

dQ/dx distribution in different regions of ProtoDUNE LArTPC

Ajib Paudel

Graduate Student

Kansas State University

In today's talk I am mostly focussing on showing the dQ/dx values for different regions in the TPC

No of Events used:~291,000

- All the tracks used in the plots are cathode piercing and TPC crossing cosmic muon tracks
- A number of tracks are removed based on the angle they make with the wire planes (parallel to or travelling straight towards the wire plane)

First few plots are the dQ/dx distribution for YZ plane in 60 cm slices in X:

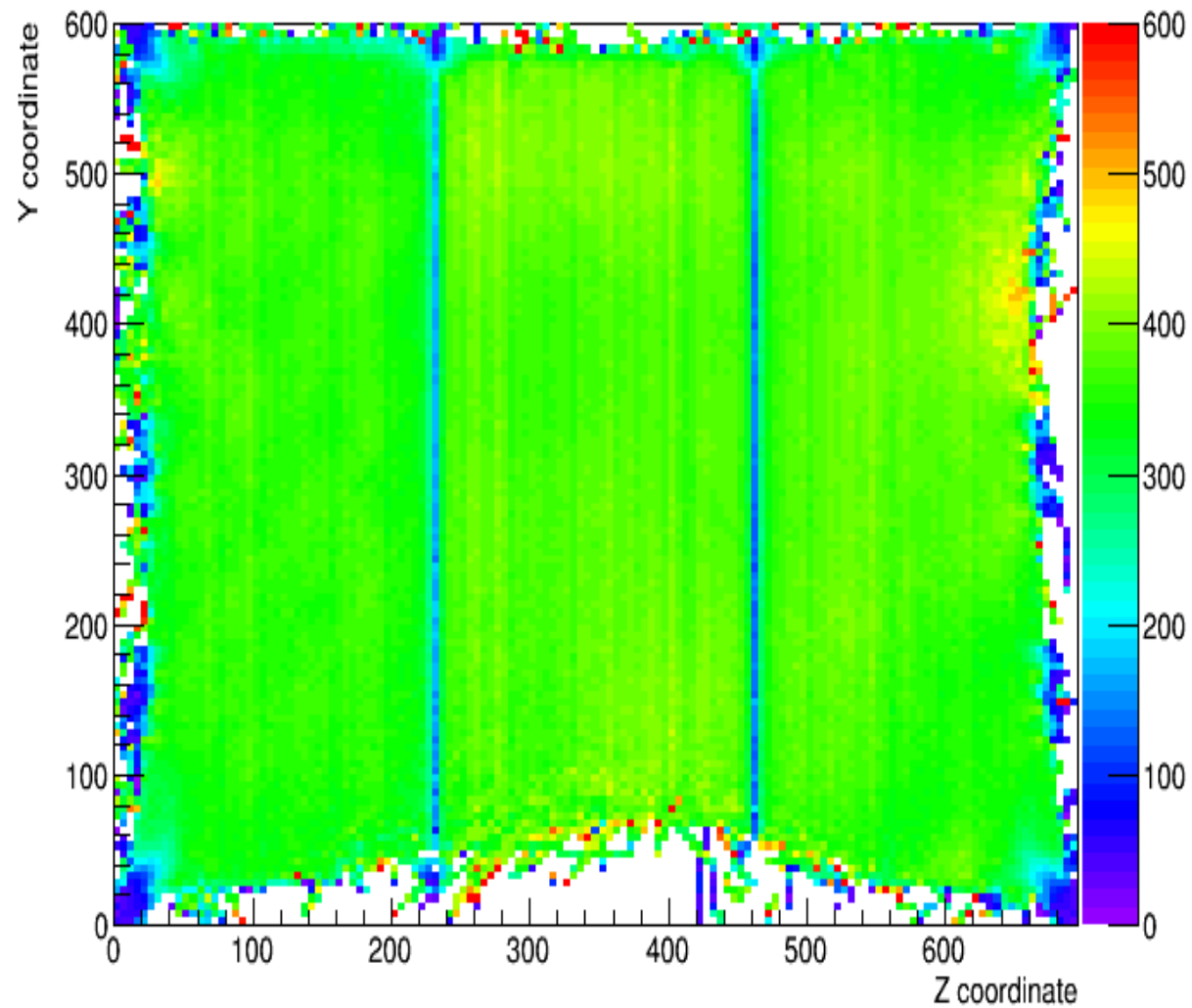
Xbin size = 60cm;

Ybin size=5cm;

Z bin size=5cm;

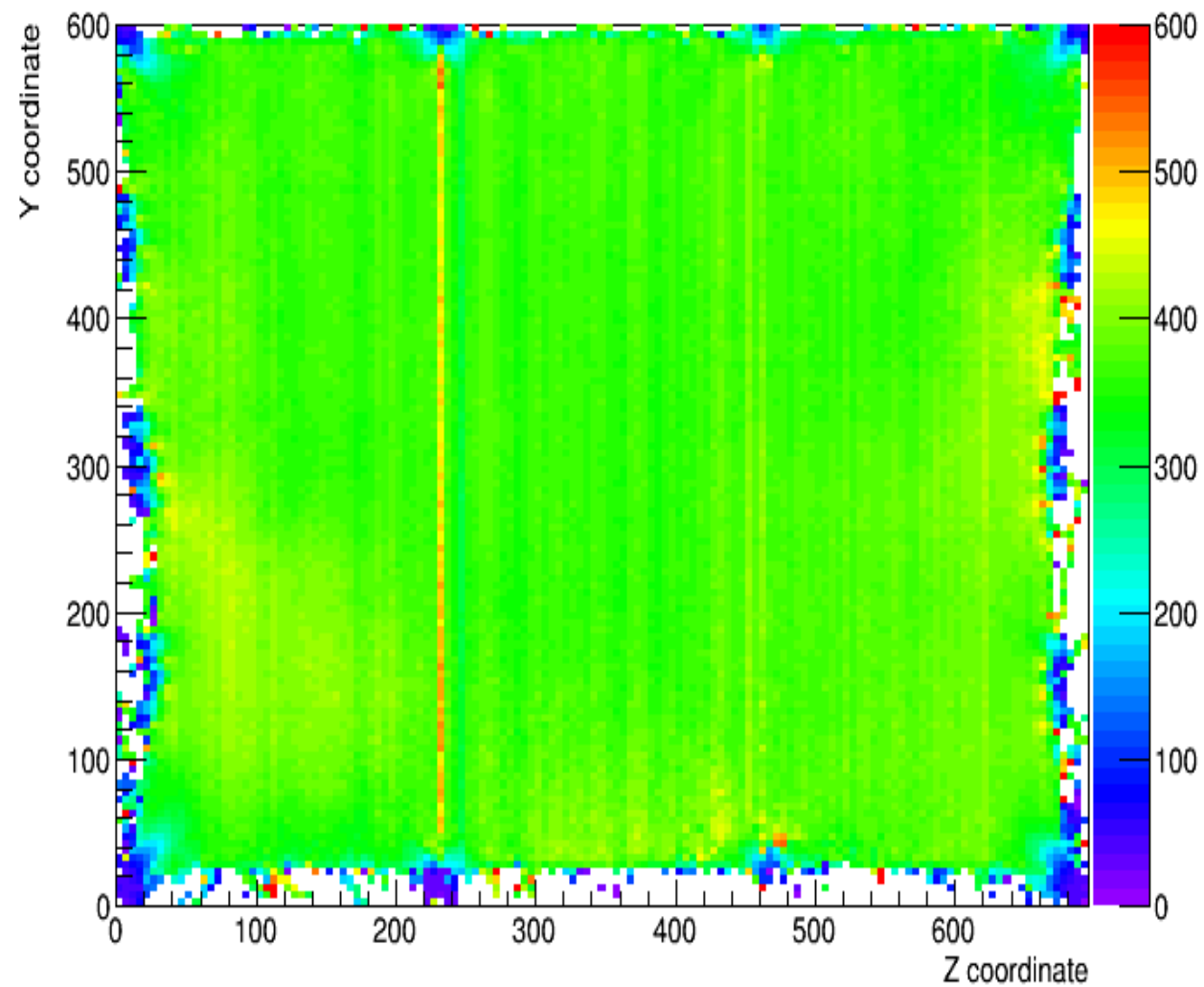
Left Plot: Beam Right

plane_2 dqdx for YZ plane for Xbin-60 to 0 cm

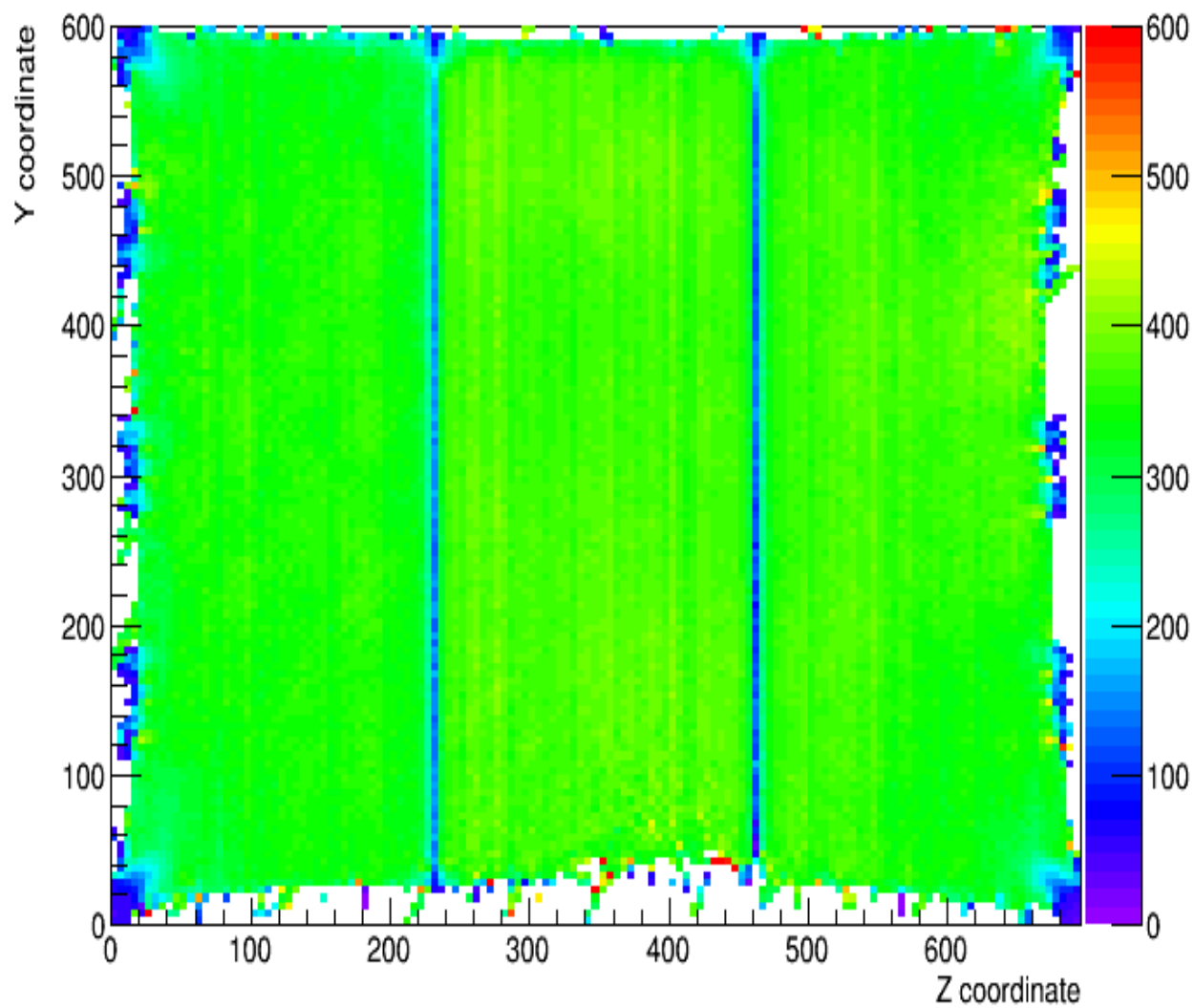


Right Plot: Beam Left

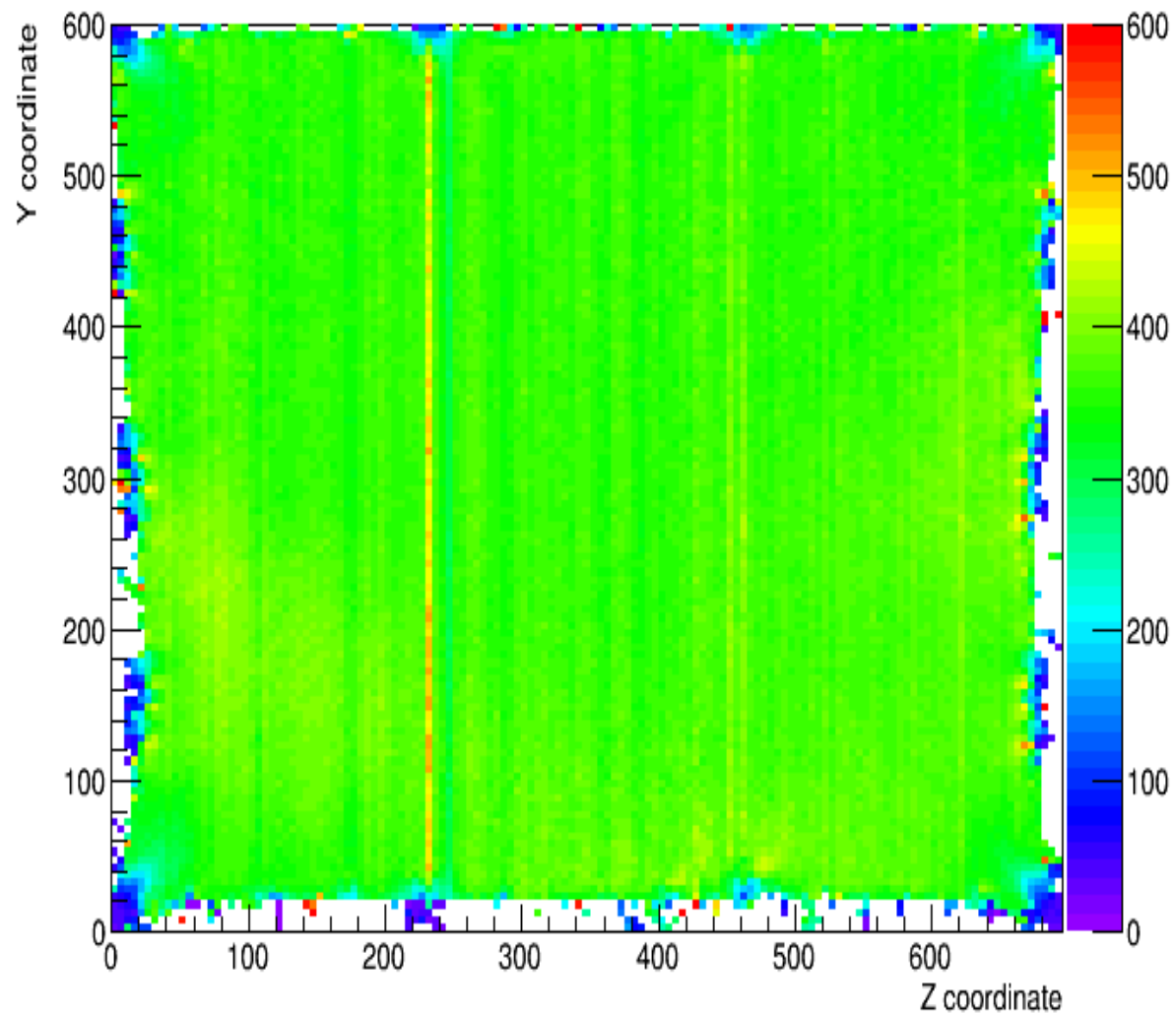
plane_2 dqdx for YZ plane for Xbin0 to 60 cm



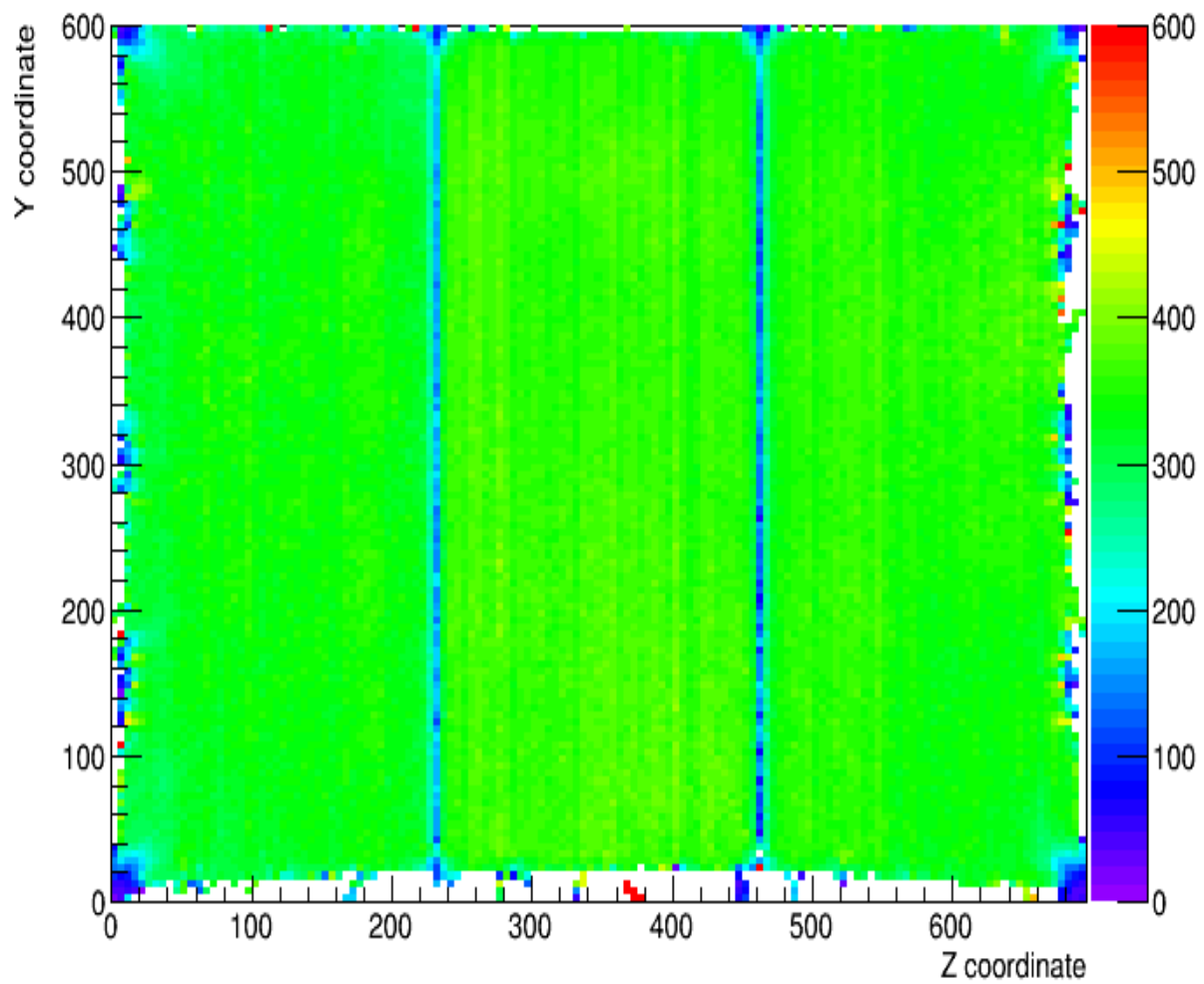
plane_2 dqdx for YZ plane for Xbin-120 to -60 cm



