

# RUN3 and RUN4 Data Analysis

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**LIBPhys-UC**



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COIMBRA



Data-taking periods:Standard Cuts:

RUN3

- 22-25 May 2023 → runs 19909 - 20415
- 12-19 July 2023 → runs 21049 - 22514

- $sc\_rms > 6$
- $sc\_tgausssigma * 0.152 > 0.5$
- $sc\_xmin > 255$  &  $sc\_xmax < 2000$
- $sc\_ymin > 300$  &  $sc\_ymax < 2000$

RUN4

- 4-14 Dec 2023 → runs 40919 - 42848
- 15-23 Jan 2024 → runs 43886 - 45213
- 24 Jan-2 Feb 2024 → runs 45252 - 46635
- 15-28 Feb 2024 → runs 48055 - 49945

Normalisation:→ Saved Images VS Total Run Duration

A single run has **400 saved images**, regardless of background conditions.

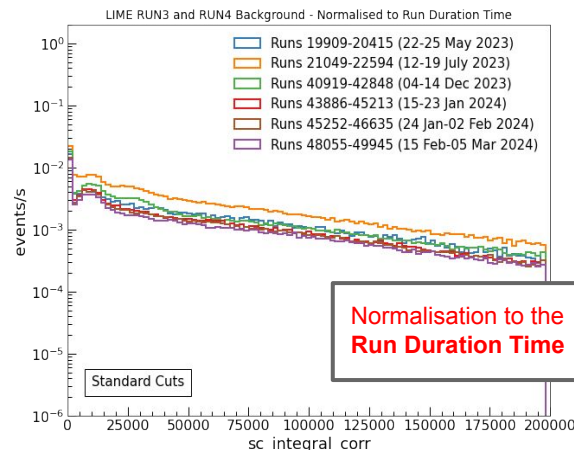
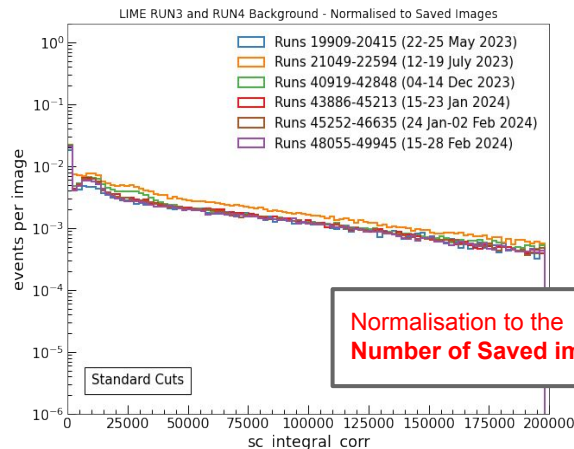
Previously, we concluded that **differences in background levels** between different data taking periods **become evident** when **normalising by total run duration** rather than by **total images acquired**.

Run Duration Time

- Duration of a specific background run calculated.
- Sum of the duration of each run in the range of interest to get the total duration of that data acquisition campaign.
- Normalisation factor applied,  $(1/\text{total\_duration}) * \text{daq\_inefficiency\_factor}^1$ , obtaining a histogram of the rate of events.

<sup>1</sup>DAQ inefficiency: (Based on Flaminia's Thesis, Page 231)

$$D = 1 + \frac{m}{k} = 1 + \frac{T_{Cam} + R_{PMT} \times T_{Window} \times t_{wf}}{T_{Window}}$$



RUN3

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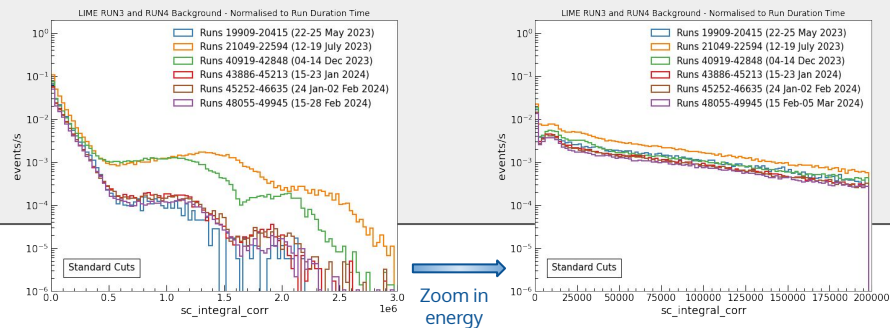
- $sc\_rms > 6$
- $sc\_tgausssigma * 0.152 > 0.5$
- $sc\_xmin > 255$  &  $sc\_xmax < 2000$
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$$D = 1 + \frac{m}{k} = 1 + \frac{T_{Cam} + R_{PMT} \times T_{Window} \times t_{wf}}{T_{Window}}$$

Normalisation:

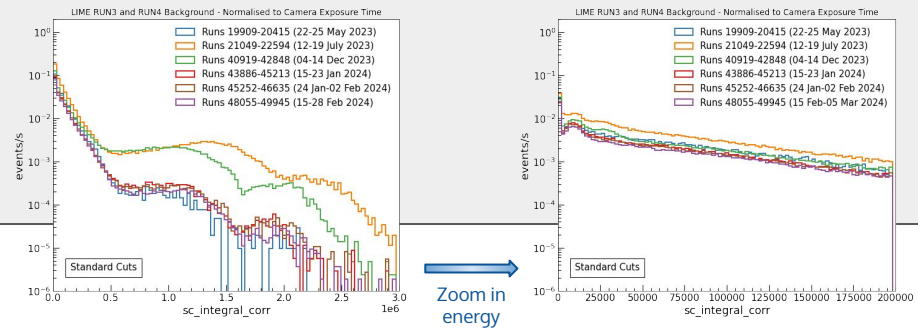
Run Duration Time

- Duration of a specific background run calculated.
- Sum of the duration of each run in the range of interest to get the total duration of that data acquisition campaign.
- Normalisation factor applied,  $(1/total\_duration) * daq\_inefficiency\_factor^1$ , obtaining a histogram of the rate of events.



Camera Exposure Time

- The estimation of **lost images study** performed by Stefano was used.
- The normalisation was done using the **total number of images (saved + lost) multiplied by the exposure time of the camera (300 ms)**.



## RUN3 and RUN4 Summary

- Stefano's analysis was applied to estimate the total number of images lost within a defined range of background runs.
- The objective was to normalise the data to the **exposure time of the camera** (Total Images x 300 ms).

Run Range	Images Saved	Images Lost	Total Images	Camera Exposure Time [s]	Run Duration [s]
<b>19909 - 20415</b> 22-25 May 2023	171 980	199 453	371 433	111 430	191 928
<b>21049 - 22594</b> 12-19 July 2023	493 877	445 704	939 581	281 874	487 638
<b>40919 - 42848</b> 4-14 Dec 2023	638 025	879 155	1 517 180	455 154	781 347
<b>43886 - 45213</b> 15-23 Jan 2024	441 573	802 753	1 244 325	373 297	639 315
<b>45252 - 46635</b> 24Jan-2Feb 2024	455 453	862 990	1 318 443	395 533	677 310
<b>48055 - 49945*</b> 15-28 Feb 2024	620 871	1 295 624	1 916 495	574 949	986 385

\*Shorter range of runs due to missing PMT files from 49946 to 50891 in the cloud (28 Feb - 5 Mar 2024).

# Energy histograms - Rita's LY correction.

**NOTE:** This `sc_integral_corr` should not be used to evaluate energy densities (e.g. `sc_integral/sc_nhits`). For those, it is better to still use the raw `sc_integral`

- Rita's LY equalisation tables were used to correct "sc\_integral".

	Run	Fe_peak	Corr	Evaluated
1	40785	9027.222185939974	9027.222185939974	0
2	40787	9072.271318007684	9072.271318007684	0
3	40789	9124.460686306997	9124.460686306997	0
4	40791	9196.899066685815	9196.899066685815	0
5	40793	9195.176852549599	9195.176852549599	0

For each run, `sc_integral_corr = sc_integral * 1e4/Corr` is evaluated<sup>1</sup>.

- After the correction, RUN3 data from May 2023 becomes more consistent with the low radon contamination data from RUN4.

