TB2020 cross-check analysis

FCAL S&A meeting
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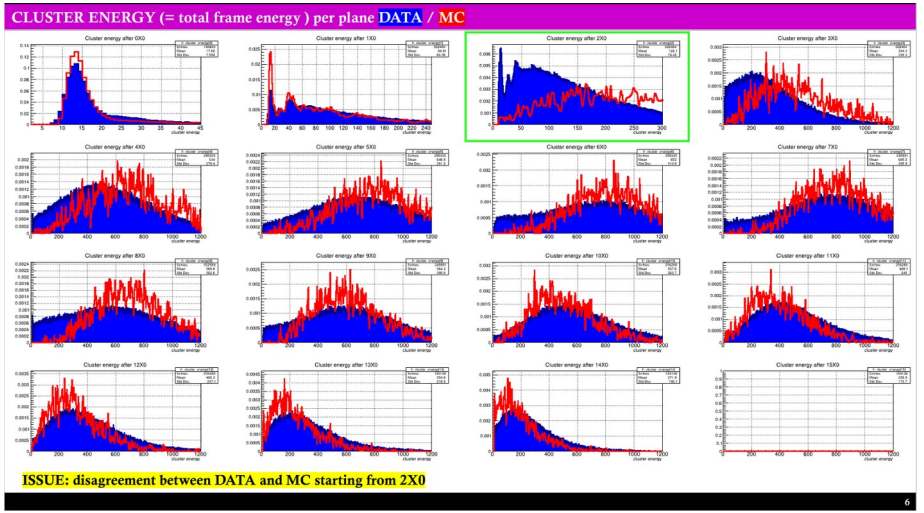
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE

Motivation

No clear data/mc agreement for a long time.
See the latest presentation by Roma

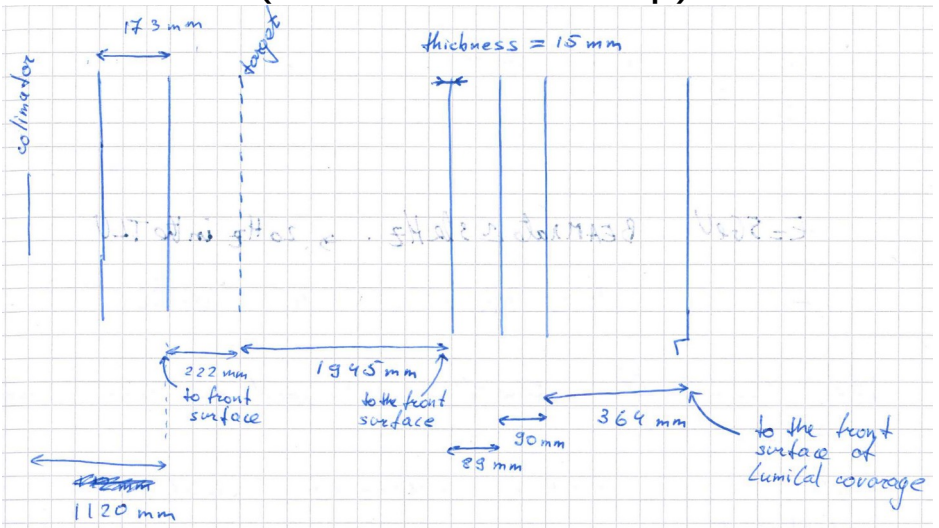


Goal

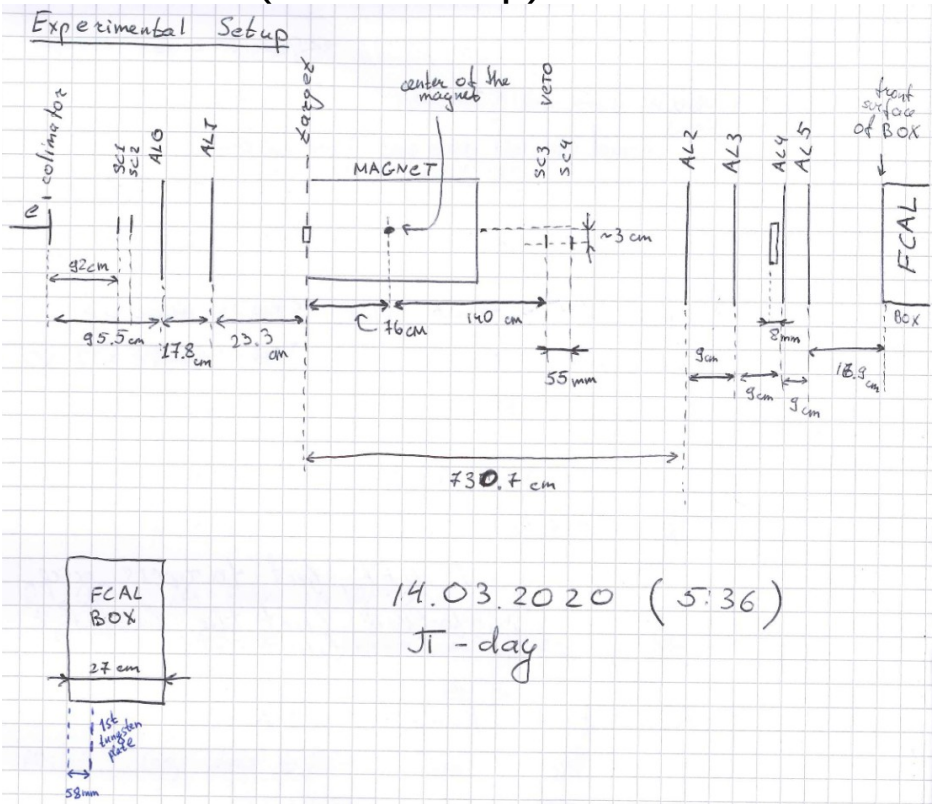
Cross check **all steps** of the data analysis **independently**

Geant4: experimental setup

04.03.2020 (FLAME scan setup)

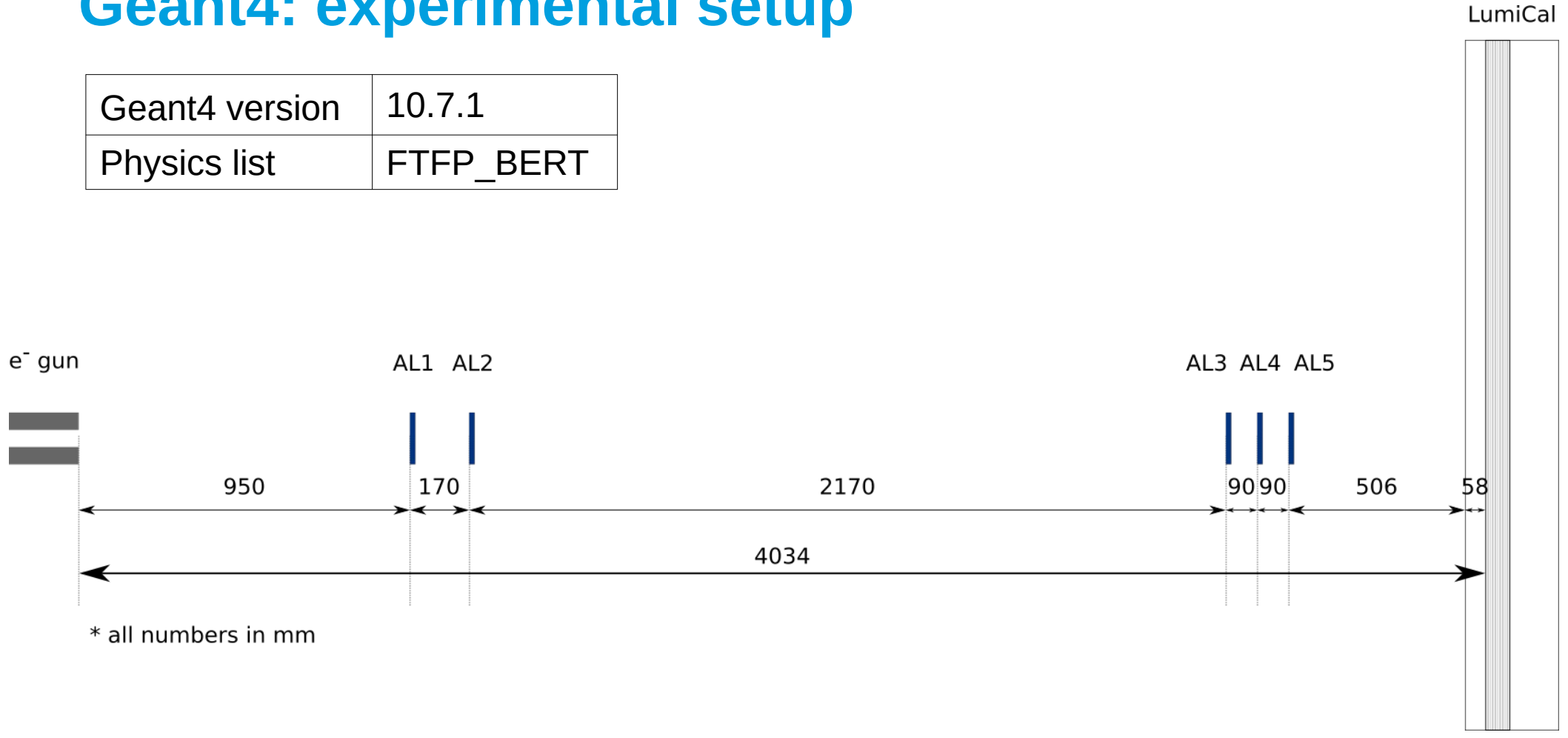


14.03.2020 (LUXE setup)



Geant4: experimental setup

Geant4 version	10.7.1
Physics list	FTFP_BERT

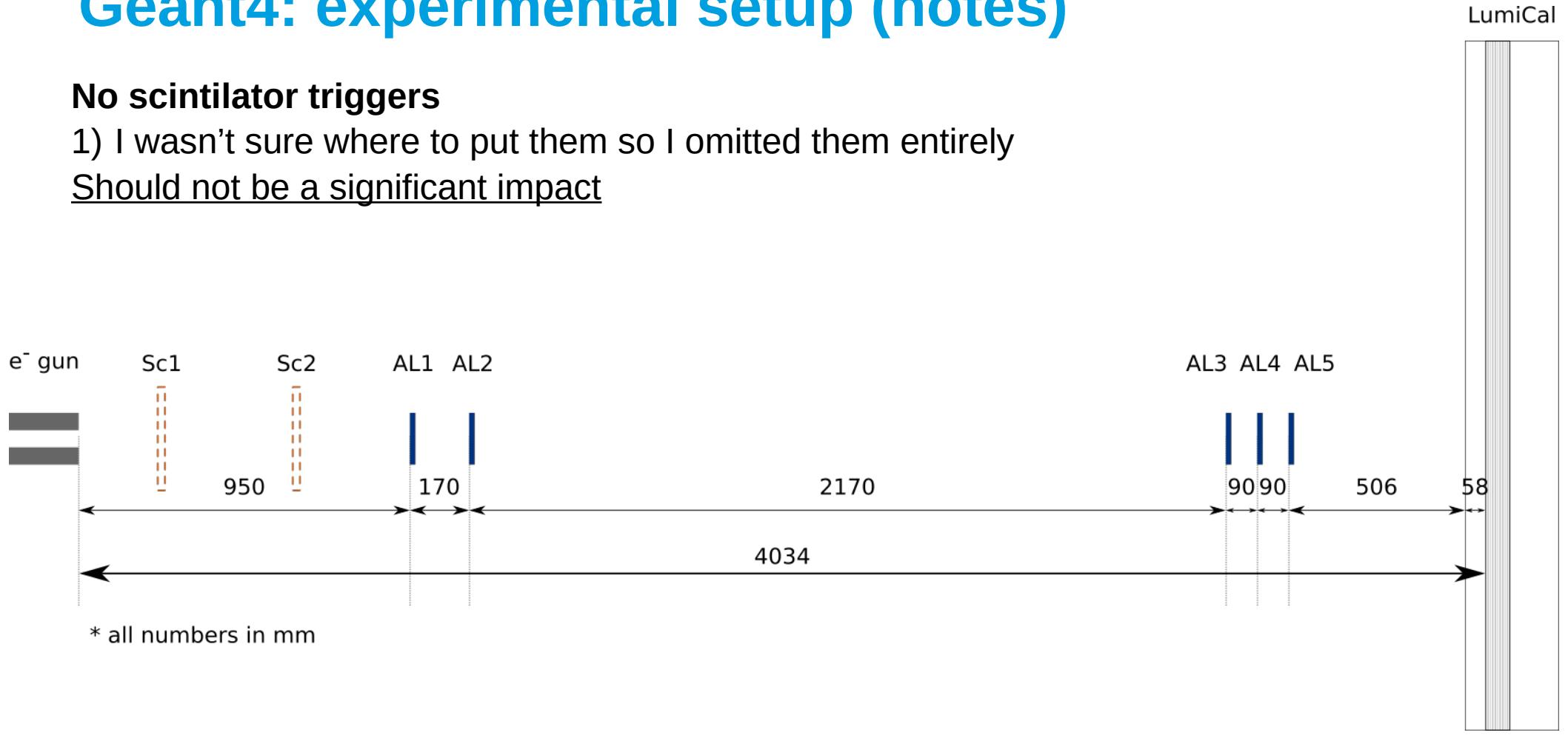


Geant4: experimental setup (notes)

