Lancaster University

Longitudinal electron diffusion :(

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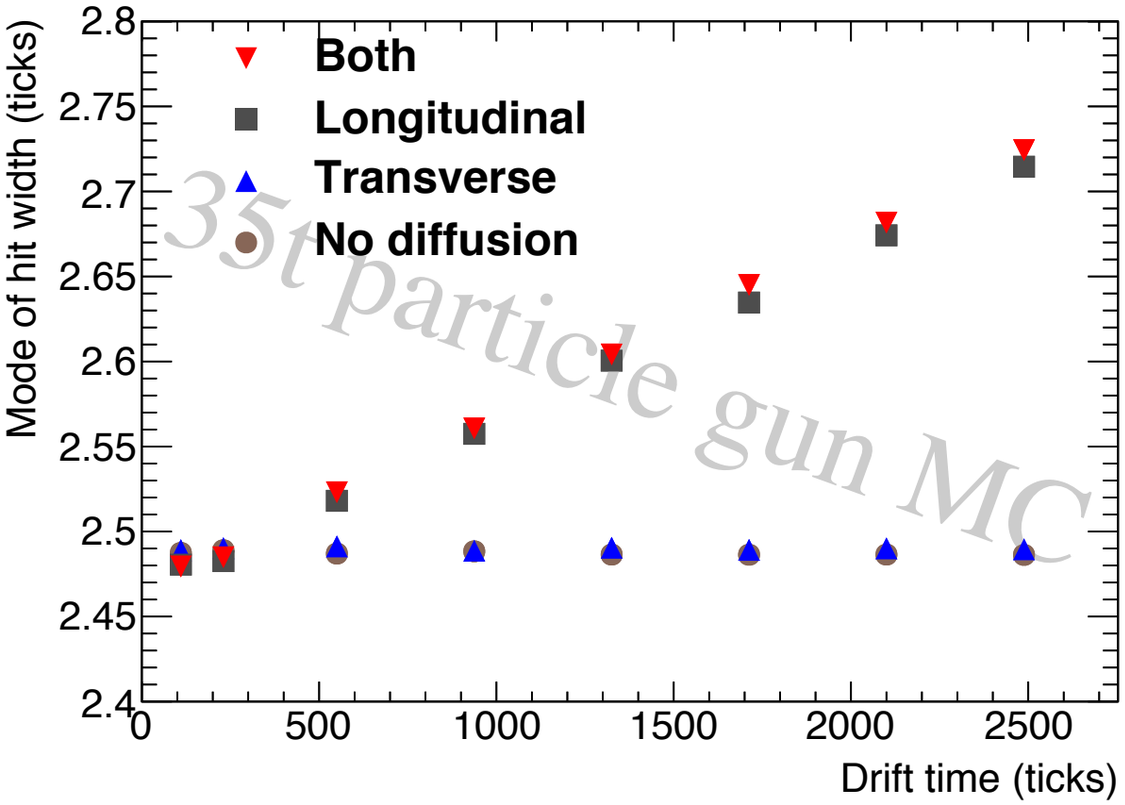
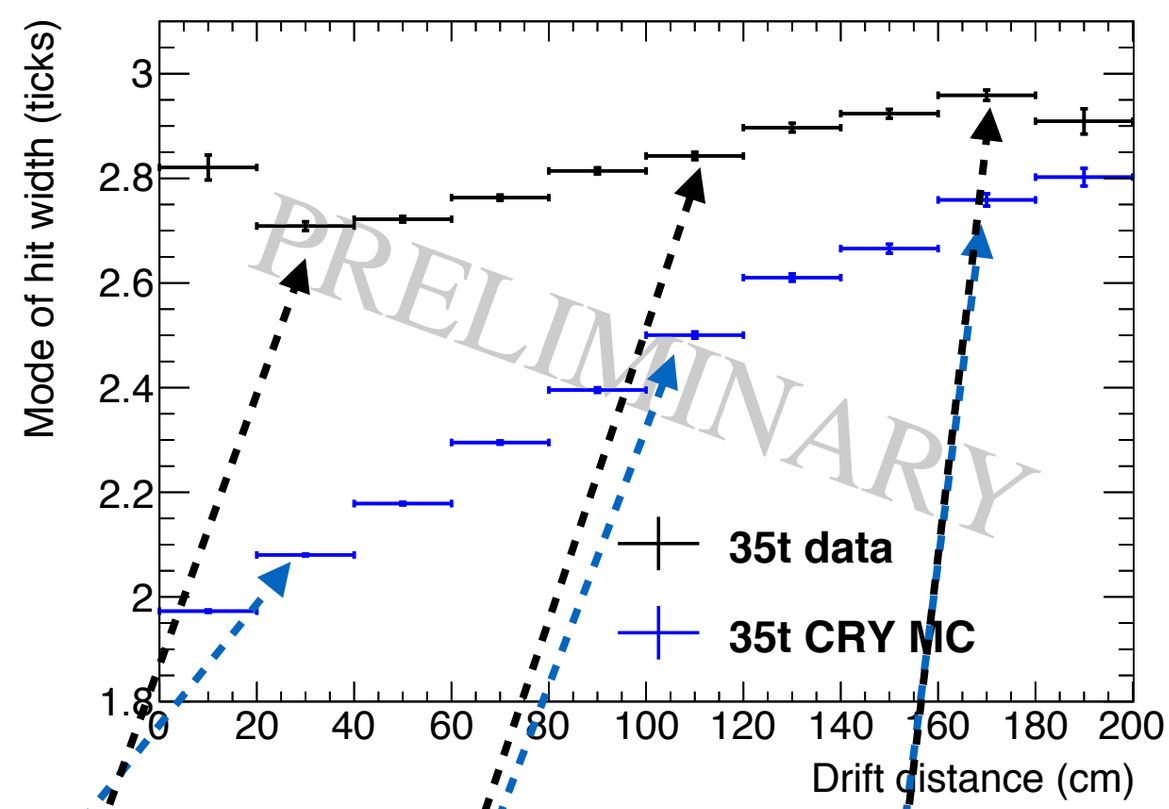
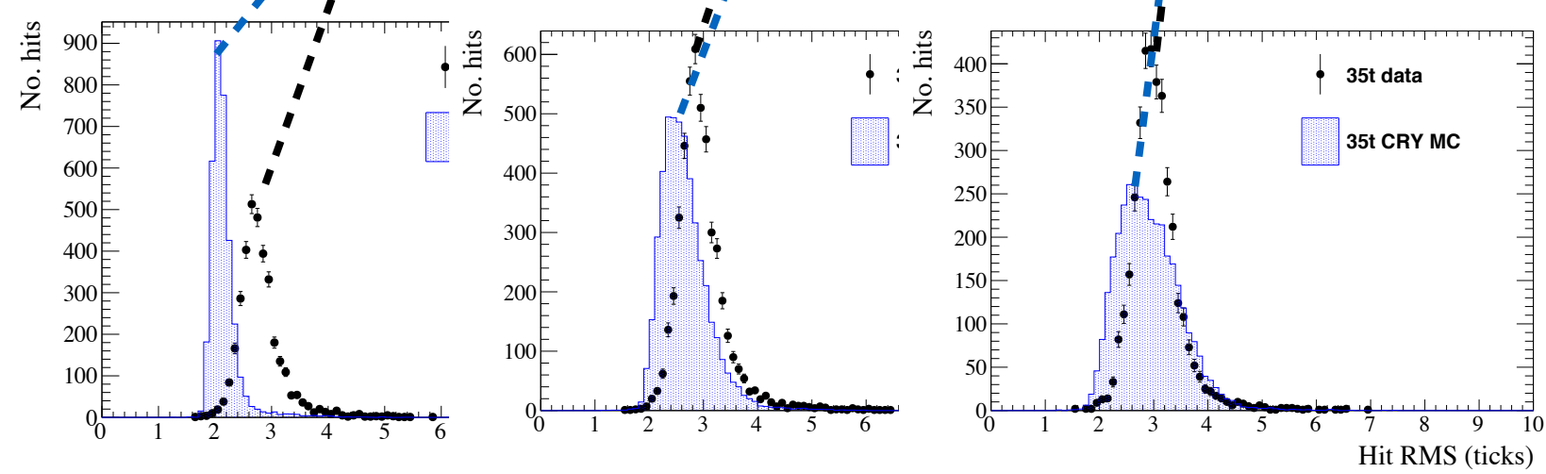
35t meeting
28/09/2016

Longitudinal diffusion



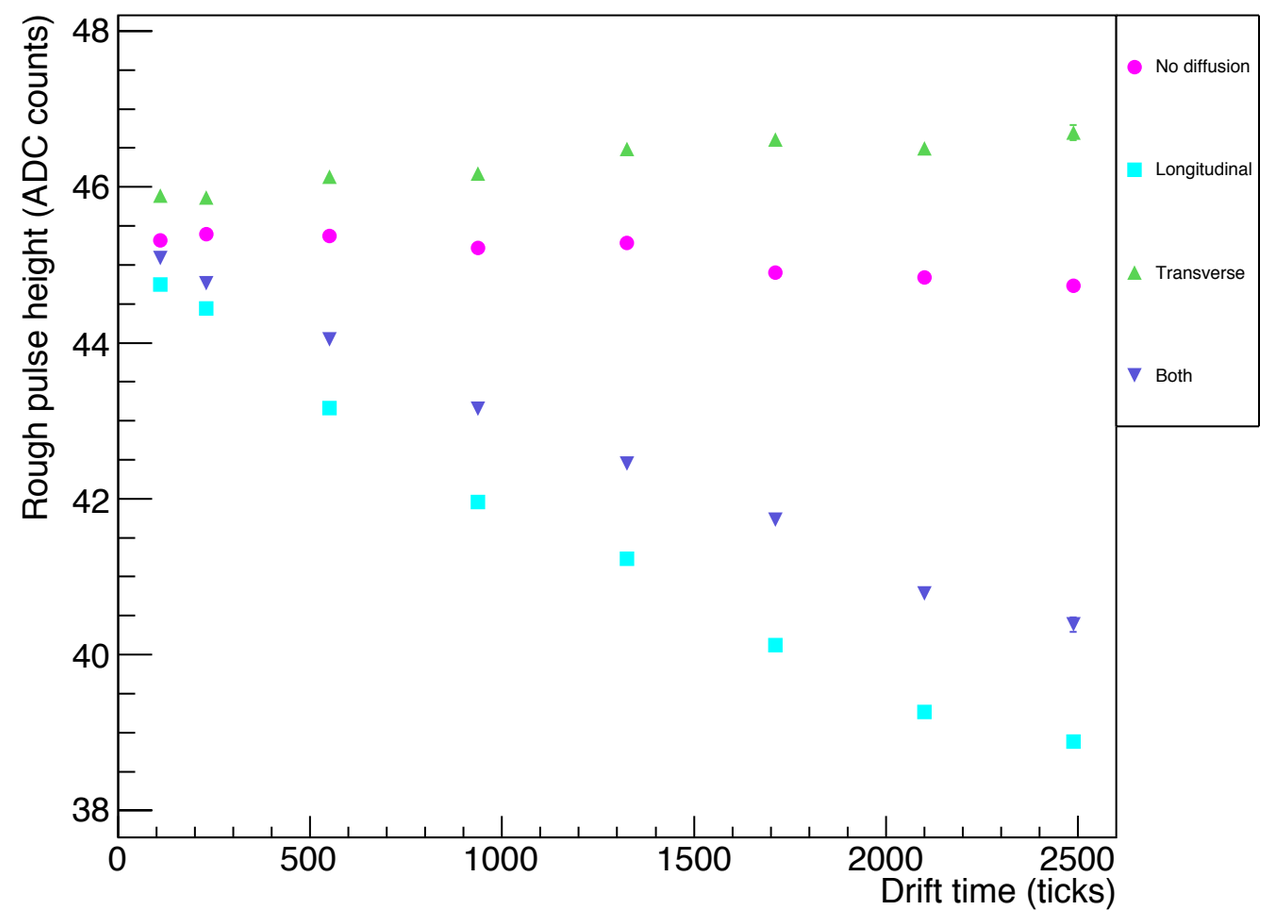




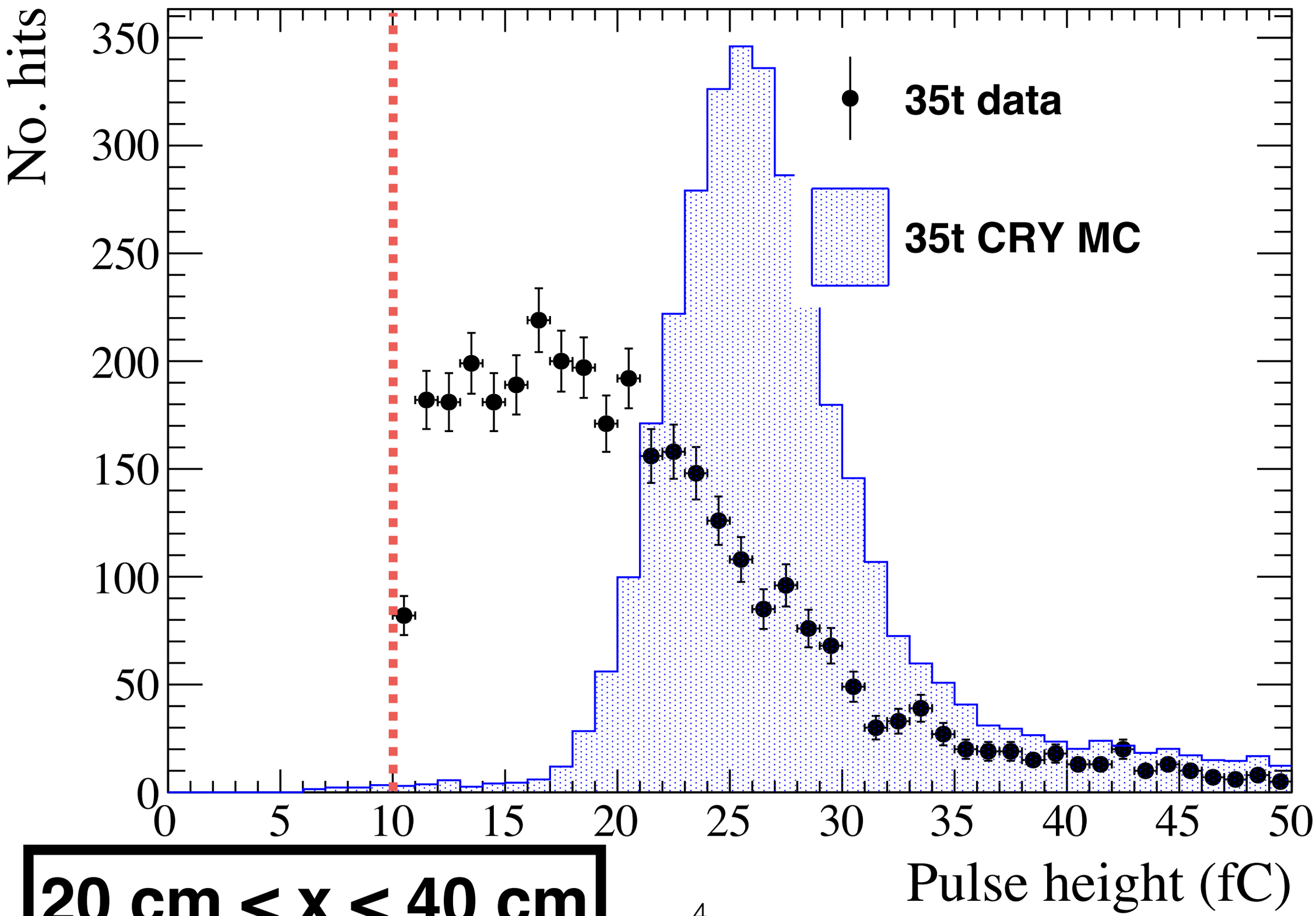
- Get at longitudinal diffusion by studying hit widths vs drift distance
- We do see the hit width depend on drift distance in data, good!

