Electron Shower Characterisations

James Pillow

10/10/2019 EM Task Force Meeting

DEEP UNDERGROUND NEUTRINO EXPERIMENT

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What I have worked on lately

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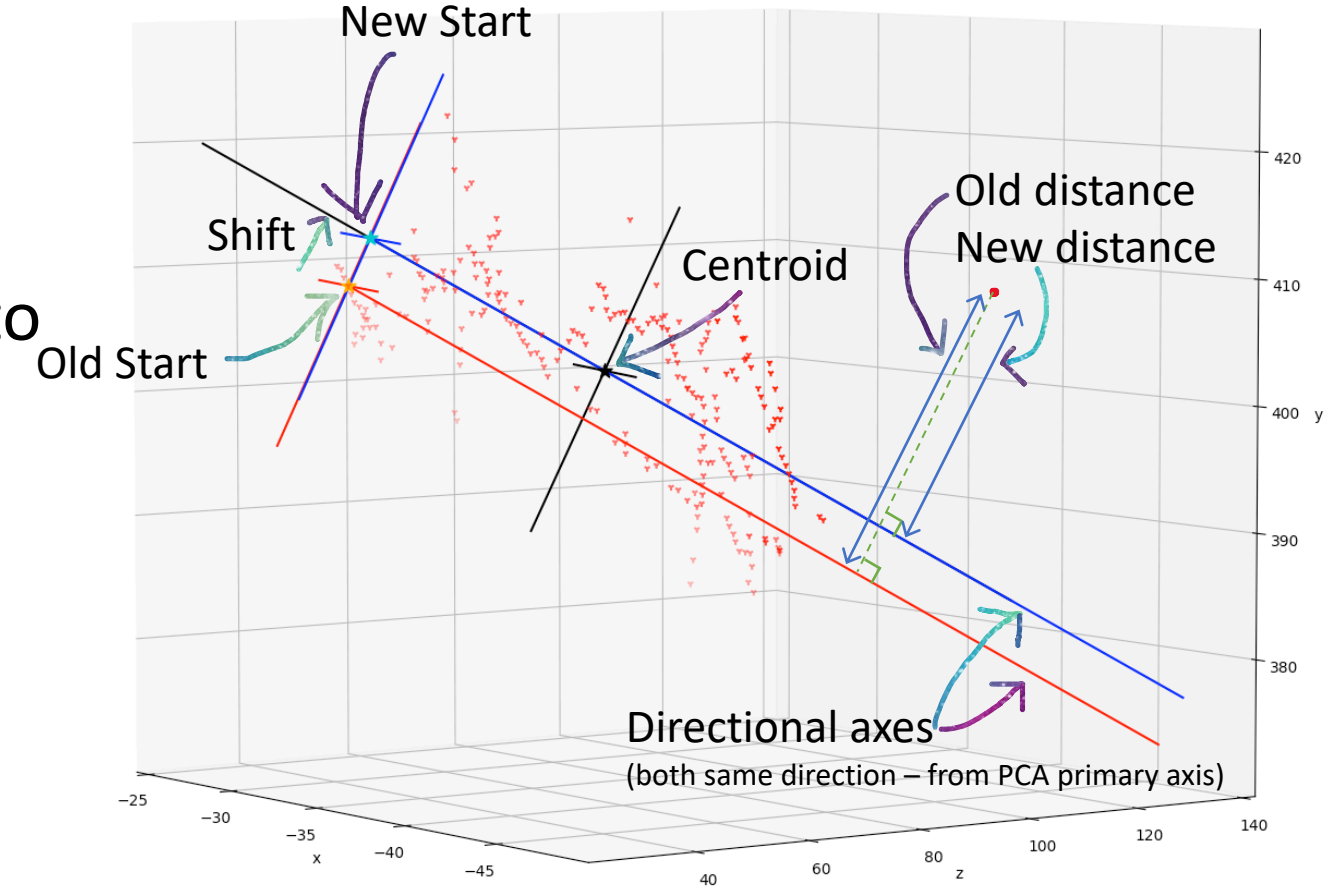
- Shower vertex - recob::Shower::ShowerStart()
- Shower start - Where the mip ends and the showery part begins
- Shower energy estimation
- Shower start dE/dx

Moving the shower vertex

- recob::Shower::ShowerStart was originally just from the PFParticle – so set before the recob::Shower was created.
- Move recob::Shower::ShowerStart to the nearest point on the PCA primary axis.
- Already added to Pandora!



Events

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- Using the MC prod2 sce dataset

- Select events with :
  - ProtoDUNETruthUtils::GetGeantGoodParticle() pdg code == 11
  - Primary reconstructed particle is a shower
  - Primary reconstructed particle is a track with a single shower daughter

Shower Start

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- Currently there is no value for where a shower object actually starts to shower.

