

APA Gap Crossers

Mike Wallbank

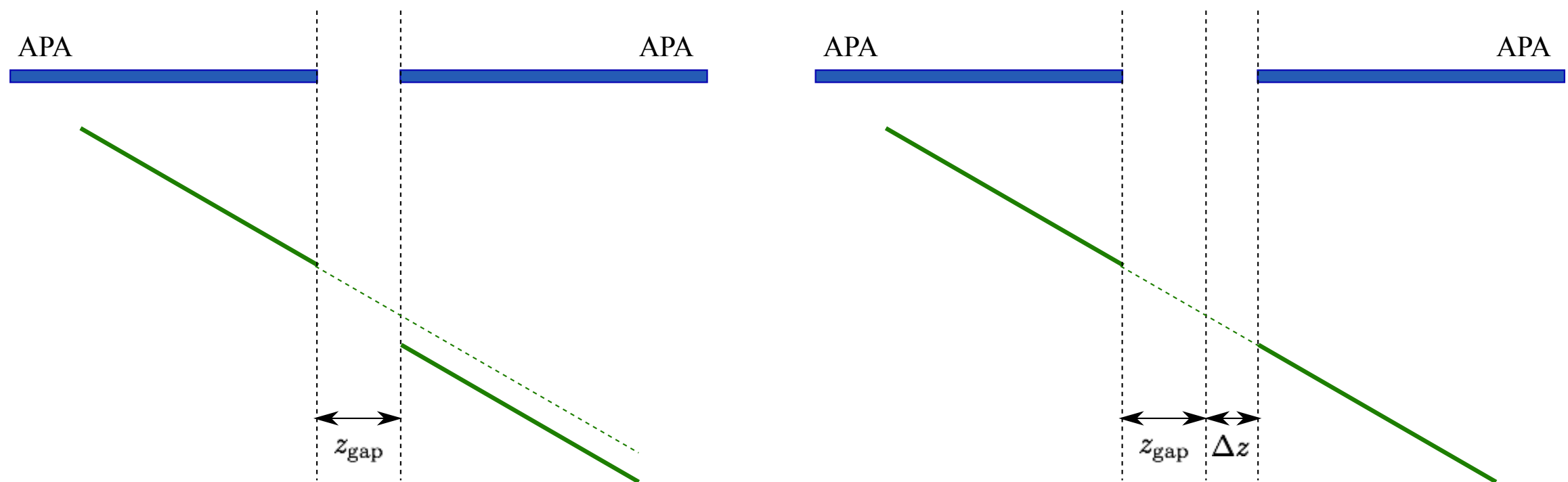
8/3/2017

Intro

- Continuing the work I did with the APA crossers and considering APA gap crossers.
- Verifying Animesh's measurements of the gaps from data.
- Progress:
 - Finalised selection;
 - Optimised method to extract both x - and z -offsets simultaneously;
 - Made all measurements;
 - Looked at charge deposited by APA-gap crossers.

Measuring APA Gaps

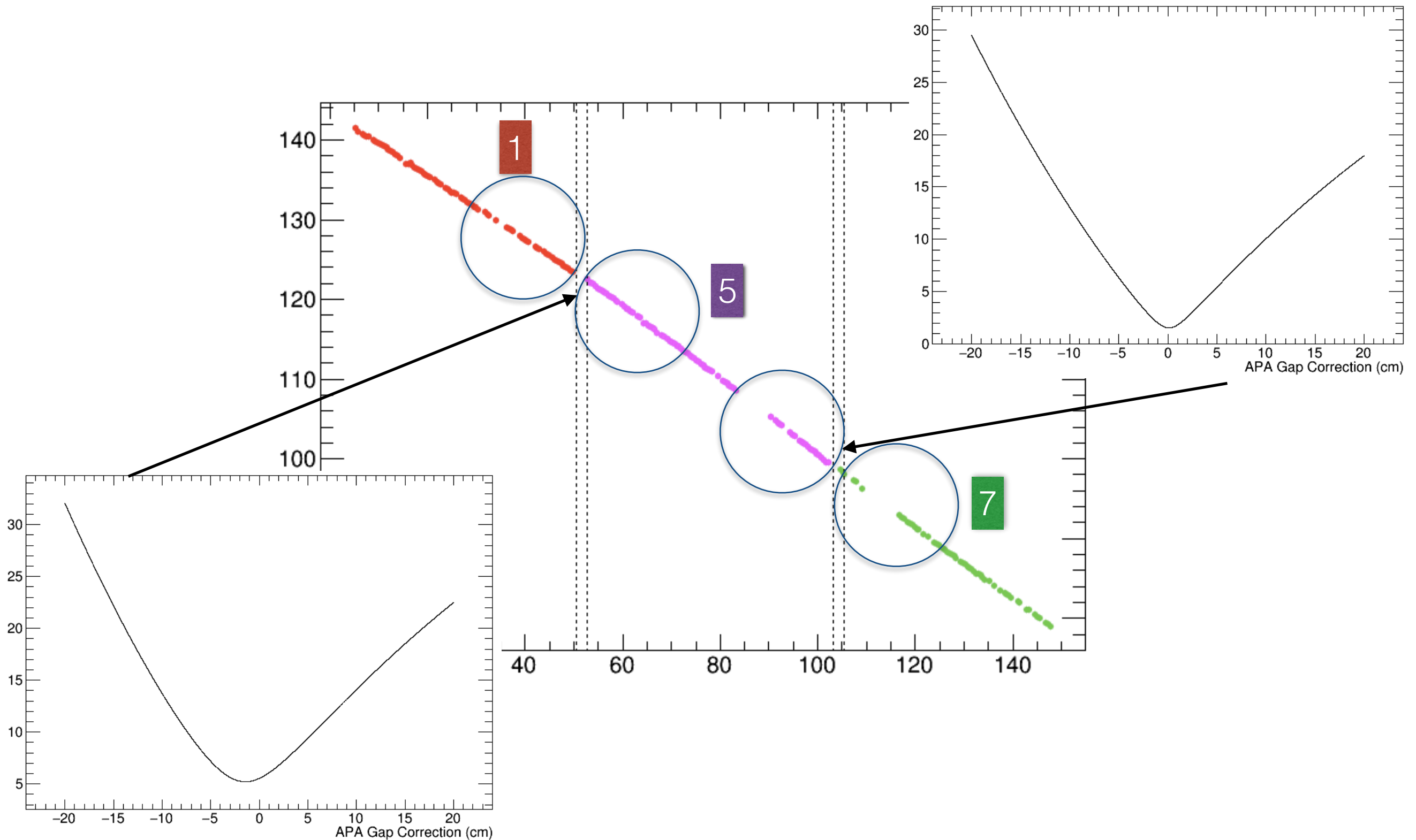
- Same code I used as APA crossers; fit linear regression, vary gap, minimise the residuals.
- Use only hits <15cm from the gap.



$$\sum_i^{nhits} \left(\frac{O_i - e_i}{\sigma_i} \right)^2$$

Minimise this 'chi-square'

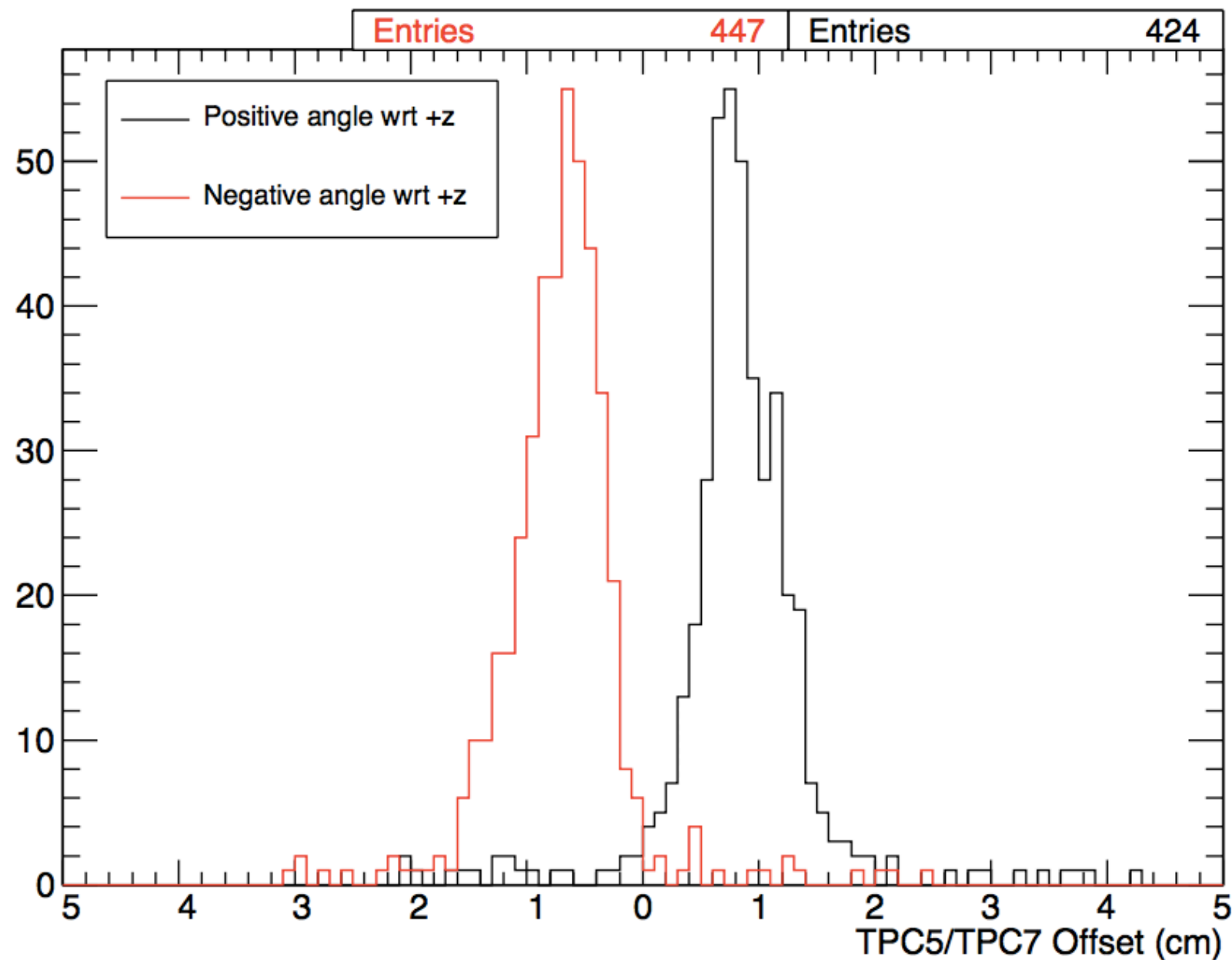
Measuring APA Gaps



Selecting Tracks

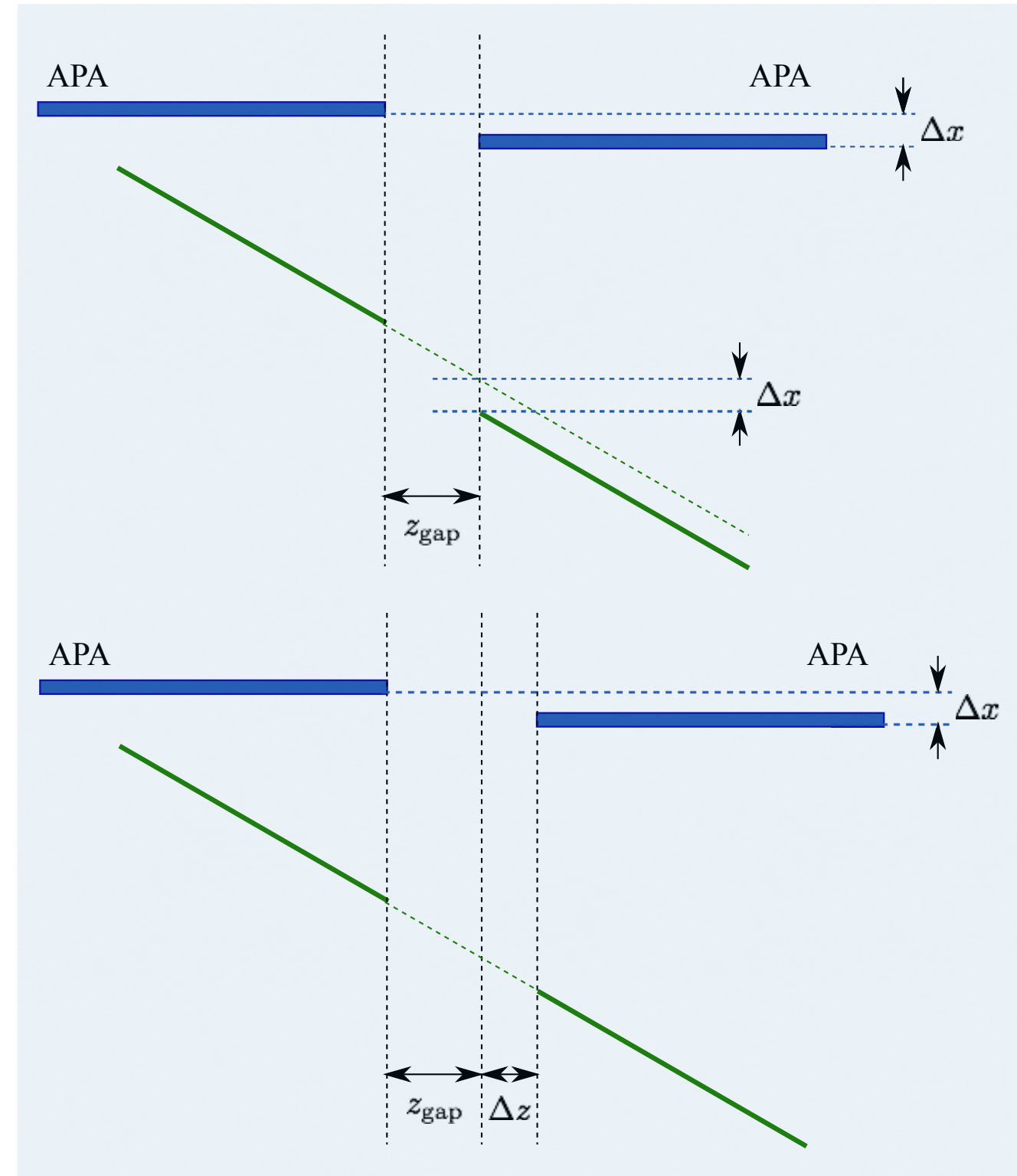
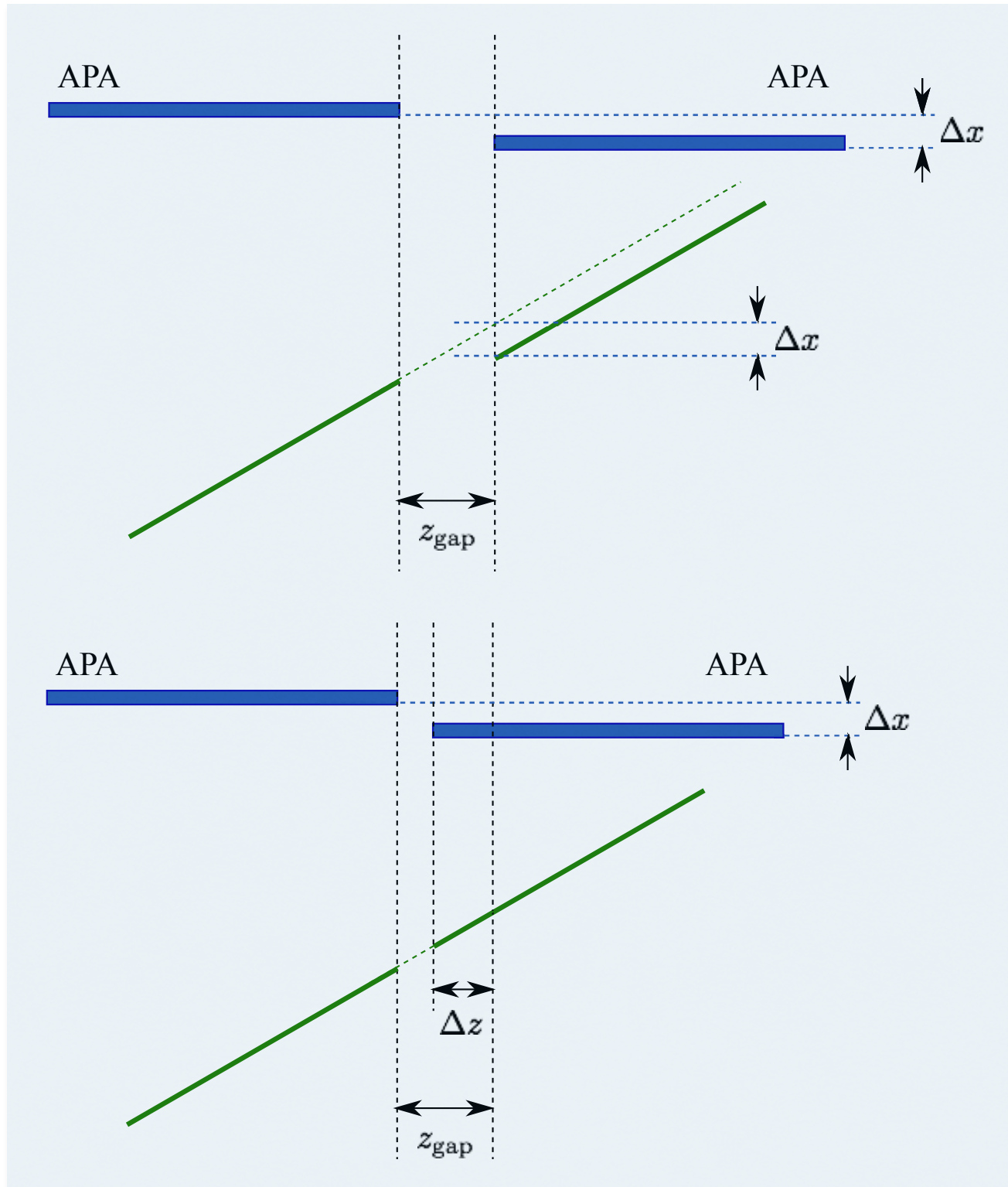
- Two main changes:
 - Fixed bug (or misunderstanding) with number of hits a track must have to be used. I was accidentally considering all hits in the TPCs, not those in the specified region near the gaps.
 - Now take hits > 1 cm and < 15 cm from the gap.
- Selection is well defined now:
 - At least three hits, 1 cm $<$ distance from gap < 15 cm;
 - Angle between these segments < 2 deg.
 - ‘Counter gradient’ ≥ 3

TPC5/TPC7 Offset Observations

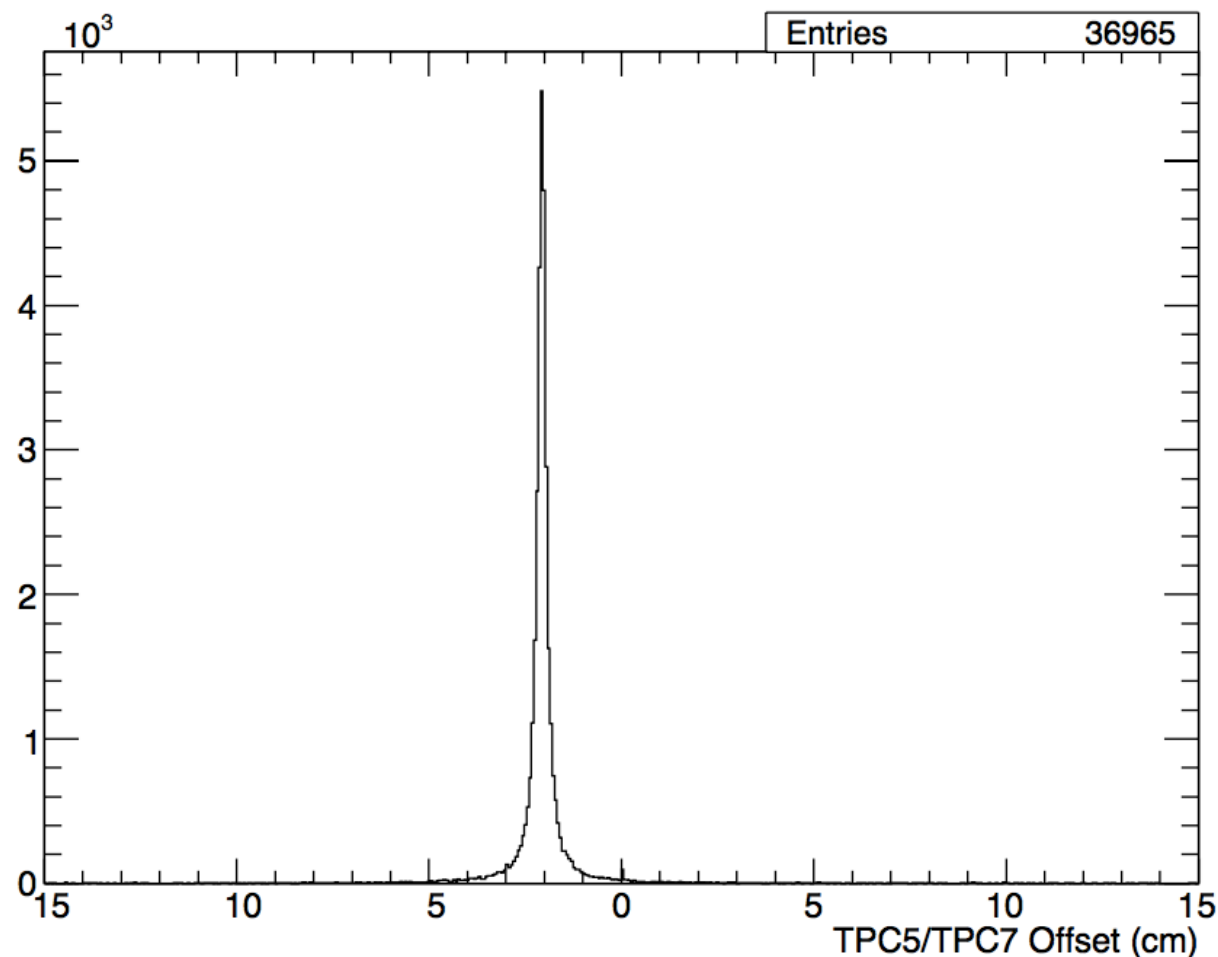


- Appears to be two peaks — and dependent on the angle the track makes to the APA frames.

