ND280 HA-TPC ANALYSIS

Sergey Suvorov

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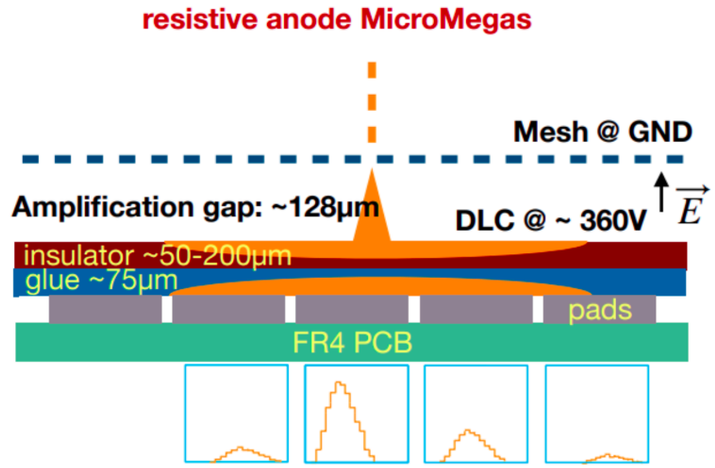
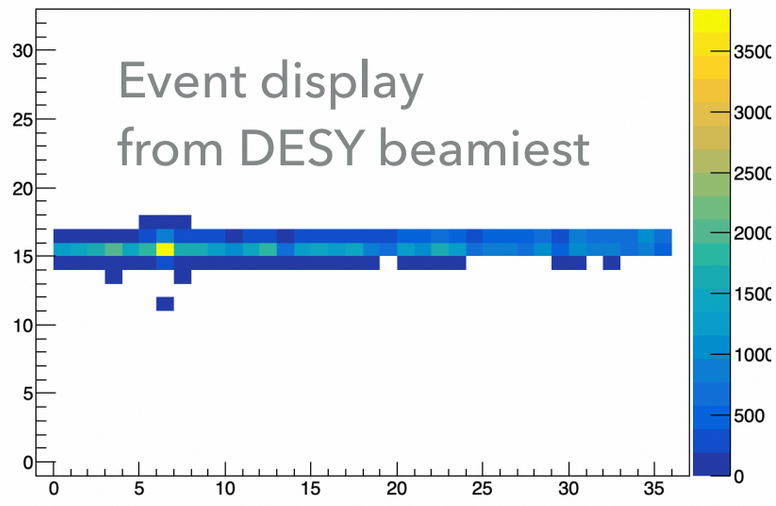
OUTLINE

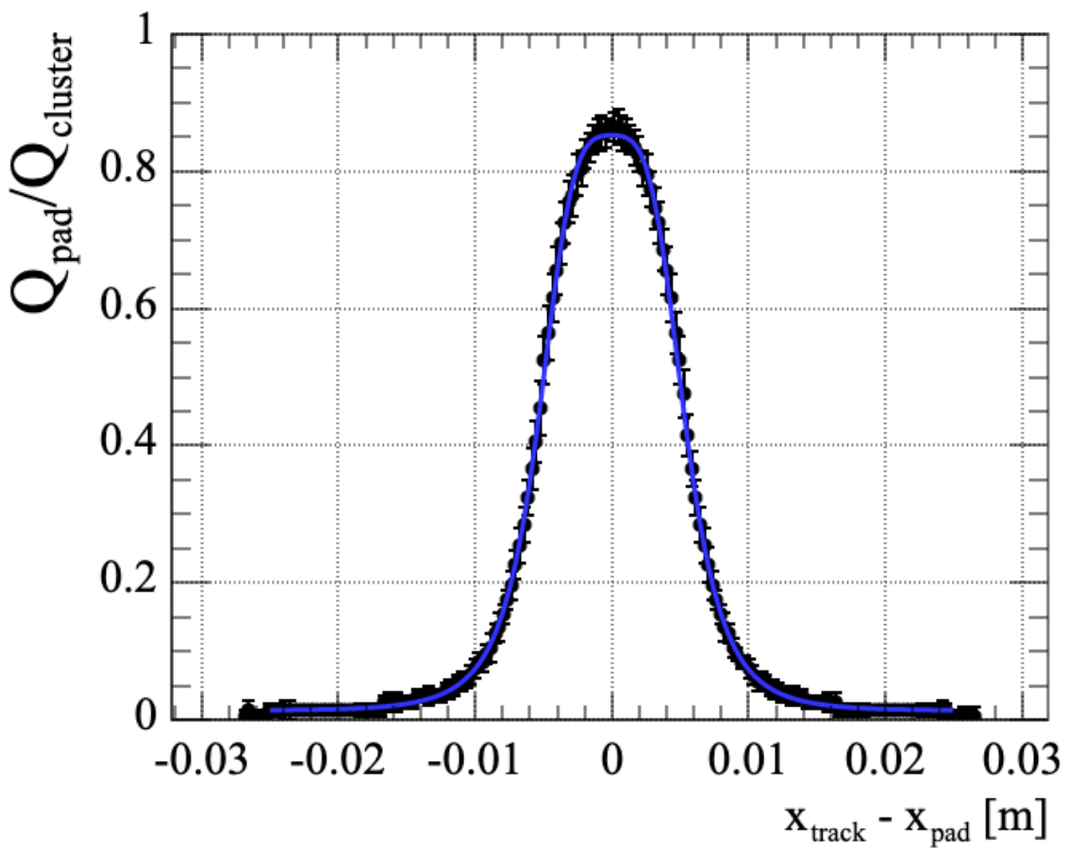
- Spatial resolution analysis of the prototype and beyond
  - Recent findings
  - Inclined tracks fitting
- Recent results of the prototype analysis
  - Anomalies in the Saclay prototype tests
- HA-TPC reconstruction work

SPATIAL RESOLUTION ANALYSIS

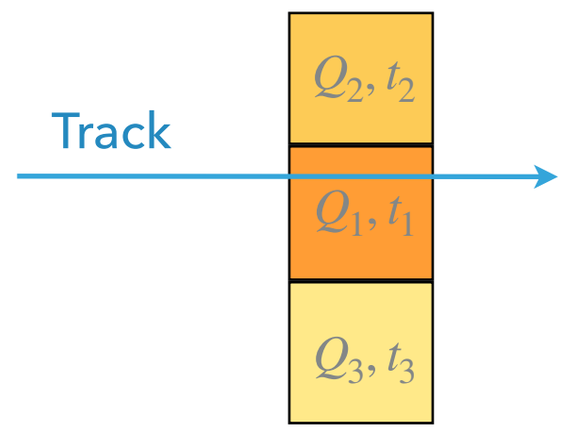
- Analysis of the prototype data was one of the main part of my thesis
- I've implemented a track resolution procedure based on the Pad Response Function (PRF)
- PRF describes charge fraction $Q_{pad}/Q_{cluster}$ over the track position w.r.t. pad
- PRF was used to reconstruct track position based on the measured charge fractions





