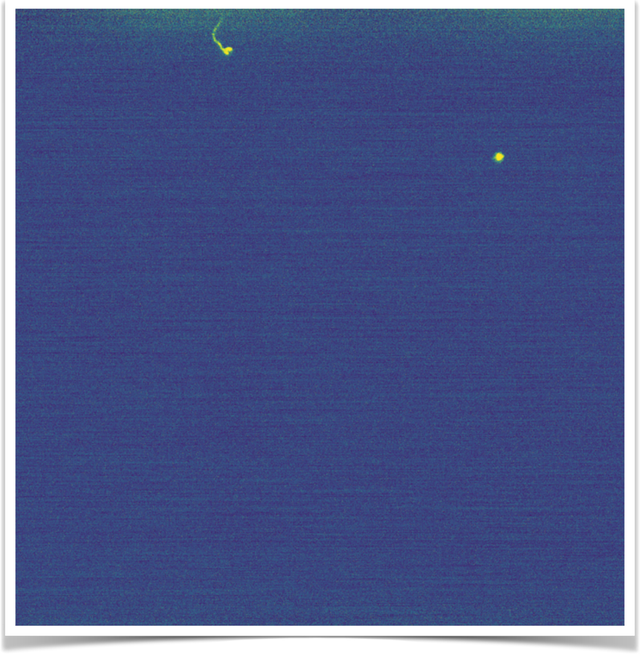
Istituto Nazionale di Fisica Nucleare

GRAN SASSO SCIENCE INSTITUTE

^{222}Rn progeny NR events from the cathode: towards z fiducialization in NR events

G. Dho, S. Piacentini



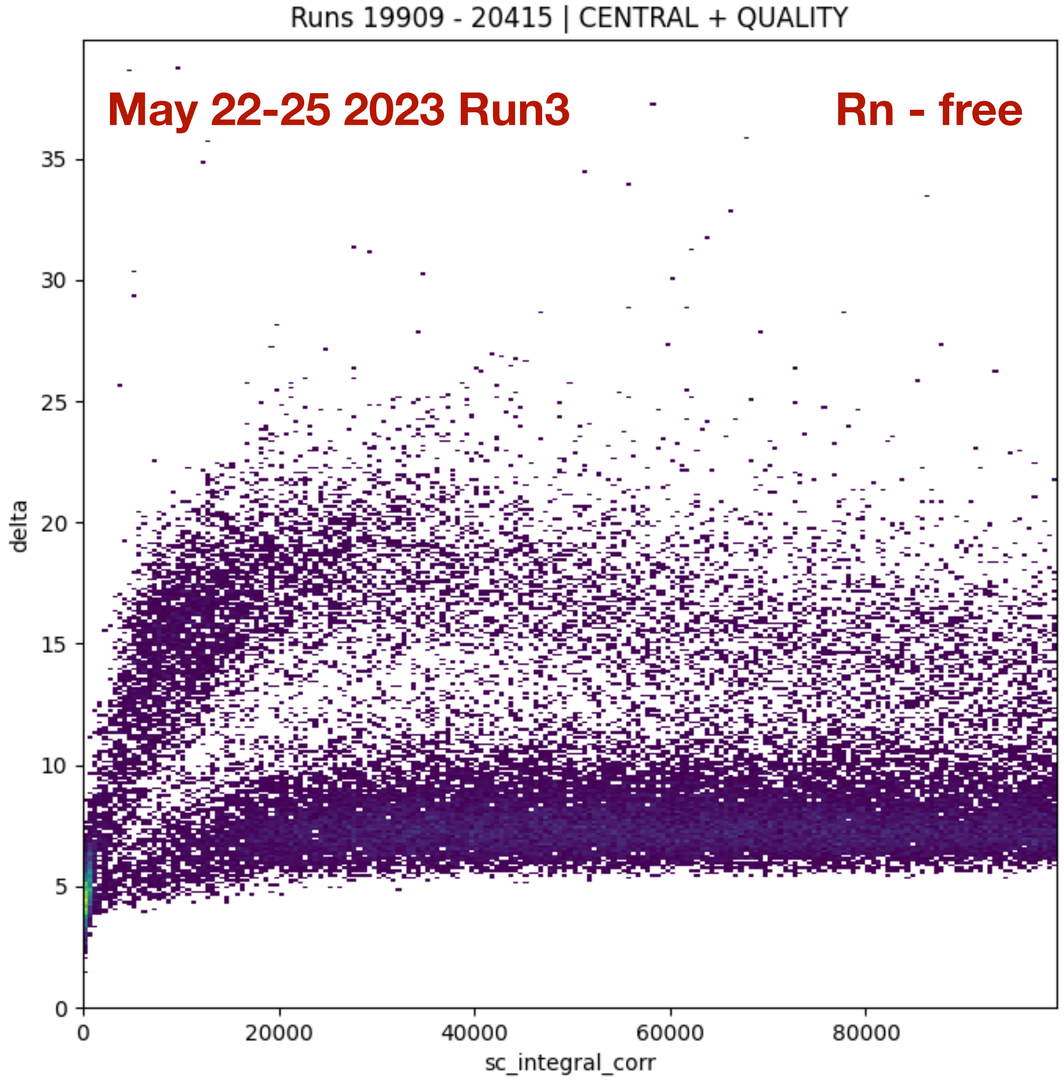
Analysis Meeting

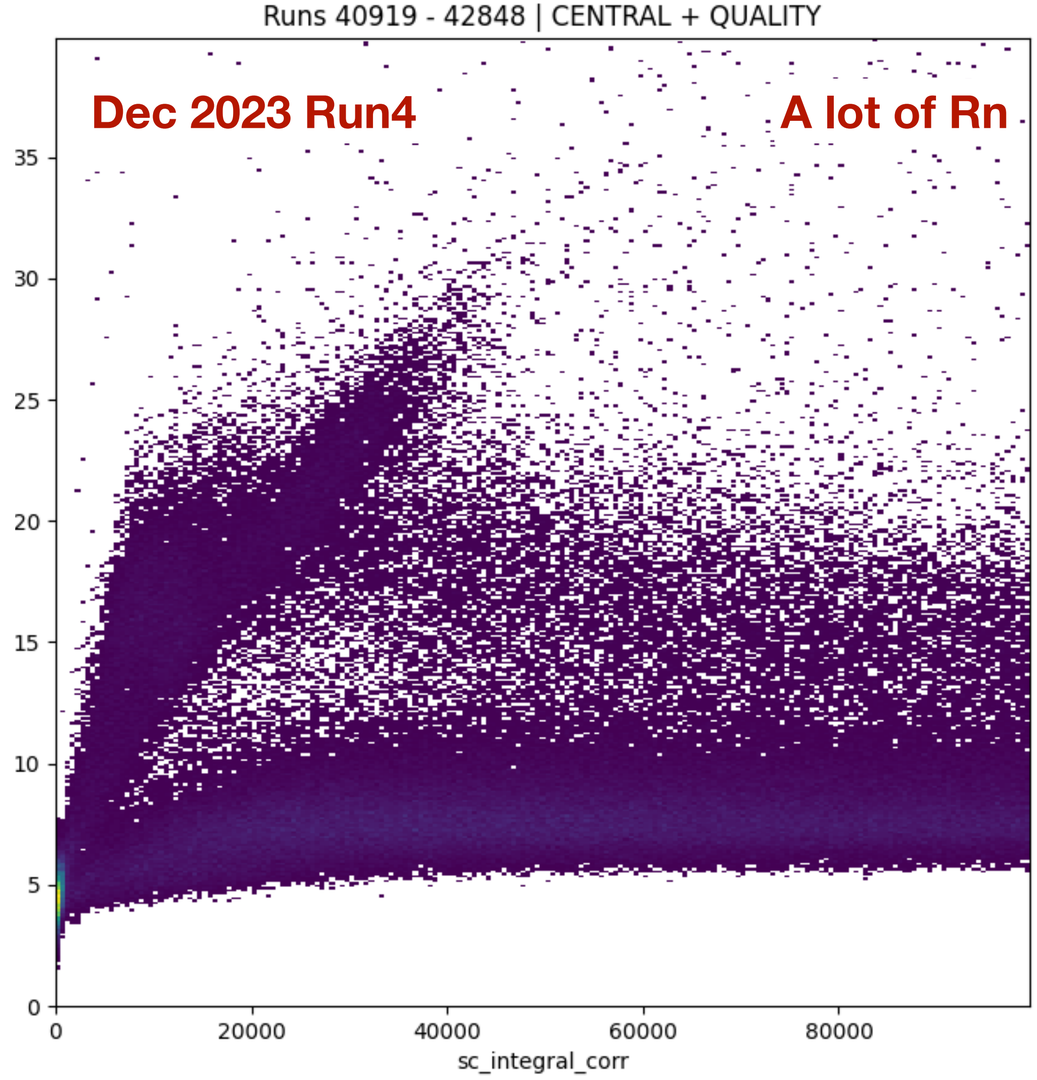
10 / 04 / 2025

To Rn or not to Rn

Data samples produced by Daniel

```
df_central = df[
 ((df["sc_xmean"]>375) & (df["sc_xmean"]<1970))
&((df["sc_ymean"]>225) & (df["sc_ymean"]<2110))
&(df["sc_rms"] > 6)
&(df["sc_tgausssigma"]*0.152>0.5)
].copy()
```





To Rn or not to Rn

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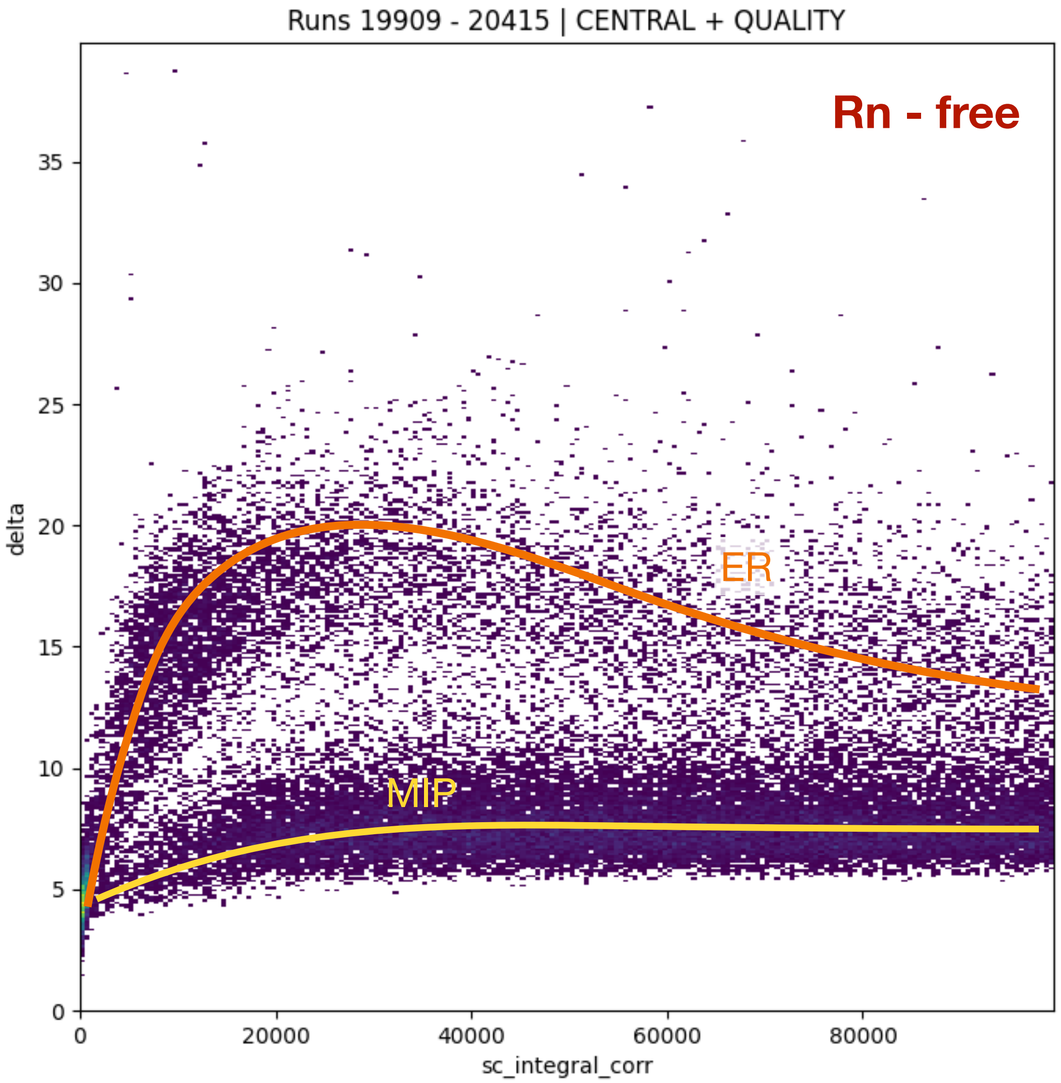

