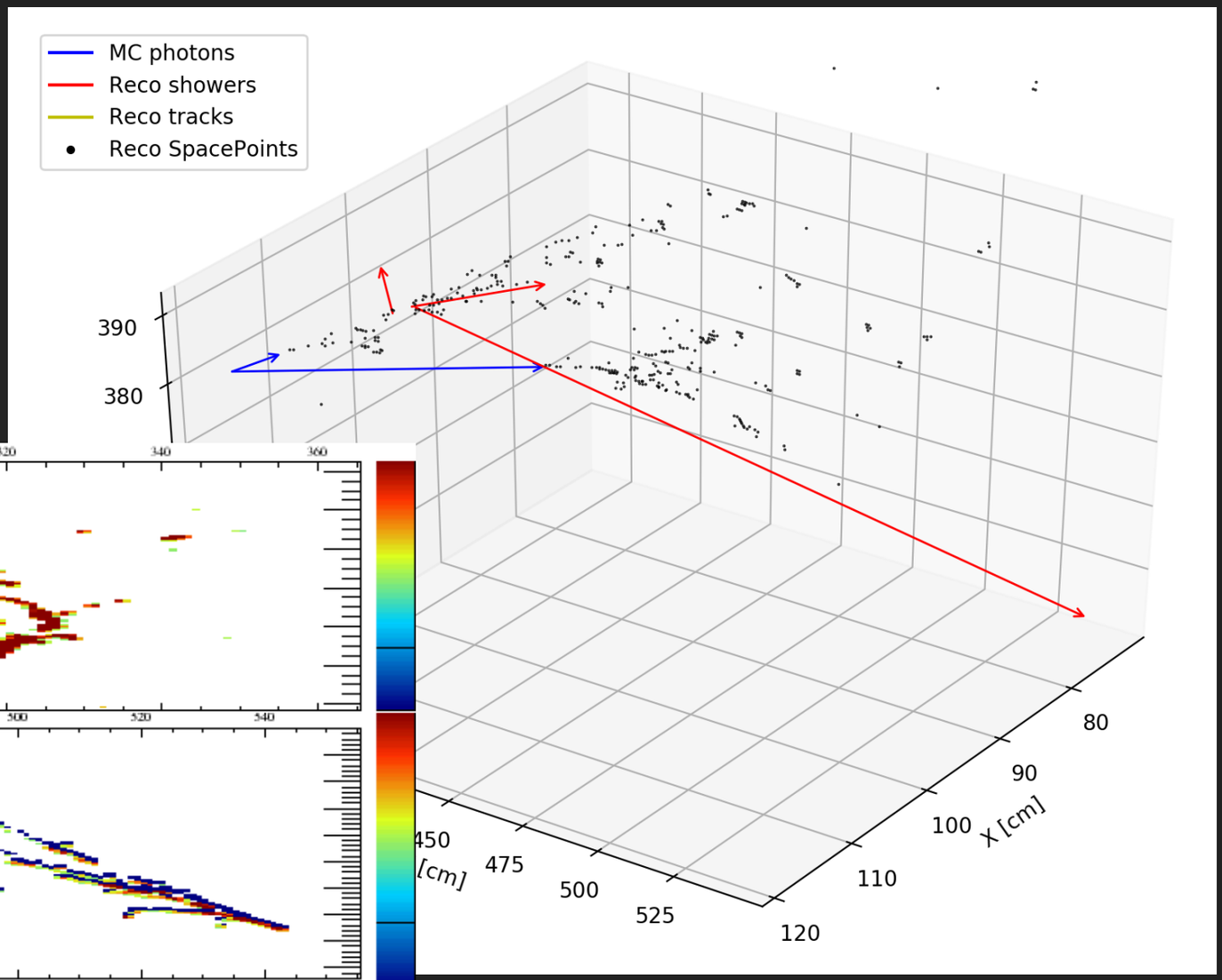

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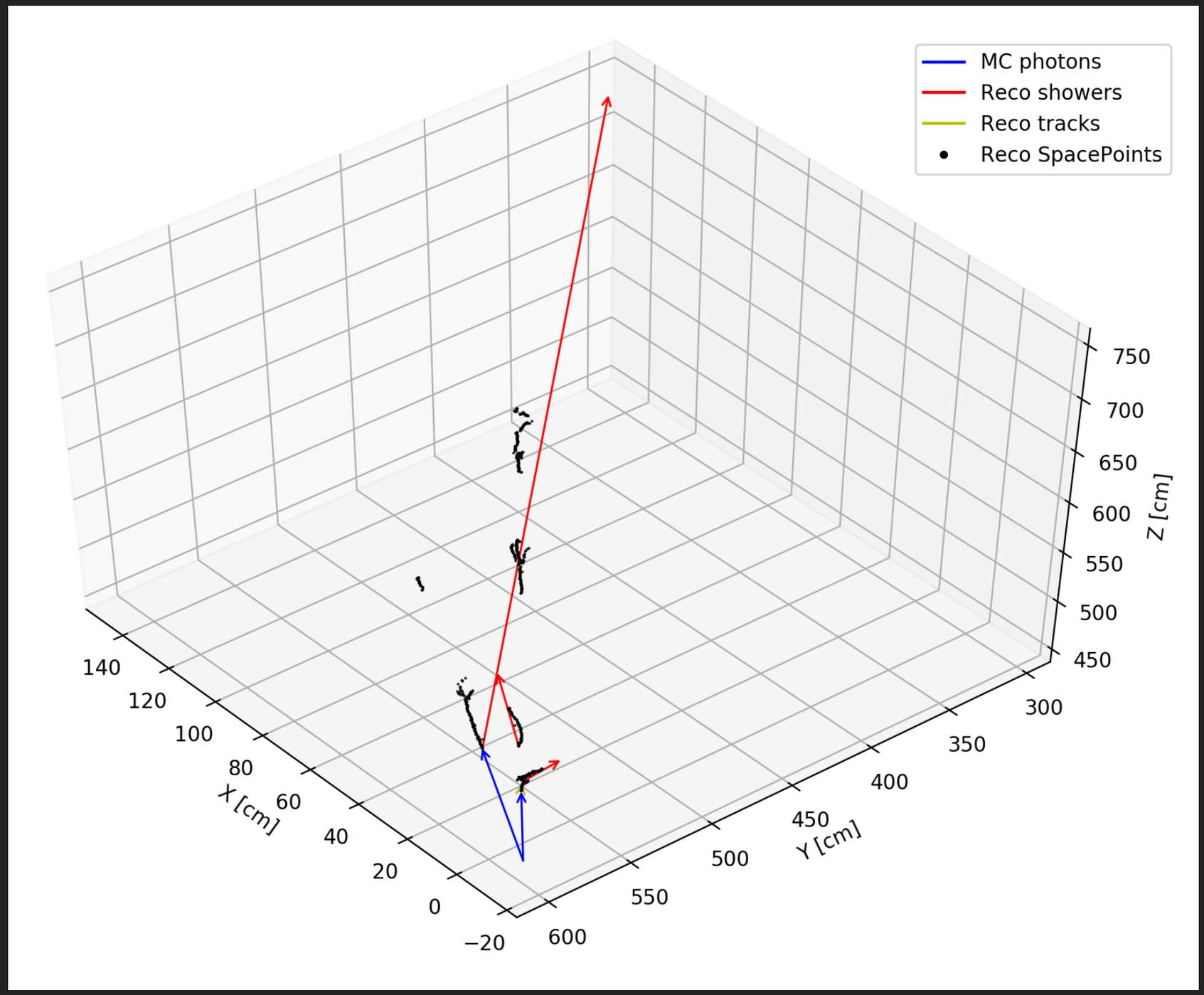