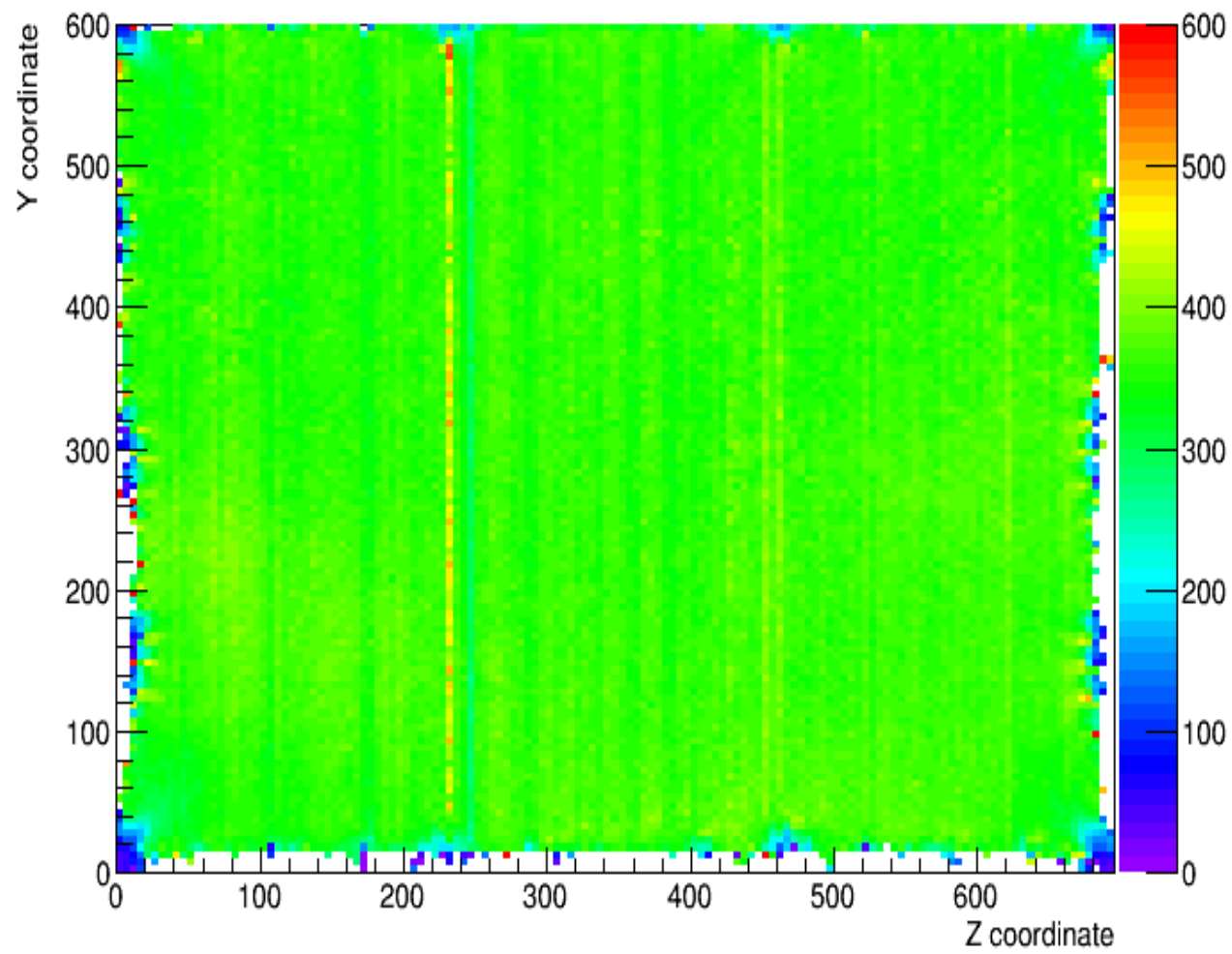
plane_2 dqdx for YZ plane for Xbin60 to 120 cm



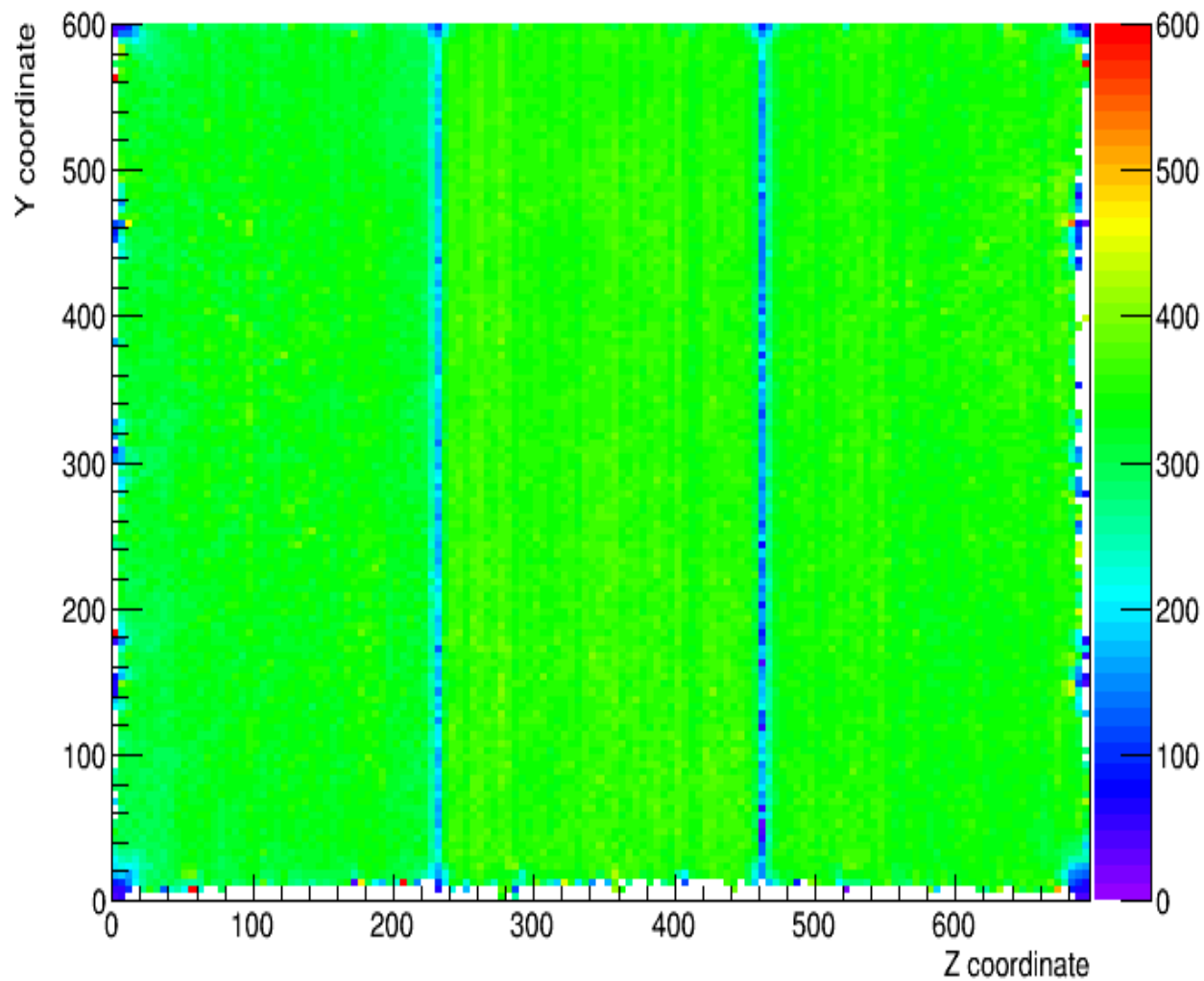
plane_2 dqdx for YZ plane for Xbin-180 to -120 cm



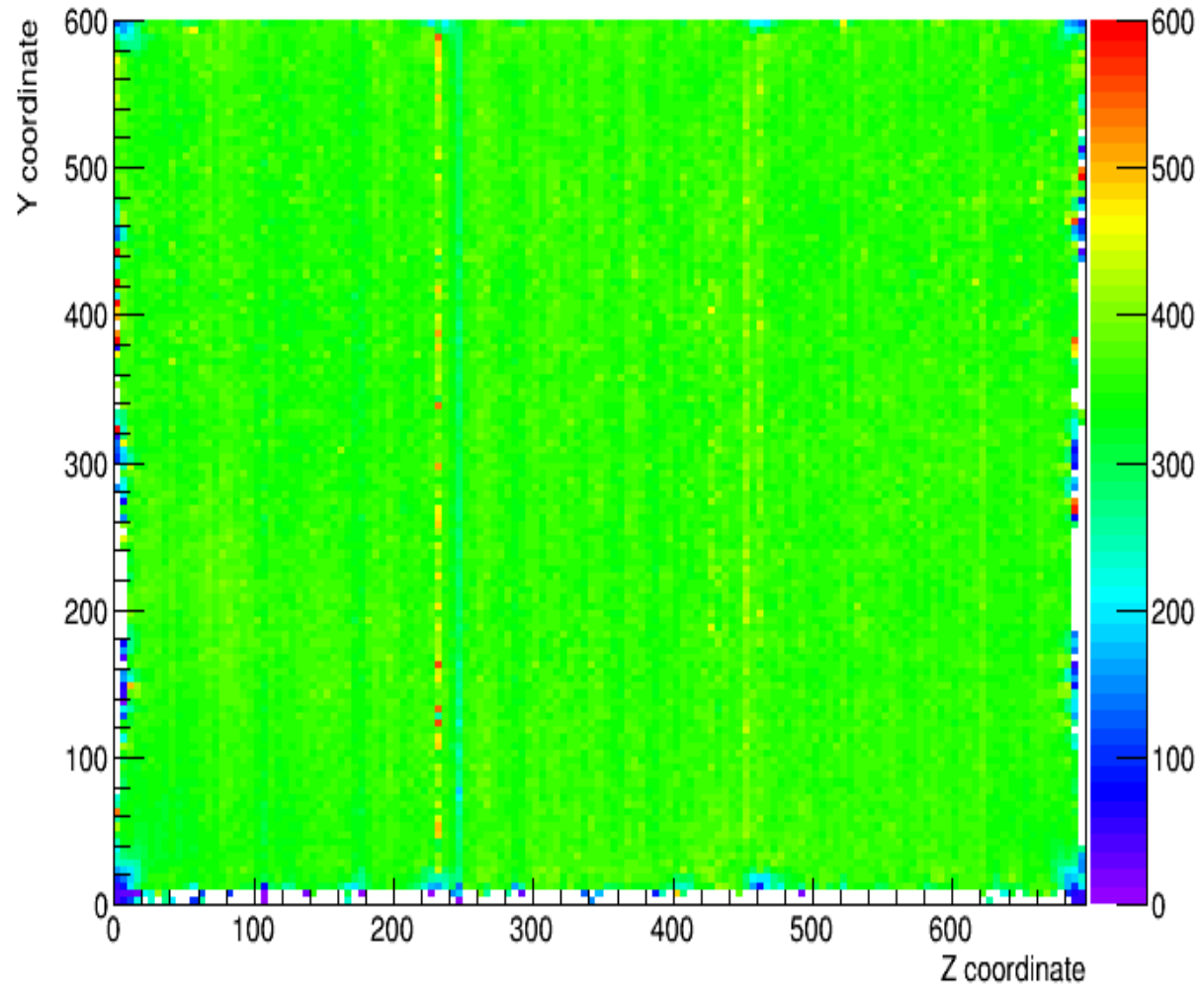
plane_2 dqdx for YZ plane for Xbin120 to 180 cm



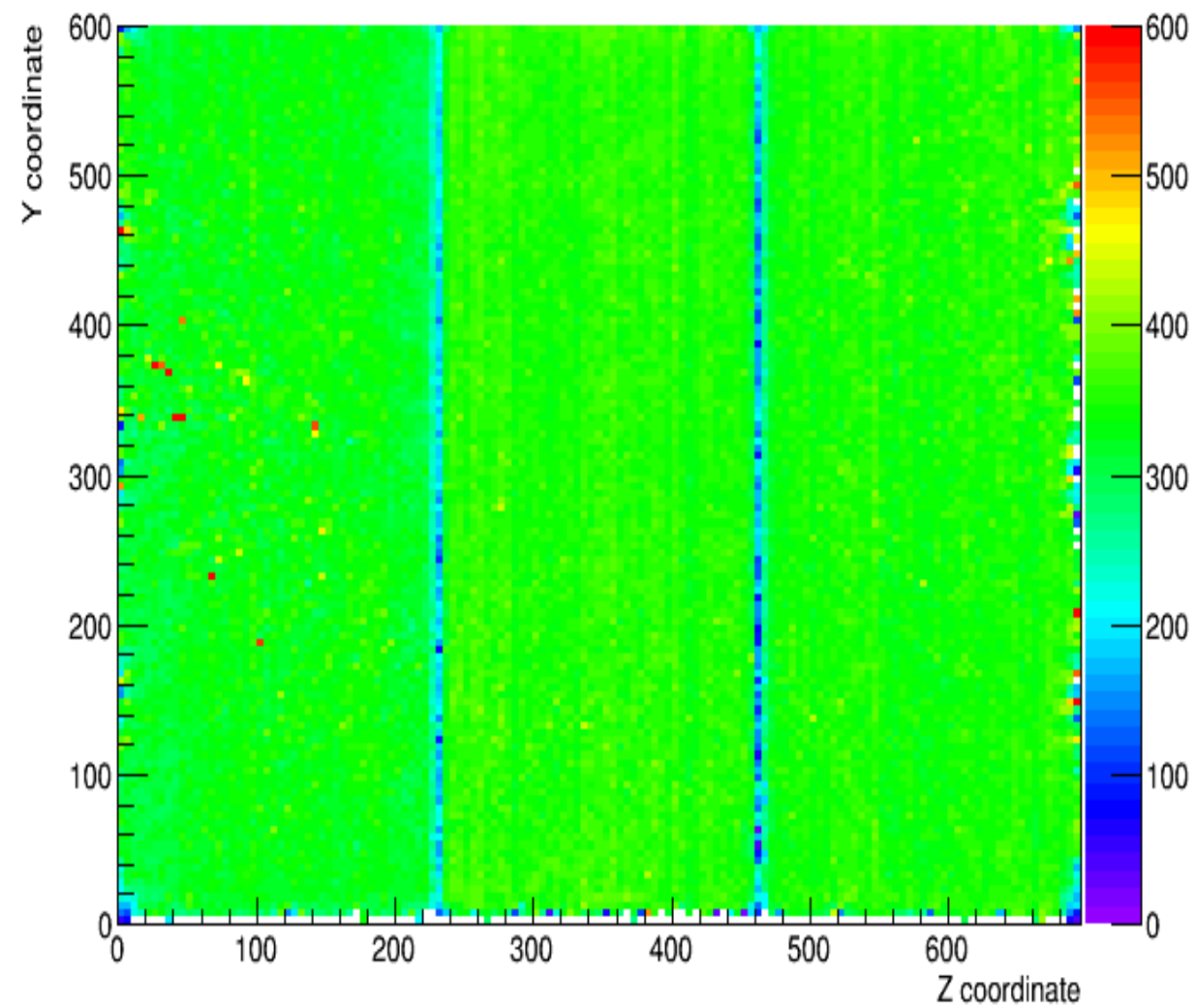
plane_2 dqdx for YZ plane for Xbin-240 to -180 cm



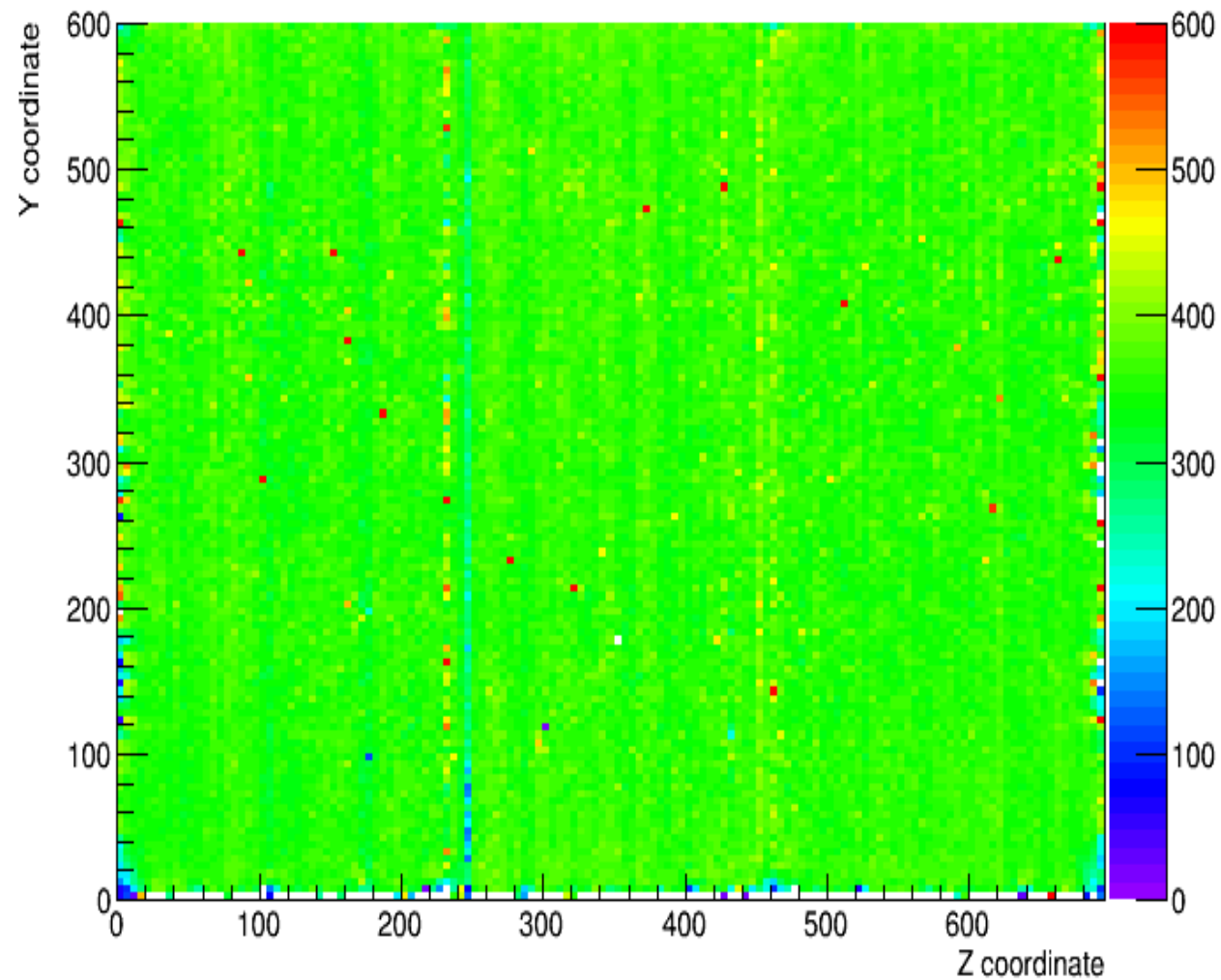
plane_2 dqdx for YZ plane for Xbin180 to 240 cm



