PMT and Camera length inter-calibration

Luca Zappaterra, Davide Pinci, 5th June 2024

Datasets

Two main datasets in the analysis:

- Stability runs from **RUN 3**.

1	Start	Stop	Numbers			Description	Data runs	Data pics
50			25486		25772	Stability - Line 1	286	

- Standard campaign from **RUN 4** which features a large contamination of Radon and has PMT TTree.

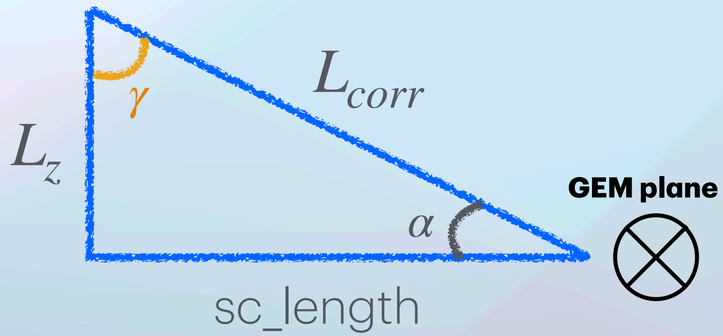
49946, start of pmt reconstruction in RUN 4

1	Start	Stop	Numbers			Description	Data runs	Data pics	Gas Flow	Filter Line 1	Filter Line2
36	2024-02-15 15:35:22	2024-03-05 9:33	48055	-	50891	Bkg + Daily Calibrations	2836	1134400	5	**Blu + Rosso**	Not in use
42	2024-03-23 18:20:34	2024-03-26 9:41:19	53110	-	53502	Bkg + Daily Calibrations	392	156800	5+20	**Blu + Rosso**	Not in use
43	2024-03-29 10:01:40	2024-04-02 10:02:22	53707	-	54403	Bkg + Daily Calibrations	696	278400	5+20	**Blu + Rosso + RADON**	Not in use
45	2024-04-04 8:31:50	2024-04-08 8:26:06	54503	-	55093	Bkg + Daily Calibrations	590	236000	5+40	**Blu + Rosso + RADON**	Not in use

Length correction strategy

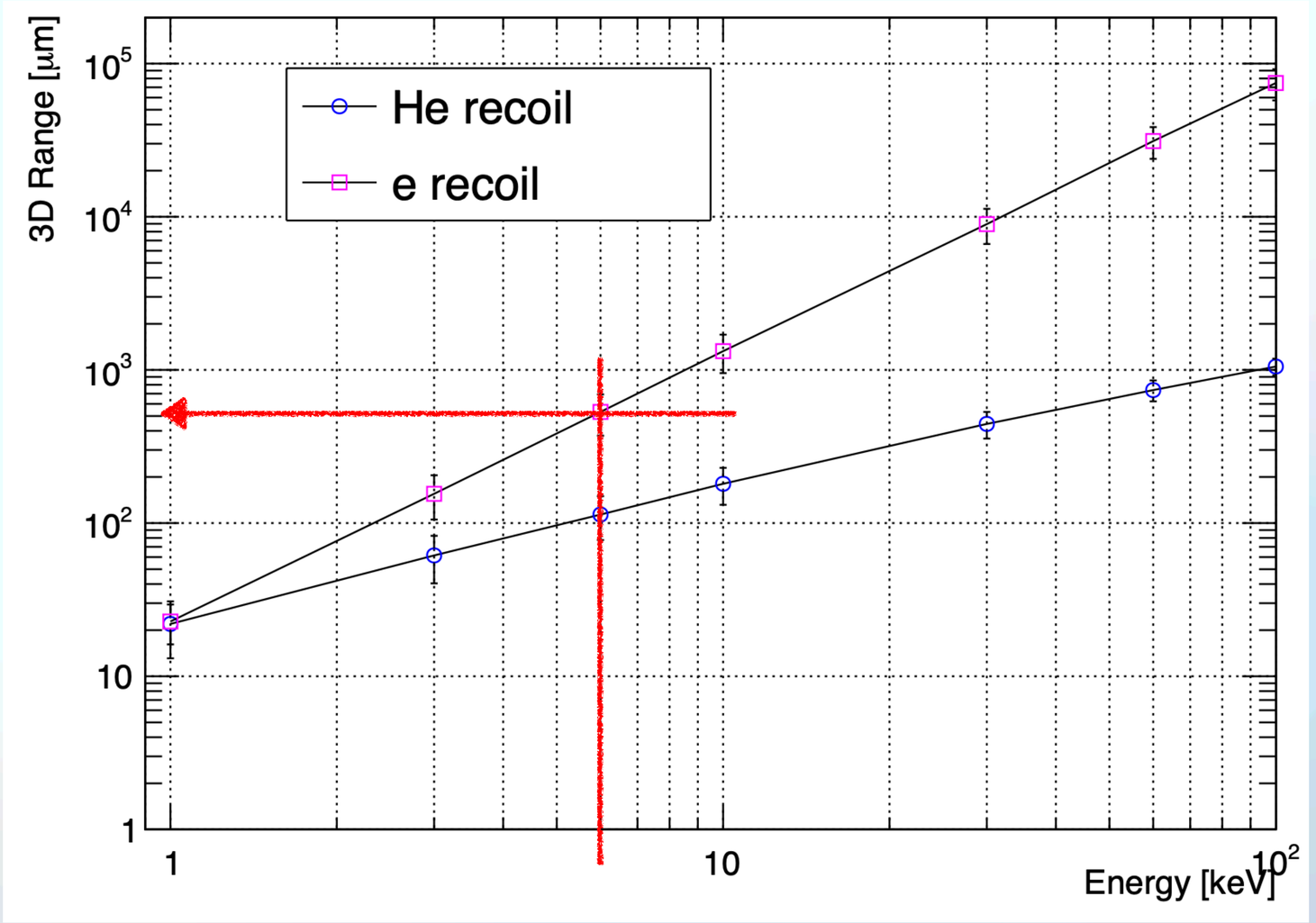
The idea is to make use of the PMTs information (**slow digitizer**) and correct the projected length on the GEM plane (sc_length). To do so:

- Only events which are alone in the image and have a 1:1 match with PMT waveforms are selected.
- Relevant information from both camera and PMTs reco are merged in a single dataset.
- The corrected length is computed with $L_{corr} = \sqrt{\text{sc\_length}^2 + L_z^2}$ where $L_z = \text{TOT} \times v_{drift}$ is the distance travelled by the electrons along the drift direction, with:
  - **TOT** being the highest `pmt_wf_TOT_time` for the given event;
  - $v_{drift} \approx 5$ cm/μs.



