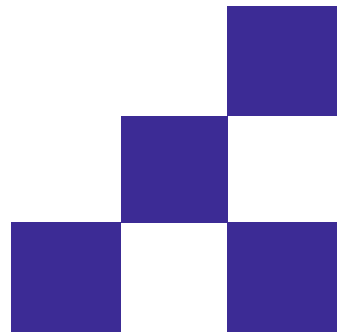
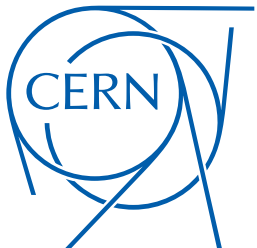




Cosmic Overlay Studies in ProtoDUNE-SP

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31/10/16



Introduction

- I am a new CERN fellow working in the new neutrino group
- Amongst other things, I want to know how the cosmic rays are going to affect the reconstruction
 - Numerous overlapping tracks
 - Association of delta-rays
 - Muon Bremsstrahlung (or other photons?)
 - etc...
- I've just been looking at truth information so far to find my feet in the software framework

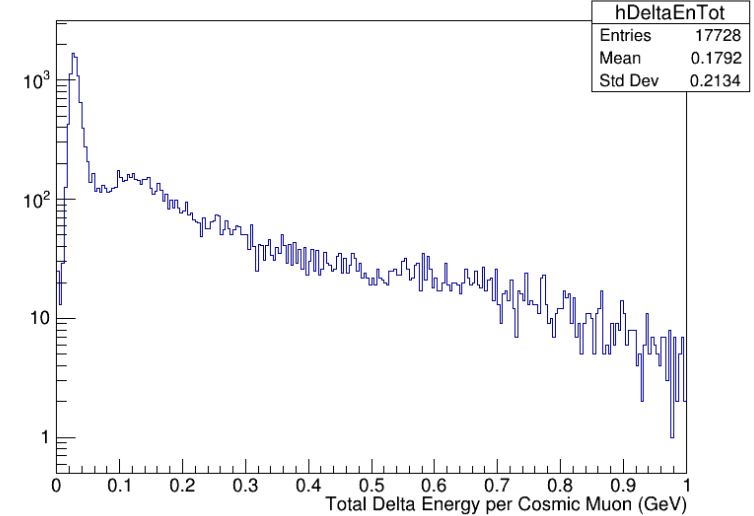
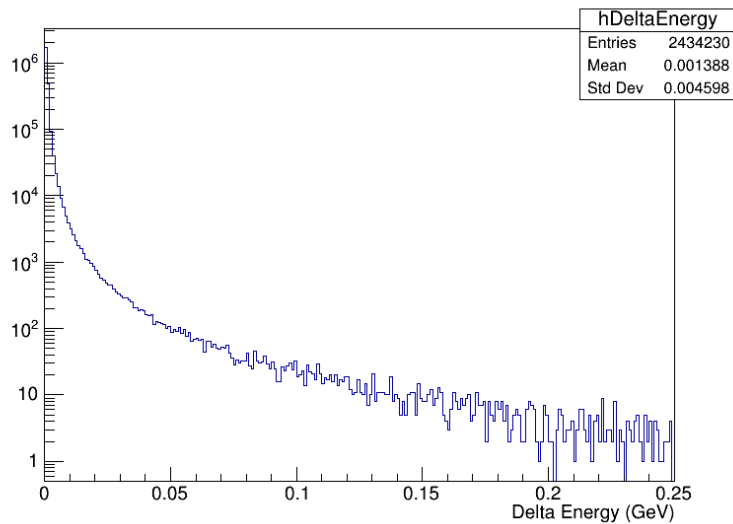
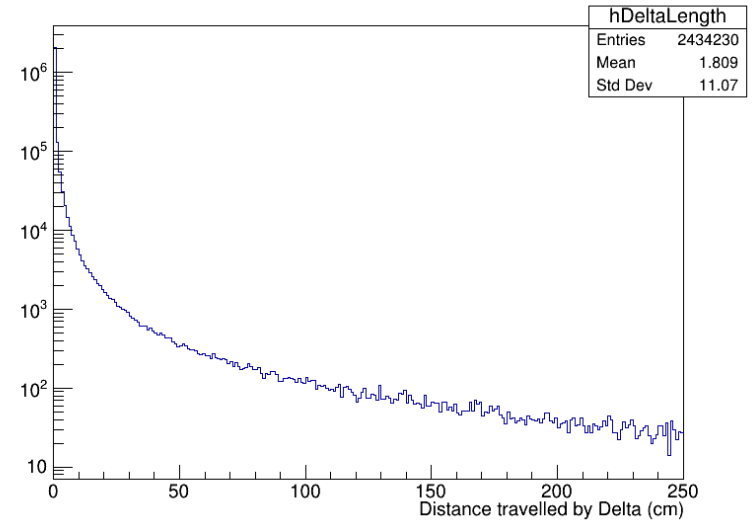
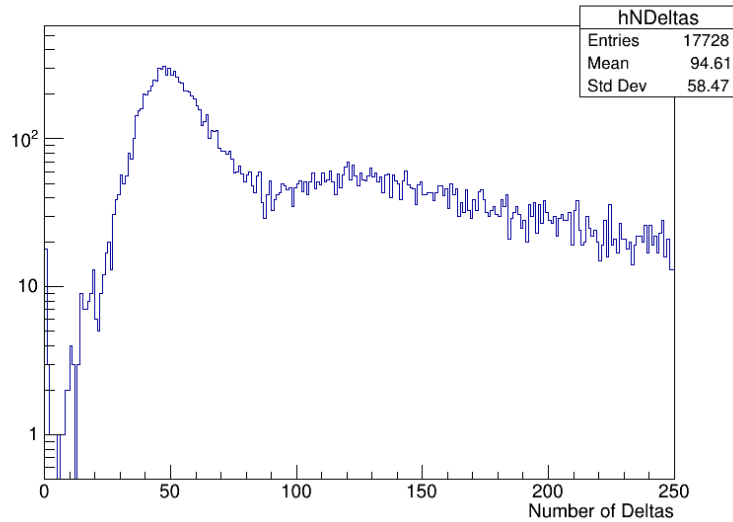
A question of TrackIds

