PMTs
Status of reconstruction code

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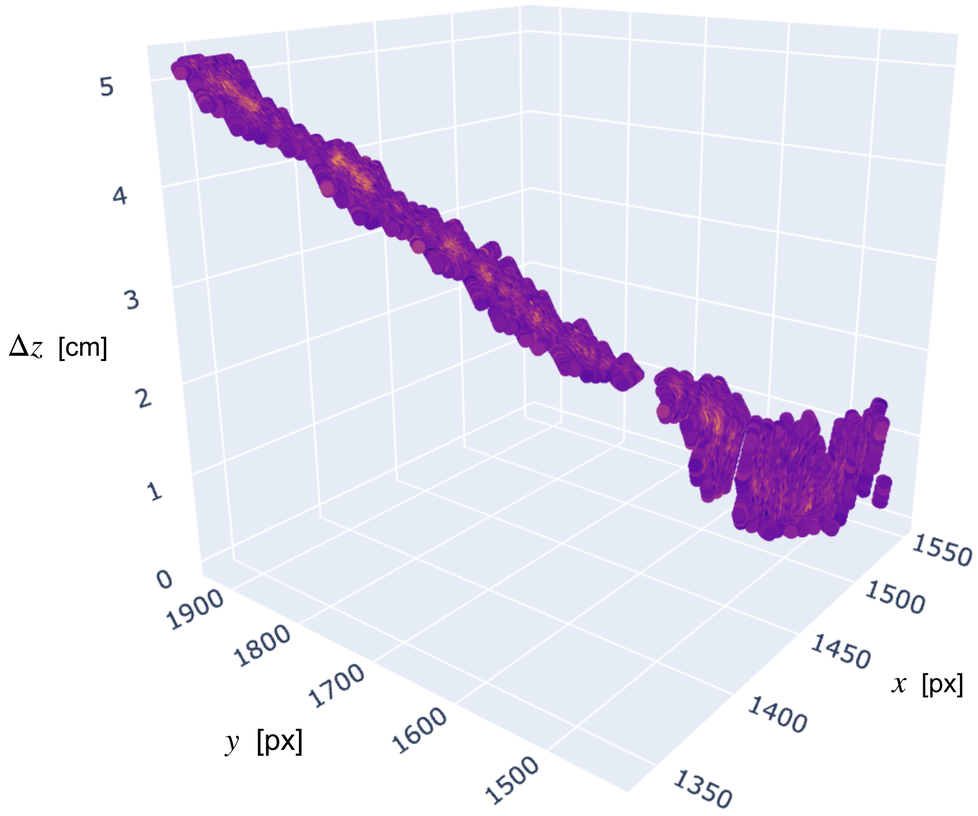
Outline

- Why is needed
- What is measured
- Method
- Calibration procedures
- Performance on Fe
- Integration with reconstruction code
- RUN2 background spectrum

Why is needed

- Integral of the waveform not a good variable for the energy (talks of David & Matteo)

- Necessity of associate **1 to 1** waveform and clusters for a 3D reconstruction



Cherry picked event!

What is measured

- **Charge**: proportional to the light collected by the PMT.
- **Signal length**: see David and Matteo's talks

Charge collected: integral of the waveform divided by the termination resistance:

$$I = \frac{V}{R} = \frac{Q}{t} \longrightarrow Q \cdot R = \int_{t_0}^{t_1} V(t)\,dt$$

$$\longrightarrow Q = \frac{\int_{t_0}^{t_1} V(t)\,dt}{R}$$

Method (1)

Measure $L_{1\text{-}4}$

Infer x, y, L

Reconstruction performed with a Bayesian analysis:

Likelihood

Prior *pdf*

$$p(\boldsymbol{\theta}|\{x_i\}) = \frac{p(\{x_i\}|\boldsymbol{\theta}) \cdot \pi(\boldsymbol{\theta})}{p(\{x_i\})}$$

Posterior *pdf*

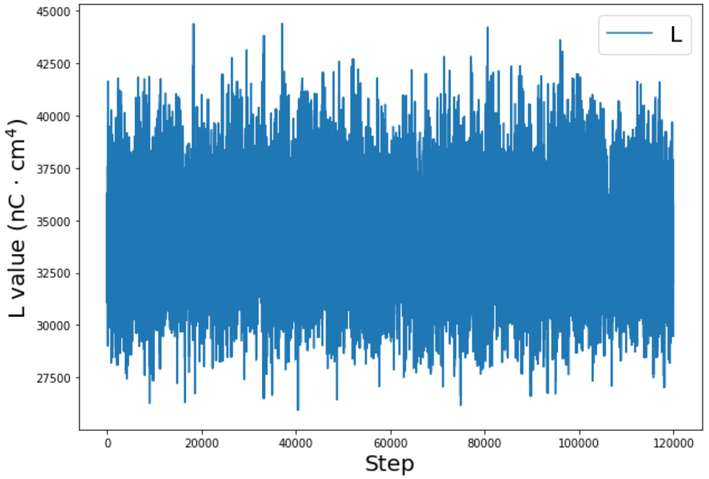
Normalization factor

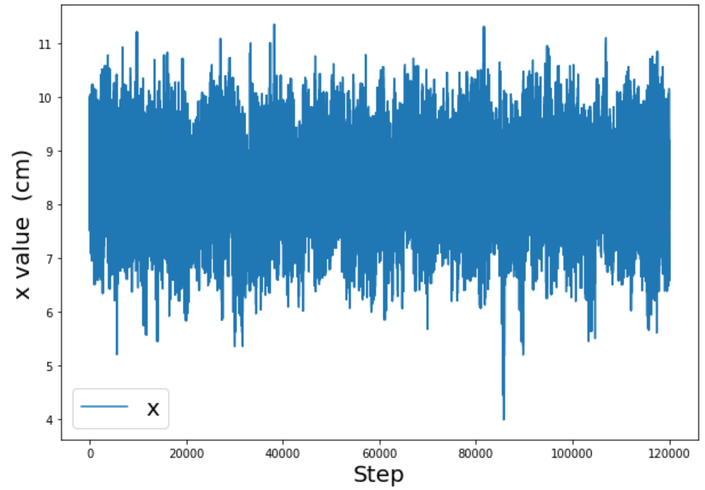
Where:

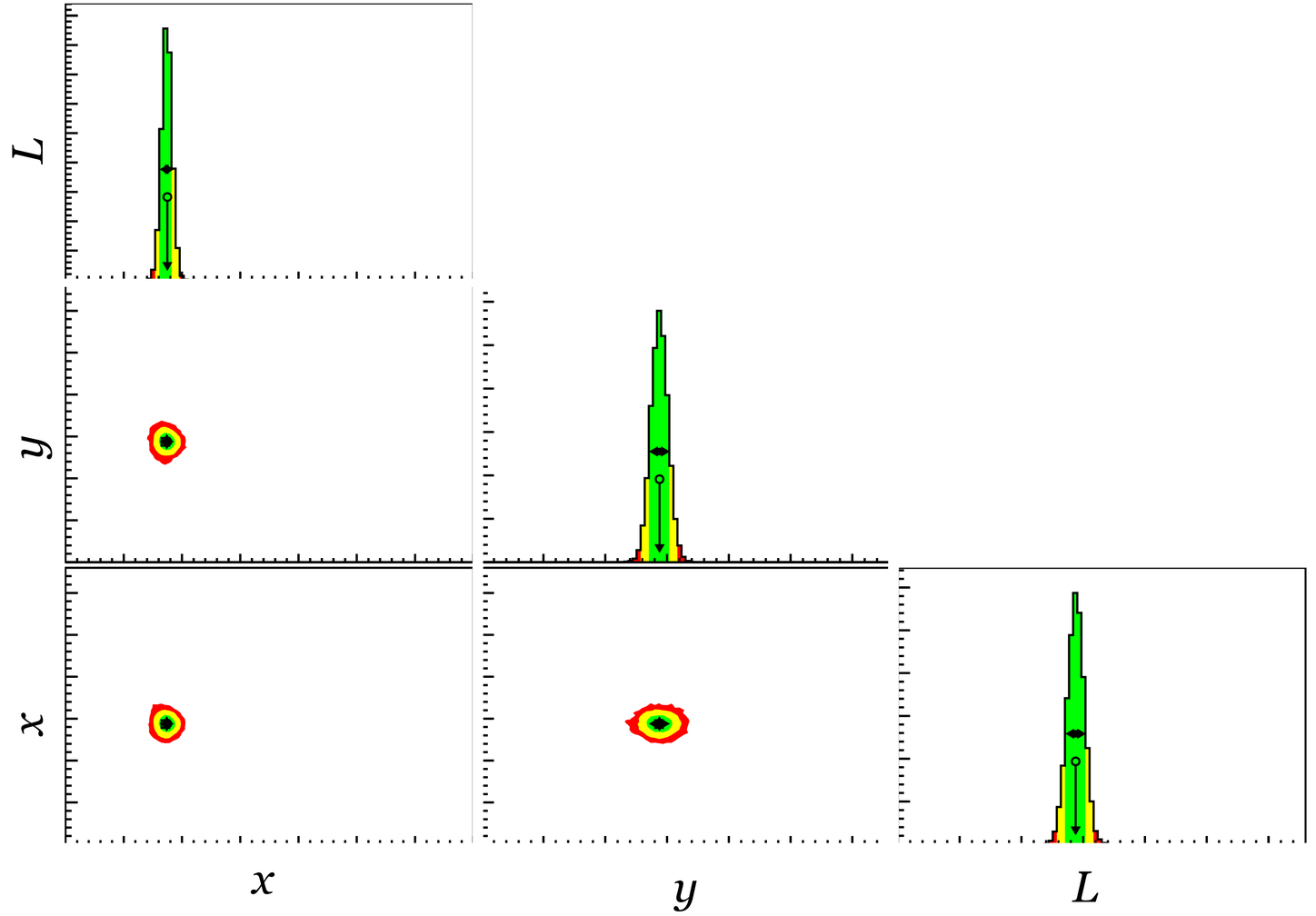
$$R_i = \sqrt{x_i^2 + y_i^2 + z_i^2}$$

Likelihood: $p(\{x_i\}|\boldsymbol{\theta}) = \prod_i \mathcal{N}(\{x_i\}|\mu_i(\boldsymbol{\theta}))$ $\longrightarrow$ $\mu_i = \frac{L}{R_i^4}$

Method (2)

