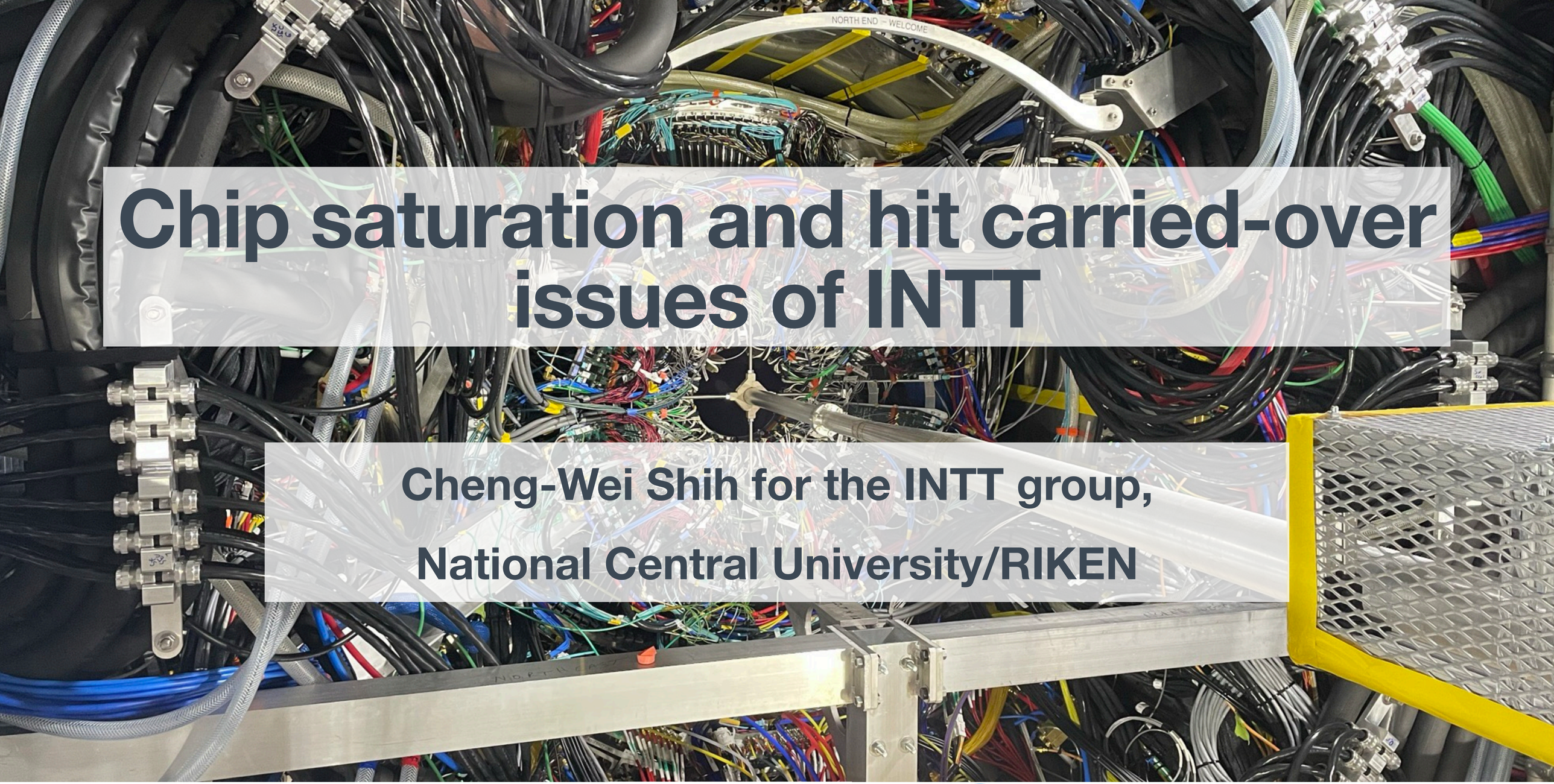


Chip saturation and hit carried-over issues of INTT

Cheng-Wei Shih for the INTT group,

National Central University/RIKEN

March 14th, 2025
Operation Board meeting

sPHENIX INTT sPHENIX 國立中央大學 National Central University RIKEN

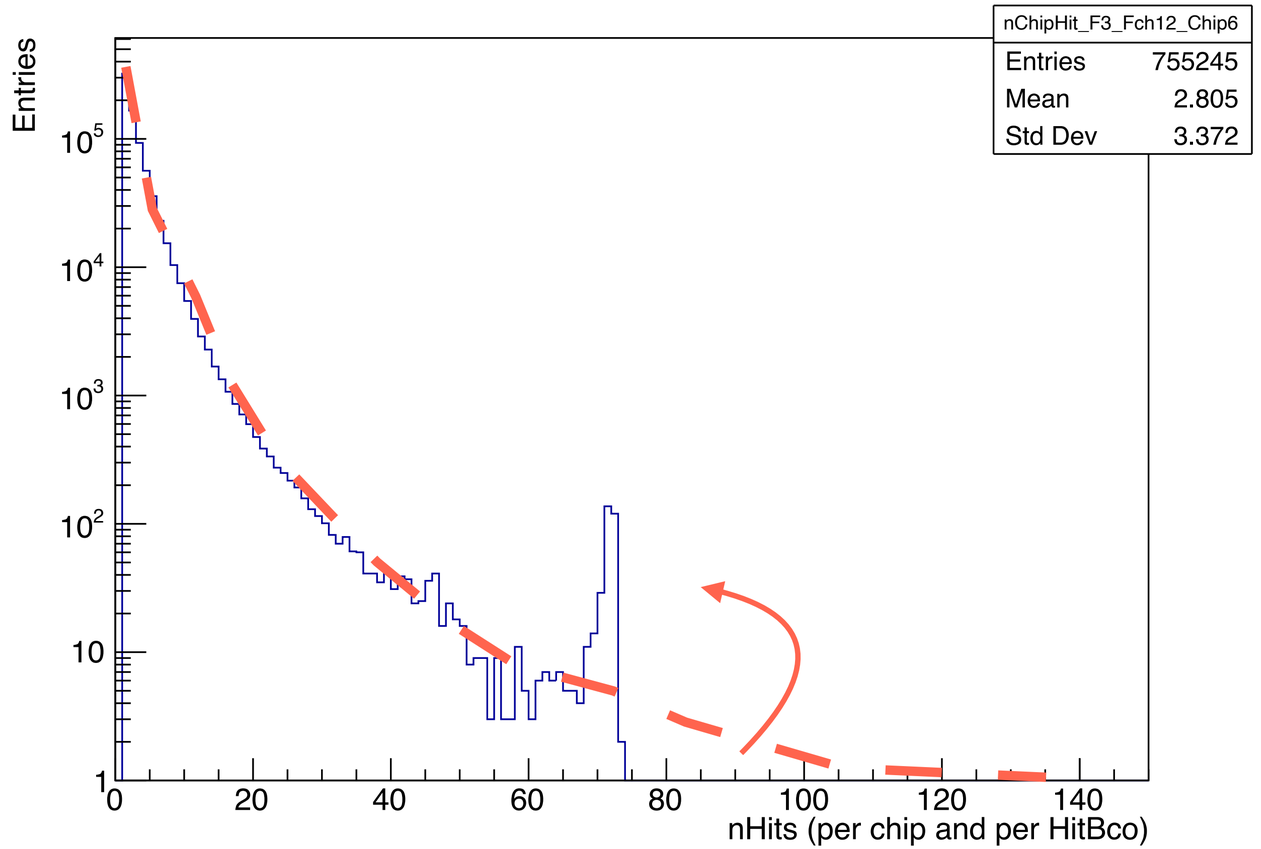
Overview

- Two issues were identified/confirmed recently that might affect the INTT operation in Run 2025
  - **Chip saturation issue** (Hits are discarded artificially during data taking):
    - The INTT hits are rejected by FELIX if they arrive at FELIX too late
  - **Hit carried-over issue** (Hits originated from one collision are split into two F4A events):
    - The next trigger signal is sent to FELIX too quick that FELIX has not yet finished the process of the current event. The current event is truncated
    - This problem can be more severe in Run25 due to expected higher trigger rate, ~10k Hz?
- INTT group would like to propose/discuss the potential mitigation strategies, and request a dedicated time with collisions during commissioning period for confirming the current understanding/hypotheses
- The plots shown in the slides were made using run 54280 taken in Run24

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

Chip saturation issue

Count the number of hits of each chip in each bunch crossing (Clone hits are removed*)

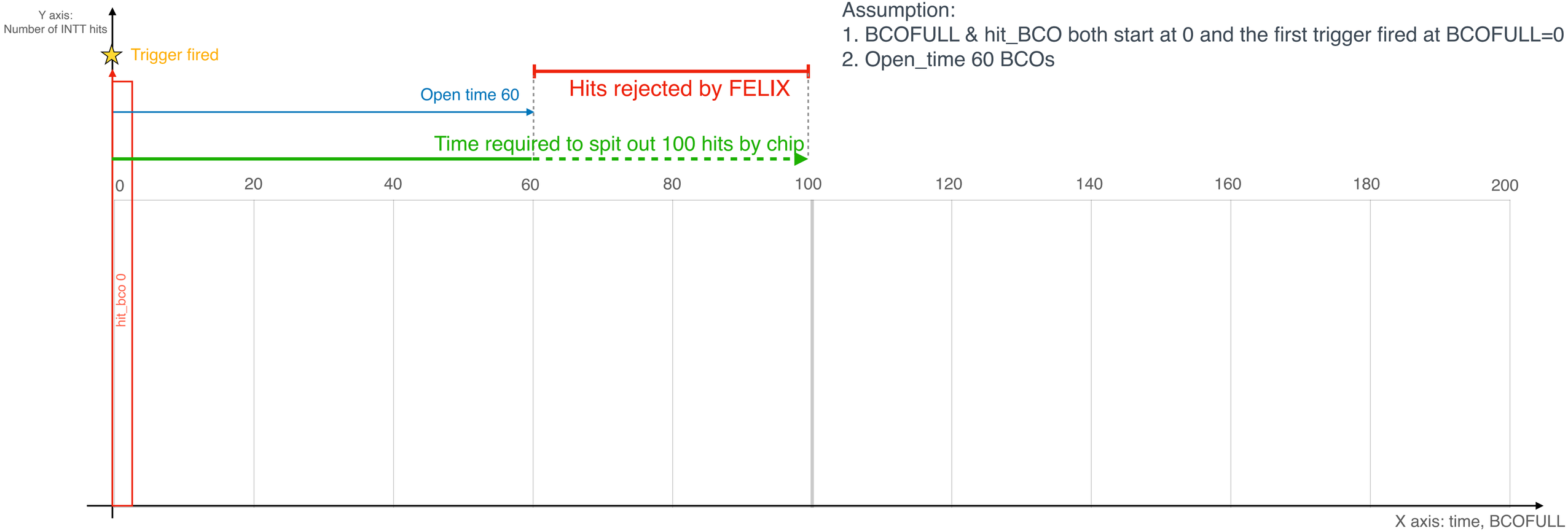


- The distinct cutoff in the right edge of the distribution indicates that INTT has chip saturation issue
- The issue could happen in all the INTT chips

