UPDATES ON MUON TRACKS SELECTION FOR TRACK DECONVOLUTION

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Recap

Goal:

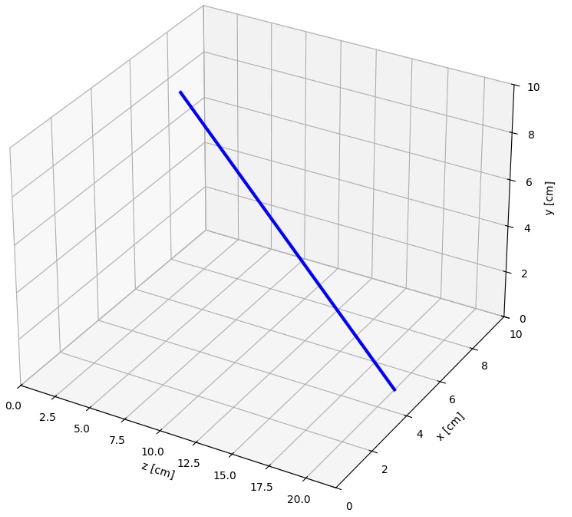
- Improve angular resolution and measure z coordinate using a neural network capable of performing a deconvolution using a stack of PSFs;

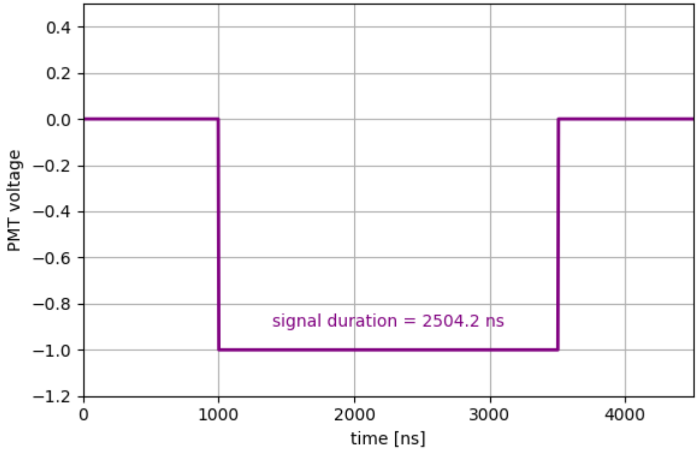
What is needed:

- Measure the point spread function at different z using muons tagged by scintillators;
- Create a dataset to fine-tune the neural network and extract the z coordinate.

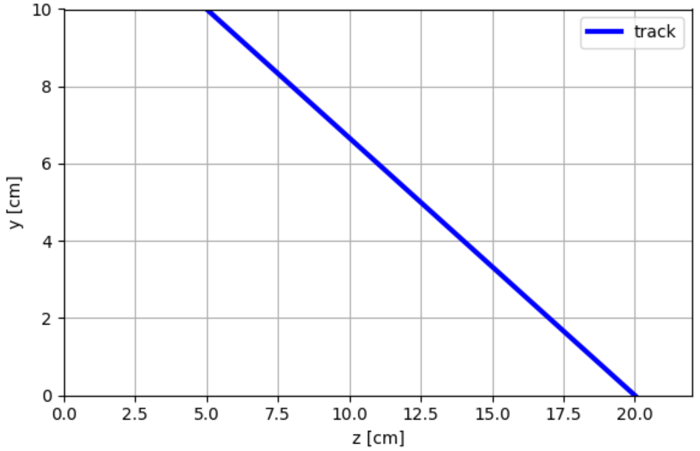
Muon selection

- The images containing muons in the desired range of z are tagged using waveforms from the PMTs inside GIN.
- To remove electron showers, do avoid tagging images where the z-width of the track is larger than the width of the scintillators $(7, 1cm)$.





$$\Delta t = \frac{\Delta z}{v_{drift}}$$



Muon selection

Signal width is larger than the width of the scintillators.