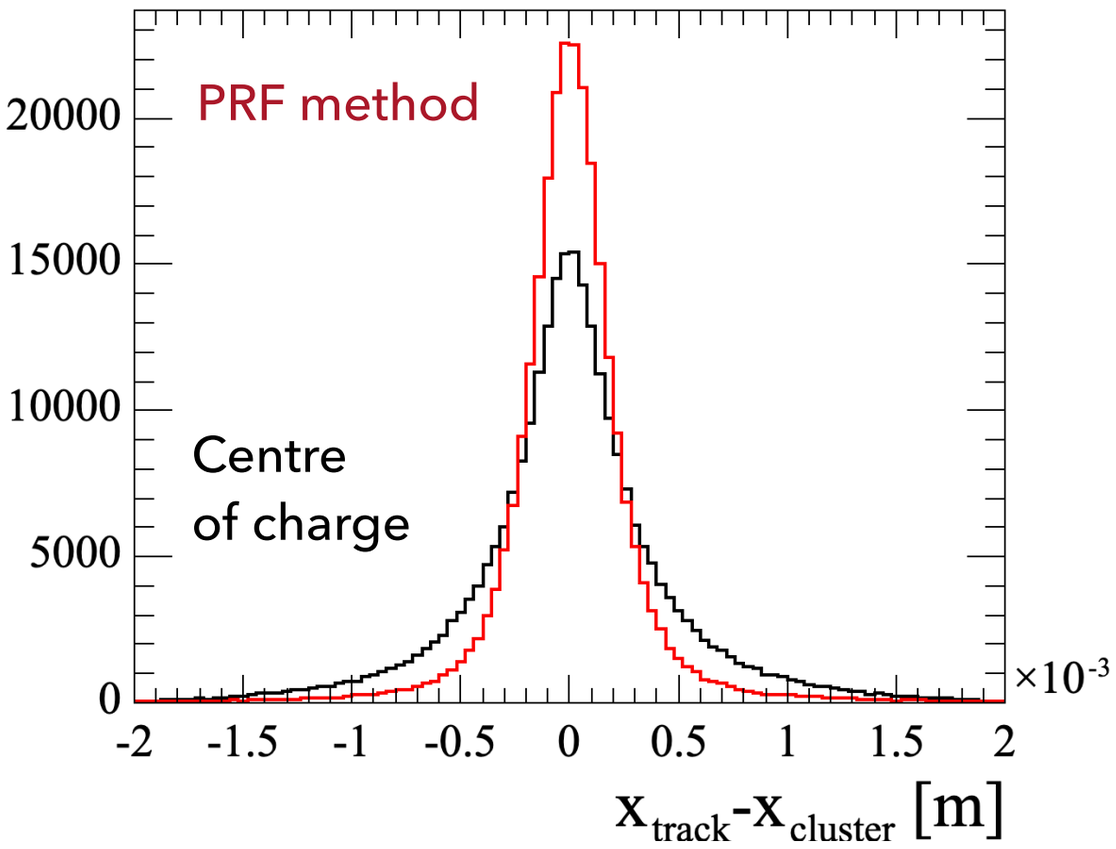


Charge sharing



SPATIAL RESOLUTION ANALYSIS

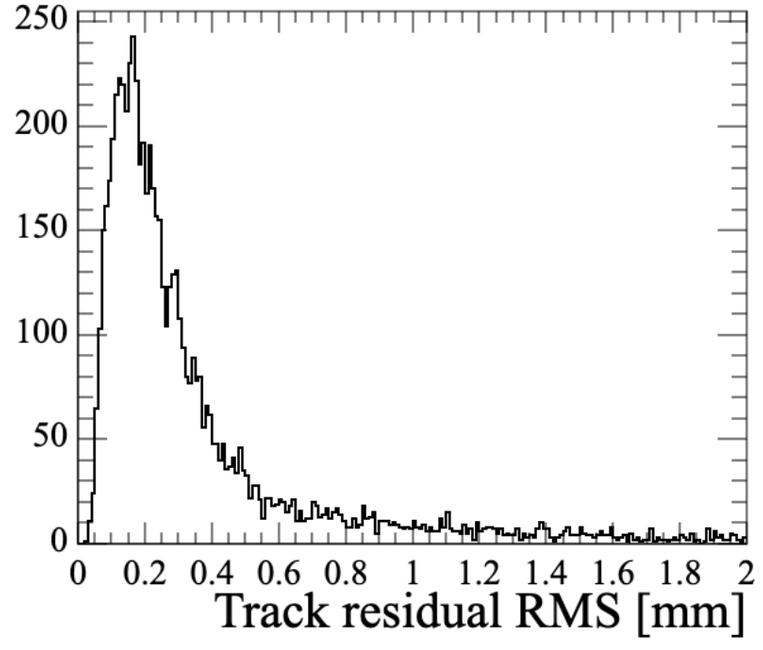
- Based on known PRF the track position in the cluster is extracted
- All the clusters are fit together to form a track
- The difference between the global fit result and fit in the particular cluster gives residuals
- The sigma of the residual defines the resolution



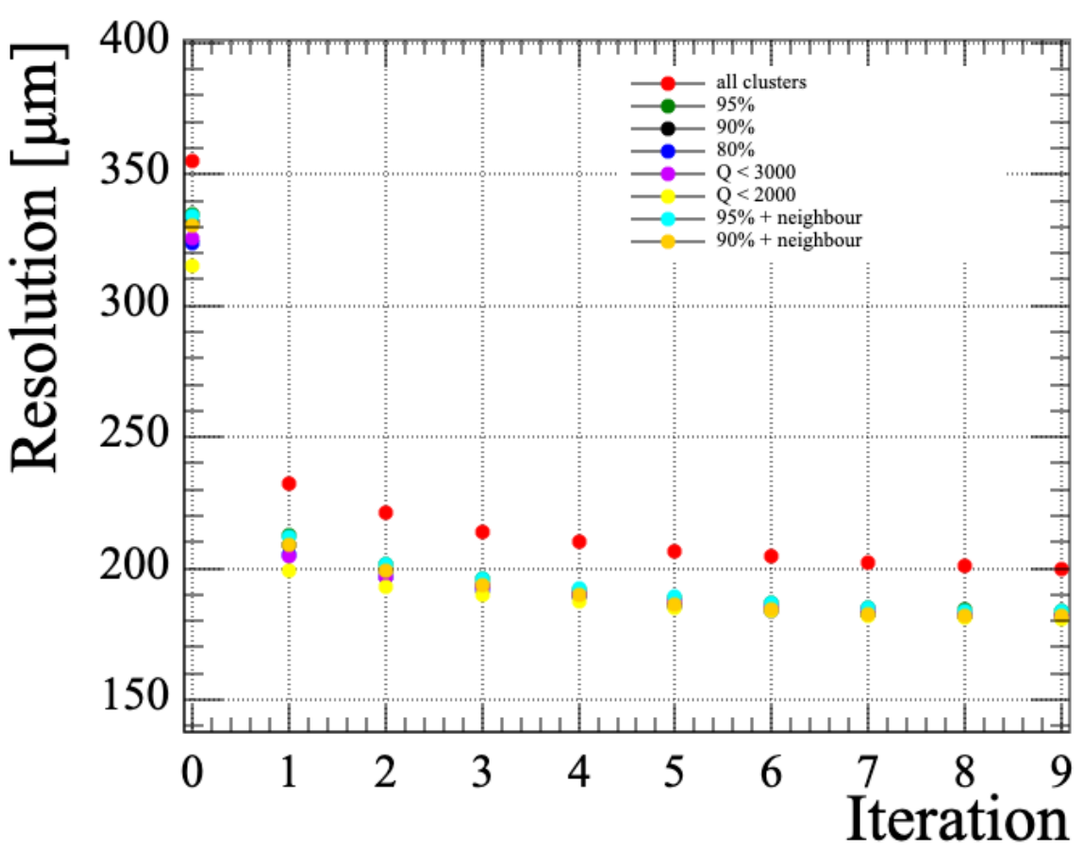
- PRF method was proved to improve the precision

SPATIAL RESOLUTION. RECENT FINDINGS.

- Different method of the resolution estimation was proposed
  - Take an RMS of 36 residuals per track
  - Tails towards high RMS values were observed
  - Inspired to look in details at “suspicious” tracks
  - Many of them were a subject of charge fluctuations
- Perform the analysis with omitting of:
  - Some fraction of high energetic clusters
  - Clusters above the certain threshold

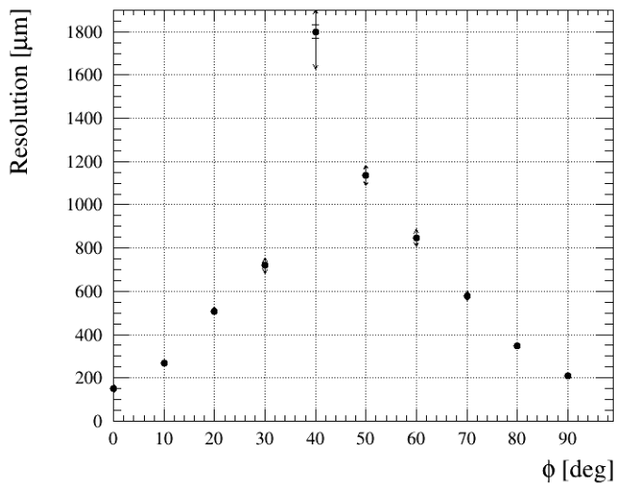


- The improvements was found
  - Omitting just 1-2 clusters gives the same result as omitting ~30% of clusters
  - Results with different cut converges
  - Further improvements may be limited by method/detector

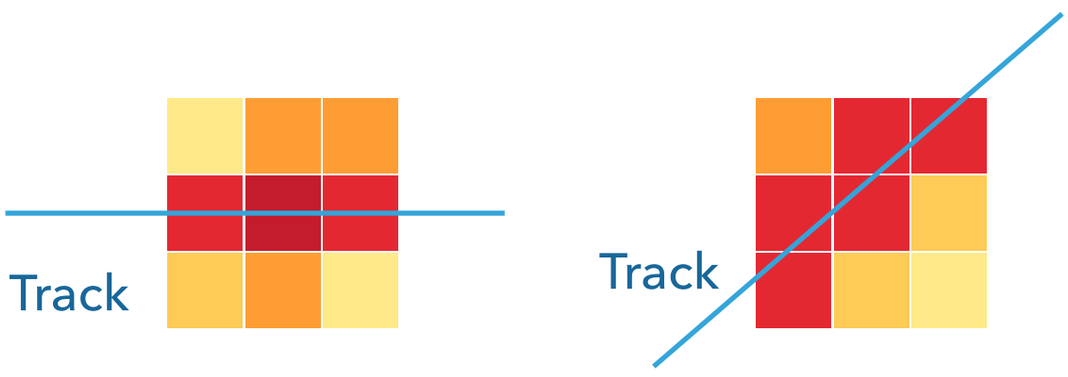


SPATIAL RESOLUTION. INCLINED TRACKS

- PRF method can be applied to the inclined tracks
- For each cluster it's decided if it's vertical or horizontal and the proper cluster is fit
- Conservative limit on the oblique tracks was set

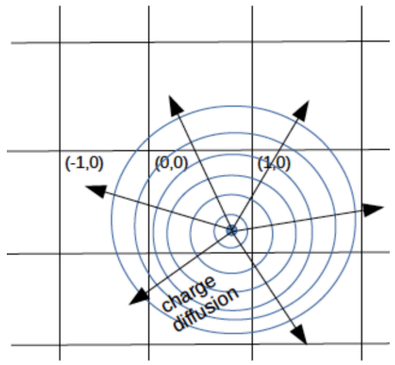


- The problem:
  - For horizontal track only transverse spreading was used
    charge deposition fluctuation is not affecting measurements
  - For oblique tracks longitudinal fluctuations charge fluctuation start play an important role