- Important bit of information
  - Could be used to improve dE/dx
  - Electron/photon discrimination

Shower Start – Method

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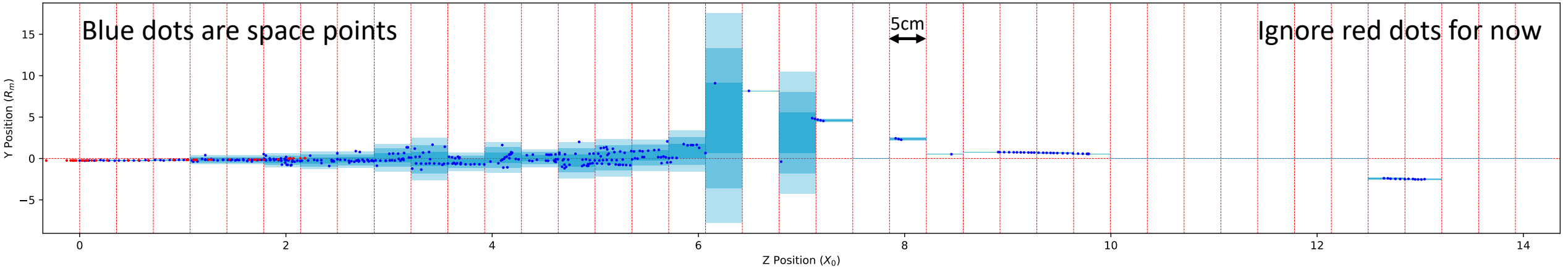
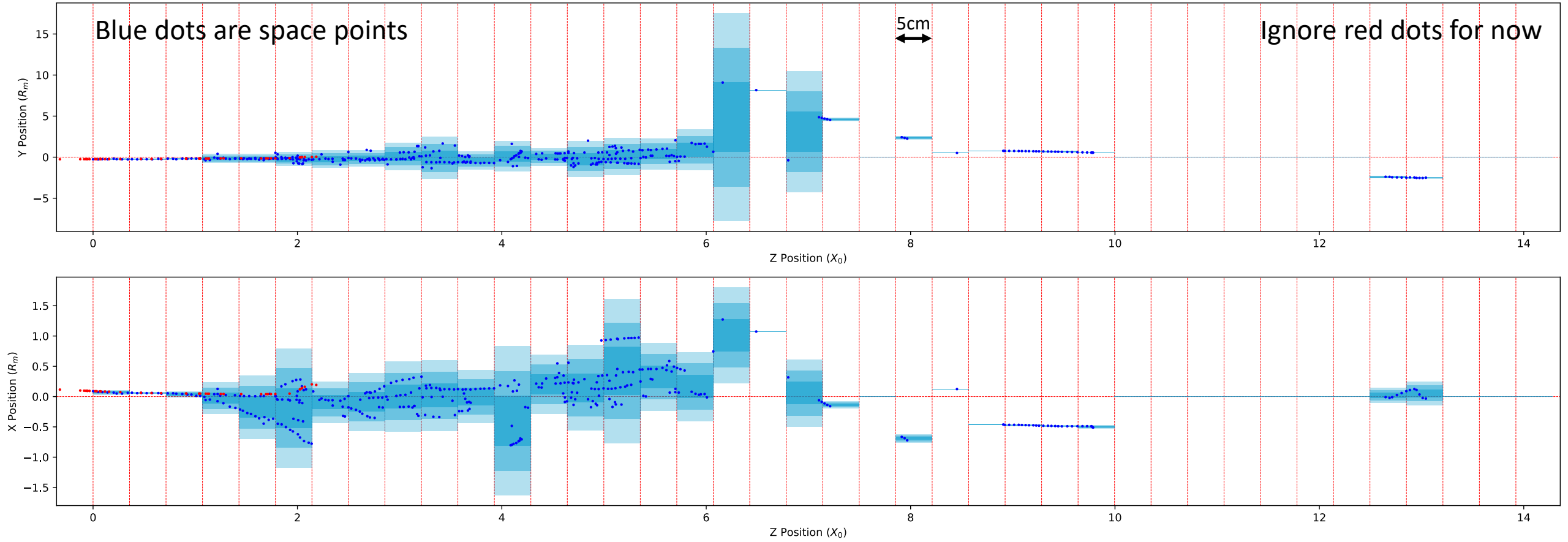
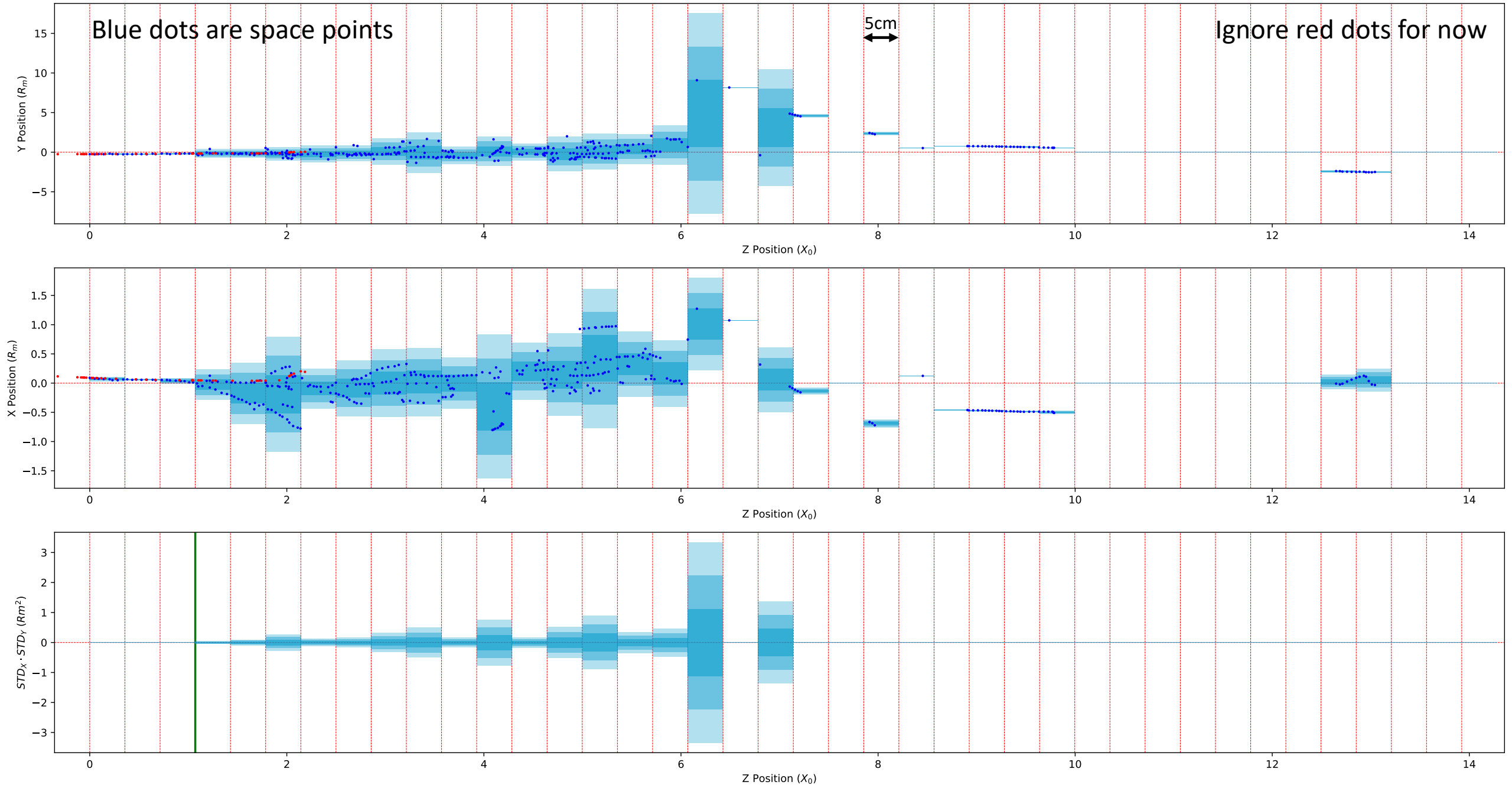
- Using a shower's recob::SpacePoint.
- Rotate the space points to the PCA coordinates.
- Convert position along primary axis into terms of radiation length (X0).
- Convert position along secondary/tertiary axis into terms of Moliere radius (Rm).
- Remove any small number of hits appearing far before rest of hits.
- Shift space points in z so space point with smallest z value is 0.