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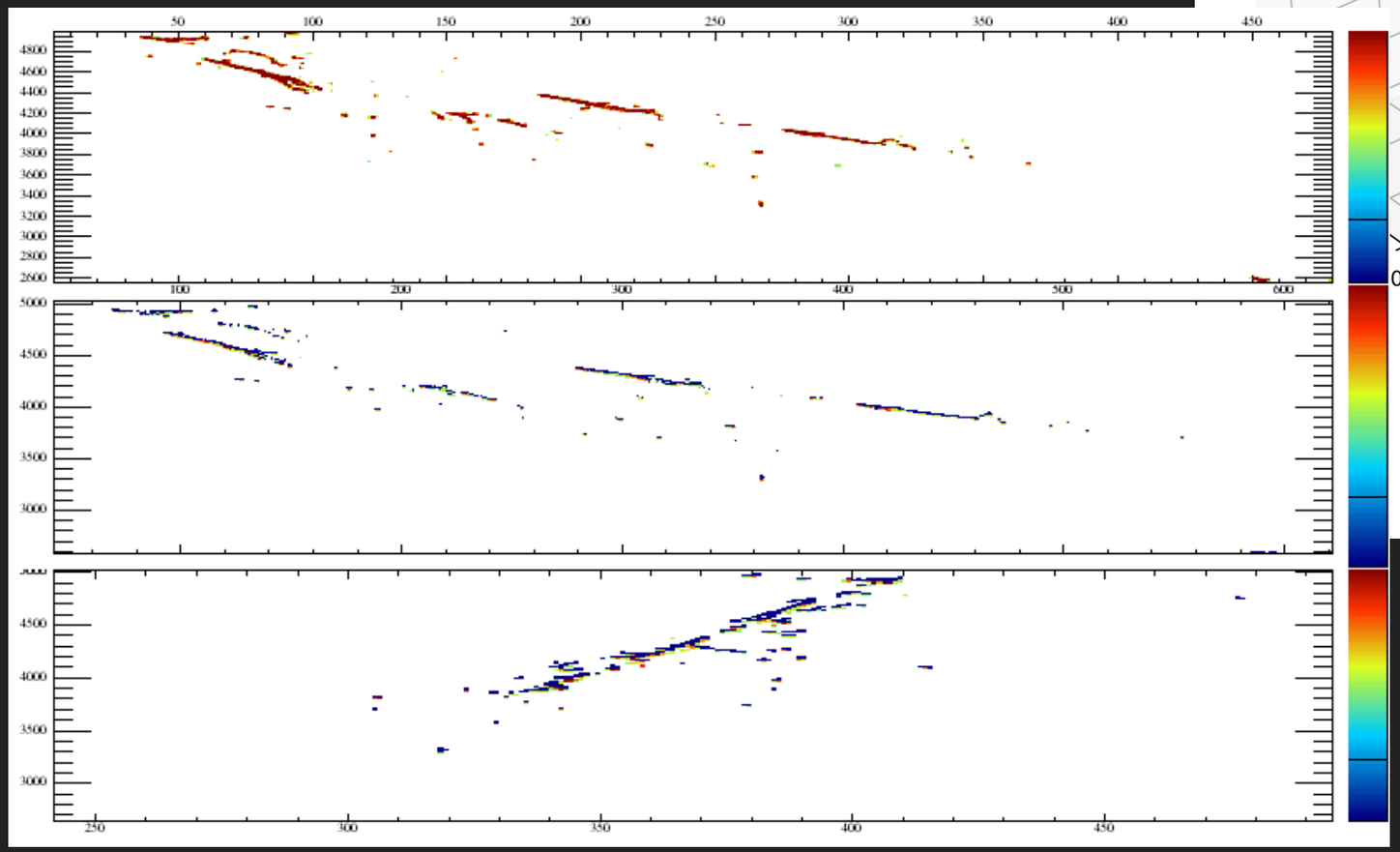
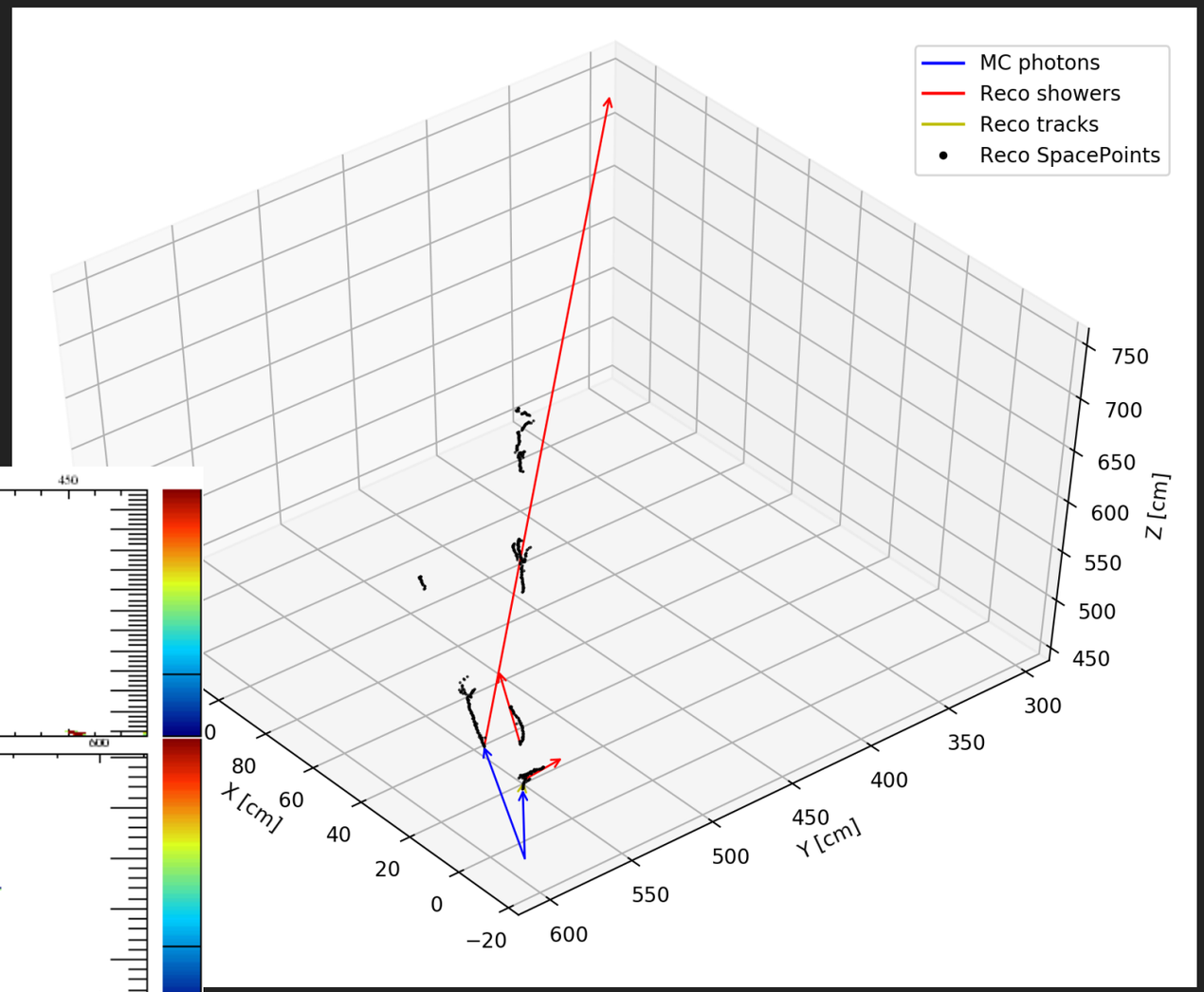
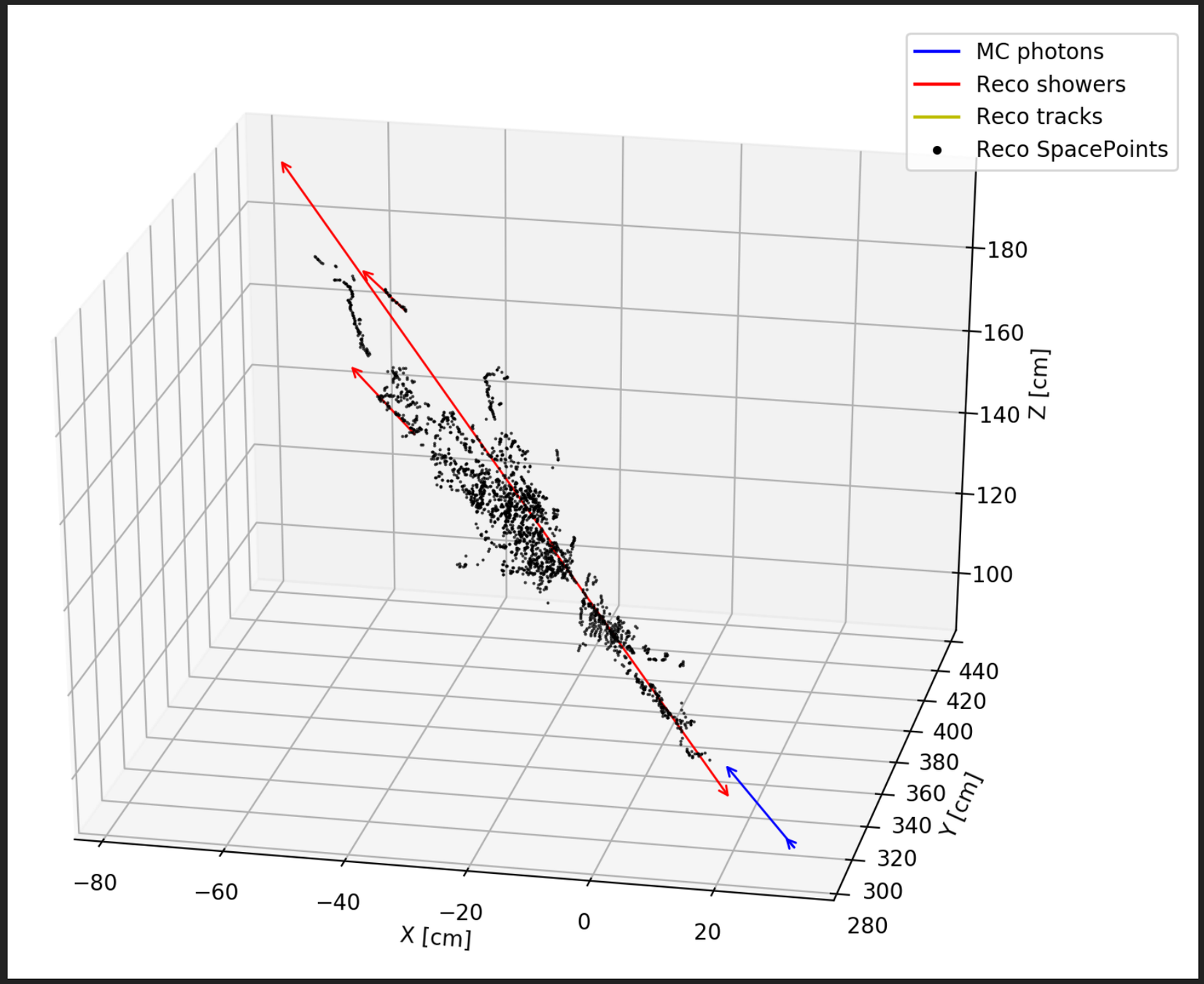