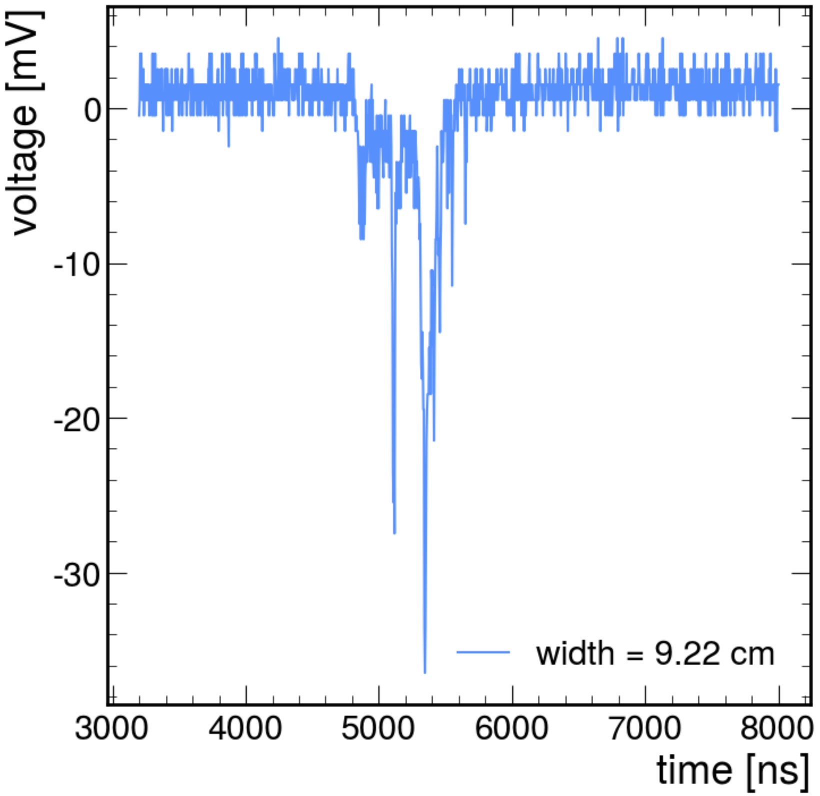
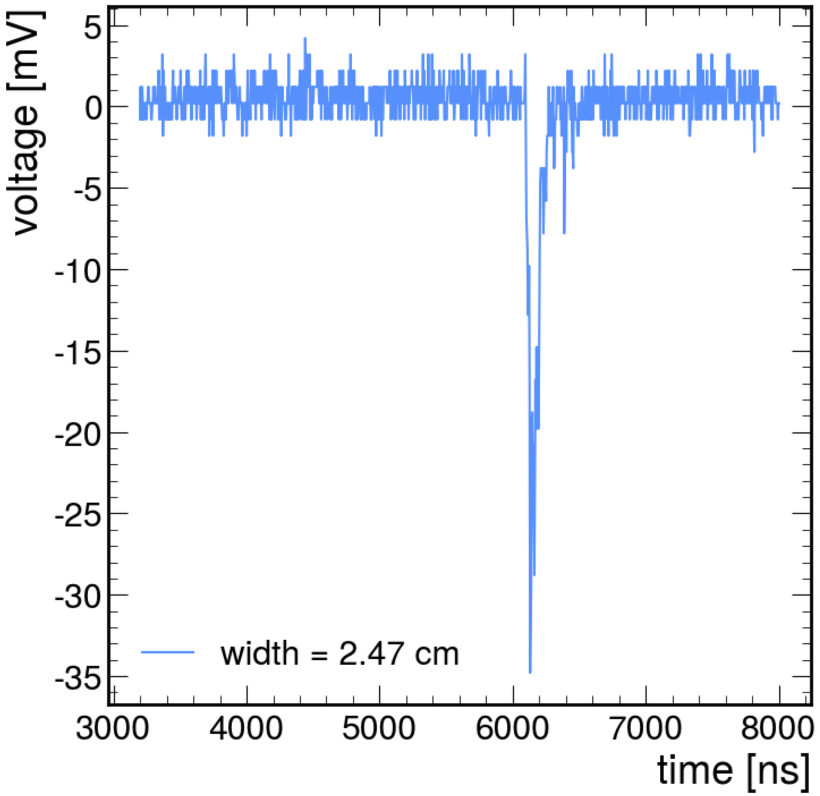