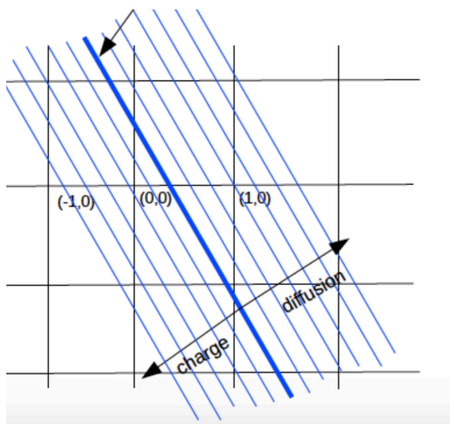


SPATIAL RESOLUTION. INCLINED TRACKS

- Few approaches were considered:
  - Use time information instead/in addition to charge,
    time delay is not affected by fluctuation as charge
    not easy to extract a precise time measurement from a waveform
  - Use a likelihood based approach for 3x3 or 5x5 pads regions
    analytical solution for charge spreading is known
    electronics contribution to signal need to be understood in this approach



$$Q(r,t) = \frac{RC}{2t} e^{-\frac{r^2 RC}{4t}}$$



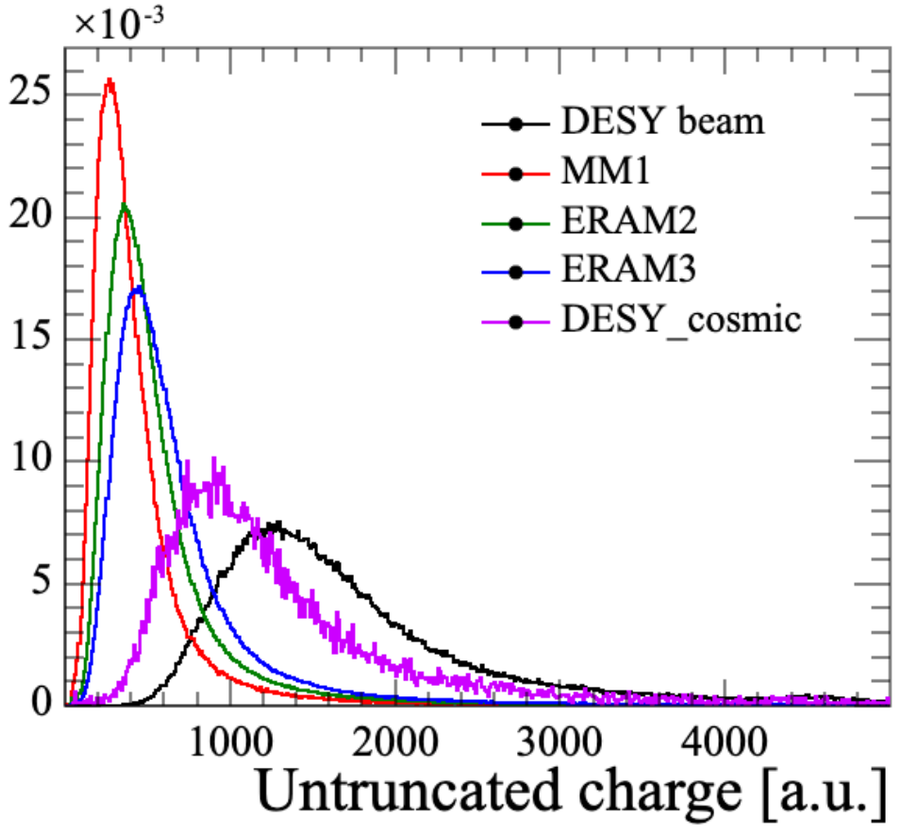
$$Q(x,t) = \sqrt{\frac{RC}{4\pi t}} e^{-\frac{x^2 RC}{4t}}$$

- Other possible corrections procedures are under discussion with Pierre

SACLAY PROTOTYPES

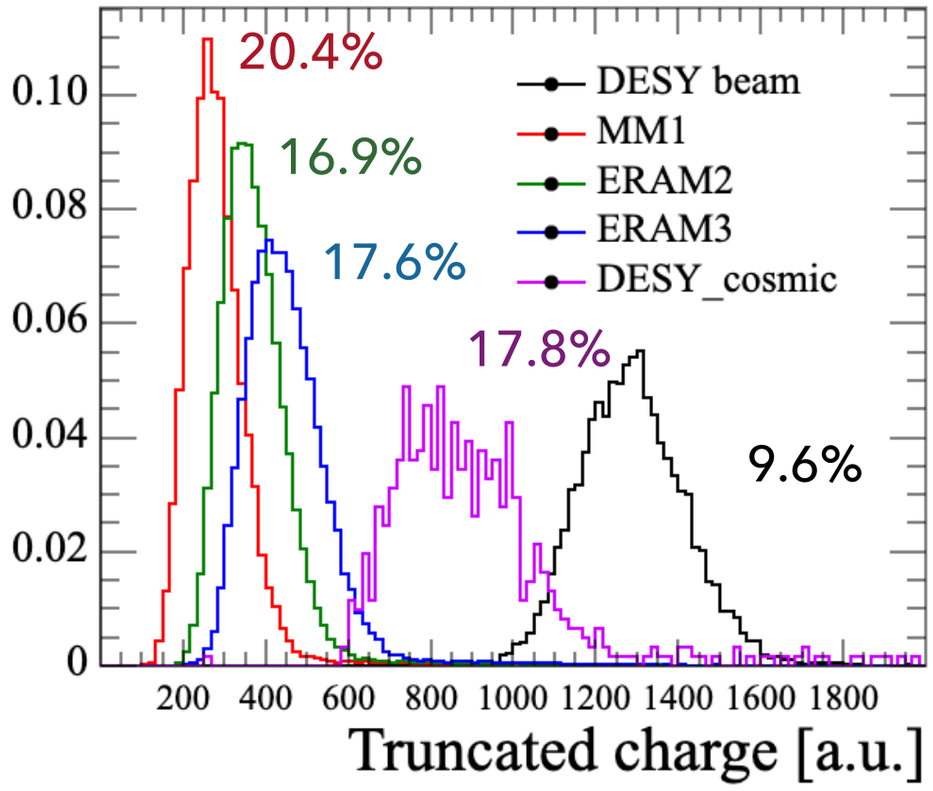
- Since DESY test beam new detectors (ERAM) with larger spreading were produced and studied at Saclay with cosmic
- Few anomalies were found in the data

- The charge significantly lower comparing to DESY test
  - Charge from MIP and electrons is consistent in DESY
  - Signal from MIP in Saclay is dramatically lower