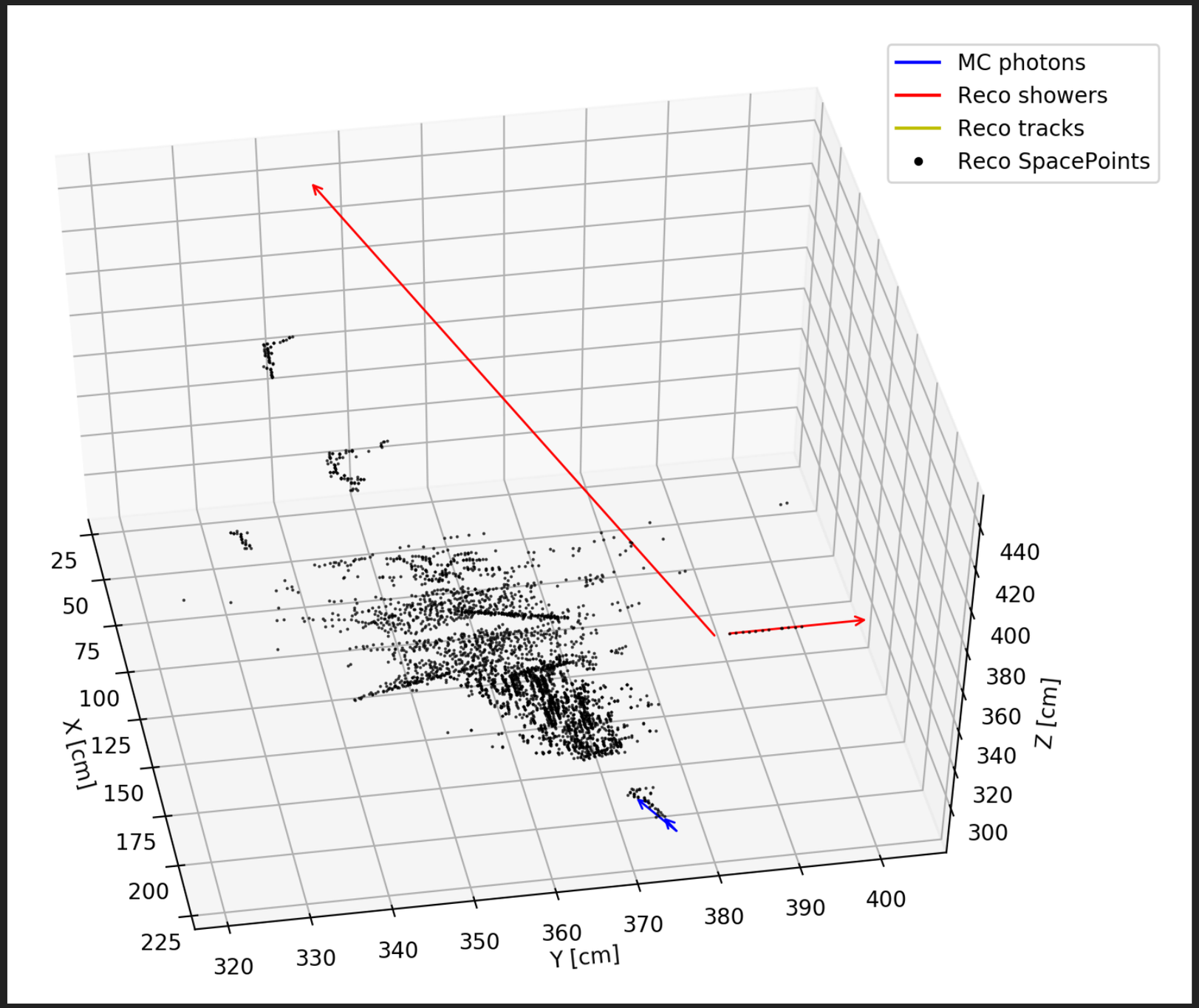
PROTODUNE MODIFIED RECONSTRUCTION — 5 GEV Π⁰

- Bigger showers recognised, but still split up



PROTODUNE MODIFIED RECONSTRUCTION — 5 GEV Π⁰

- Strangely misplaced showers in some events (in X, Y and Z)
- Otherwise good direction



