Using CPA grid shadow to study SCE spatial distortion in ProtoDUNE-SP

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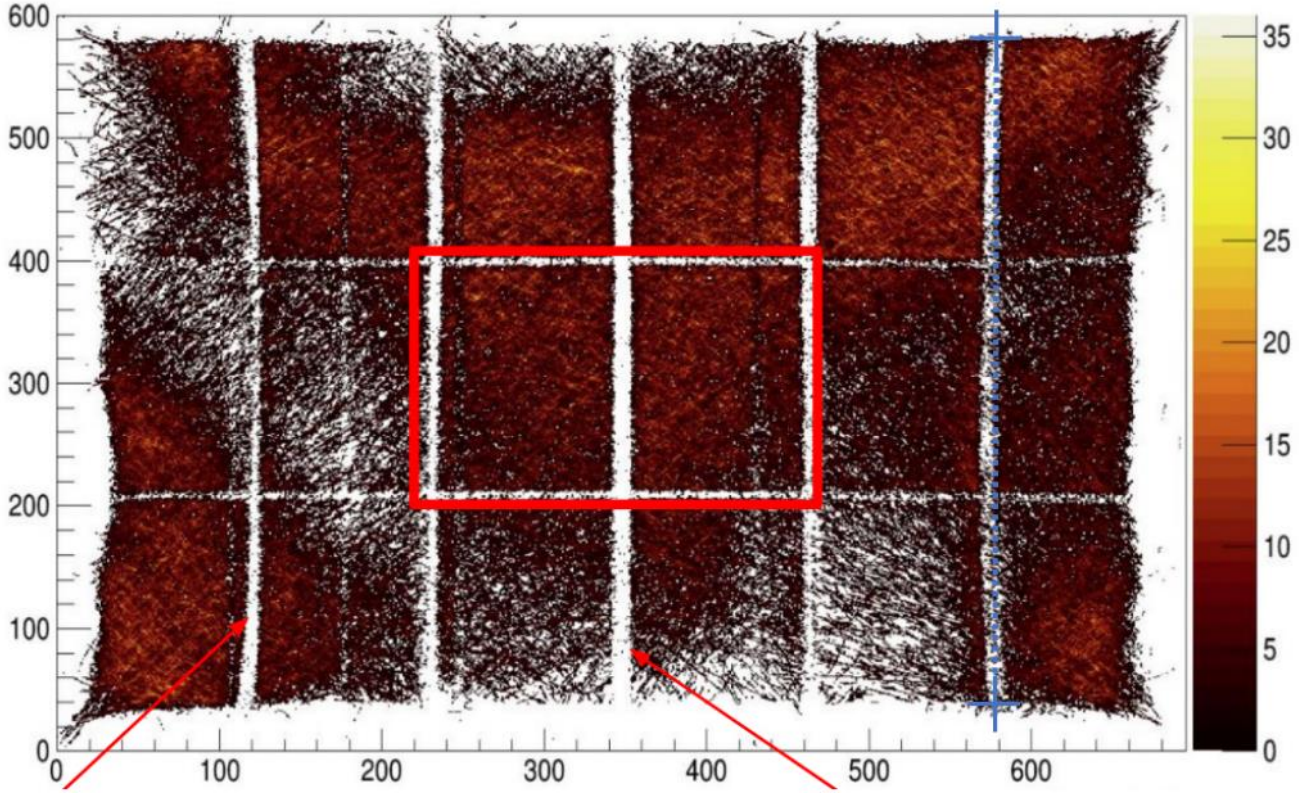
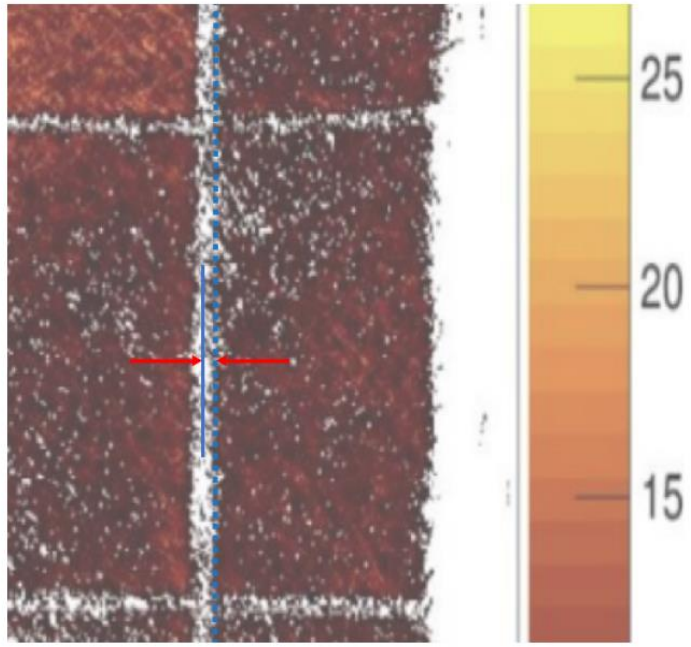
Below is the link for the slides showing CPA frames shadow:

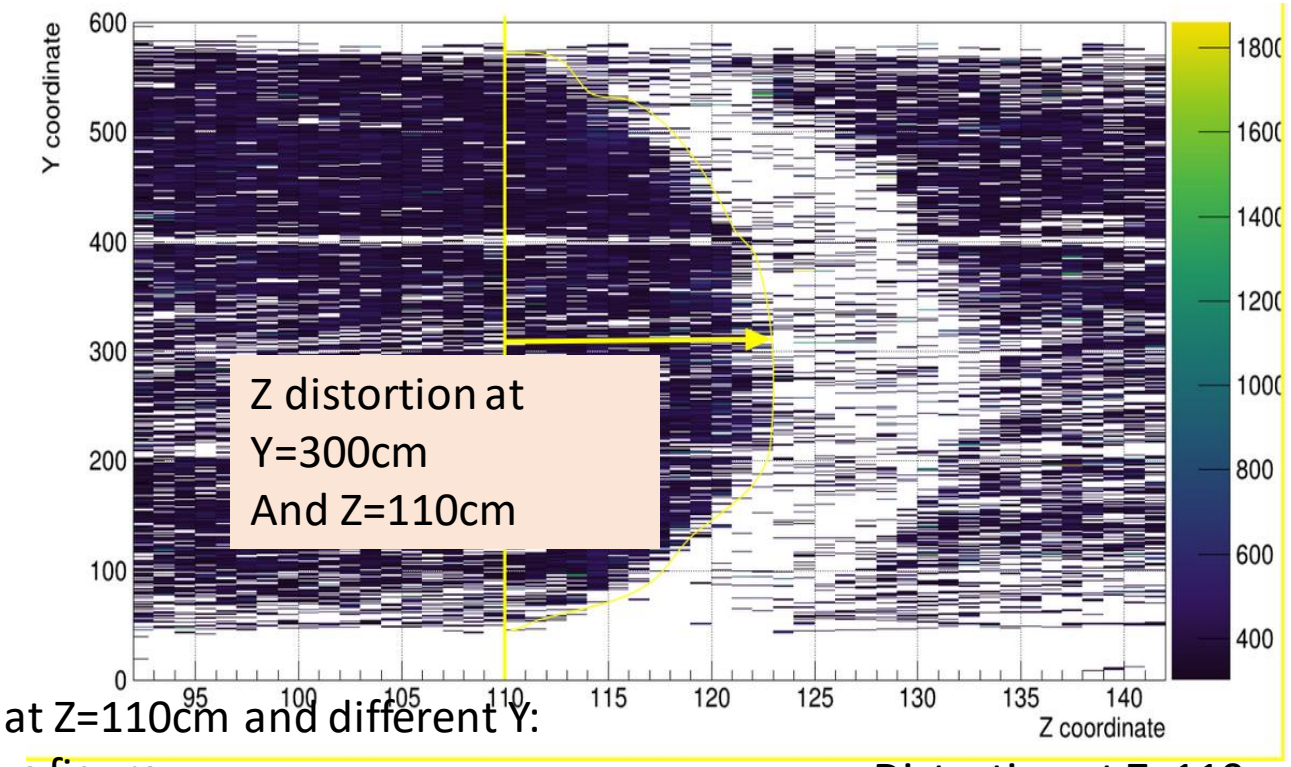
https://docs.dunescience.org/cgi-bin/private/RetrieveFile?docid=15031&filename=looking_at_CPA_structure_using_cosmic_ray_muons_v1.pdf&version=2

Sandro suggested measuring the Z-distortion directly using shadow of the CPA (images from Sandro's email)





I tried to measure the Z distortion at a few points. Bin size is 1X1cm along YZ,



There are scattered hits that makes it difficult to measure distortion.
Also, I am not sure about the posiition of correct reference line. If known offset from the yellow vertical line can be applied to measured values of distortion.

And bin size is 1cmX1cm which leads to additional uncertainty

Distortion at Z=110cm and different Y:

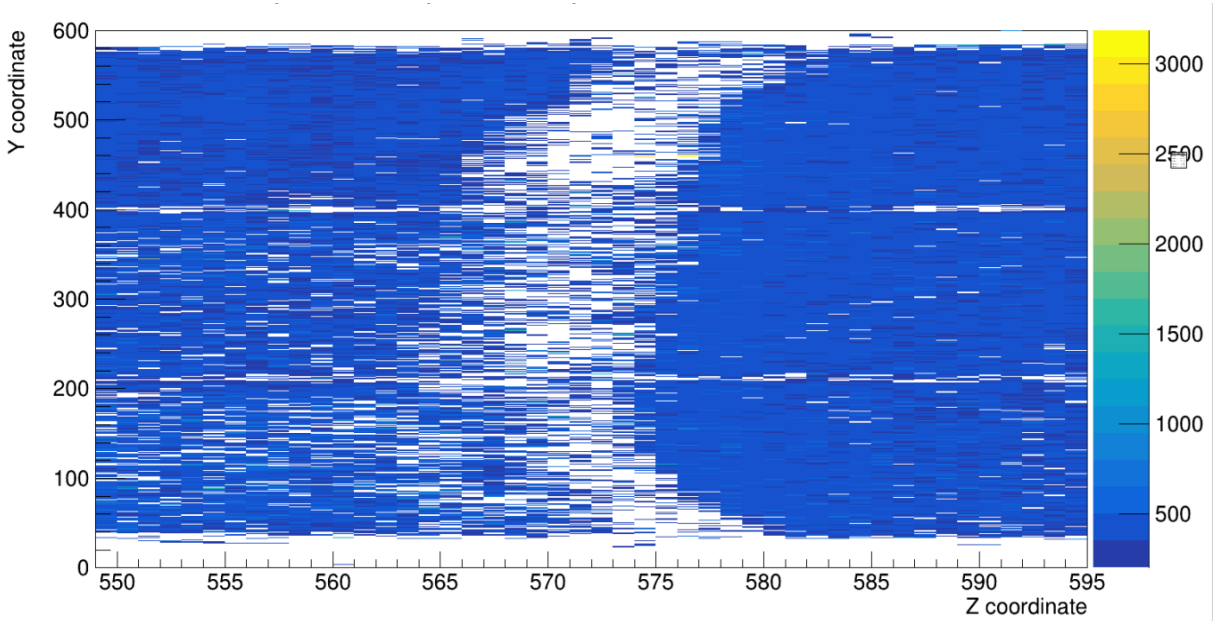
Using above figure:

Y=100, distortion=6cm
Y=150, dist=10cm
Y=200, dist=12-13cm
Y=300, distortion=12-13cm
Y=400, dist=11-12cm
Y=450, dist=9cm
Y=500, dist=6cm
Y=550, dist=3cm

Distortion at Z=110cm from SCE map developed by Mike Mooney

Zdist at Y= 100 is 6.49829cm
Zdist at Y= 150 is 8.15621cm
Zdist at Y= 200 is 10.3222cm
Zdist at Y= 300 is 9.8463cm
Zdist at Y= 400 is 8.35472cm
Zdist at Y= 450 is 6.88881cm
Zdist at Y= 500 is 5.4125cm
Zdist at Y= 550 is 3.3999cm

Distortion at Z=585cm beam right:



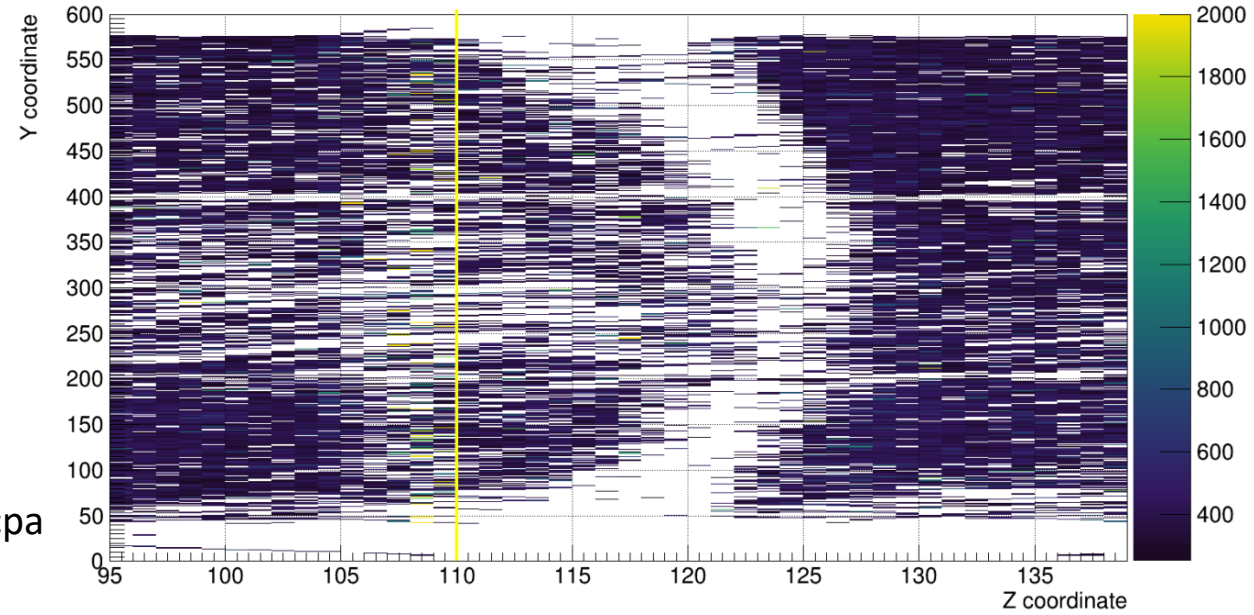
Magnitude of Measured
using cpa frames shadow:

Y=100 distortion=12cm
Y=200 distortion=15cm
Y=300 distortion=14cm
Y=400 distortion=12cm
Y=500 distortion=7cm

All values have +/-1cm
uncertainty

Z Disortion values at Z=585cm using SCE map
Zdist at Y= 100 is -6.24508 cm
Zdist at Y= 150 is -7.83865 cm
Zdist at Y= 200 is -9.85585 cm
Zdist at Y= 300 is -10.466 cm
Zdist at Y= 400 is -9.1278 cm
Zdist at Y= 450 is -7.4173 cm
Zdist at Y= 500 is -5.26704 cm
Zdist at Y= 550 is -3.25849 cm