- Started off looking at Elizabeth's cosmic ray overlay files
 - Series of cosmics overlaid on 1 GeV beam muons
- The beam particles can be selected using `origin==4`
 - The primary can then be obtained by asking `primary_process==1`
- The “Mother” ID for the (`origin == 4`) particles suggests that the primary beam particle should have `TrackID==1`
 - This is true for just a single particle interaction without overlays
- However, all cosmic particles are inserted at lower TrackIds than the beam particles
 - Beam primary ends up with a TrackId around 400000 or so
 - The “Mother” field for the beam particles doesn't seem to be updated to match this

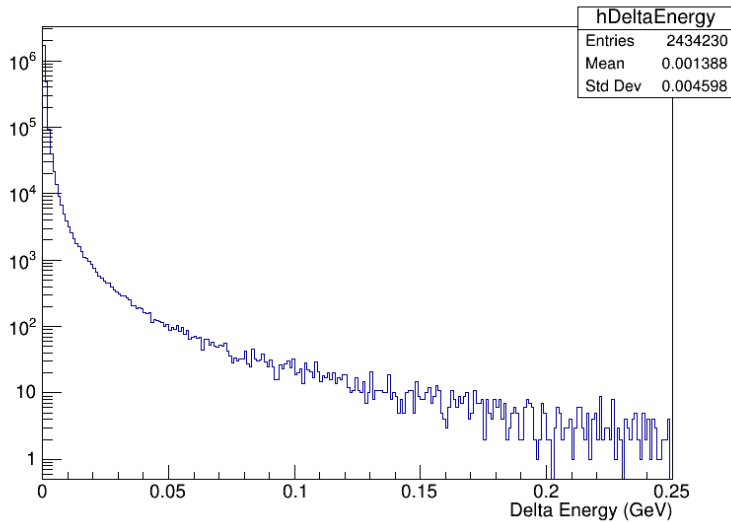
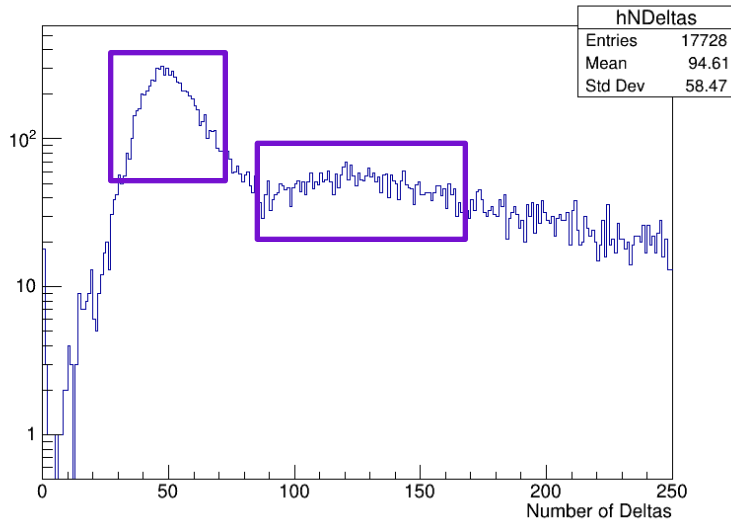
Looking at the Cosmics

- In any case, the TrackId issue doesn't affect the cosmics, so I started to look at these.
- By default, the true particles that start small EM showers are not stored
 - Dorota reprocessed a file such that I would have access to this information
- Current recipe:
 - Find all primary cosmic muon (and anti-muon) tracks
 - Find all of the electrons and photons who are daughters of these muons.
 - Only consider those daughters not originating from the muon end point.
 - This should give us the delta-rays and photons.