Blue dots are space points
5cm
Ignore red dots for now
Y Position (R_m)
Z Position (X_0)
15
10
5
0
−5
0
2
4
6
8
10
12
14


Blue dots are space points
5cm
Ignore red dots for now
Y Position (R_m)
Z Position (X_0)

X Position (R_m)
Z Position (X_0)


Blue dots are space points
5cm
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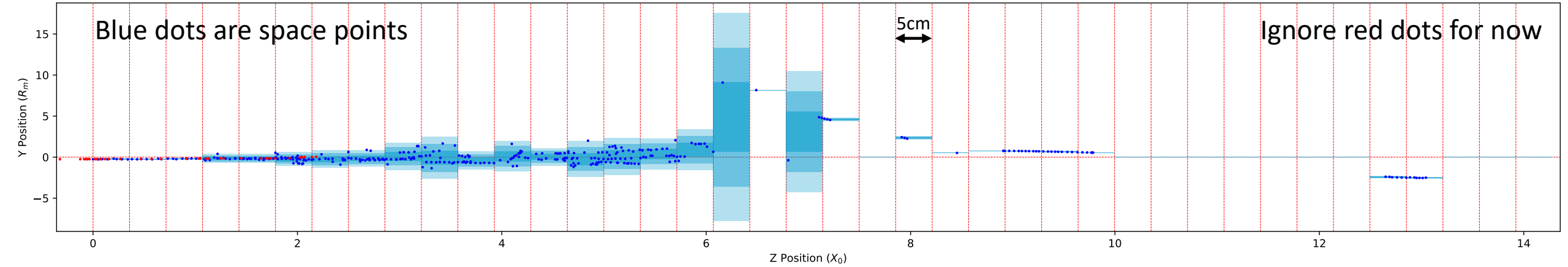
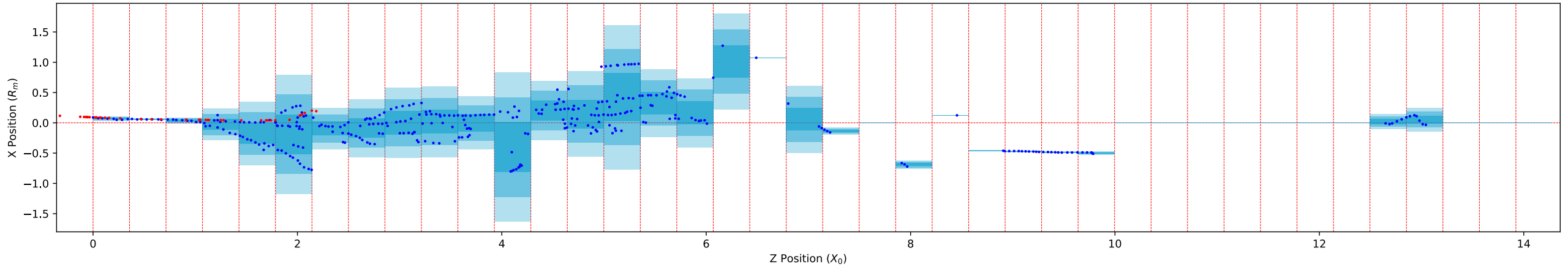
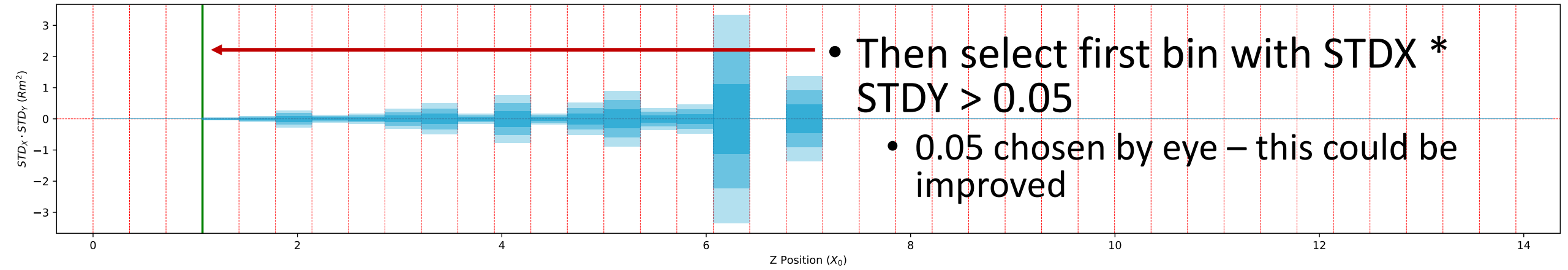
Y Position (R_m)
Z Position (X_0)
X Position (R_m)
Z Position (X_0)
$STD_X \cdot STD_Y$ (Rm^2)
Z Position (X_0)







- Then select first bin with STDX * STDY > 0.05
  - 0.05 chosen by eye – this could be improved

