Charge equalisation on collection channels

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On behalf of the DUNE-IFIC group.

Objectives

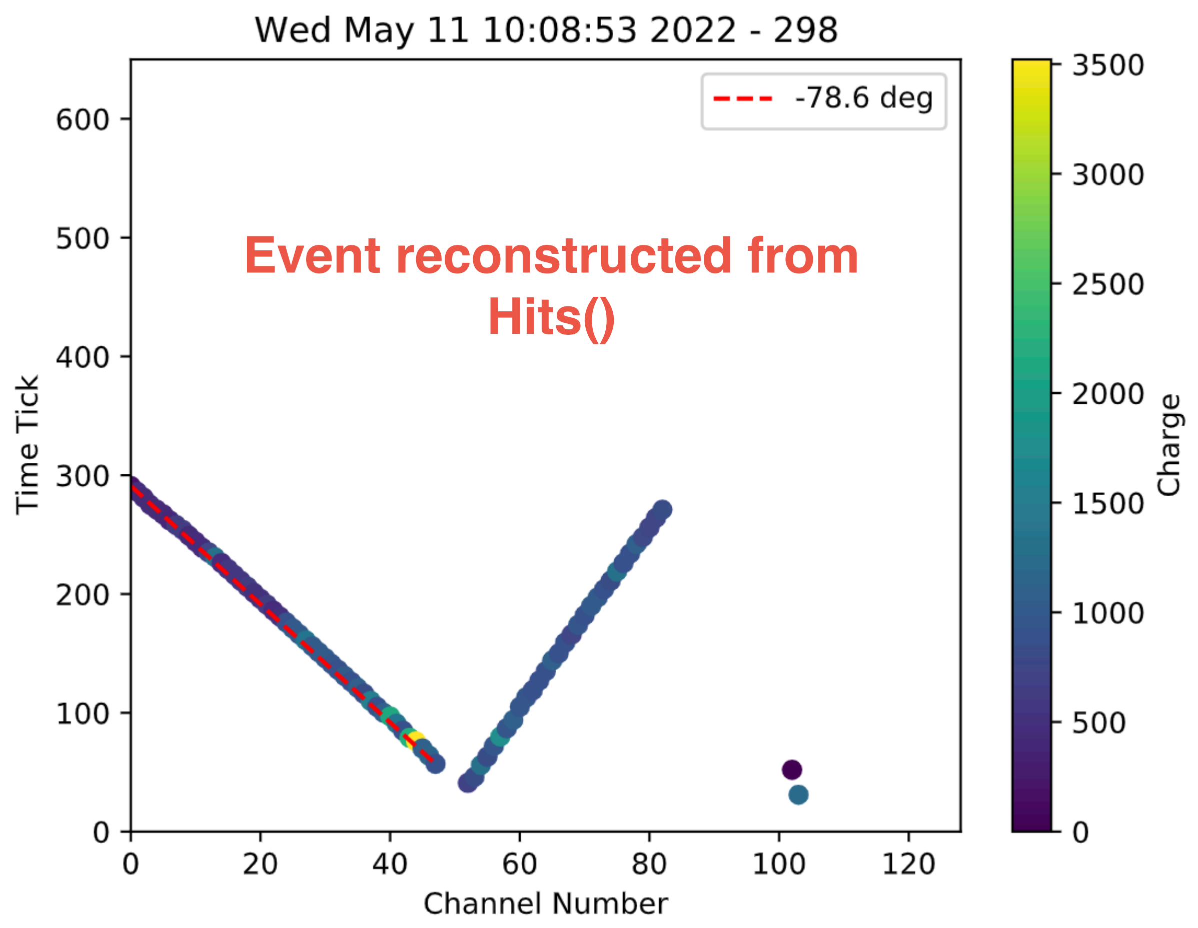
- Major goal: **to understand the electrical gain for each collection channel and characterise the gain differences between strips**.
- Muons deposit the same amount of energy alongside the track, so a selection only consisting into fully-contained muons must be performed.
- By assuming the same energy deposit on each of the channels, obtaining the **electrical gain equalisation** for the collection strips.
- One needs to properly calculate the track segment length projection on the collection channels to correctly account for the dQ/dz quantity.