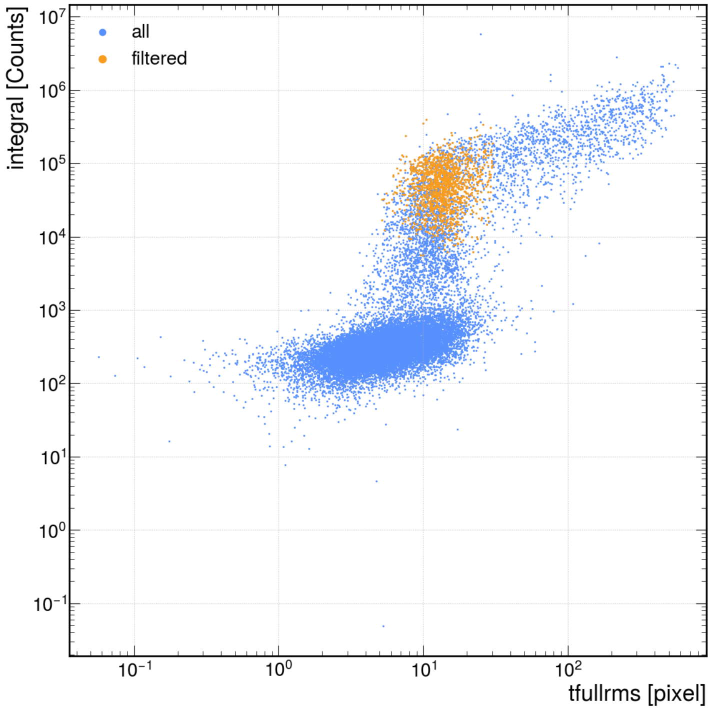
Image is tagged as muon.

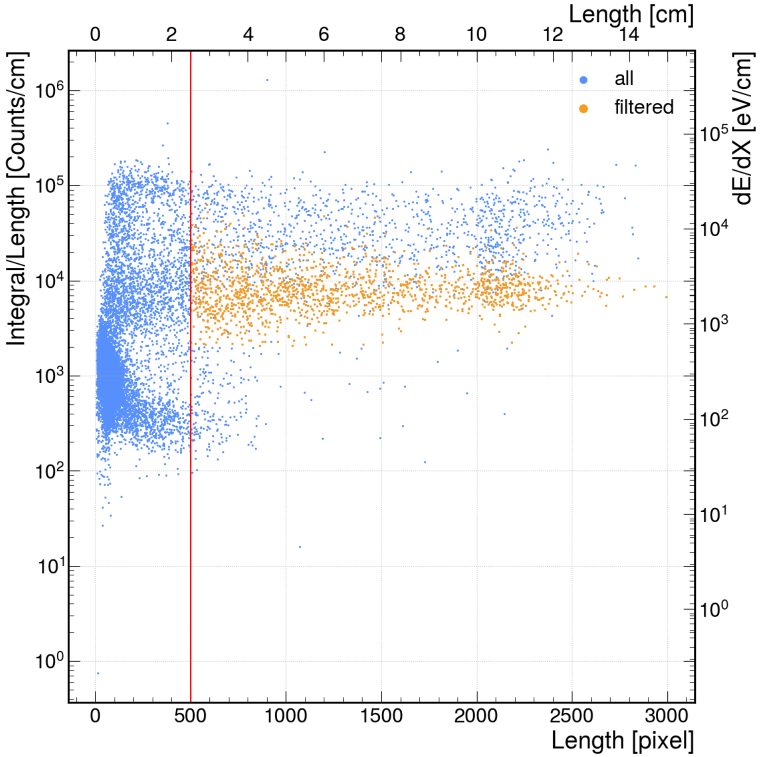


Muon selection

- Images tagged as containing muons have many clusters and only one of these is the muon of interest.
- The solution to this problem is to implement cuts on the reco variables to select only the muon clusters.