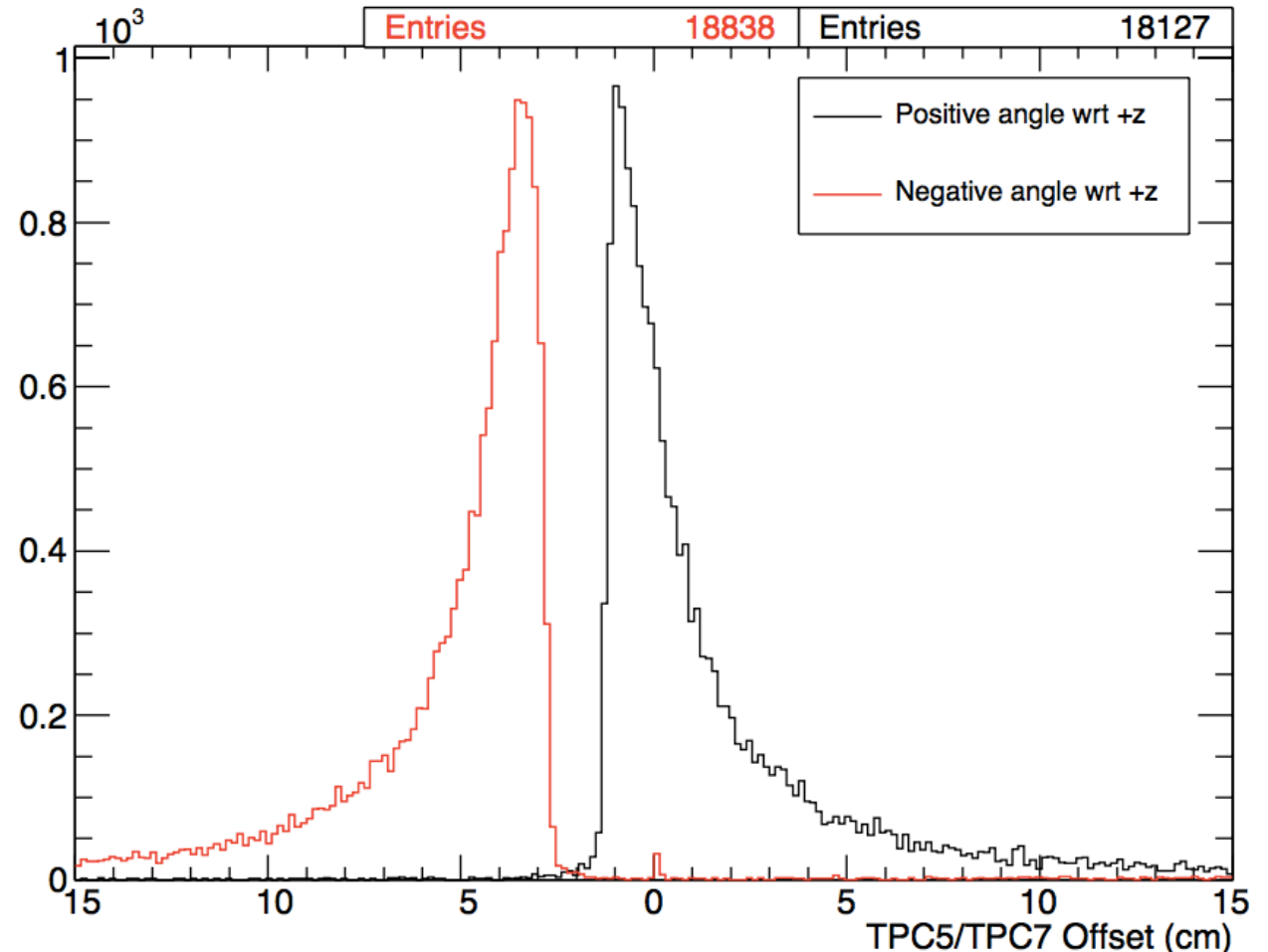
Potential x-(or time-) Offset



Offsets in Simulation



2 cm z-offset

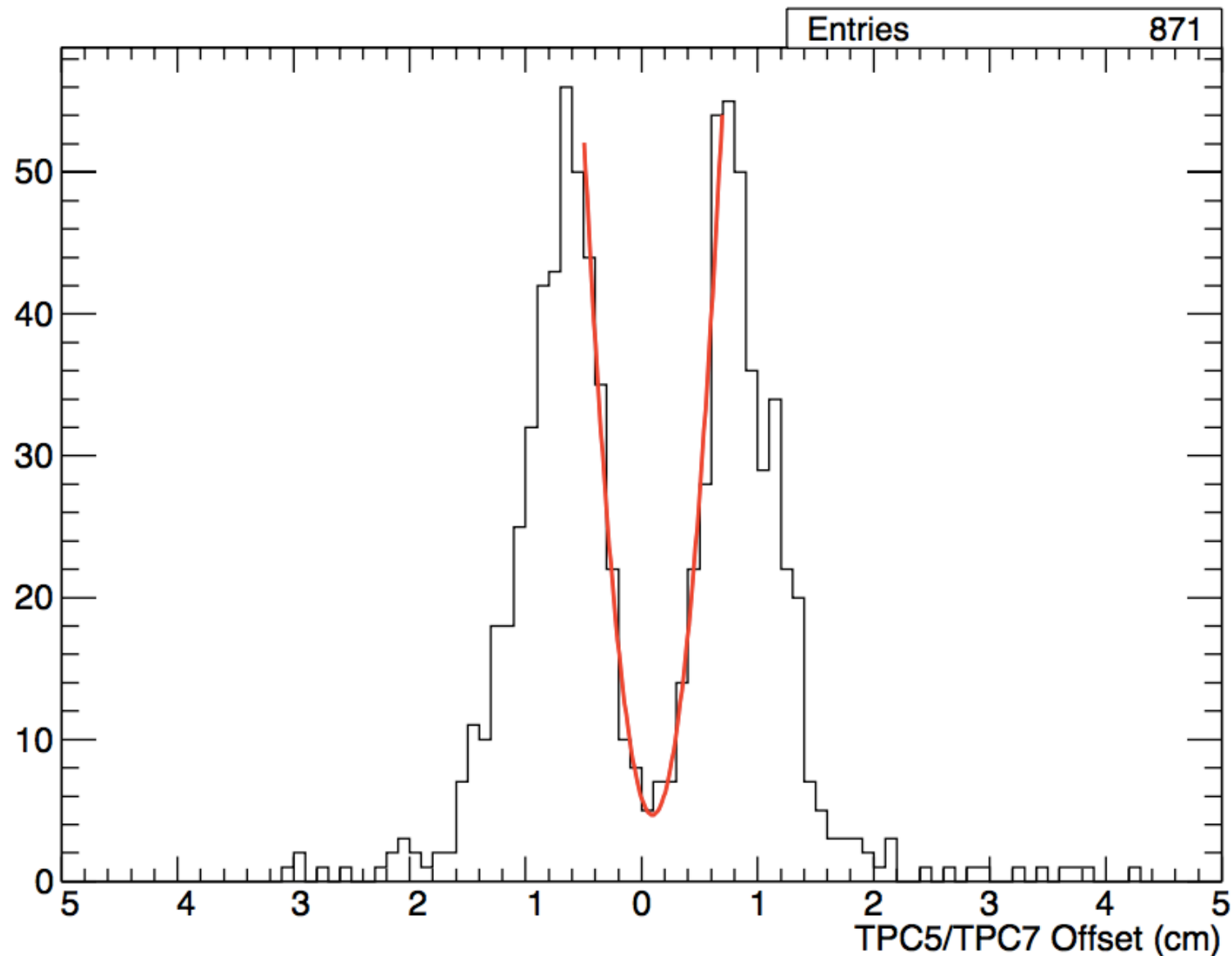


2 cm z-offset & 0.5 cm x-offset

- Just a z -offset does not cause this effect.
- A combined z -offset and x -offset appears to explain what we're seeing in the data. Can measure the z -offset from the simultaneous minima of the distributions.

TPC5/TPC7 Offsets

- Use the minimum of the distribution to find z -offset.

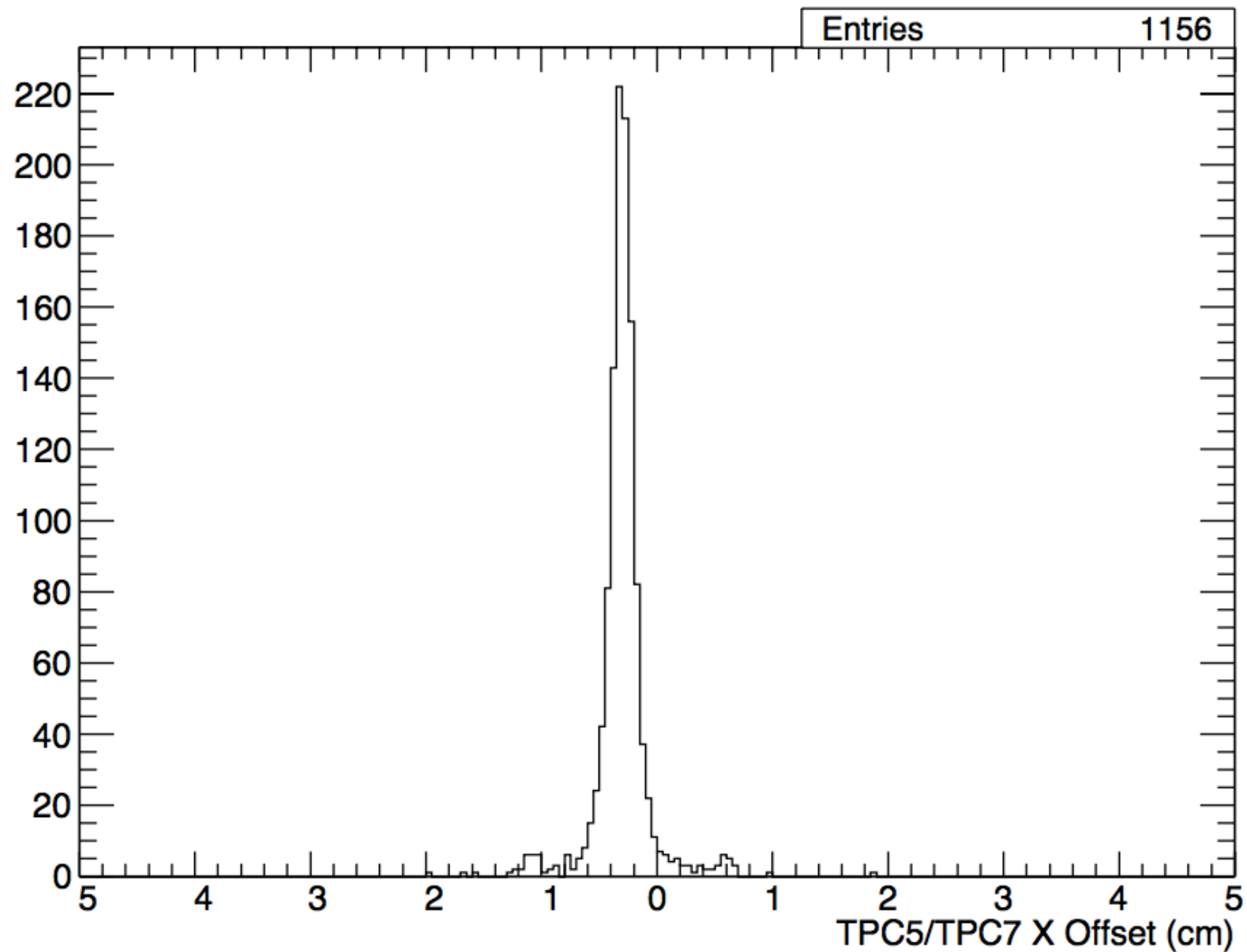


Fit function of form
$$f(x) = a(x - b)^2 + c$$
and extract b as the z -offset.

- z -offset = 0.1 cm.

TPC5/TPC7 Offsets

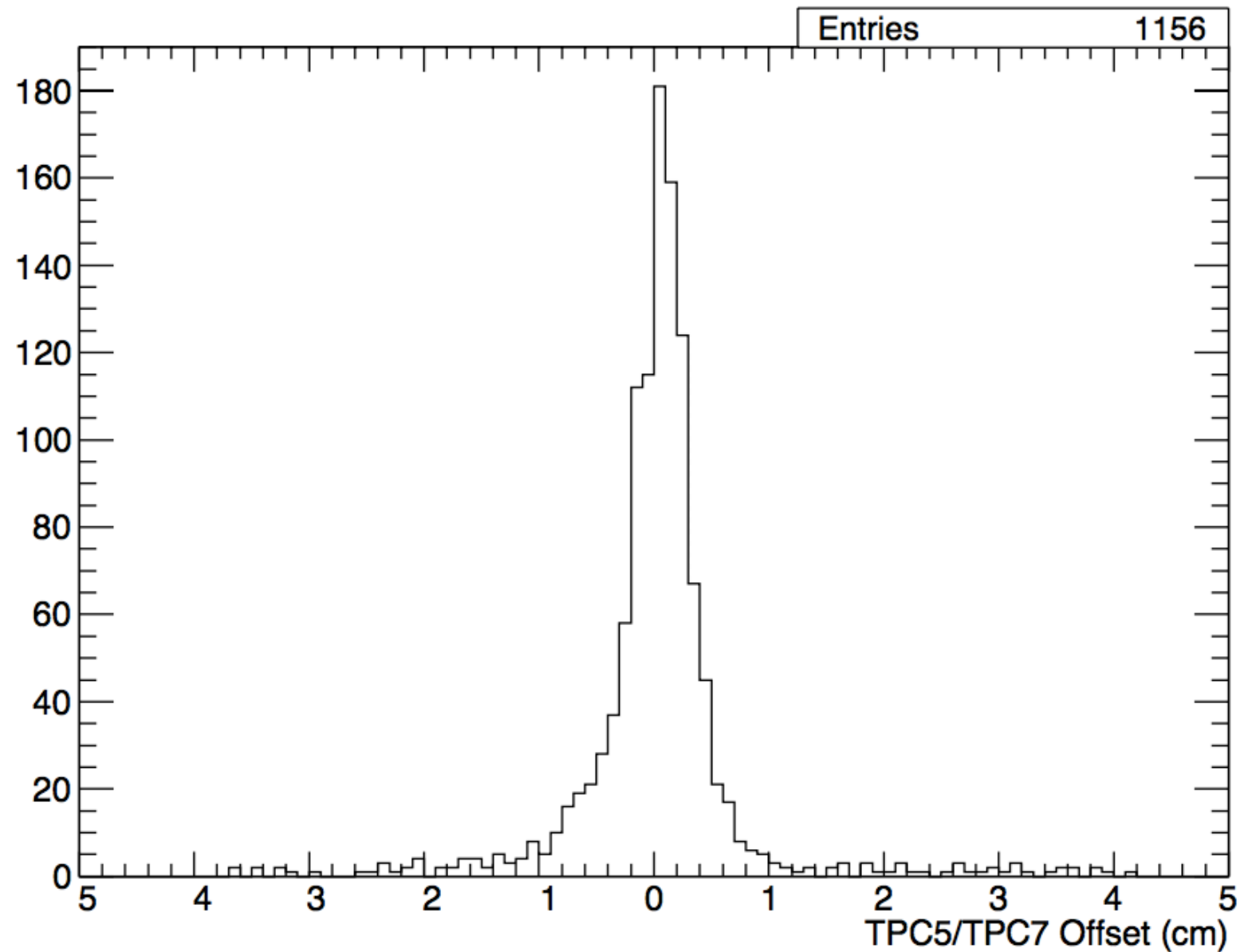
- Apply this offset to the tracks and measure x -offset:



- x -offset = -0.3 cm.

TPC5/TPC7 Offsets

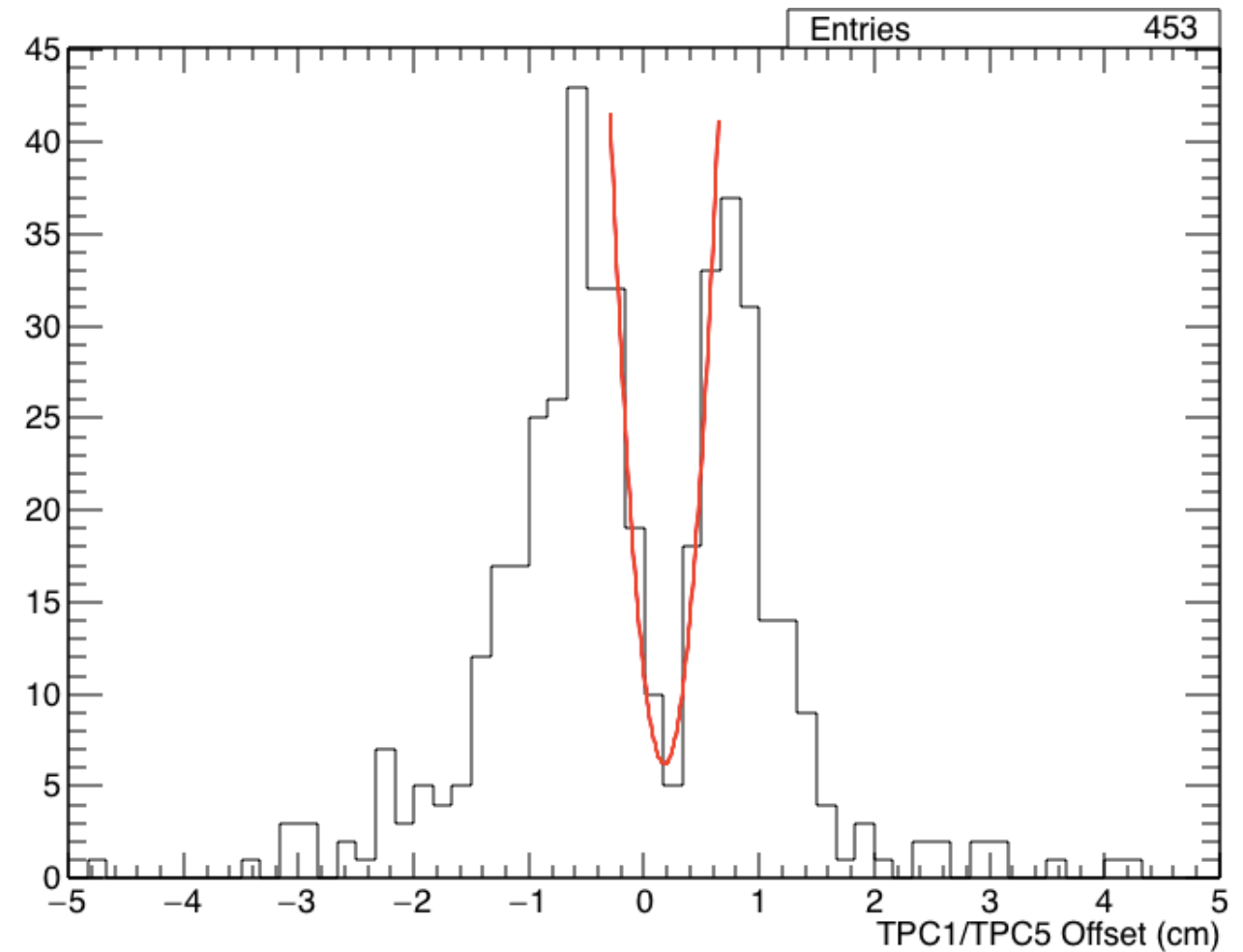
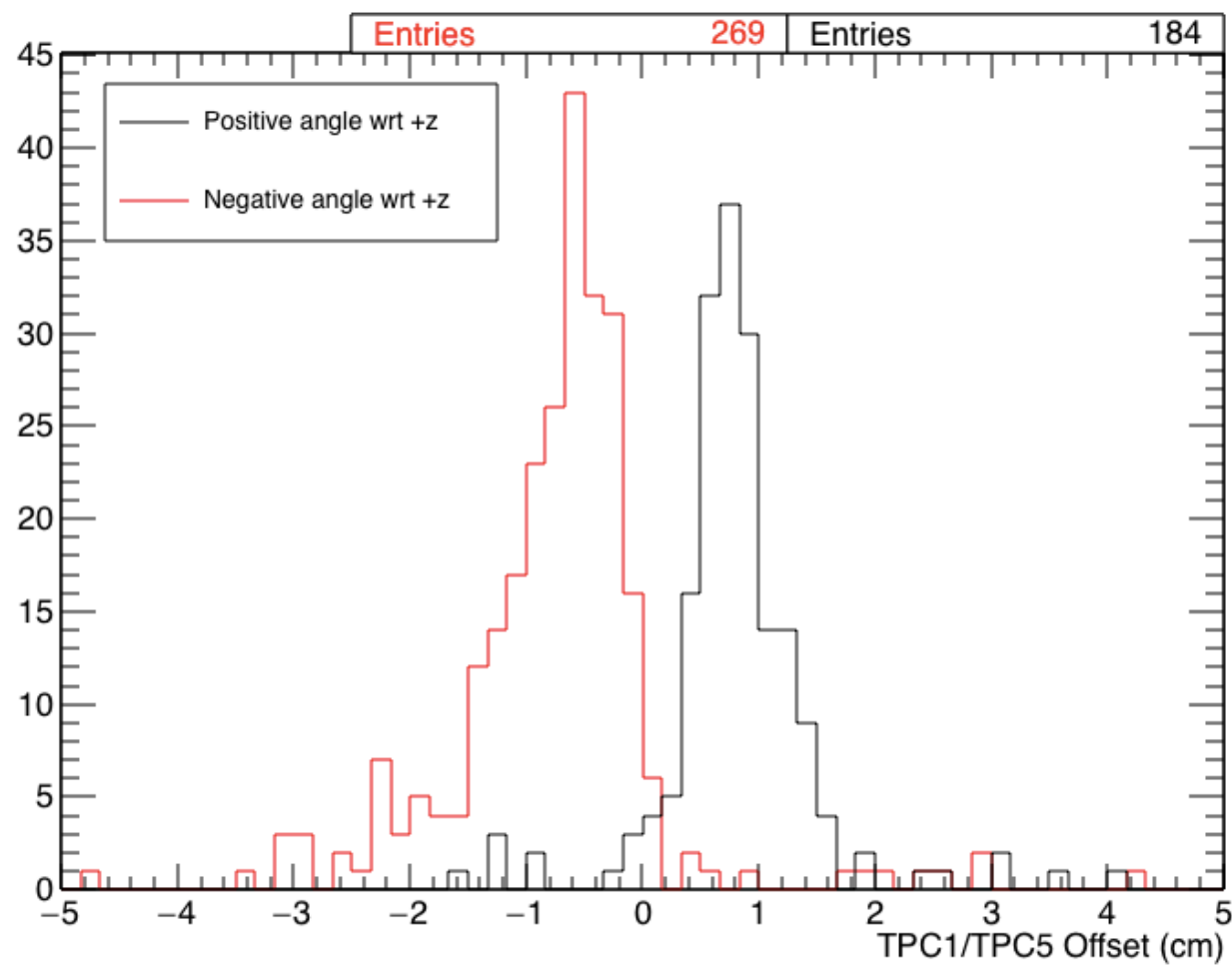
- Should then be a nice peak at the value of z -offset measured:



- Measure z -offset = 0.06 cm (c.f. 0.09 cm) — and ambiguity resolved!