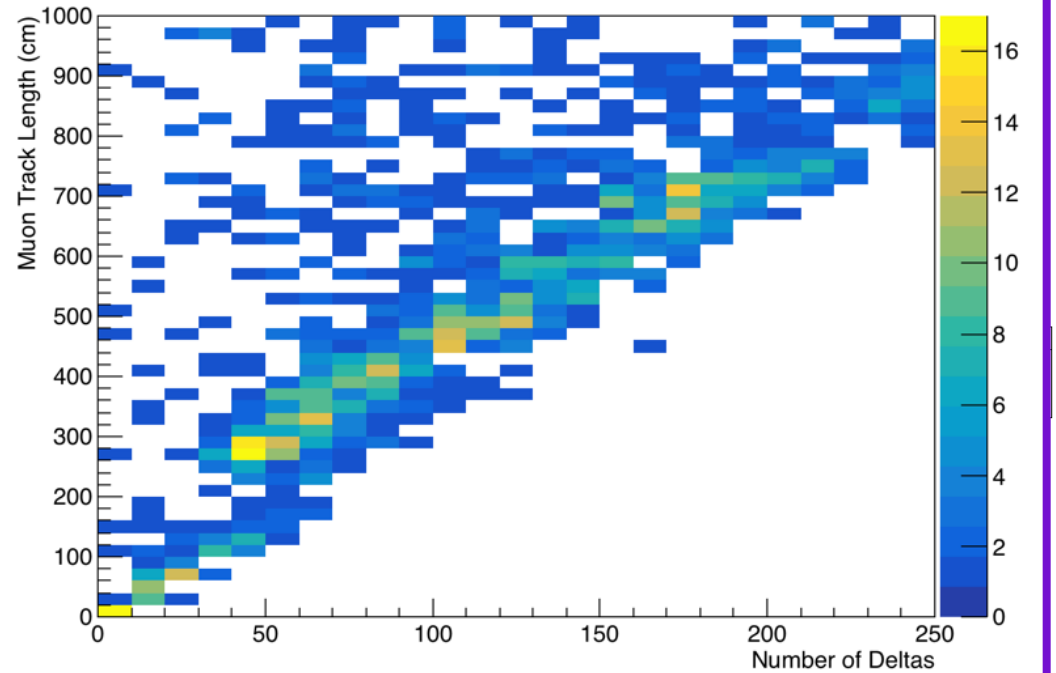
Delta Rays



Delta Rays



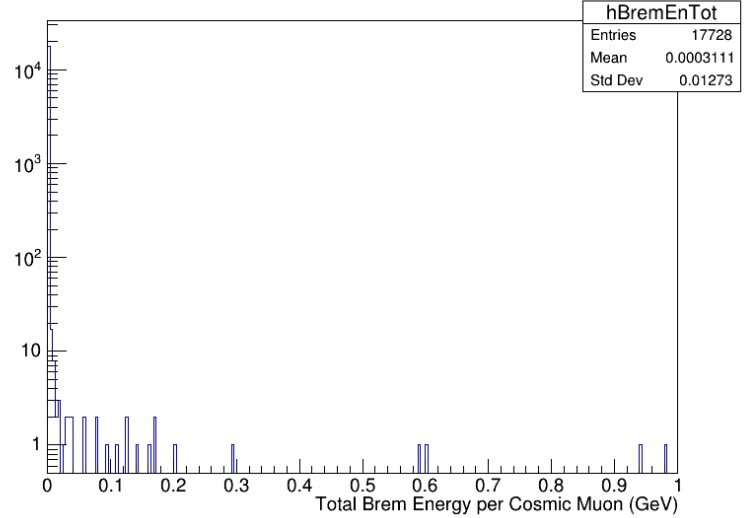
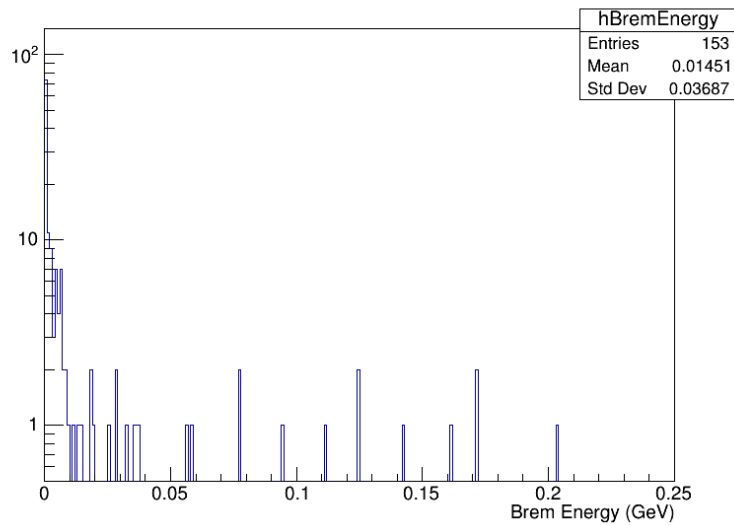
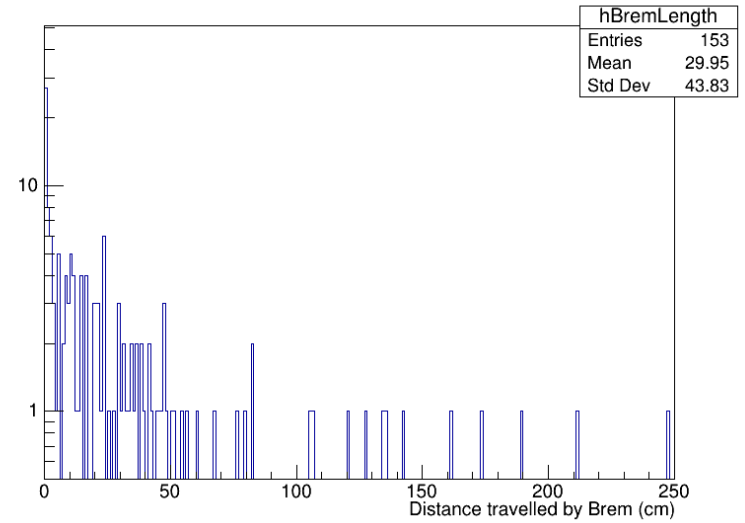
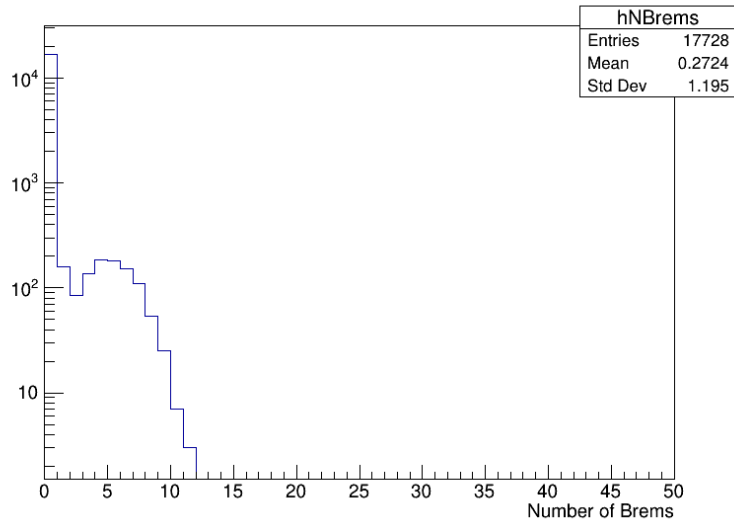
Looks like two populations here?