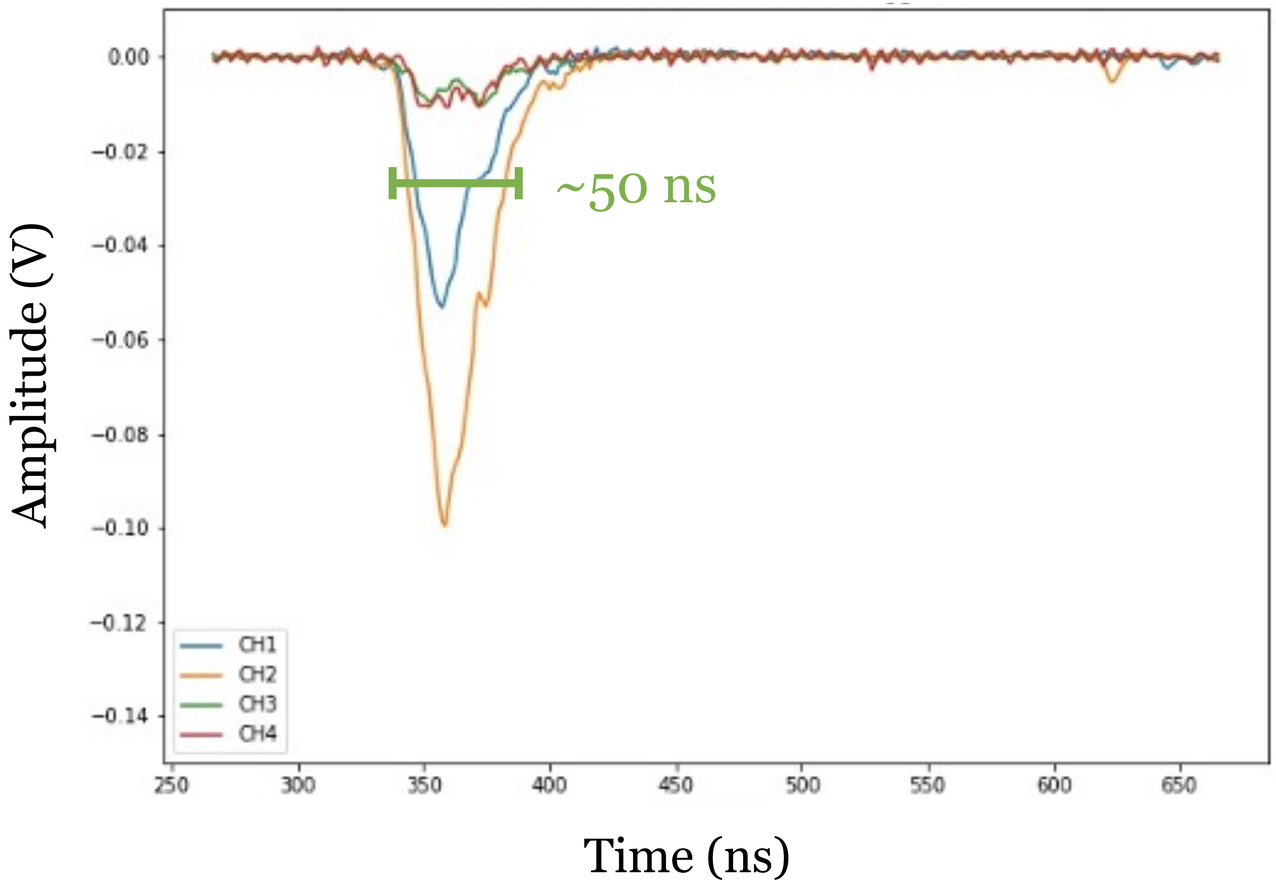






Method (3): spot-like interactions

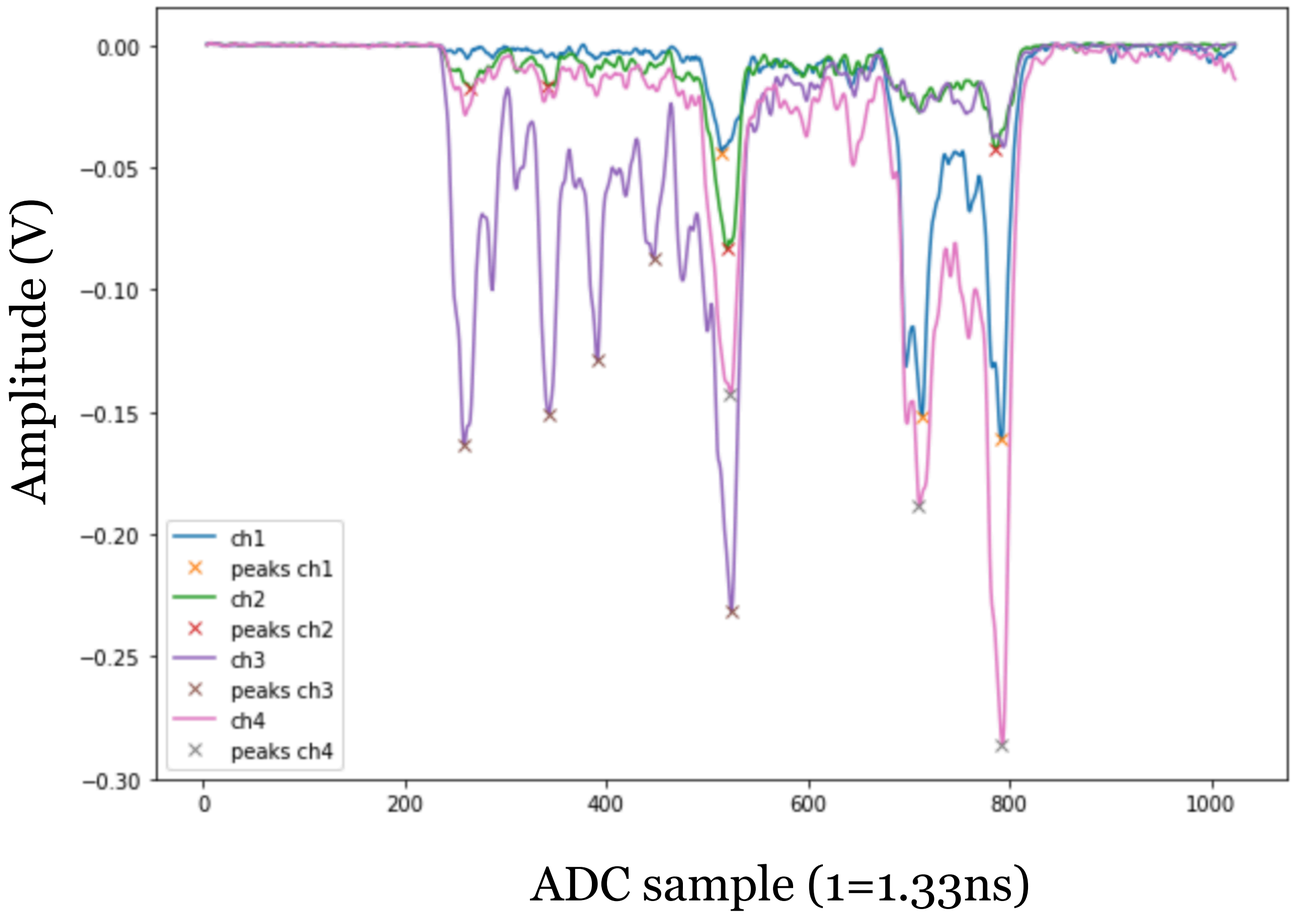
- Find “majority 2 peak”
- Integrate 50 samples (~0.4cm resolution in *z*)
- Perform the Bayesian fit over the 4 PMTs’ charges



Method (4): longer waveforms

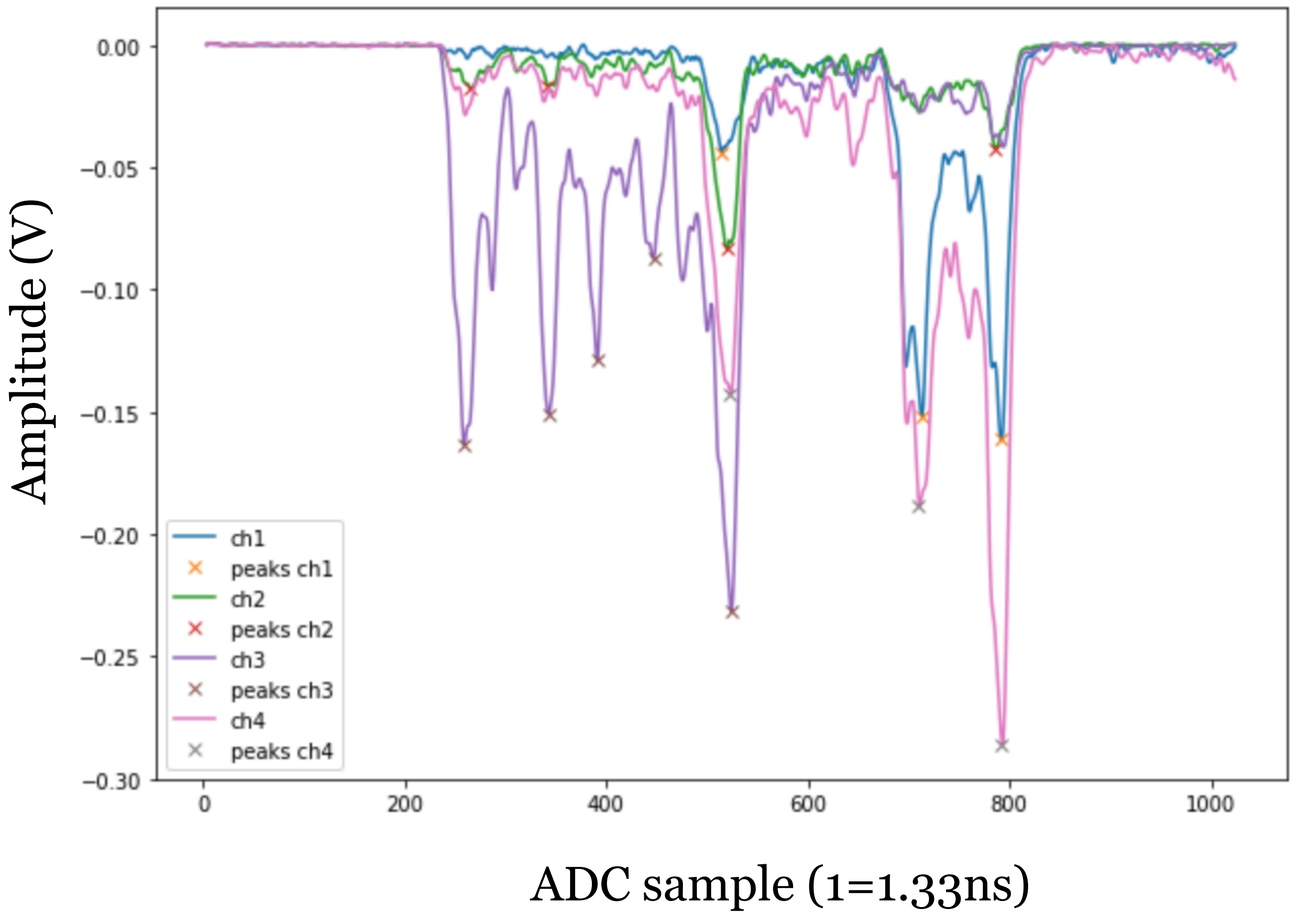
Two approach:

- Position focused
- “Energy” focused



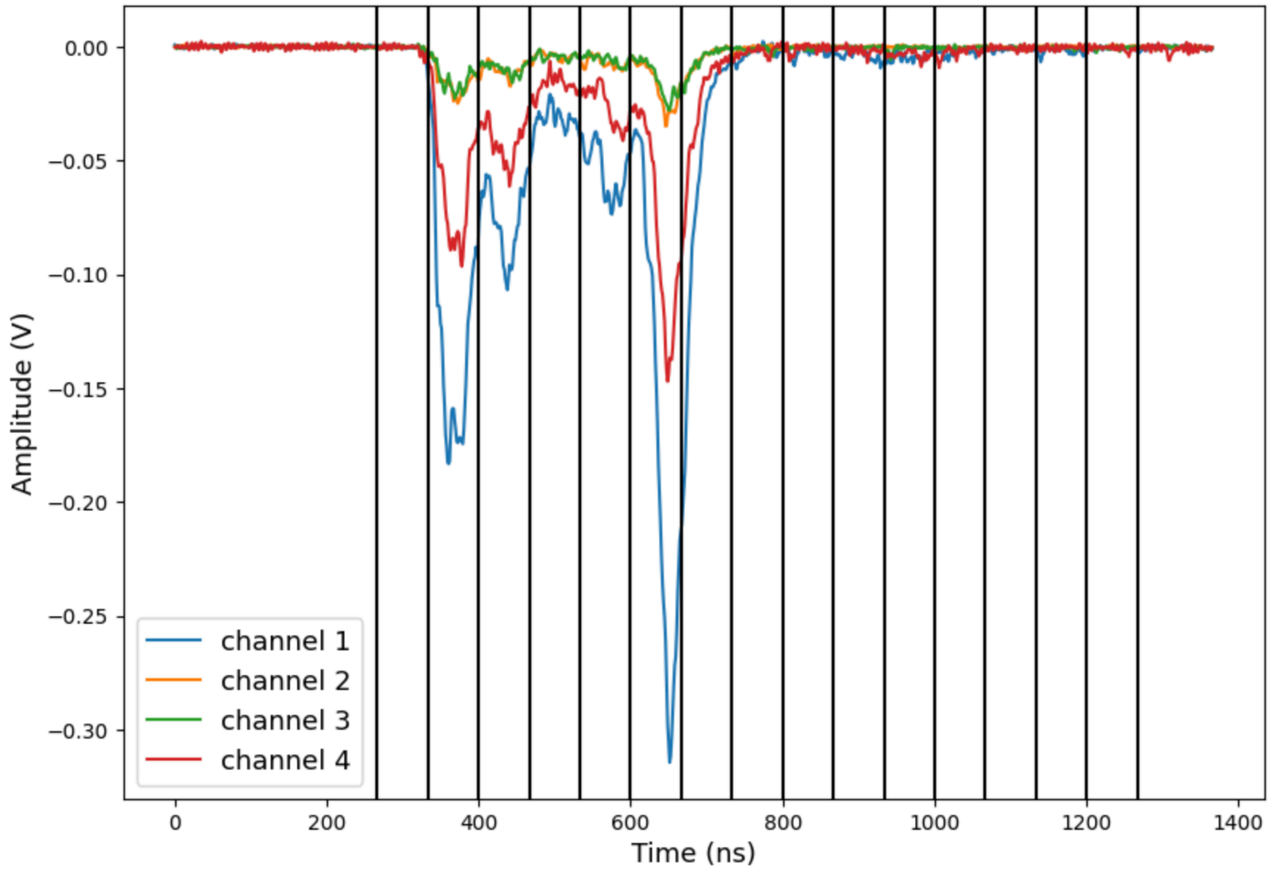
Method (4): position focused

- **Find peaks** of the waveform
- Take **majority 2 peaks**
- **Open a window** around these peaks of 50 samples
- Fit the slice of the waveform **as a spot-like interaction**