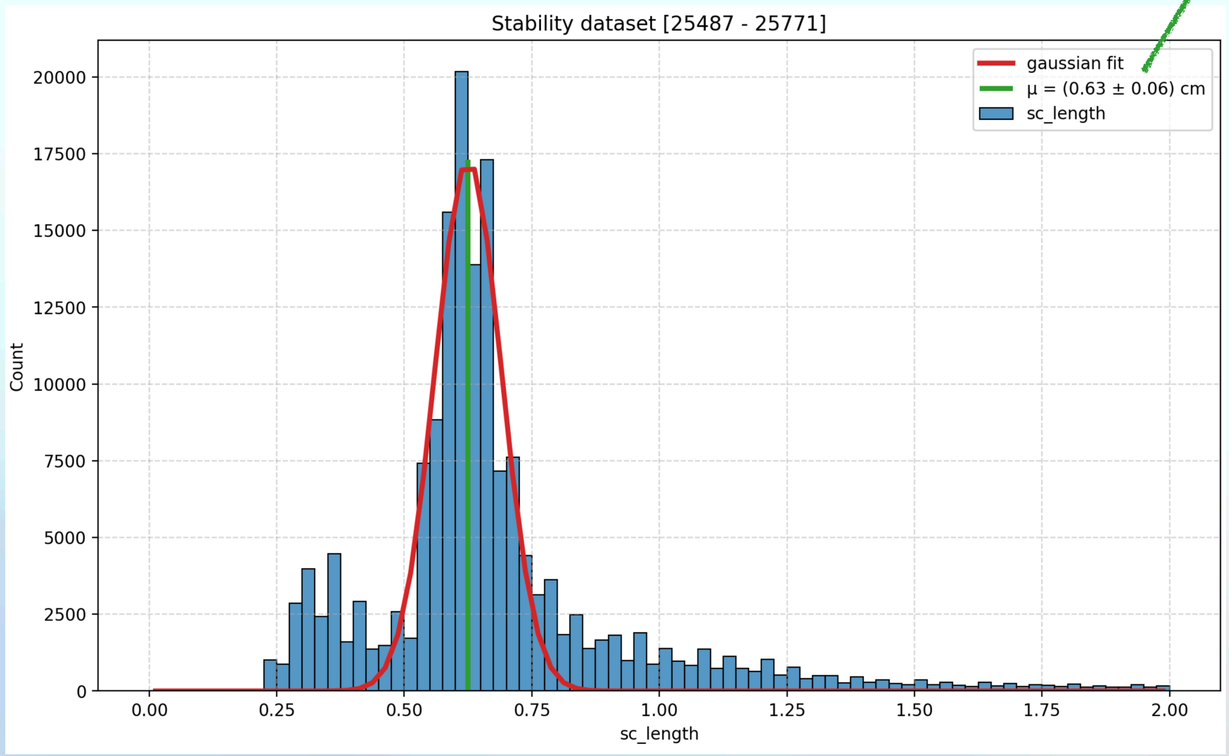
^{55}Fe electrons range in He:CF_4

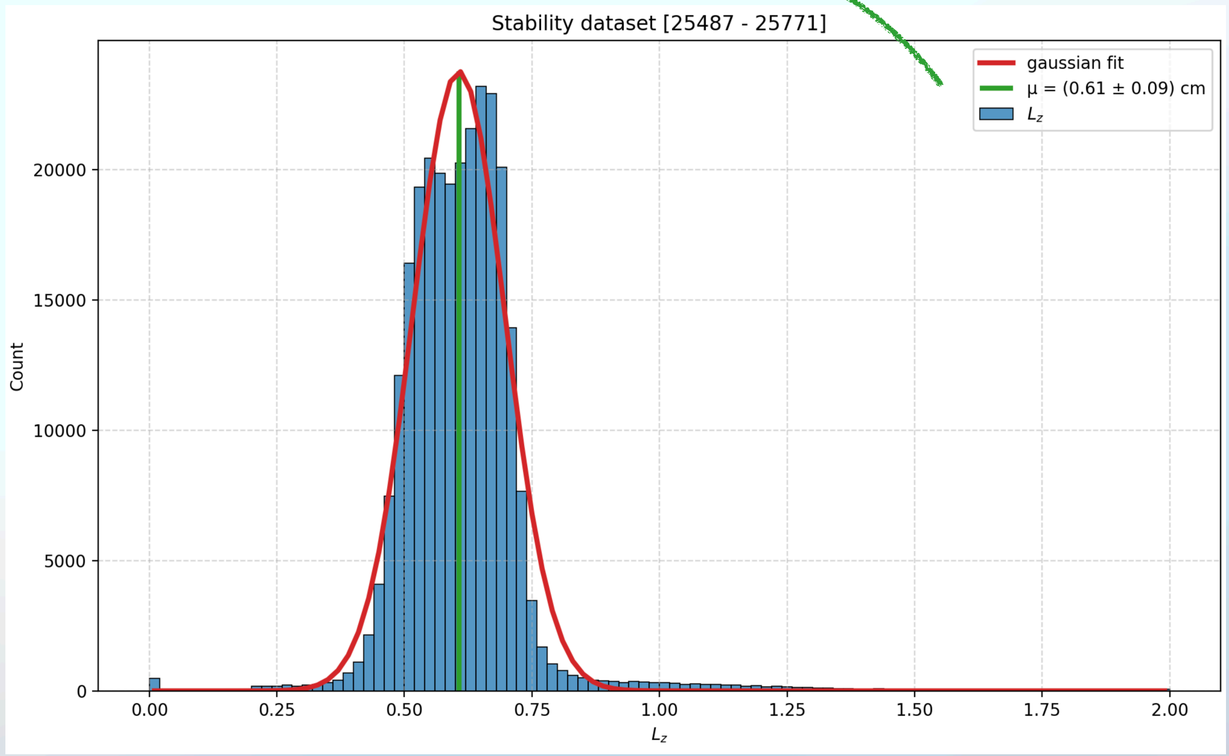
- Iron electrons (6 keV) should travel **~0.5 mm** in the gas and should be our “zero”.
- This can be verified from stability runs by fitting:
  - the iron `sc_length` peak;
  - the $v_{drift} \times$ TOT peak;