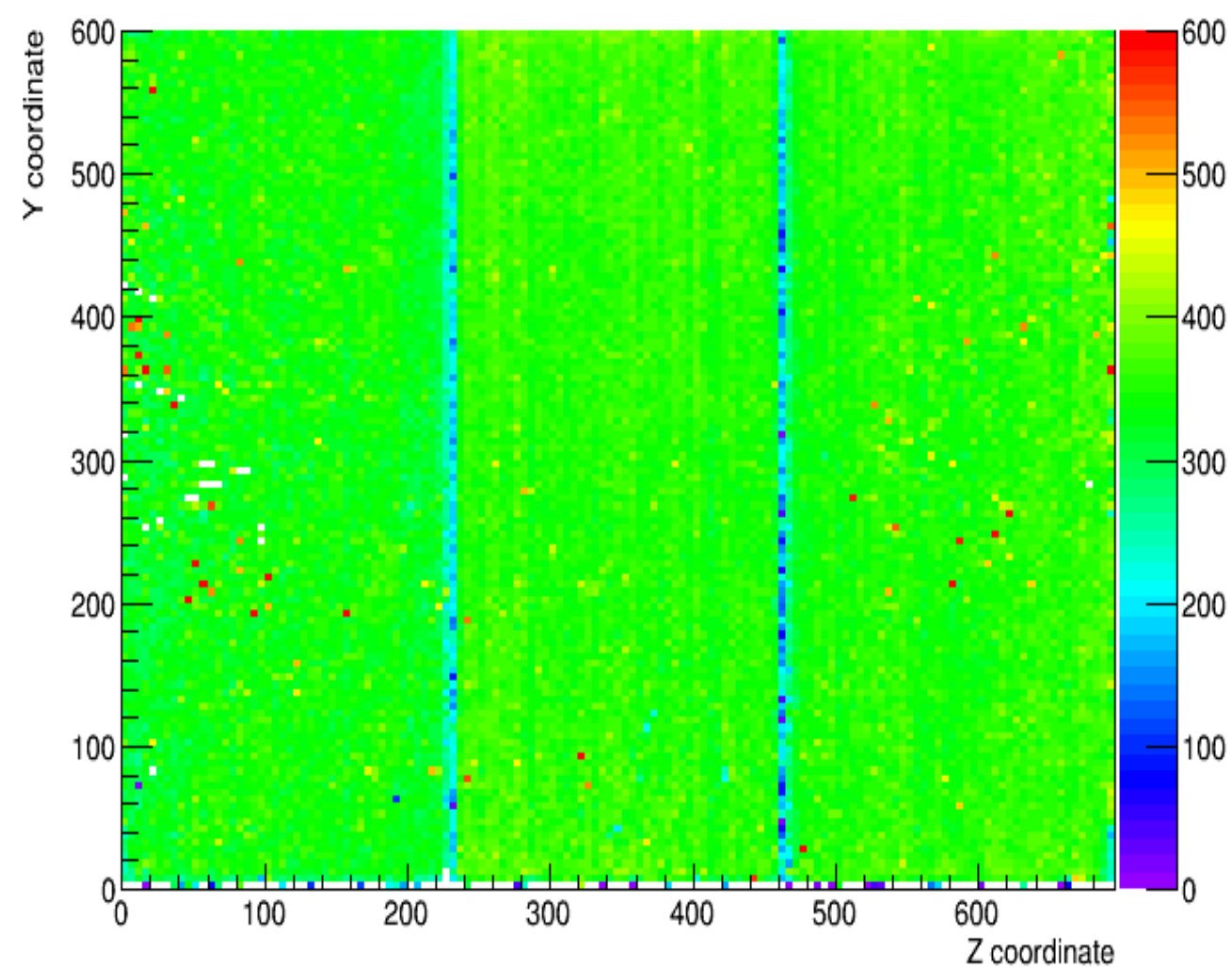
plane_2 dqdx for YZ plane for Xbin-300 to -240 cm



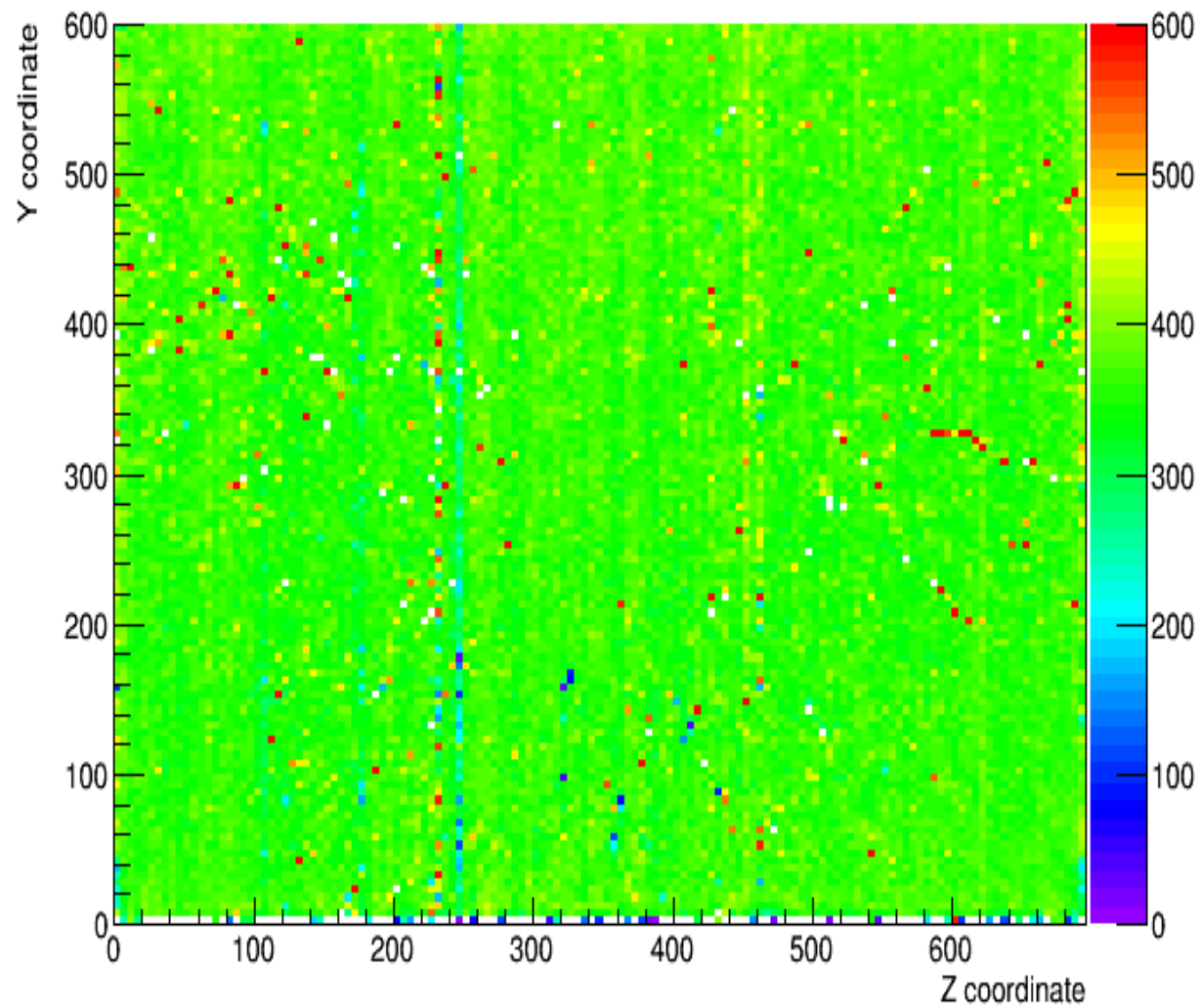
plane_2 dqdx for YZ plane for Xbin240 to 300 cm



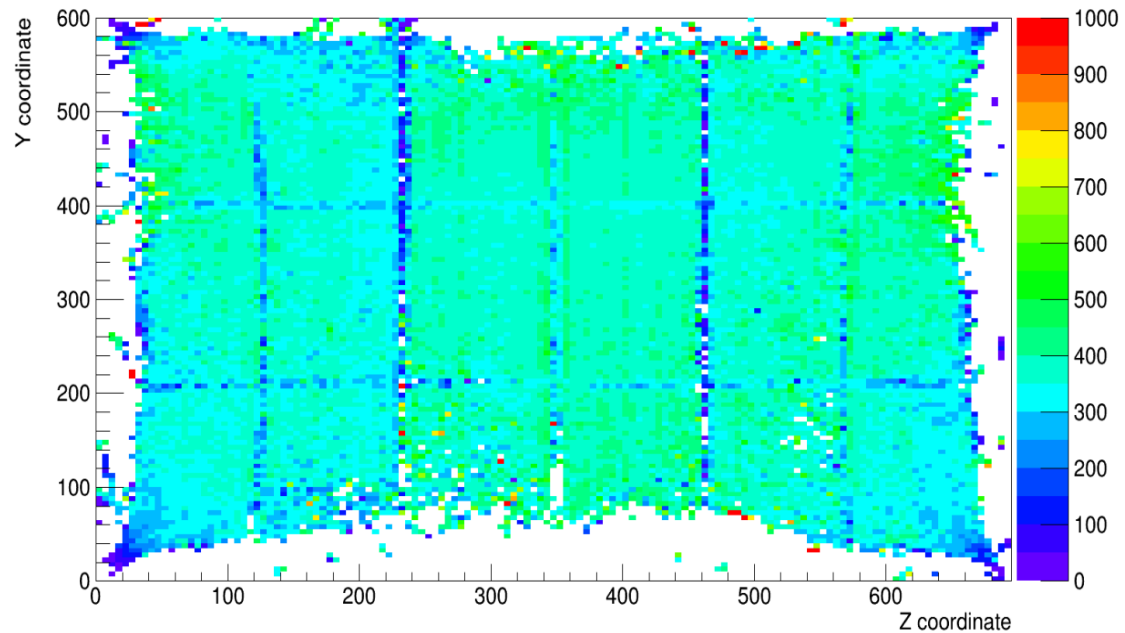
plane_2 dqdx for YZ plane for Xbin-360 to -300 cm



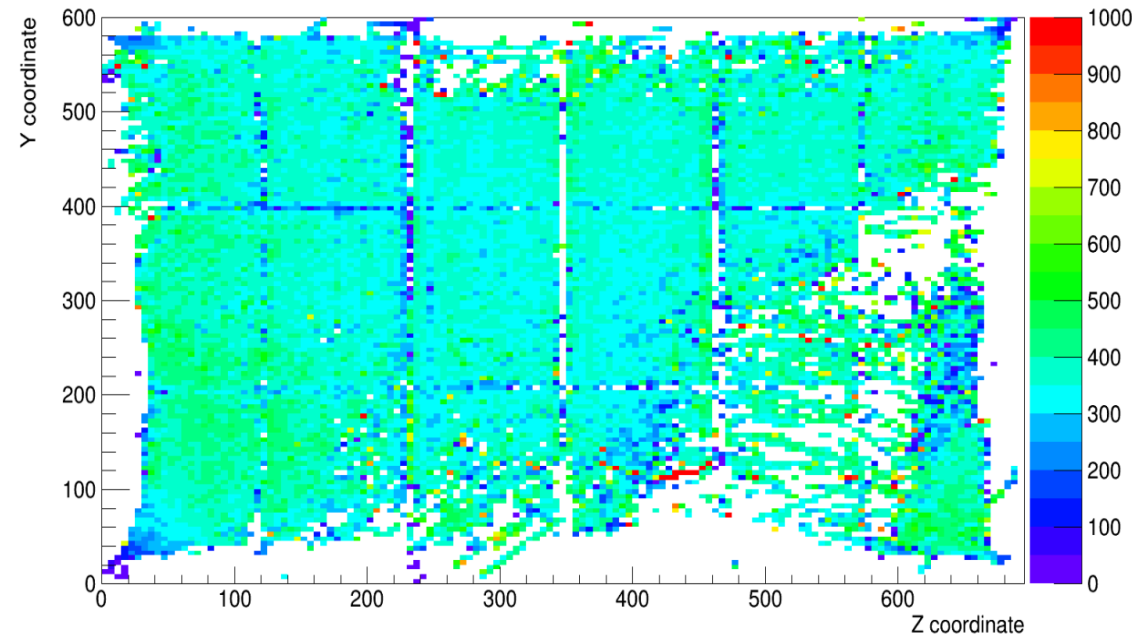
plane_2 dqdx for YZ plane for Xbin300 to 360 cm



plane_2 dqdx for YZ plane for Xbin-3 to 0 cm



plane_2 dqdx for YZ plane for Xbin0 to 3 cm

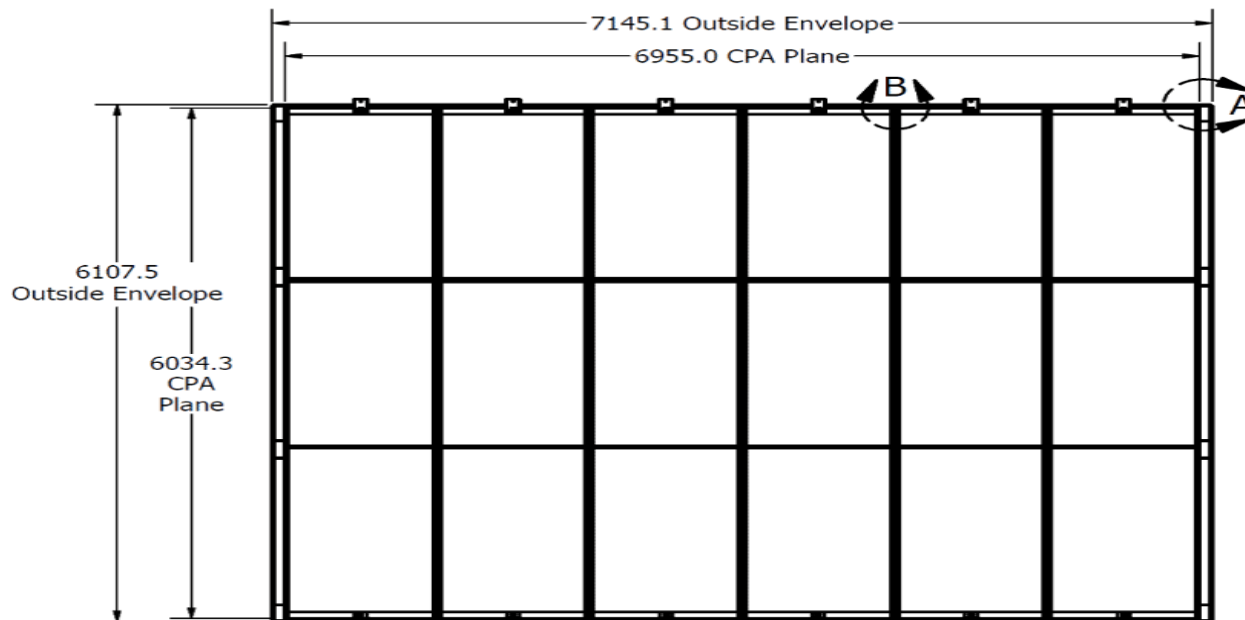


Top Left: dQ/dx distribution for beam right (0 to -3cm)

Top Right: dQ/dx distribution for beam left (0 to 3cm)

Bottom right: CPA frames from ProtoDUNE SP TDR

Plotting dQ/dx very close to CPA boundaries we can see the CPA array



Next few plots are the dQ/dx distribution for XY plane in 58 cm slices in Z:

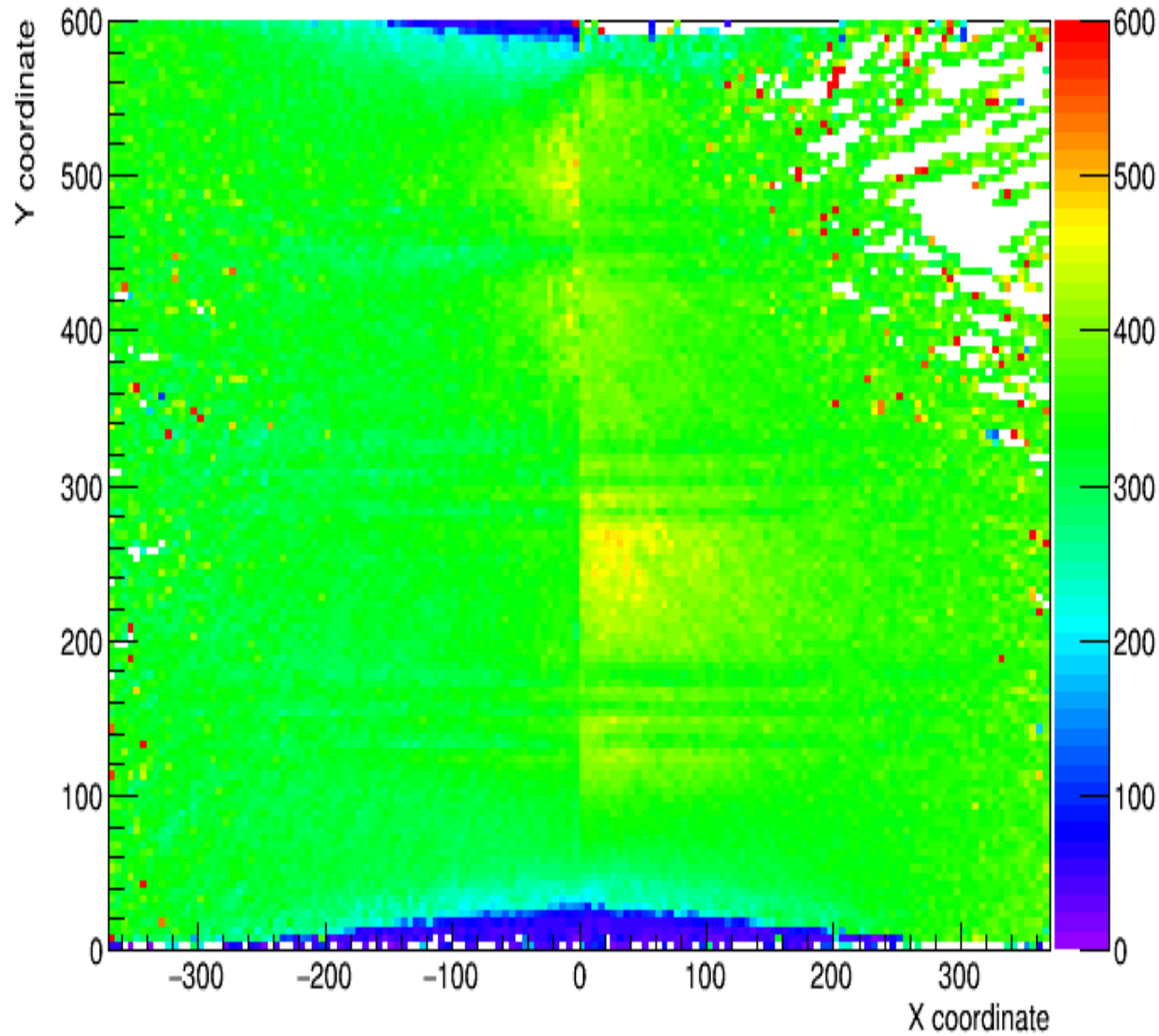
Zbin size = 58cm; // 12 bins (from 0 cm to 696cm)

Xbin size=5cm; //148 bins (-370cm to +370)

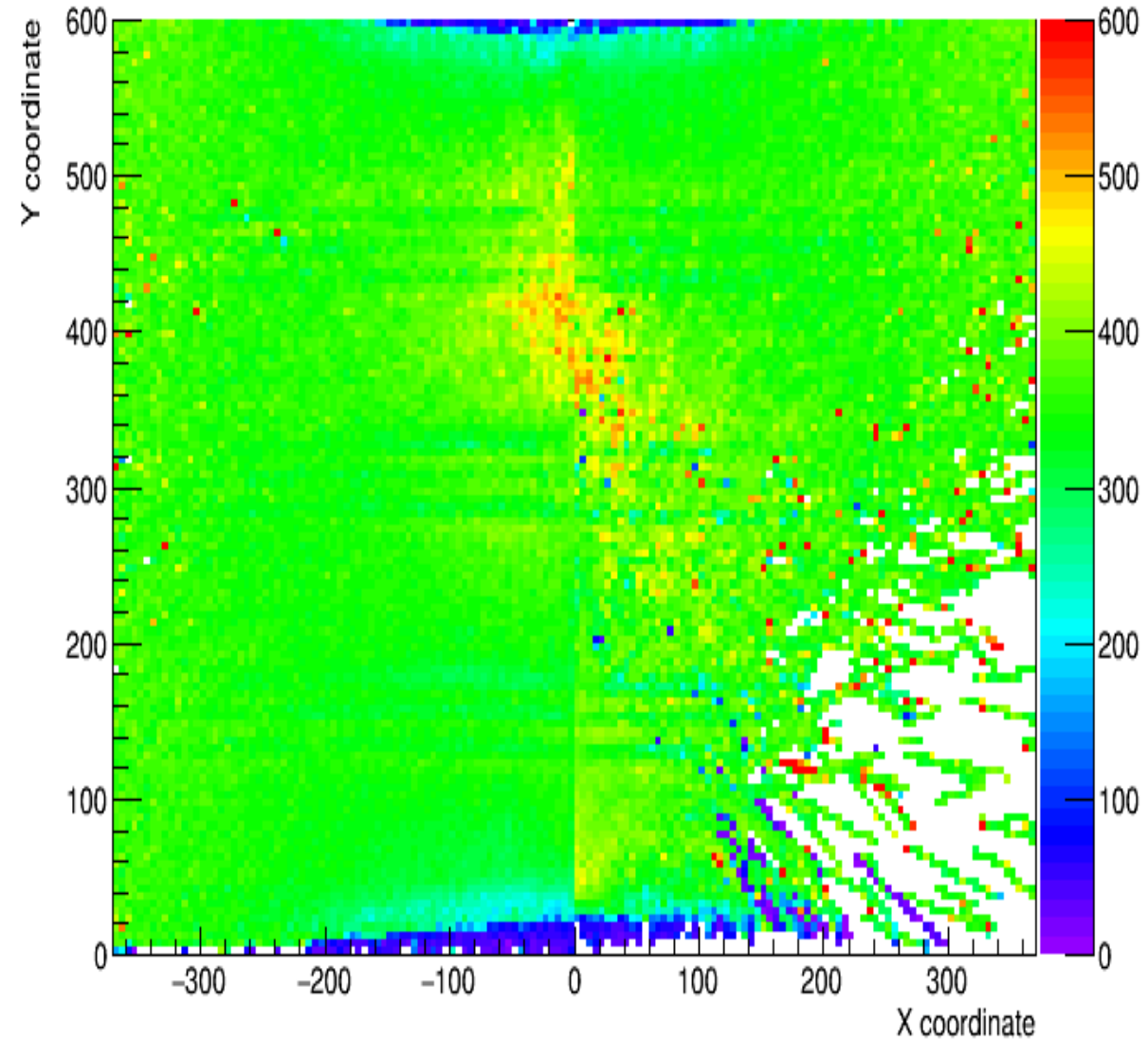
Y bin size=5cm;//120 bins (0cm to 600cm)

dQ/dx distribution for XY plane for first 58cm in Z and last 58 cm in Z respectively

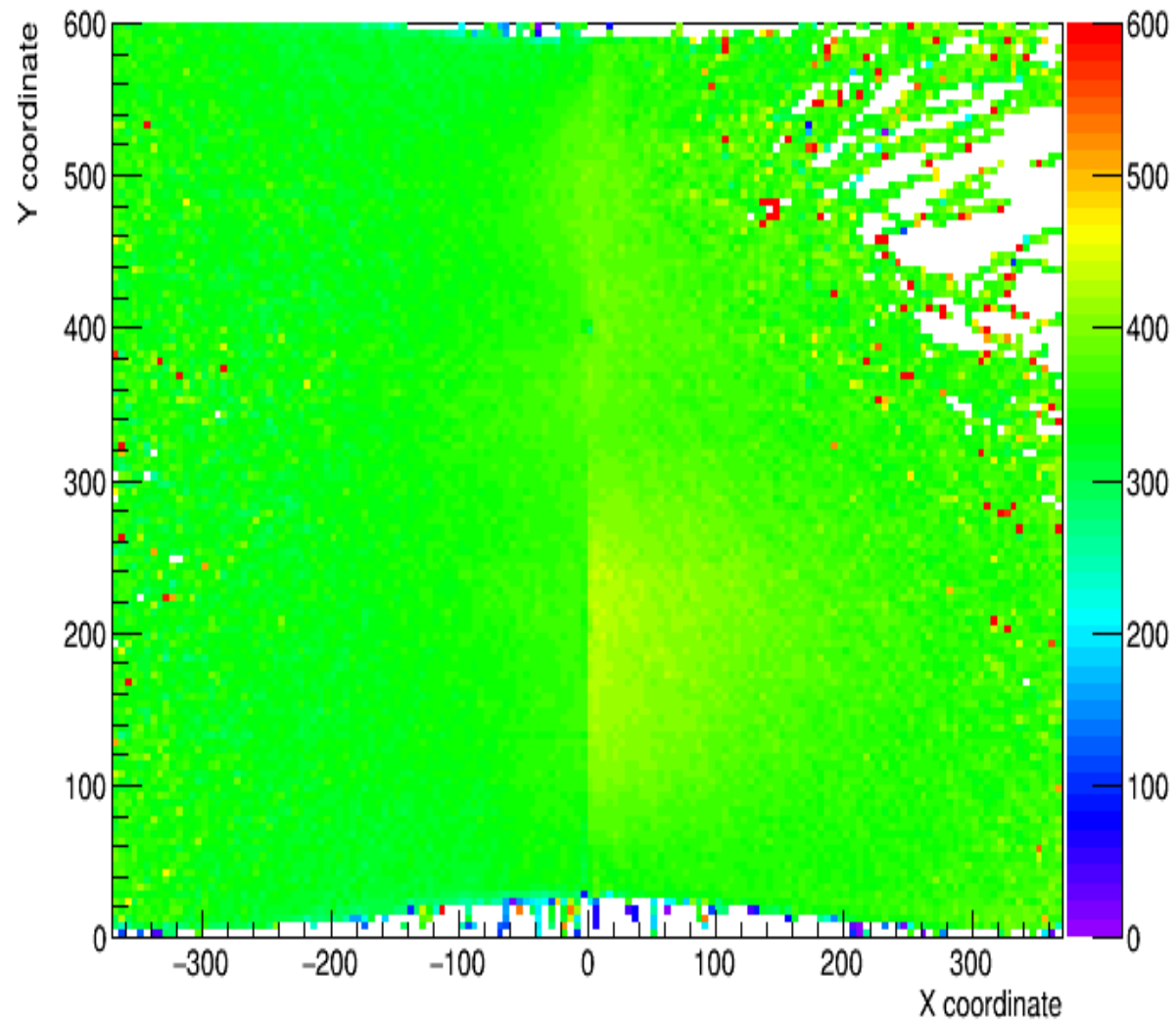
plane_2 dqdx for XY plane for Z bin 0 to 58 cm



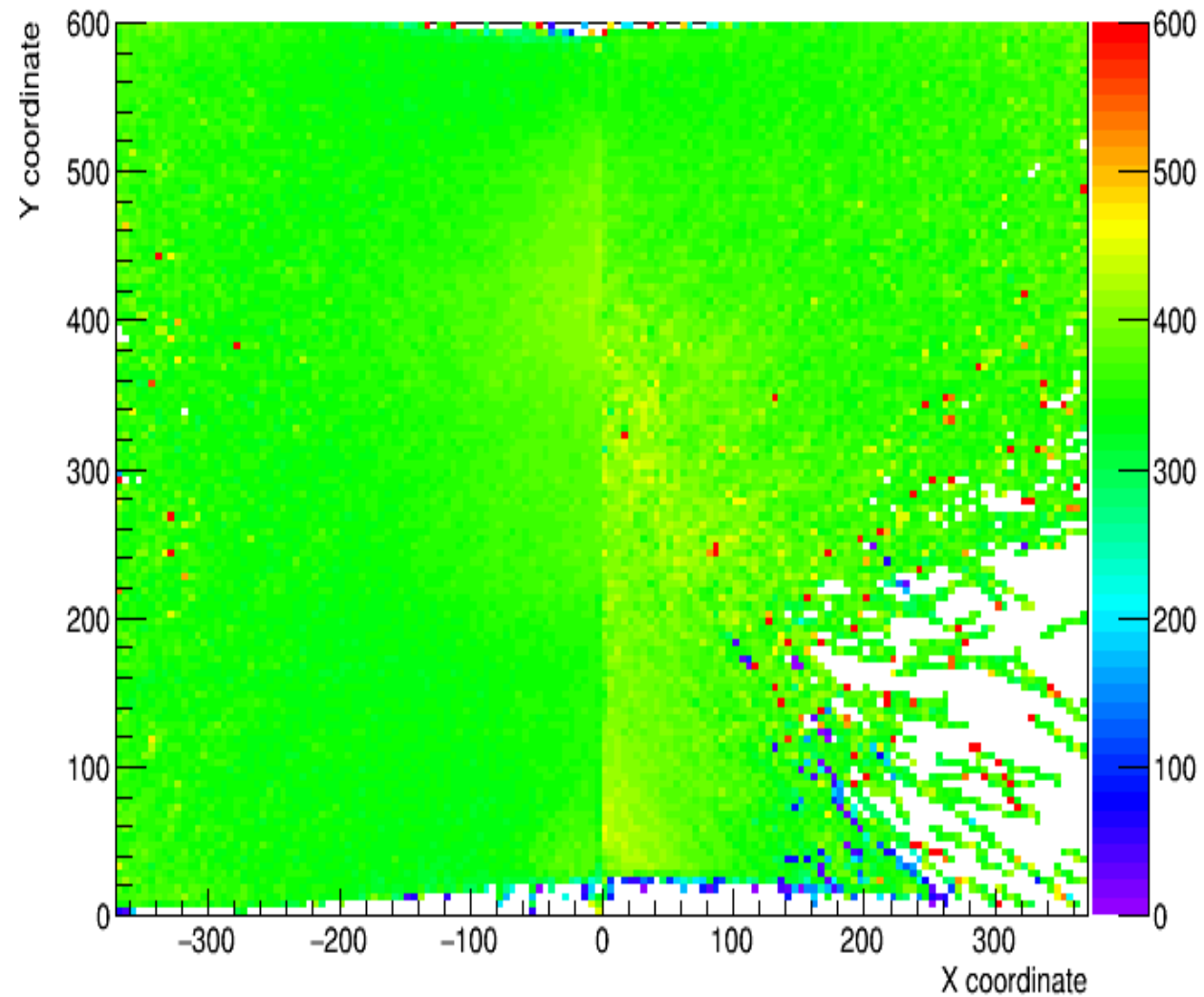
plane_2 dqdx for XY plane for Z bin 638 to 696 cm



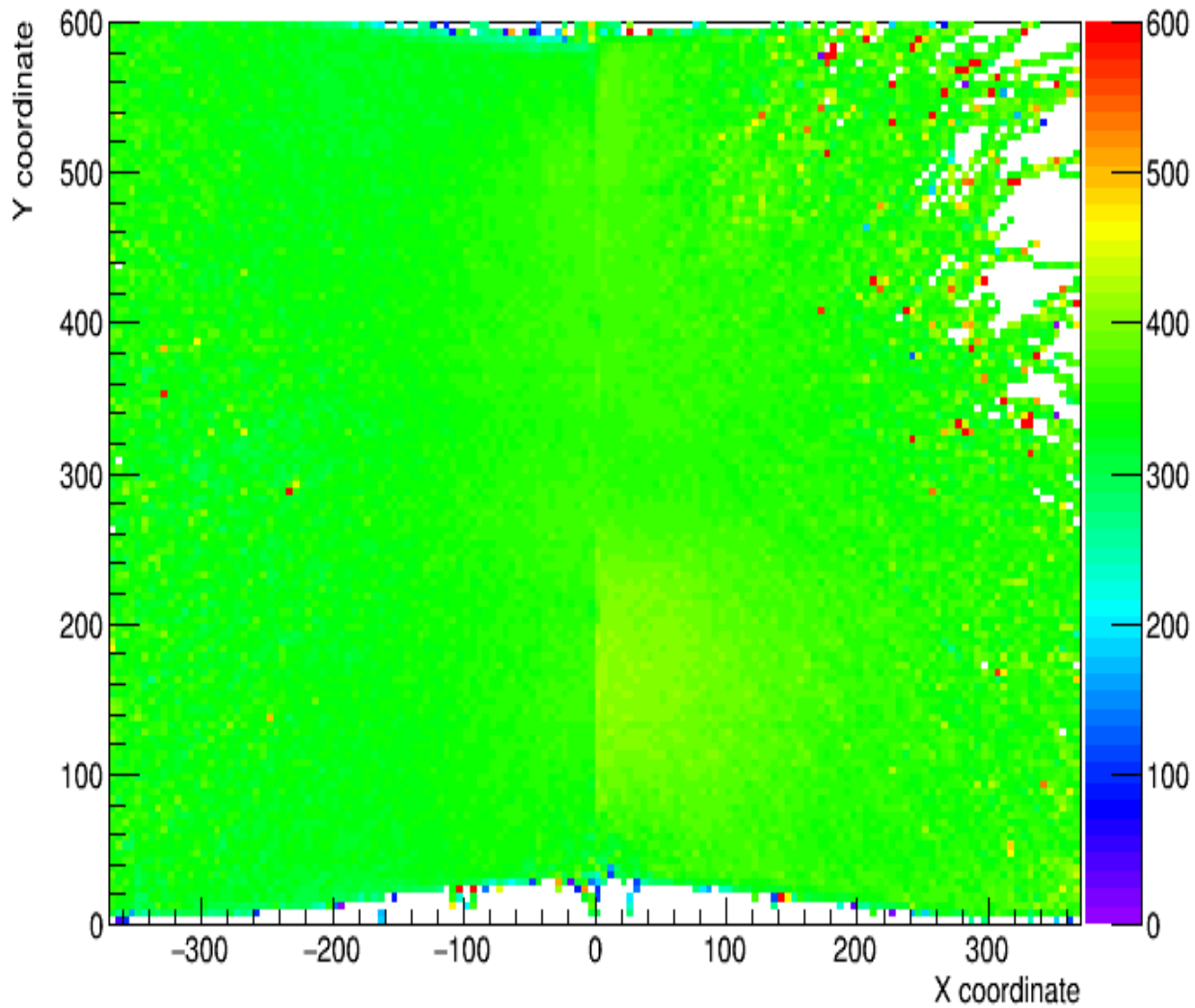
plane_2 dqdx for XY plane for Z bin 58 to 116 cm