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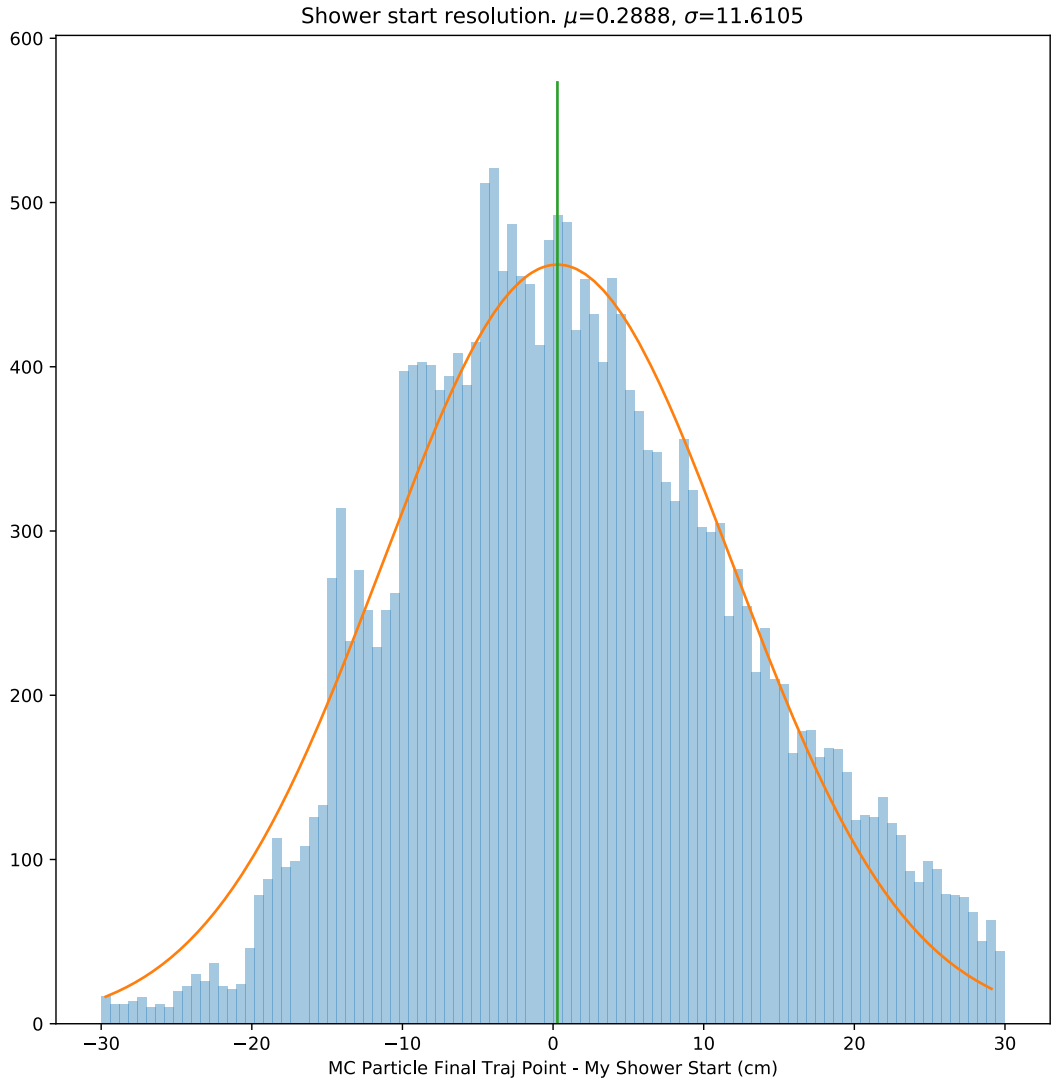