^{55}Fe electrons range in practice

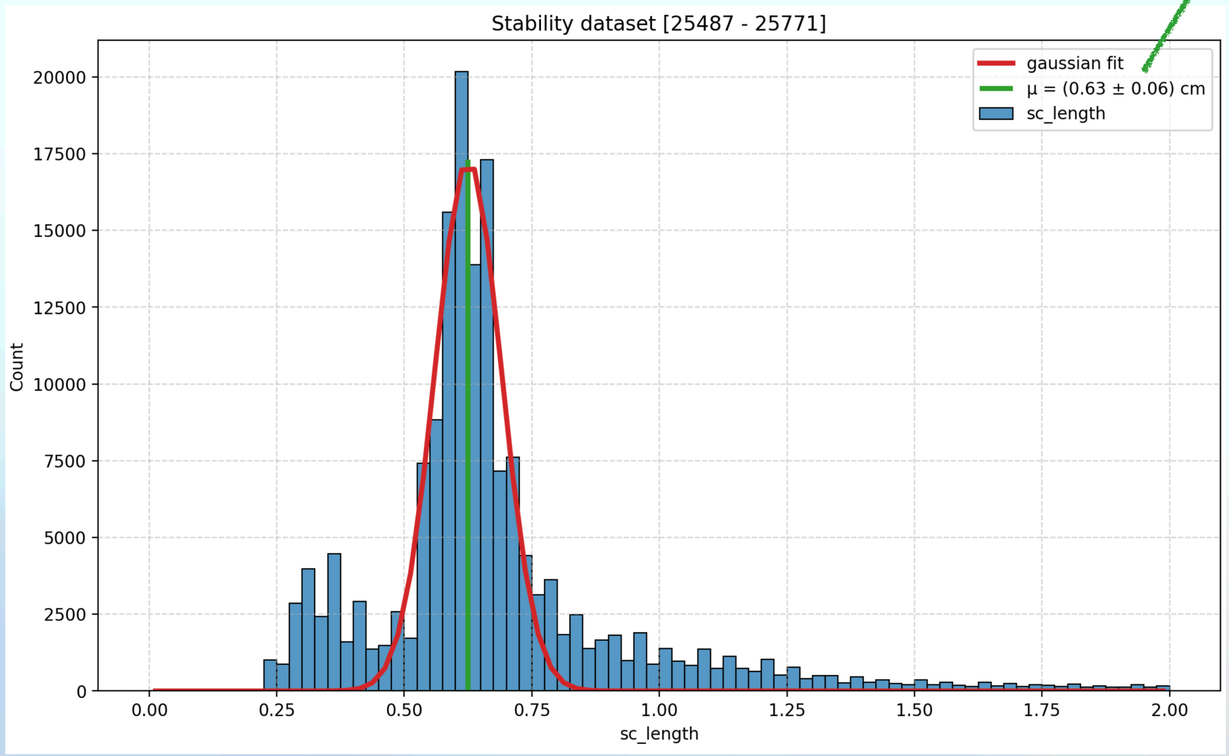
$$L_{corr} \approx 8.76\,\text{mm}\,!$$

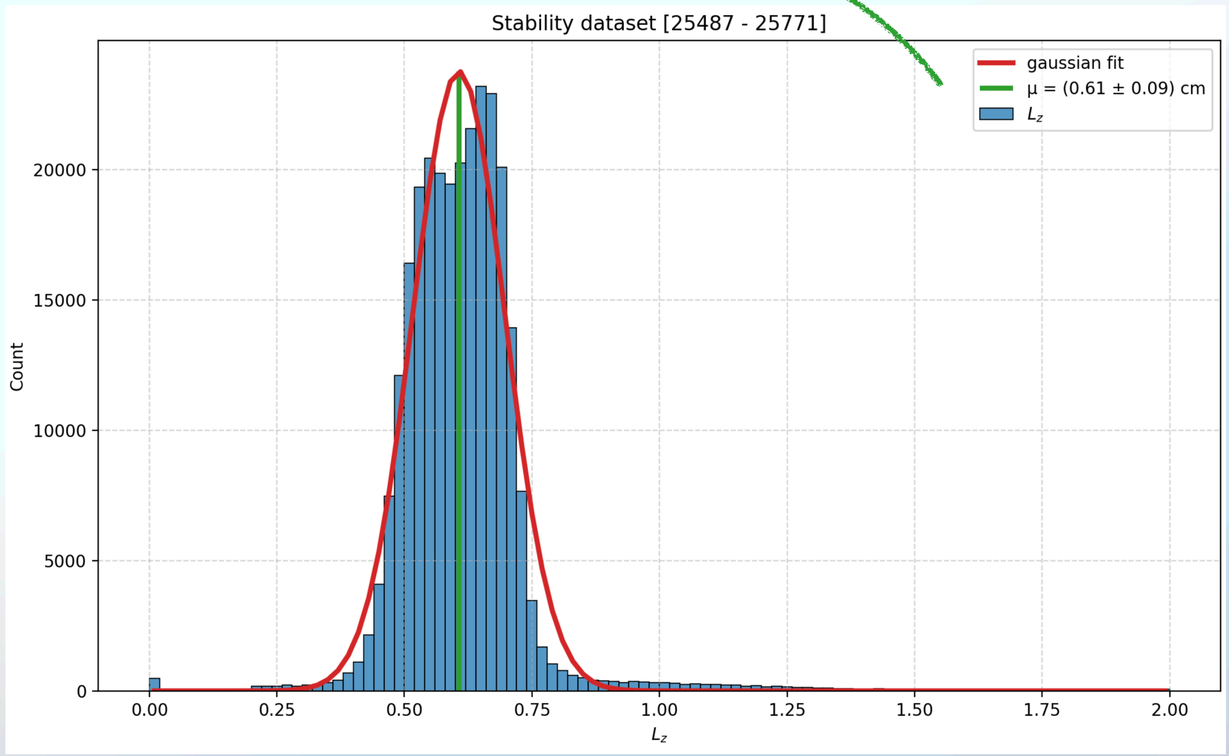




^{55}Fe electrons range in practice

We should subtract these values (maybe refined) to sc_length and L_z to rescale the values





