PMT Analysis

Francesco Borra, Andrea Messina, Stefano Piacentini

Discriminating Fe signals

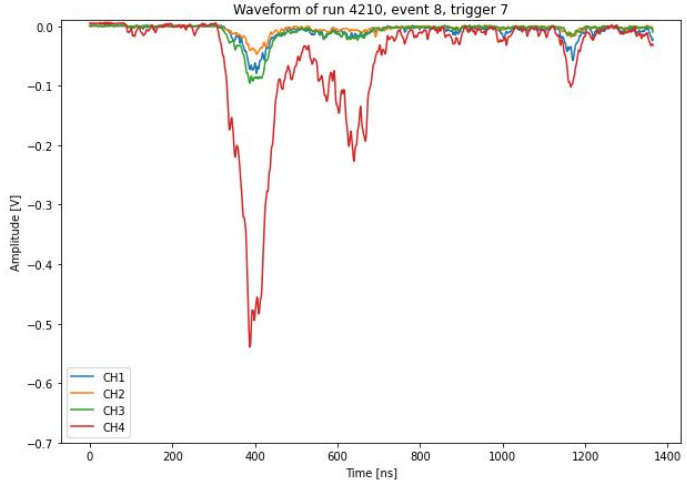
Quasi-equalized PMTs, tensions at:
(813, 836, 774, 770) V.

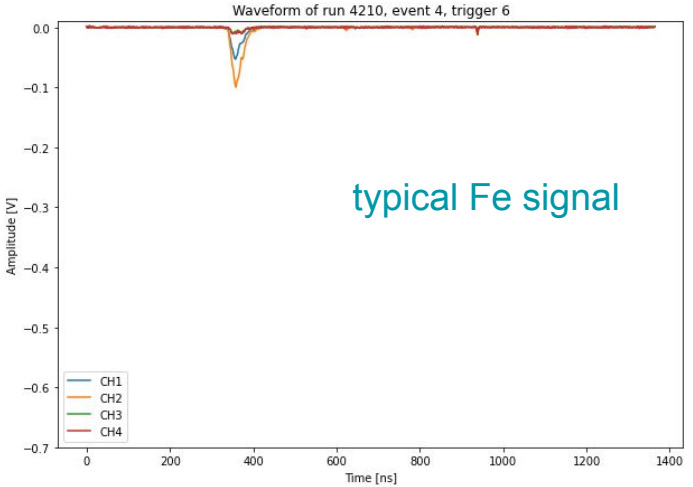
Runs:

- 4210 - 4218 **Fe**
- 4304 - 4308 **no Fe**.

Selection on signal:

- V th = 30 mV
- length th = 15 samples (1 sample ≃ 1.33 ns).





typical Fe signal

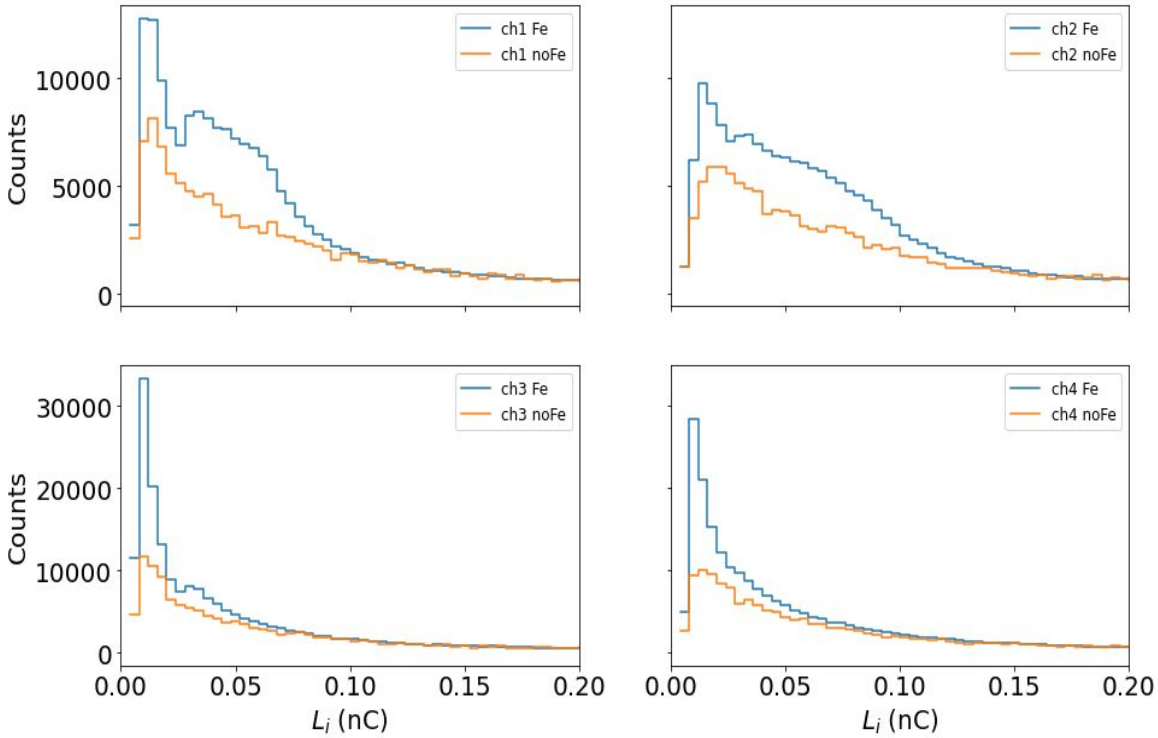
Discriminating Fe signals

Calculating waveforms integrals:

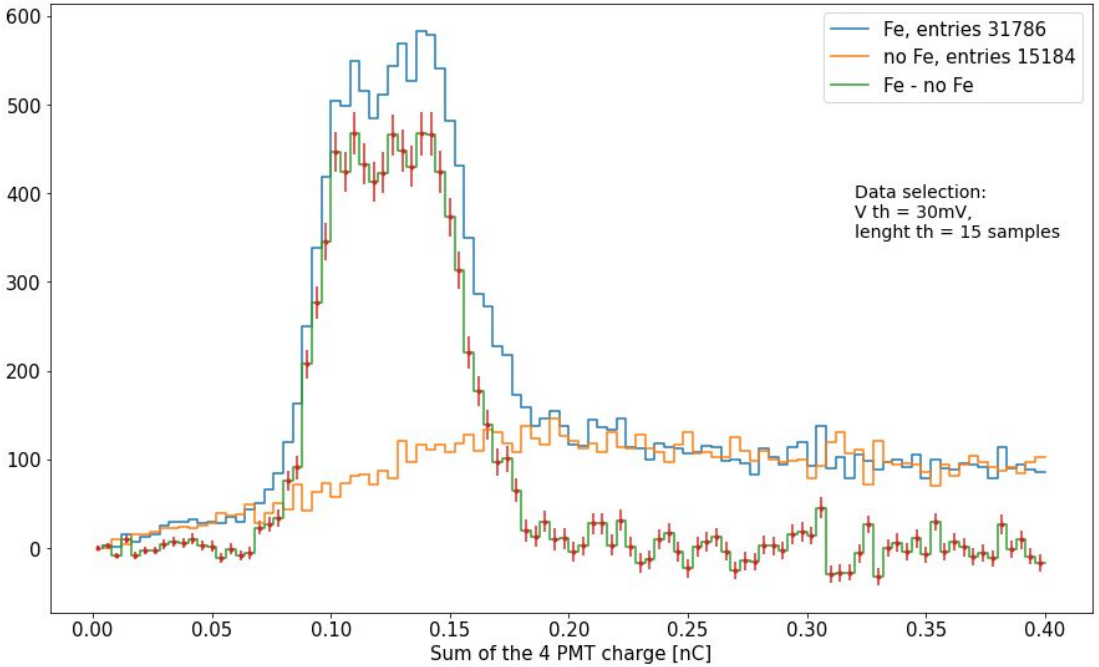
- selected waveforms
- Integrating on the peak
- Charge collected = integral/50Ohm

The **selection was the same for runs with and without the Fe source**.

Fe - noFe comparison



Rough reconstruction: sum of charges



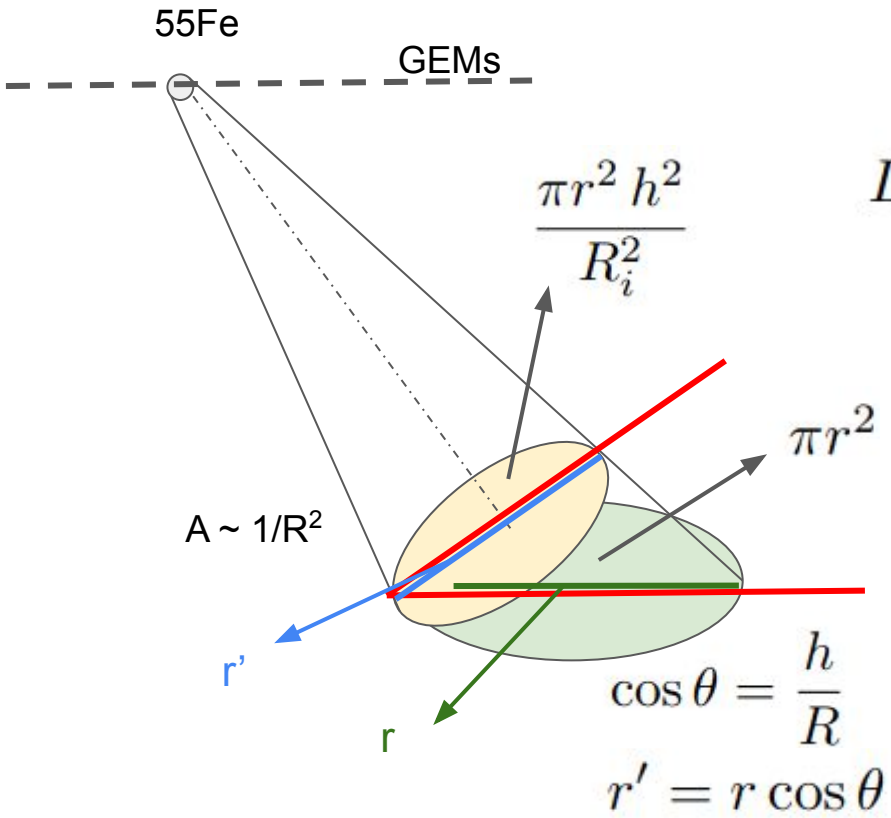
The peak **can't be gaussian**:

- **Light** collected **depends on spot position** on the GEMs plane (will be illustrated after)
- The 4 PMTs, in principle, respond to light differently

Fast but rough estimation.

PMT light collection

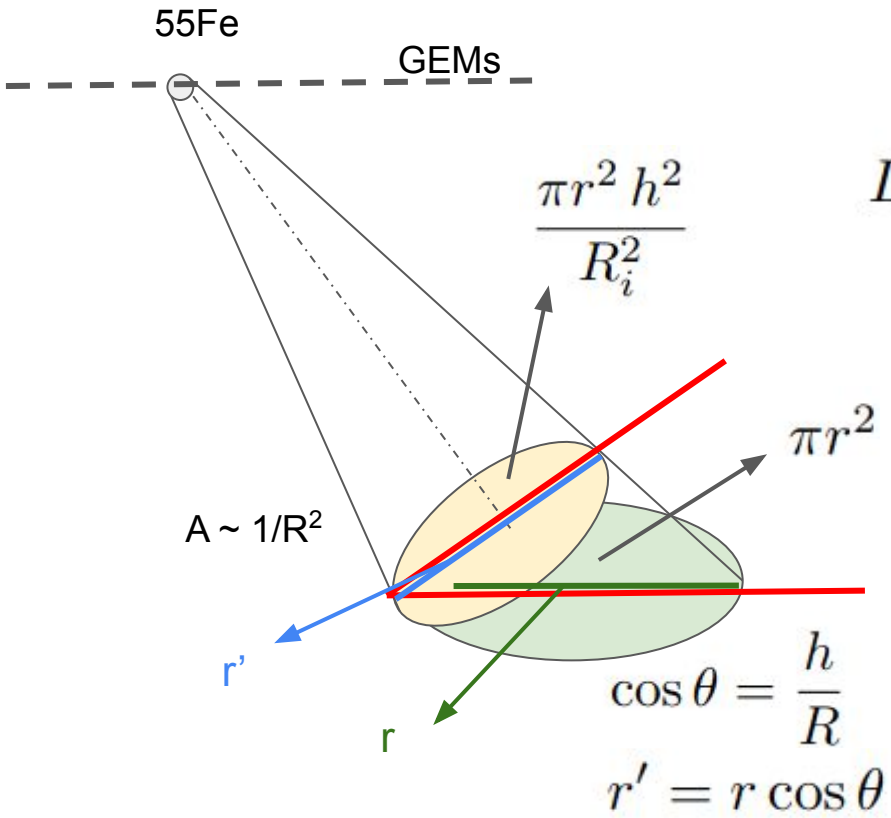
h: distance from the GEM plane
r: sensor radius



$$L_{PMT} = \frac{L_{spot}}{4\pi R_i^2} \frac{\pi r^2 h^2}{R_i^2}$$

PMT light collection

h: distance from the GEM plane
r: sensor radius



$$L_{PMT} = \frac{L_{spot}}{4\pi R_i^2} \frac{\pi r^2 h^2}{R_i^2}$$

Measure:

L_1, L_2, L_3, L_4

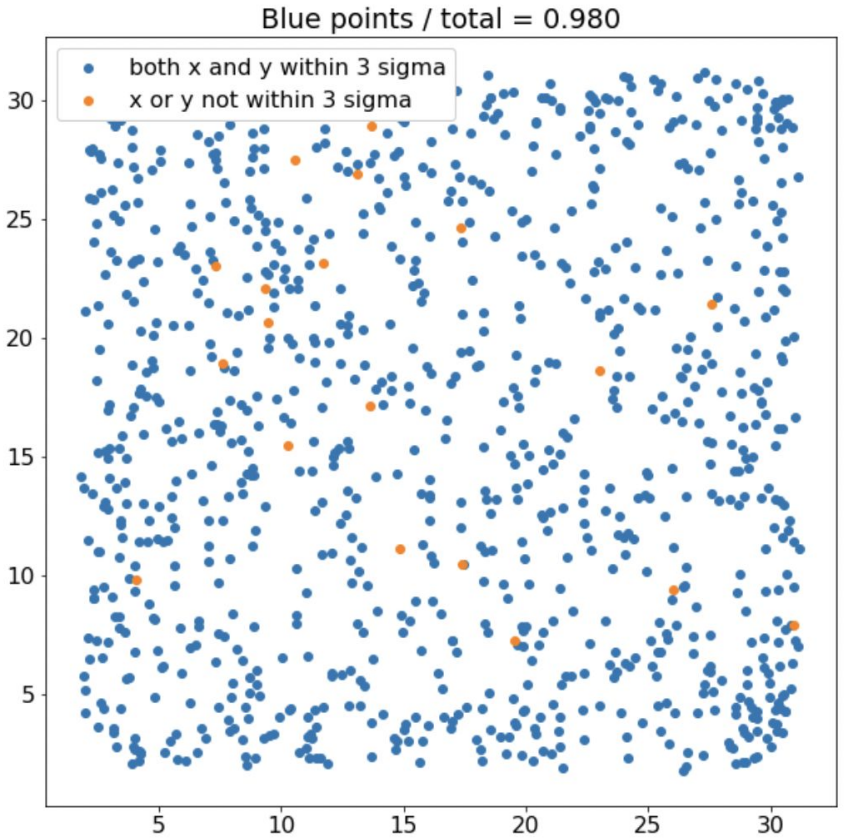
Infer:

L_{spot}, x, y

Fit implementation

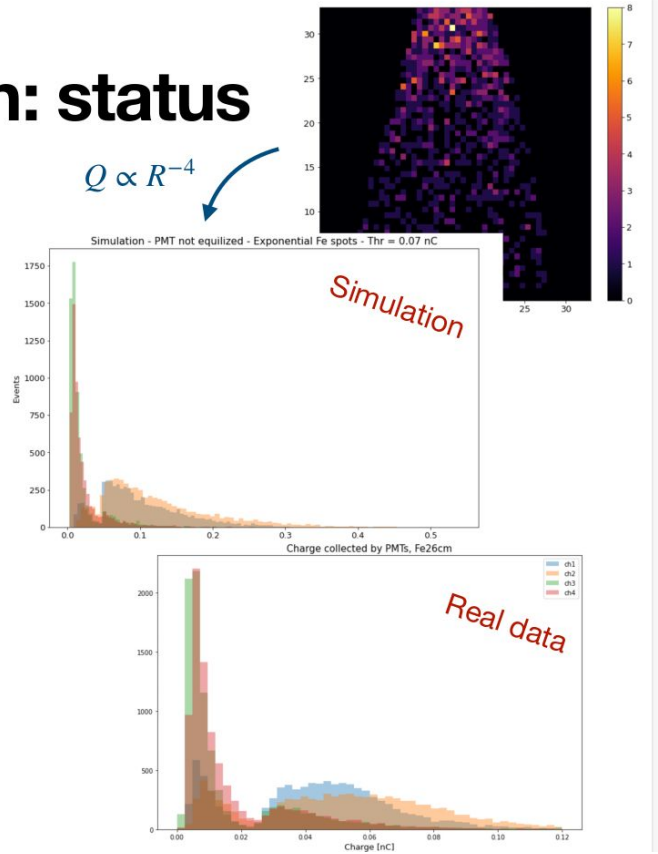
Using the charge collected by the PMTs is possible to reconstruct the position in the GEM plane and the light emitted by the spots.

For testing we simulated spots in the GEM plane, calculated the charge collected by the 4 pmts, reconstructed the positions and **then compared with the generated ones**.



Fast parametric simulation: status

- From ^{55}Fe **data** extract mean and sigma of relevant quantities (energy of the spot in terms of total light produced at the GEM plane)
- **Simulate** ^{55}Fe position, attenuation length, spot intensity
- Include light attenuation and **generate charge** in the PMTs



From Stefano P.'s presentation at Sim meeting 28/11

Fitting PMTs calibration const

Using L_1, L_2, L_3, L_4 is it possible to reconstruct the x-y position and the gain of each PMT.

Strict selection on the waveforms to take possibly only Fe spots.

4 spots for each fit. L_{spot} considered uniform for every spot.

The fitted parameters are:

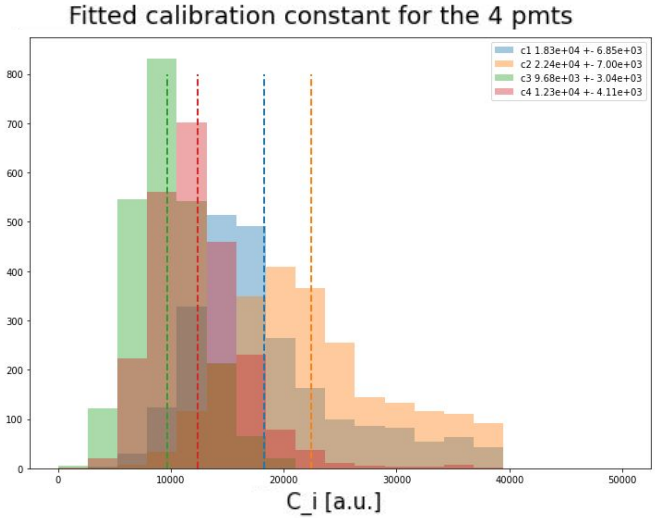
- $(x, y)_{i = 1\text{-}4}$
- c_1, c_3, c_3, c_4.

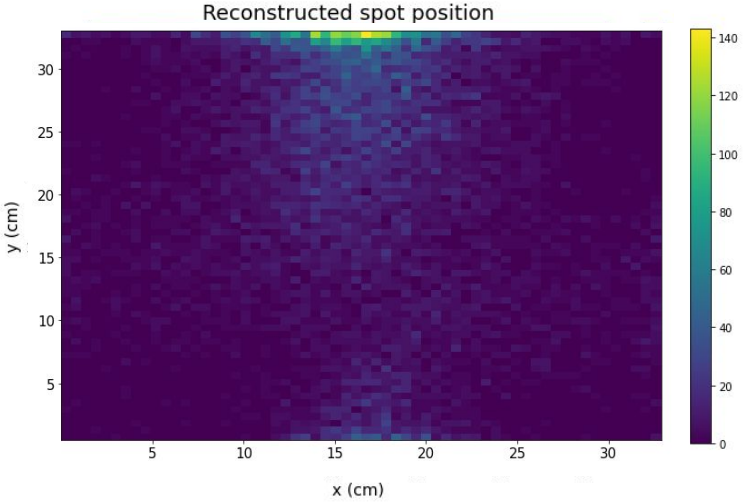
$$\frac{c1}{c1} = 1,$$

$$\frac{c2}{c1} = 1.22,$$

$$\frac{c3}{c1} = 0.529,$$

$$\frac{c4}{c1} = 0.672$$





Same fit, new data with ‘new equalization’

Setting the PMT in the **new ‘equalized’ workpoint**: (803, 803, 833, 800) V

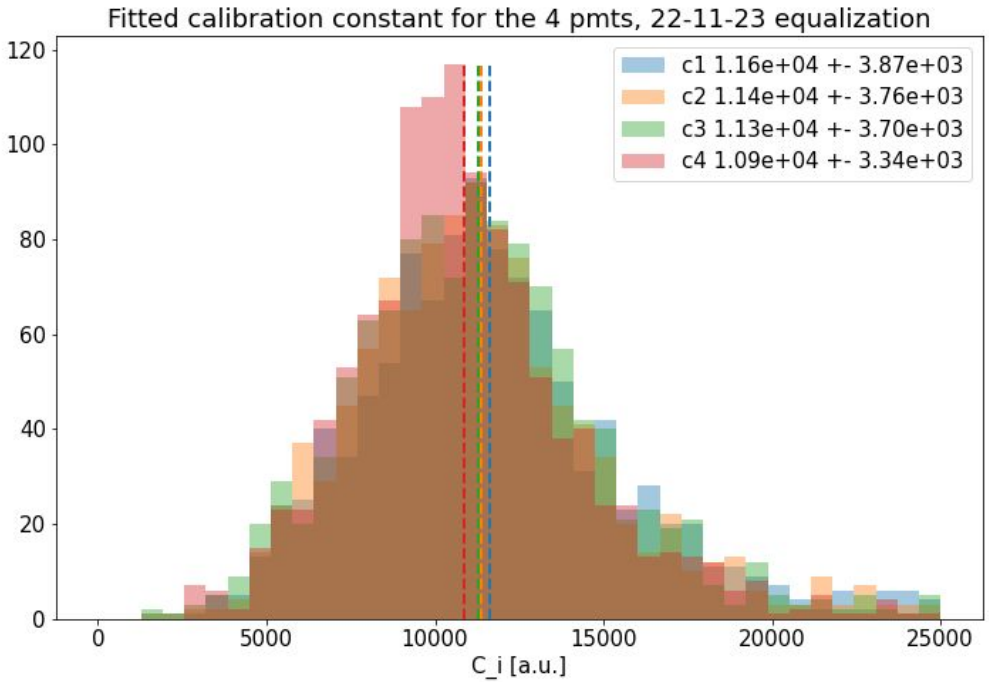
Taking **new data** to check if the fit is consistent.

Fitting again:

- $(x, y)_{i = 1\text{-}4}$
- c_1, c_3, c_3, c_4

$$\frac{c1}{c1} = 1, \qquad \frac{c3}{c1} = 0.968,$$

$$\frac{c2}{c1} = 0.975, \qquad \frac{c4}{c1} = 0.935$$



Reconstruction

Fixed calibration constant, fitting a **single spot**, parameters:

- **x, y;**
- **L.**

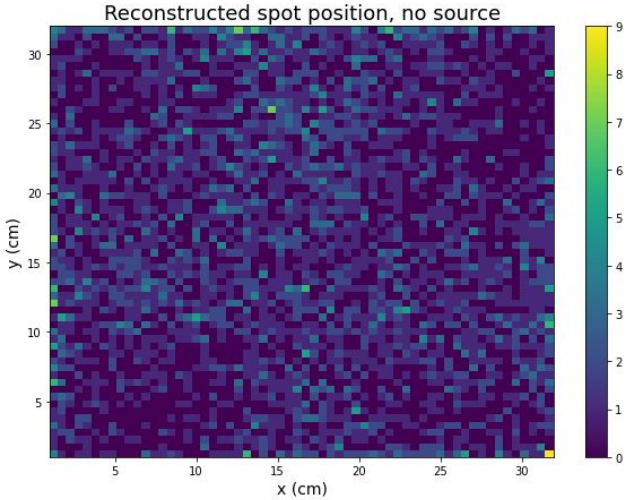
The dataset used for this reconstruction was, on purpose, **loosely selected**, to ensure that the BKG data was enough.

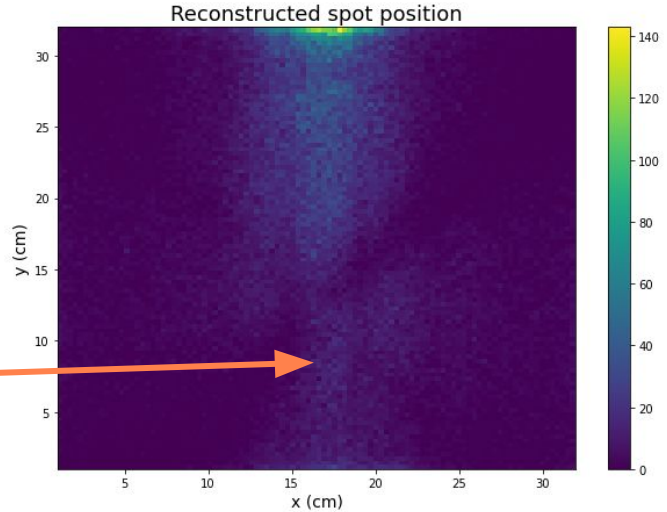
In the picture is evident that some points are badly reconstructed:

→ **working on it**

- “cross” shape of reconstructed spots

should be ⅓ of the initial spots!!





Reconstruction

Fixed calibration constant, fitting a **single spot**, parameters:

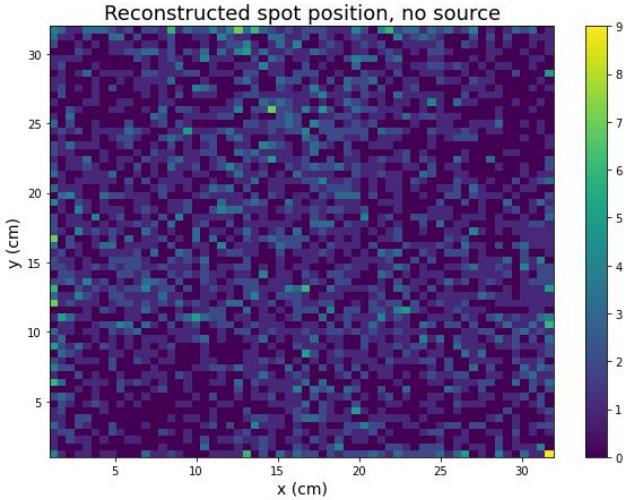
- **x, y;**
- **L.**

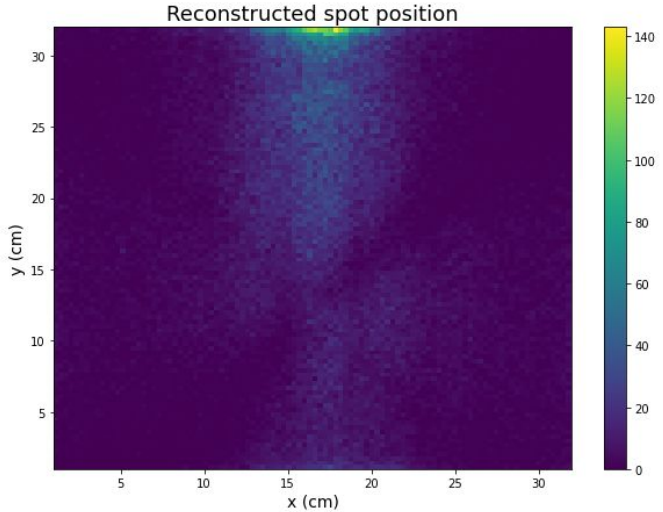
The dataset used for this reconstruction was, on purpose, **loosely selected**, to ensure that the BKG data was enough.

In the picture is evident that some points are badly reconstructed:

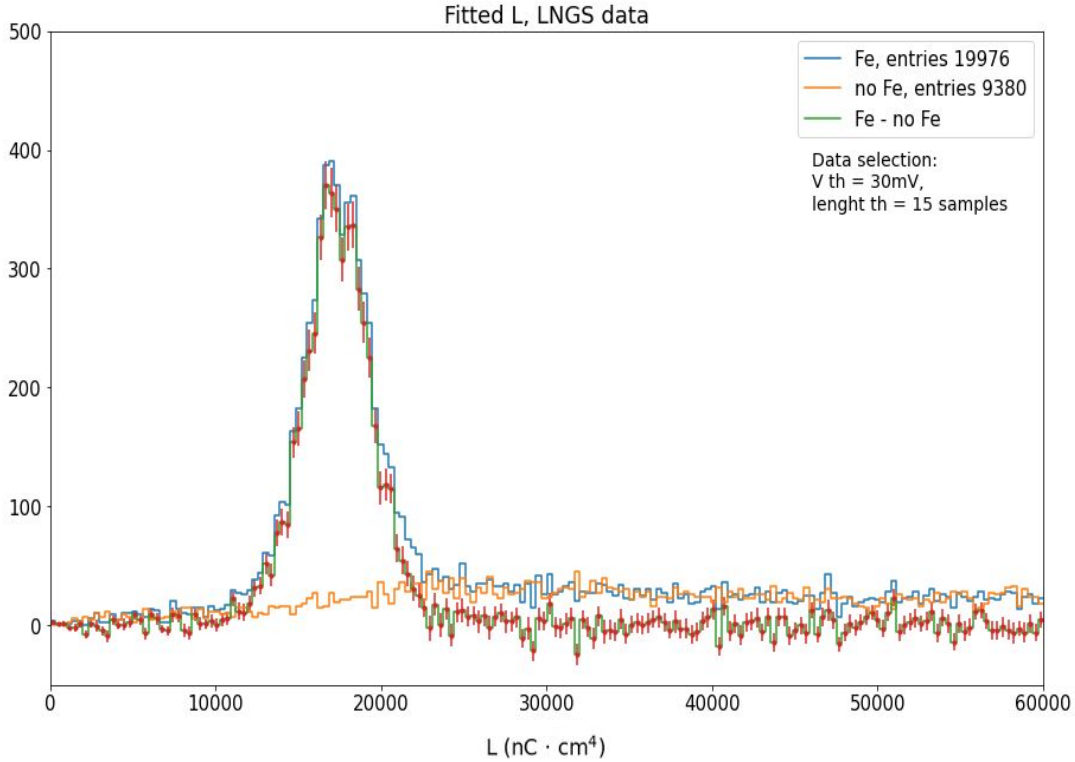
→ **working on it**

- “cross” shape of reconstructed spots



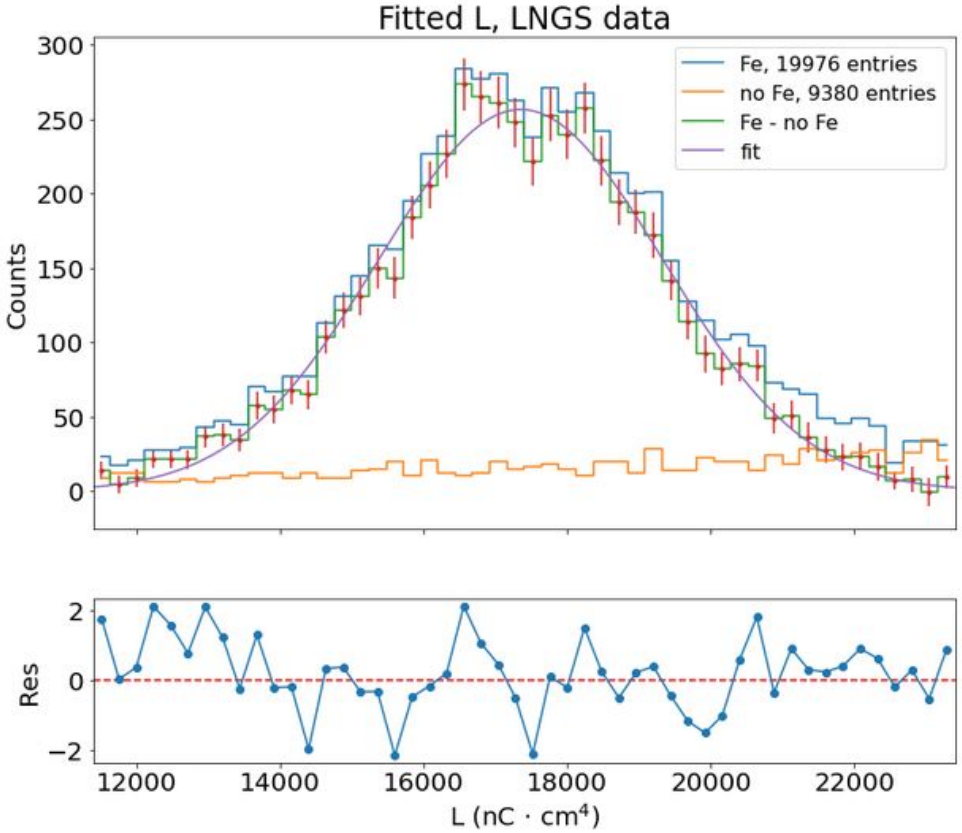


Fitted L histogram



- ‘Light’ reconstructed both for runs with source that only bkg.
- Same data selection and reconstruction algorithm for both datasets.

Reconstructed Fe light

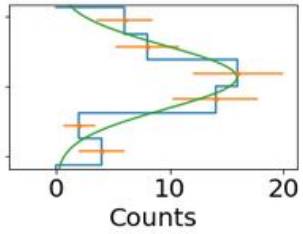


Runs: 4210 - 4218

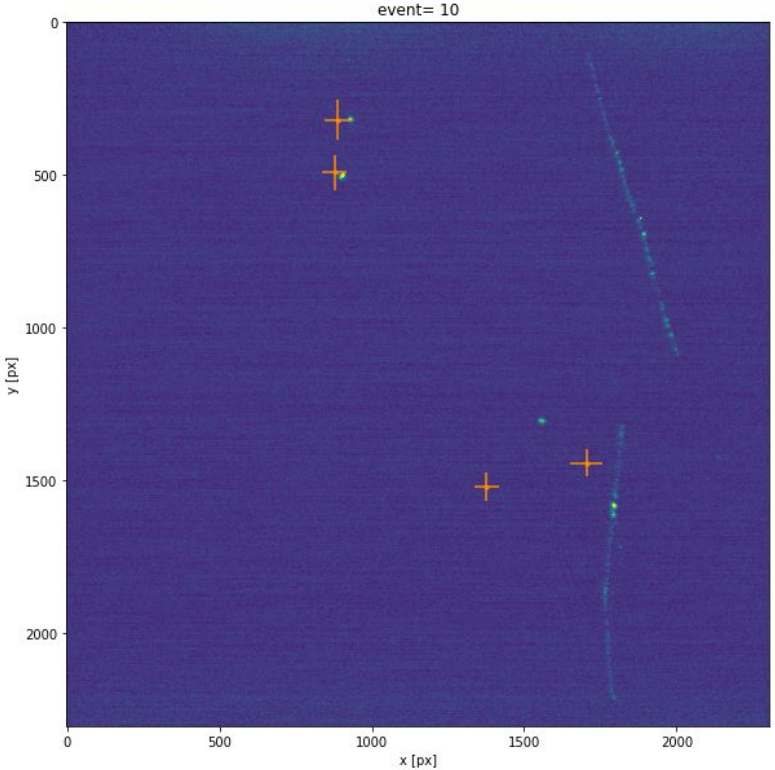
Data selection:
Offline selection
- V th = -30mV,
- lenght th = 15 samples
- Selection efficiency = 0.41
- (Fe - noFe)/Fe = 0.53

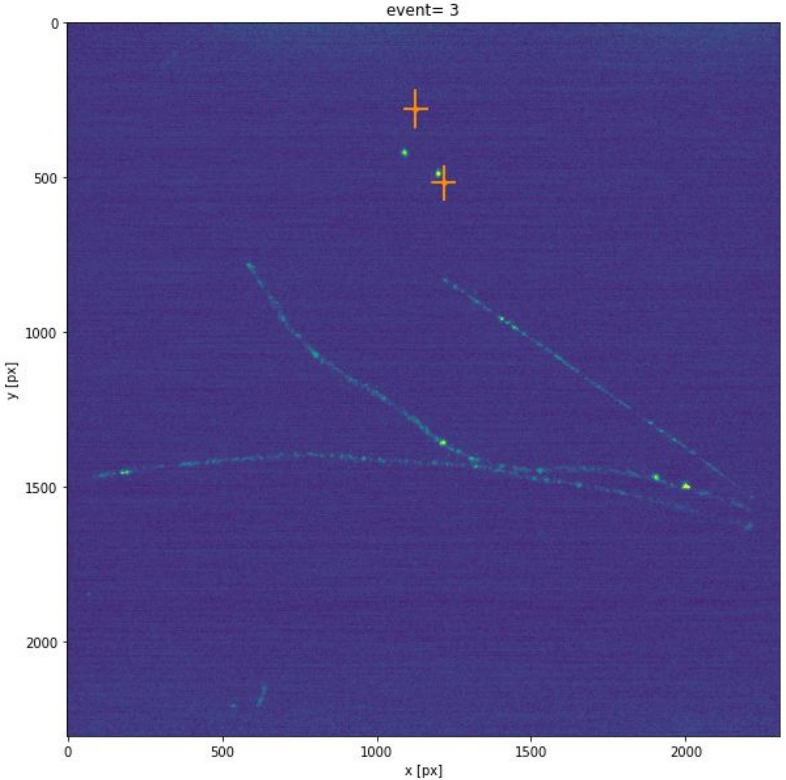
Fit
- fitted mean = 17.4e3
- fitted sd = 2.0e3
- resolution = 0.11

Residuals
- residuals mean = 0.25
- residuals std = 0.9

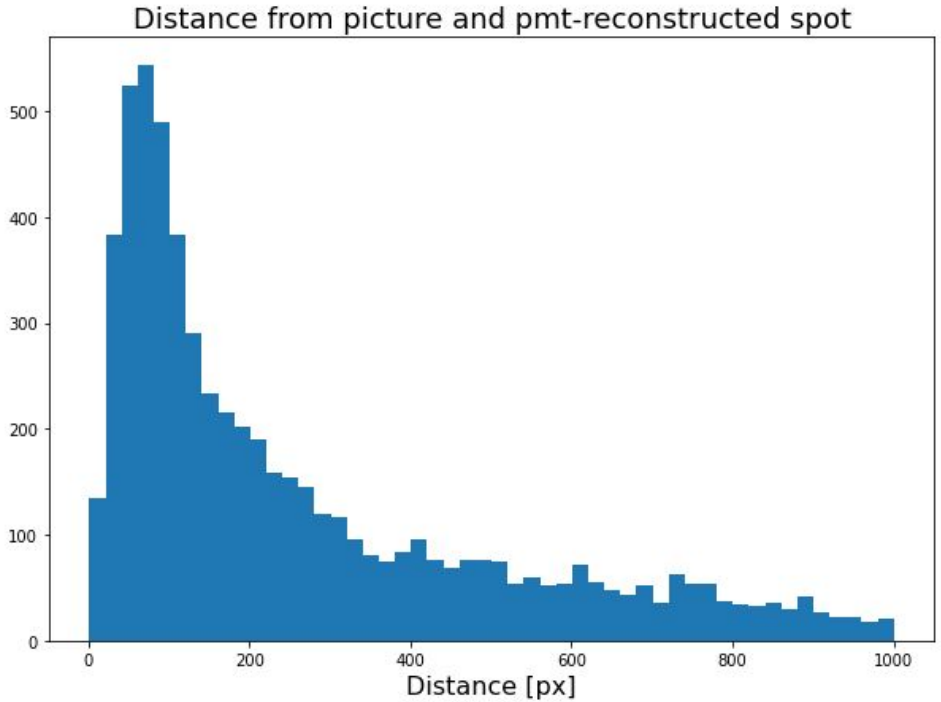


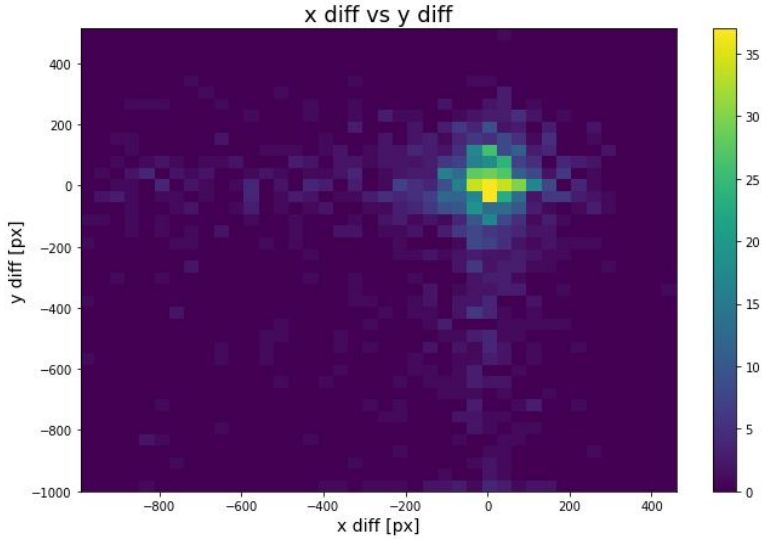
Matching with pictures

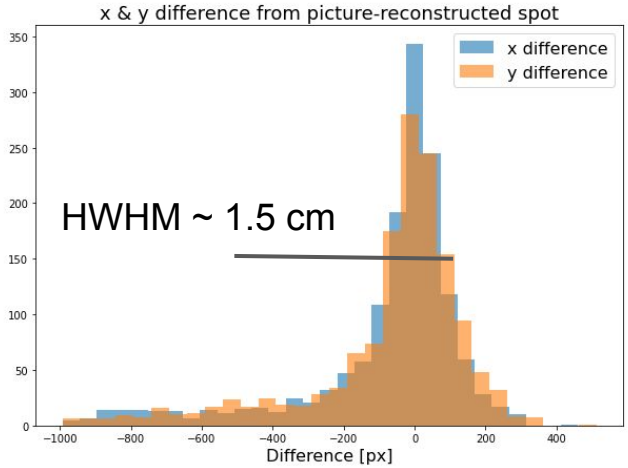




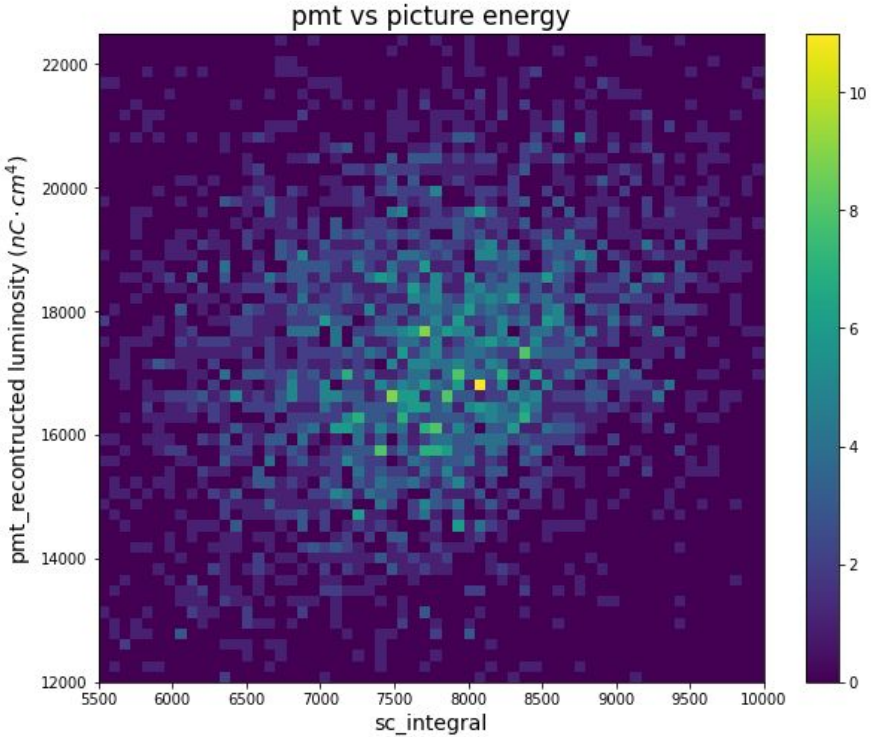
Matching with reconstructed variables (1)







Matching with reconstructed variables (2)



Conclusions

- Calibration of PMTs with the fit seems working → **need more analysis** with the new calibration

- **L** reconstructed has an **excellent resolution** (11%),

- L = 2.95 nC cm^4 per eV

- For a limited fraction of spots, **(x,y)** position not correctly reconstructed. Issue has to be fully understood yet.

- First results on **matching the pmt-reconstructed position with camera position** are promising

Thanks for your attention!