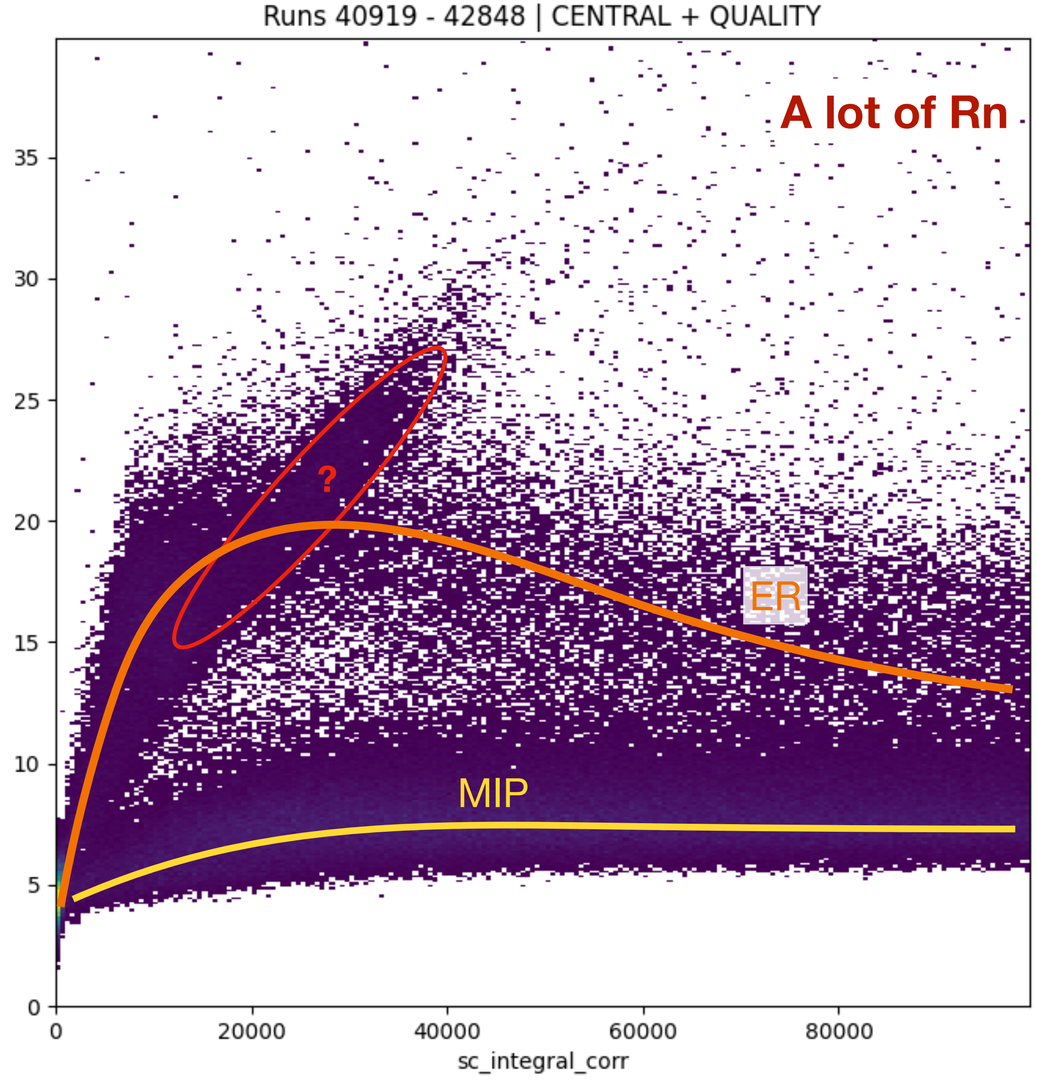

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&((df["sc_ymean"]>225) & (df["sc_ymean"]<2110))
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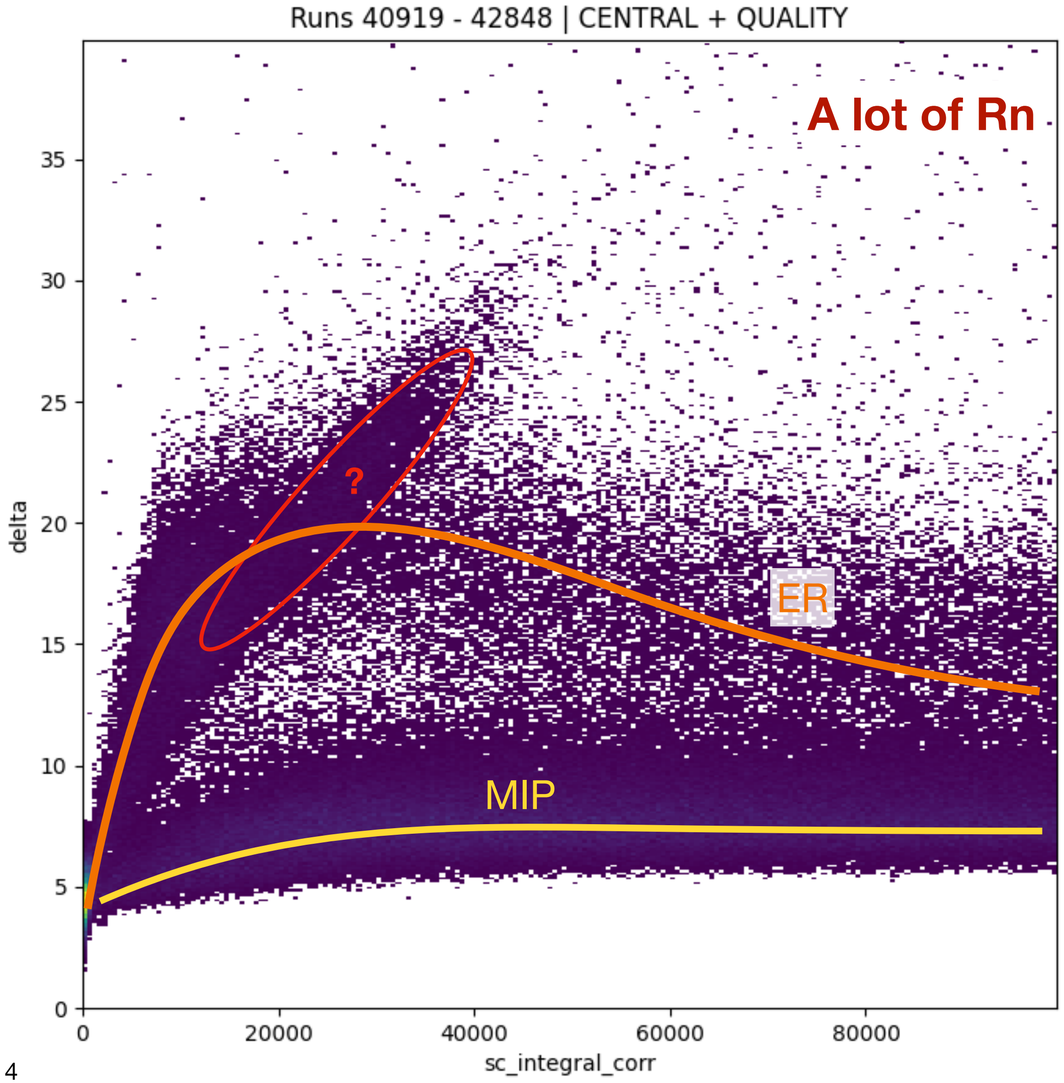
&(df["sc_tgausssigma"]*0.152>0.5)
].copy()
```

Some notes:

- They have a large energy distribution up to $\sim 22\,\mathrm{keV}_{\mathrm{Fe-e}}$
- They seem not to pertain to the ER band: why are they not falling on the MIP band with increasing energy?
- **<u>What kind of tracks are they?</u>**



First step: select them