^{55}Fe electrons range in practice

This is ***Strange***

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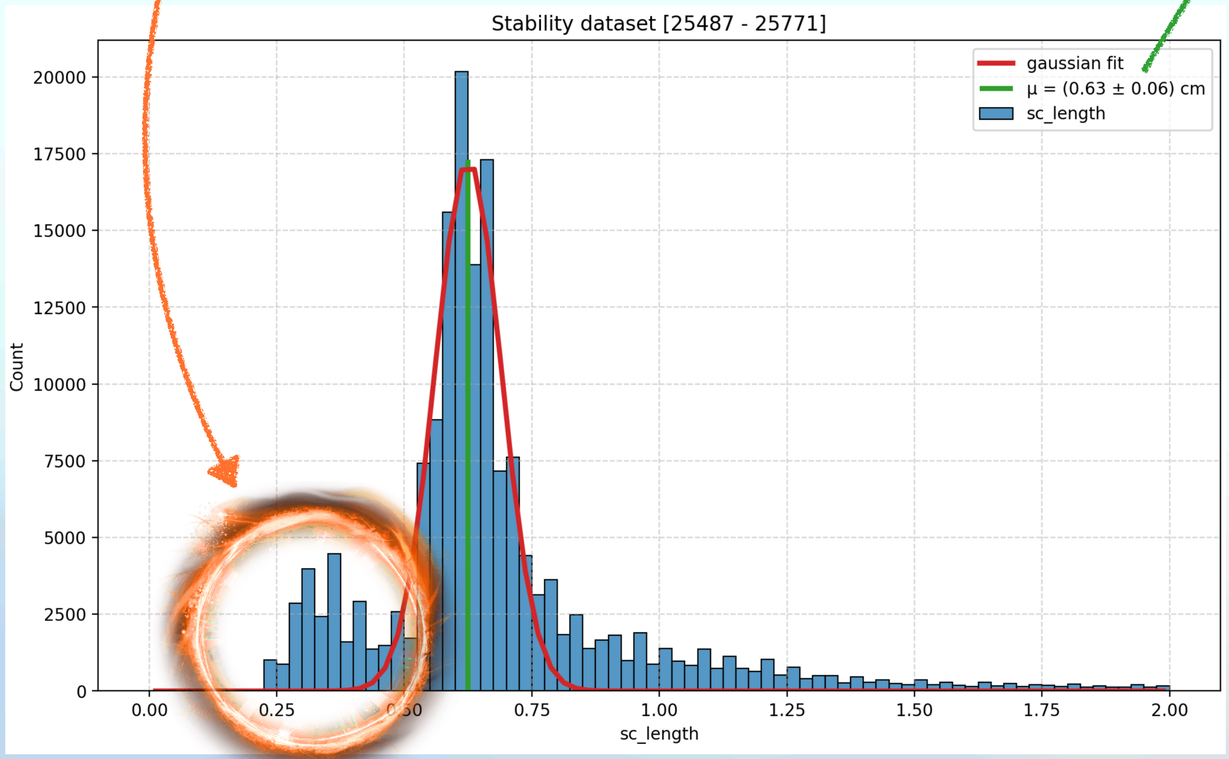
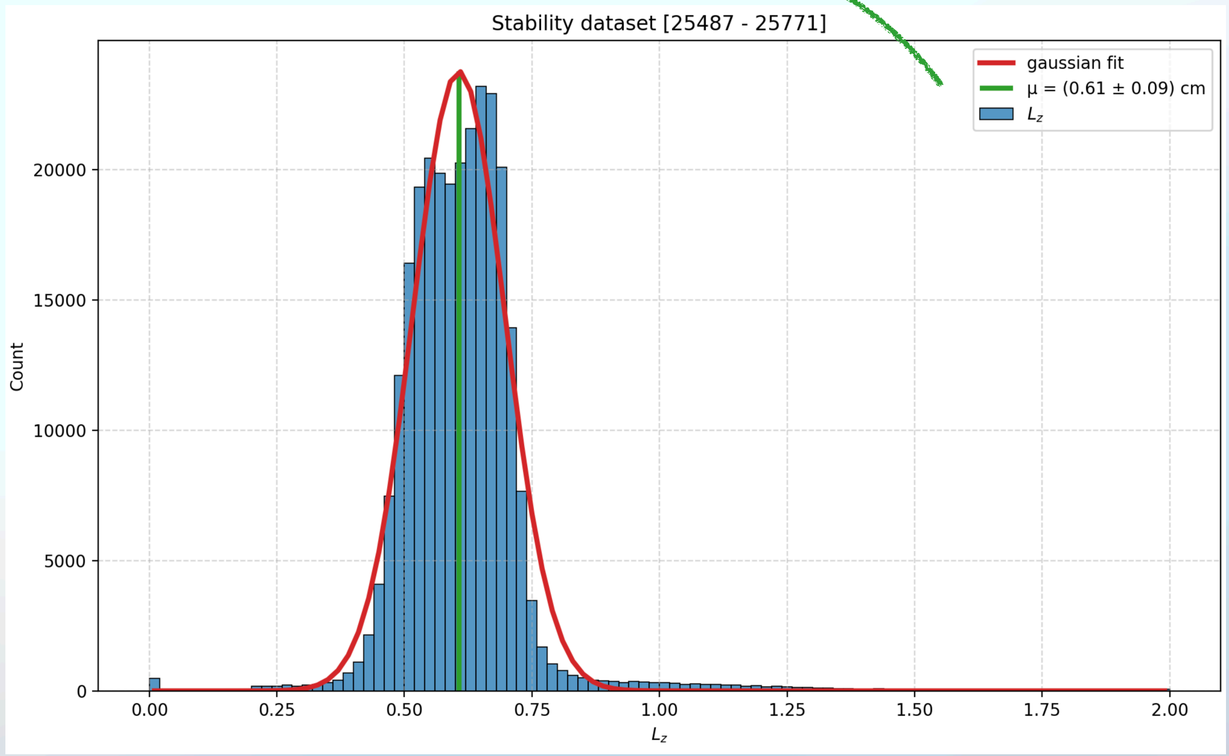
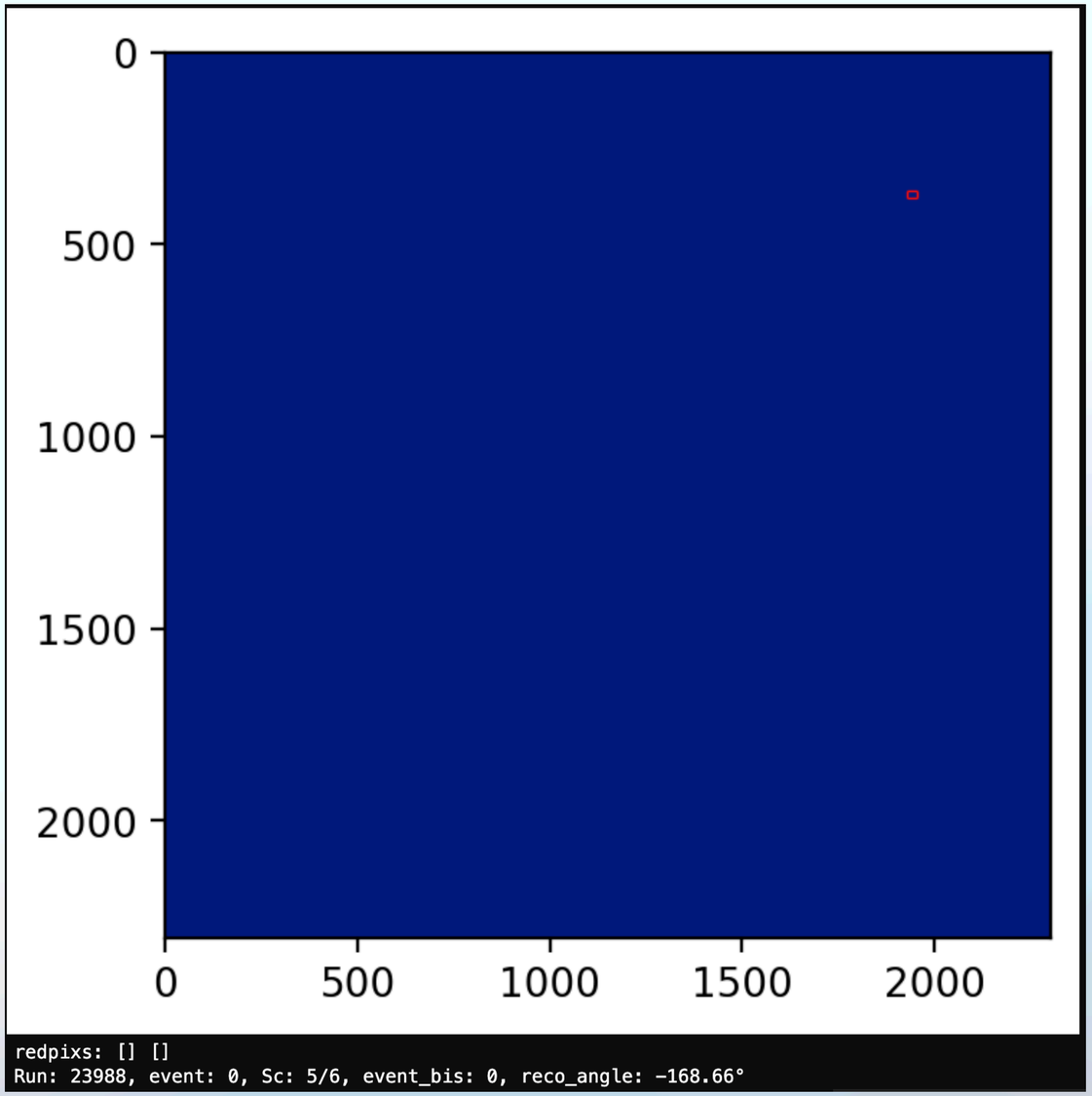




Tracks with `sc_length < 0.5 cm`

- They are mostly tracks with a single pixel or with no pixels at all.
- Is this some kind of bug?
- Is this relevant?



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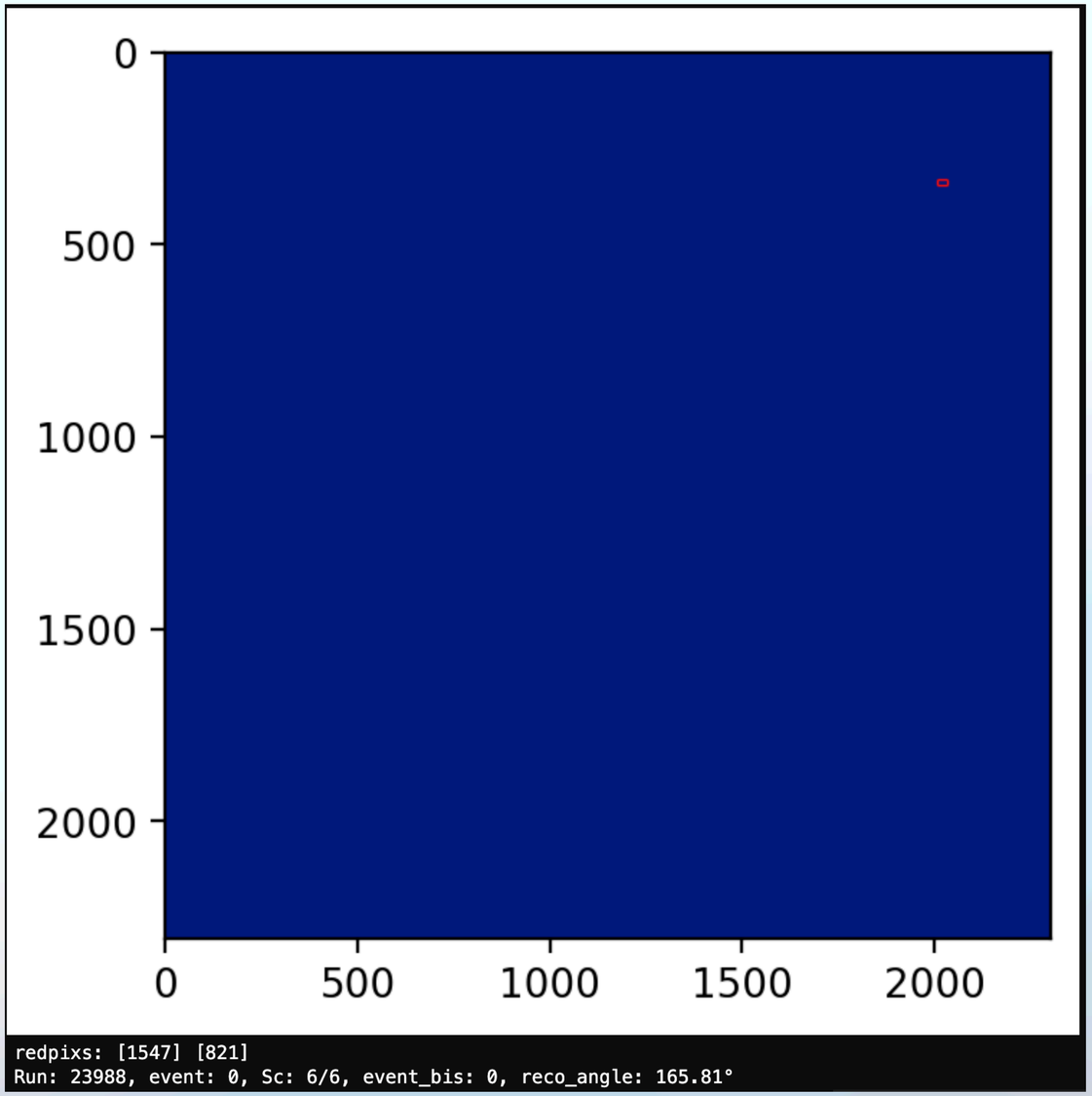