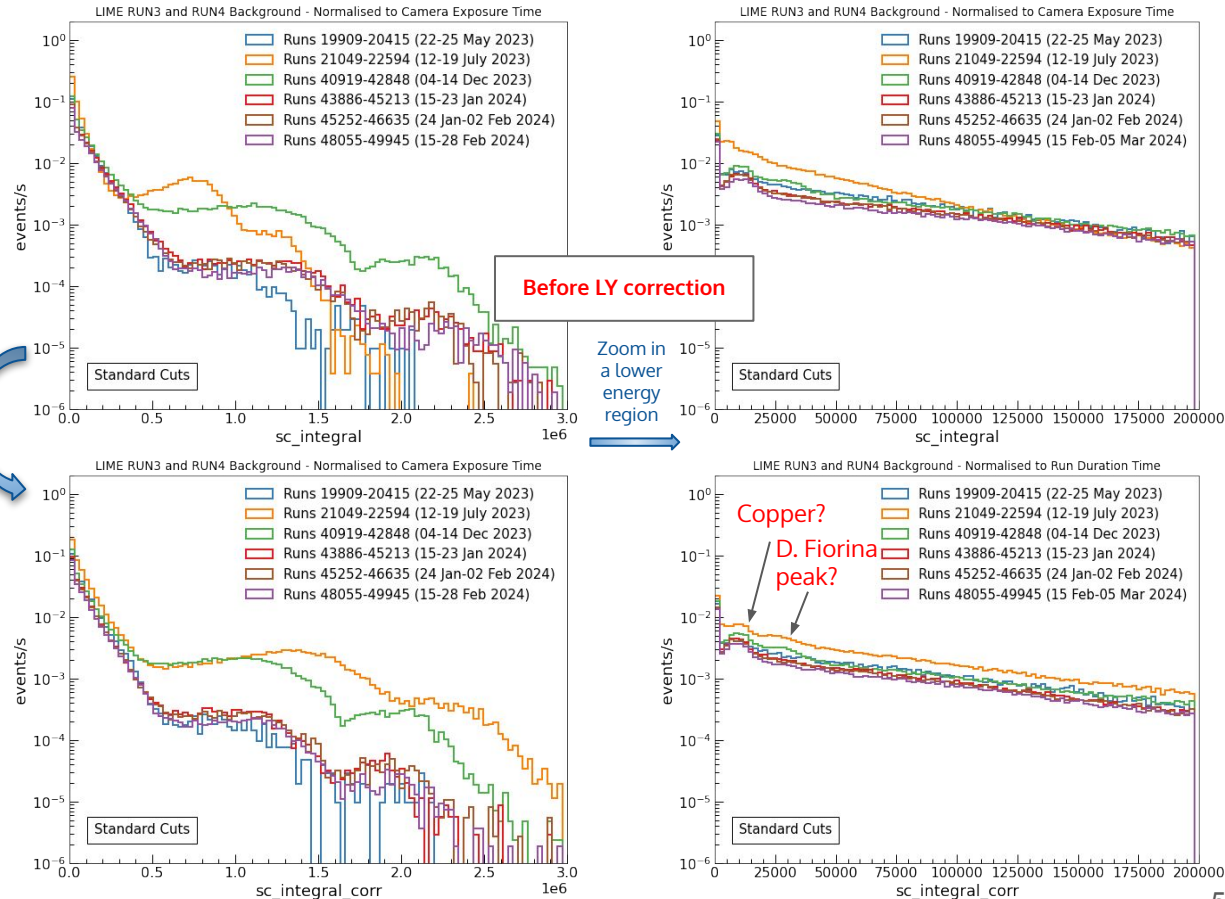
July and Dec 2023 data show two peaks in the lower energy region.

- New variables/cuts introduced by Stefano to be explored:

$$\rho \equiv \text{sc\_rms}/\text{sc\_nhits}$$

$$\eta \equiv \text{sc\_width} * \text{sc\_length} * \rho$$

LY correction applied



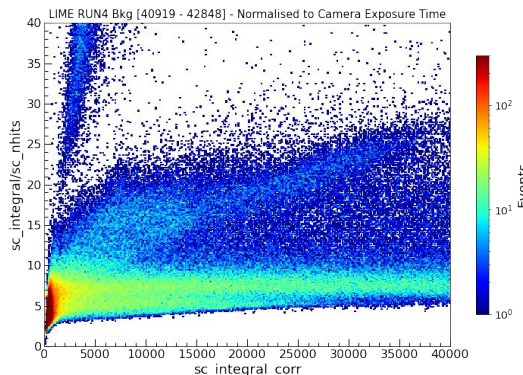
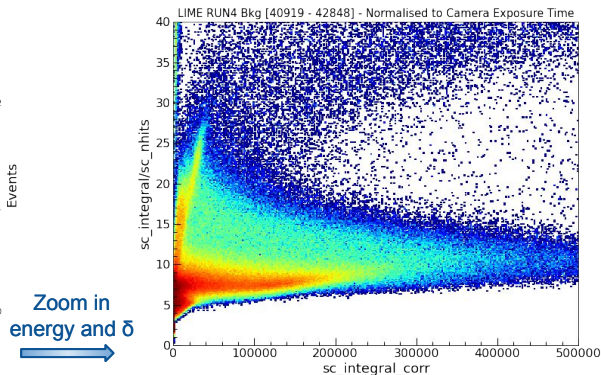
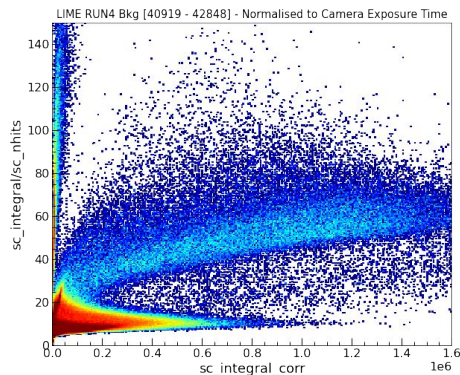


# $\delta$ vs 'sc\_integral'

Bkg Runs from December 2023

Comparison of the light density histograms:

## 1) Data **without any cuts** applied.



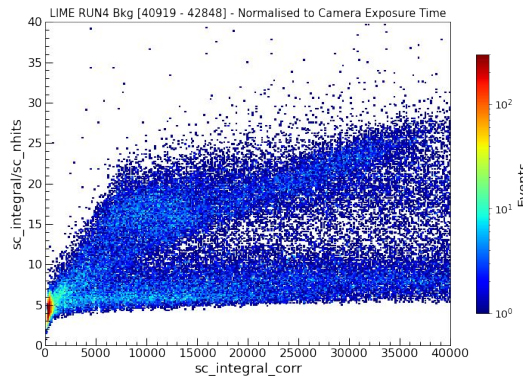
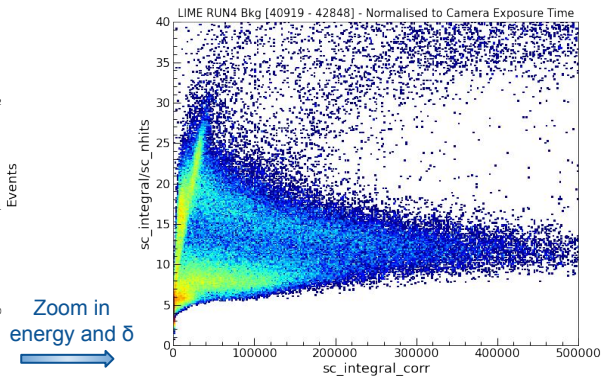
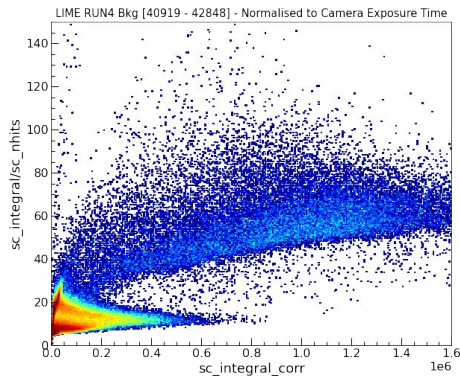
### Standard Cuts

- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgaussigma * 0.152 > 0.5$

### Stefano's Variables

- $\rho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \rho$

## 2) **Standard cuts** applied.



# $\delta$ vs 'sc\_integral'

Bkg Runs from December 2023

Comparison of the light density histograms:

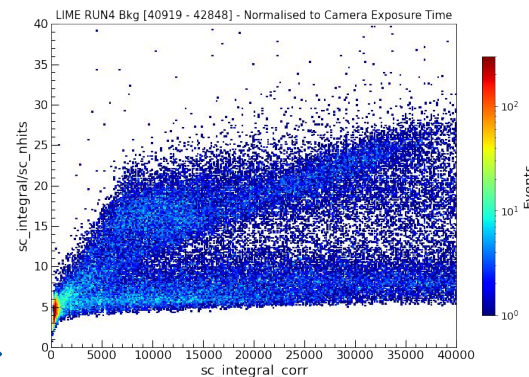
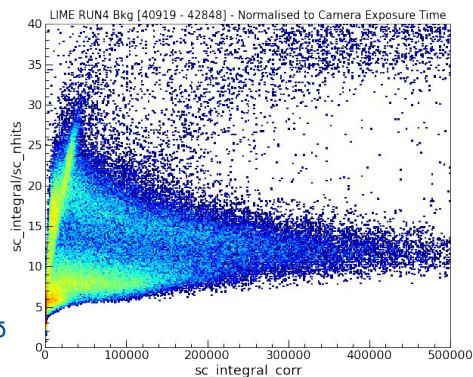
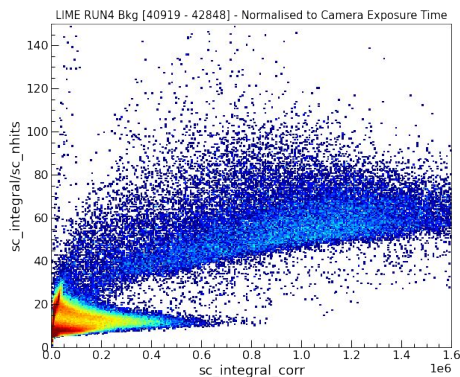
## 2) Standard cuts applied.

### Standard Cuts

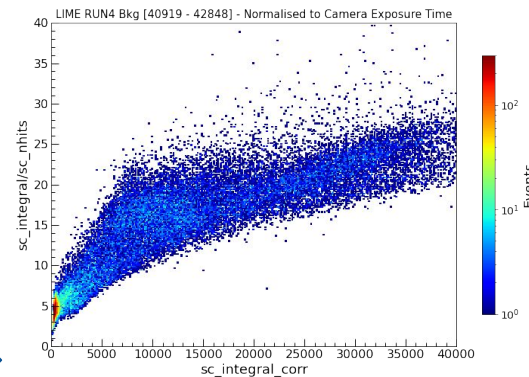
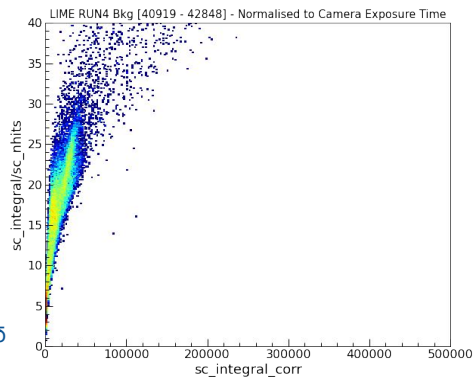
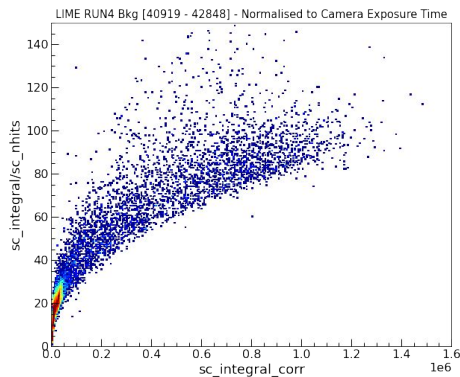
- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgaussigma * 0.152 > 0.5$

### Stefano's Variables

- $\rho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \rho$



## 3) Standard cuts + $(0.01 < \rho < 0.15)$ .

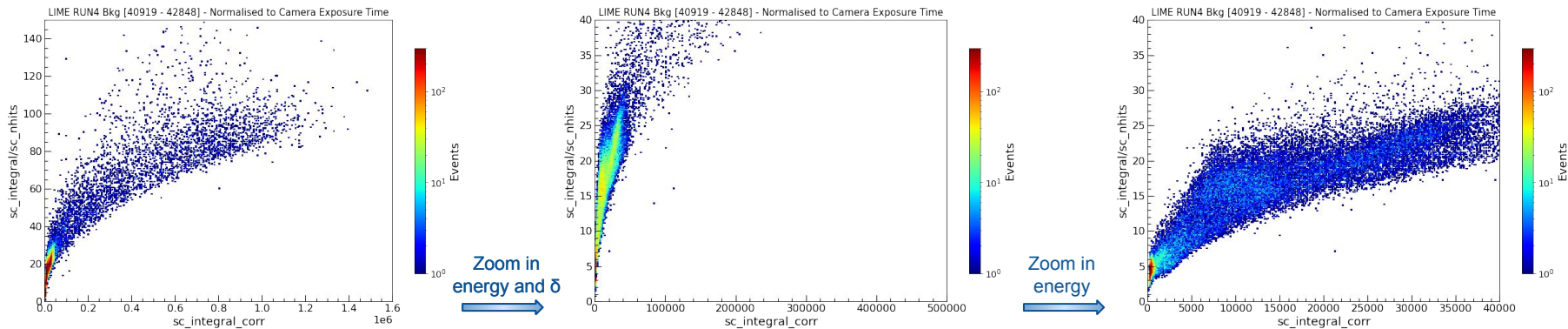


# $\delta$ vs 'sc\_integral'

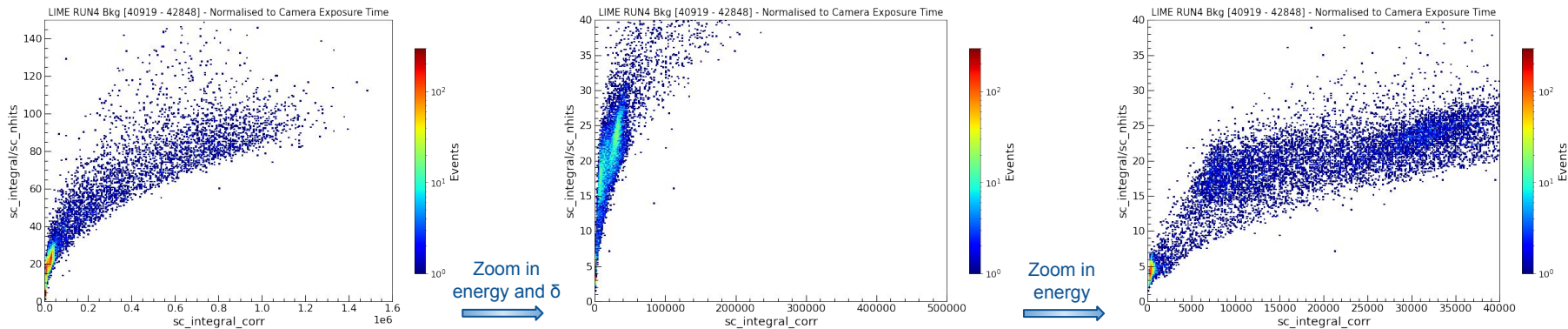
Bkg Runs from December 2023

Comparison of the light density histograms:

## 3) Standard cuts + ( $0.01 < \rho < 0.15$ ).



## 4) Standard cuts + ( $0.01 < \rho < 0.15$ ) + ( $\eta > 50$ ).



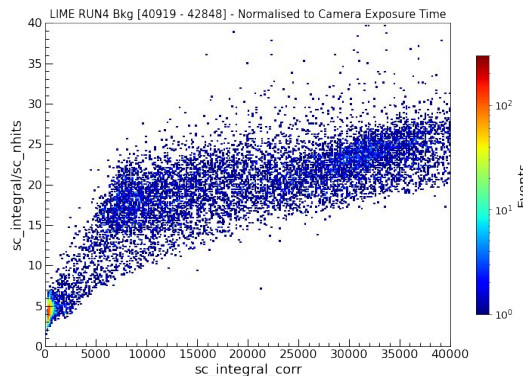
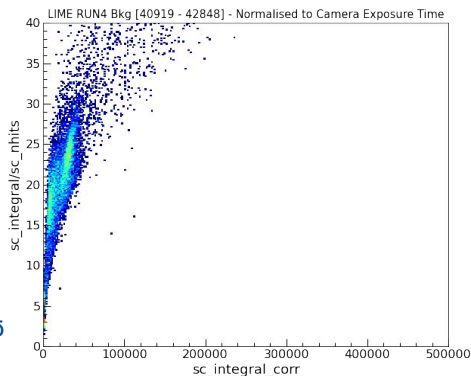
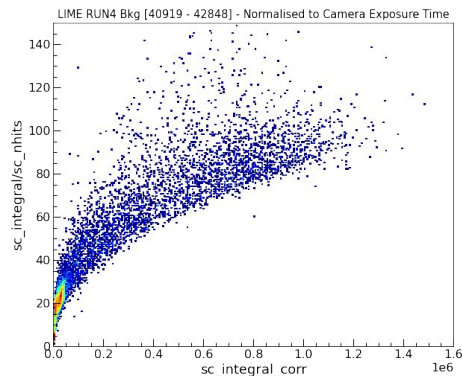