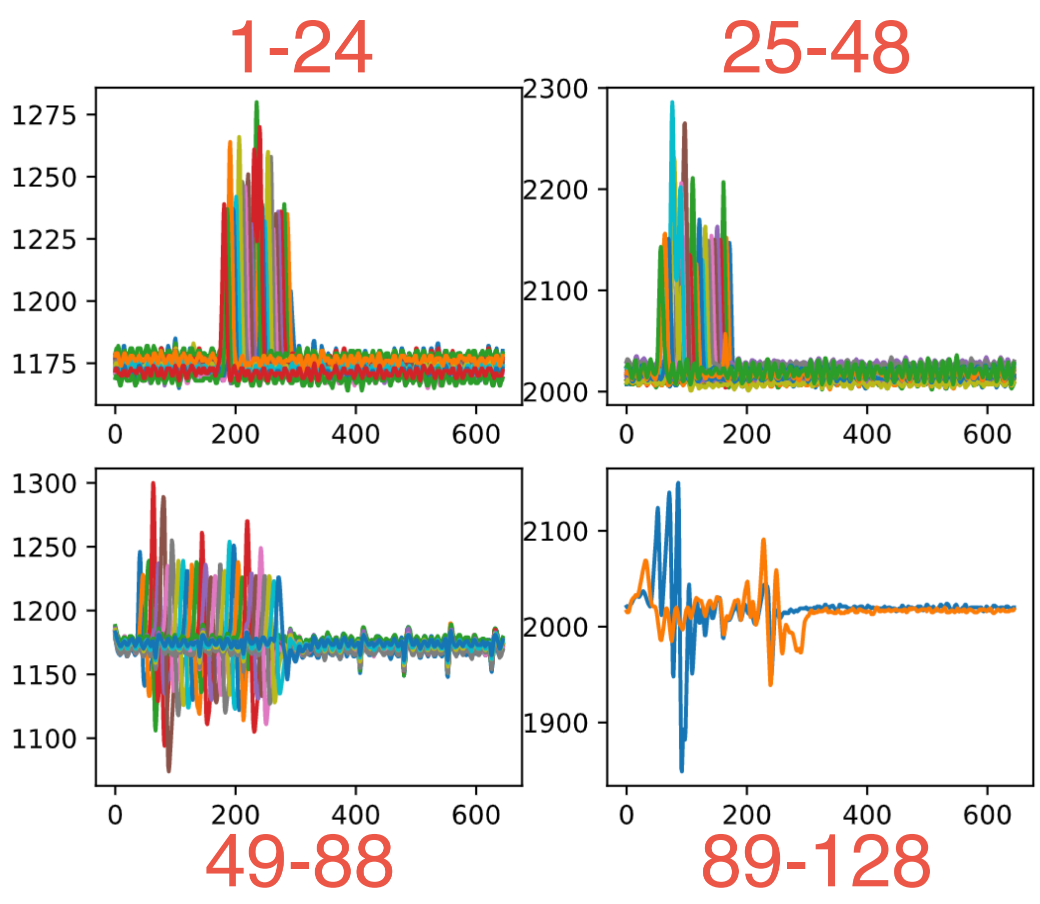
Analysis Framework

- A new OOP-pyROOT-based framework has been created.
- The framework is based on the Event() class, that contains other objects such as: Track() or Mesh().
  - Track() is formed by Voxel() which are formed from Hit() and so on.
  - Mesh() is formed by Strip() that allows to perform track reconstruction.
- One can easily access the raw waveform for each hit at the event-level, just by accessing the correct attribute of the correct constructor.
- It makes much more readable and user-friendly as well as quicker in terms of execution time.
- **The same analysis has been performed using the baseline framework to valide this one.**

Selection criteria

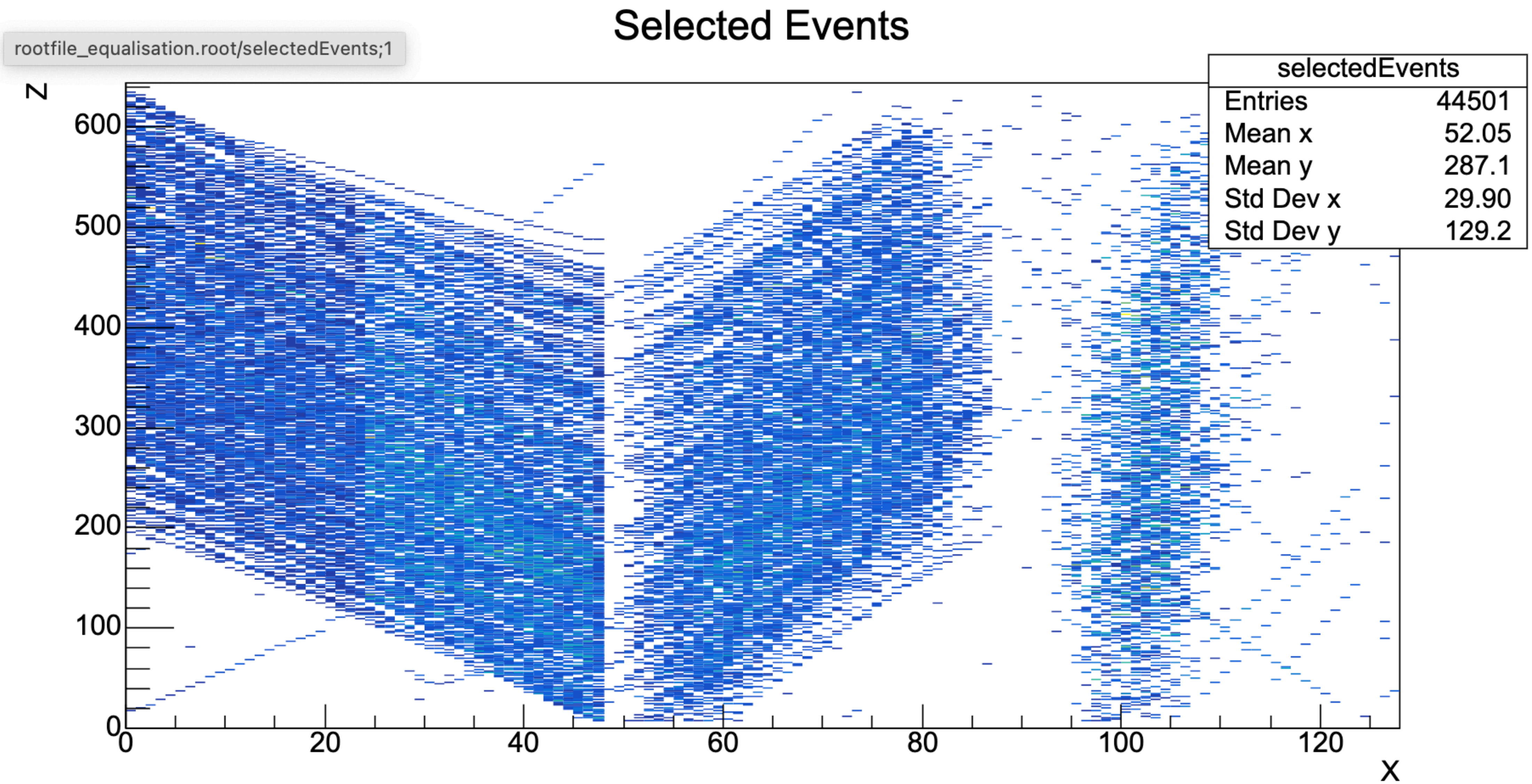
- Number of Collection channels crossed: exactly all 48.
- deltaI must be positive
- Just single tracks -> No additional hits in the selection





Selected events: 541 events

- There is a conversion issue (JSON files), and channels are labelled incorrectly -> CH1 should be CH48 and induction channels are swapped.