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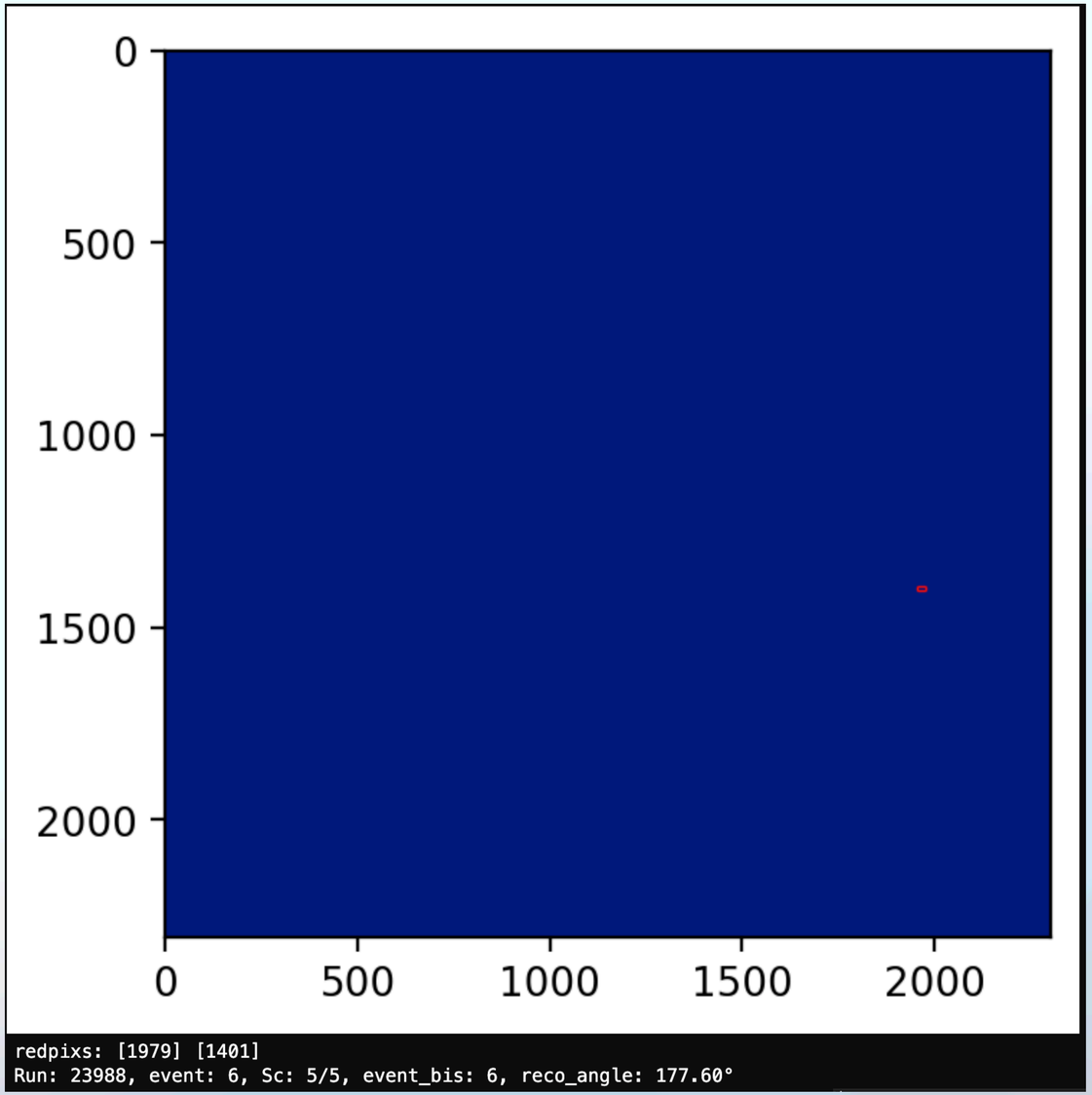


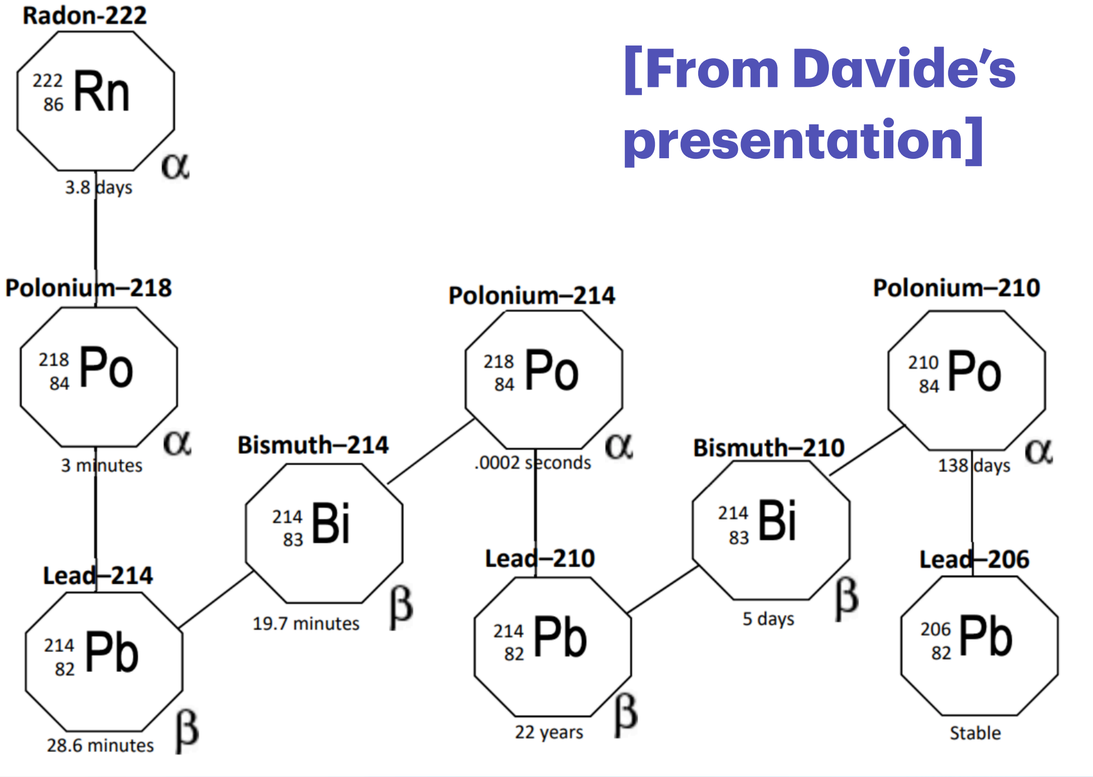
Radon isotropy assumption

- **In principle**, looking at data with Radon contamination, we expect a **non-preferential direction** for its decay products.

