Electron Shower Starts

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14/11/2019   EM Task Force Meeting

DU/VE DEEP UNDERGROUND NEUTRINO EXPERIMENT

WARWICK

What I'm trying to do

- Find the end of the MIP section of the electron showers

MC Sample

- Last update - Using the MC prod2 sce dataset

- Couldn't get processes for each trajectory point for the initial mc particle
  - Simb::MCTrajectory::TrajectoryProcesses() gives me an empty vector 99% of the time.
  - 1% of the time gives me a vector with each trajectory point having the same process.
  - Does anyone know why the TrajectoryProcesses() vector should be empty?

MC Sample

- Tried making my own dataset where I keep all the daughter mc particles of em showers.

- Tried using
  - protoDUNE_g4_35ms_sce_datadriven.fcl
  - protoDUNE_detsim_data_driven_noise.fcl
  - protoDUNE_reco_35ms_sce_datadriven.fcl
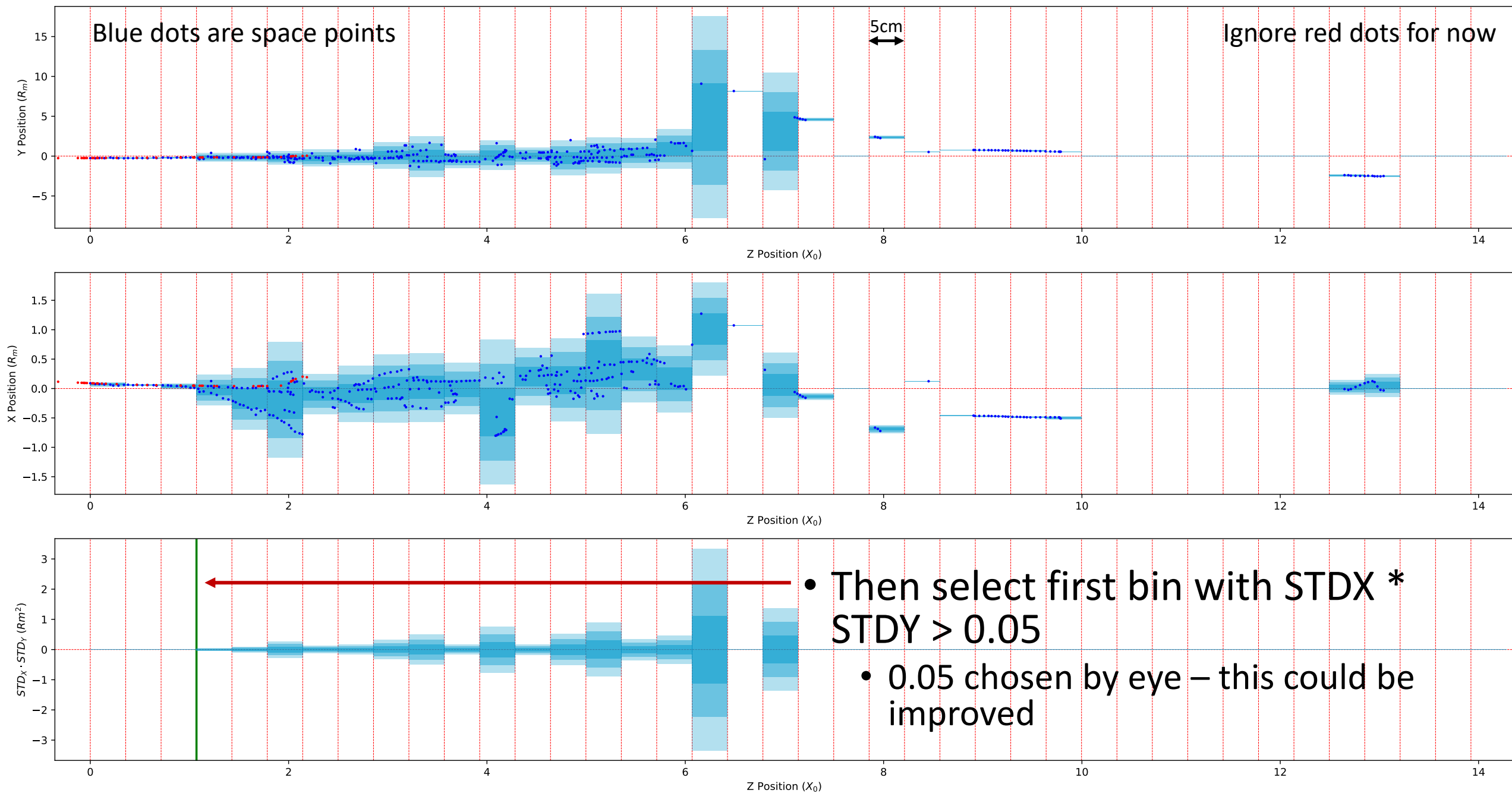
- But reconstruction seems to hang…

MC Sample

- So I made an mc sample without any sce for now.
  - Have about 7,500 events.

- Sample is 1 GeV
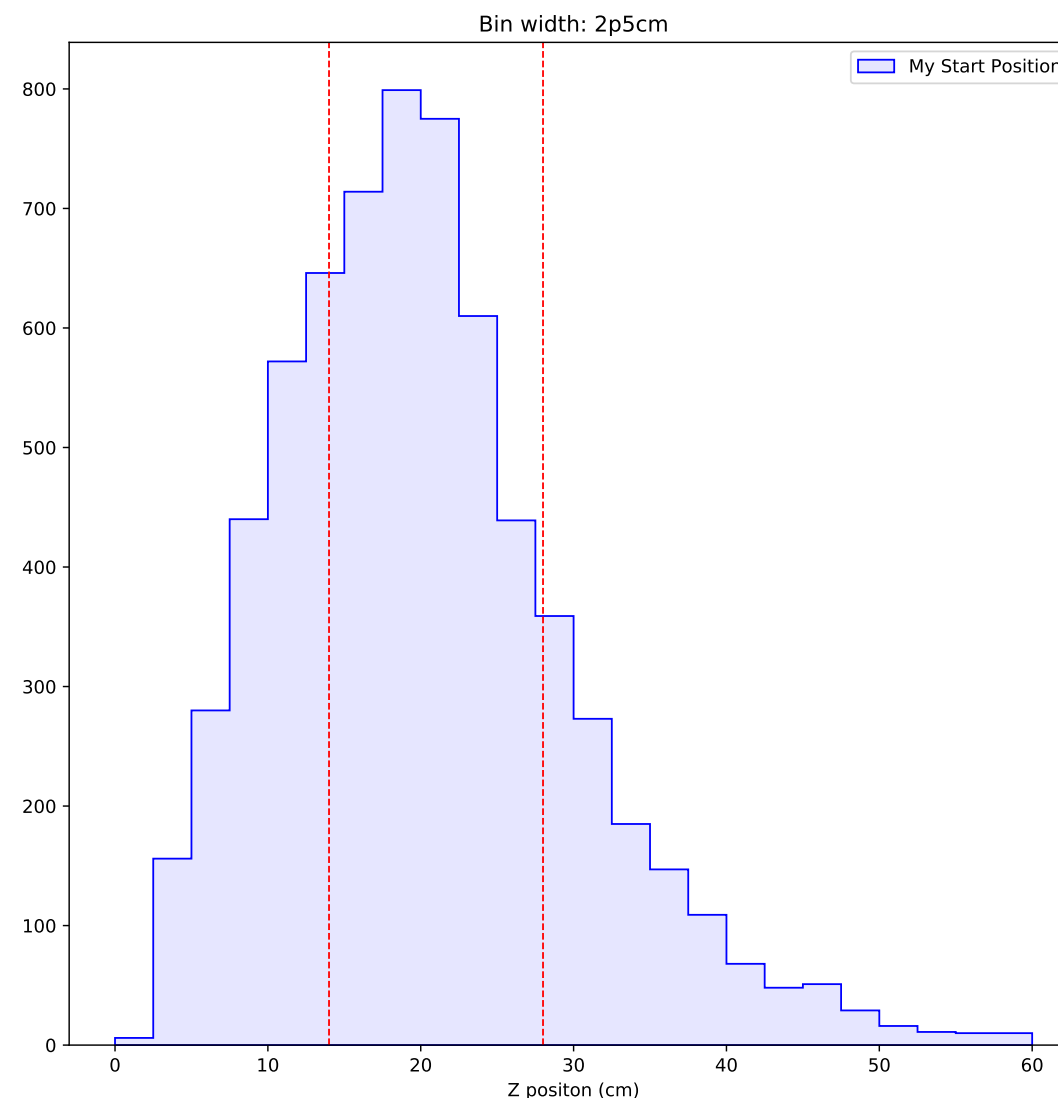 - Energy has no spread (I forgot to turn that on).

Method

- Using a shower's recob::SpacePoint.

- Transform 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 primary axis so space point with smallest primary axis value is 0.

Method

- Bin the space points along the primary axis

- Calculate the stds in each bin (for each axis).

- Multiply the stds for the secondary and tertiary axes, to form a cross-sectional area that the hits in that bin occupy.

