

# Chip saturation and hit carried over issues of INTT

Cheng-Wei Shih,  
National Central University/RIKEN

Dec 20th, 2024  
Operation Board meeting



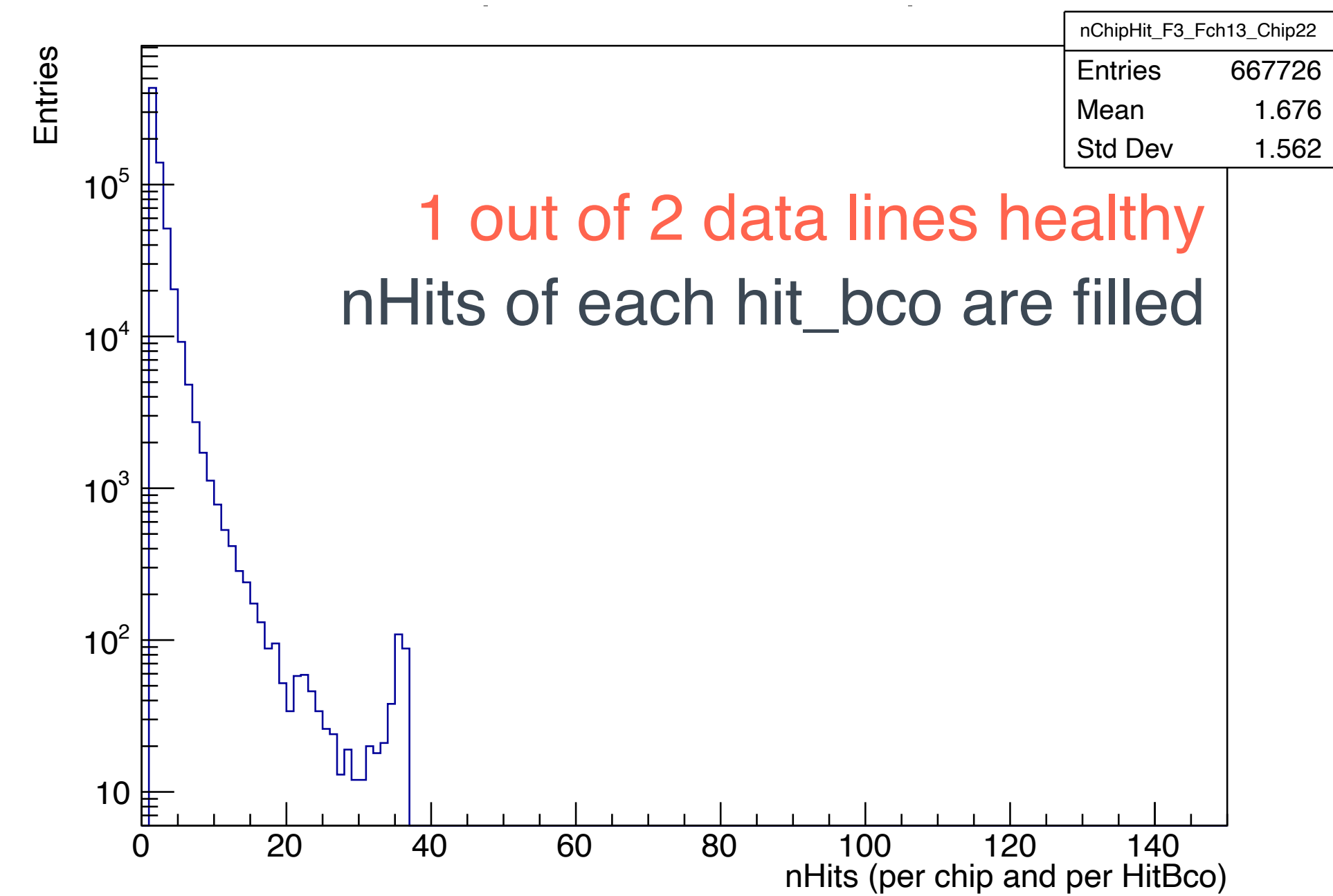
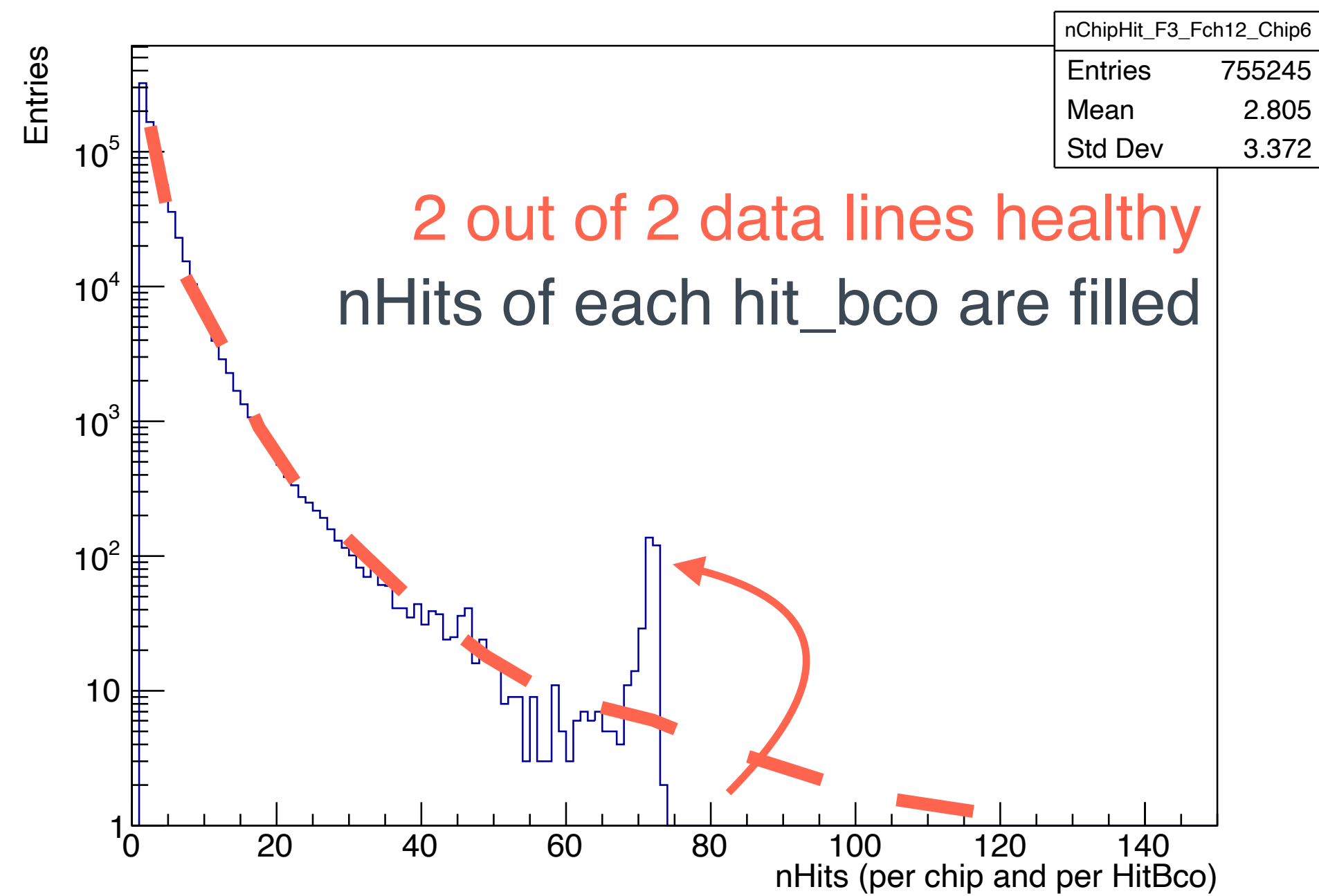
國立中央大學  
National Central University



- Two issues are identified/confirmed recently that might impact to the INTT operation in run 2025
  - Chip saturation issue:
    - The INTT hits are rejected by FELIX if they arrive at FELIX too late
  - Hit carried over issue (The hits in one event are split into two events):
    - The next trigger sent to the FELIX too quick that the FELIX is still waiting for the hits arriving and processing those hits for the previous event
    - This problem can be more severe in Run25 (due to even higher trigger rate, ~10k Hz?)
- We would like to propose/discuss the potential mitigation strategies
- The plots shown in the slides were made with the run 54280 taken in Run24

Runnumber	Collision species	Field	Trigger rate	INTT FELIX open
54280	Au + Au	zero-field	~ 3000 Hz	60

Count the number of hits of each chip, per hit\_bco (Clone hits are removed\*)



- The distinct cutoff in the right edge of each distribution indicates that INTT has chip saturation issue
- All chips (2912 chips) are suffered from the saturation issue

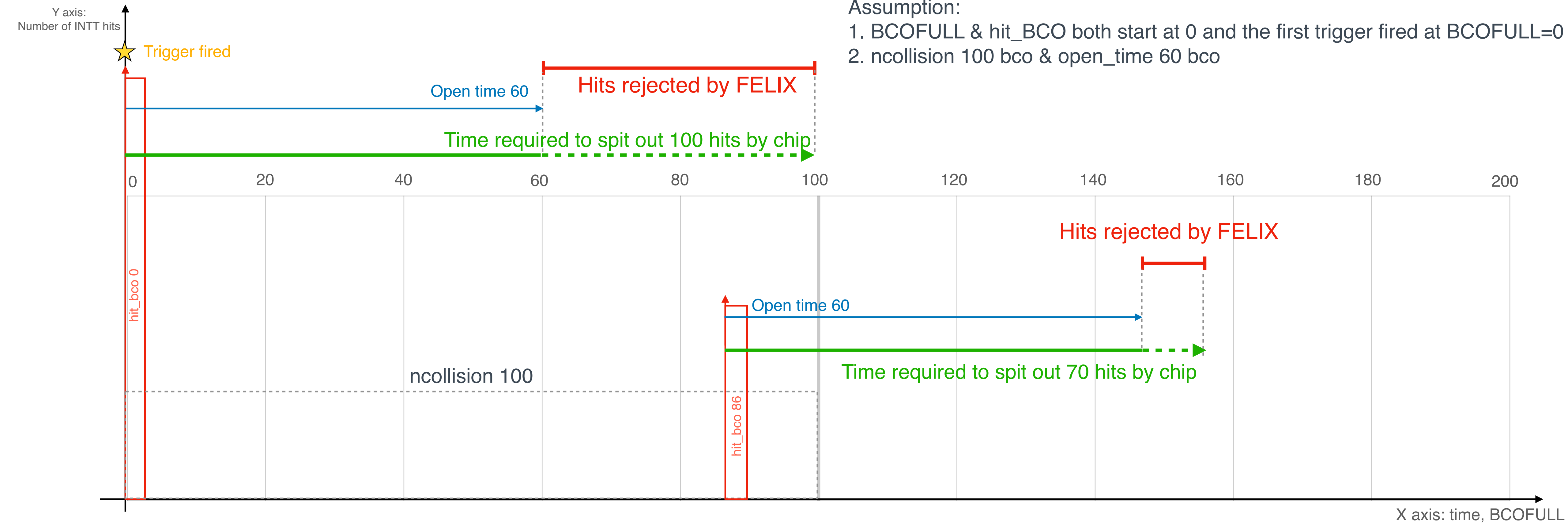
\*(CloneHit: same FELIX, FELIX\_ch, chip\_id, chan\_id, hit\_bco)

Note: the FPHX goal of hit transmission from chip to ROC: 4 hits in 4 BCOs

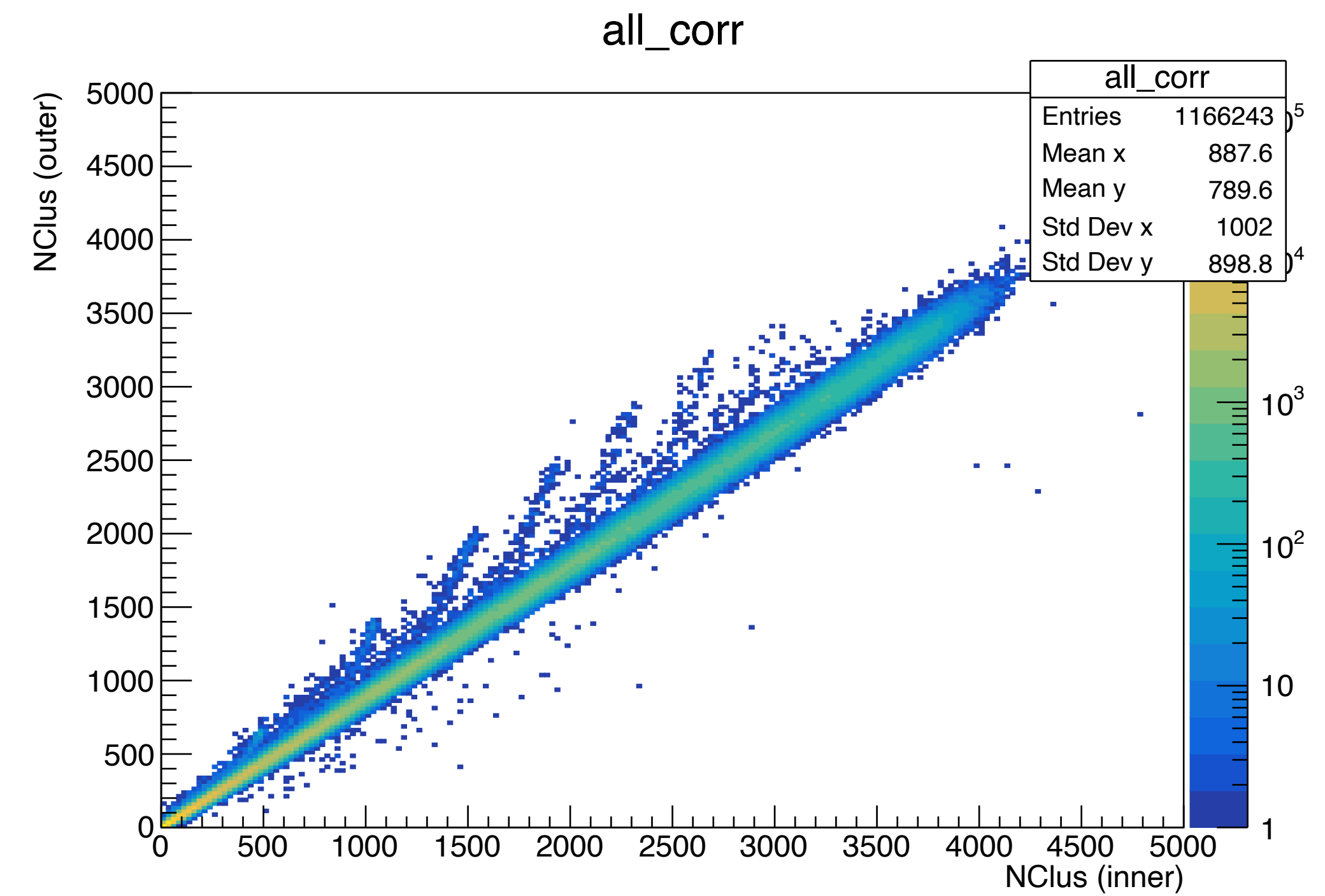
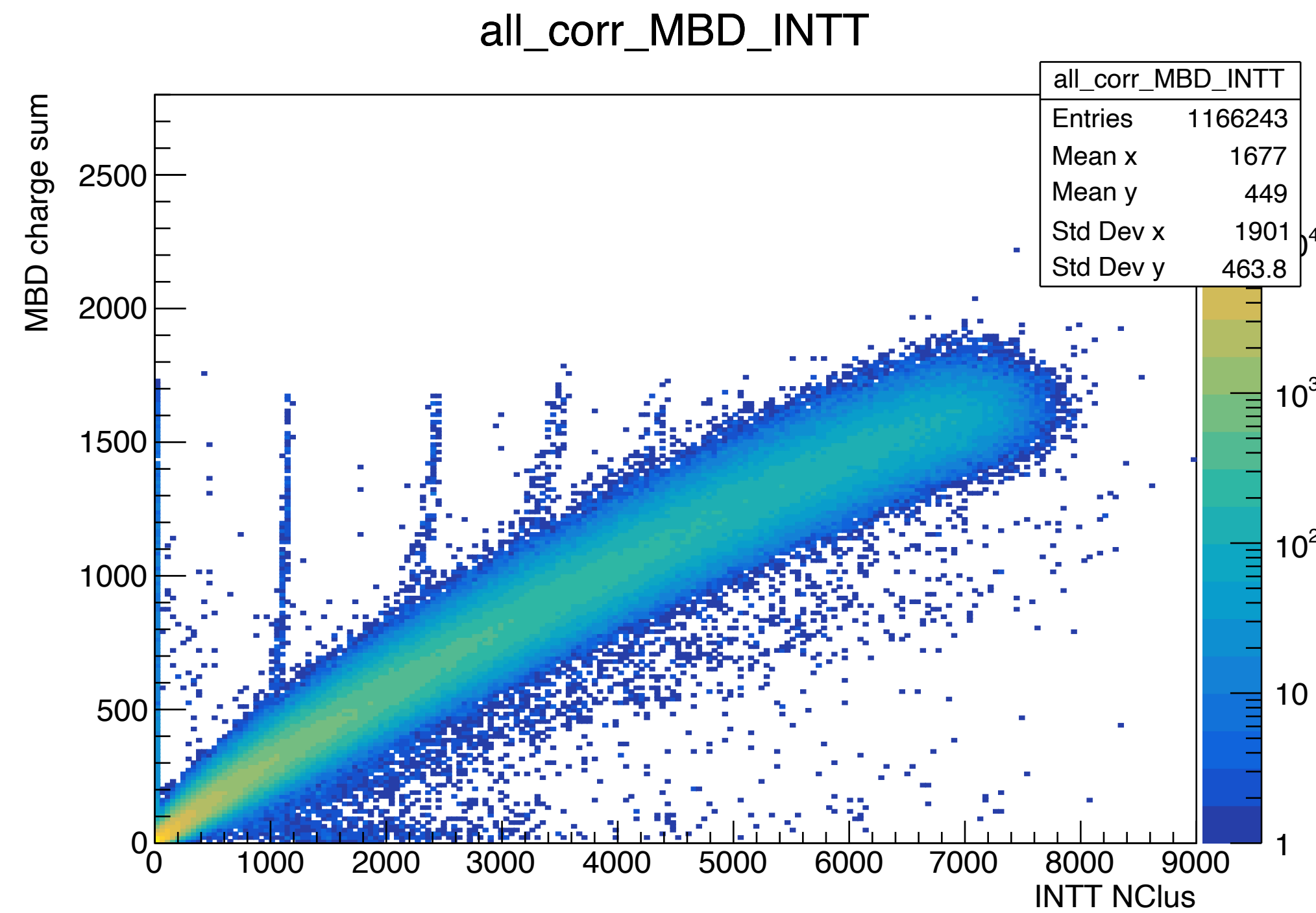
In single event