Beam left Z=110cm

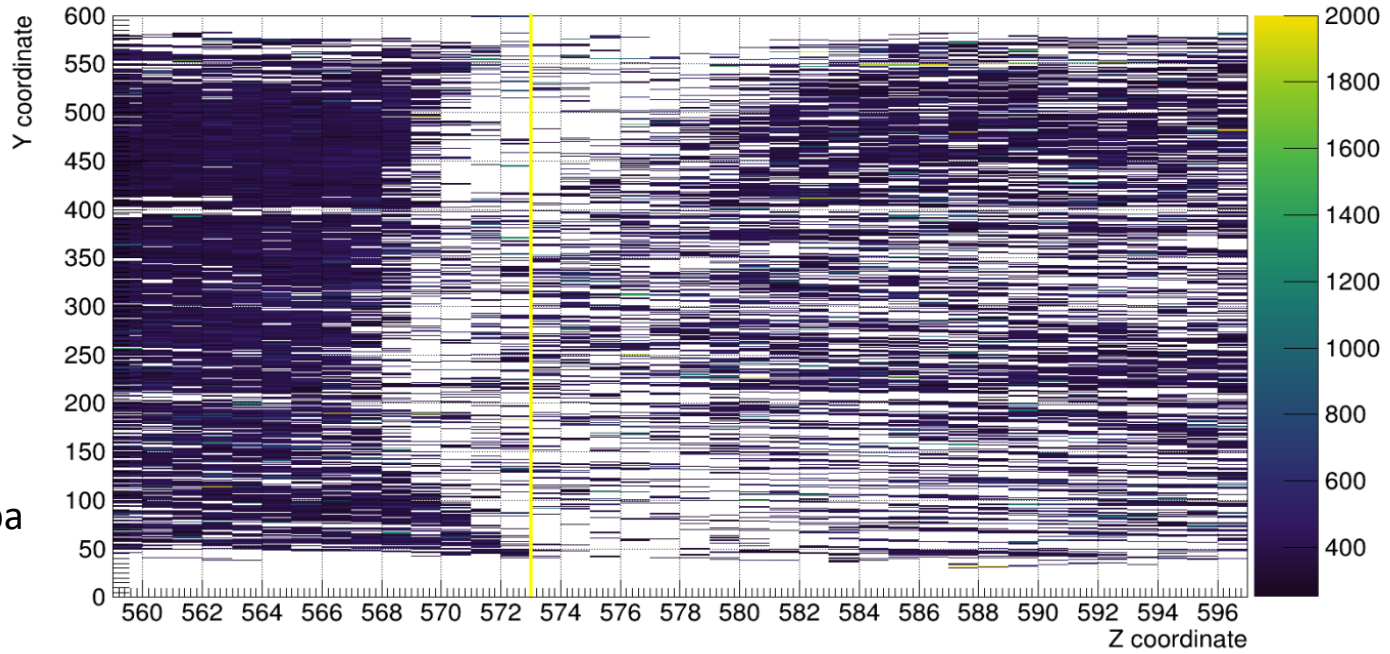


Magnitude of Measured using cpa frames shadow:

Y=100 distortion=7cm
Y=150 distortion=8cm
Y=200 distortion=10cm
Y=250 distortion=13cm
Y=300 dist=13cm
Y=350 dist=12cm
Y=400 dist=11cm
Y=450 dist = 8cm
Y=500 dist=5cm
Y=550 dist=2cm
+/- 1cm error is expected due to bin size and scattered hits

Zdistortion at Z=110cm from SCE map:
Zdist at Y= 50 is 2.91313
Zdist at Y= 100 is 5.70804
Zdist at Y= 150 is 7.32473
Zdist at Y= 200 is 9.57978
Zdist at Y= 300 is 9.69273
Zdist at Y= 400 is 8.89929
Zdist at Y= 450 is 7.56986
Zdist at Y= 500 is 6.23134
Zdist at Y= 550 is 3.99844

Beam left Z=573cm



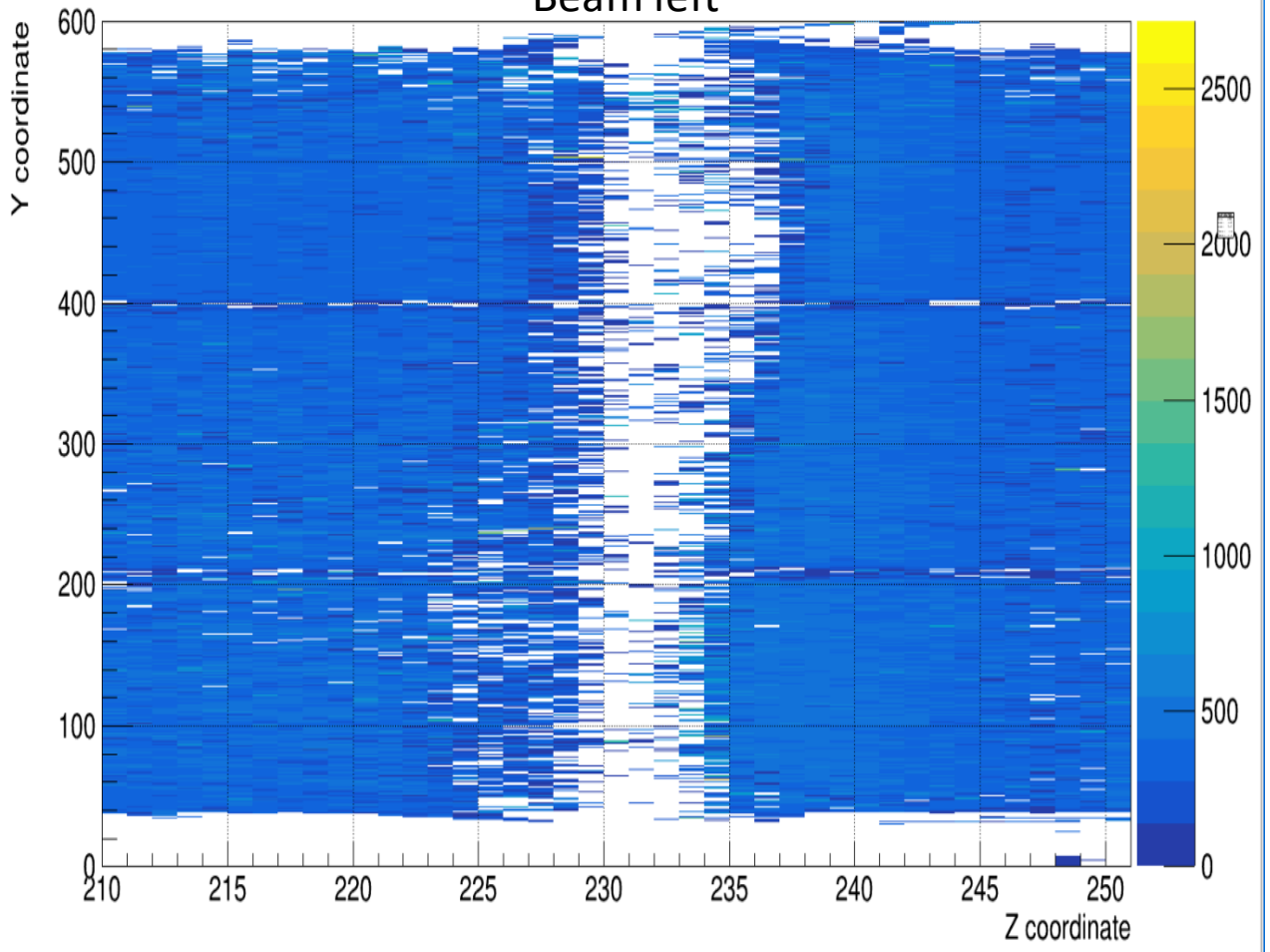
Magnitude of Measured using cpa frames shadow:

Y=50 distortion=1cm
Y=100 distortion=3cm
Y=150 distortion=5cm
Y=200 distortion=6cm
Y=250 distortion=6cm
Y=300 dist=5cm
Y=350 dist=5cm
Y=400 dist=5cm
Y=450 dist = 4cm
Y=500 dist=4cm
Y=550 dist=2cm
+/- 1cm error is expected due to bin size and scattered hits

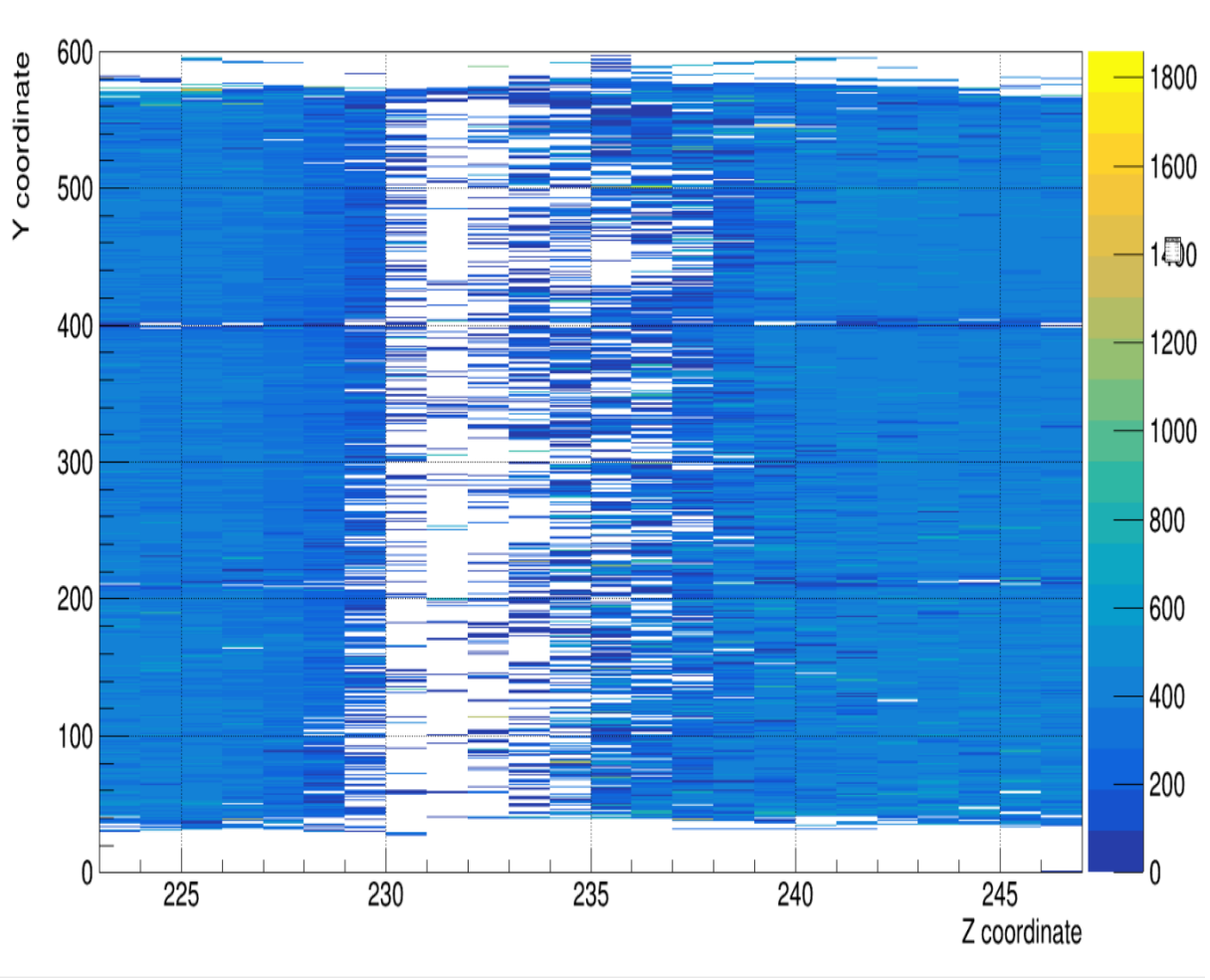
Distortion using SCE map
Zdist at Y= 50 is -2.75911
Zdist at Y= 100 is -5.48611
Zdist at Y= 150 is -7.04022
Zdist at Y= 200 is -9.14767
Zdist at Y= 300 is -10.3029
Zdist at Y= 400 is -9.72208
Zdist at Y= 450 is -8.14994
Zdist at Y= 500 is -6.0634
Zdist at Y= 550 is -3.83202

