How to most valuably use the pion runs ?

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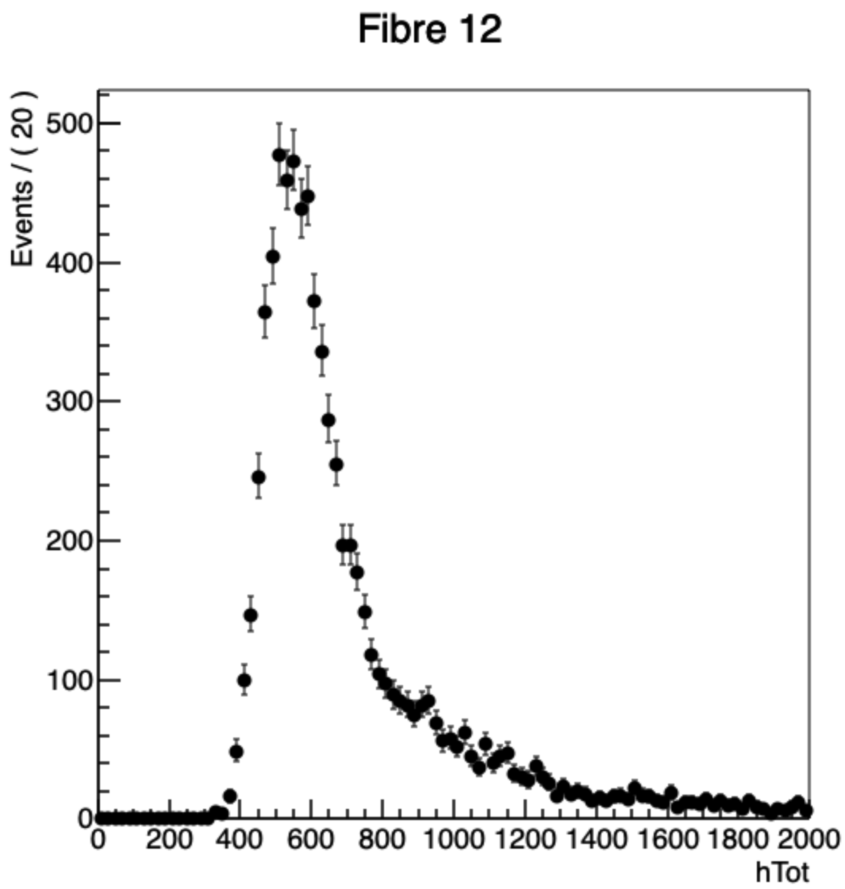
1. Position of the problem

- The pion runs are making most of our statistics
- In one instance (Troll2) it is the unique information available
- The pion beams present two “features” that must be mitigated:
  - The beam was contaminated by electrons
  - Some of the pions can experience a nuclear interaction within GRAiNITA. We calculated the rate to be $O(5\%)$.
- The optimal estimator of the fibre response would be to the most probable value of the ionisation part of the spectrum.
- This talk is meant to provide a method.
- The samples analysed are Run59 (pion) and Run(60), e.g. Troll1, HL.

1. Position of the problem

- The typical distribution of pions:



- It seems that the dE/dx can be measured.

2. Method to measure the pion MPV of their Landau

- Discussion of the selection requirements:

$$\mathrm{htotVal} = \sum_{i=0,15} \mathrm{hitCor}(i)$$

  - evenType == 4 (beam event)
  - 0 < htotVal < 2000 (relevant region)
  - muonDZ > 0 (the track exists)
  - diffTrack2 < 1 (good track)

$$\mathrm{diffTrack2} = \sum_{\mathrm{i}=1,3} \frac{(\mathrm{x_{fit}} - \mathrm{x_i})^2 + (\mathrm{y_{fit}} - \mathrm{y_i})^2}{6\sigma_{\mathrm{cut}}^2},$$