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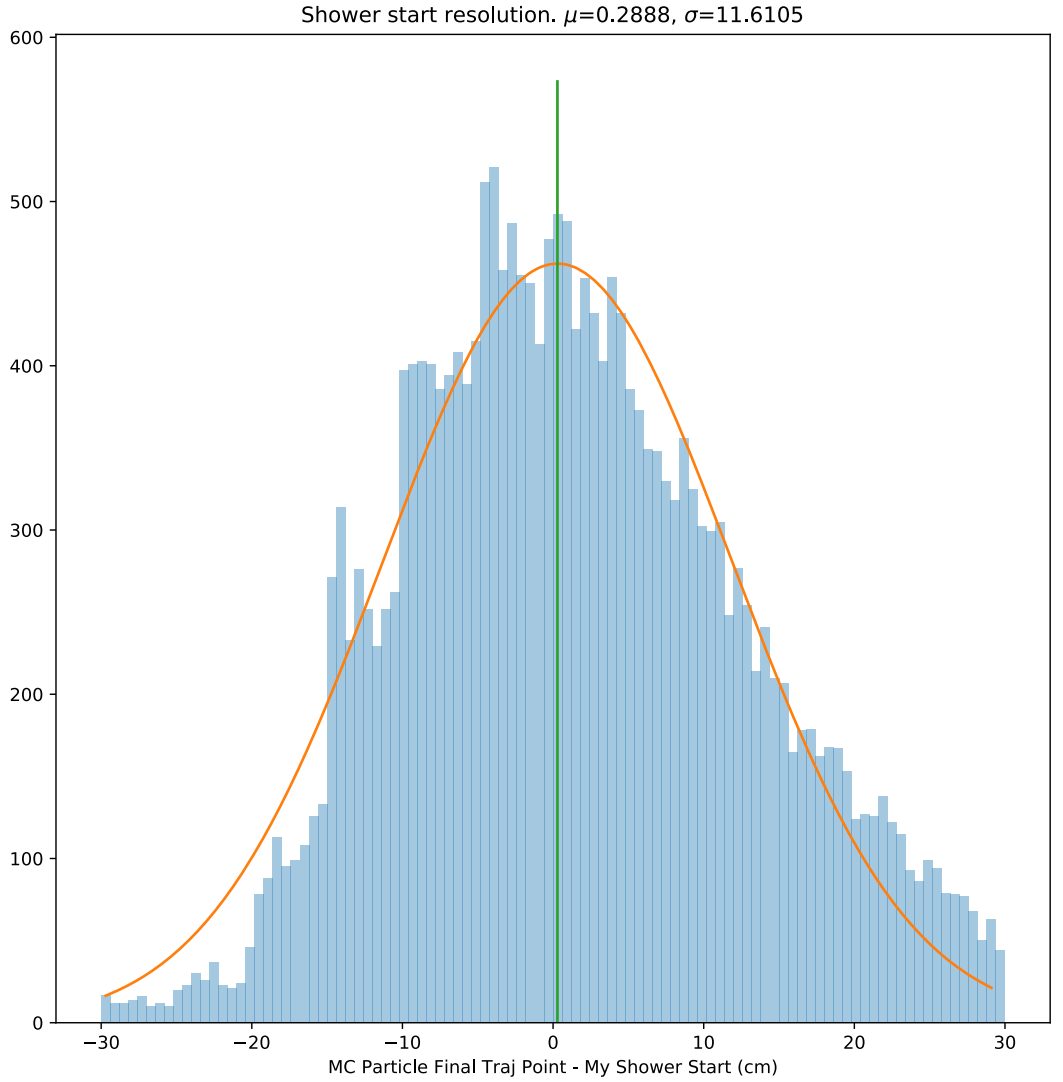
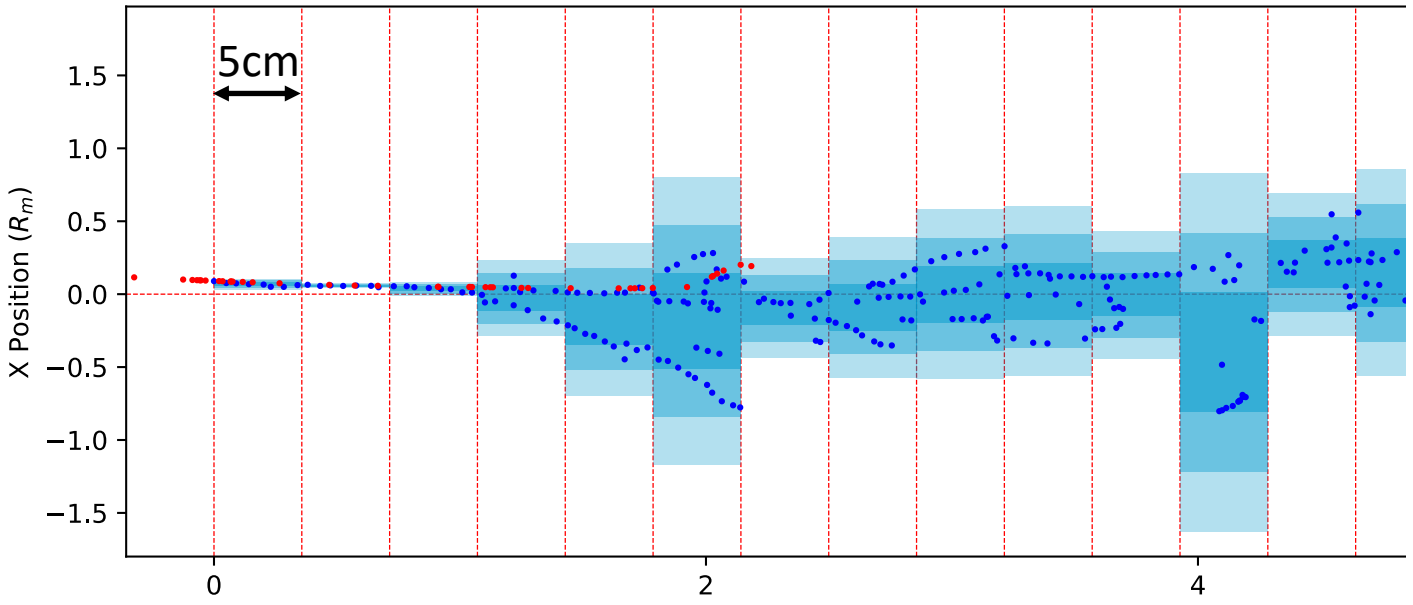