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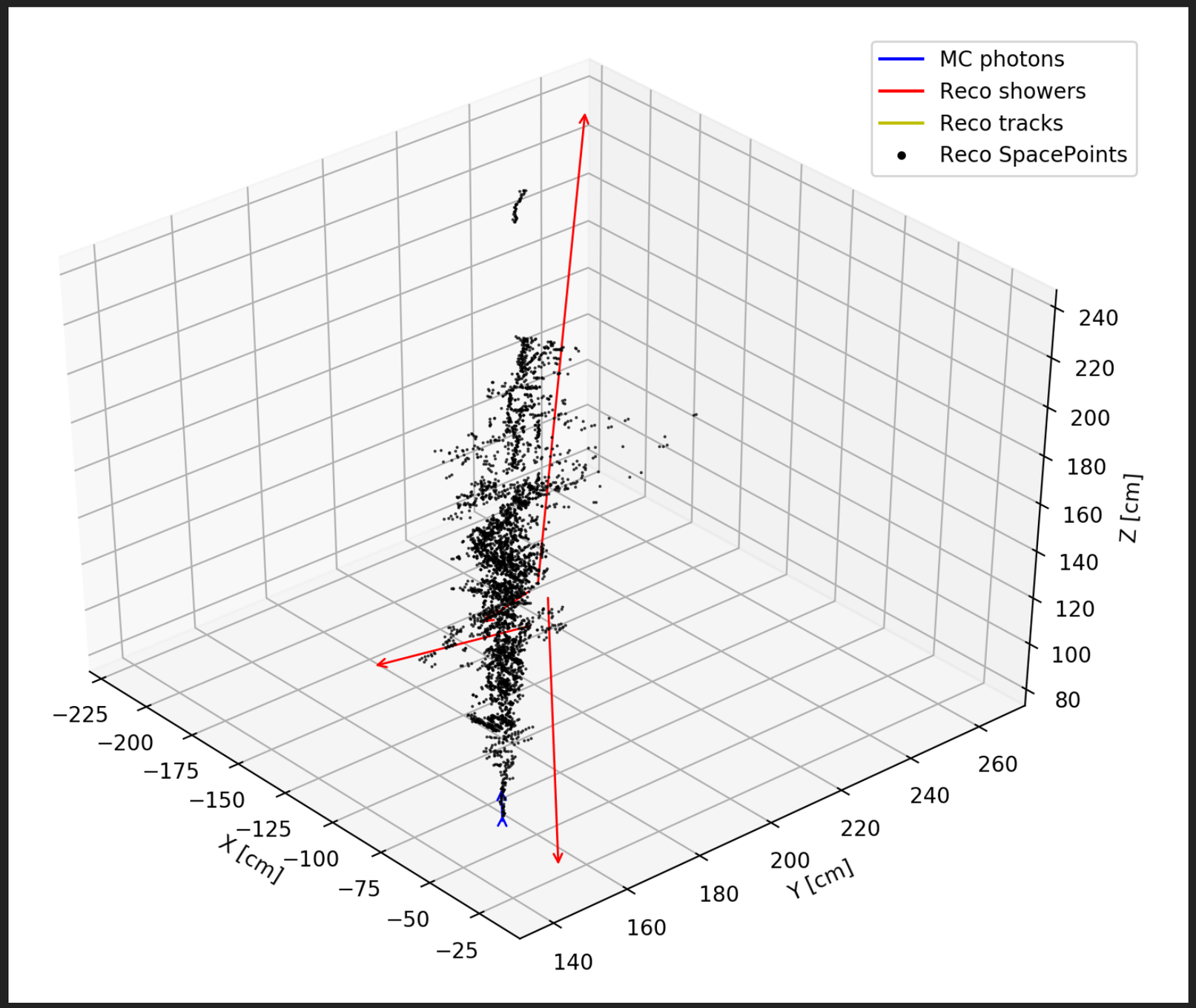
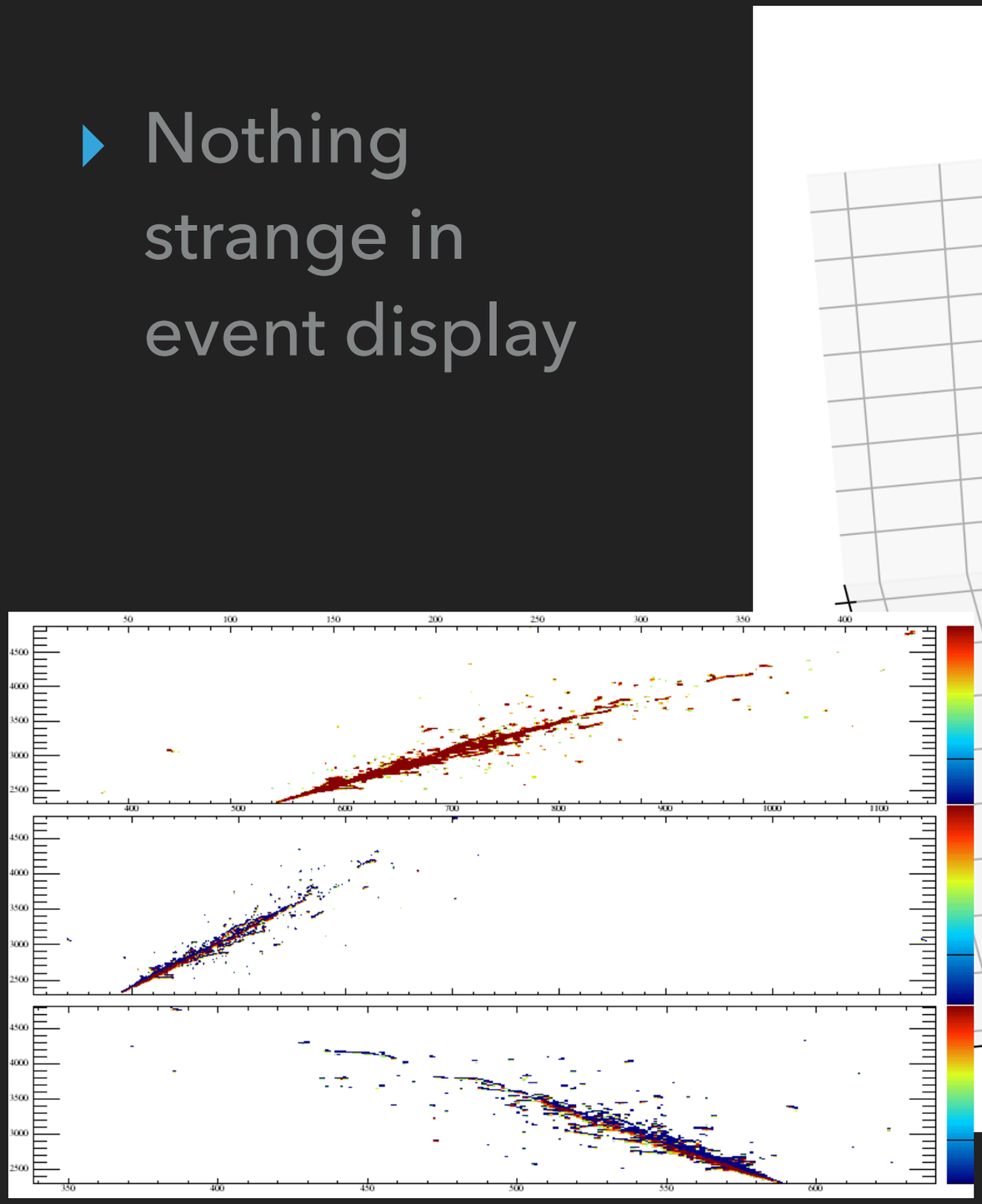
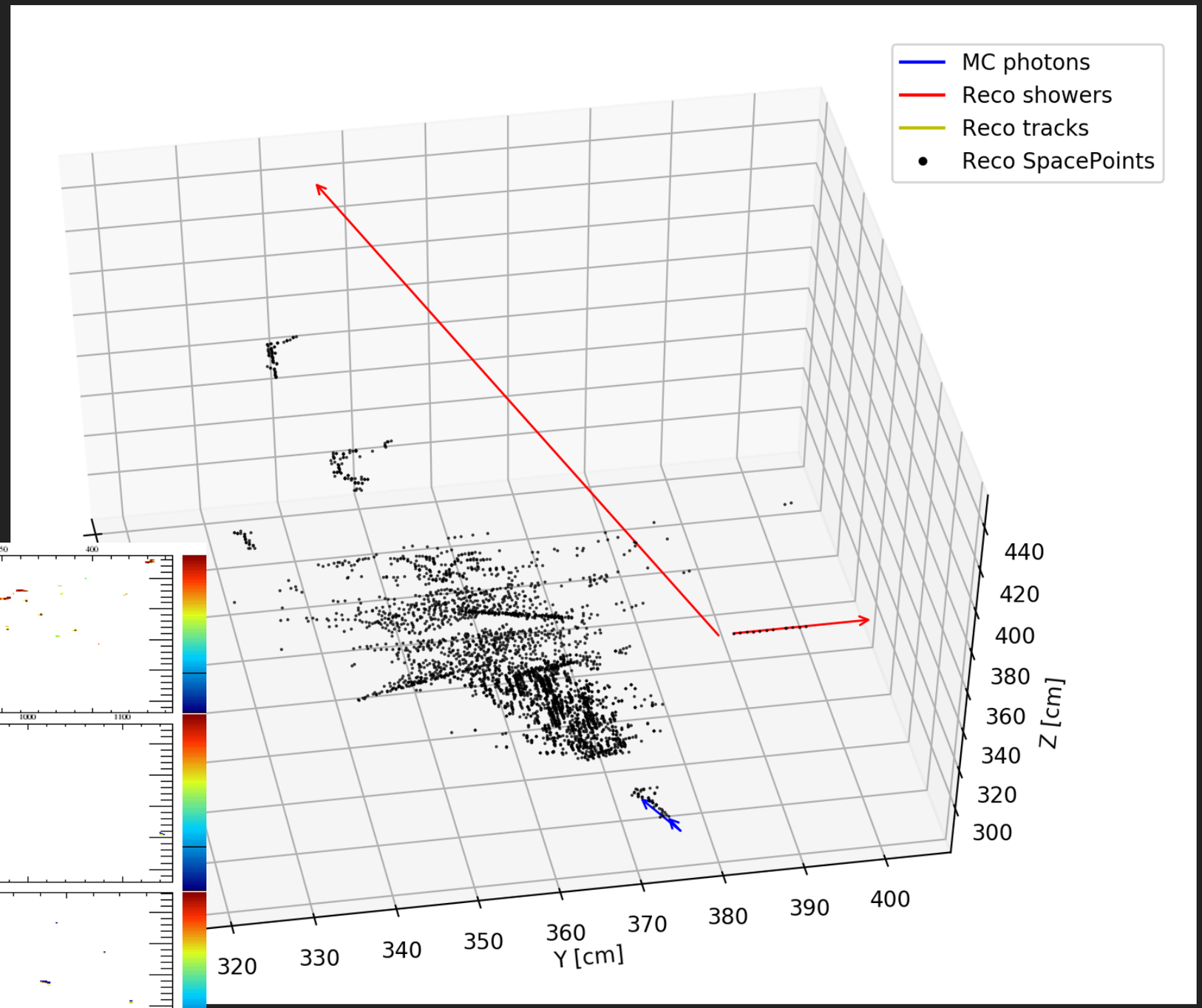