Assumption:

1. BCOFULL & hit\_BCO both start at 0 and the first trigger fired at BCOFULL=0
2. ncollision 100 bco & open\_time 60 bco



1. Assume in the triggered event (hit\_bco 0, BCOFULL=0), there is one chip detecting 100 hits. It's going to take a period of time (~ 100 BCO) to send out all the hits
2. When FELIX detects the first hits with the "hit\_bco\_0", it's going to open a certain time window (controlled by open\_time) to accept the hits with "hit\_bco\_0", vice versa.
3. Assuming open\_time is 60. There will be ~ 40 hits that cannot make it to arrive at the FELIX on time. They are therefore dropped by FELIX

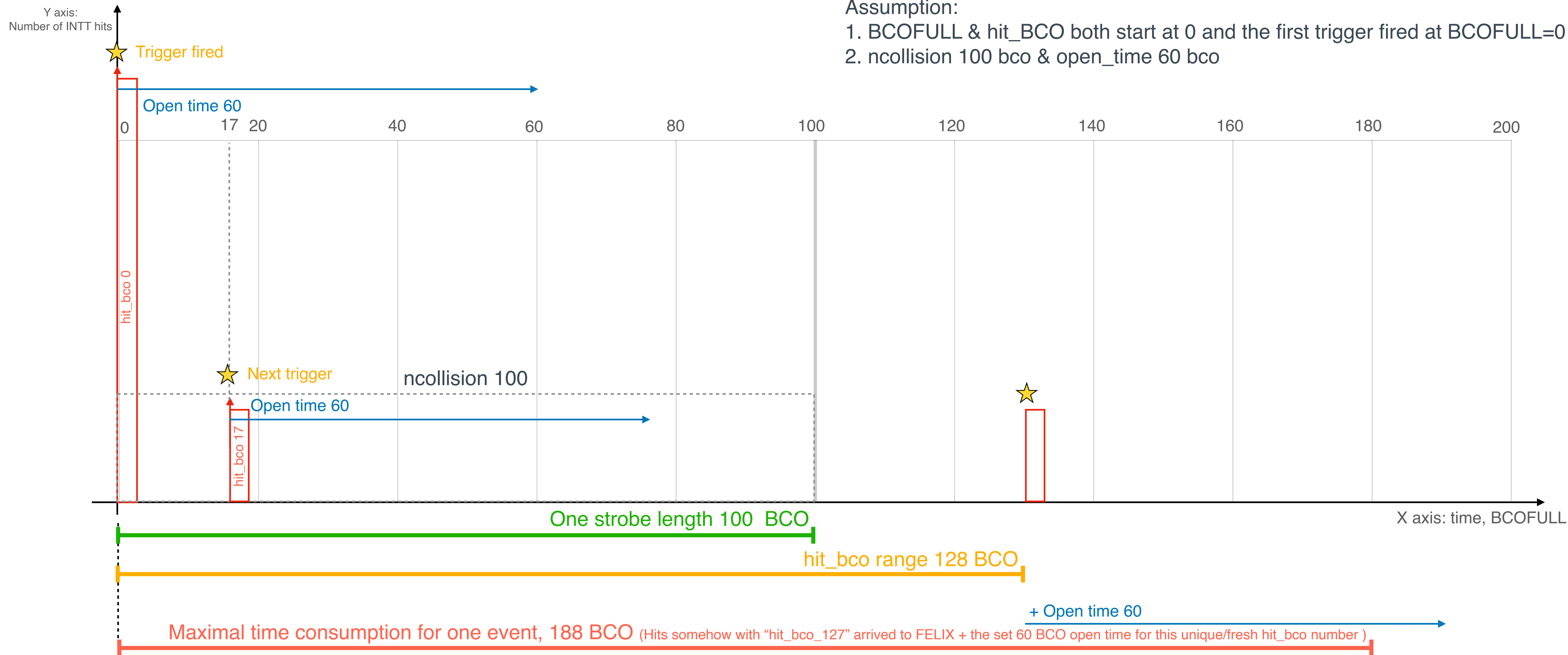


- Off-diagonal entries observed in the number of inner v.s outer clusters and number of INTT clusters v.s MBD charge sum correlations
- Those entries were later identified to be due to hits carried over to the next event (INTT hits in one event are split into two events)

Note: the FPHX goal of hit transmission from chip to ROC: 4 hits in 4 BCOs

Assumption:

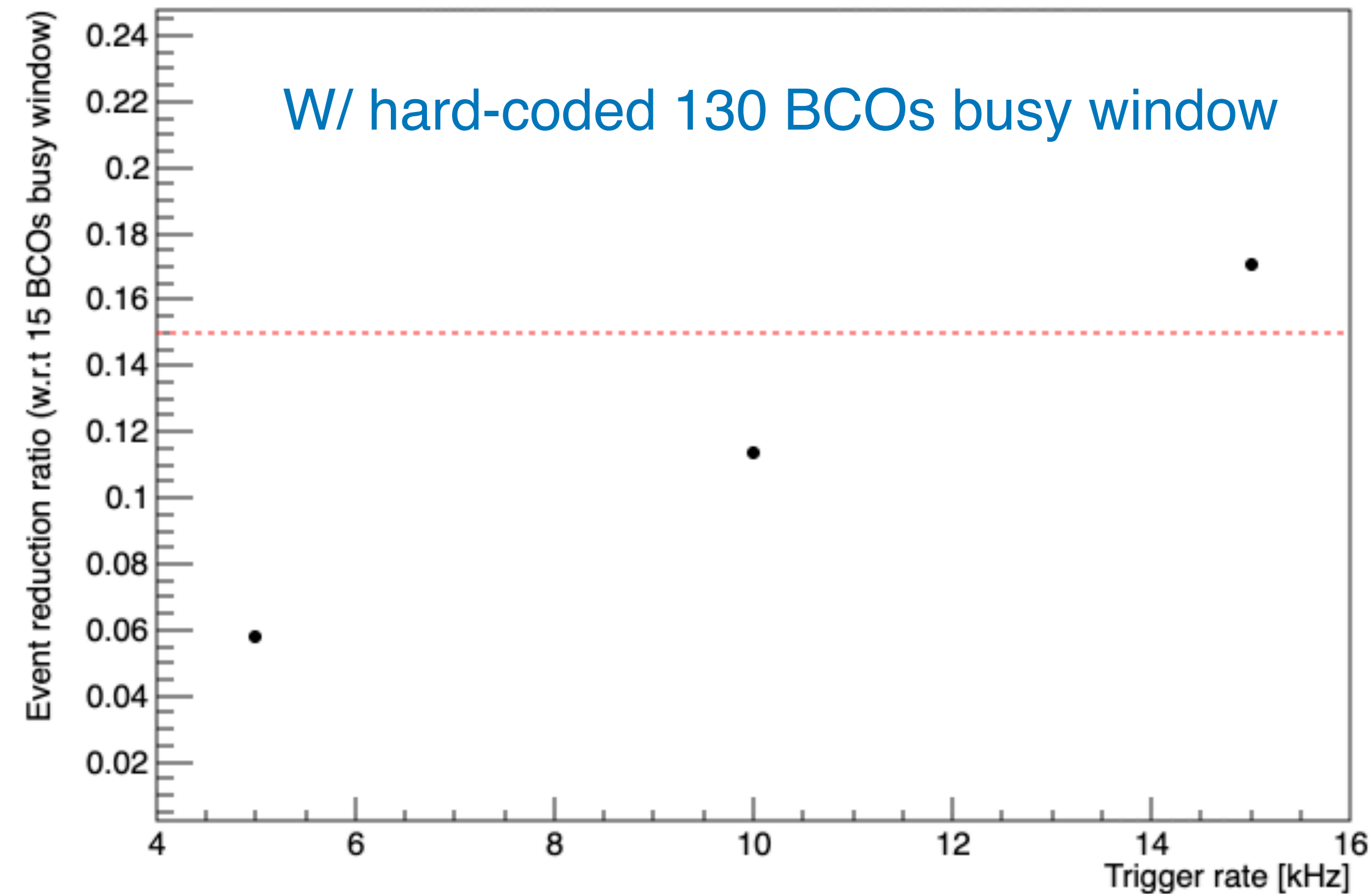
1. BCOFULL & hit\_BCO both start at 0 and the first trigger fired at BCOFULL=0
2. ncollision 100 bco & open\_time 60 bco



- According to Raul, he didn't expect that the next trigger would be sent to subsystems within ~200 BCOs. Raul will check what will happen if next trigger conflicts with FELIX open\_time

- Chip Saturation issue
  - Increase the `INTT FELIX open\_time` to the maximum (128 BCOs)
  - Do the open\_time scan in Run25 if time can be assigned
- Hit carried over issue
  - Run with the current configuration and remove the problematic events in the offline analysis
  - The hard-coded GTM busy (say 130 BCOs)...? ▲ (Trigger rate reduction)
  - Dynamic busy implementation in the FELIX (need additional development)
  - Any other ideas? ▲ (Trigger rate reduction)

Event reduction ratio vs. Trigger rate



- With the trigger rate of 10k Hz, ~11.4% of the triggered events (w.r.t to the current 15 BCOs busy window) will be rejected if 130 BCOs busy window is set
- In the other words, if we keep the same configuration for Run25, up to ~11.4% of INTT events would have the hit-carried-over issue



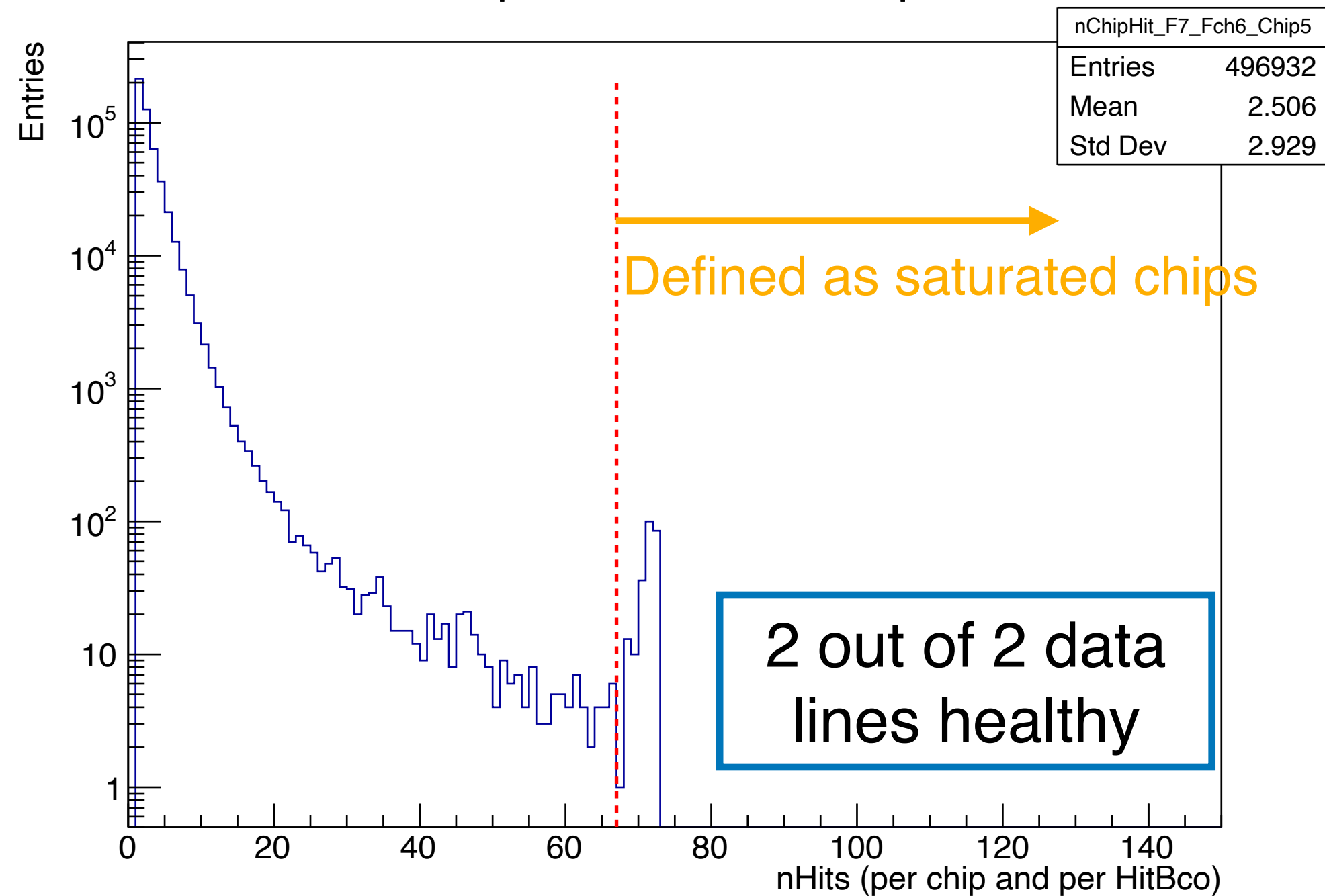
**Back up**

# Chip saturation issue

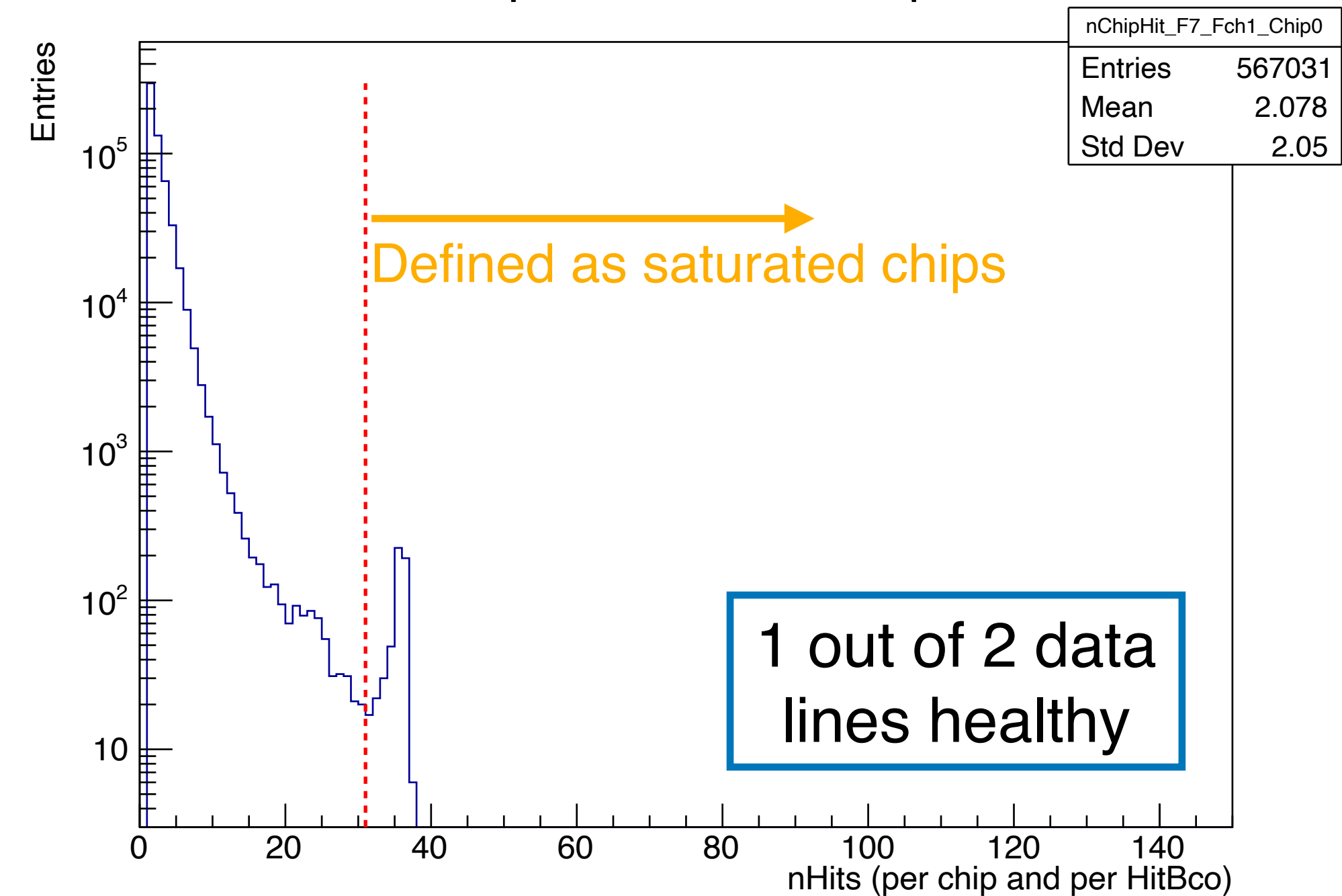
## Selection

```
std::pair<double,double> normal_range = {60,80};  
double normal_threshold = 67;  
  
std::pair<double,double> halfentry_range = {30,40};  
double halfentry_threshold = 31;
```