- Find the bin for when the cross-sectional area goes above 0.05Rm^2

- Find the mean position along the primary axis for this bin – set that as the end of the MIP section

Blue dots are space points

Ignore red dots for now

5cm

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

- End of MIP section peaks around 20cm

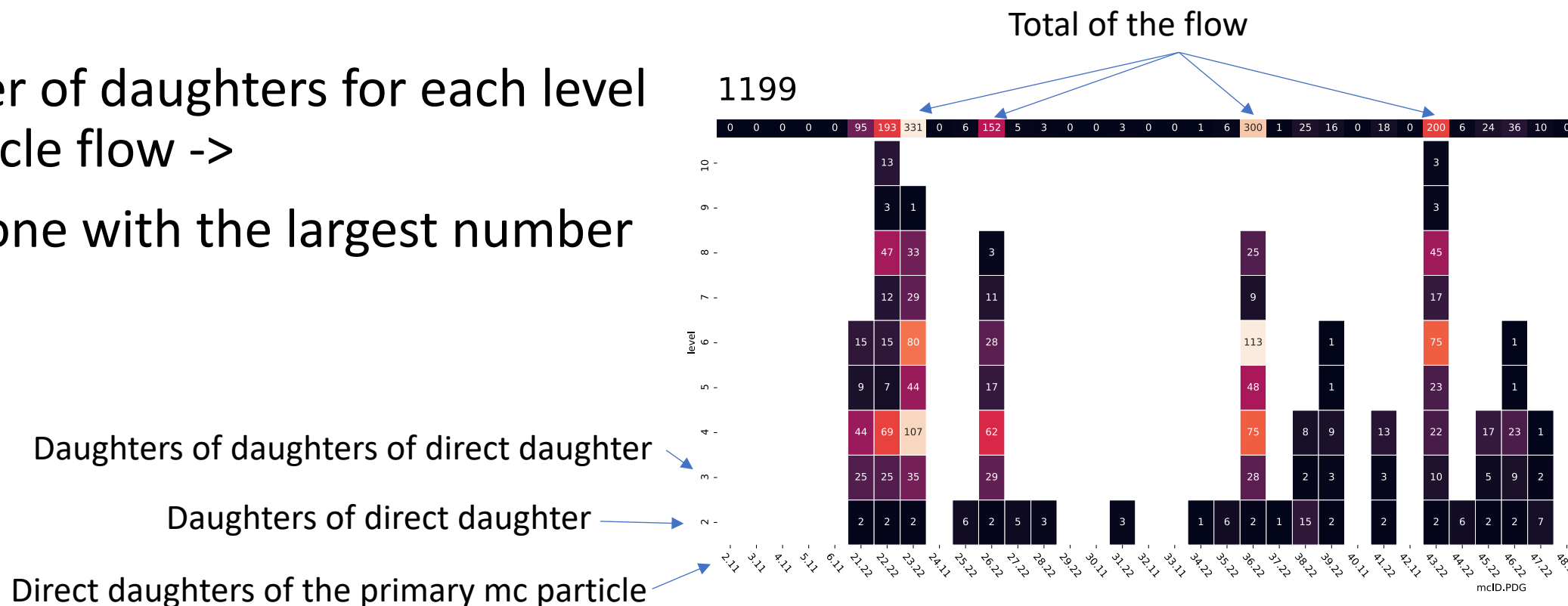- Red lines are 14cm and 28cm (1 and 2 radiation lengths)

1003 | bin width: 2.5cm
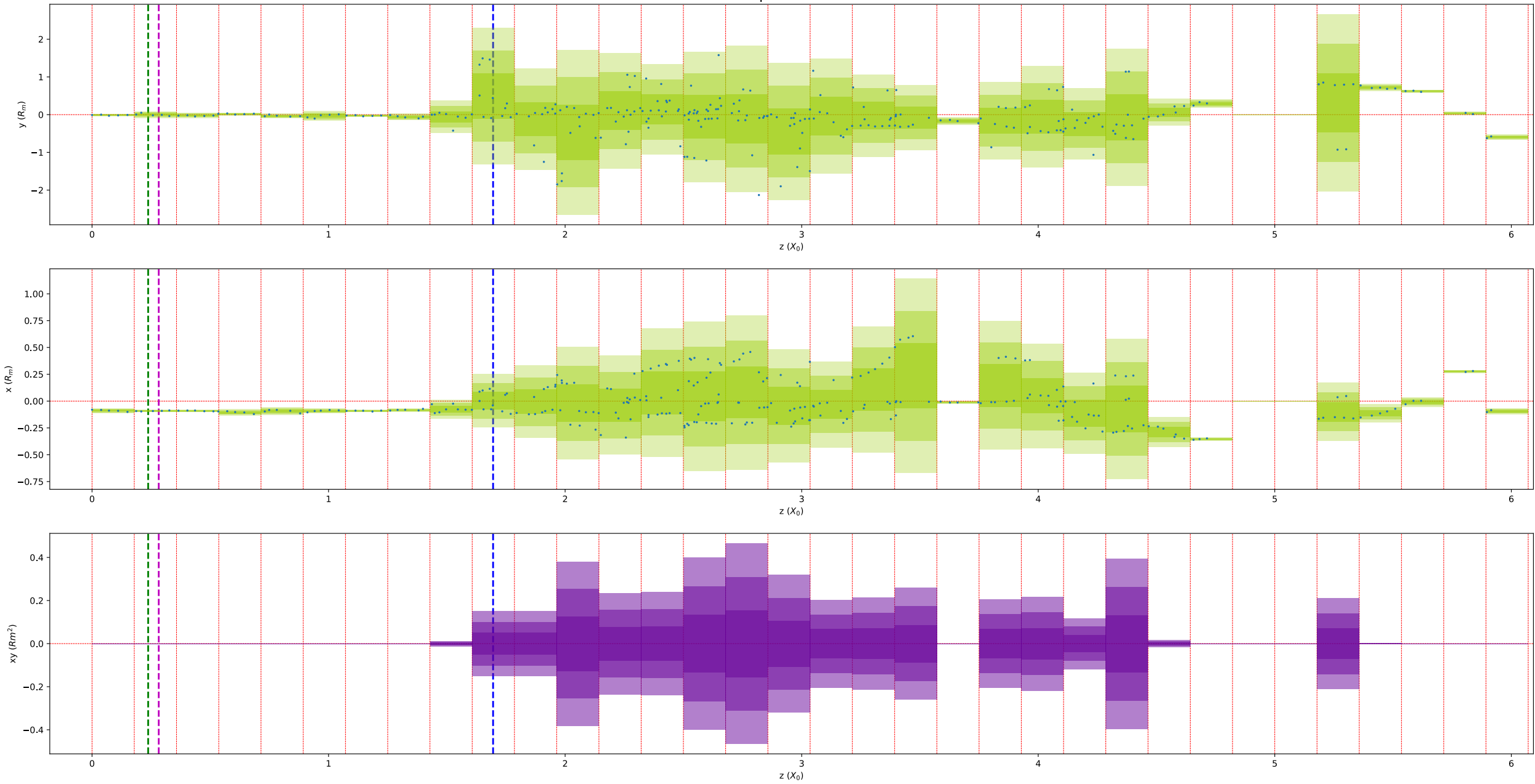
Estimating the true MIP end

- Dominant energy loss for electrons in proto-dune is brem.

- So electron should start showering when radiated photons convert to e+/e- pair.

- Select the radiated photon with the largest 'flow'.
  - Define flow as the recursive sum of the number of daughters of the mc particle.

- Take the last trajectory position of that daughter photon.