- Given the geometrical description in slide 3, it **should be fair to expect an angle** wrt the GEM plane (α) **which in average is 45°**.

  - 3 alphas:
    - ^{222}Rn -> 5.590 MeV (about 43 mm)
    - ^{218}Po -> 6.115 MeV (about 50 mm)
    - ^{214}Po -> 7.833 MeV (about 73 mm)

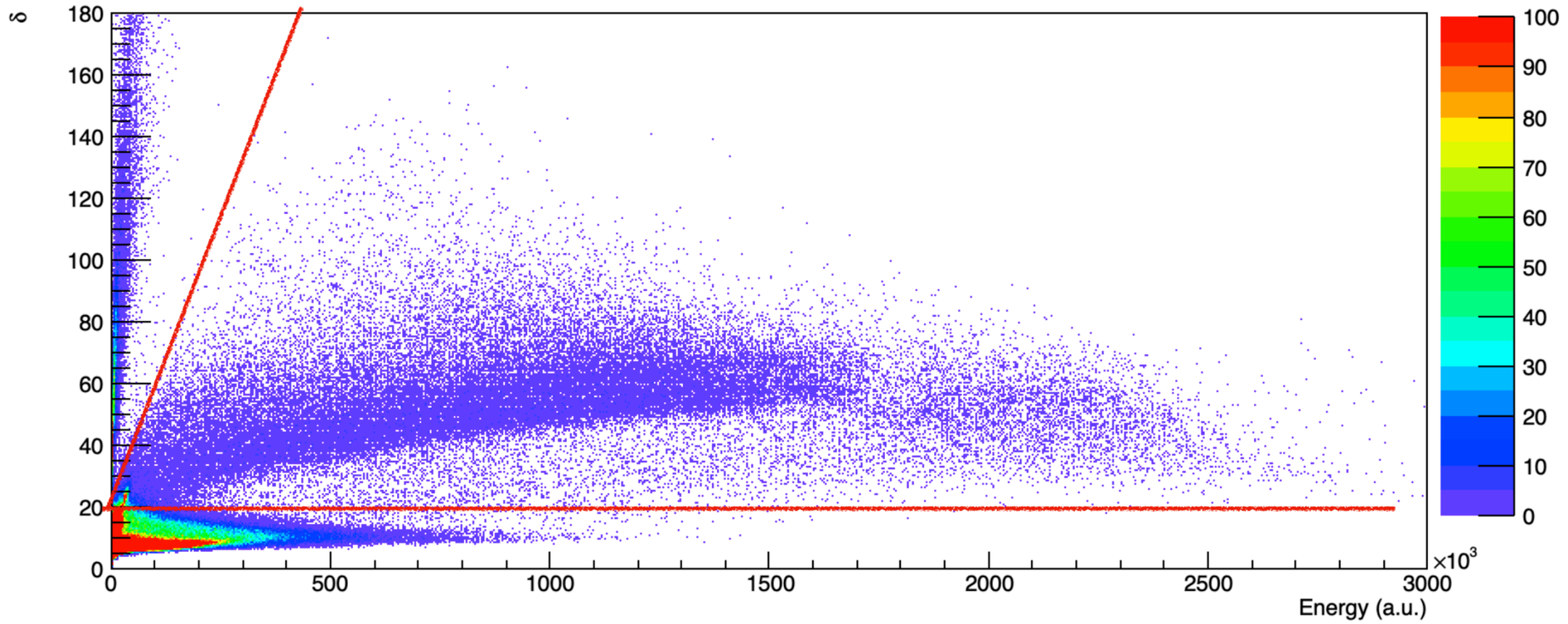
[From Davide's presentation]



Radon isotropy in practice

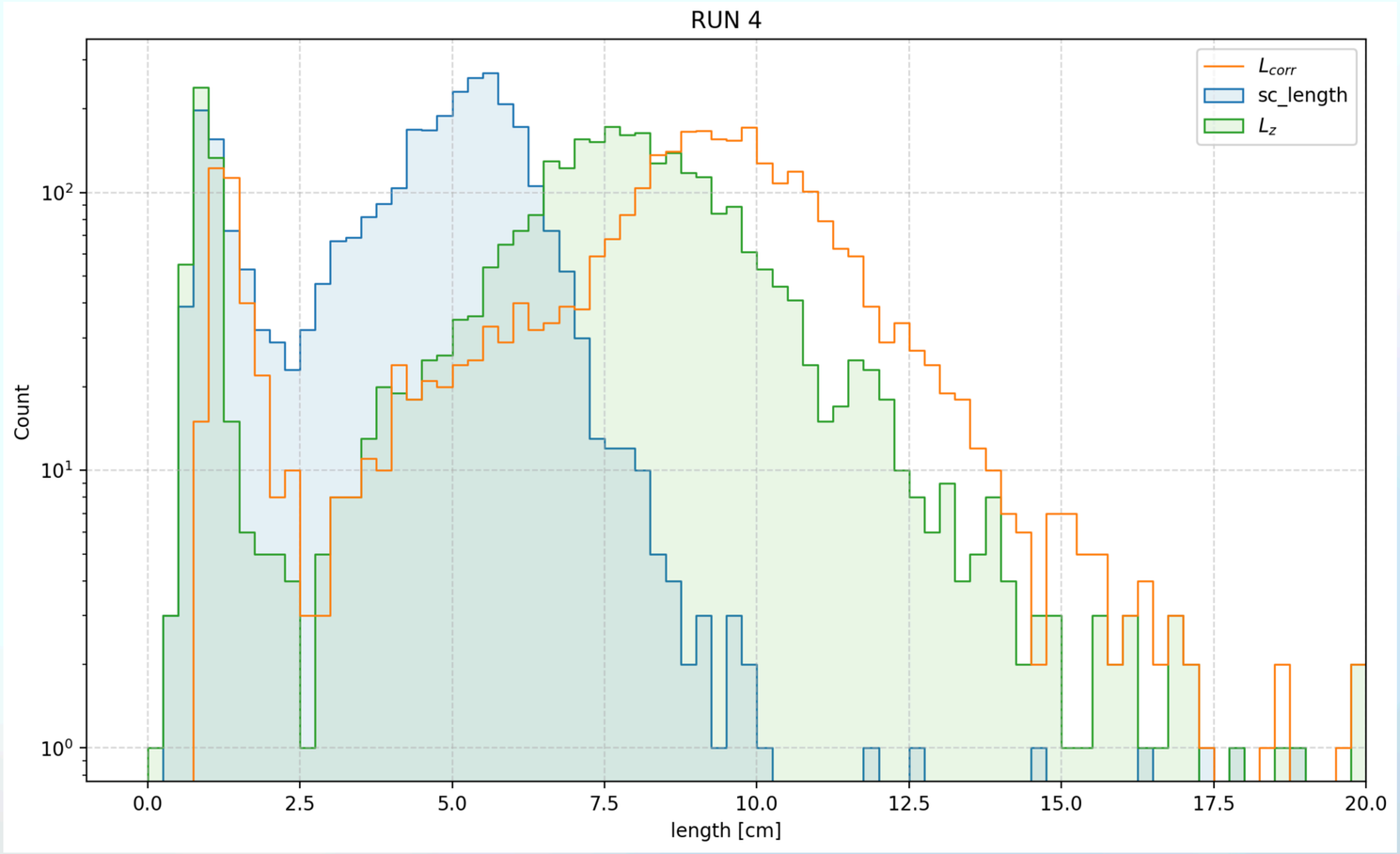
- Radon events are selected with the same cuts used in **Davide's presentation**