Effective track pitch length: calculation

$$\Delta L = \sqrt{(\Delta Z)^2 + \frac{4}{3}[(\Delta C)^2 + (\Delta I)^2 - \Delta I \Delta C]}$$

$$L_{projected} = \frac{\Delta L}{N_{Collection\ strips}}$$

$$\Delta Z = N_{time\ ticks} \cdot \delta t \cdot v_d$$

$$\Delta C = N_{Collection\ strips} \cdot \delta_C$$

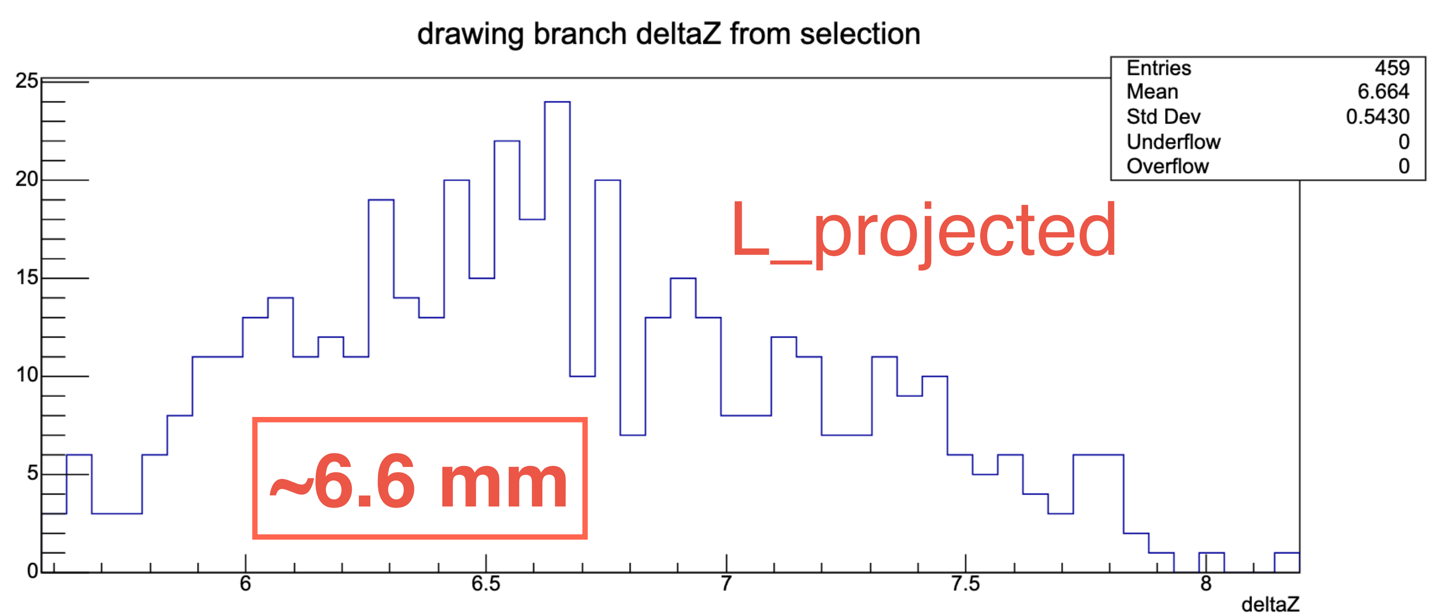
$$\Delta I = N_{Induction\ strips} \cdot \delta I$$