Estimating the true MIP end

- Plot number of daughters for each level of the particle flow ->

- Select the one with the largest number

Total of the flow

Daughters of daughters of direct daughter

Daughters of direct daughter

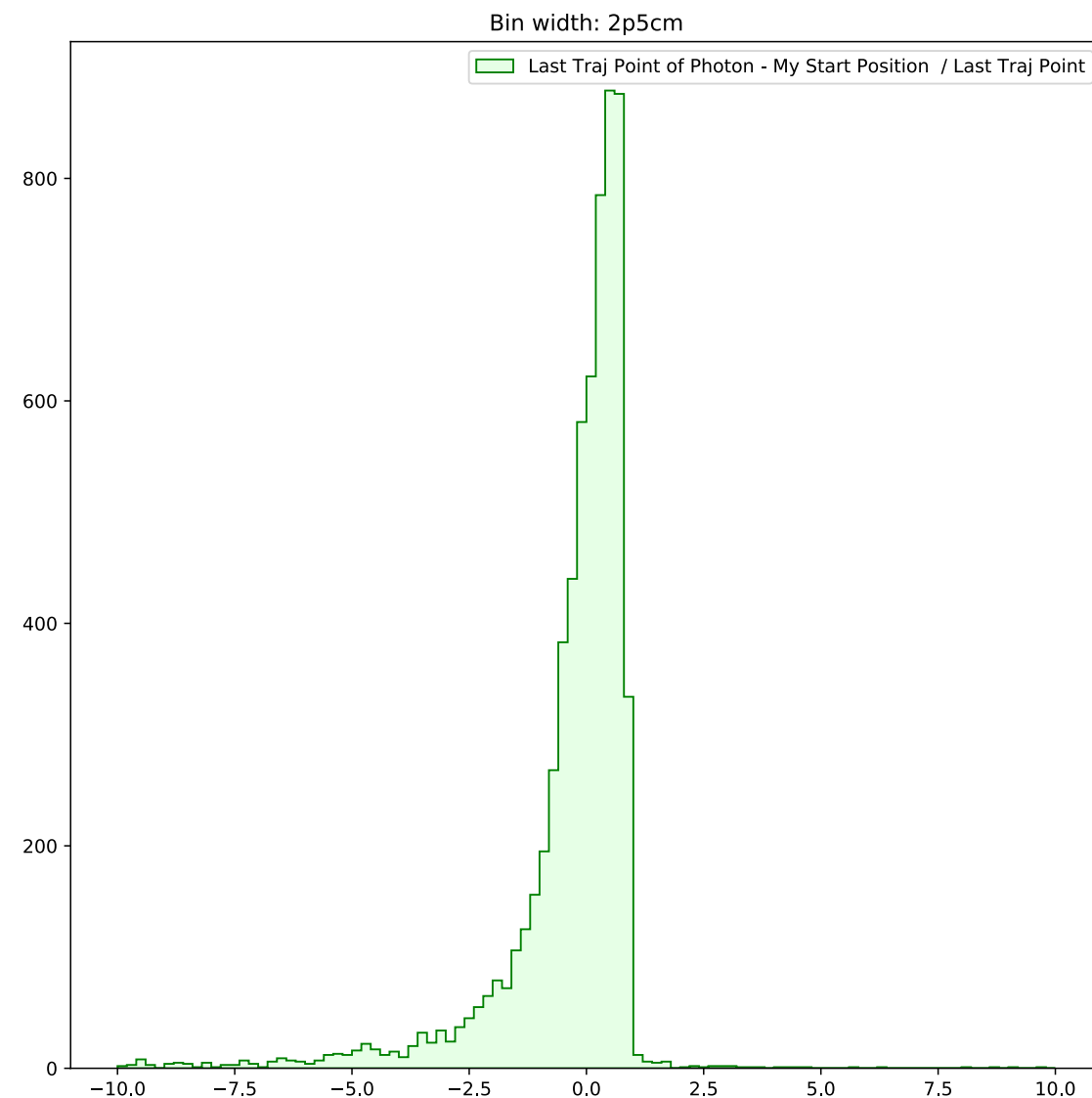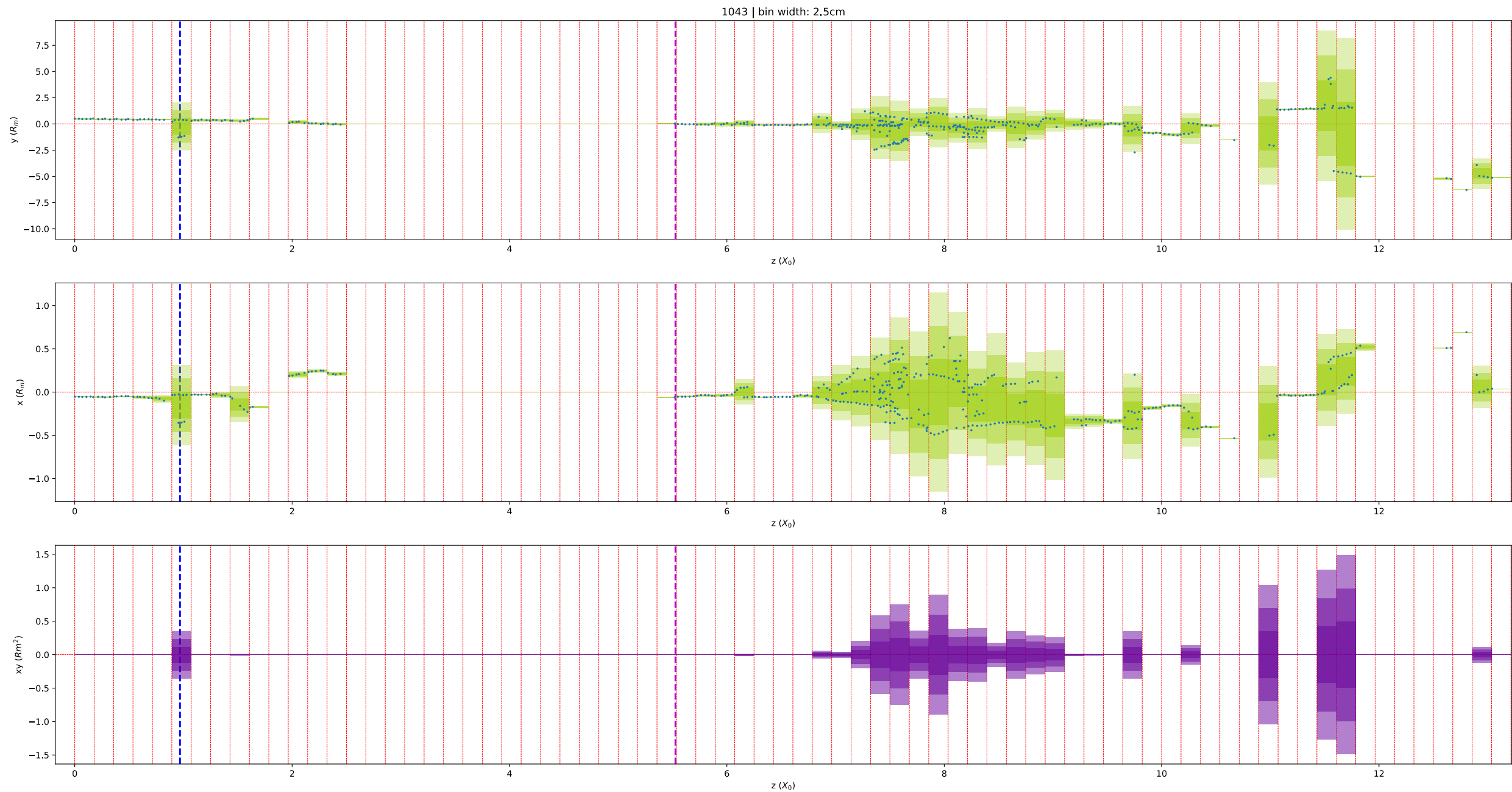Direct daughters of the primary mc particle

Comparison to my mip end

- Quite a wide distribution.

- Negative tail
  - My end of mip position is being set upstream of the final trajectory point of the largest daughter flow.