- To select alpha we use their large energy density (δ = sc_integral/sc_nhits) > 25;



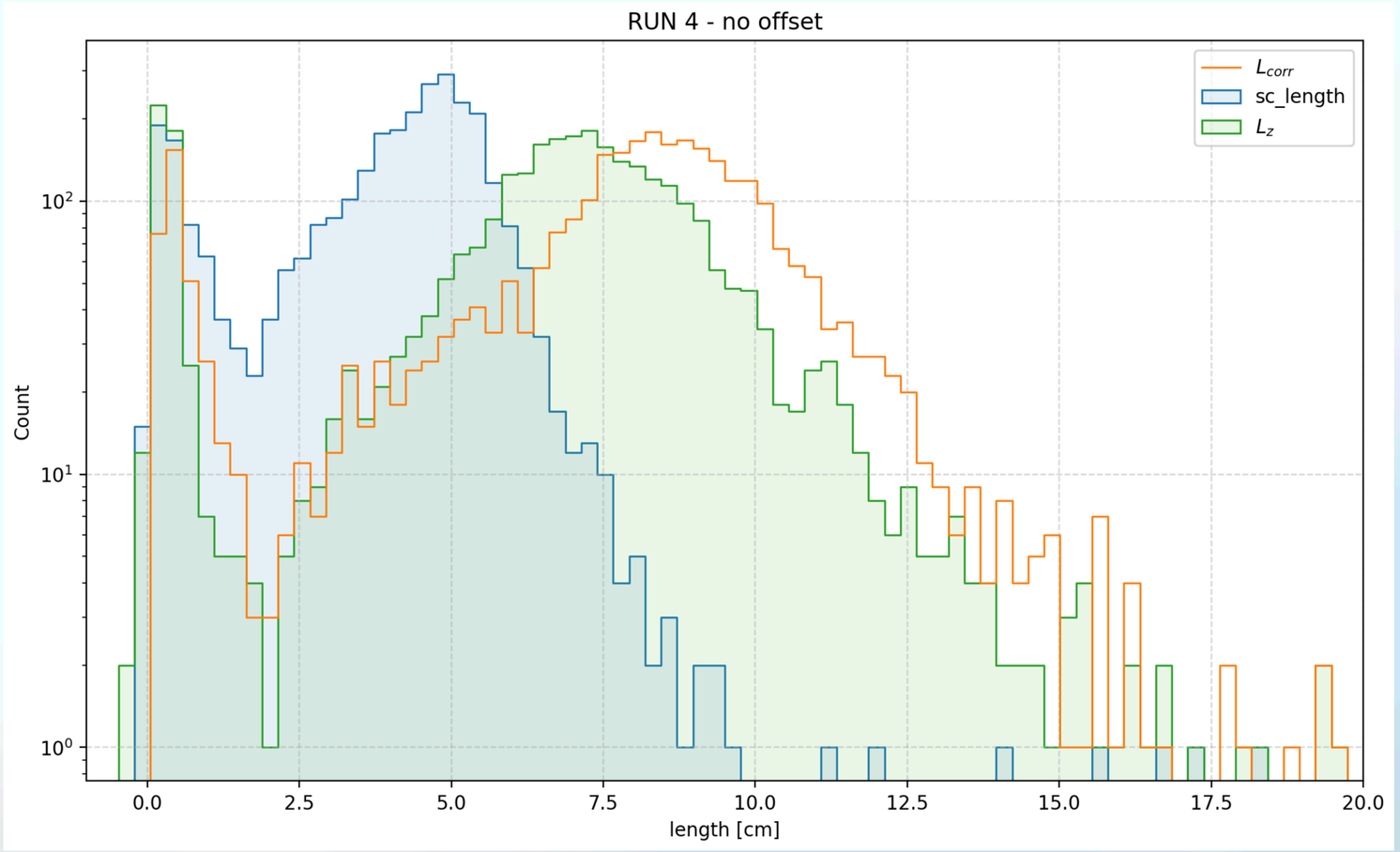
Radon isotropy in practice

- PMTs data indicates a larger L_z wrt `sc_length`.
- L_{corr} has a peak around 10 cm.



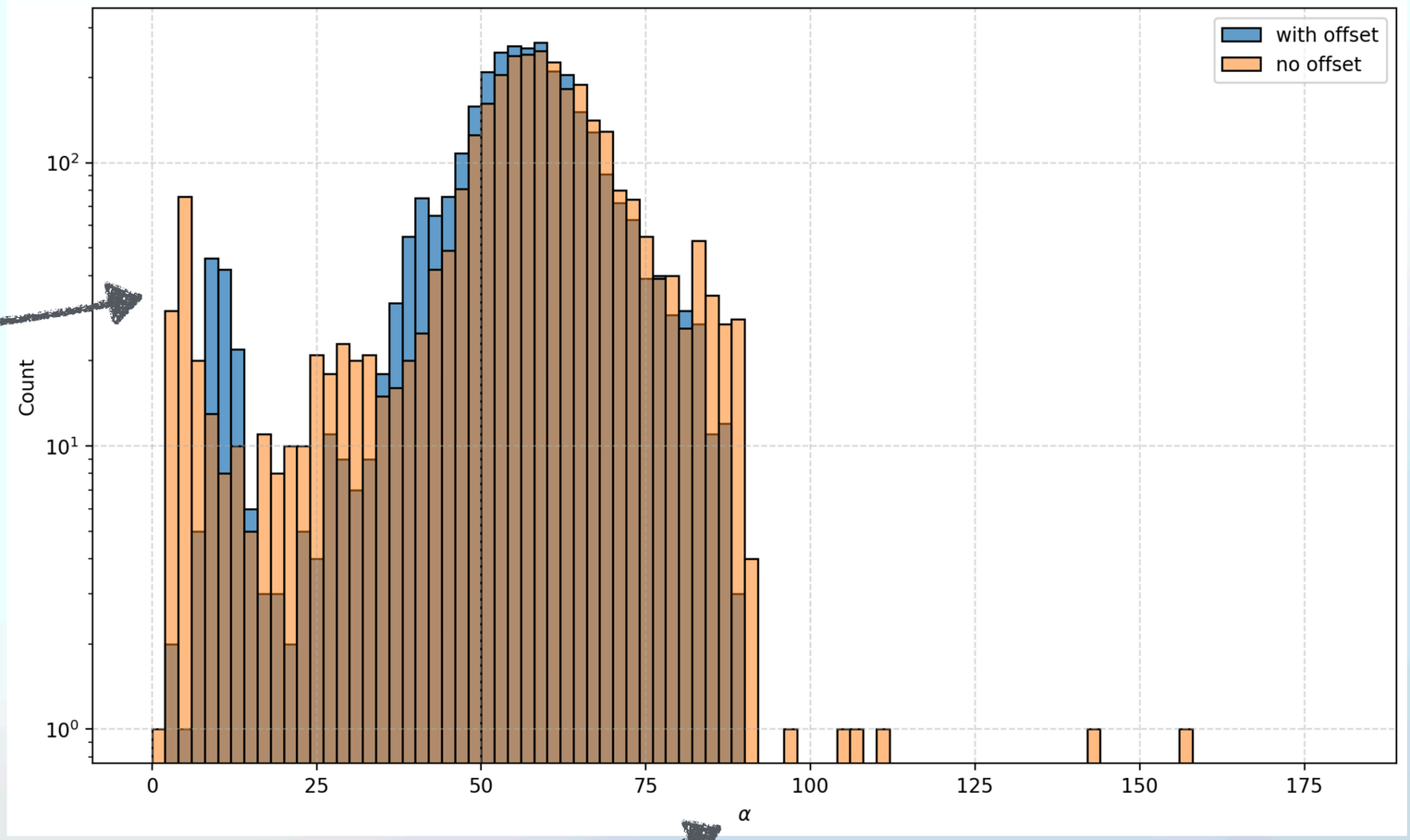
Radon isotropy in practice - **Questions**