# $\delta$ vs 'sc\_integral'

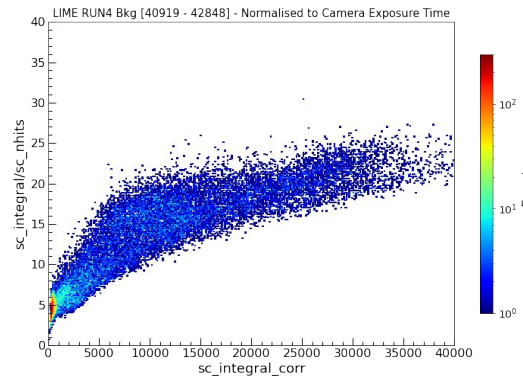
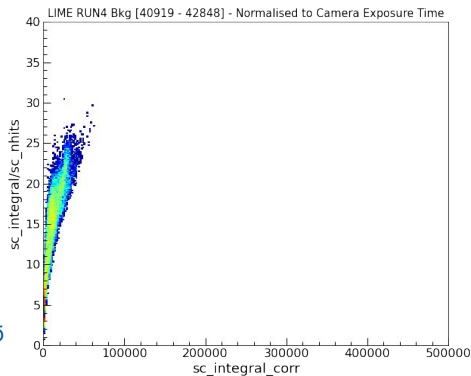
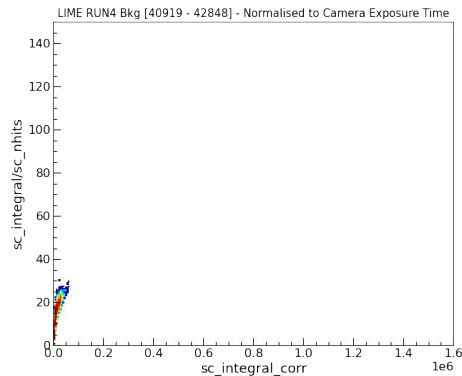
Bkg Runs from December 2023

Comparison of the light density histograms:

## 4) Standard cuts + $(0.01 < \rho < 0.15)$ + $(\eta > 50)$ .



## 5) Standard cuts + $(0.01 < \rho < 0.15)$ + $(\eta < 50)$ .



### Standard Cuts

- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgaussigma * 0.152 > 0.5$

### Stefano's Variables

- $\rho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \rho$

# RUN3 and RUN4 Background Runs

(normalised to the exposure time of the camera)

Data **without any cuts** applied.

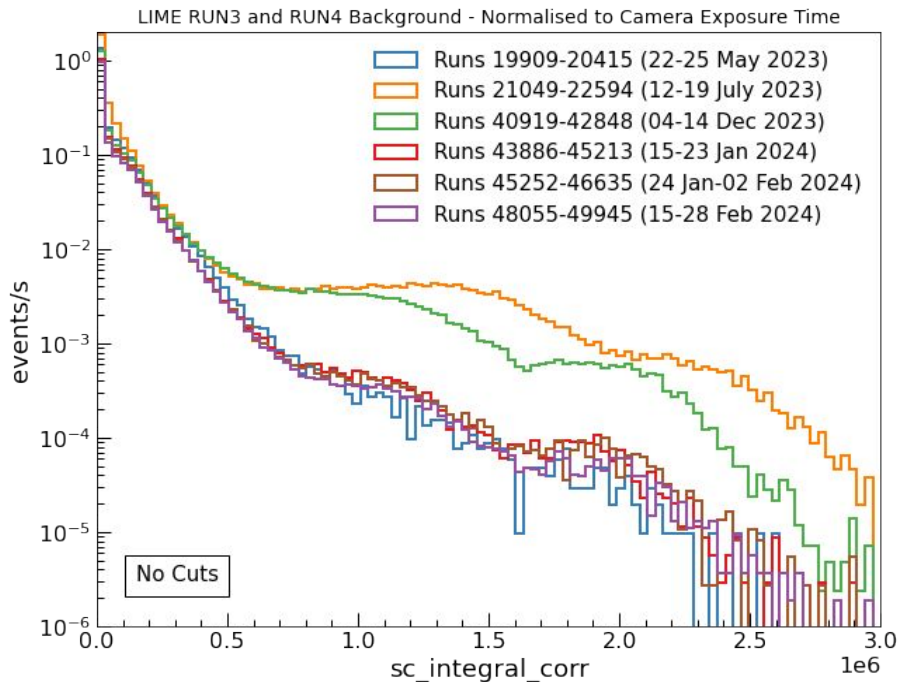
- No distinguishable peaks in the lower energy region.

## Standard Cuts

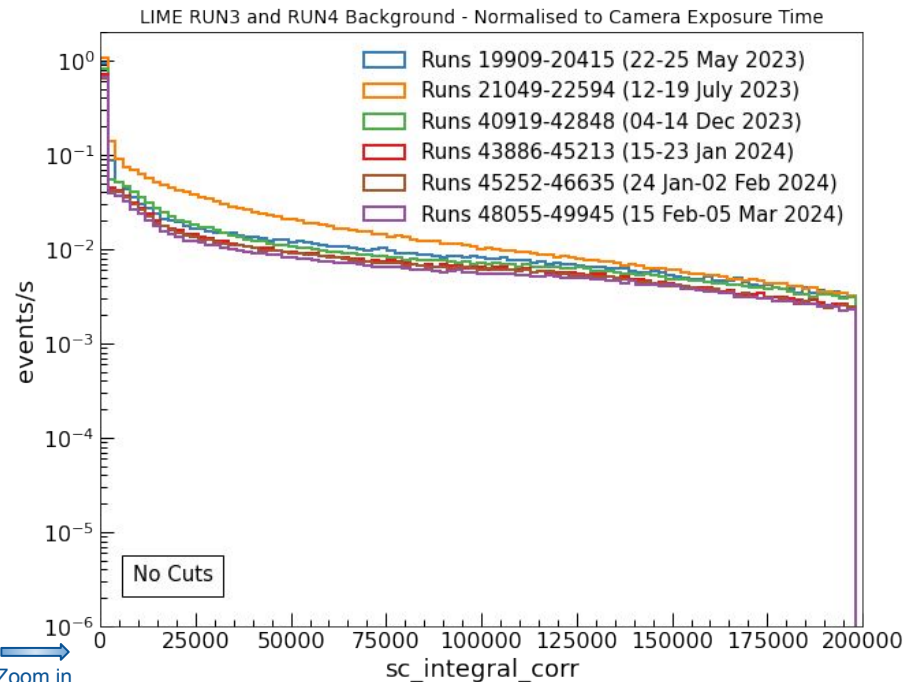
- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgausssigma*0.152 > 0.5$

## Stefano's Variables

- $\varrho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width*sc\_length*\varrho$