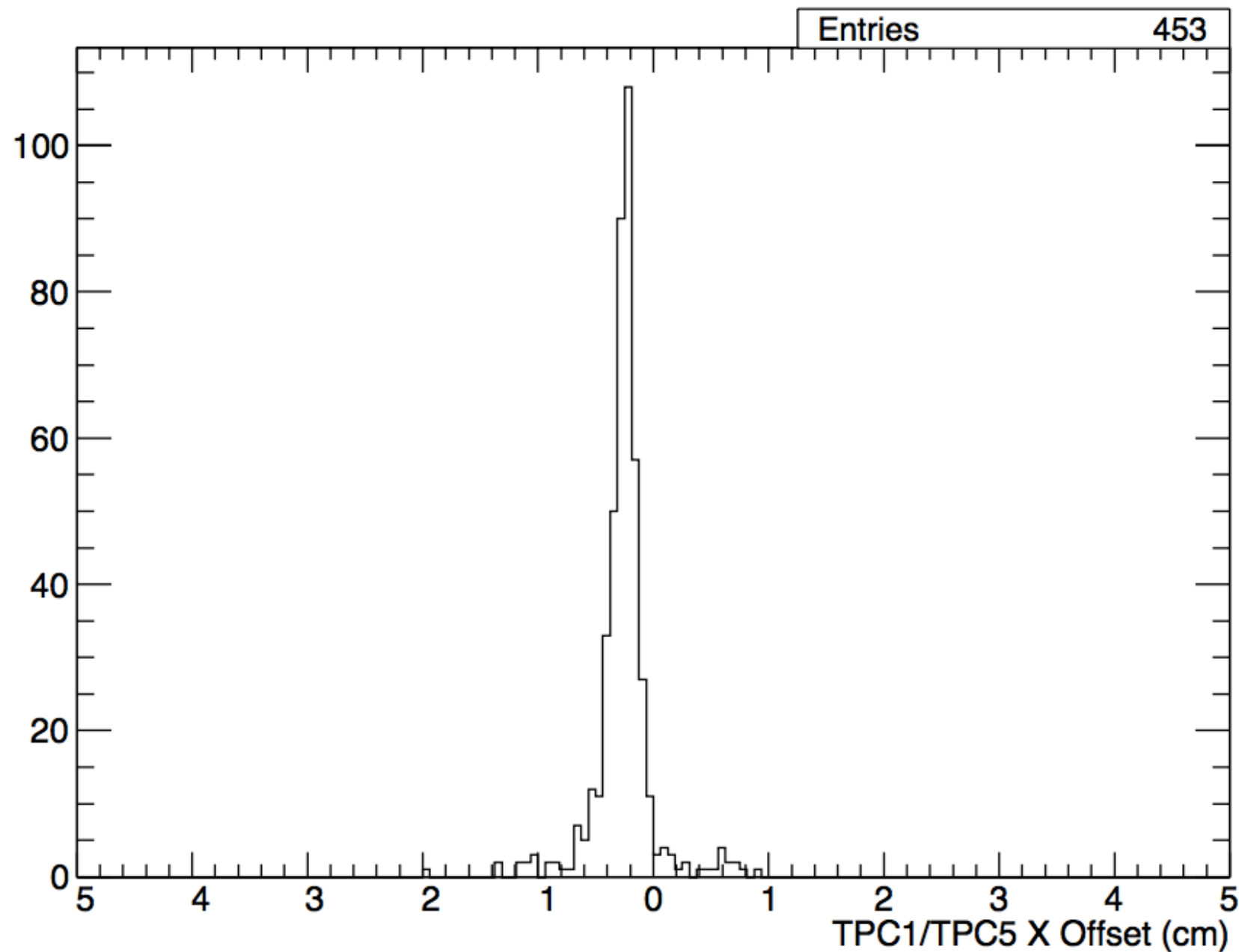
TPC1/TPC5 Offsets

- A relatively large x -offset is apparent here...



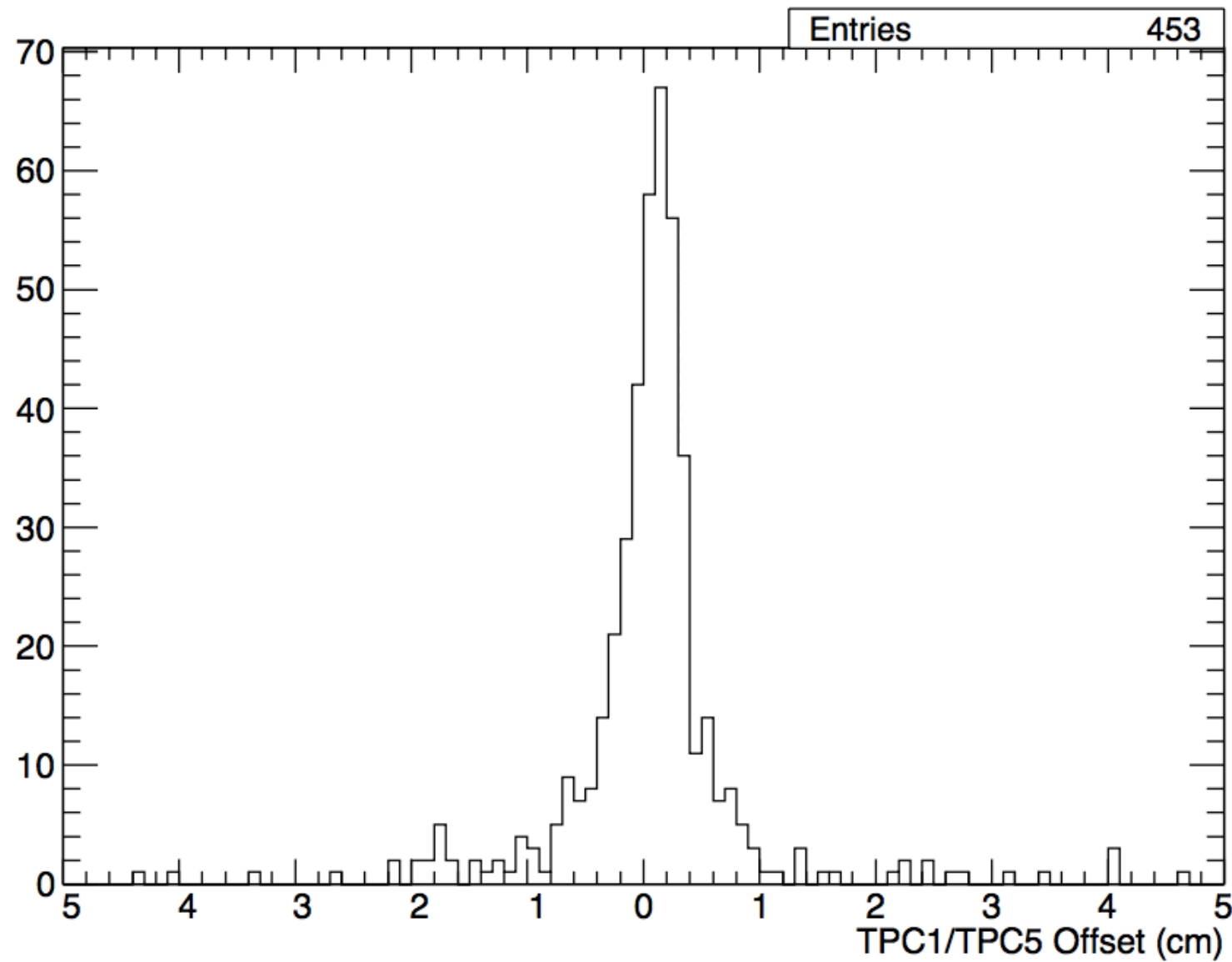
- Measure z -offset = 0.2 cm.

TPC1/TPC5 Offsets



- x -offset = -0.25 cm.

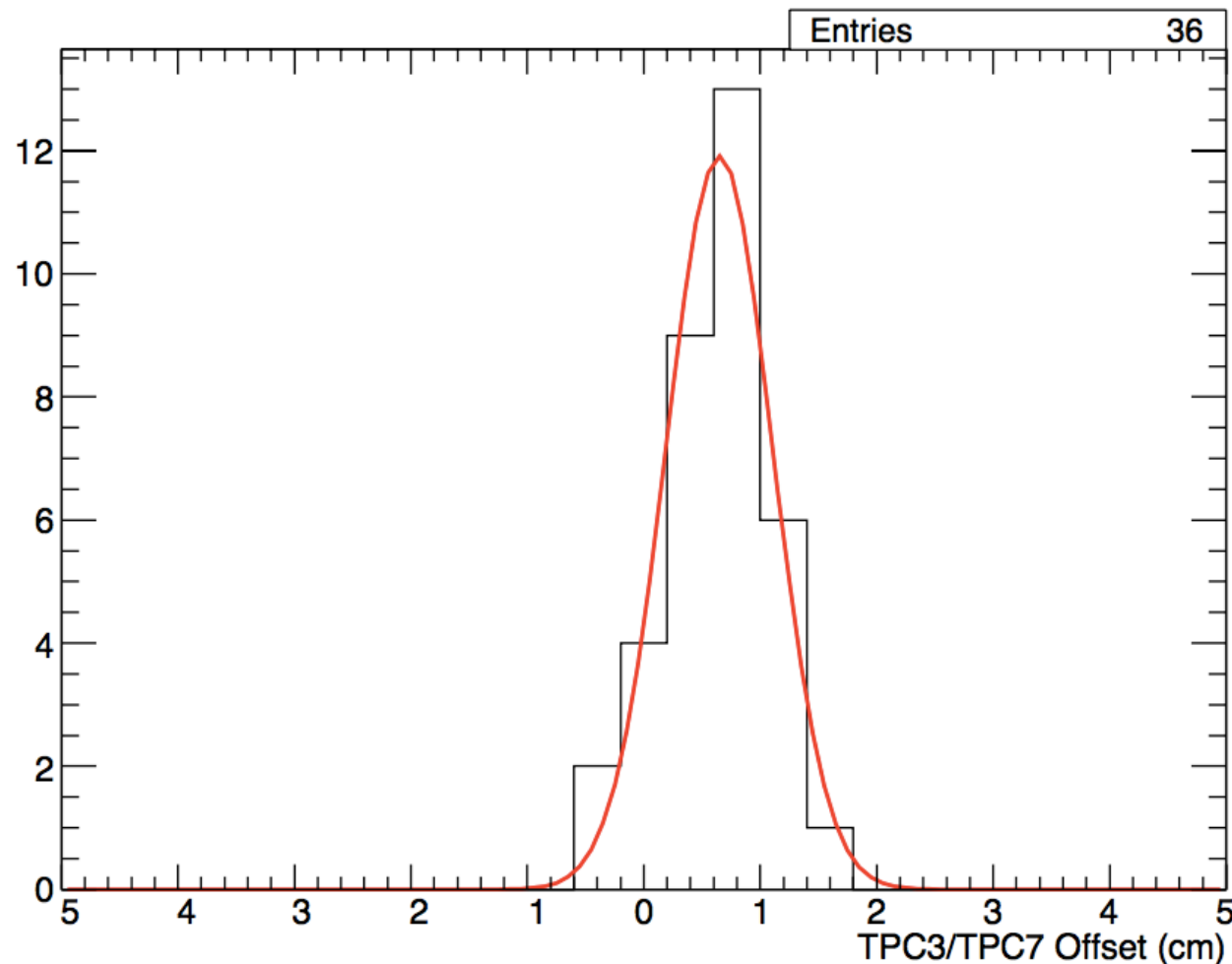
TPC1/TPC5 Offsets



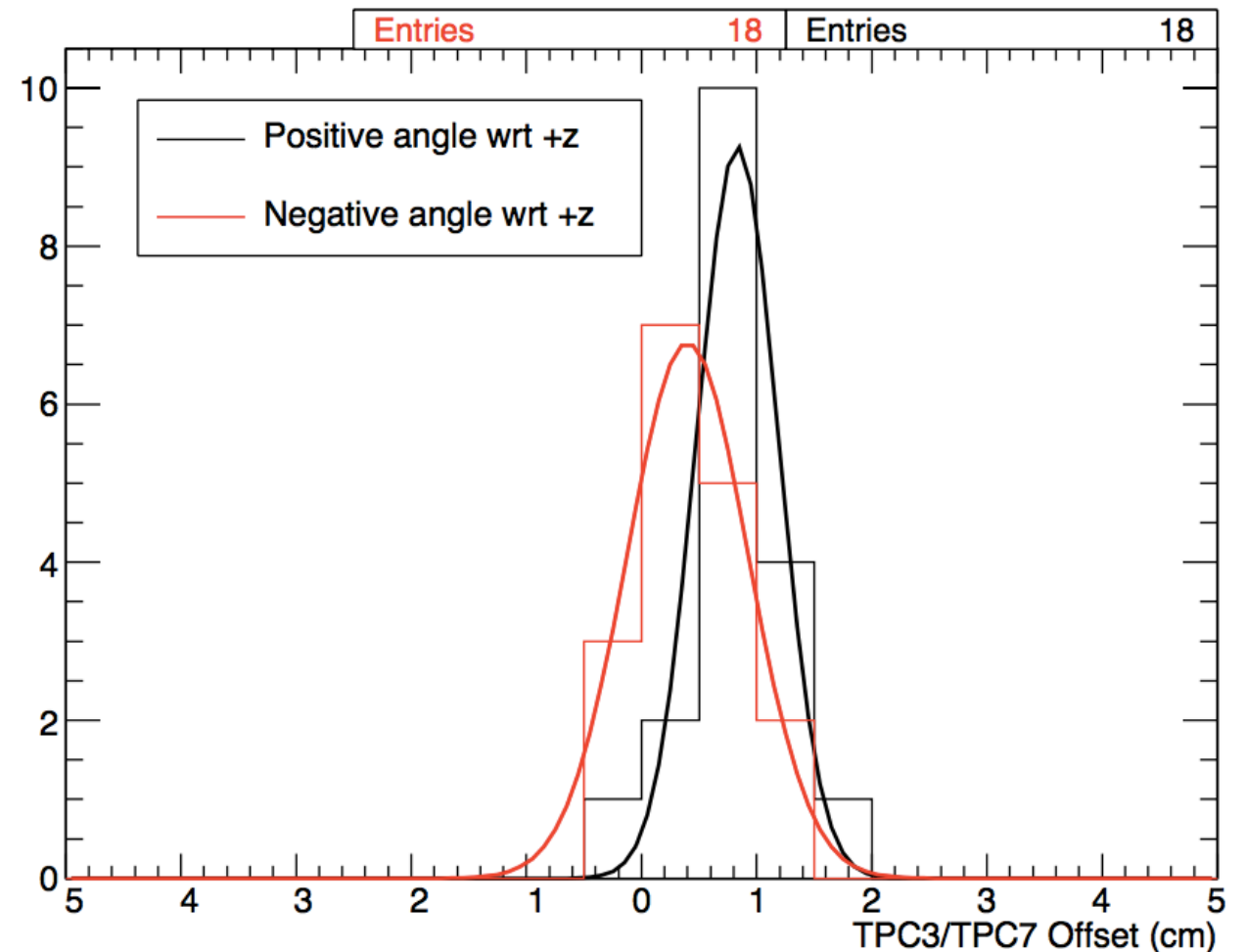
- Measure z -offset = 0.1 cm (c.f 0.2 cm previously...).
- Nice single peak though, no ambiguities!

TPC3/TPC7 Offsets

- VERY low stats. Consistent with z -offset of 0.6 cm.



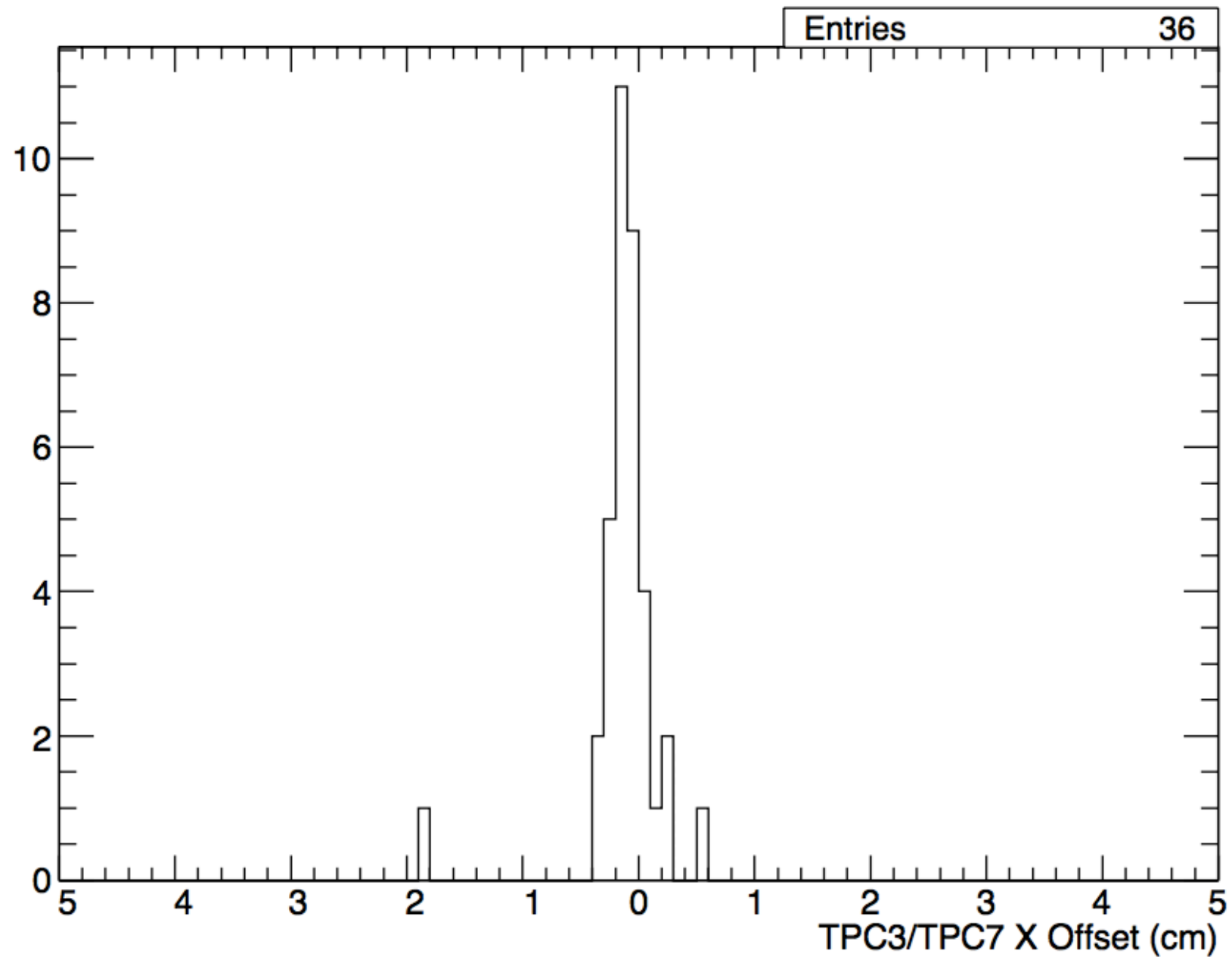
Gaussian mean: 0.6 cm



Gaussian means: 0.4 and 0.8 cm

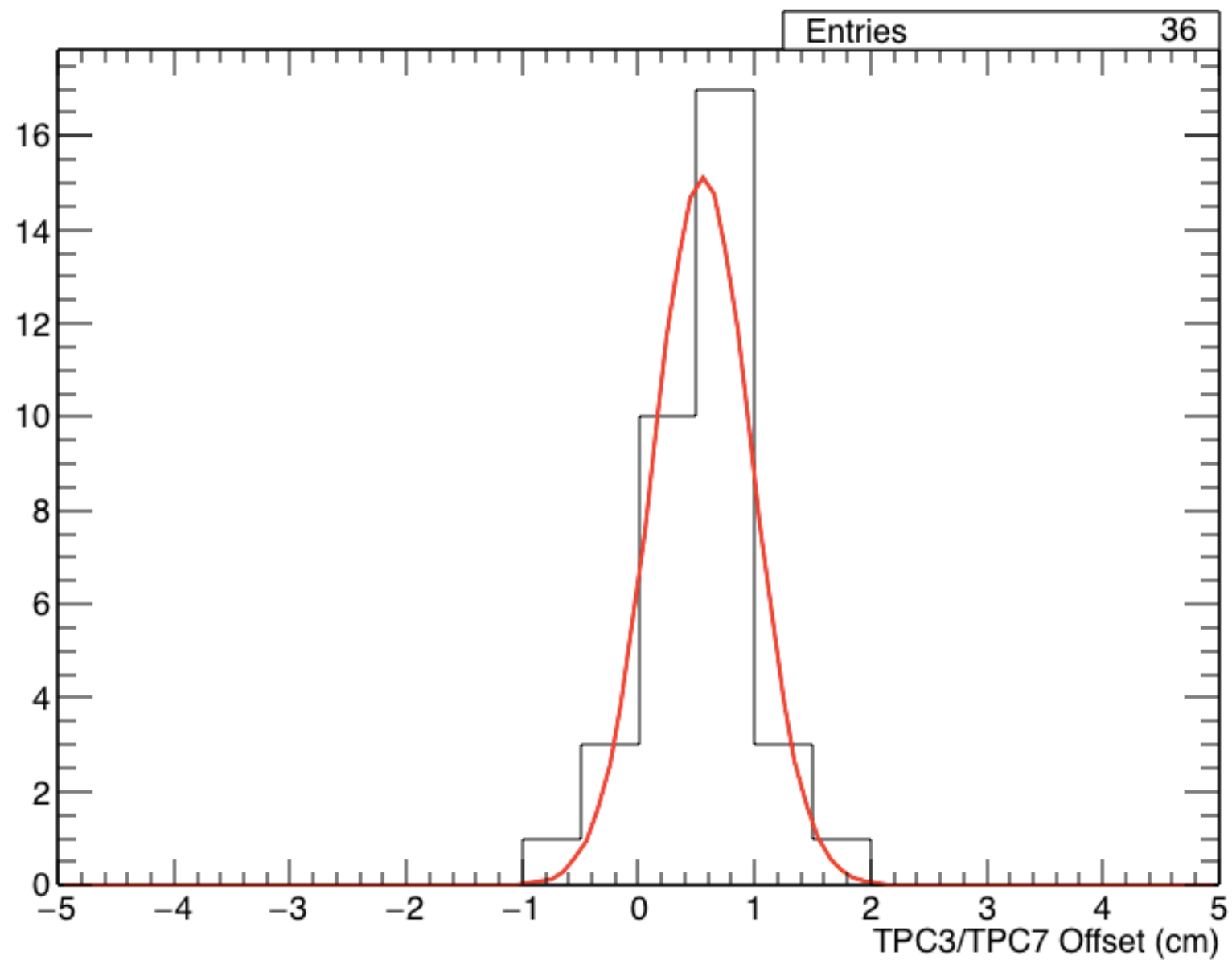
- Can't really fit a parabola in this case! But the separation in the distributions implies a (probably small) x -offset here too.

TPC3/TPC7 Offsets



- x -offset = -0.1 cm.