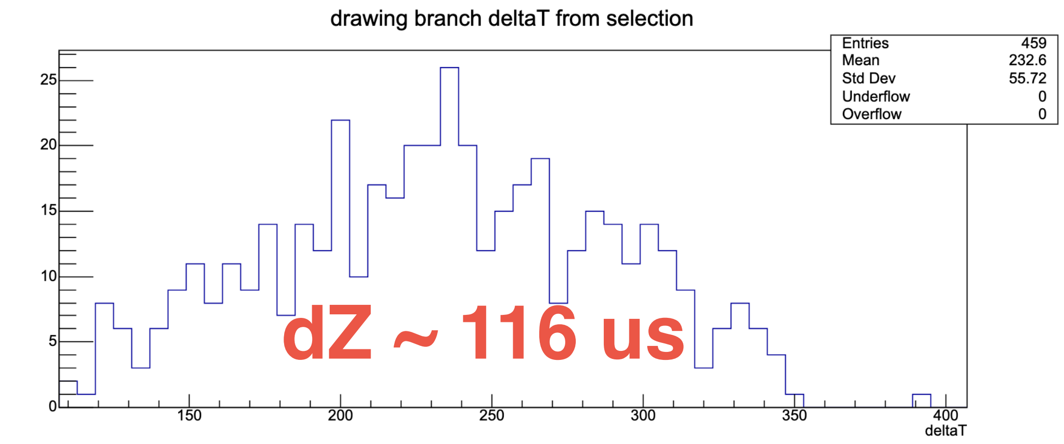
$$v_d = 1.55\ mm/\mu s$$

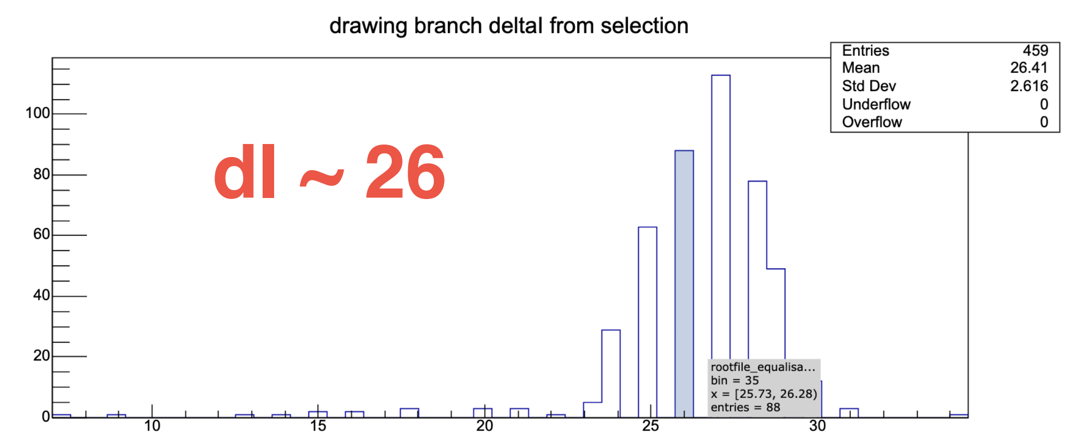
$$\delta_C = 5\ mm$$

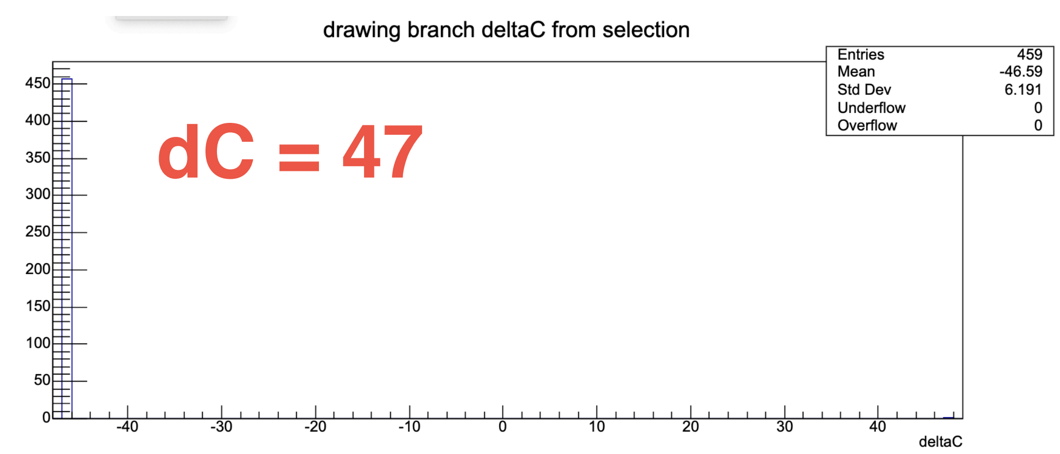
$$\delta_I = 7.5\ mm$$

$$\delta_t = 0.5\ \mu s$$



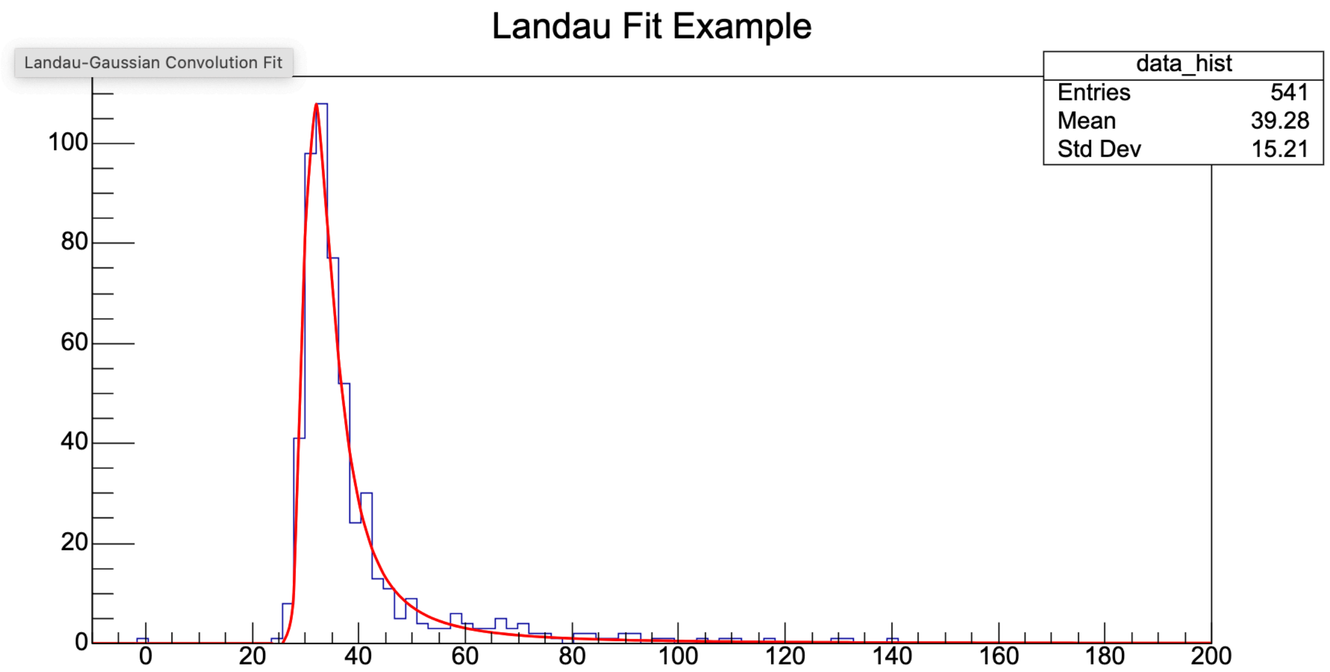


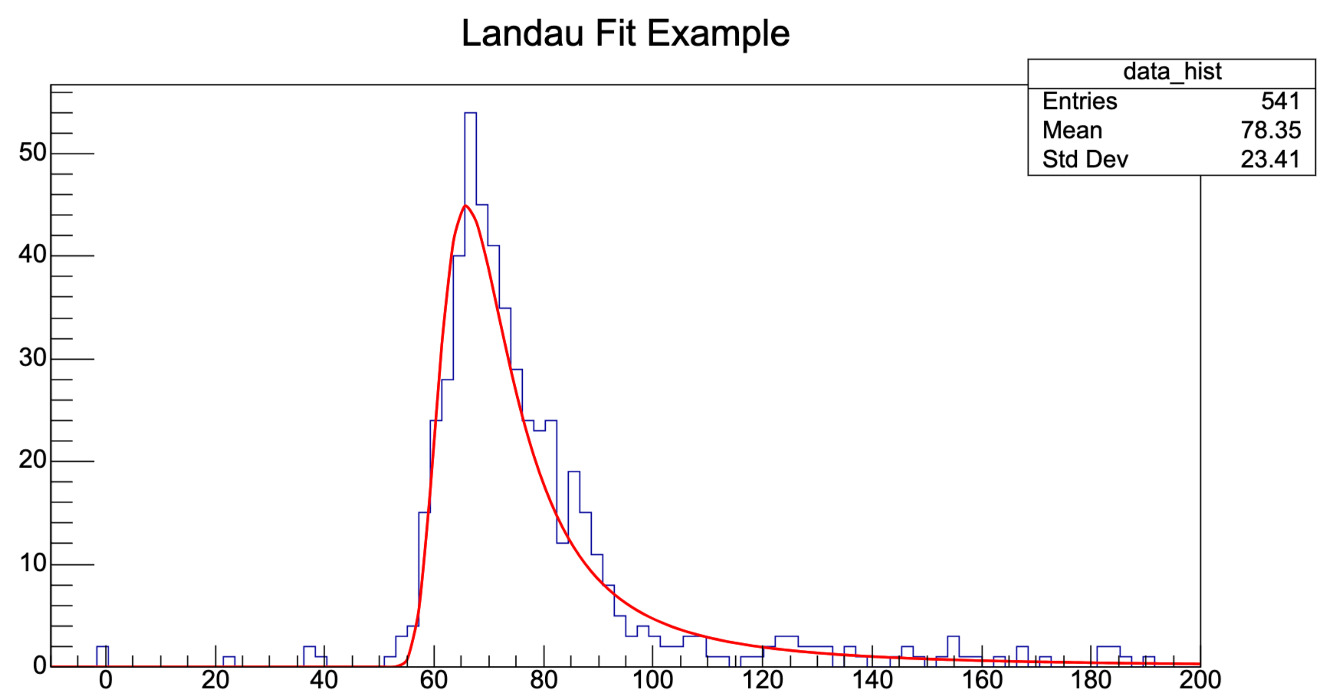