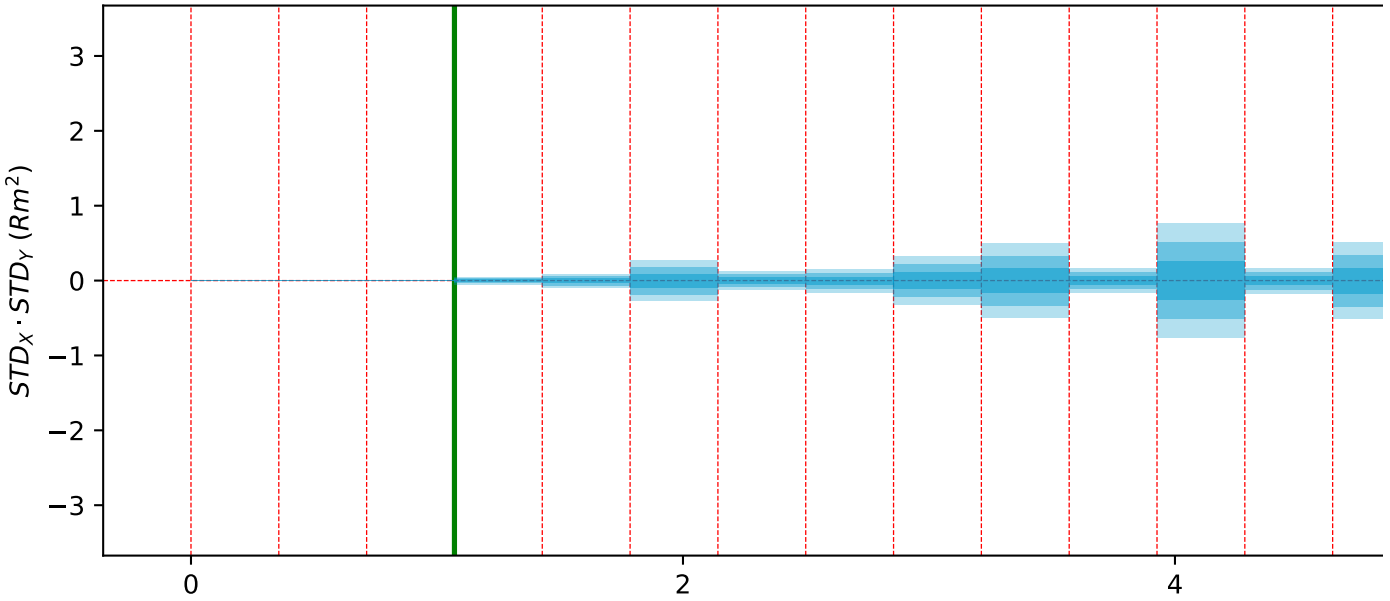
- I think this more says that the above is not the best estimate for truth.