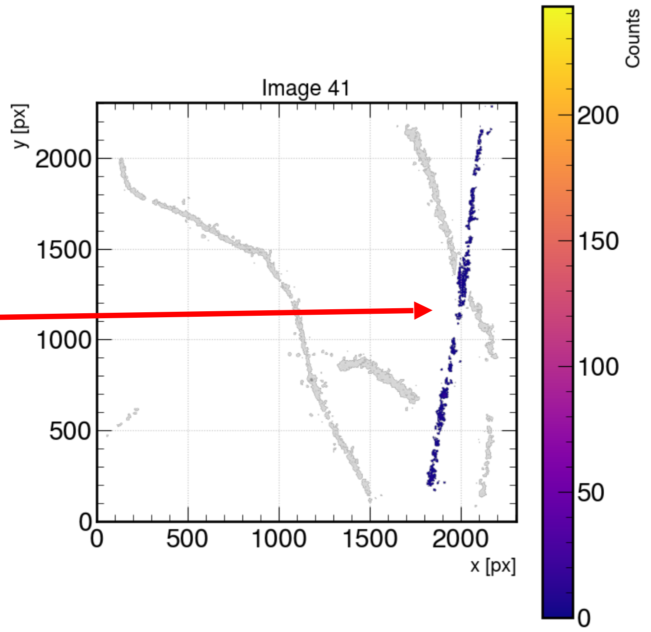
  - sc_integral $\in [2 * 10^3, 1 * 10^5]$ sc_trms $\in [1,30]$;
  - sc_length $\geq$ 500px;
  - delta < 10.





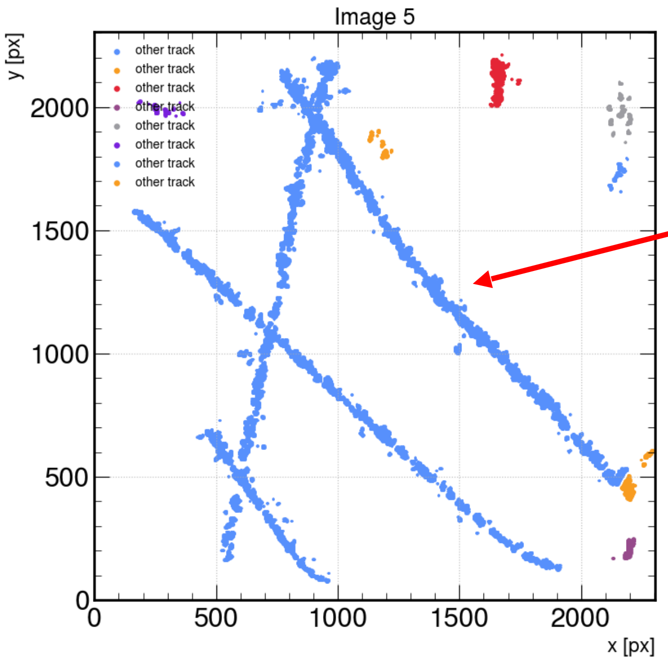
Muon selection

- With these cuts, most of the selected clusters are indeed muons, whose tracks can be used to extract the point spread functions.