```
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&((df["sc_ymean"]>225) & (df["sc_ymean"]<2110))
&(df["sc_rms"] > 6)
&(df["sc_tgausssigma"]*0.152>0.5)
&(df["sc_integral_corr"]>19_000)
&(df["sc_integral"]/df["sc_nhits"] > 0.0005 * df["sc_integral_corr"] + 5)
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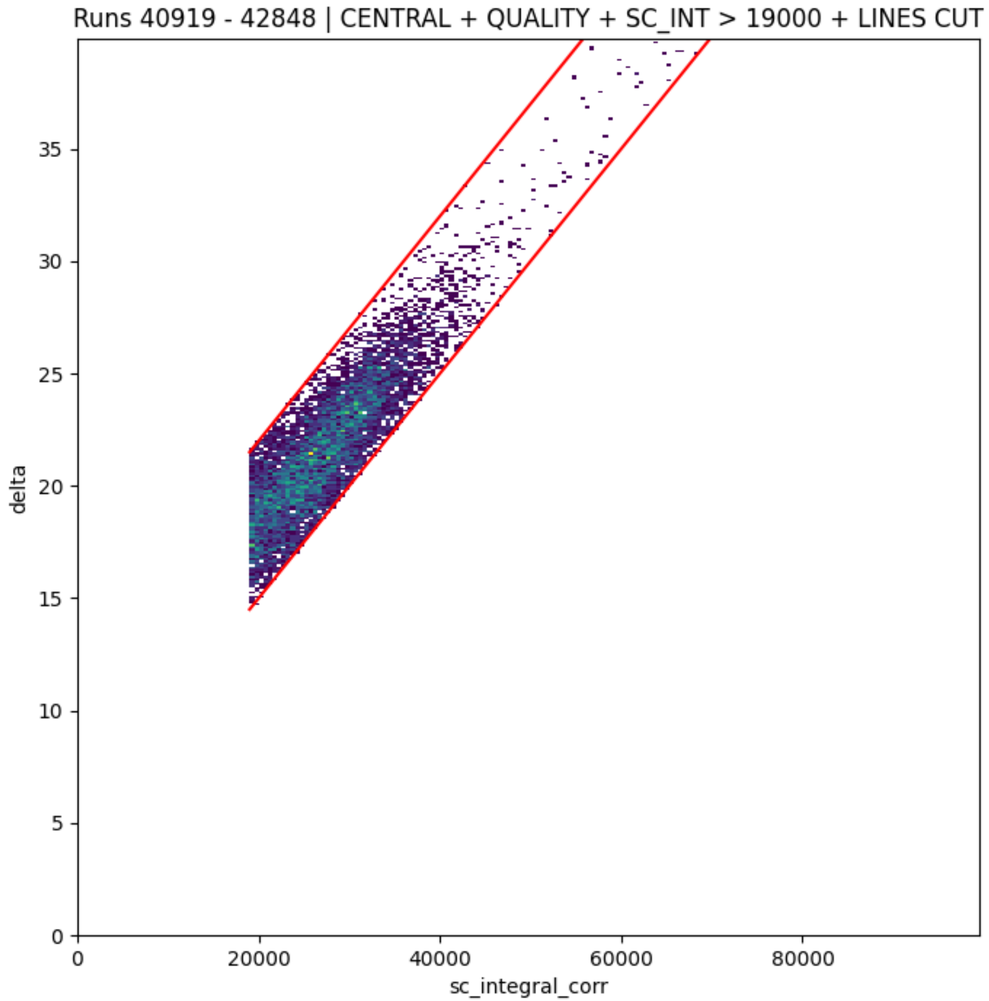
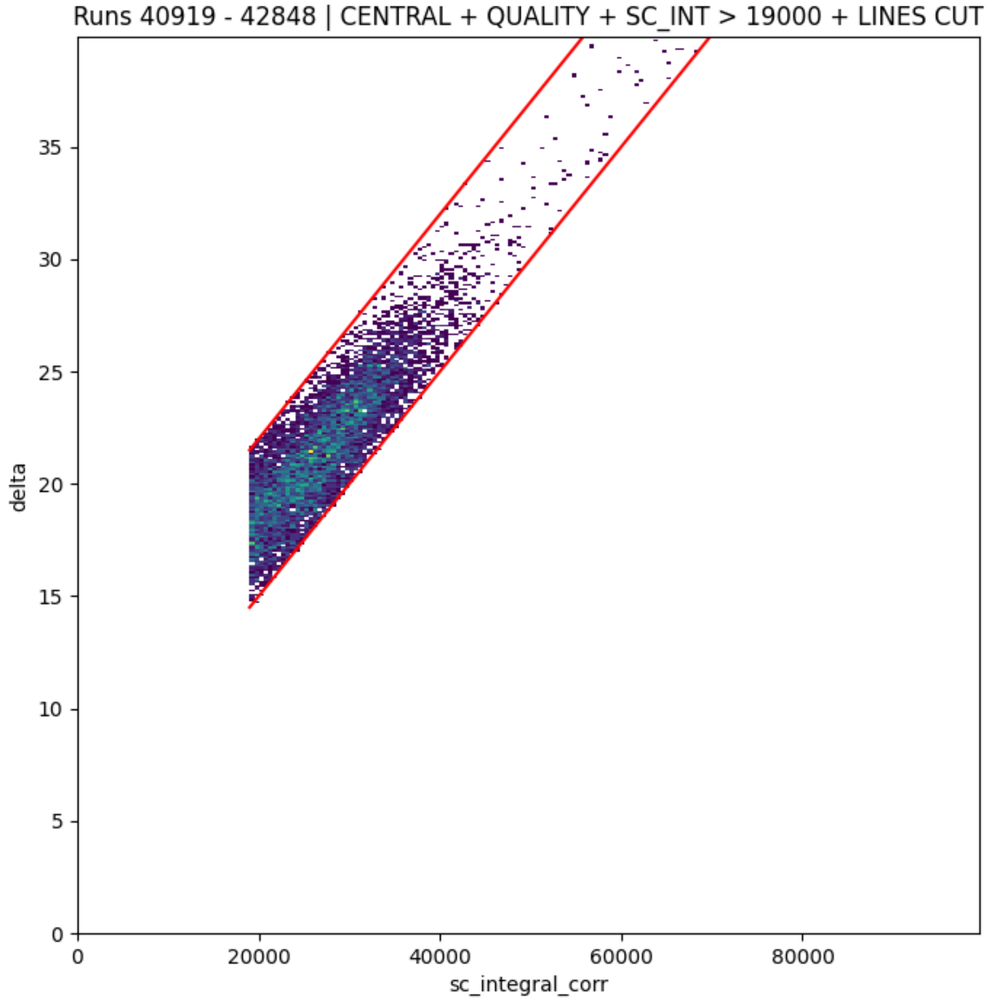
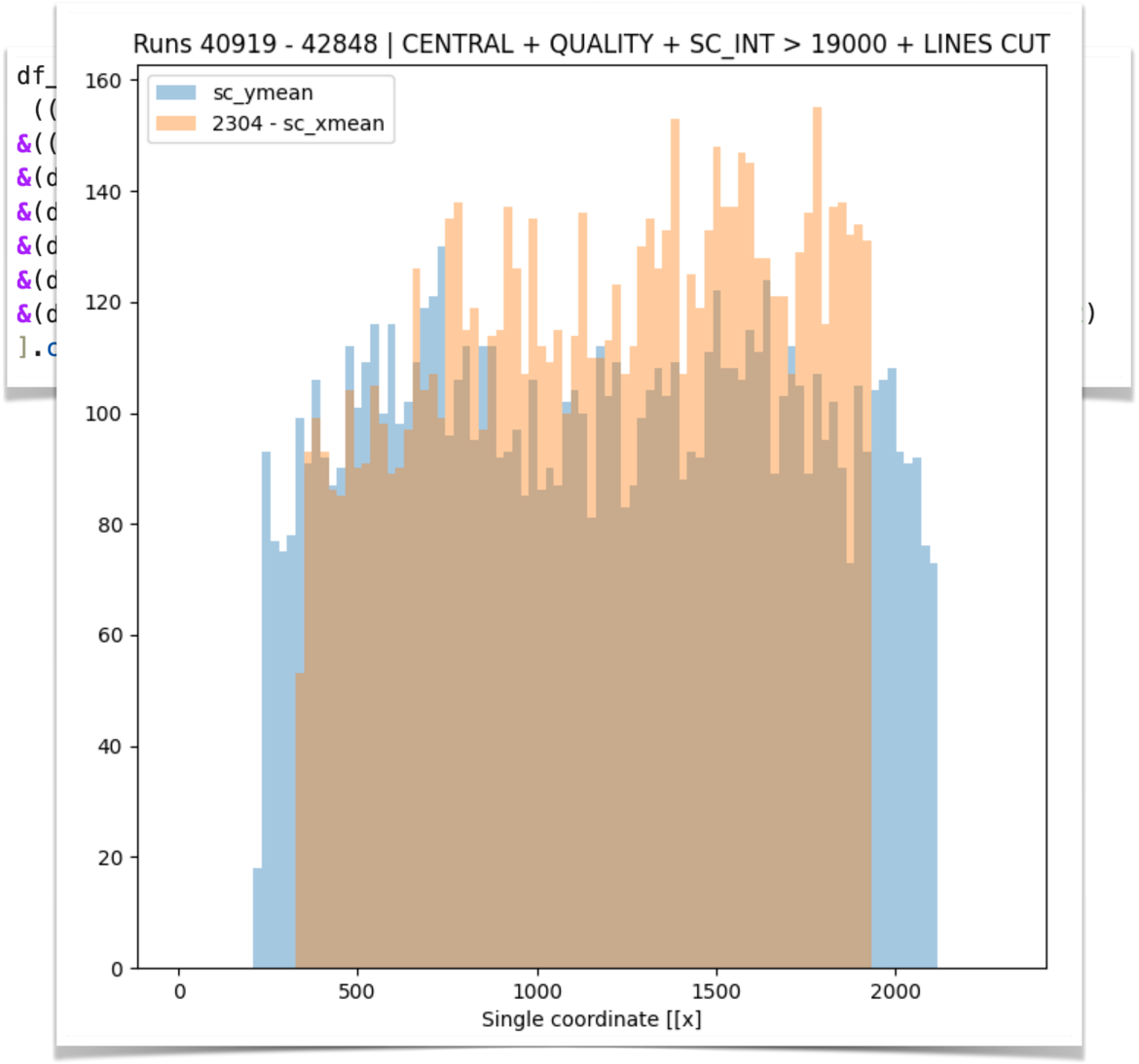
].copy()
```

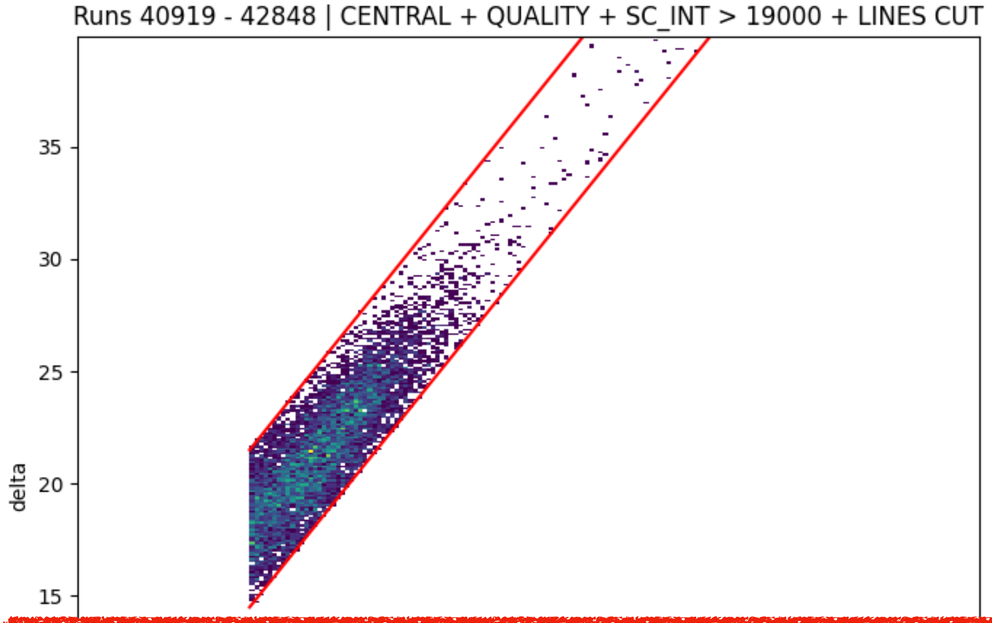


Second step: 2D spatial distribution



Second step: 2D spatial distribution (isotropic)



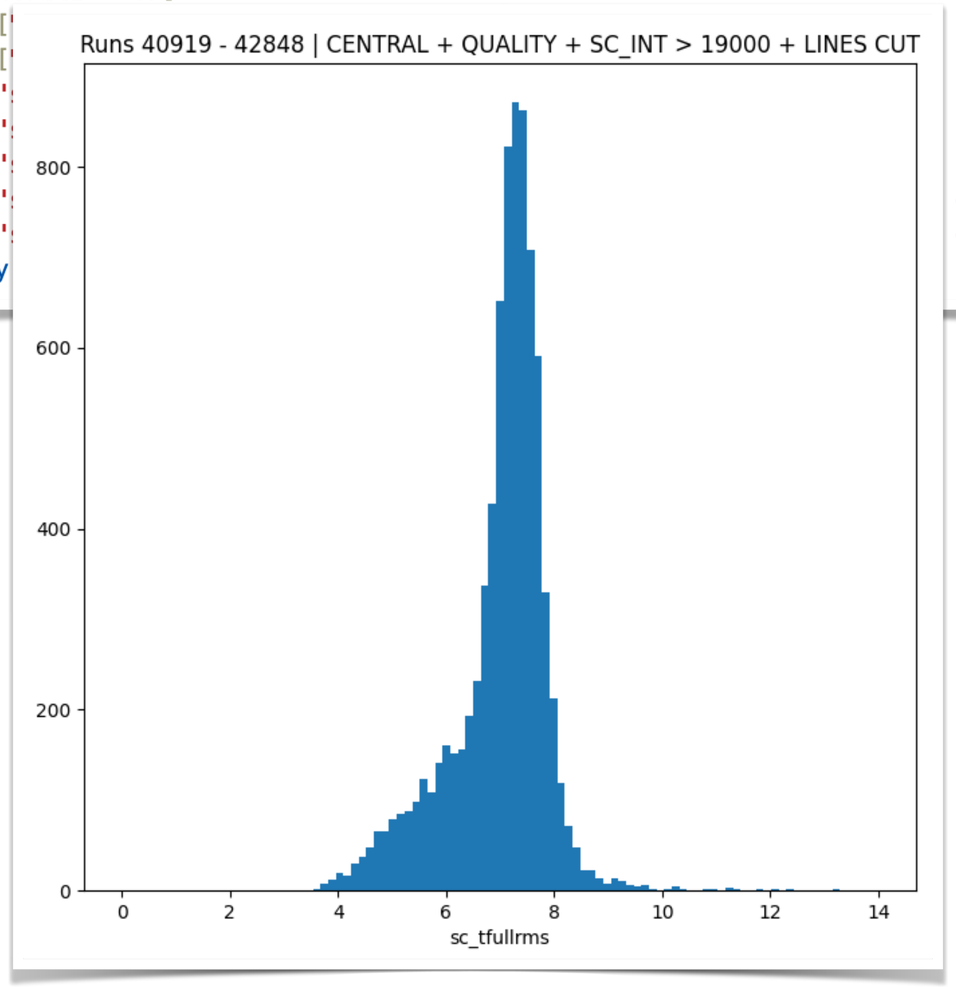


N.B. It <u>seems</u> not uniform in the vertical coordinate **BUT remember that the top part of LIME has a better LY and we are cutting on the LY → <u>top and bottom have different energy threshold for this cut!</u>**

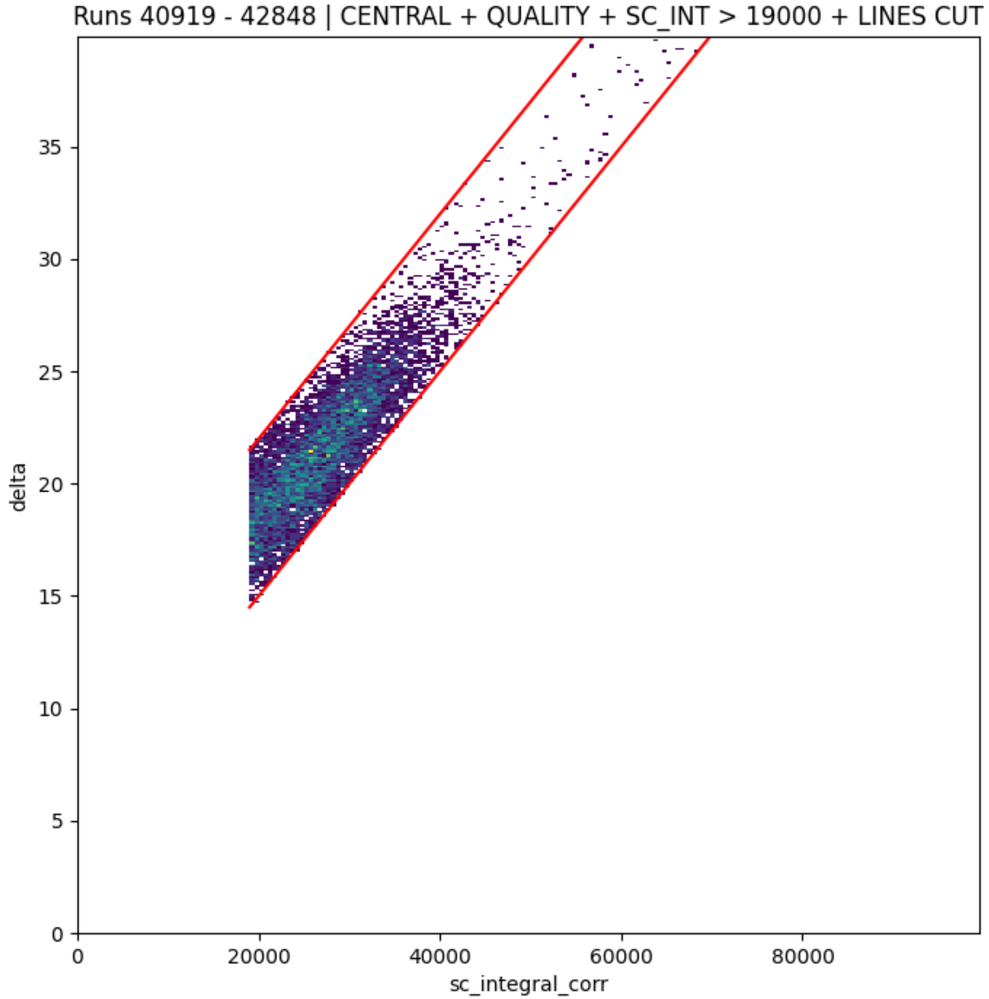
<u>If the original distribution was isotropic a cut on the LY would result in more events at the top and less at the bottom!</u>

Second step: z spatial distribution