PROTODUNE MODIFIED RECONSTRUCTION — 5 GEV Π⁰

- Nothing strange in event display



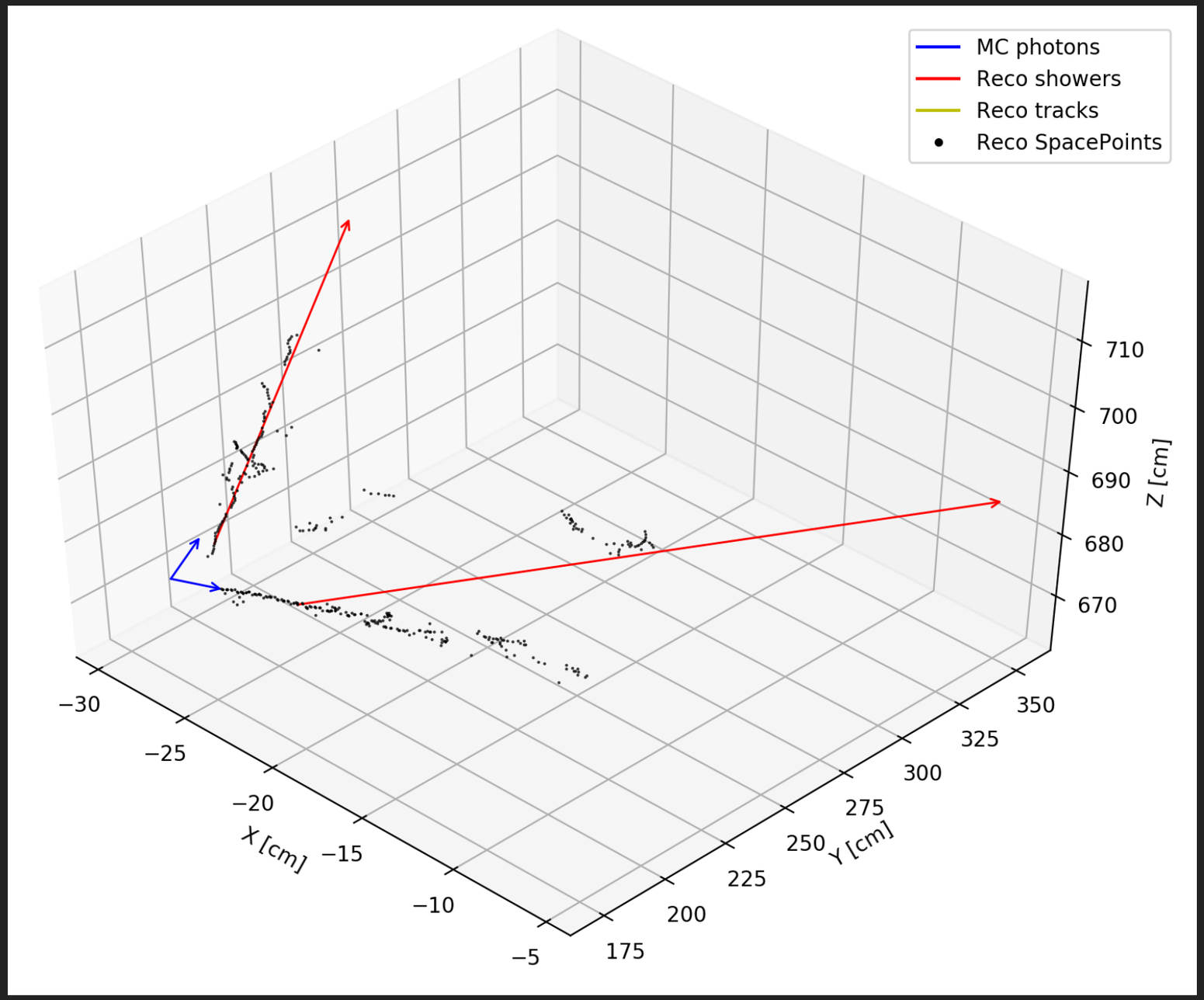


DUNE STANDARD RECONSTRUCTION

- Single π^0 events generated with standard 10kt fcl parameters

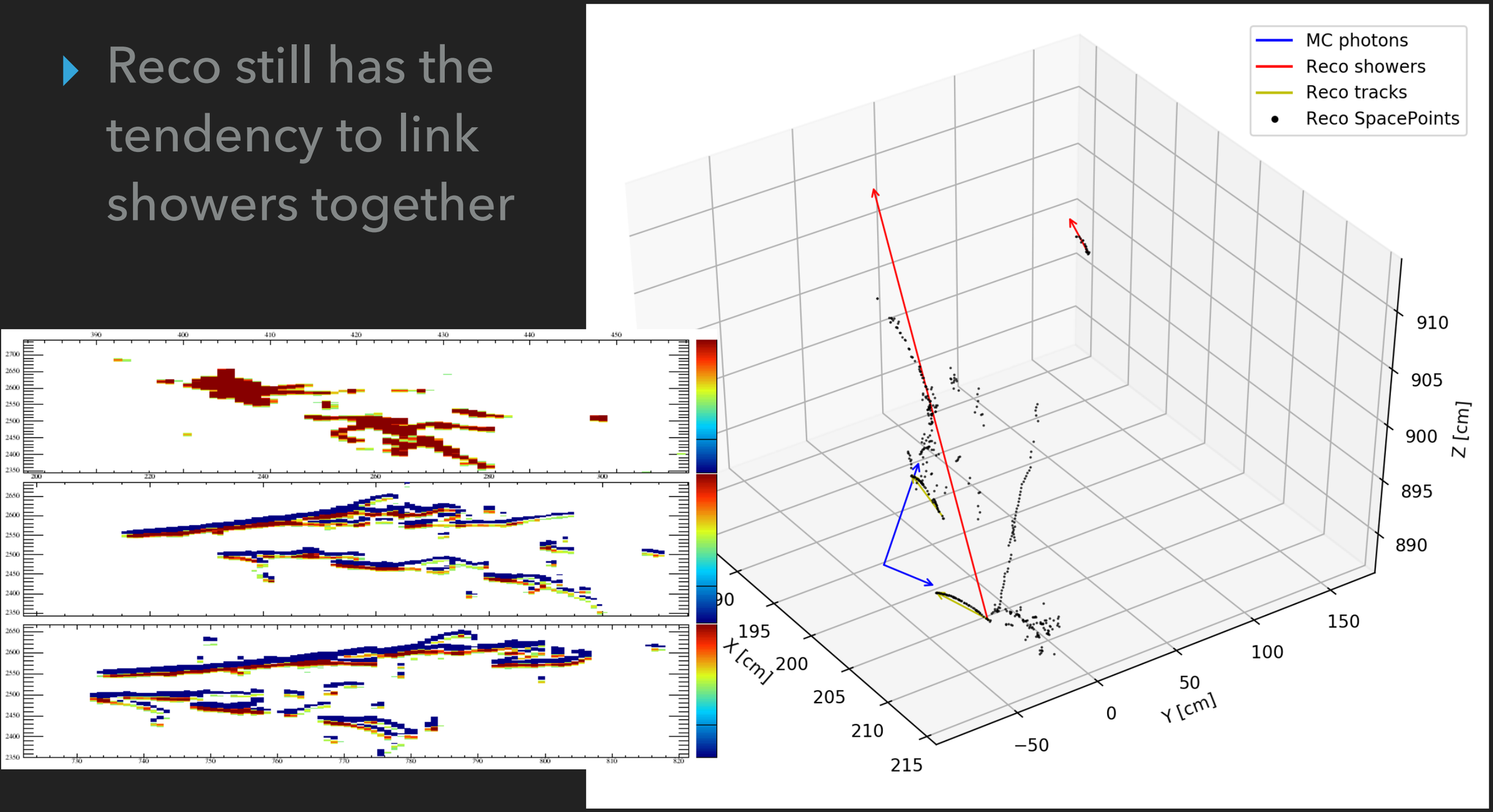
DUNE STANDARD RECONSTRUCTION — 1 GEV Π⁰

- Looks more like the modified than standard ProtoDUNE reco
- Few tracks, showers mostly in the right place