- Red dots are the mc particle's trajectory points.
- Here we can see that the trajectory points go ~15cm past where my method selects the shower start.

- Any suggestions on how to improve estimating the true start of the shower part?
  - Currently I suspect I might have to make my own small mc sample that saves more information (if anyone knows how to do that, I'd appreciate the help!)

Shower Energy Estimation

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- I estimate the energy of each hit using:

```
( caloAlg.ElectronsFromADCArea( hit->Integral(), plane) * caloAlg.LifetimeCorrection(hit->PeakTime()) ) / kGeVtoElectrons * recombination
```

CalorimetryAlg.cxx function to estimate number of electrons based on hit charge

Lifetime correction

Convert number of electrons to GeV (from physical constant)

Recombination correction (average value from modbox from Nick)

- I then total the energy estimation of each hit.
- I also then add together the total energy estimation for all particles in the PFParticle hierarchy.

Shower Energy Estimation

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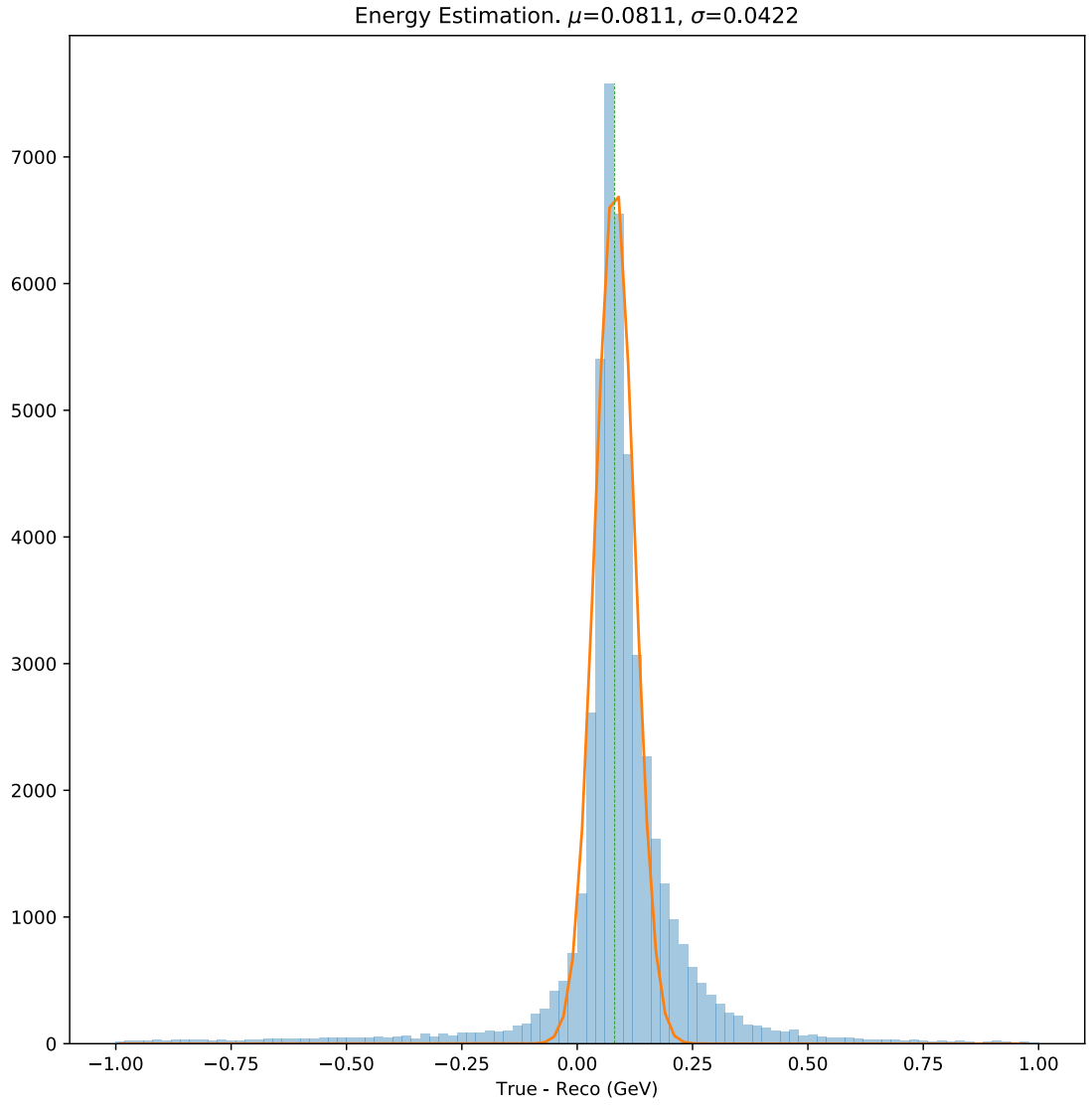
- Truth used is from ProtoDUNETruthUtils
  - GetDepEnergyMC()
- Slight asymmetry
  - Seems to favour underestimating energy