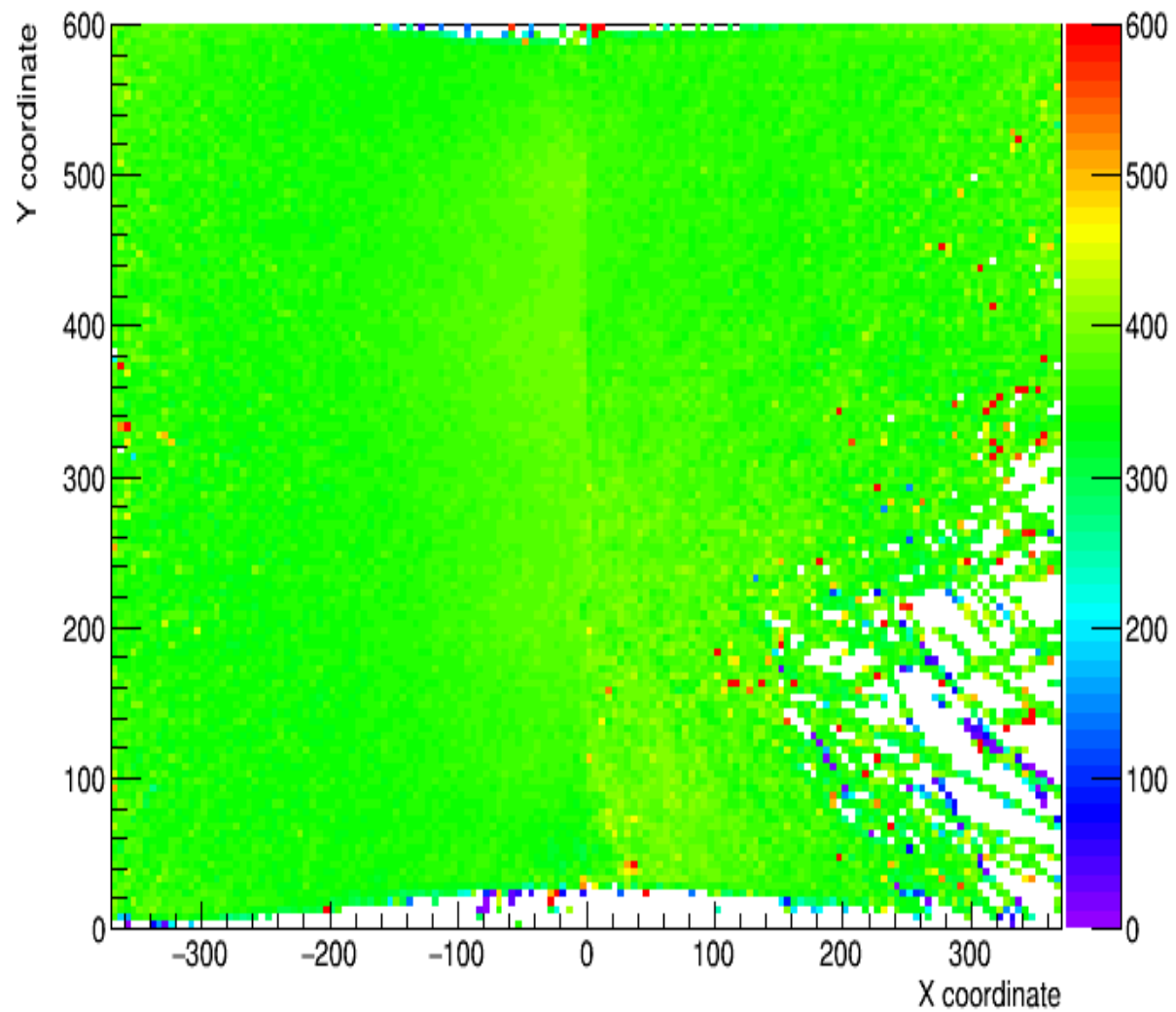
plane_2 dqdx for XY plane for Z bin 580 to 638 cm



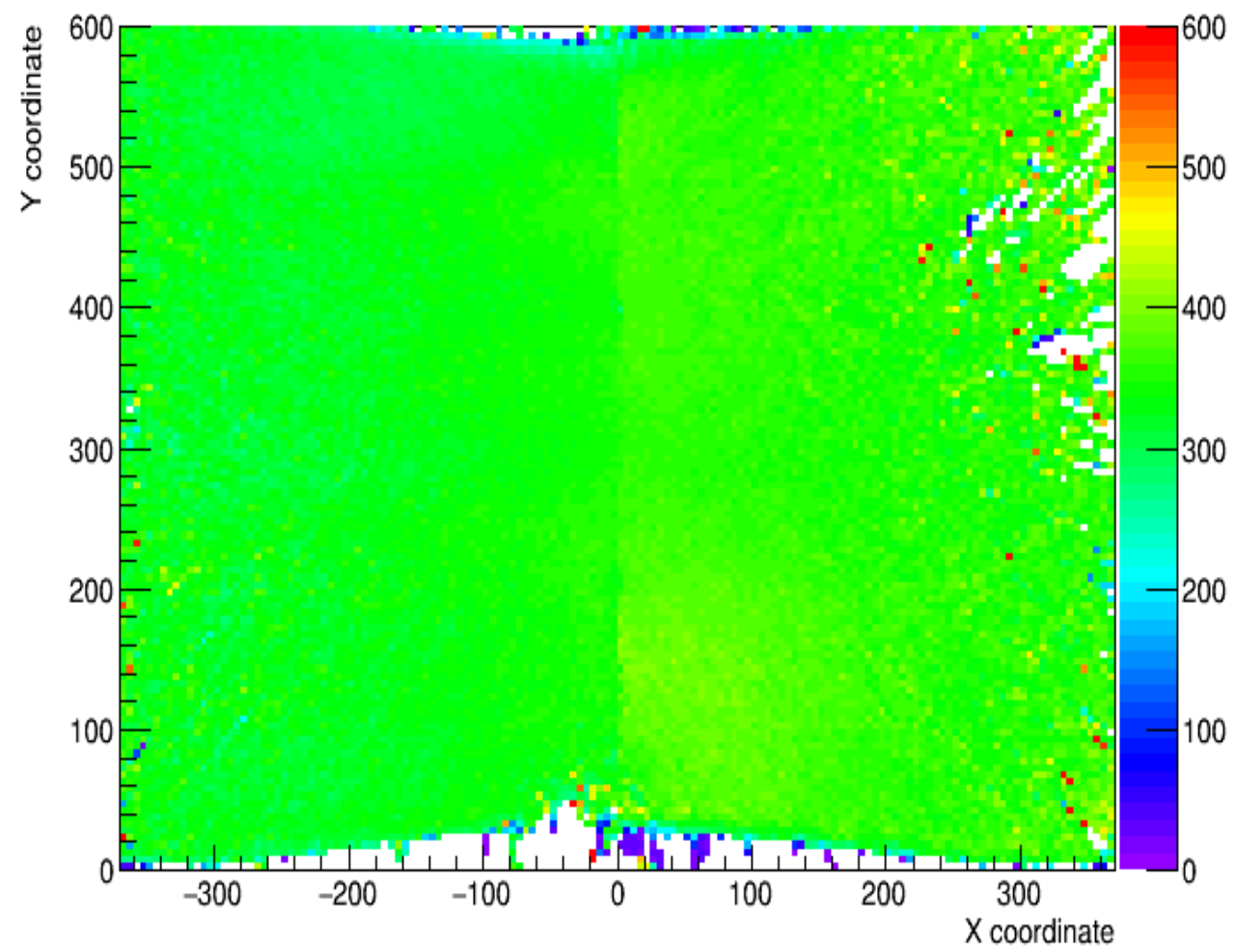
plane_2 dqdx for XY plane for Z bin 116 to 174 cm



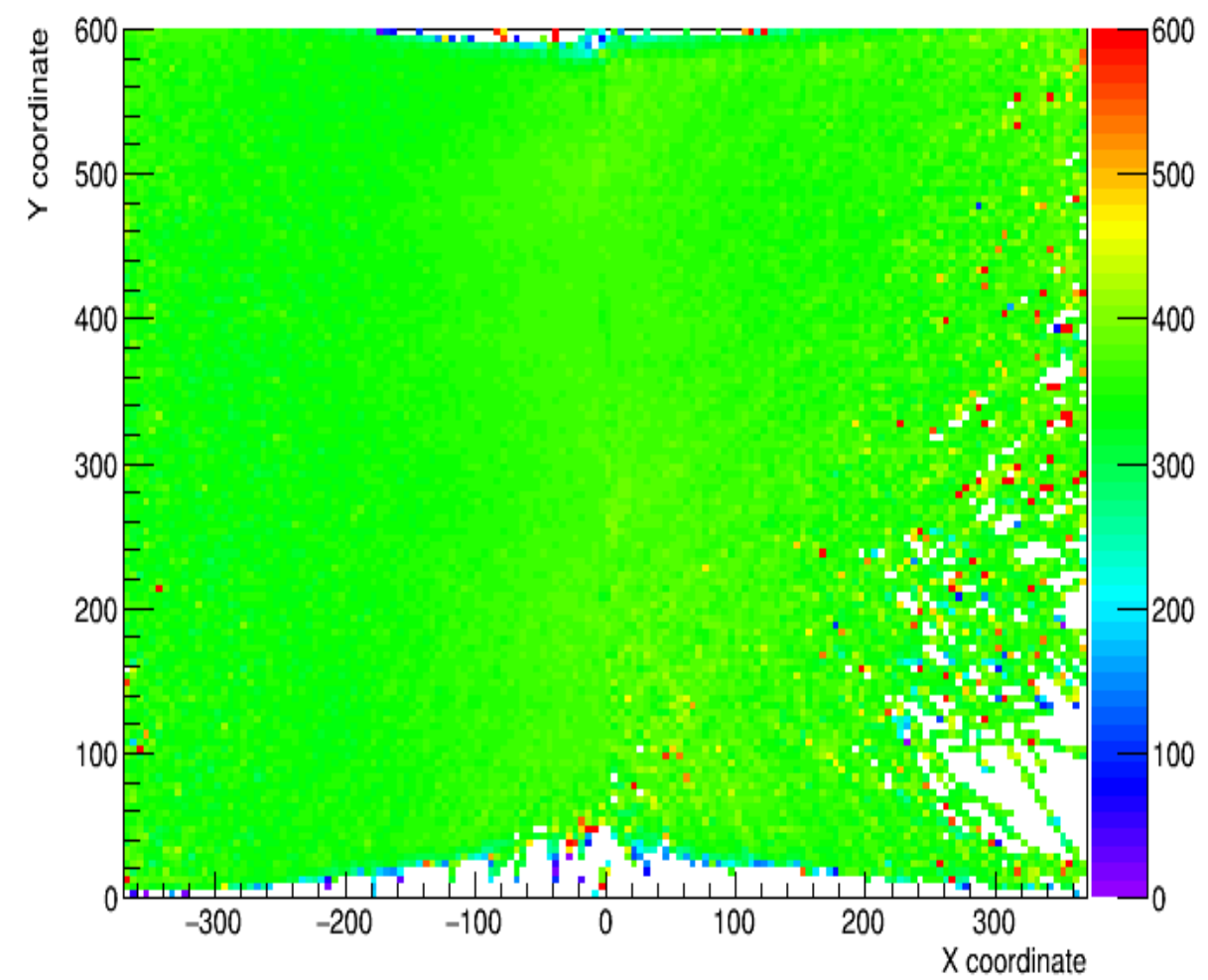
plane_2 dqdx for XY plane for Z bin 522 to 580 cm



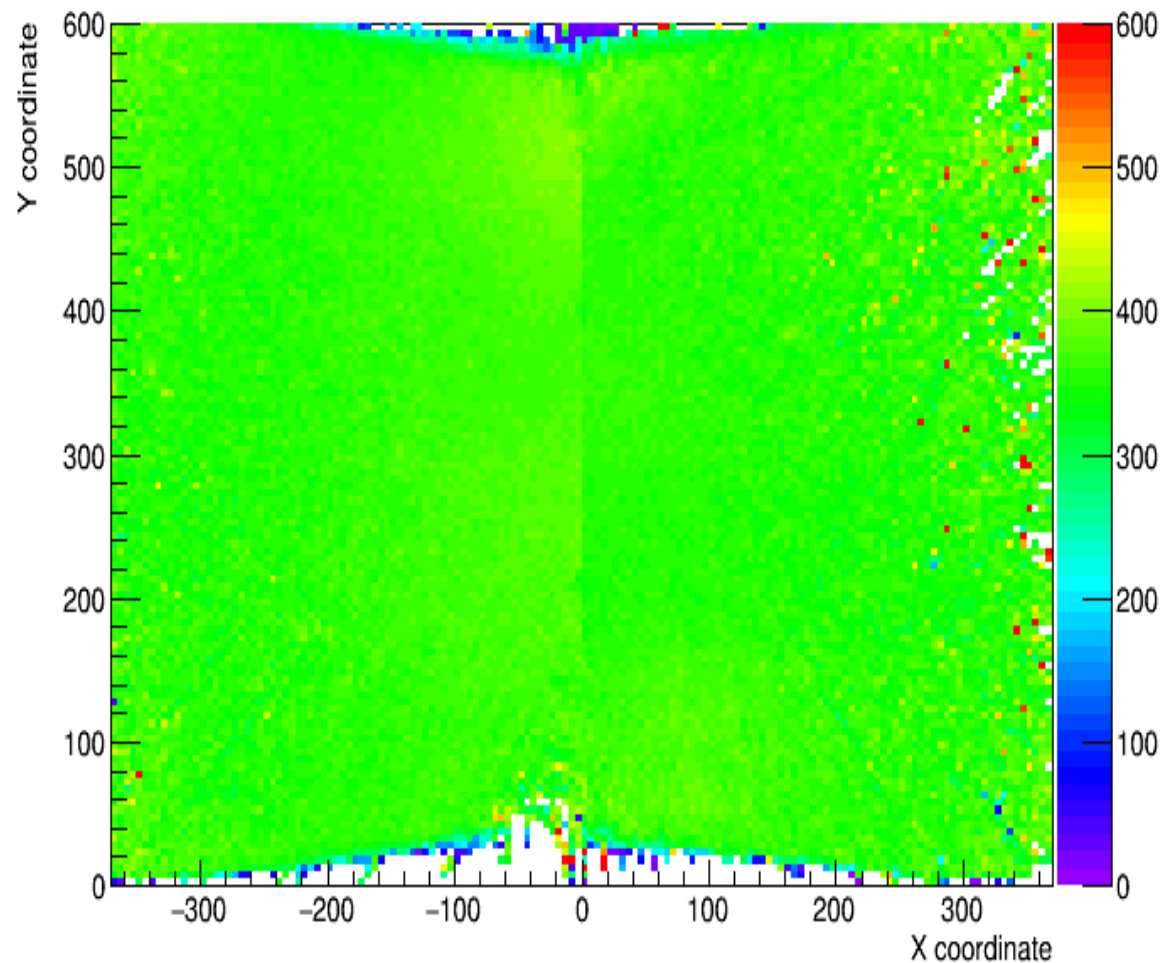
plane_2 dqdx for XY plane for Z bin 174 to 232 cm



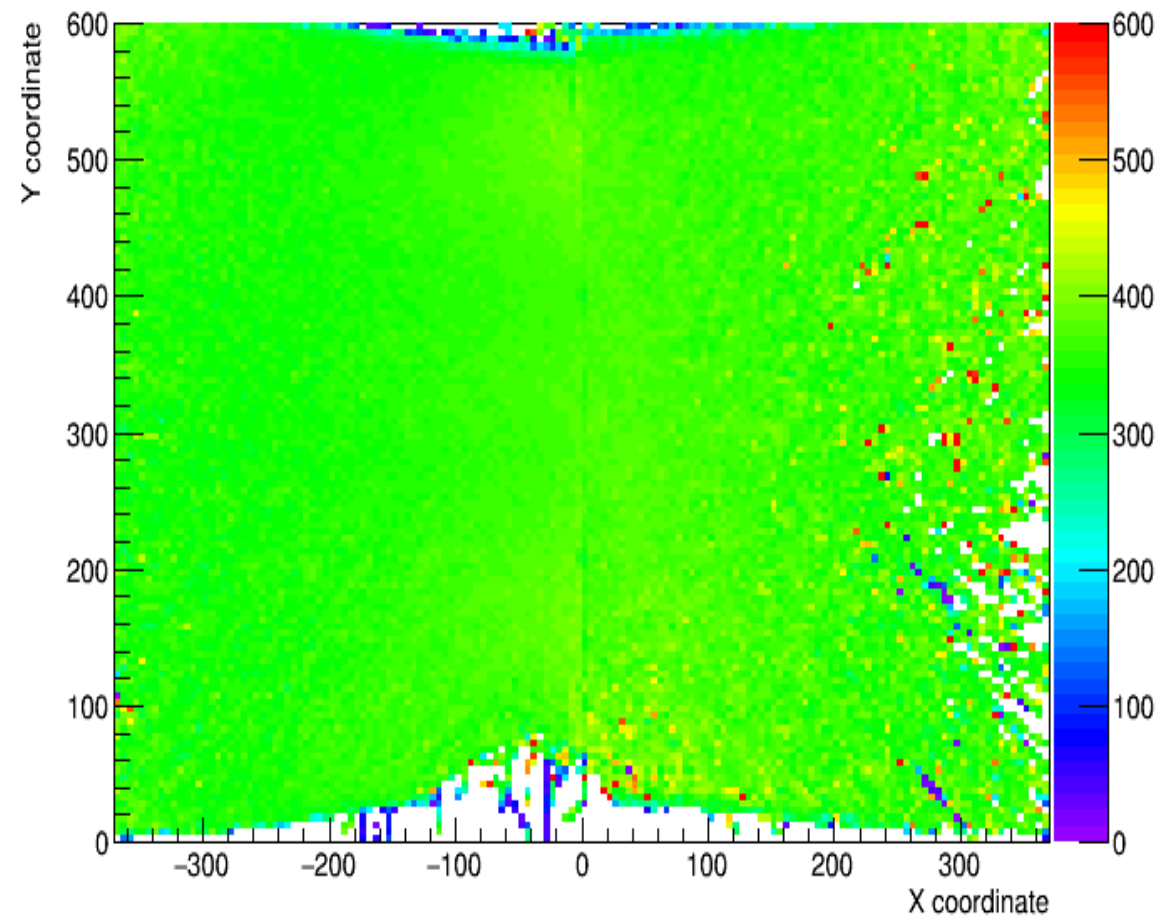
plane_2 dqdx for XY plane for Z bin 464 to 522 cm