Landau Fitting: MPV & Sigma

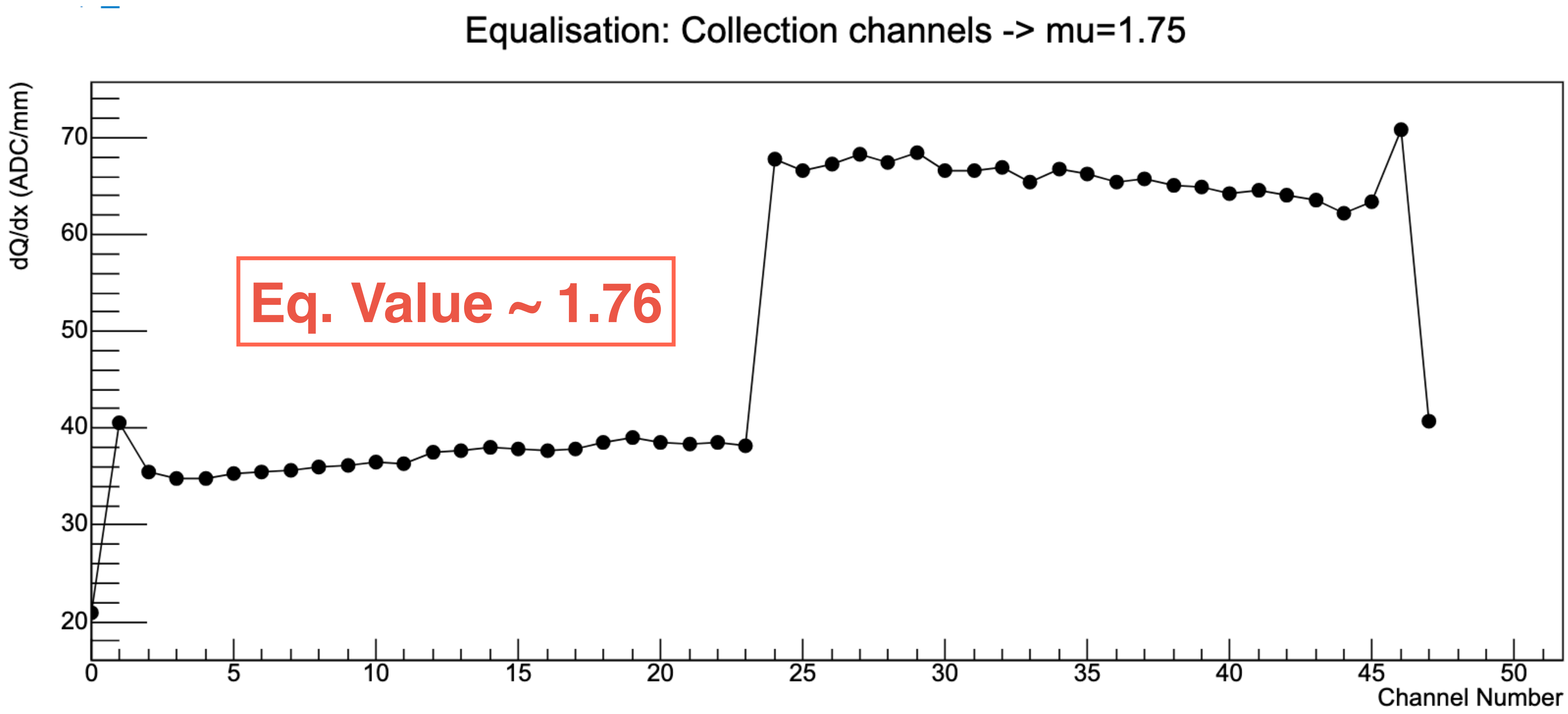
- Landaus for the first 24 channels are narrower than for the channels 24-48.
- Landau fits are not 100% accurate, a gaussian needs to be convoluted to account for the high-charge deposit region.