nChipHit\_F7\_Fch6\_Chip5

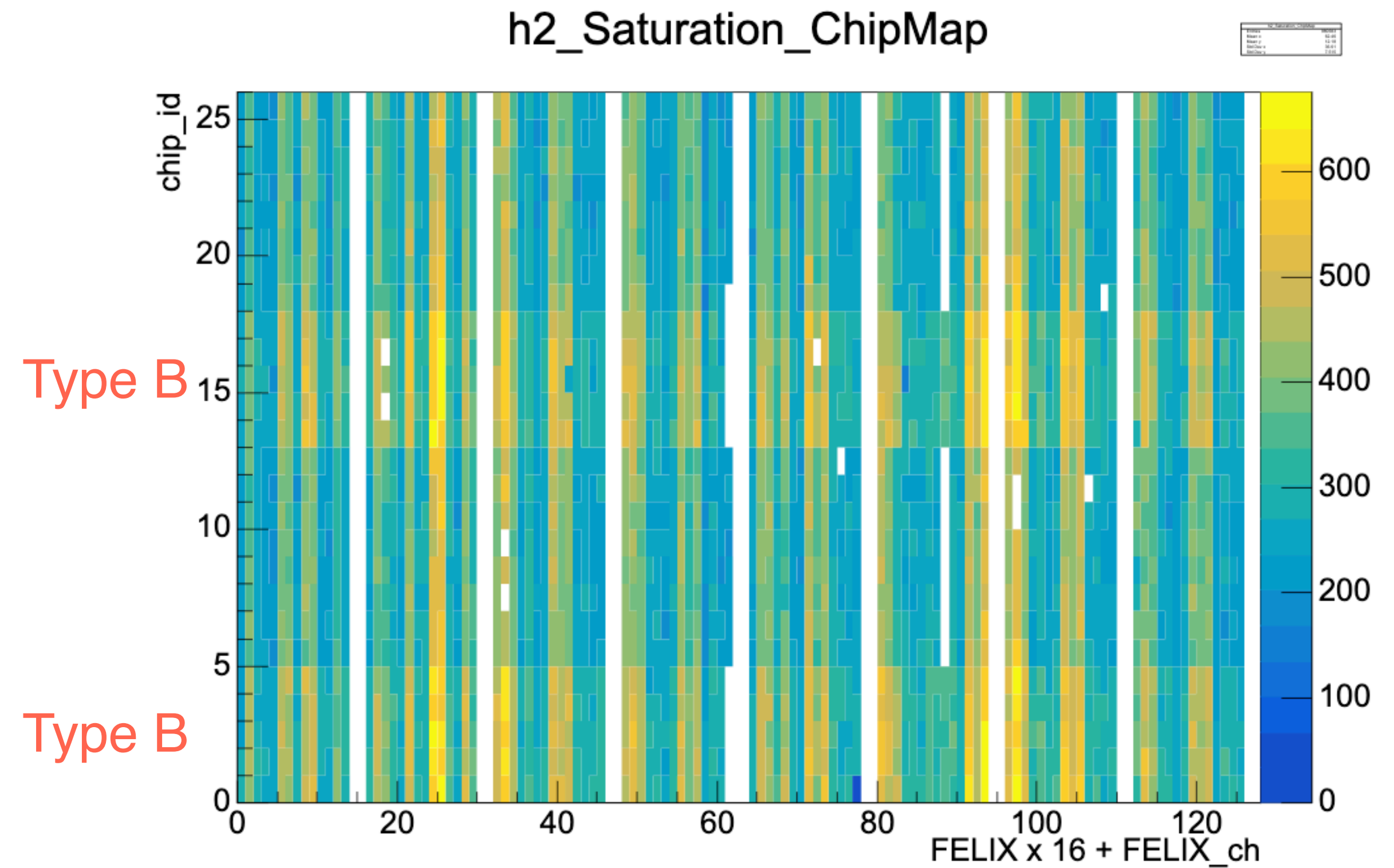
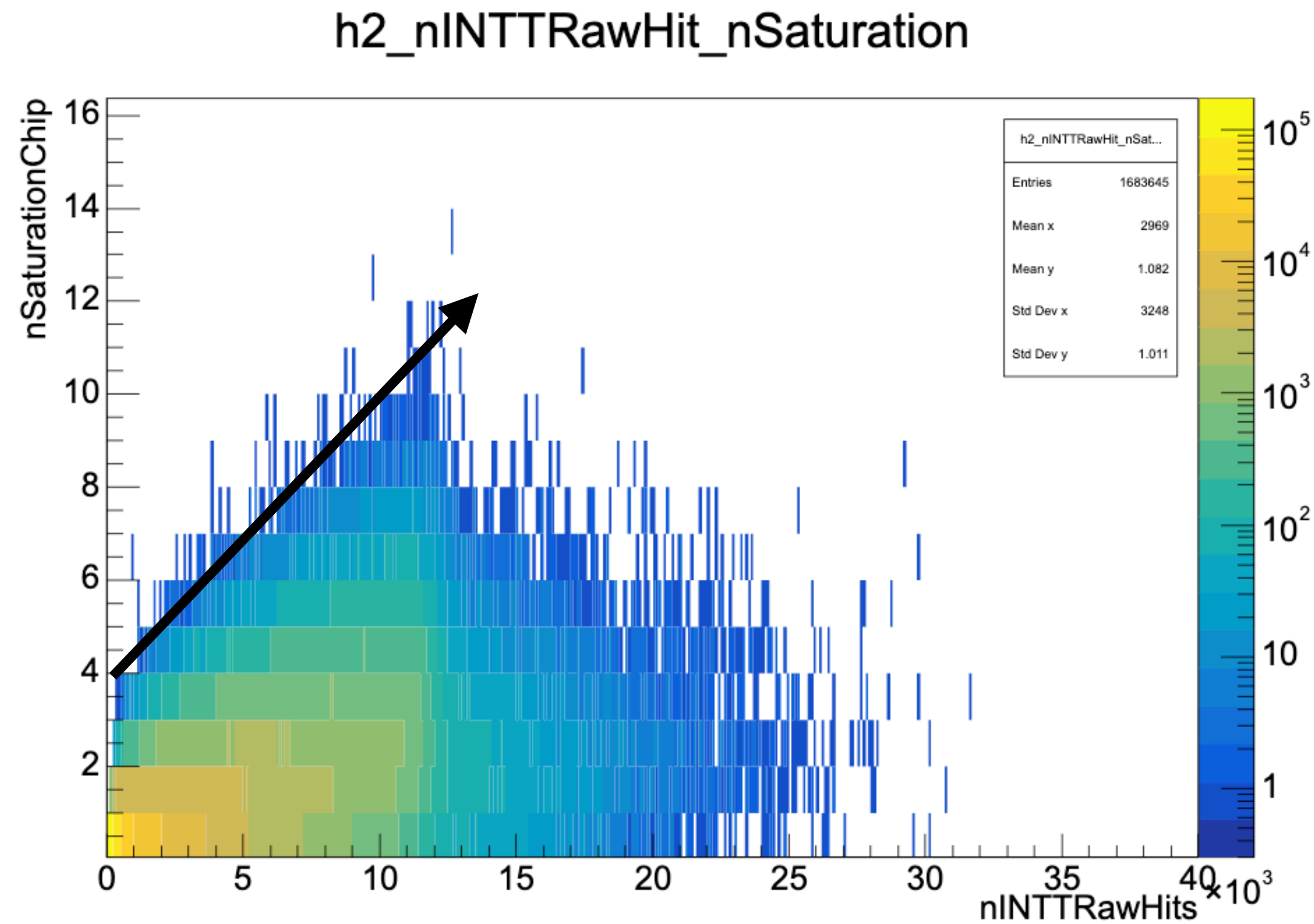


nChipHit\_F7\_Fch1\_Chip0



Try to have the selections to pick up the chips saturated

# Number of the chips saturated



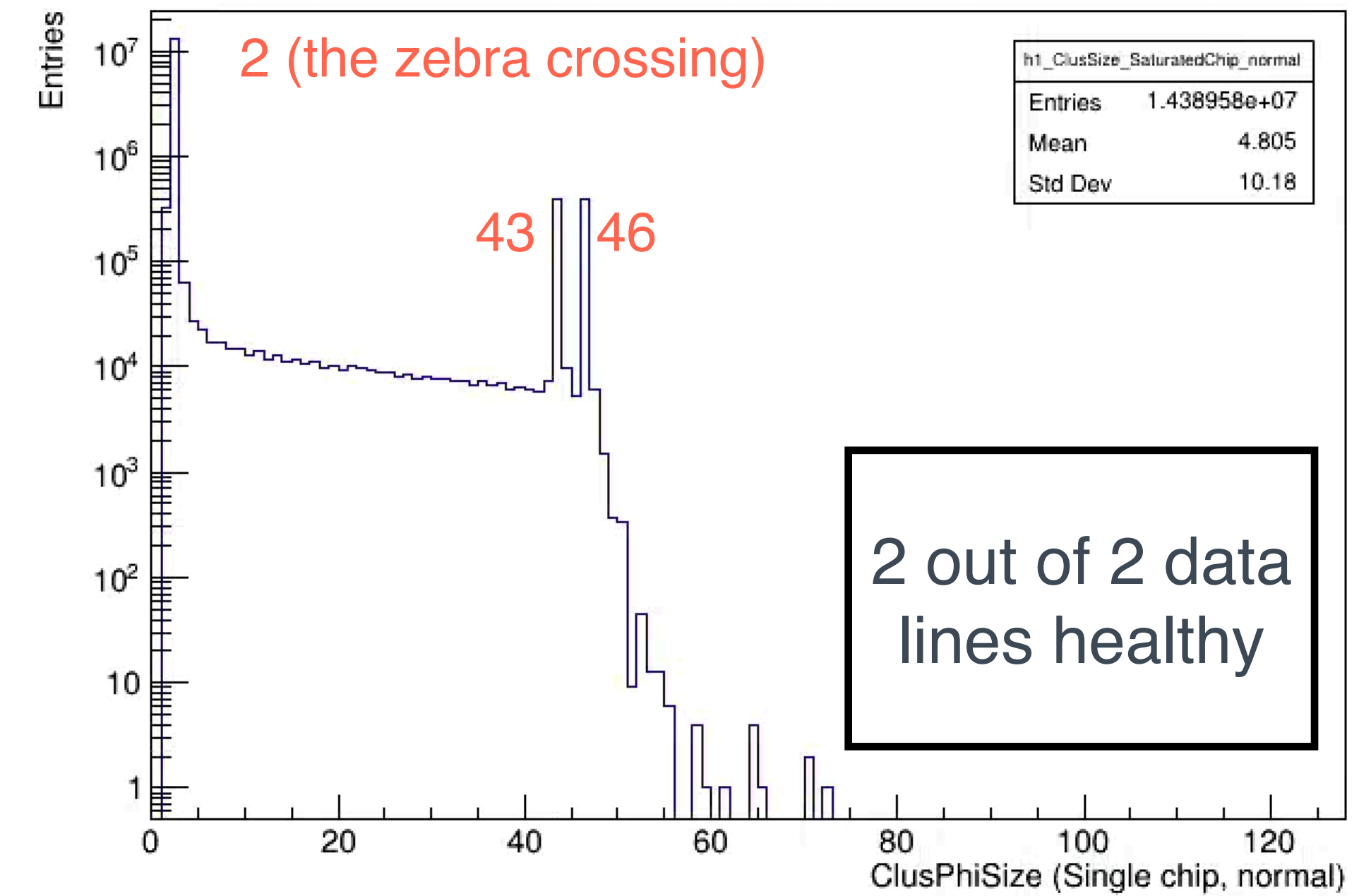
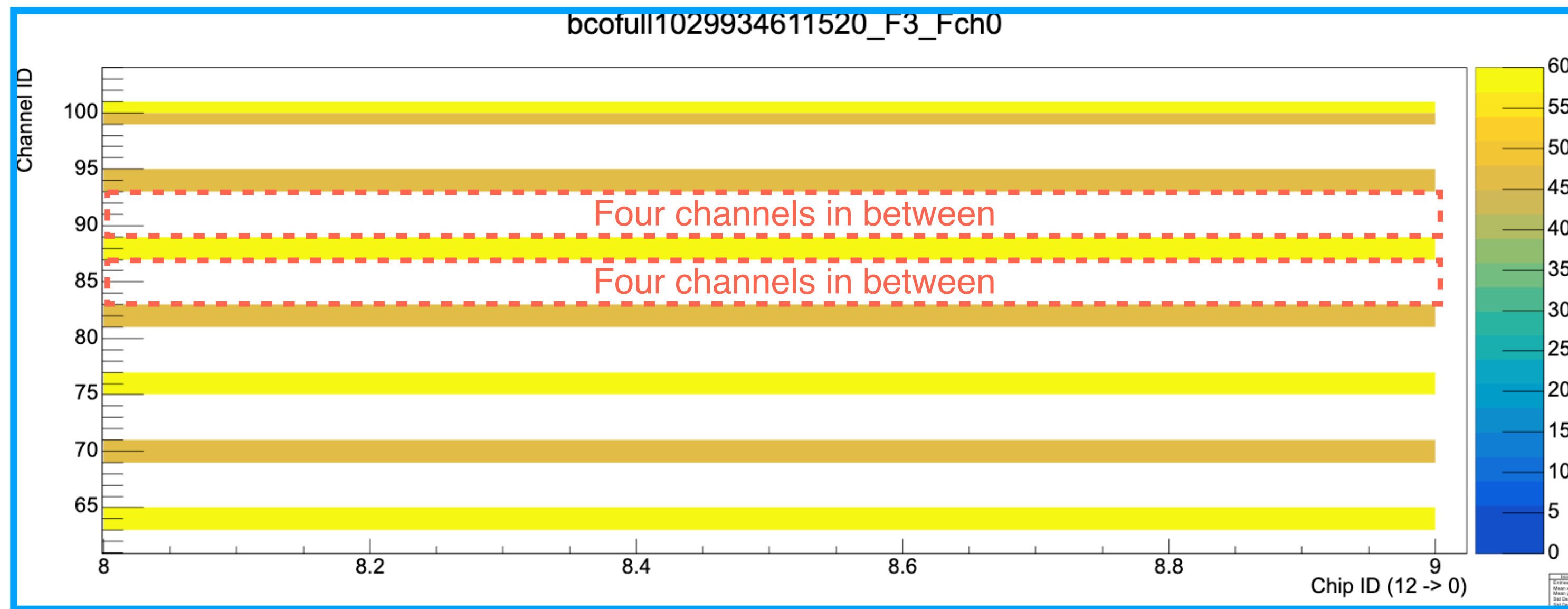
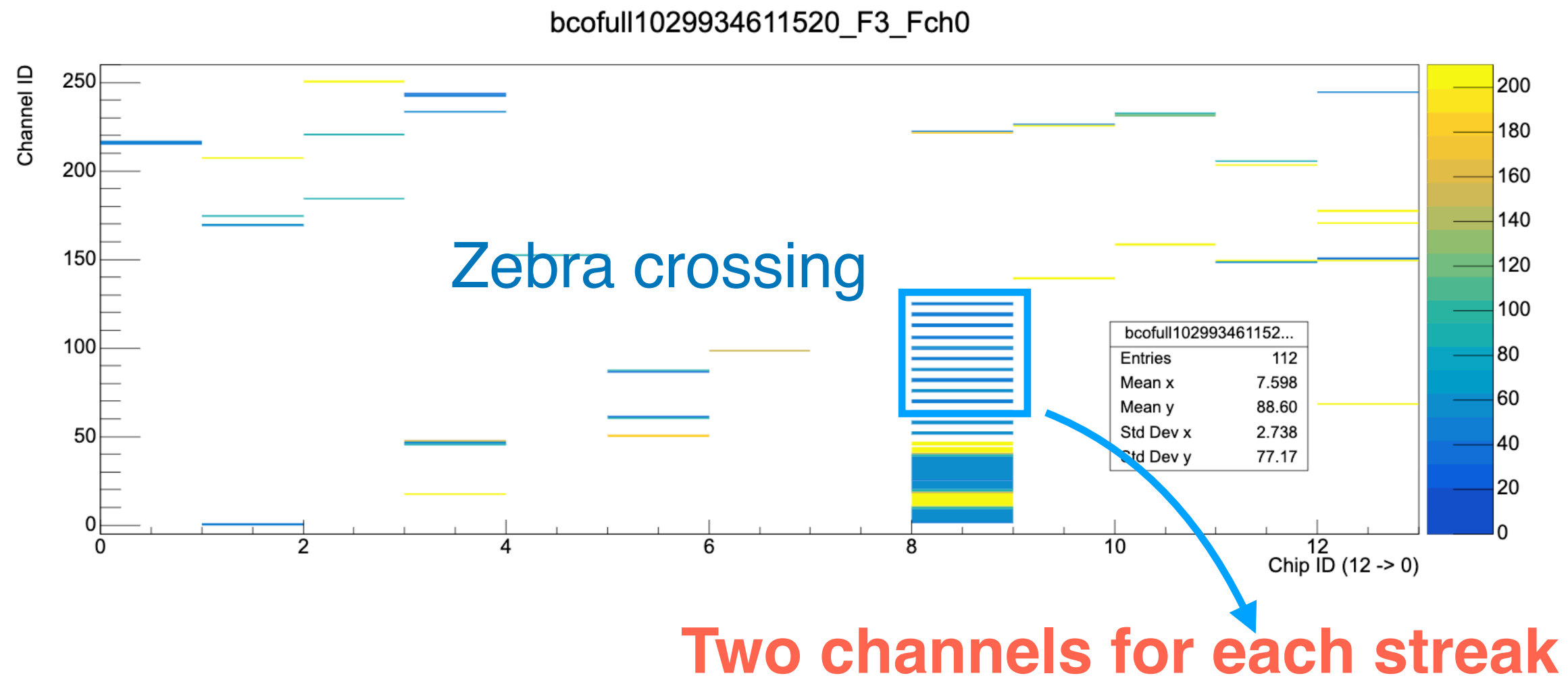
In the worse case, 12 out of 2912 chips are saturated in one event

Assuming those chips have all channels fired,  $(128 - 73) * 12 = 660$  hits are dropped by FELIX servers

$660 / (13000 + 660) = \sim 5\%$  of the hits are missing

But we might gain more clusters (non-physical)