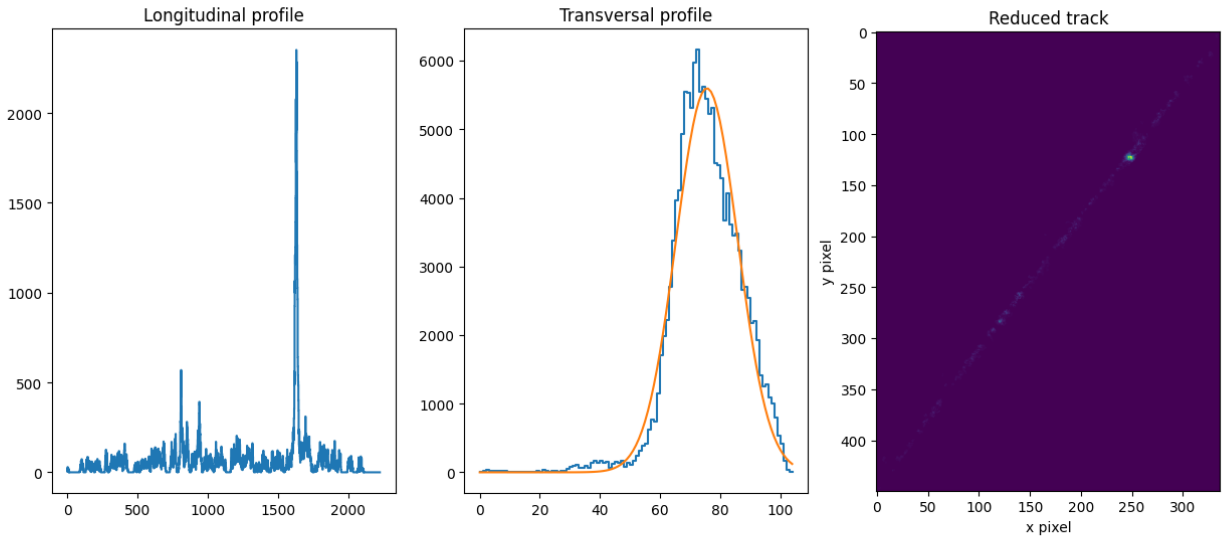
Muon track properly selected

4 tracks grouped together as a single cluster



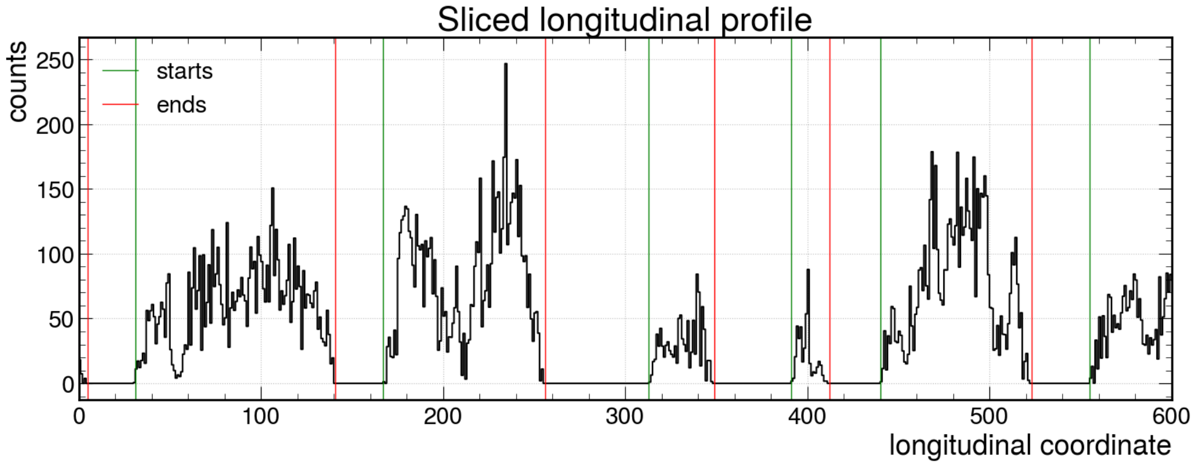
- Alas the reco has a tendency to group large tracks together hence the actual muons do not appear as clusters and long electron tracks are selected instead.

PSF extraction



- The PSFs can be evaluated directly from the muon tracks by looking for the smallest clusters, ideally containing a single electron.

- We look for these small clusters by plotting the longitudinal histogram of the muon and look for the clusters that are both small and have low energy deposit.