360V
Area
norm to 1

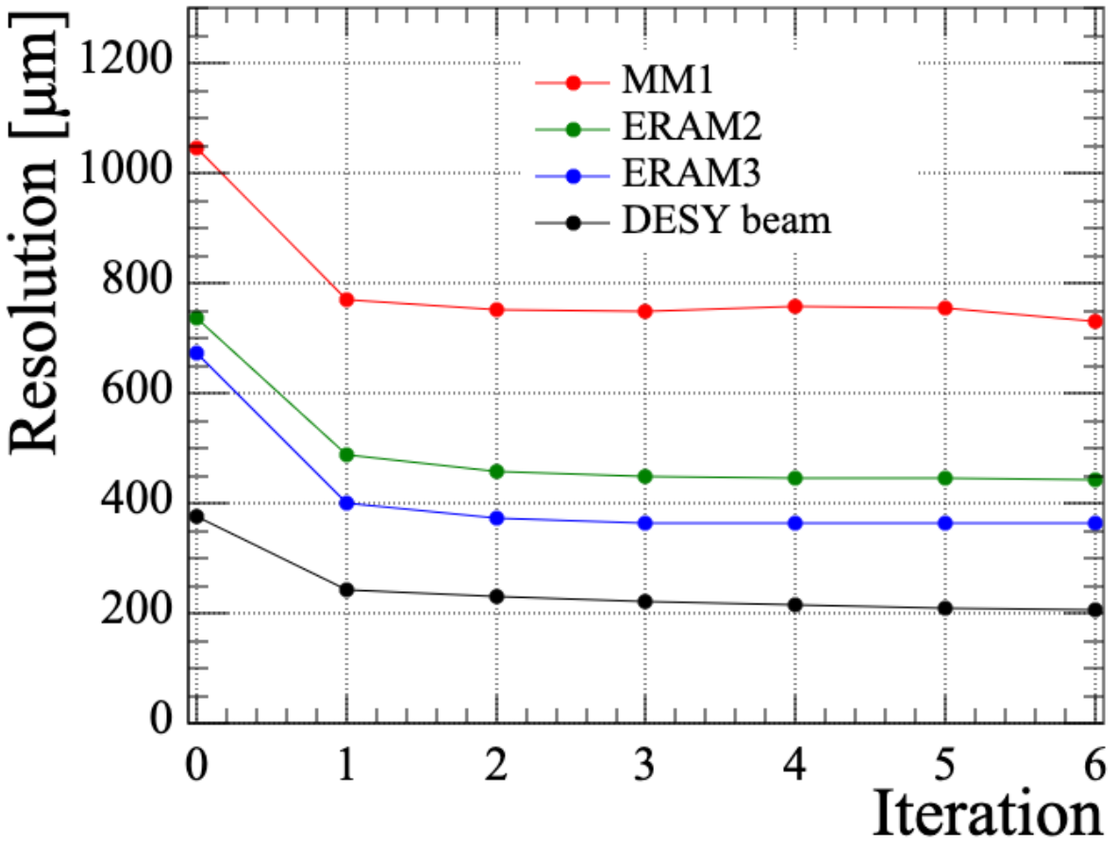
dE/dx resolution



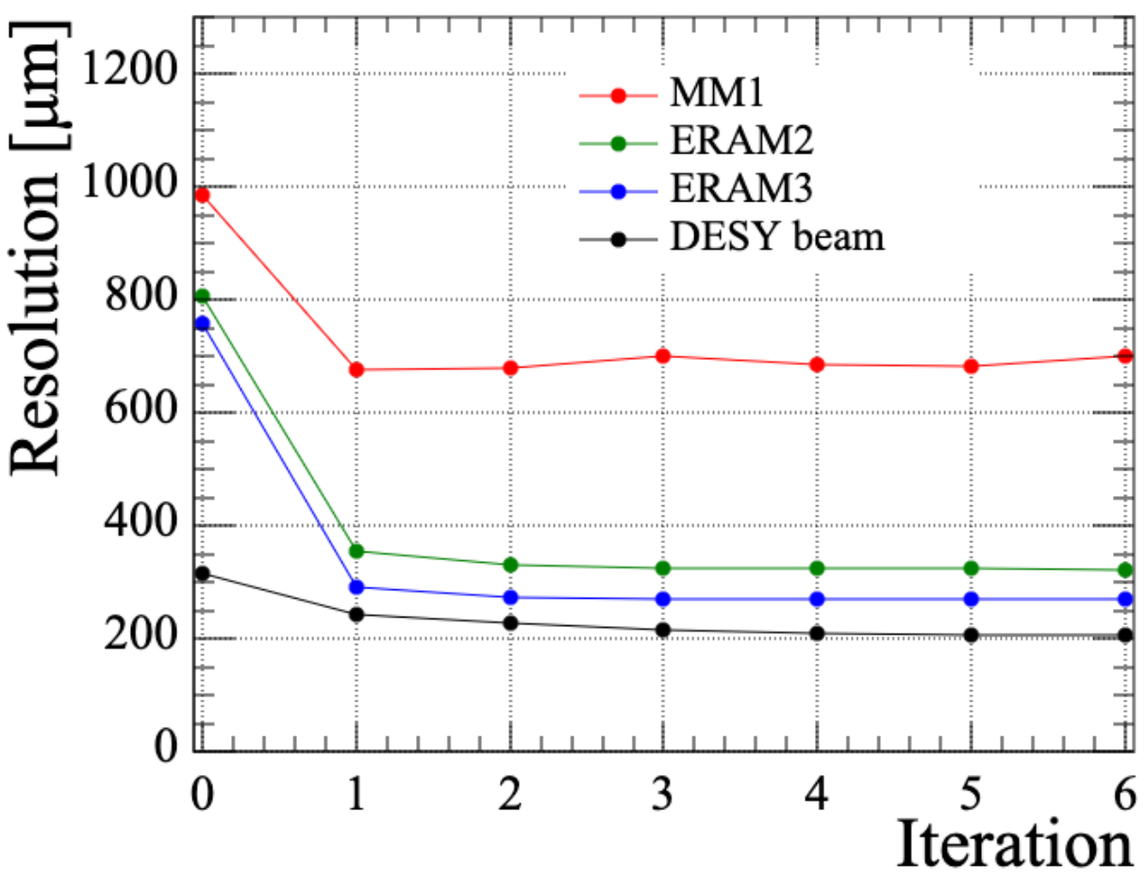
SACLAY PROTOTYPES

- Spatial resolution in the Saclay prototypes was worse, comparing to expectations from DESY beamiest
- The large difference between Centre of Charge and PRF for ERAM is not understood
  - With larger charge spreading we expect mean charge method to work better

360 V

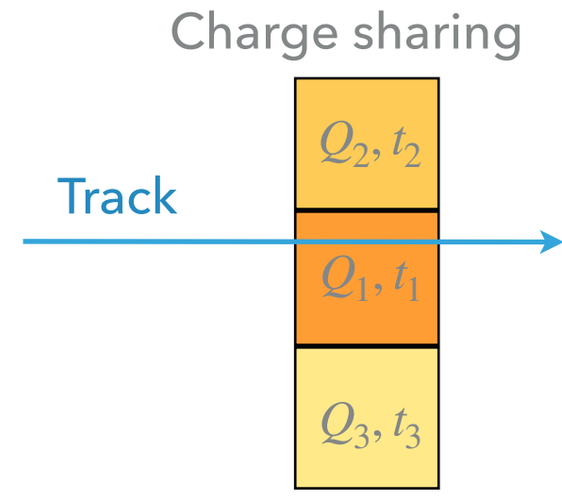


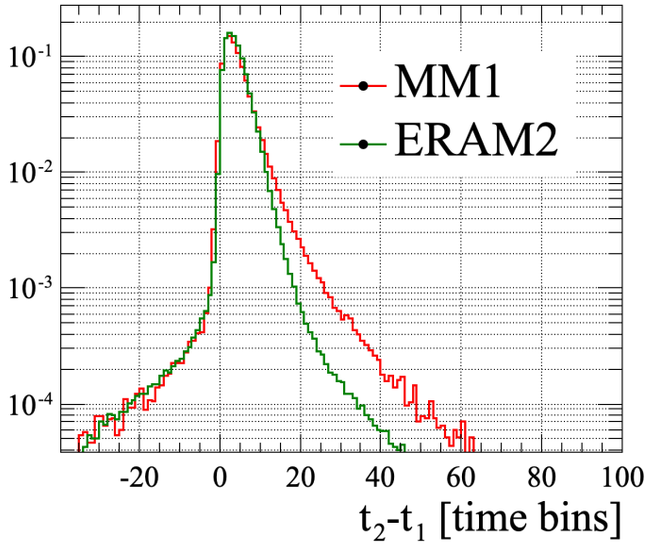
380 V

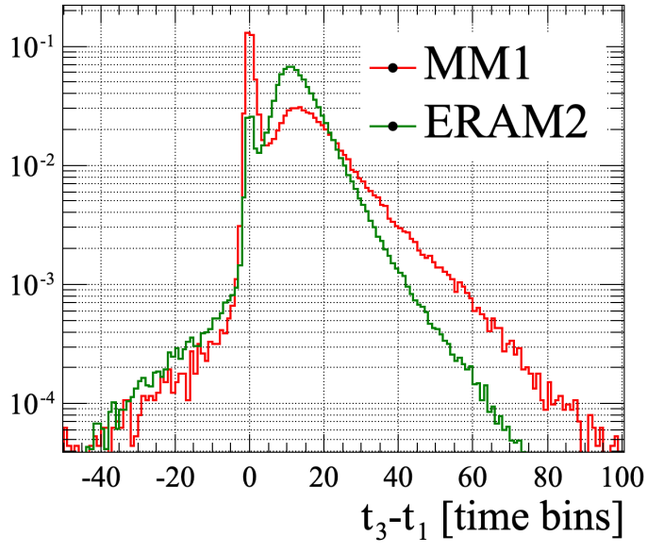


SACLAY PROTOTYPES

- The other anomaly in time measurements was observed
  - The 3rd pad is not expected to receive a charge at the same time as a leading pad
  - The possible explanations are: induction in pads, electronics cross-talk, …
  - The effect on the Spatial resolution is very small, but detector behaviour need to be understood



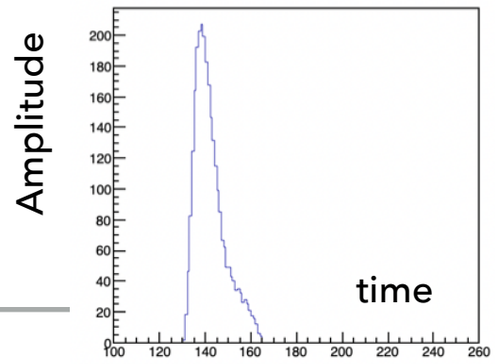




Reference points:

- $t_2 - t_1 < 0$ wrong reco (3%)
- $t_2 - t_1 = 0$ track over pad border
- $t_3 - t_1 \leq 0$ should never happen

Waveform example:



HA-TPC RECONSTRUCTION

- The analysis goal is to use data from prototypes to test the reconstruction algorithms within ND280 software
- Successfully converted DESY beamiest data into ND280 data format

- Implemented the prototype analysis algorithm in to the ND280 software:
  - We used DBSCAN for pattern recognition and PRF for extracting track position
  - At the moment ND280 use TREx (based on A*)

- Having both algorithms will allow to test their performance and to those the best one for the final reconstruction

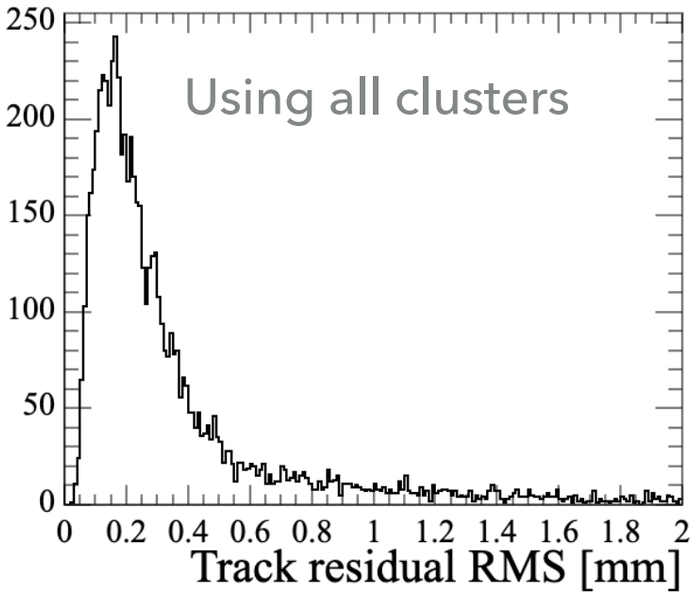
- Still working on obtaining the similar results as with the prototype analysis software

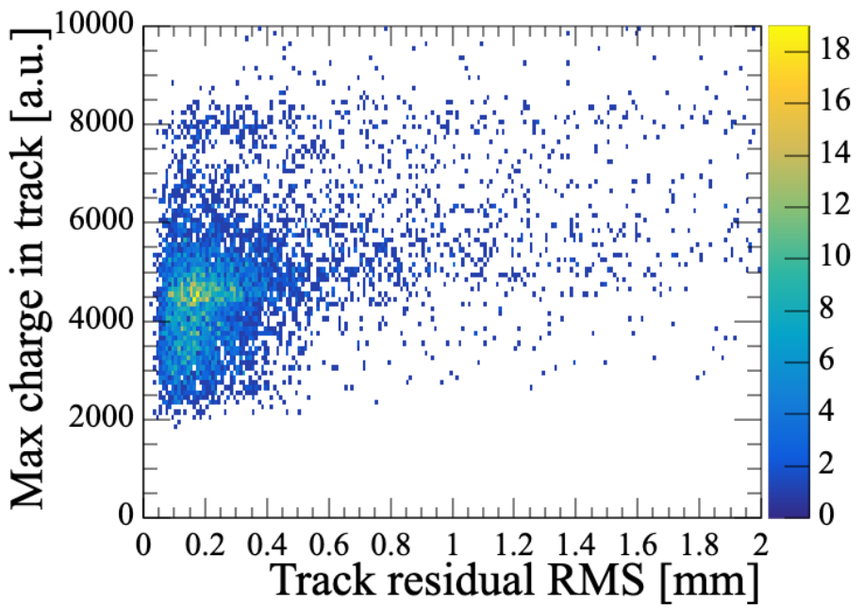
BU

- Position in the cluster fit based on known PRF

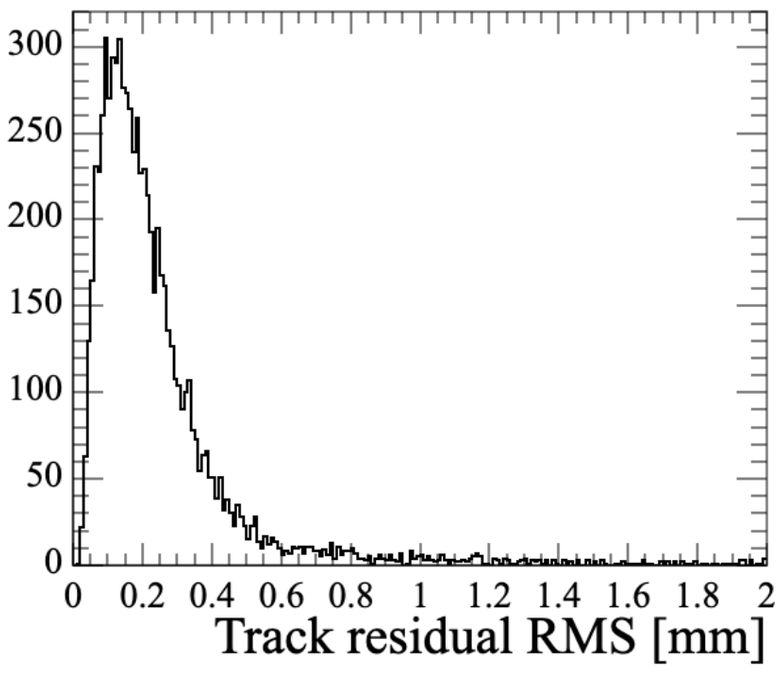
$$\chi^2_{row} = \sum_{row} \left[\frac{a^{col}_{row} - PRF\left(Xpad^{col}_{row} - Xtrack^{col}\right)}{\sigma_{a^{col}_{row}}} \right]^2 \qquad a = Q^{column}_{row} / Q^{column}_{total} \qquad \sigma_Q = \sqrt{Q}$$