Bin width: 2p5cm

Comparison to my mip end

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Bin width: 2p5cm

Last Traj Point of Photon - My Start Position / Last Traj Point

Blue dashed line: My mip end   Magenta dashed line: Last photon trajectory point

1043 | bin width: 2.5cm

Blue dashed line: My mip end   Magenta dashed line: Last photon trajectory point   Green line: First photon trajectory point
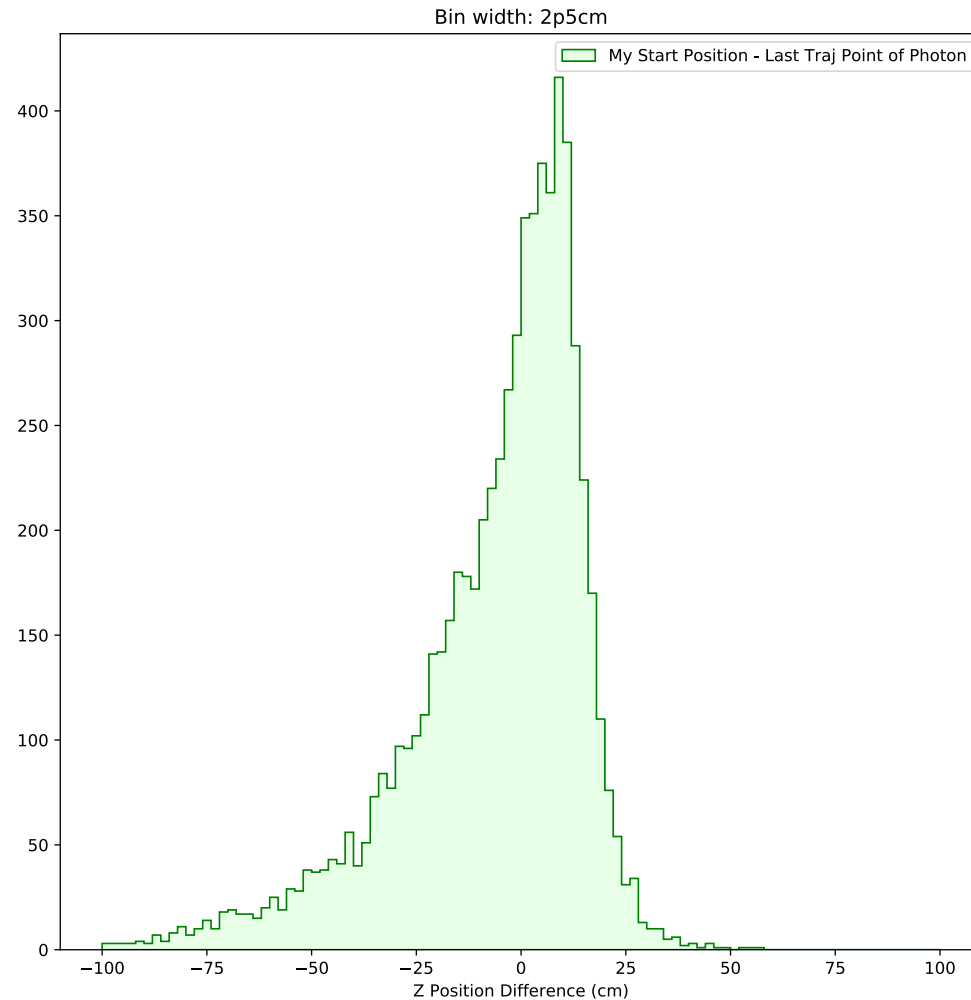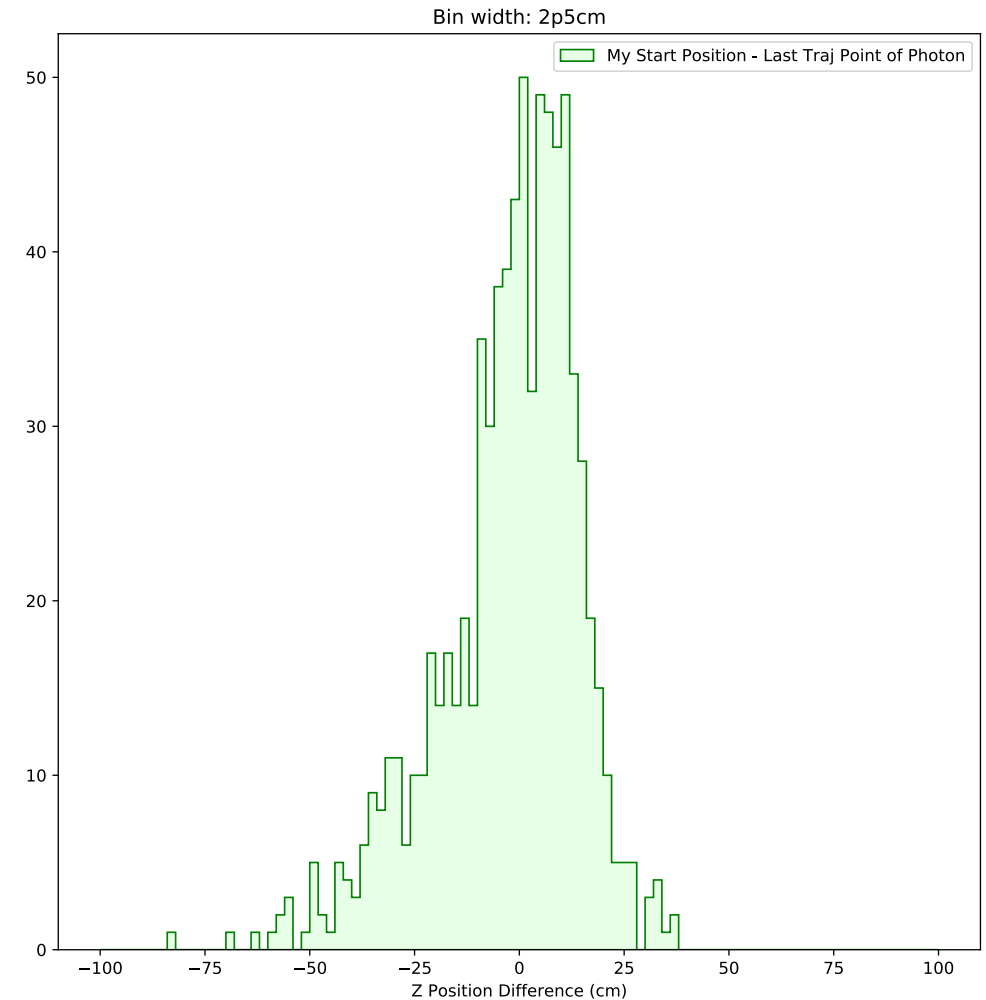
1397 | bin width: 2.5cm
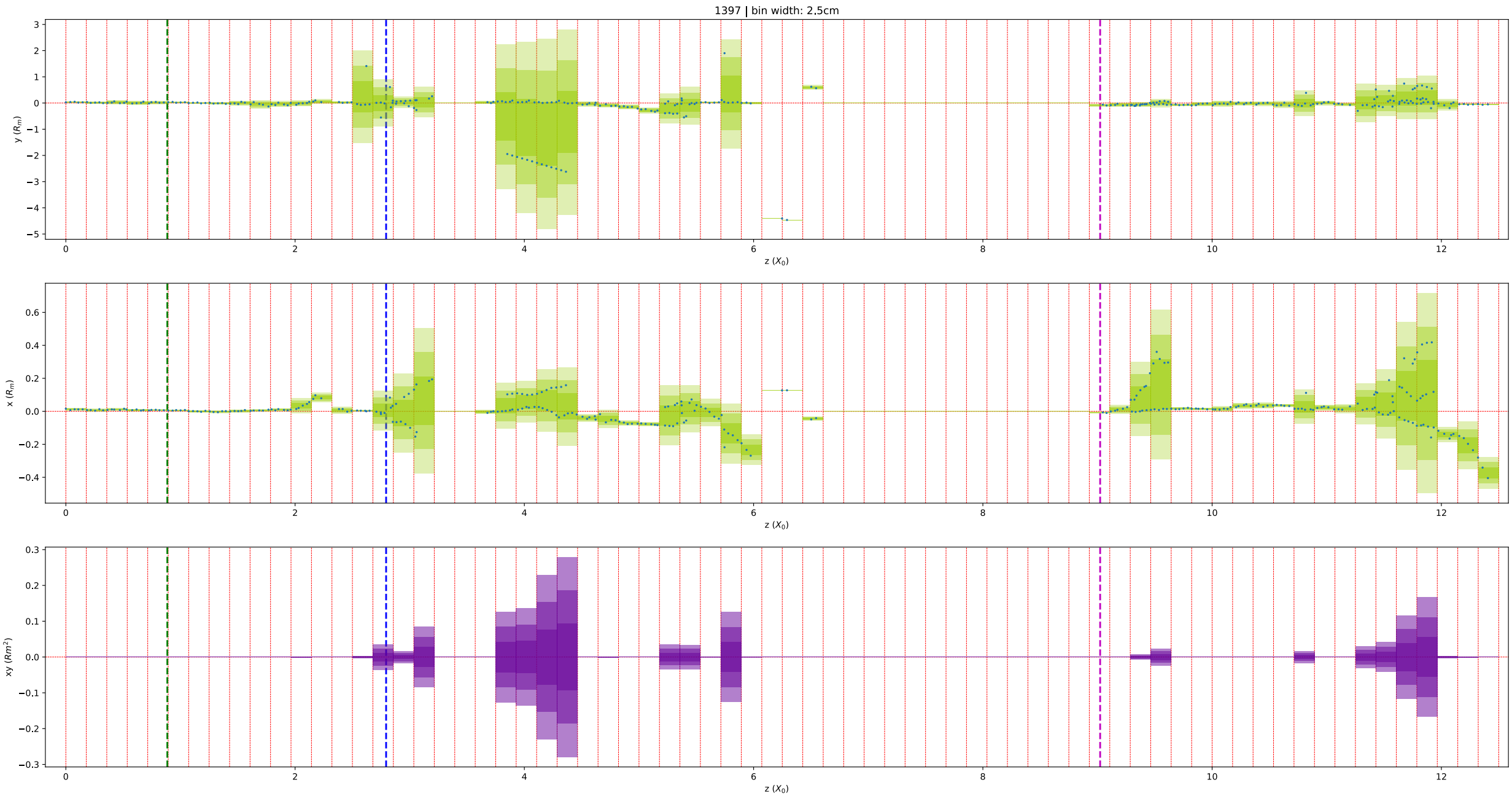
Shower sections

- Thought maybe I can remove these non-contiguous showers.

- Plot on right:
  - A section is defined as a continuous set of bins that have at least 1 hit in them