Zdistortion at Z=230cm

Beam left



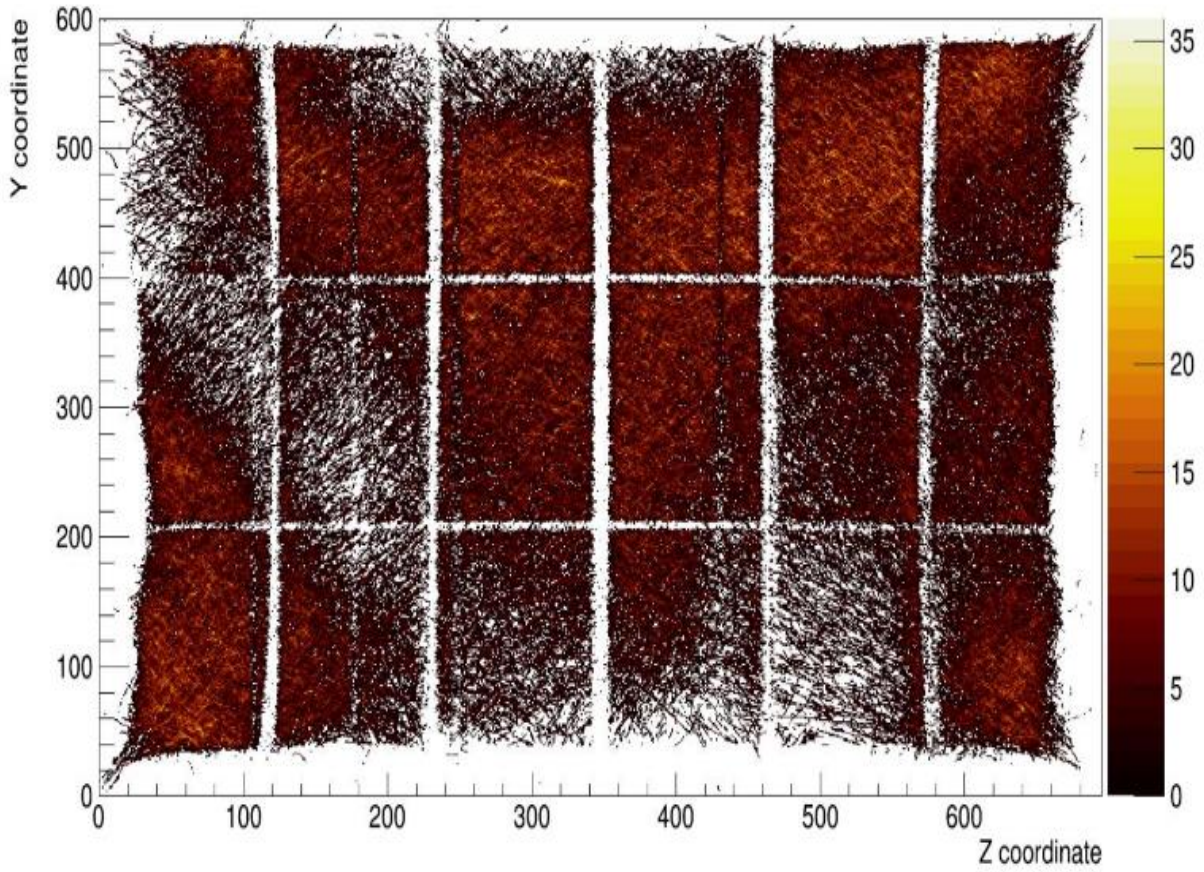
Beam right



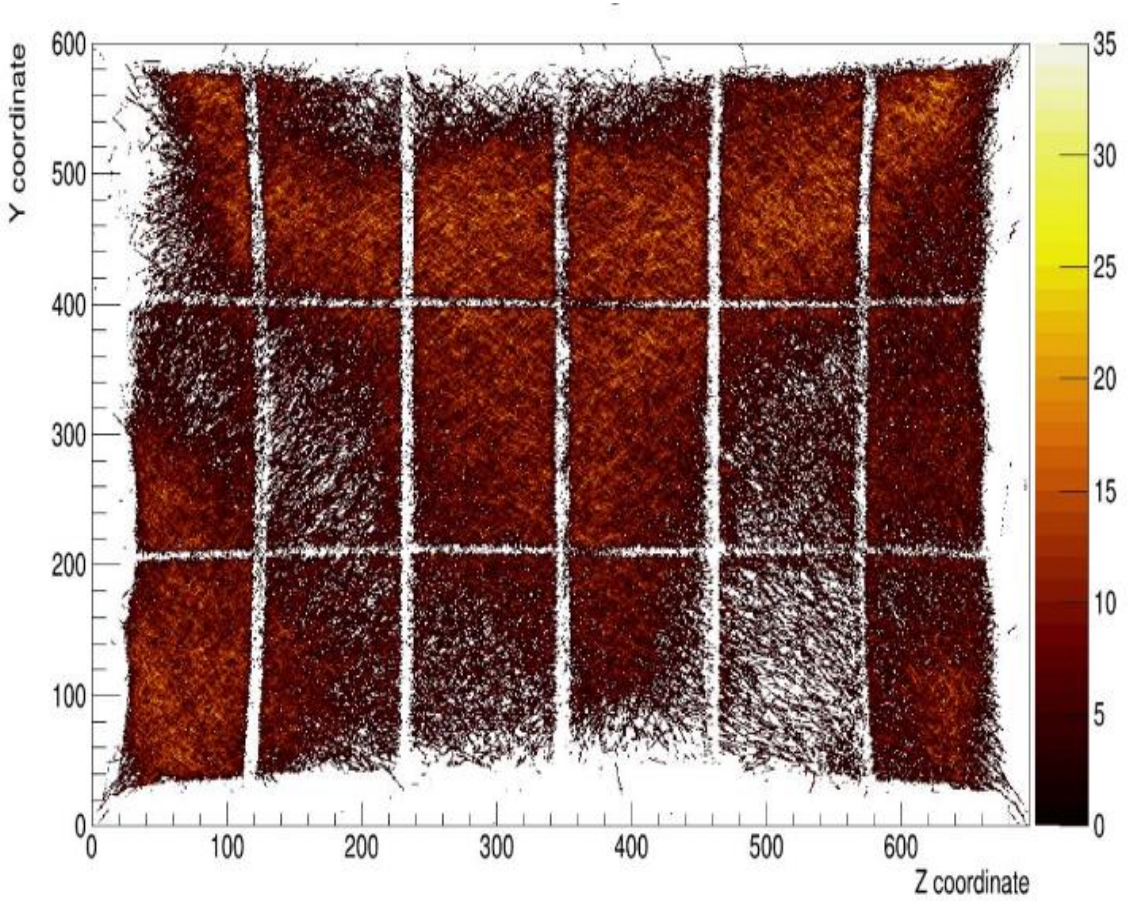
Z distortion appears to be very small at Z=230cm, Zdist=1-2cm

There are electron diverters too at this location which may play some role.