dE/dx

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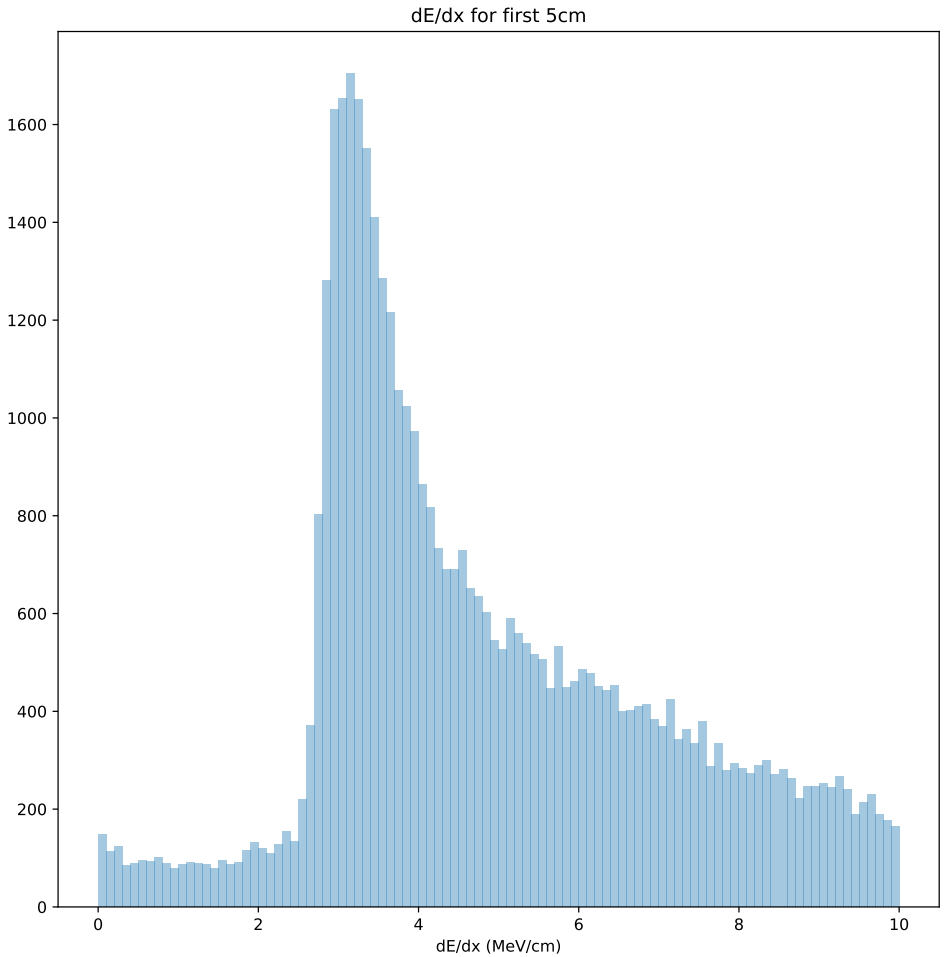
- Calculate the dE/dx by summing the energy of the hits in a bin, and dividing by the bin width
  - Currently I use 5cm bins, so I just take the value for the first bin
- Peaks just over 3MeV/cm, with a large tail.
  - Not quite sure why this doesn't mirror Aaron's result.



Back-up

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