Zoom in energy

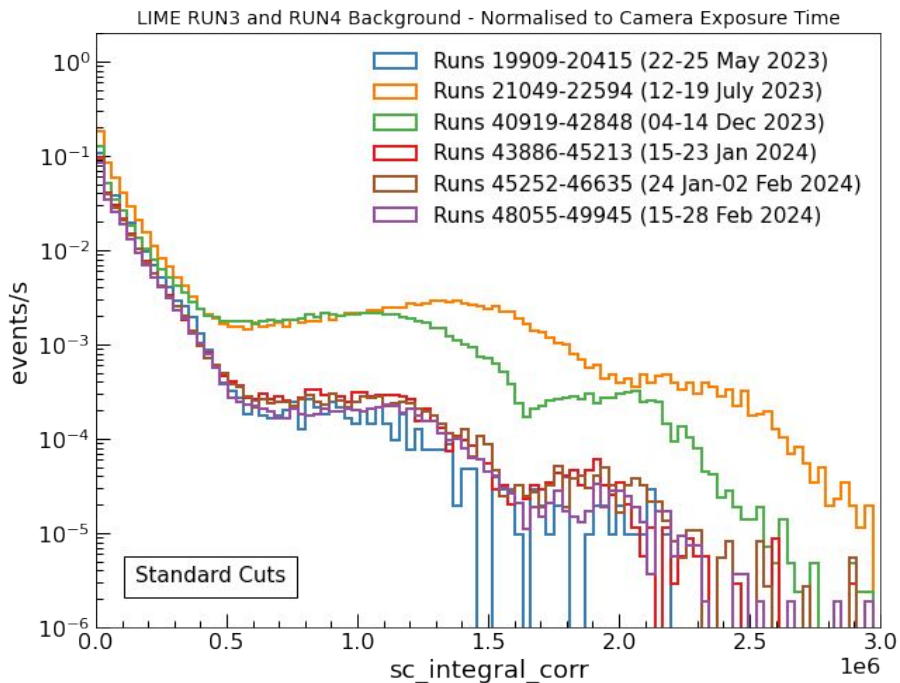


# RUN3 and RUN4 Background Runs

(normalised to the exposure time of the camera)

**Standard cuts** applied.

- Two peaks appearing around  $10e3$  and  $27e3$ .

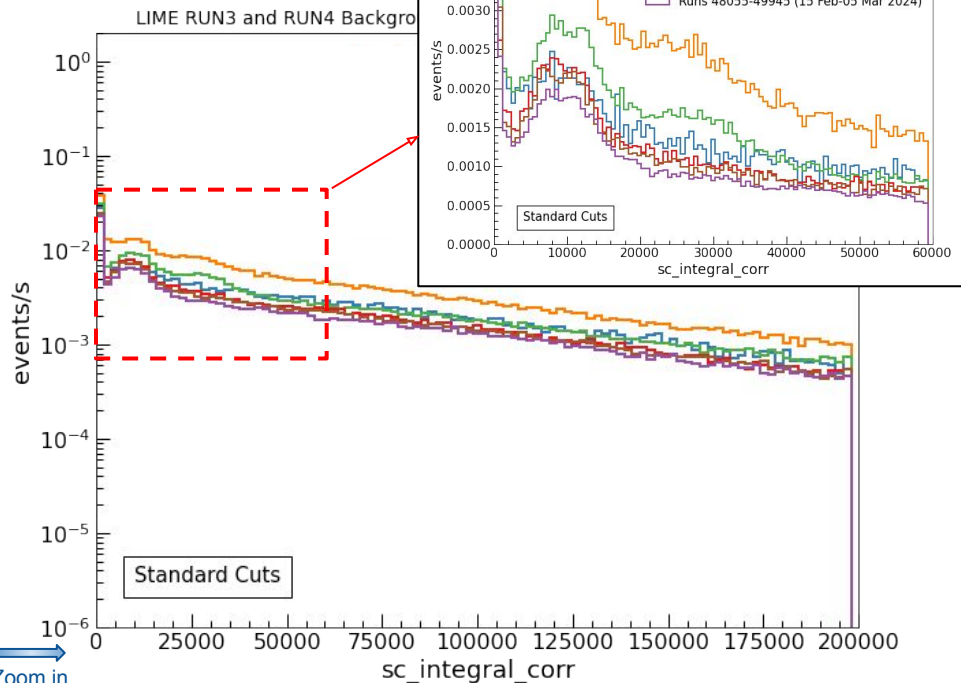


## Standard Cuts

- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgausssigma * 0.152 > 0.5$

## Stefano's Variables

- $\varrho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \varrho$



# RUN3 and RUN4 Background Runs

(normalised to the exposure time of the camera)

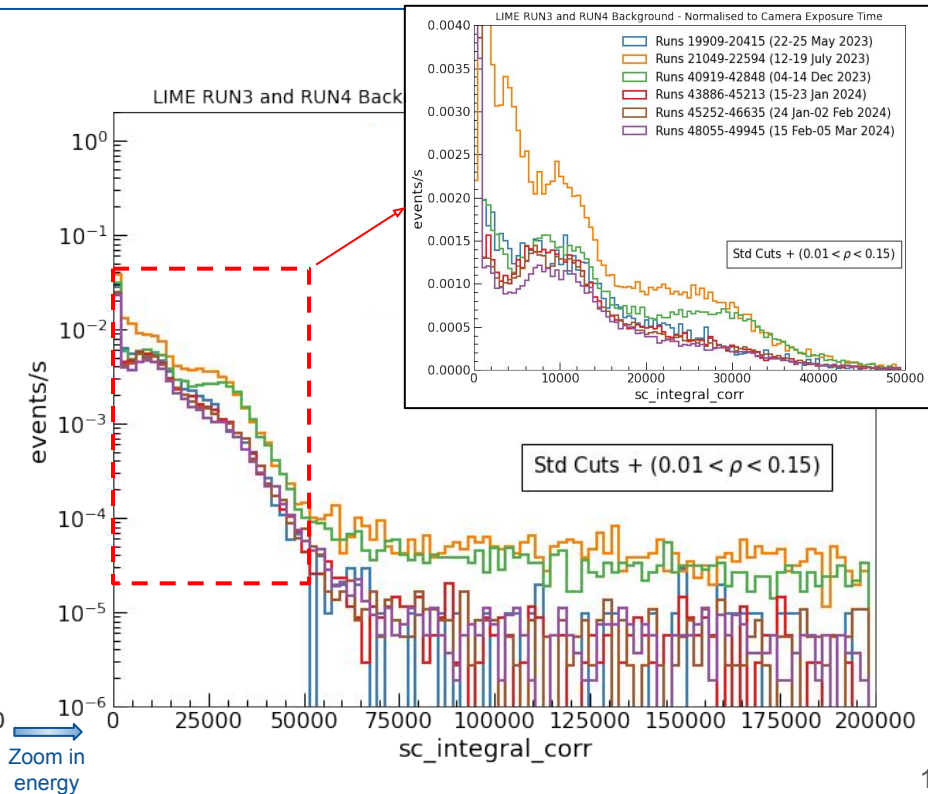
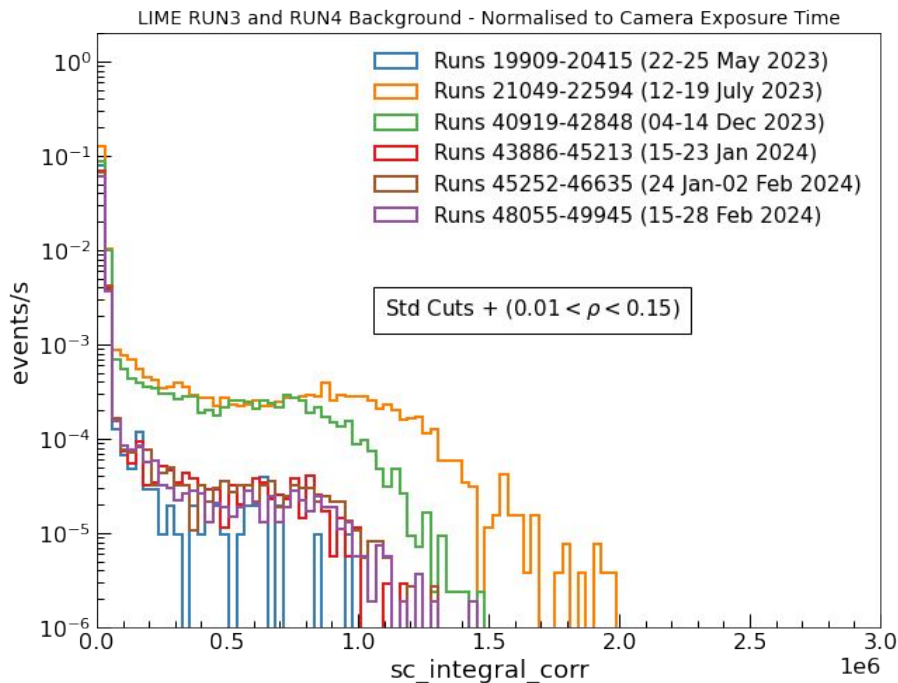
Standard cuts + ( $0.01 < \rho < 0.15$ )