YZ distribution of hits close to cathode before SCE correction:

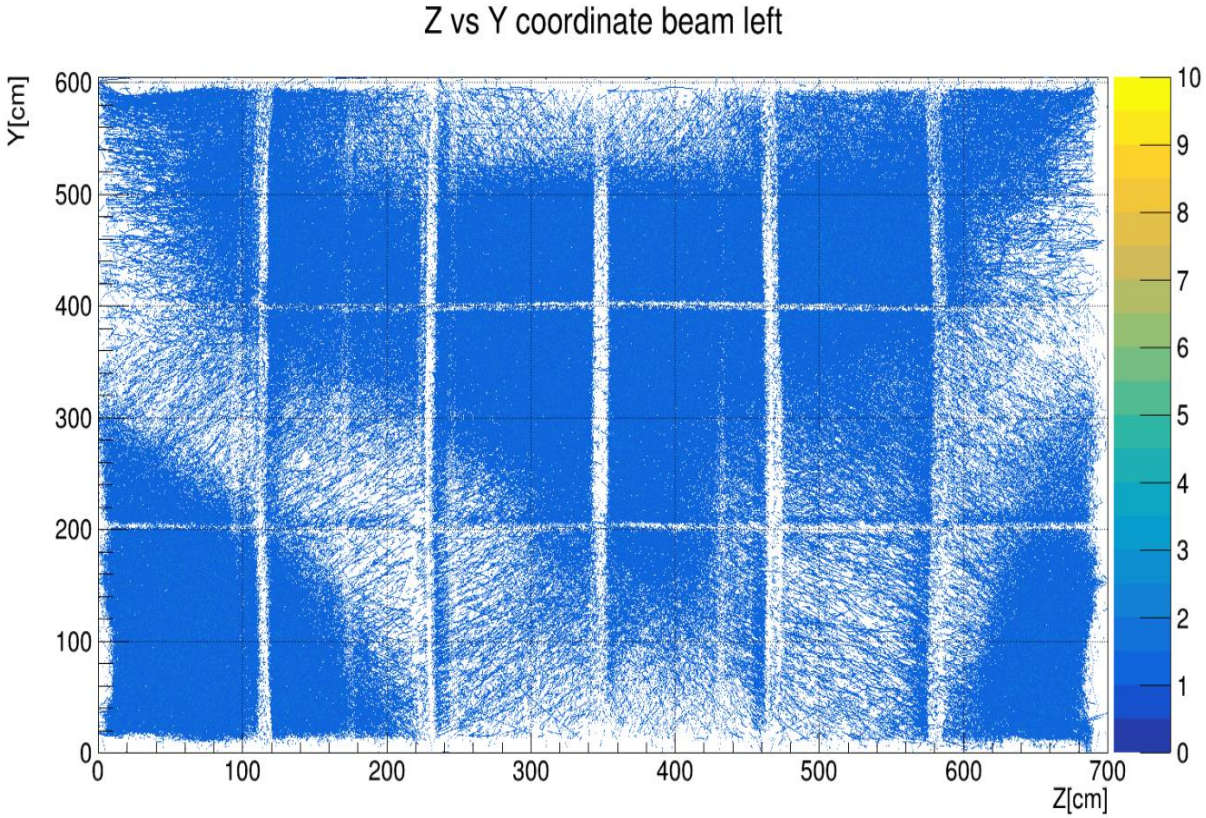


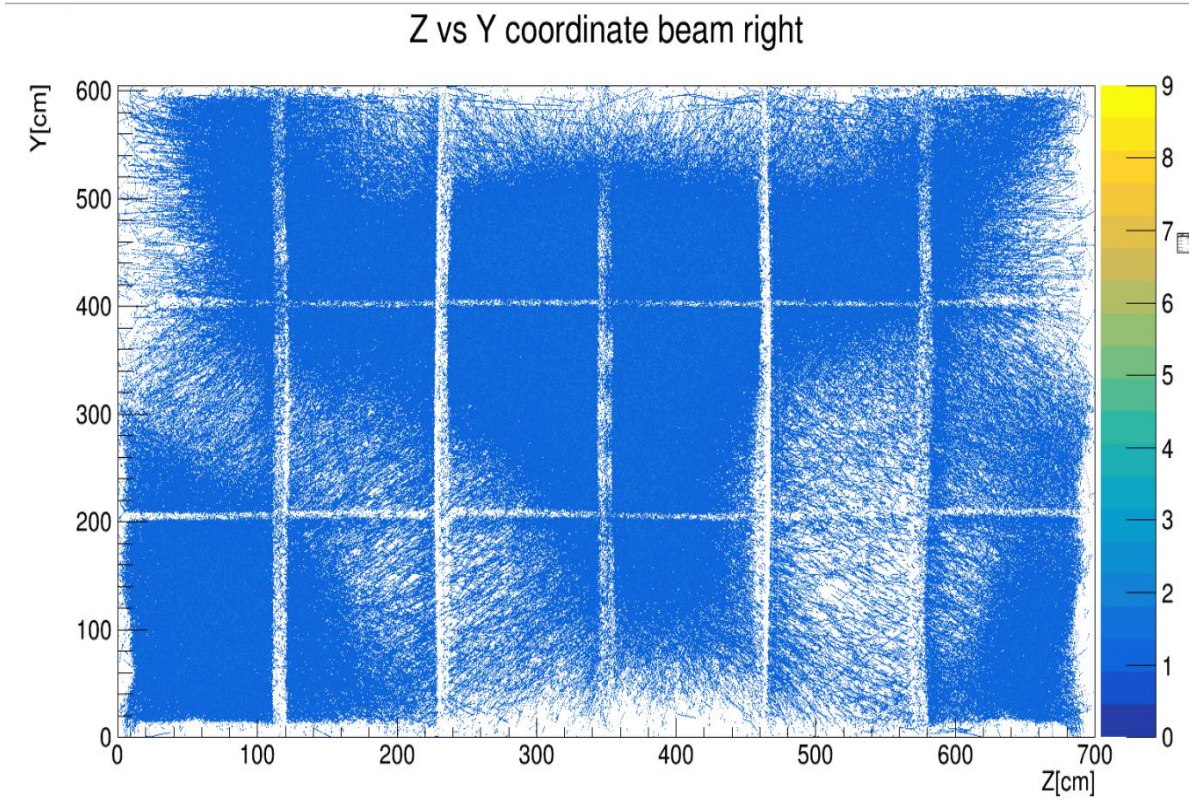
Beam right



Beam left

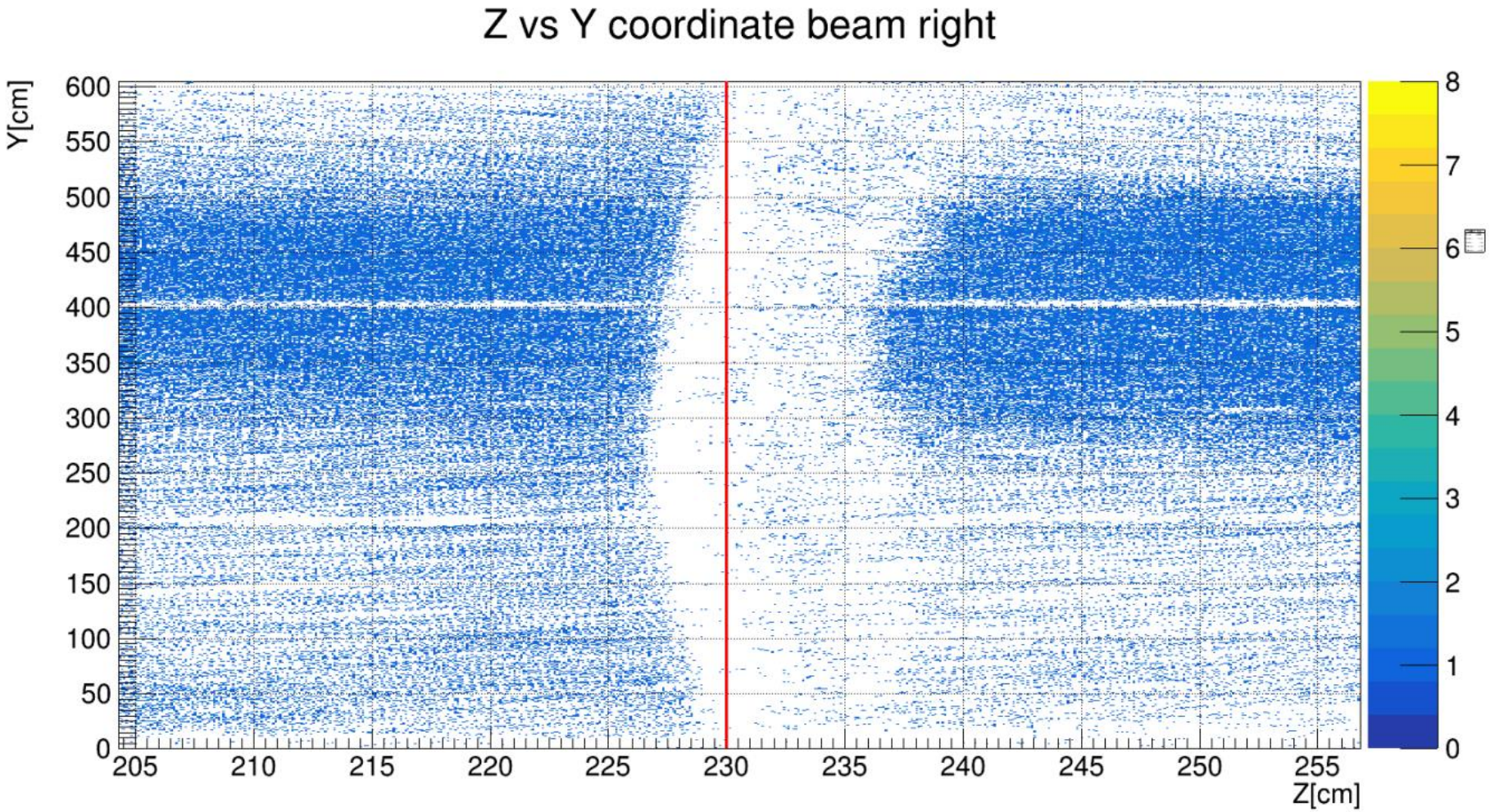
YZ distribution of hits after SCE correction:





Bins closer to edges shows big improvement.
Bins in the central region shows slightly more distortion than the uncorrected distribution, which can be seen from zoomed out figure in next slide.

This is a zoomed view of the plot in the previous slide (after SCE correction) . There is a maximum distortion ~3cm after SCE correction.



Also I am trying to measure the Z distortion at the cathode usign anode-cathode-anode crossing tracks. First results shows an unusual pattern described in slide 9 of the link, which could possibly from fluid flow.
https://indico.fnal.gov/event/23248/contribution/1/material/slides/0.pdf