$$\sigma_{\mathrm{cut}} = 250\ \mu\mathrm{m}.$$

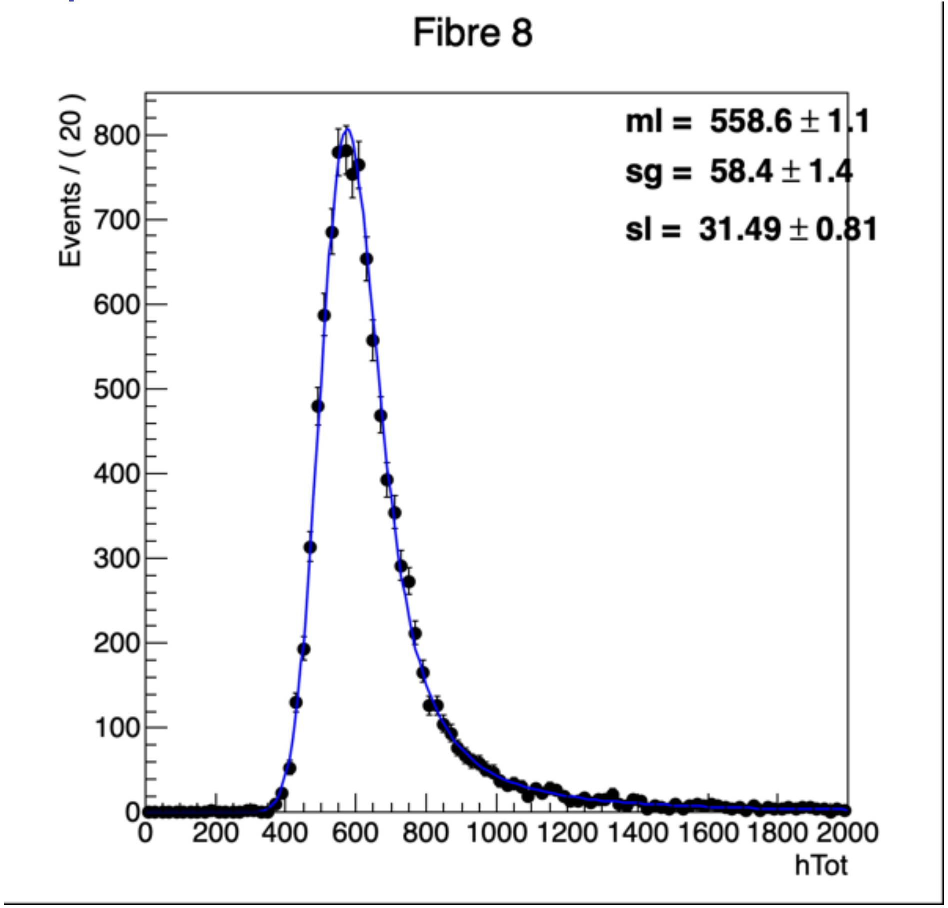
- This selection is applied to obtain all the distributions presented (including the one the previous slide).

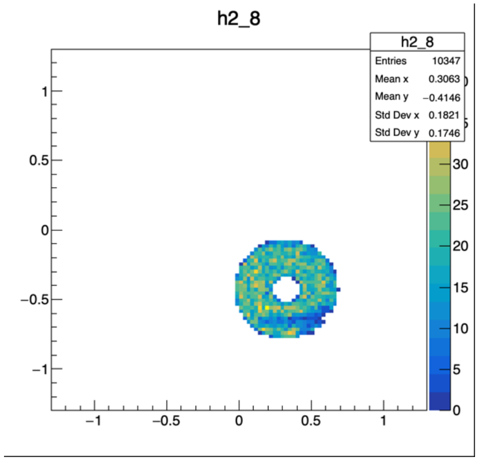
2. Method to measure the pion MPV of their Landau

- The muon beam is clean: fit the distribution of the total number of hits with a Landau function convoluted by a gaussian near a calibrating fibre.
- Model the the pion distribution with a Landau convoluted with a gaussian and a possibly universal shape to describe the showers. We chose Asymmetric Crystal Ball with:
  - mean value = sqrt(2)*MPV
  - sigma = sigma_Landau
  - The power law parameters alpha_L and n_L are floated together with the fraction of minimum ionisation events f_sig.
- Fit the pion distribution of the calibrating fibre by fixing the Landau o Gauss parameters to the muon ones, but the MPV.
- Use this model with CB parameters fixed to fit the pion MPV of the Landau on all other fibre positions