The pulse height

- Another way to look at diffusion is to look at the pulse height
  - RHS plot is a **very** old plot showing pulse height vs drift distance for PG muons (fast hit finder)
- For longitudinal diffusion, the pulse height anti-correlates with drift distance
- **We have a severe cut on the pulse height threshold in the gaus hit finder (10 fC). This could be (and in my opinion is) a big problem**

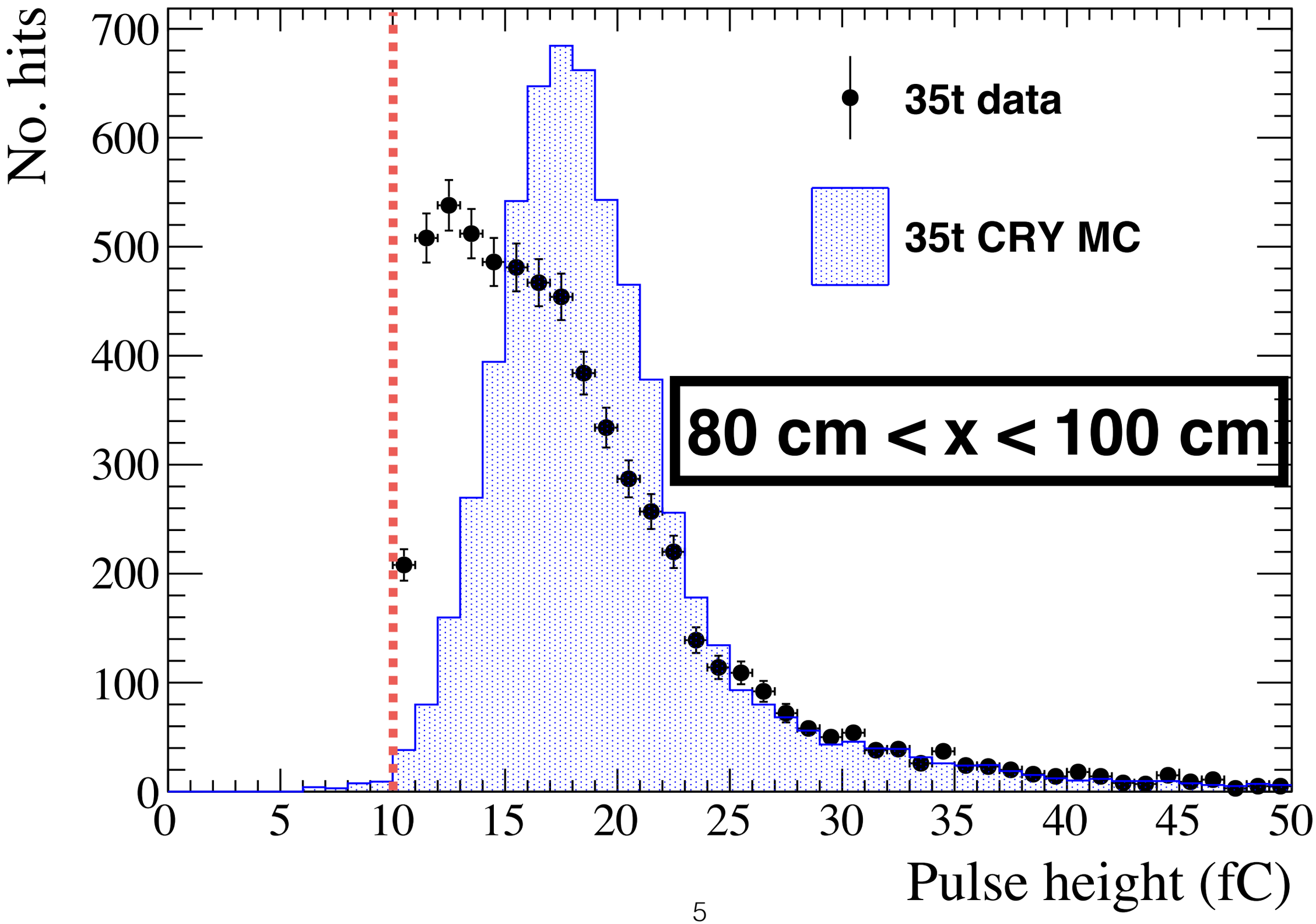


The pulse height

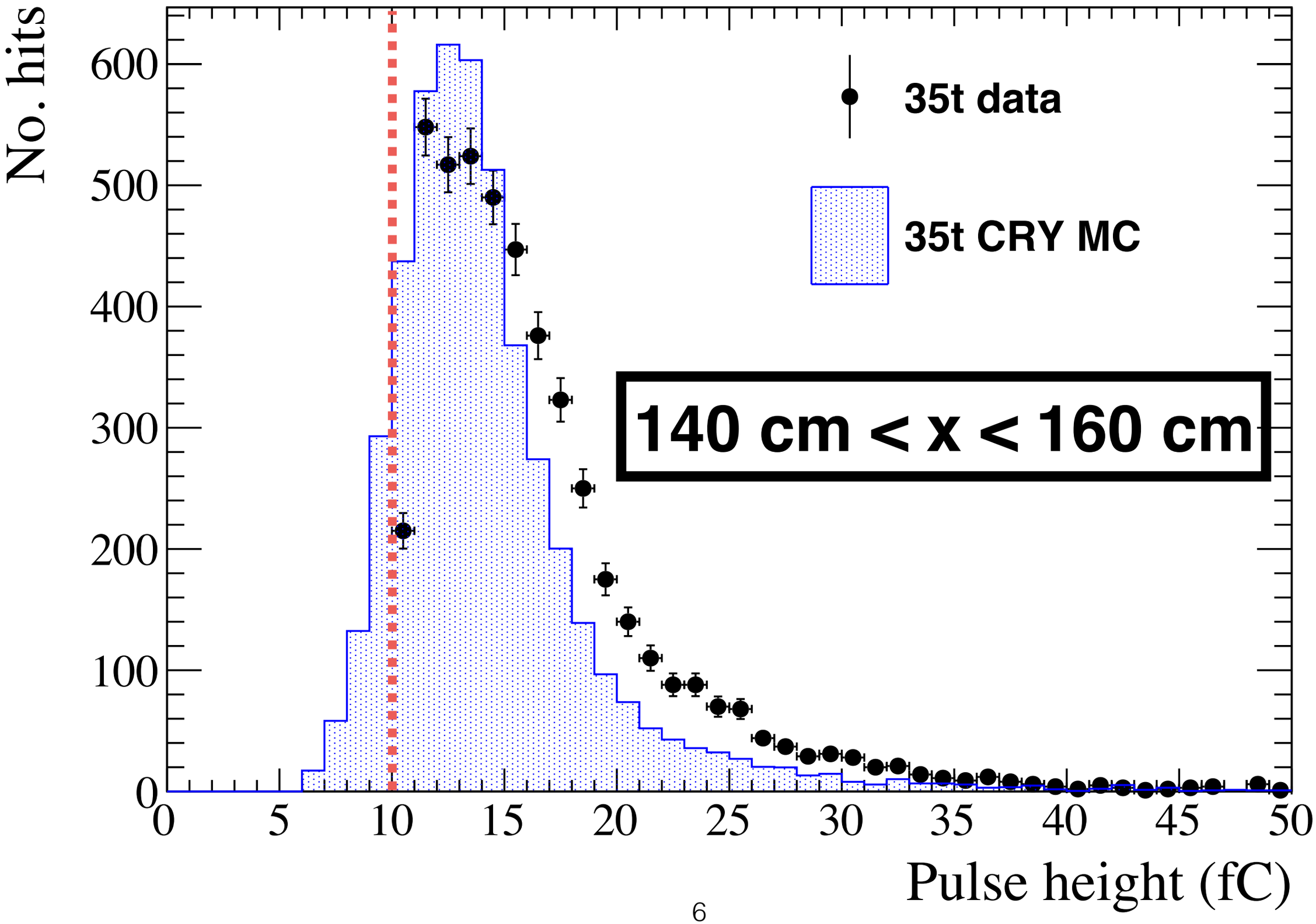


20 cm < x < 40 cm

The pulse height

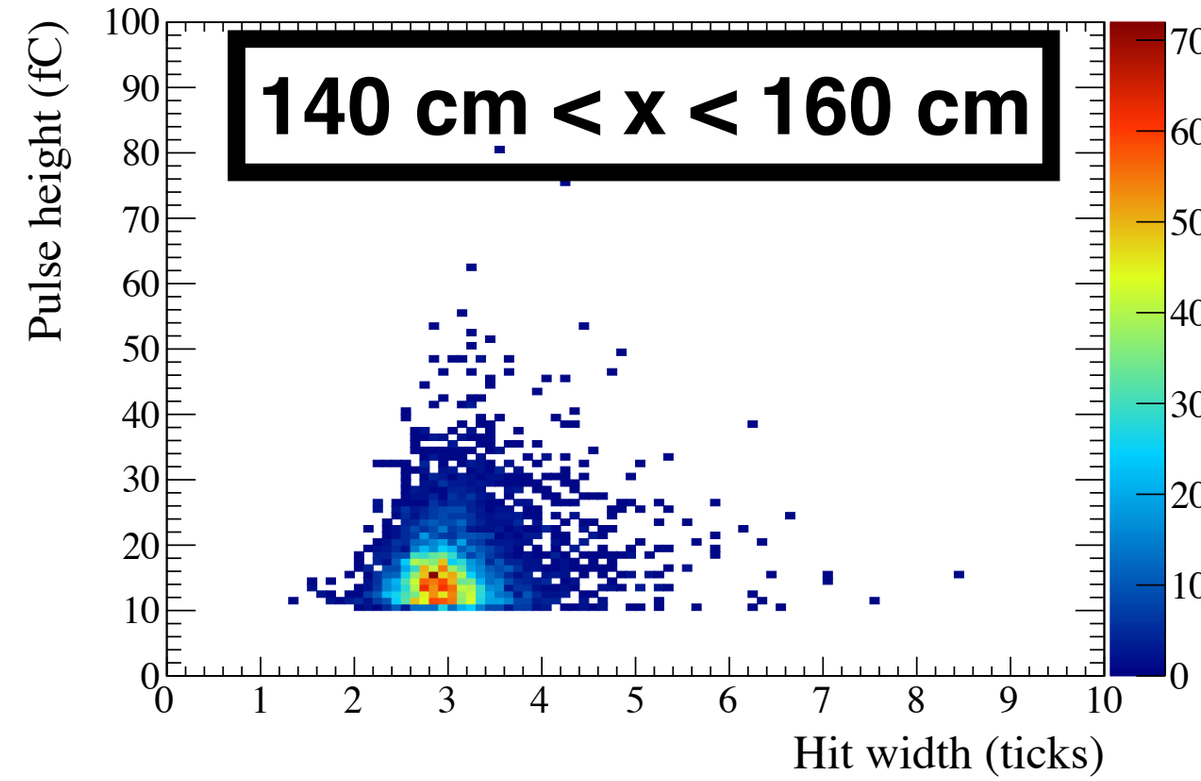


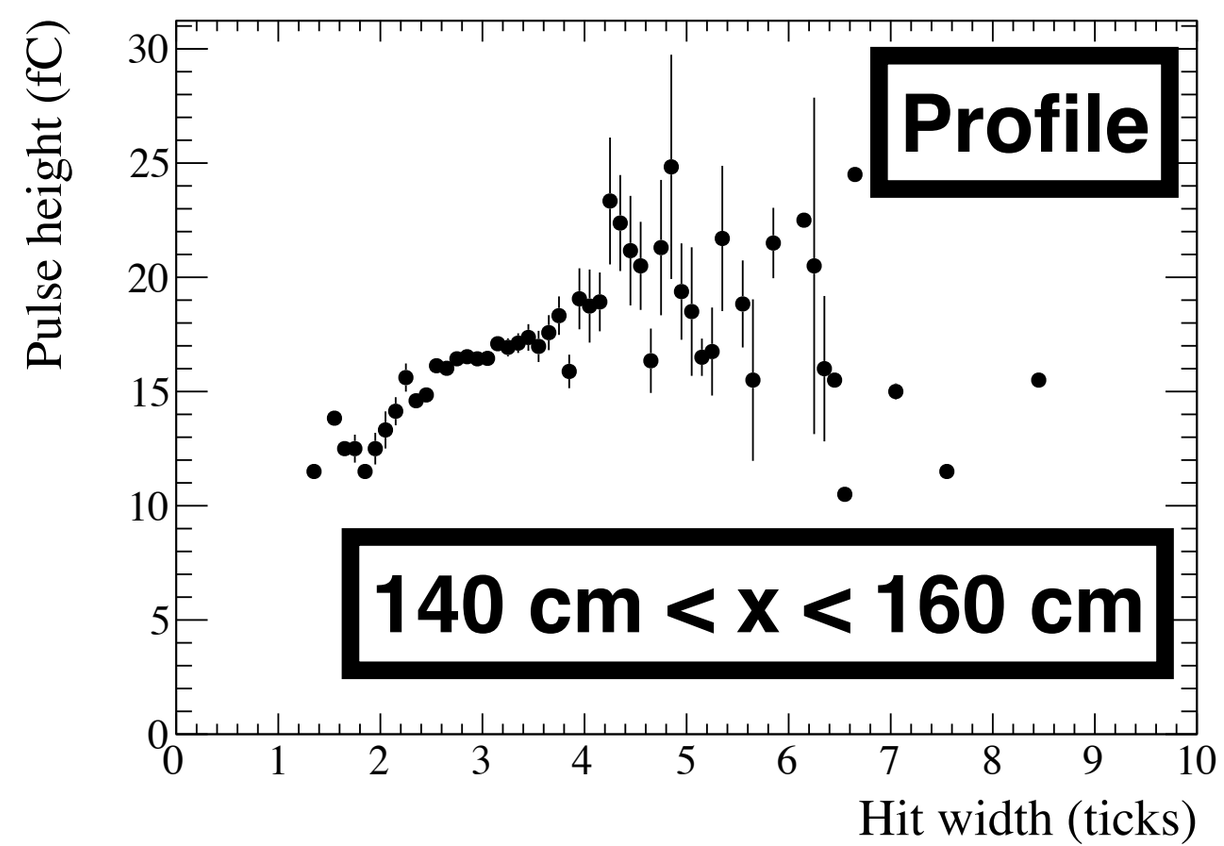
The pulse height



Hit width vs pulse height

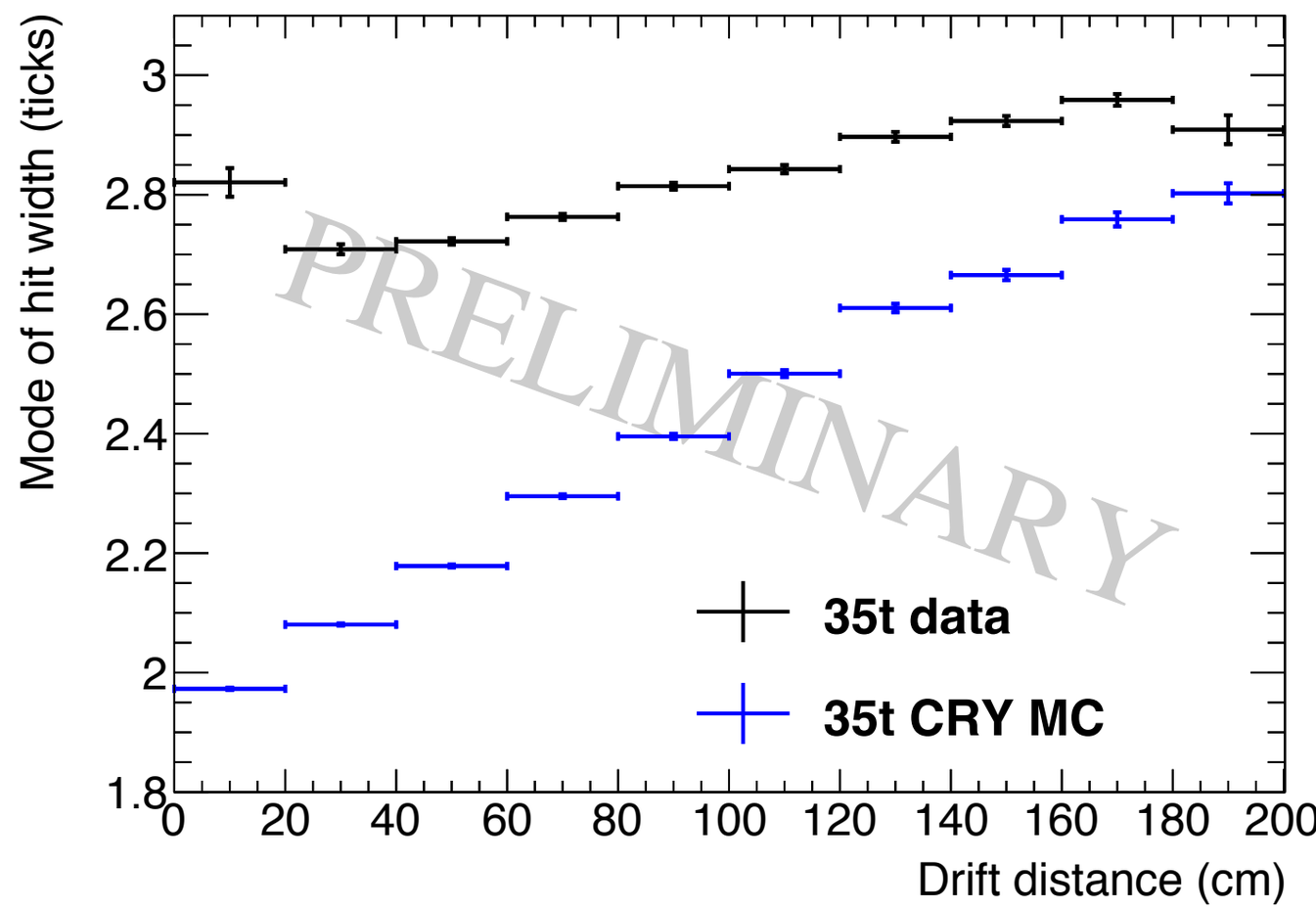
- RHS plots show the pulse heights vs the hit widths for hits between 140 cm and 160 cm in selected **data**
- The hit width peak sits very close to the pulse height threshold
- The hit widths correlate with the pulse height
  - The correlation could be artificial and driven by the pulse height threshold
- Still, the correlation remains