Equalisation

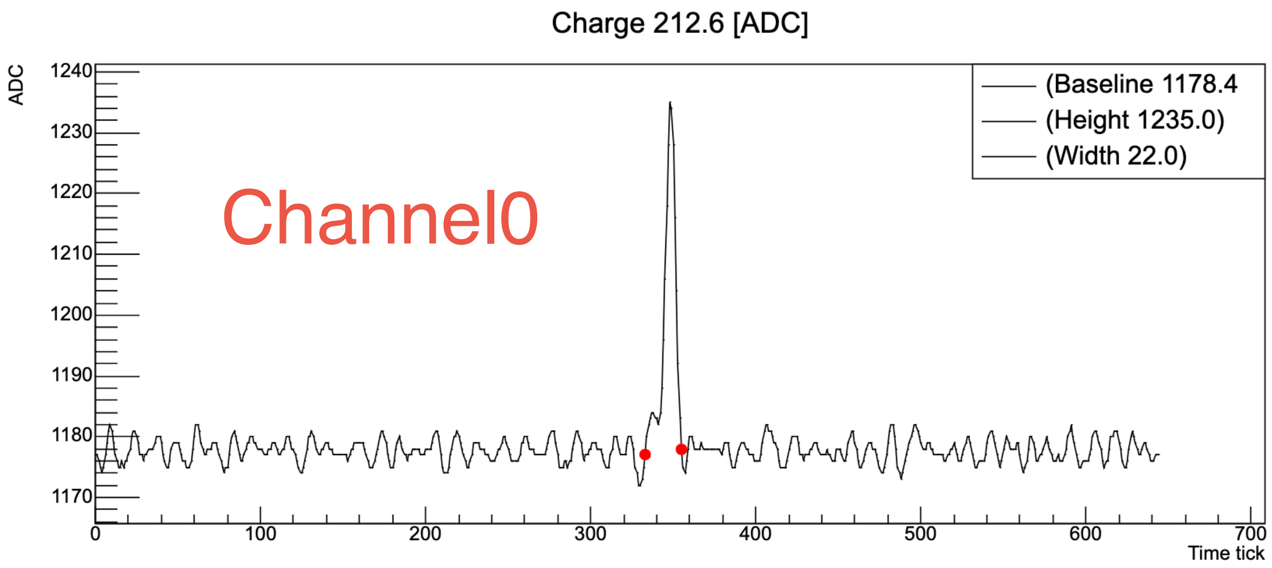
- **Channels 0 and 47 are much more noisy than the others ->** Excluded from the analysis.
- Channels 1 and 46 show are also strange -> Kept in the analysis.

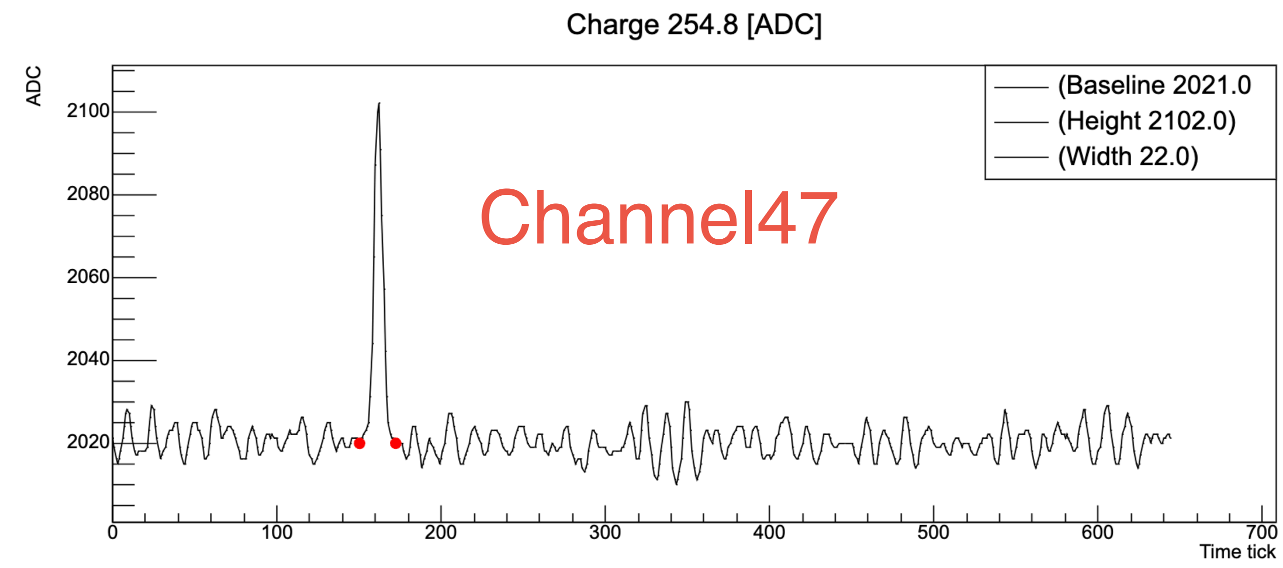


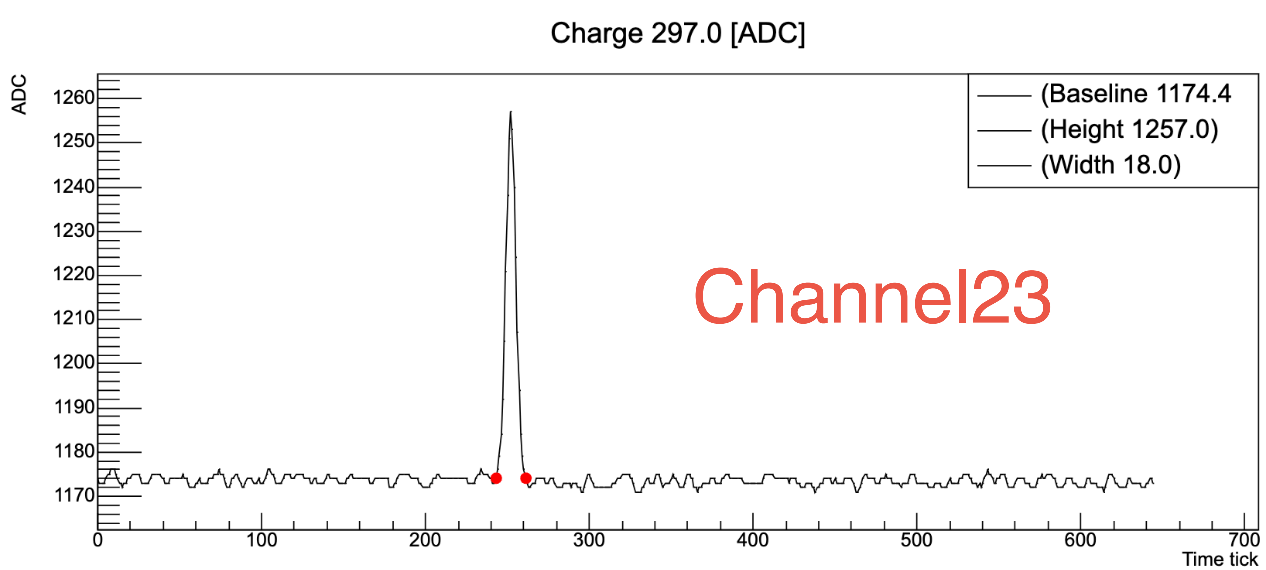
Suspicious channels: why?