## Standard Cuts

- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
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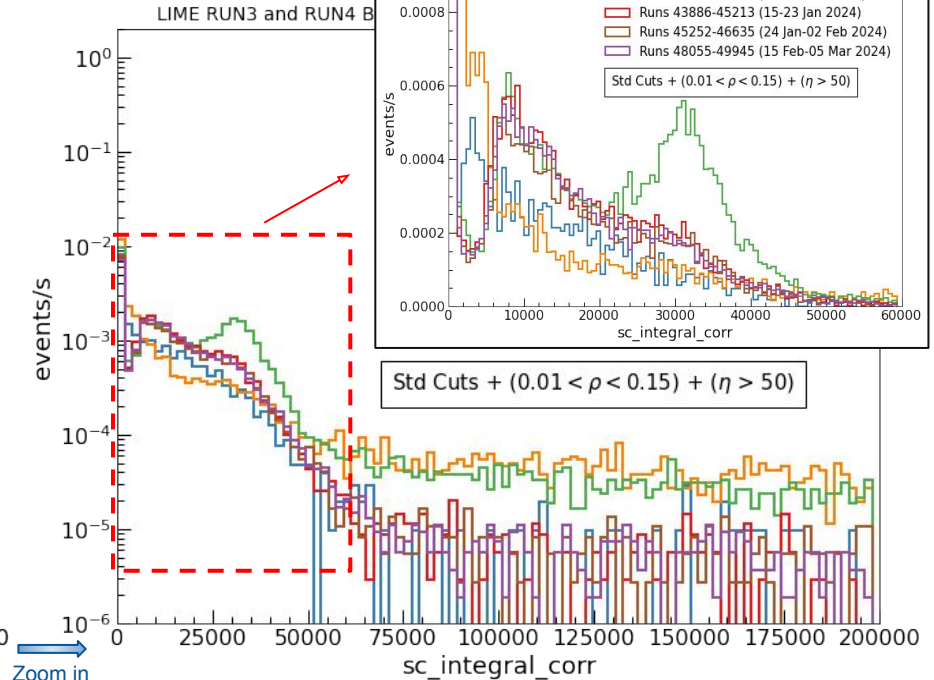
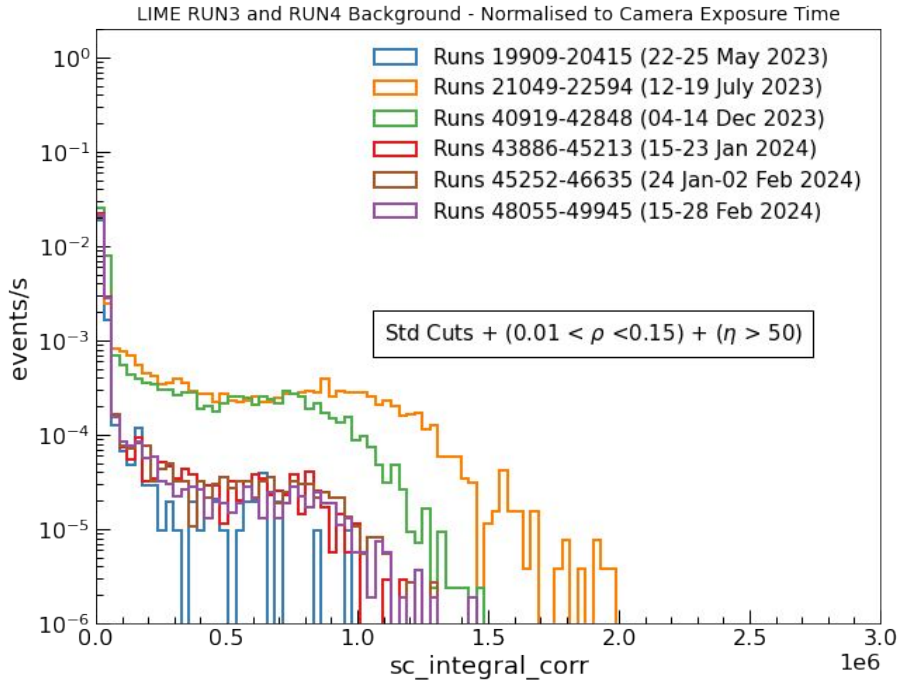
Standard cuts +  $(0.01 < \rho < 0.15) + (\eta > 50)$

## Standard Cuts

- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgausssigma * 0.152 > 0.5$

## Stefano's Variables

- $\rho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \rho$





# RUN3 and RUN4 Background Runs

(normalised to the exposure time of the camera)

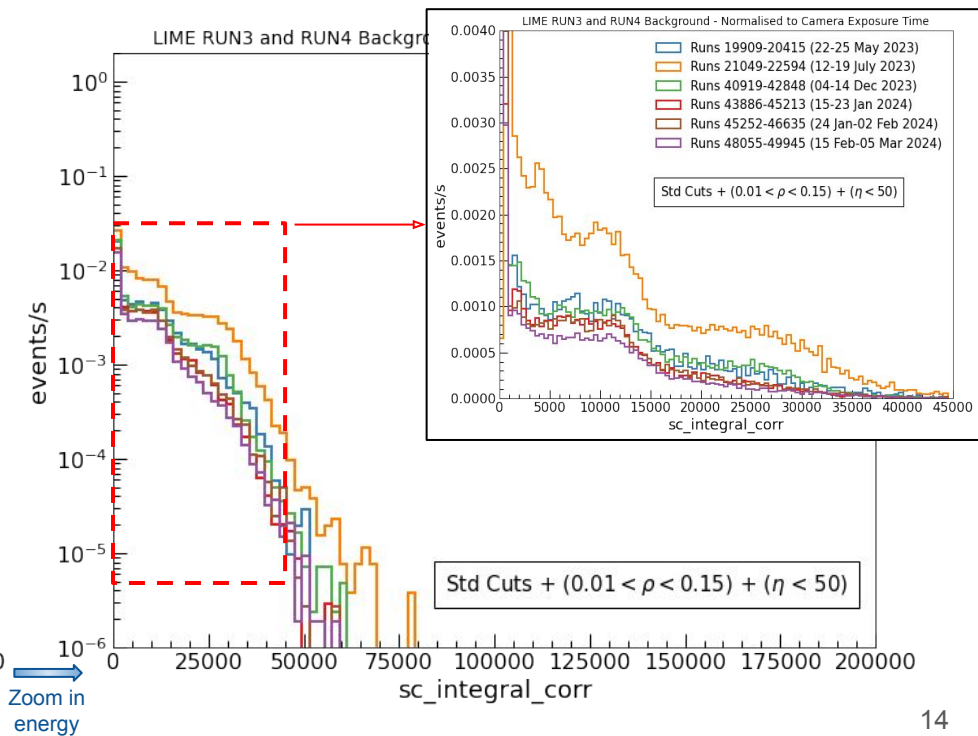
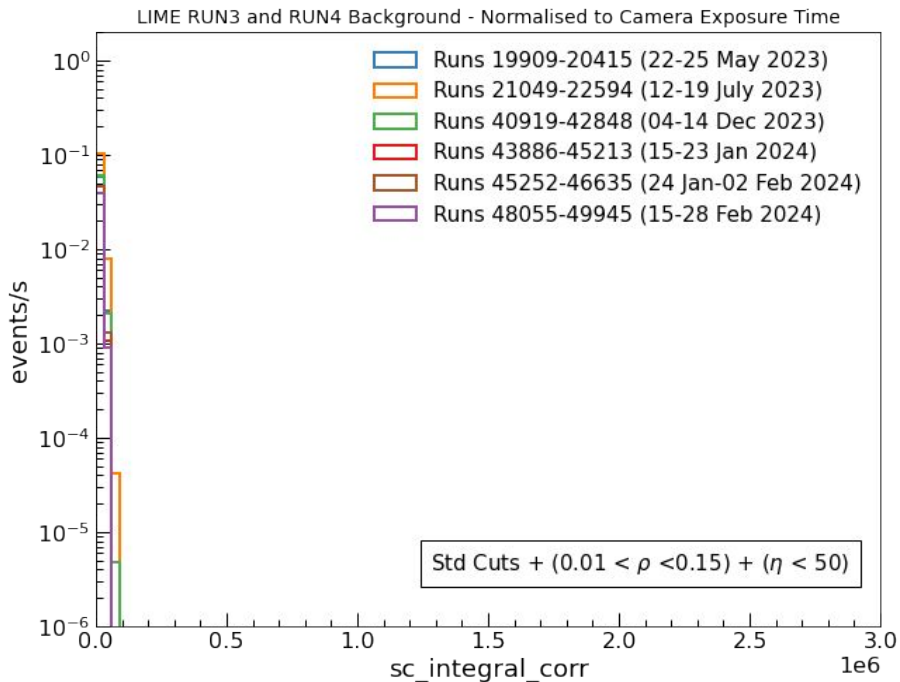
Standard cuts +  $(0.01 < \rho < 0.15) + (\eta < 50)$