- We could easily be biasing the hit width measurements due to the pulse height threshold





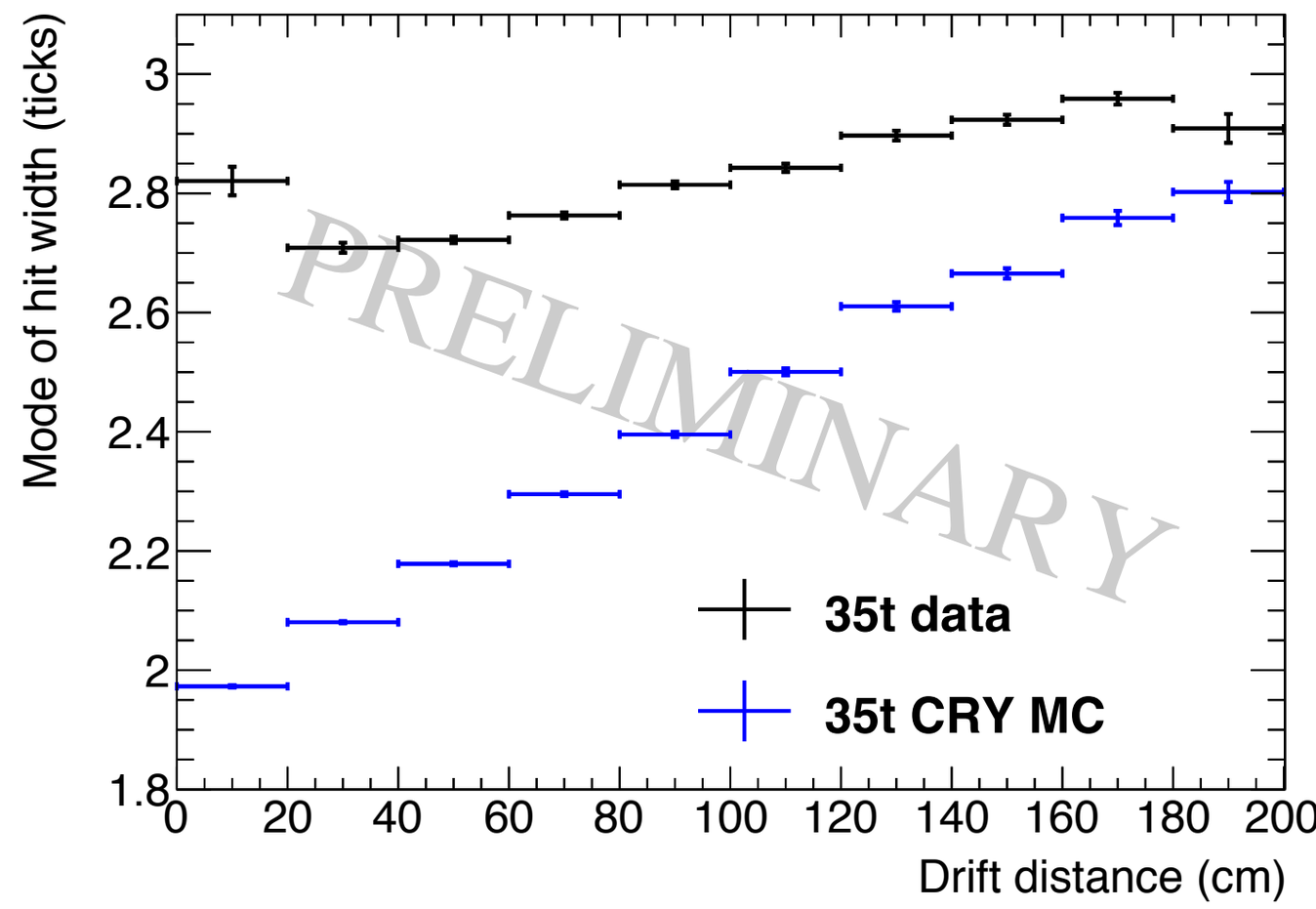
Conclusions and future

- This provokes the question: should we believe this plot?
- Put another way, could the pulse height threshold cause a bias in the hit width
- I am inclined to say yes
- We can check this: I plan to apply an artificial pulse height threshold to my MC selection



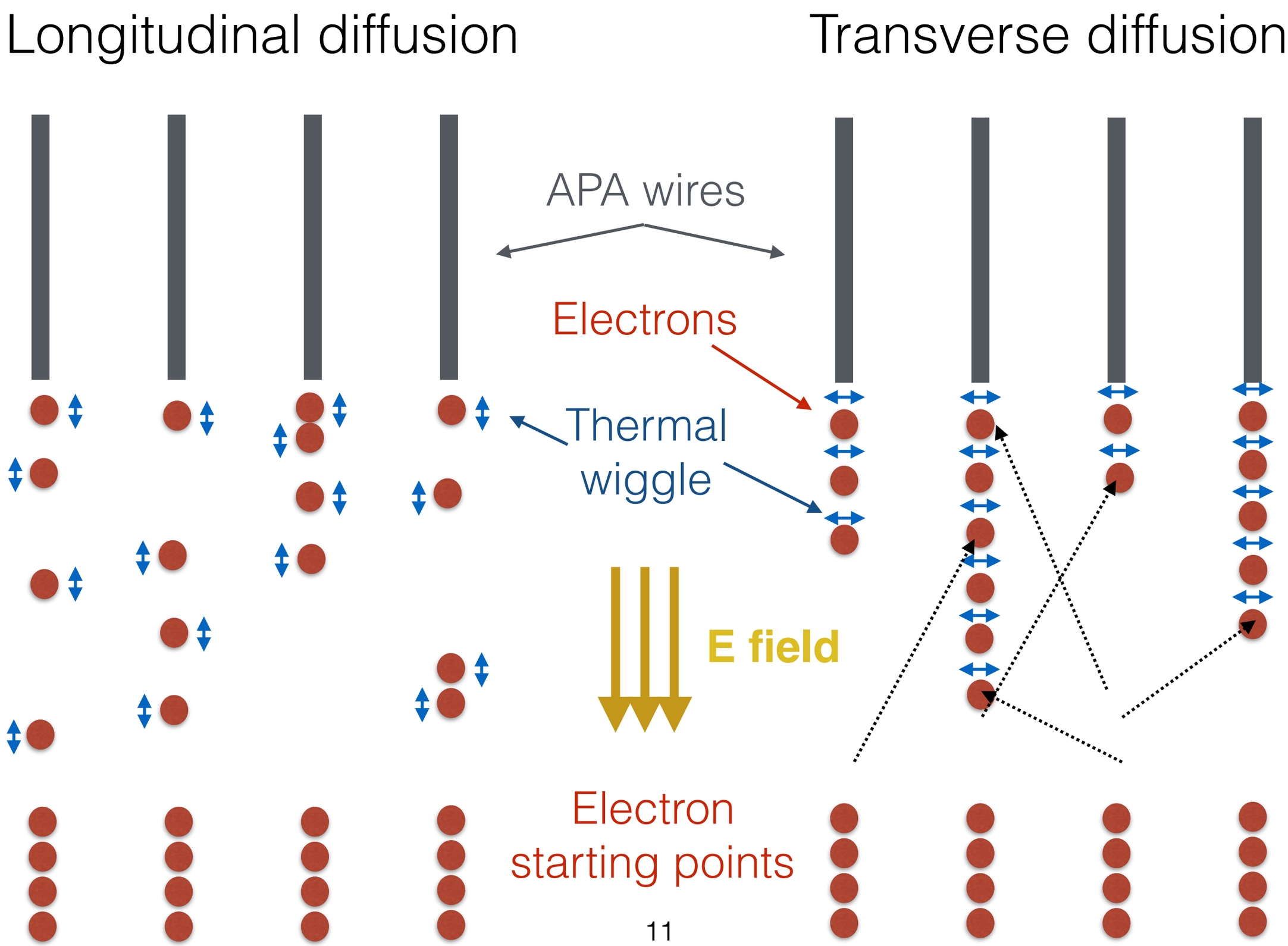
Conclusions and future

- I'm starting to feel like a diffusion constant measurement is unlikely
- We can change how this analysis proceeds
- Michelle suggested pushing forward with publishing a measurement method which defines the analysis limitations
  - Likelihood fit or maybe Bayesian analysis
  - How does noise change the output?
  - What is the maximum S/N ratio before such an analysis breaks down?



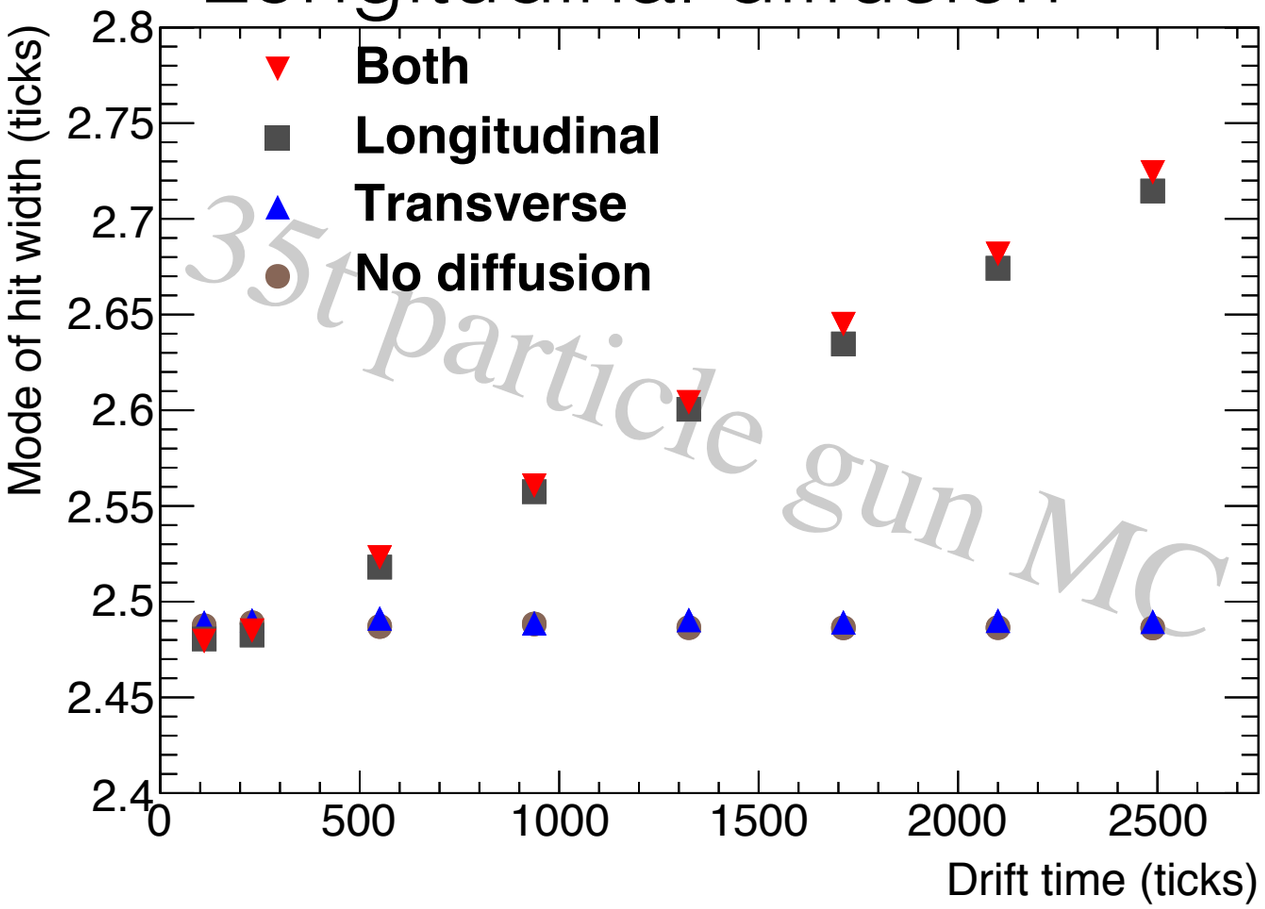
Backups

Electron diffusion



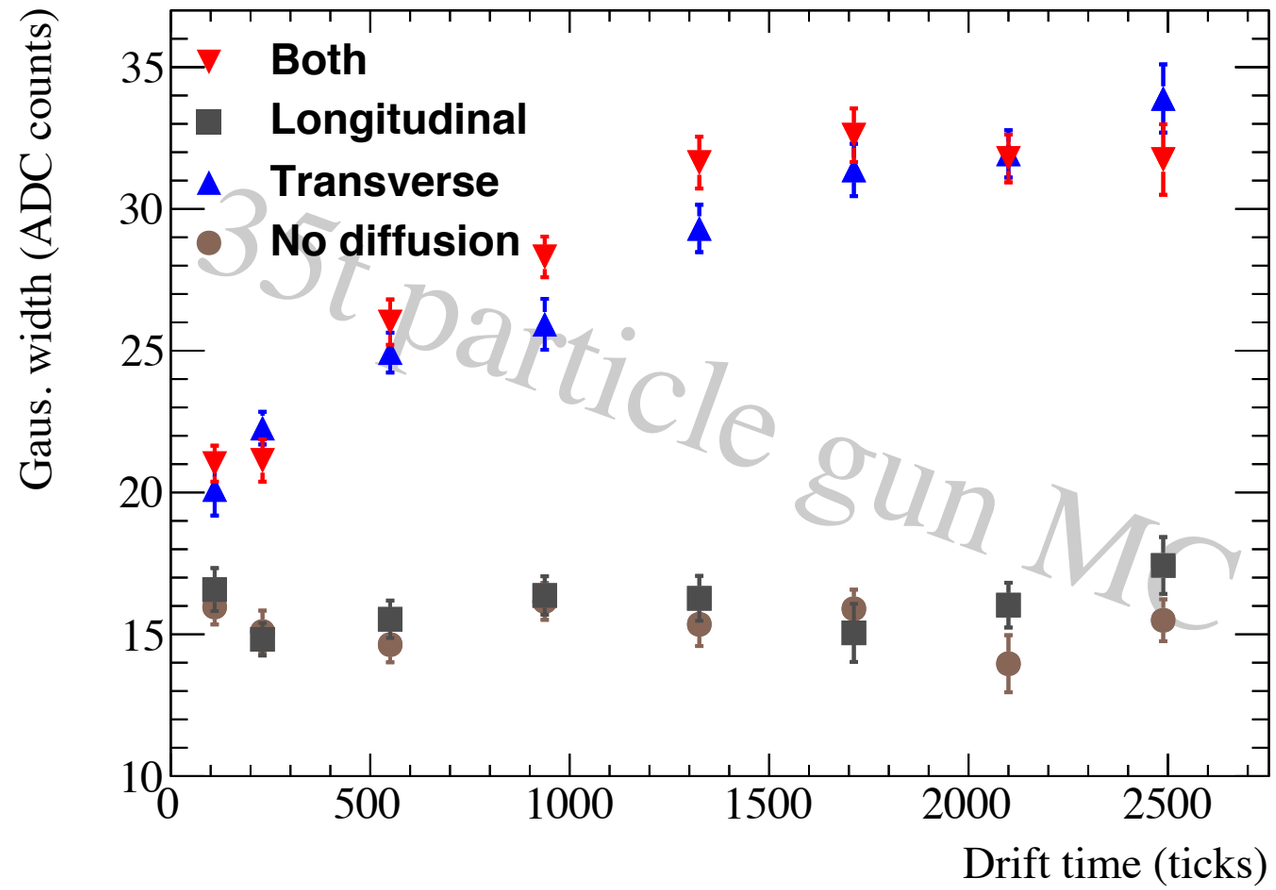
Electron diffusion

Longitudinal diffusion



- Measure the modal hit RMS as a function of time (distance)

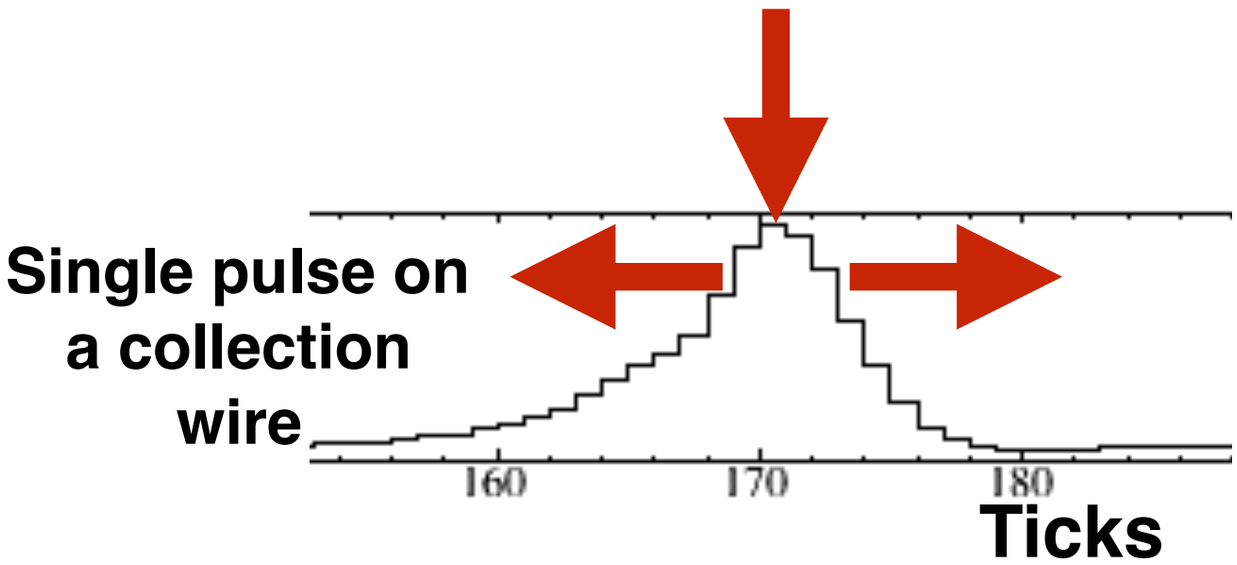
Transverse diffusion

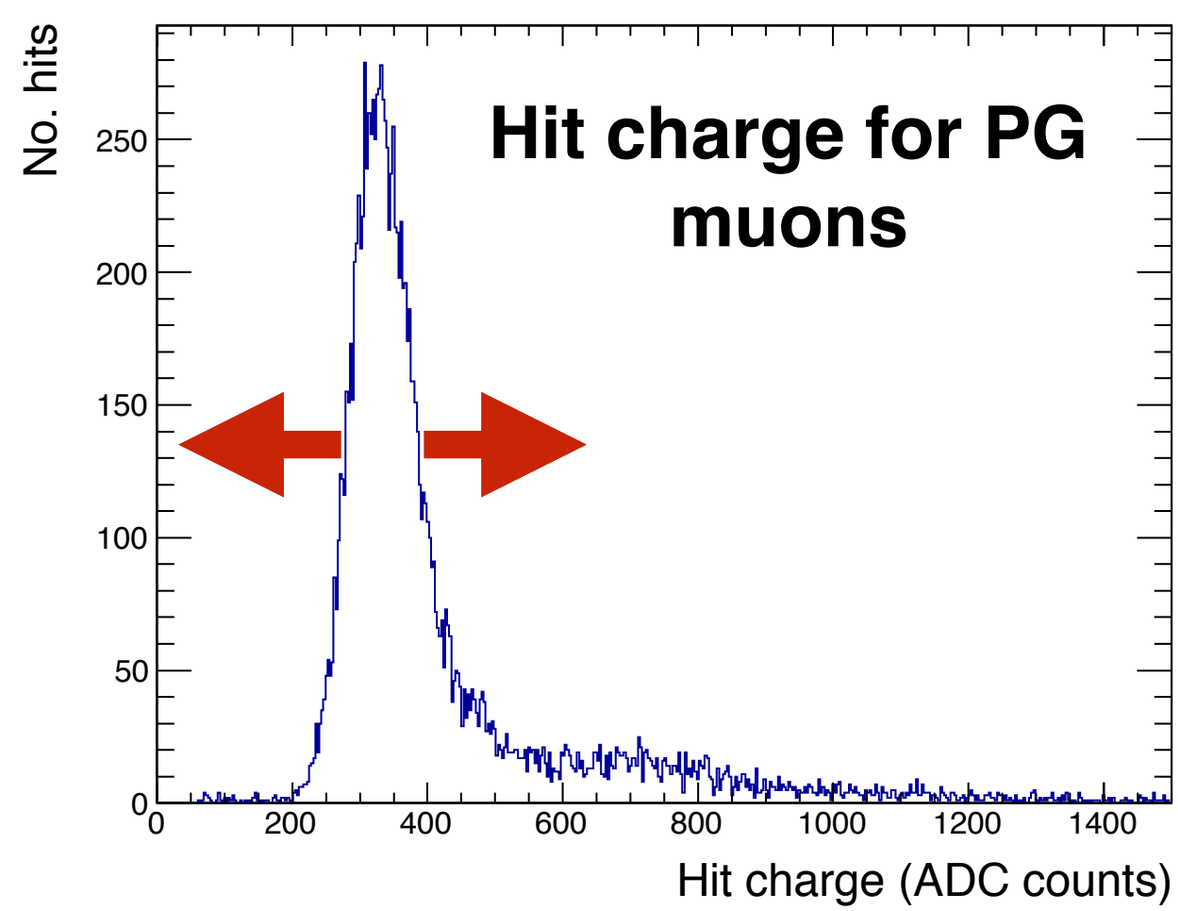


- Measure the Gaus width of the hit charge distribution (landau gaussian dist.) as a function of time (distance)

Sample: PG muons fired through the EW counter with perfect LAr purity. Fast hit finder.

Electron diffusion

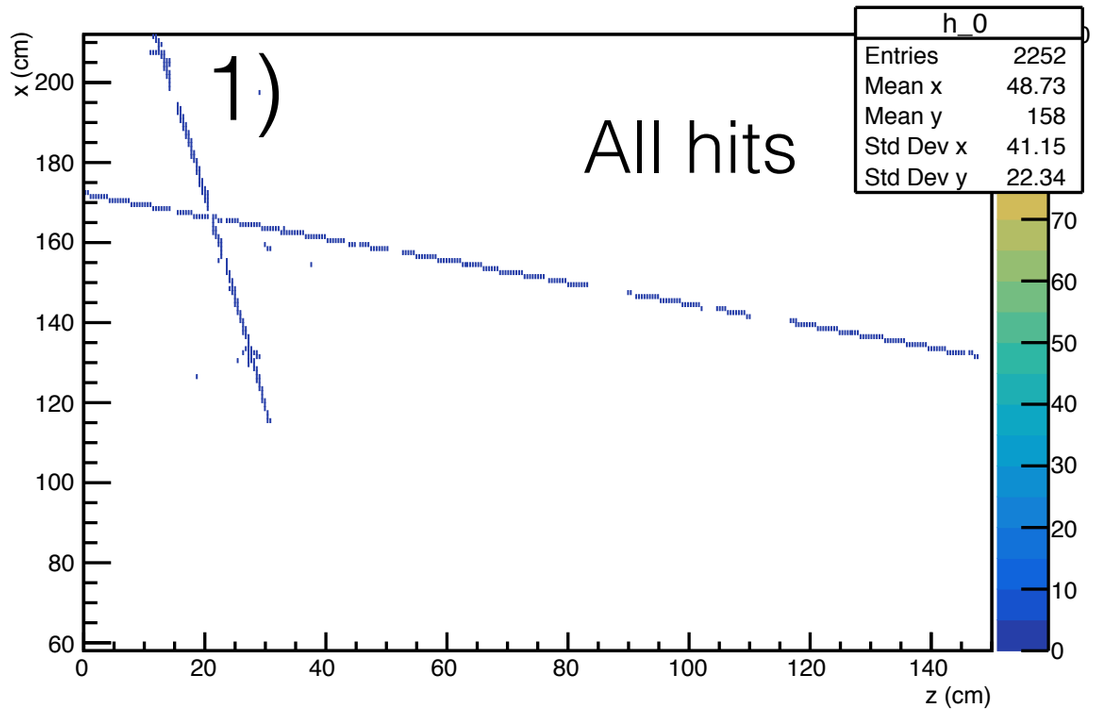


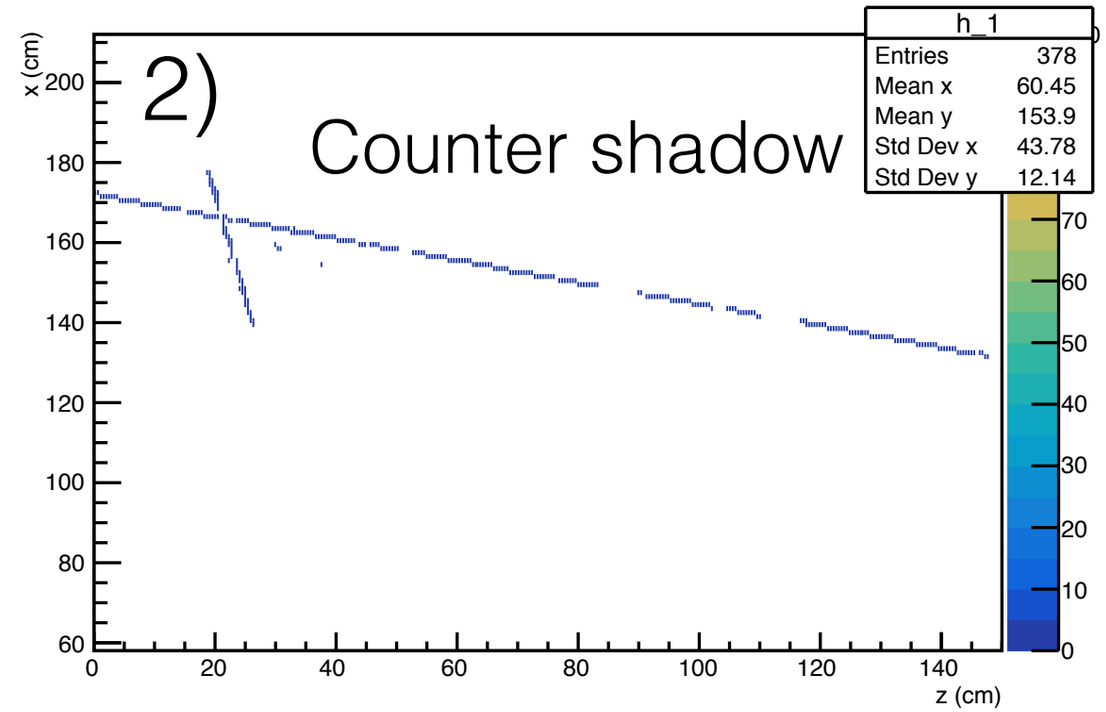


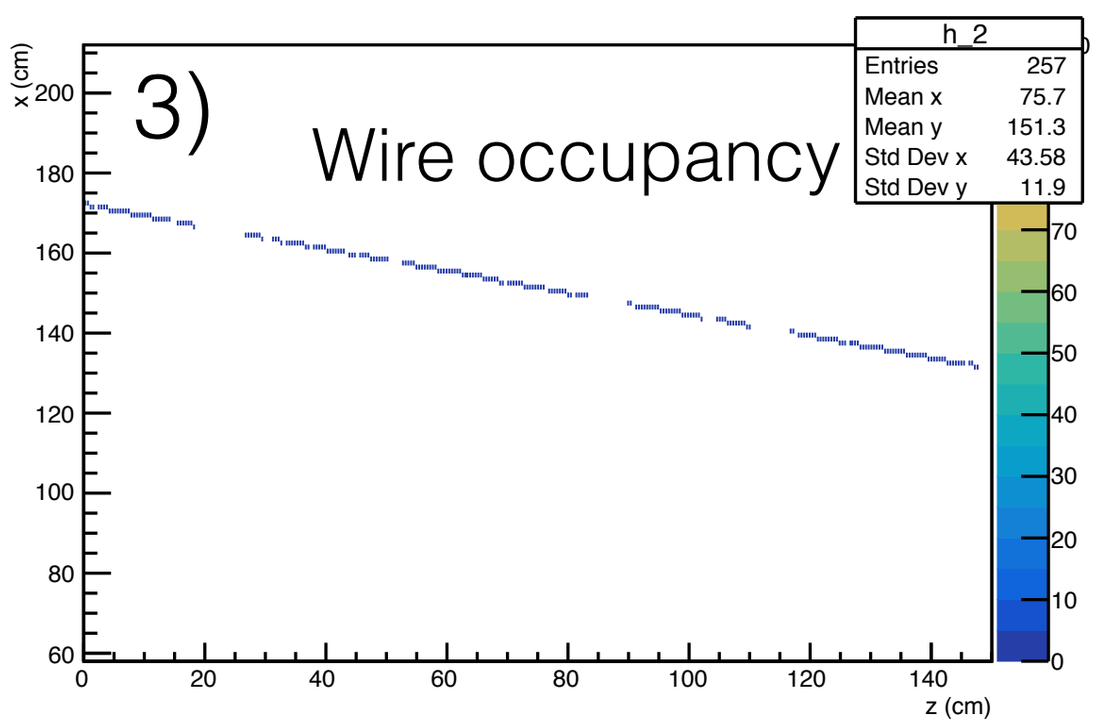
- Longitudinal diffusion spreads the hit out in time which widens the hits
- To conserve electron number, the pulse height shortens
- Drift distance dependent