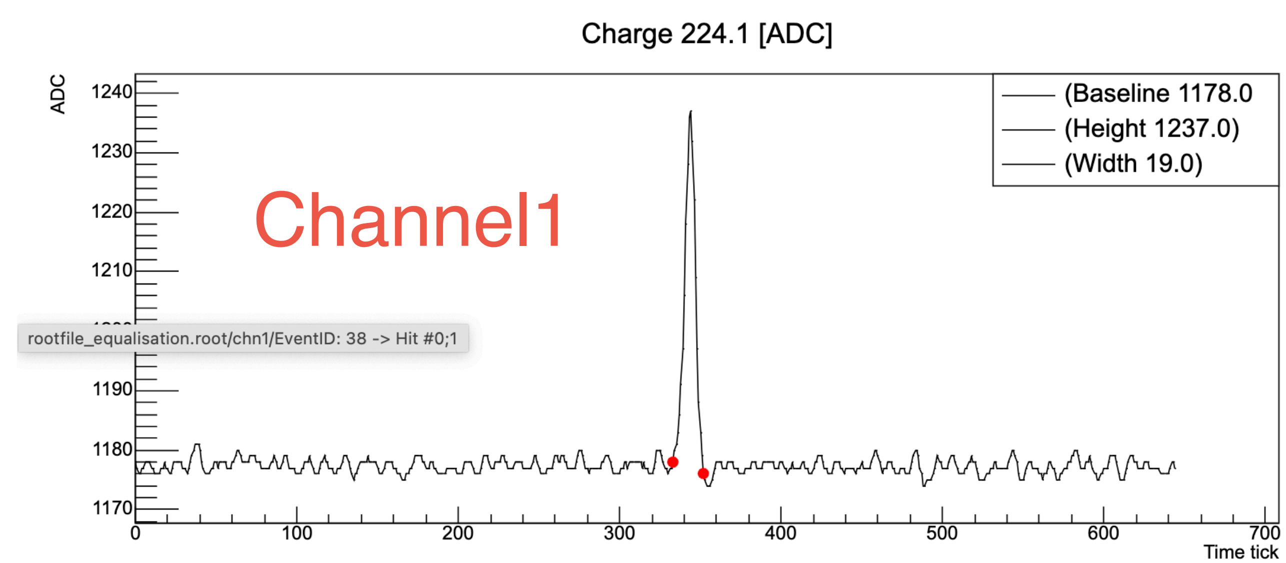
- Channels 0 & 47:
  - Baseline noise is much larger in these two channels.
  - Peaks are smaller in terms of height and also narrower in time.
  - This causes the integrated charge to be smaller for these two than for the others.
- Channels 1 & 46:
  - Peaks are wider in these channels than they are in the rest, this explains why deposited charge appears to be larger.
  - Peak heights and baselines are equally large for those channels and the rest.
  - This causes integrated charge to be larger for these two.

Individual Waveforms: event #38









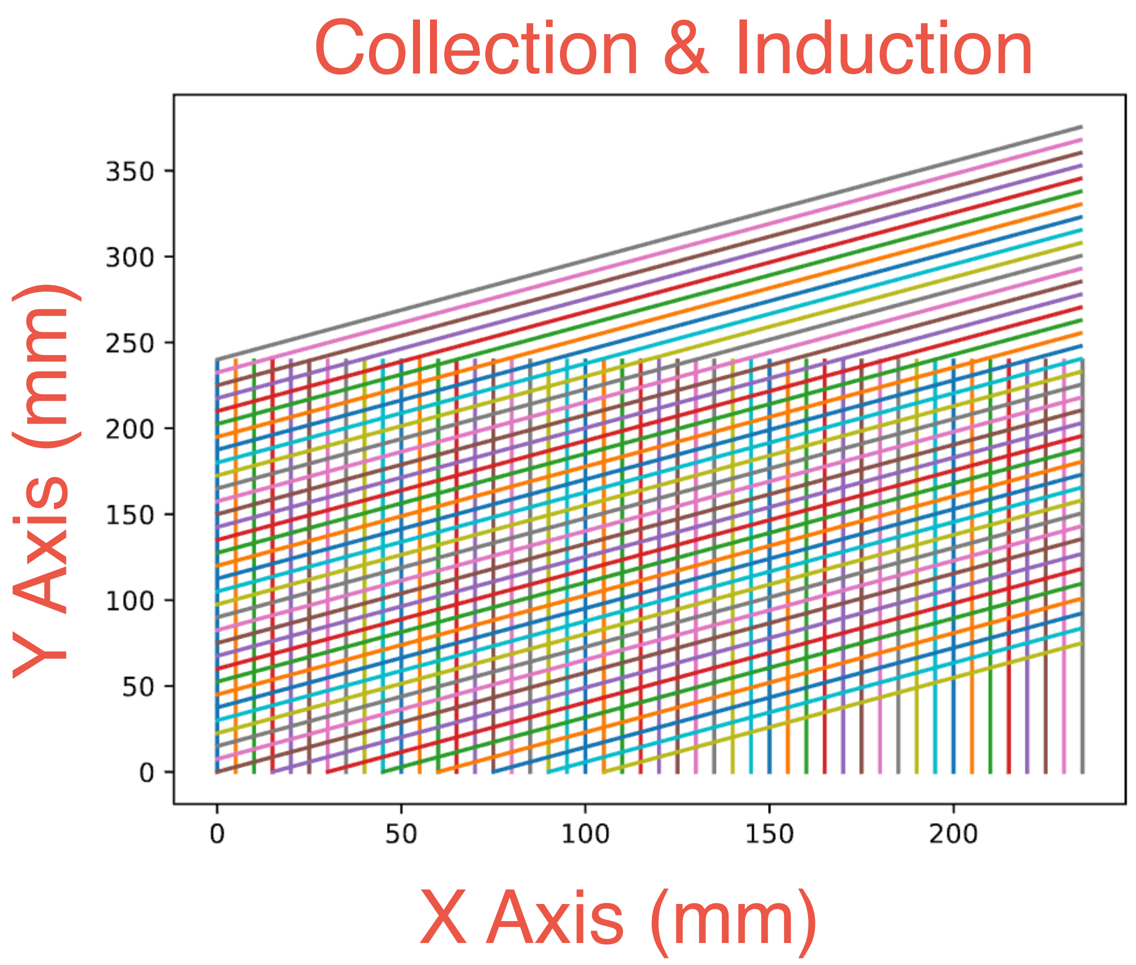
Converter work: ROOT file

- To iterate over JSON files is very slow.
- A converter that takes data from JSON and converts it into a ROOT file has been created.
  - Reduction of ~93% of disk memory for the same amount of events.
  - Reduction of 75% of executing time for the same amount of events, on the selection.
  - In-line visualisation and interactive ROOT plotting.
- The correspondence of the conversion has been checked event-by-event comparing it then with the JSON files.
- **The converter has to be set-up in order to accept the RAW binary files as input and create the same output.**