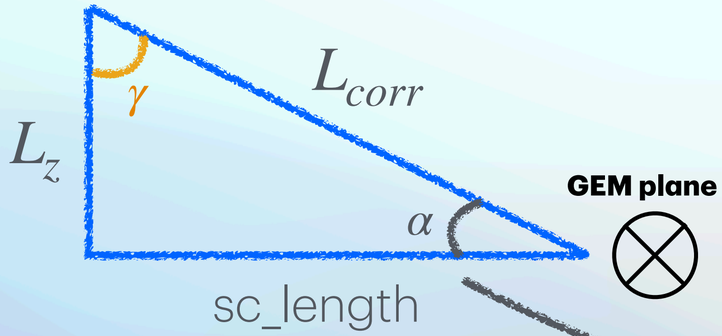
- We can **subtract the offsets** to both `sc_length` and L_z.
- What do we believe: **Isotropy or Data?**
- Data is clearly telling us that the ***Radon has a preferential direction***.
- Moreover we should tune the 10 cm peak to be 5 cm, since if this is Radon we expect a peak around that length (slide 9).



Radon angle wrt GEMs plane

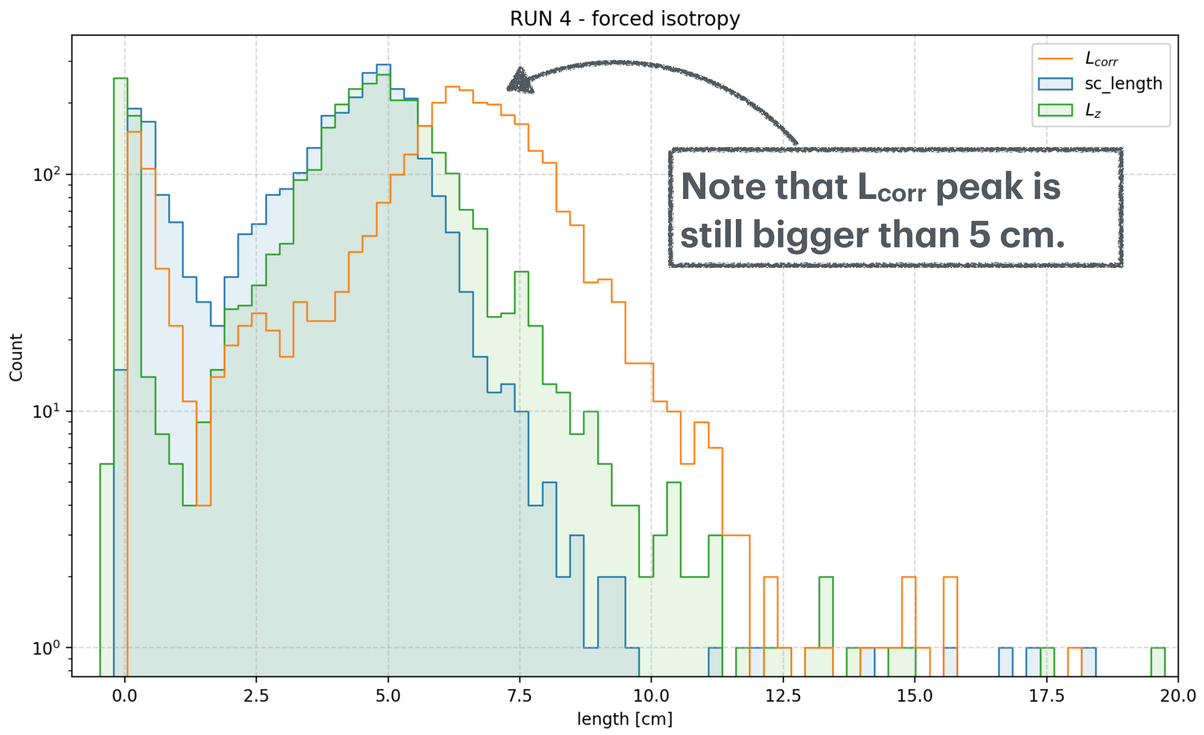
- The α distribution points to **60°**, with also a **good amount of tracks parallel** to the GEM plane

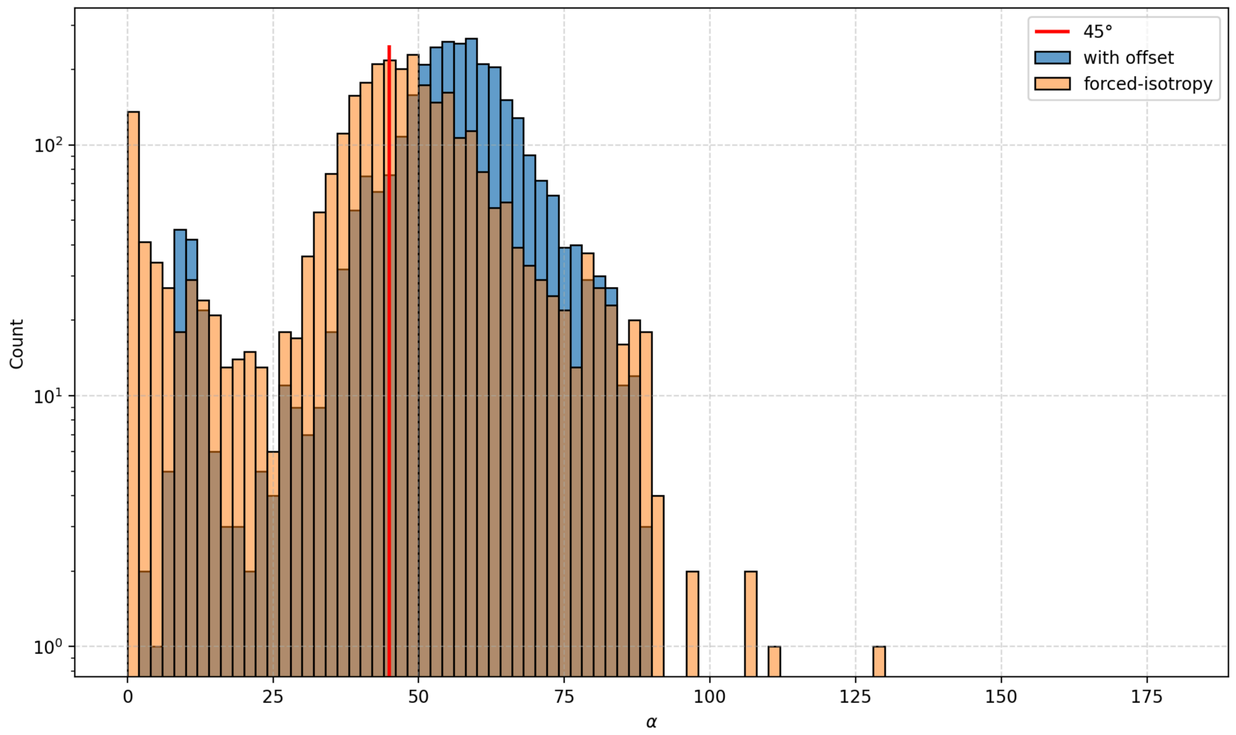




Length inter-calibration (very naive approach)

- If we choose to believe to the isotropy assumption, we can impose the 45° constraint.
- This can be done by rescaling the L_Z distribution such that it is superimposed with `sc_length`.





What do you think?
Thank you for your attention!