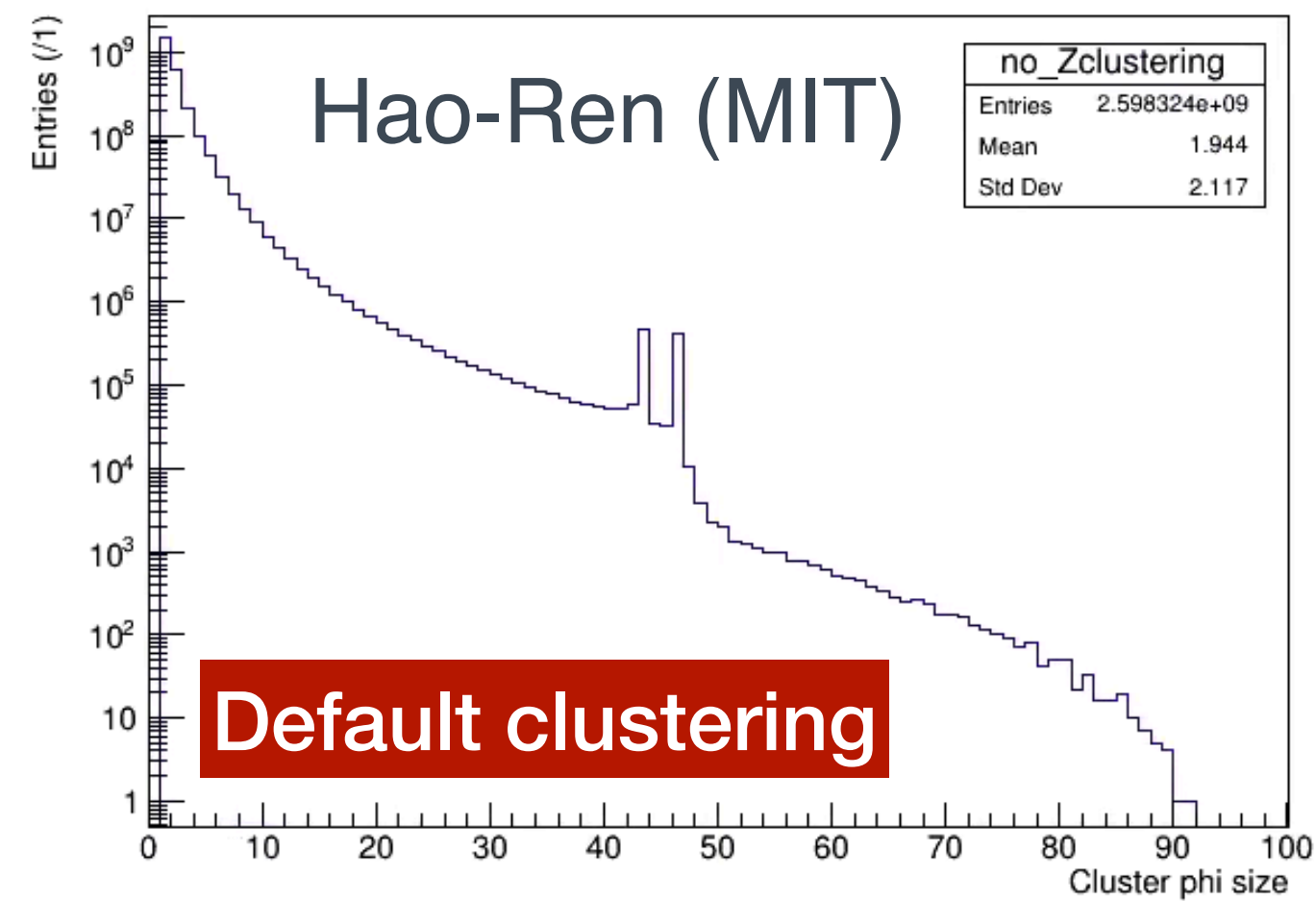
# Chip saturation, the patterns



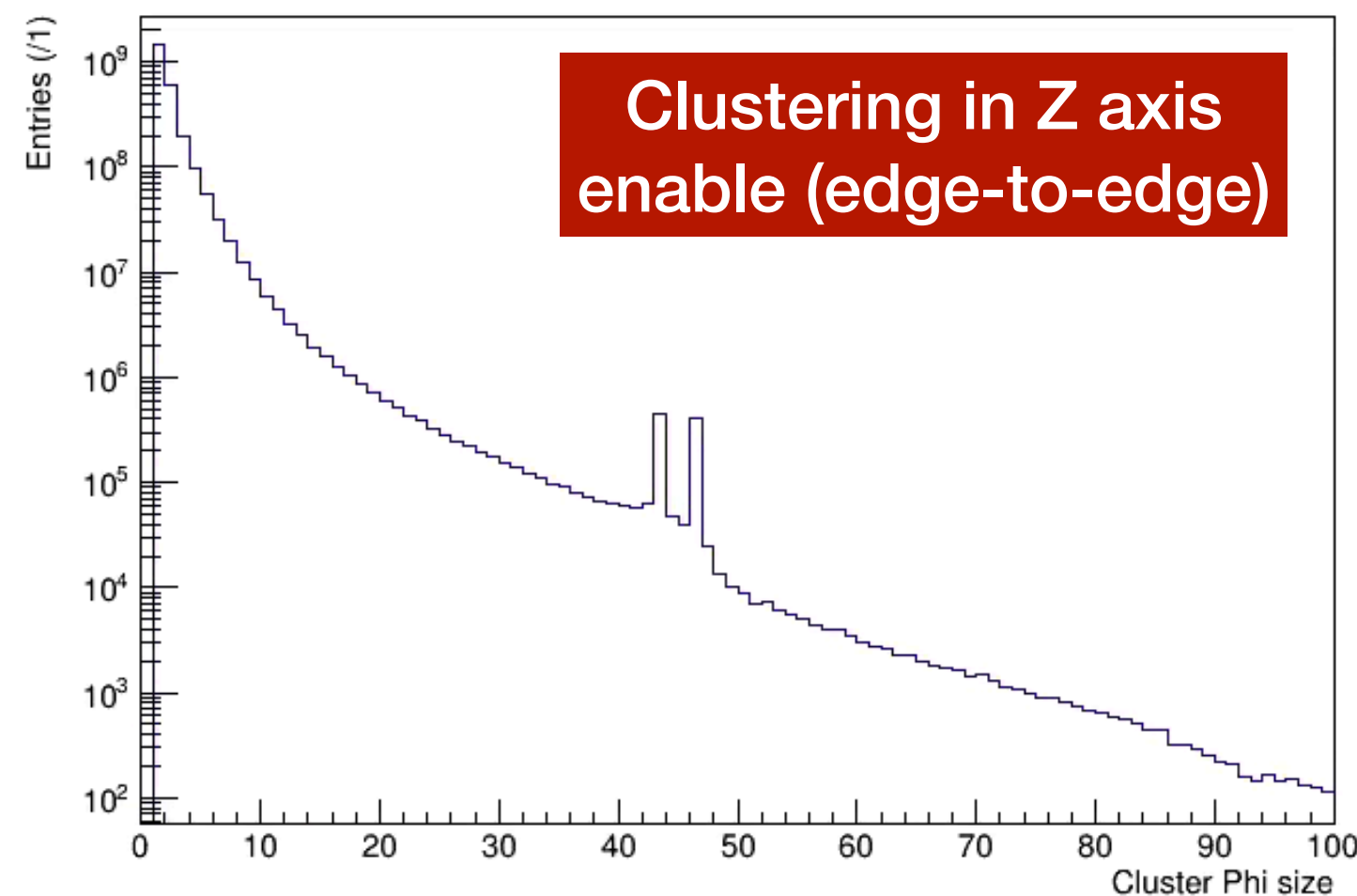
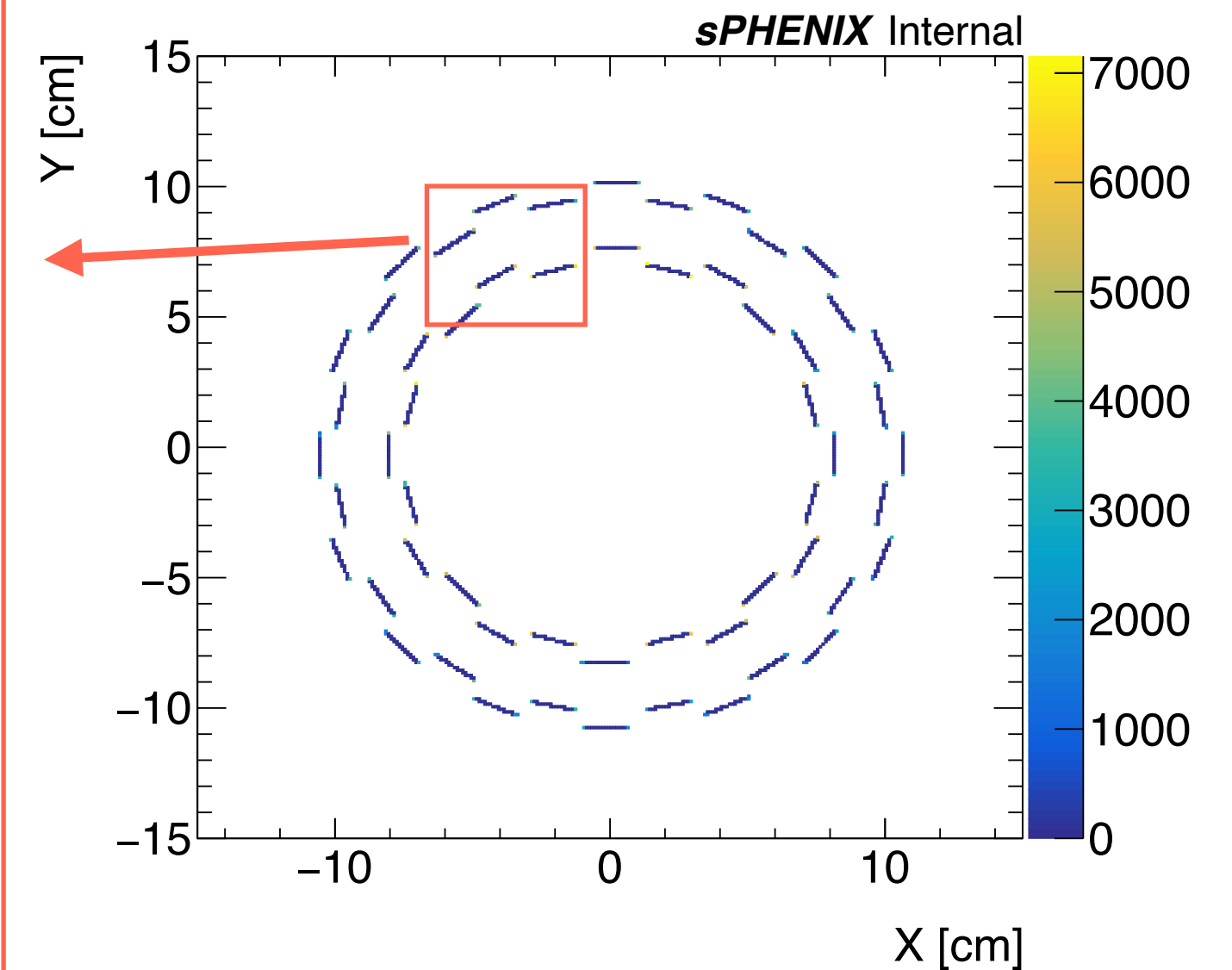
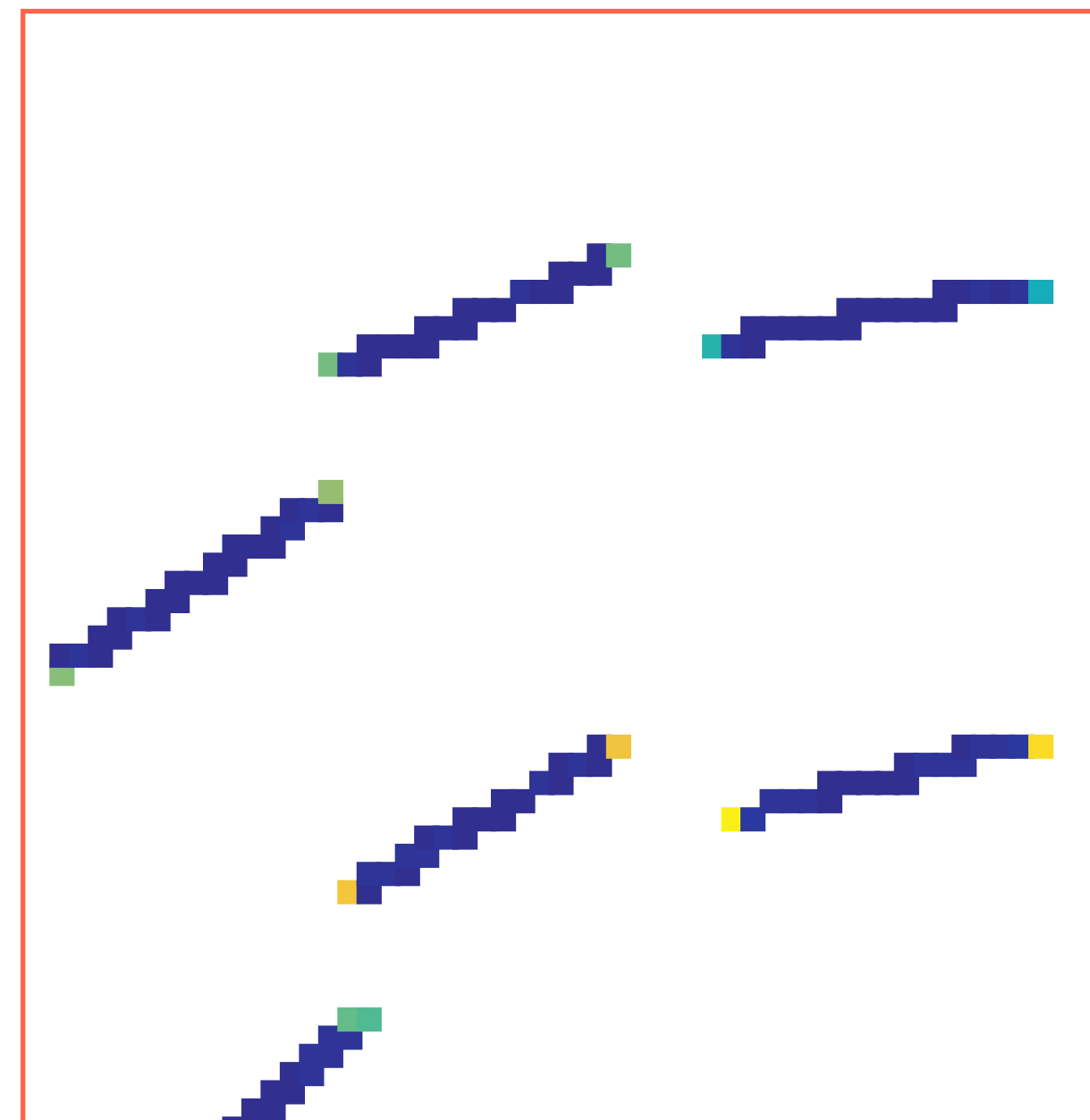
The pattern : big chunk + zebra crosswalk, and big chunk always closer to the edge

# Cluster phi size distribution

- There are two spikes in the cluster phi size distribution regardless the clustering requirement
- Issue was first spotted by Hao-Ren (MIT) with run 23 Au+Au data (it's the problem across the runs)