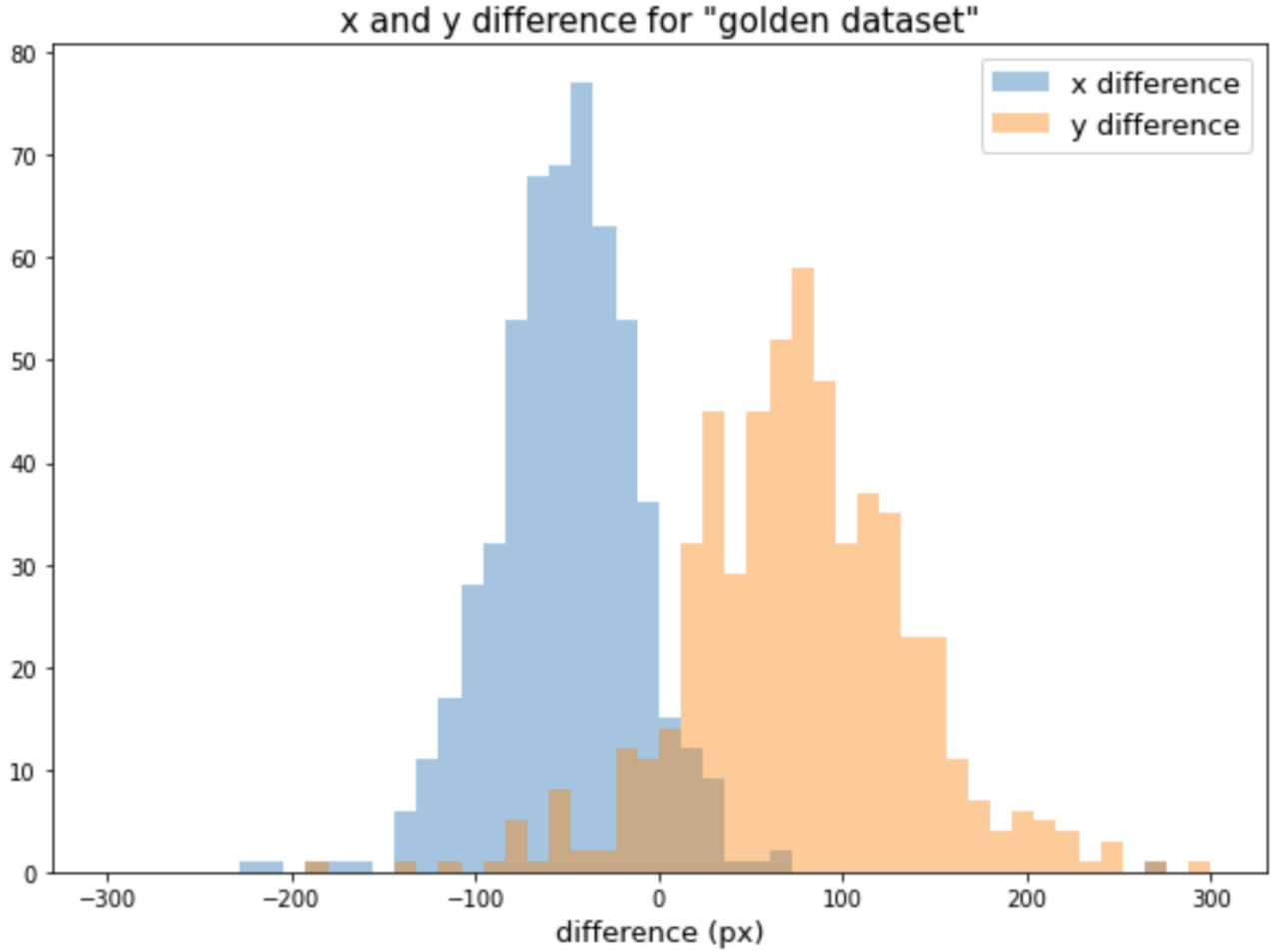
Method (4): “energy” focused

- Slice the waveform in 50 samples slices
- Fit **all the slices** of the waveform **as a spot-like interaction**
- Roughly 6 times slower for background runs



Calibration with the golden dataset

- Matteo's iron golden dataset
  - All waveforms were successfully reconstructed
- x and y offset is clearly visible

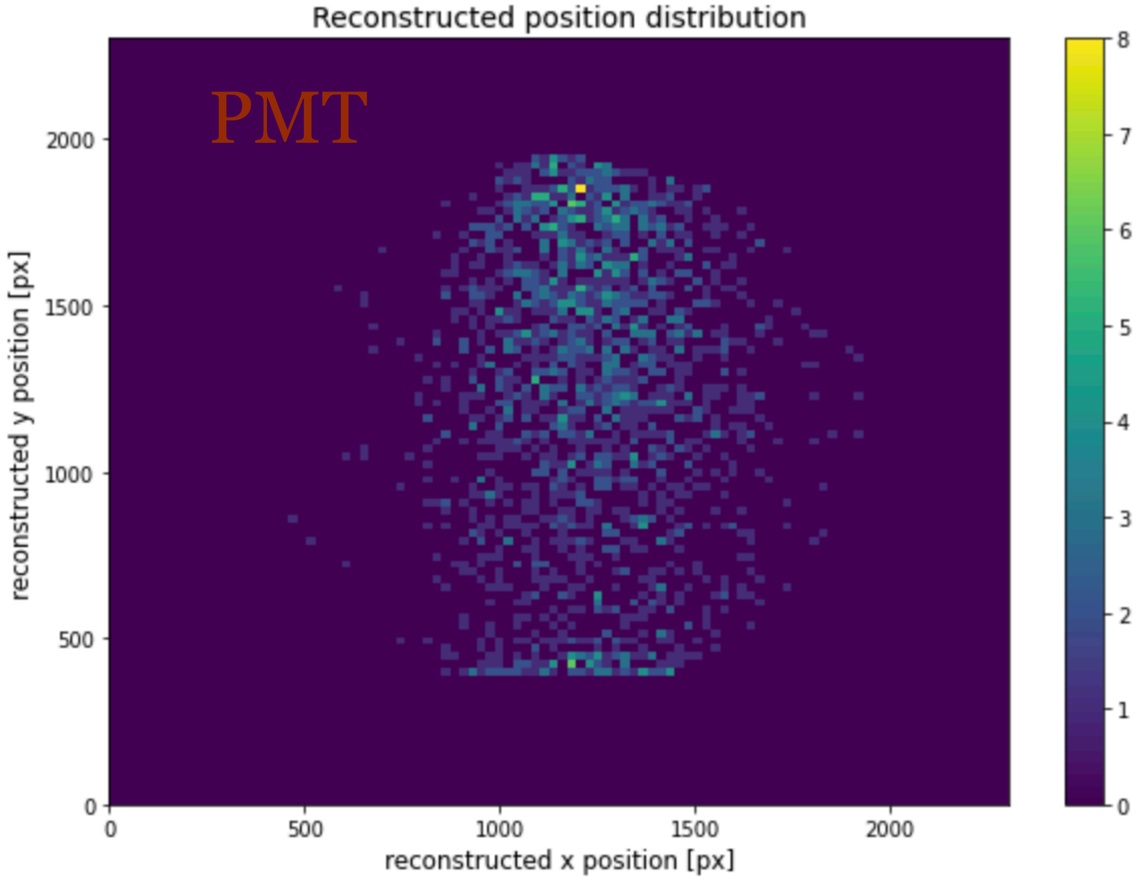


Performances on ^{55}Fe (1)

- **Waveform cut:**
  - Majority2 peaks == 1
  - R<800px (same as picture)
- **Fit converged** ~ 99.7% for the “Fe” cut