*(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

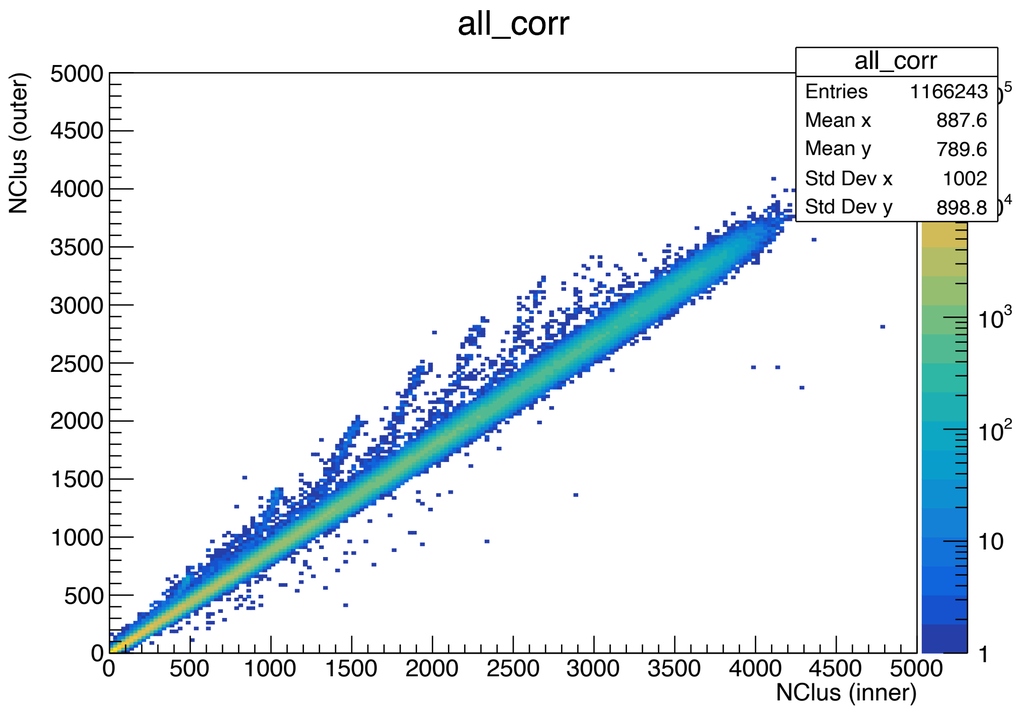
In single event

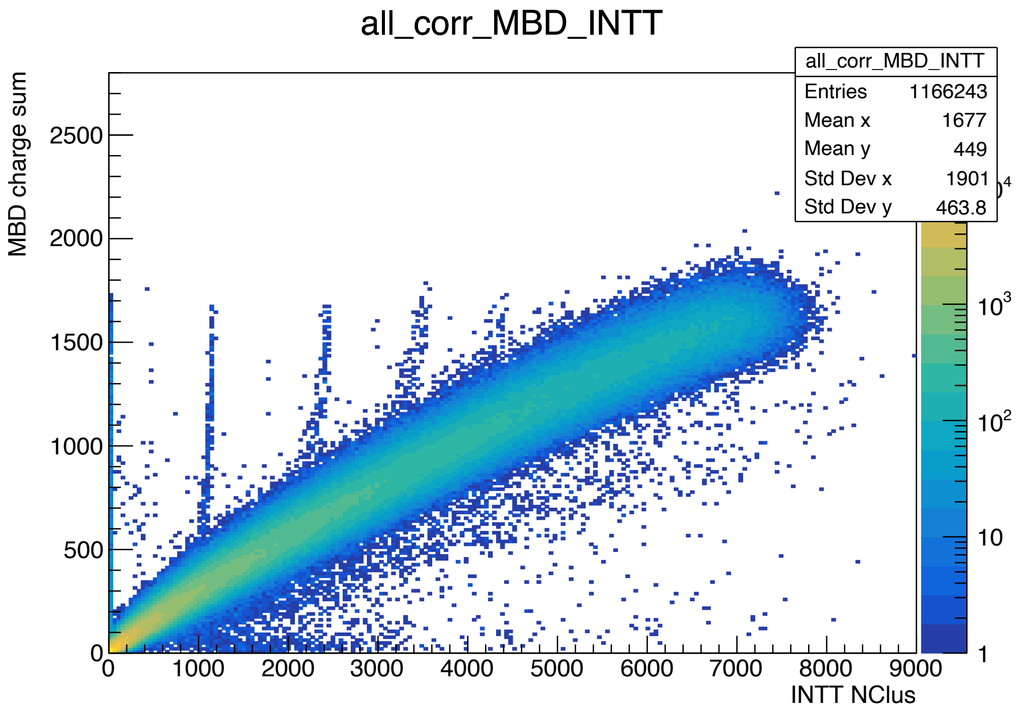


Assumption:
1. BCOFULL & hit_BCO both start at 0 and the first trigger fired at BCOFULL=0
2. Open_time 60 BCOs

1. Assuming in a triggered collision (hit_bco=0, BCOFULL=0), there is one chip with 100 channels activated. It's going to take a period of time (~ 100 BCOs) to send out all the hits for this chip
2. When FELIX detects the first hits with the "hit_bco_0", it then opens a certain time window (controlled by **open_time**) to accept the hits with "hit_bco_0"
3. Assuming open_time is 60. There could be ~ 40 hits that cannot make it to arrive at the FELIX on time. They are therefore discarded by FELIX

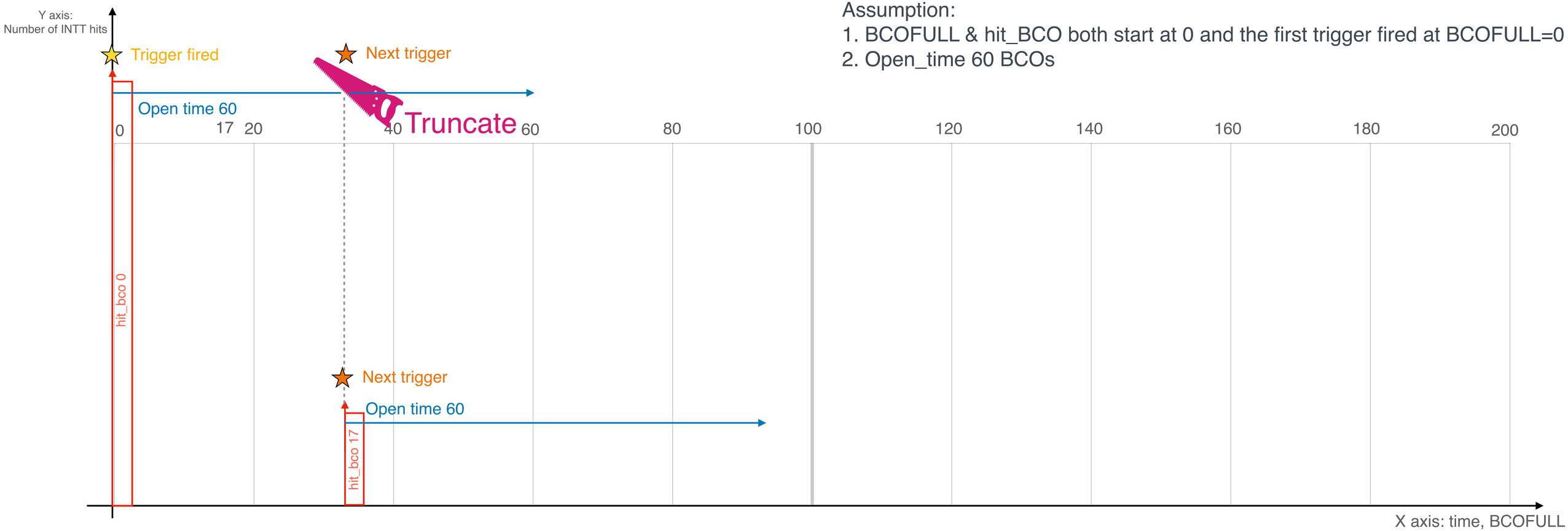
Hit carried over issue





- Off-diagonal entries observed in the correlations of number of inner clusters vs. number of outer clusters and number of INTT clusters vs. MBD charge sum
- Those entries were identified as being due to hits carried over to the next F4A event (INTT hits from one collisions are split into two F4A events. Some hits are missing, hence no good correlation observed)

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



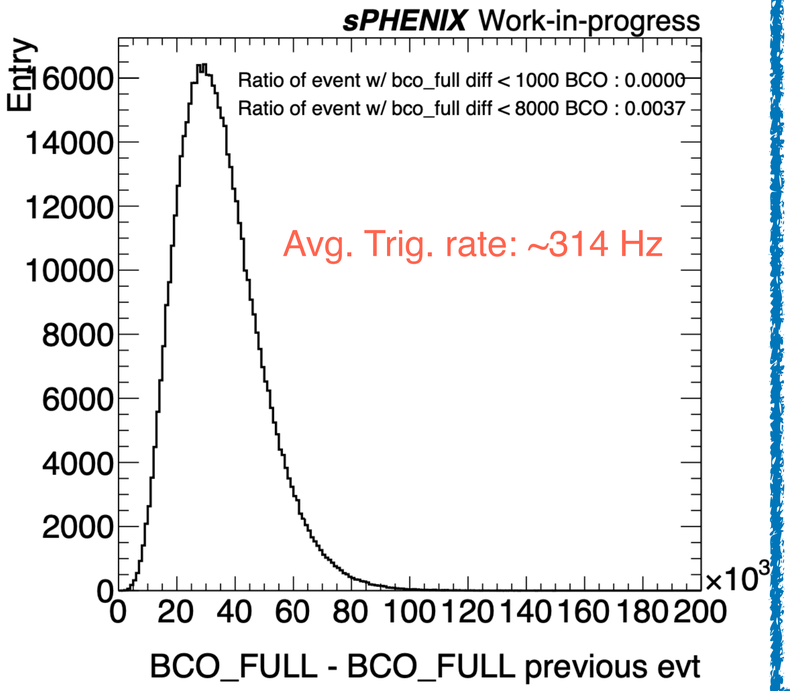
Assumption:
1. BCOFULL & hit_BCO both start at 0 and the first trigger fired at BCOFULL=0
2. Open_time 60 BCOs

- Job of FELIX server: associate INTT hits with trigger clock (GTM clock)
- When a new trigger signal comes to FELIX, new trigger clock replaces the previous one
- If the next trigger signal comes to FELIX while FELIX is still working on the hits from the current collision, the INTT hits will hence be associated to the next trigger clock (next F4A event)

- No busy signal issued by INTT FELIX to reject the new trigger signal when the current processing is on going
  - According to Raul, he didn't expect that the next trigger would be sent to subsystems within ~200 BCOs.