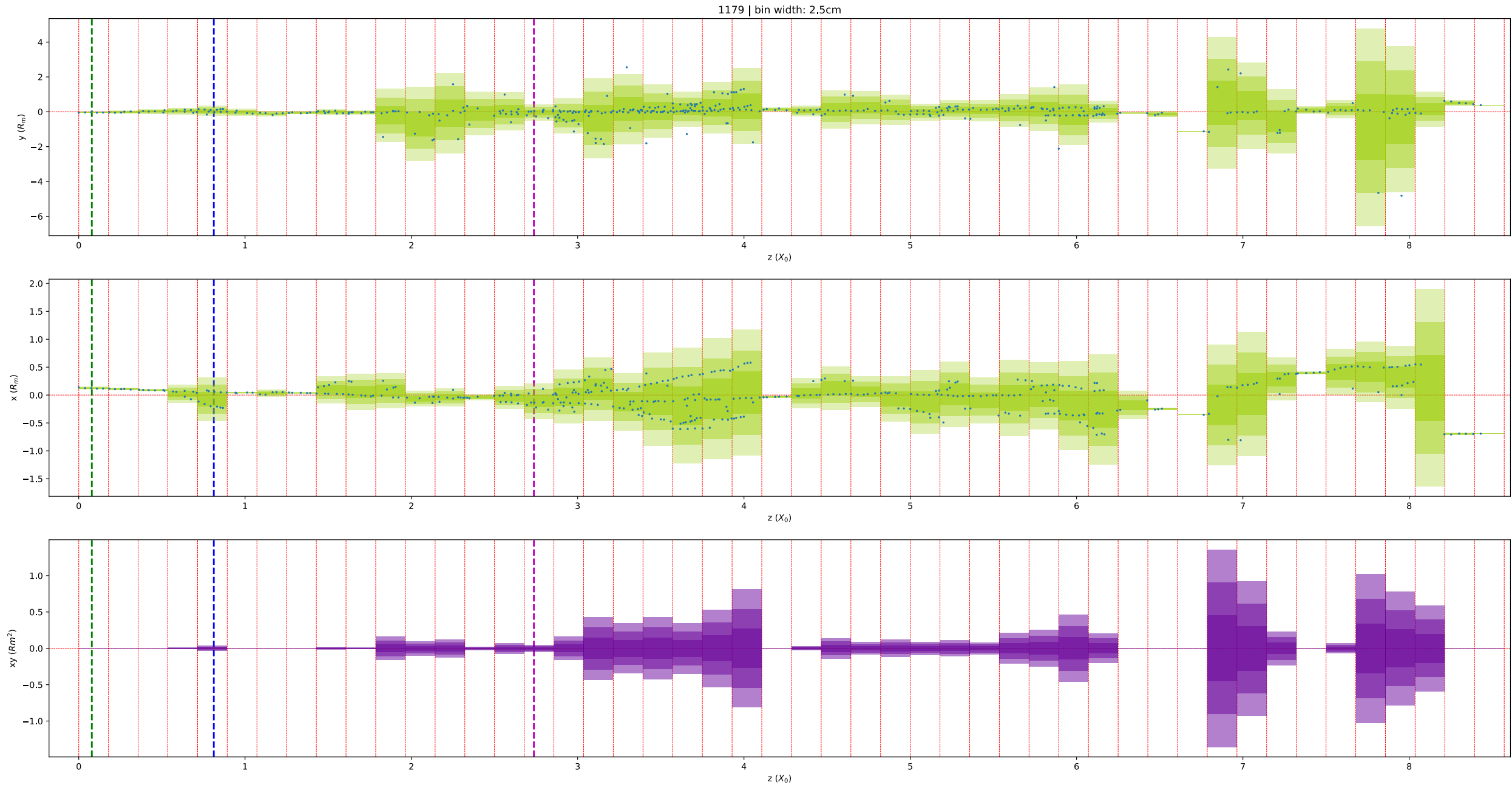- Select the showers with only 1 section
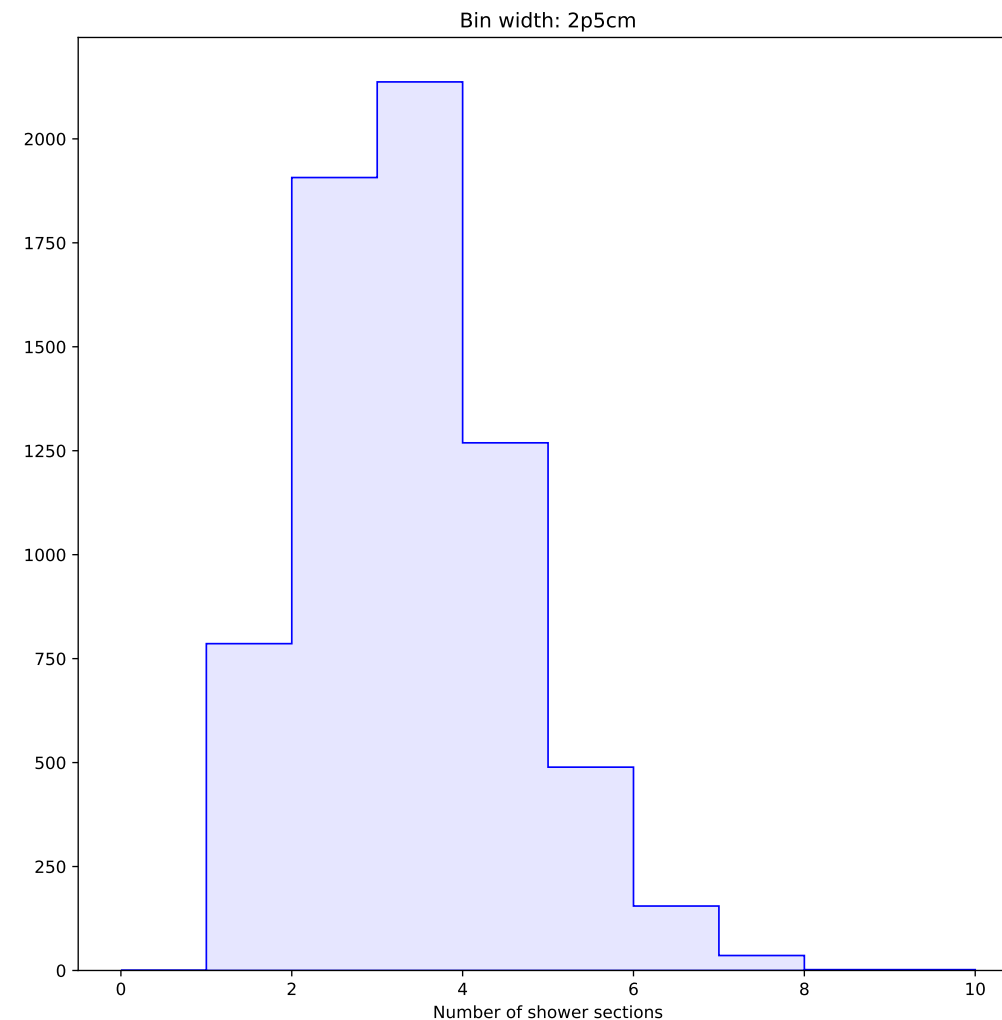
Shower sections