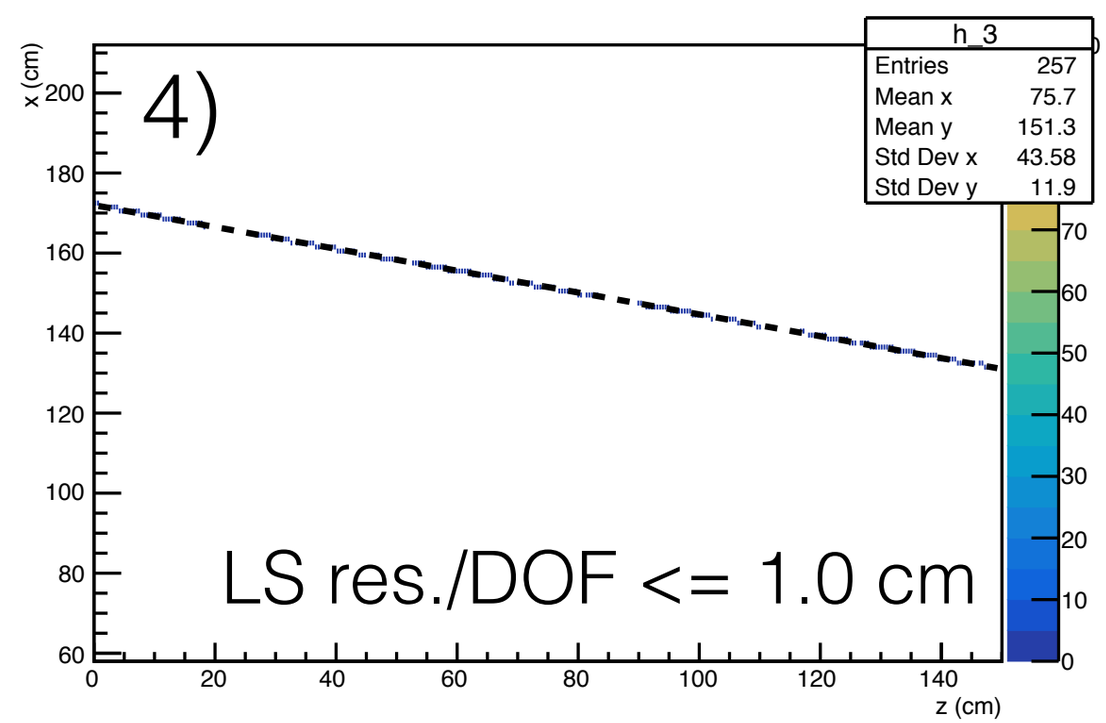
- Transverse diffusion mixes charge between wires
- This widens the hit charge distribution (coarser charge resolution)
- Drift distance dependent

Selection example: MC





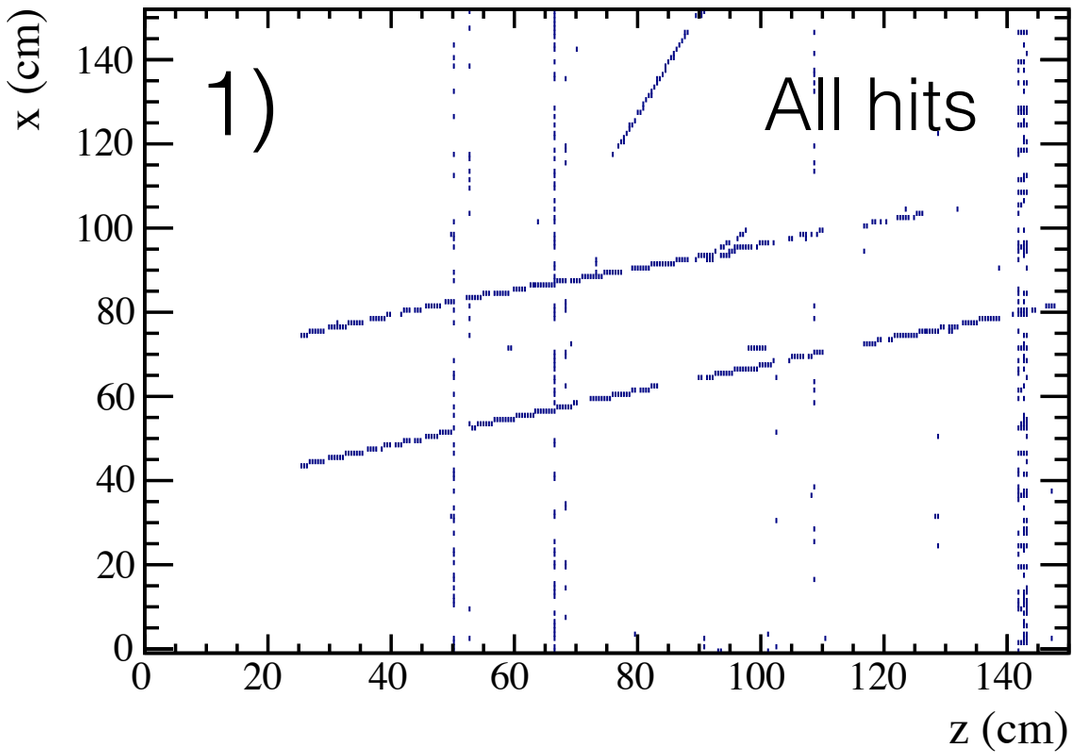


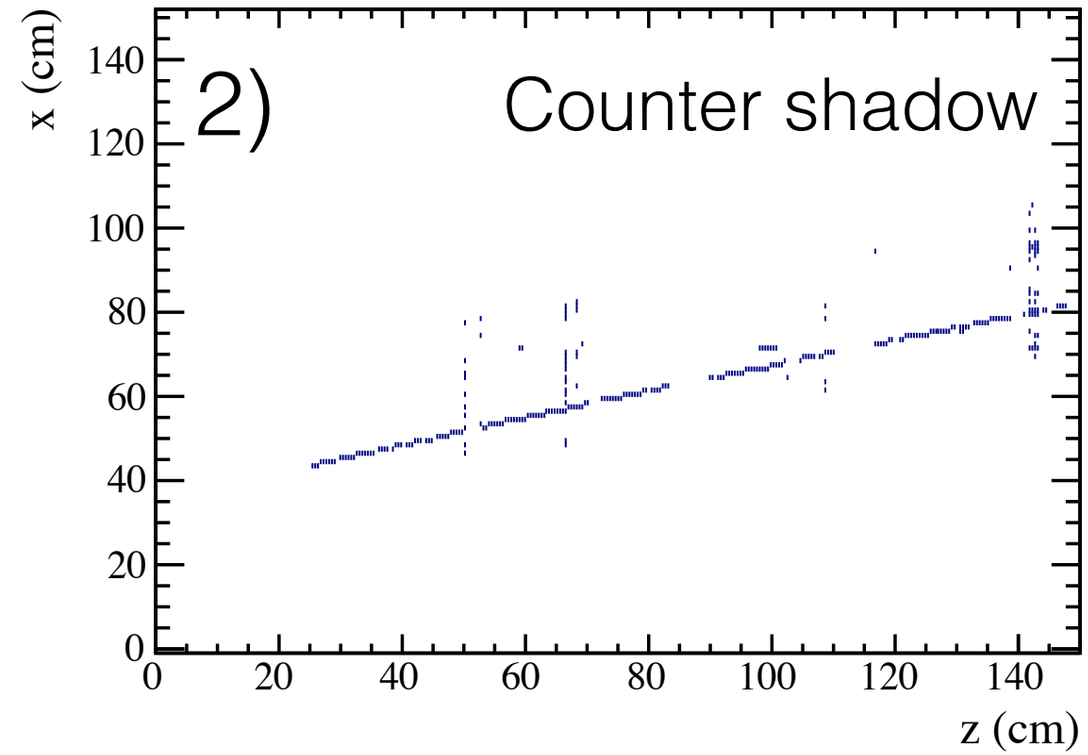


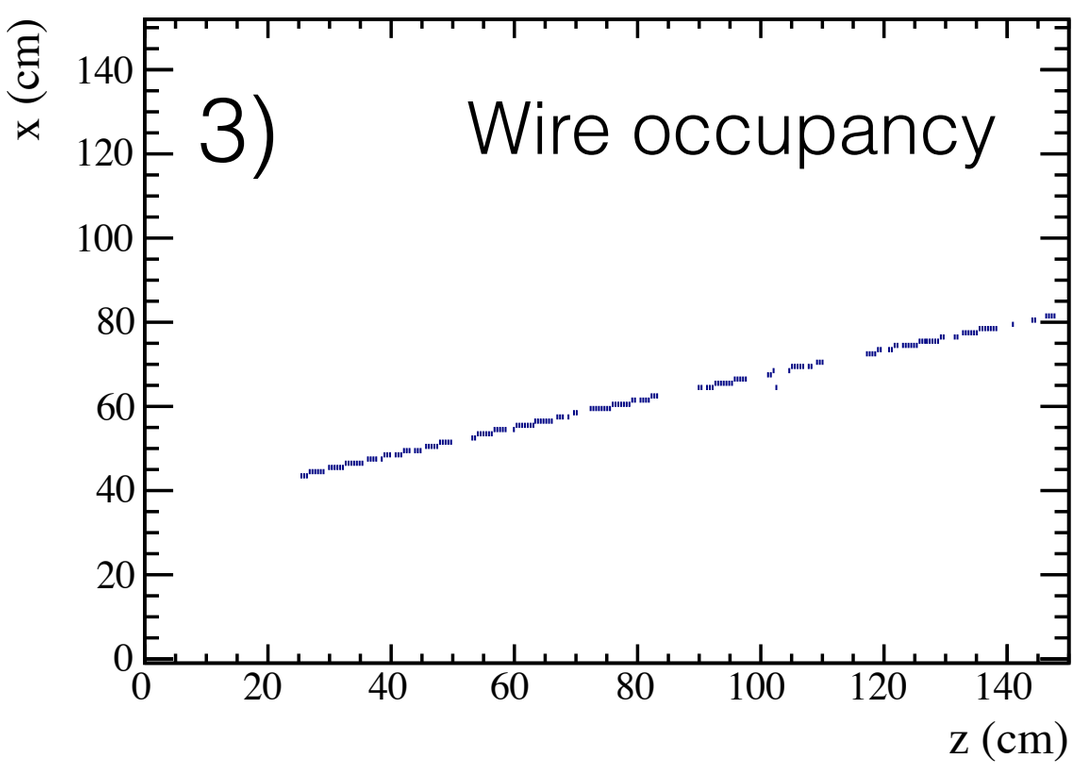
Samples and selection

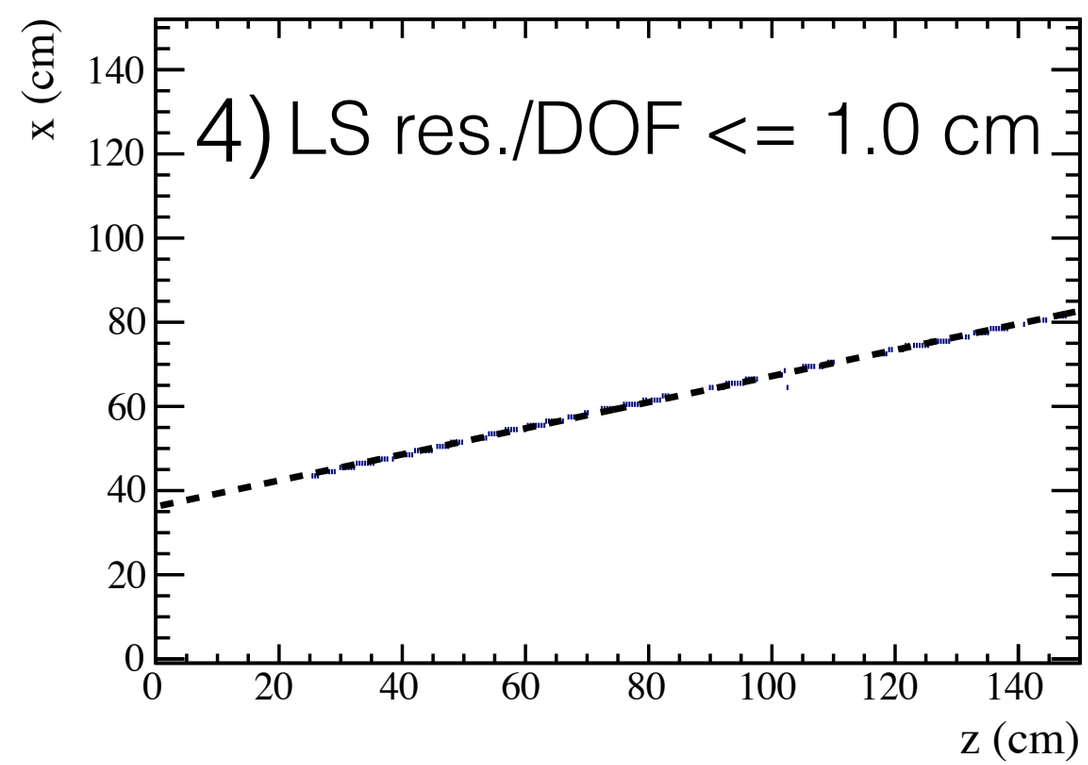
- Data: Runs 14531 to 14580. Split on EW trigger. Standard reco up to gaus hit. Uses dataprep noise removal routines
- MC: CRY EW counter sample. Standard reco. up to **gaus** hit
  - **Includes deconvolution**
  - **E field made the same as data**
- Selection (only uses collection plane hits in long TPC volumes):
  - Hits within counter shadow
  - Wire occupancy
  - Hits make straight line (LS residual/DOF <= 1.0 cm)
  - Delta counter number == 4 (highest stats in data)

Selection example: data



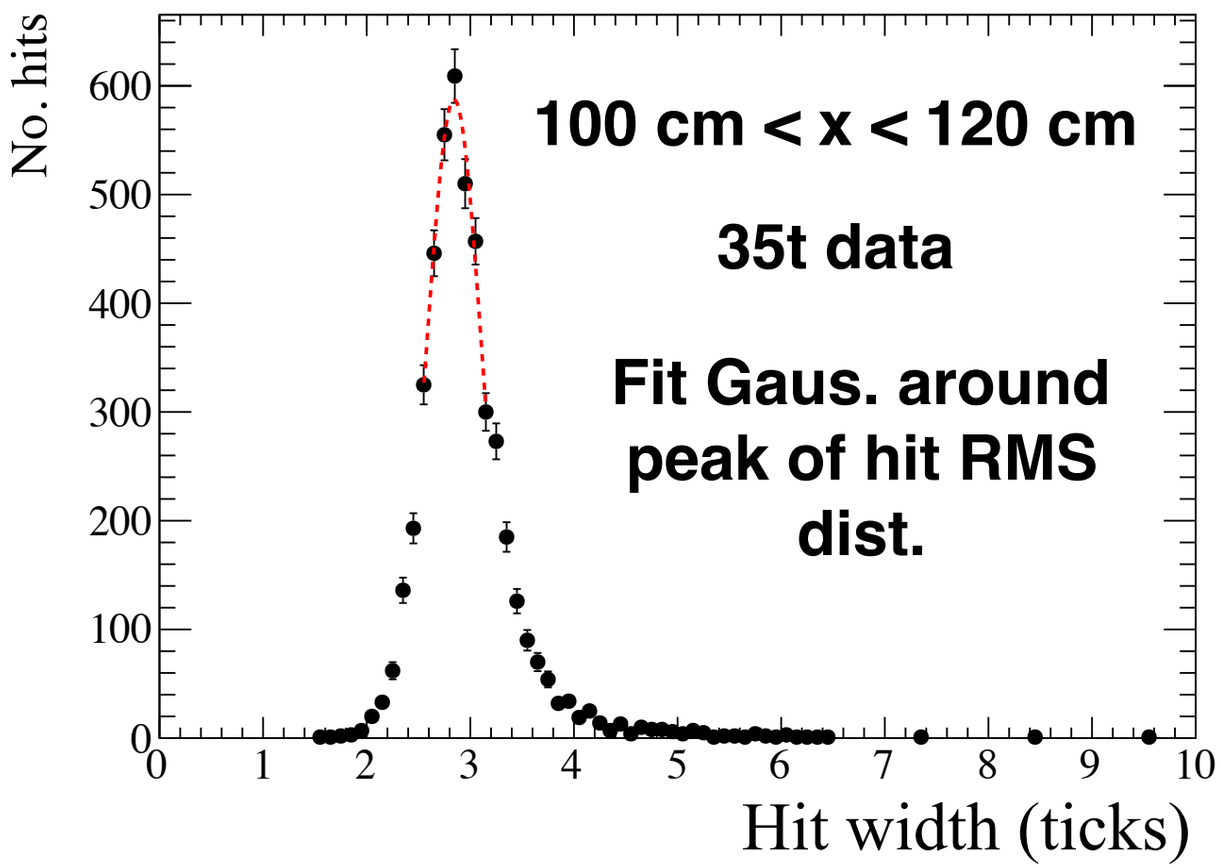




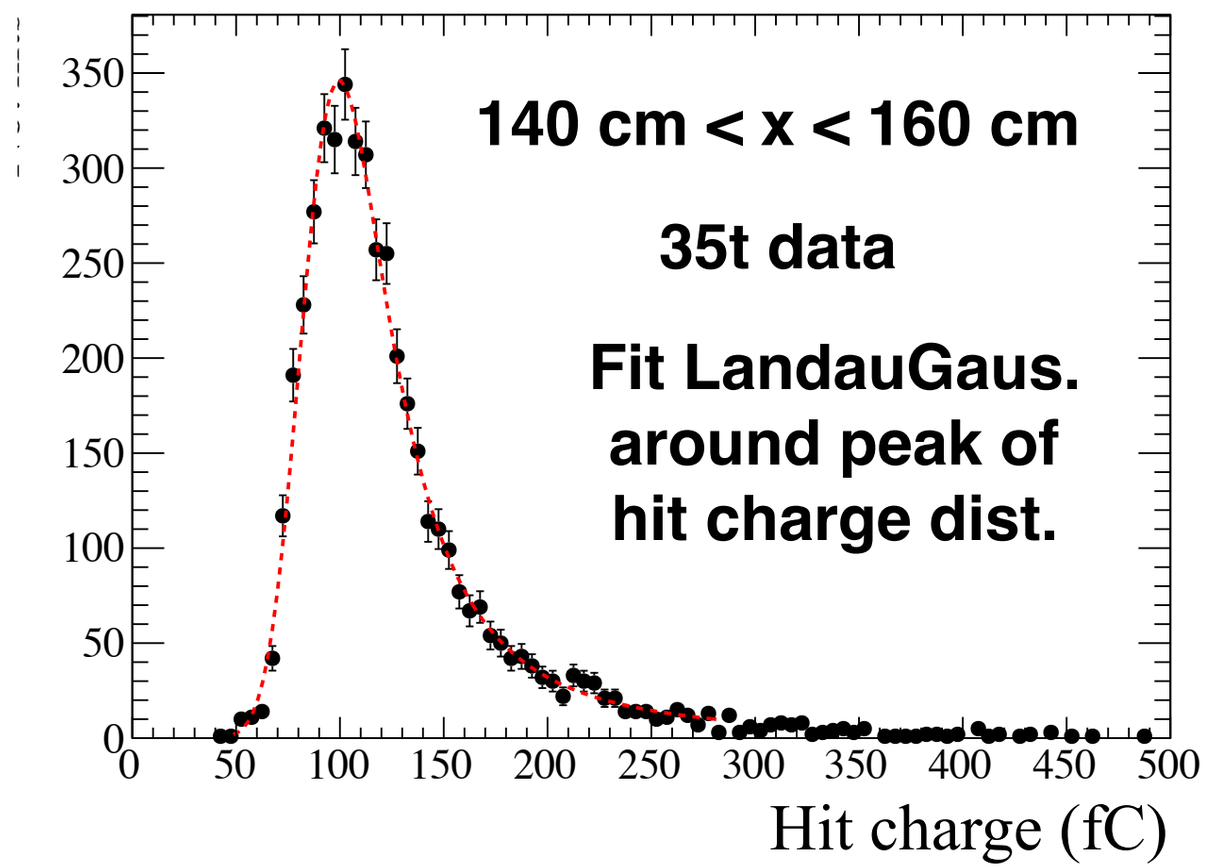


Getting to diffusion

Longitudinal diffusion

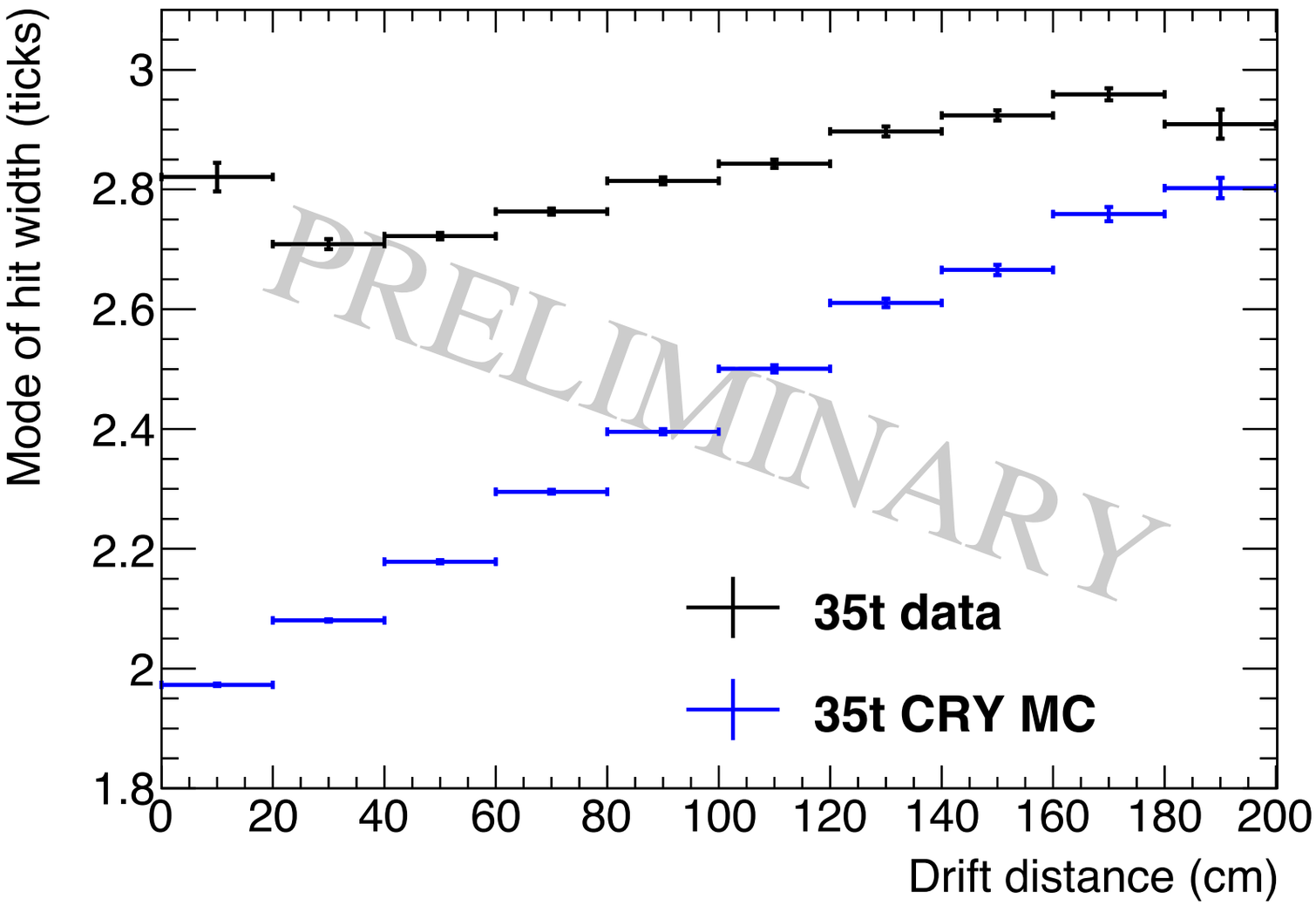


Transverse diffusion



- Separate the hits according to distance from APA (20 cm chunks from 0 cm to 200 cm)
  - Uses A. Booth's formula for calculating x

Could this still be long. diffusion?



Back of envelope gradient calculation

Data

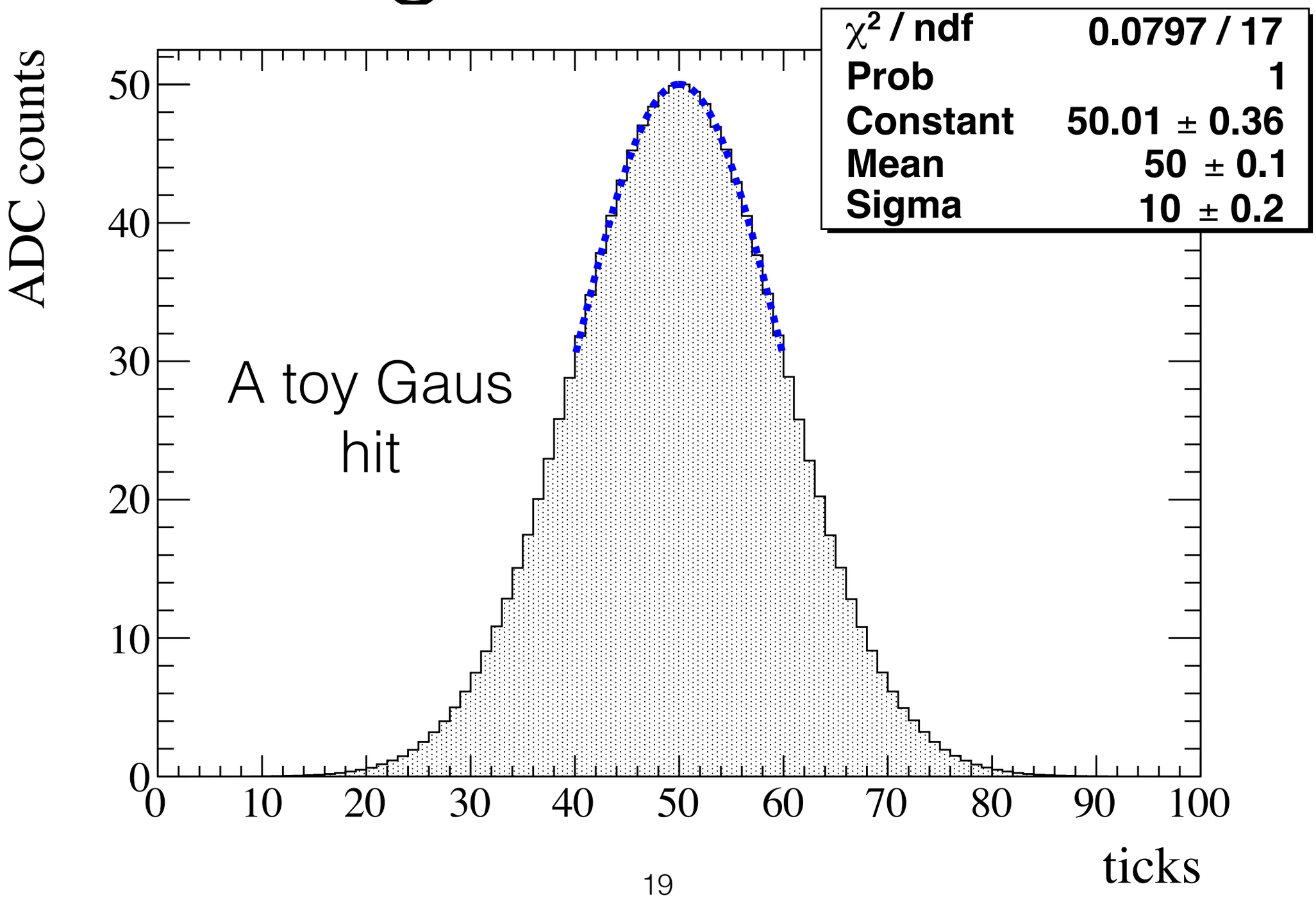
(3.0-2.6)/(190-10) = 0.002 ticks/cm

MC

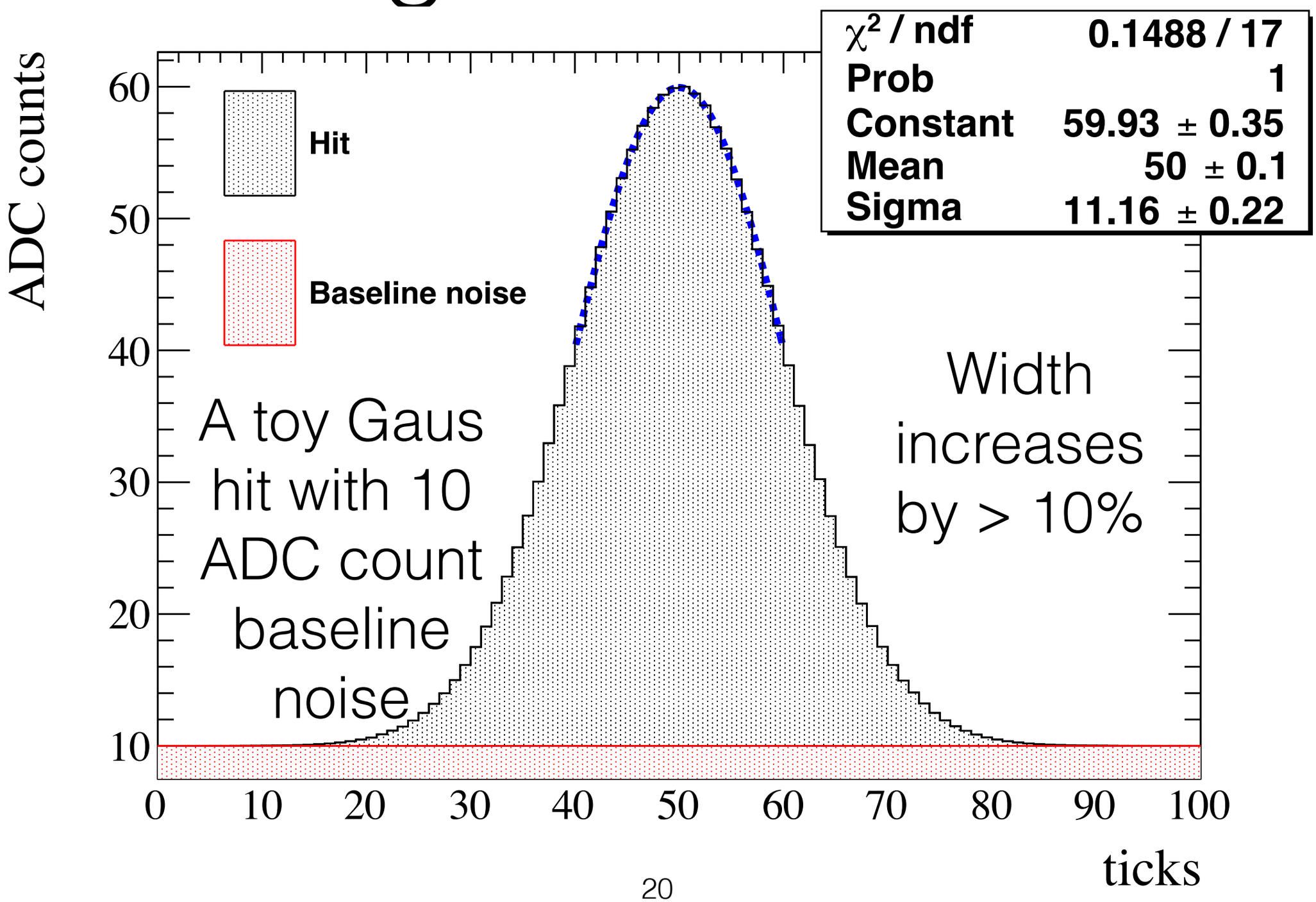
(2.8-2.0)/(190-10) = 0.004 ticks/cm

- At x=0cm, there should be minimal long. diffusion effects, so in 35t data the intrinsic width is ~2.6 ticks. This is notably higher than MC. Noise is very possibly the cause of this
  - The higher normalisation in data potentially comes from noise
- Slope of both distributions SHOULD be proportional to long. diffusion effects. Data slope is lower than MC
- **Possible** conclusion, we overestimate longitudinal diffusion in MC but our pulses are intrinsically wider in data

Can correlated noise change the hit width?