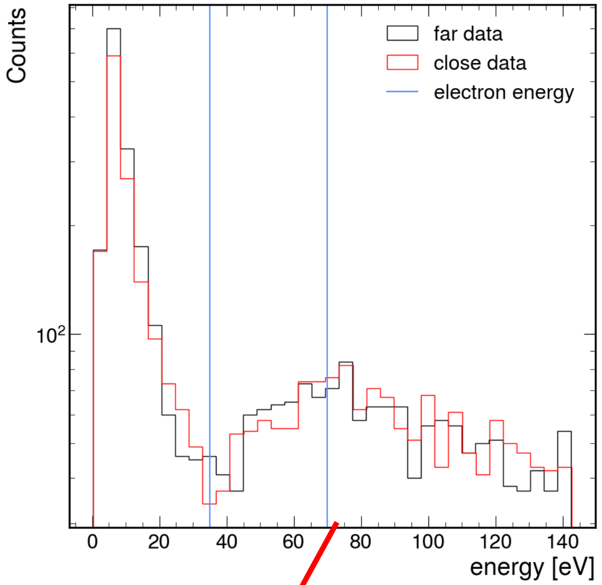


PSF extraction (WIP)

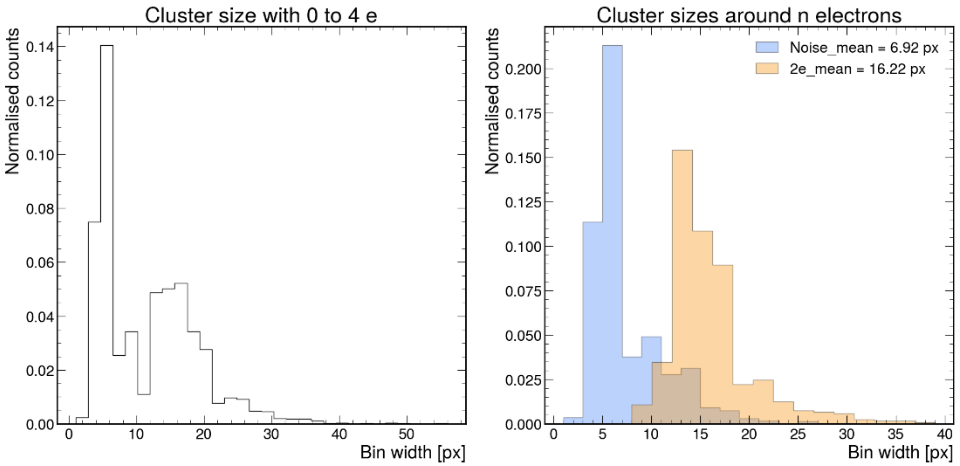
- The light of these subclusters along the muon longitudinal profile is calculated and using the energy calibration figures, converted into eV:

$$1eV \approx 3{,}5\ counts$$

- Another useful figure can be obtained by plotting the width of these subclusters with energies below $4W = 140eV$ shows a noticeable peak at around $16px$ $(800\mu m)$.



Small bump around 2W suggests the energy threshold is above $35eV$, meaning the minimum number of primary electrons we can see is 2.



PSF extraction (WIP)

- One possible way to test whether we can actually see clusters containing only a single electron is to slice again the longitudinal tracks of the muons, this time in equal slices of 15px (the hypothesised with of clusters containing 2 to 4 electrons);
- In principle we would see a series of peaks corresponding to polya functions, whose widths are connected to gain fluctuations, centered around the energies corresponding to multiple integers of W;
- If the gain fluctuations are too large, the single peaks cannot be distinguished and all we see is a continuous distribution resembling a Landau.

Expression of the polya distribution, m is the shape parameter that determines the variance of the polya while G is connected to the gain.