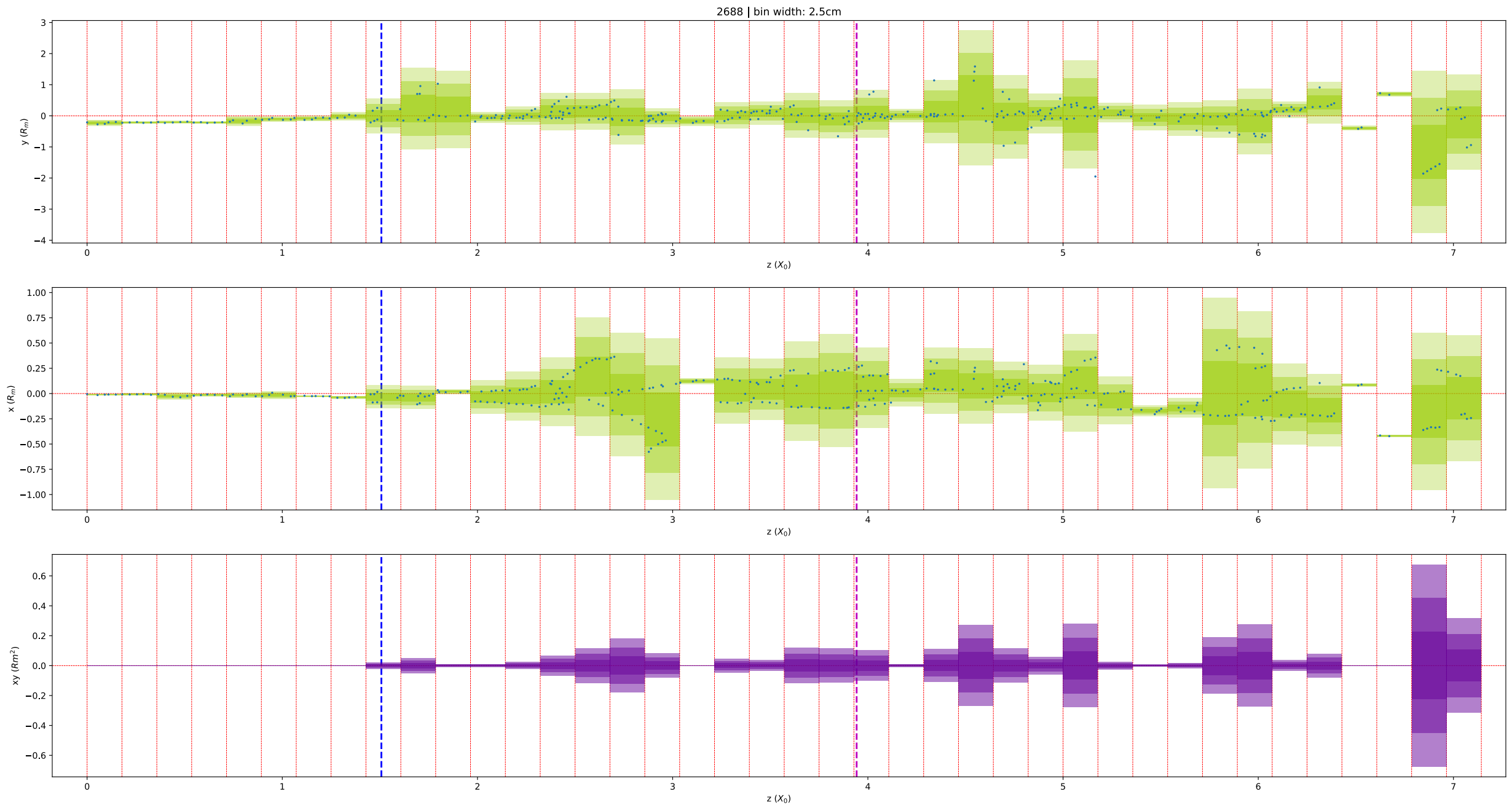Select showers with only one section

Blue dashed line: My mip end   Magenta dashed line: Last photon trajectory point   Green line: First photon trajectory point
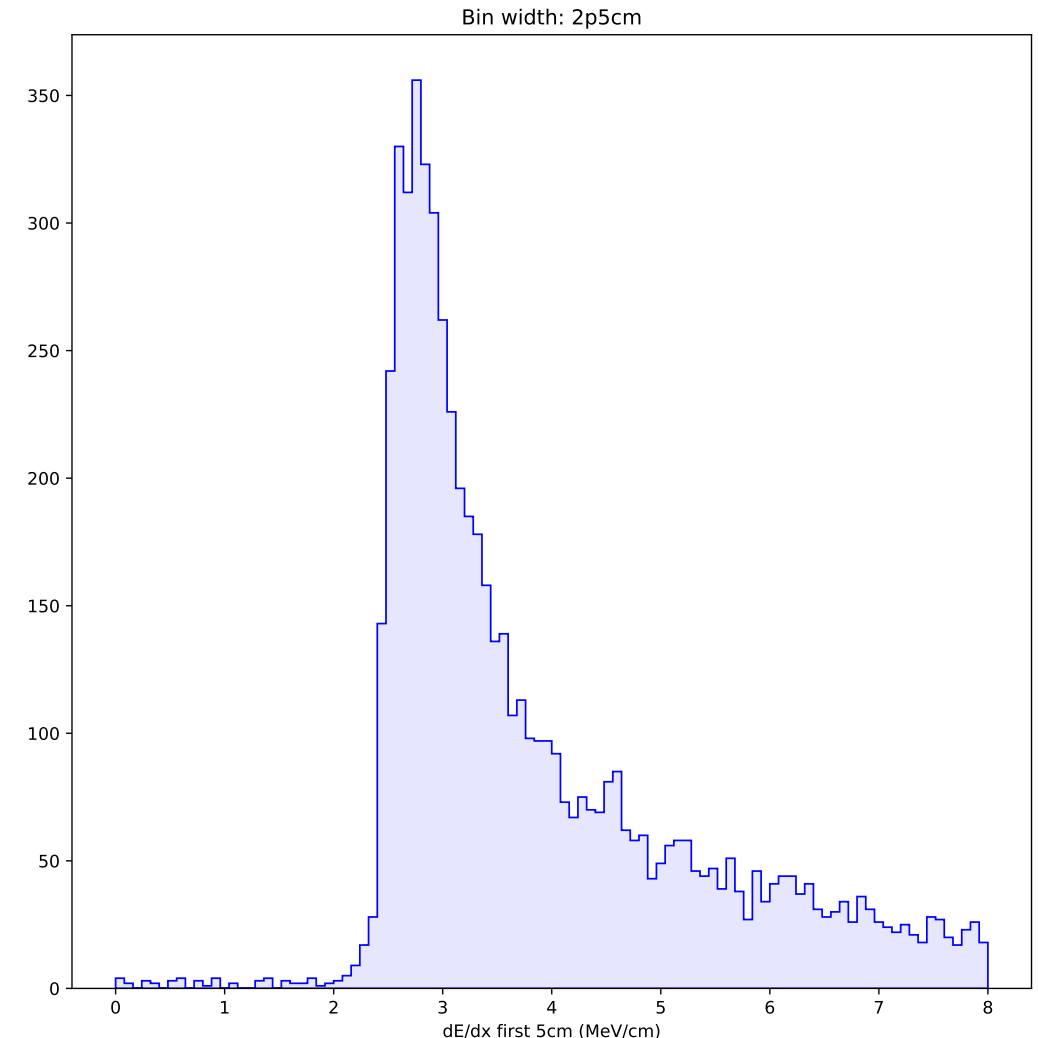
1179 | bin width: 2.5cm
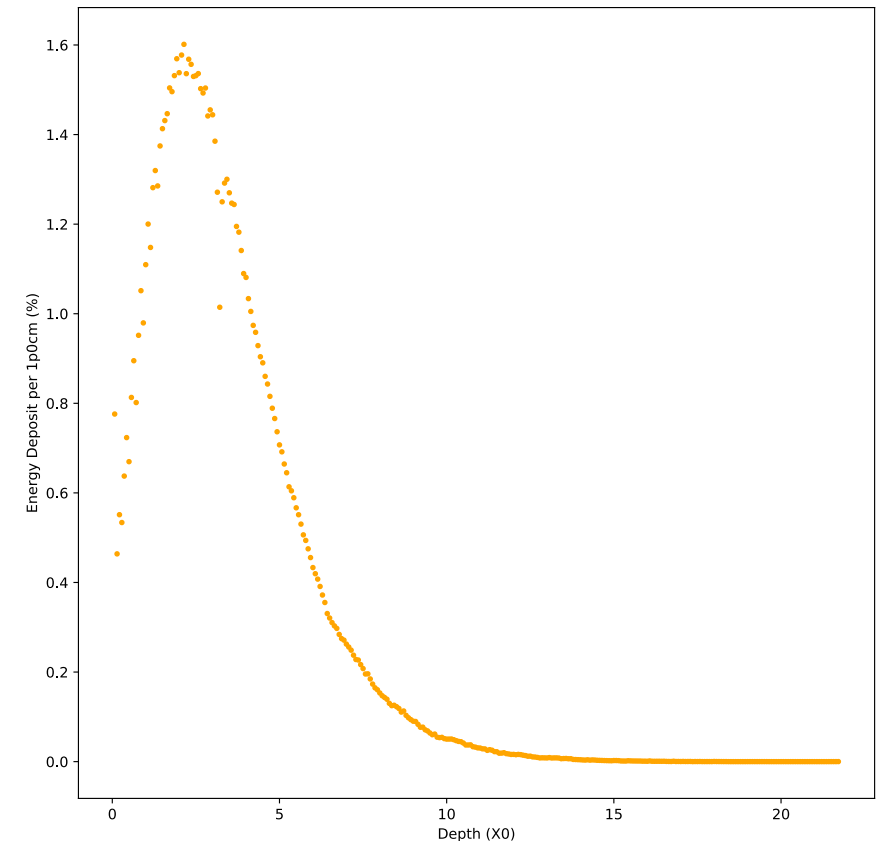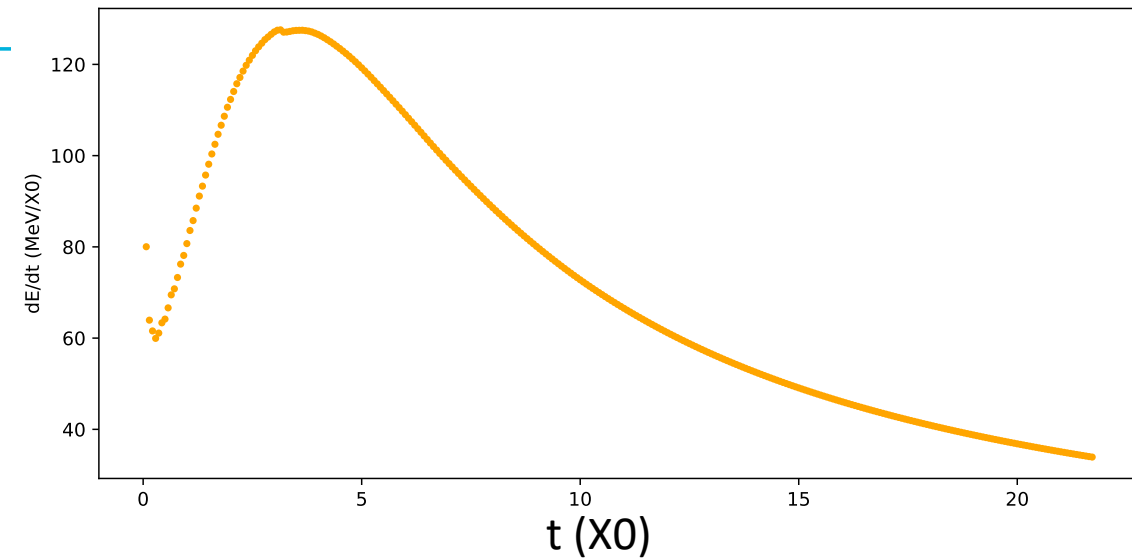
2688 | bin width: 2.5cm

dE/dx

- Calculate the dE/dx by summing the energy of the hits in a bin, and dividing by the bin width