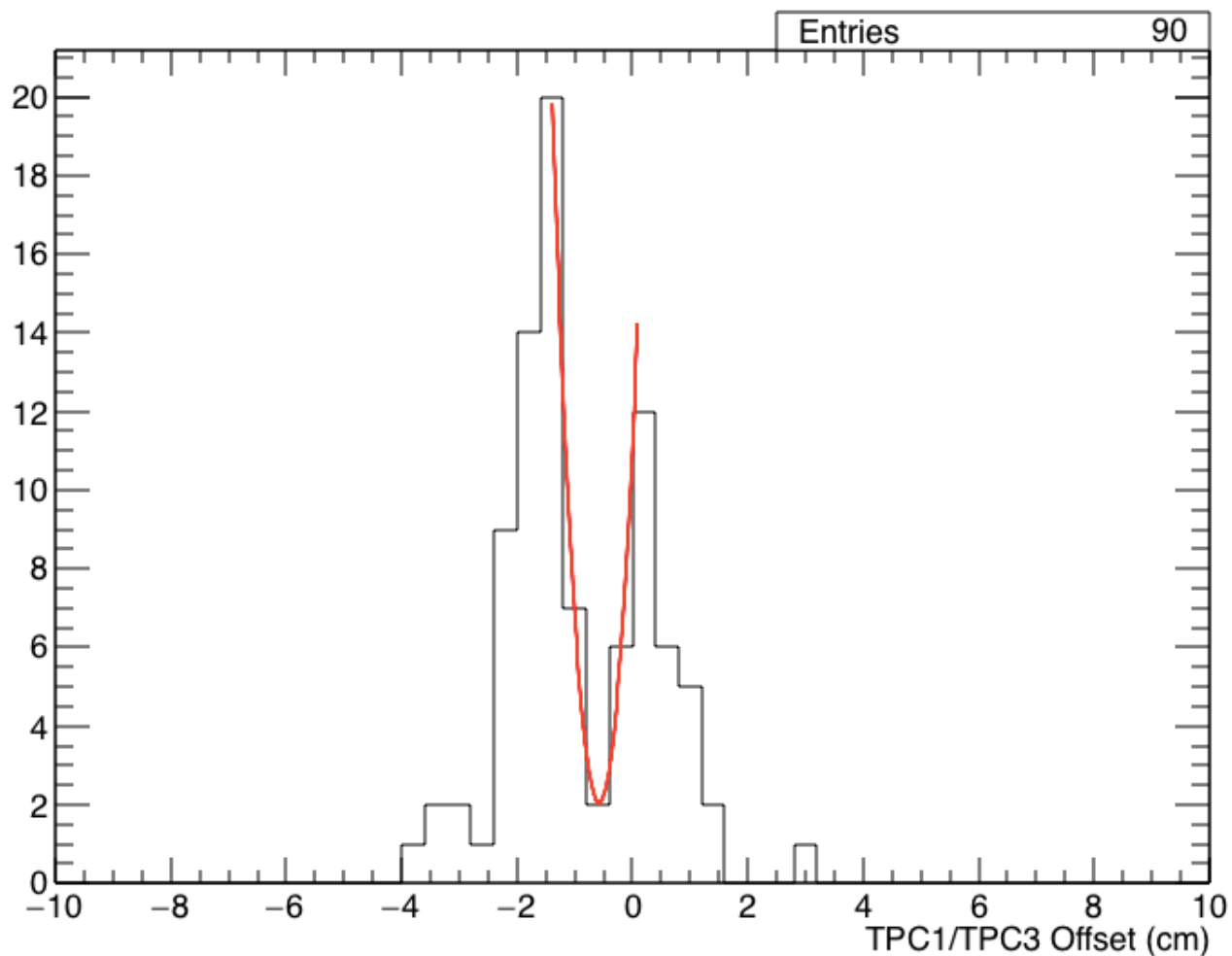
TPC3/TPC7 Offsets



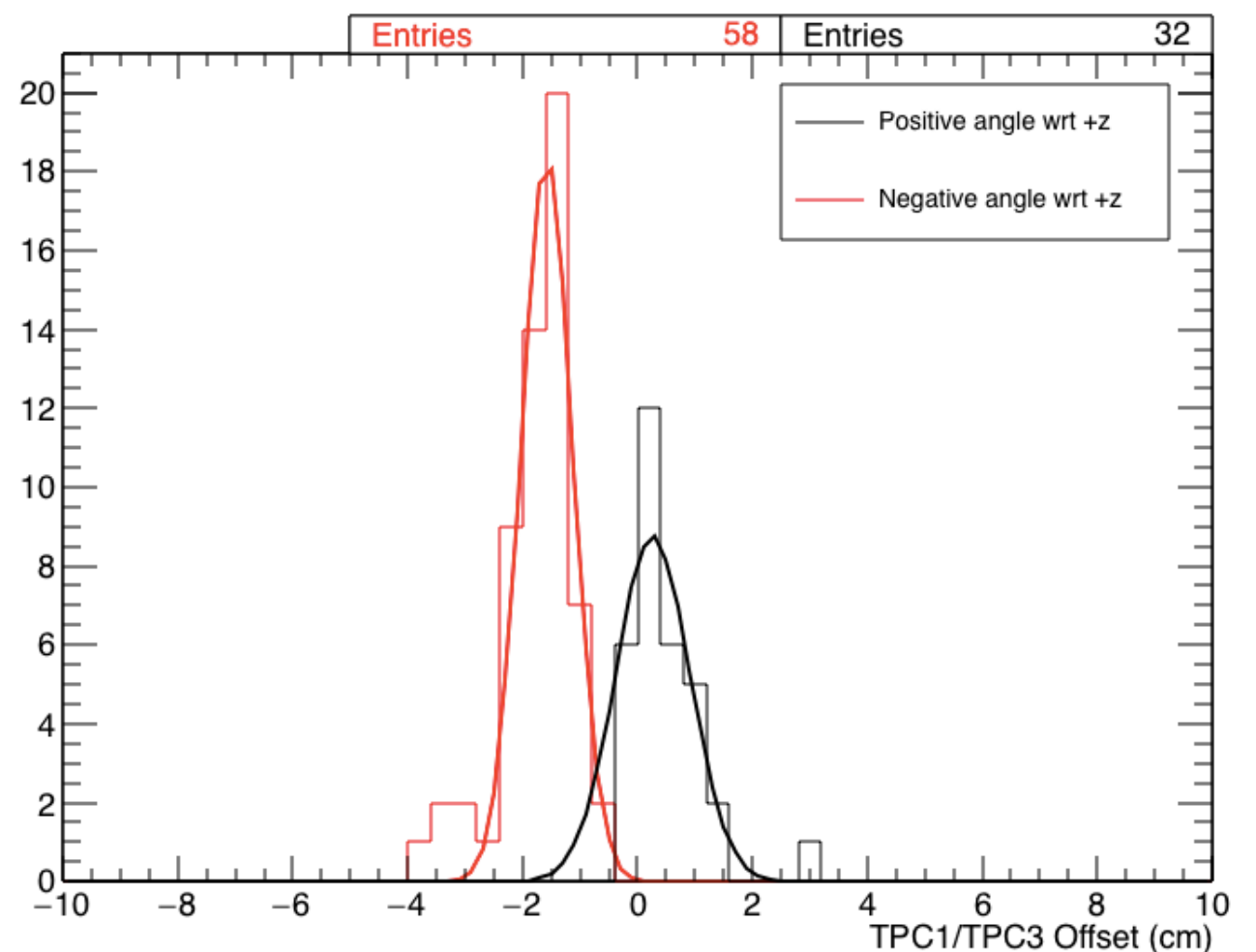
- Get z -offset = 0.6 cm again!

TPC1/TPC3 Offsets

- Low stats — difficult to make a measurement here. Another obvious x -offset.
- z -offset = -0.6 cm.

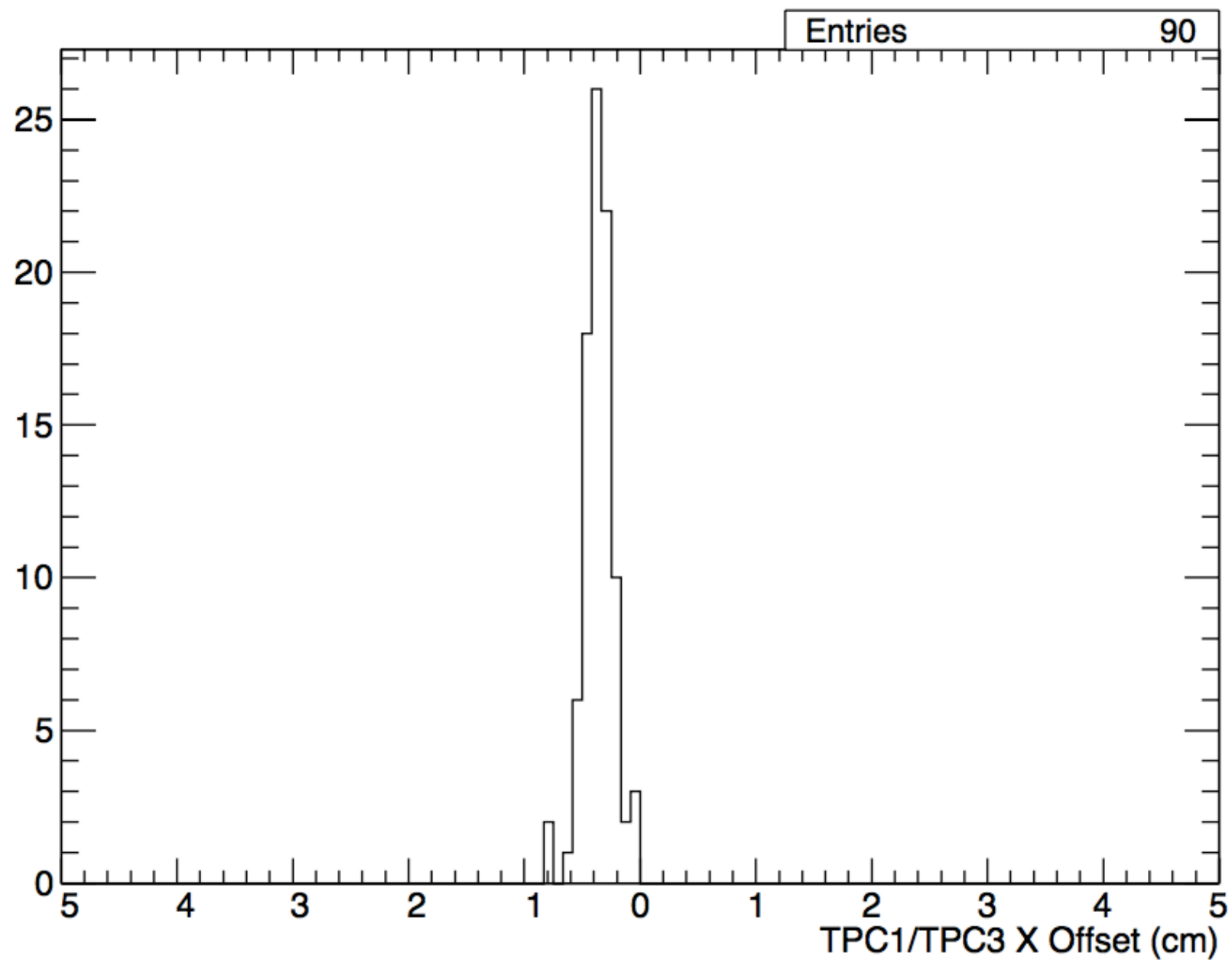


Dip of parabola: -0.58 cm



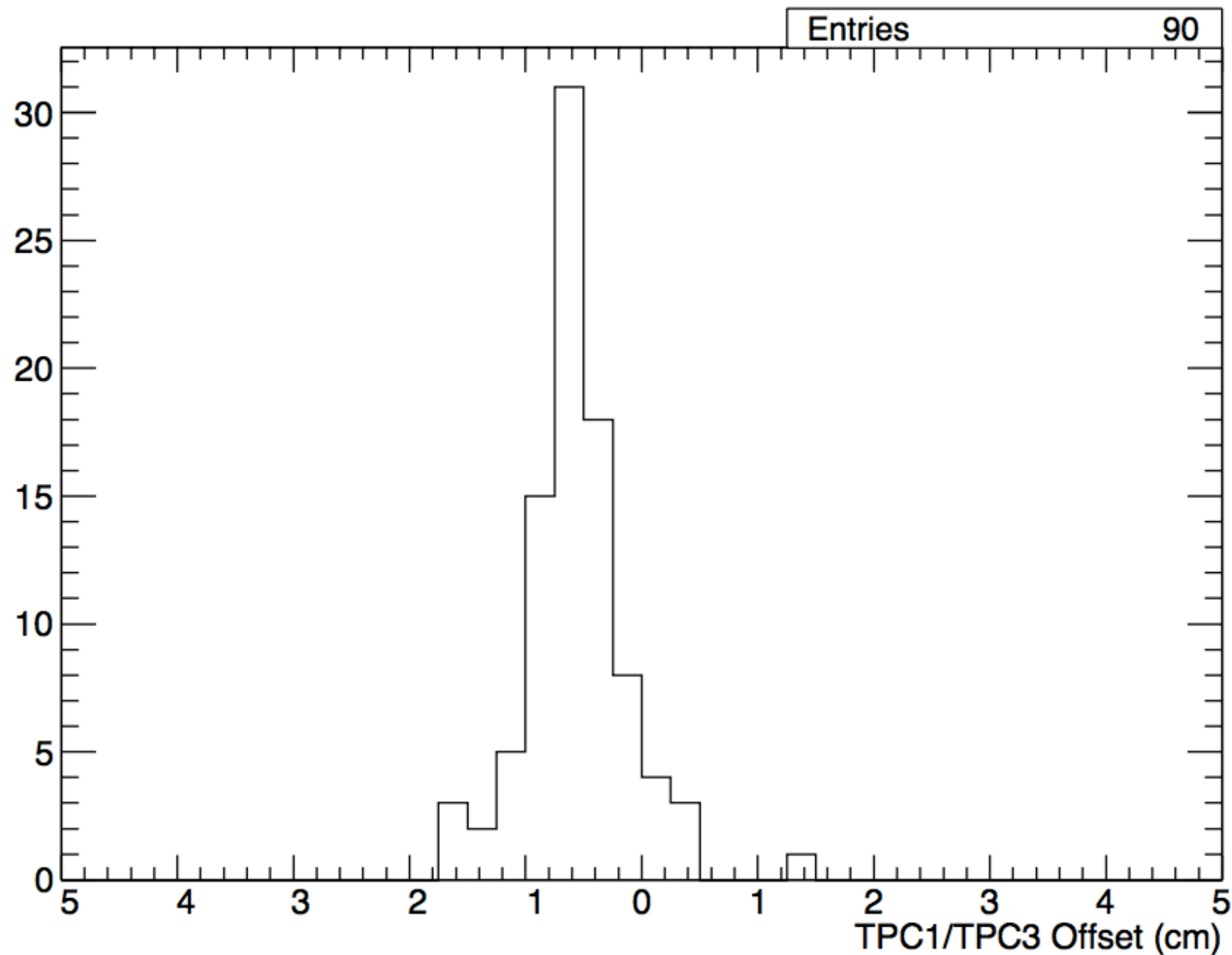
Gaussian peaks: 0.26 cm and -1.58 cm
(Average -0.66 cm)

TPC1/TPC3 Offsets



- x -offset = -0.35 cm.

TPC1/TPC3 Offsets



- Single peak — and measure -0.6 cm again!

LDV TPC Offsets Summary

	TPC1/TPC3	TPC1/TPC5	TPC3/TPC7	TPC5/TPC7
z-offset (double peak)	-0.58 cm	0.18 cm	0.60 cm	0.09 cm
x-offset	-0.36 cm	-0.25 cm	-0.12 cm	-0.30 cm
z-offset (single peak)	-0.57 cm	0.09 cm	0.55 cm	0.06 cm

- z -offsets seem consistent with the short APA shifted in the $-z$ direction (by ~ 6 mm).
- There is also consistency in the x -offset measurements:
 - **TPC1- \rightarrow 3- \rightarrow 7**: -3.6 mm - 1.2 mm = -4.8 mm; **TPC1- \rightarrow 5- \rightarrow 7**: -2.5 mm - 3.0 mm = -5.5 mm.
 - Agrees to within ~ 0.7 mm.

LDV TPC Offsets Summary

- Corrected gaps based on best estimate:

	Assumed	Correction	Corrected
TPC1/TPC3	2.53 cm	-0.6 cm	1.93 cm
TPC1/TPC5	2.08 cm	0.1 cm	2.18 cm
TPC3/TPC7	1.63 cm	0.6 cm	2.23 cm
TPC5/TPC7	2.08 cm	0.1 cm	2.18 cm
Implied TPC1/(3)/TPC7	4.16 cm	0 cm	4.16 cm
Implied TPC1/(5)/TPC7	4.16 cm	0.2 cm	4.36 cm

- Implies the APAs are slanted by ~2 mm, more spaced out at the top than at the bottom?

A Thought on the x -offsets

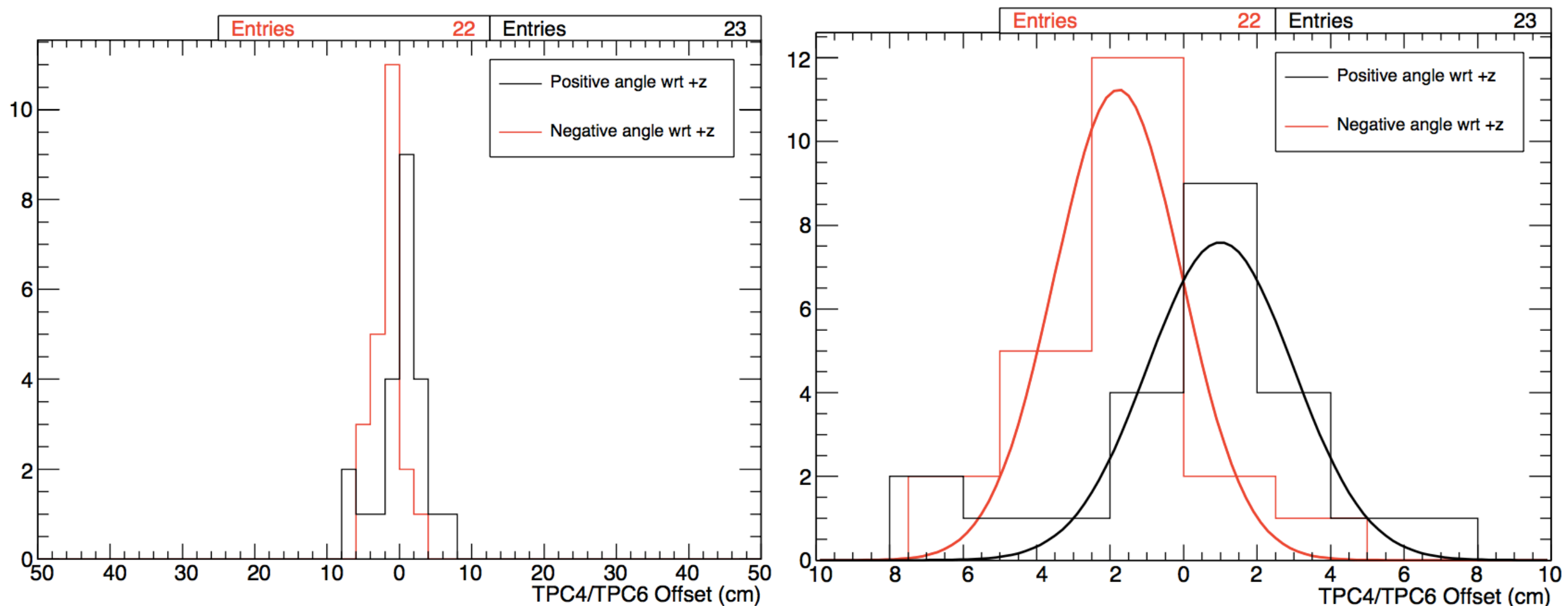
- It was discussed at the last meeting how these x -offsets may indeed just be a timing offset (and in fact, how the distinction isn't hugely important).
- The difference, as far as I can see, is how believable it is!
 - We can always expect small (and not so small, ~ 6 us) timing offsets, but a 2 mm offset in the placing of an APA seems like it would have been noticed.
- My issue with this being a timing offset is that this appears to be pretty consistent across a whole APA, and these are read out by multiple (four) FE boards and then processed by multiple (four) RCEs [only two in each drift regions, so I conceded just two in these cases].
 - As far as I know the FE boards and RCEs aren't treated any differently depending on the APA they're reading out.
 - There is however a very obvious correlation between the physical position of an APA and its x -coordinate.
- It seems much more likely to be an actual x -offset (as opposed to timing offset) to me — what does everyone else think?

Short Drift Volume

- Attempted to make some measurements here.
- Very challenging — in general, so so few events to play with.
- I found relaxing the cuts biased the measurements (looks like it's not all sampled from the same distribution) — so had to deal with low stats.

TPC4/TPC6 Offsets

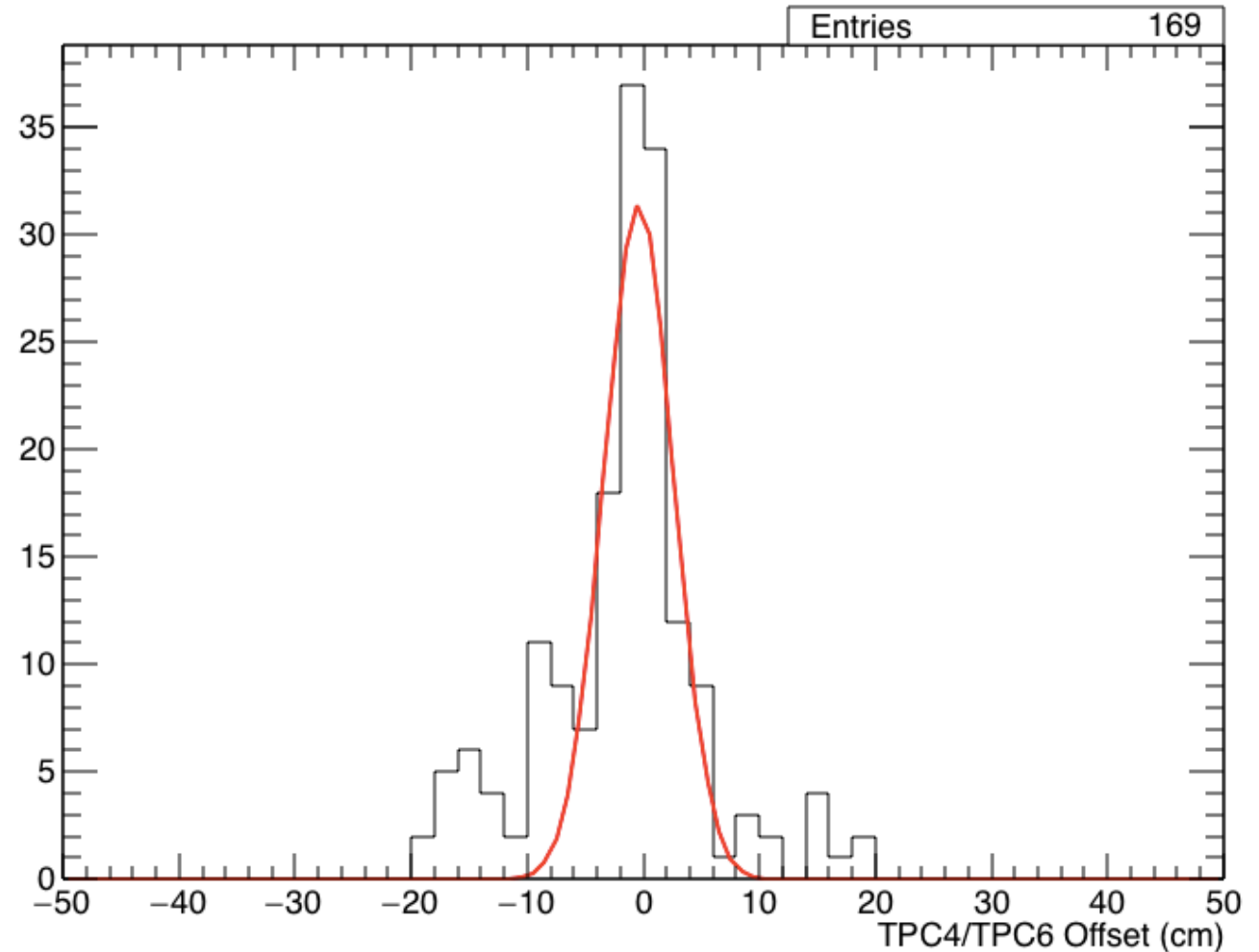
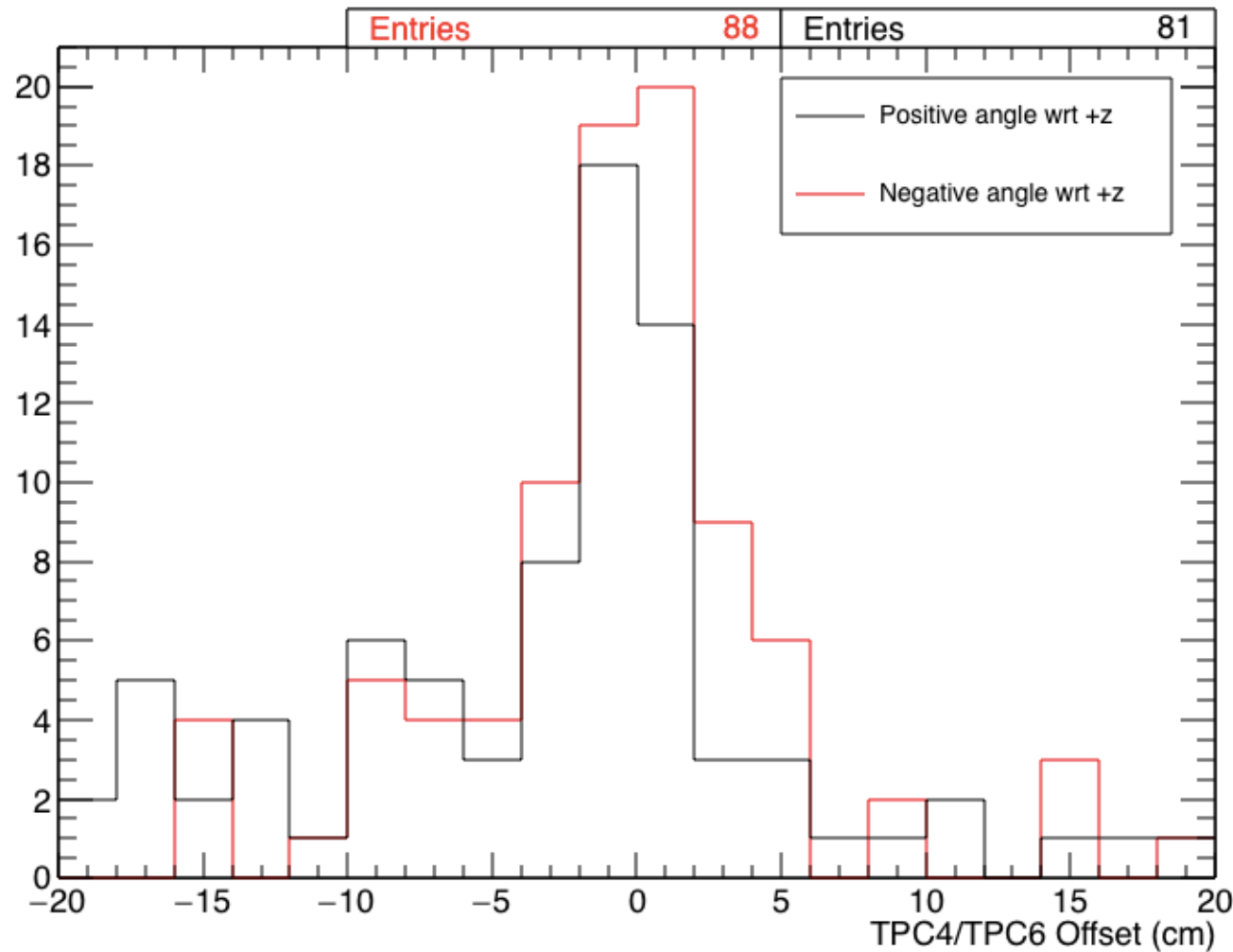
- The 'golden gap' (TPC5/TPC7 equivalent). Still, there are *so few* events!
- Without any x -offset correction:



Gaussian means: -1.78 cm and 1.00 cm — average -0.39 cm

TPC4/TPC6 Offsets

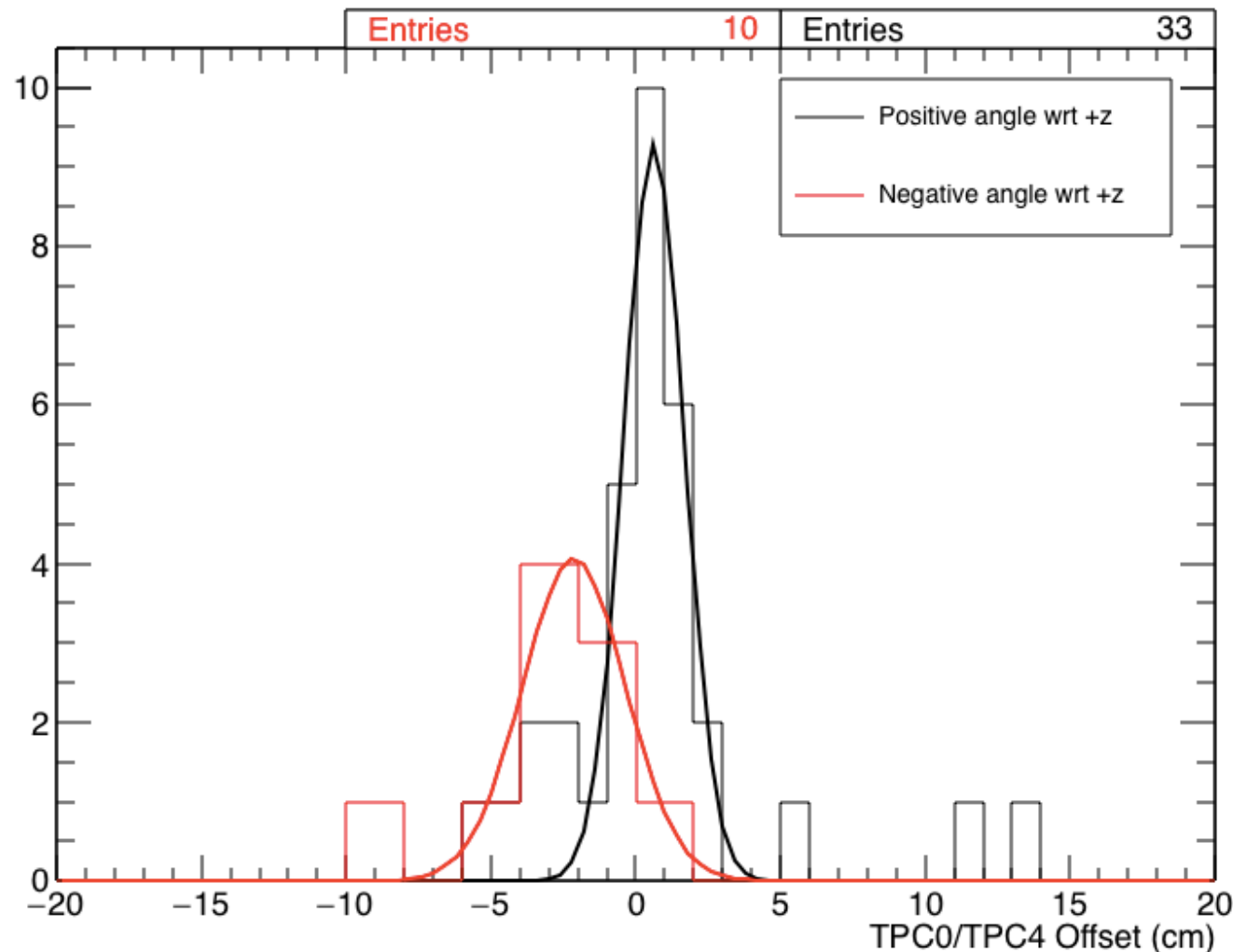
- Applying the x -offset found between TPCs 5 & 7 in the LDV (APAs 2&3):



- Appears to correct for bias in track angle.
- Measure -0.40 cm again!

TPC0/TPC4 Offsets

- Before correcting for any x -offsets:

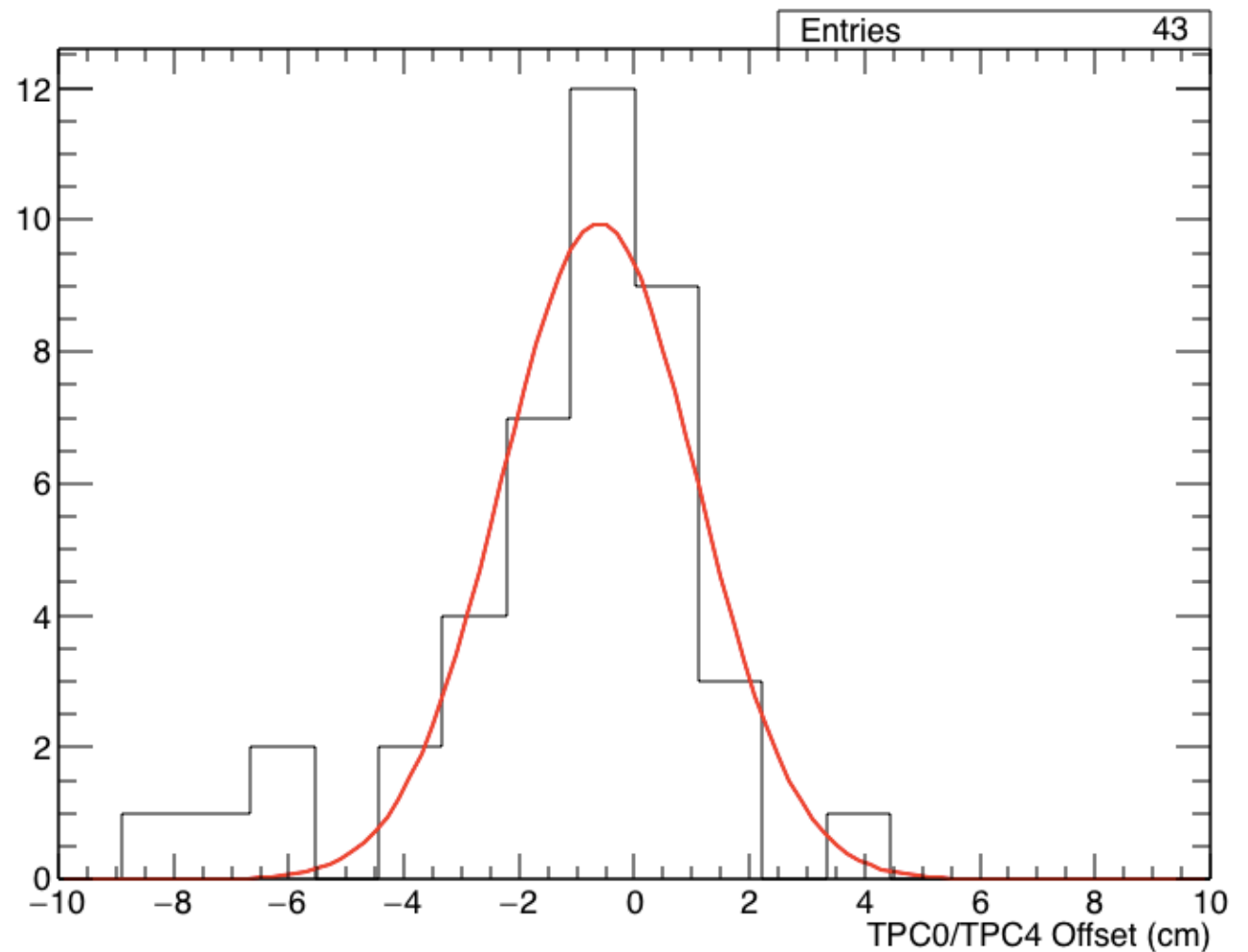
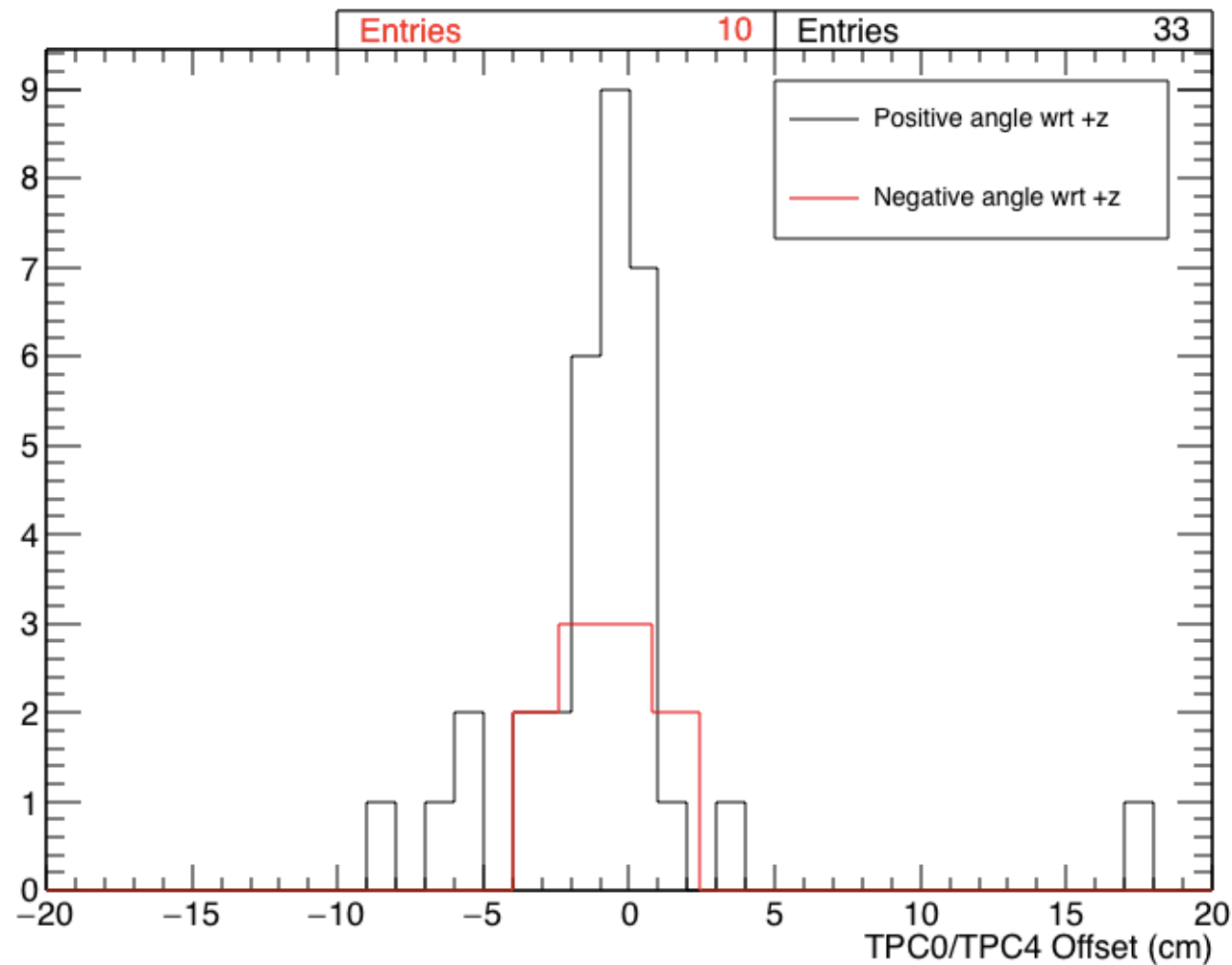


Gaussian means: -2.13 cm and 0.62 cm — average -0.75 cm

- Stats are *SO* low! Just 10 negative-z tracks pass the cuts!

TPC0/TPC4 Offsets

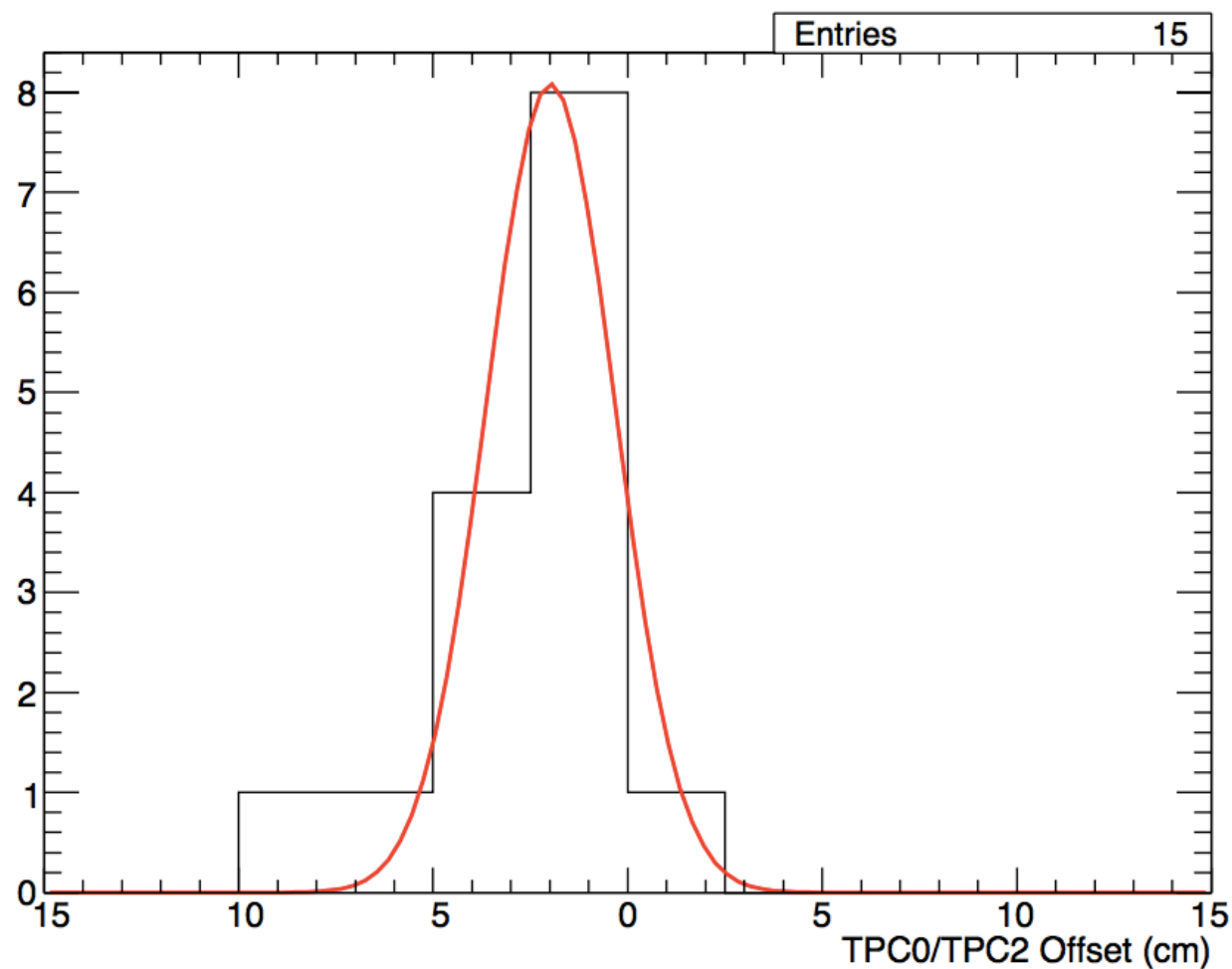
- After applying the same offset found for TPC1/TPC5 (APAs 0&2):



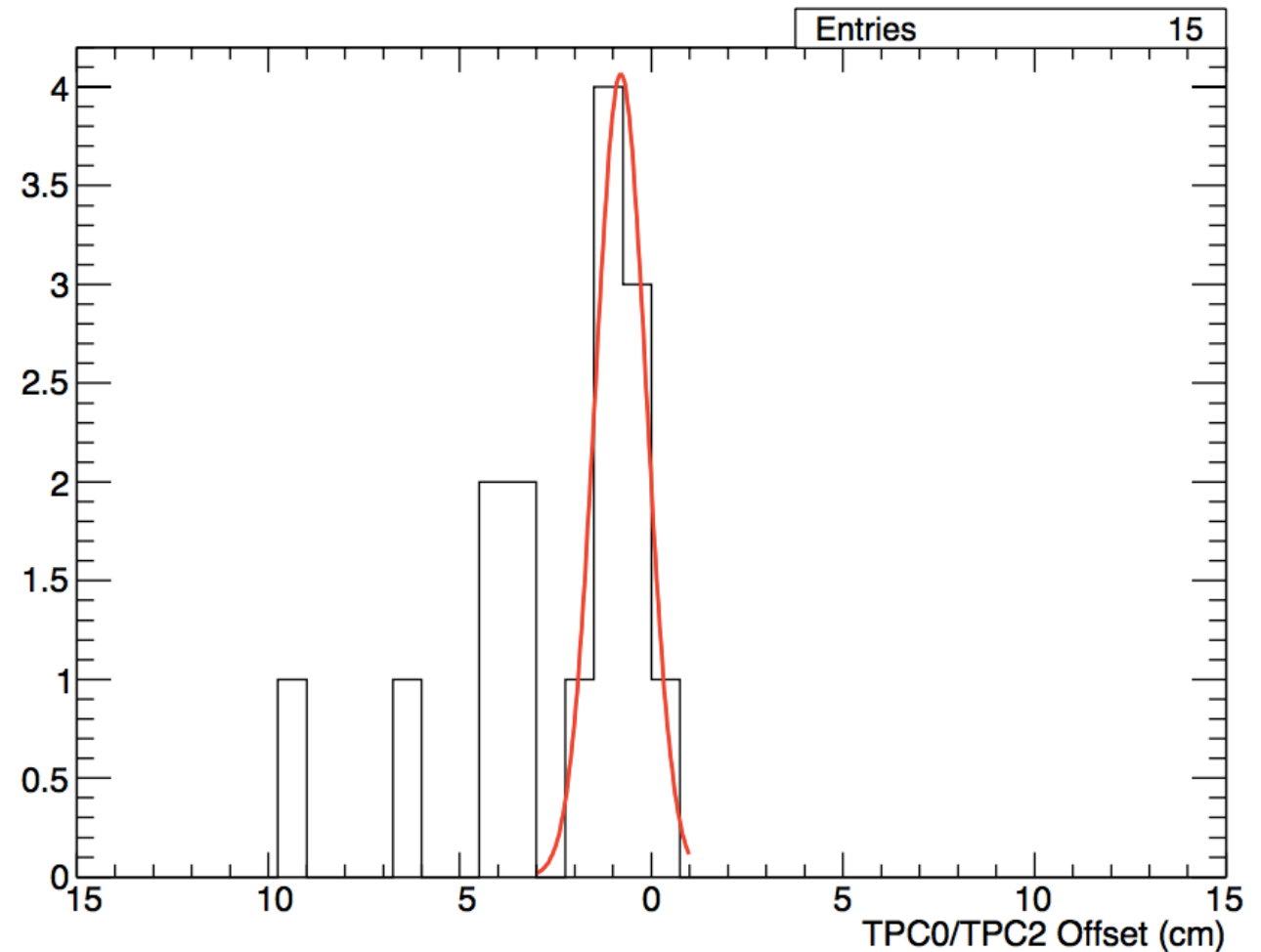
- No separation wrt track angle now.
- Measure z -offset = -0.6 cm from the fit.

TPC0/TPC2 Offsets

- No point looking into this too much! Only 2 tracks with negative angle pass the cuts...



z -offset = -2.0 cm. I think we can ignore this...

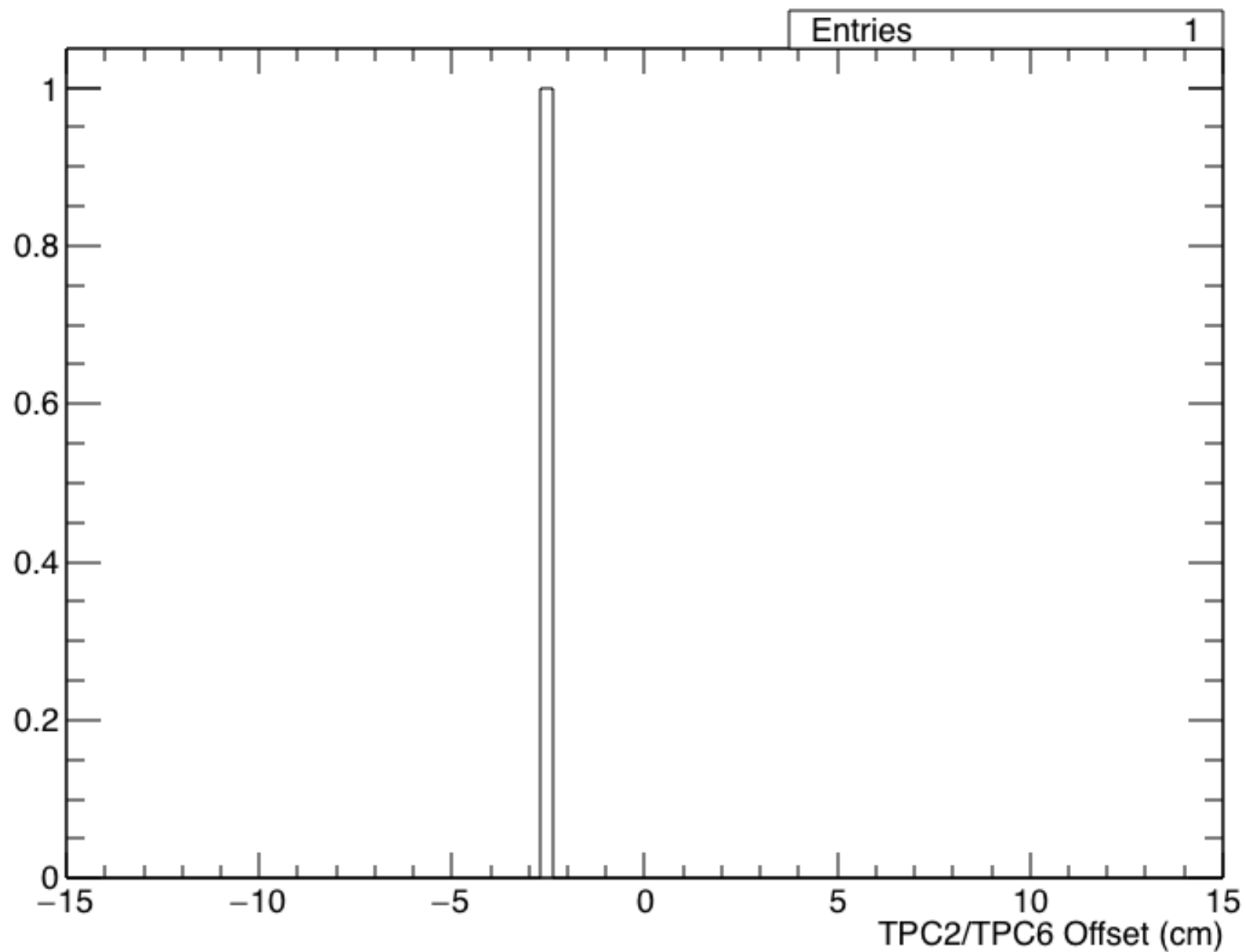


Just fitting between -3 and 1 gives the more likely value of -0.8 cm (no justification here though!)

- Stats are wayyy too low to make meaningful observations.

TPC2/TPC6 Offsets

- All the tracks which pass my cuts:



SDV TPC Offsets Summary

	LDV	SDV
APA0/APA1 (LDV: TPC1/TPC3, SDV: TPC0/TPC2)	-0.6 cm	-2.0 cm* -0.8 cm*
APA0/APA2 (LDV: TPC1/TPC5, SDV: TPC0/TPC4)	0.1 cm	0.6 cm
APA1/APA3 (LDV: TPC3/TPC7, SDV: TPC2/TPC6)	0.6 cm	-2.5 cm*
APA2/APA3 (LDV: TPC5/TPC7, SDV: TPC4/TPC6)	0.1 cm	-0.4 cm

~Confident

~Confident

APA2 SDV
collection
wires
shifted 1
in +z?

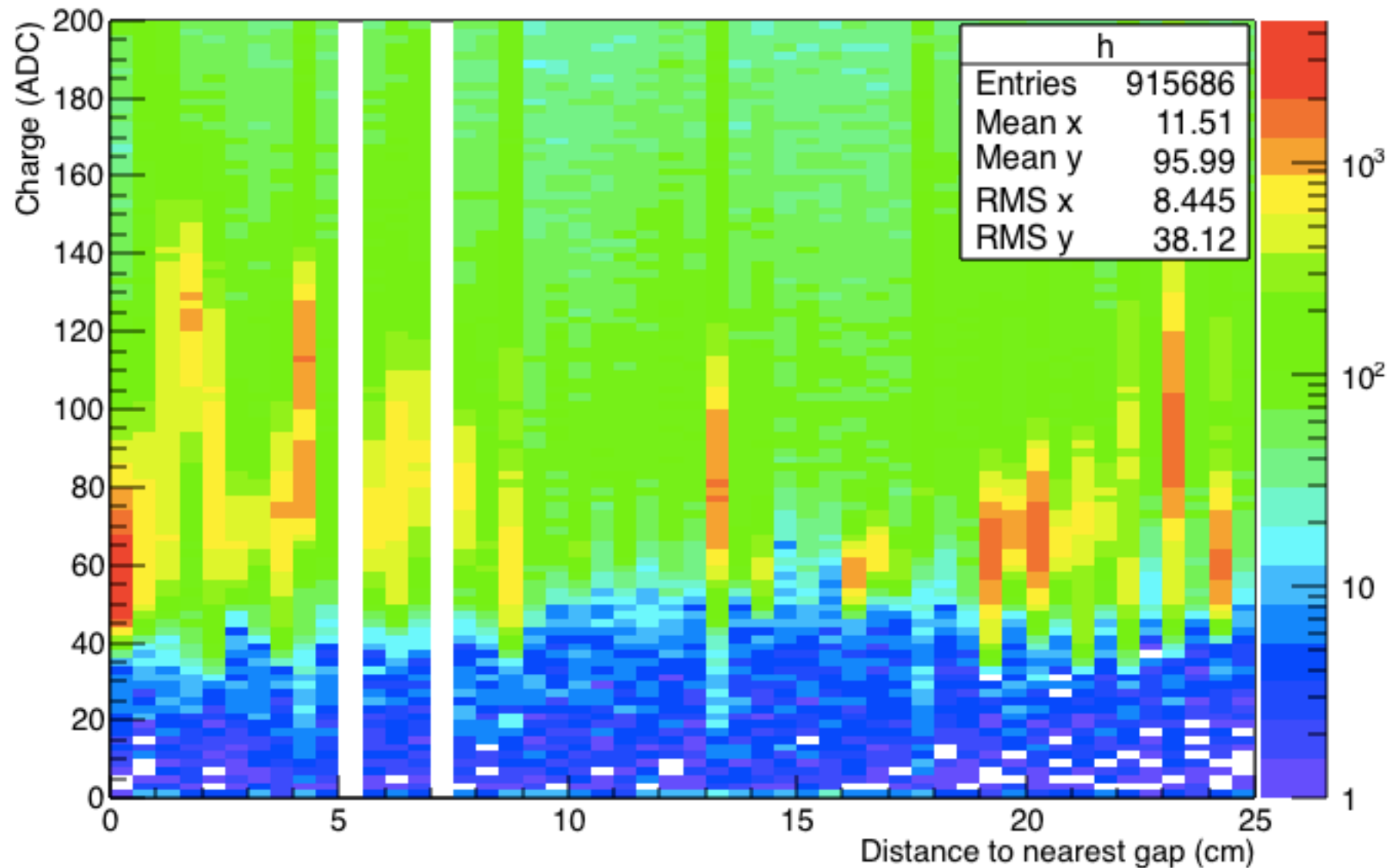
* not to be taken seriously!

Gap Summary

- Measured all gaps (within reason);
 - In general the SDV gaps have far too low stats to say anything of note...
- I'm very confident with my measurements of LDV x - and z - offsets.
- Any comments?!
- Do we want something along these lines in the paper? (I know Animesh has written something about the z -offsets.)

Charge Deposited — TPC1

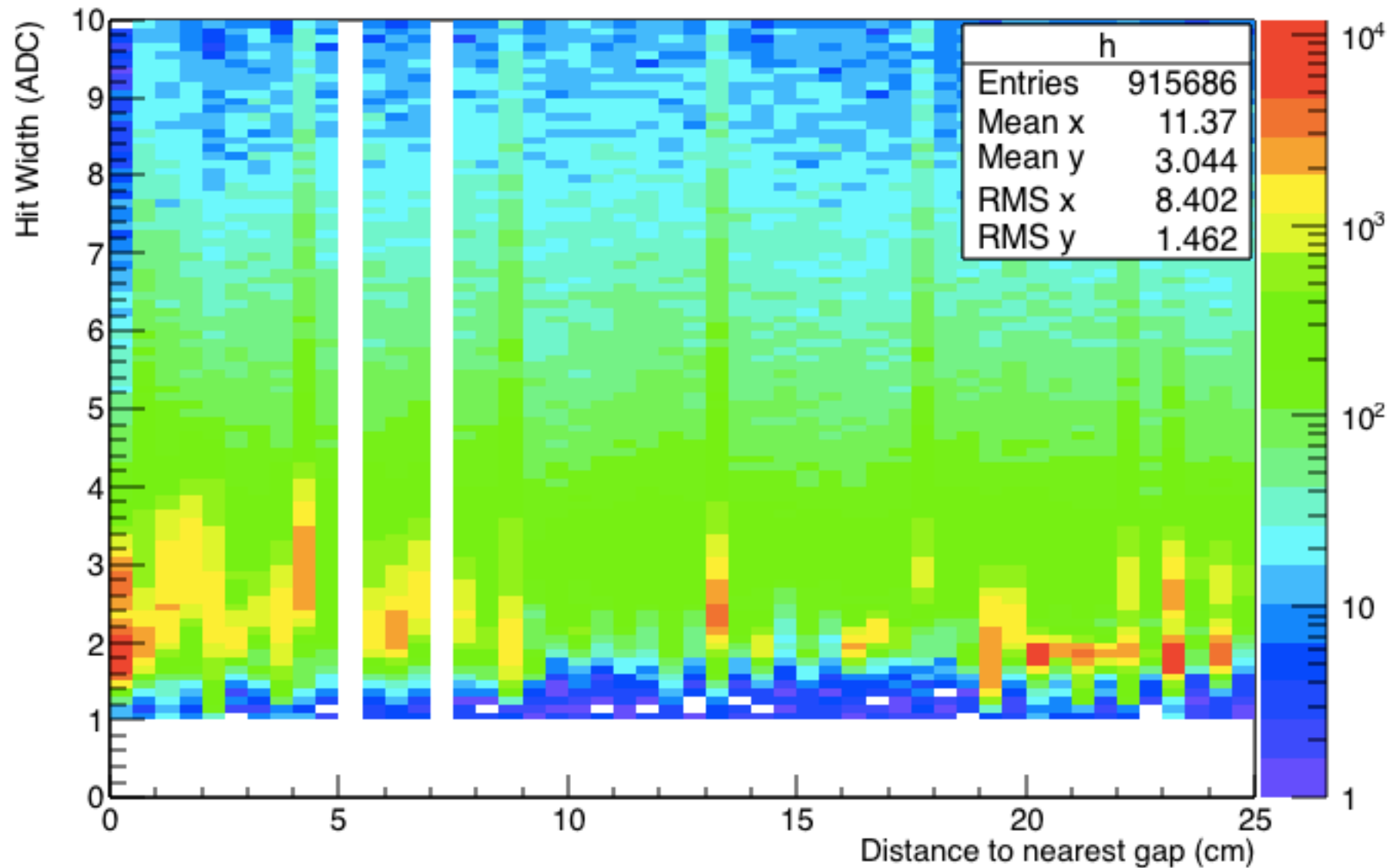
- Charge as a function of distance to nearest gap.



- There are many more hits < 0.5 cm from gap, slightly lower charge on average.

Charge Deposited — TPC1

- Hit widths as a function of distance to nearest gap.

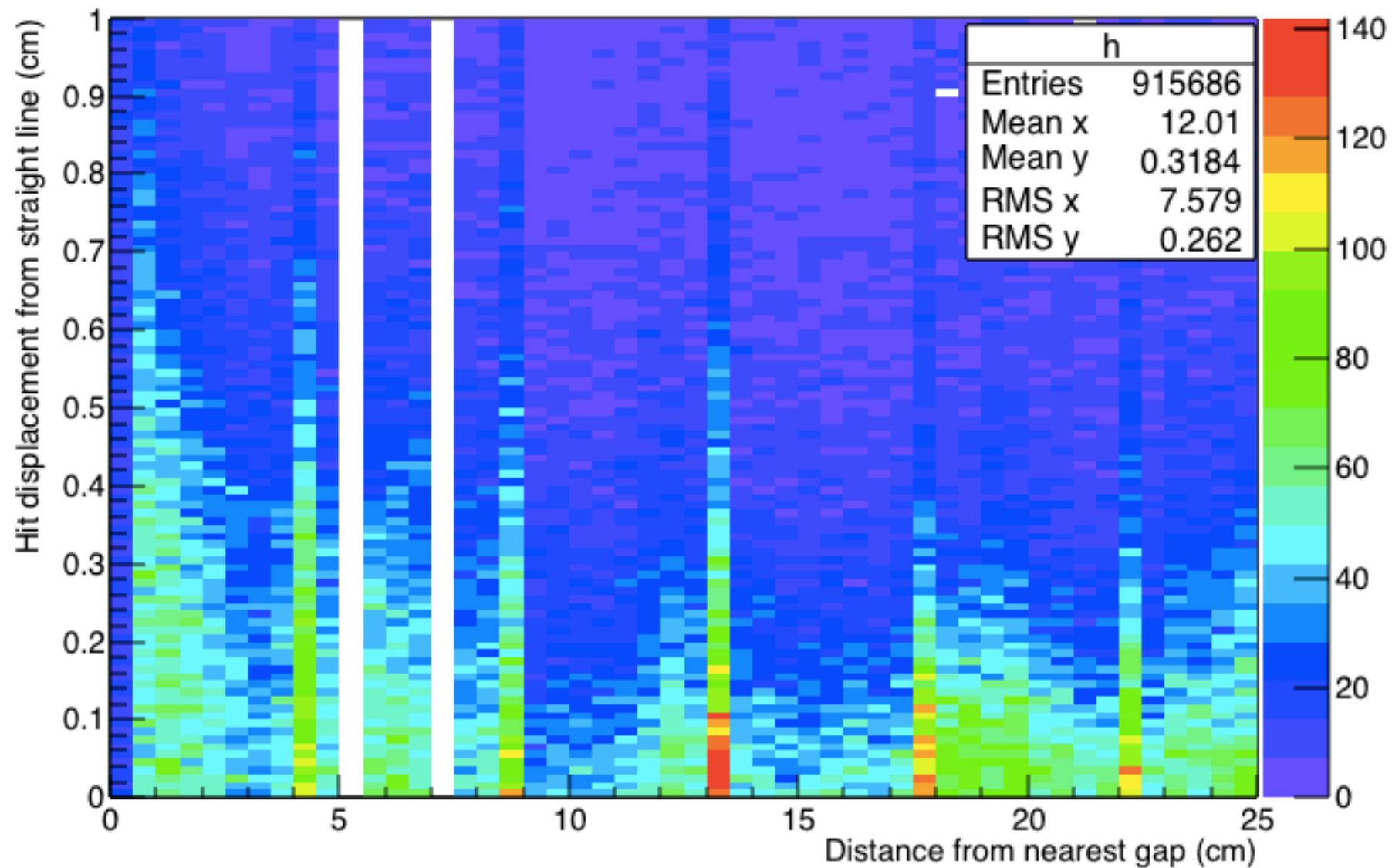


- Hits don't appear to be any wider...

Charge Deposited — TPC1

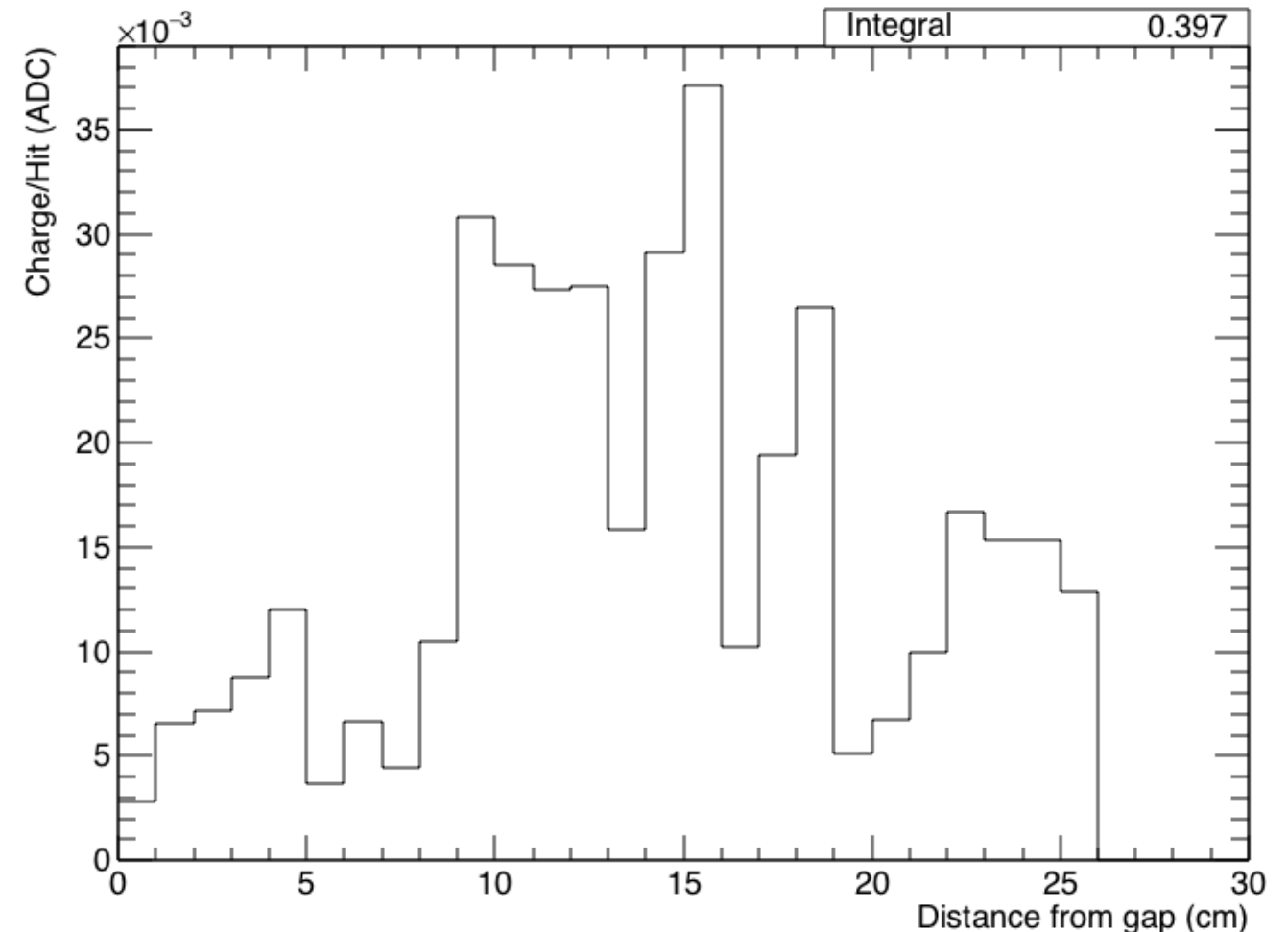
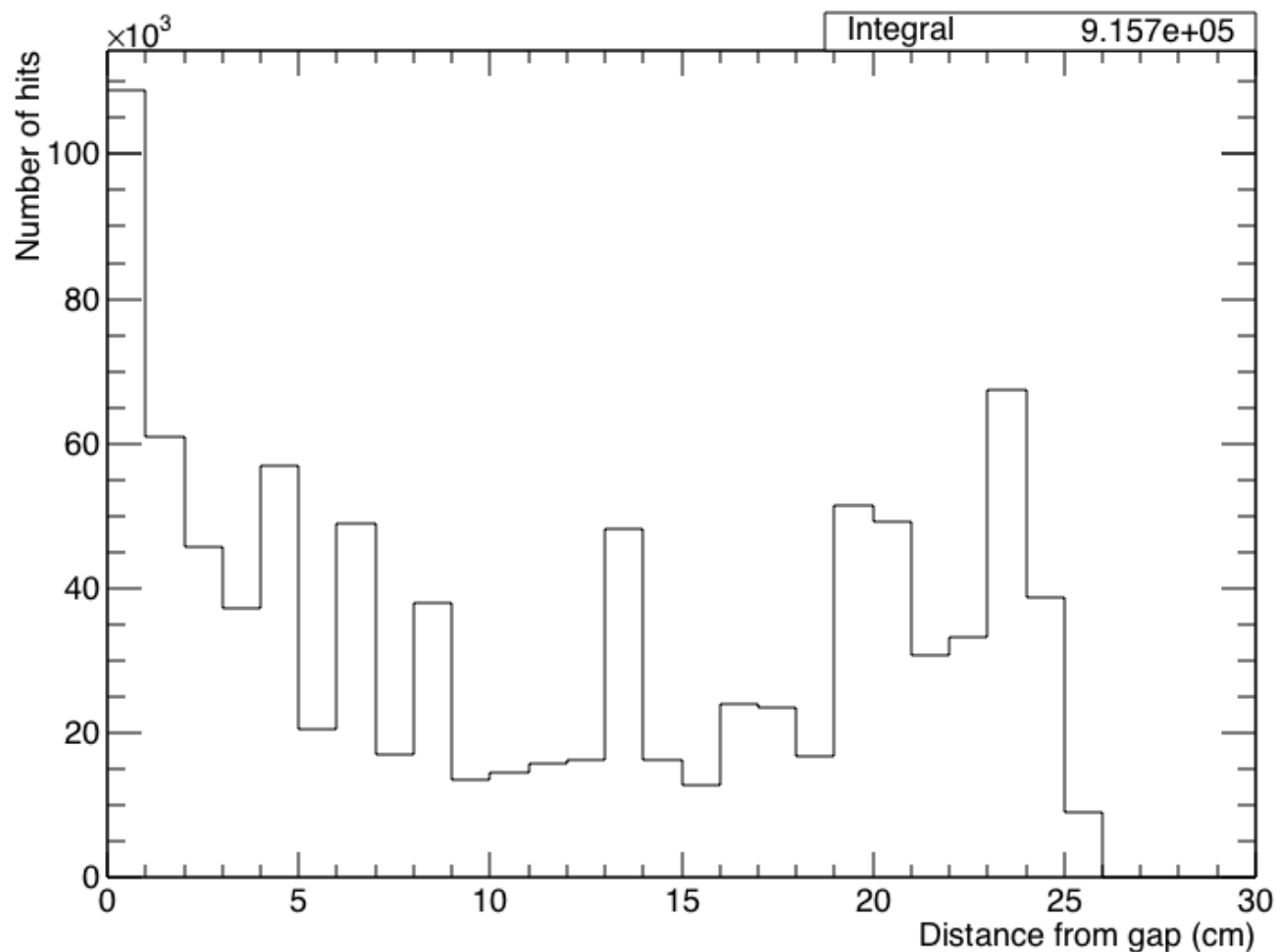
- Hit displacement from fitted straight line.