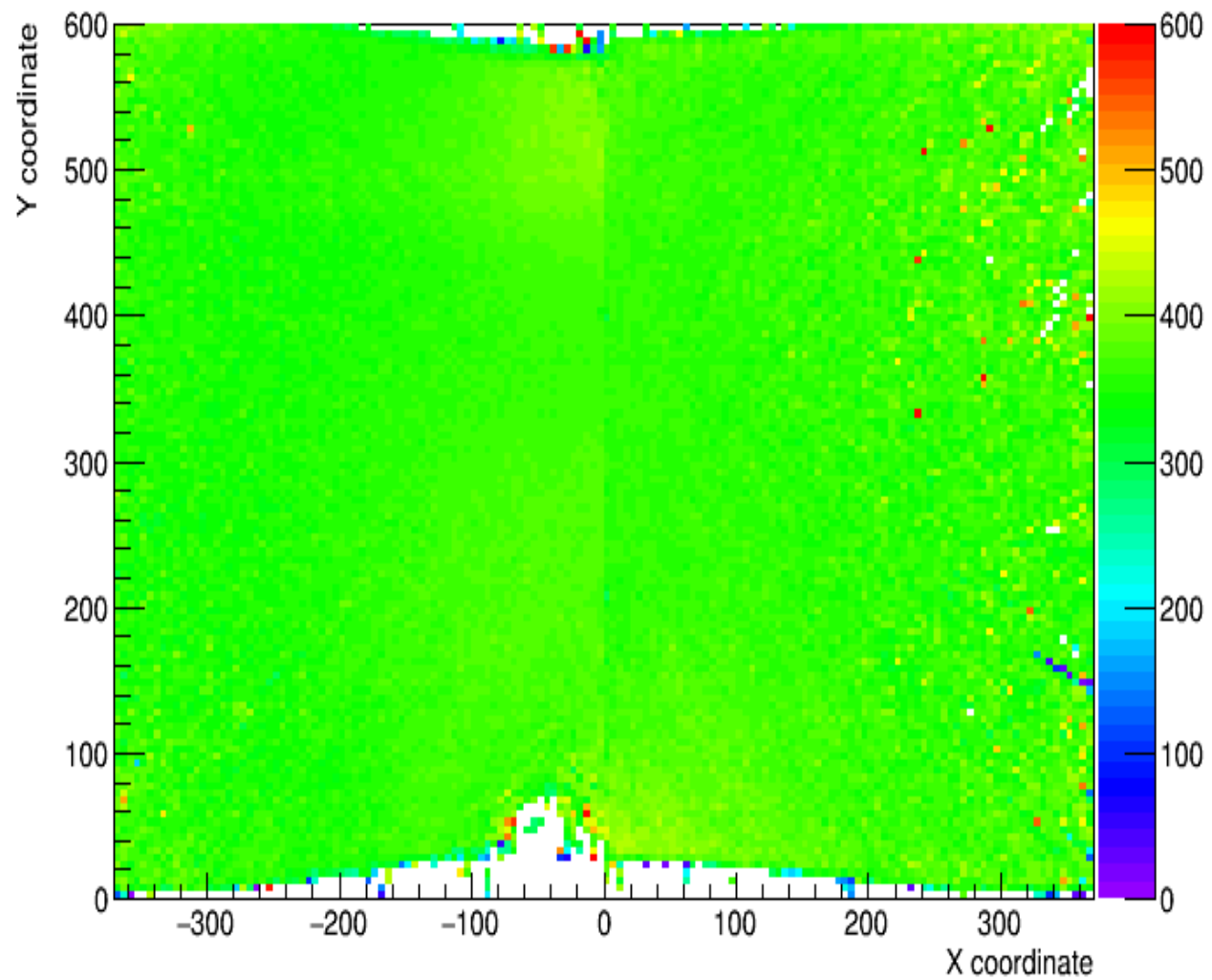
plane_2 dqdx for XY plane for Z bin 232 to 290 cm



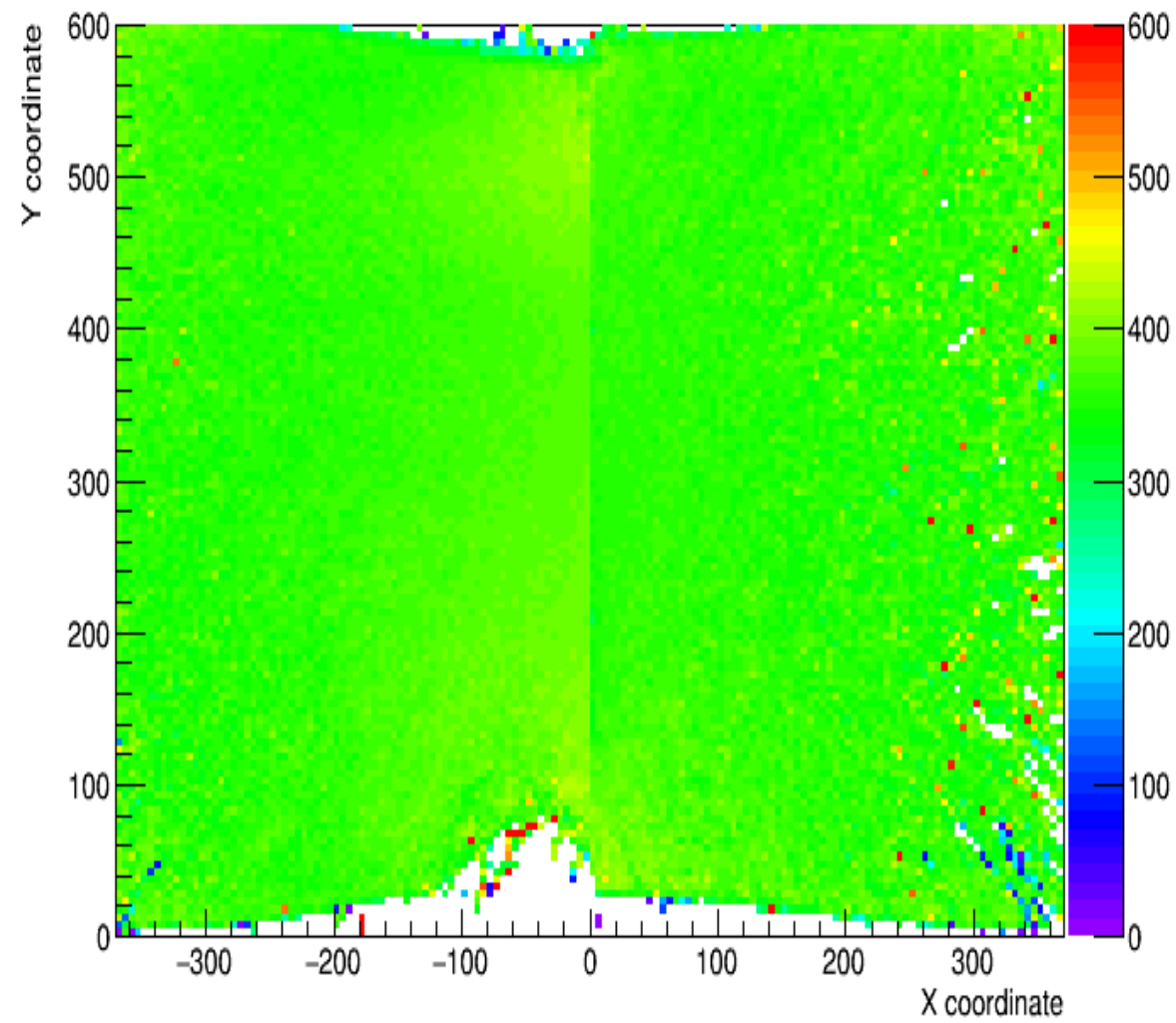
plane_2 dqdx for XY plane for Z bin 406 to 464 cm



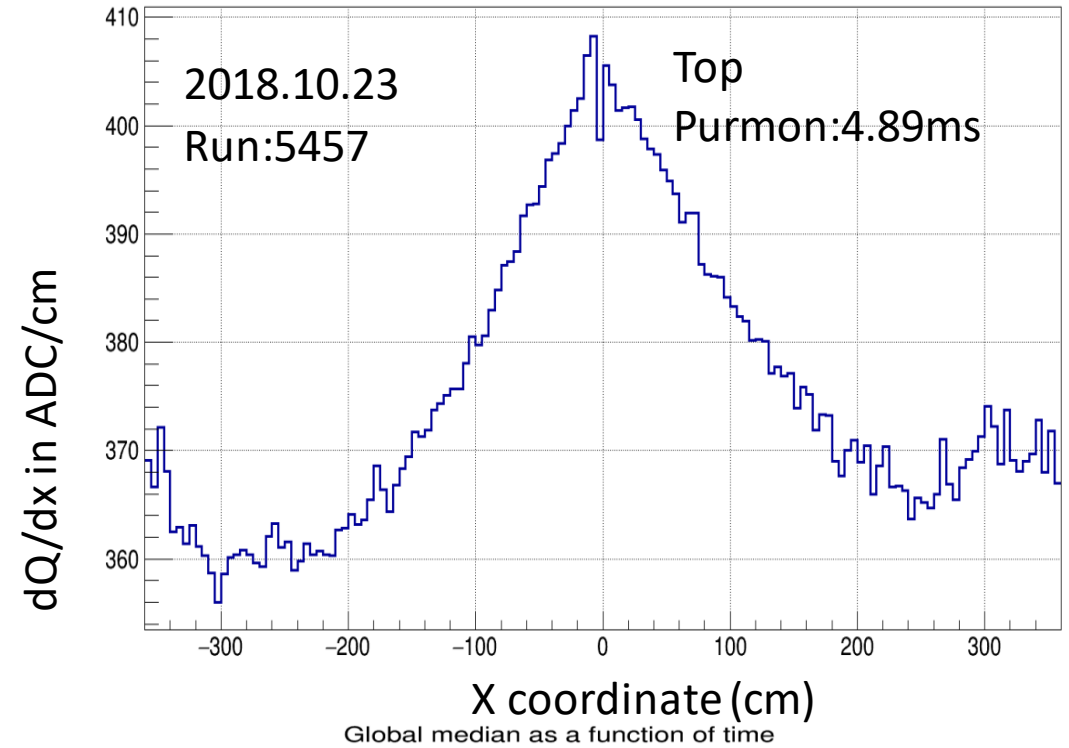
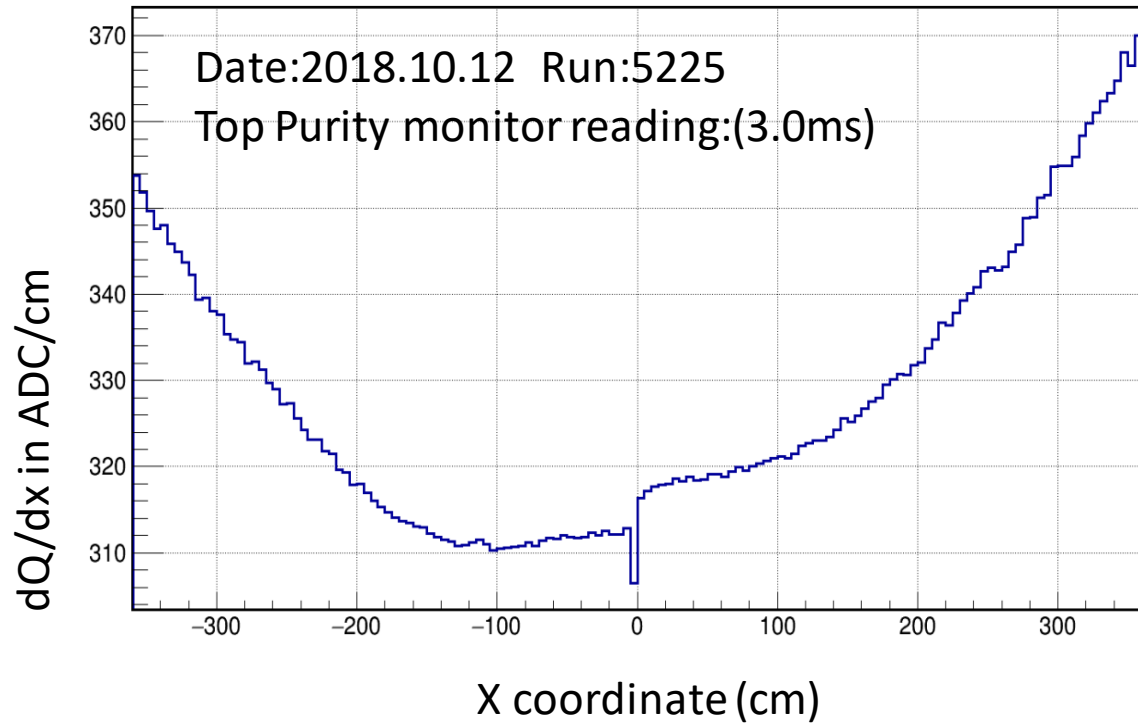
plane_2 dqdx for XY plane for Z bin 290 to 348 cm



plane_2 dqdx for XY plane for Z bin 348 to 406 cm



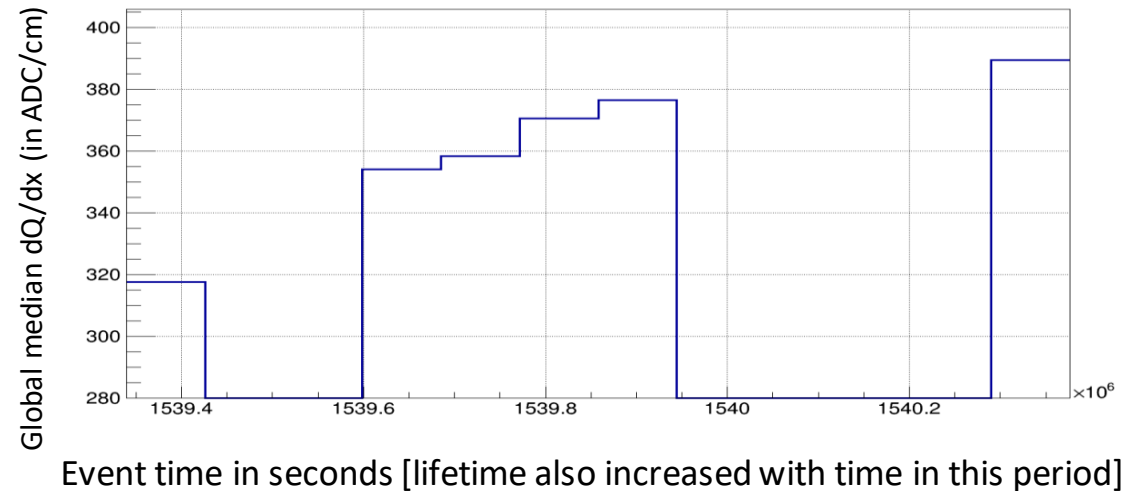
Finally, I want to show the variation of dQ/dx as a function of drift distance:



the plot on the bottom right is binned per day,

lifetime increases \rightarrow global median dQ/dx value (median taken including dQ/dx values throughout the TPC) is also increasing,

Only few random 180KV+1GeV momentum runs included (which caused empty bins)



Summary:

- We can see the dQ/dx values vary throughout the TPC due to a number of factors (namely, attenuation, Space Charge Effect, broken channels or wires etc, to name a few).
- Our calibration scheme focusses on making dQ/dx (detector response) uniform throughout the TPC and finally do the dE/dx calibration using stopping cosmic muons

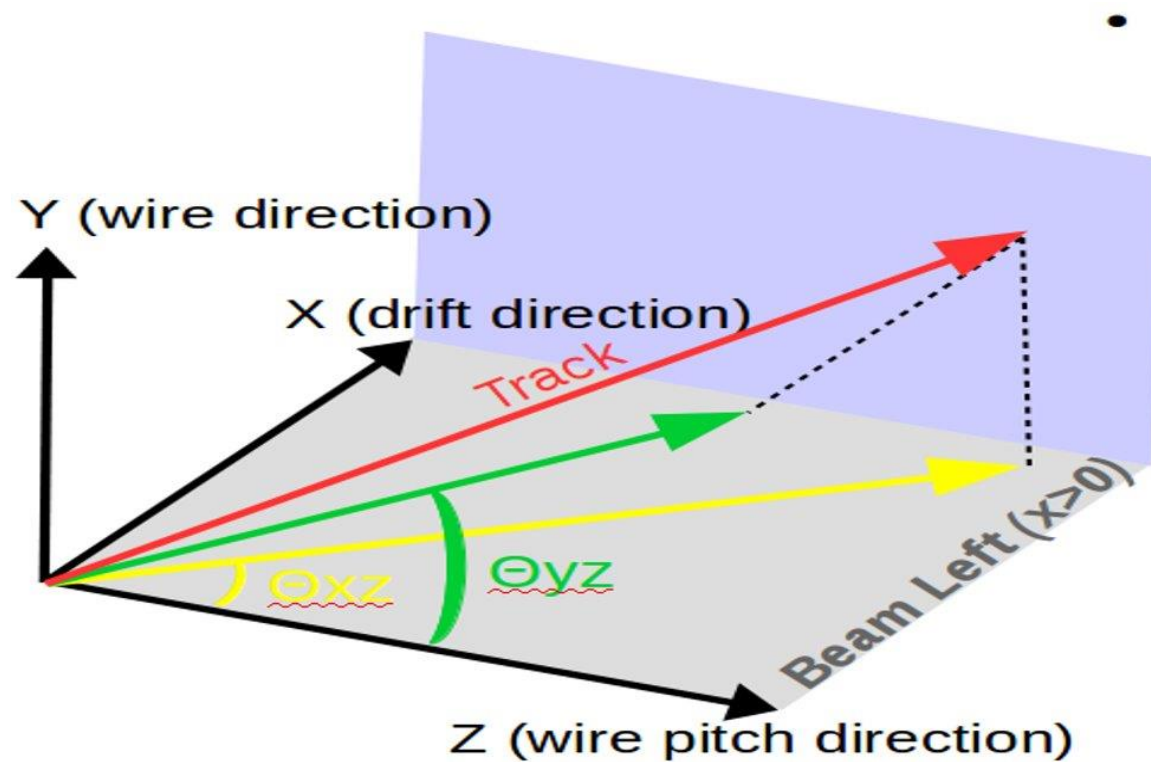


Thank You

Backup Slides

Some more plots:

- Before looking into the next few plots I will like to describe θ_{XZ} and θ_{YZ} :