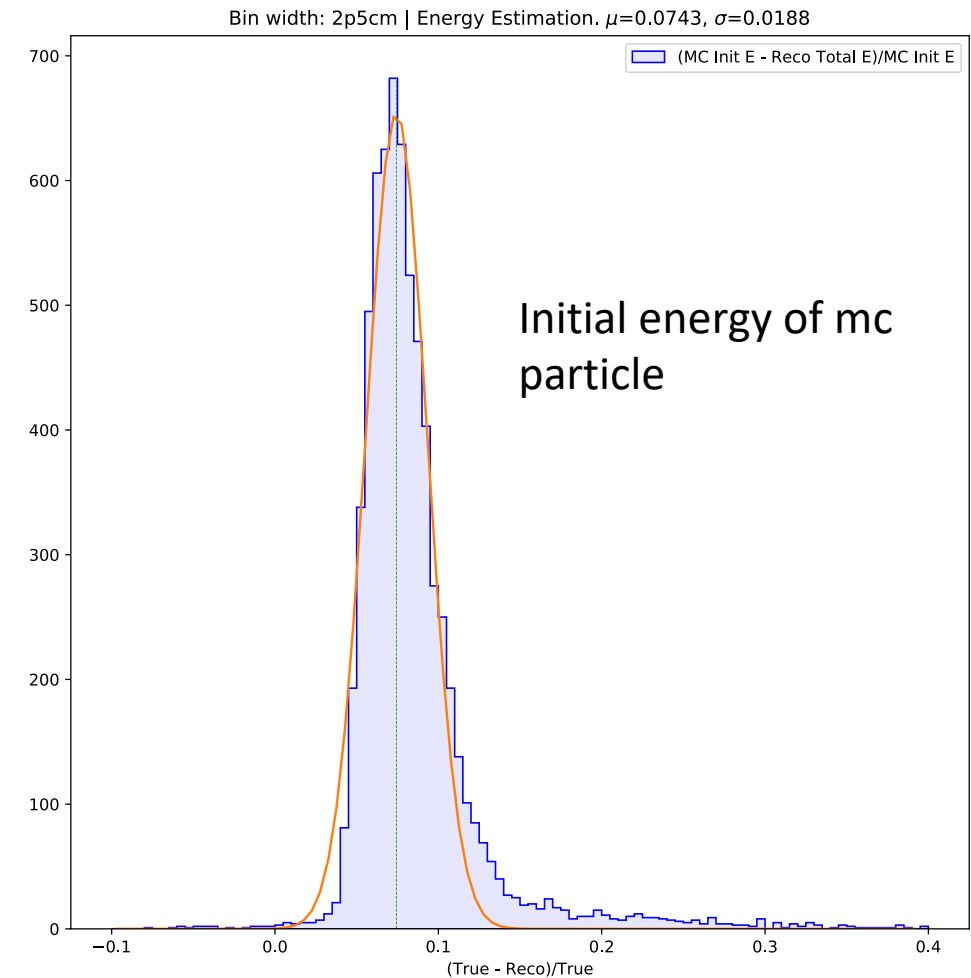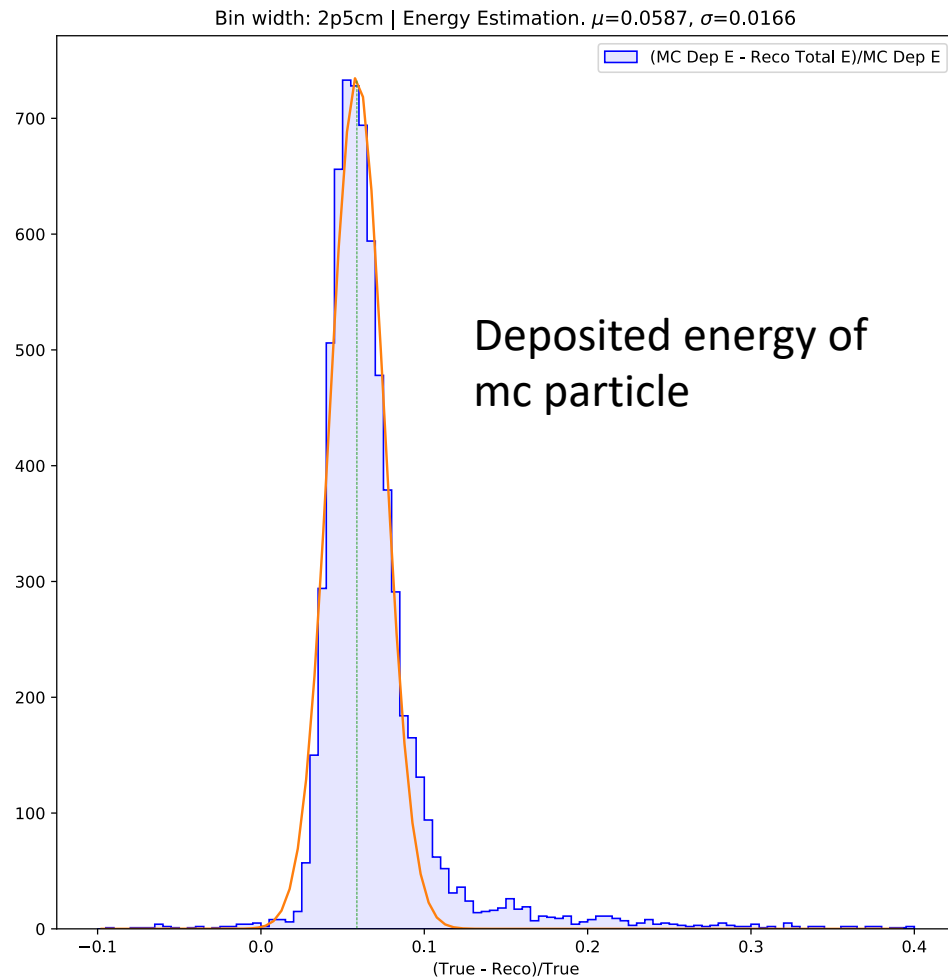- For first 5cm of shower, still getting a slightly too high value for dE/dx

Bin width: 2p5cm

dE/dx first 5cm (MeV/cm)

dE/dt

- Shape of the energy deposition doesn't seem crazy.

- Peak of dE/dt does seem higher than what Aaron had in his slides at https://indico.fnal.gov/event/21362/contribution/0/material/slides/0.pdf

Check Energy estimation

Bin width: 2p5cm | Energy Estimation. $\mu=0.0587$, $\sigma=0.0166$

(MC Dep E - Reco Total E)/MC Dep E

Deposited energy of mc particle

(True - Reco)/True

Bin width: 2p5cm | Energy Estimation. $\mu=0.0743$, $\sigma=0.0188$

(MC Init E - Reco Total E)/MC Init E

Initial energy of mc particle
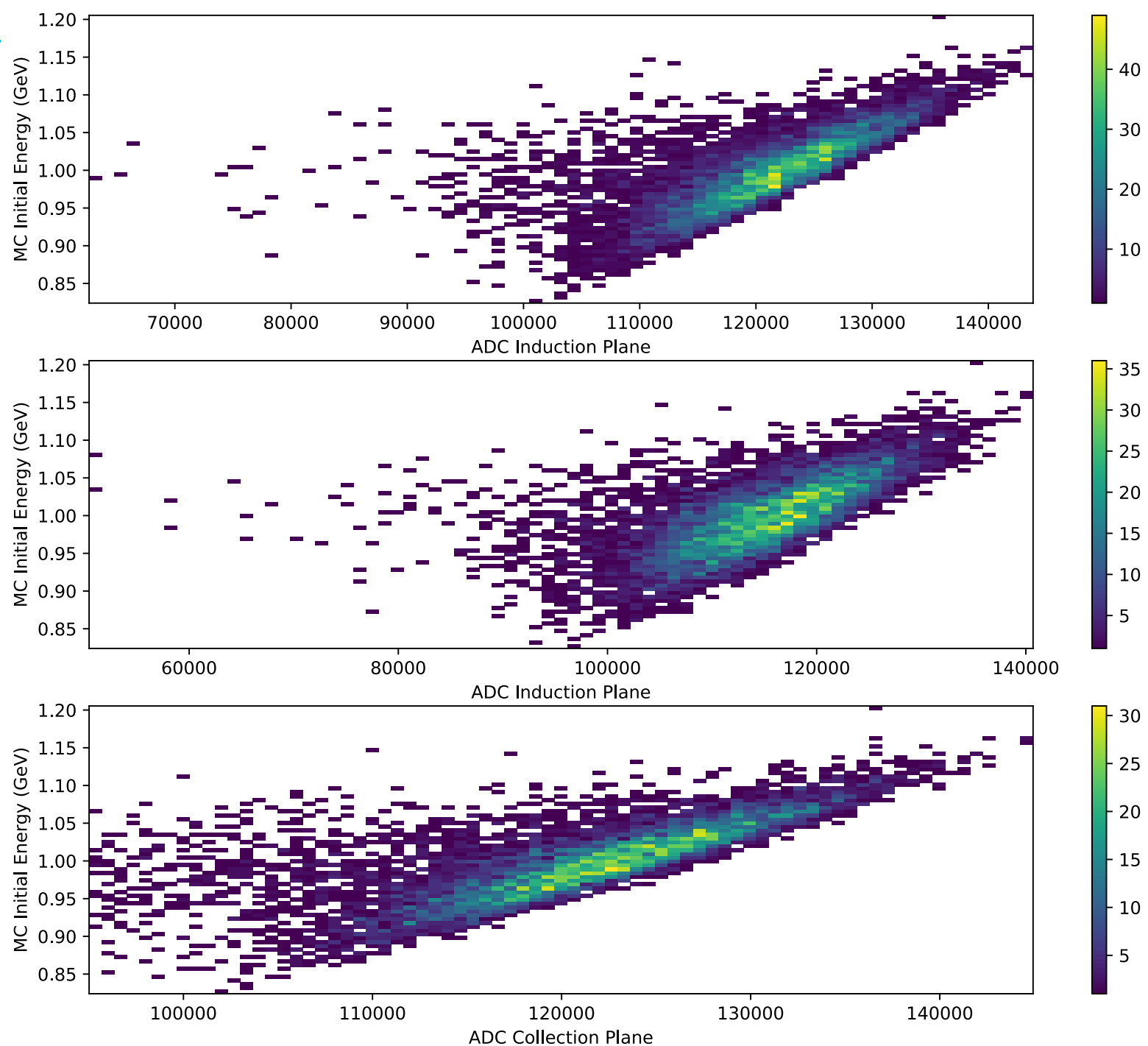
(True - Reco)/True