```
df_central2 = df[
 ((df['
&((df['
&(df["
&(df["
&(df["
&(df["
&(df["
].copy
```



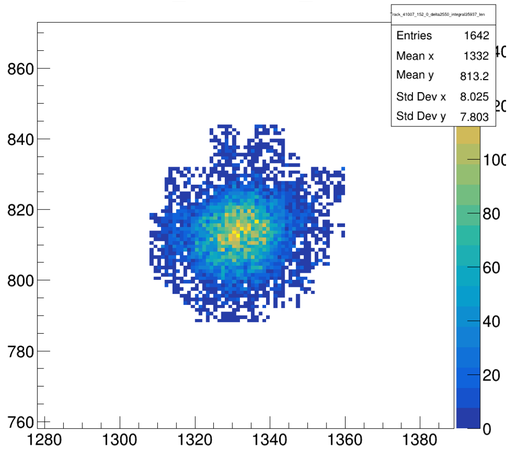

```
+ 5)
+ 12)
```



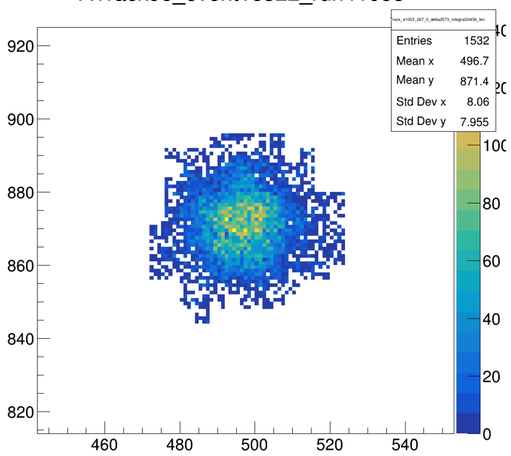
Peaked distribution in z ???

Third step: let's look at them

ATrack61_event10185_run41007



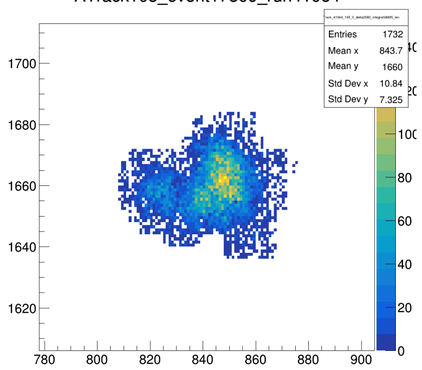
ATrack96_event16322_run41053



Almost all of them are **almost perfectly round** tracks (at $\sim$ 15-20 $\mathrm{keV_{Fe-e}}$)

Examples of ERs at the same energy scale

ATrack105_event17809_run41064



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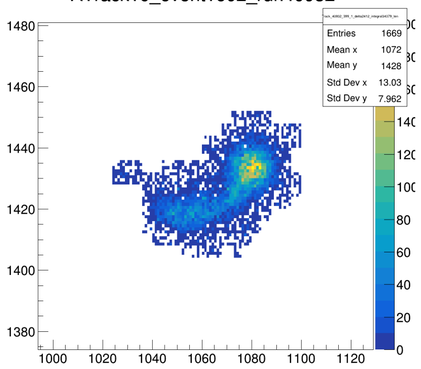
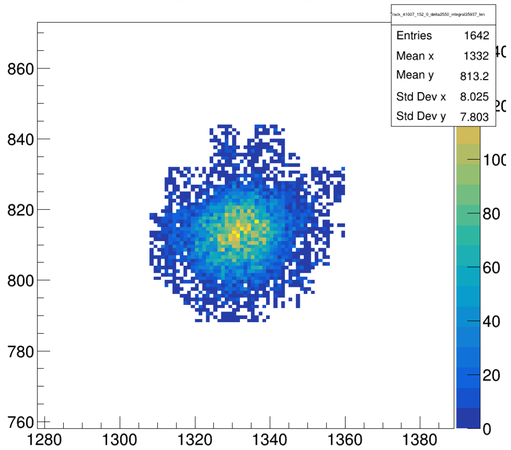


Third step: let's look at them

And they are short in time!

ATrack61_event10185_run41007



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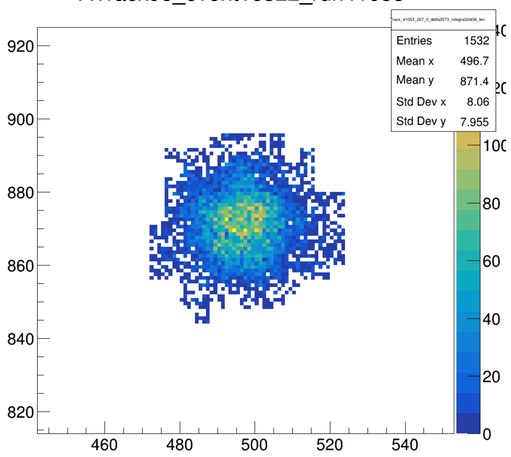