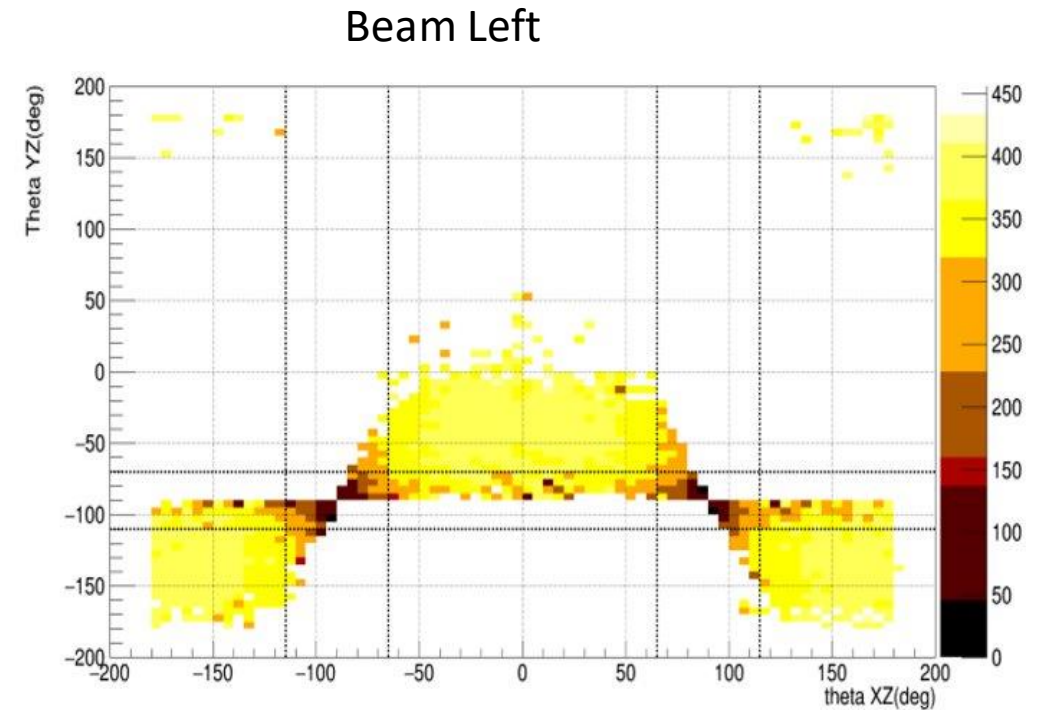
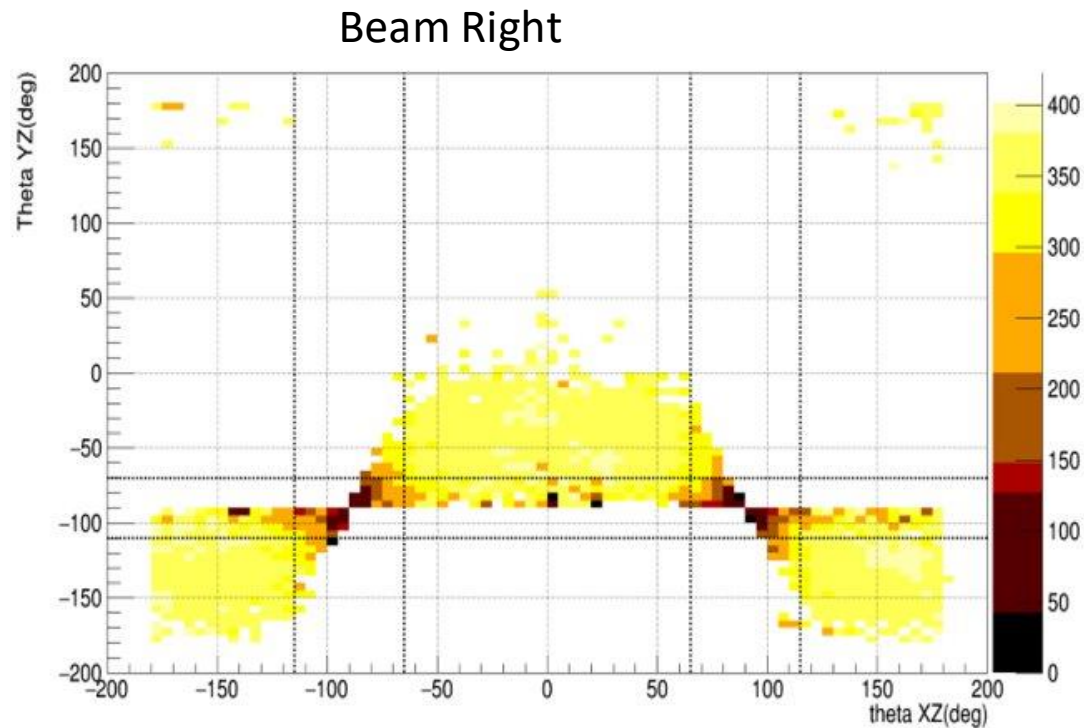


θ_{XZ} is the angle made by the projection of a track on the XZ plane with the Z coordinate

θ_{YZ} is the angle made by the projection of a track on the YZ plane with the Z coordinate

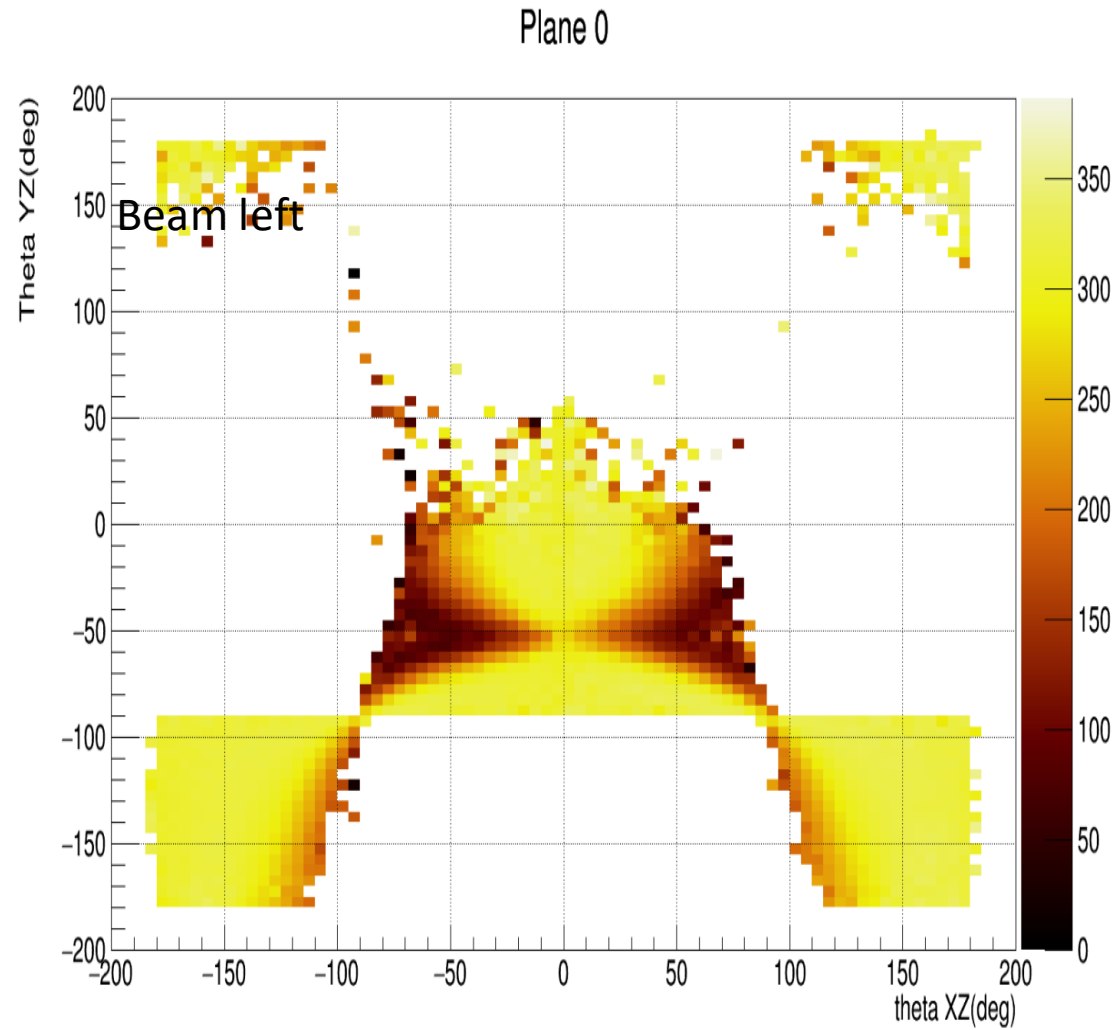
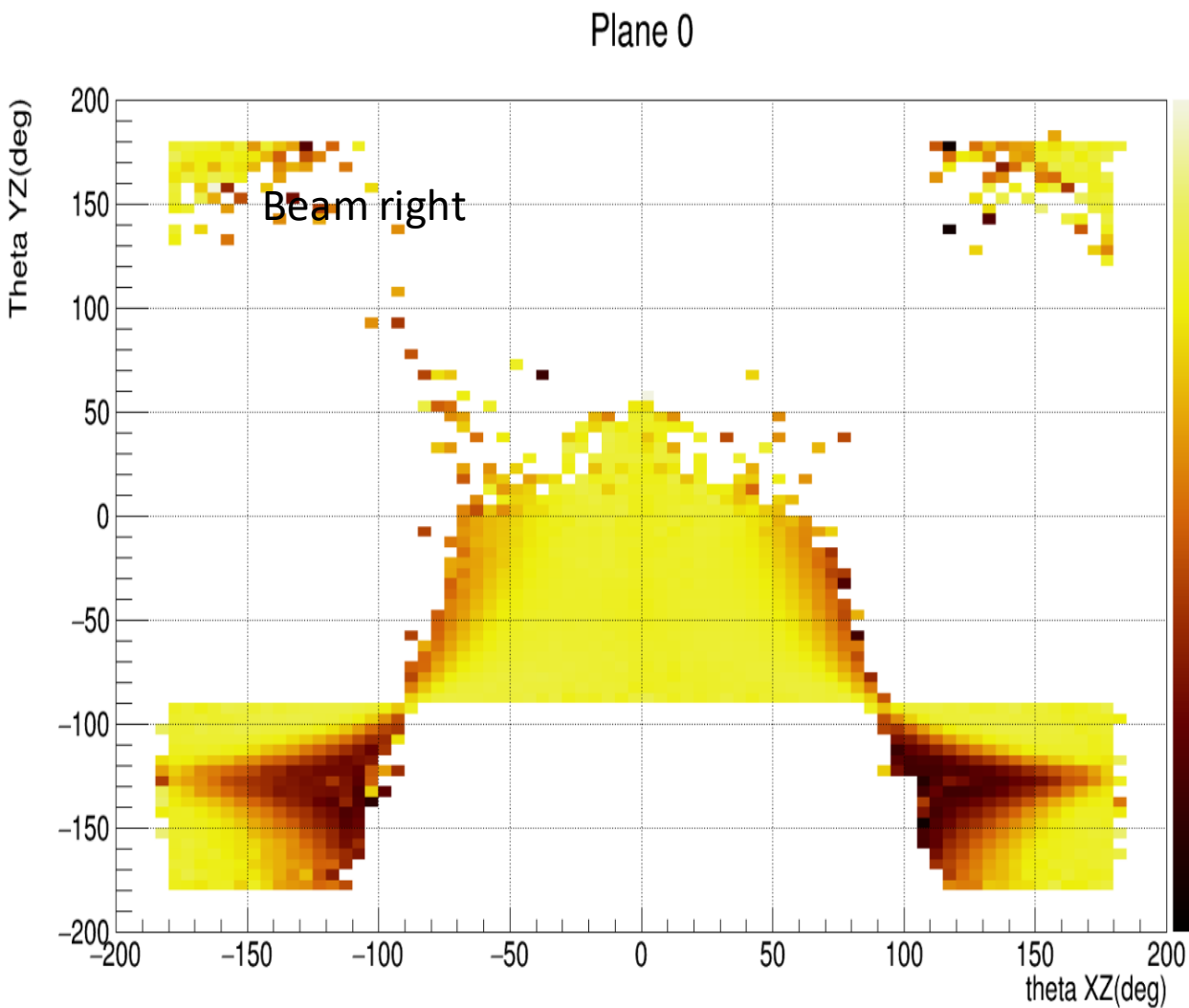
Tracks which are parallel to the wire planes or moving straight towards the wire planes are not reconstructed well, we remove those tracks based on the angle made by the projection of the track on the XZ and YZ planes with Z axis:

Plots below show dQ/dx distribution as a function of θ_{XZ} and θ_{YZ} for plane 2 (Collection Plane)

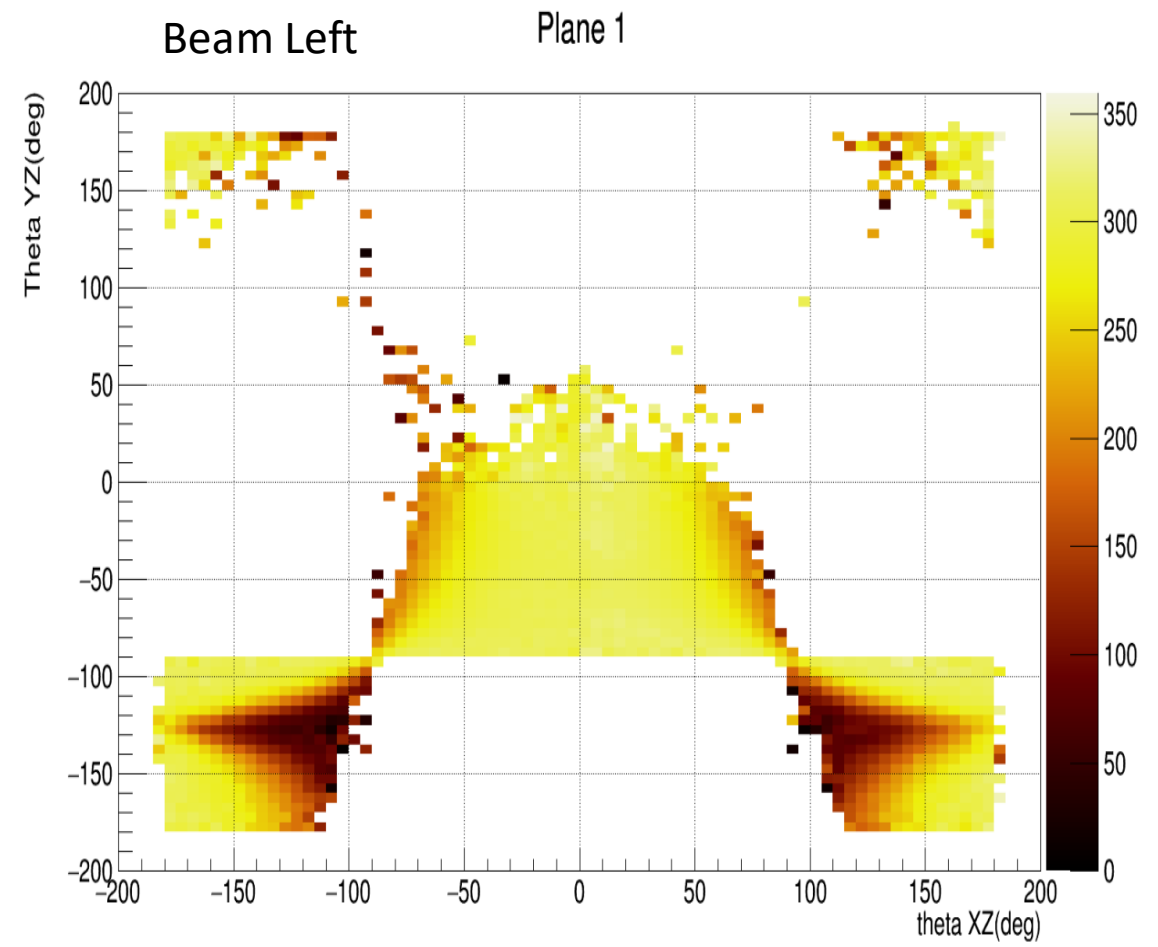
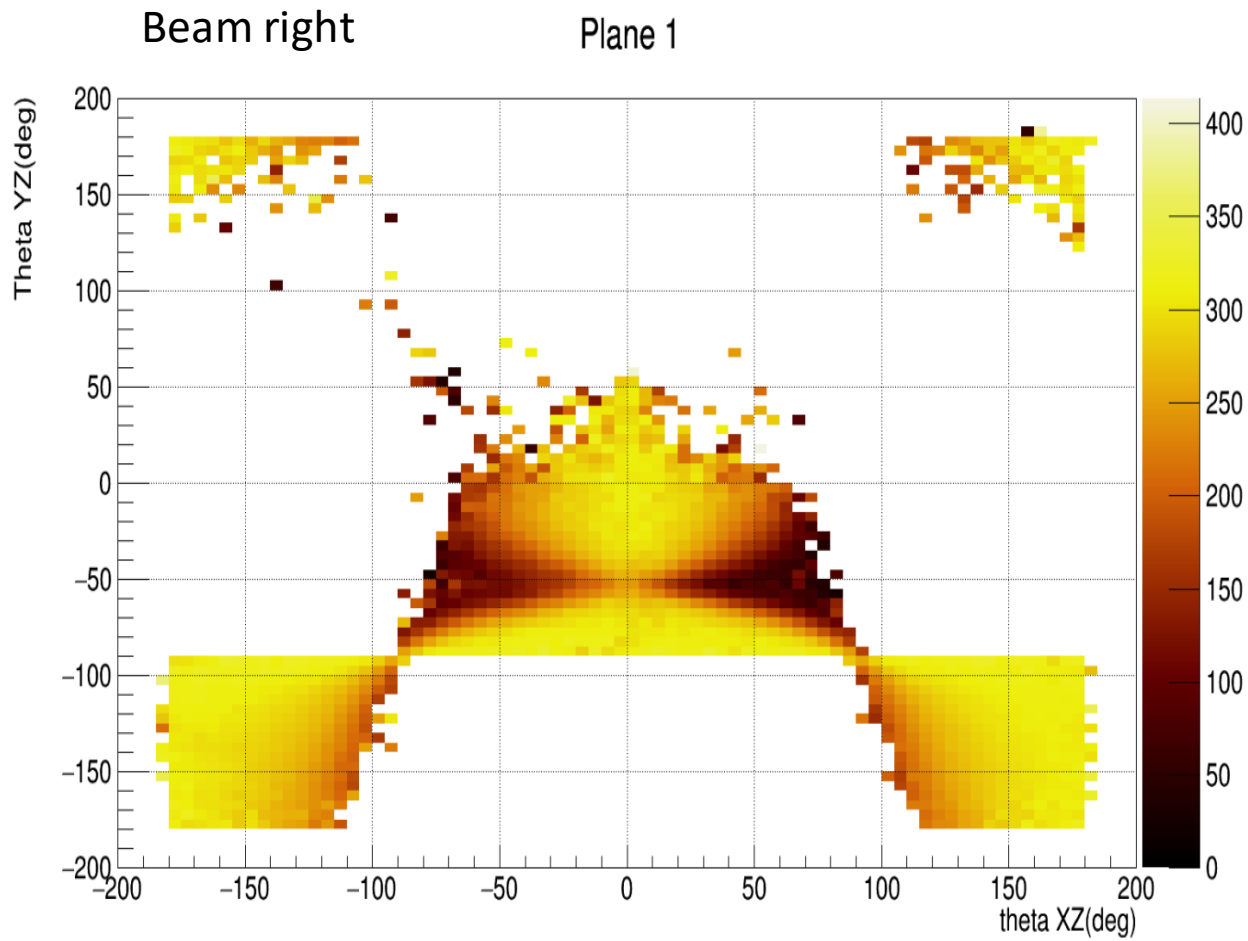


Region inside the dotted line refers to unusually low dQ/dx region which is due to tracks which are parallel to wire planes or moving straight towards them. They are not well reconstructed so those tracks are removed in our analysis.