Looks mostly linear as a function of muon track length, so likely a geometry effect.

Total Delta Energy per Cosmic Muon (GeV)

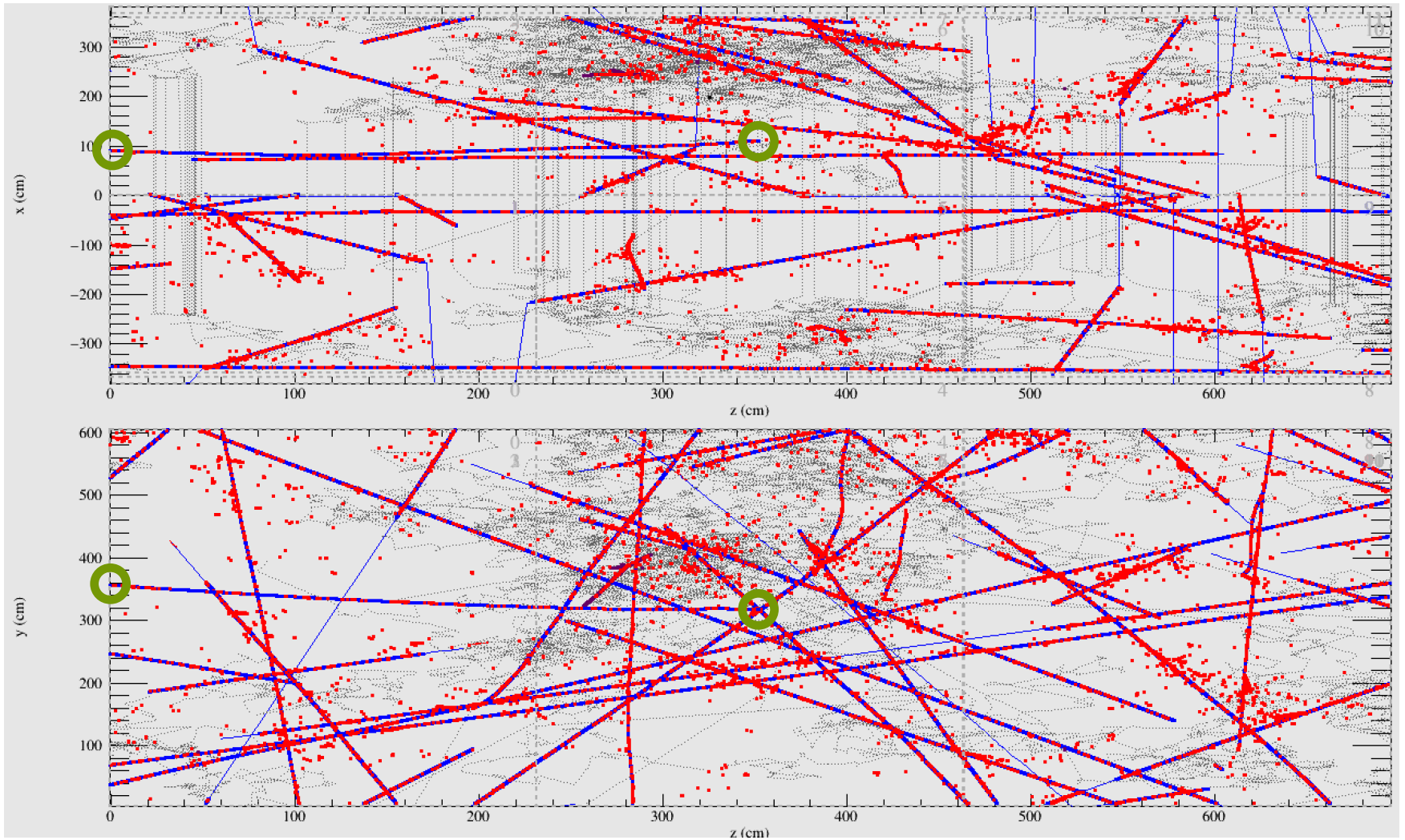
Bremsstrahlung?