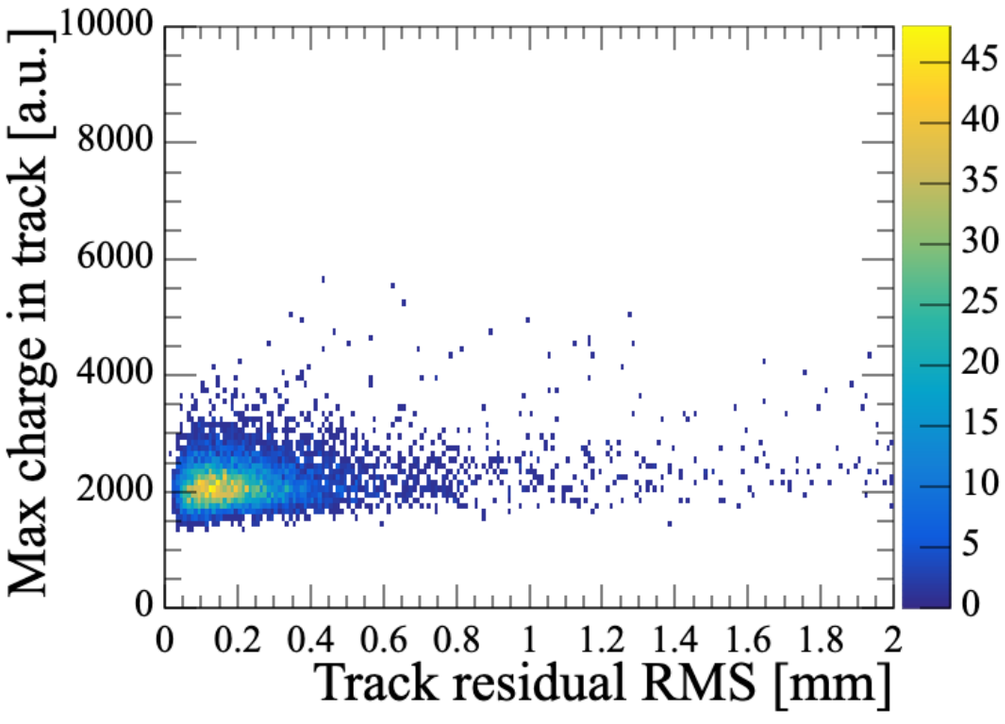
- Tail in the track residual RMS distribution => some tracks has a large residual RMS
  - Is it caused by few wrong reconstructed clusters with large energy deposition?





- 80% of low energy clusters used:

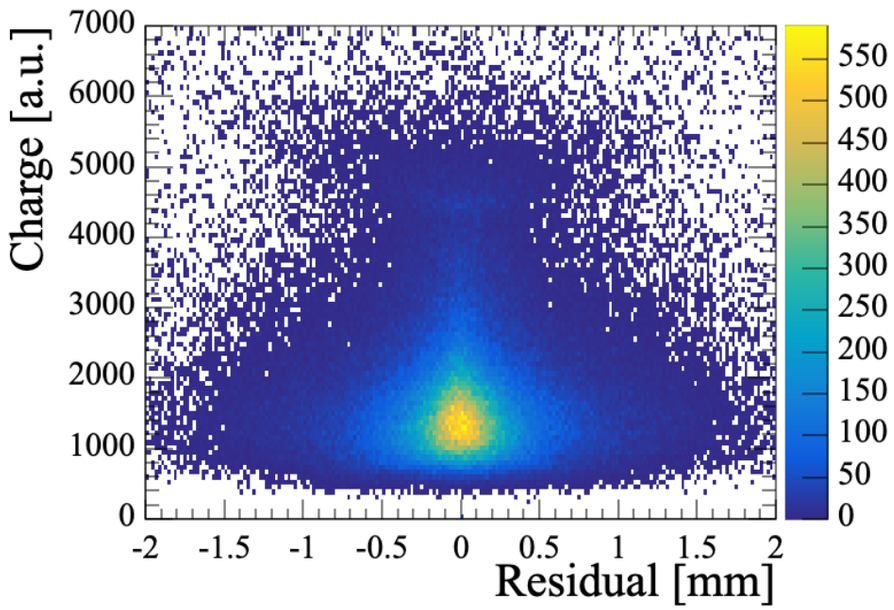




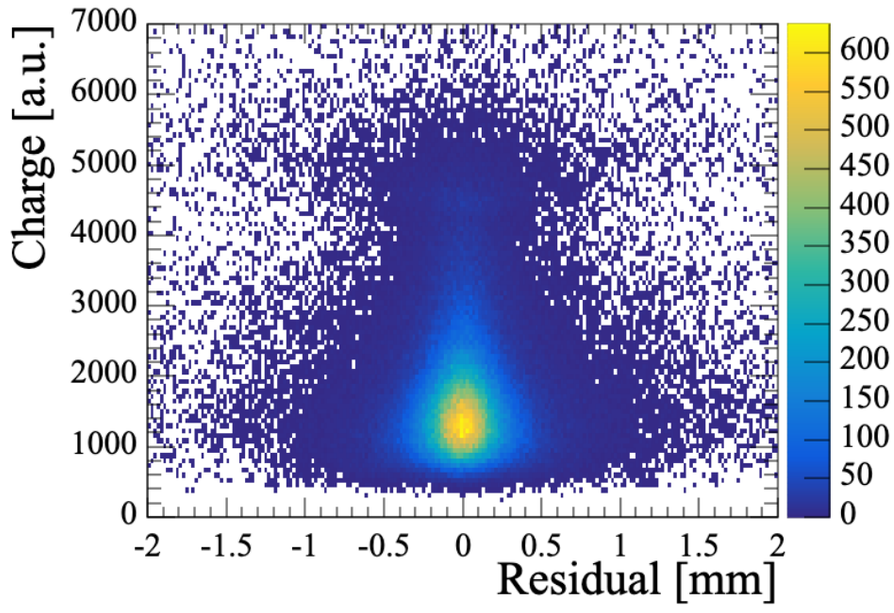
Text

- All the plots are for 360V 200 ns DESY beam events

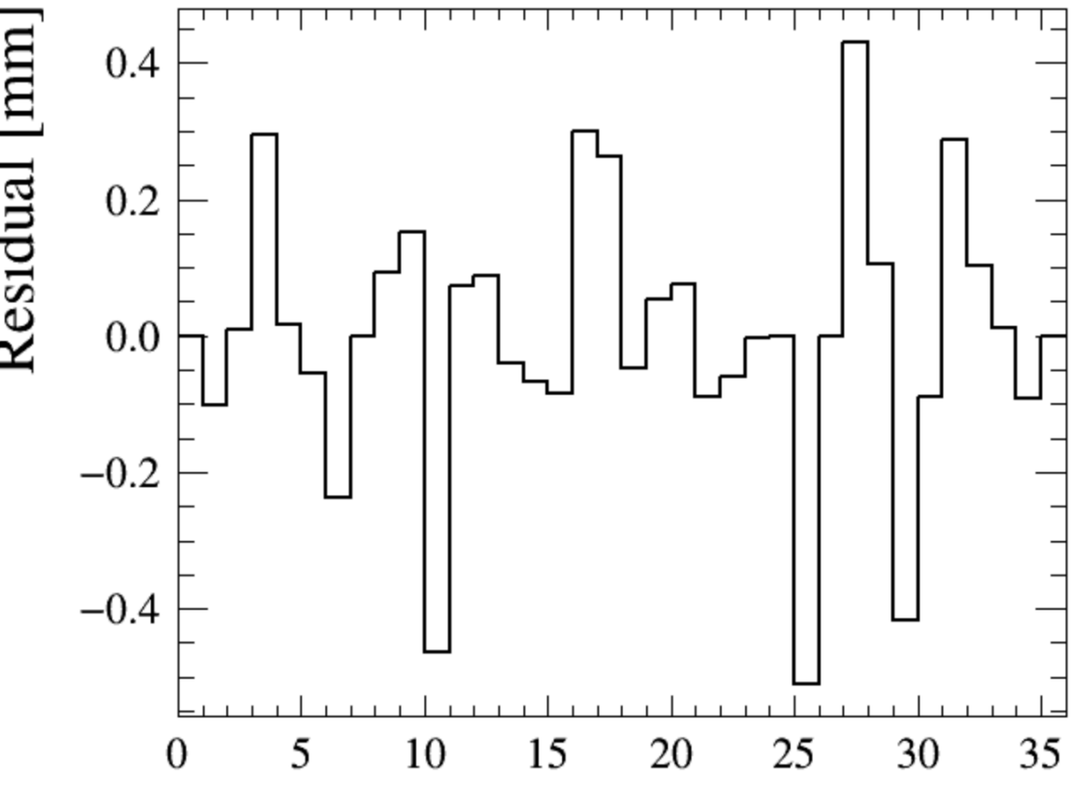
- CoC:



- PRF iter 9:



- Clusters with more charge **don't** systematically cause larger residual spread


Residual [mm]
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0.2
0.0
−0.2
−0.4
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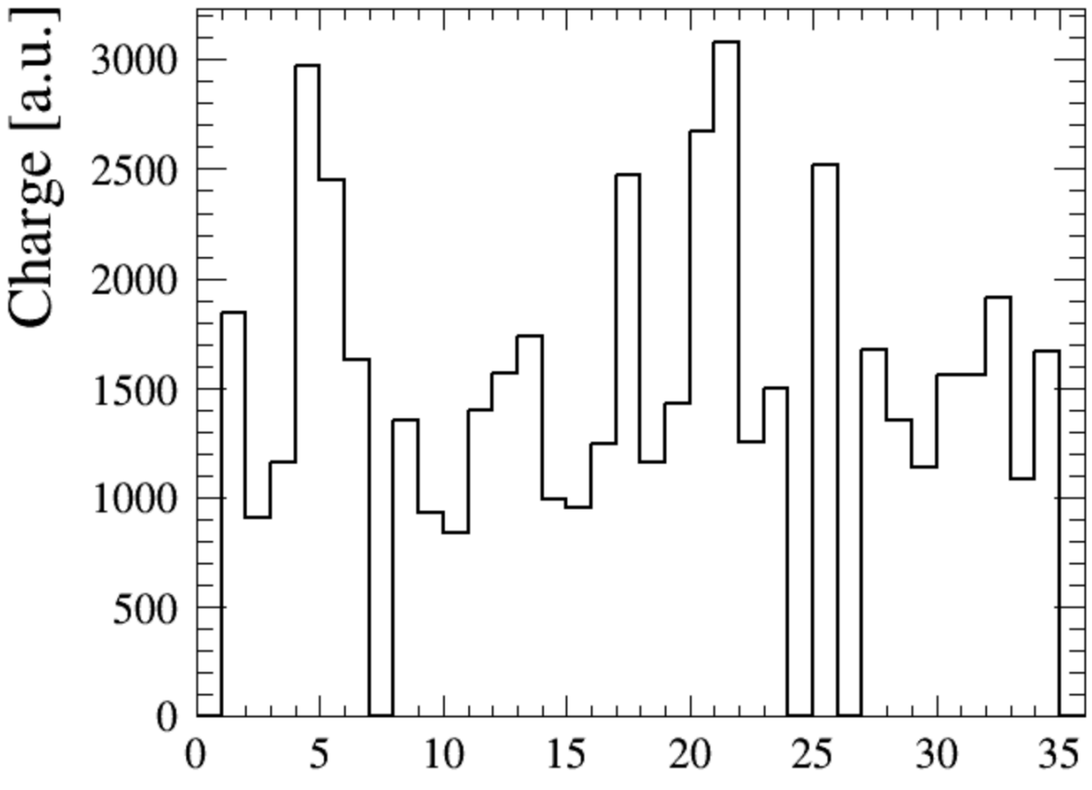
15
20
25
30
35


Charge [a.u.]
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1000
500
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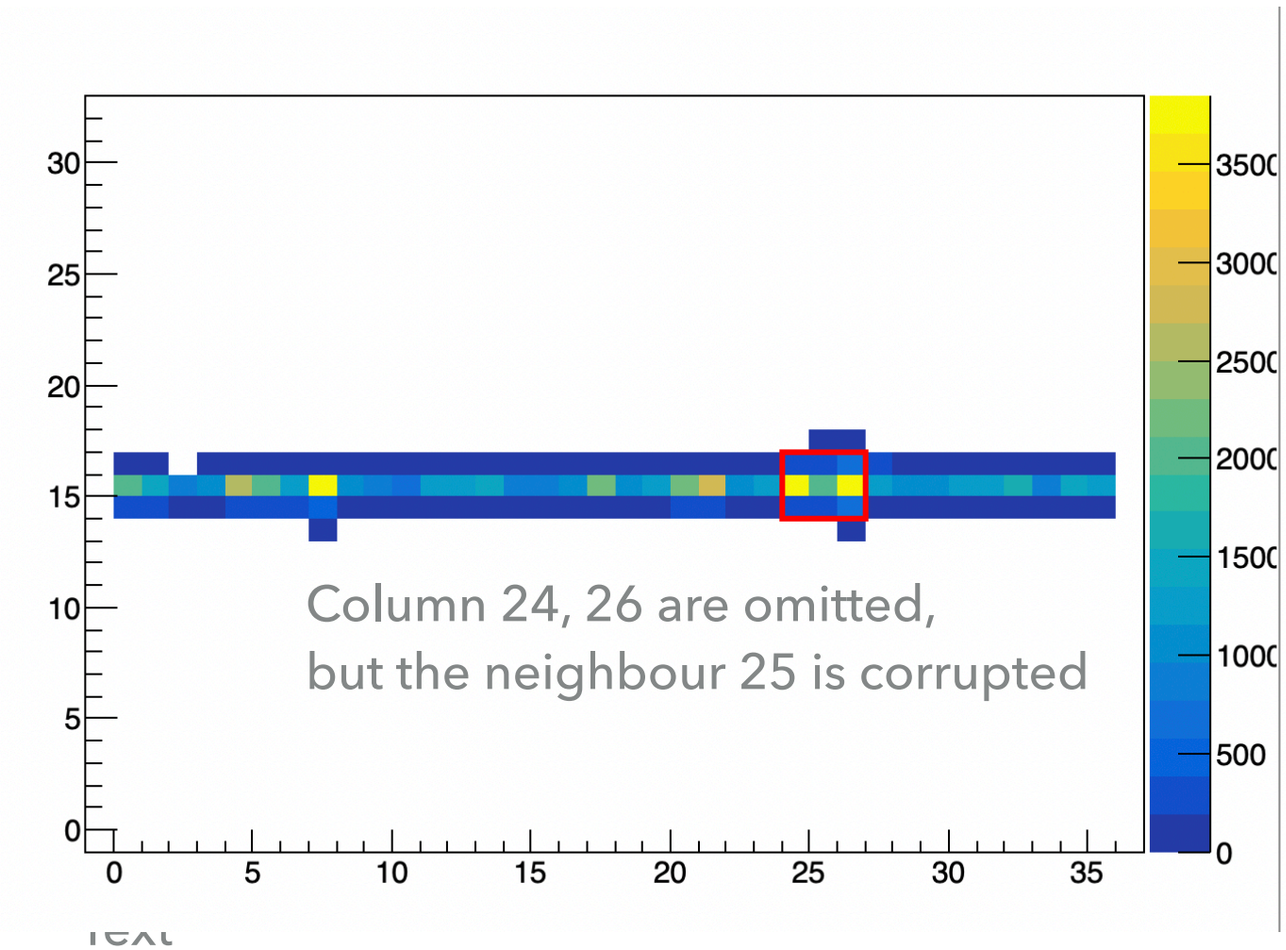
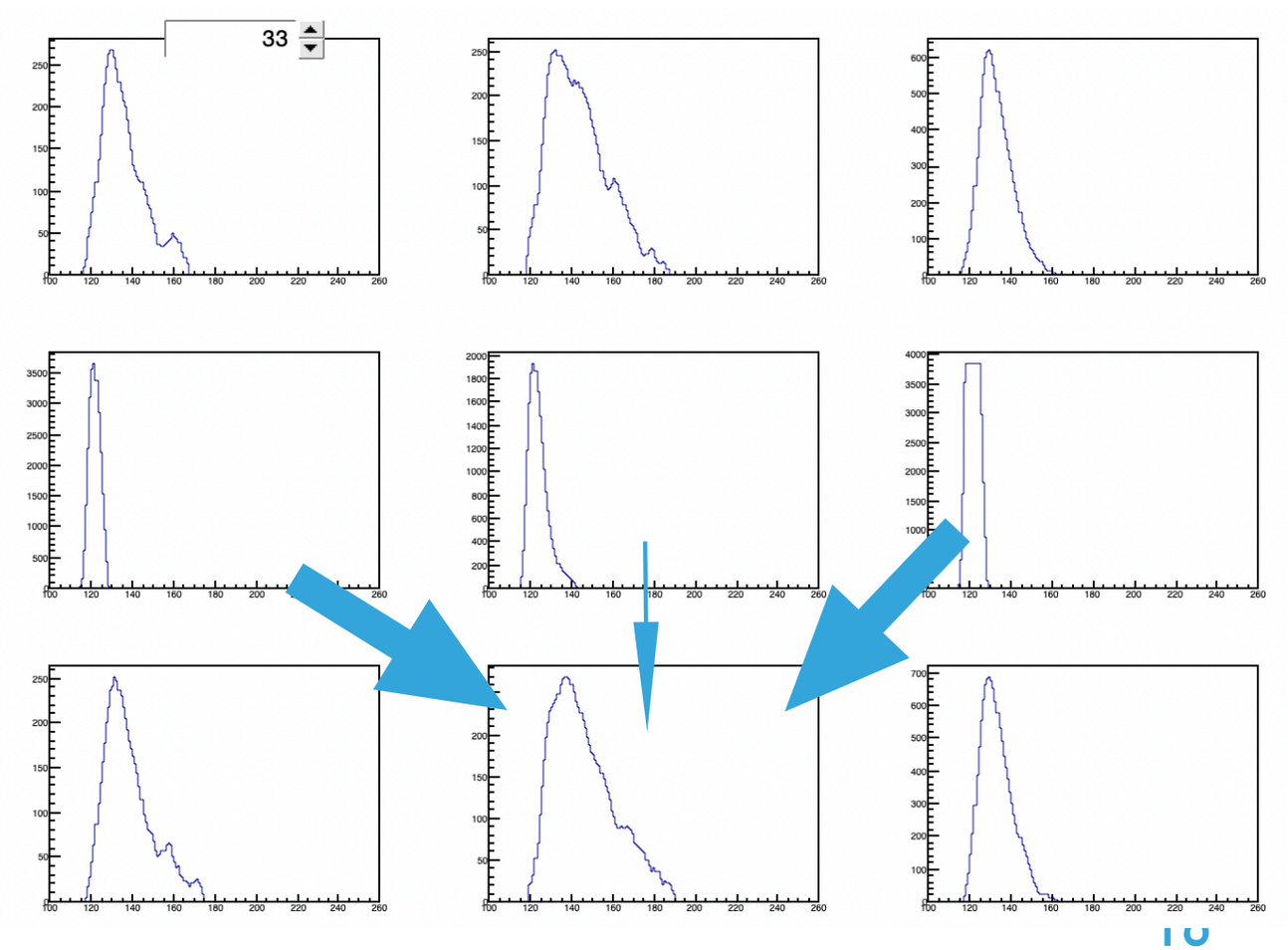
30
35