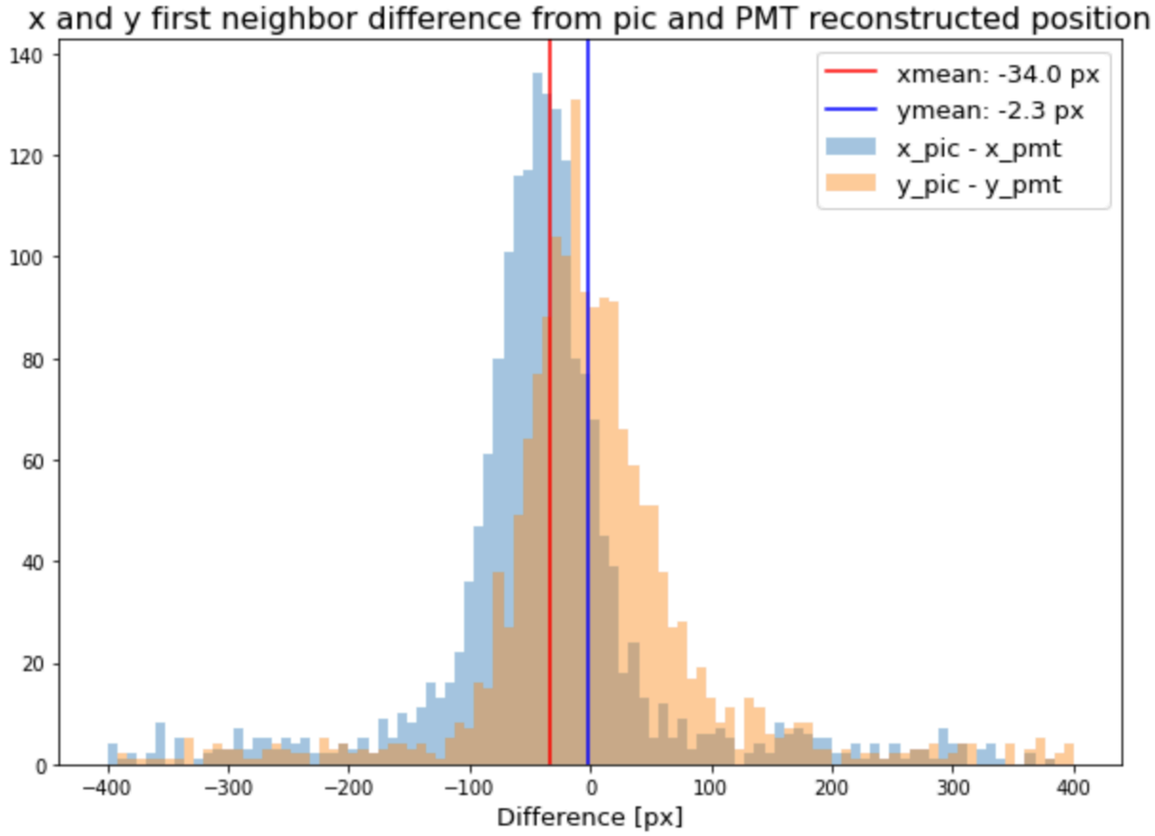
- **Cluster cuts:**
  - sc_rms > 6
  - R < 800px
  - 0.152*sc_tgausssigma > 0.3
  - 0.152*sc_length < 80
  - sc_width/sc_length > 0.8
  - sc_integral > 1000

Performances on ^{55}Fe (2): distributions



Performances on ^{55}Fe (3)

Closest neighbour (PMT waveform assigned to the closest cluster found)



- **Performance:**
  - 37% within 1cm
  - 73% within 2cm
- **To be understood:**
  - PMT - camera coordinate transformation
  - Effects of lens distortion (need spots in a wider GEM space)
  - Strange behaviour on different source positions