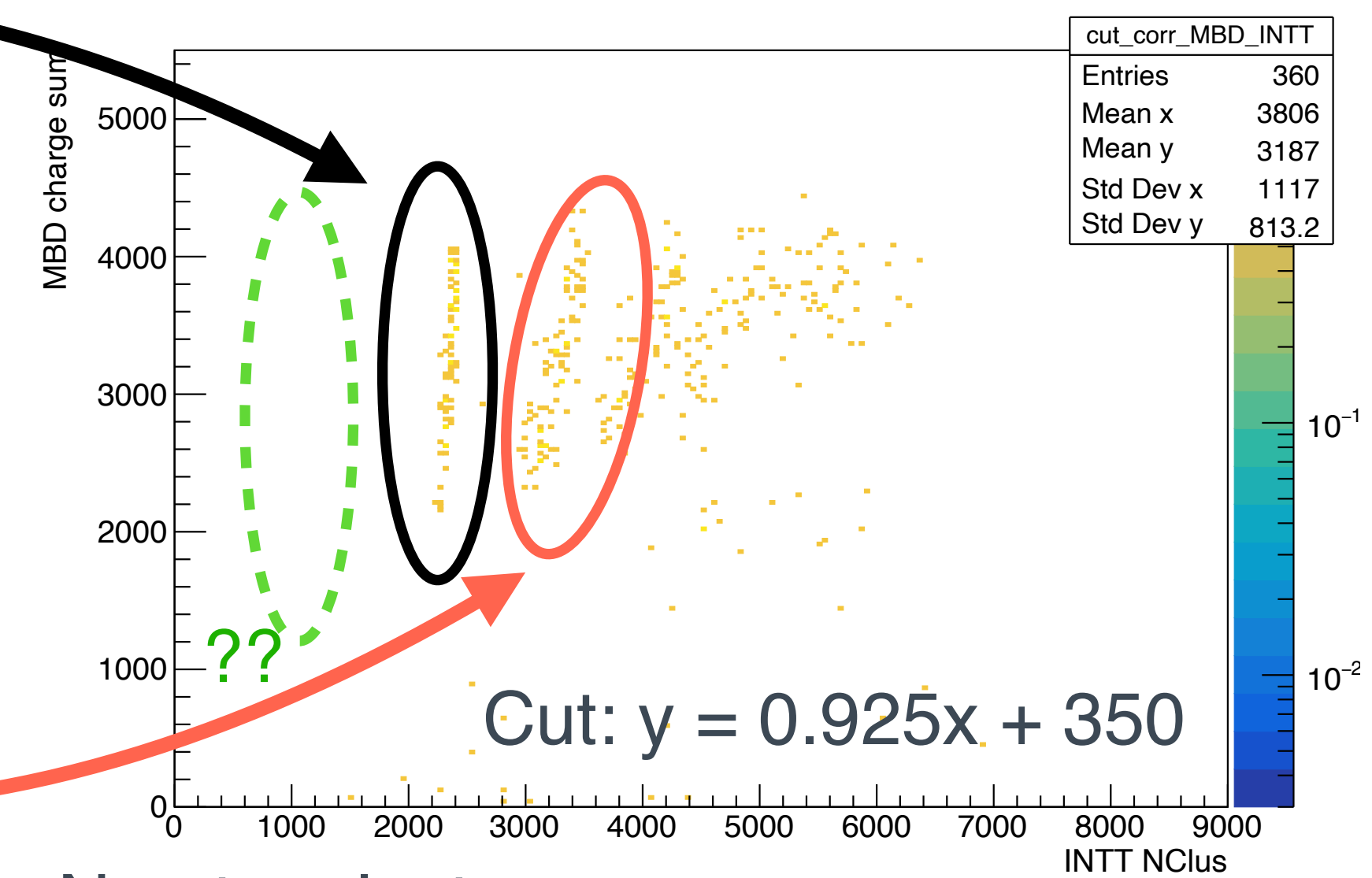
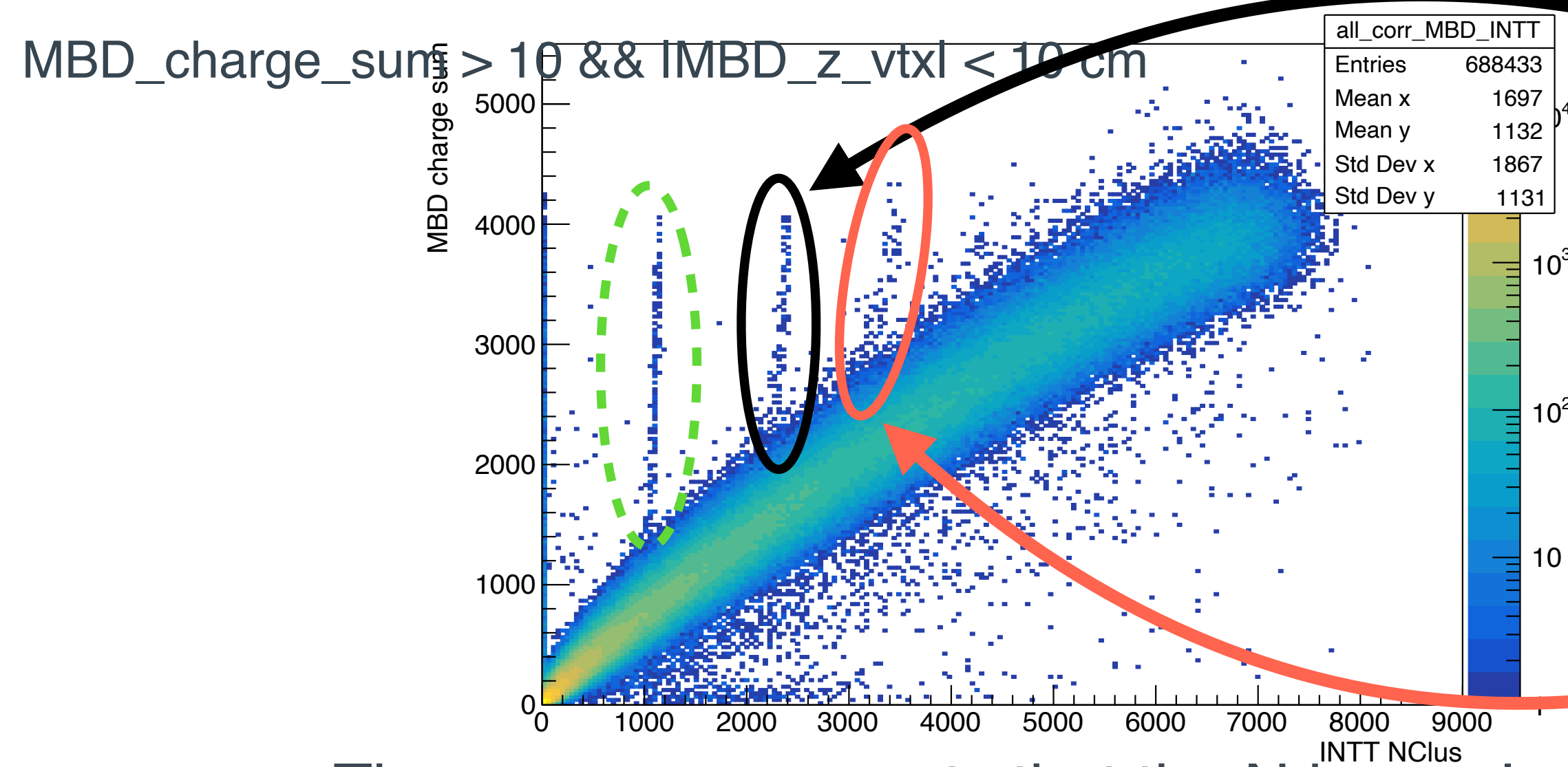
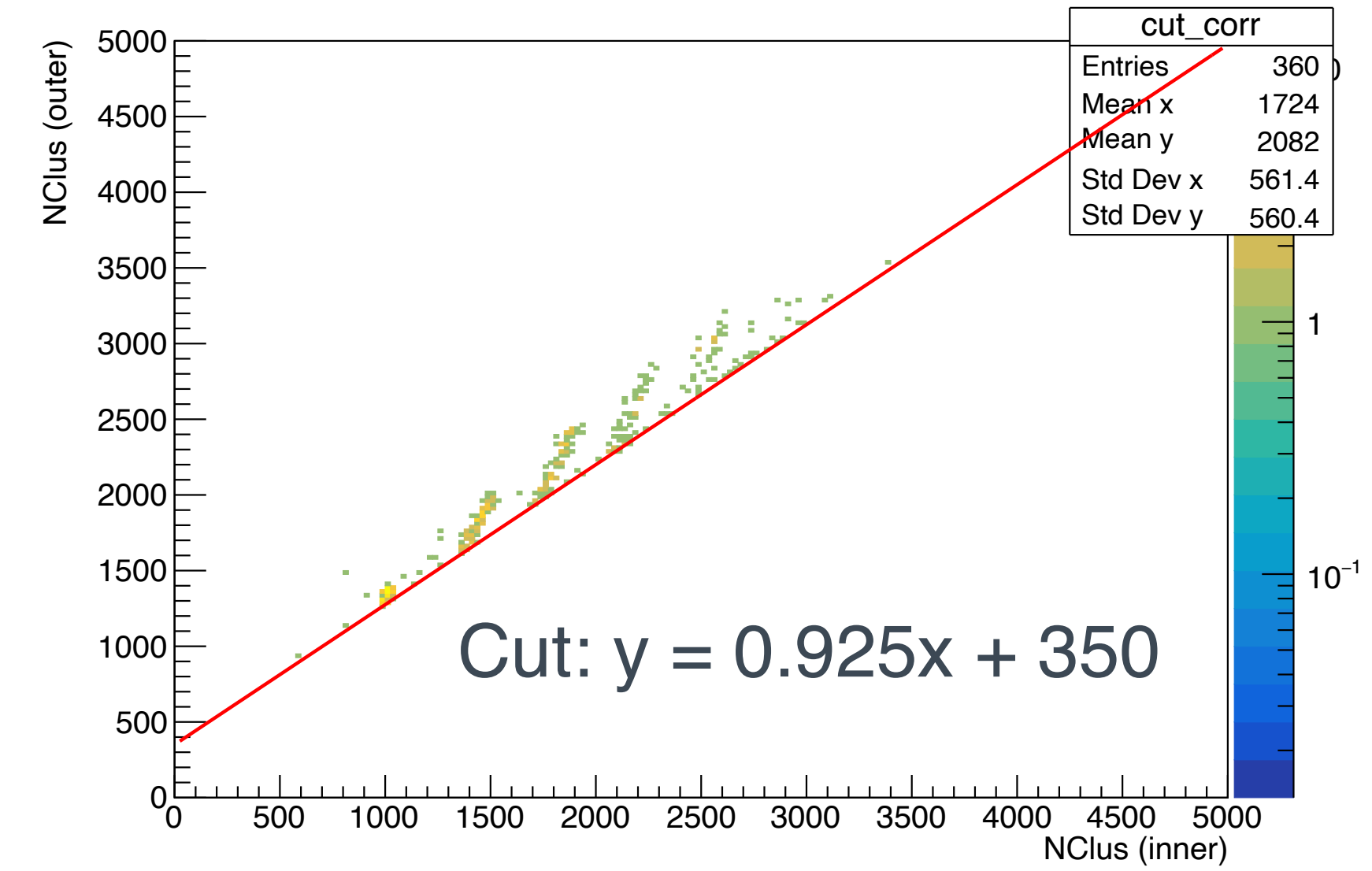
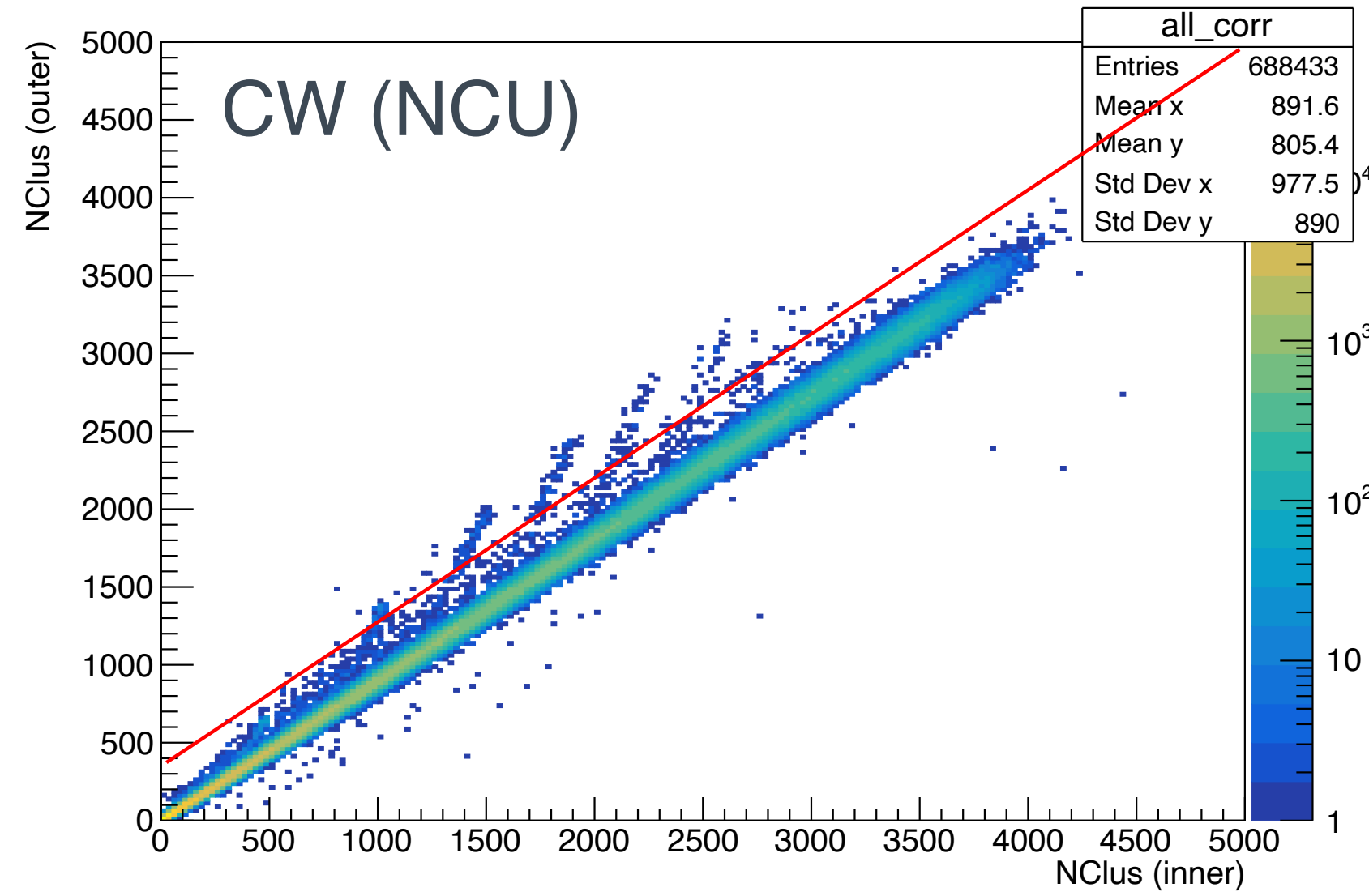


The positions of the clusters with phi size 43 or 46 (default clustering)



They tend to appear at the edge of sensor

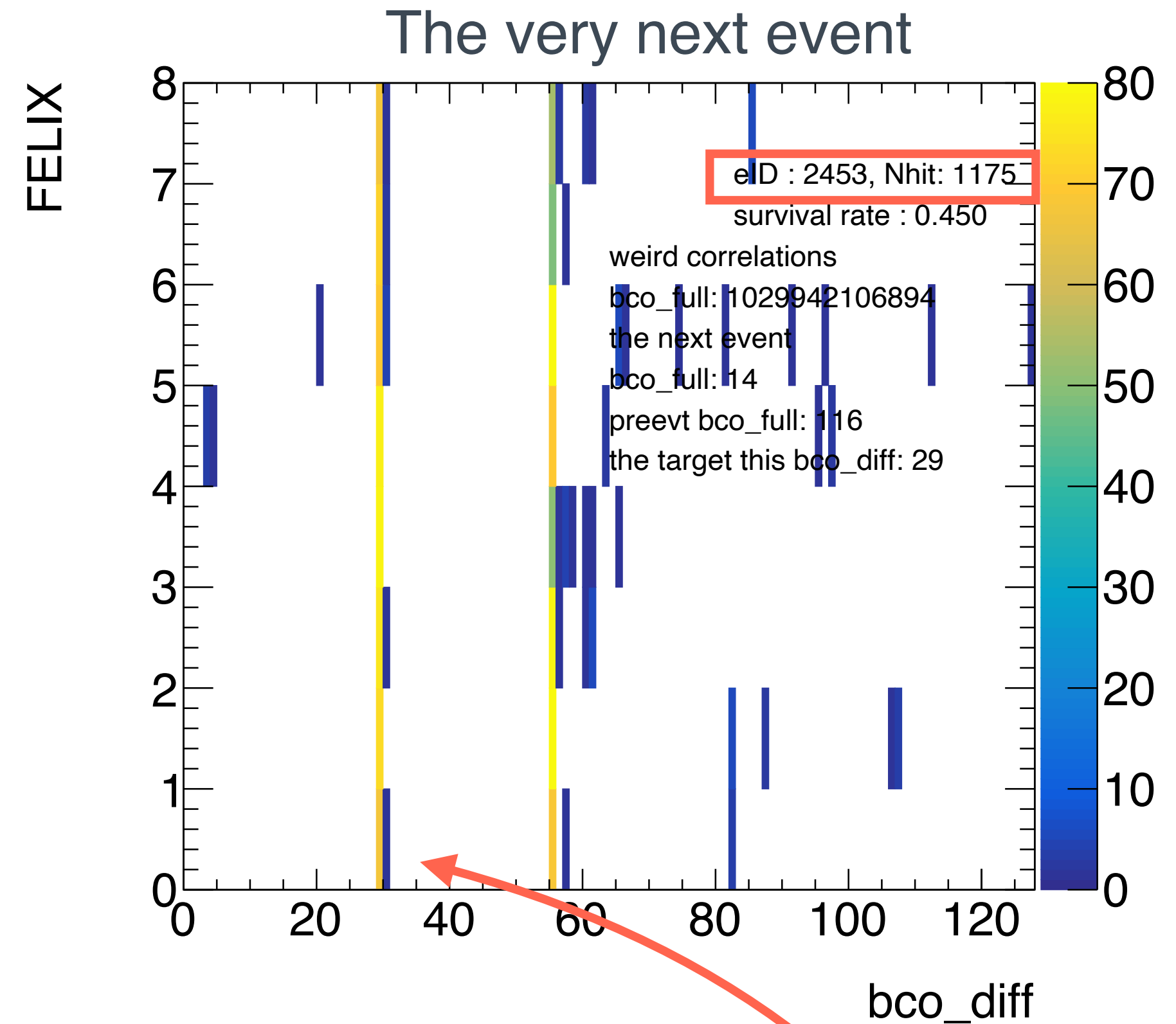
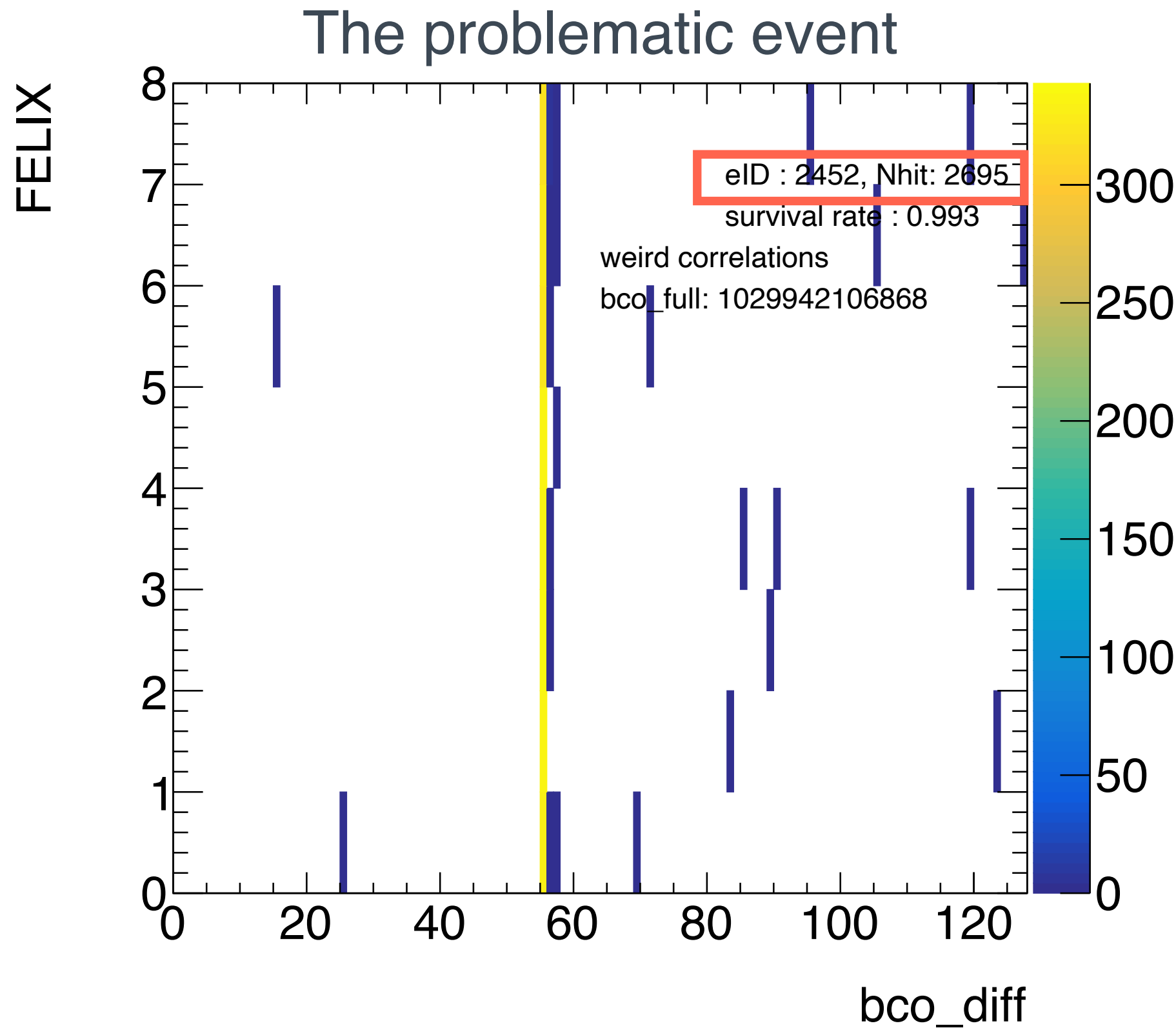
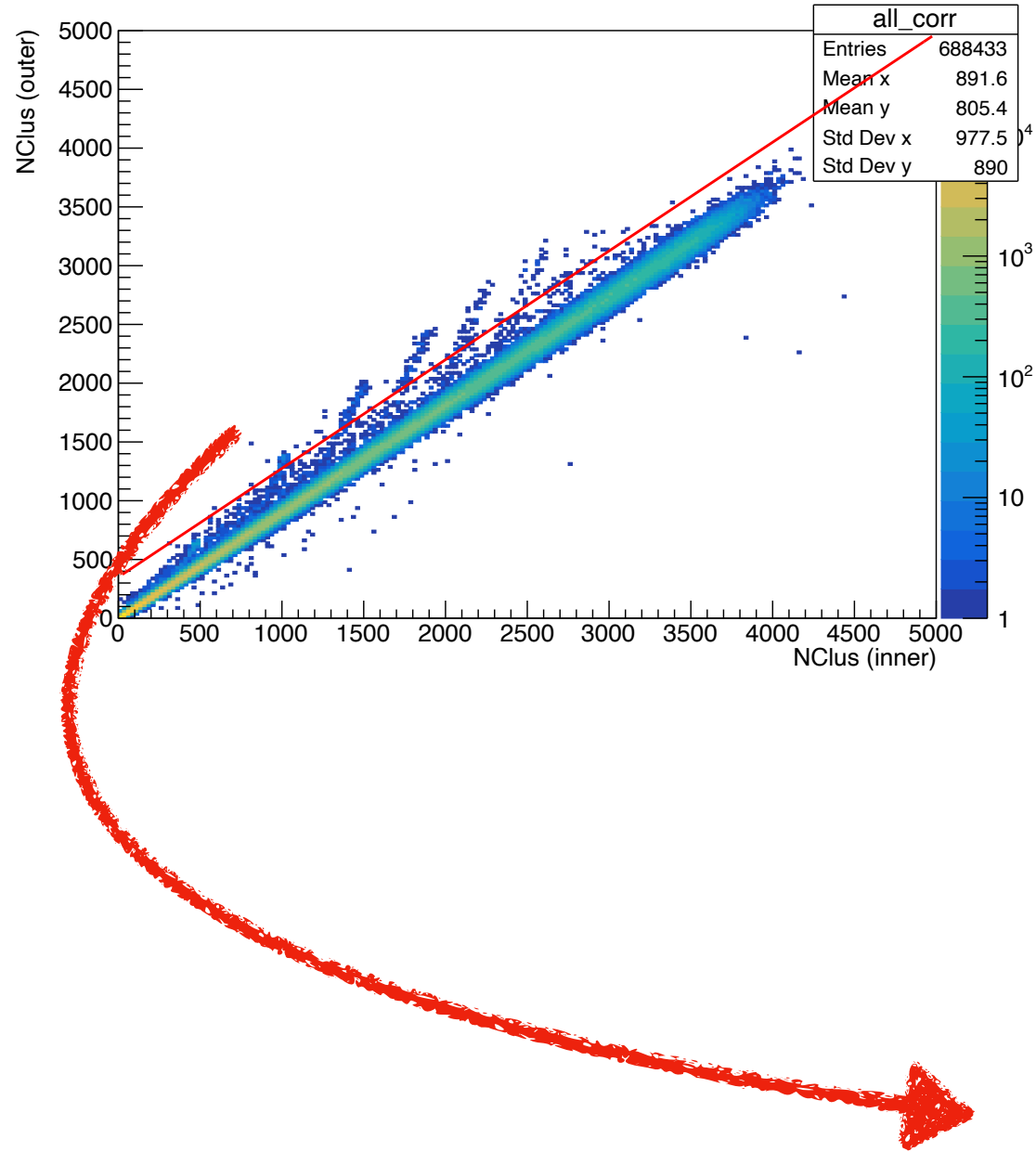
# Hit carried over issue



There are some events that the N inner cluster < N outer cluster

The outliers are correlated to the outlier groups in the MBD-INTT multiplicity correlation

# Hit carried over issue

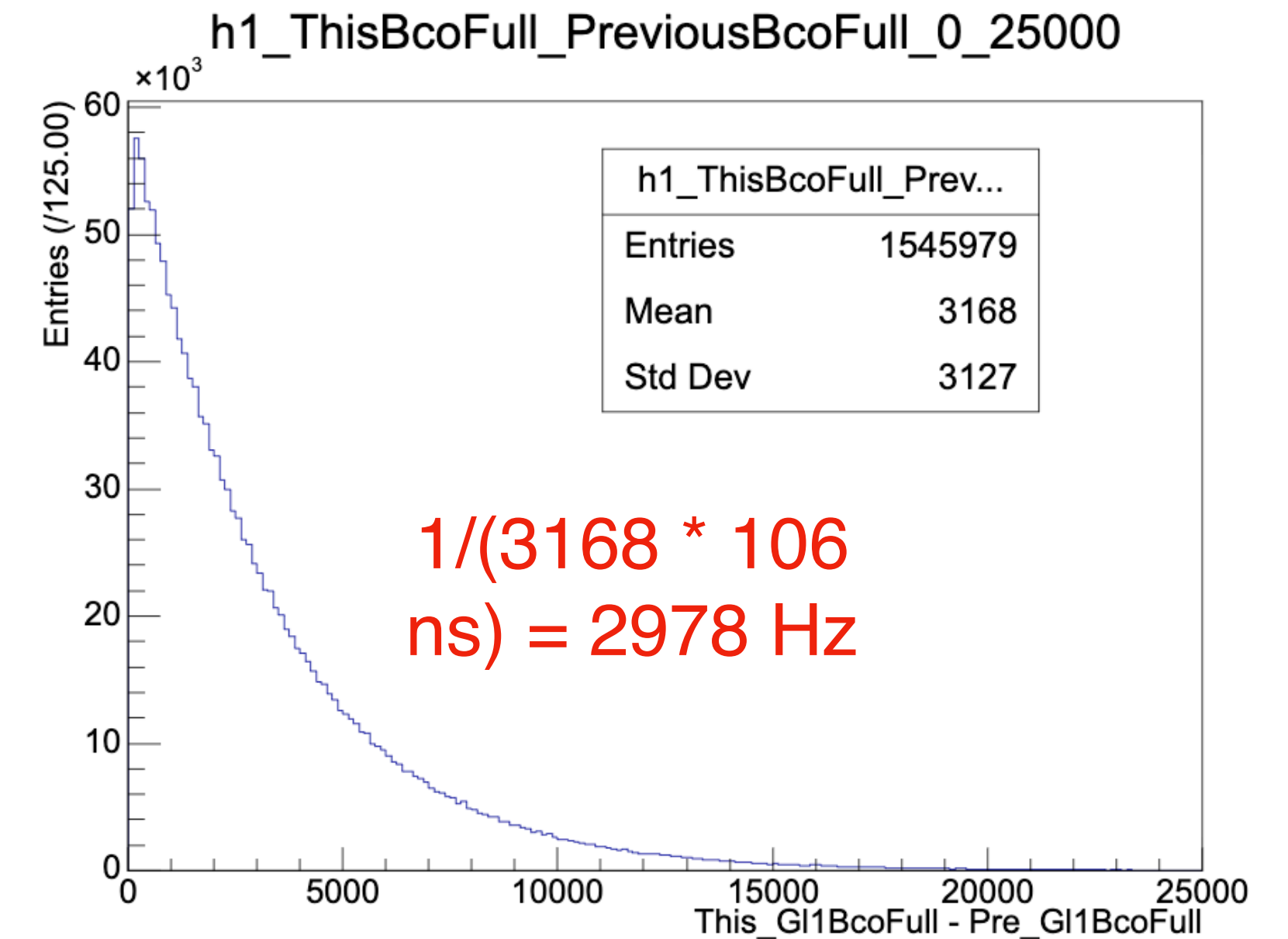
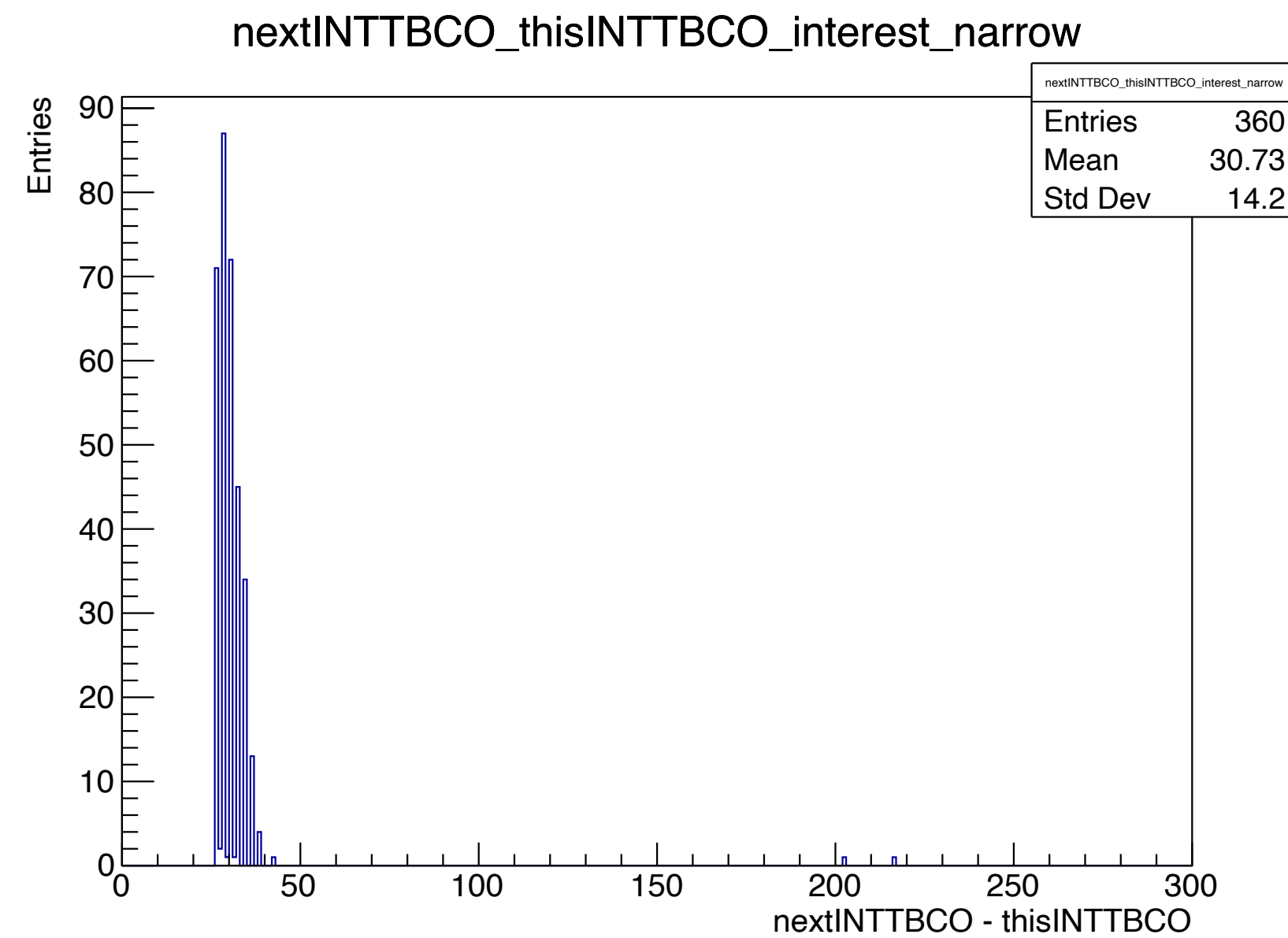
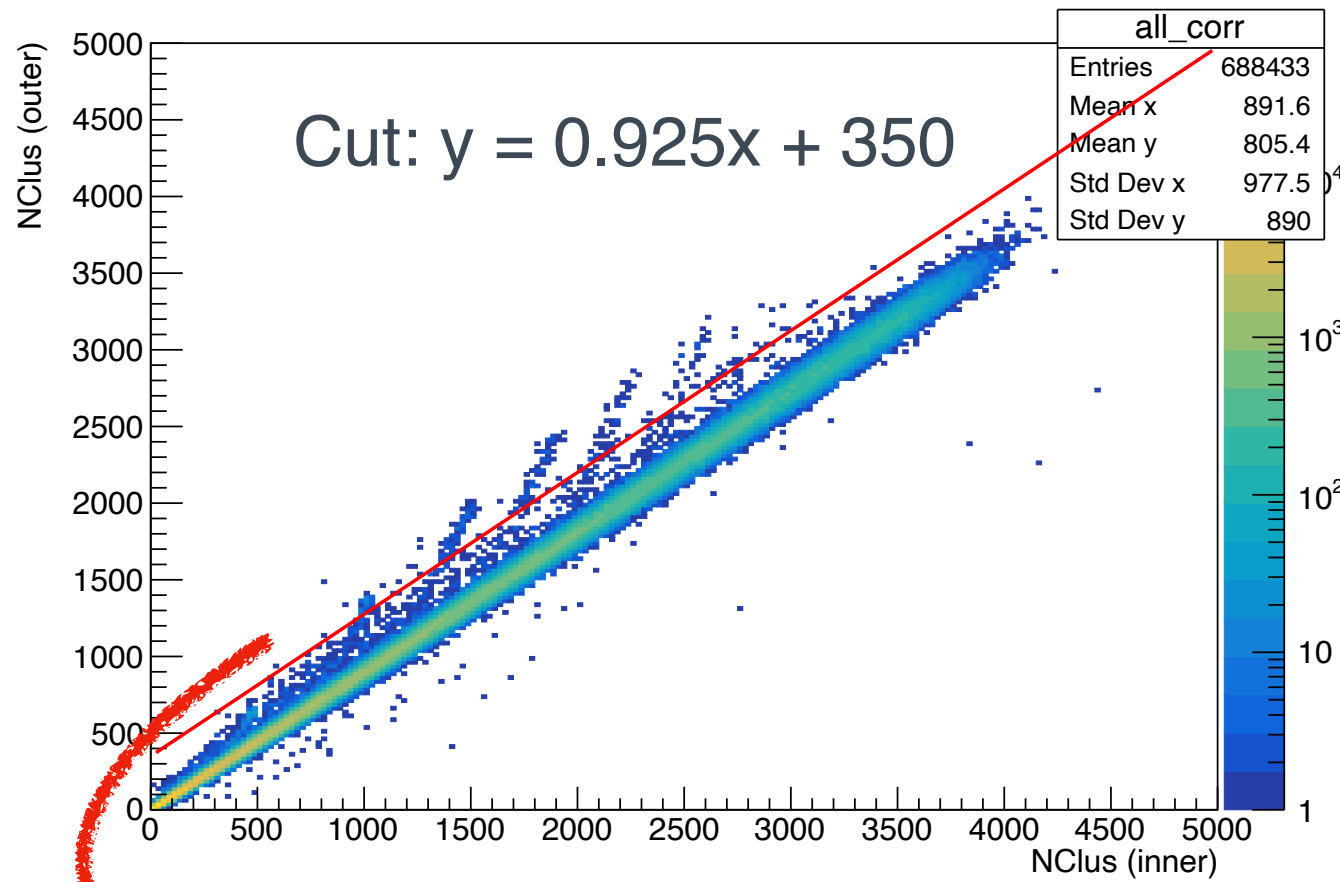


**INTT has hits carried over**

- In this event, if the hits are carried over to the next event, the “**time bucket of this hit\_bco w.r.t next\_BcoFull**” would have to be **29**, where you can see the yellow strip in the right plot
- The evidence of hits varied over to the next event

(1)	this bco_full & 0x7fU	116
(2)	correct hit_bco	43
(3)	Next bco_full & 0x7fU	14
(4)	(2) - (3)	29

# Hit carried over issue



The very next events of the problematic events are very close to problematic events in time wise

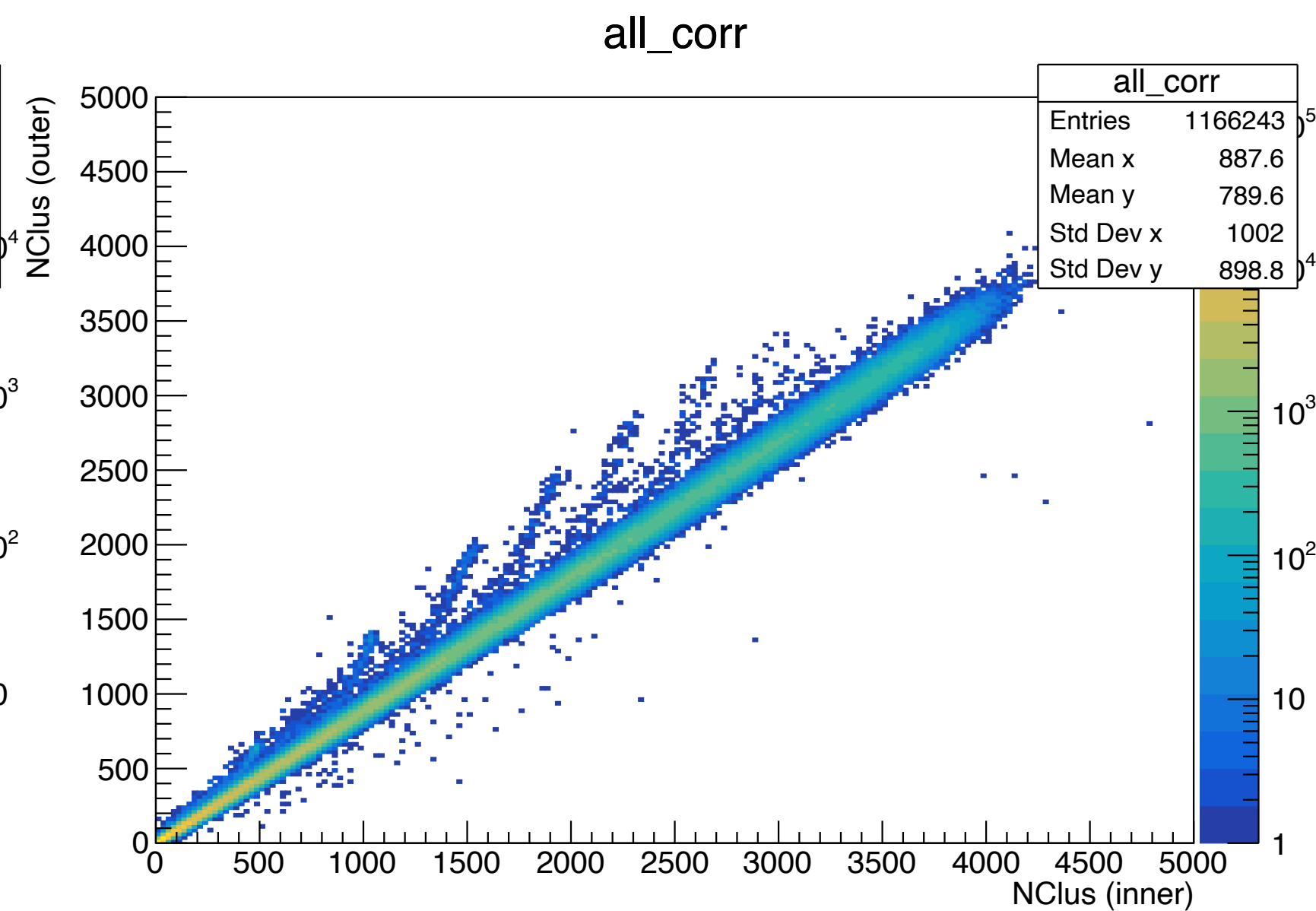
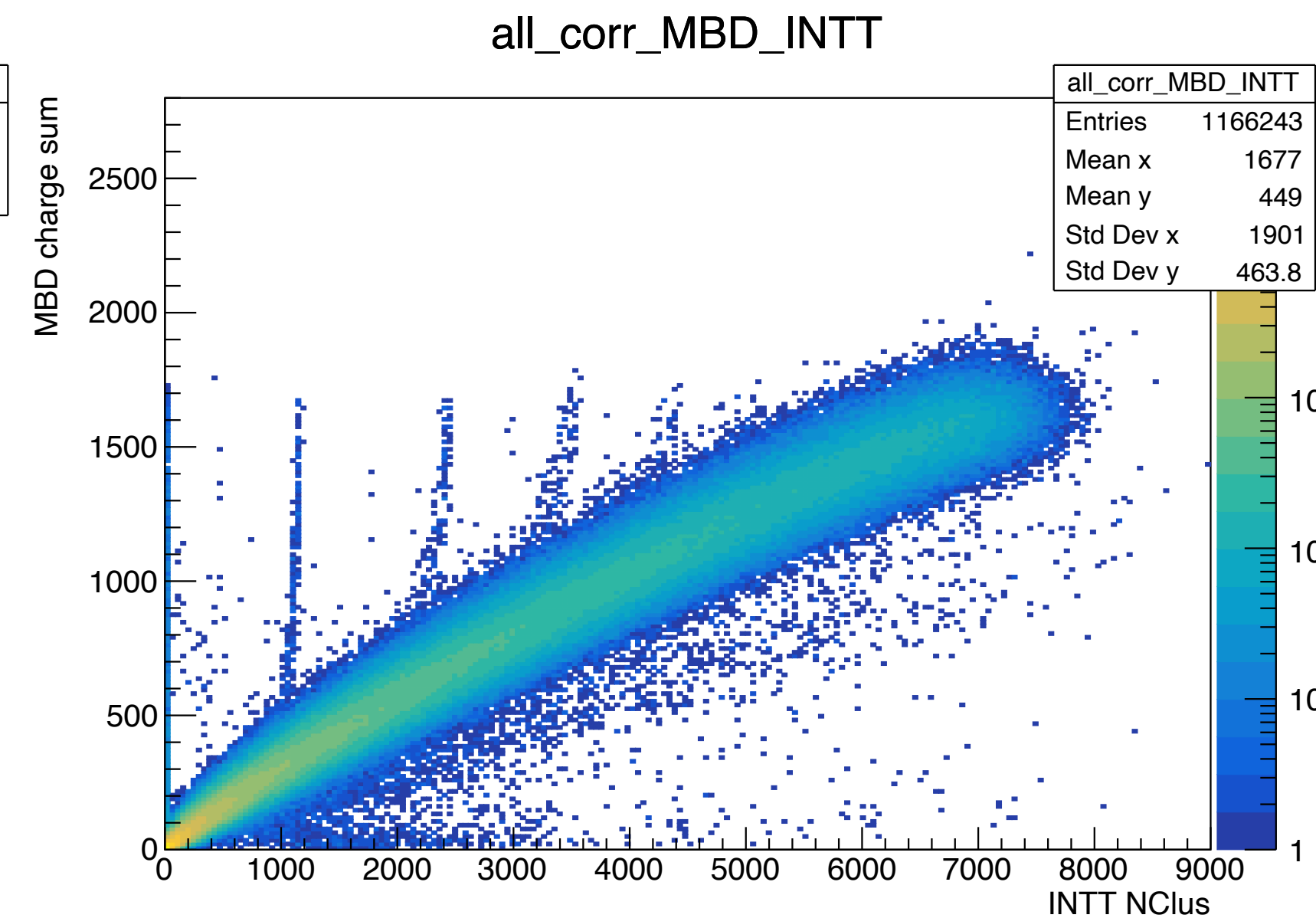
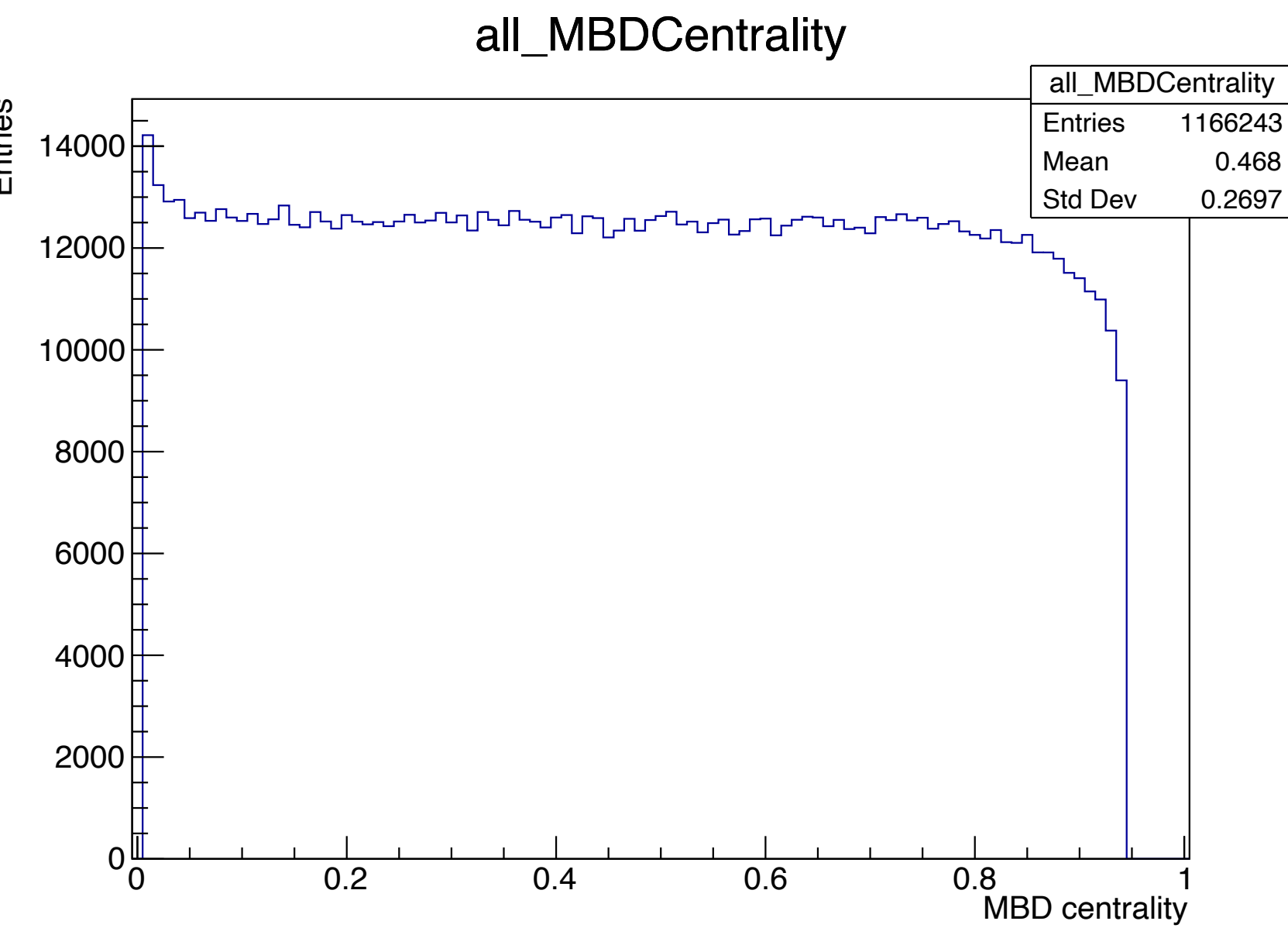
Hypothesis: Hits in FELIX been assembled with INTTheader (INTT\_bcofull) and sent out to the down stream. Since FELIX receives new trigger, the previous INTT\_bcofull is overwritten. The hit assembly continues, but with the new INTT\_bcofull

Can we probably just have a simple "BCOFULL\_diff" cut?



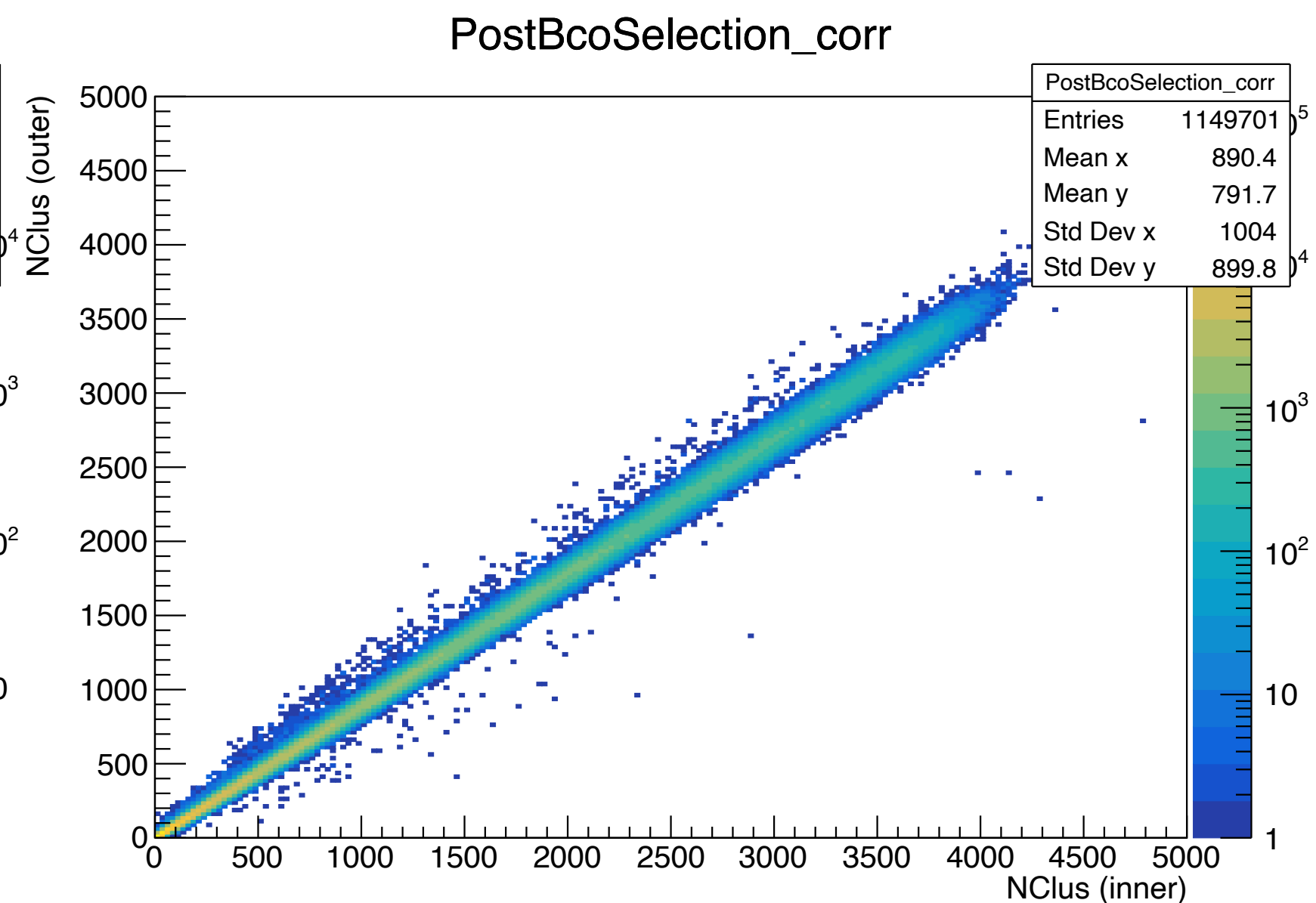
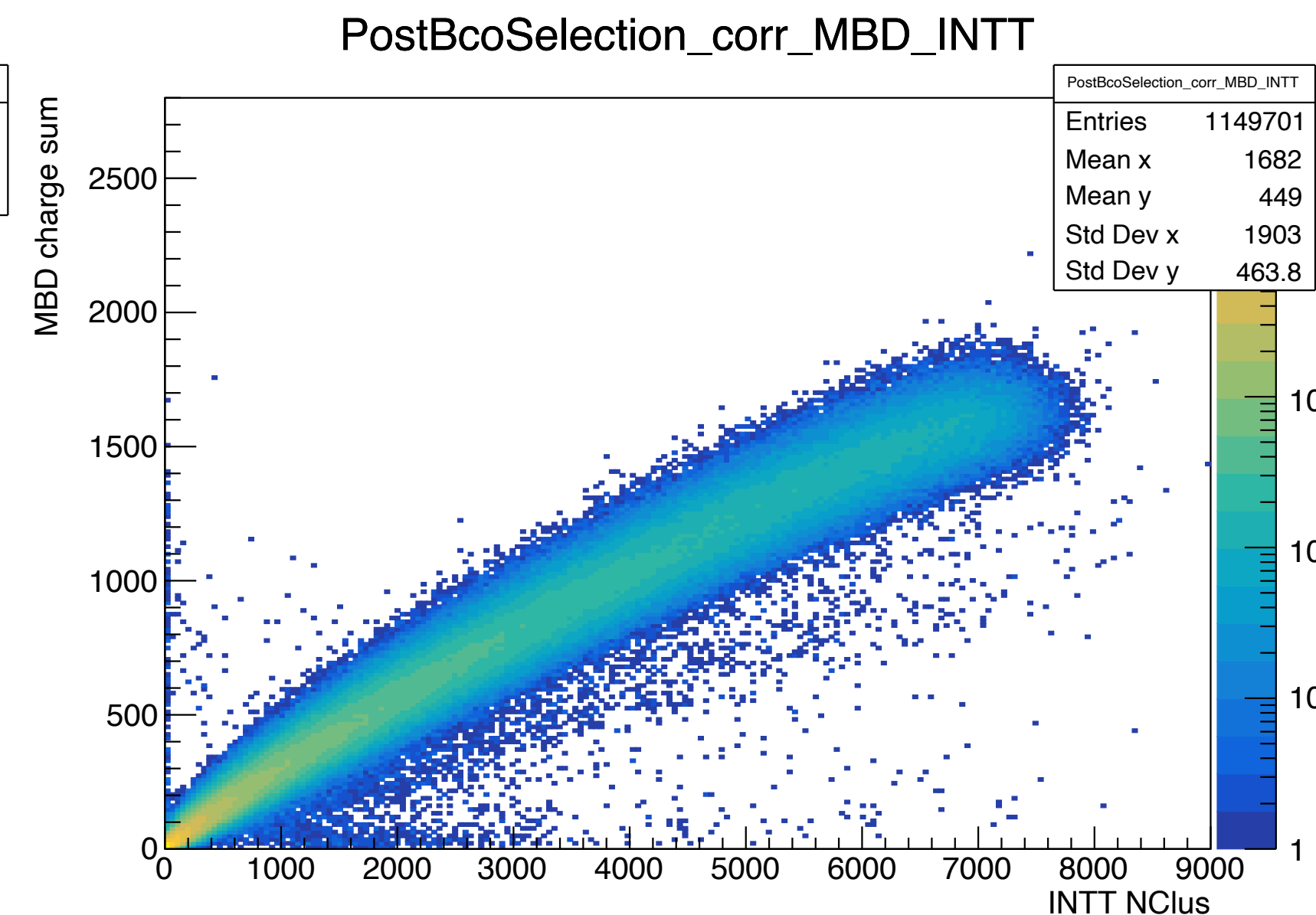
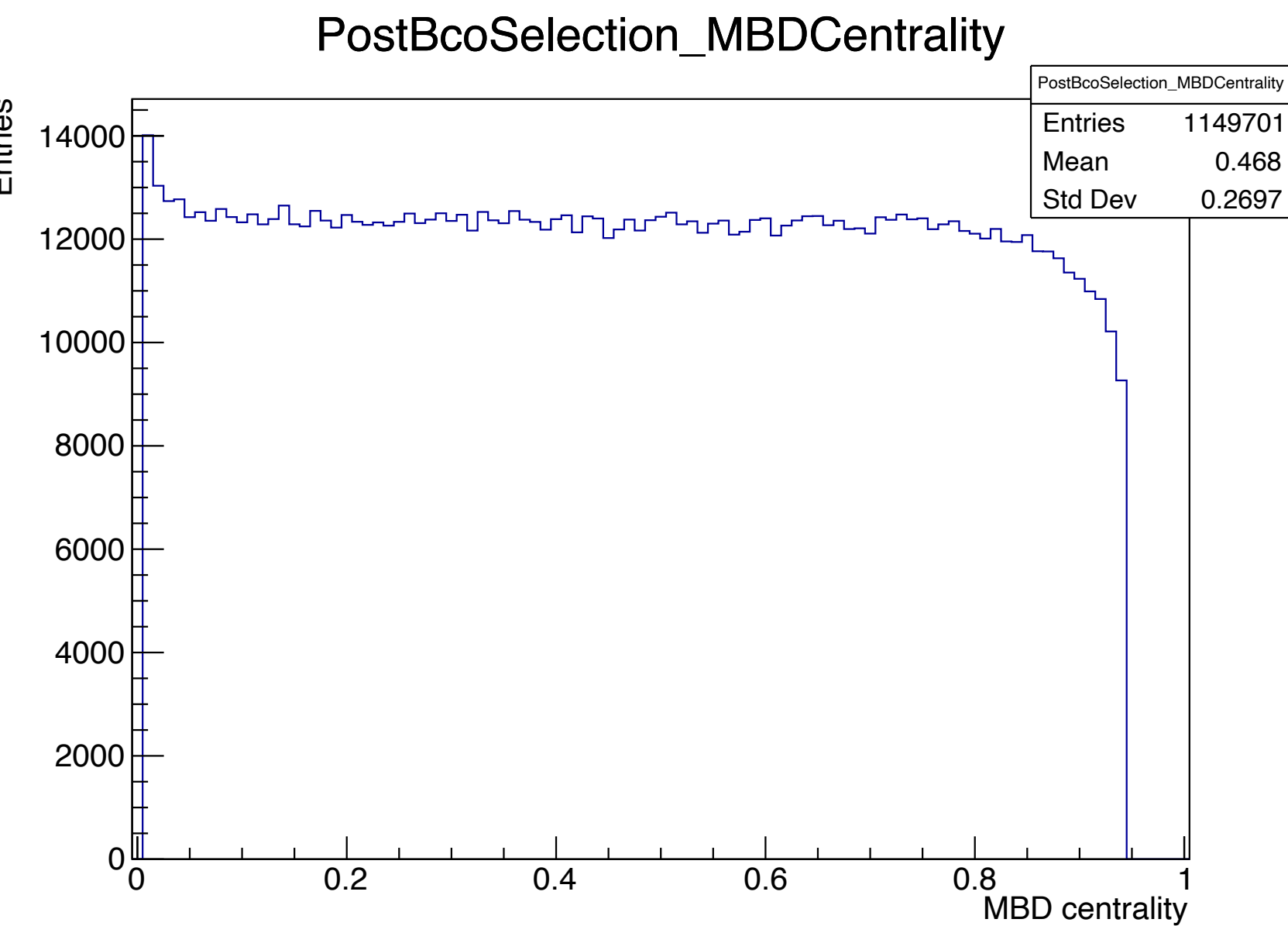
# Hit carried over issue

Only evens with  $-10 \text{ cm} < \text{MBD\_z\_vtx} < 10 \text{ cm}$  are included



# Hit carried over issue

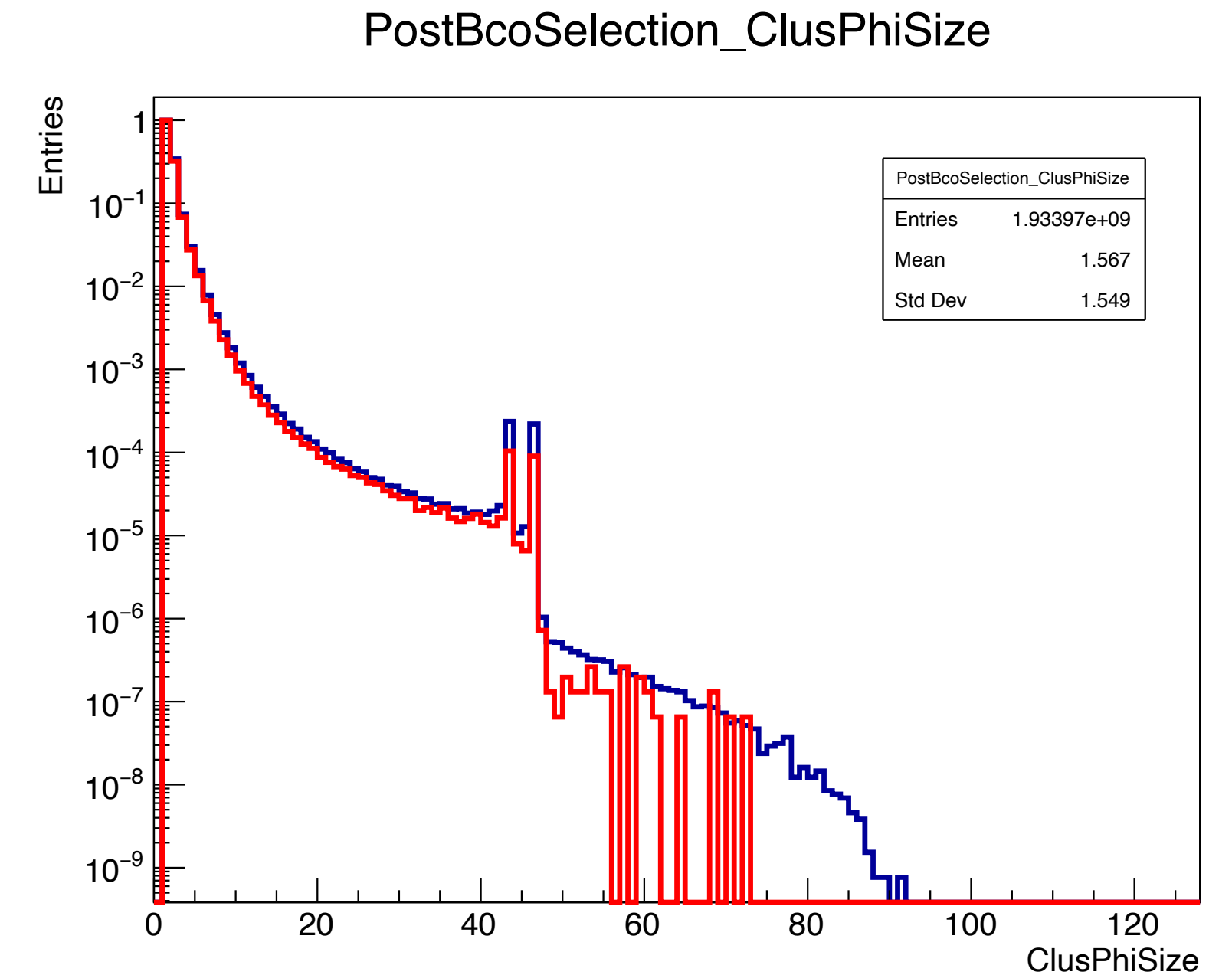
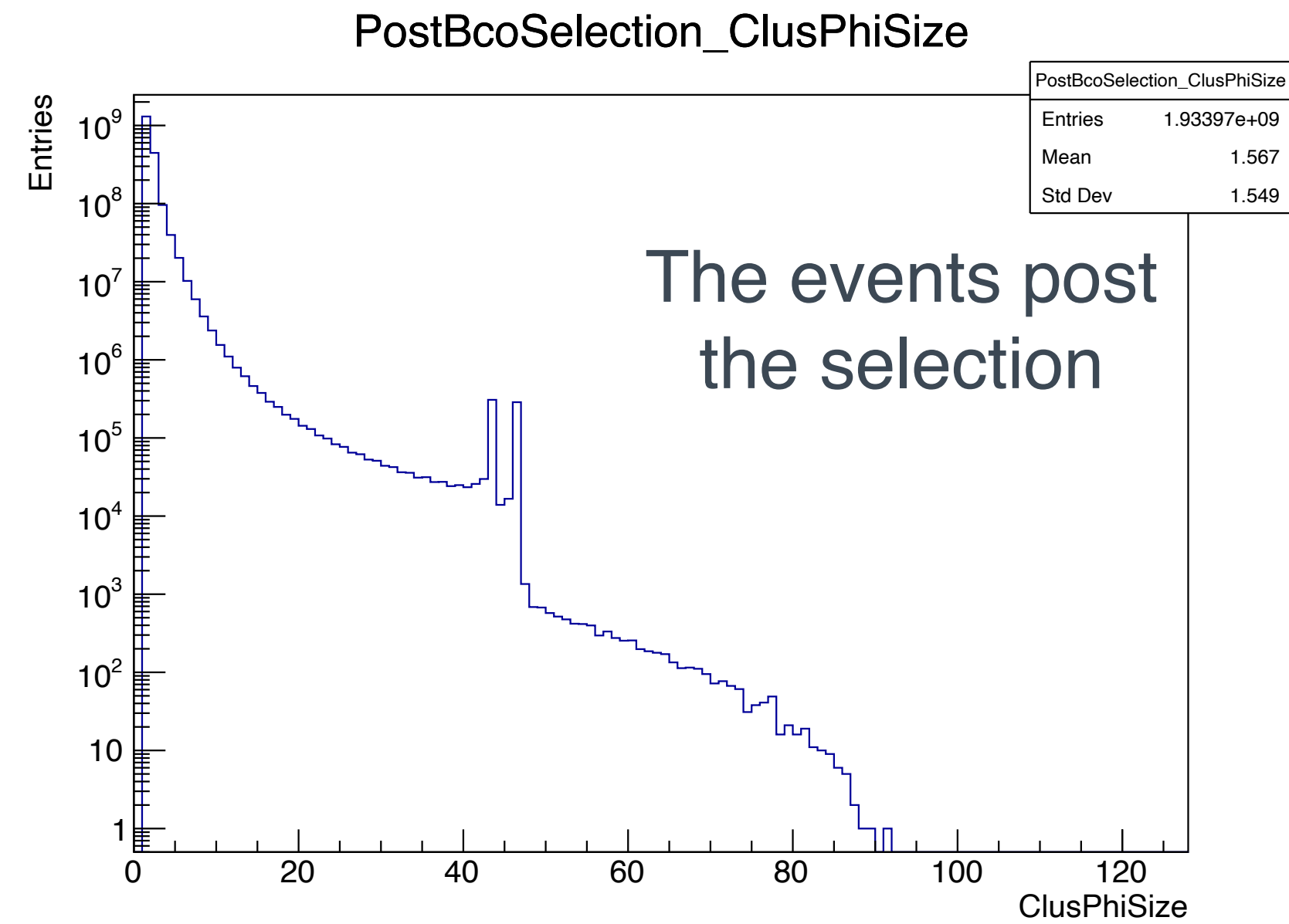
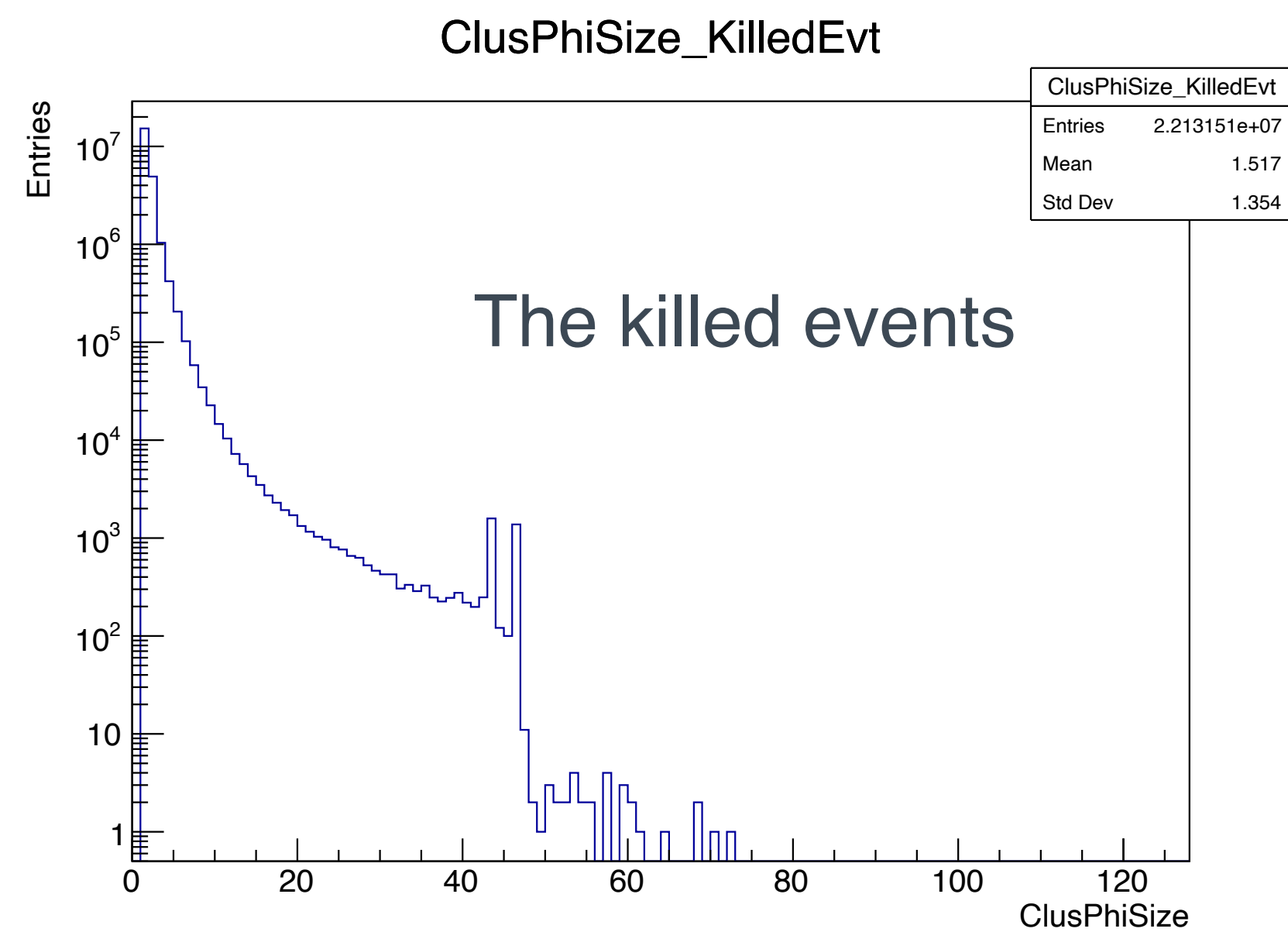
Only evens with  $-10 \text{ cm} < \text{MBD\_z\_vtx} < 10 \text{ cm}$  are included  
Events w/  $\text{NextInttBcoFull} - \text{ThisInttBcoFull} > 61$  are kept



16,542 out of 1,166,243 events are excluded  $\rightarrow$  1.42%

# Hit carried over issue

Only evens with  $-10 \text{ cm} < \text{MBD\_z\_vtx} < 10 \text{ cm}$  are included  
Events w/  $\text{NextInttBcoFull} - \text{ThisInttBcoFull} > \underline{61}$  are kept



The comparison  
(normalized by the first bin)

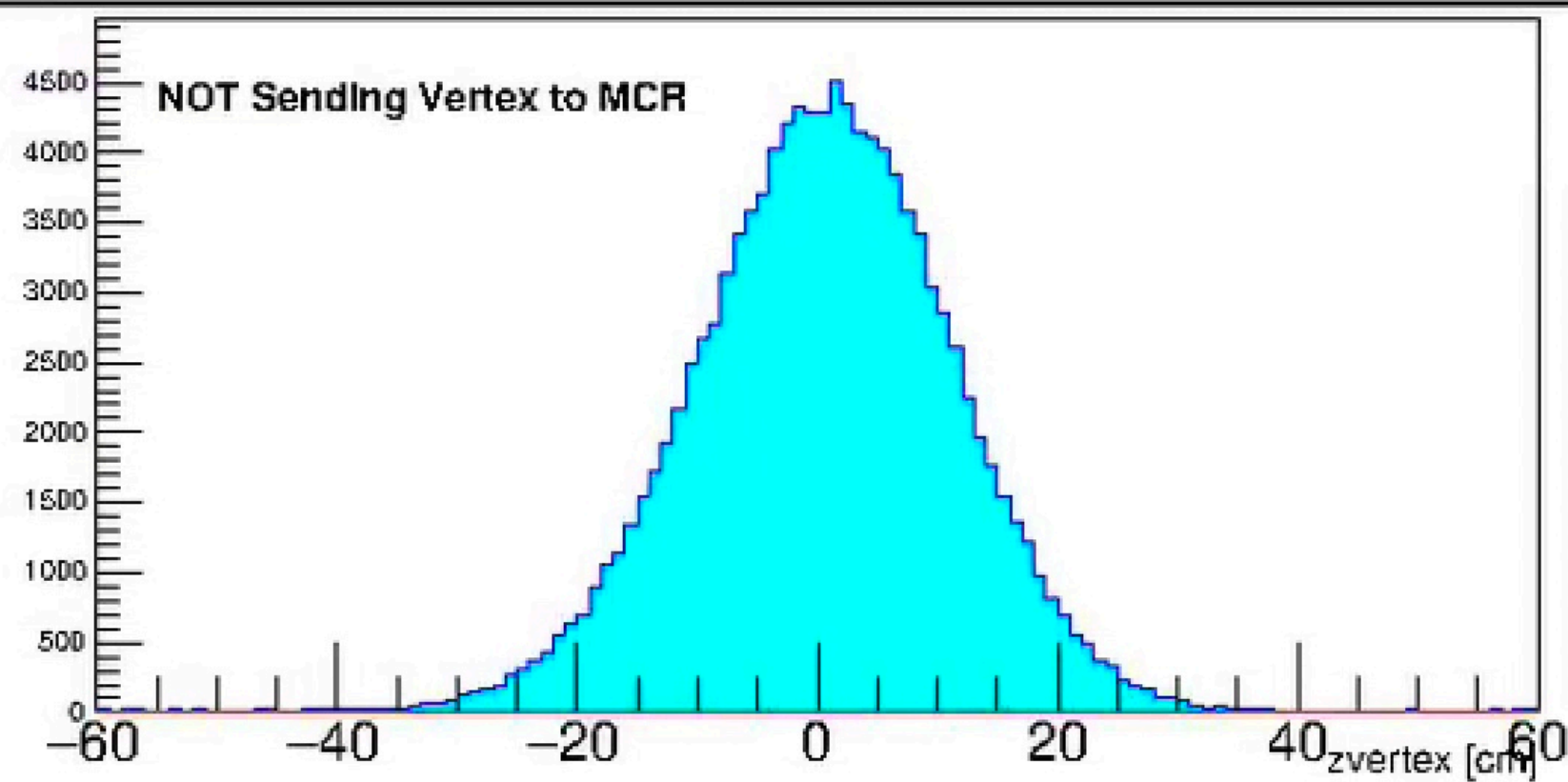
Don't get confused, the hit carried over issue is independent to the hit saturation issue

# Run description - 54280

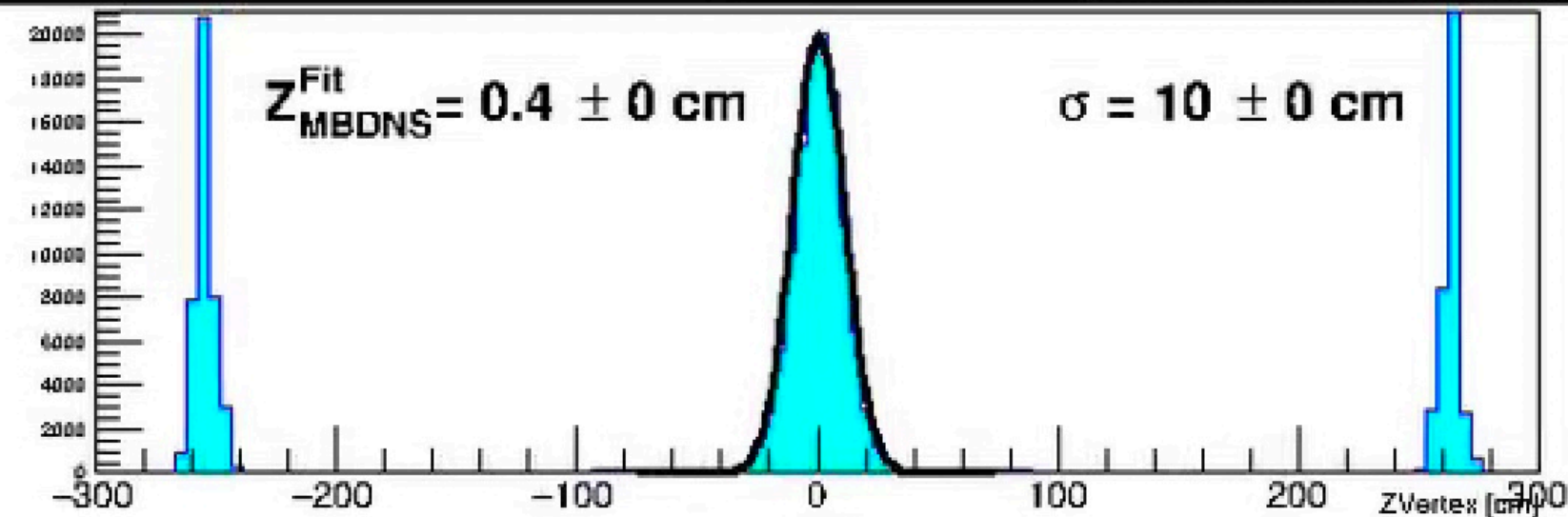
- Spike appears at each end of MBD
- The mini-bias definition is not yet available (as far as I know)
- Live trigger available to constraint the MBD vertex Z

Run #54280 Events: 204357 Date: Thu Oct 10 06:43:31 2011

MBD zvertex



MBD ZVertex (TRIG = MBDNS>=1)



Trigger input channel	Name	enabled	Scaledown	Raw	Live $\langle \div \rangle$	Scaled	Live (%)
0	Clock	yes	93810	33836274325	33663041357	358838	99.5
1	ZDC South	yes	off	102829214	102308816	0	99.5
2	ZDC North	yes	off	98430768	95872319	0	97.4
3	ZDC Coincidence	yes	60	9417100	9370209	153672	99.5
4	HCAL Singles/Coincidence	yes	off	30282609	30125423	0	99.5
5		yes	off	33836274325	33663041357	0	99.5
6		yes	off	0	0	0	0
7		yes	off	0	0	0	0
8	MBD S >= 2	yes	off	86958423	86380777	0	99.3
9	MBD N >= 2	yes	off	85797943	85195687	0	99.3
10	MBD N&S >= 2	yes	0	10242665	10187457	10187457	99.5
11	MBD N&S >= 1	yes	off	18093659	17967450	0	99.3
12	MBD N&S >= 2, vtx < 10 cm	yes	off	4021509	4000602	0	99.5
13	MBD N&S >= 2, vtx < 30 cm	yes	off	5799143	5768655	0	99.5