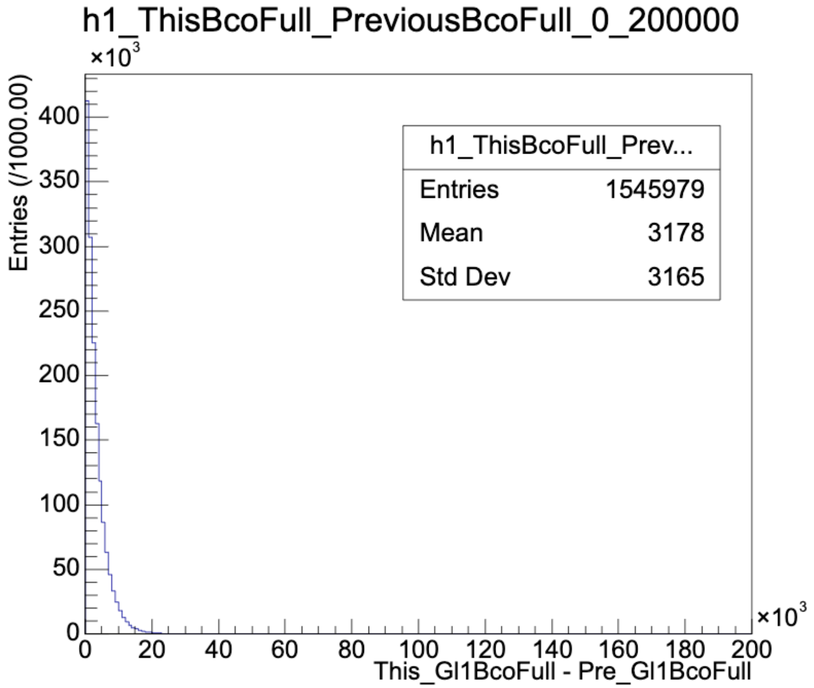
Trigger interval (unit: BCO)

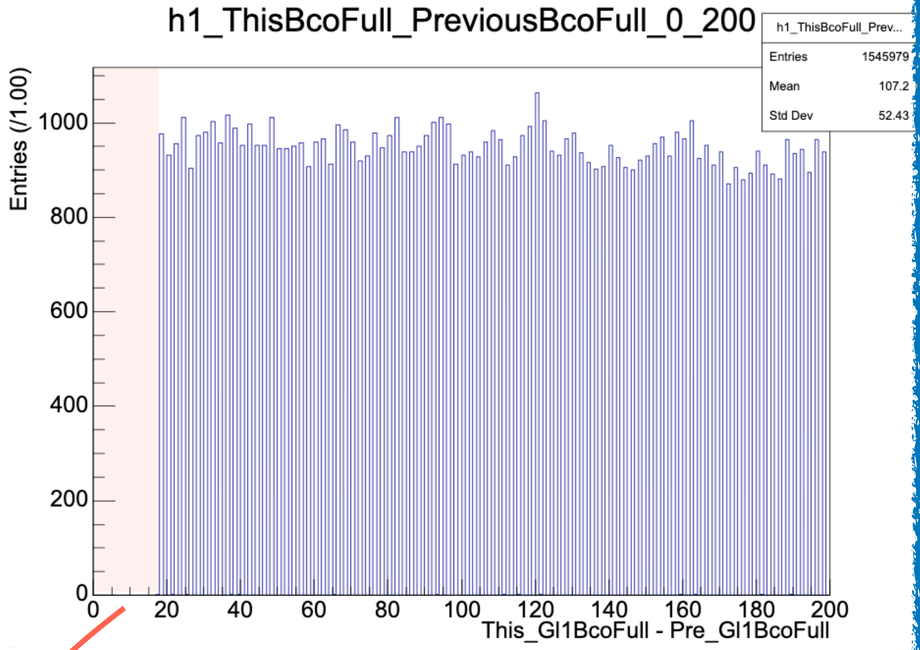
Run23, run 20869



Run24, run 54280

Avg. Trig. rate: ~3000 Hz





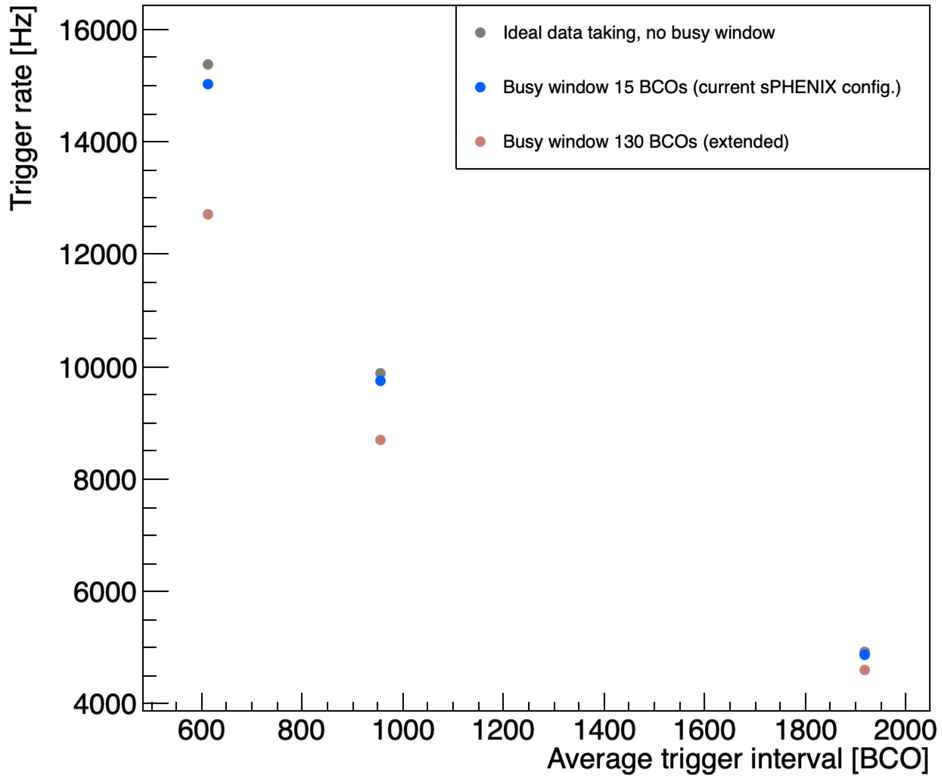
Default busy window(15 BCOs)

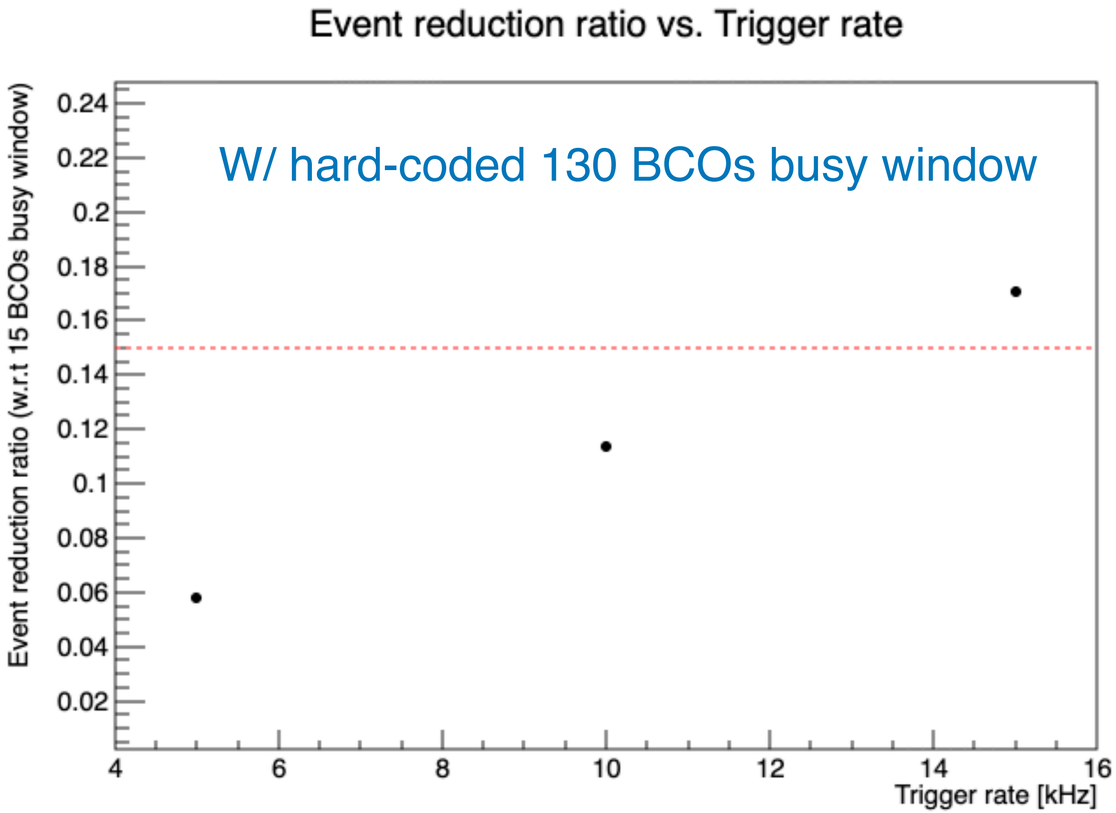
Mitigation strategies for run 2025

- Chip saturation issue [relatively minor issue, < 0.1% hits in one event missing]
  - Increase the `INTT FELIX open_time` to the maximum (128 BCOs)
  - Perform the open_time scan in Run25 commissioning period to confirm the hypothesis

- Hit carried over issue [serious issue, ~10% of accumulated events could be affected]
  - Increase hard-coded GTM busy (to 130 BCOs, for example) ▲(Trigger rate reduction)
  - Run with the current configuration and remove/resolve the problematic events in the offline analysis
    - There might be a way to put the hits back to where they should be, under investigation
  - Any other suggestions?

Estimation of event reduction with longer busy window





- 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

Beam time request

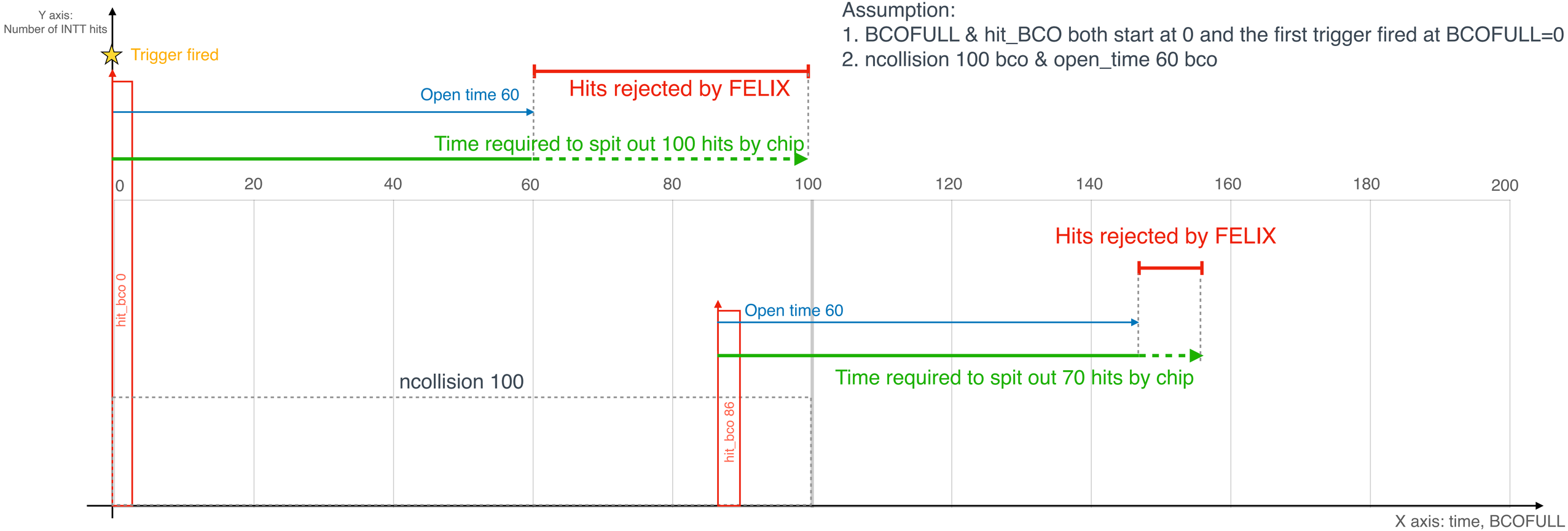
- What described are the best hypotheses we come up with based on the results from the data available currently
- INTT group proposes to have a dedicate time to take some special runs with customized firmware/slow control settings, which are essential to confirm the hypotheses

	Importance	RHIC config.	Settings	Total duration
Carry over hit	1 (Crucial)	High trigger rates (>5 kHz)	1. DEAD4N: 15 and 200 BCOs 2. INTT extended-readout region : 3 and 100 BCOs	1 hours
Chip saturation	2	Each	1. DAQ busy window (DEAD4N): 200 BCOs 2. INTT_bco_window: 0..10..60..128	2 hours
INTT timing resolution	2	Low # of bunch crossings (1x1 or 6x6)	1. DEAD4N: nominal 2. INTT extended-readout region: 100 BCOs	Can run with MVTX
INTT background w/ beam	3	Single beam (If Physics declared)		Can run with MVTX

Back up

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

In single event

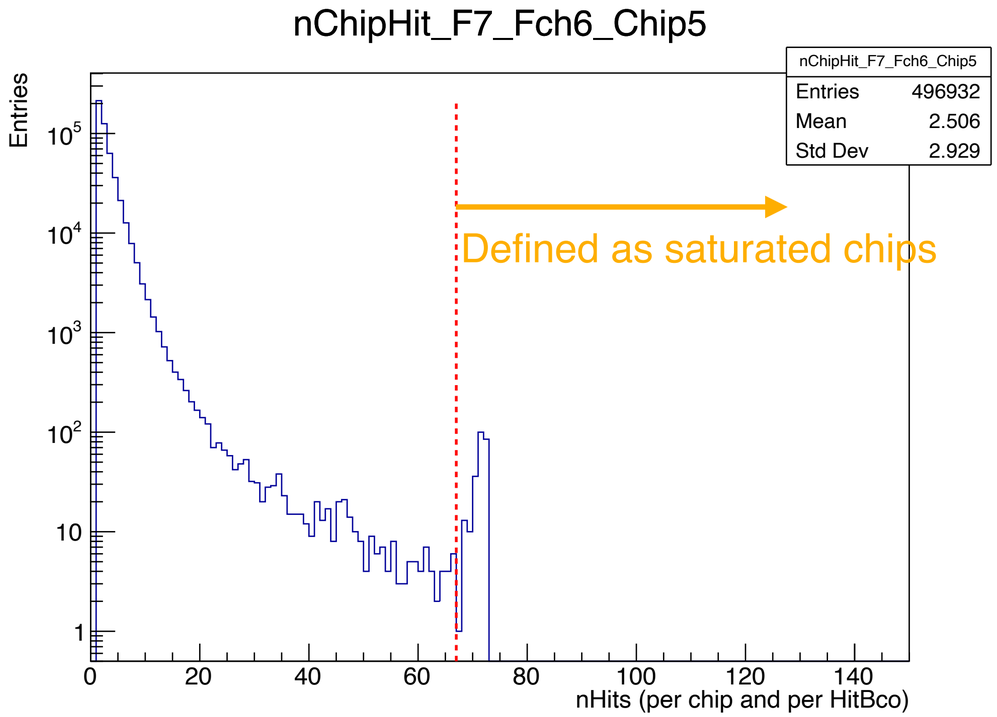


Assumption:
1. BCOFULL & hit_BCO both start at 0 and the first trigger fired at BCOFULL=0
2. ncollision 100 bco & open_time 60 bco

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

Chip saturation issue

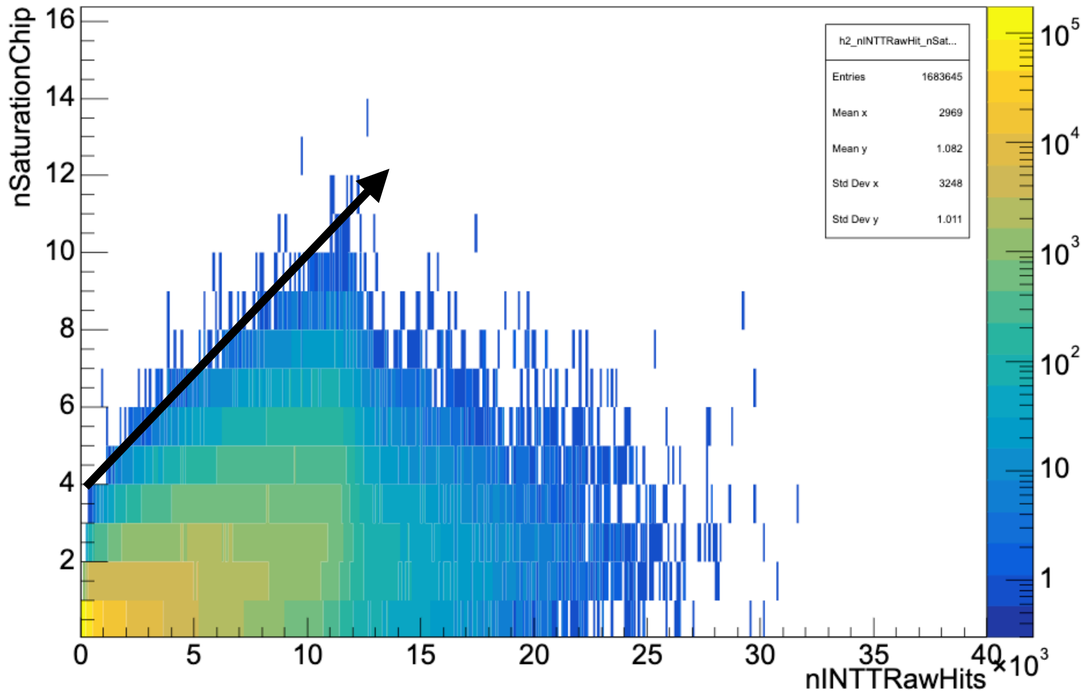
Run 54280

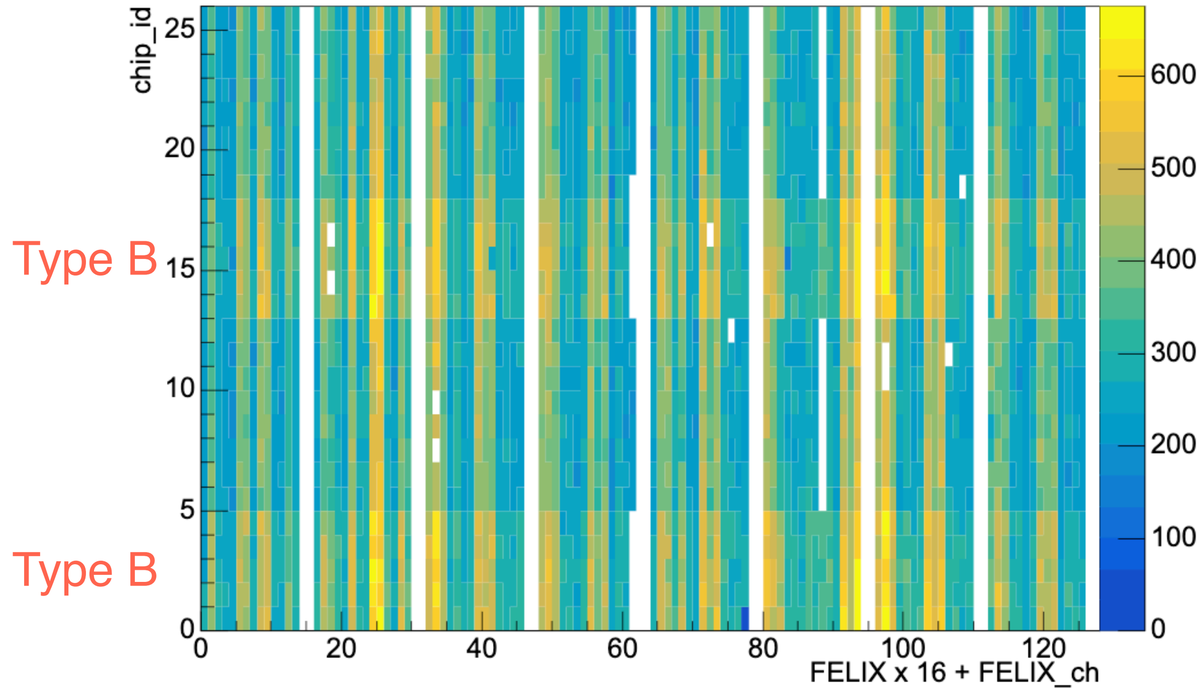


Try to have the selections to pick up the chips saturated

Number of the chips saturated

Run 54280





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

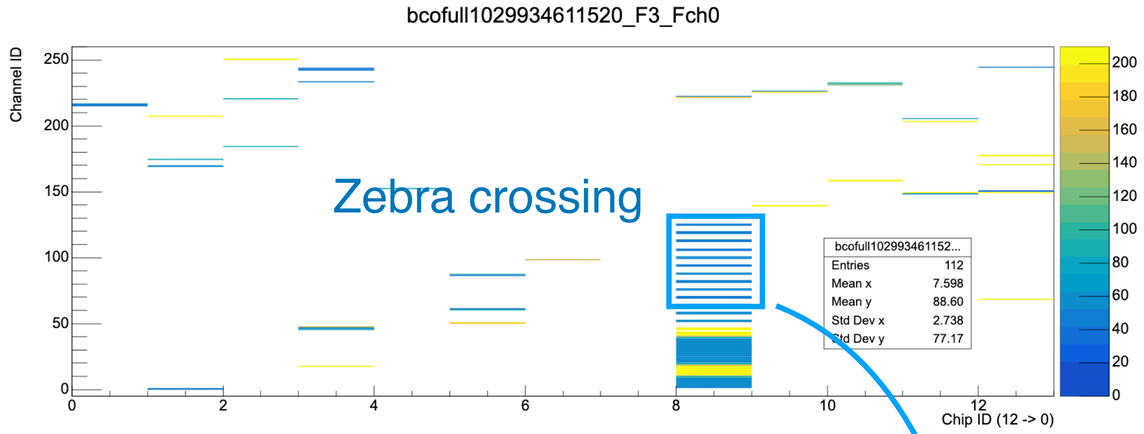
Assuming those chips have all channels fired, (128 - 73) * 12 = 660 hits are dropped by FELIX servers

660 / (13000 + 660) = ~ 5% of the hits are missing

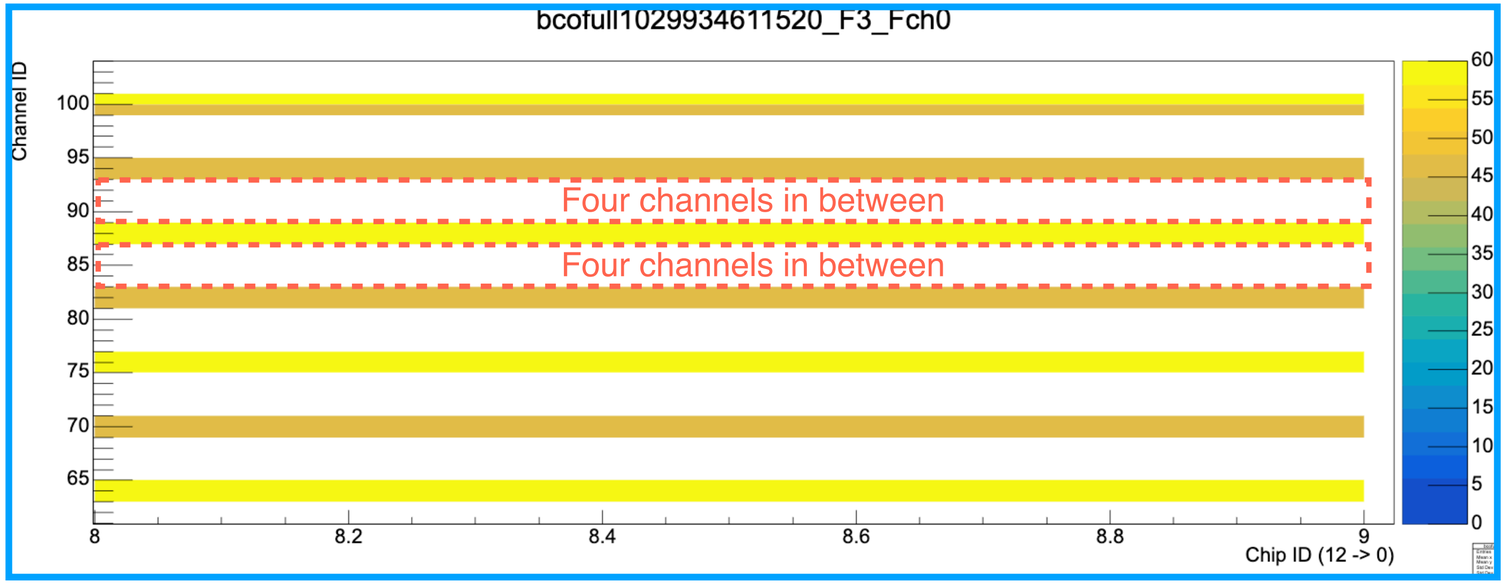
But we might gain more clusters (non-physical)

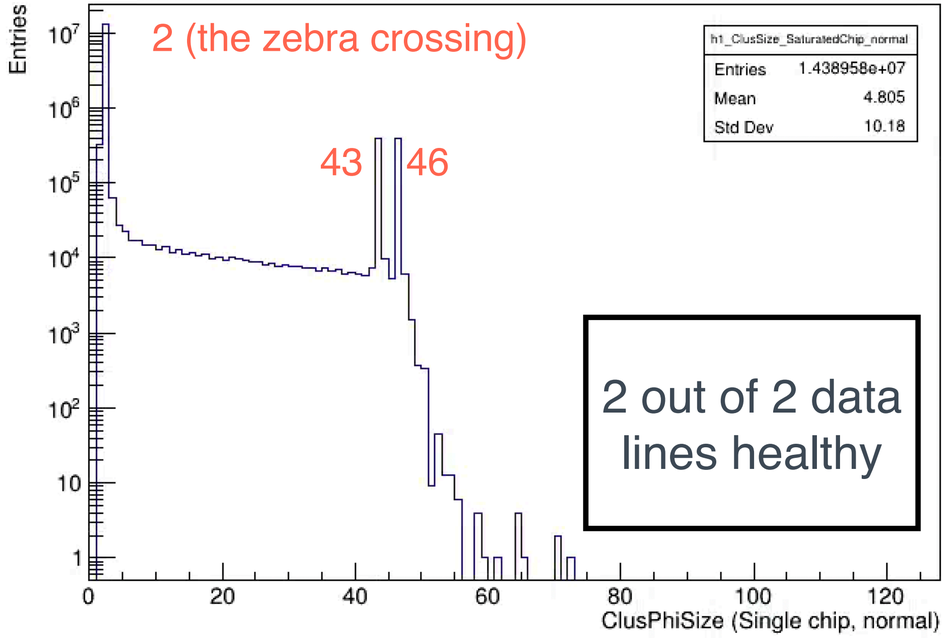
Chip saturation, the patterns

Run 54280



Two channels for each streak



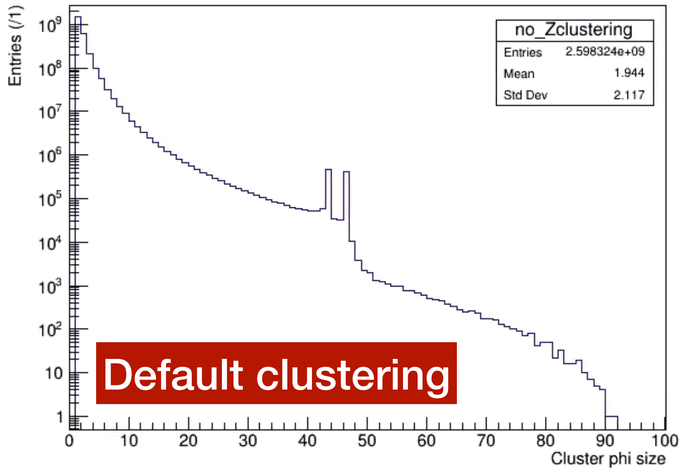


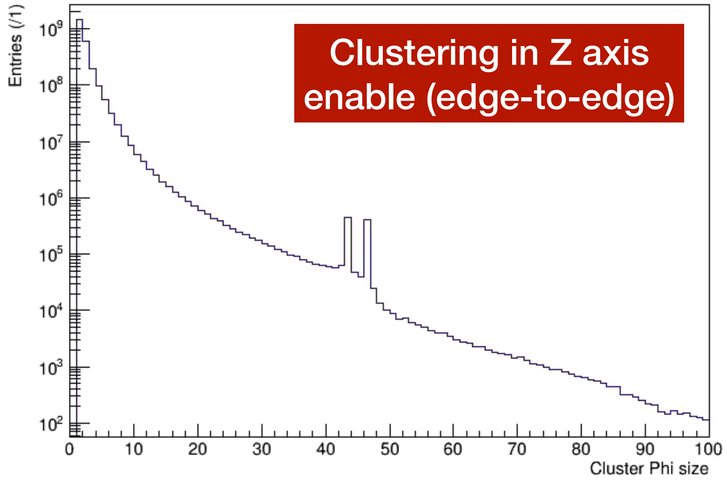
The pattern : big chunk + zebra crosswalk, and big chunk always closer to the edge

Cluster phi size distribution

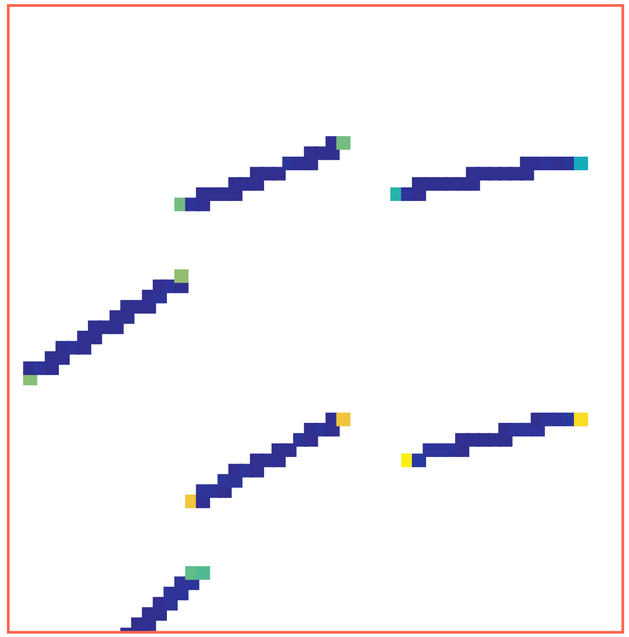
Run 54280

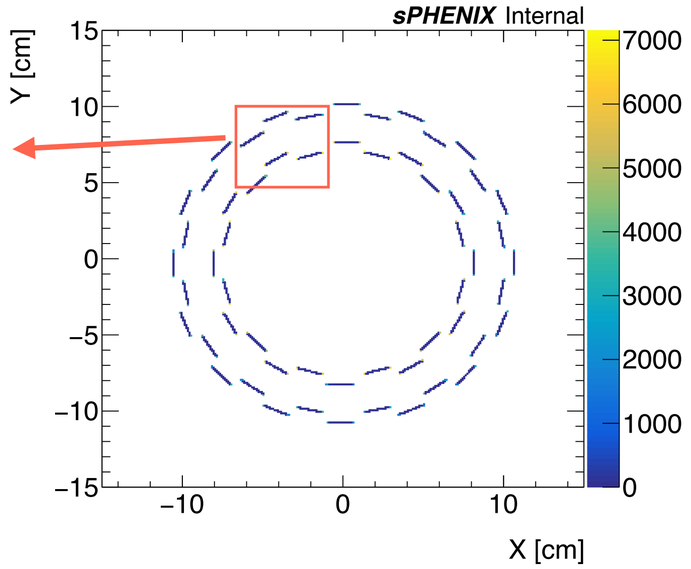
- There are two spikes in the cluster phi size distribution regardless the clustering requirement
- Issue was first spotted by Hao-Ren (MIT) with run 23 Au+Au data (it's the problem across the runs)





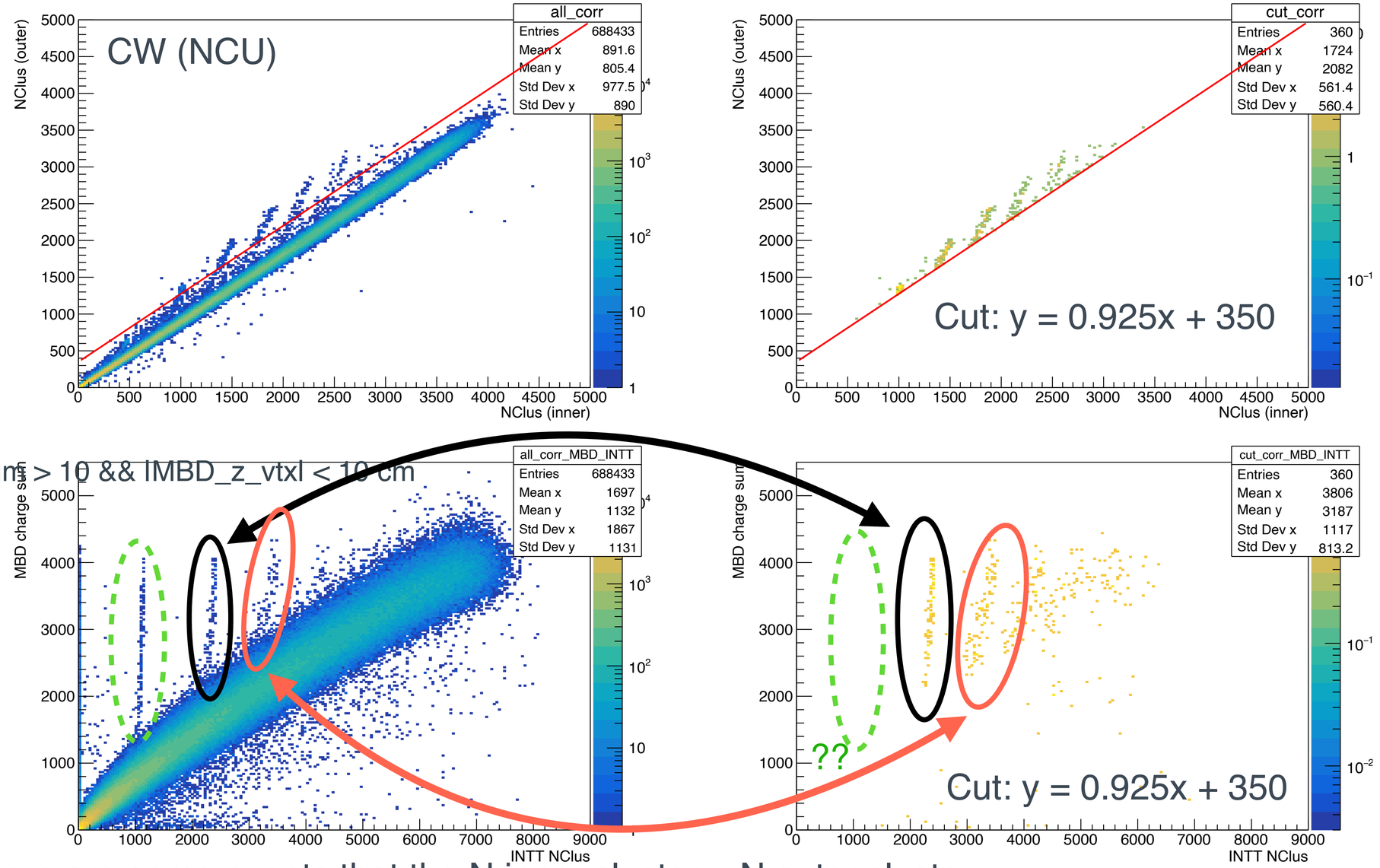
The positions of the clusters with phi size 43 or 46 (default clustering)





They tend to appear at the edge of sensor

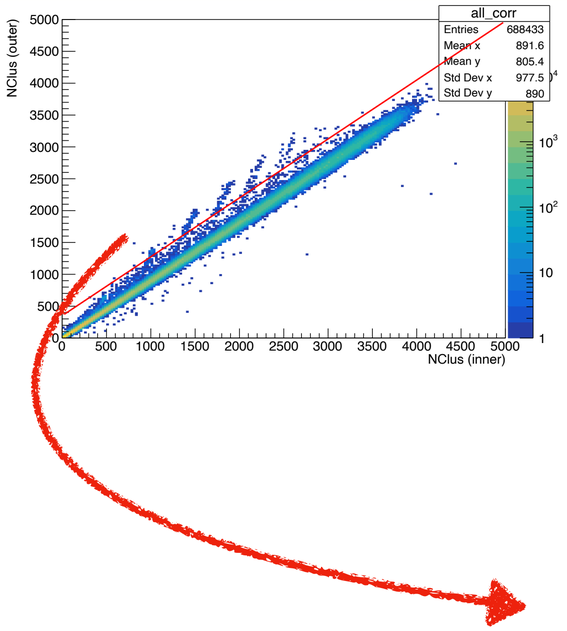
Hit carried over issue

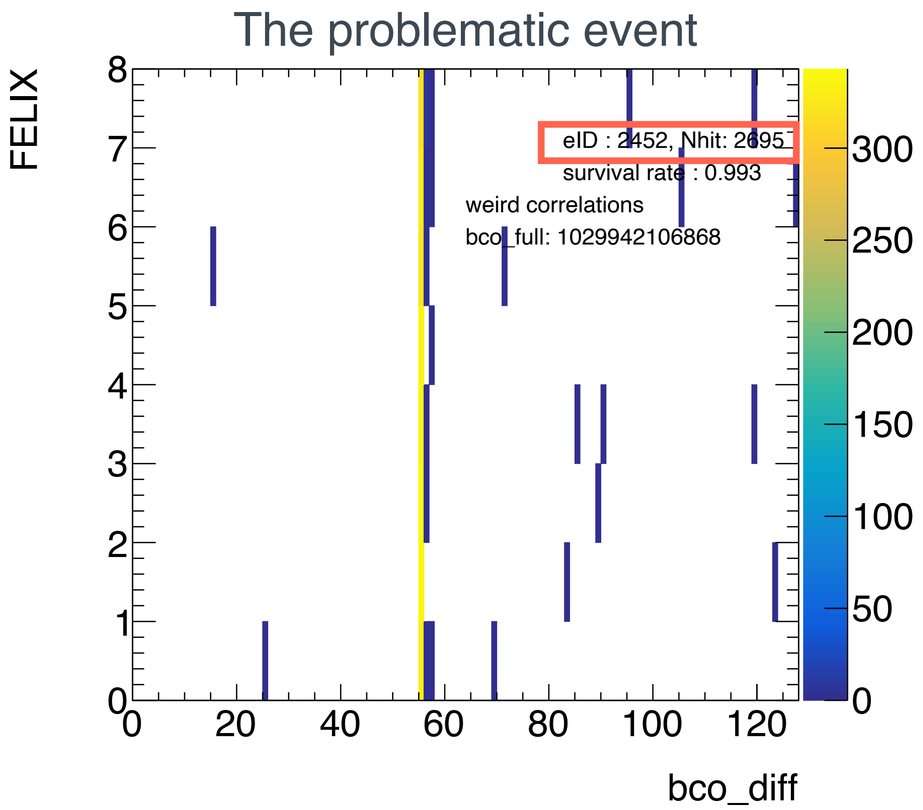


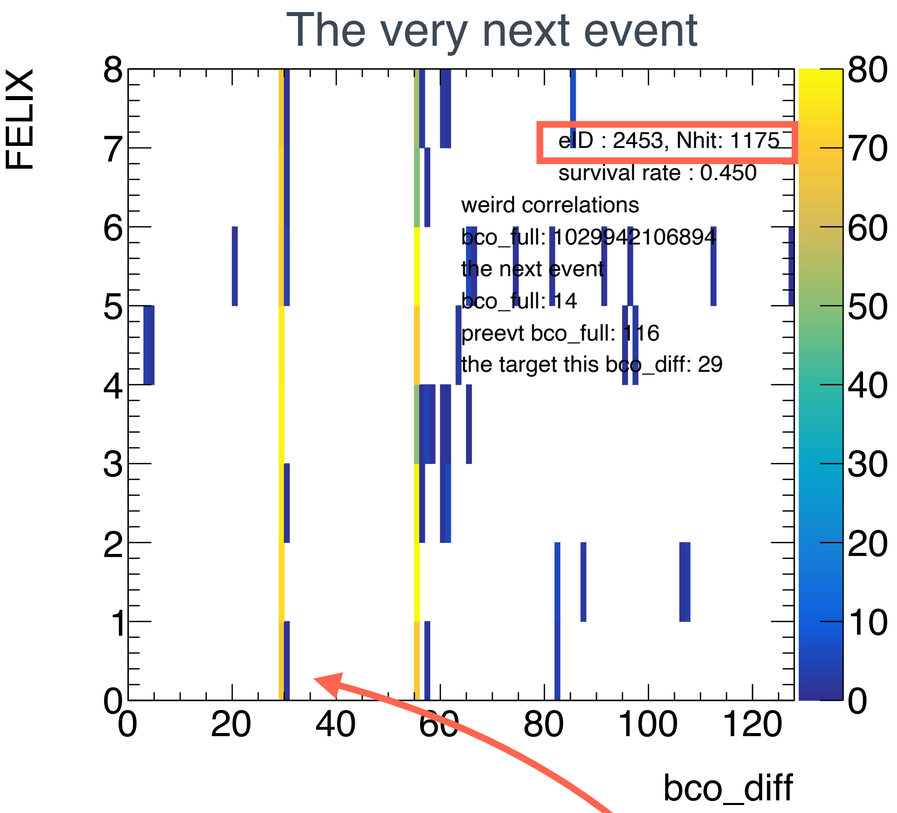
There are some events that the N inner cluster < N outer cluster

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

Hit carried over issue







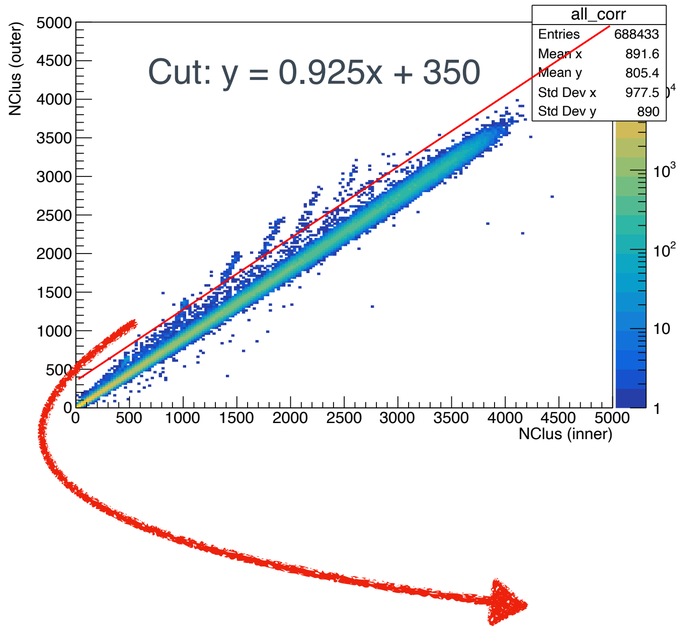
INTT has hits carried over

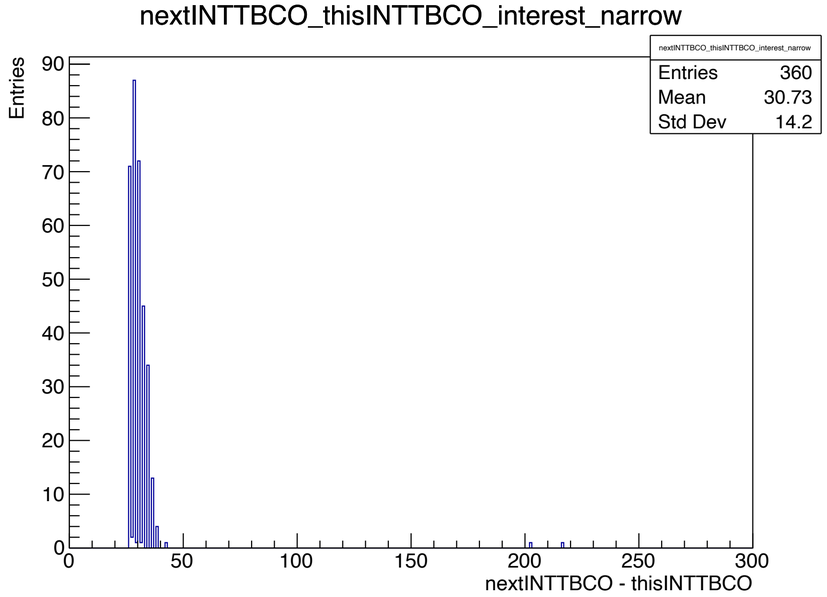
- In this event, if the hits are carried over to the next event, the "**time_bucket of this_hit_bco w.r.t next_BcoFull**" would have to be **29**, where you can see the yellow strip in the right plot
- The evidence of hits varied over to the next event

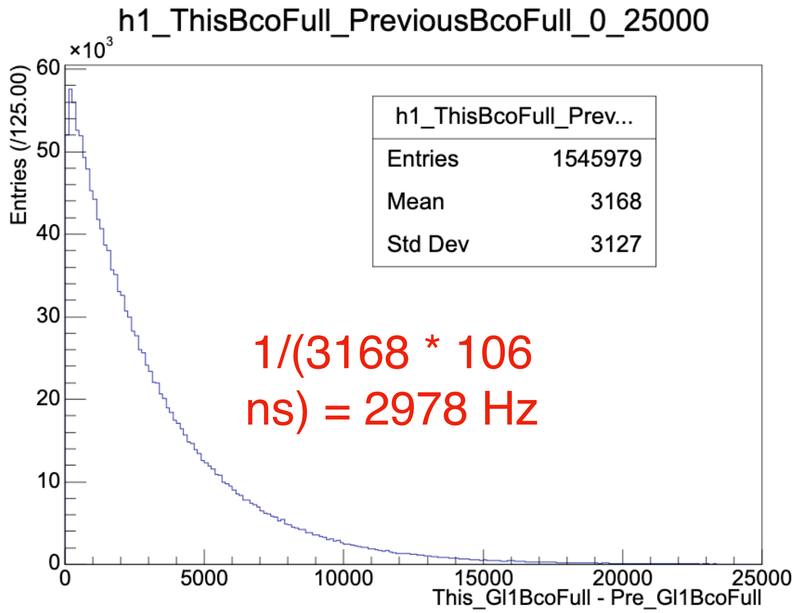
(1)	this bco_full & 0x7fU	116
(2)	correct hit_bco	43
(3)	Next bco_full & 0x7fU	14
(4)	(2) - (3)	29

Hit carried over issue

Run 54280







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

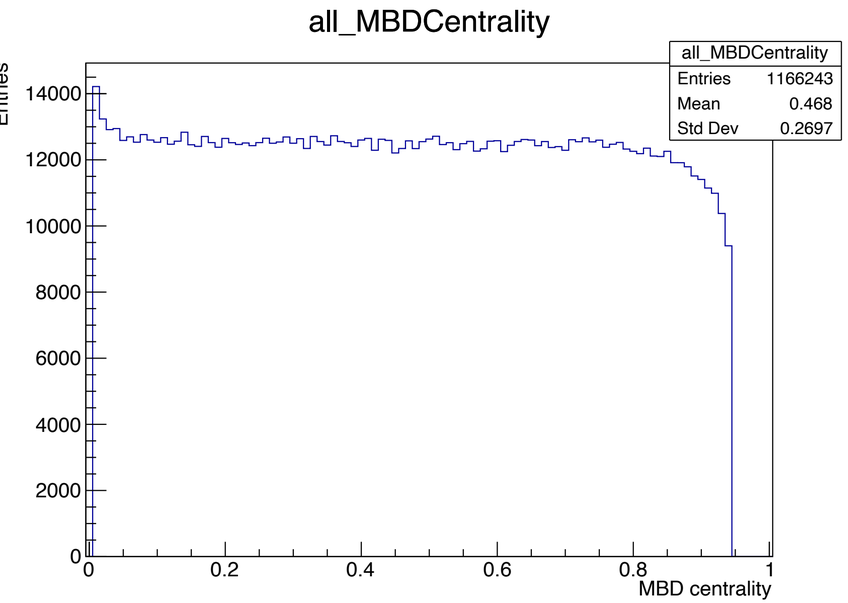
Hypothesis: Hits in FELIX been assembled with INTTheader (INTT_bcofull) and sent out to the down stream. Since FELIX receives new trigger, the previous INTT_bcofull is overwritten. The hit assembly continues, but with the new INTT_bcofull

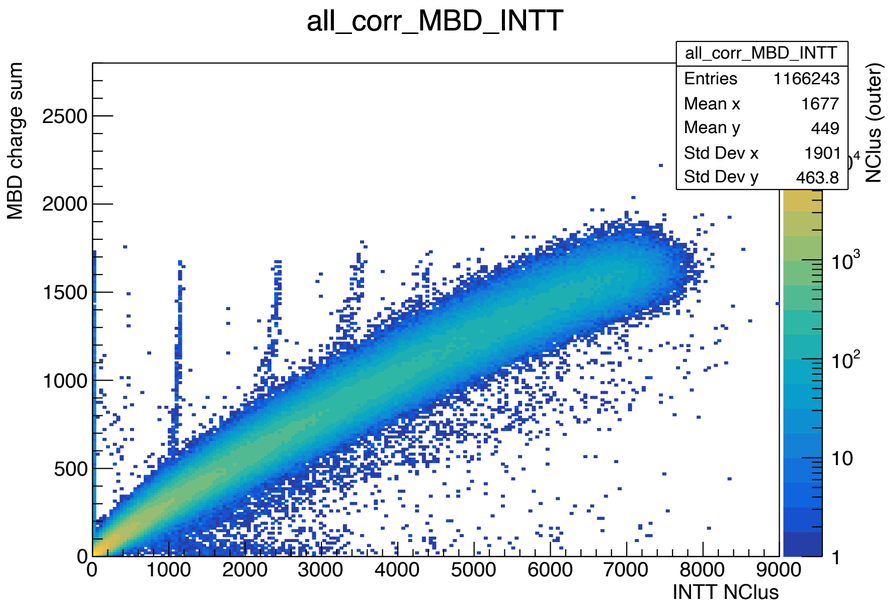
Can we probably just have a simple “BCOFULL_diff” cut?

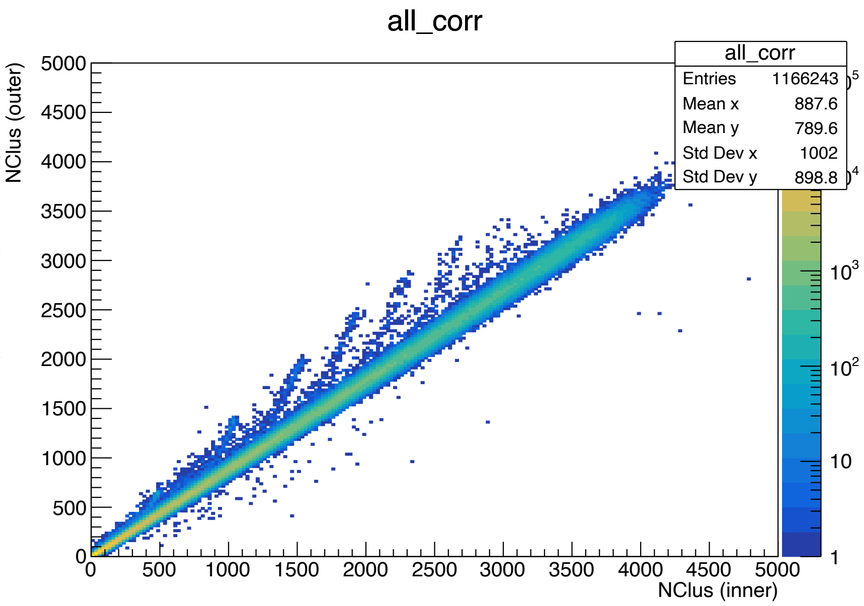
Hit carried over issue

Run 54280

Only evens with -10 cm < MBD_z_vtx < 10 cm are included



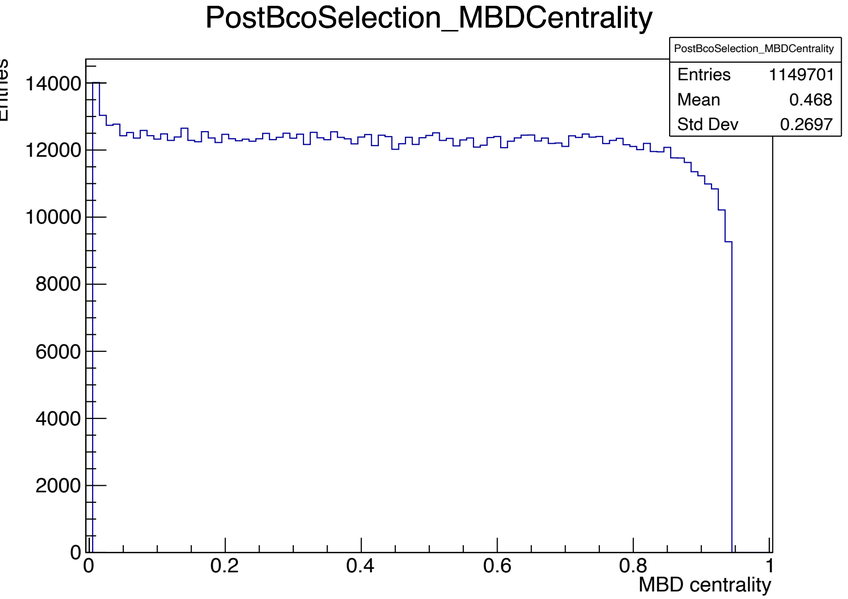


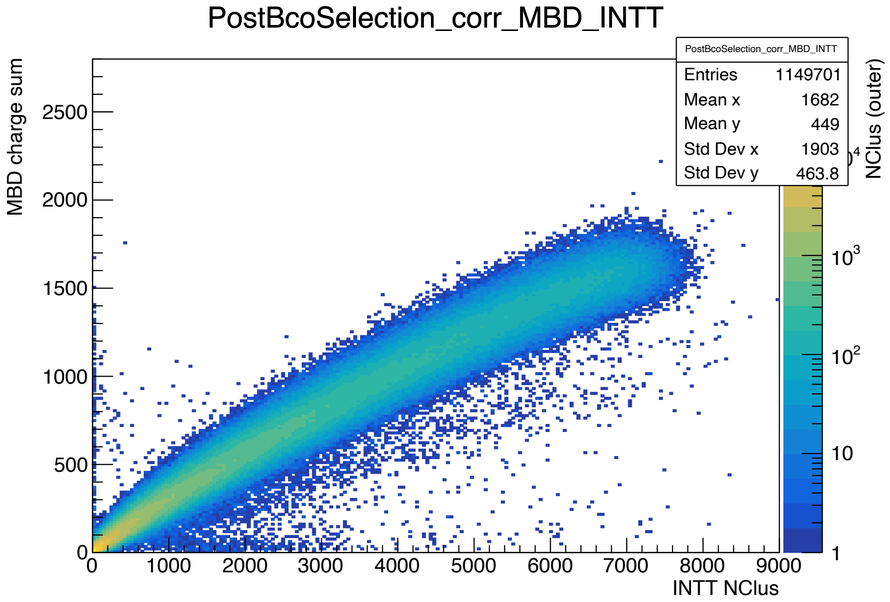


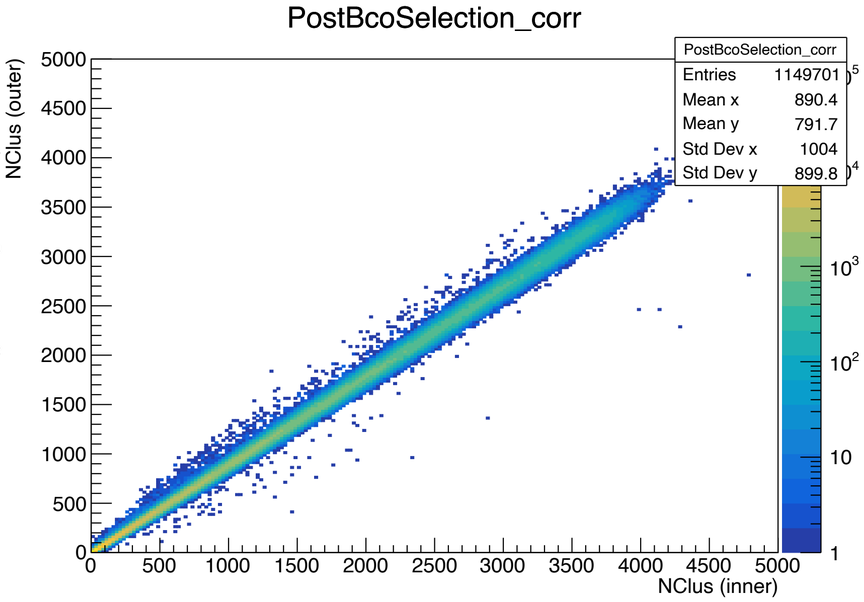
Hit carried over issue

Only evens with -10 cm < MBD_z_vtx < 10 cm are included

Events w/ NextInttBcoFull - ThisInttBcoFull > **61** are kept





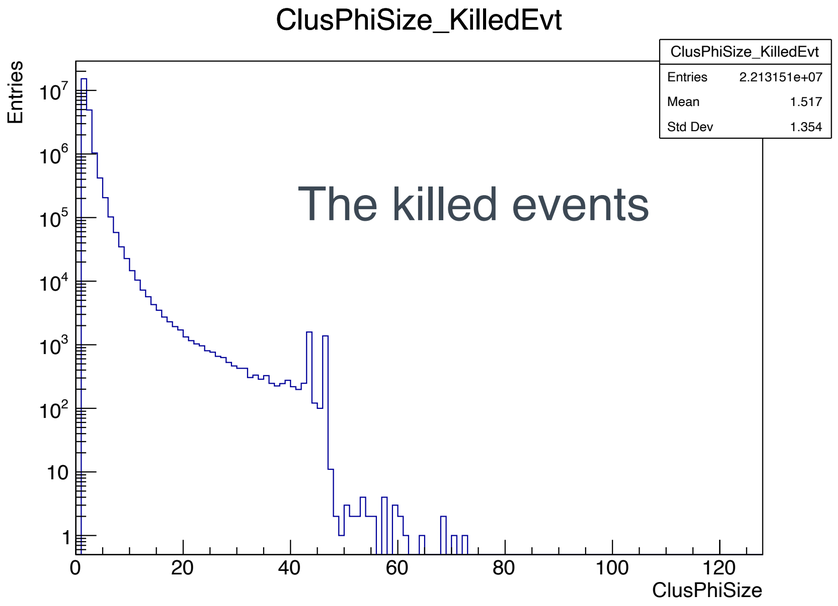


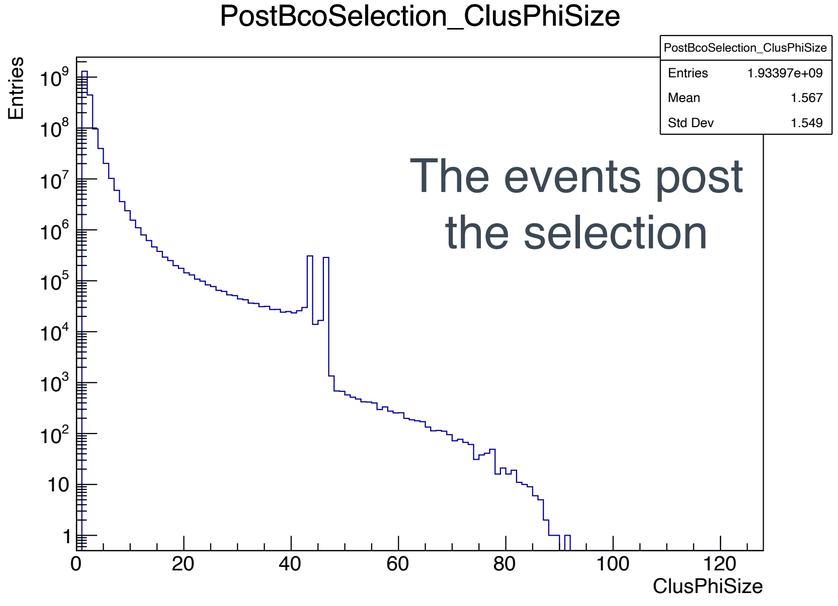
16,542 out of 1,166,243 events are excluded → 1.42%

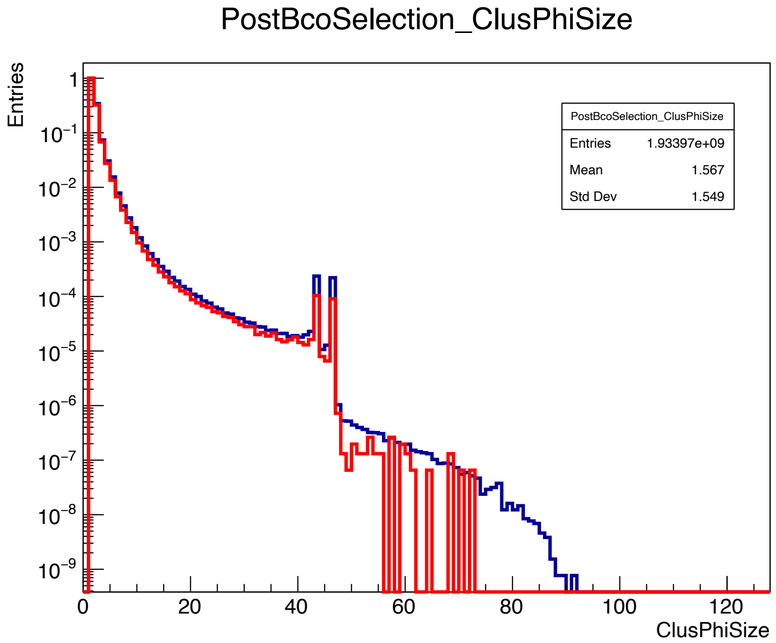
Hit carried over issue

Only evens with -10 cm < MBD_z_vtx < 10 cm are included

Events w/ NextInttBcoFull - ThisInttBcoFull > **61** are kept





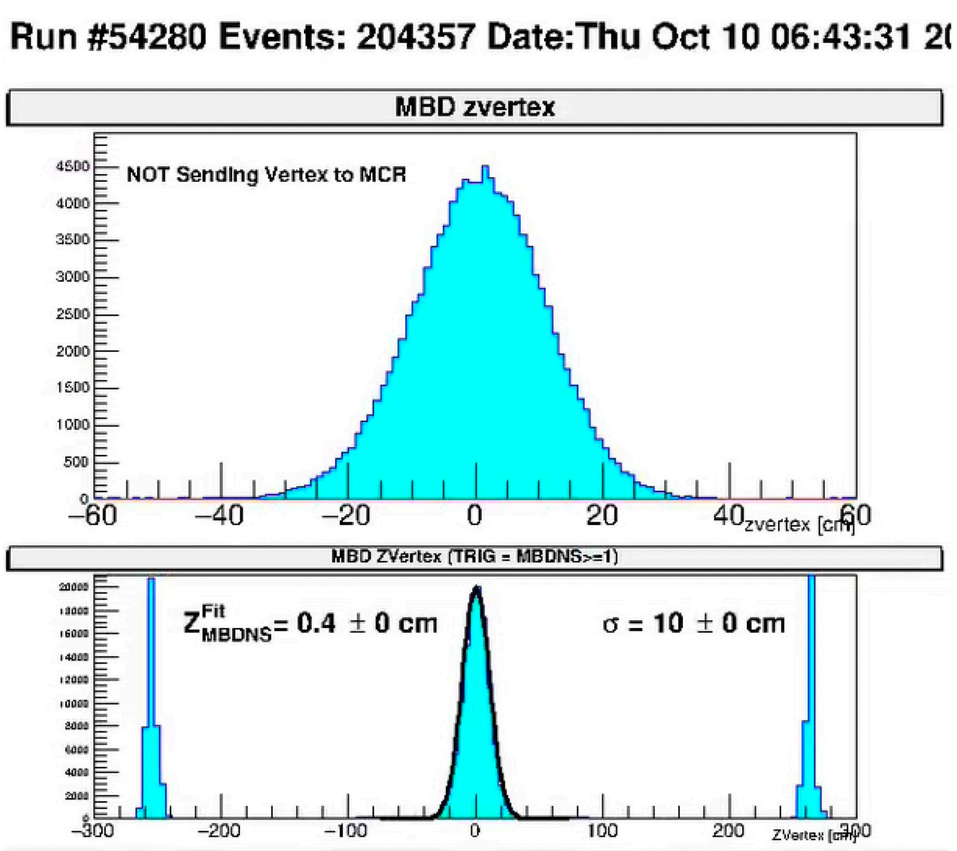


The comparison
(normalized by the first bin)

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



Trigger input channel	Name	enabled	Scaledown	Raw	Live <\div>	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

Suggestions to the future run

- Using `MBD N&S >= 1, vtx < 60 cm` for the data taking, instead of `MBD N&S >= 1`
  - To reduce the beam background

- Have the TDC modules back for ZDC
  - To minimize the syst. unc. of the MBDNS trigger cross section