Next

- Next, I'm going to dive into one event that sits in the dE/dx peak, and see what's going wrong.
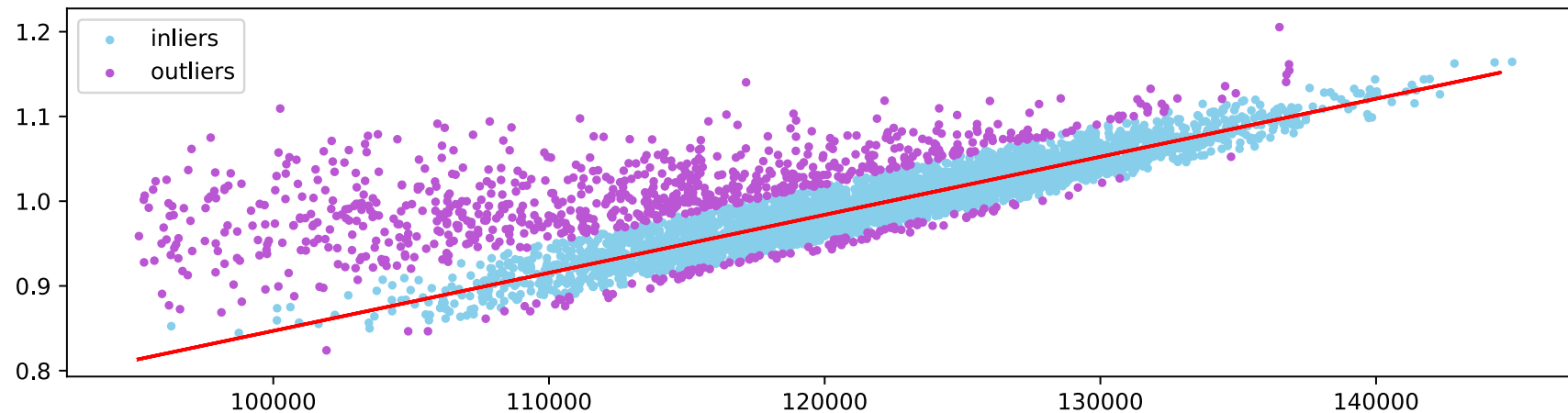
Energy estimation from summed ADC
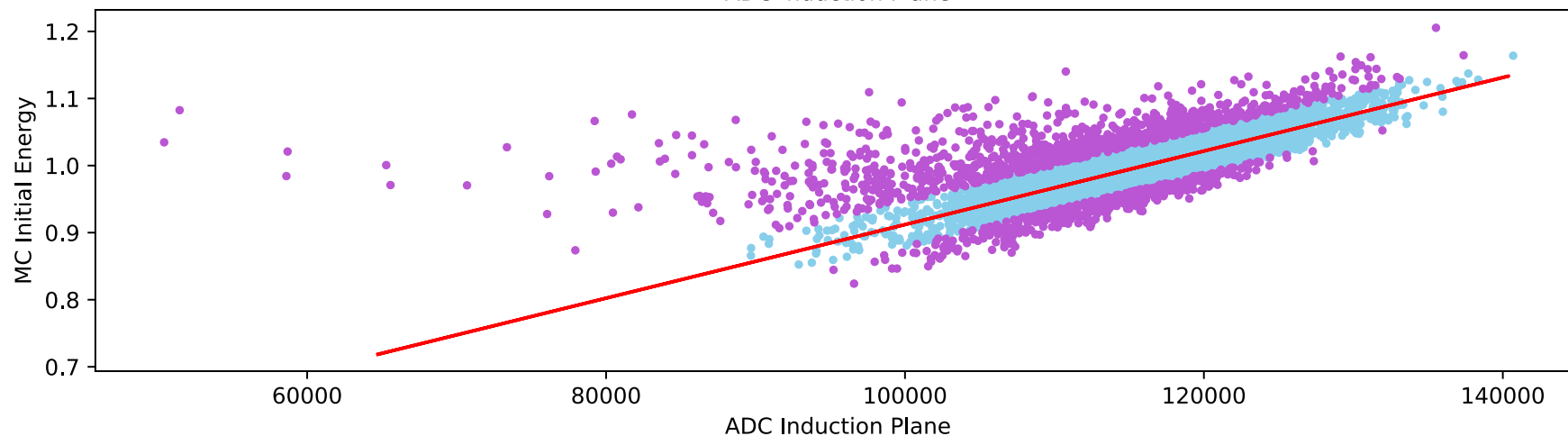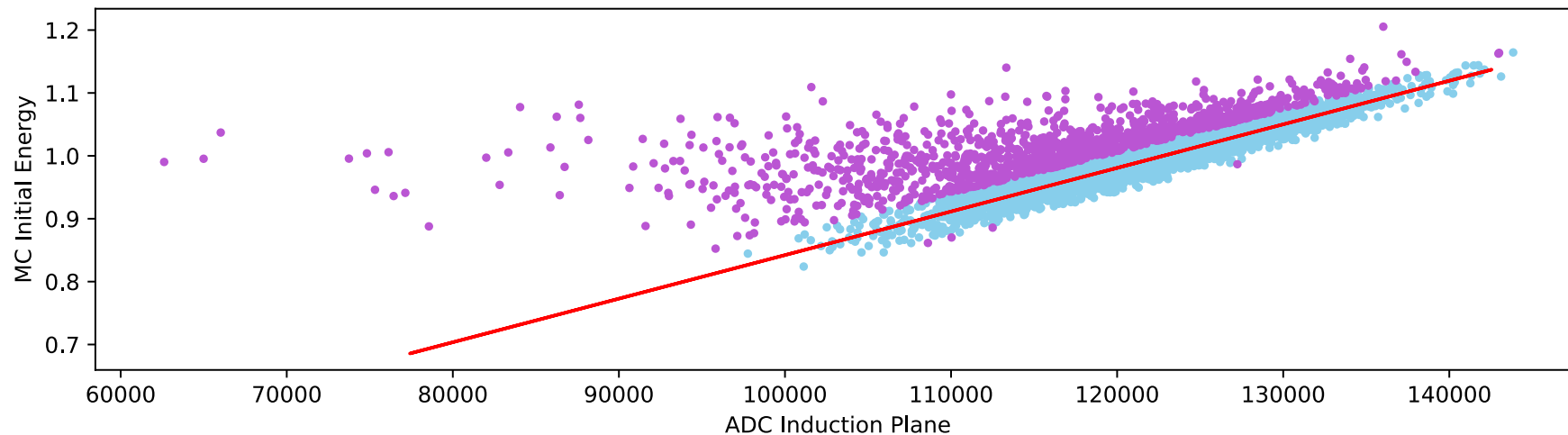
- Can we go straight from total ADC for a particle to the energy?

- What does total ADC vs initial mc energy look like?

- First split events into train (70%) and test (30%)

- Use a robust linear regressor.
  - De-weights outliers

- Result is distribution of the same shape, but with a mean closer to 0.

- Red histograms are all the same energy estimation based only on collection plane, so ignore the top two red histograms
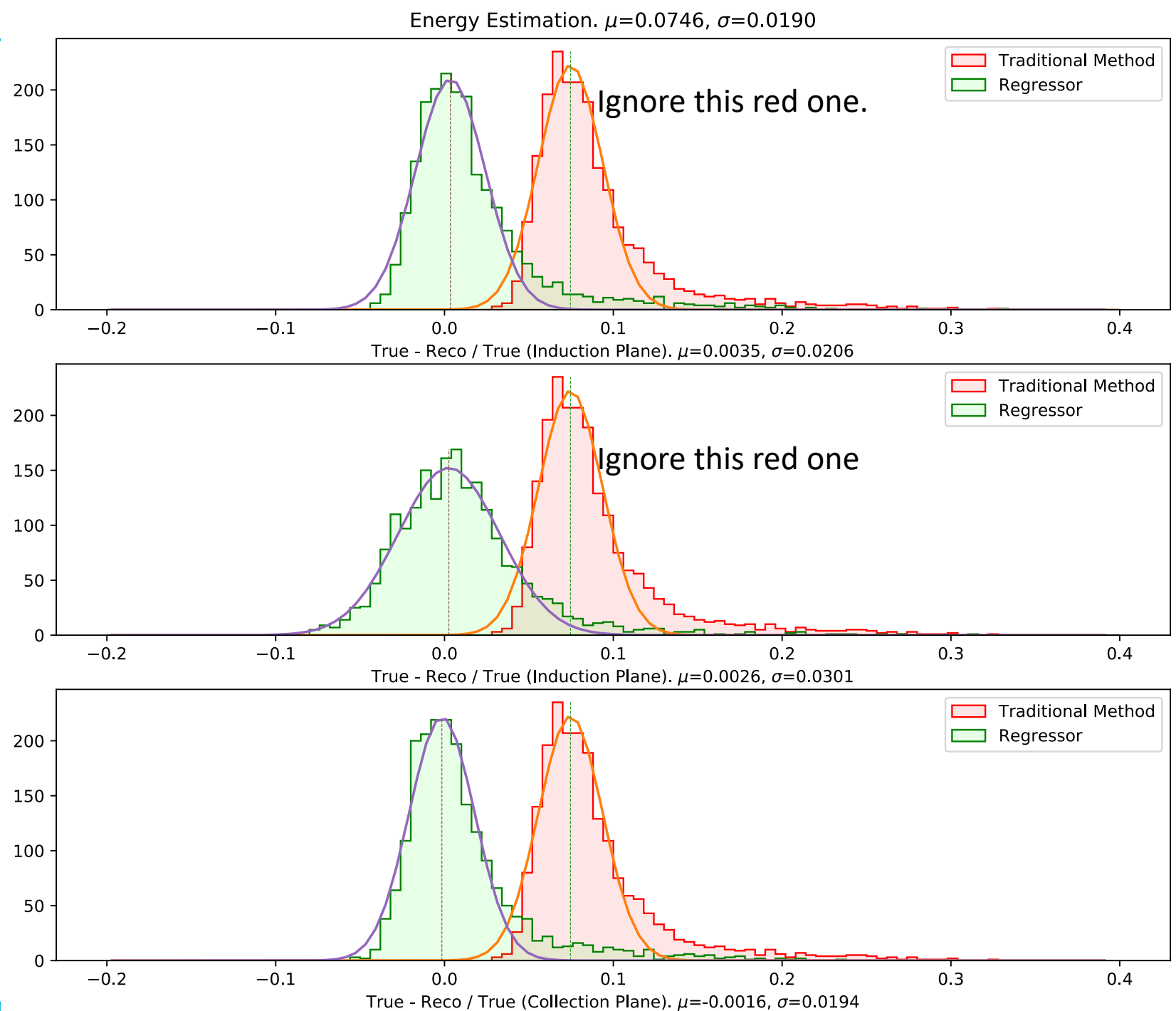
Back-up

James Pillow

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NEUTRINO EXPERIMENT**

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Shower Energy Estimation

- 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.

Comparison of MC Initial Energy to MC Deposited Energy

Bin width: 2p5cm

Absolute difference

MC Initial E - MC Dep E (GeV)

Bin width: 2p5cm

Relative difference

(MC Initial E - MC Dep E)/MC Initial E

Deposited energy of mc particle

Initial energy of mc particle