Additional work: Event Reconstruction

- Based on the TPC geometry, coordinates of the events can be reconstructed.
- Strips are characterised by a line equation.
- Intersection points between strips provide the (x,y) coordinates, and the hit time provides the z.

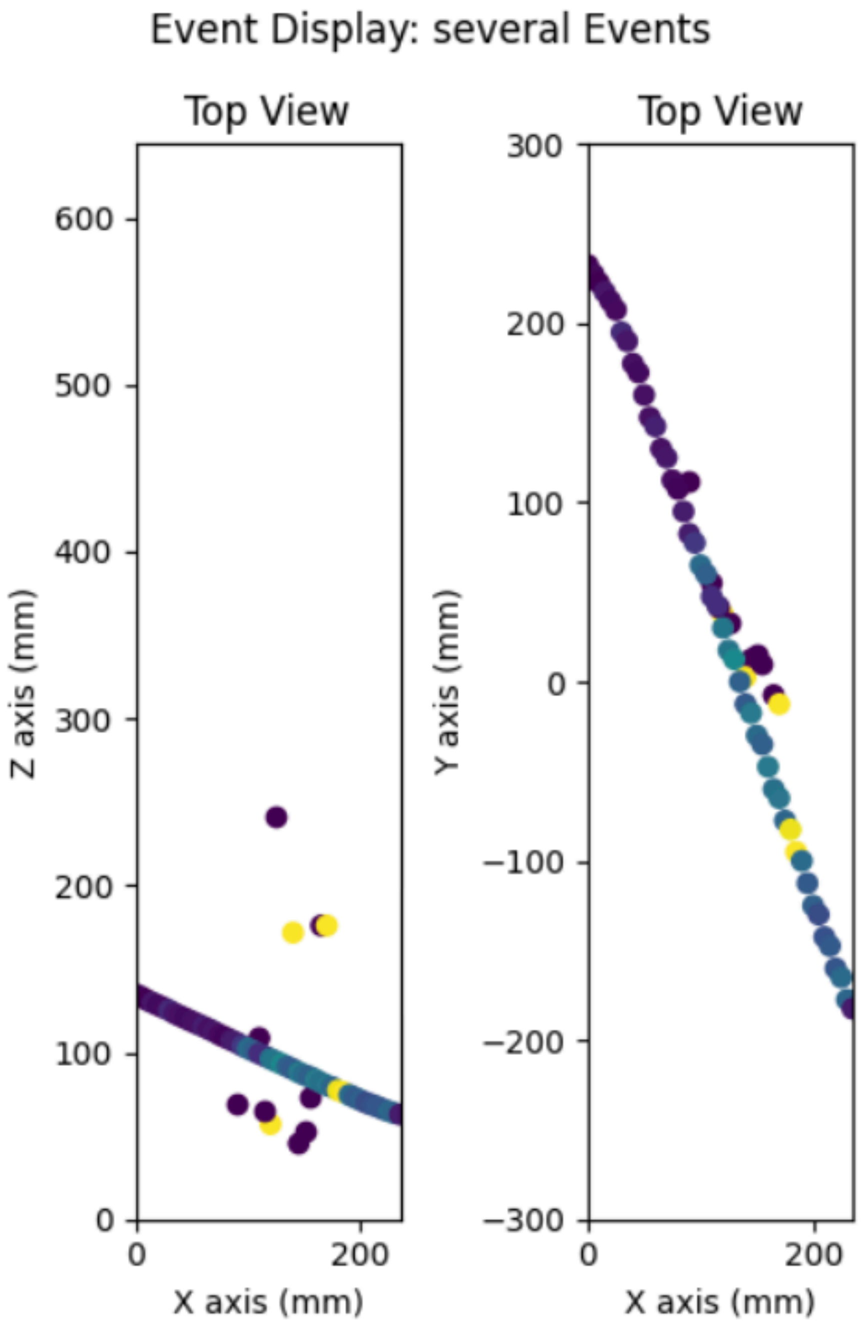
Preliminary



Event Reconstruction

Preliminary

- Using this information, voxelization can be performed.
  - The voxel size is now a rectangle with square shape of the size of the collection pitch, and height equal to the time tick size.
  - The charge/energy contained in each voxel must be properly calculated: now only collection charge is considered.
- For isolated muon-like tracks, the track angle can be computed and the dQ/dz could be also calculated using the reconstruction.



Talk Conclusions

- A new OOP-pyROOT-based framework is available and will be pushed to gitLab after approval.
- A **muon-like selection** has been performed and the **effective track pitch length calculated** in great accordance with previous results (*Furkan's CM September 2022 talk*).
- Landau fits must be improved by adding **gaussian convolutions** (*in progress*).
- Mean **equalisation value** of *~1.76* compatible with expectation *~1.8*
- pyROOT-based converter significantly improves time consumption and event handling.
- A preliminary voxelisation/clusterisation algorithm has been proposed -> It may help refine the accuracy of the equalisation?

Next steps

- **Find the appropriate convolution in order to obtain a more precise MPV for the landau distributions.**
- **Understand better the behaviour of the 4 outlying channels.**
- **Perform the equalisation for the induction strips also.**
- **Work on the ROOT converter so that it accepts binary RAW data as input instead of JSON files: to be decided.**
- *Improve the hit coordinate finder algorithm by applying contour conditions on Y axis.*
- *Create ROOT-based event display, improve the clusterisation algorithm, implement cluster properties finder…*