PMT
Reconstruction
& Analysis

2-day Analysis meeting
19-20/09/2024, L'Aquila
David Marques

PMT Signal basic properties – Resume

Let's resume all the information:

1. **Time over threshold** gives me the alpha **ΔZ**
   - Together with camera XY angle ⇒ **theta angle**

2. The **position of the Bragg** peak tells me **angle theta signal in Z**
   - (Towards cathode or GEMs)

3. **Relative amplitudes between PMTs** give me the **quadrant position** in X-Y
   - Useful for **basic association** cluster-waveform

~~4. Skewness of Bragg peak (within the waveform) difference between PMTs gives me the direction of the particle (head-tail)~~

- **Analyser class (directionality)** gives me **Angle in X-Y (phi)** and the **ΔXY**
  - Could be confirmed / tested against PMT Bragg peak skewness method

- ~~Bragg peak more prominent because the track are small, thus geometrical effect plays a smaller role~~
- ~~Also gives a hint of the X-Y angle, but this is easier to get with the camera~~

Reconstructed info:

- **ΔZ**
- **Theta angle**
- **ΔXY**
- **Phi angle**
- **Signal of theta + phi == Head-tail**

⇓

3D reconstruction

PMT Reco & Analysis - *Previously*

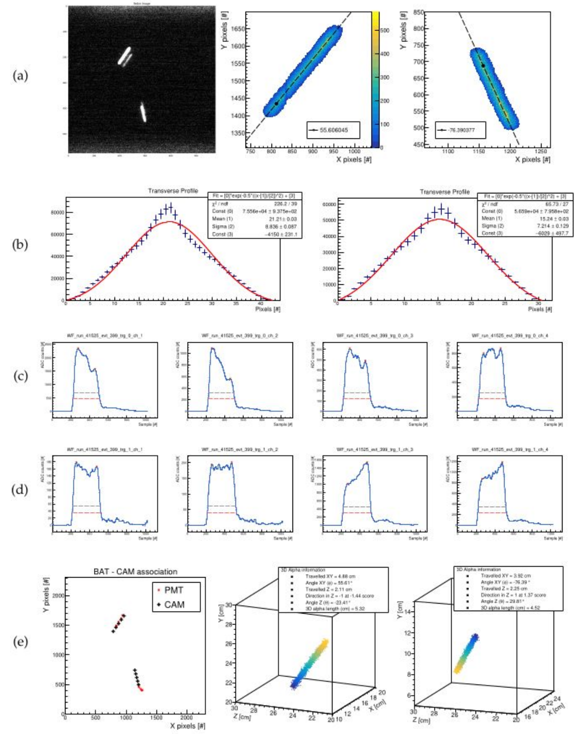

Figure 1.18: Full example of the analysis pipeline for the alpha particles identified in a given picture (run 41525, picture 399): (a) Original picture and sCMOS analysis of both alphas; (b) Light transverse profile of the alpha tracks; (c) and (d) the set of 4 waveforms for each trigger identified as alpha tracks; (e) waveform - cluster association and final 3D projection in the real LIME framework.

Previous episodes:

1. [https://agenda.infn.it/event/41735/]
   Initial look at alpha tracks for directional & head-tail determination
2. [https://agenda.infn.it/event/42030/]
   1 Update on … - 3D reconstructed alpha tracks
3. [https://agenda.infn.it/event/42653/]
   2 Update on … - 3D reconstructed alpha tracks
4. [https://agenda.infn.it/event/43123/]
   3 Update on ... Techical_update_**Coordinates_&_Shadows**

Full framework retrieves and saves all the relevant information automatically, including plots .

#4 Update on …

3D alphas -

Statistical results

David Marques

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BAT 1-to-1 association

PMT 3D reco – Conclusions

1. Missing (?) features
   - Color gradient is fake ⇒ Worth to associate it to longitudin
   - Electron cloud not plotted ⇒ Worth to take 2D transversal
   - ToT doesn't take into account minimum signal temporal wi
   - Improve association
     - Using BAT?
   - Improve theta signal calculation ⇒ Also probably using BAT
   - Get some basic PMT Alpha cuts to allow PMT-only analysis
   - Optimize Analyzer code (cross-check parameters, increase

PMT 3D reco – BAT-CAM association

To improve the **cluster-trigger association** **(1-to-1 association)**, we use the ***BAT-fit to position the PMT signal in the GEM plane:***

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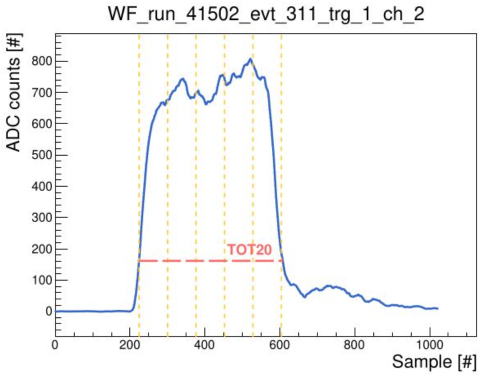

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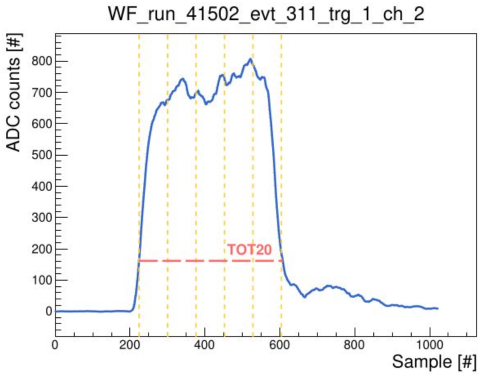

$$V = R * I \Rightarrow V = R * Q/\Delta t \Rightarrow Q = \frac{V * t}{R} \quad (1.4)$$

$$\begin{aligned} Q[nC] &= A[ADU] * \frac{\text{DGTZ dynamic range}[V]}{\text{DGTZ resolution}[bits]} * \Delta t / R \\ &= A[ADU] * \frac{1[V]}{12[bits]} * \frac{1}{\text{DGTZ sampl. freq.}}[ns] / R[Omega] \quad (1.5) \\ &= A * \frac{1}{4096} * \frac{4}{3} * \frac{1}{50} \end{aligned}$$

	run	event	trigger	index	L1	L2	L3	L4
0	11278	95	1	0	0.005768	0.012255	0.054120	0.022083
1	11278	103	1	0	0.036428	0.026936	0.012346	0.013160
2	11278	170	1	0	0.015781	0.018762	0.025400	0.018652
3	11278	204	2	0	0.014438	0.021052	0.028779	0.017780
4	11278	267	3	0	0.023758	0.030755	0.011108	0.006798
...	...	...	...	...	...	...	...	...
200	11177	342	0	0	0.016921	0.019090	0.016594	0.018878
201	11176	41	1	0	0.013646	0.025133	0.025018	0.013525
202	11176	114	0	0	0.024645	0.026661	0.012077	0.013246
203	11176	219	1	0	0.017910	0.027555	0.026793	0.021970
204	11176	339	0	0	0.010736	0.009577	0.043512	0.029371

Input data:

- *index* = peak index in the waveform (needed for non spot-like tracks!)
- $L_{1\text{-}4}$ must be in **nC**!
- **Input file** must have each line with these fields separated by a tab.

Reco_3D > bat_files > input_for_bat.txt

```
41525	399	1	0	0.000932541	0.000983476	0.00531117	0.00458673
41525	399	1	1	0.00107476	0.00119337	0.00691235	0.0058587
41525	399	1	2	0.000985412	0.00119586	0.00764	0.00607585
41525	399	1	3	0.000980864	0.00121351	0.00910747	0.00674264
41525	399	1	4	0.000837121	0.00097389	0.00774152	0.00586954
```

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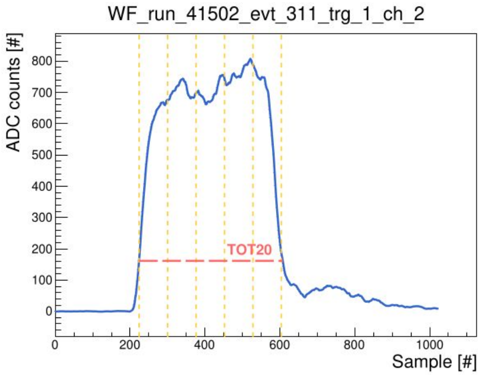

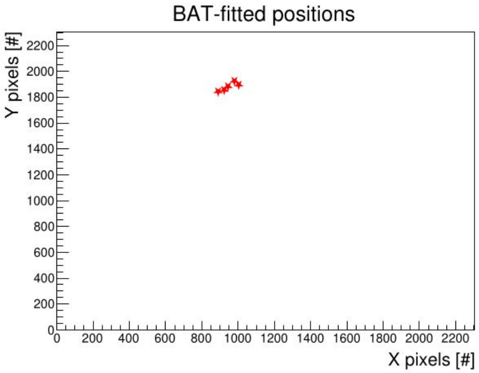

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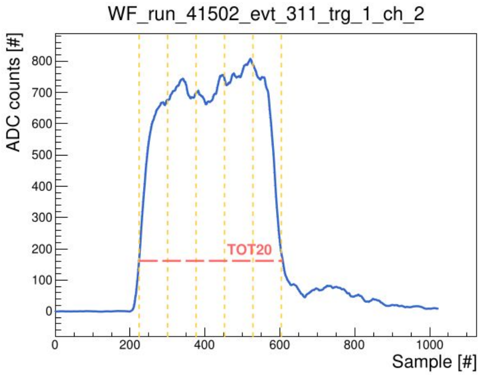
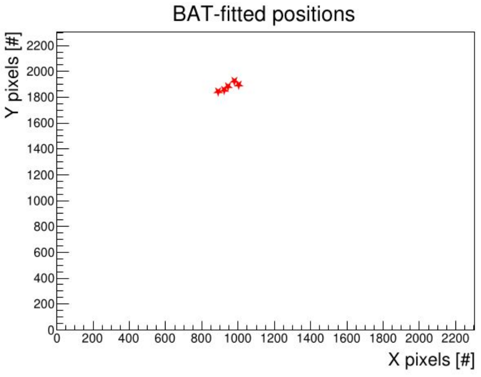
4. Same for CMOS (using Analyzer::Edges)
5. **Distance between points calculated**
6. **Cluster-trigger association done by smaller distances**





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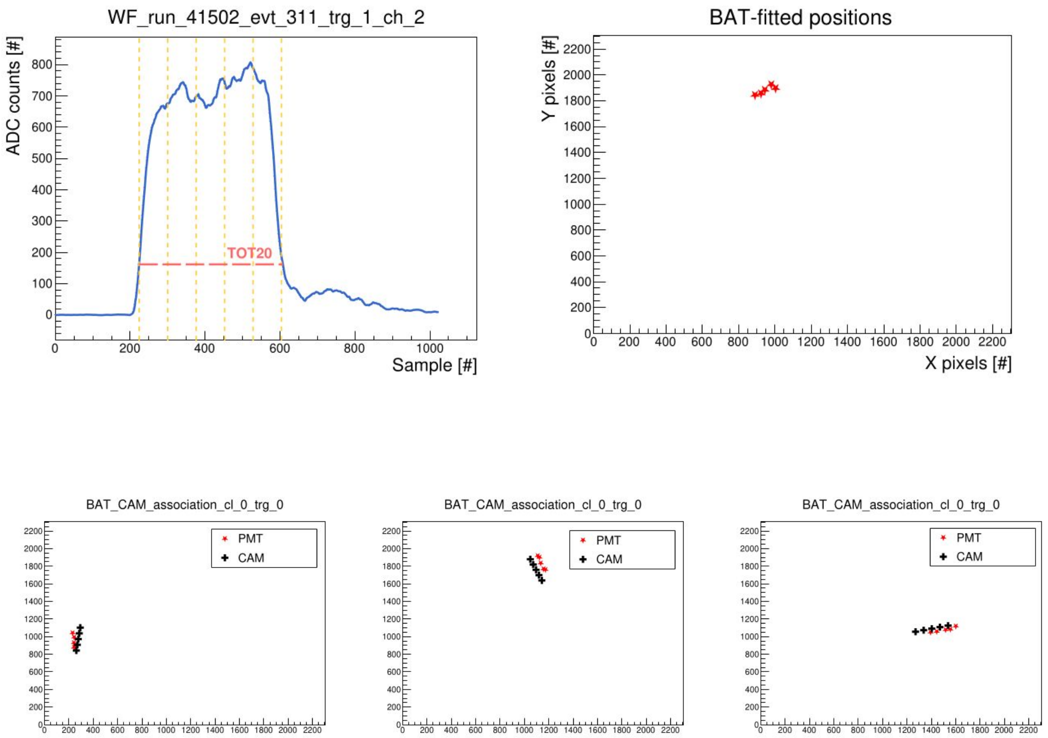
⇒ Works surprisingly well!



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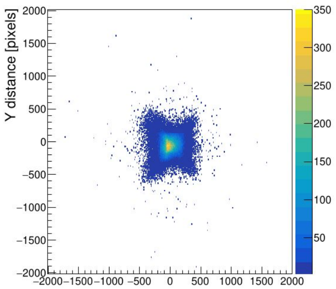

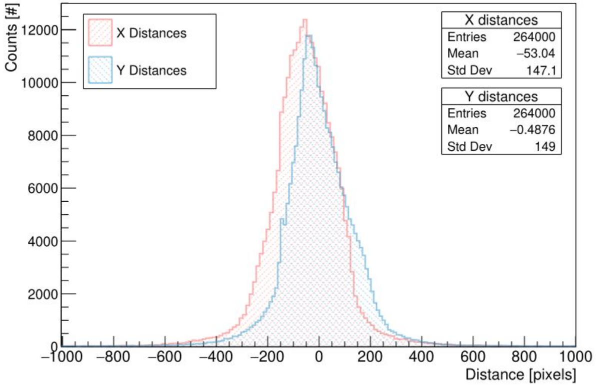

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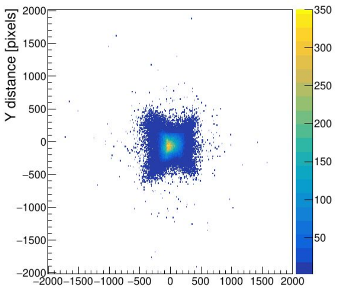

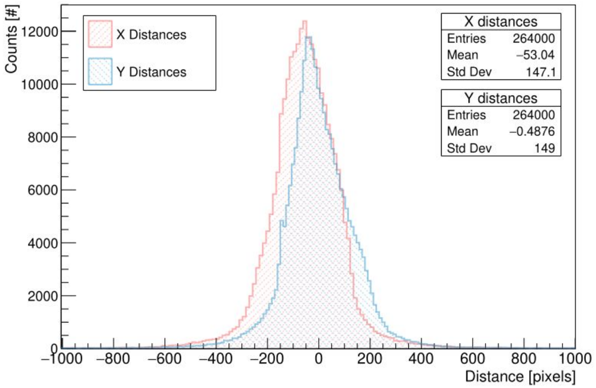

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  - Standard deviations of **~150 pixels = 2,325 cm**

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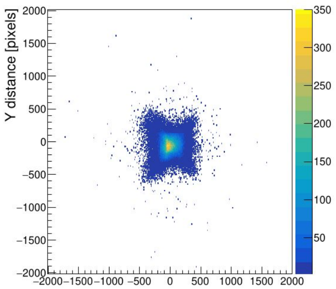

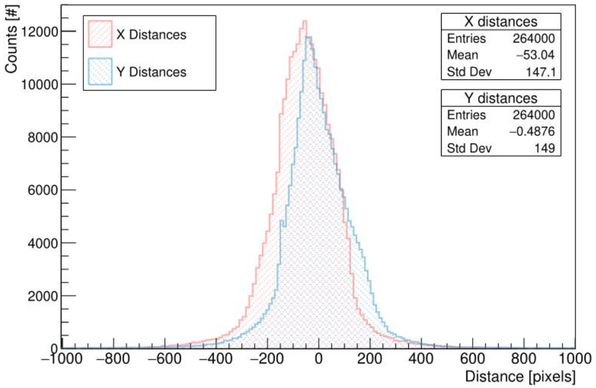

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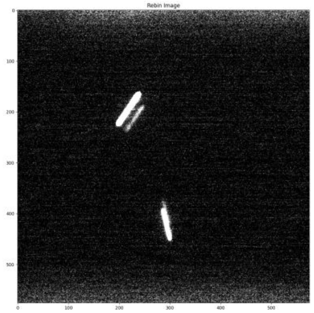
  - Rarely 2 in one pic.
  - This resolution is more than enough.
    - At closer distances, also the **CMOS reco** starts *failing and merging the tracks*, which renders useless the 3D reco.



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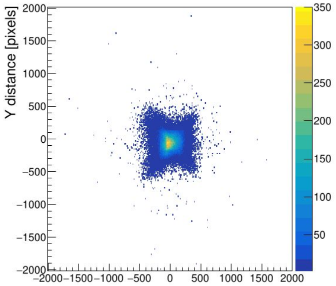

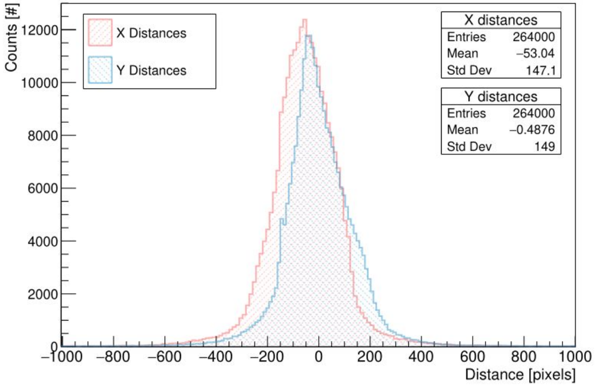

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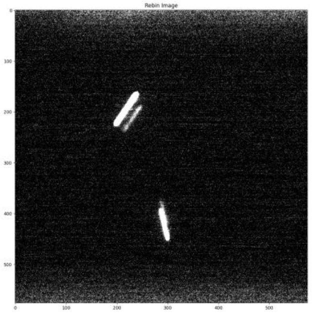

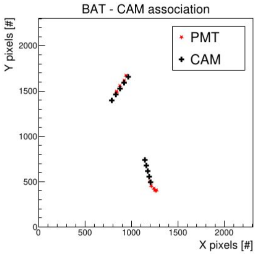

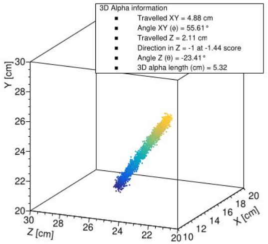

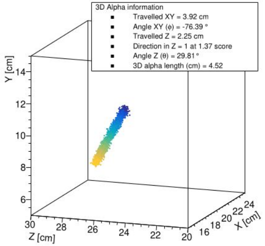

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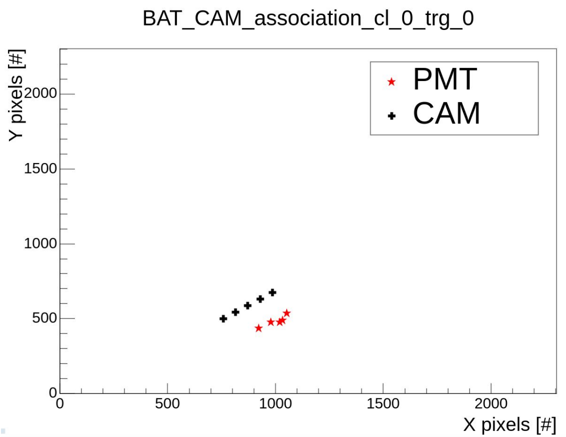
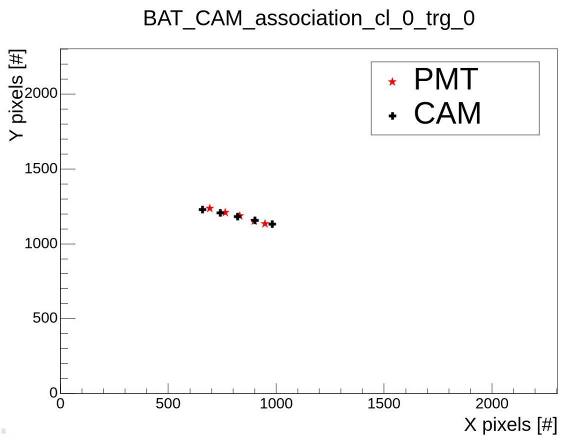
I have many examples, there's a bit of everything…





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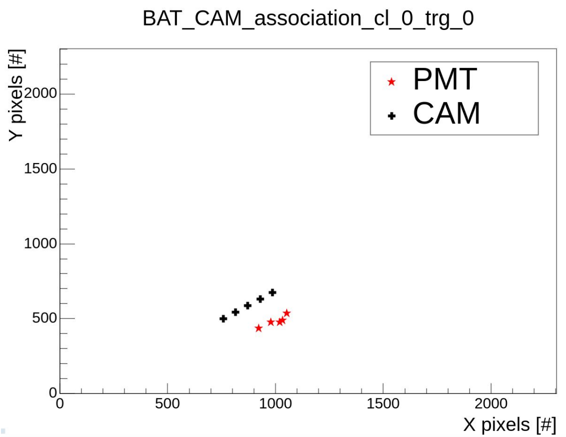

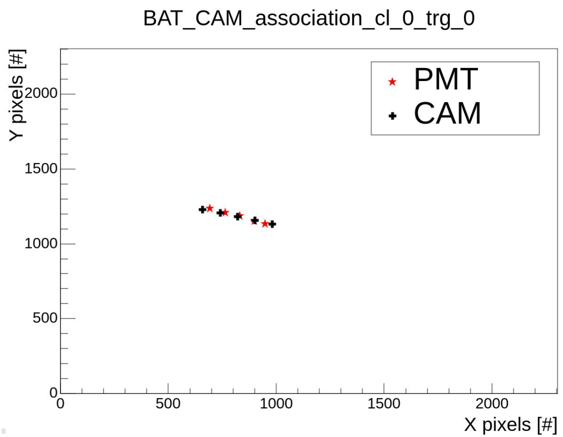

There are clear reasons to not have a perfect fit:

1. When the waveforms are saturated due to high gain, we **lose proportionality** ⇒ BAT-fit works better in the middle region.
2. Offsets due to inaccurate gain balance ⇒ **F. Borra recently updated the code to improve this, but I haven't checked.**
3. Barreling effect from lens towards the sides farther difficulties the fit ⇒ Giorgio working on it

While this is interesting, the **optimization**; test of other **types of particles**; implementation at **front-end level** is *out-of-scope for my work*.

Statistical Results

PMT Reco & Analysis

The datasets used were:

1. **Run 3**
   - For optimization only
2. **<u>Run 4</u>**
   - **Most of the long ranges of Bkg + calibs**
3. **Run 5**
   - Different gain:
     - Interesting by will *maybe* require parameter tuning… in the pipeline.

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STATUS	present in SSD?	Batch	Start	Stop	Numbers		Description	Data runs	Data pics	Gas Flow	Filter Line 1
			2023-12-01 15:08	2023-12-04 9:39	40784 -	40917	Stability	133	53200	5	Blu
DONE	YES	1	2023-12-04 10:23	2023-12-14 16:40	40919 -	42848	Bkg + Daily Calibrations	1929	771600	5	Blu
			2023-12-14 18:07:07	2023-12-16 10:17:27	42863 -	43185	Bkg + Daily Calibrations Low GAIN	322	128800	5	Blu
			2023-12-15 11:54:46	2023-12-15 14:44:20	42985	43050	VGEM1 scan	65	26000	5	Blu
			2023-12-16 23:50:59	2023-12-17 21:53:14	43186 -	43231	Stability + Daily Calibrations- LOW Gas Flow : 2 l/h	45	18000	2	Blu
			2023-12-17 22:45:16	2023-12-22 16:18:47	43232 -	43308	Stability + Daily Calibrations- LOW Gas Flow : 1 l/h	76	30400	1	Blu
			2023-12-17 22:45:16	2023-12-22 16:18:47	43316 -	43486	Stability + Daily Calibrations- LOW Gas Flow : 1 l/h	170	68000	1	Blu + Rosso
			2023-12-31		43502 -	43508	Daily Calibration			1	Blu + Rosso
					43509 -	43515	Daily Calibration			1	Blu + Rosso
			2024-01-04		43517 -	43522	Daily Calibration			1	Blu + Rosso
			2024-01-06		43524 -	43529	Daily Calibration			1	Blu + Rosso
			2024-01-08		43531 -	43536	Daily Calibration			2	Blu + Rosso
			2024-01-10		43636 -	43641	Daily Calibration			2	Blu + Rosso
			2024-01-12		43732 -	43738	Daily Calibration			5	Blu + Rosso
			2024-01-14		43849 -	43855	Daily Calibration			5	Blu + Rosso
			2024-01-16		44047 -	44053	Daily Calibration			5	Blu + Rosso
			2024-01-17		44203 -	44209	Daily Calibration			5	Blu + Rosso
			2024-01-18		44367 -	44372	Daily Calibration			5	Blu + Rosso
			2024-01-19		44553 -	44559	Daily Calibration			5	Blu + Rosso
			2024-01-08 12:00:15	2024-01-08 18:38:15	43537 -	43701	Stability + Daily Calibrations- LOW Gas Flow : 2 l/h	164	65600	2	Blu + Rosso
			2024-01-08 18:38:15	2024-01-15 9:00:00	43702 -	43885	Stability + Daily Calibrations- Gas Flow : 5 l/h	183	73200	5	Blu + Rosso
NO			2024-01-15 9:11:14	2024-01-23 12:31	43886 -	45213	Bkg + Daily Calibrations	1327	530800	5	Blu + Rosso
			2024-01-23 15:44:30	2024-01-24 9:53:11	45214 -	45251	Stability + Daily Calibrations- Gas Flow : 5 l/h	37	14800	5	Blu + Rosso
DONE	YES	2	2024-01-24 10:27:00	2024-02-02 9:42	45259 -	46628	Bkg + Daily Calibrations	1369	547600	5	Blu + Rosso
			2024-02-02 9:47:28	2024-02-04 11:21:19	46636 -	46740	Stability + Daily Calibrations- Gas Flow : 4 l/h	104	41600	5	Blu + Rosso
			2024-02-04 11:21:19	2024-02-05 14:03:49	46741 -	46802	Stability + Daily Calibrations- Gas Flow : 5 l/h	61	24400	5	Blu + Rosso
			2024-02-05 14:13:49	2024-02-06 23:50	46803 -	47023	Bkg + Daily Calibrations	220	88000	5	Blu + Rosso
			2024-02-06 23:59:42	2024-02-07 10:03:47	47024 -	47051	Stability + Daily Calibrations- LOW Gas Flow : 1 l/h	27	10800	1	Blu + Rosso
			2024-02-07 10:03:47		47052 -	47108	Stability + Daily Calibrations- LOW Gas Flow : 0 l/h	56	22400	1	Blu + Rosso
					47982 -	47985	DT test: trigger rate 36 Hz, PMT 590 V	4	1600	1	Blu + Rosso
					47986 -	47989	DT test: trigger rate 26 Hz, PMT 580 V	4	1600	1	Blu + Rosso
					47990 -	48014	DT test: trigger rate 4 Hz, PMT 560 V	25	10000	1	Blu + Rosso
					48015 -	48054	DT test: trigger rate 2 Hz, PMT 555 V	40	16000	1	Blu + Rosso
			2024-02-10 14:55:57	2024-02-15 13:07:13	47209 -	47981	Bkg + Daily Calibrations	772	308800	5	Blu + Rosso
DONE	YES	6	2024-02-15 15:35:22	2024-03-05 9:33	48055 -	50891	Bkg + Daily Calibrations	2836	1134400	5	Blu + Rosso
			2024-03-17 16:20:14	2024-03-18 15:14	52664 -	52808	Bkg + Daily Calibrations	144	57600	5	Blu + Rosso
			2024-03-18 15:42:55	2024-03-19 15:19:04	52816 -	52874	Stability + Daily Calibrations- LOW Gas Flow : 1 l/h	58	23200	1	Blu + Rosso
			2024-03-19 16:46:18		52882 -		Stability + Daily Calibrations- Gas Flow : 5 l/h	121	48400	5	Blu + Rosso
						53003	Stability + Daily Calibrations- Gas Flow : 5 l/h			5	Blu + Rosso
			2024-03-21 17:51:00		53004 -	53109	Stability + Daily Calibrations- LOW Gas Flow : 1 l/h	105	42000	1	Blu + Rosso
DONE	YES	3	2024-03-23 18:20:34	2024-03-26 9:41:19	53110 -	53502	Bkg + Daily Calibrations	392	156800	5+20	Blu + Rosso
DONE	YES	5	2024-03-29 10:01:40	2024-04-02 10:02:22	53707 -	54403	Bkg + Daily Calibrations	696	278400	5+20	Blu + Rosso + RADON
			2024-04-02 10:42:22		54411 -	54502	Stability + Daily Calibrations- HIGH recirculation 40 l/h	91	36400	5+40	Blu + Rosso + RADON
DONE	YES	4	2024-04-04 8:31:50	2024-04-08 8:26:06	54503 -	55093	Bkg + Daily Calibrations	590	236000	5+40	Blu + Rosso + RADON
NO			2024-04-08 13:00:06		55101 -	56883	Bkg + Daily Calibrations - Low Gain - Low Drift	1782	712800	5+40	Blu + Rosso + RADON

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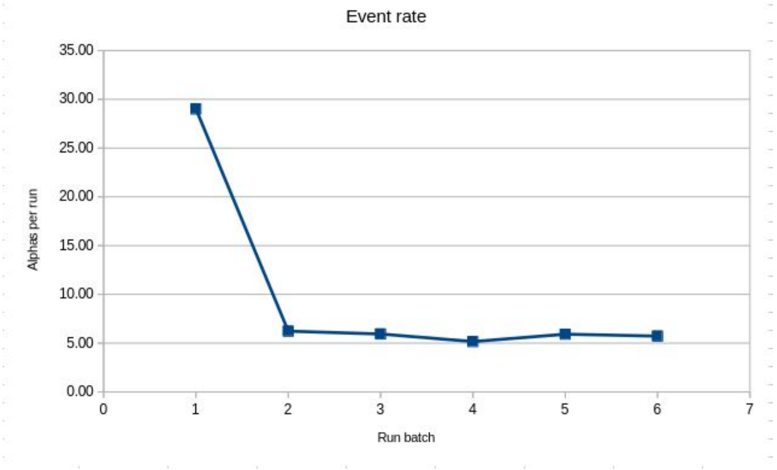
- For the whole analysis, I don't use many cuts, as I only saved ***matched and alpha-PID*** signals
  - You can assume ***near-perfect*** selection.
- You will sometimes see the cut: **" pmt_direction !=0 "**
  - When calculating the angles, I am sometimes unsure of the **sign** of the Z angle (but not the value). To not skew the distribution, I assign it **randomly (-1 or +1)**
    - **Later I realized this can alter (flatten) the distribution if the statistics are very high, so I remove these events.**

PMT Reco & Analysis

1. Alpha frequency in each batch

Batch	Runs	N runs	N matched alphas	N alphas per run
1	40919-42848	1820	52800	29.01
2	45259-46628	1370	8529	6.23
3	53110-53502	390	2315	5.94
4	54503-55093	591	3050	5.16
5	53707-54403	531		
6	48055-50891	2794	15974	-



High number of alphas in December, before oxygen and humidity filters were installed (correct?) ⇒ **6x reduction**

PMT Reco & Analysis

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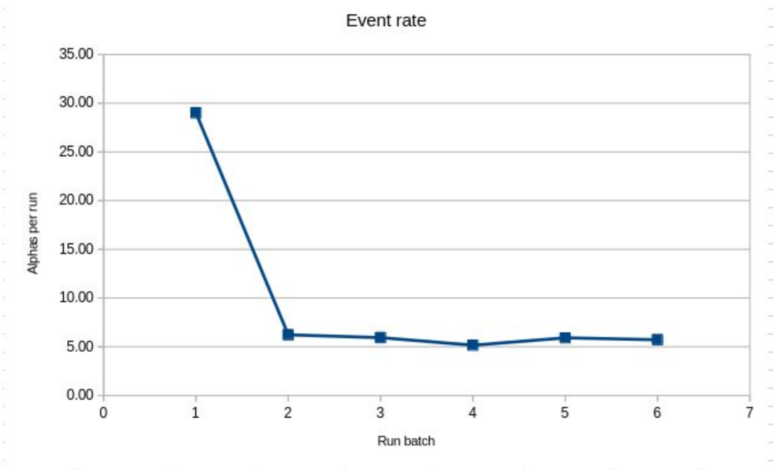


High number of alphas in December, before oxygen and humidity filters were installed (correct?) ⇒ **6x reduction**

Given the statistics, I'll group the data as *before (batch 1) and after Christmas (batch 2-6)*.

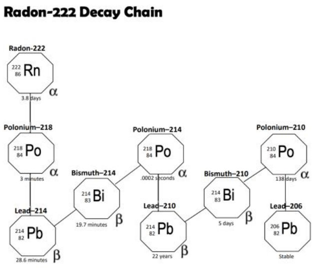
I later rerun the analysis, correcting the angles, and adding the transverse profile sigma fit to the tree

2. *3D lengths distributions*

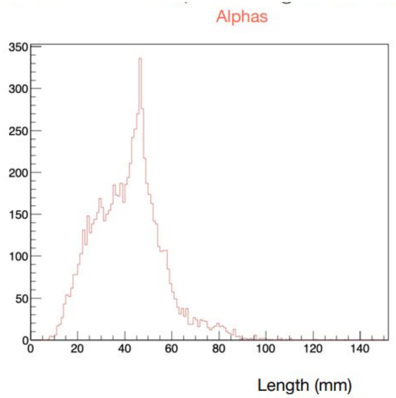
2. 3D lengths distributions

…comparing with Pinci's slides (2D alpha lengths)

The Radon Contamination



- So, a Rn contamination would produce:
  - 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)
  - 2 betas
  - a lot of gammas from 50 keV to 2200 keV



@Pinci, do we know the precision and source of these numbers.

Flaminia has slightly higher values for these alphas (?)

2. 3D lengths distributions

...comparing with Pinci's slides (2D alpha lengths)

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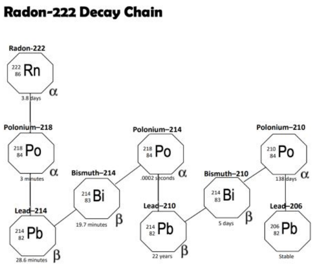

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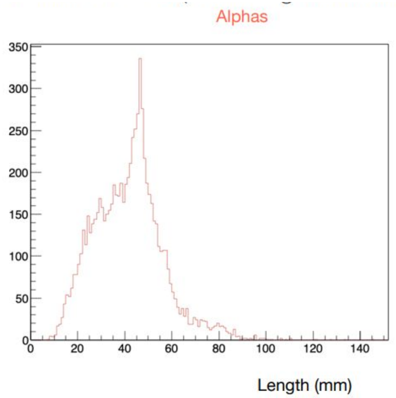
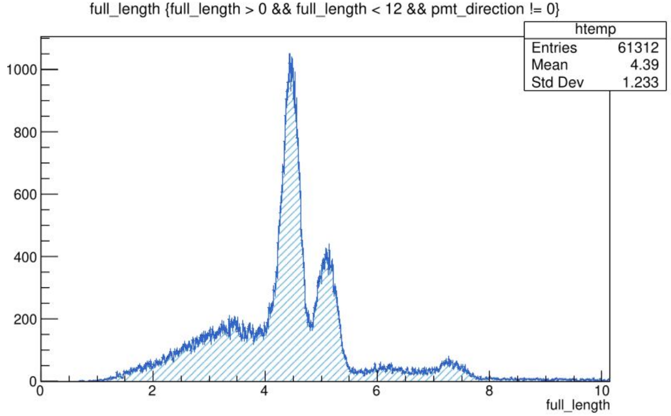


Adding 3rd coordinate



2. 3D lengths distributions

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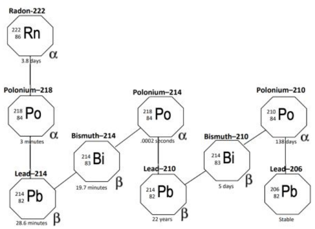
The Radon Contamination

Radon-222 Decay Chain



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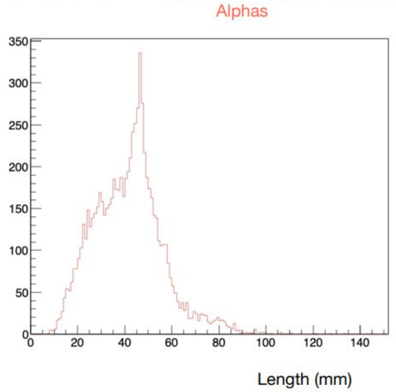

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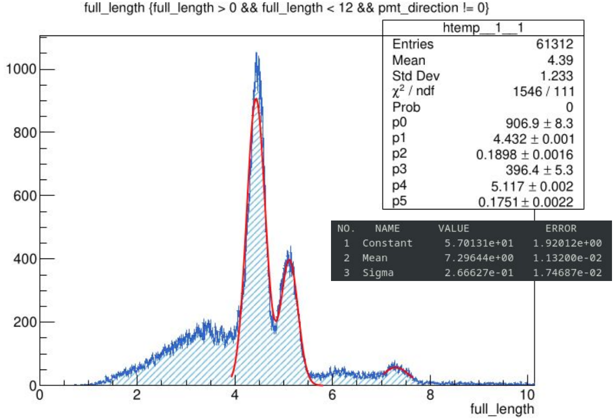


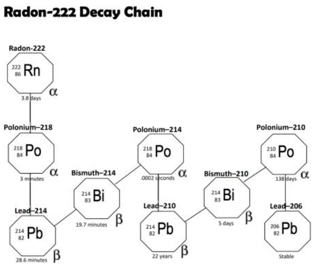
Peaks:

- **4.43 cm**
- **5.12 cm**
- **7.29 cm**

2. 3D lengths distributions

...comparing with Pinci's slides (2D alpha lengths)

The Radon Contamination



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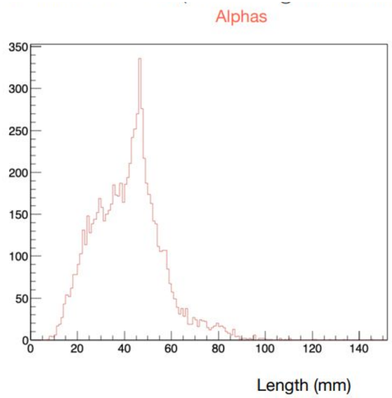
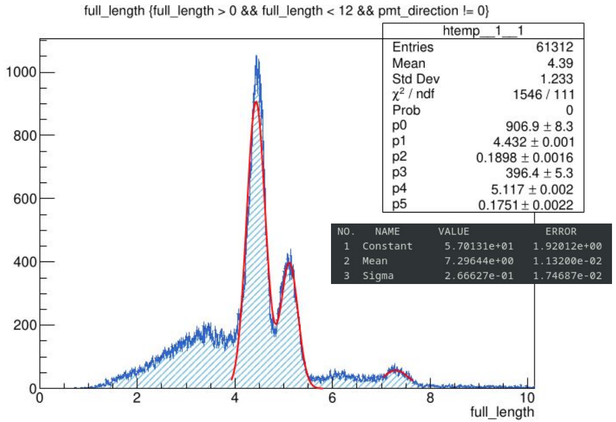


Adding 3rd coordinate

Very similar!



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2. 3D lengths distributions

… Comparing batches:

- ***before (1)** **vs** **after (2-6)** **Rn filters***
- *Normalized to 1*

2. 3D lengths distributions

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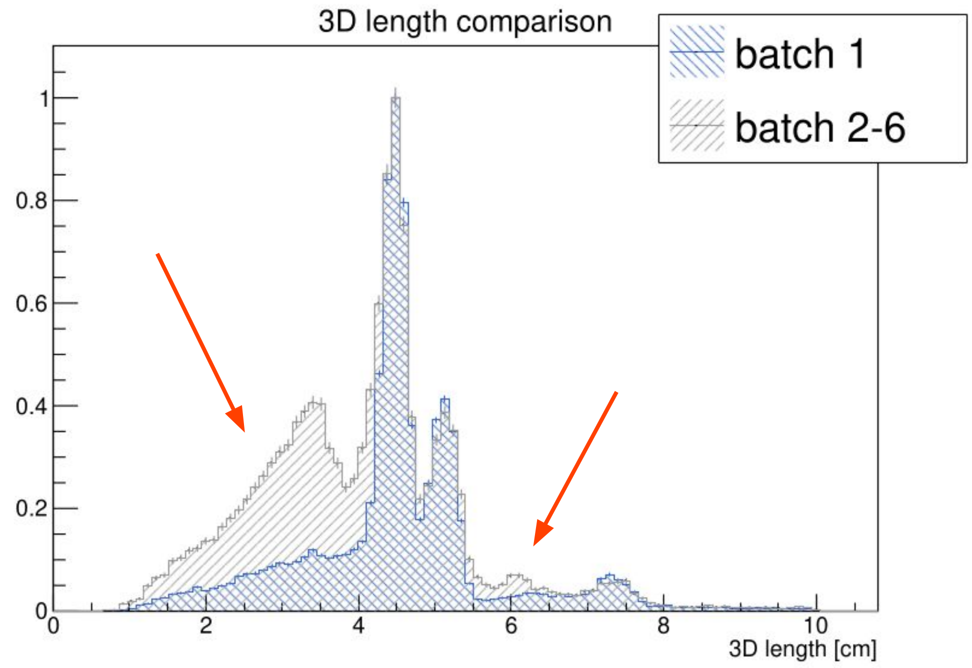

PMT Reco & Analysis

2. [3D lengths distributions]

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- *before (1)* ***vs*** *after (2-6)* ***Rn filters***
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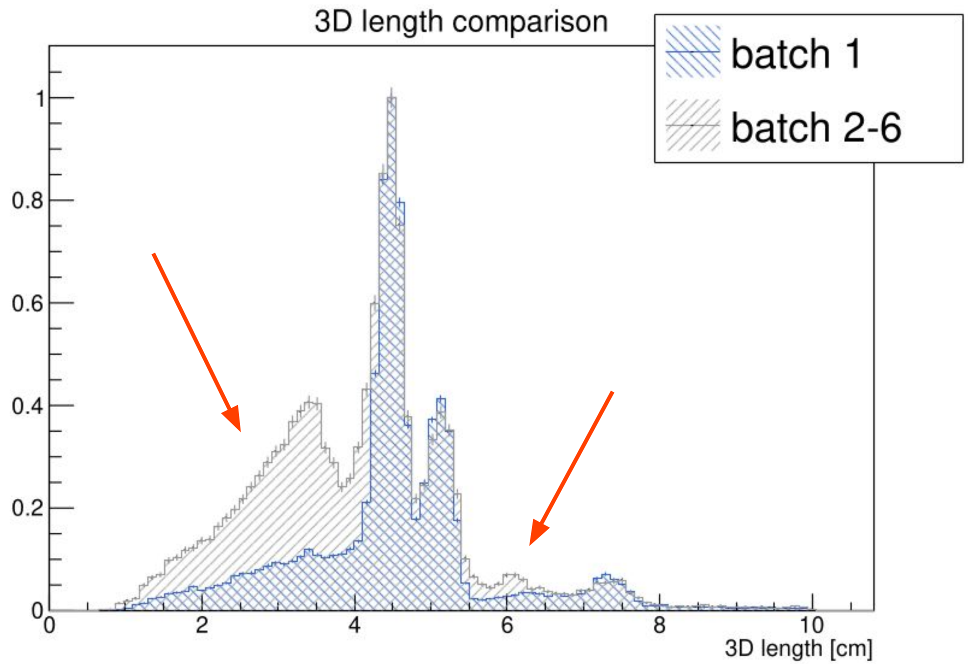

→ The **Rn peaks** are in the same positions
  - ◆ Good consistency ✅

→ The relative quantity of Rn alphas in batch 2-6 reduced, ***highlighting other peaks***.
  - ◆ Another **proof of presence of Rn** and posterior effectiveness of filters ✅

2. 3D lengths distributions

… Caveats:

➔ Actually, there is some discrepancy in my numbers and Pinci's ⇒ mine are systematically bigger.

PMT Reco & Analysis

2. *3D lengths distributions*

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- Likely due to the fact that I'm not subtracting the **"minimum temporal signal"** from the measured ToTs.

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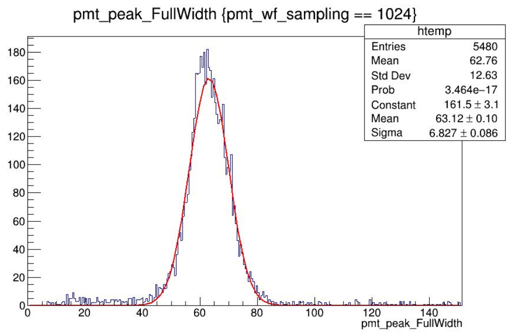
  - If I were to remove the ^{55}Fe length (= 63 samples = 4.6mm)...



➔ **FullWidth distribution of ^{55}Fe in calib runs in the same data set**

PMT Reco & Analysis

2. [3D lengths distributions]

*** NB:** This correction was also applied in the tilted cosmic (flux) studies (https://agenda.infn.it/event/38654/contributions/217319/)

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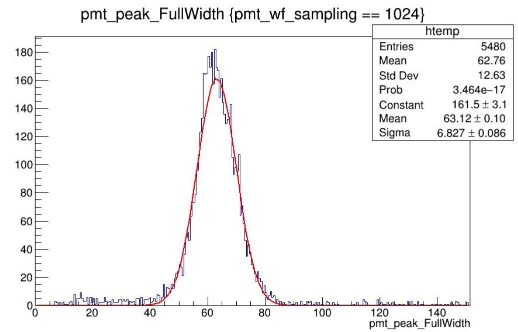
- Likely due to the fact that I'm not subtracting the **"minimum temporal signal"** from the measured ToTs.
  - If I were to remove the ^{55}Fe length (= 63 samples = 4.6mm)…
    - ***The results would be even closer.***



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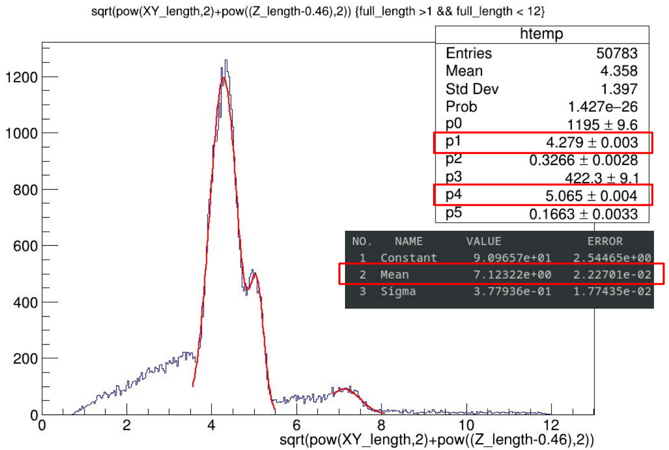

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PMT Reco & Analysis

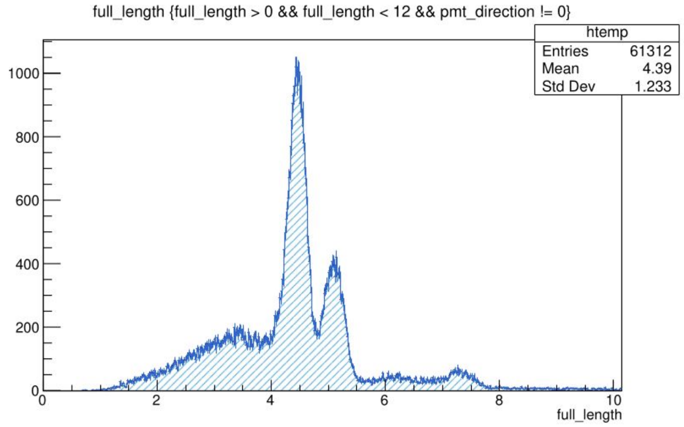
2. 3D lengths distributions

… Conclusions:

2. 3D lengths distributions

... Conclusions:

- Results are very interesting because, ***unlike the energy that saturates*** and spoils the spectrum, **the length of the tracks can be quite precise**, and indeed we can see, also with a **good resolution**!



PMT Reco & Analysis

2. 3D lengths distributions

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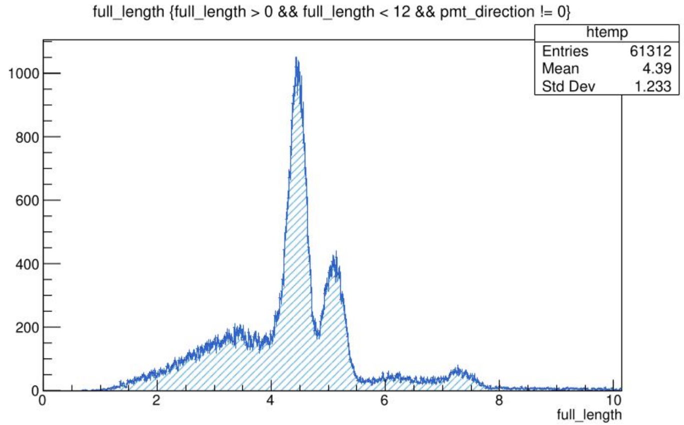

We are clearly in the presence of ^{222}Rn as we see the 3 contributions.

PMT Reco & Analysis

2. [3D lengths distributions]

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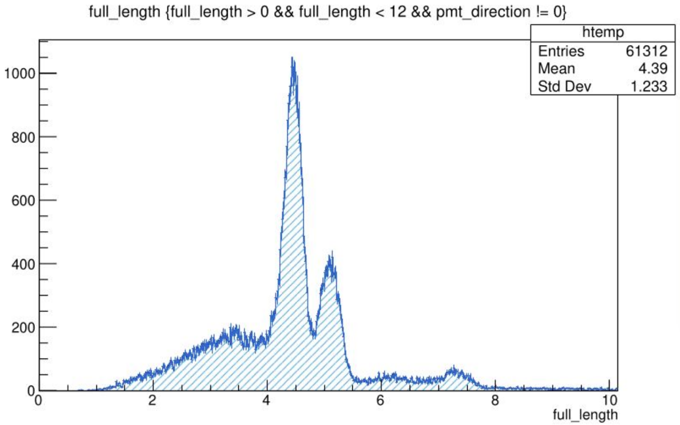

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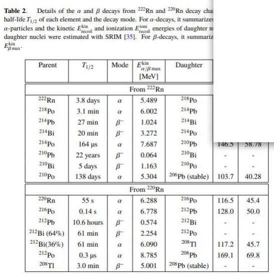


Table 2. Details of the α and β decays from ^{222}Rn and ^{220}Rn decay chai… half-life $T_{1/2}$ of each element and the decay mode. For α-decays, it summarizes… α-particles and the kinetic E^{kin}_{recoil} and ionization E^{ioni}_{recoil} energies of daughter n… daughter nuclei were estimated with SRIM [35]. For β-decays, it summariz… $E^{kin}_{\beta\,max}$.

Parent	$T_{1/2}$	Mode	$E^{kin}_{\alpha/\beta\,max}$ [MeV]	Daughter		
From ^{222}Rn						
^{222}Rn	3.8 days	α	5.489	^{218}Po		
^{218}Po	3.1 min	α	6.002	^{214}Pb		
^{214}Pb	27 min	β^-	1.024	^{214}Bi		
^{214}Bi	20 min	β^-	3.272	^{214}Po		
^{214}Po	164 μs	α	7.687	^{210}Pb	146.5	58.78
^{210}Pb	22 years	β^-	0.064	^{210}Bi	-	-
^{210}Bi	5 days	β^-	1.163	^{210}Po	-	-
^{210}Po	138 days	α	5.304	^{206}Pb (stable)	103.7	40.28
From ^{220}Rn						
^{220}Rn	55 s	α	6.288	^{216}Po	116.5	45.4
^{216}Po	0.14 s	α	6.778	^{212}Pb	128.0	50.0
^{212}Pb	10.6 hours	β^-	0.574	^{212}Bi	-	-
^{212}Bi (64%)	61 min	β^-	2.254	^{212}Po	-	-
^{212}Bi(36%)	61 min	α	6.090	^{208}Tl	117.2	45.7
^{212}Po	0.3 μs	α	8.785	^{208}Pb	169.1	69.8
^{208}Tl	3.0 min	β^-	5.001	^{208}Pb (stable)	-	-

- ➔ How to assess if the **ratios** are correct? Simulation?
- ➔ What about ^{220}Rn? MiMac also considers it in their paper

[First detection of radon progeny recoil tracks by MIMAC - IOPscience]

3. dE/dx vs energy and vs length

… a quick look:

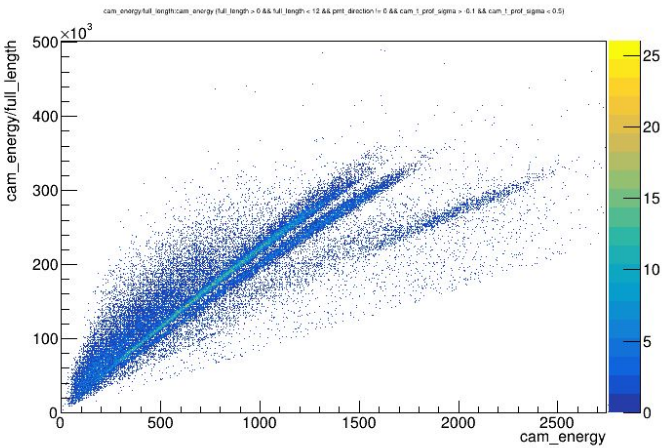
PMT Reco & Analysis

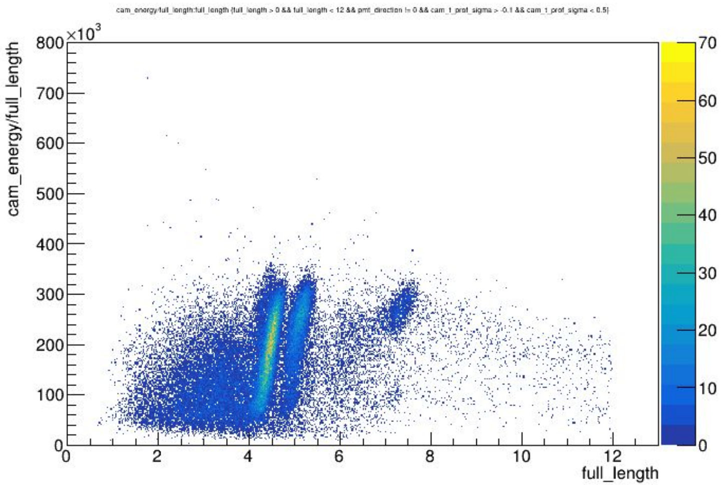
3. dE/dx vs energy and vs length

... a quick look:

➔ Lines likely correspond to the **3 alphas observed**.

- They are not points because of saturation!
  - *Could saturation be studied from here?*

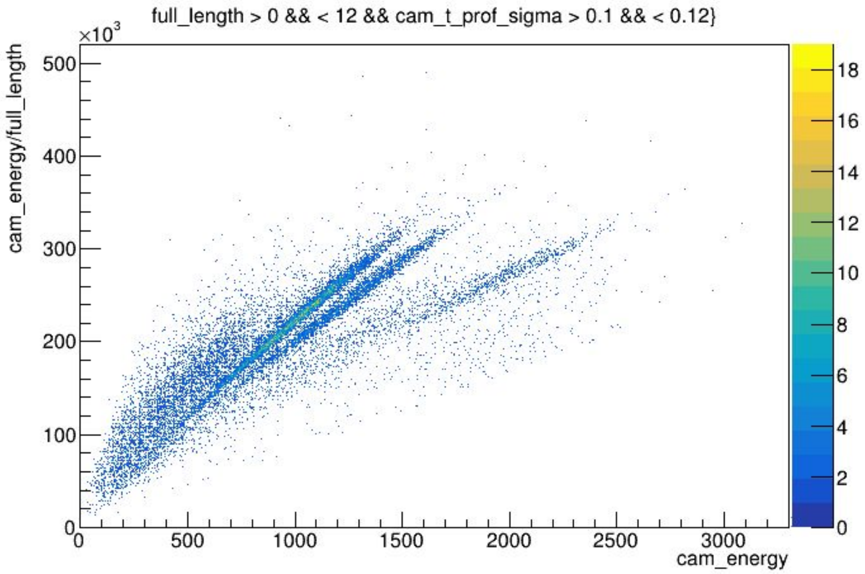




PMT Reco & Analysis

3. dE/dx vs energy and vs length

... It was suggested to look at the dE/dx at different absolute Z



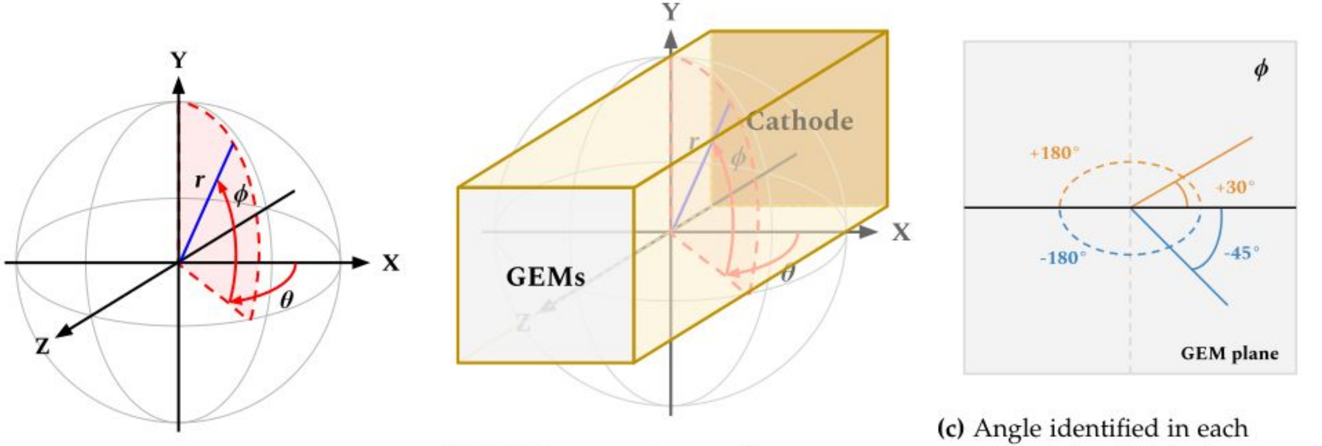
➔ By selecting a band in "diffusion" (ie, selecting a "Z band":

- I **shrink the length of the dE/dx line**, which starts looking more **point-like**, as expected due to the saturation feature.

4. Angles

4. Angles

… Reference frame



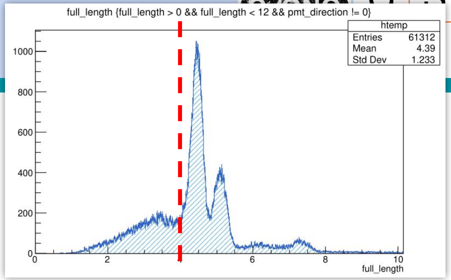
(a) Coordinate system.

(b) LIME on superimposed on top of the coordinate system.

(c) Angle identified in each picture of the GEM plane. optional or move to another place

Figure 1.5: System of coordinates and angles used in the analysis of LIME data.

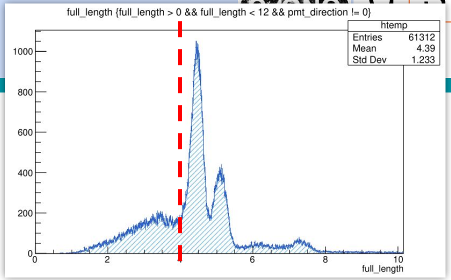
PMT Reco & Analysis



4. Angles ➔ Cuts based on the alpha 3D lengths:

- **> 4 cm: Rn alphas**
- **< 4 cm: Everything else**

PMT Reco & Analysis



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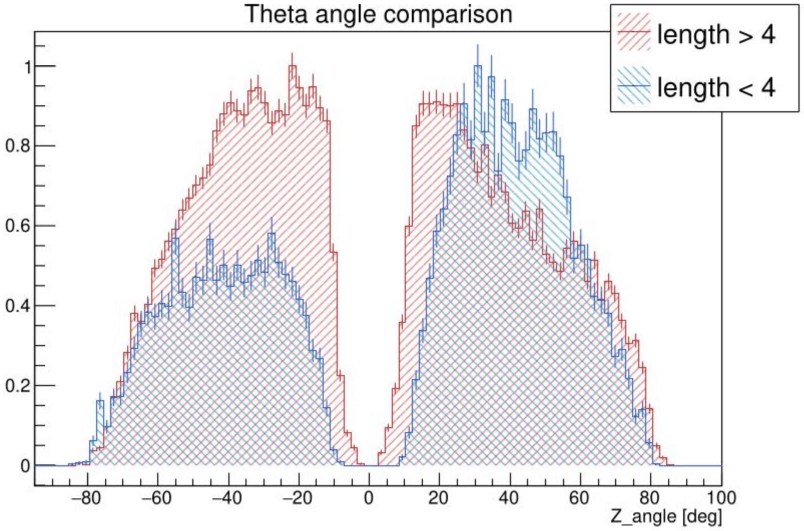


➔ Before Christmas/Rn filters

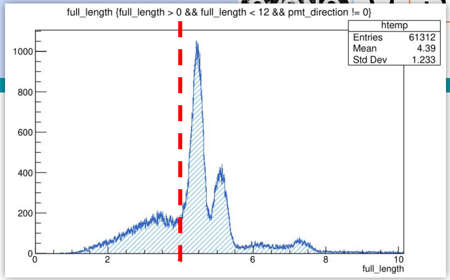
➔ Rn alphas have symmetric(ish) distribution of angles.

- Makes sense since emission is random

➔ Non-Rn alphas have preferential direction towards GEM

- Perhaps coming from cathode? ⇒ To investigate with absolute Z

PMT Reco & Analysis



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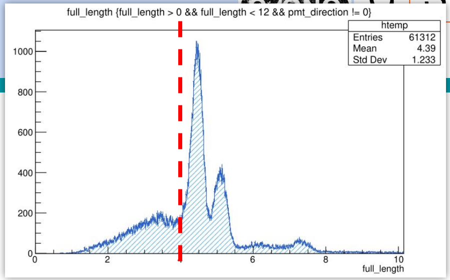
PMT Reco & Analysis



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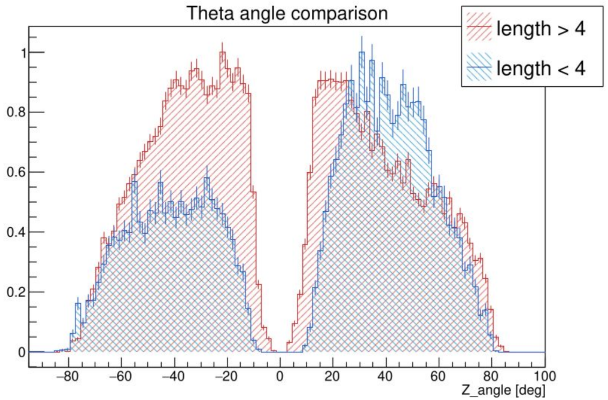
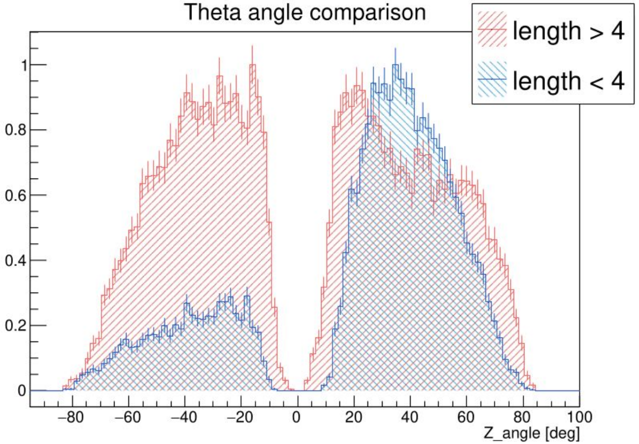
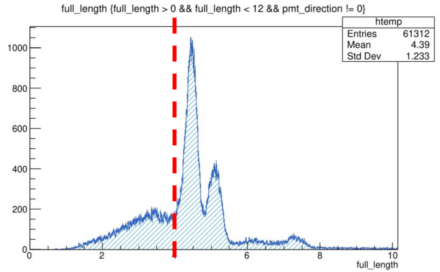


Before Christmas



After Christmas

PMT Reco & Analysis



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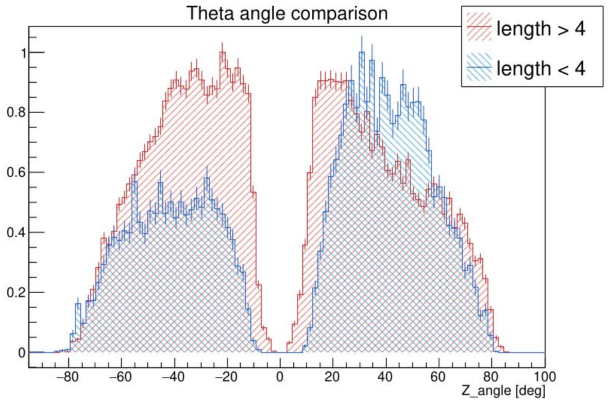

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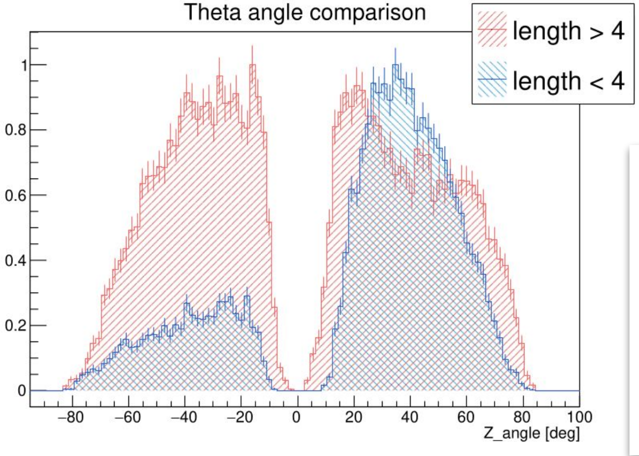


After Christmas

➔ Proportion of non-Rn alphas travelling towards GEMs increased.
  - To study correlation from specific materials (?)

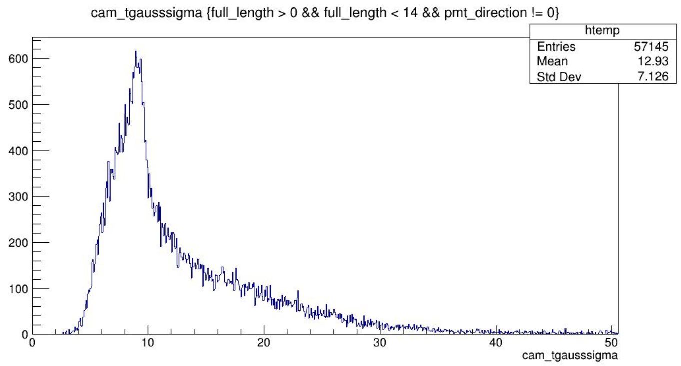
5. *Defining absolute Z*

PMT Reco & Analysis

5. Defining absolute Z

➔ Many correlations are related to the absolute Z.

- This can be kind of assessed with **tgaussigma**, ***but it's hard***



5. Defining absolute Z

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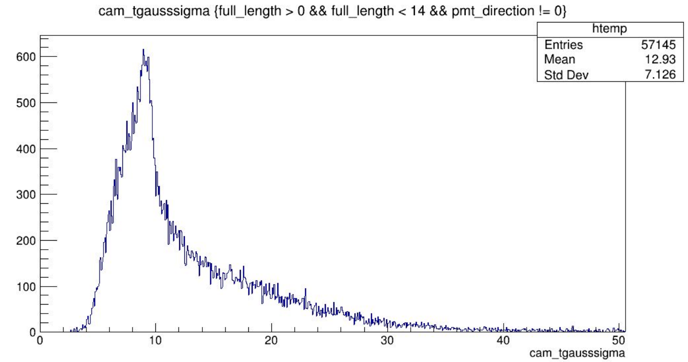
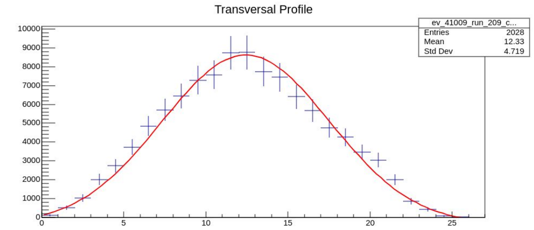
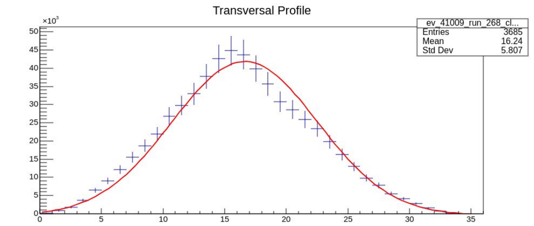
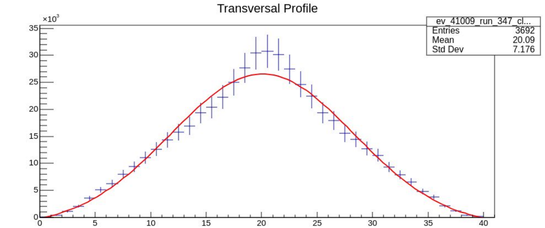
- This can be kind of assessed with **tgaussigma**, ***but it's hard***
  - I used the **sigma of the transverse profile of the track**.
  - Fit : `[0]*exp(-0.5*((x-[1])/[2])^2) + [3]`

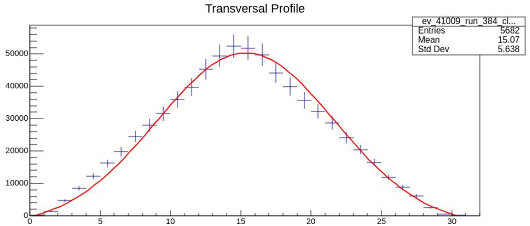
*NB the constant term











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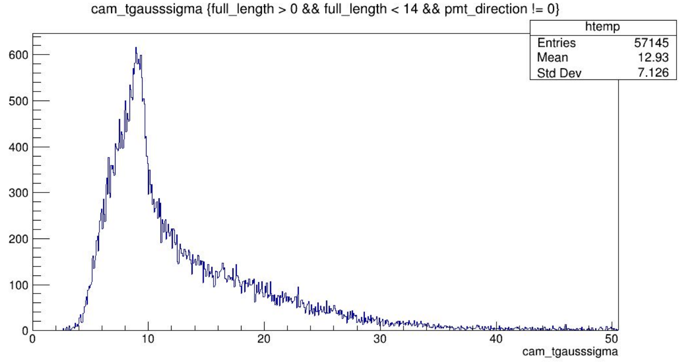
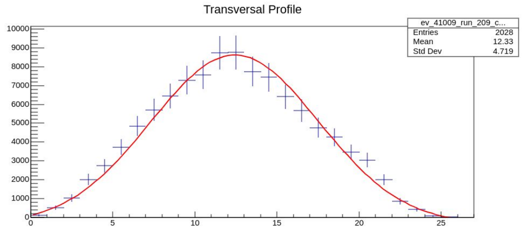
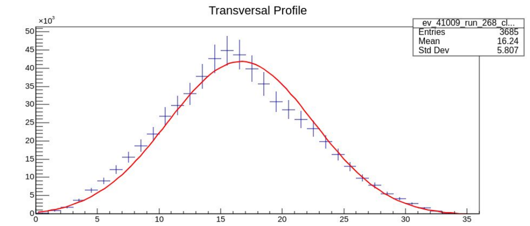
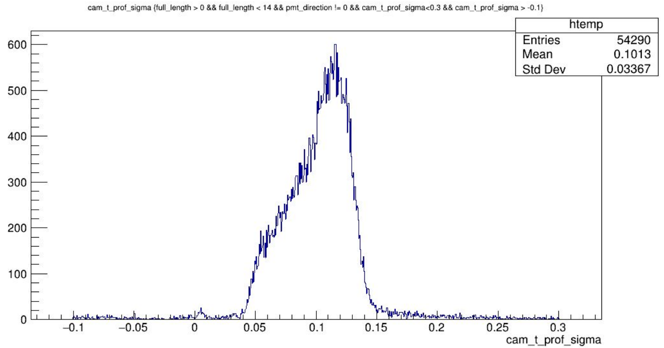
- This can be kind of assessed with **tgaussigma**, ***but it's hard***
  - I used the sigma of the transverse profile of the track.
  - Fit : `[0]*exp(-0.5*((x-[1])/[2])^2) + [3]`

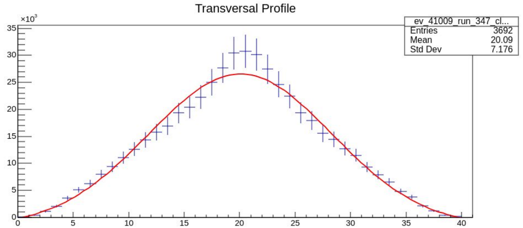
*NB the constant term

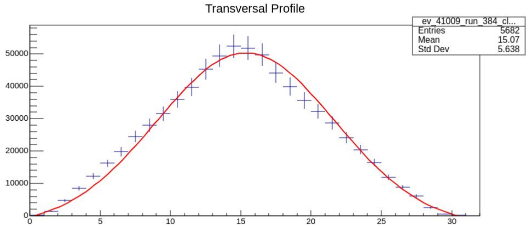












6. Correlations

… Can we trust the fit of the transverse profile?

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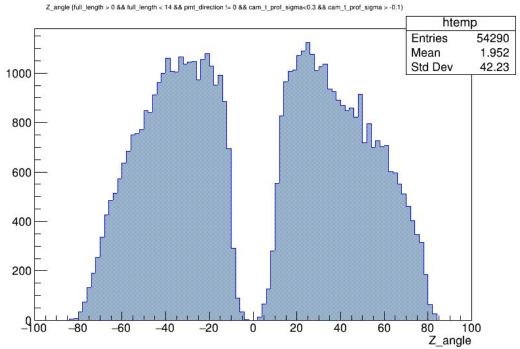
Theta angle distribution, no cuts



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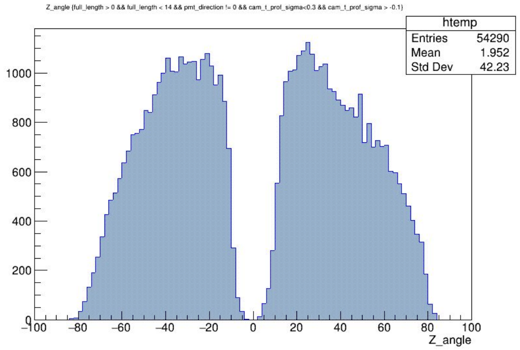

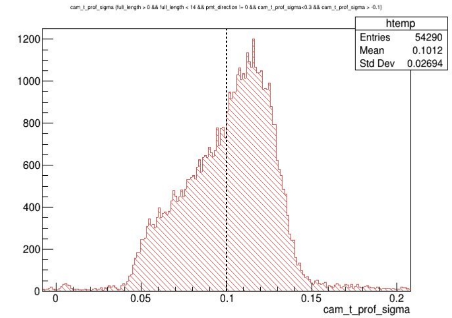

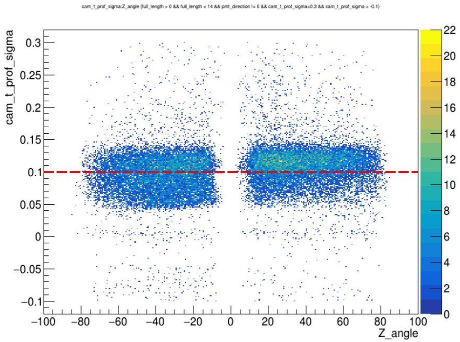

*batch1 dataset

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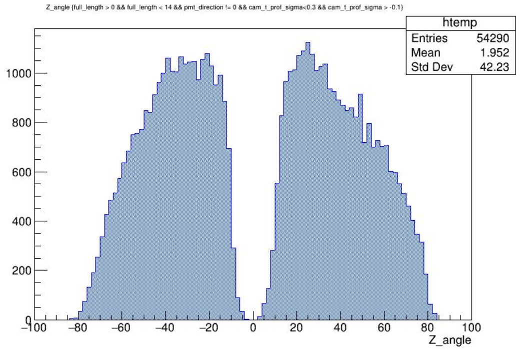

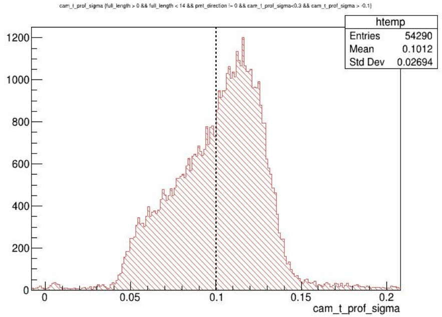

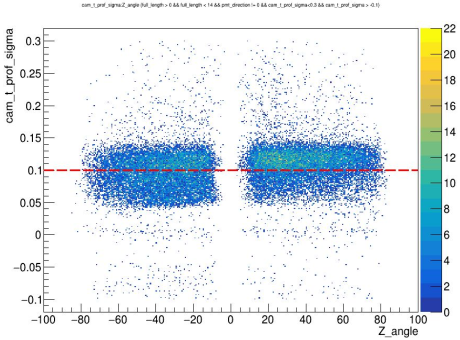

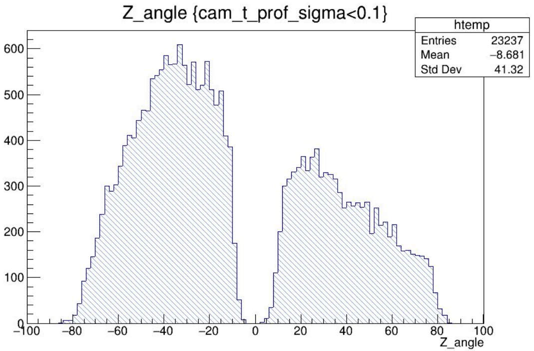

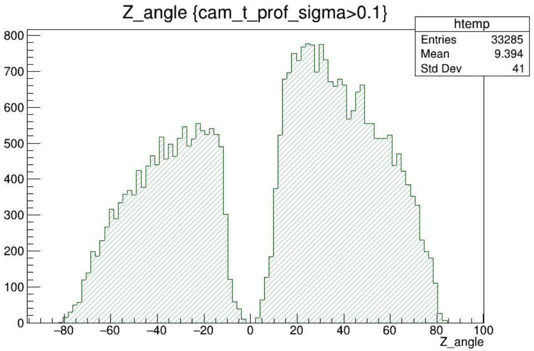

Smaller sigma shows more tracks towards the cathode (eventually from GEMs); while higher **sigmas** show more angles towards GEM (eventually from cathode)

6. Correlations

… We can look at it from a different perspective, separating between Rn and non-Rn alphas:

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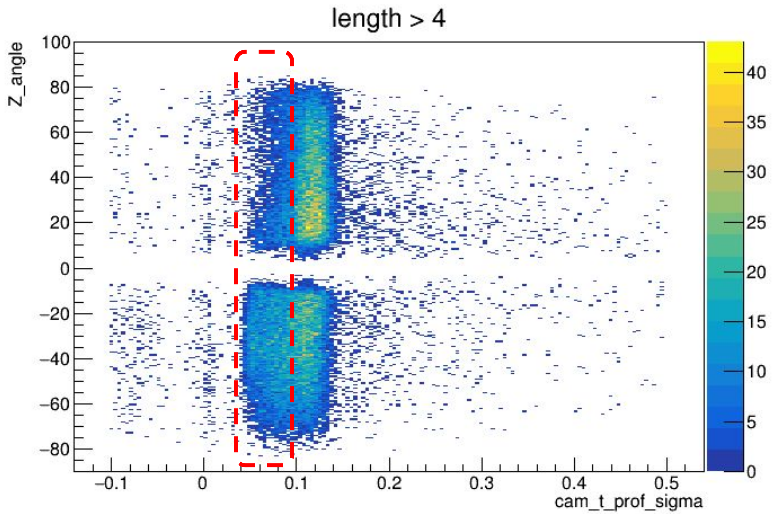

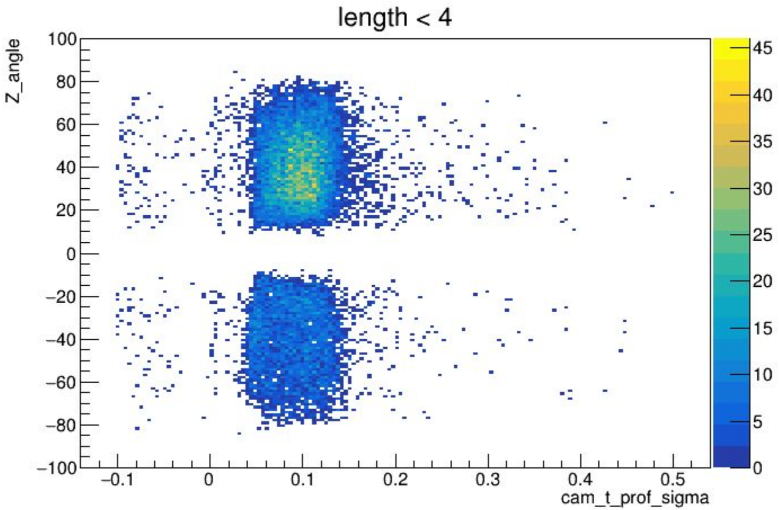

6. Correlations

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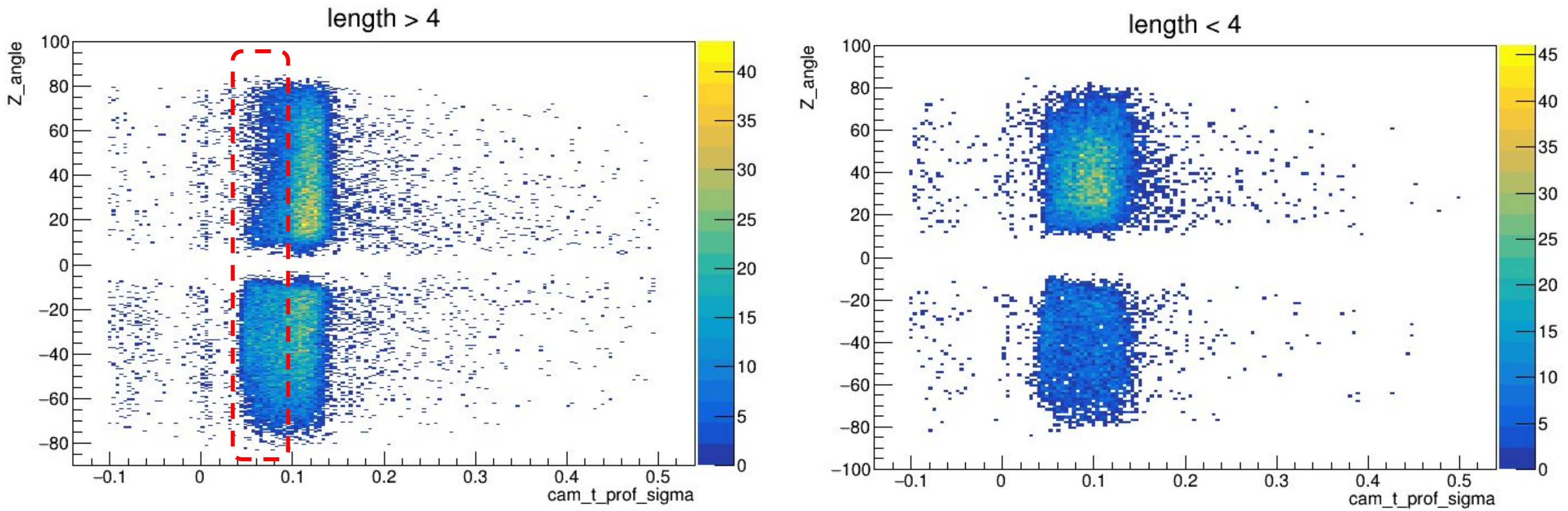

For Rn alphas: towards GEMs, preferentially at higher Z, while towards the cathode is more evenly distributed. For random alphas, all Z mixed.

PMT Reco & Analysis

6. *Correlations*

...We can also look at the distribution of angles

PMT Reco & Analysis

*batch1 dataset

6. Correlations

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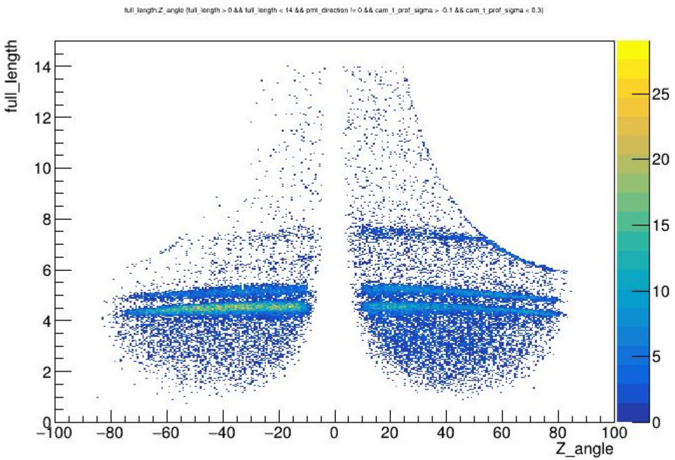

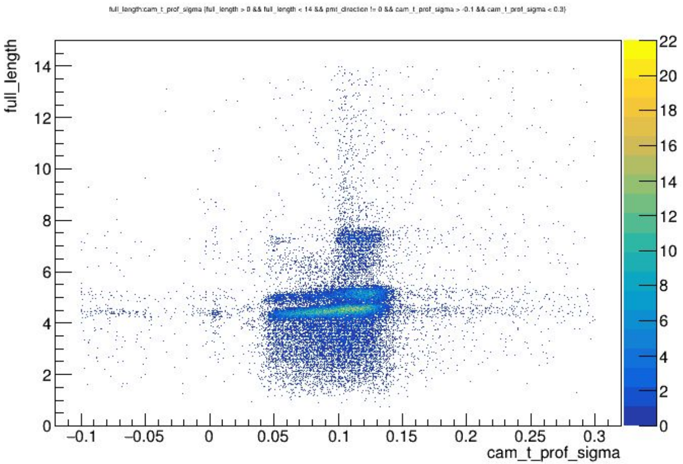

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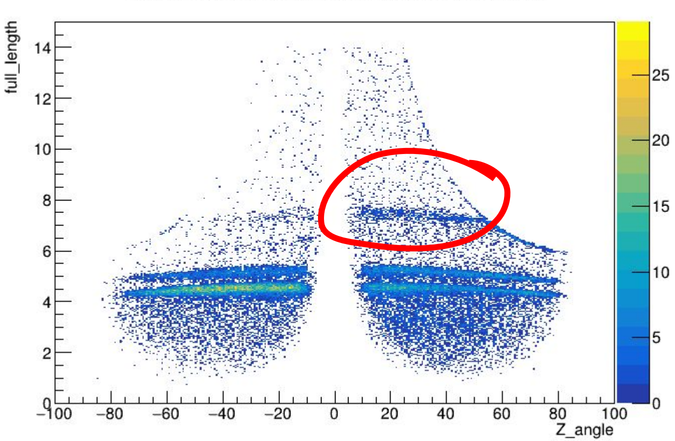

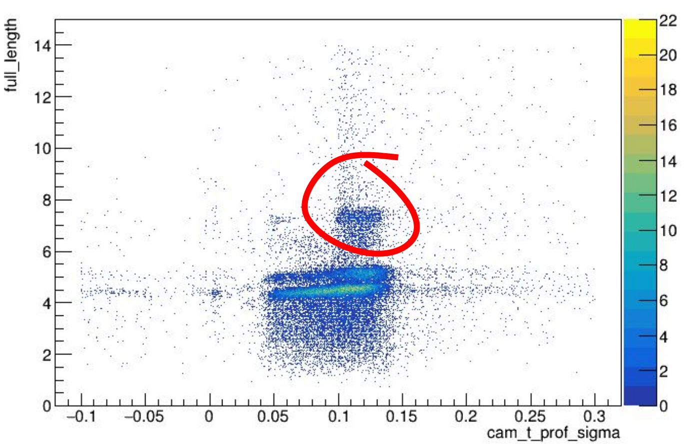

→ Alphas of 7 cm length preferentially towards GEM and at high absolute Z. Similar for 5 cm length tracks.

6. Correlations

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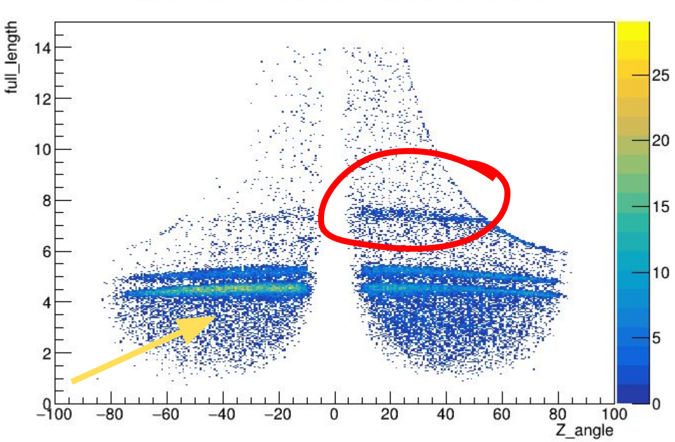

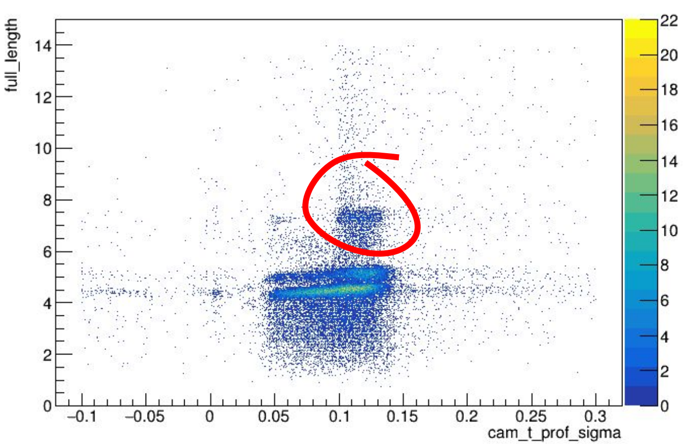

- ➔ Alphas of 7 cm length preferentially towards GEM and at high absolute Z. Similar for 5 cm length tracks.
- ➔ Alphas at 4 cm length also see a big preference towards the cathode instead.

6. Correlations

…. Can I confirm this? If I cut on the profile sigma

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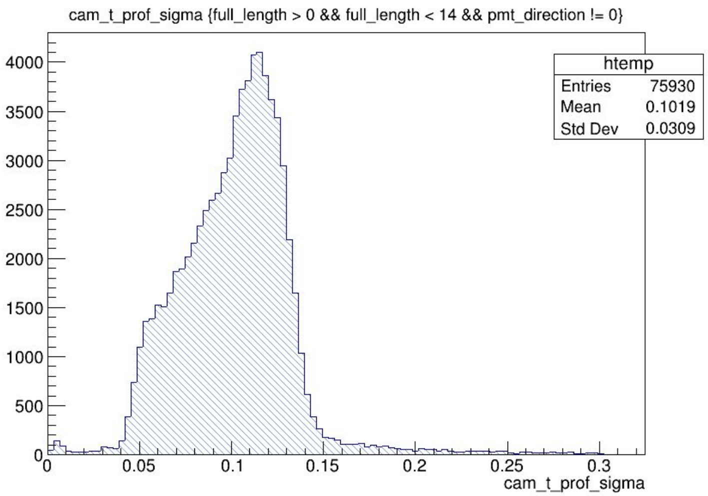

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6. Correlations

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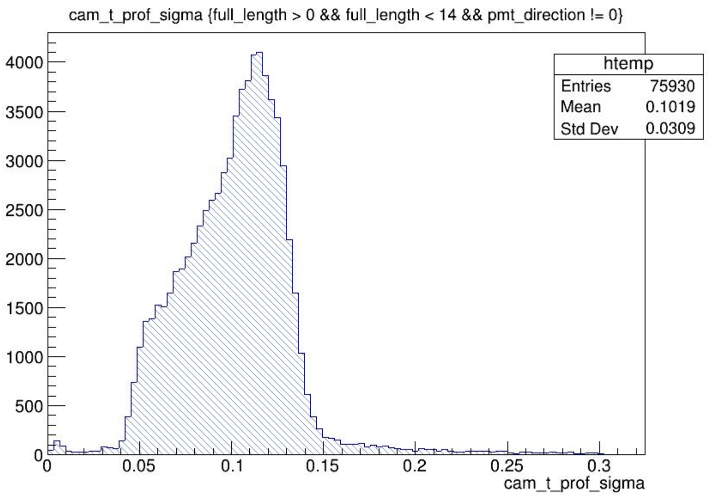

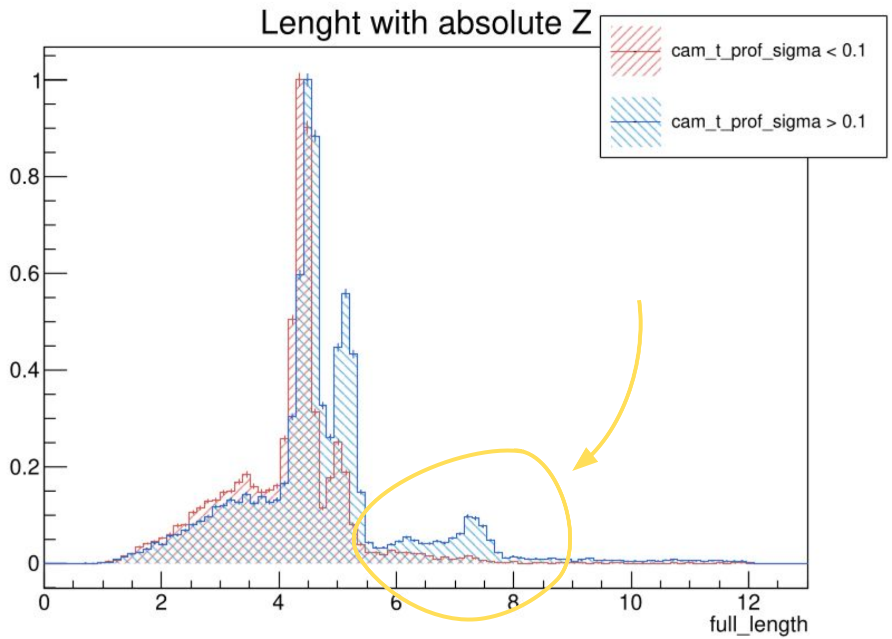

➔ When cutting the high Z tracks, the alpha component at 7 cm disappears.

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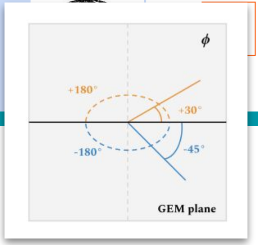
6. Correlations

… We can also look at XY angle, meaning CMOS-only analysis*

PMT Reco & Analysis



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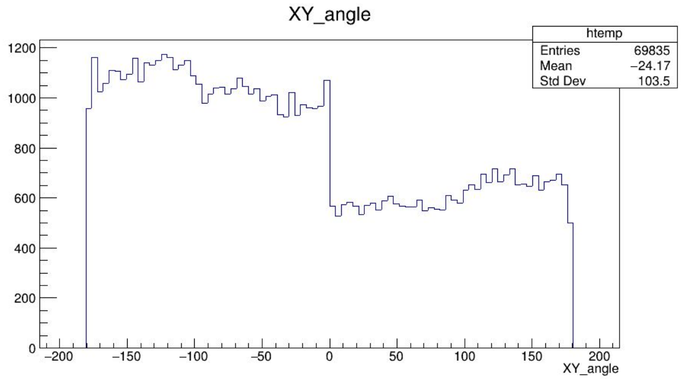
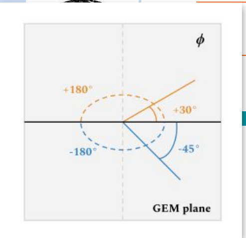


➔ This shows a much greater amount of track going downwards, which could be from the resistors?

PMT Reco & Analysis



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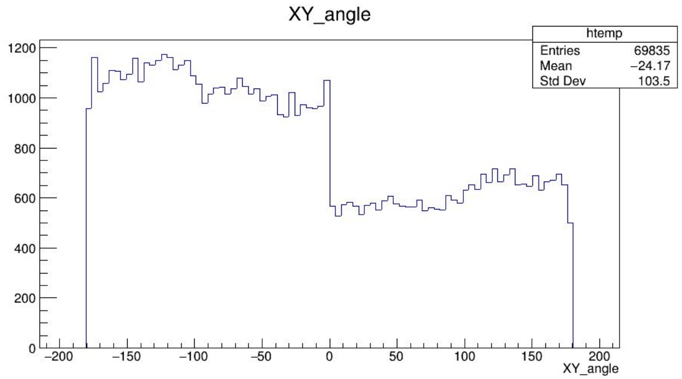

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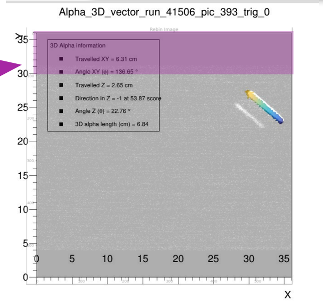
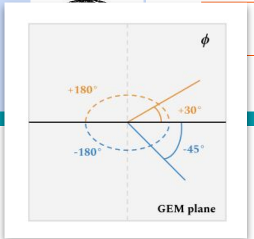
➔ Applying a cut on position:

Y_begin > 30



PMT Reco & Analysis



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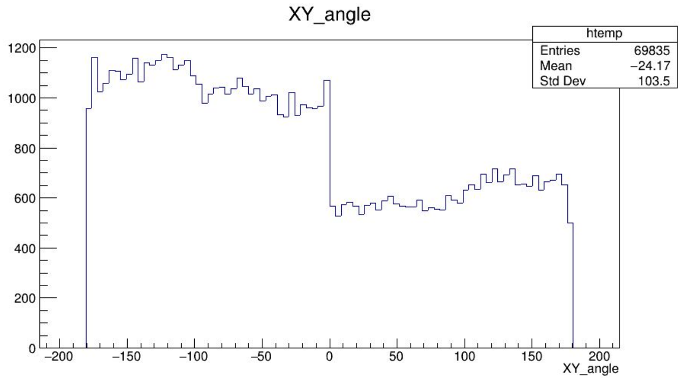

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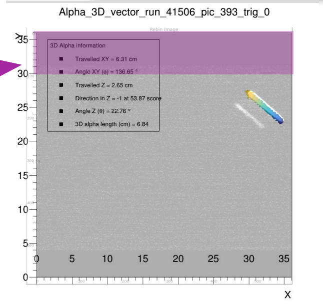
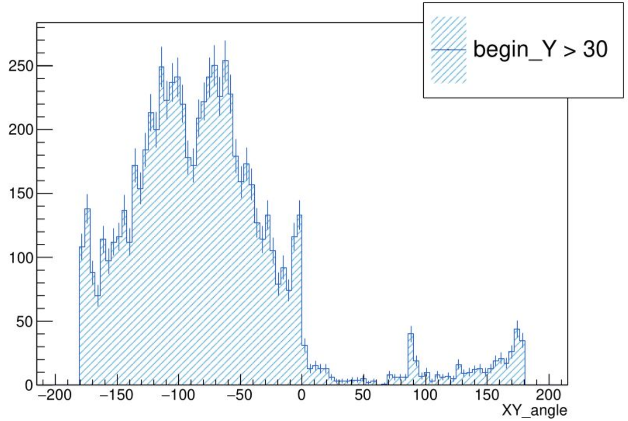




➔ This shows a much greater amount of track going downwards, which could be from the resistors?

➔ **Checks out!** ✅

PMT Reco & Analysis

Conclusions:

- **3D reco & analysis framework is built and working well for alpha particles.**
    - Selection and cuts focused on alpha particles.
        - Application of the methodology for other types of particles is to be done!
- 3D length is a great variable to perform analysis on alpha particles since it doesn't saturate like the energy
- Distribution of different angles indicative of source of alpha particles. To be deepened.

Next steps (from my side):

- Study of Rn progeny chains and comparison with literature (Mimac / Drift / Leubenstein / Flaminia's thesis) ⇒ For final results for my thesis. Brief work.
- Comparison with simulation ⇒ Flaminia has simulated also the background alphas in LIME, without digitization. This is enough for me to compare the statistics and eventually assess the accuracy of my analysis.
- Addition of digitization ⇒ D. Fiorina has made a back of the envelope simulation of alphas in our gas. Digitization of these events can confirm some of our results (like Rn alpha lengths) and test accuracy of CMOS:Analyzer for alphas (NB it was optimized for ER directionality)

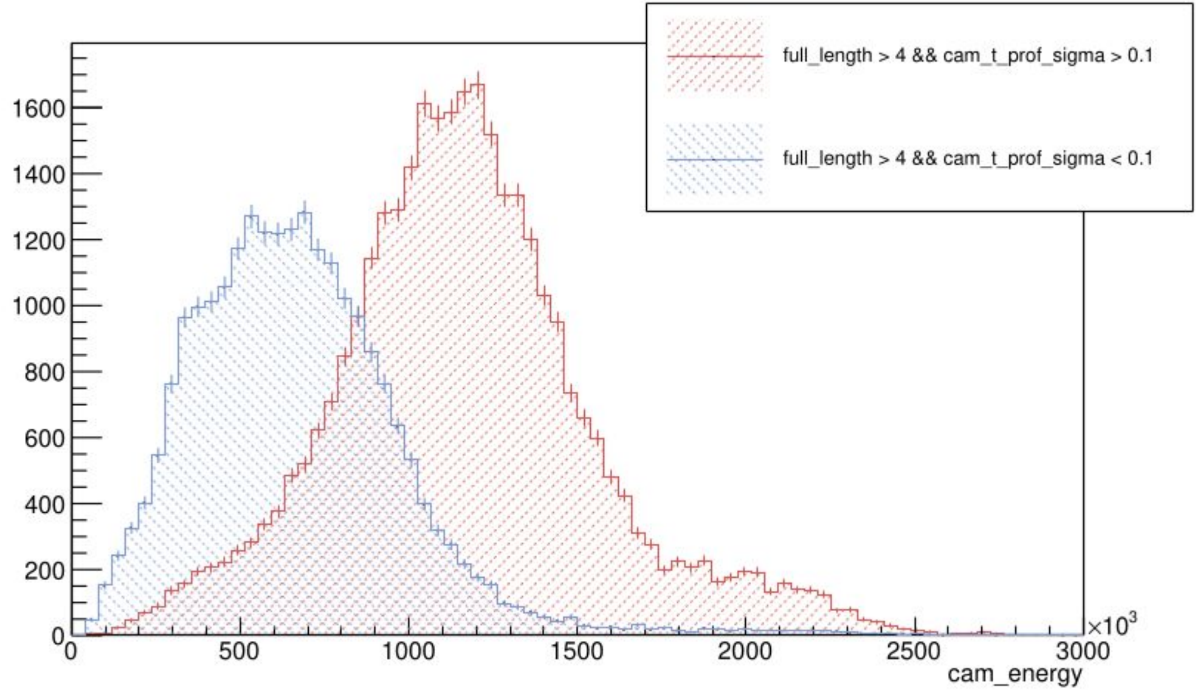
Other comments:

- PMT simulation would be great to test and optimize the whole 3D analysis framework and to start optimizing it for lower energy ERs and NRs! *(...not for me...)*

Backup

PMT Reco & Analysis

Energy vs. "absolute Z"



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