Similar Plots for Plane 0 (U plane):(Z-axis or colored scale represents dQ/dx value)

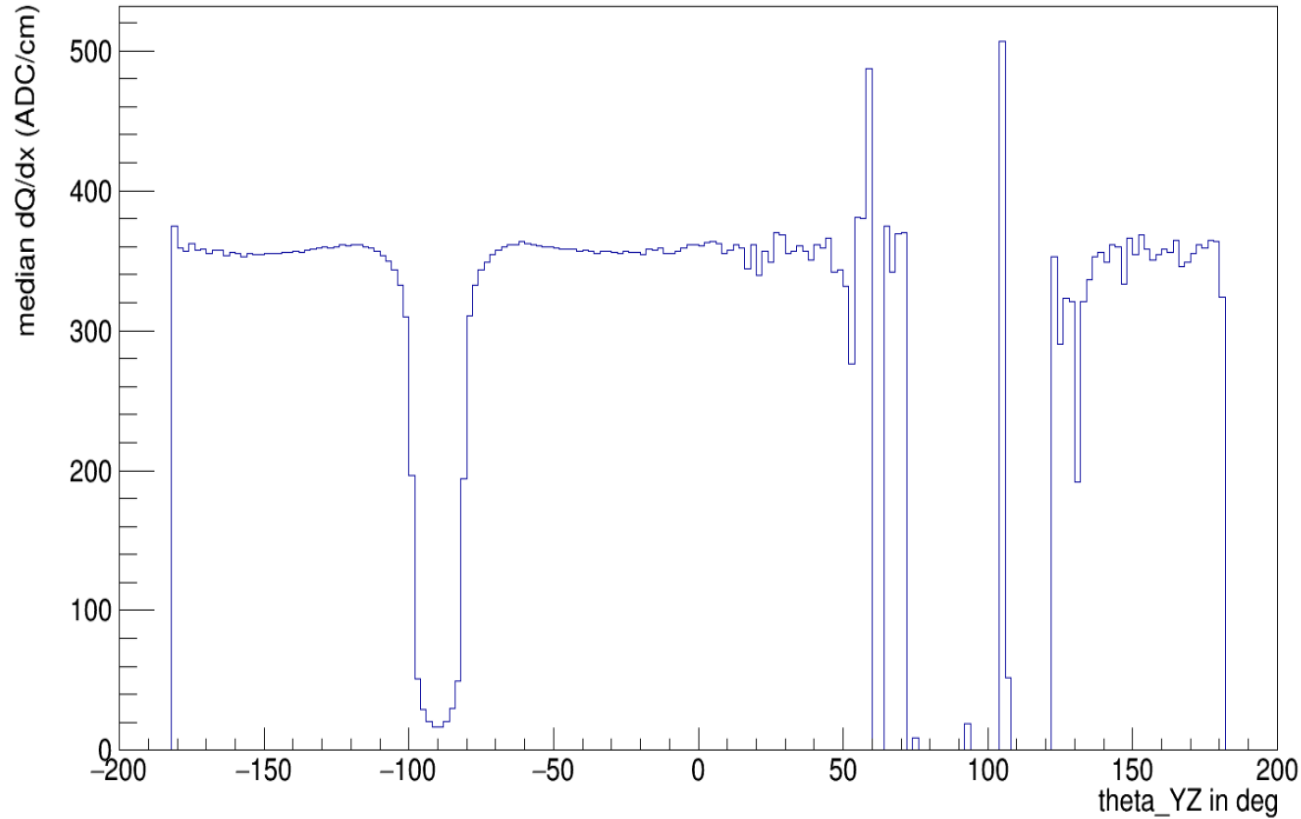


Similar Plots for Plane 1:(Z-axis or colored scale represents dQ/dx value)

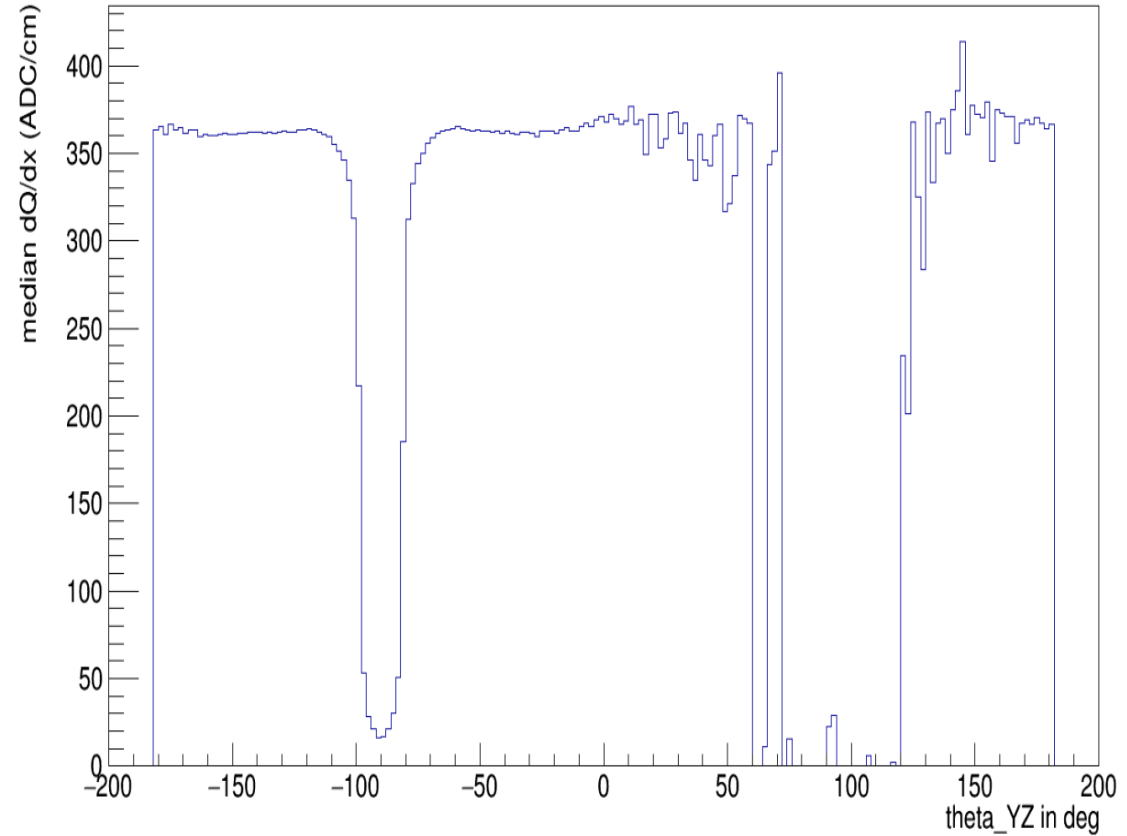


Median dQ/dx binned in theta_YZ:

median dQ/dx vs YZ for plane2 negative X

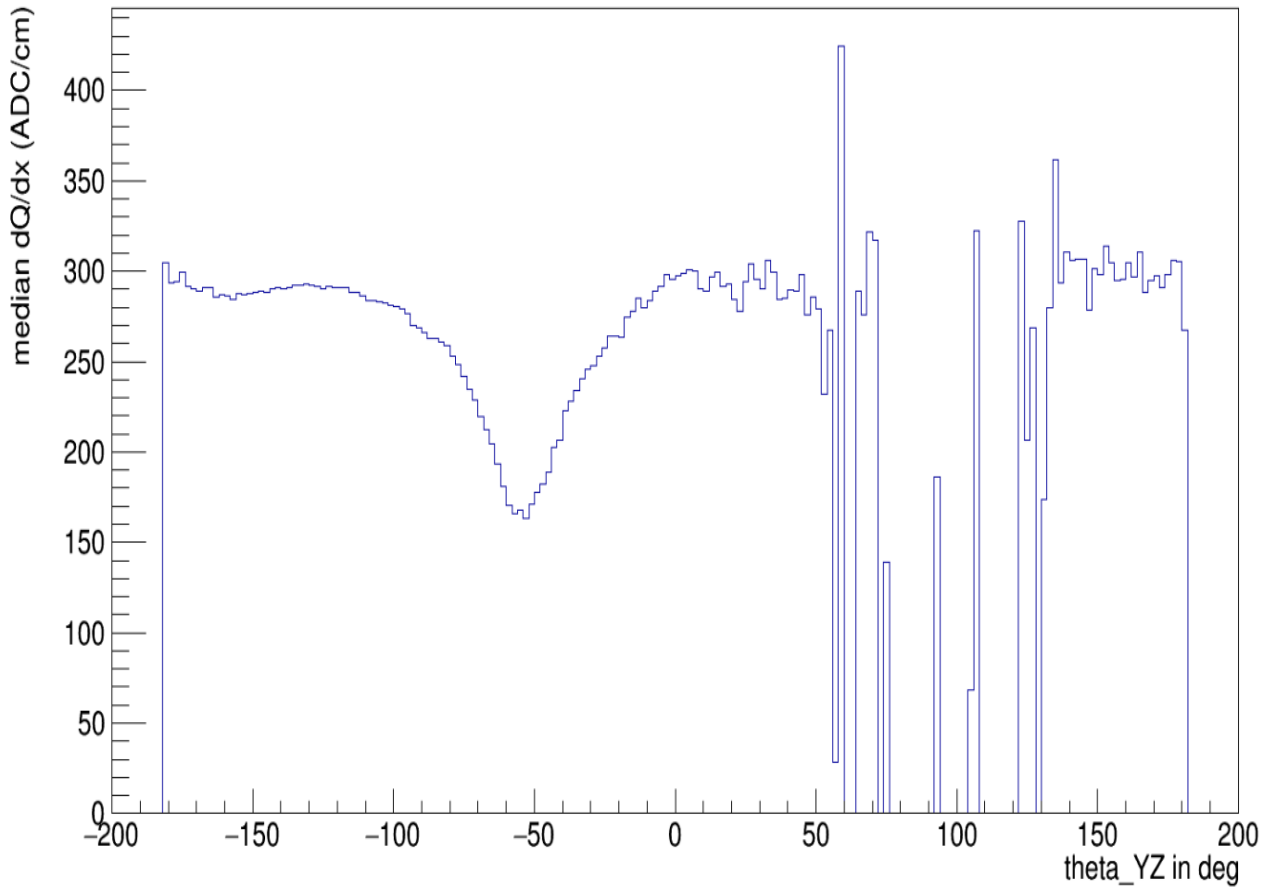


median dQ/dx vs YZ for plane2 positive X

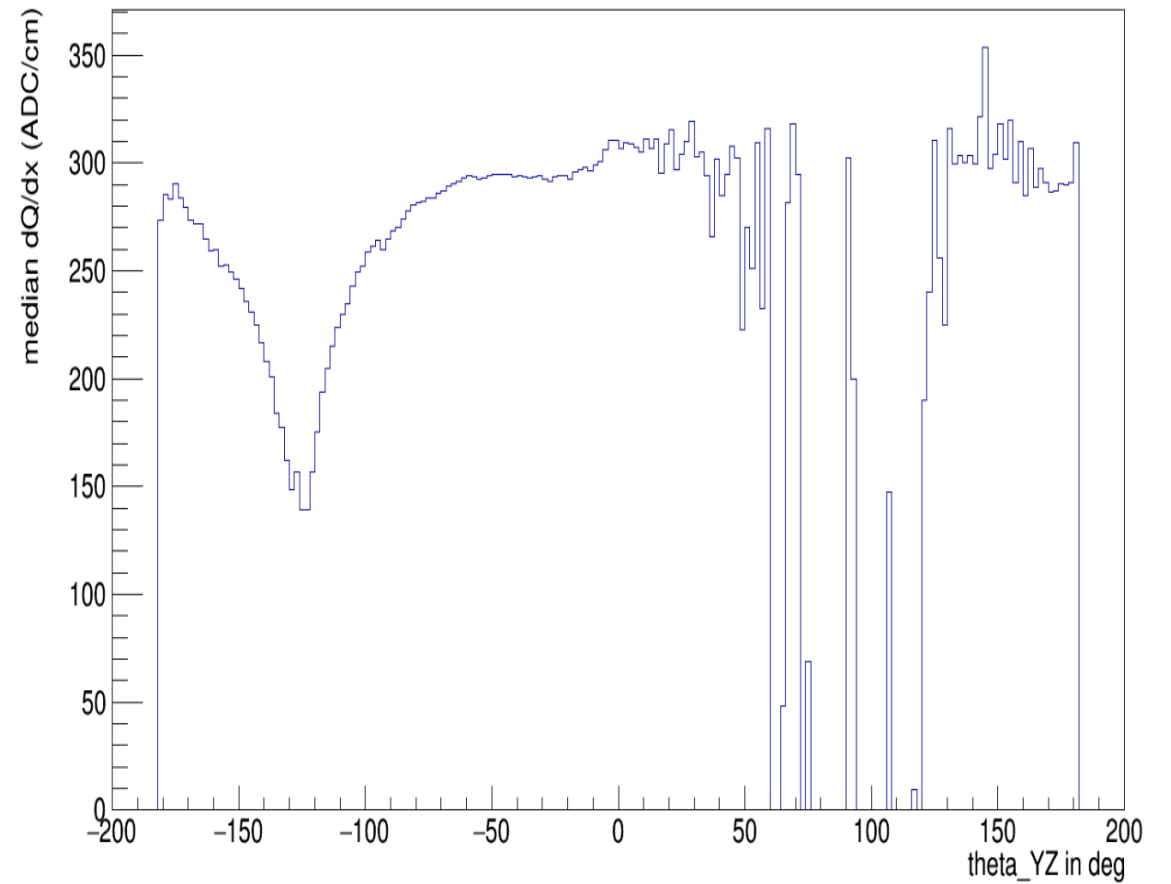


Collection Plane wires are on the YZ plane and makes an angle 90deg with the Z coordinate, we can see that if the cosmic track has $\theta_{YZ} \sim 90\text{deg}$, dQ/dx drops very close to 0. Those tracks being parallel to collection plane wires, the hits from those tracks are badly reconstructed in collection plane view.

median dQ/dx vs YZ for plane1 negative X



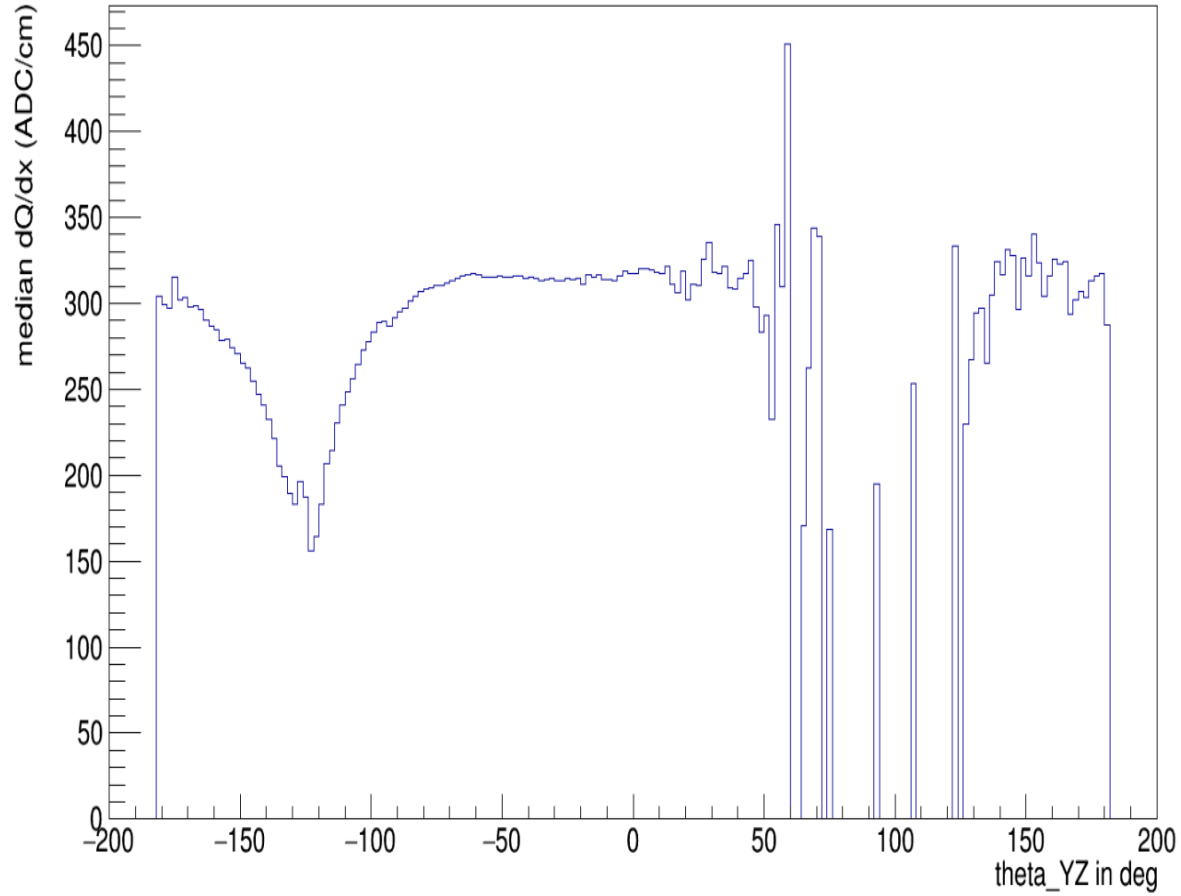
median dQ/dx vs YZ for plane1 positive X



Similar to plane 2, here as well hits from tracks which are parallel to the wires are badly reconstructed (also as the angle made by the V plane wires with Z coordinate is different for beam left and beam right so the angle for minimum dQ/dx values varies on the two sides)

Similar plots for Plane 0 (U plane)

median dQ/dx vs YZ for plane0 negative X



median dQ/dx vs YZ for plane0 positive X