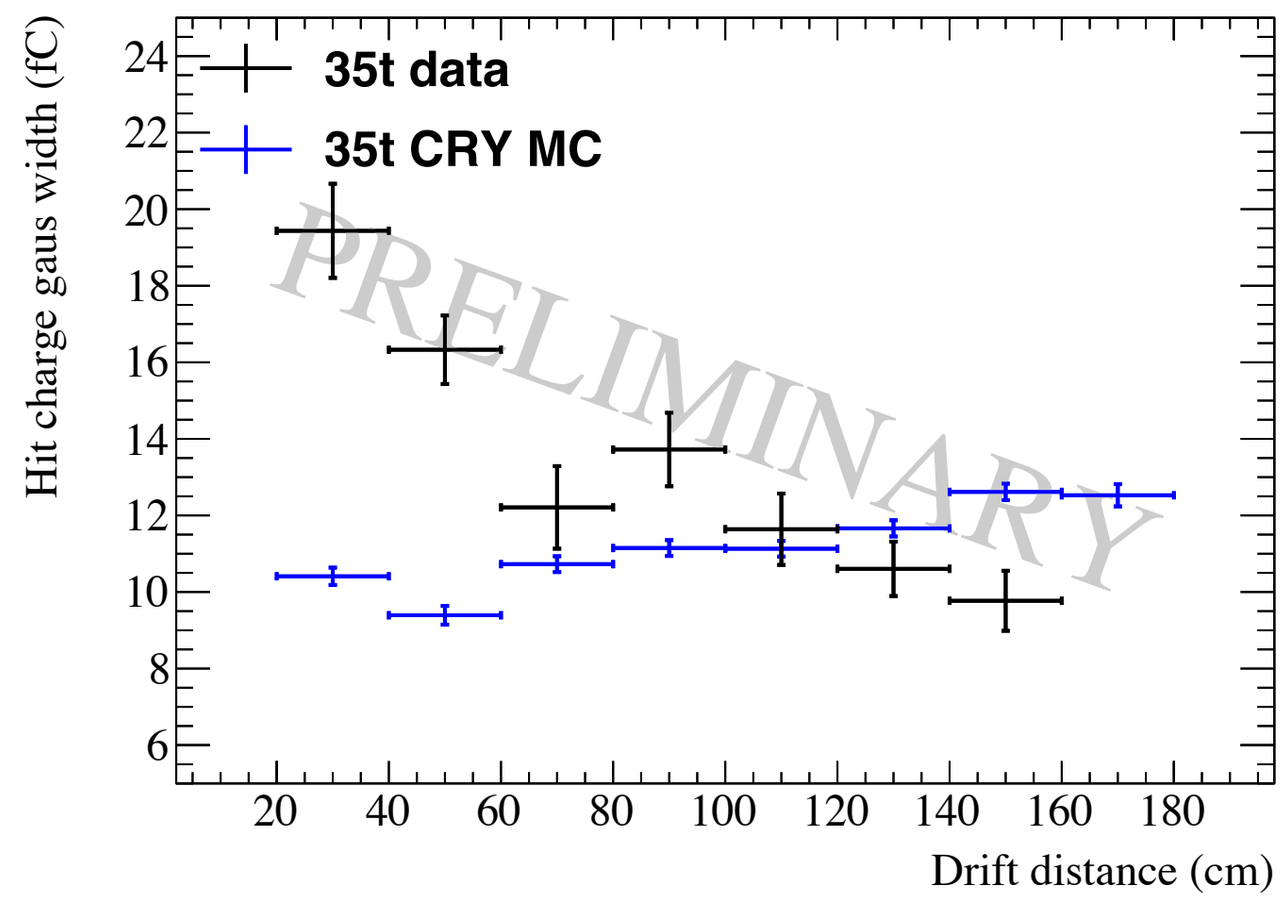


Can correlated noise change the hit width?

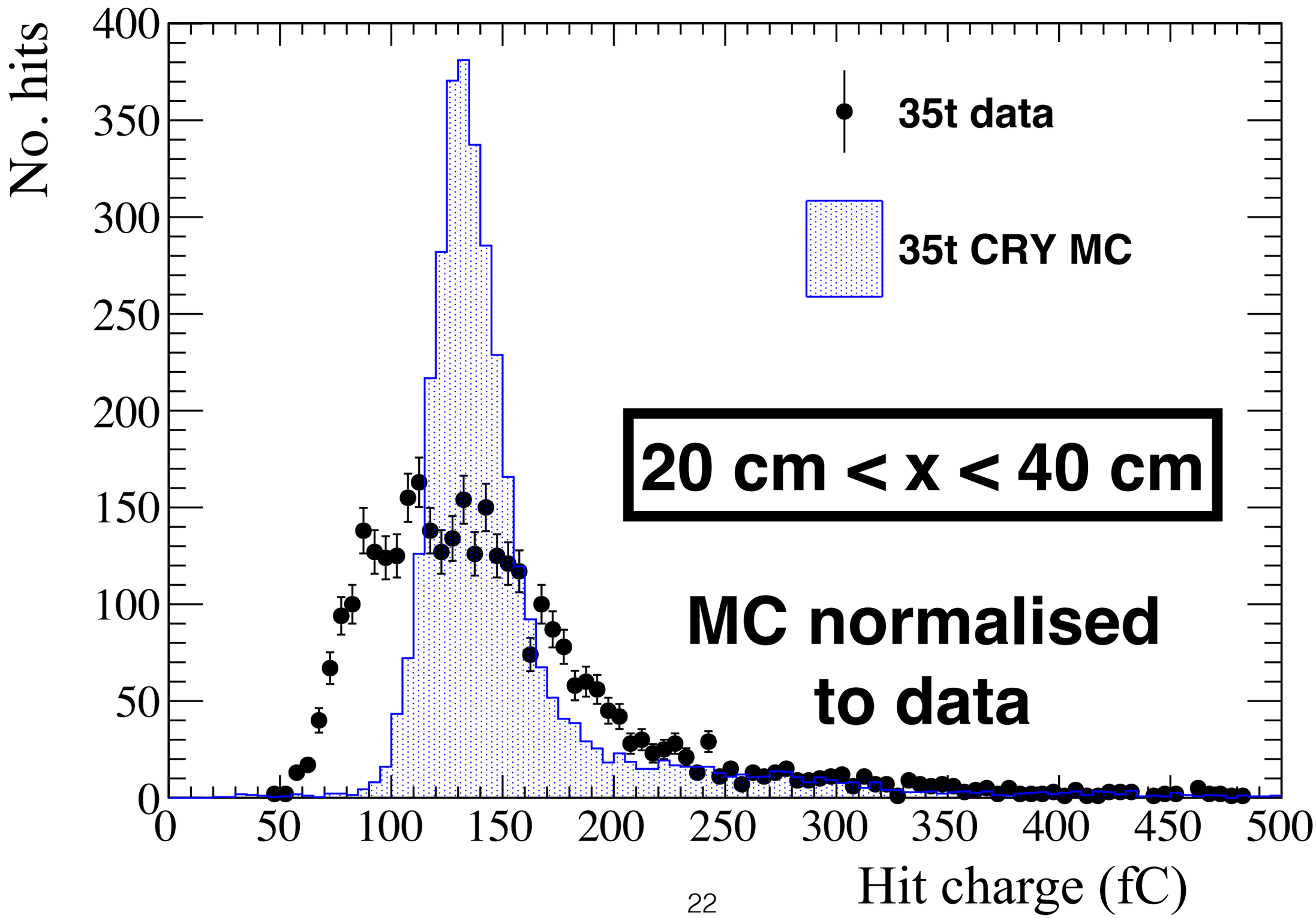


Could this still be trans. diffusion?

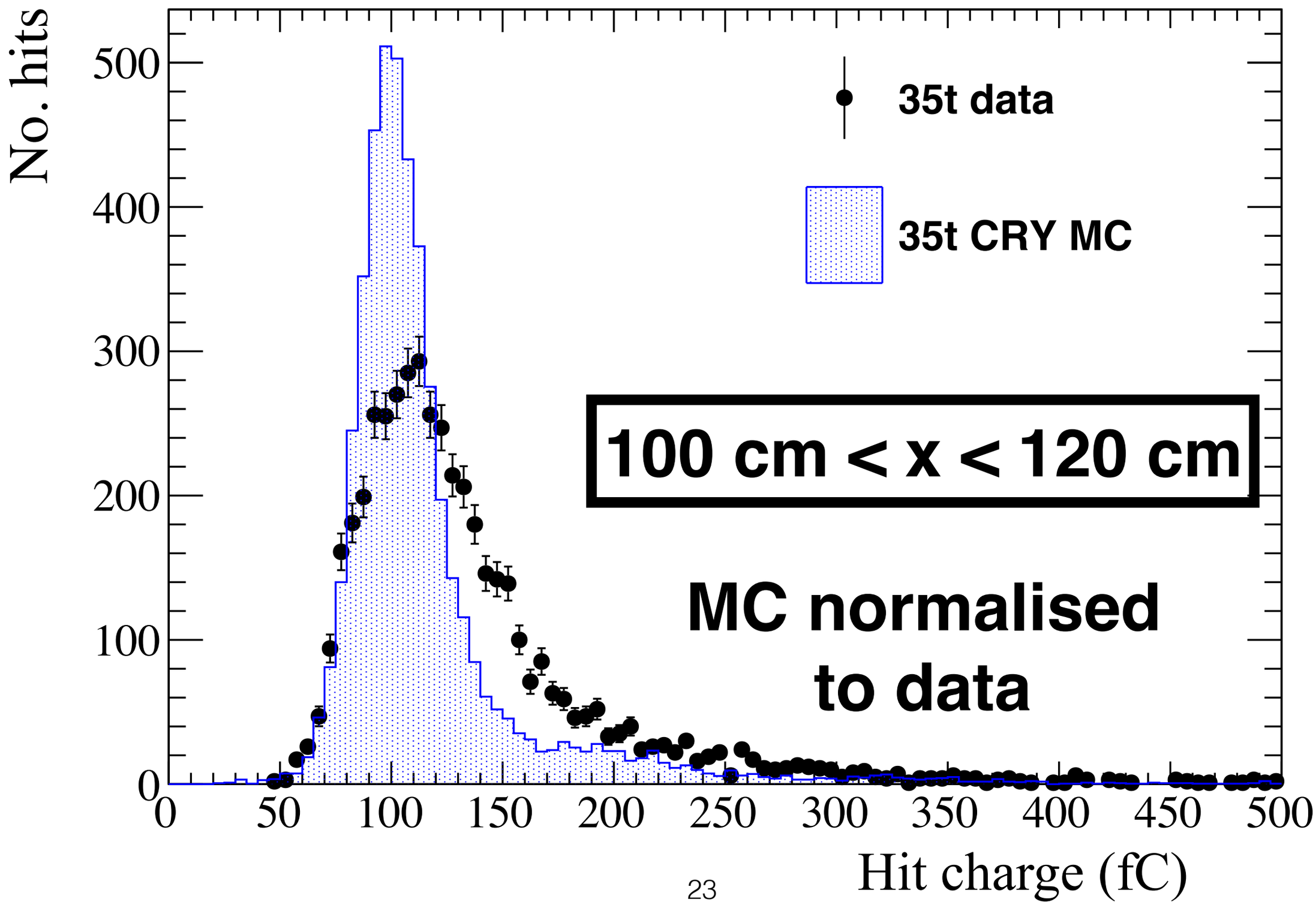
- A lot more difficult to draw conclusions
- I'm not sure how to explain the Gaus. width decreasing with distance…
- One possible explanation is the high pulse height requirement to form a hit could be eating into the lower end of the charge distribution