DUNE STANDARD RECONSTRUCTION — 1 GEV Π⁰

- Reco still has the tendency to link showers together



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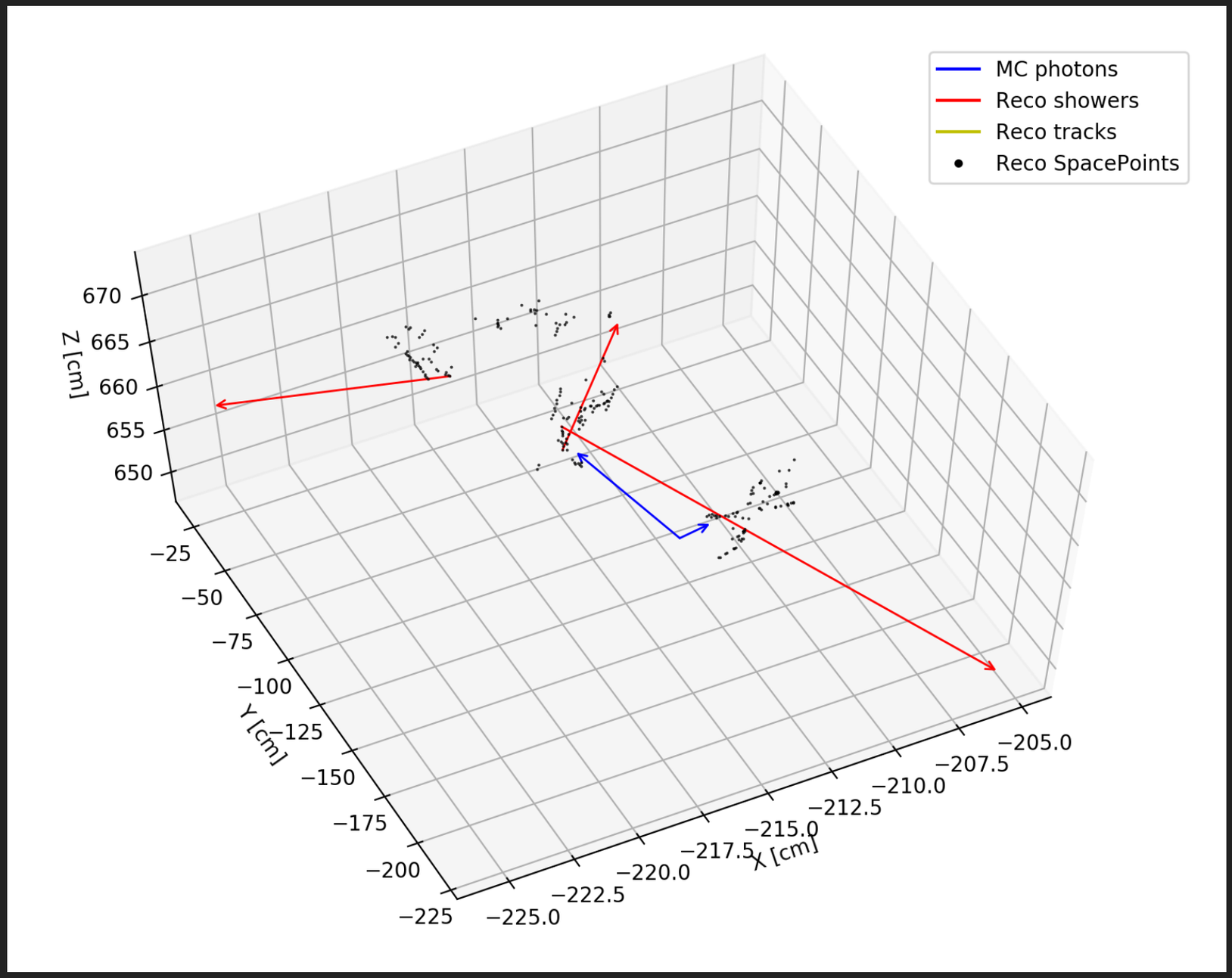
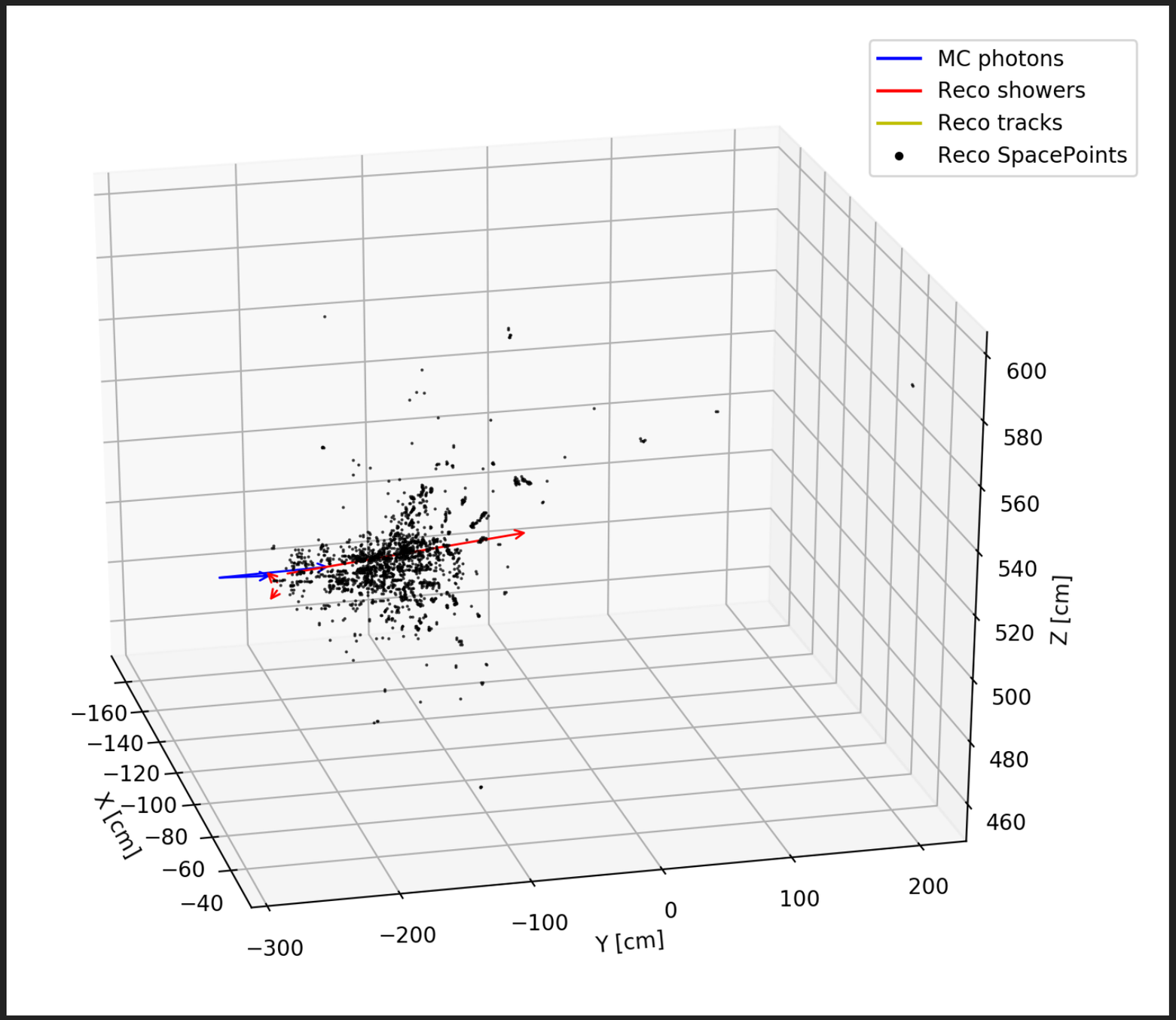


DUNE STANDARD RECONSTRUCTION — 1 GEV Π⁰

- Found a couple good events as well



SUMMARY AND PLANS

- Reconstructed showers in the form shown here often do not seem to match actual showers

- Look more into Pandora shower reconstruction if needed
- π^0 reconstruction cannot proceed without accurate shower reconstruction