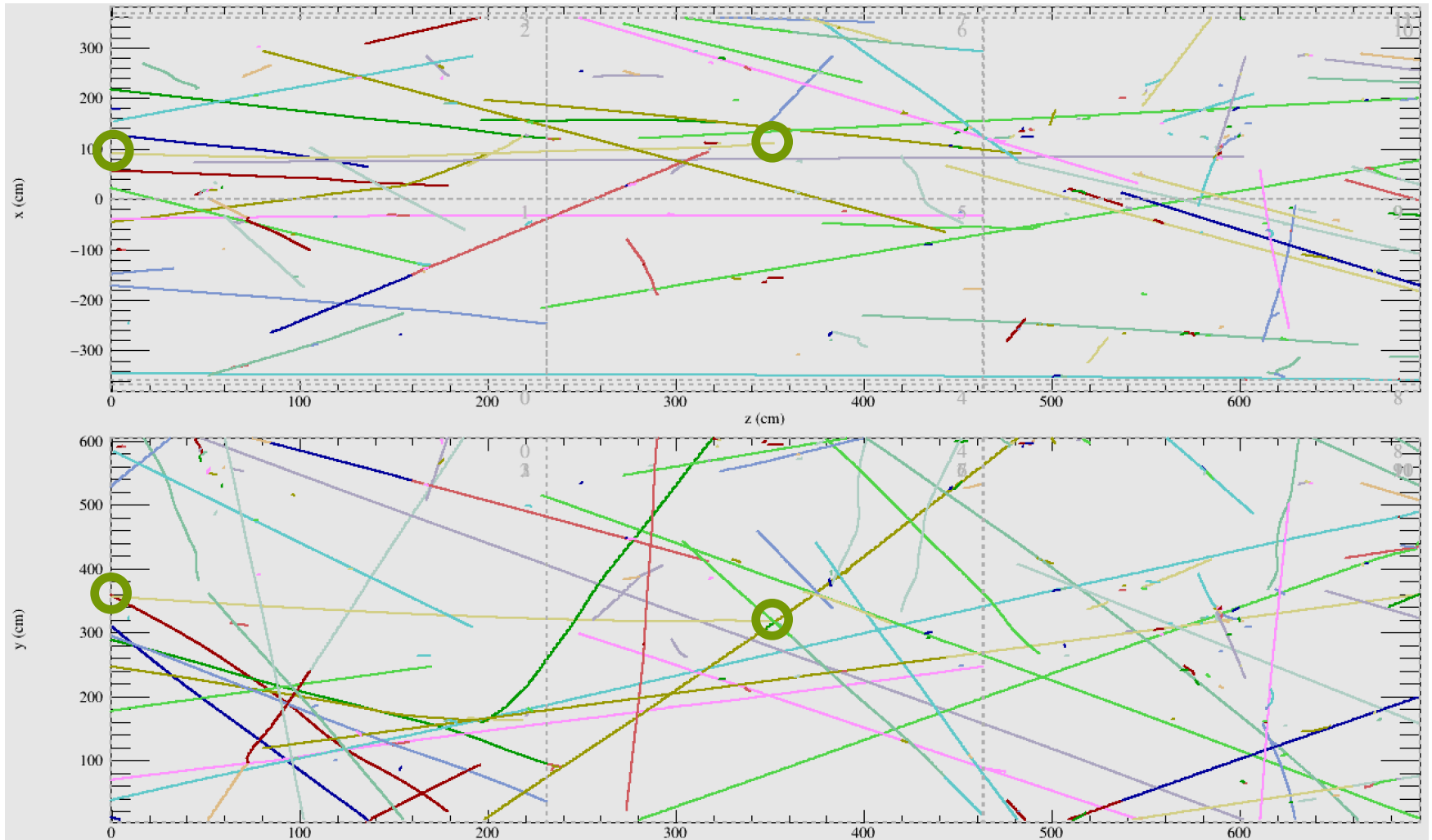
First look at reconstruction

- First step is to have a look at some events to see how things are working.
- Next few slides show some true and reconstructed views of a single beam muon event with a number of overlaid cosmics.
- Beam interactions enter the active volume at roughly (90cm,356cm) in (x,y).
 - I will highlight the start and end points in both.

Event 1: True

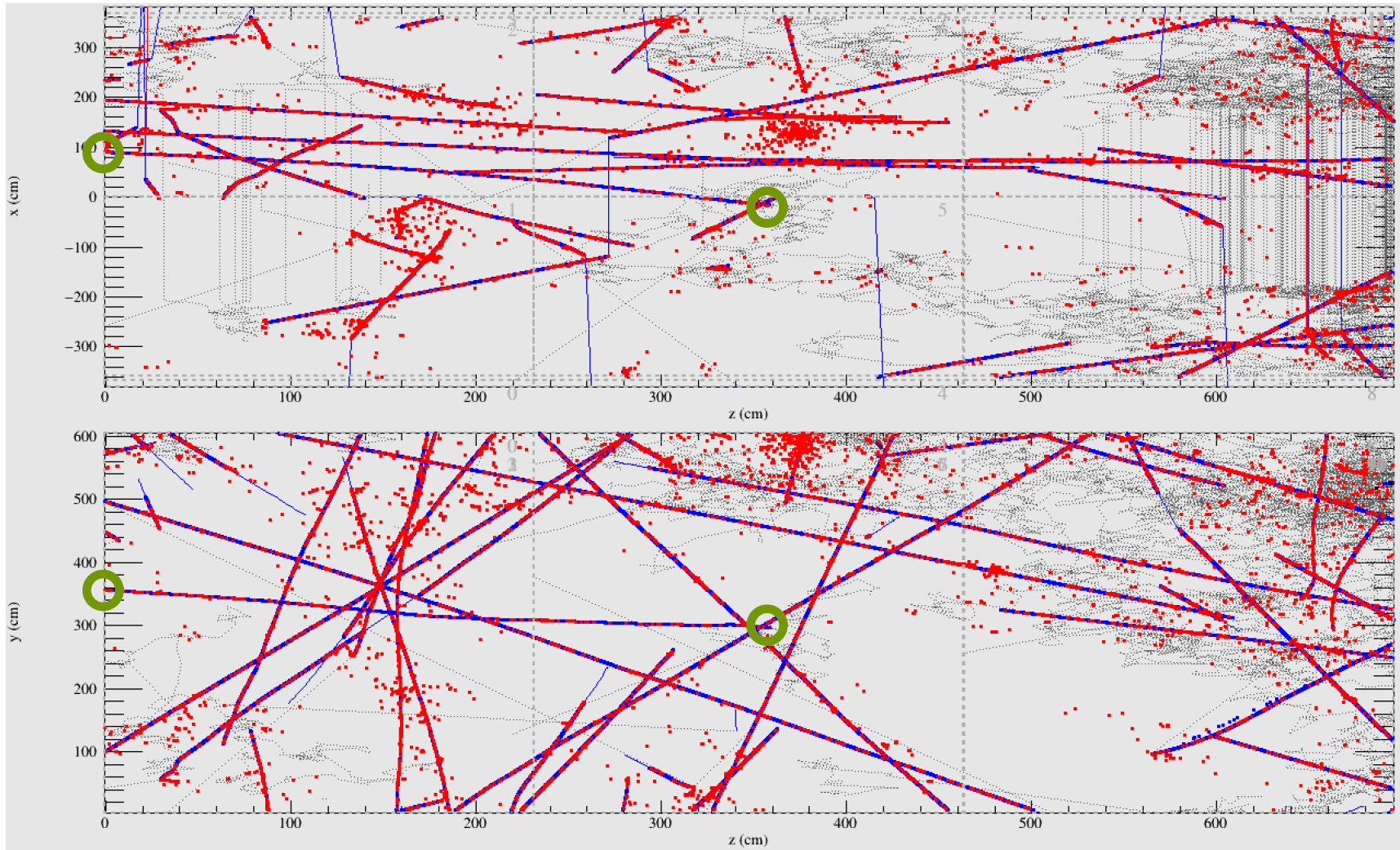


Event 1: Reconstructed

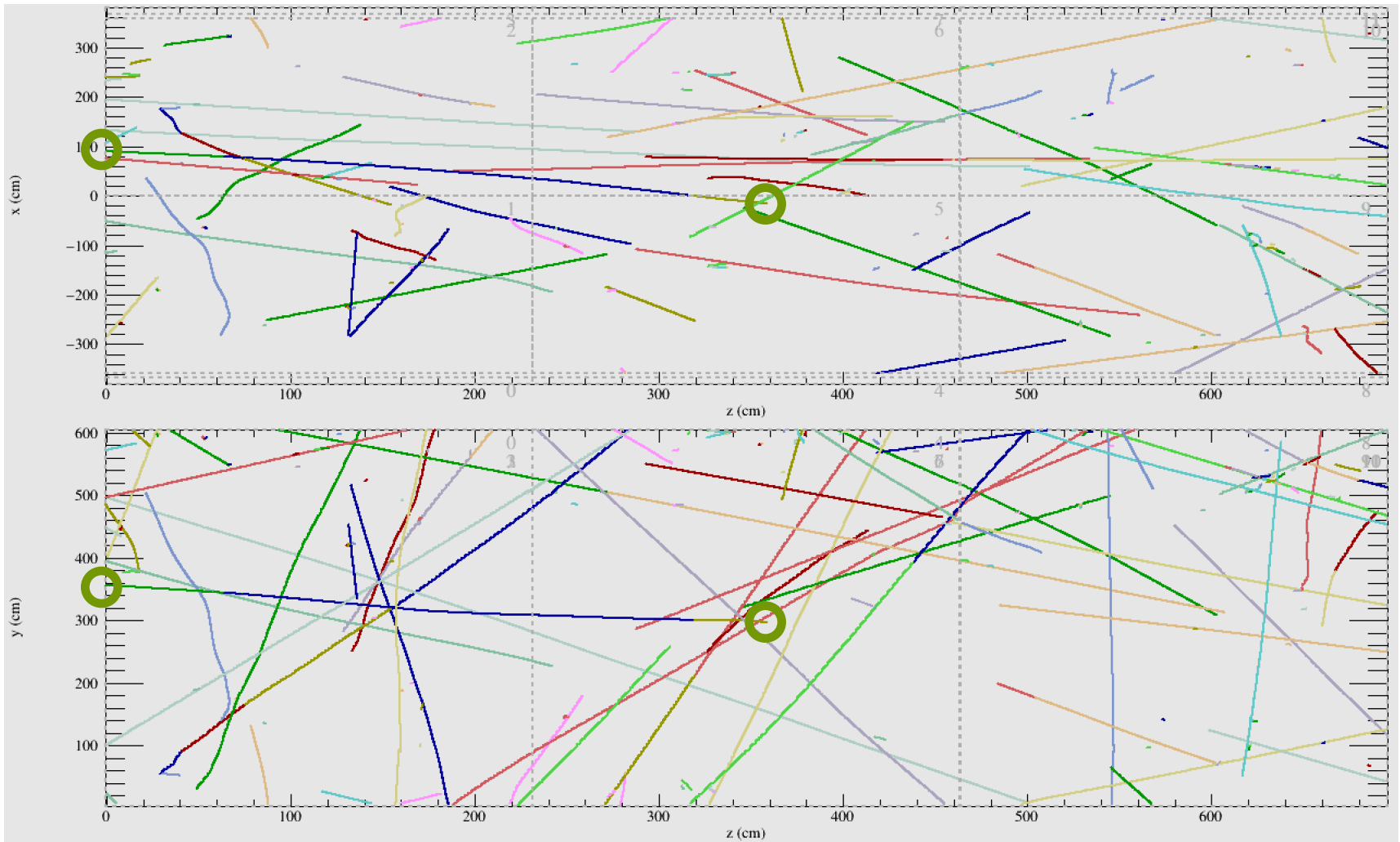


Looks to be reconstructed correctly as a single track.

Event 2: True

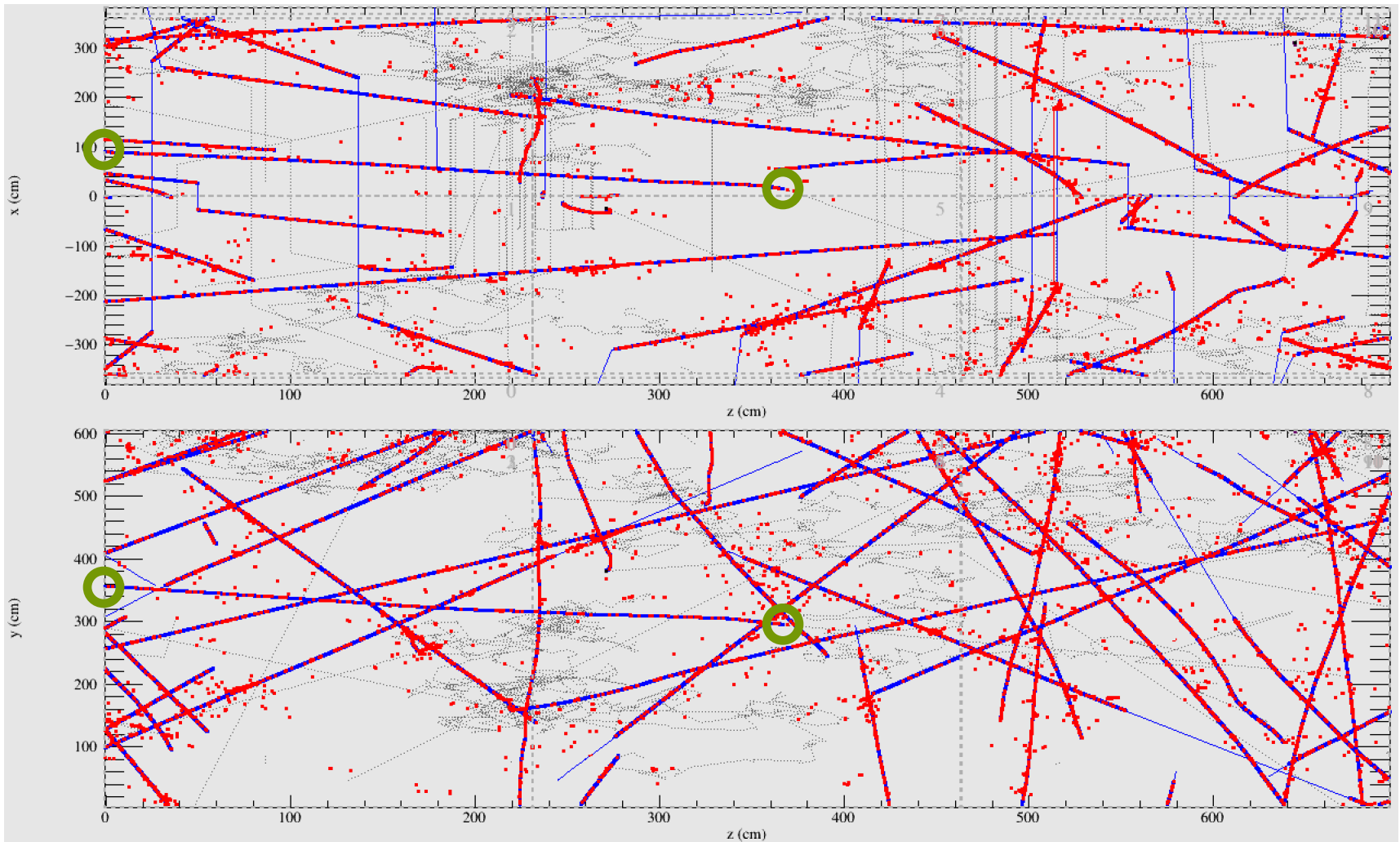


Event 2: Reconstructed

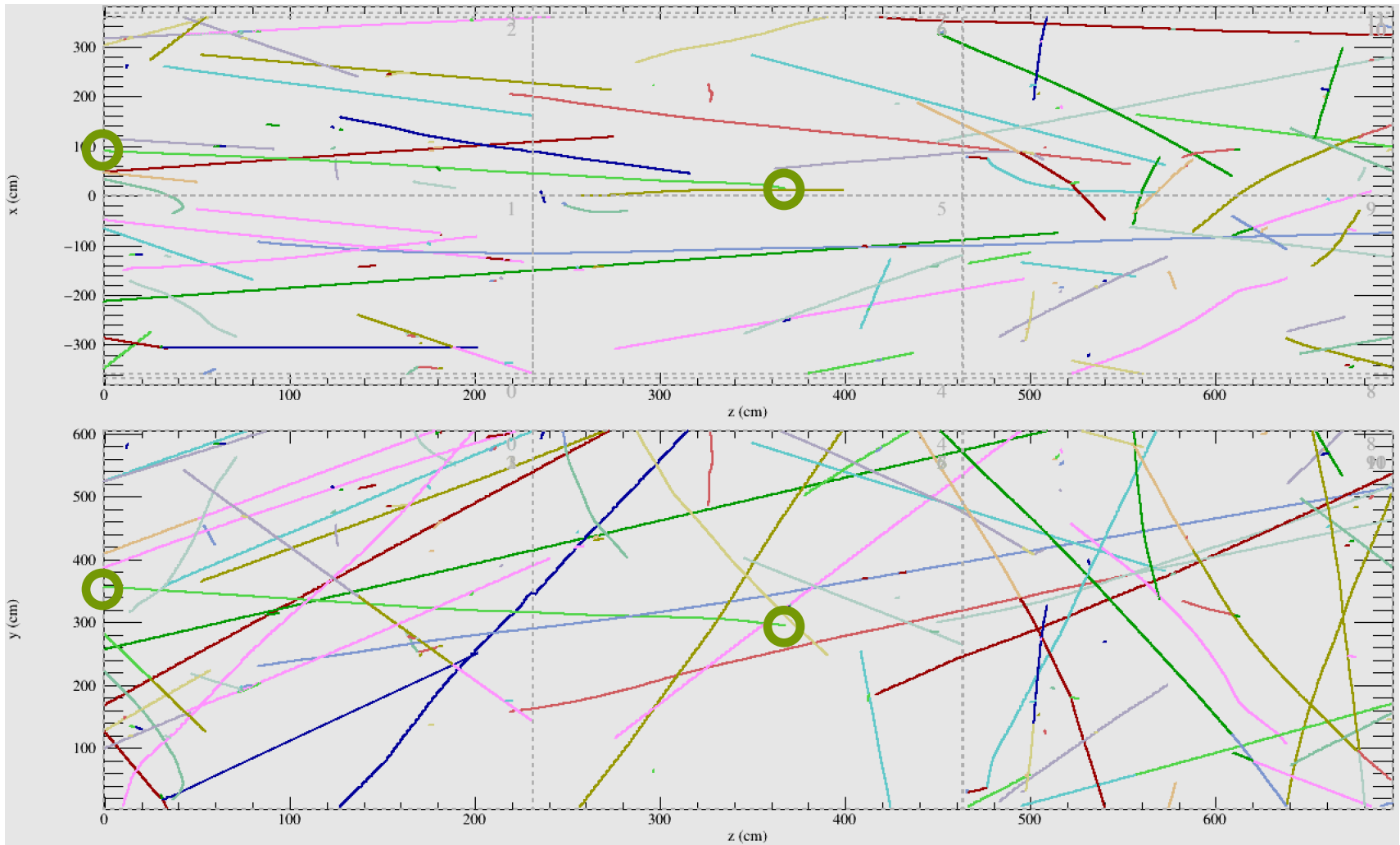


Track seems to have been split into three segments: firstly at an overlap, then as it crosses TPCs.

Event 3: True



Event 3: Reconstructed



Looks to be reconstructed correctly as a single track.

Summary

- Started to look into the effect of cosmics on the beam particle reconstruction.
 - Simple truth level distributions so far.
- Will move on to looking at the outputs of the reconstruction and try to match up the clusters with the delta rays and photons.
 - Have started hand scanning a few events in the event display.