2. Method to measure the pion MPV of their Landau

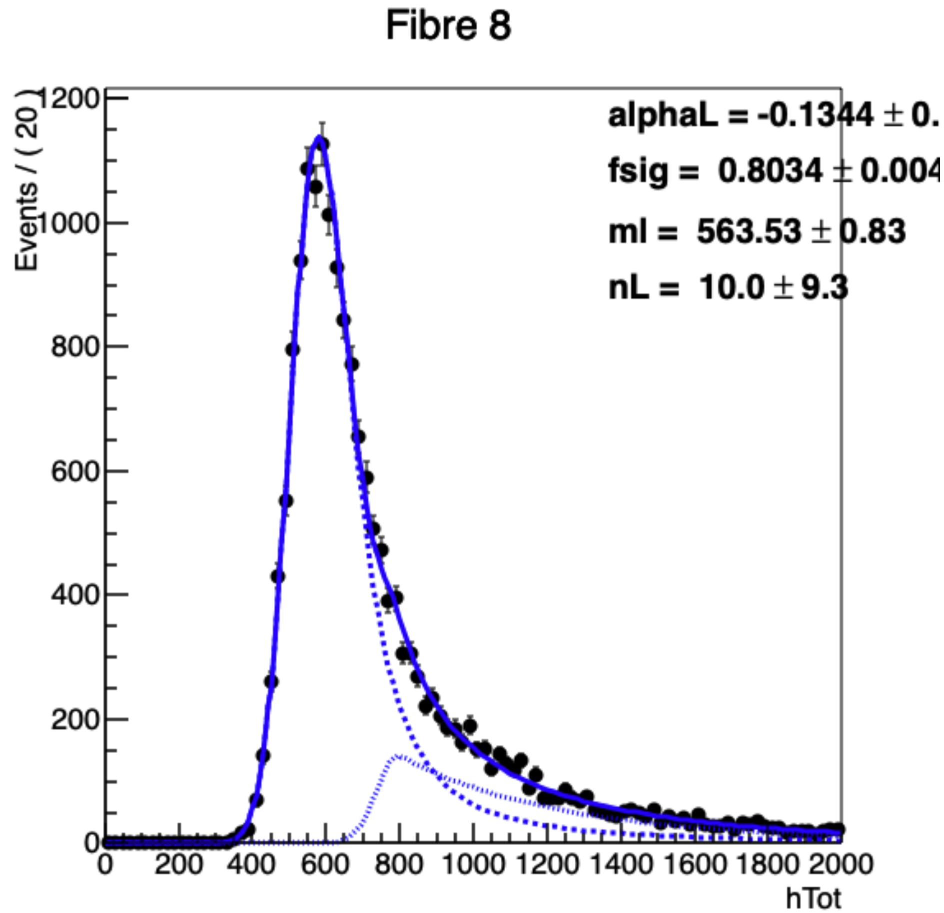
- The muon beam is clean: fit the distribution of the total number of hits with a Landau function convoluted by a gaussian.
- Example with fibre 8:





2. Method to measure the pion MPV of their Landau

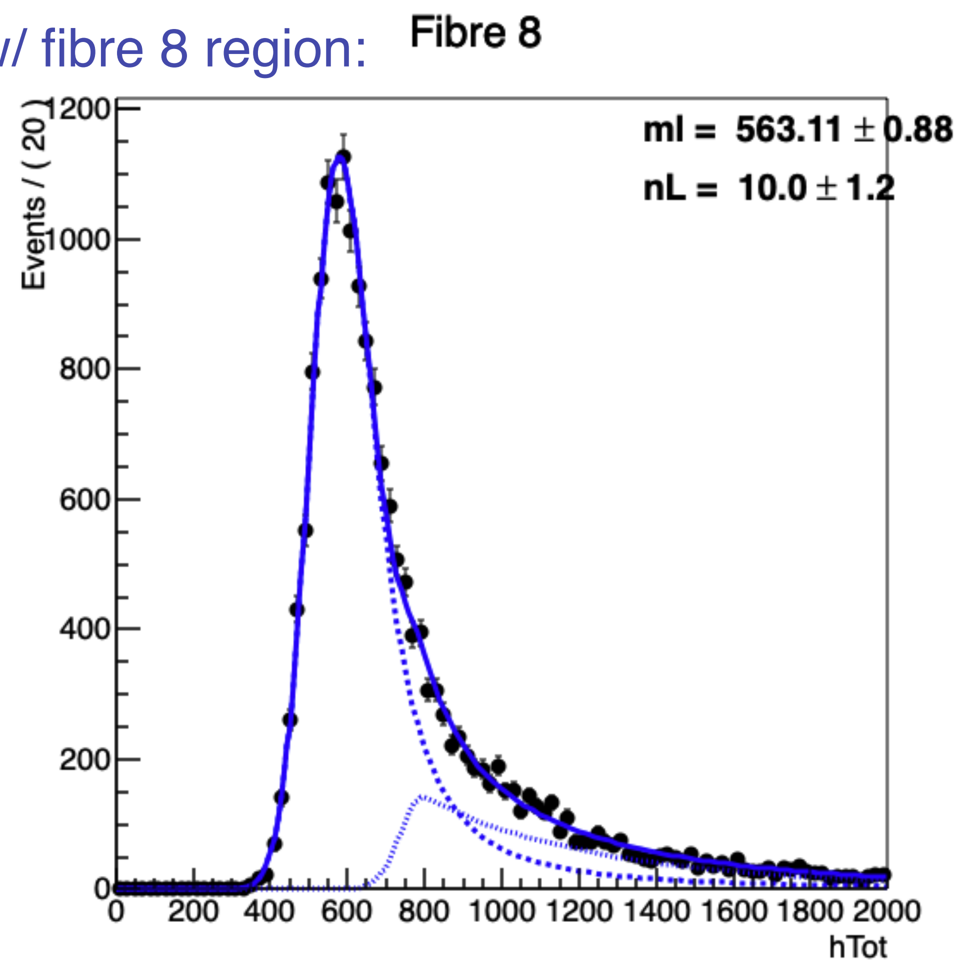
- We then fix in the same pion distribution response the Landau parameters, but the MPV.
- Example with fibre 8:



Note: the MPV is let free because 1) muon and pion samples can have a different response (liquid leak), 2) we can! We indeed see that there's more light in the pion run.