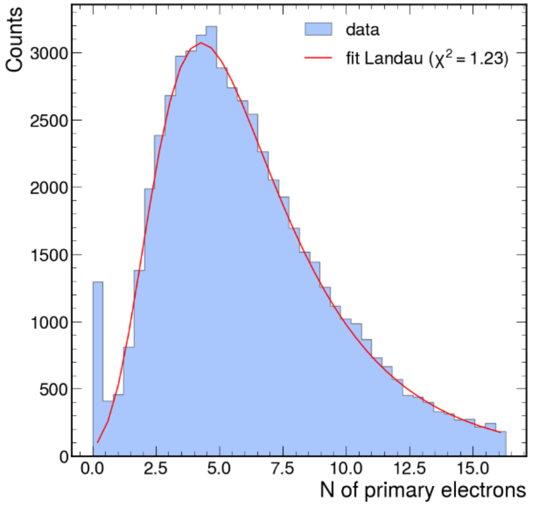
$$p(n) = a_0 \frac{m^m}{\Gamma(m)} \left(\frac{n}{G}\right)^{m-1} e^{-\frac{mn}{G}}$$

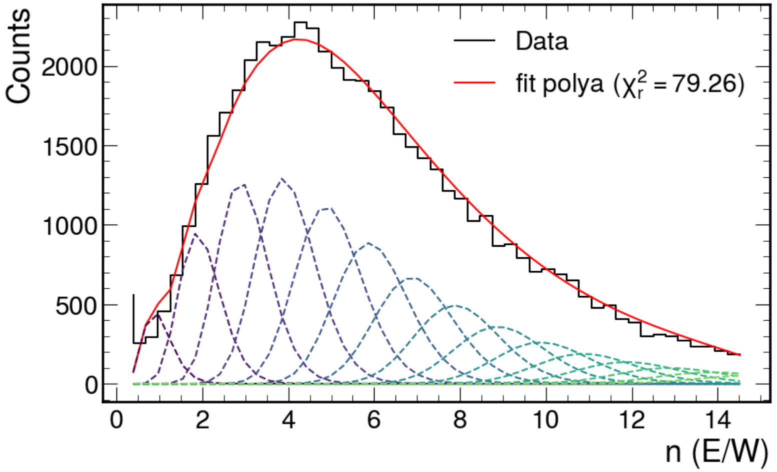
$n = \frac{E}{W}$ is the expected number of primary electrons that have been amplified.

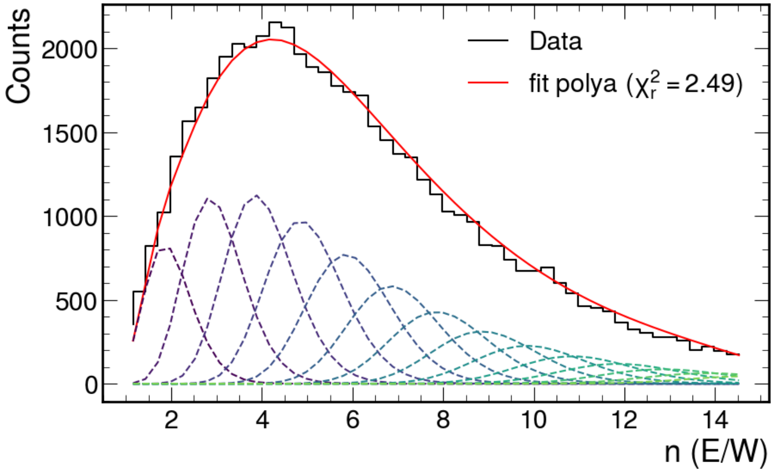
- For the fit we used the fact that, assuming the gain fluctuations of k electrons are indipendent processes, the distribution of the sum of two polyas with the same gain and shape parameter, is again a polya but with parameters: $m' = \mathrm{k}m,\ G' = \mathrm{k}G$.

PSF extraction (WIP)

- In GIN it seems that the gain fluctuations are indeed too large to discern the single peaks.
- By fitting the polyas and constraining the amplitudes to follow the fitted landau distribution, two distinct fits have been obtained:







The better model appears to be the one without the polya centered at n=1

THANK YOU

backup slides

μuonisation procedure

The idea to construct the data ground truth data is:

- Find smallest clusters (with few electrons, ideally no more than 3);
- Slice the longitudinal profiles and get the transversal profile for each slice;
- The integral of these sliced clusters will be an multiple of the smallest.
- From this we can infer how many electrons are in that cluster.
- Finally use the longitudinal and transversal slices to produce points (electrons) for the simulated track.