TPC1



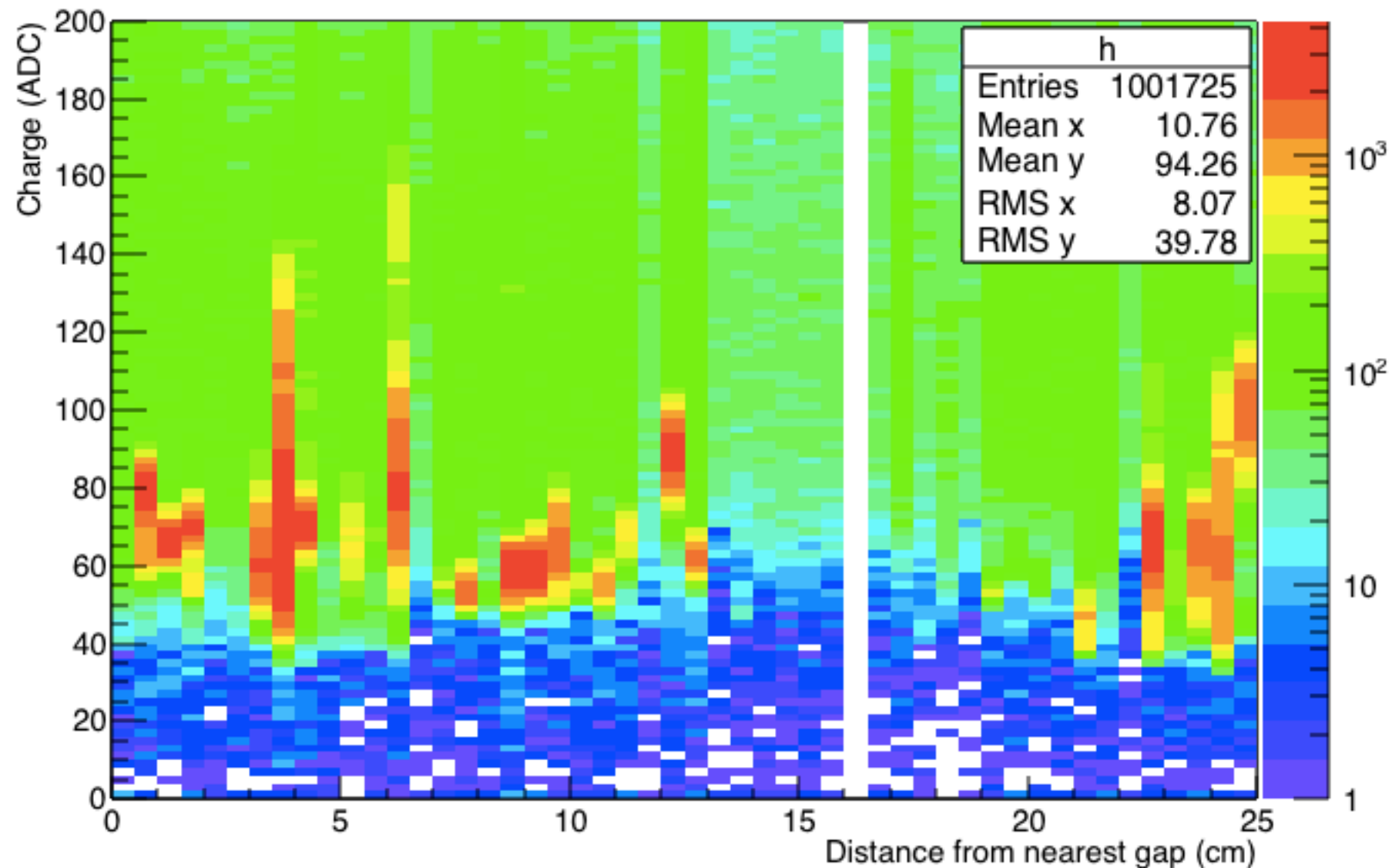
- In general, hits are further from the linear fit line the closer to the gap it is.

Number of Hits — TPC1



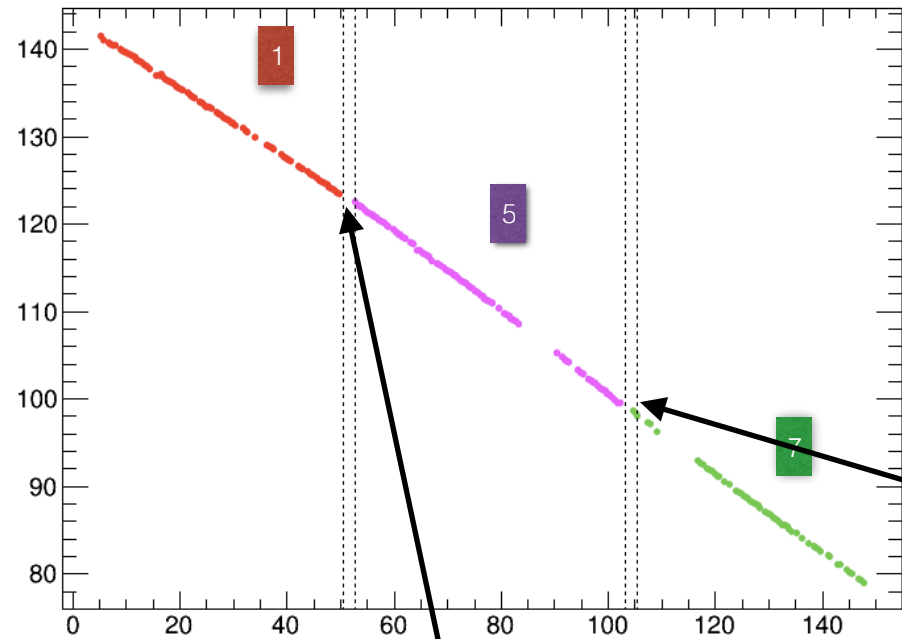
- As indicated previously, there are most hits closer to the gap but around the same charge seems to be collected...

Charge Deposited — TPC5

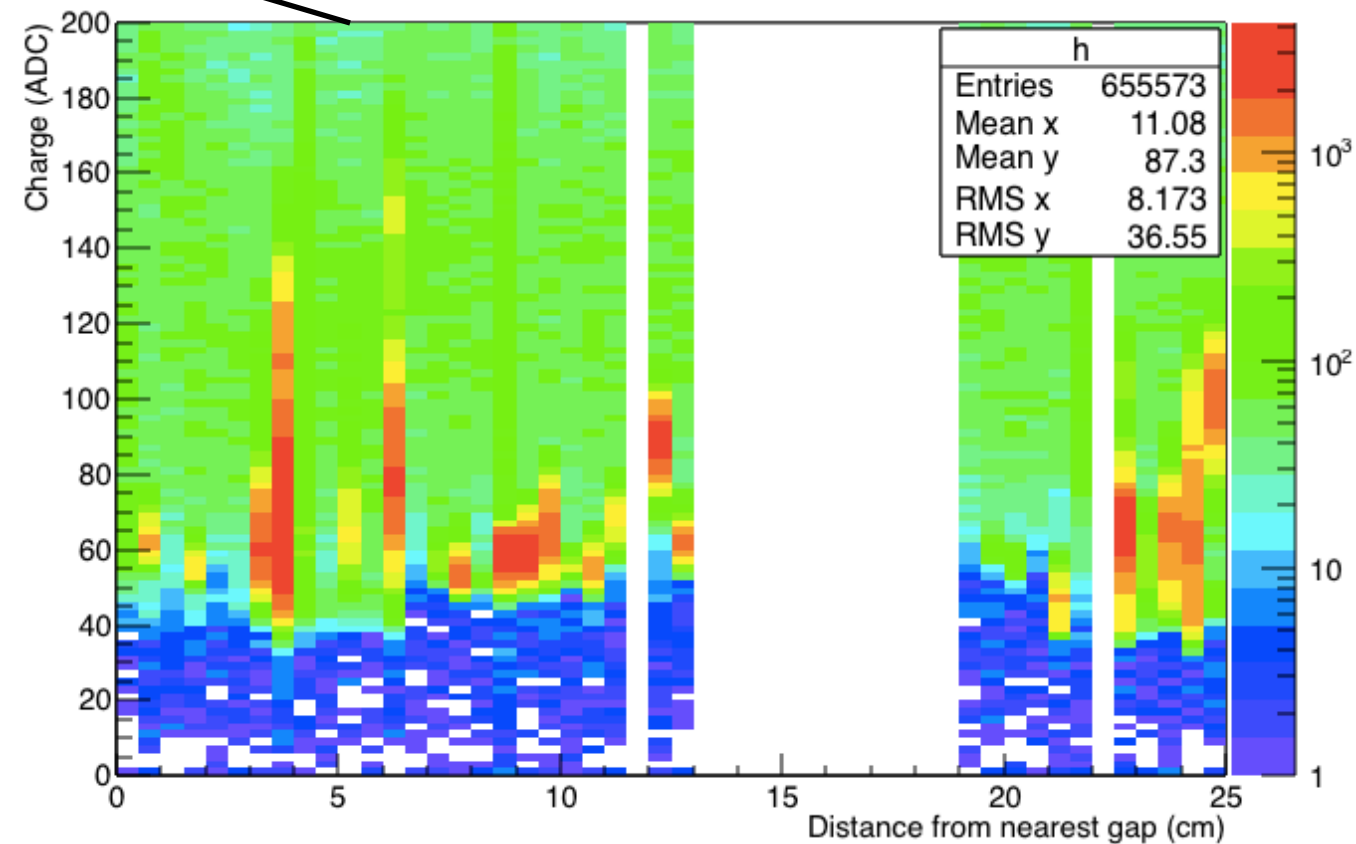
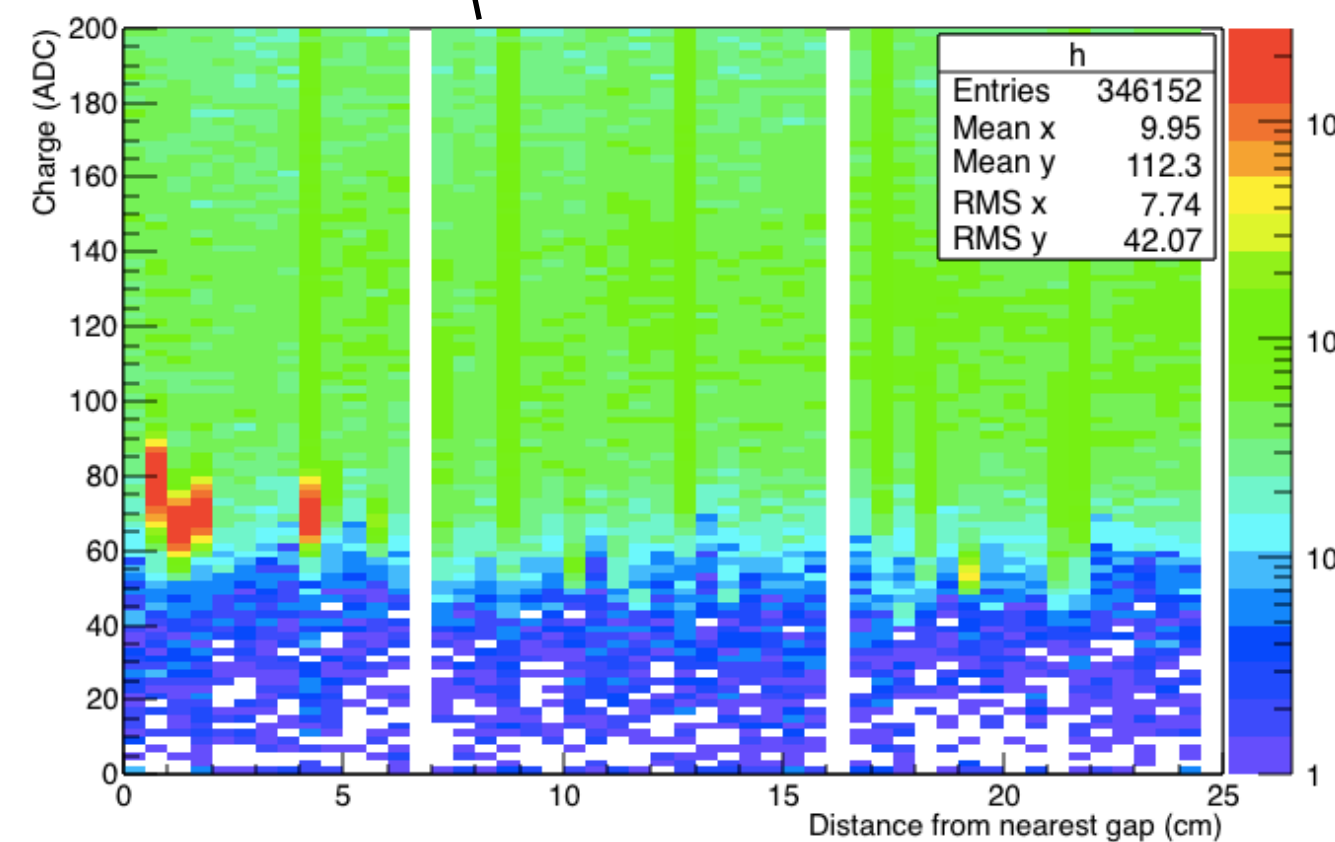


- Odd distribution — lots of peaks.
- Could be due to dead wires.

Charge Deposited — TPC5



- Example track from before — dead regions can be seen in TPCs 5 and 7.
- Look at the charge deposited nearest each gap in turn...

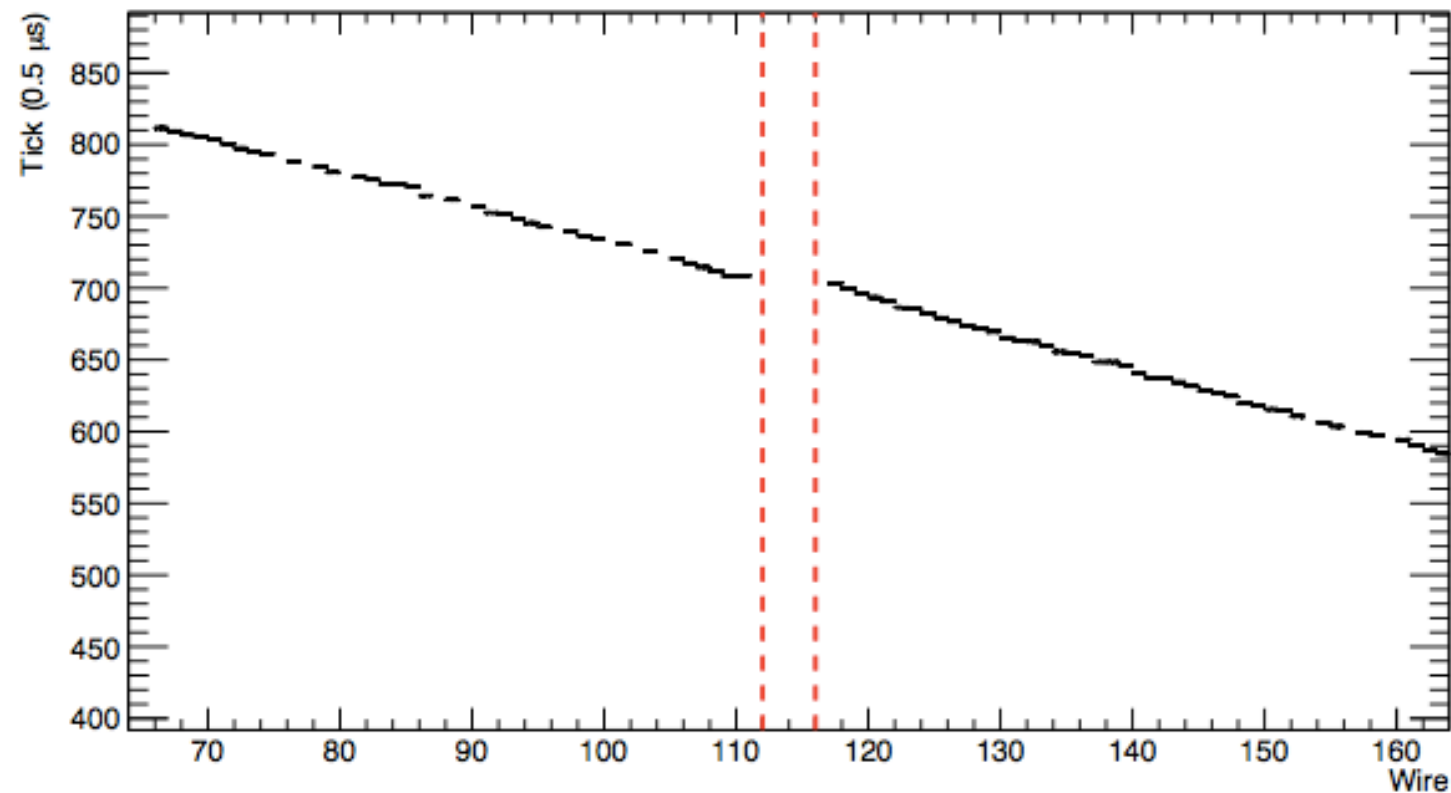
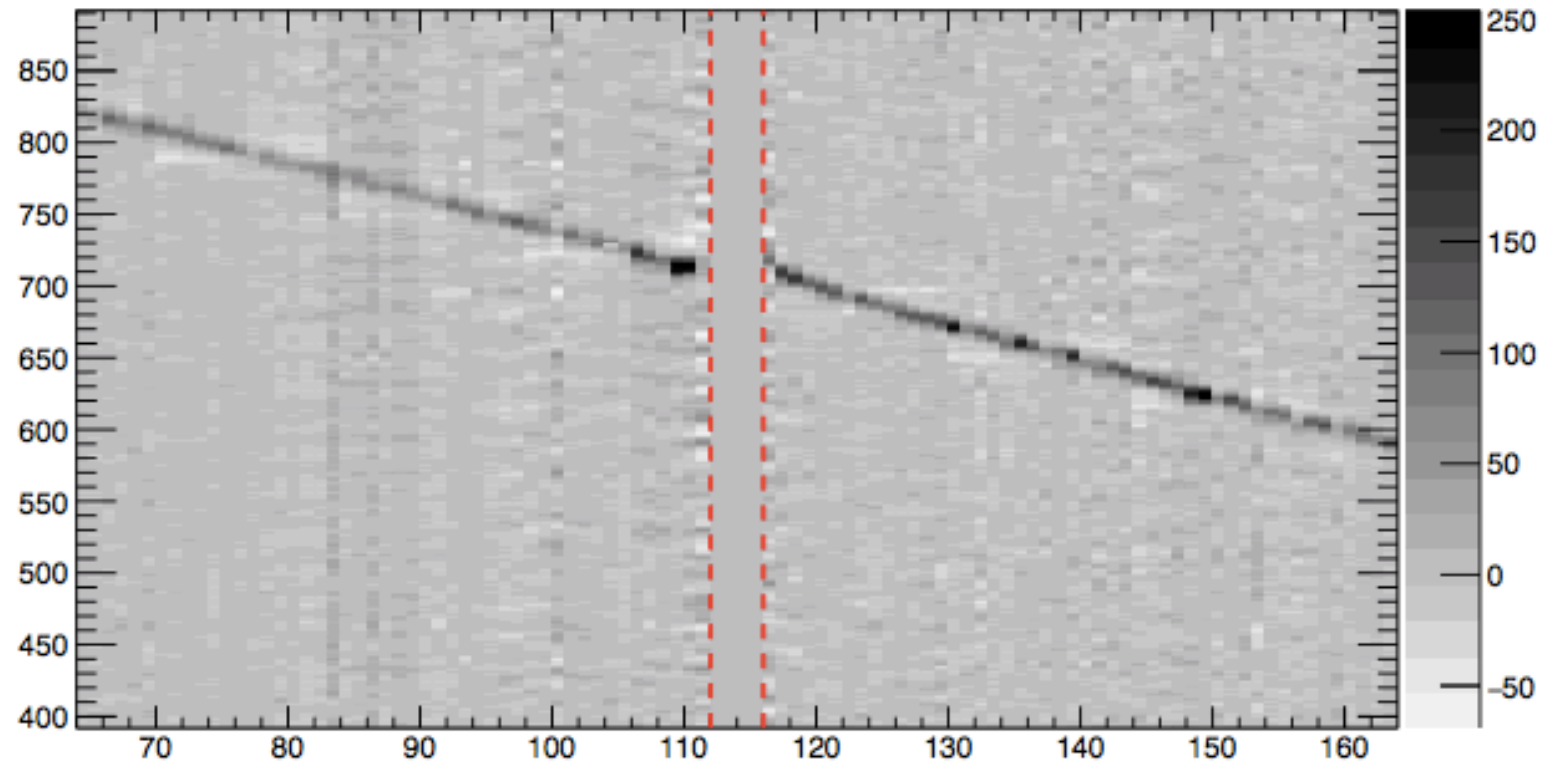