No scintilator triggers

1) I wasn't sure where to put them so I omitted them entirely

Should not be a significant impact

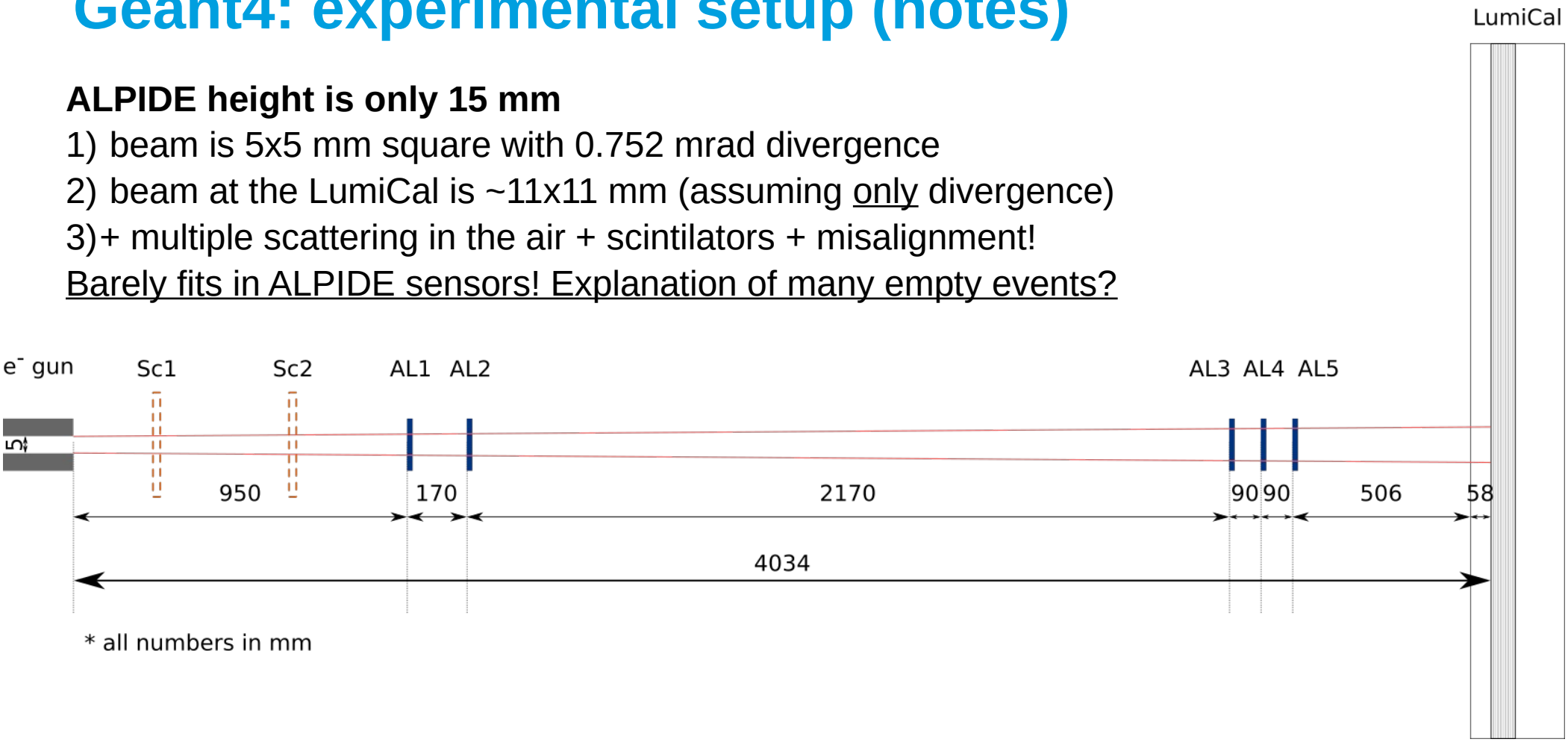


Geant4: experimental setup (notes)

ALPIDE height is only 15 mm

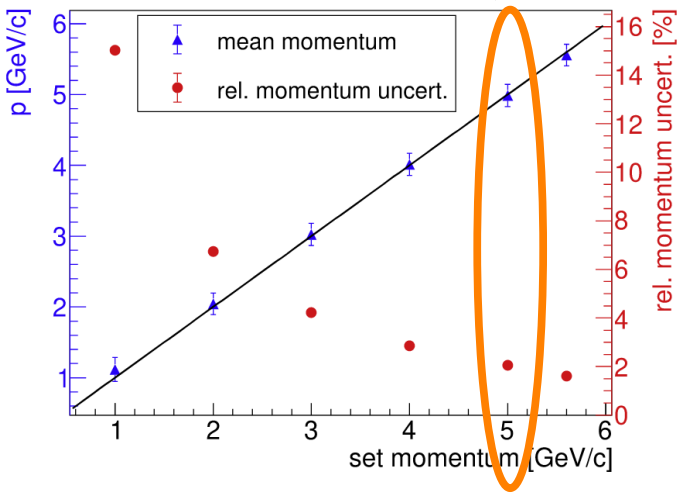
1) beam is 5x5 mm square with 0.752 mrad divergence
2) beam at the LumiCal is ~11x11 mm (assuming only divergence)
3)+ multiple scattering in the air + scintilators + misalignment!

Barely fits in ALPIDE sensors! Explanation of many empty events?



Geant4: a gun

Size	5x5 mm	square plane
Energy	5 GeV ± 105 MeV	Gaussian
Angular	0.752 mrad	isotropic



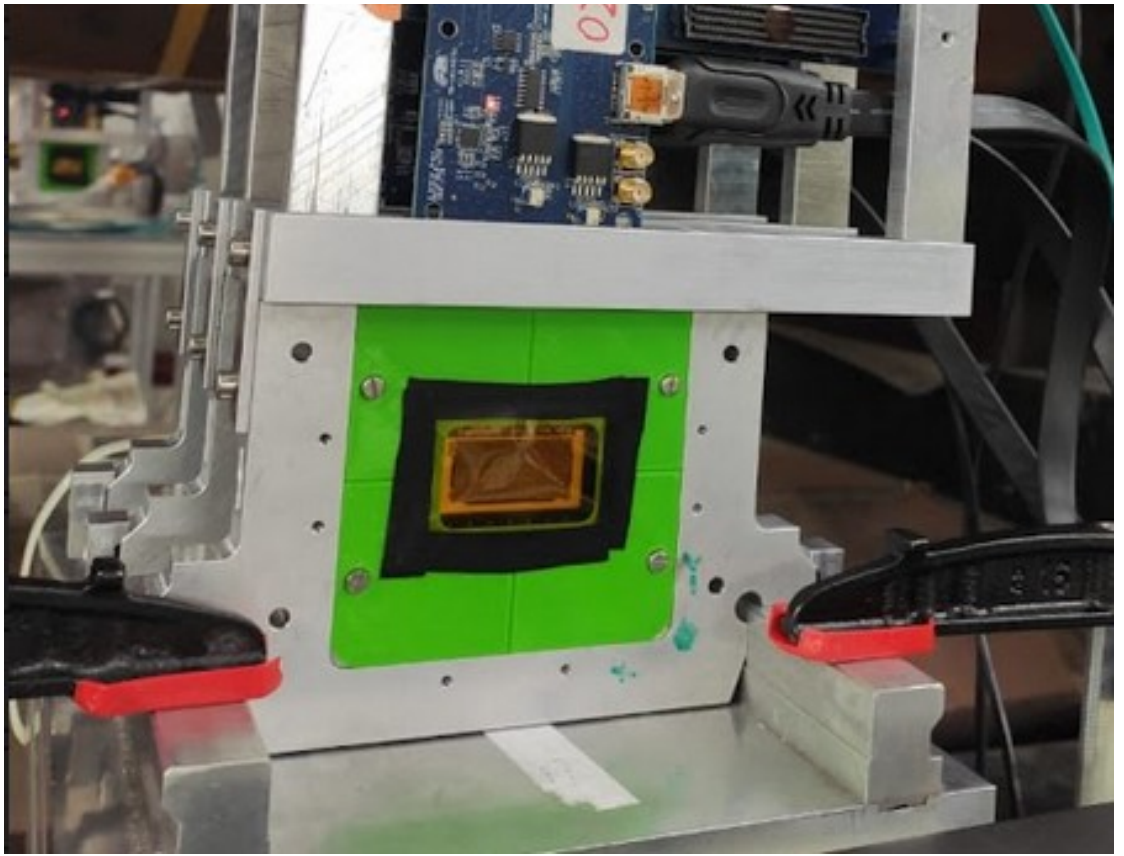
The DESY II Test Beam Facility

This is something to <u>doubt and check</u>

I used it in TB2016 simulation to match the beam width

Geant4: ALPIDE

Size	30x15 mm
Thinkness	50 μm
Material	Si

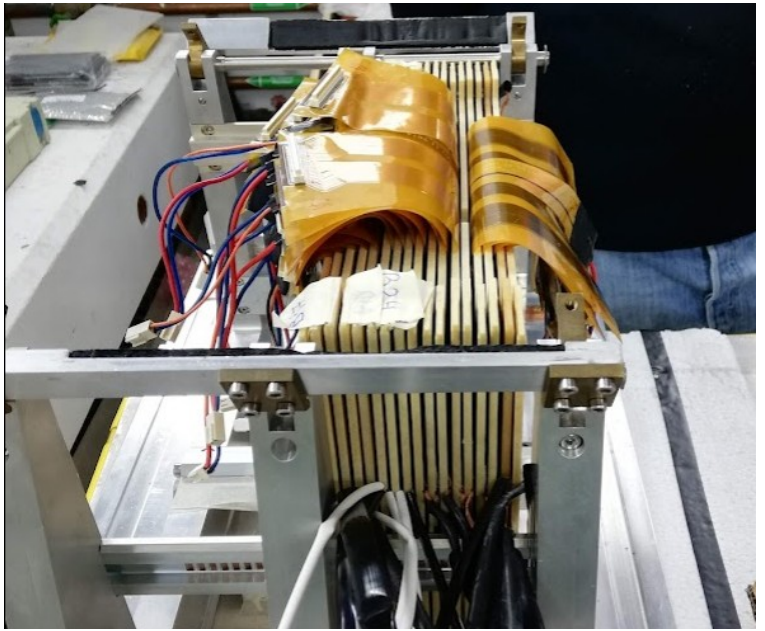


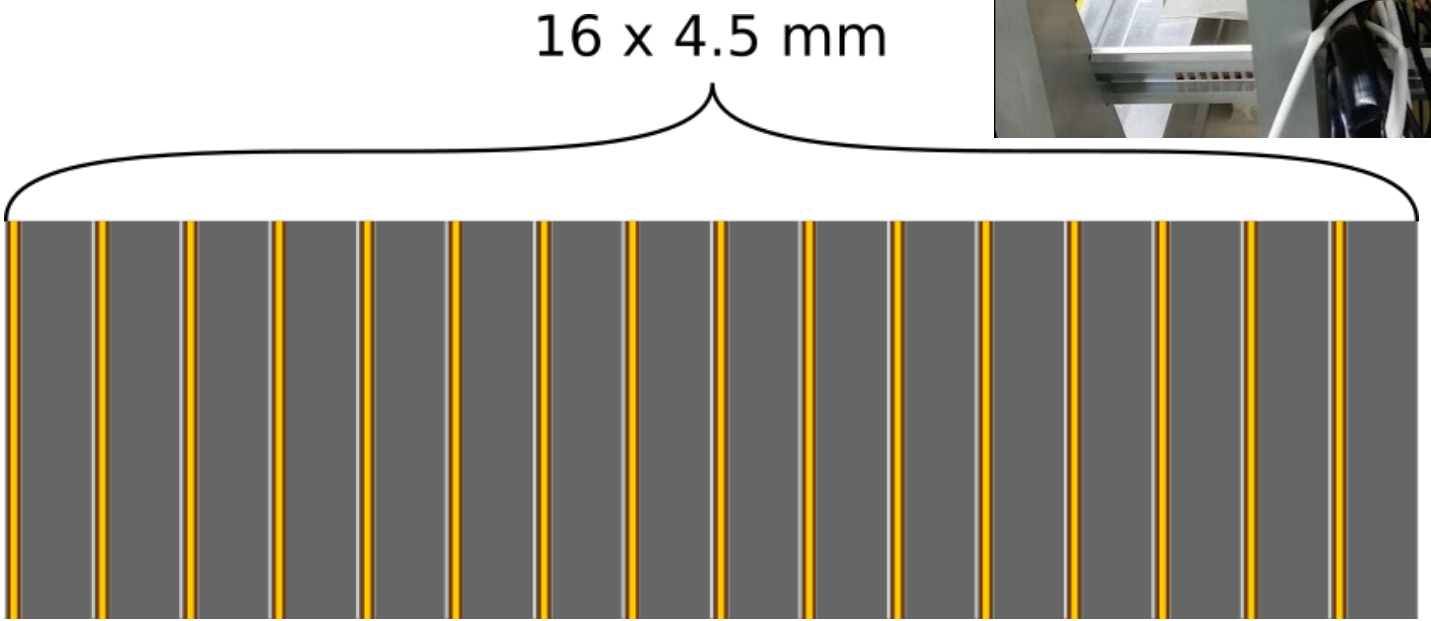
Geant4: LumiCal

- xy size: 200 x 200 mm
- Length: 72 mm = 16 layers x 4.5 mm
- Done via G4PVReplica: each layer is identical

Note:

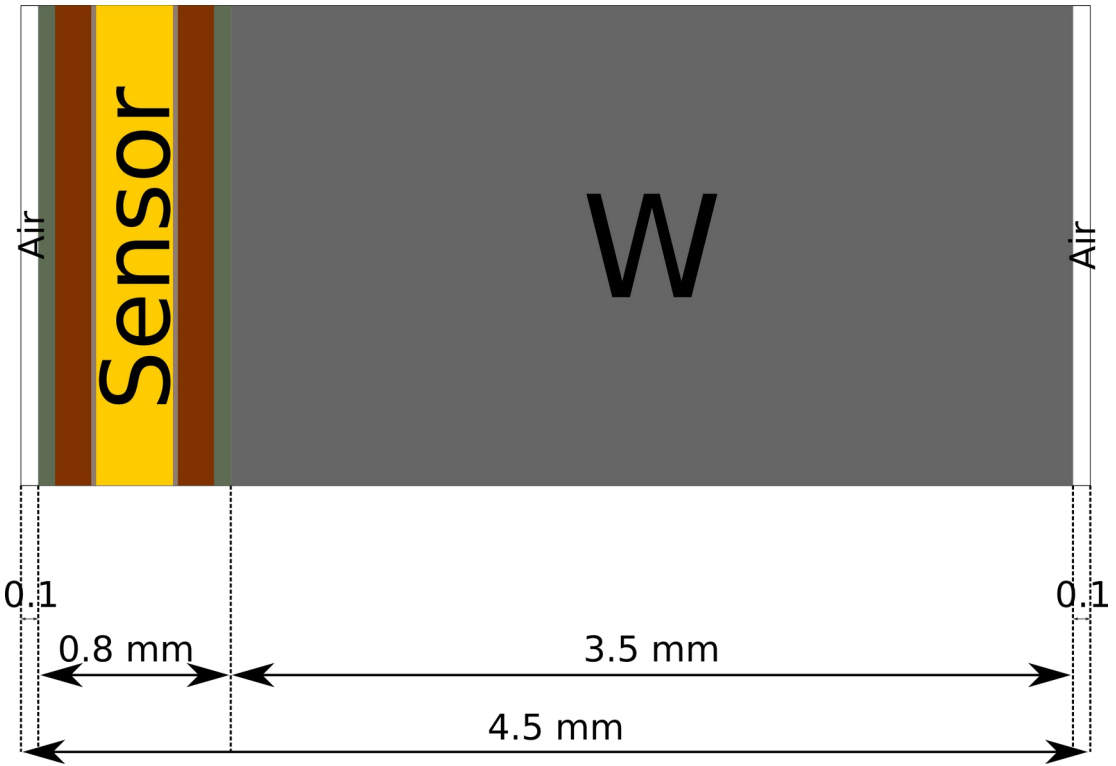
Simulation has extra sensor in front!





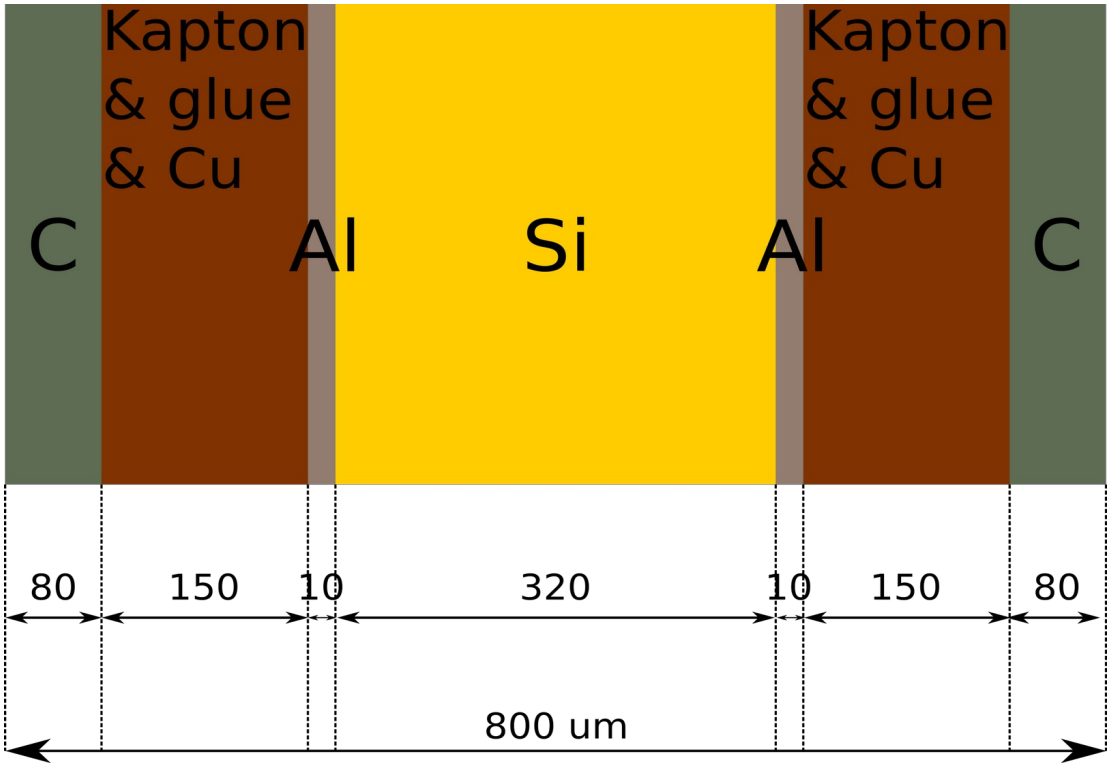
Geant4: Layer in LumiCal

- All W absorbers are 3.5 mm
- 200 μm air gaps between layers
- No gap between sensor and absorber



Geant4: Sensor in LumiCal

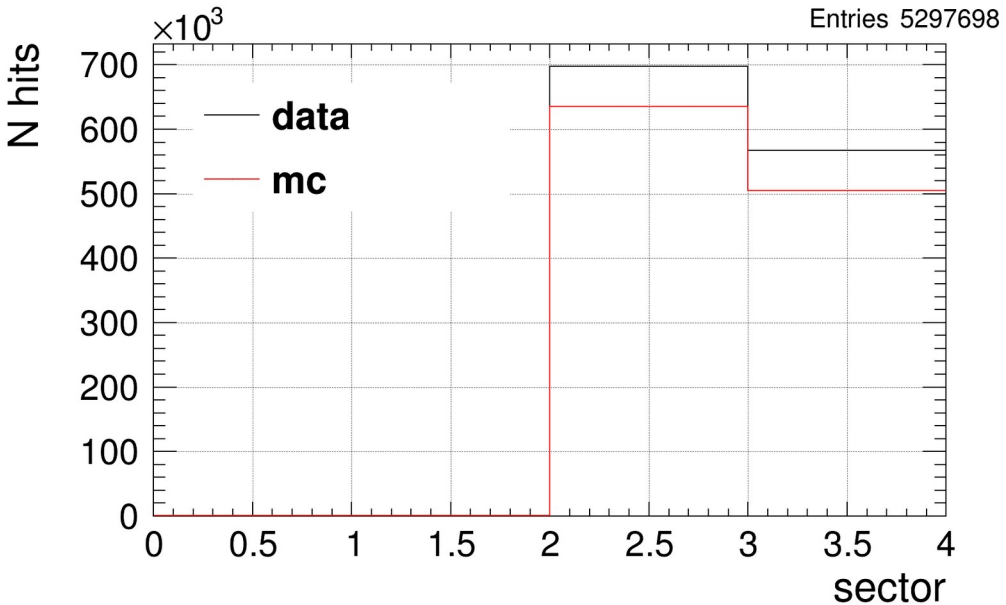
- Only Si is a sensitive volume
- Simplified **symmetric** design

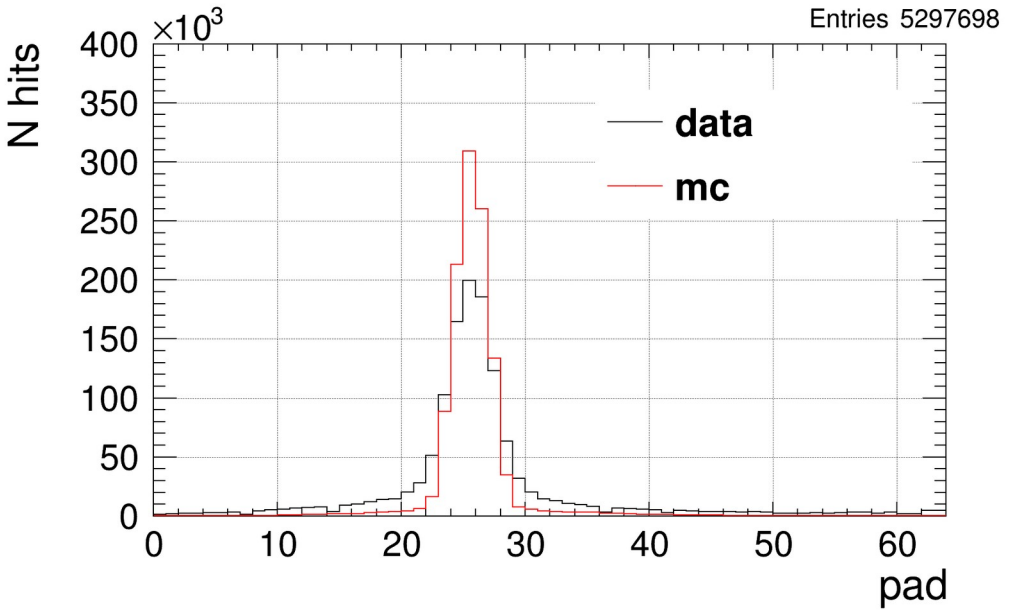


Geant4: Where to shoot?

- Try to match pad & sector beam position for $0X_0$ layer
- The best I could get using fail&try method

Shift LumiCal:
Left: 16.1 mm
Up: 12.4 mm
gun is at x,y = {0, 0}





Geant4: Summary

Many simplification:

- No scintilators
- No noise
- No energy sharing between pads
- Not precise sensor & layer design (how much air between layers? Kapton front/back?)
- Beam angular divergence under question
- No simulation of digitization & charge development in Si sensor

However, I believe it should do fine!

FLAME: get the data

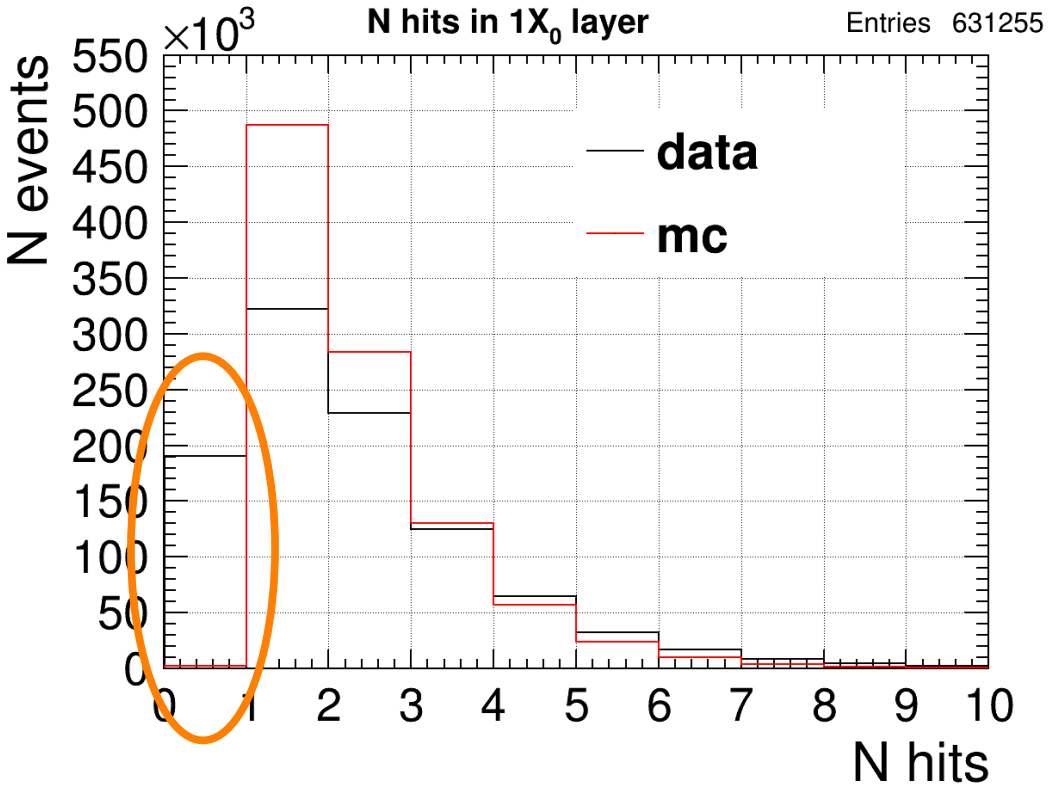
```
flame_data_0.tar.gz: 5-51 and 600-638
flame_data_1.tar.gz: 639-651
flame_data_2.tar.gz: 652-660
flame_data_4.tar.gz: 661
flame_data_5.tar.gz: 662
flame_data_8.tar.gz: 663
flame_data_9.tar.gz: 664-670
flame_data_10.tar.gz: 671
flame_data_11.tar.gz: 672
flame_data_13.tar.gz: 673-674
flame_data_15.tar.gz: 675-711
flame_data_16.tar.gz: 712-739
flame_data_17.tar.gz: 740
flame_data_18.tar.gz: 741
flame_data_19.tar.gz: 742-758
flame_data_20.tar.gz: 759-809
flame_data_21.tar.gz: 810-826
flame_data_22.tar.gz: 827
flame_data_23.tar.gz: 828
flame_data_24.tar.gz: 829
flame_data_25.tar.gz: 830-912
flame_data_26.tar.gz: 913-1074
flame_data_27.tar.gz: 1075-1197
flame_data_28.tar.gz: 1198-1252
flame_data_29.tar.gz: 1253-1514
flame_data_30.tar.gz: 1515-1543 and 53076
```

- First 5 GeV entry in the logbook is in the 11th tar!
- Had to download all of them to check...
- I put it here if somebody will need it later
- BUT it would be very nice to have this relation on the download page, so people can check runs they need before downloading and not download all > 30 GB of data...

FLAME: get the data

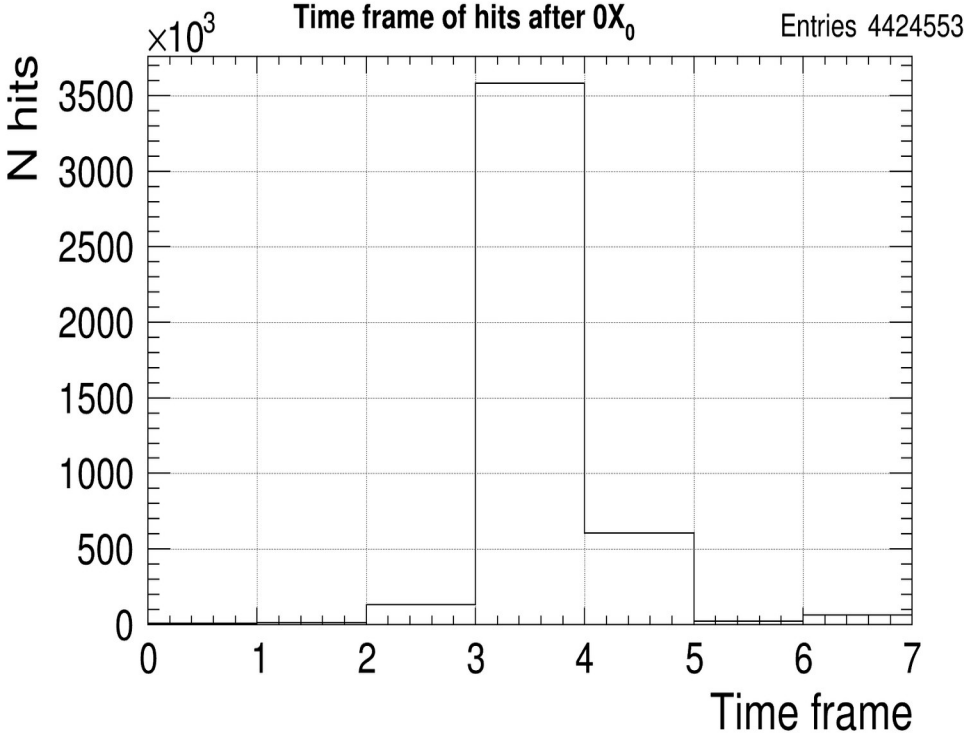
Short name	Occupied layers	Total events
a	$1X_0$, $2X_0$, $3X_0$	631 255
b	$4X_0$, $5X_0$, $6X_0$	554 901
c	$7X_0$, ~~$8X_0$~~, $9X_0$	754 365
d	$10X_0$, $11X_0$, $12X_0$	539 300
e	$13X_0$, $14X_0$, $15X_0$	616 479
f	$8X_0$	519 562
aa	$0X_0$, ~~$1X_0$, $2X_0$~~	7 069 123
MC	ALL	1 000 000

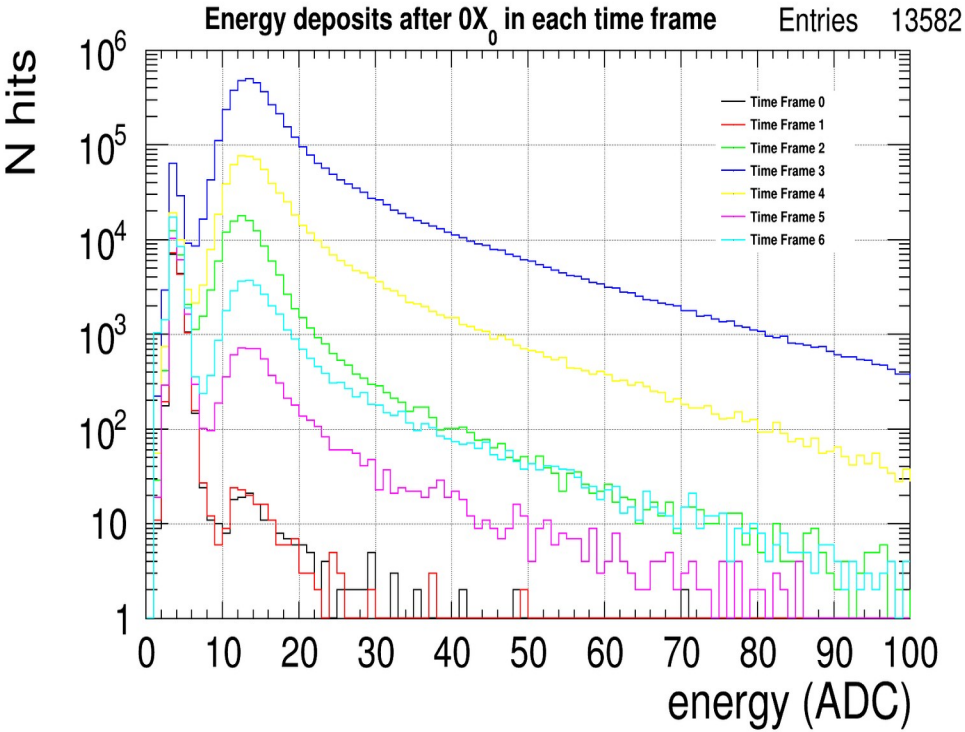
FLAME: Normalization



- Almost 1/3 of events are empty in DATA
- Use only NON-empty for normalization!
- I do “non-empty” check for each plane

FLAME: Time frames

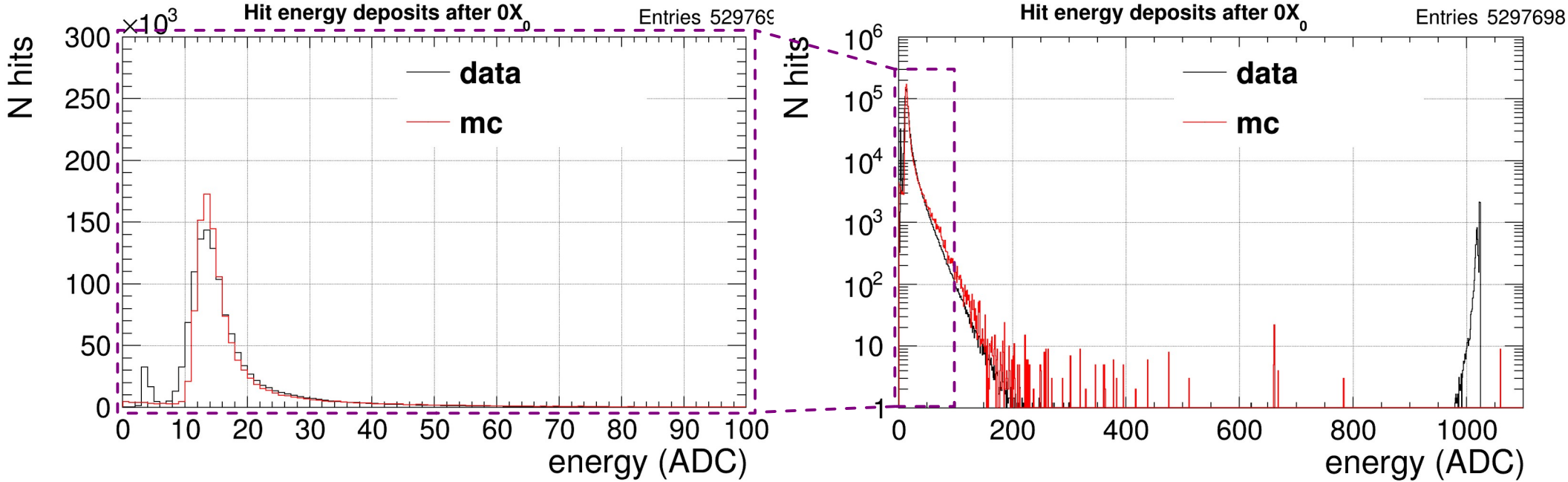




- In FLAME: 1 event = 7 time frames
- Previously only 2, 3, 4 time frames were used.
- I will use all time frames. Signals seem physical

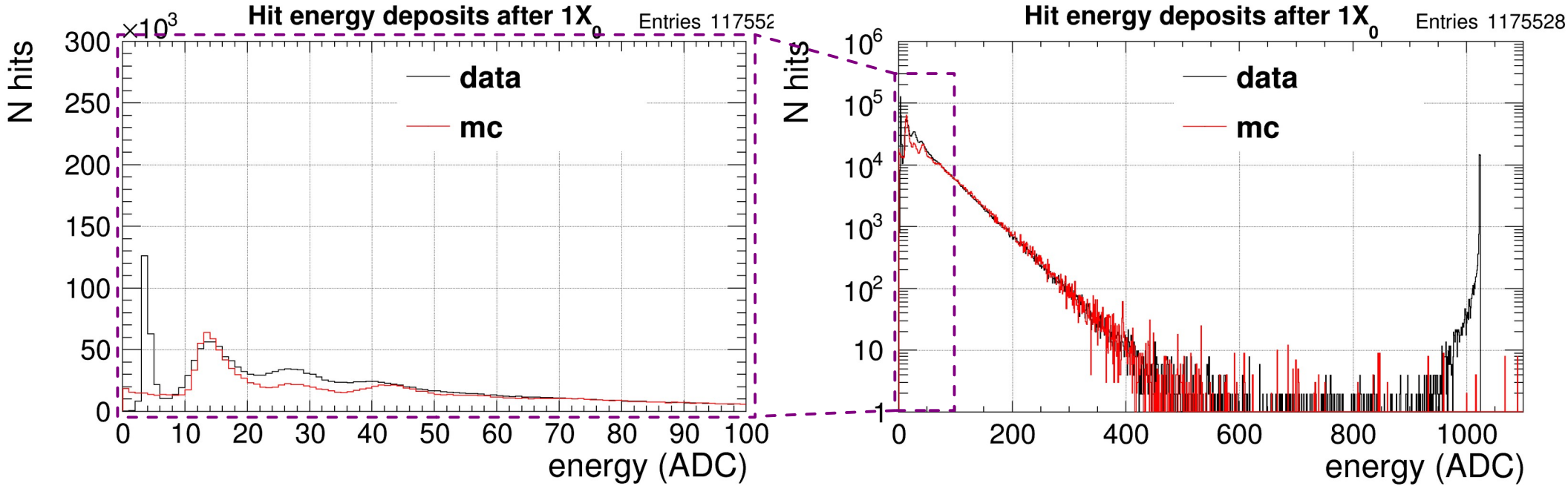
Control plots: energy depositions per pad

MC energy scaled by 145.5288



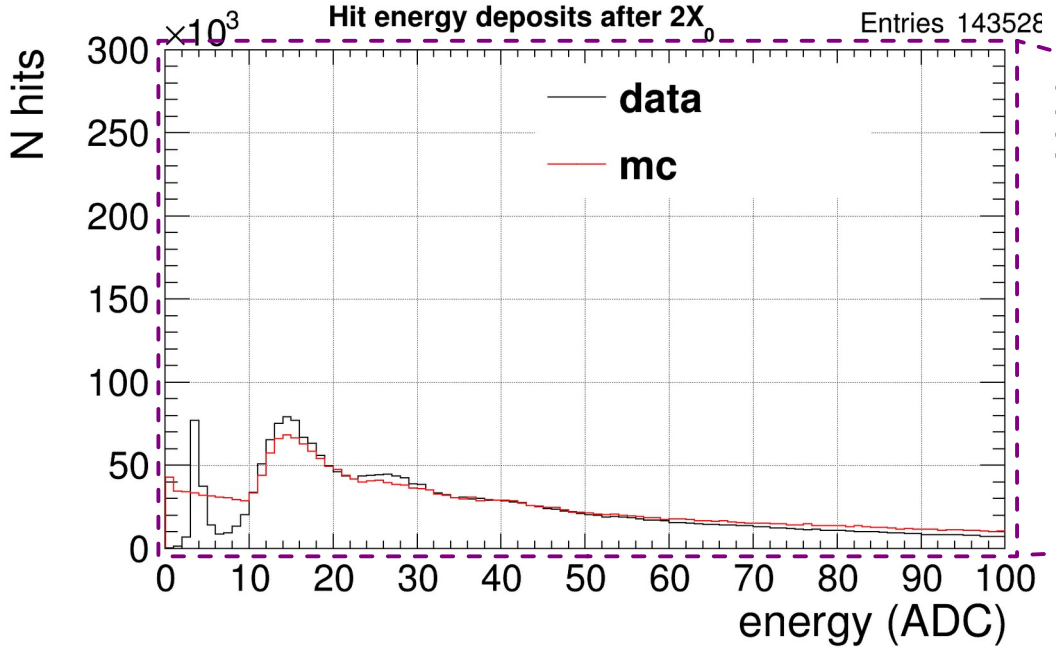
Control plots: energy depositions per pad

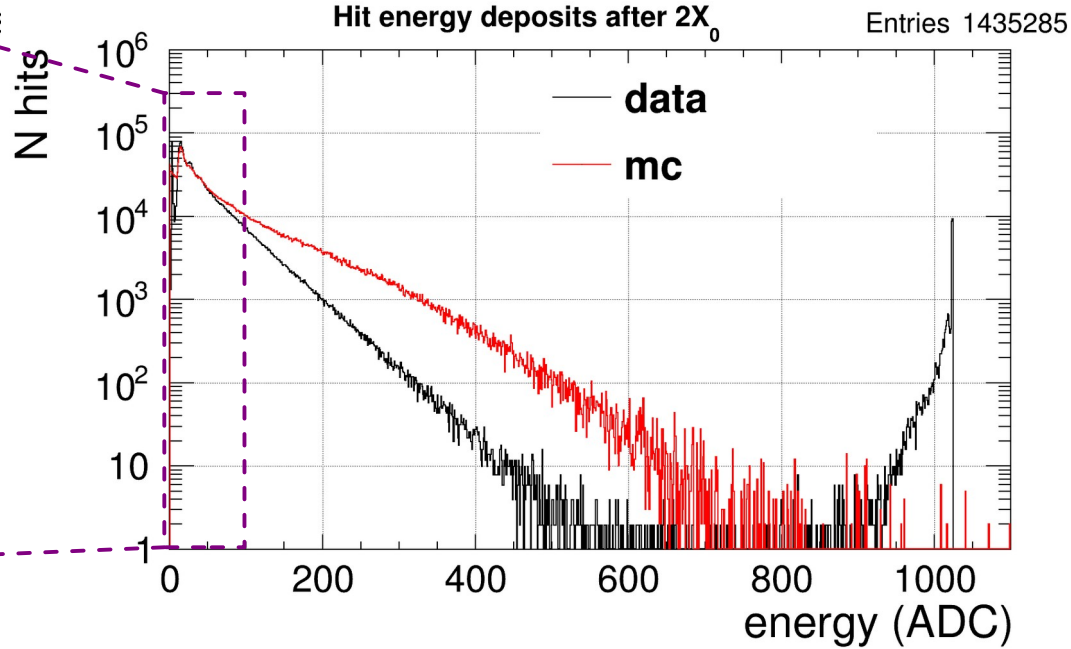
MC energy scaled by 145.5288



Control plots: energy depositions per pad

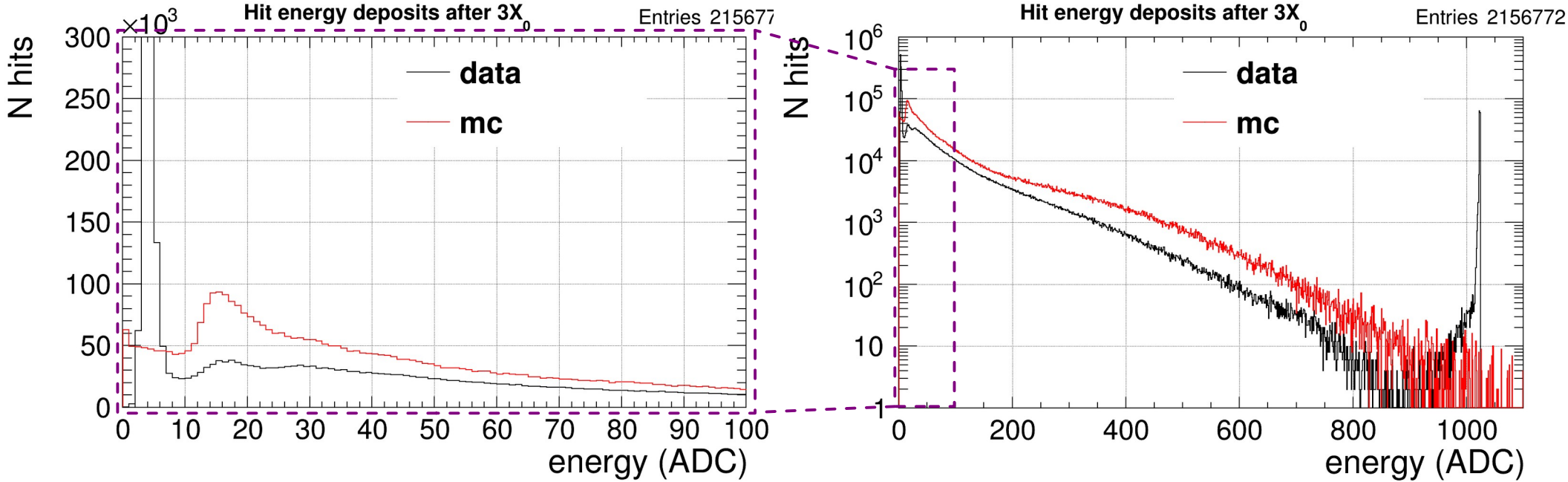
MC energy scaled by 140.2467





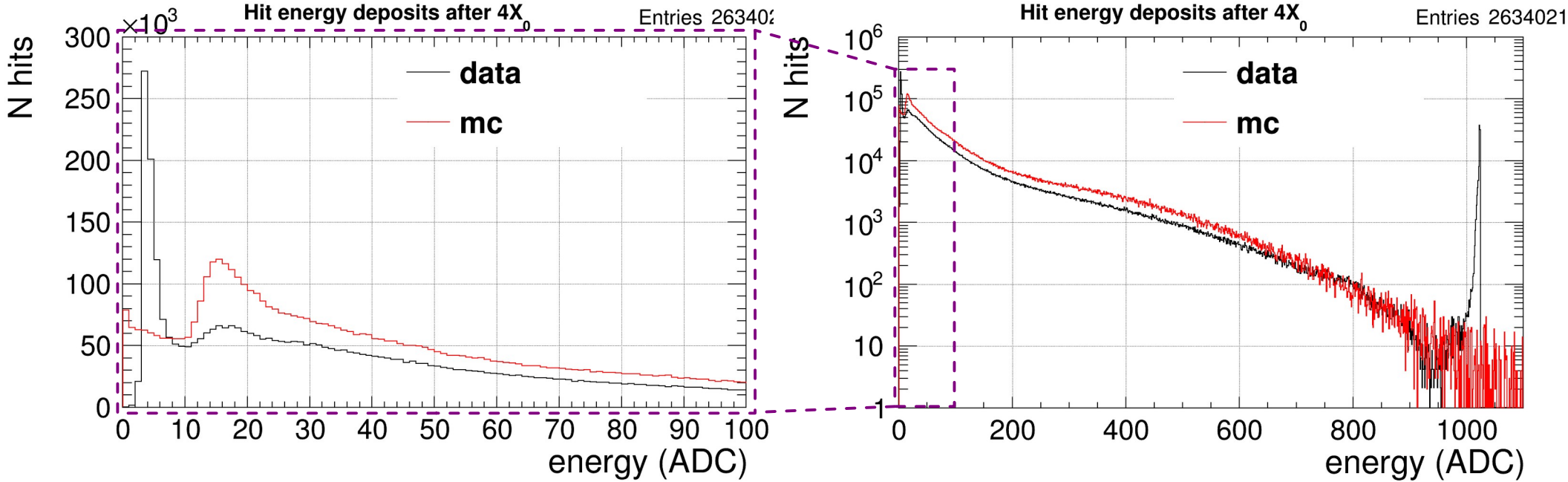
Control plots: energy depositions per pad

MC energy scaled by 145.5288



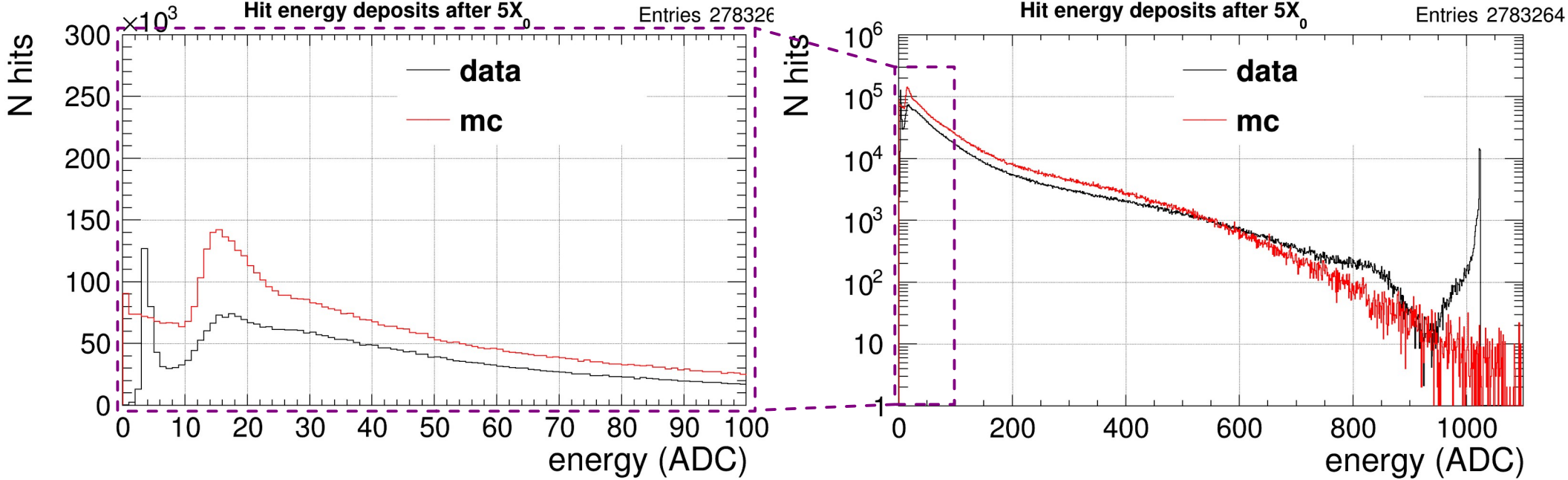
Control plots: energy depositions per pad

MC energy scaled by 145.5288



Control plots: energy depositions per pad

MC energy scaled by 145.5288



Control plots: energy depositions per pad

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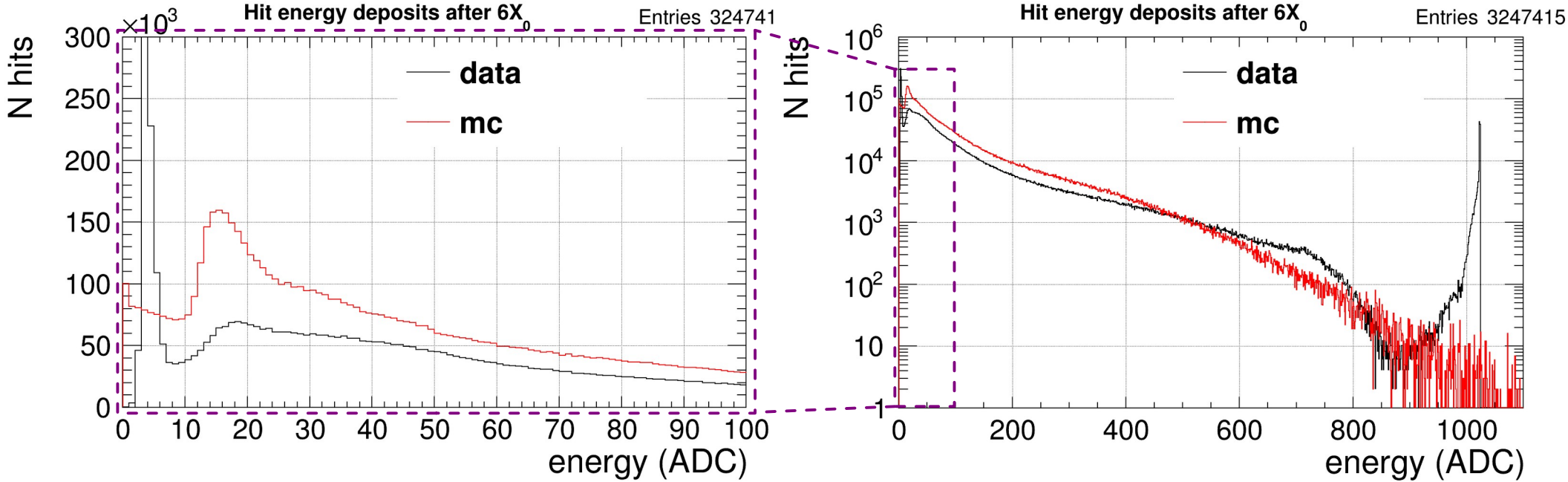
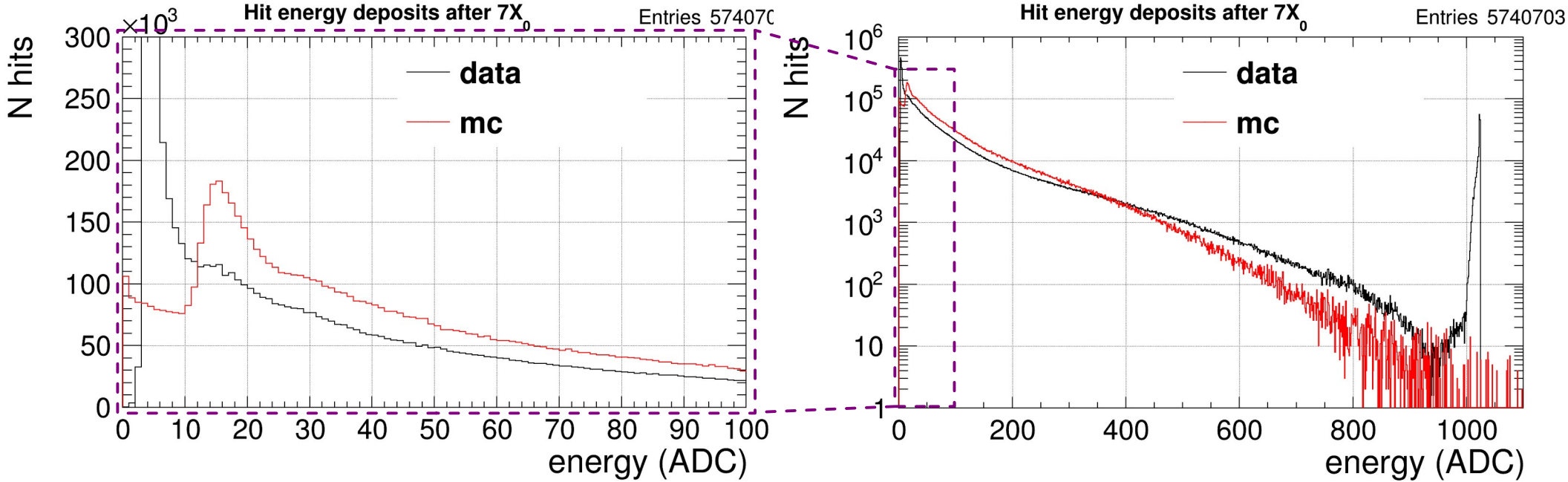


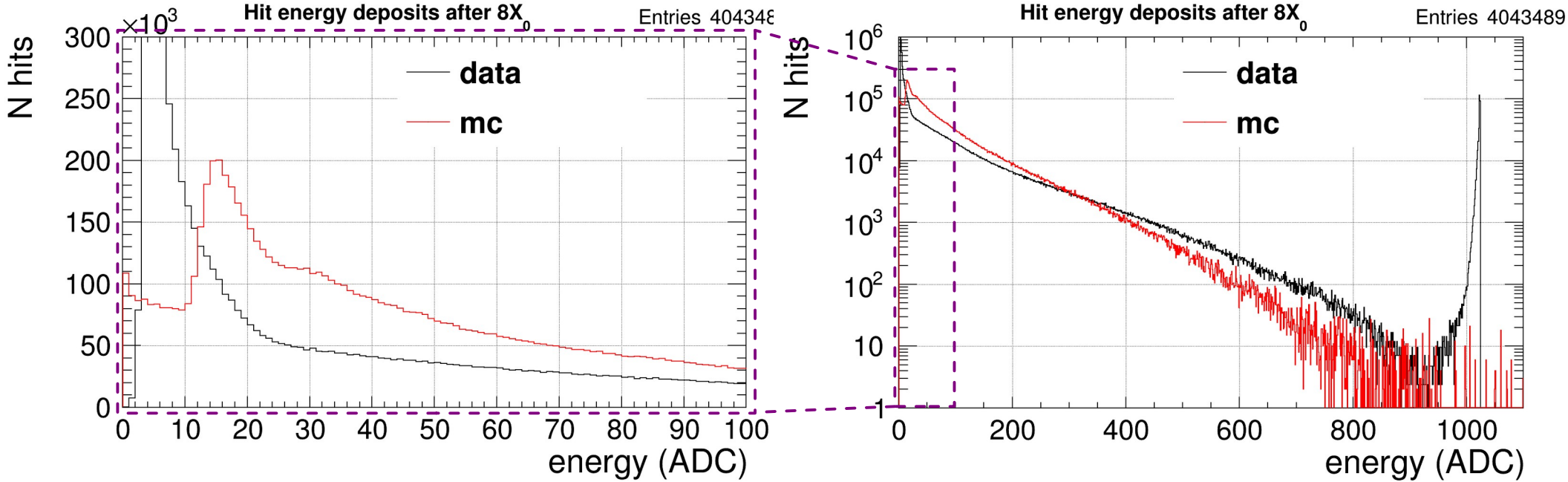
Control plots: energy depositions per pad

MC energy scaled by 145.5288



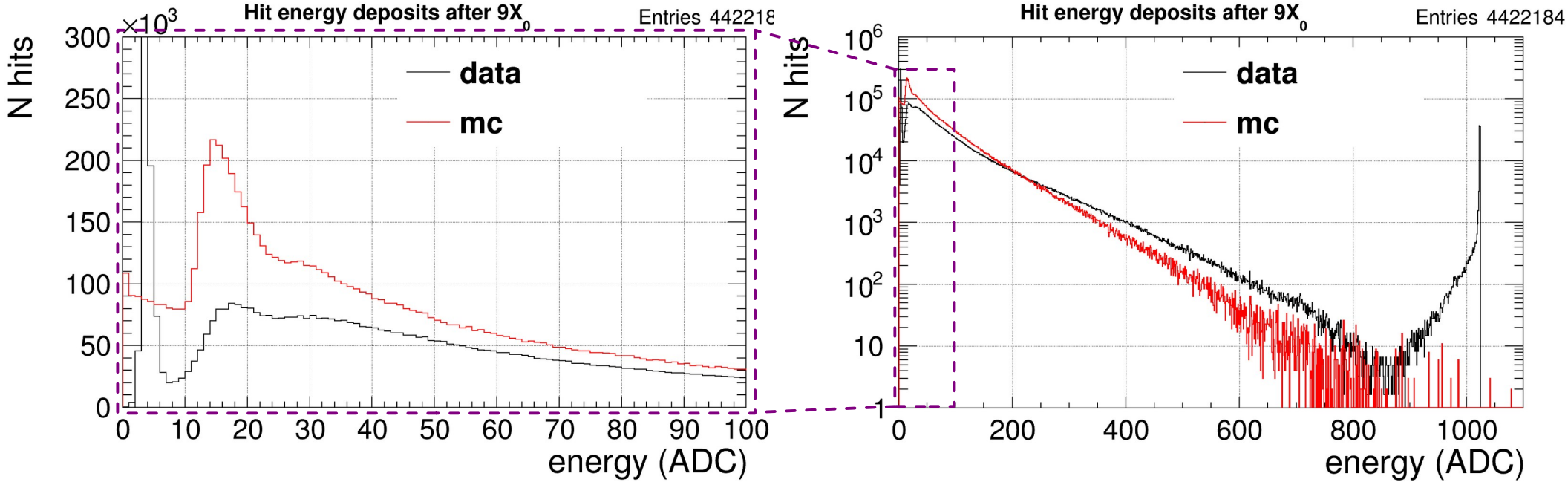
Control plots: energy depositions per pad

MC energy scaled by 145.5288



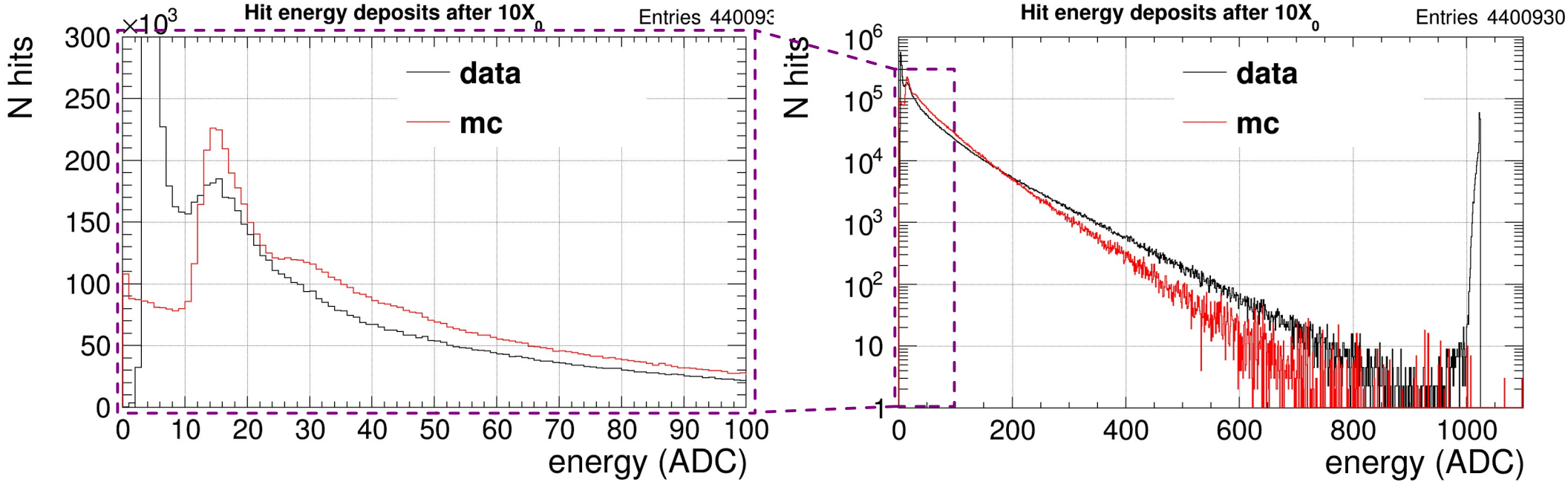
Control plots: energy depositions per pad

MC energy scaled by 145.5288



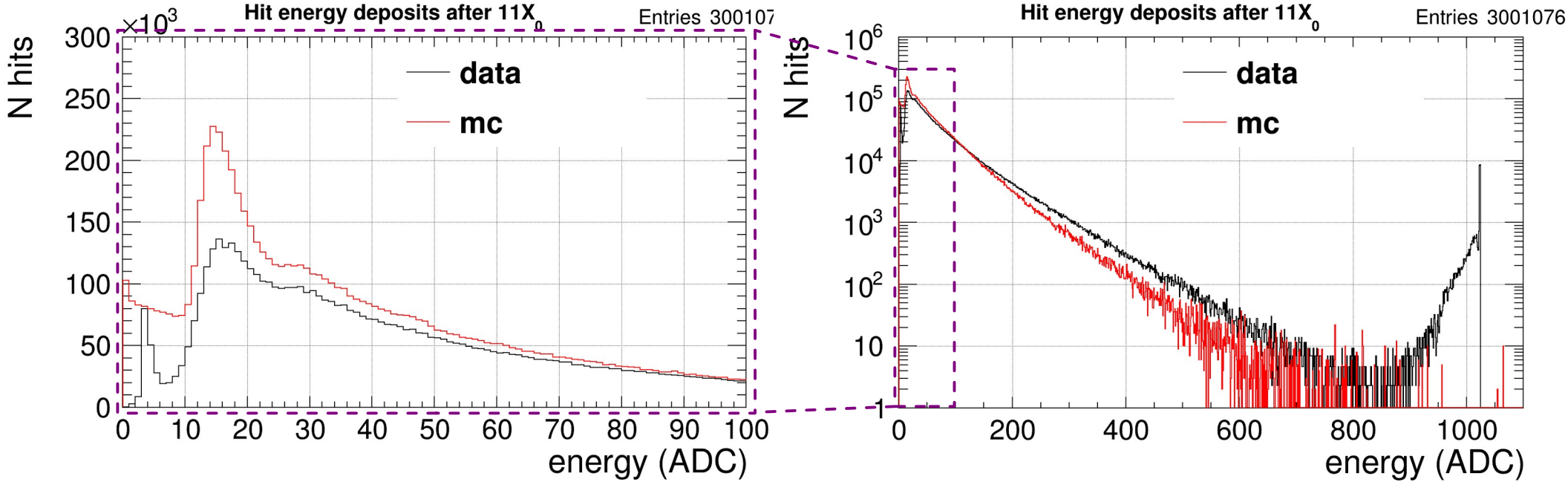
Control plots: energy depositions per pad

MC energy scaled by 145.5288



Control plots: energy depositions per pad

MC energy scaled by 145.5288



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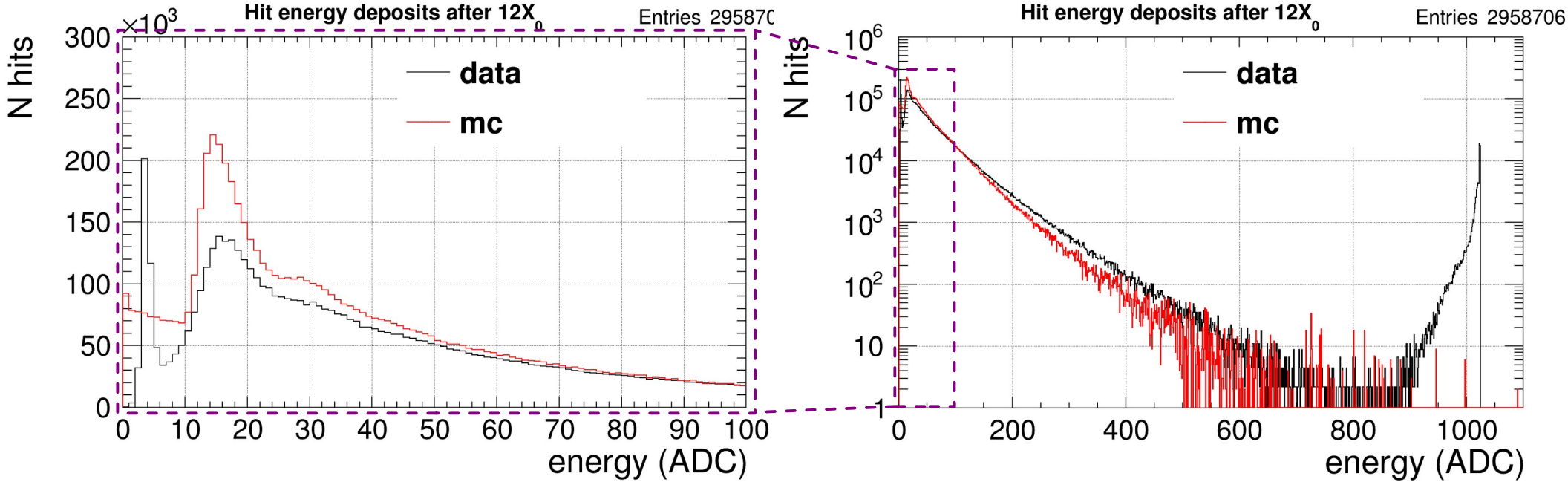
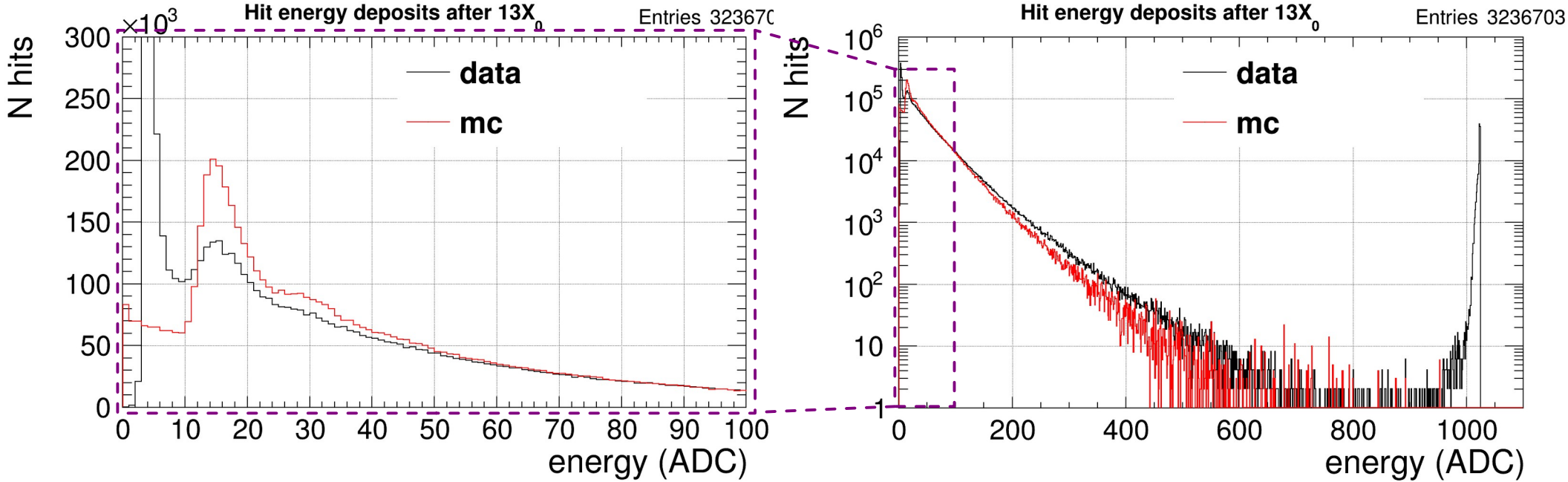


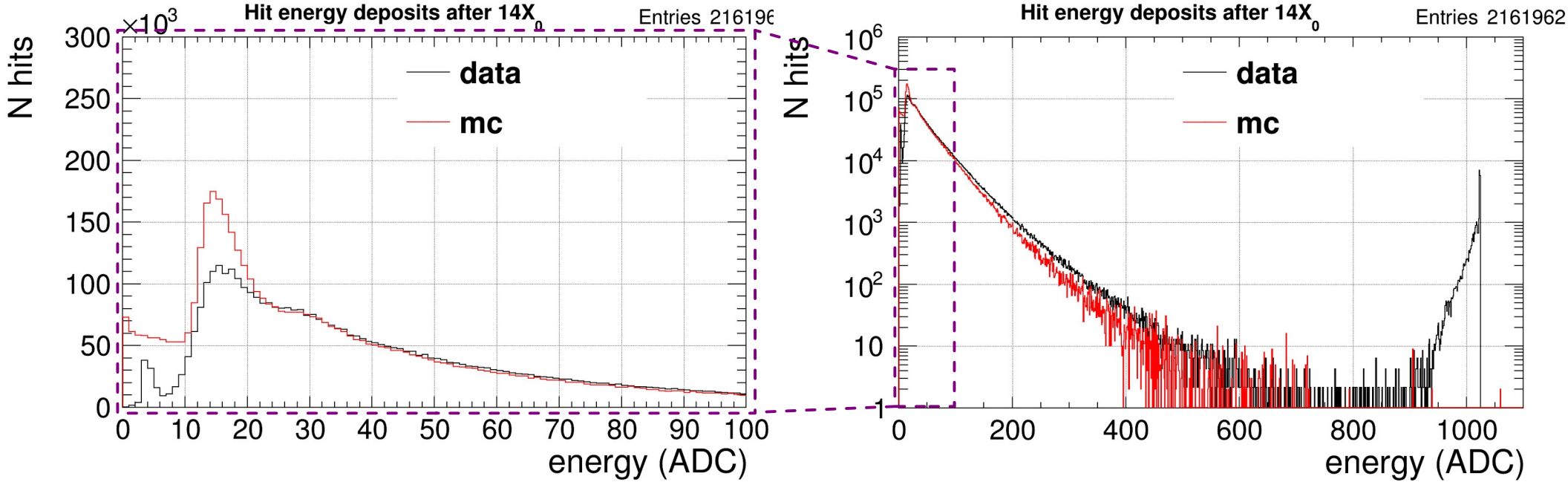
Control plots: energy depositions per pad

MC energy scaled by 145.5288



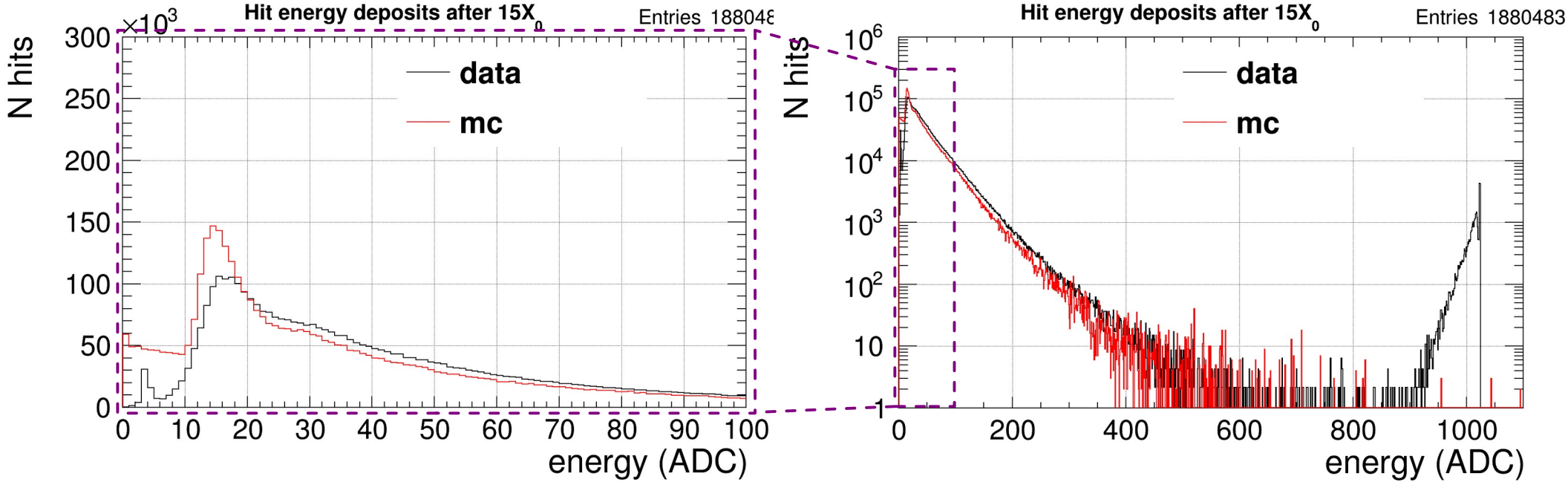
Control plots: energy depositions per pad

MC energy scaled by 145.5288



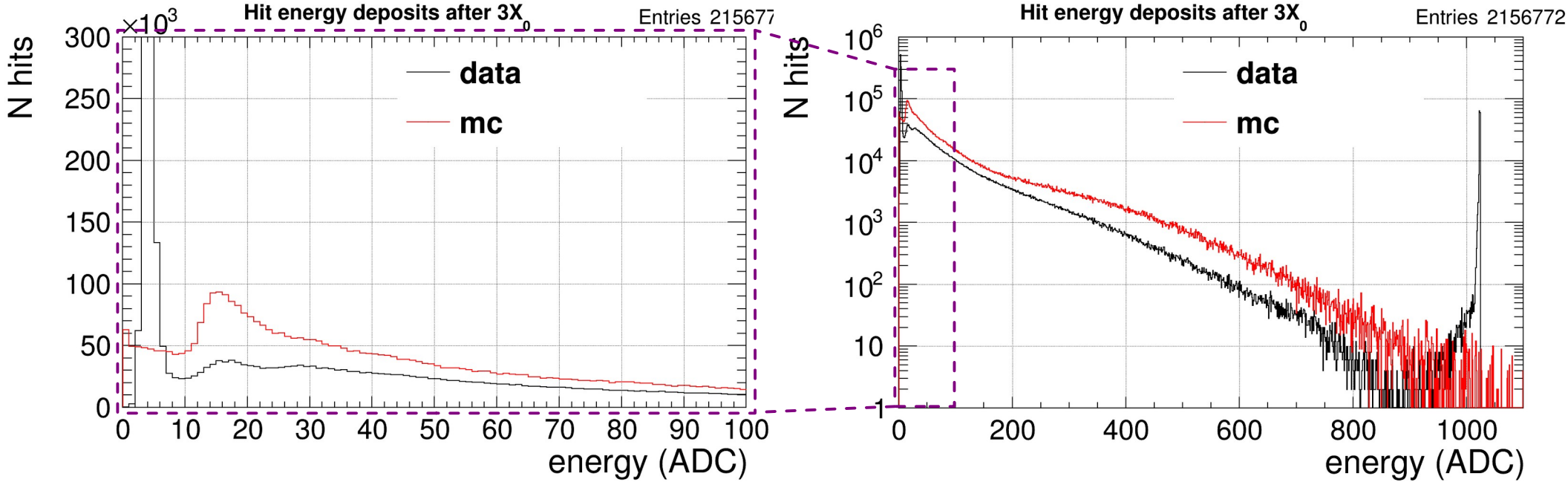
Control plots: energy depositions per pad

MC energy scaled by 145.5288



Control plots: try to cut and then normalize!

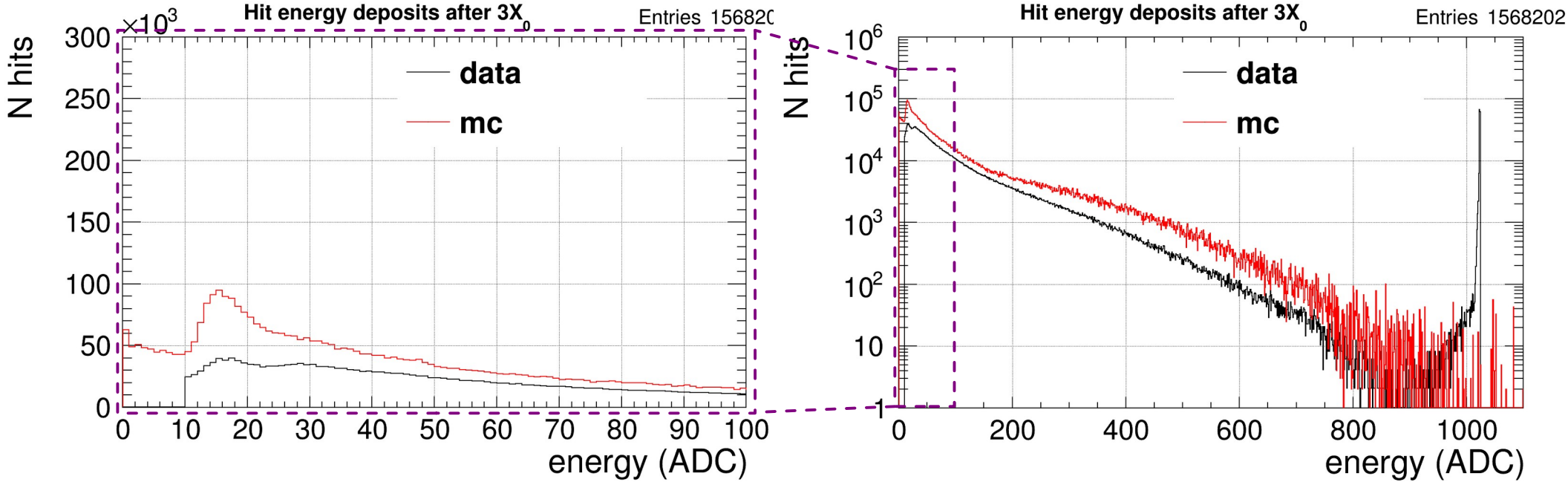
MC energy scaled by 145.5288



- Maybe there are “almost” empty events but with some noise hits!?
- I should also reject those for normalization!
- Try to cut < 10 ADC hits and normalize only non-empty events again

Control plots: try to cut and then normalize!

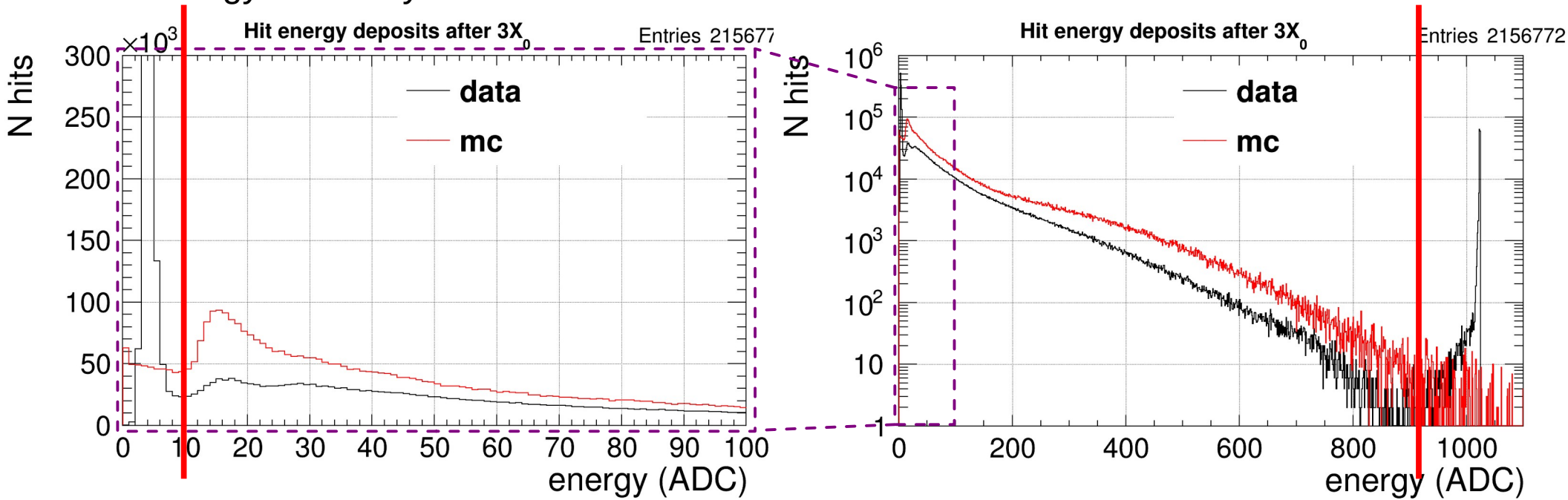
MC energy scaled by 145.5288



- It doesn't work.
- It means "noise" hits come mostly in events with normal hits!
- They are not empty events.

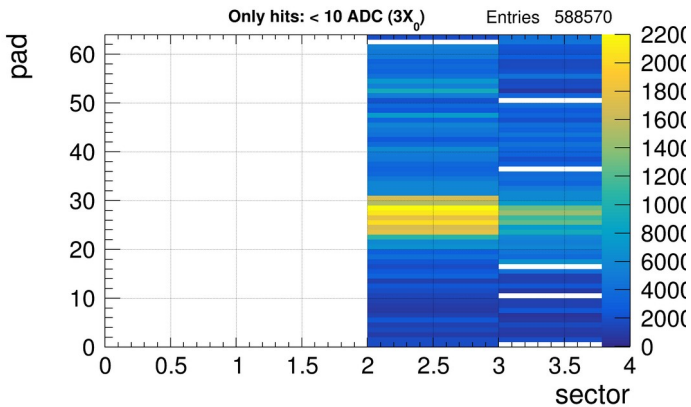
Control plots: try to cut and then normalize!

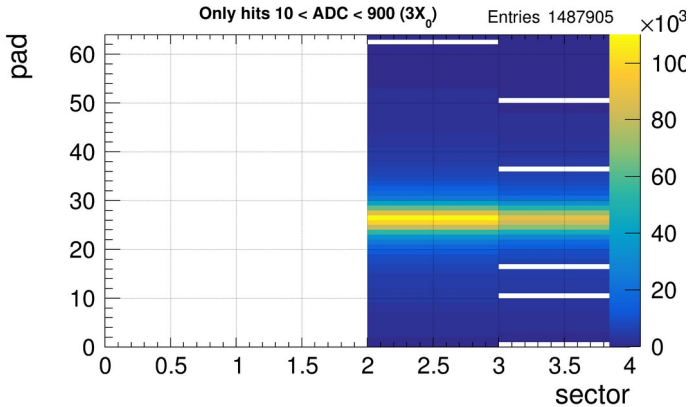
MC energy scaled by 145.5288

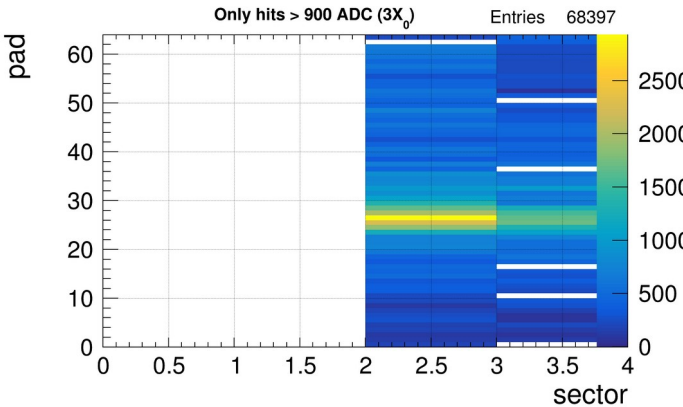


- Check what are those “noise hits”

Control plots: studying “noise” hits

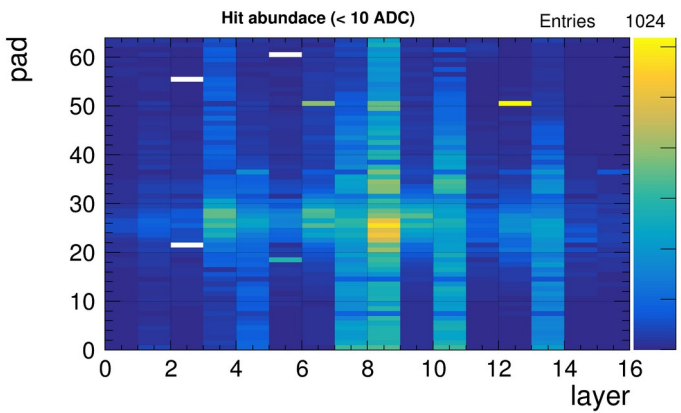


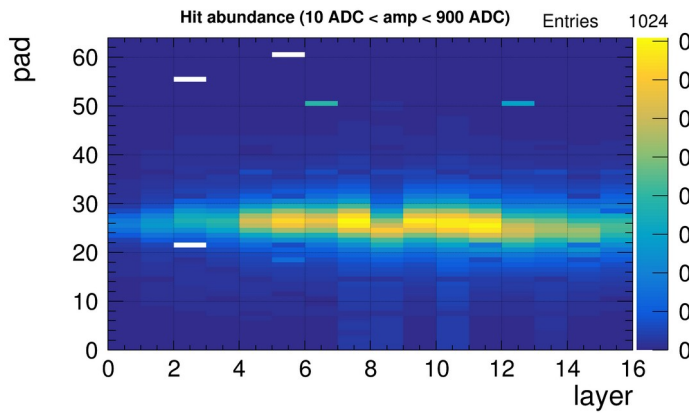


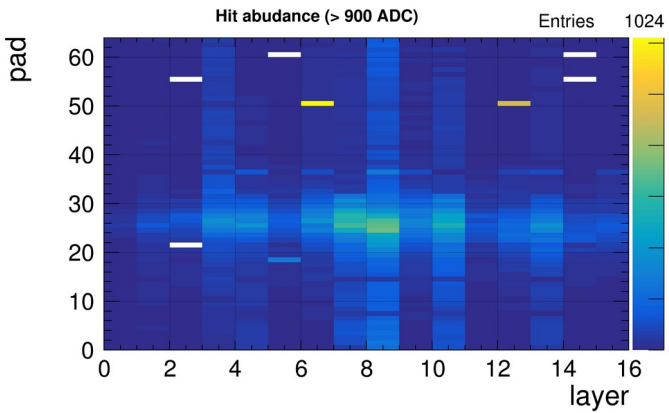


Beam profile is visible even in noise hits!?

Control plots: studying “noise” hits







Beam profile is visible even in noise hits!?

My guess:

- Sometimes FLAME fails to measure energy properly

Control plots: What about SRS?

```
srs_data_1.tar.gz: 101 - 118
srs_data_2.tar.gz: 11, 12, 13, 15, 118, 157-164
srs_data_3.tar.gz: 16, 164-179
srs_data_4.tar.gz: 179-191
srs_data_5.tar.gz: 19, 191-200
srs_data_6.tar.gz: 20, 200-218
srs_data_7.tar.gz: 22-36, 218, 219, 239
srs_data_8.tar.gz: 36-48,70-77
srs_data_9.tar.gz: 77-92
srs_data_10.tar.gz: 92-99
```

Runs: 78, 79, 80
No FLAME, only SRS in layers 1-8
LumiCal tilted by 2 degrees
5 GeV beam
Beam position ~4 pads above than in FLAME runs

Control plots: What about SRS?

Summary

- MC is good
- Missing events! → Check telescope!
- Missing hits in FLAME - ?
- Wrong energy assignment in FLAME?
- Check SRS agreement? Slightly more complicated because cuts will influence N empty events more

Back up: couldn’t easily convert ADC to MeV...