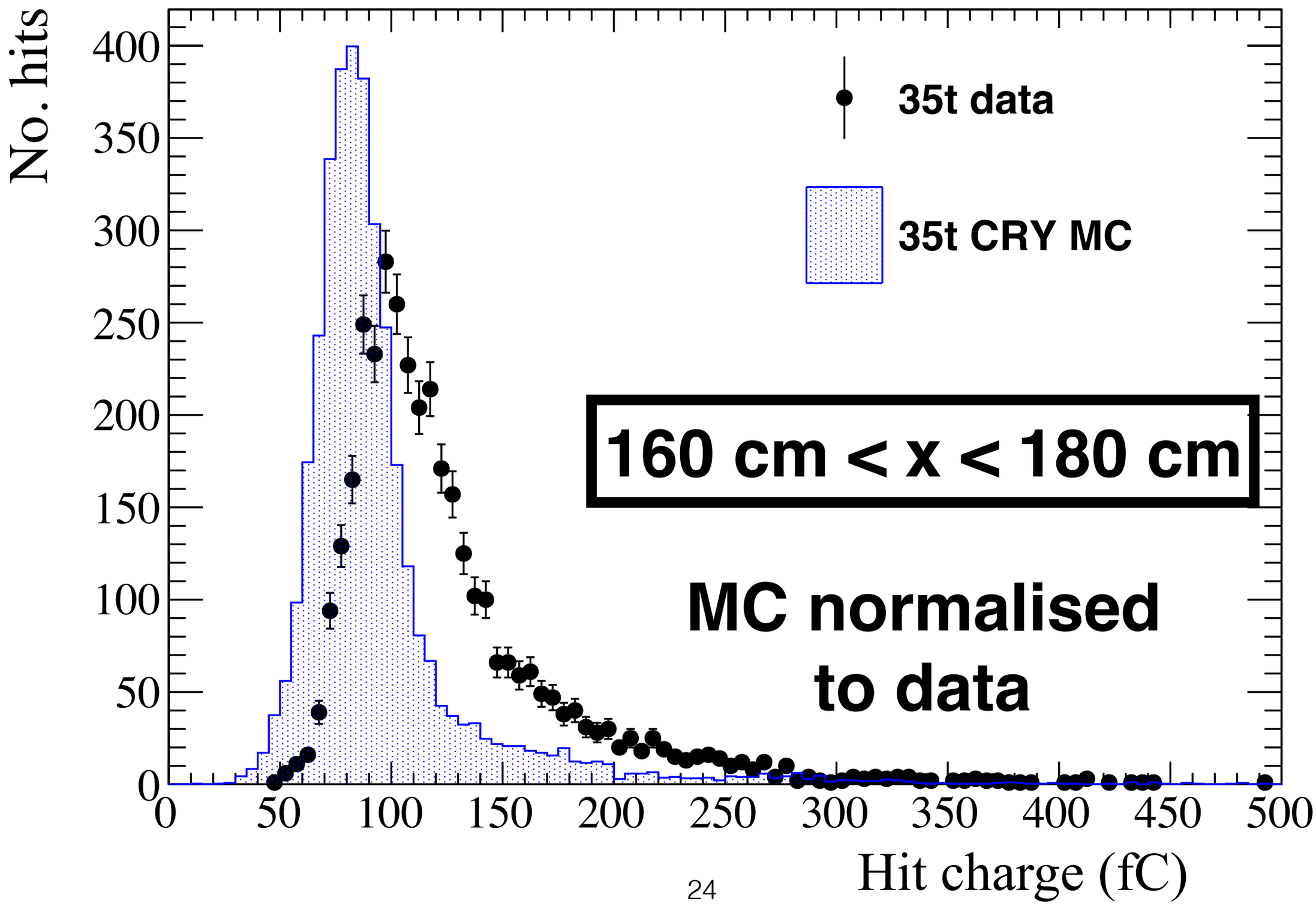
The hit charge distributions



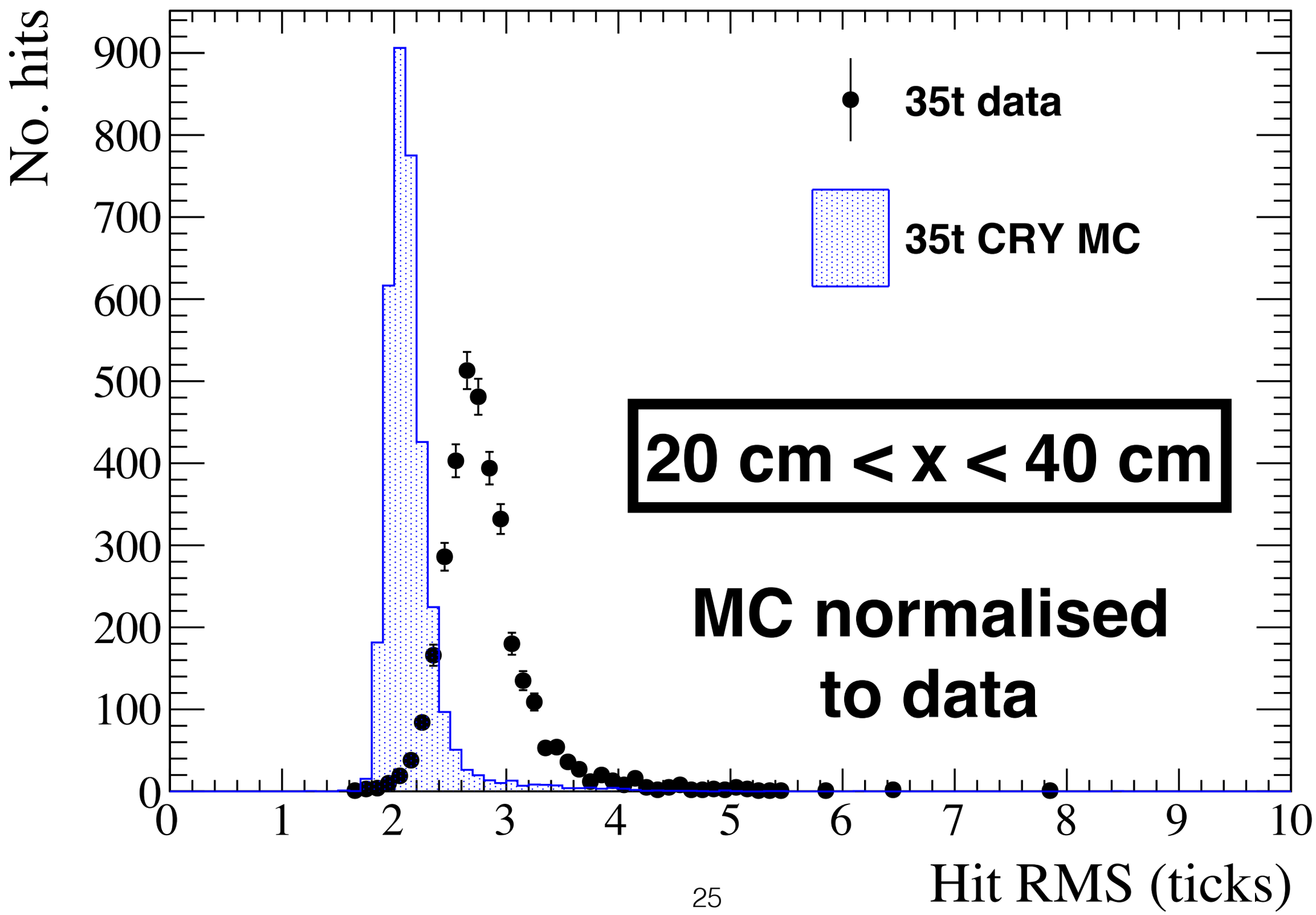
The hit charge distributions



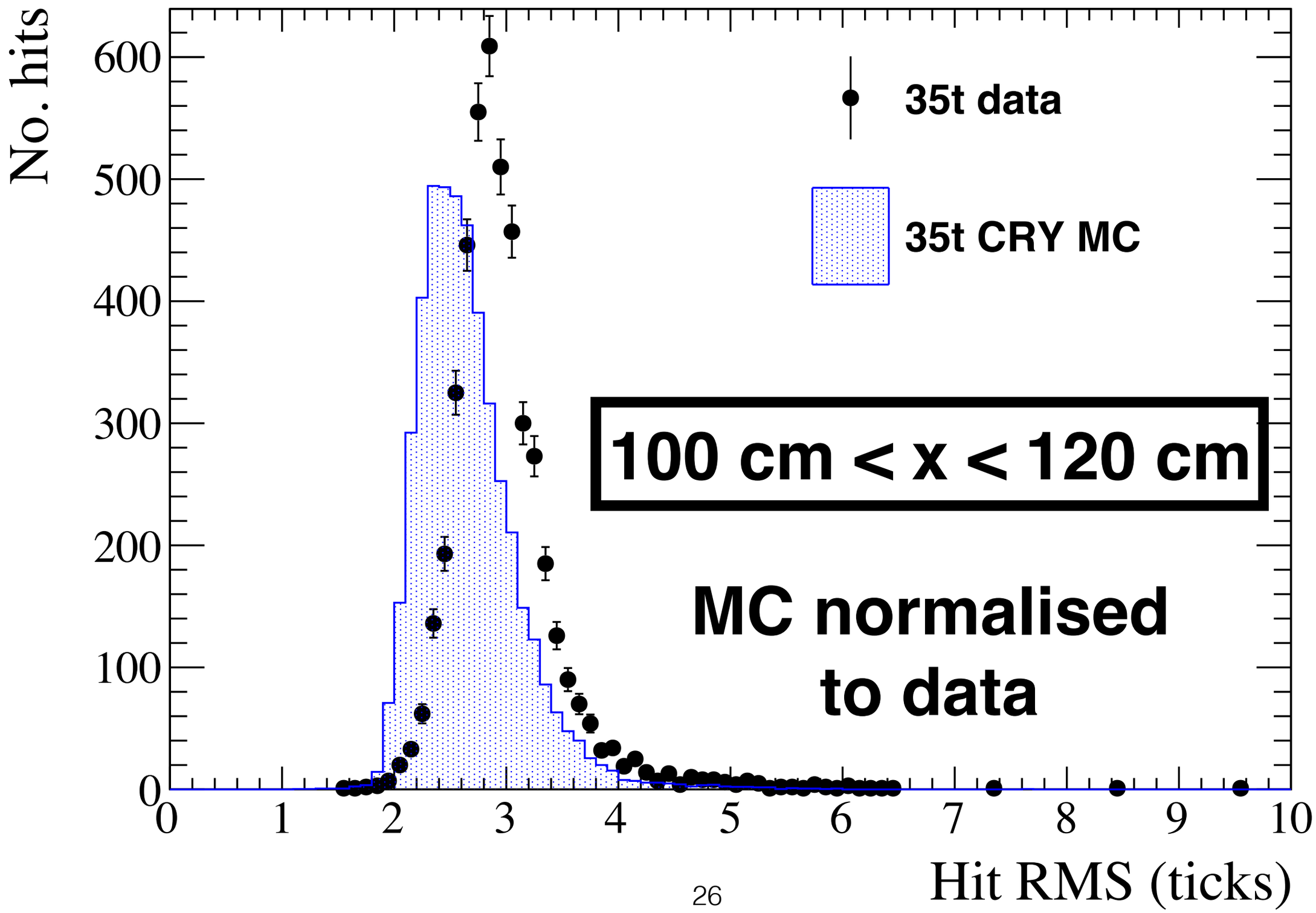
The hit charge distributions



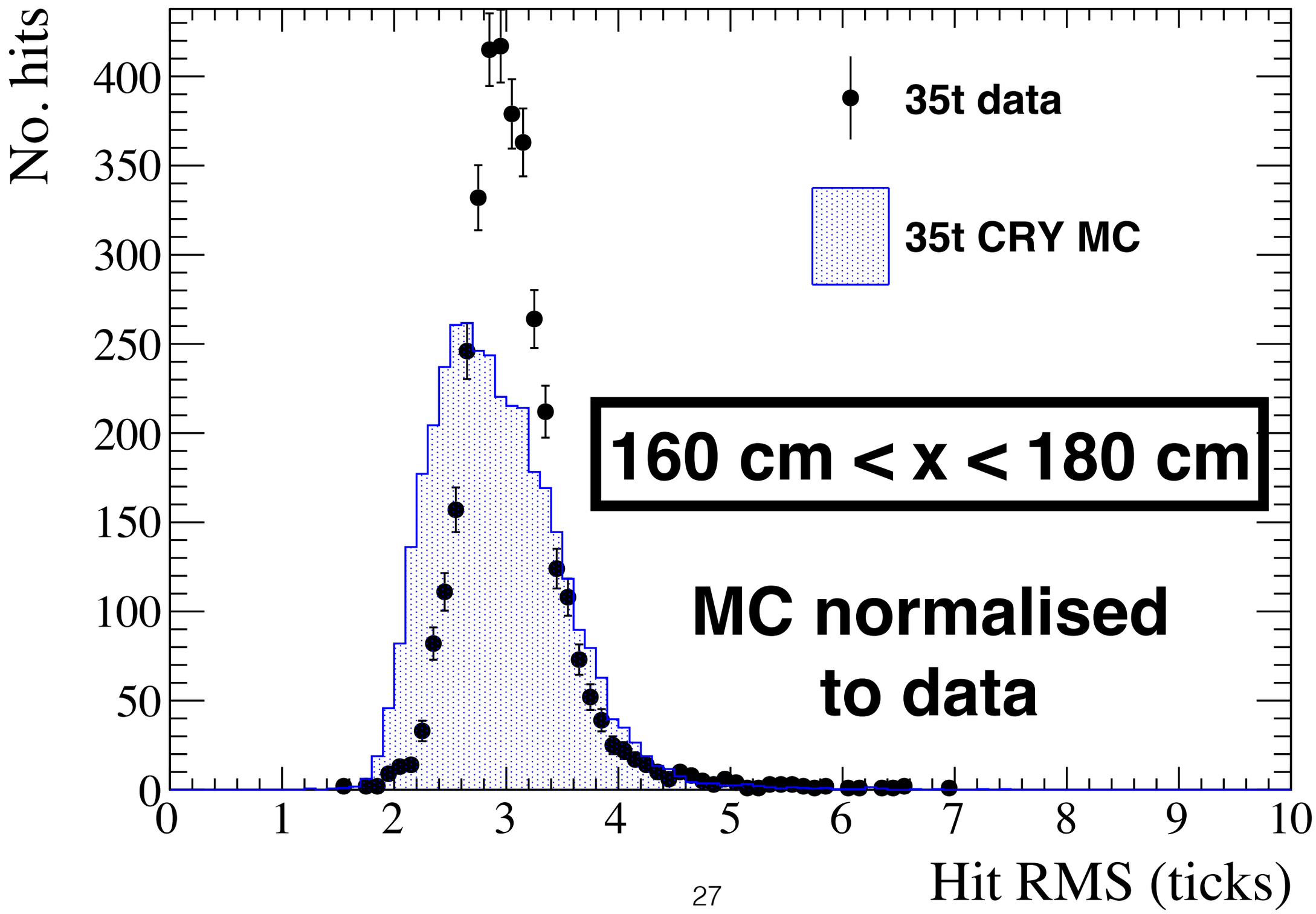
Hit RMS


No. hits
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
Hit RMS (ticks)
35t data
35t CRY MC
20 cm < x < 40 cm
MC normalised
to data

Hit RMS

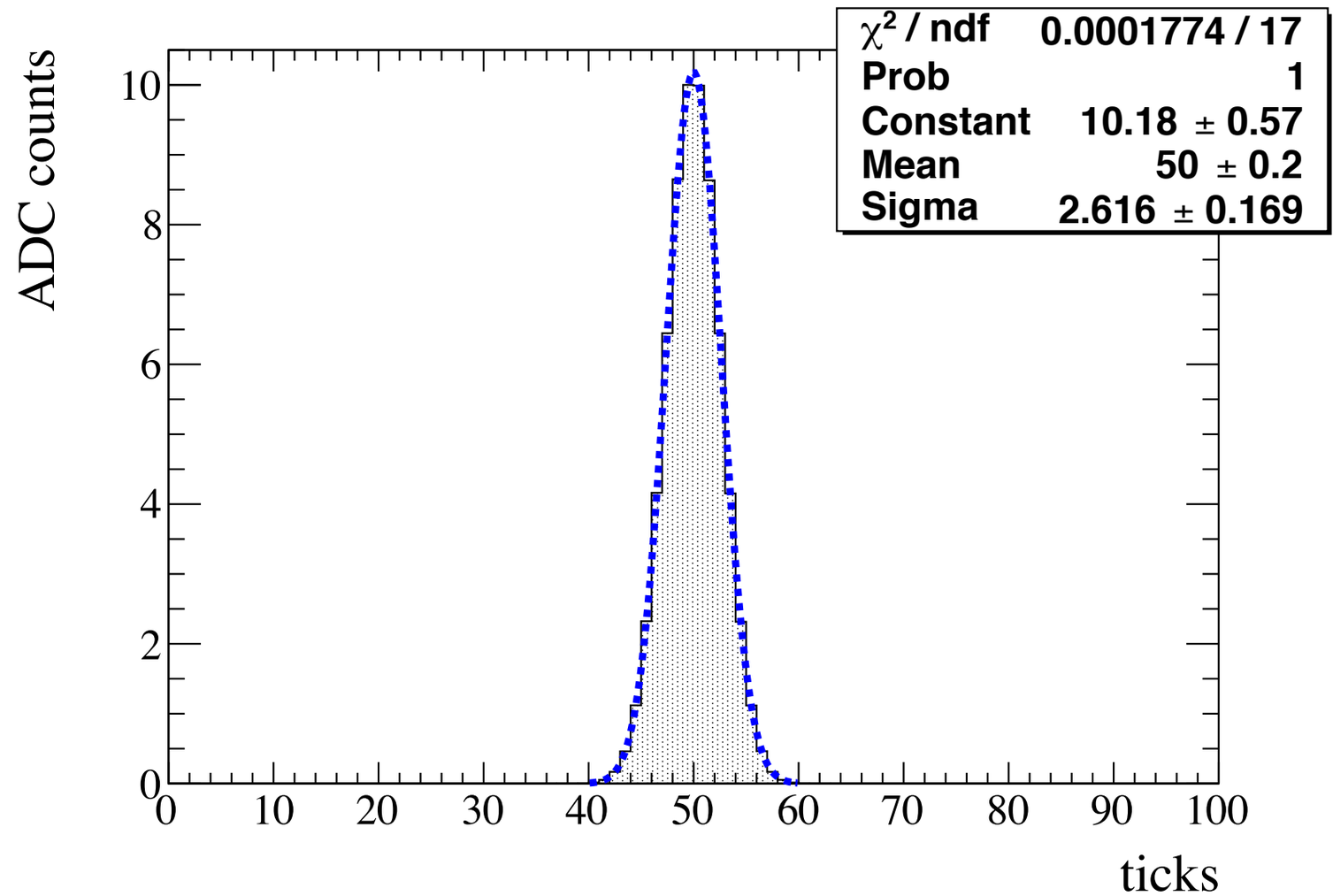

No. hits
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
Hit RMS (ticks)
35t data
35t CRY MC
100 cm < x < 120 cm
MC normalised
to data

Hit RMS


No. hits
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
Hit RMS (ticks)
35t data
35t CRY MC
160 cm < x < 180 cm
MC normalised to data

Could the pulse height threshold be killing the hits?

- Make another toy hit
  - Make the height 10 ADC counts (data pulse height threshold)
  - Make the width the same as data for low drift distance (2.6 ticks)



- **Integral is 66 ADC counts**