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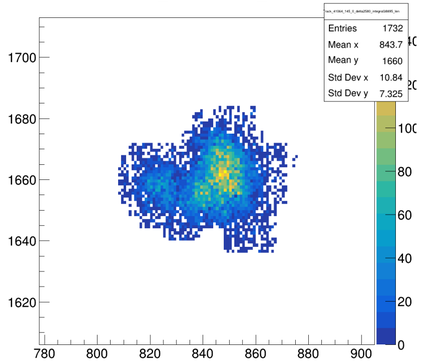
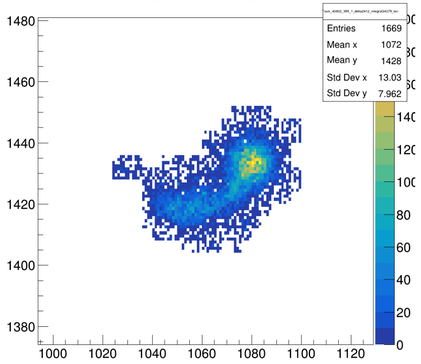
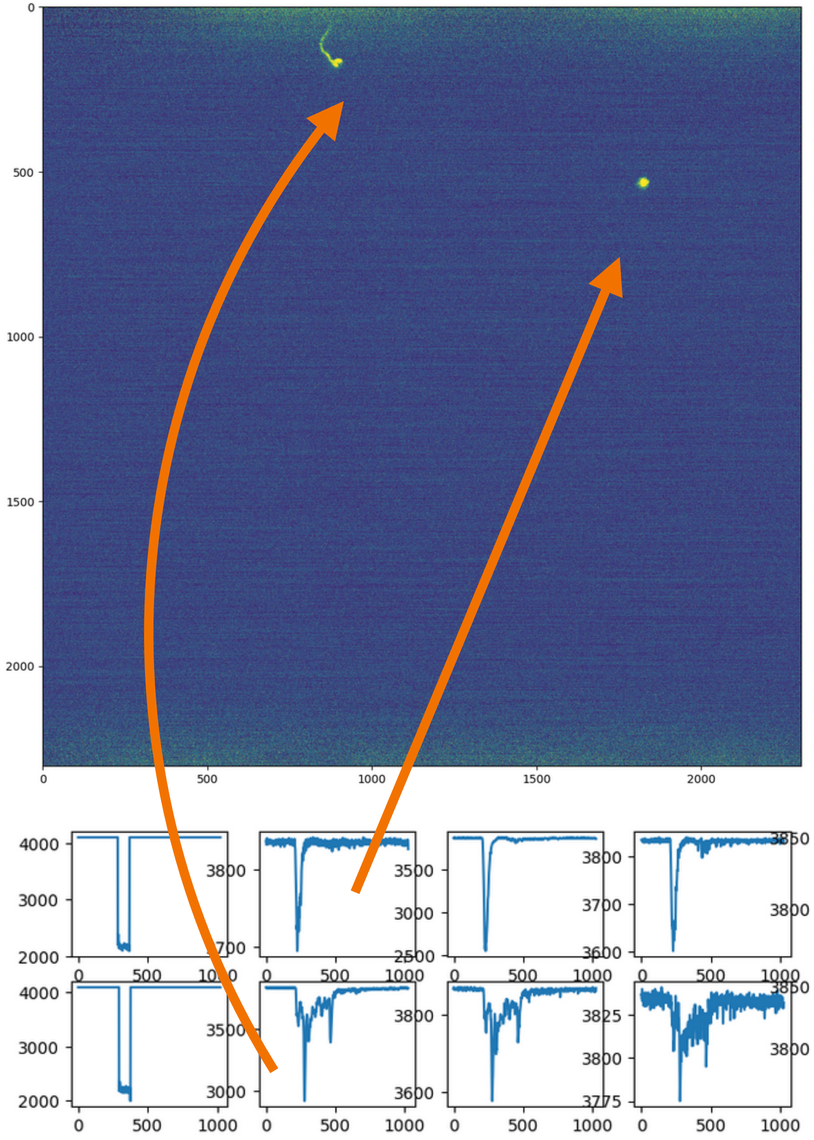
Examples of ERs at the same energy scale

ATrack105_event17809_run41064

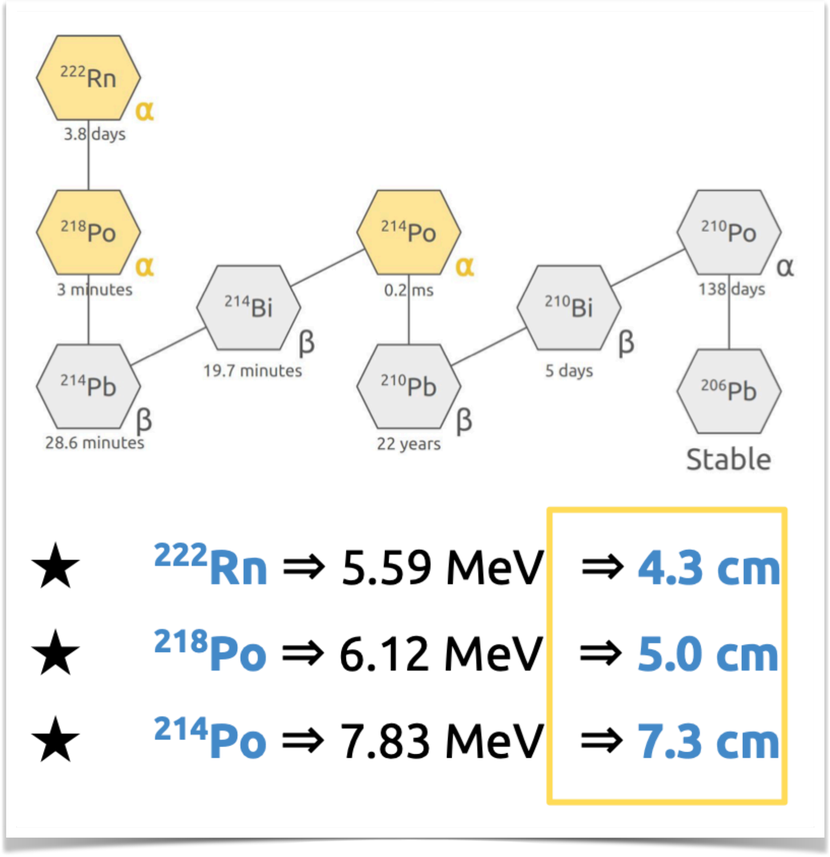


ATrack10_event1602_run40932





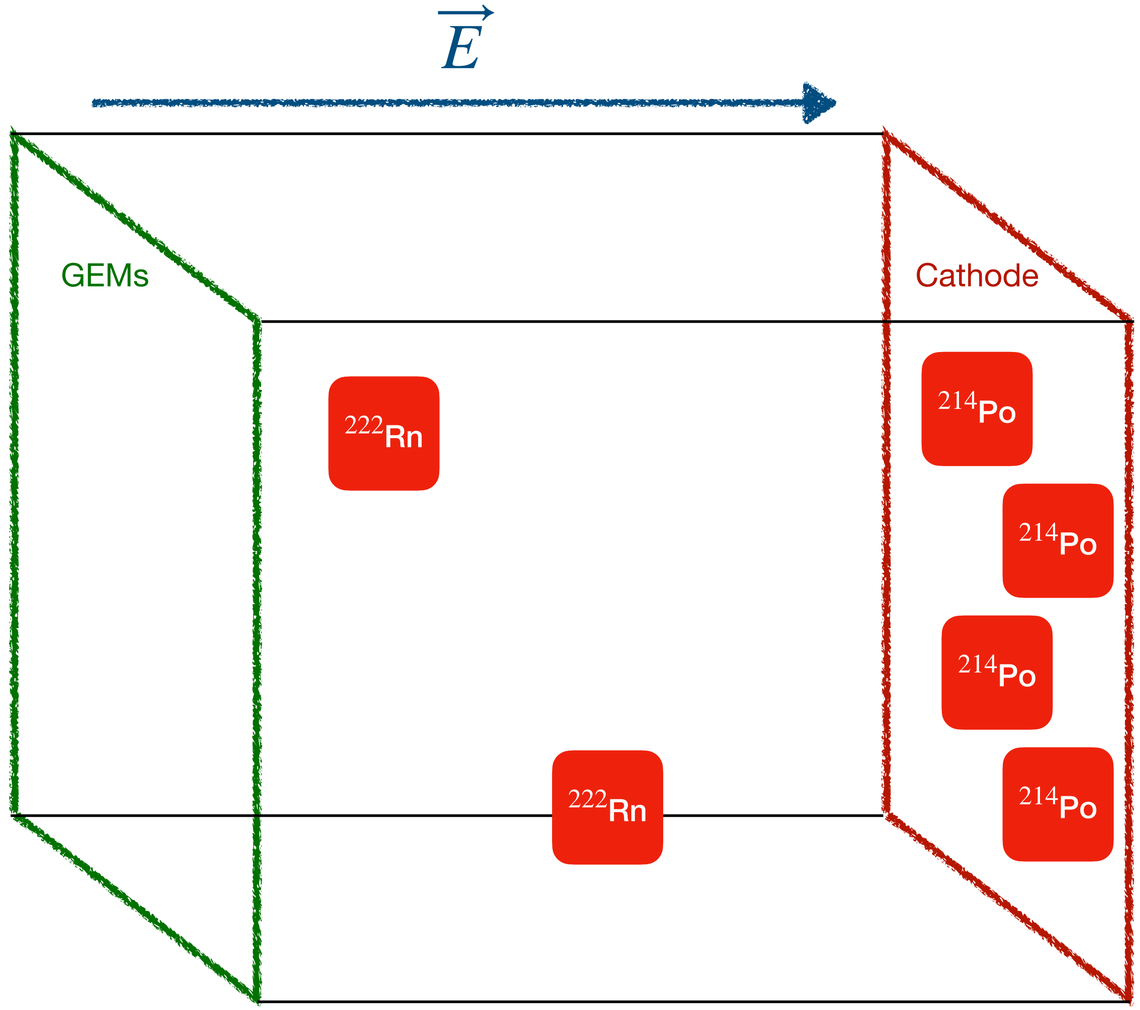
Interpretation: ^{222}Rn alpha decays



★ ^{222}Rn ⇒ 5.59 MeV ⇒ 4.3 cm

★ ^{218}Po ⇒ 6.12 MeV ⇒ 5.0 cm

★ ^{214}Po ⇒ 7.83 MeV ⇒ 7.3 cm



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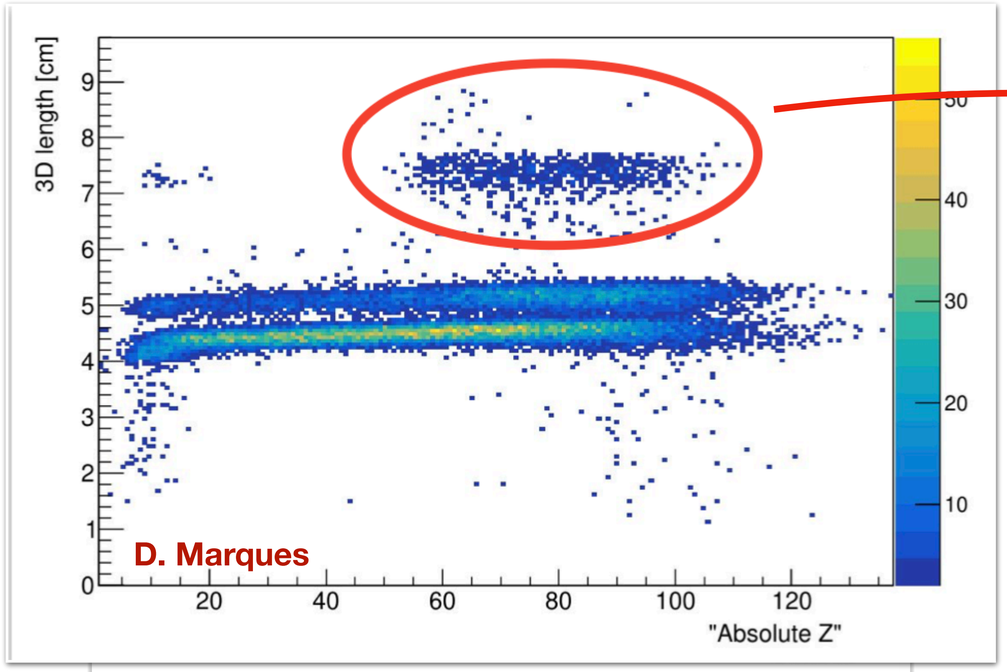

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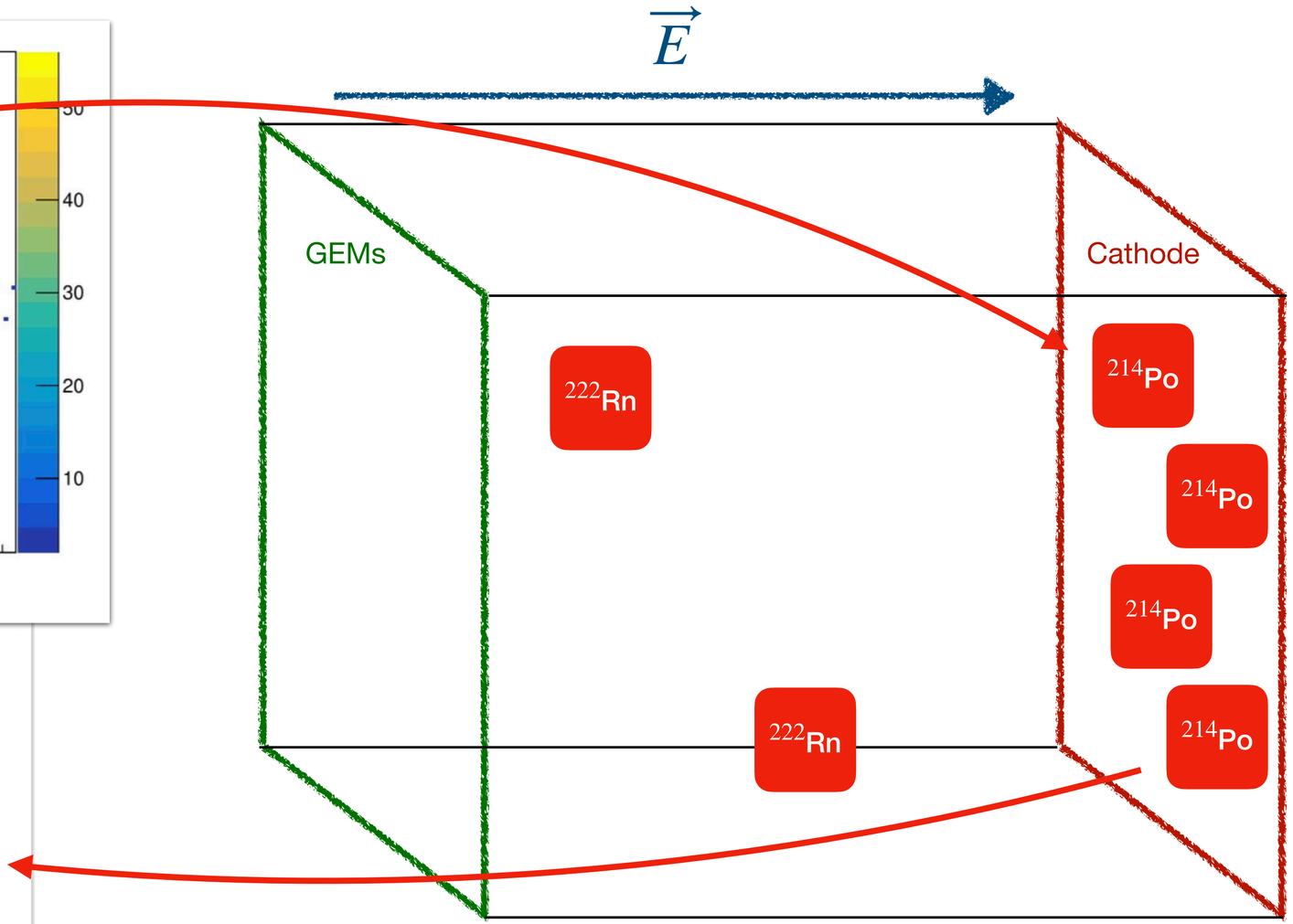

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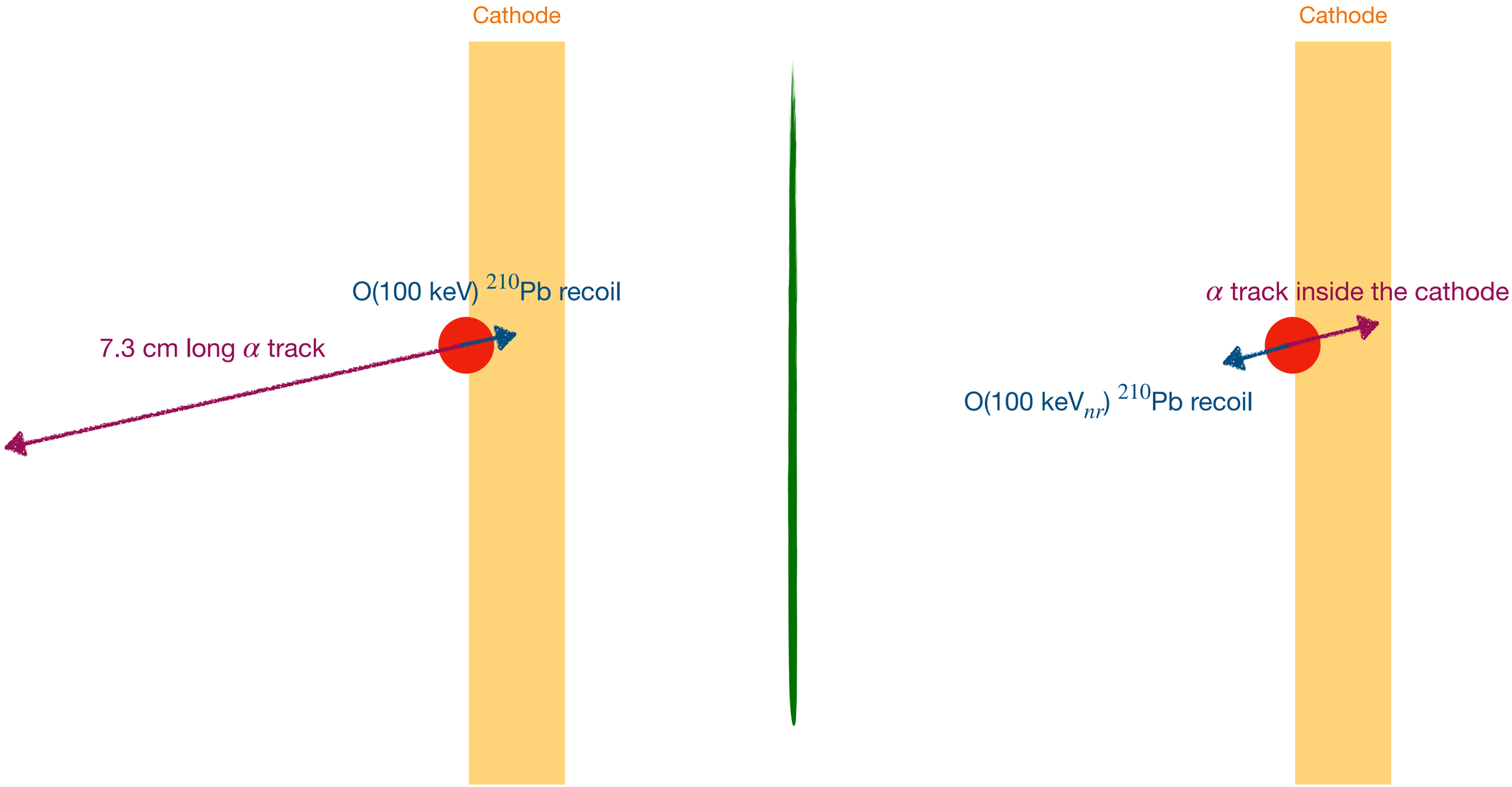

Interpretation: MIMAC (and DRIFT) already found this

DRIFT paper: https://doi.org/10.1016/j.nima.2007.10.013