Charge Deposited

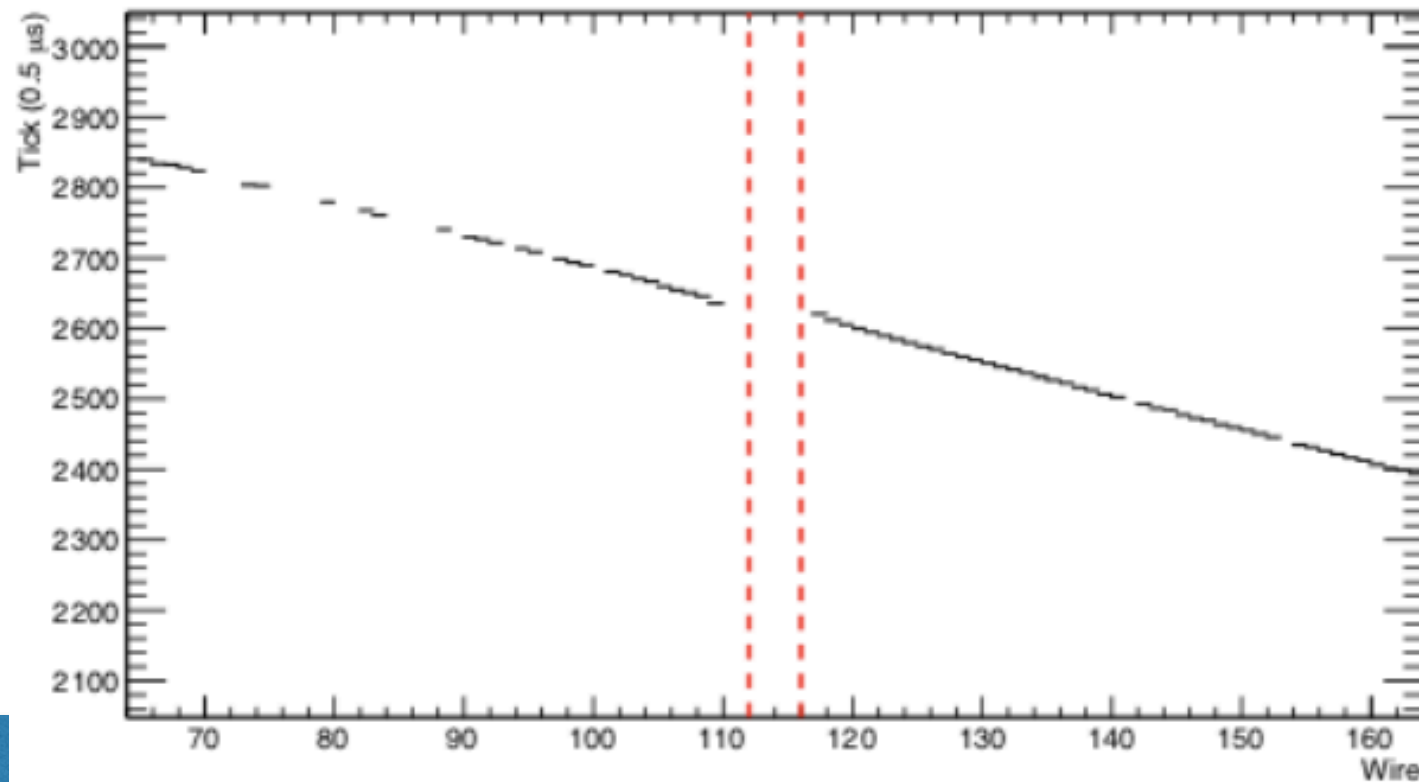
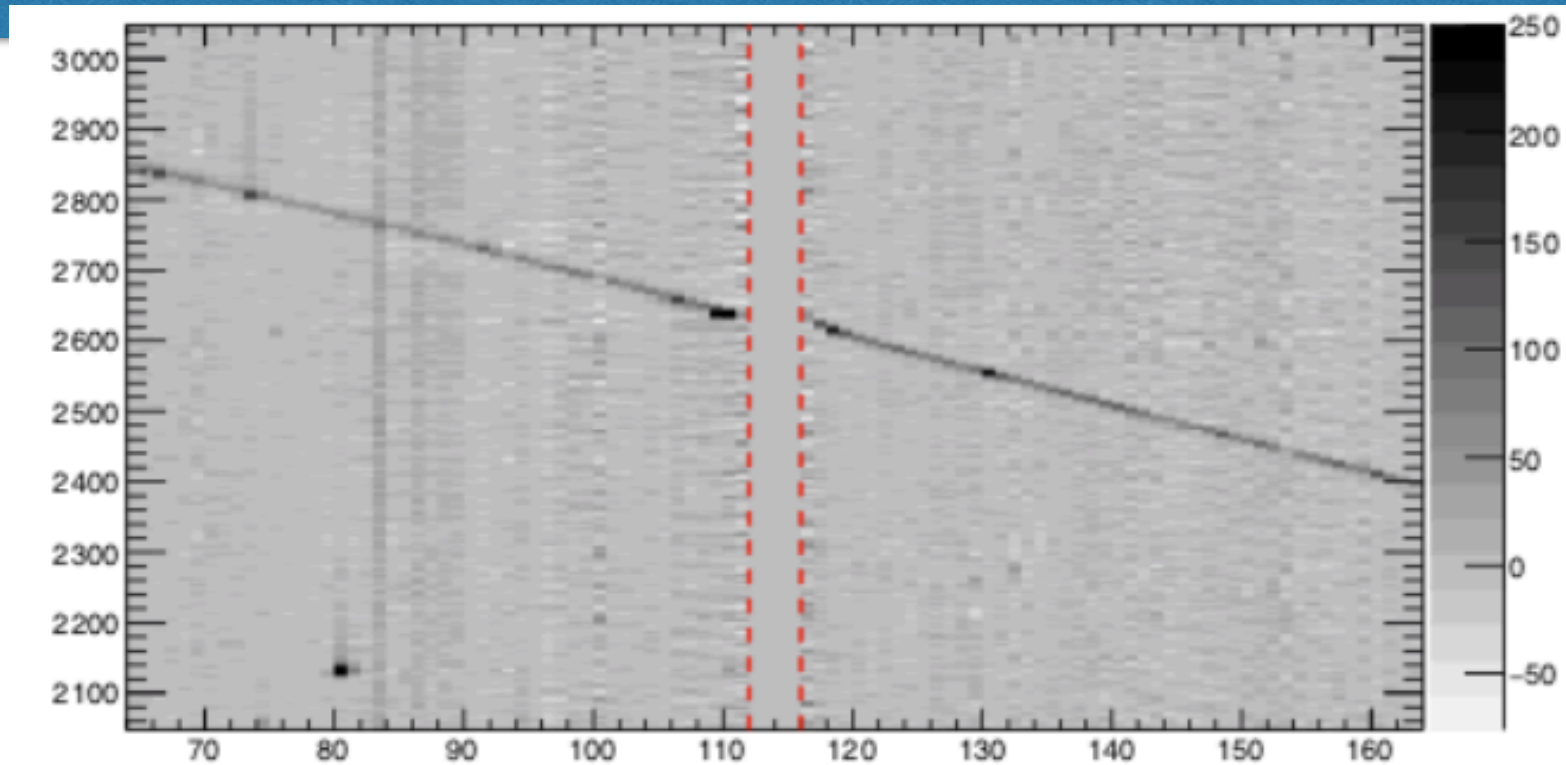
- Looks like there's more hits deposited near a gap in active collection wires.
- The hits appears to have similar properties (charge, width) than the other hits.
- That's about all I can surmise, and it's not that surprising!
- But, can we SEE these extra hits?

Some EVDs

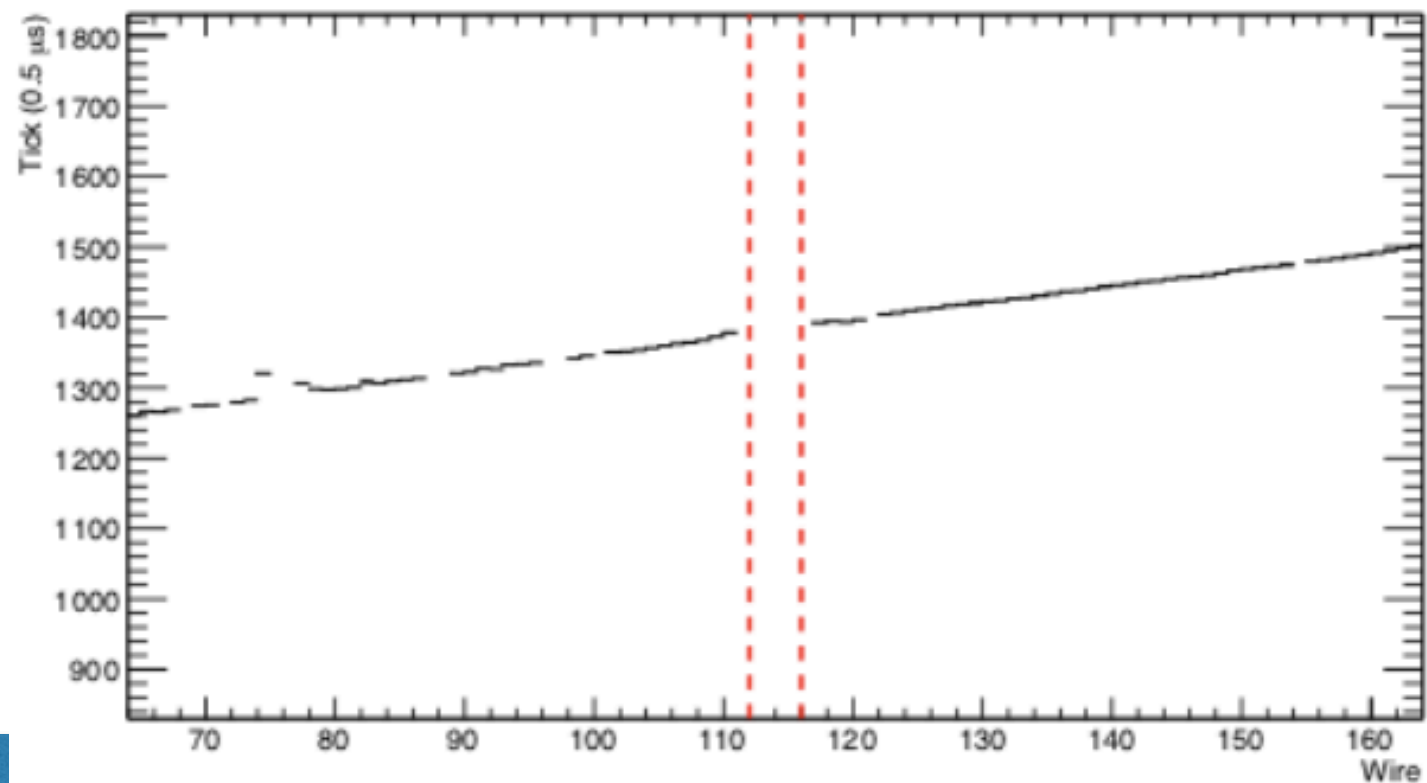
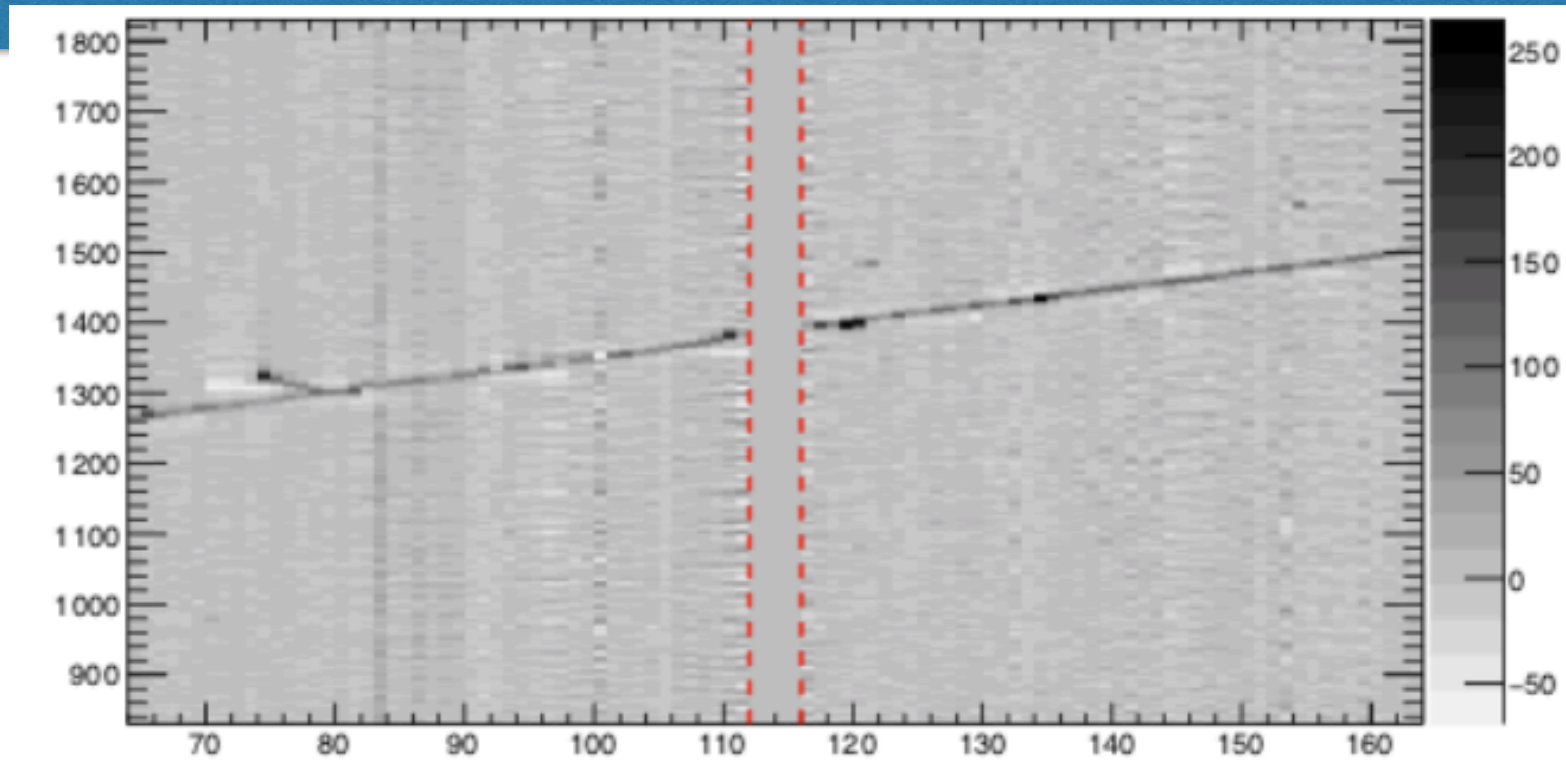
Effect doesn't seem as noticeable as we may have thought...



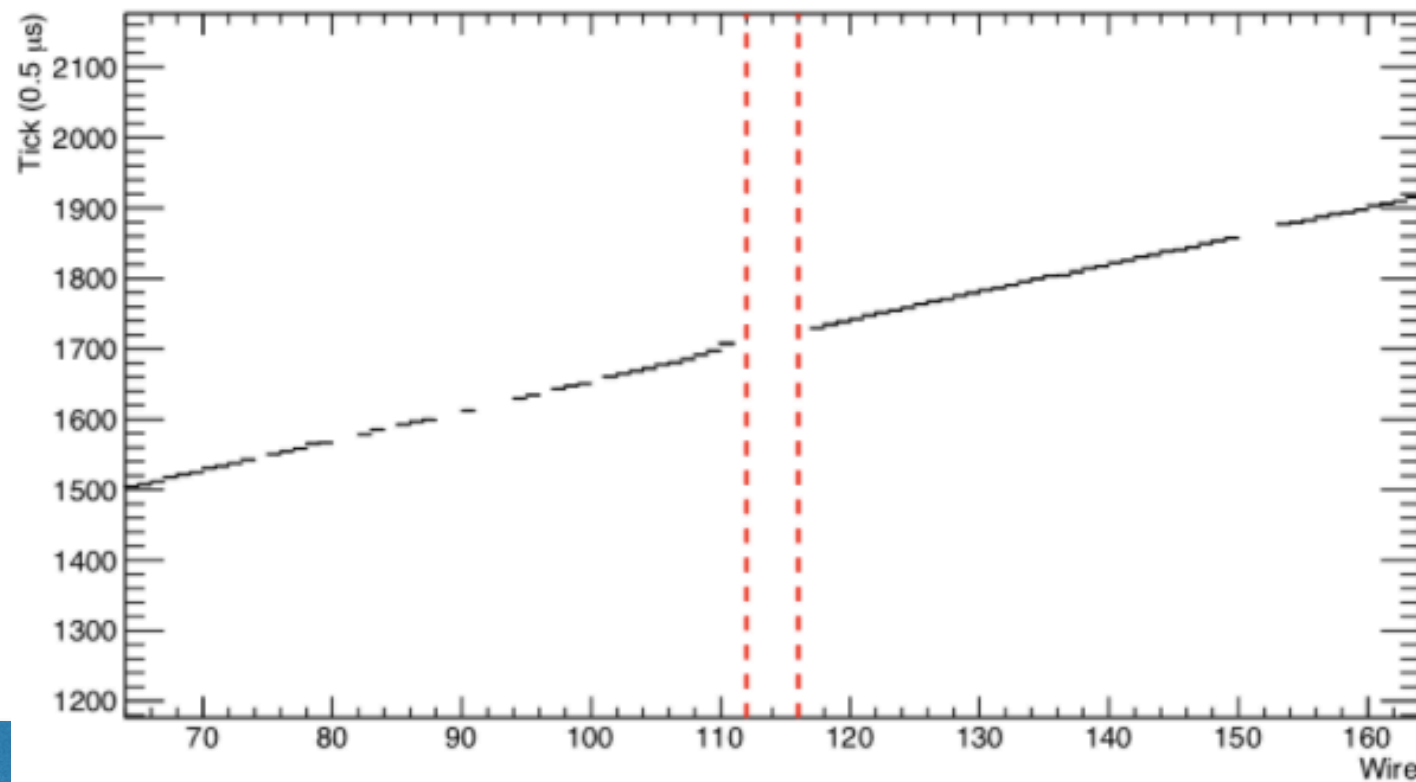
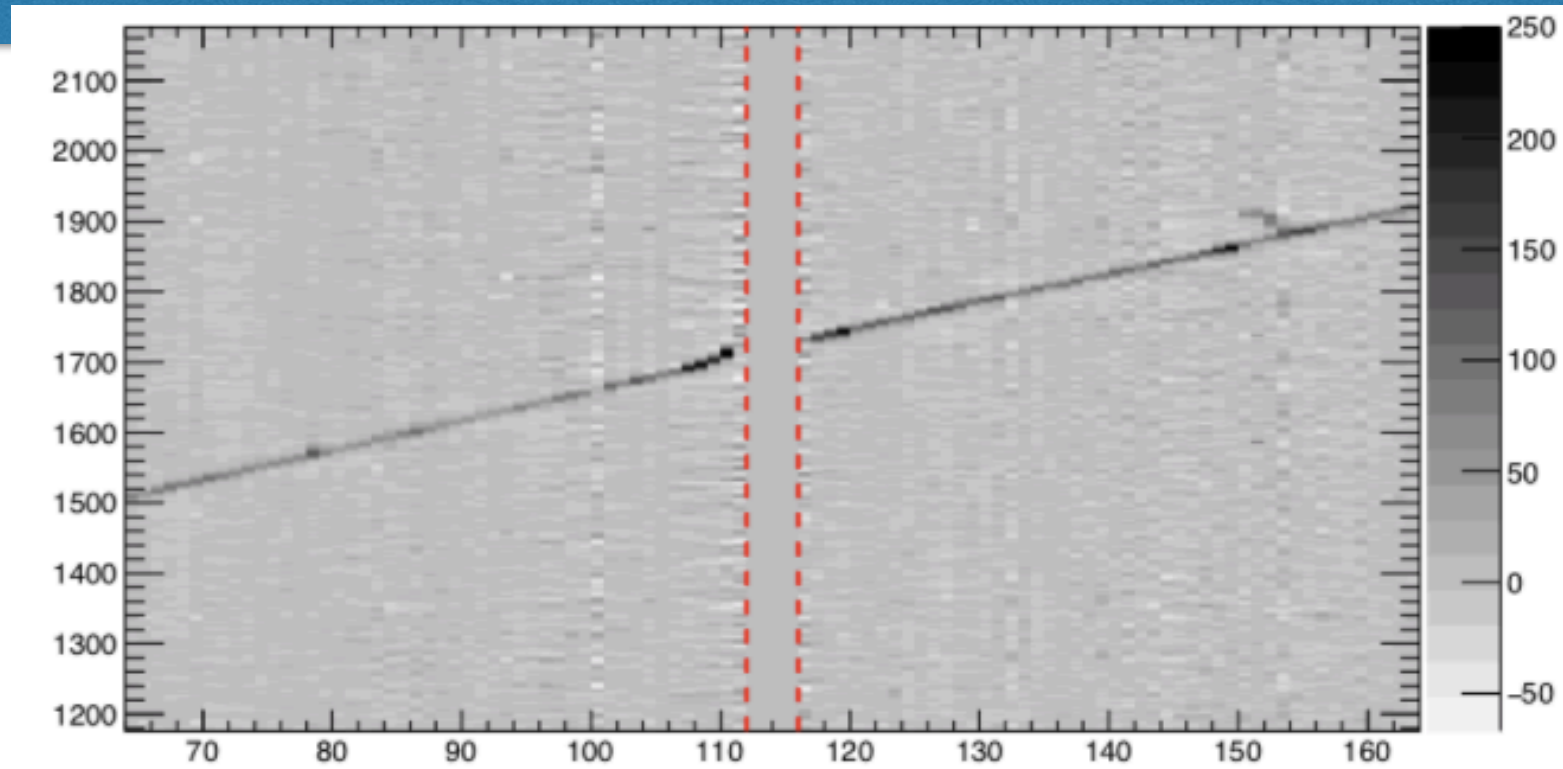
Some EVDs



Some EVDs



Some EVDs



Summary

- Coming to the end of the z -gap crosser study.
- Measured all gaps (which are possible to measure!) and also the offsets in x .
- Had a quick look at the charge left by the particles and where it is collected.
 - Can't think of much more that would be interesting here.
- Thoughts? Suggestions?