## Standard Cuts

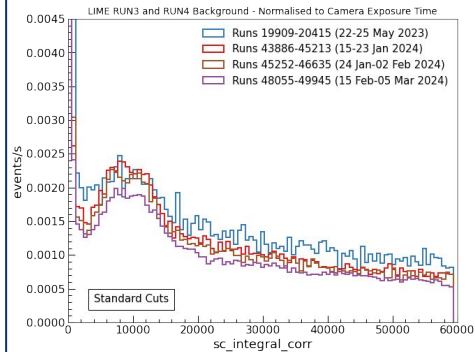
- $sc\_xmin > 255$  ;  $sc\_xmax < 2000$
- $sc\_ymin > 300$  ;  $sc\_ymax < 2000$
- $sc\_rms > 6$
- $sc\_tgausssigma * 0.152 > 0.5$

## Stefano's Variables

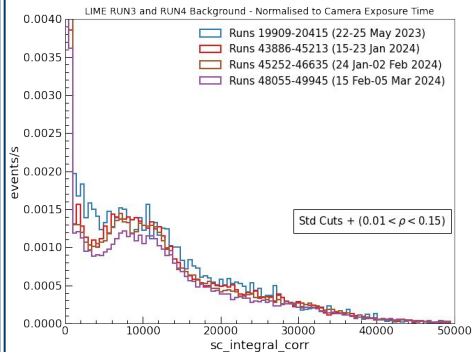
- $\rho \equiv sc\_rms/sc\_nhits$
- $\eta \equiv sc\_width * sc\_length * \rho$



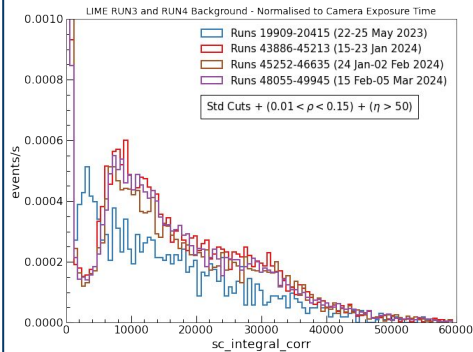
## Standard cuts



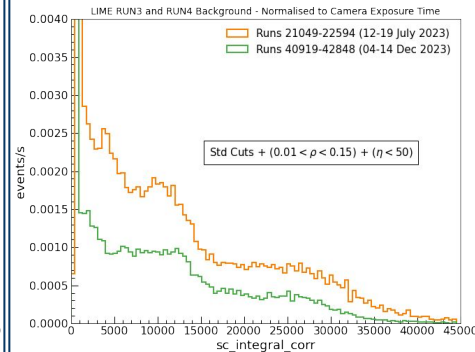
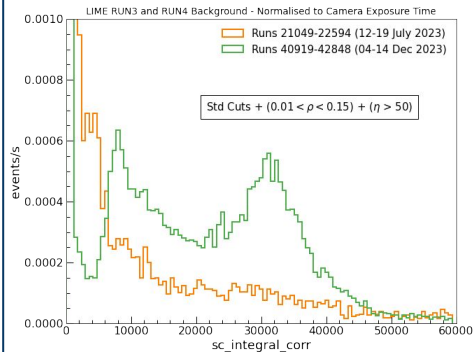
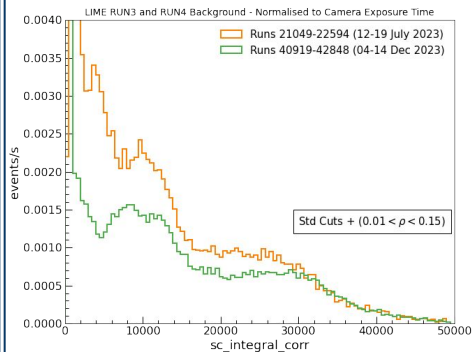
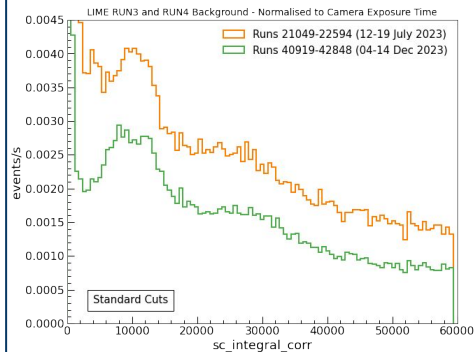
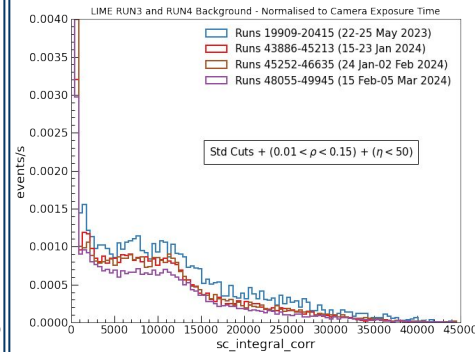
## Standard cuts $0.01 < \rho < 0.15$



## Standard cuts $0.01 < \rho < 0.15$ $\eta > 50$



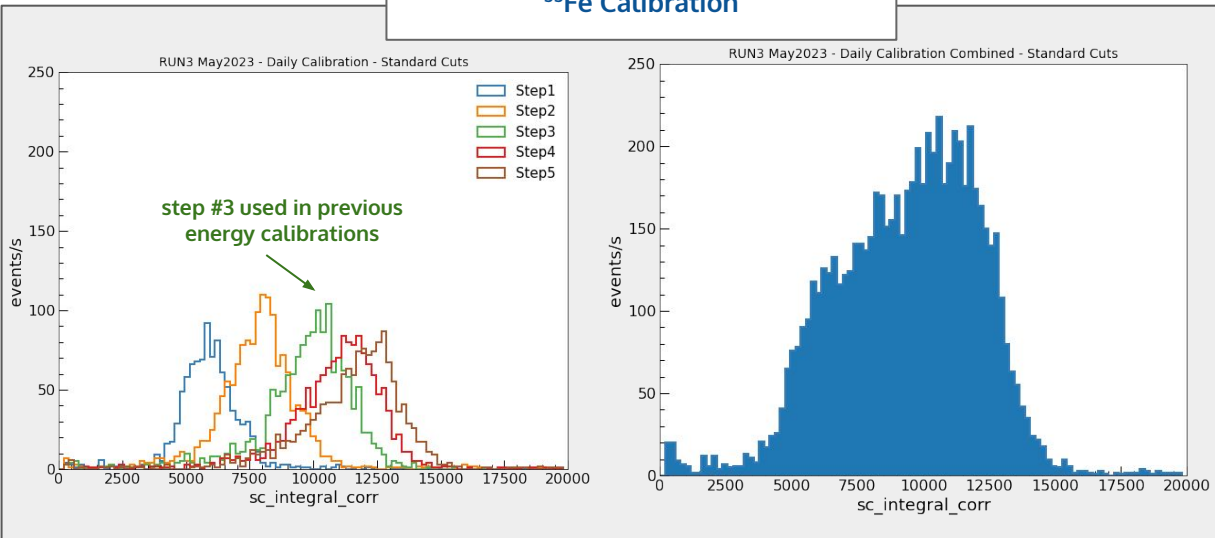
## Standard cuts $0.01 < \rho < 0.15$ $\eta < 50$