Column 24, 26 are omitted,
but the neighbour 25 is corrupted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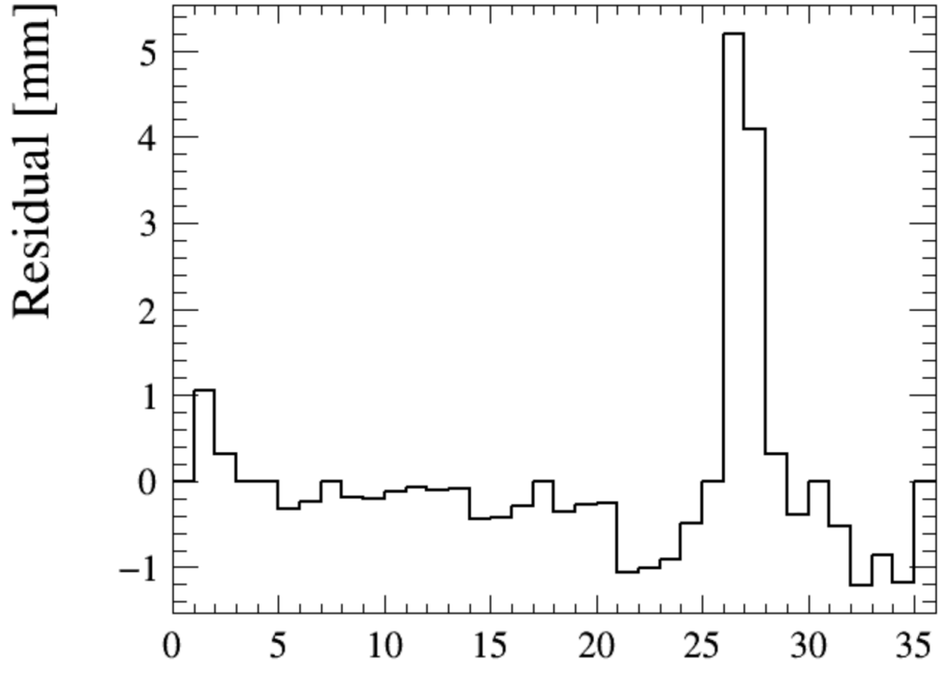
Residual [mm]
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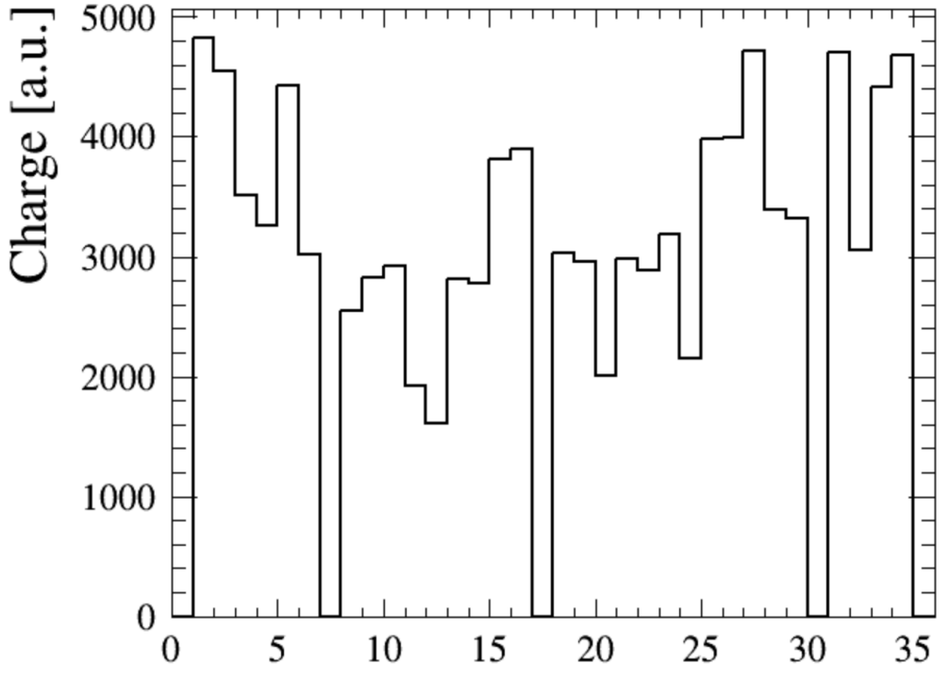
Charge [a.u.]
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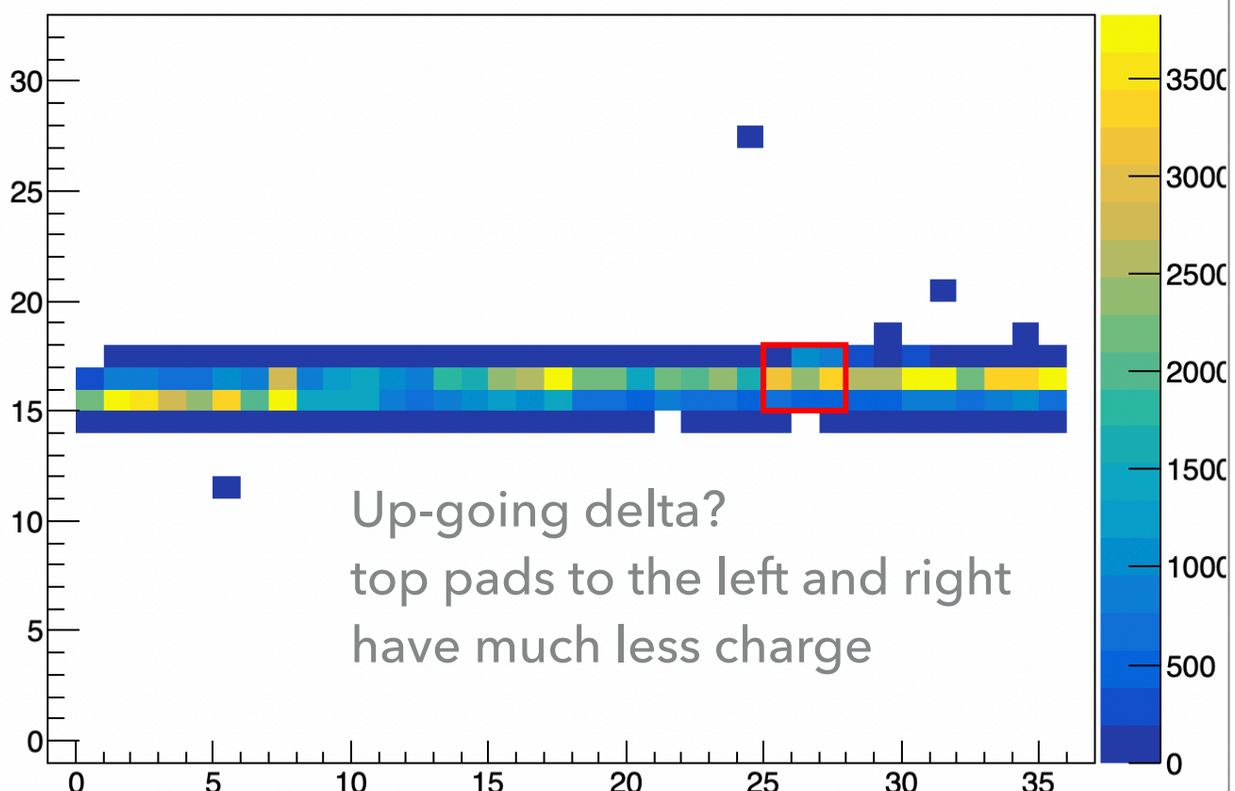
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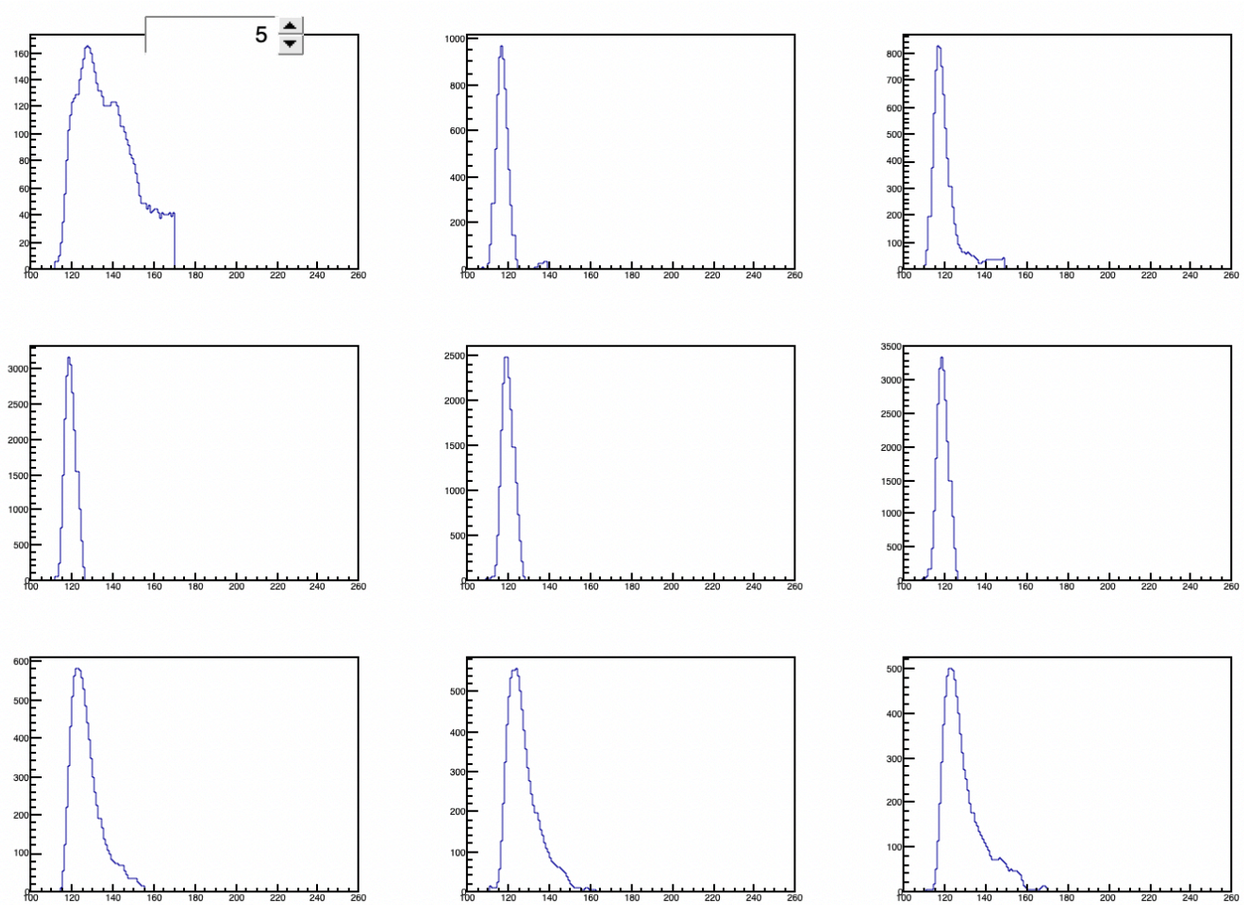
Up-going delta?
top pads to the left and right
have much less charge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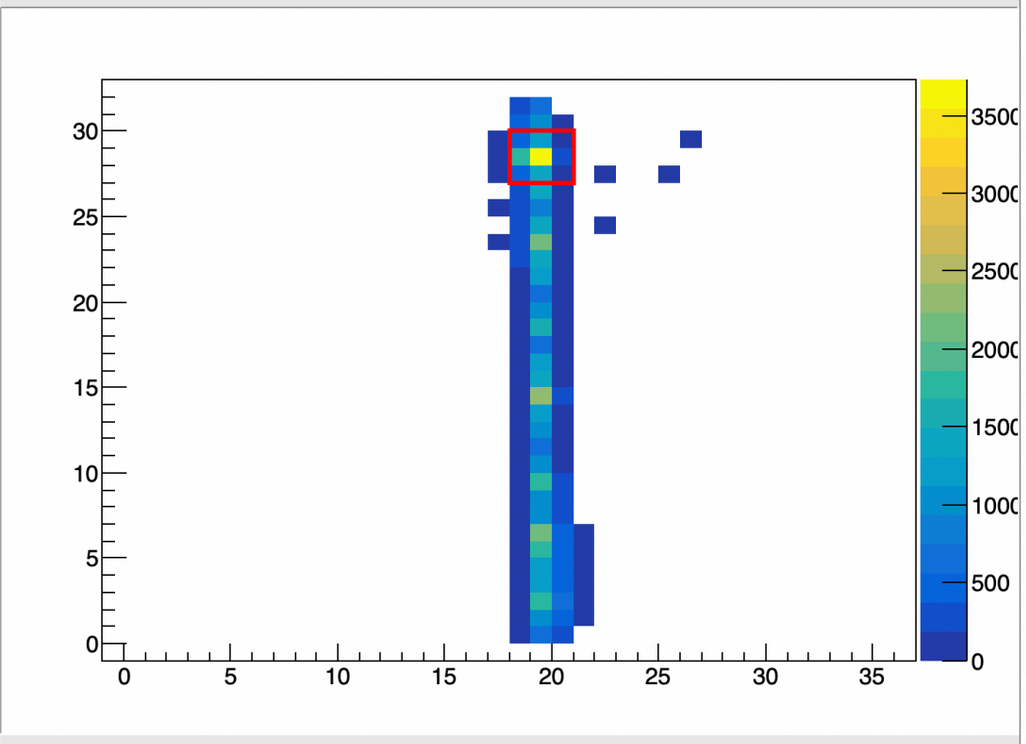
Text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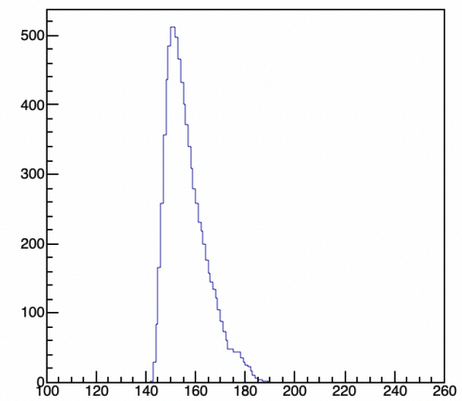