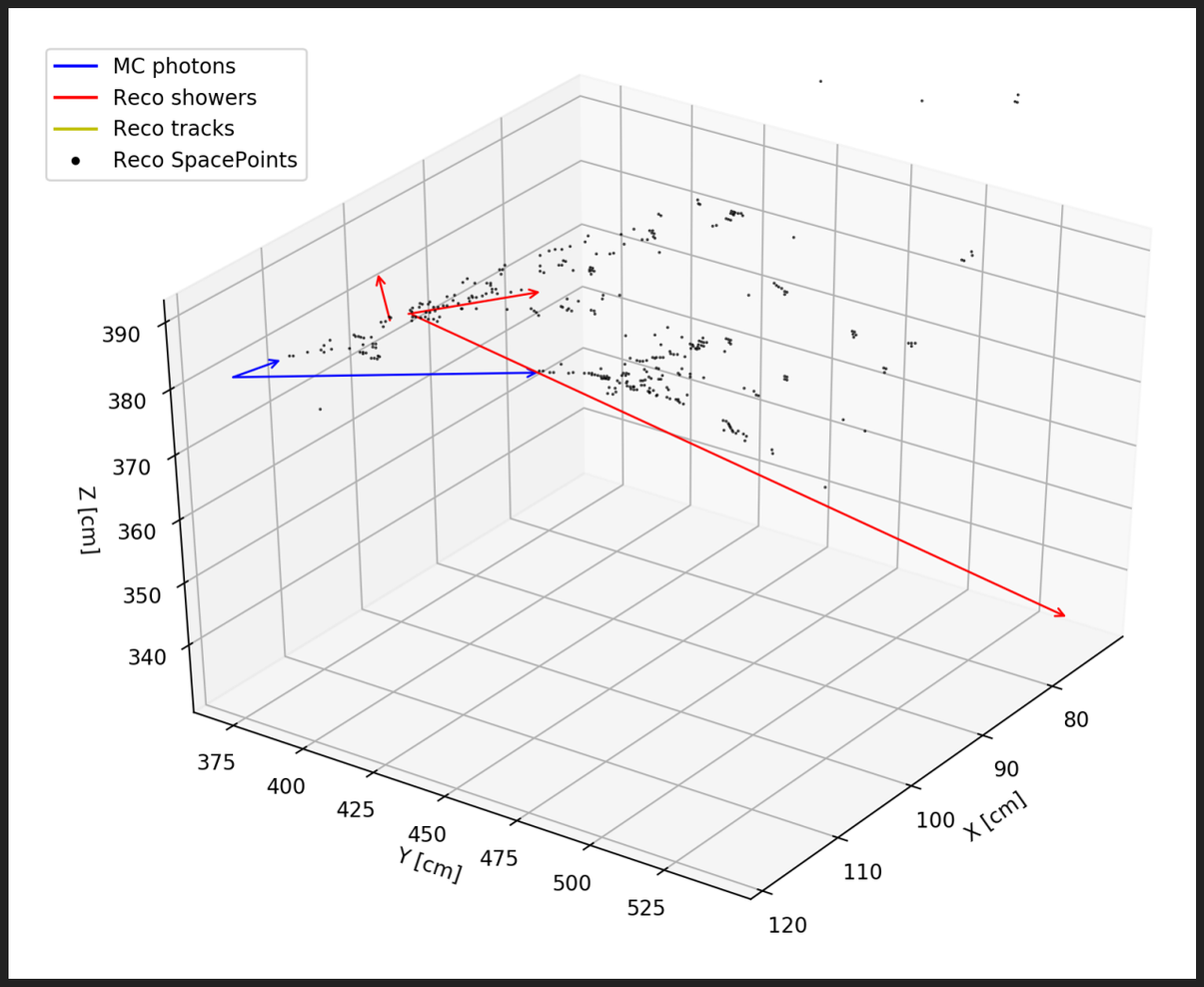
BACKUP

SPOT THE BUG

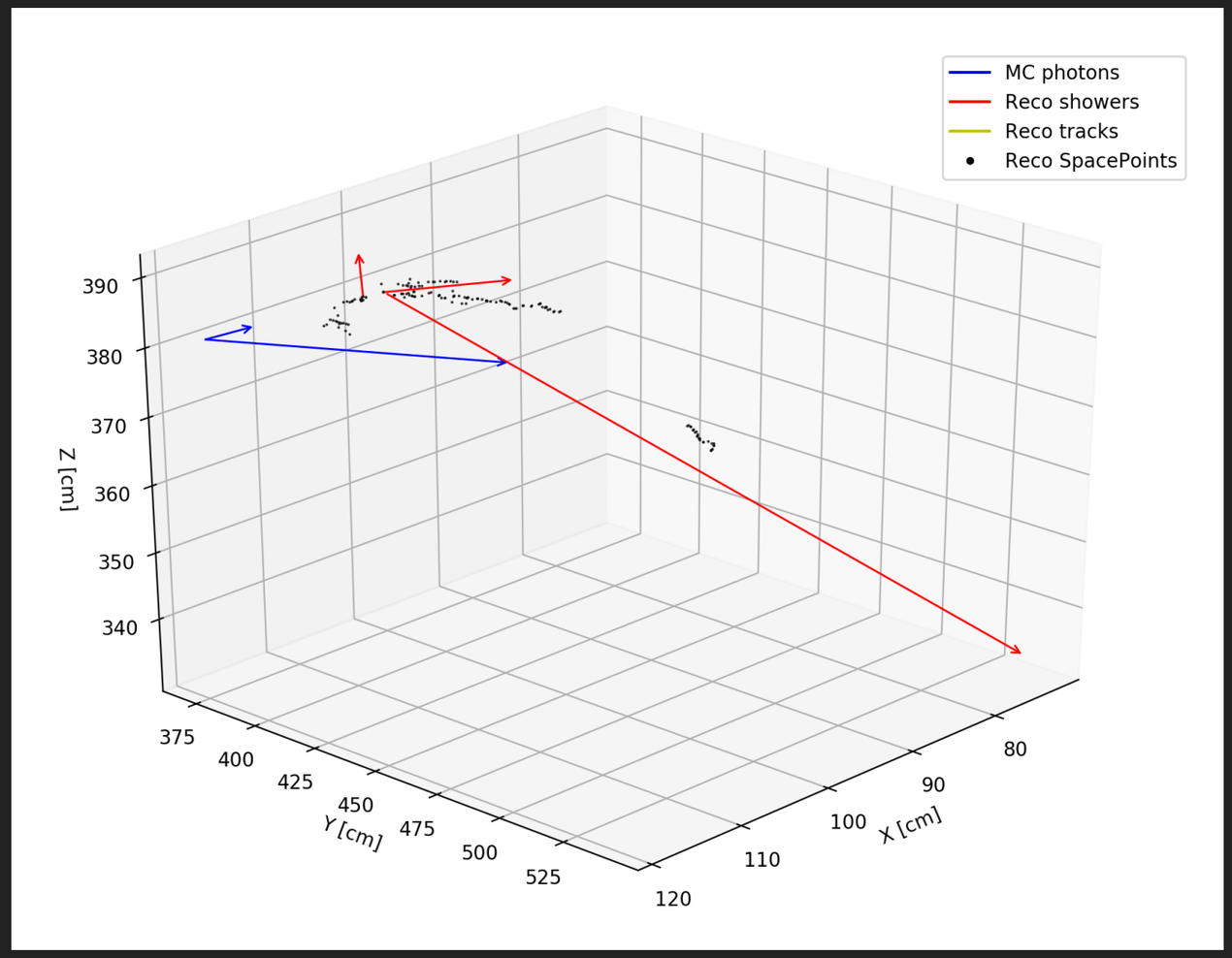
```
const TVector3 shStart = shower->ShowerStart();
const TVector3 shEnd = shStart + shower->Direction()*shower->Length();
```

```
shfile << shStart.X() << ' ' << shStart.Y() << ' ' << shStart.Z() << ' '
       << shEnd.X() << ' ' << shEnd.Y() << ' ' << shEnd.Z() << '\n';
```

COMPARISON RECO3D AND PANDORA SPACEPOINTS



reco3d



pandora

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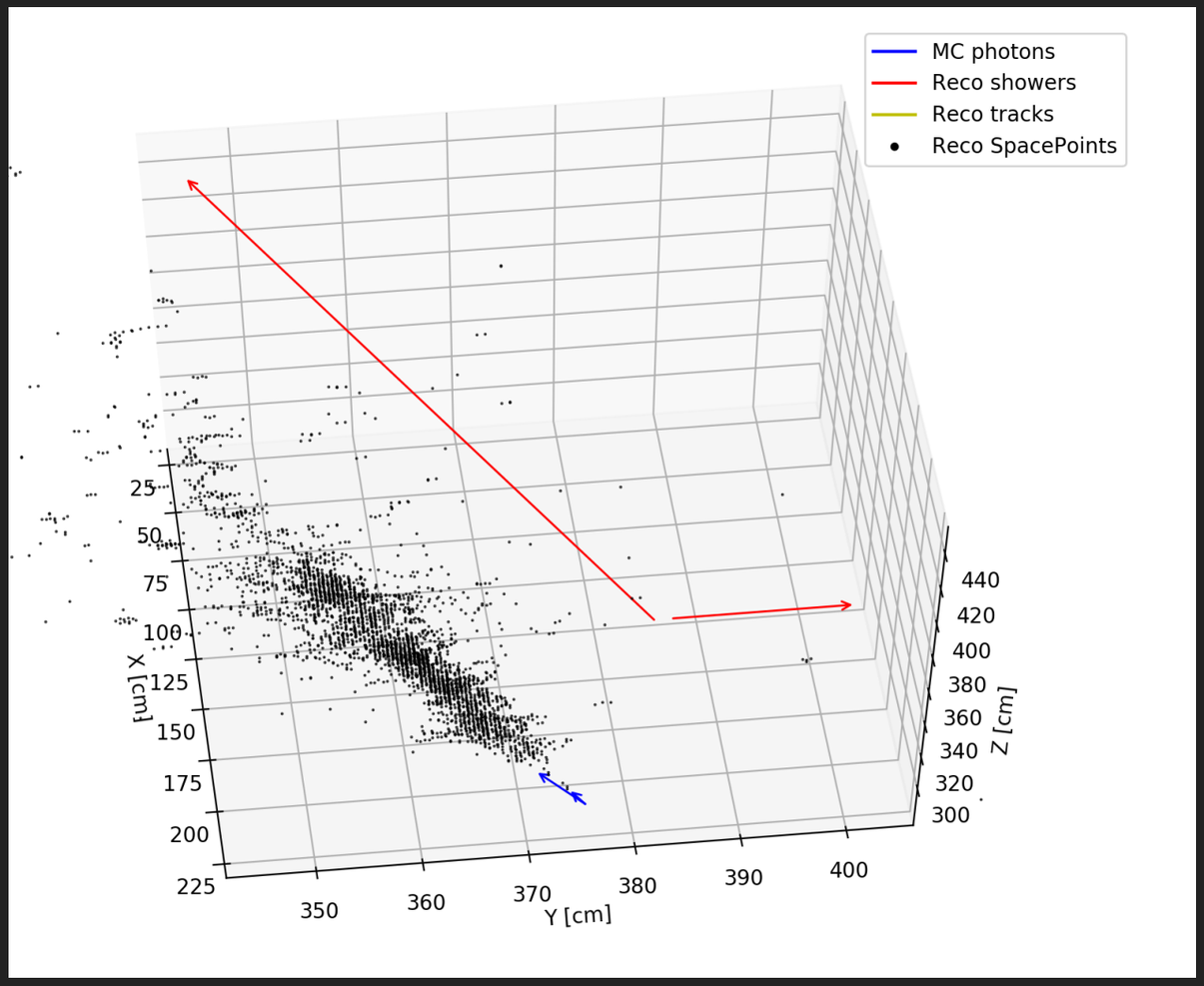
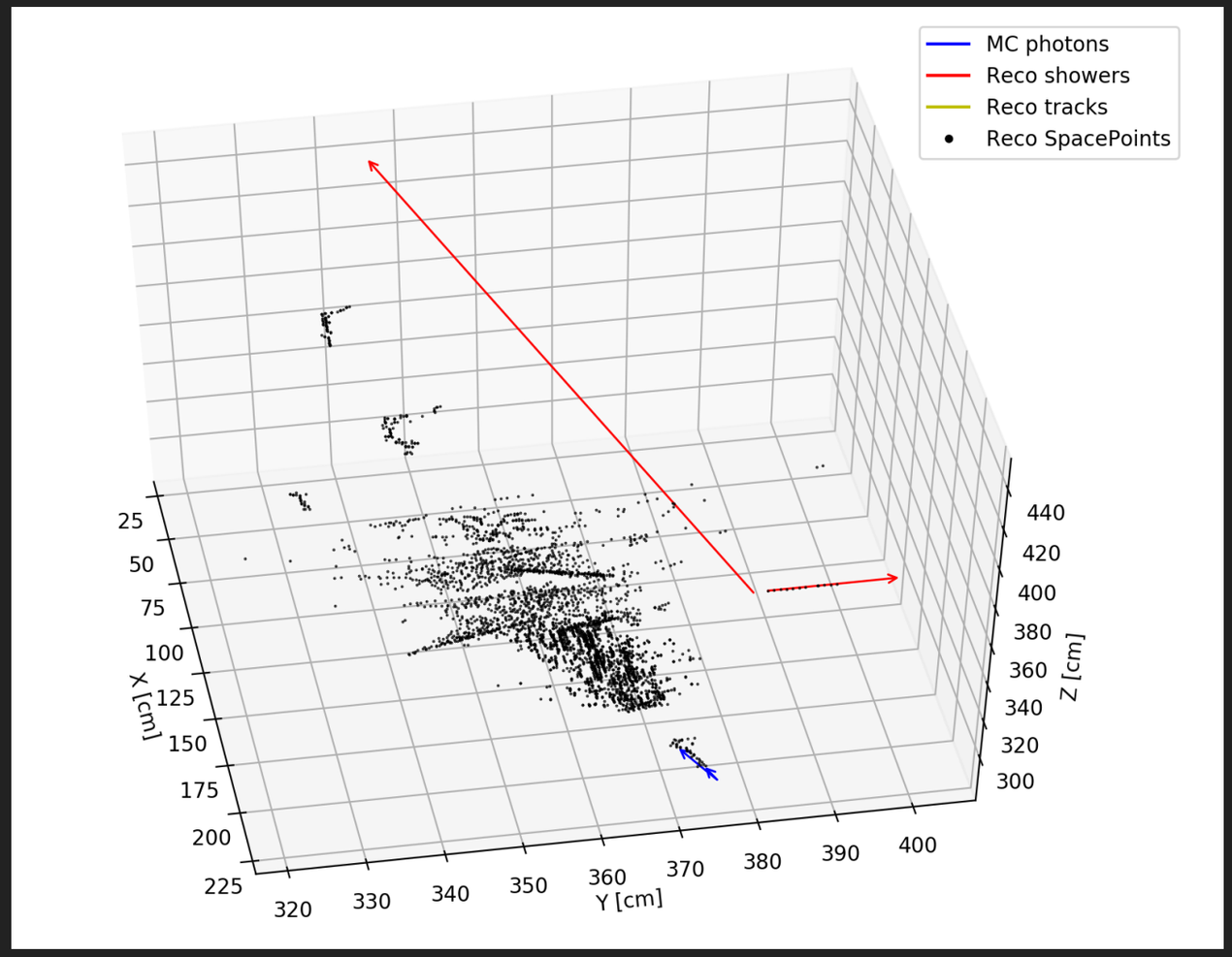