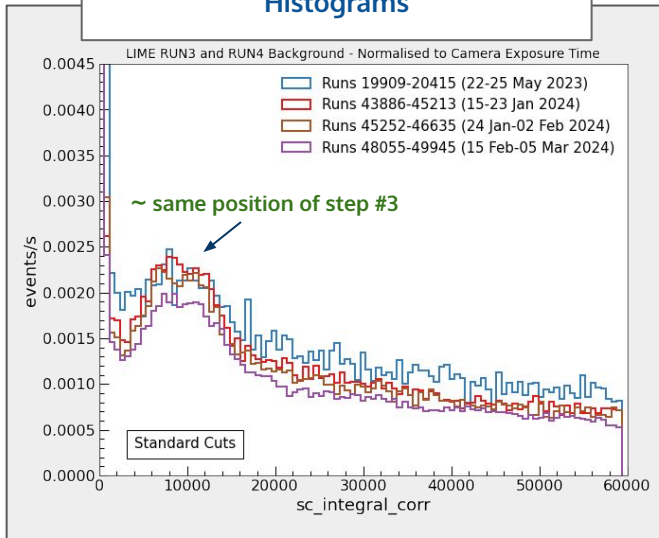
# Future Work

## 1. Energy Calibration.

### May of 2023 $^{55}\text{Fe}$ Calibration



### Background Energy Histograms



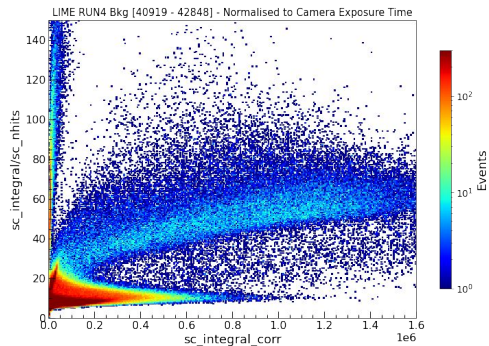
## 2. ...suggestions?

**Thank you for your attention!**

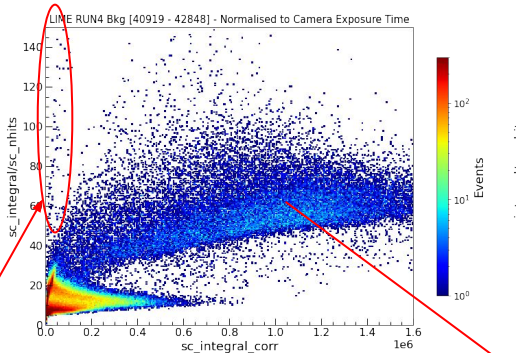
**Backup**



### 1) Data without any cuts applied.

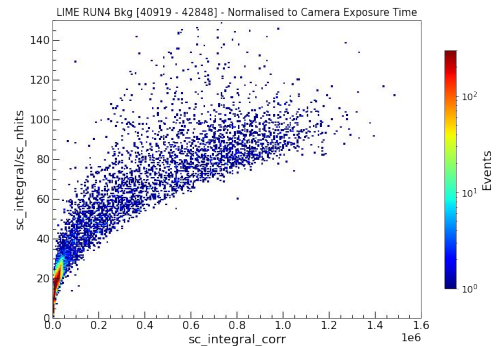


### 2) Standard cuts applied.



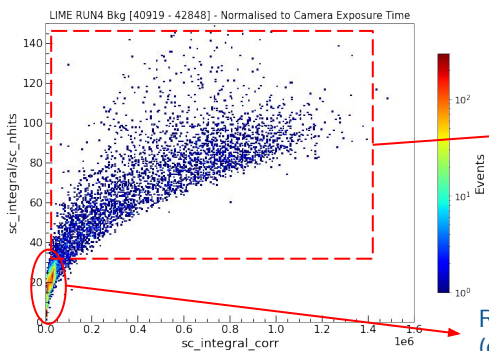
Some events on the sensor still present.  
They are removed when  $\rho$  is applied.

### 3) Standard cuts + ( $0.01 < \rho < 0.15$ ).



High energy, high density events (alphas) also removed  
when  $\rho$  is applied. Also MIPs.

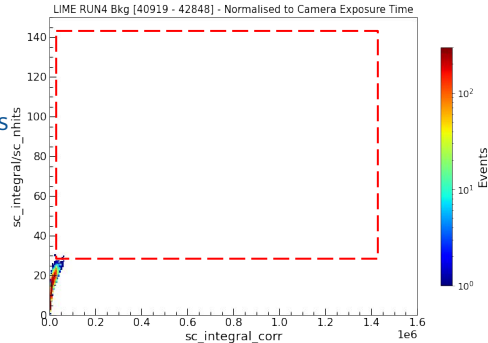
### 4) Standard cuts + ( $0.01 < \rho < 0.15$ ) + ( $\eta > 50$ ).



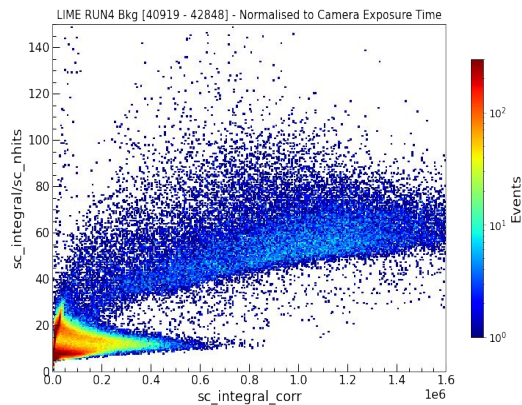
Nuclear recoils removed if eta is  
inverted ( $\eta < 50$ )

Reduction of events in this region  
(electron recoils)

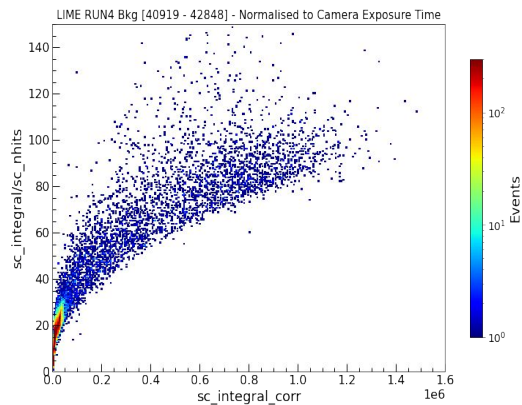
### 5) Standard cuts + ( $0.01 < \rho < 0.15$ ) + ( $\eta < 50$ ).



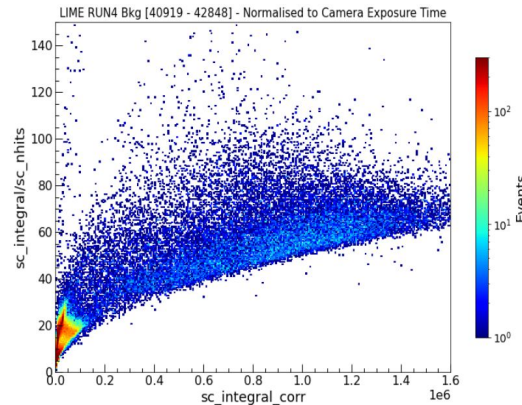
### 1) Std cuts



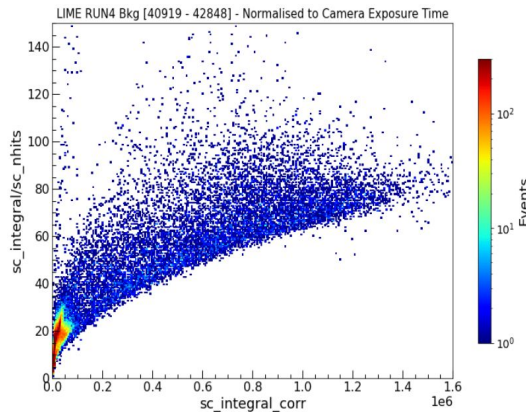
### 2) Std cuts + ( $0.01 < \rho < 0.15$ ).



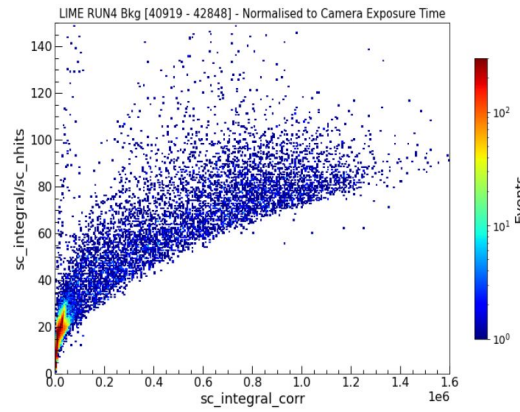
### 3) Std cuts + ( $\rho > 0.03$ ).



### 4) Std cuts + ( $\rho > 0.05$ ).



### 5) Std cuts + ( $\rho > 0.07$ ).



### 6) Std cuts + ( $\rho > 0.09$ ).