First detection of radon progeny recoil tracks by MIMAC

Q. Riffard, D. Santos, O. Guillaudin, G. Bosson, O. Bourrion, J. Bouvier, T. Descombes, C. Fourel, J.-F. Muraz, L. Lebreton Show full author list

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Journal of Instrumentation, Volume 12, June 2017

Citation Q. Riffard *et al* 2017 *JINST* **12** P06021

DOI 10.1088/1748-0221/12/06/P06021

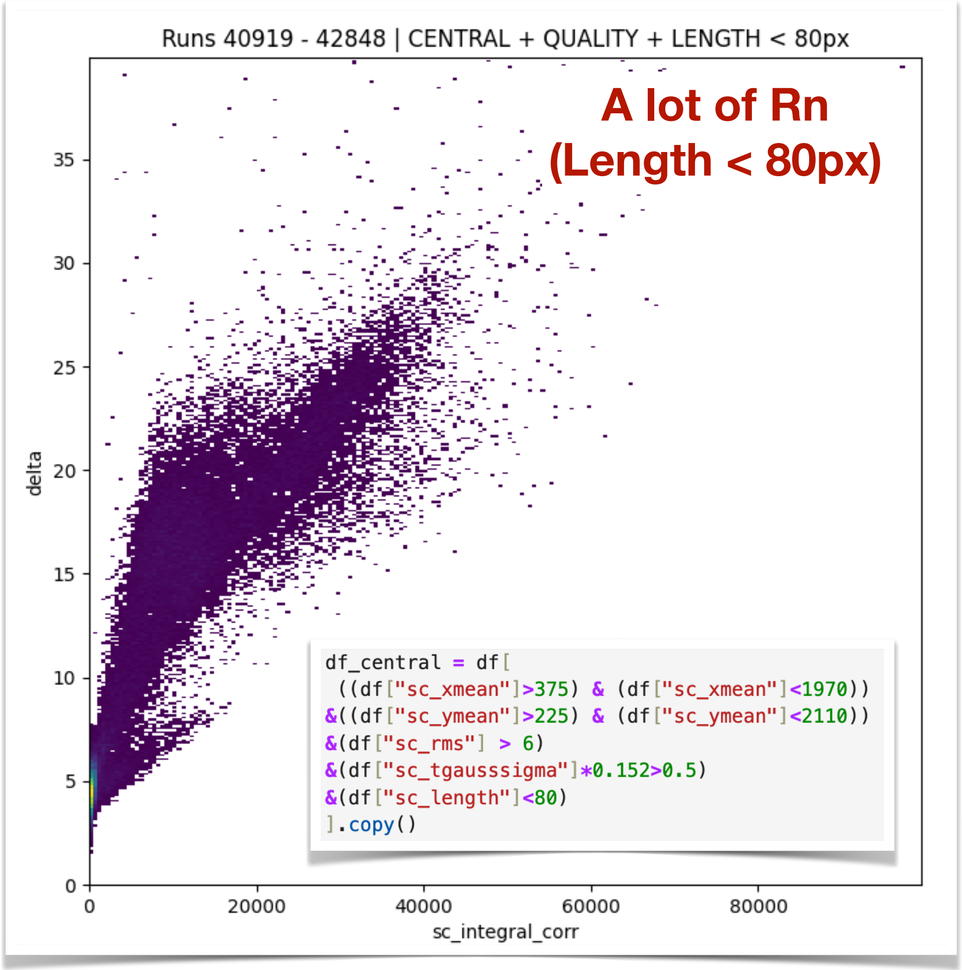
MIMAC paper: 10.1088/1748-0221/12/06/P06021

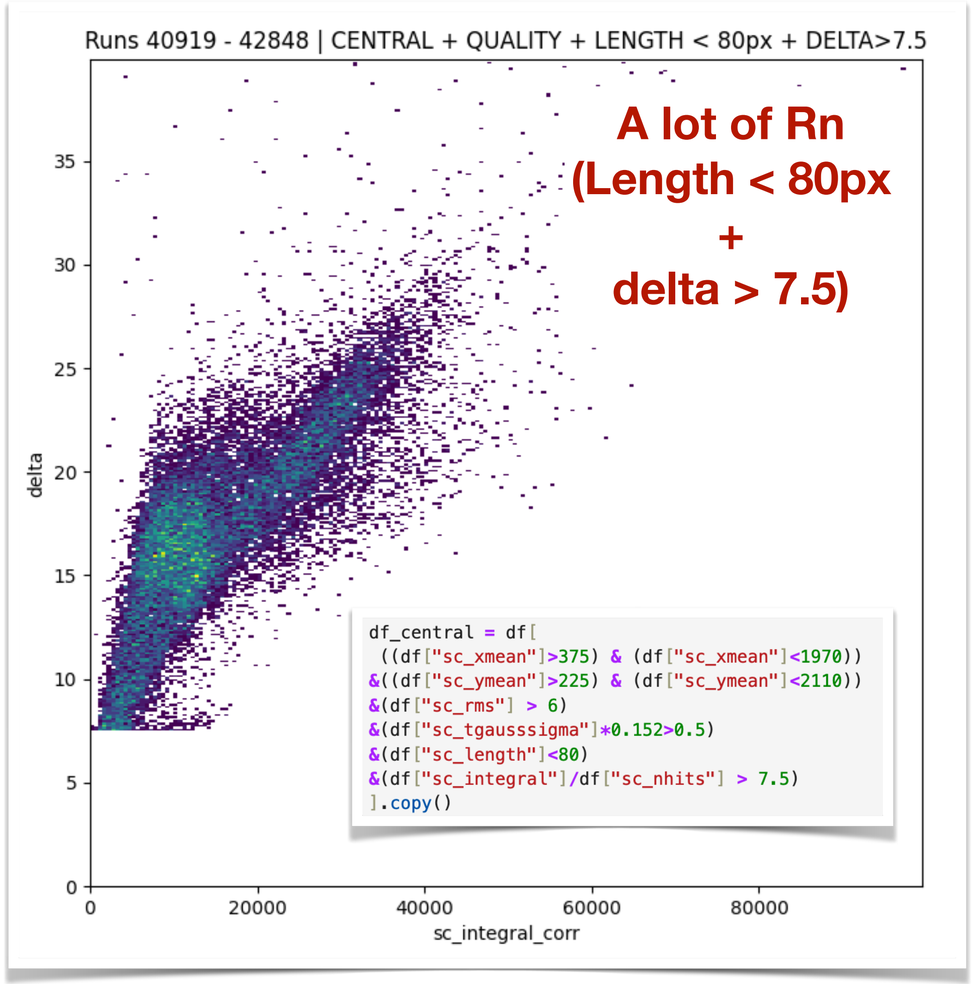
Parent	$T_{1/2}$	Mode	$E^{\text{kin}}_{\alpha/\beta\,\text{max}}$ [MeV]	Daughter	$E^{\text{kin}}_{\text{recoil}}$ [keV]	$E^{\text{ioni}}_{\text{recoil}}$ [keVee]
From ^{222}Rn						
^{222}Rn	3.8 days	α	5.489	^{218}Po	100.8	38.23
^{218}Po	3.1 min	α	6.002	^{214}Pb	112.3	43.90
^{214}Pb	27 min	β^-	1.024	^{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

If we consider an O(10-20%) QF for Pb nuclear recoils in He:CF_4 at atmospheric pressure

We should observe ~ 15 - 20 keV$_{\text{Fe-e}}$ nuclear recoils at high Z!

Different selection: length<80px & delta > 7.5





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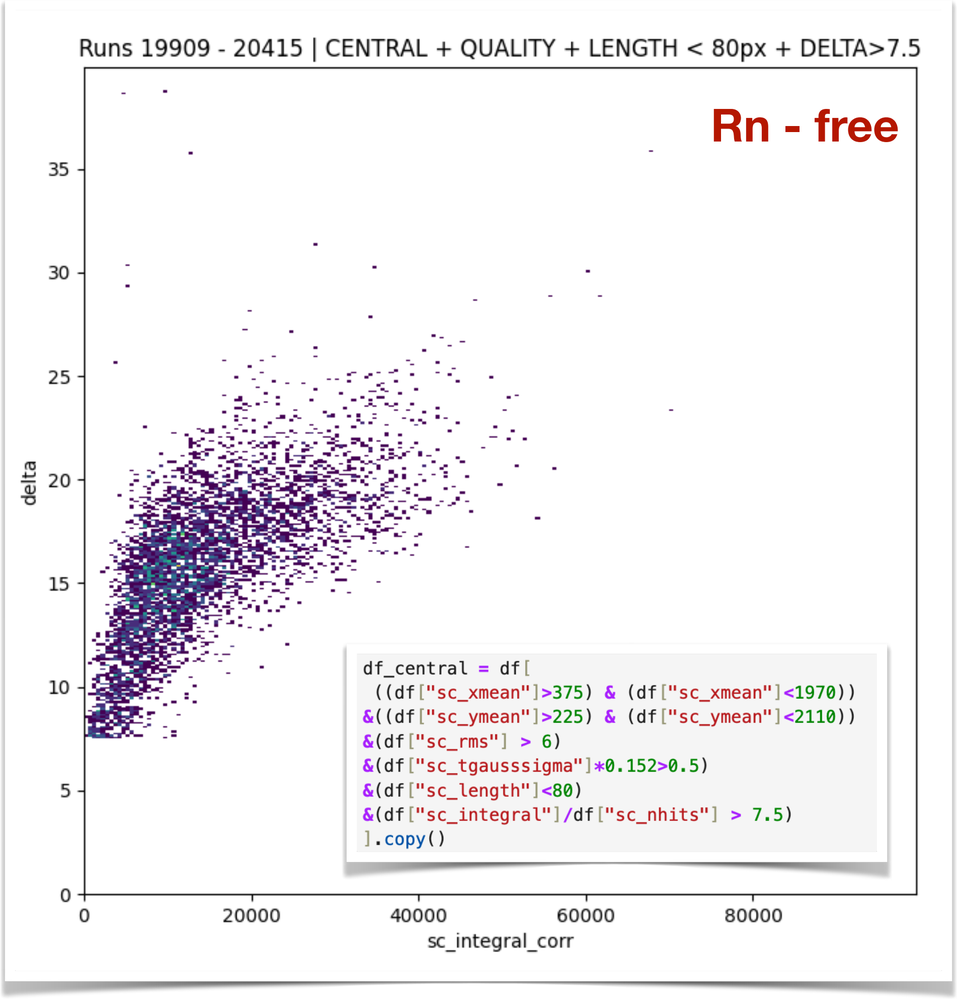

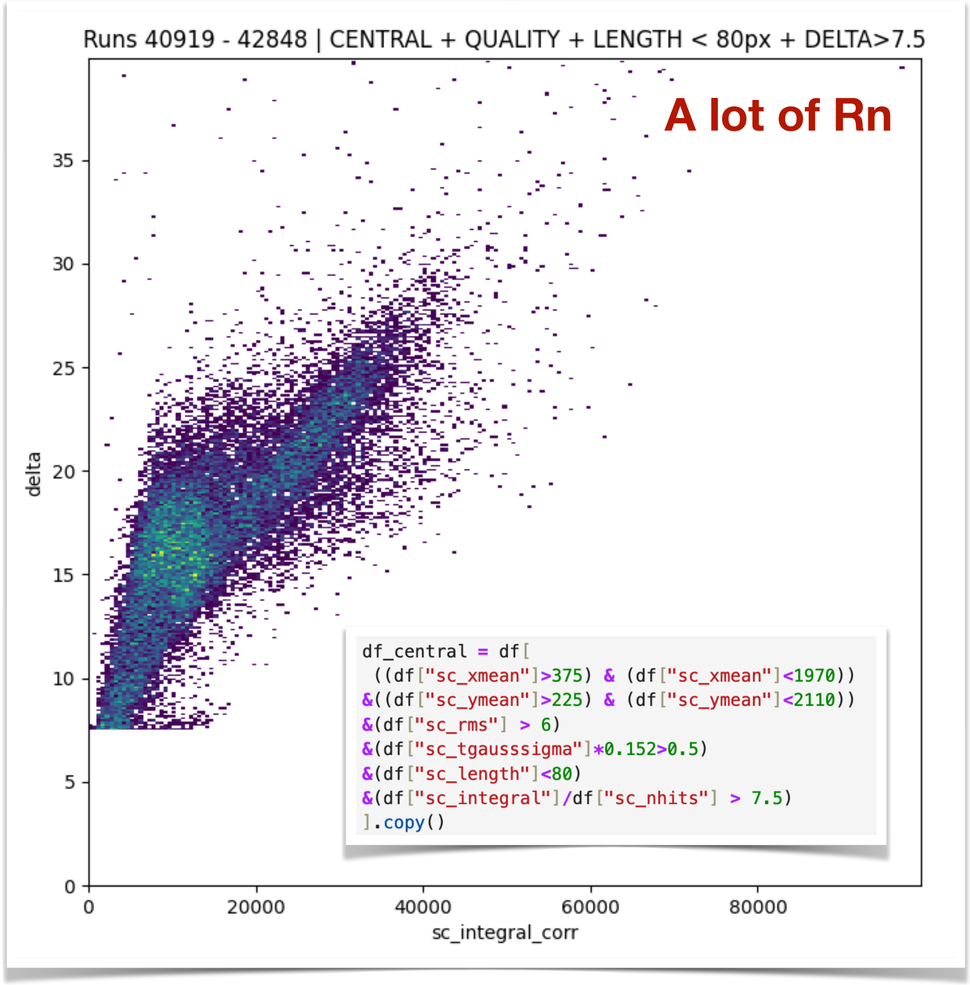

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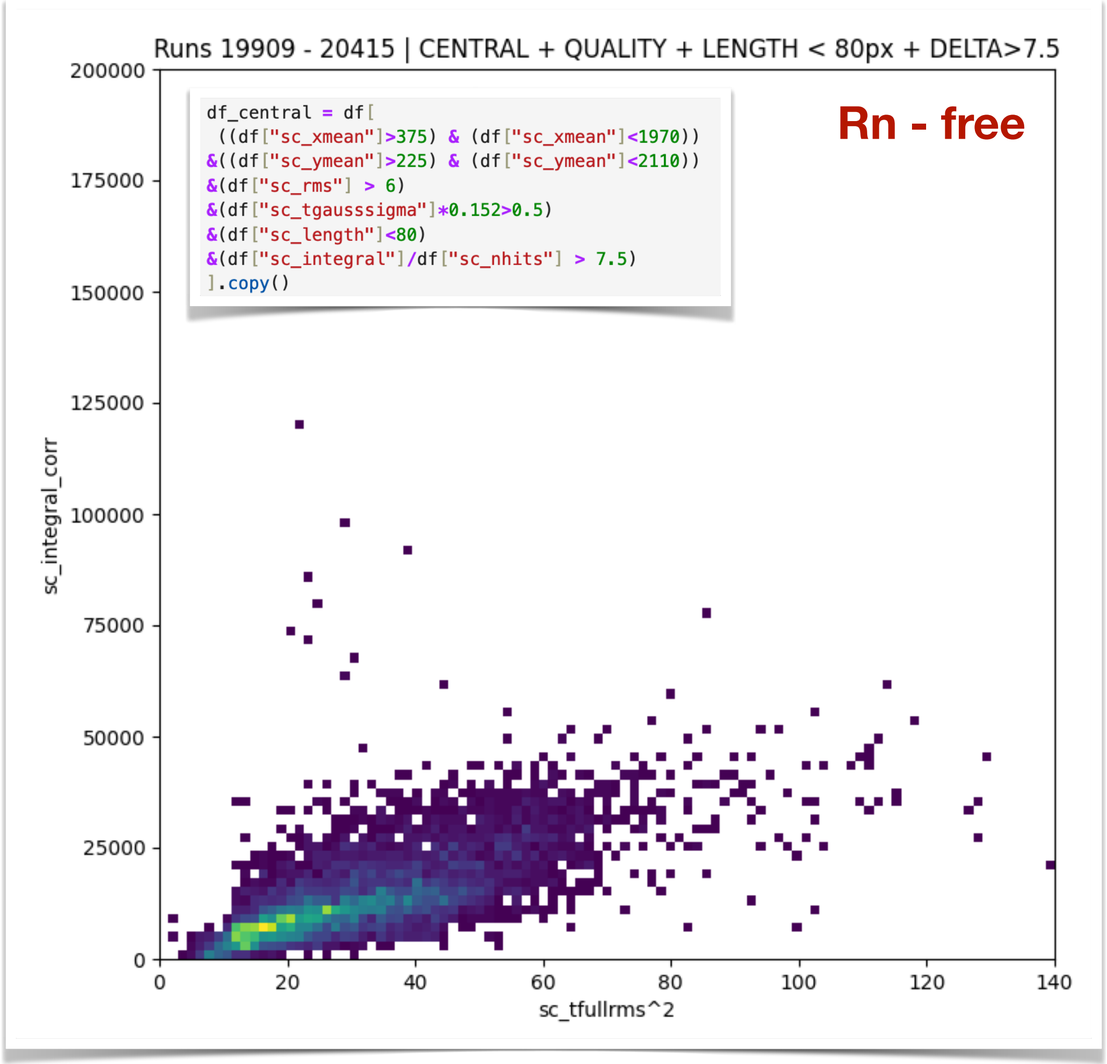

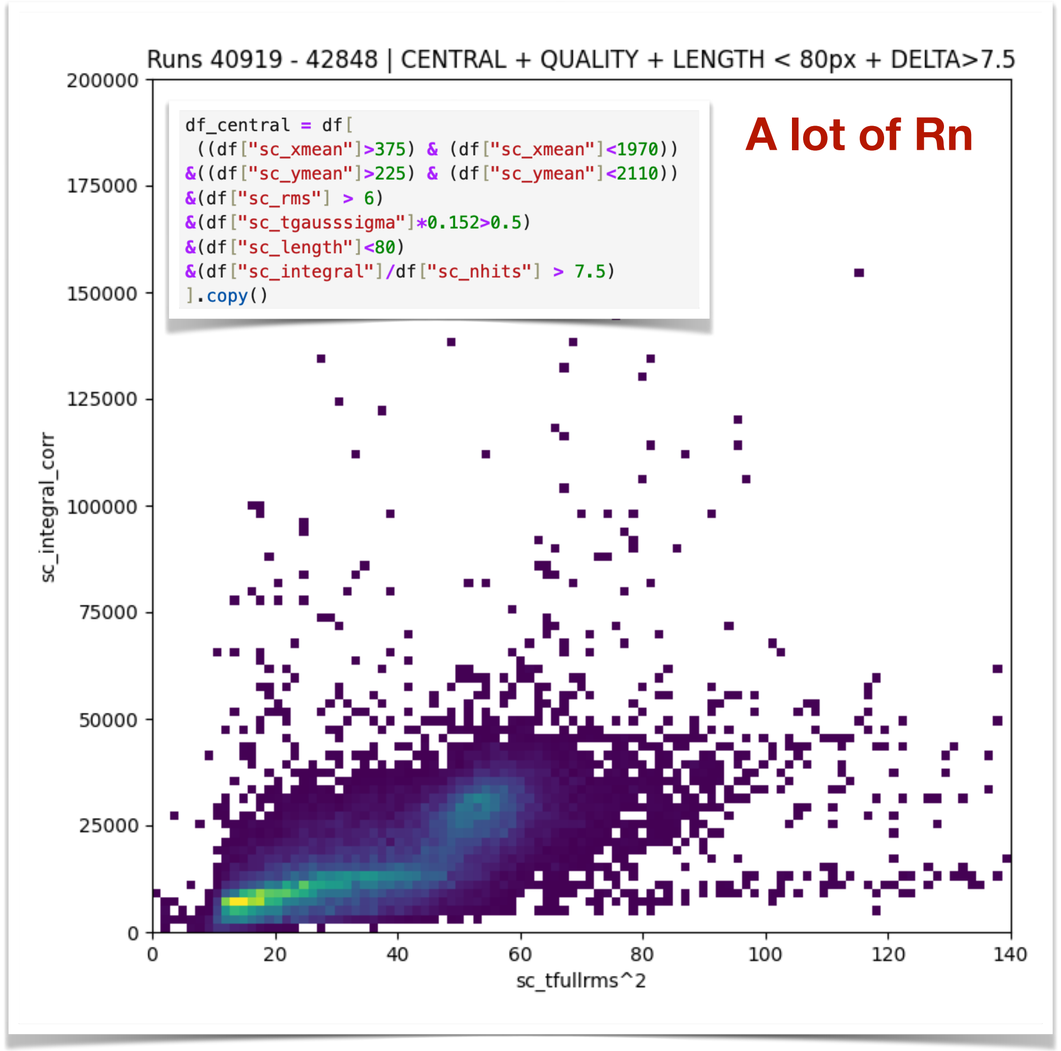

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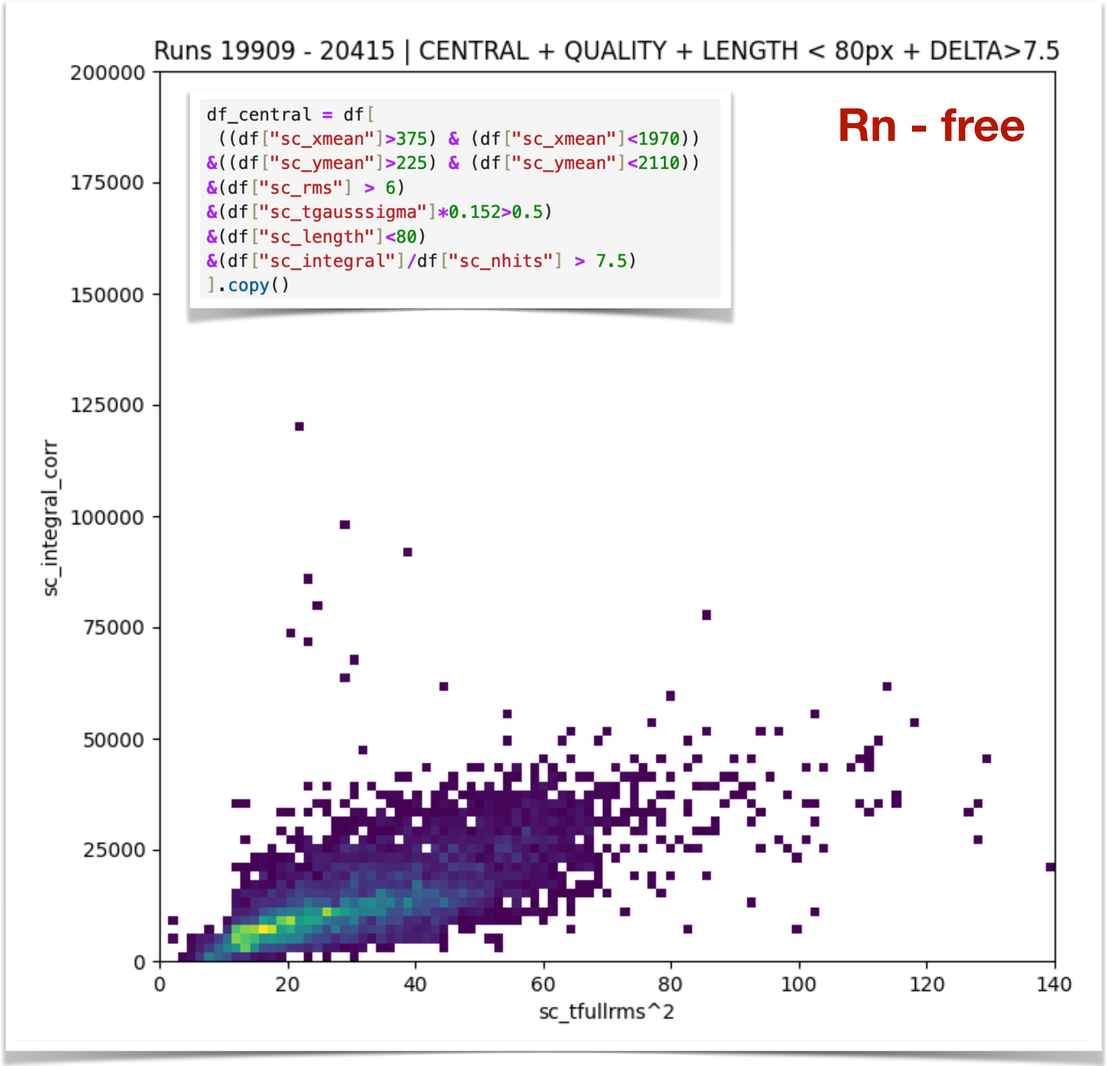

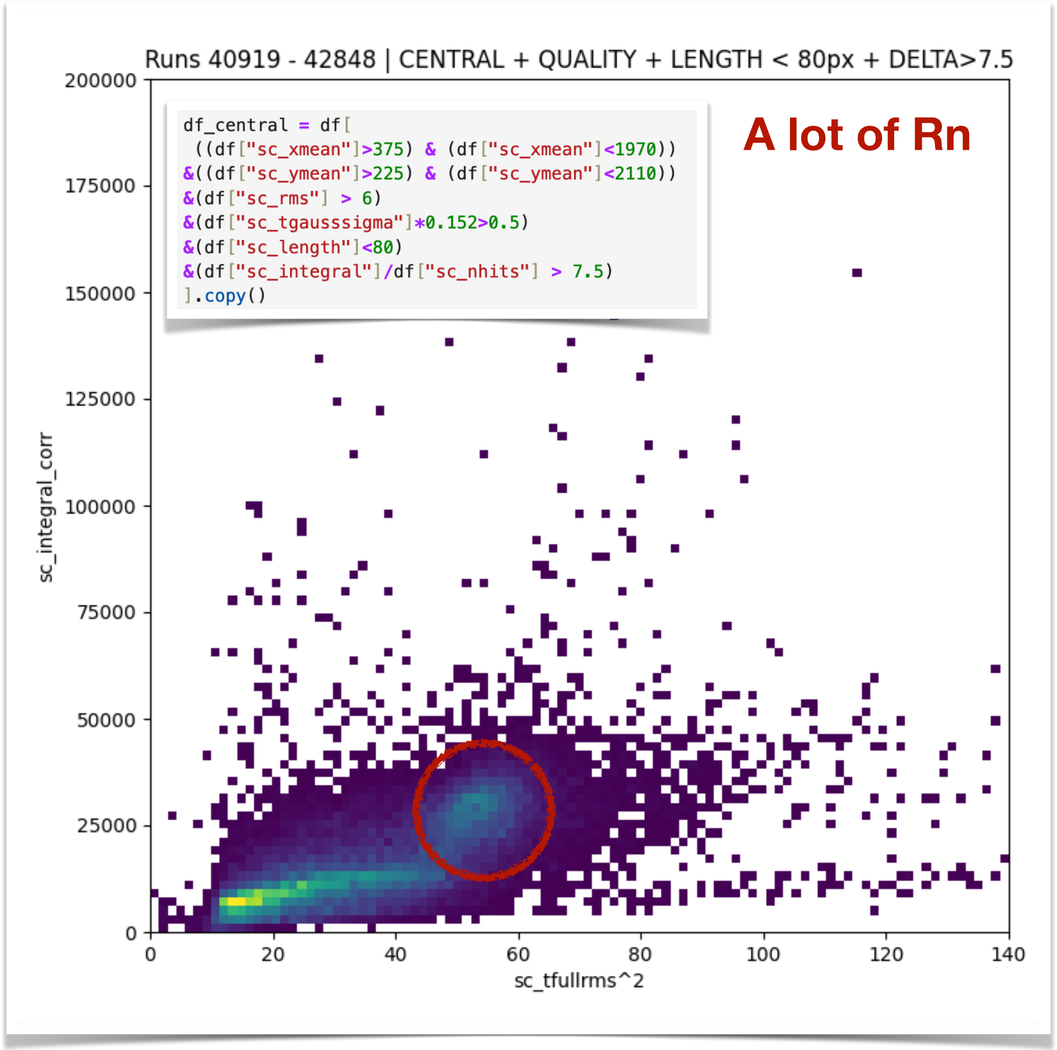

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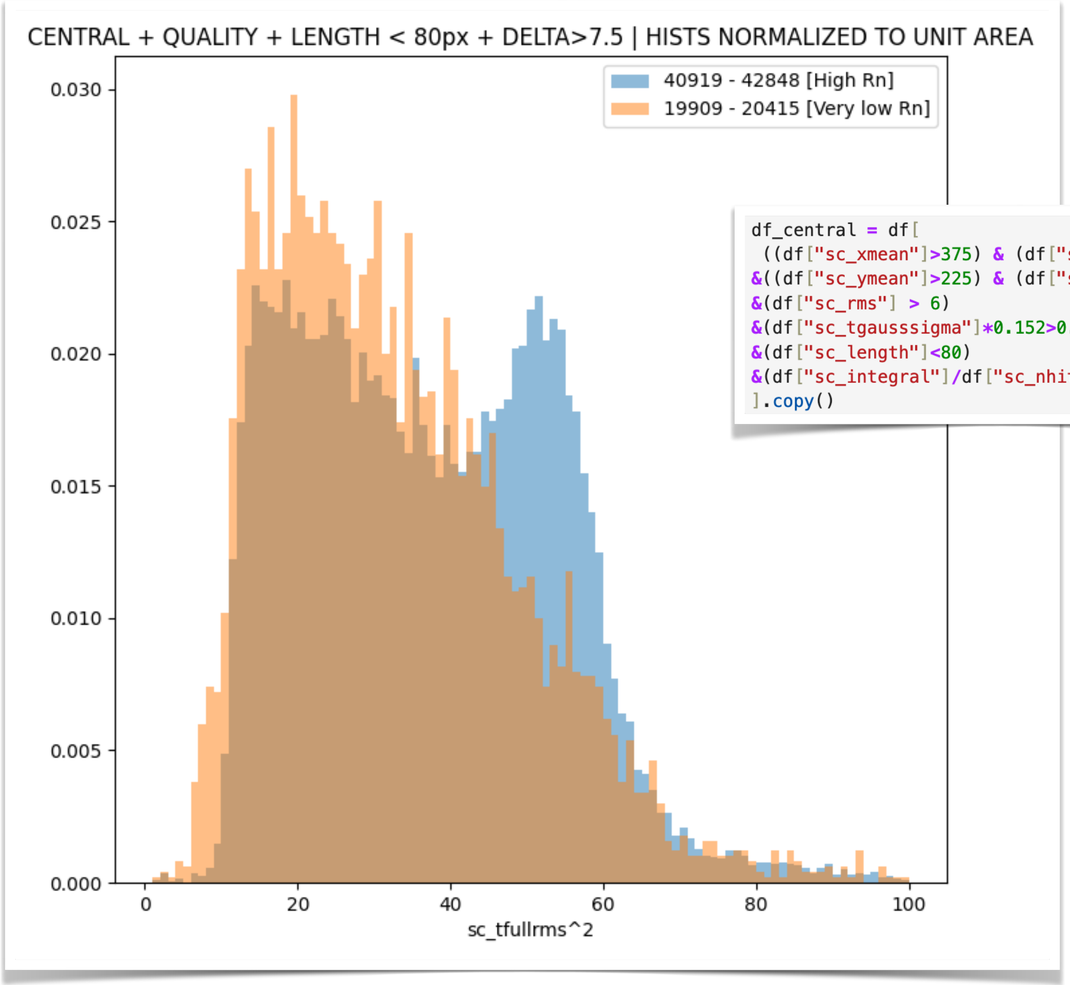


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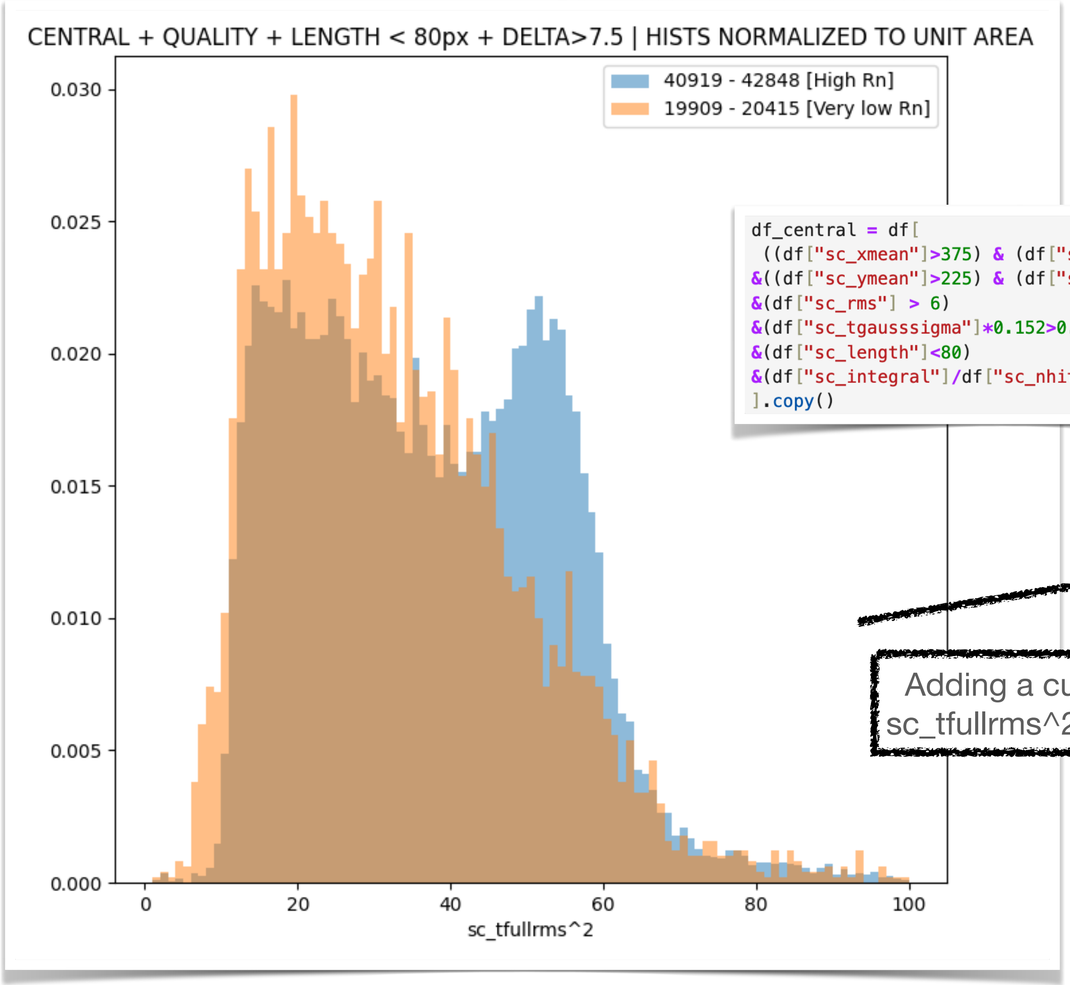
&(df["sc_length"]<80)
&(df["sc_integral"]/df["sc_nhits"] > 7.5)
].copy()
```

Different selection: length<80px & delta > 7.5

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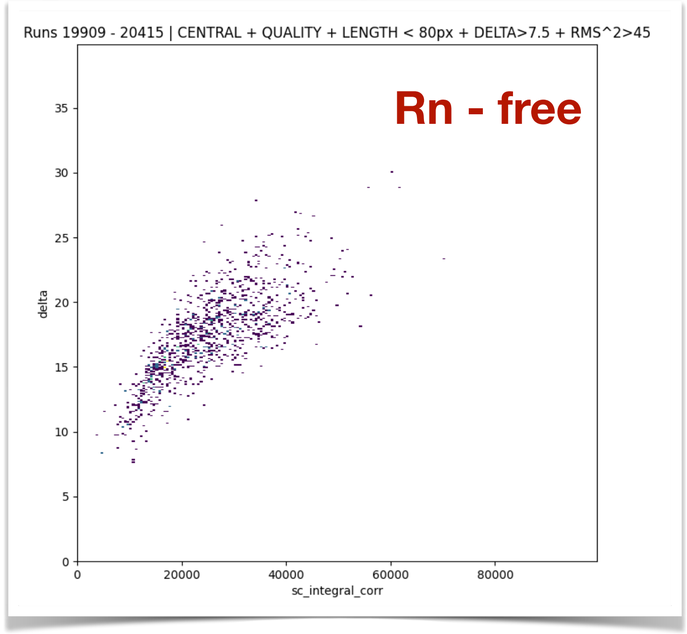
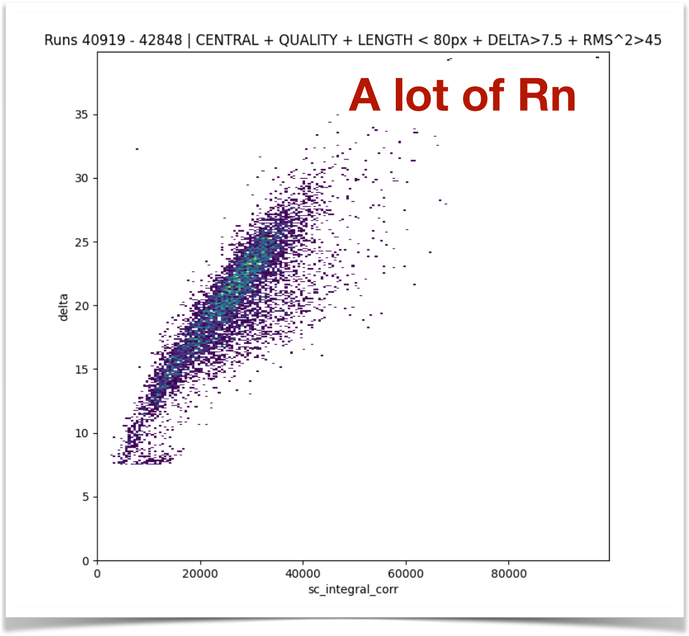
&(df["sc_tgausssigma"]*0.152>0.5)
&(df["sc_length"]<80)
&(df["sc_integral"]/df["sc_nhits"] > 7.5)
].copy()
```

Adding a cut on
sc_tfullrms^2 > 45





Conclusions

- We have a strong suggestion that ^{222}**Rn alpha decays come along with short NR-like spotlike deposits at high z**
- The **energy** and **density** of these deposits can **harldy be interpreted as ERs**
- **These events <u>are</u> the same populating the ~ 20 keV$_{\mathrm{Fe-e}}$ peak in Daniel's spectra**
- An interpretation explaining the entire scheme: **NR from alpha decays of Rn progeny accumulated on the cathode surface!** (already observed by MIMAC and DRIFT)
- **<u>A more in-depth and systematic work is needed!</u>**
- If this is the case:
  - ◉ we demonstrated that **<u>we can fiducialize low energy NRs in z!!!</u>**
  - ◉ we have another **<u>strong signature of Rn presence in LIME</u>**
  - ◉ we should compare these NRs with the AmBe NRs induced on He!