reco3d



pandora

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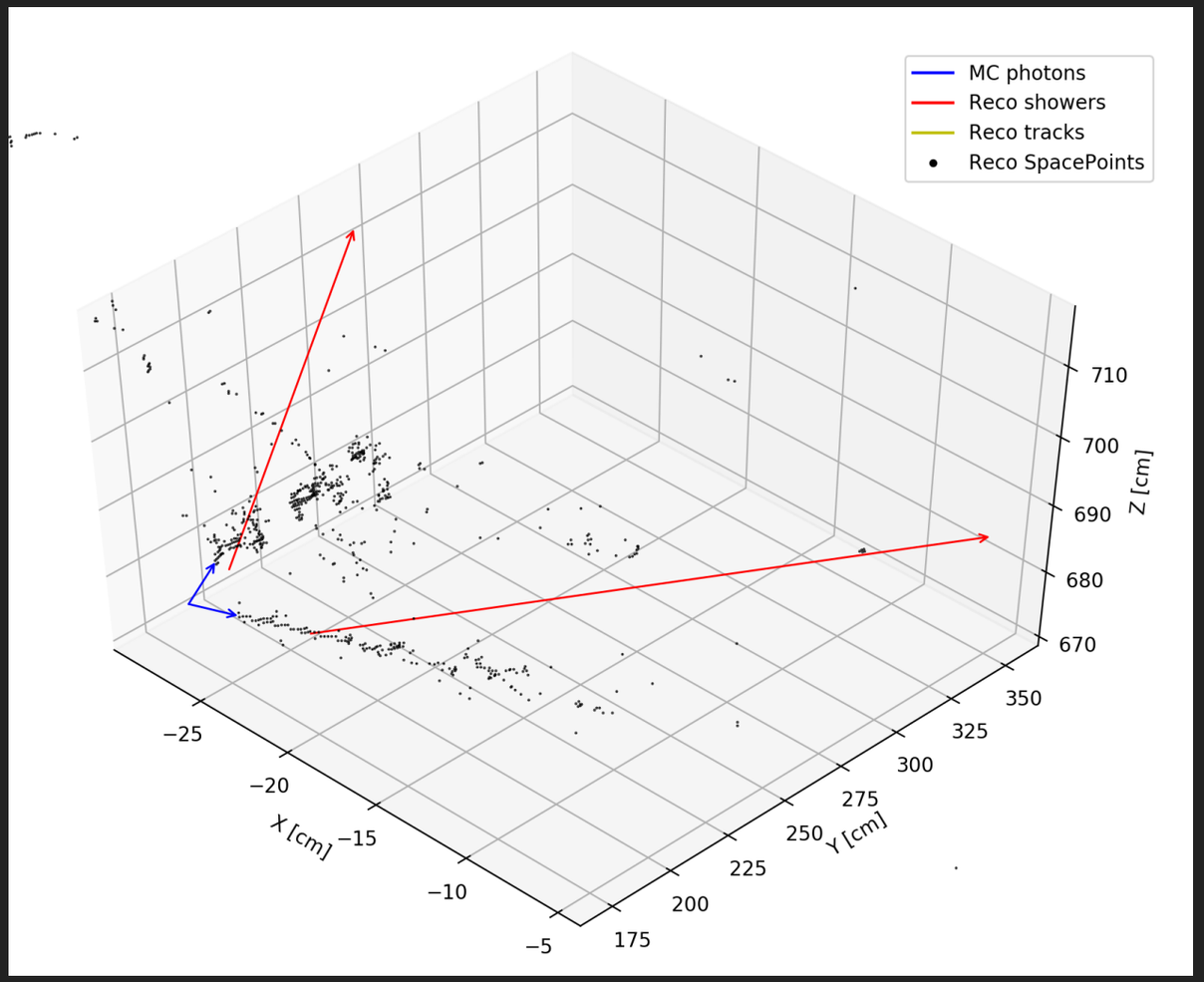
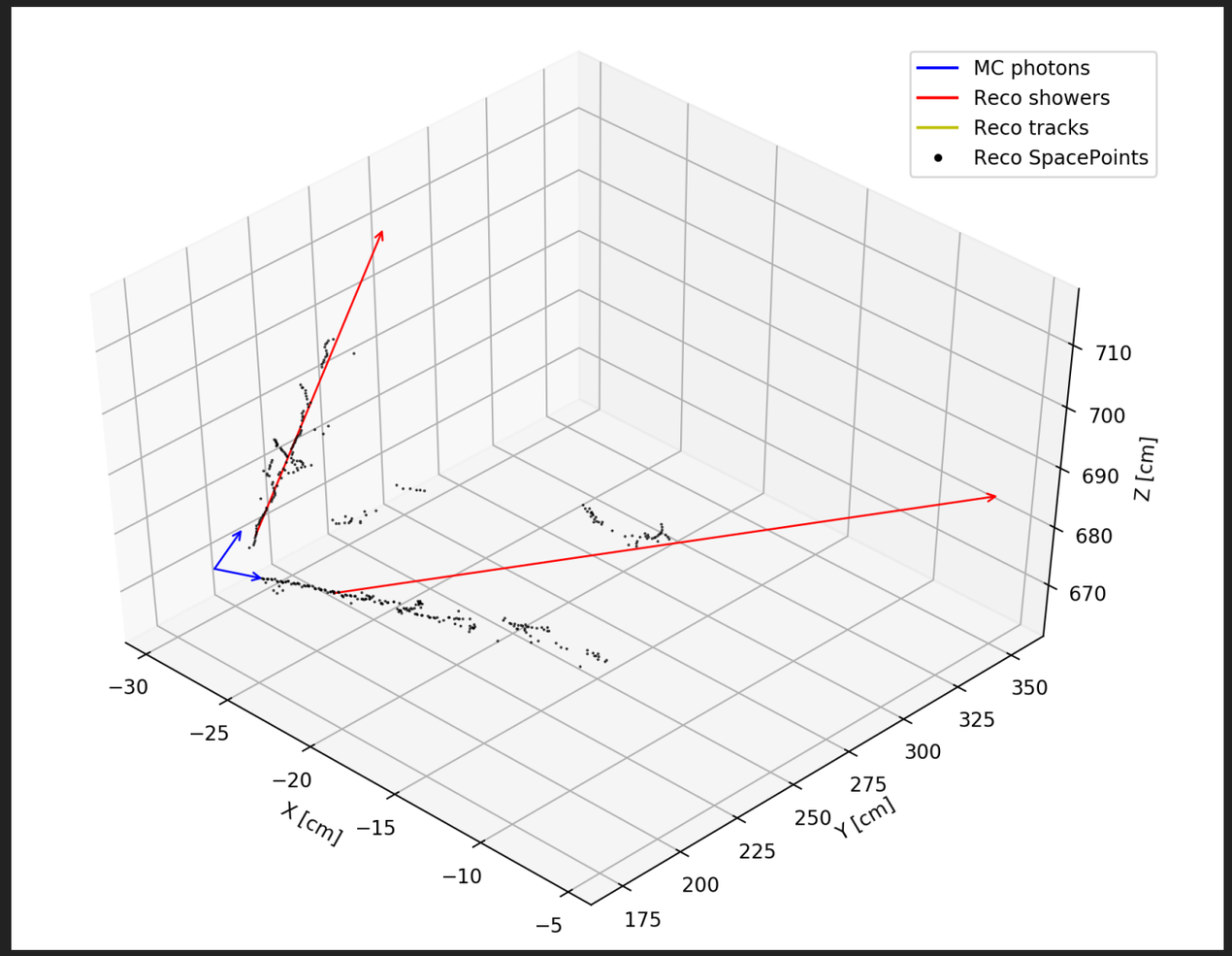


reco3d



pandora