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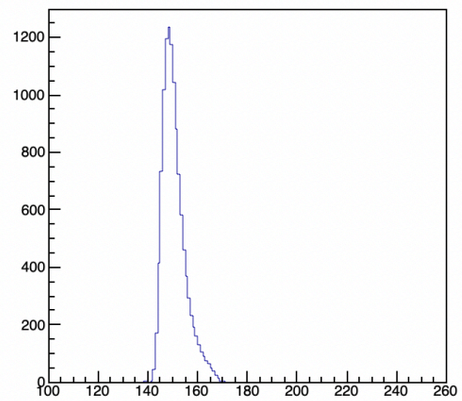
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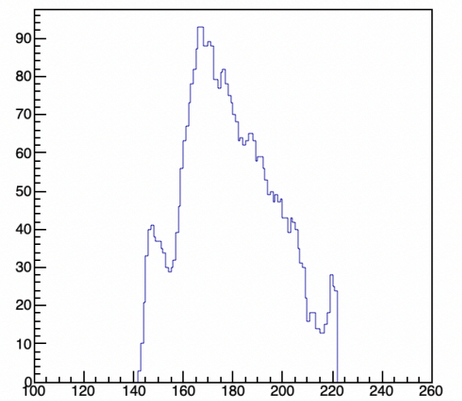
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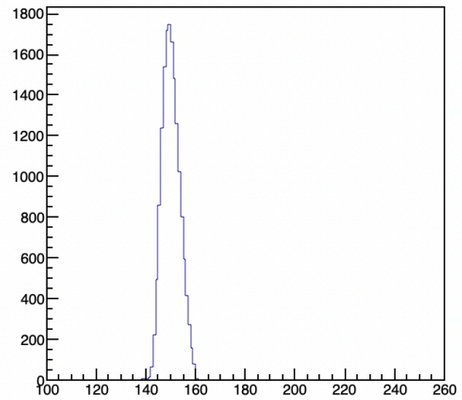
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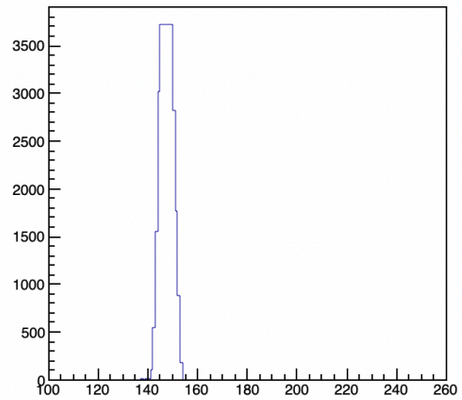
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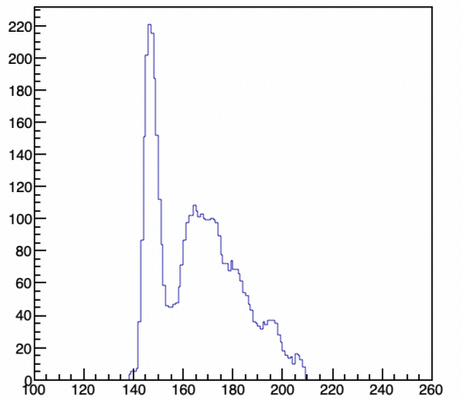
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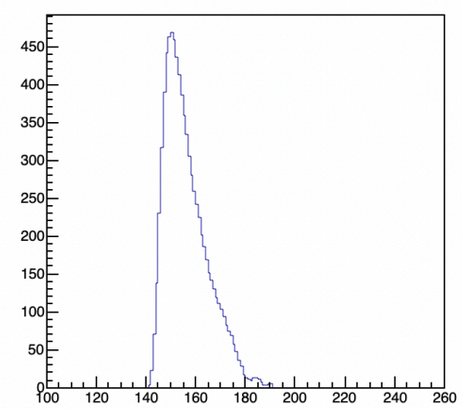
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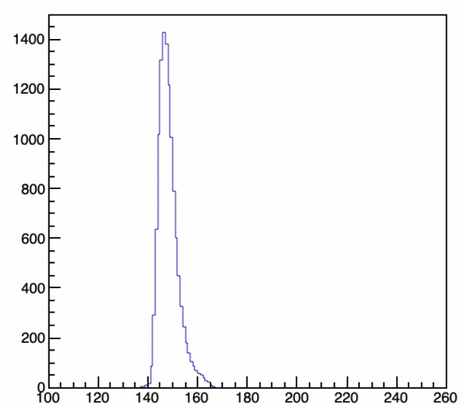
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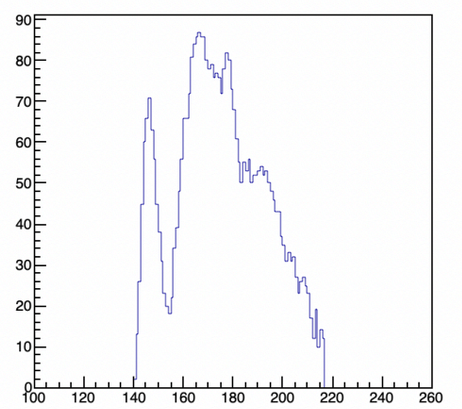
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