2. Method to measure the pion MPV of their Landau

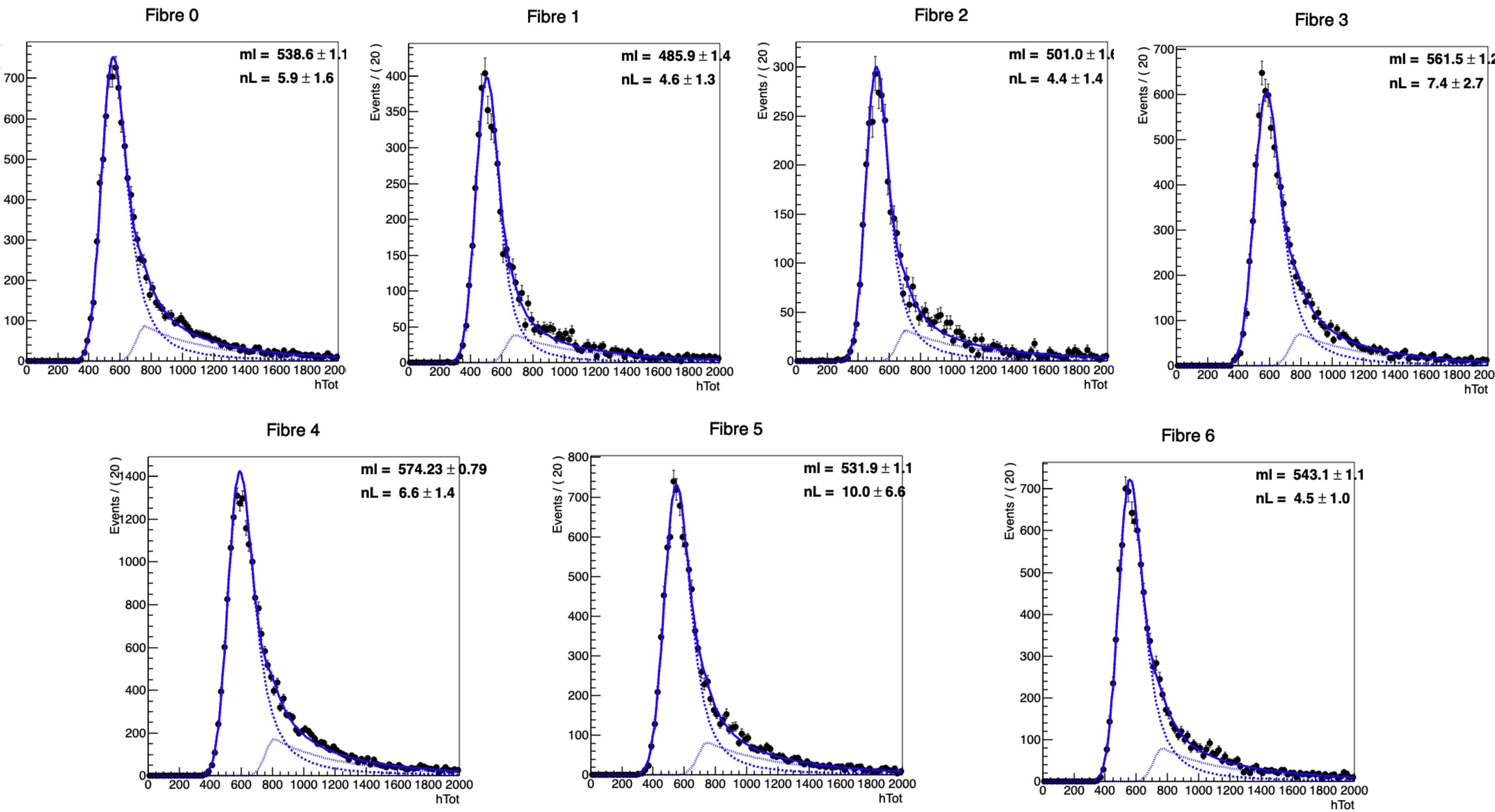
- Next we fit all the other fibre positions with the model having the MPV of the Landau floating and all other parameters fixed [either to muon fit (sigma L o G) or calibrating fibre fit (CB)]
- Example with fibre 12 calibrated w/ fibre 8 region:



Note#1: the parameter of the power law n_L is subjected to large fluctuations. We keep it free in all fits but it is not necessary.

2. Method to measure the pion MPV of their Landau

- Half the fibres calibrated by 8: this works pretty well



2. Method to measure the pion MPV of their Landau

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- Can we estimate a systematic uncertainty related to the method?
- Yes we can!
  - Use one fibre region to calibrate: get the responses for the 15 others.
  - Change the fibre region and redo the job.

==> we have 15 different and equivalent ways to obtain the pion response. Their spread can be the systematic uncertainty estimate.

==> if the results for all fibre regions are all seen consistent, we can even combine them, fit them and quote a single number in the publication.

I obtain here a precision better than half a percent.

==> An additional systematic comes from the choice of the magic number sqrt(2). Make it vary by 5% and quote the variation of the results as systematic unc. estimate.

3. Conclusions

- Muon sample is pretty clean and can be used to assess performance on the Troll 1 with Heavy Liquid (well, with what was left of it)
- Pion samples are plagued by electrons and shoring pions.
- Yet, we designed a method that allows to obtain the Most Probable Value of their Landau:
  - The non-dE/dx component of the signal is modelled with a CB having its mean value and sigma constrained by the (Landau o Gauss) parameters to obtain a “universal” background shape.
- It seems to work with acceptable systematics. Pions can be used!