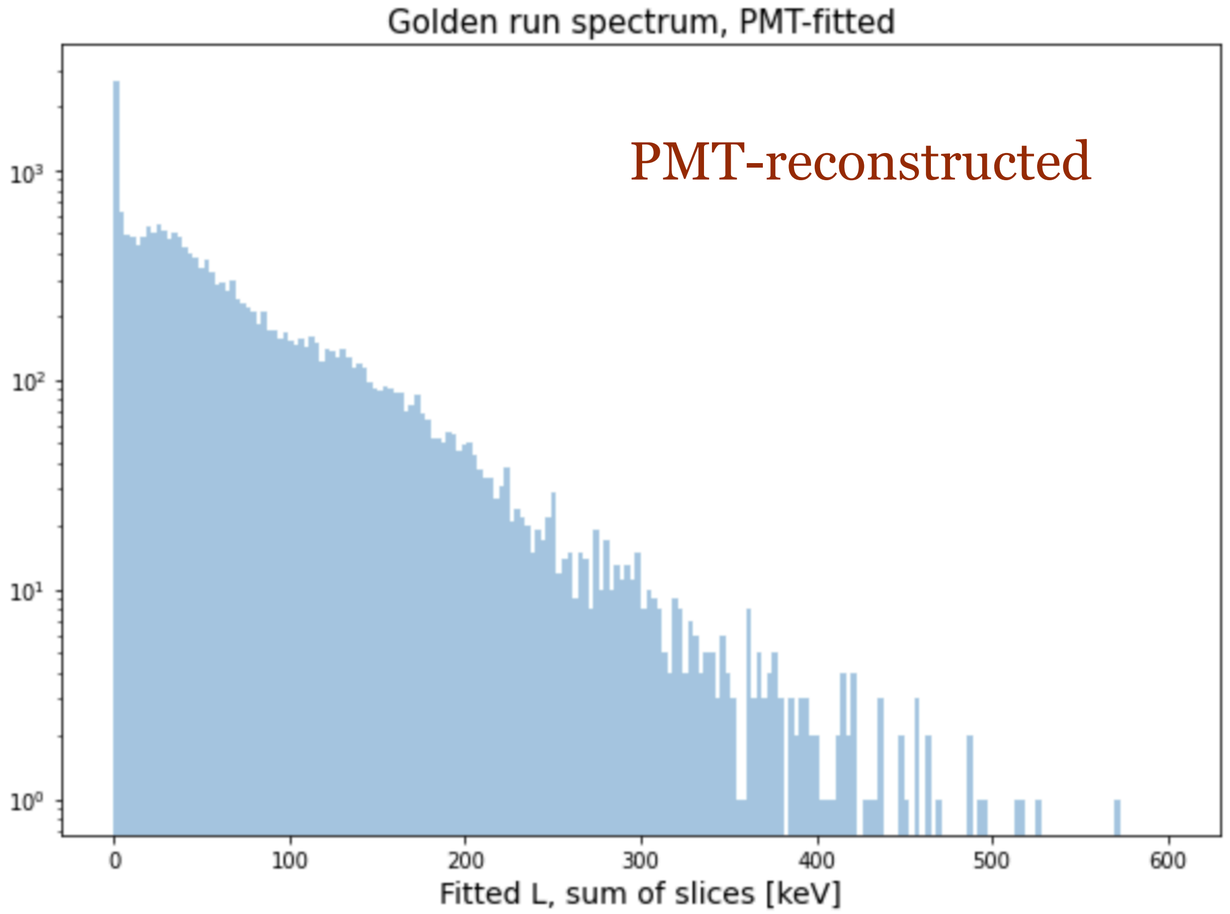
Integration with reconstruction code

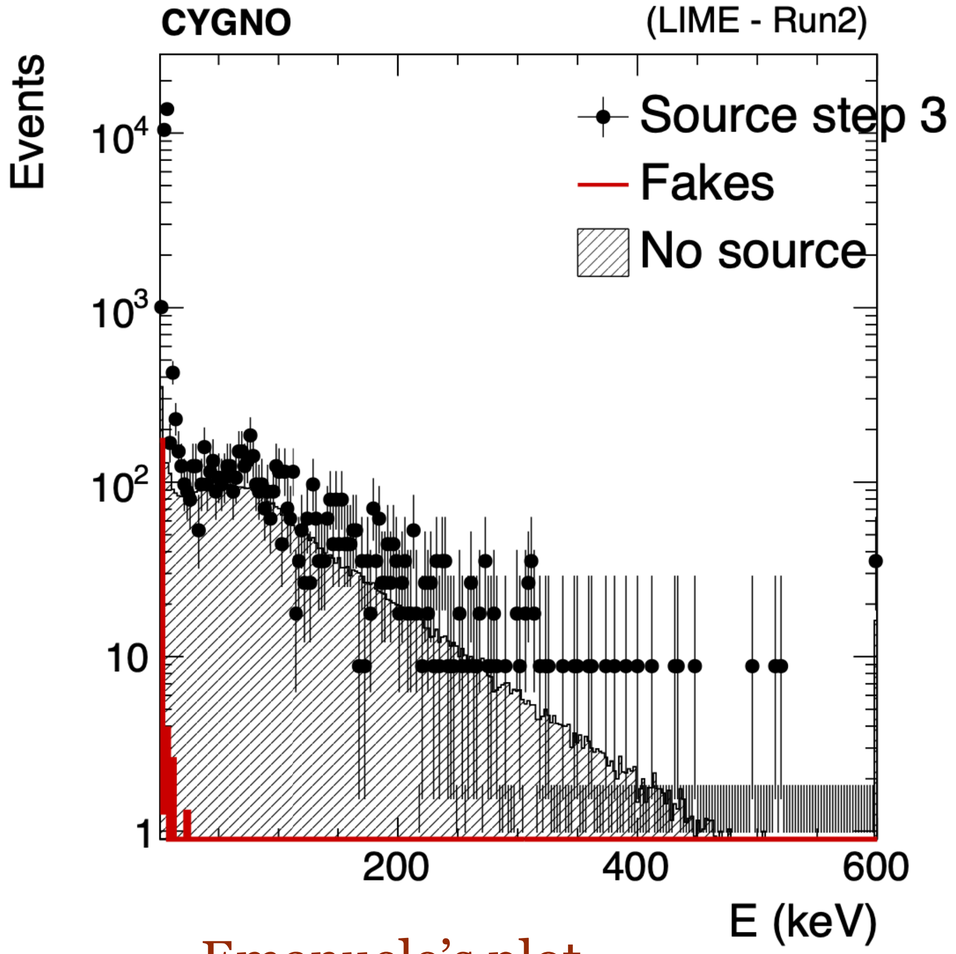
- Run the fit **within the reconstruction code**:
  - **Time consuming**
  - Fit still “on beta”
- Make a **Friend-tree**

- **What variables do we want?**
  - x, y
  - L
  - First cluster neighbour?
  - Others?

RUN2 background spectrum (1)

- **“Energy” focused** approach
- Cut on negative integrals



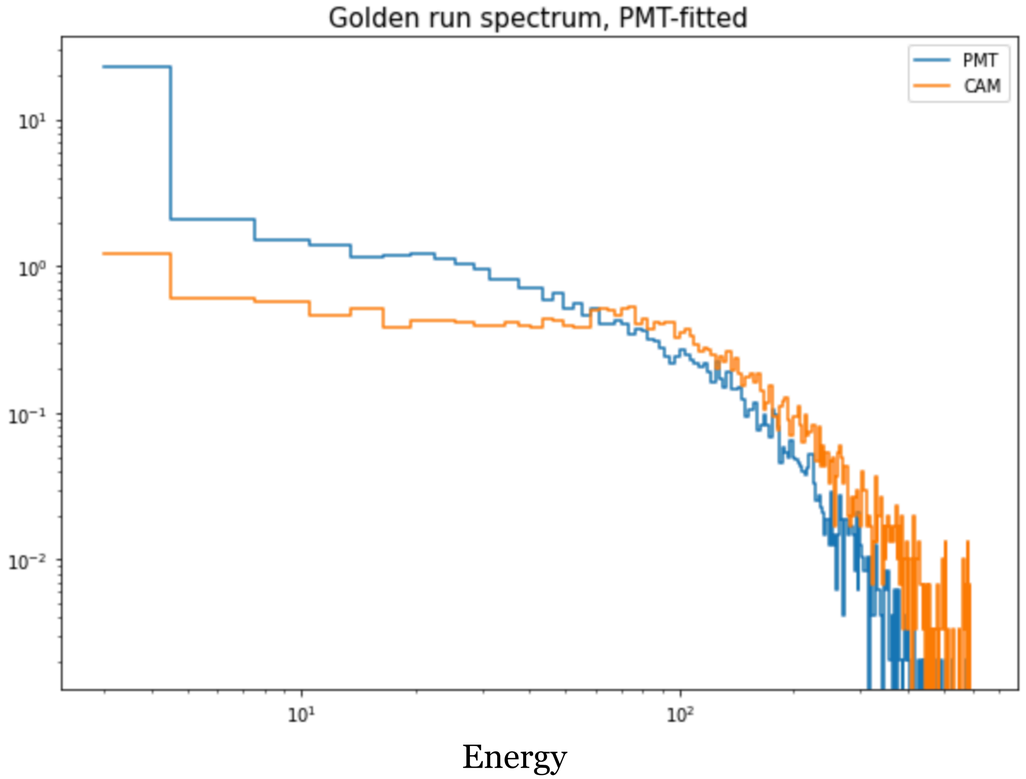


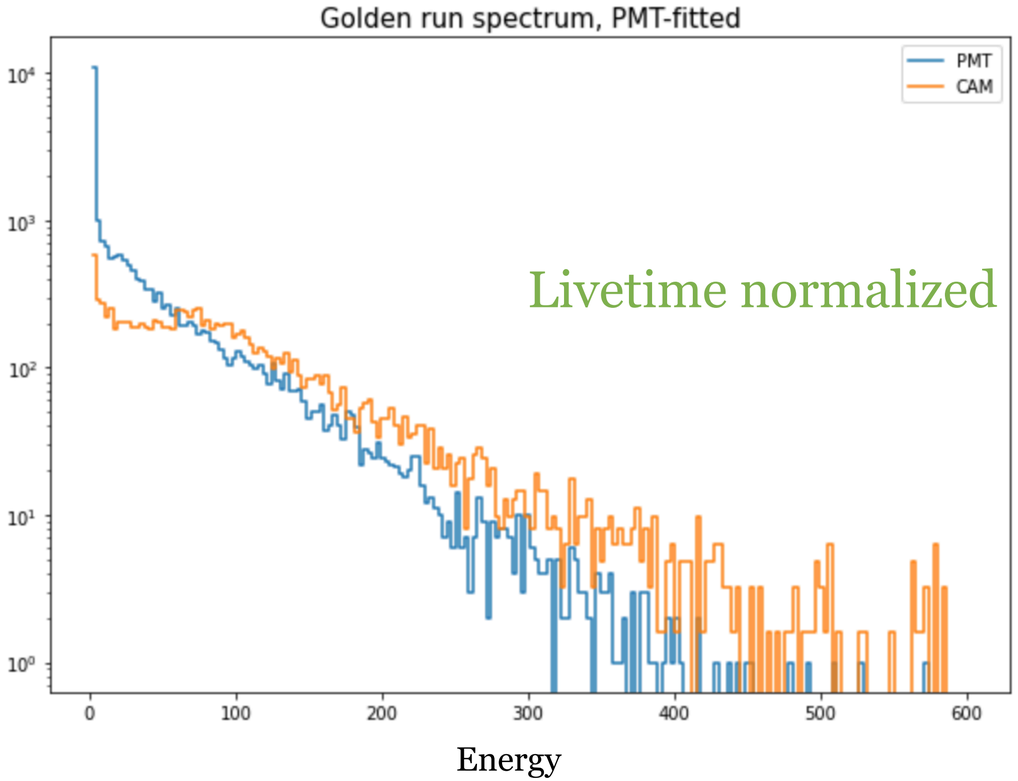
Emanuele’s plot

RUN2 background spectrum (2)

- Camera cuts:
  - Fake clusters
  - R<800
- PMT cuts:
  - R < 800

- High energy underestimate on PMTs: longer tracks cut
- Why we have more lower energy events?





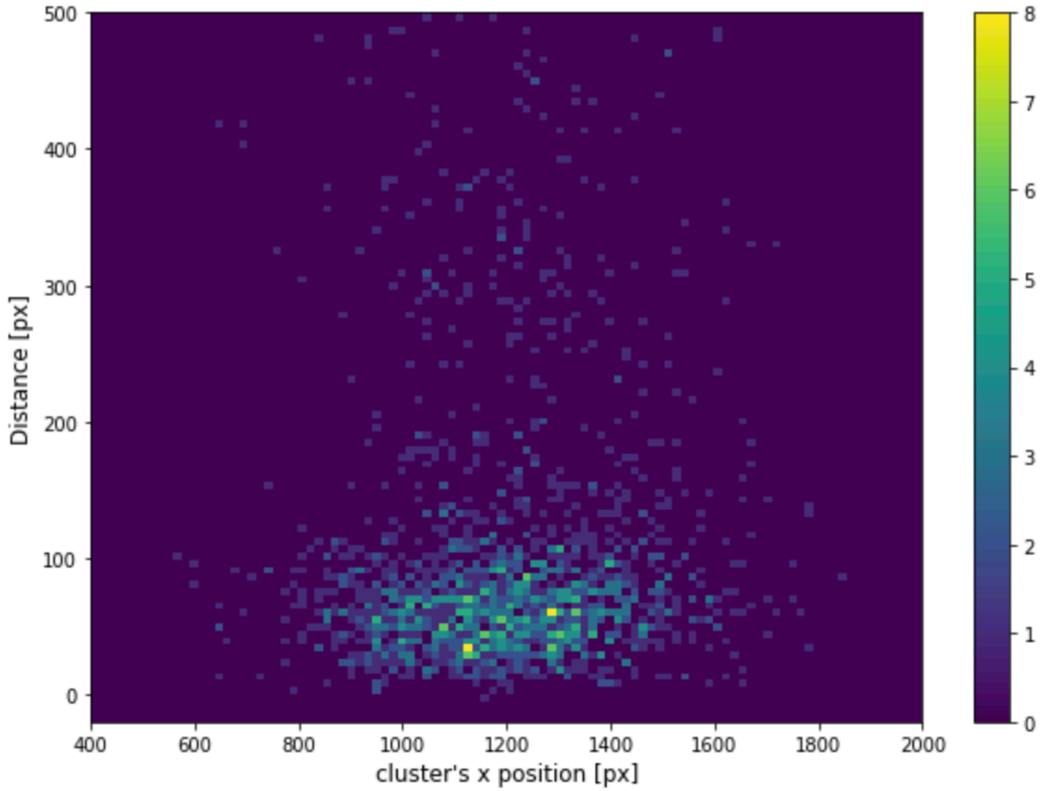
Conclusion

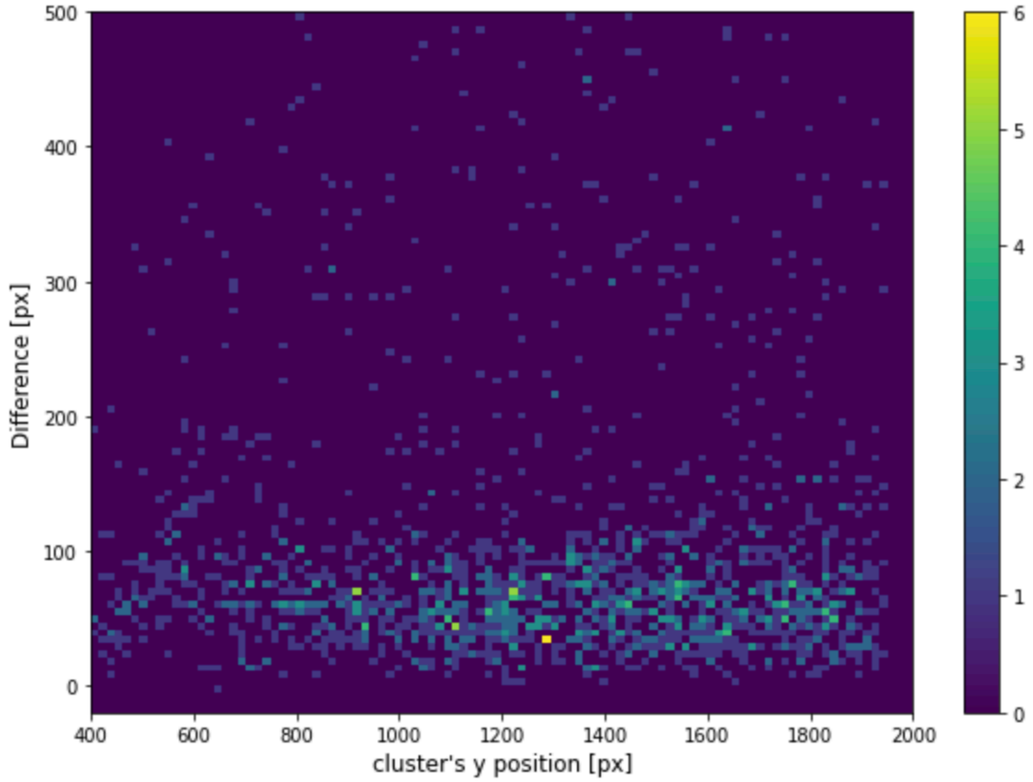
- Good performance for spot like interactions
- Coordinate conversion **not understood yet —> need for proper measurements**
- Background seems compatible with the camera one
- Different **X-ray sources** for energy calibration

Backup

Fe different steps

Fe dataset, distance vs cluster position:





Fe dataset, difference vs cluster position: