國立中央大學
National Central University

RIKEN

sPHENIX INTT

sPHENIX

Cheng-Wei Shih (NCU / RIKEN)

@

for 2024

Workshop

Documentation in wiki

Wiki link

Analysis topic (proposed) [edit | edit source]

1. Prepare the beam test paper
    1. In the beam test, we focus on the hit detection efficiency and the some comparisons between data and MC
    2. We have the money plots and the results in place, now we just need to review them, and prepare the draft article, hopefully it can be ready before the workshop
1. dNdEta analysis
    1. This analysis measures the charged-particle multiplicities of the AuAu collisions by the INTT detector.
    2. I am improving the analysis framework now.

Presentations given during the workshop [edit | edit source]

1. The work plan in the first student session (link)
2. Presentation in the dNdEta meeting (Nov 18 2024) (link)
3. Discussion regarding the INTT service tasks (link)
4. The mid-term report in the second student session (link)
5. Presentation given in the CHiP/TIDC annual meeting (Internal)
6. Presentation in the dNdEta meeting (Nov 28 2024) (link)
7. The final report presented in the third student session (link)

Focus topic 1 - vertex Z module [edit | edit source]

- Document can be found in (GitHub sPHENIX analysis repo)

- One of the motivations to have this module is for the MBD timing calibration
- Since it's "modulized", other people can also use it (such as the comparison with other reconstructed vertex Z)
- Some time in the future I think we will move this module to the `coresoftware/offline/package/intt`
- Some time in the future probably the module has to be updated to handle the followings
    1. vertex in each bunch crossing in one F4A event (one strobe length)
    2. The multiple collision points in Z axis in single bunch crossing (in-time pile-up)
    3. To update the acceptance region (this is simple)

Documentation in wiki

Wiki link

Focus topic 2 - the carried over hits [edit | edit source]

- Documentation can be found in (slide presented in the dNdeta meeting)

- It's all begin with discovering the outlier groups in the correlation between INTT-MBD multiplicity and INTT inner-outer barrel multiplicity.
- The outliers suggest that somehow the number of outer clusters is more than that of inner clusters.
- If we checked only those outliers and their very next events, we found that the very next events have the distinct signatures which are having two spikes in the time_bucket distribution in the very next events, which can be found in the (link here)
- One interpretation can go in the way that the possibly we have the hits been carried over to the next events
  - If this is true, we can perform a simple calculation.
  - Assuming the hits are moved to the next events with the hit_bco been kept. We can calculate where we should see them in the time_bucket distribution of the very next events. And my calculation matches with the observation.
  - The tentative conclusion is, this is the direct evidence of the INTT hits been carried over to the next events in the event-by-event approach.

Focus topic 3 - INTT bad channel map [edit | edit source]

- Documentation can be found in (page 2 of the slide)
- The full hitmap plots after applying the new bad channel map is in (the set of plots here)

- Jaein has provided the bad channel map of run 54280. As a user, I want to check the performance of it. I therefore made the module to check the hitmap half-ladder by half-ladder. The module can be found in (GitHub)
- The document can be found in readme.md of GitHub
  - I found that there is one chip whose timing peak was shifted during the data taking. This is something new I believe. Which for sure needed to be investigate more
  - I found that there are some cold/hot channels cannot be picked up by the original algorithm of the bad channel identifier.
  - This is because that the original bad-channel identifier is conducted with the reference FELIX-server by FELIX-server.
  - Jaein has try to new way, which is doing the same thing but half-ladder by half-ladder. And the result is good

Focus topic 4 - INTT hitmap event-by-event [edit | edit source]

- I made the analysis modules to make the INTT hit map half-ladder by half-ladder and event-by-event. The module can be found in (GitHub)
- The document can be found in readme.md of GitHub

Topic Raise [edit | edit source]

- I would like the propose to the INTT Detector group to look into the INTT data more, in addition to the physics topics ones are interested in.
- We all know that the good understanding of the detector performance is the foundation of good physics results.
- We still have several open questions that need people to take a look, which can be found in the (google online doc)

Documentation in wiki - INTT overview

Wiki link

INTT Overview

Back to INTT top page

Specification [edit | edit source]

- INTT is a barrel strip tracker.
- The role of INTT in the sPHENIX detector is unique. It's the only tracking detector that can provide the sufficiently precise timing resolution to associate the individual tracks and events. In addition, it offers two spatial hit points, acting as the bridge between the MVTX and TPC tracks.
- INTT is designed to have full coverage in the azimuthal angle, and have the η coverage at least ±1 in the vertex Z range of ±10 cm.
  - It is composed of 2 barrels, inner barrel and outer barrel. Each barrel is made of two sublayers.
  - The drawing of INTT barrel can be found in here.
  - INTT strip length depends on the channel location in Z axis.
    - Strip length 16 mm for the channels with the Z positions within ±130 mm.
    - Strip length 20 mm for rest of channels.
  - To check the structure of INTT barrel, please refer to INTT_Barrel
  - To check the components making up INTT detector, please refer to INTT_components

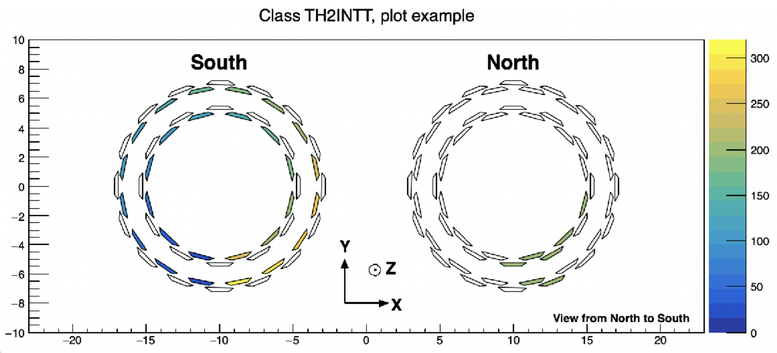
Element	Value	Unit
Strip width (ϕ angle)	78	μm
Strip length (Z axis)	16 or 20	mm
Radiation length of one ladder	1.08%	X0
Sampling rate	9.4	MHz
Timing resolution	single-bunch crossing	Nan
Average barrel radius	74.94 and 100.05	mm
Number of channels per ladder	6,656	
number of ladders	56	
Total number of channels	372,736	

The sensor radius of each INTT sublayer (in design)

INTT sublayer ID	B0L0	B0L1	B1L0	B1L1
Radius [cm]	7.1888	7.800	9.680	10.330

Modules available

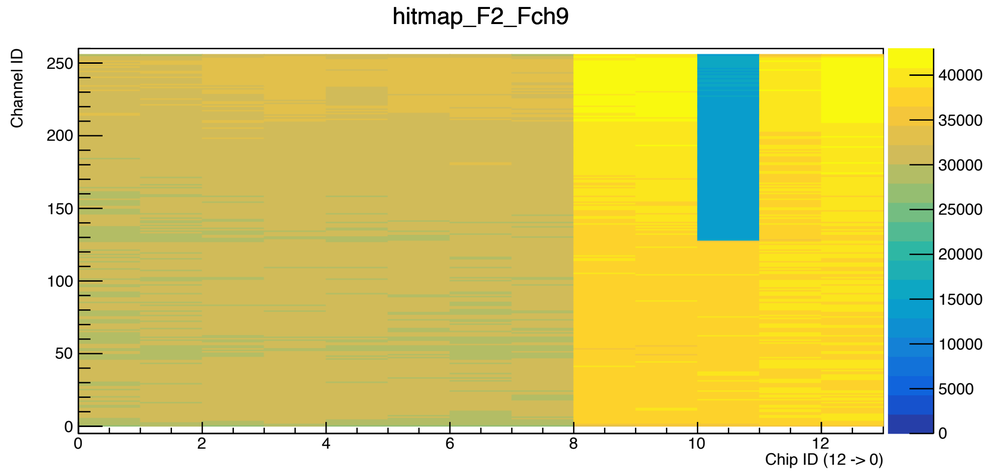
- INTTHitMap (GitHub): a module to make the half-ladder by half-ladder hitmap
- INTTHitMapEvt (GitHub): a module to make the half-ladder by half-ladder & event-by-event hitmap
- INTTvtxZTrapezoidal (GitHub): a module to reconstruct the vertex Z by INTT and save the reco. vertex Z into DST
- TH2INTT (GitHub): a module for presenting INTT in the unit of half-ladder
  - Valid under the ROOT framework, can be updated for g++ compilation upon necessity
- The instruction can be found in the readme.md of each folder

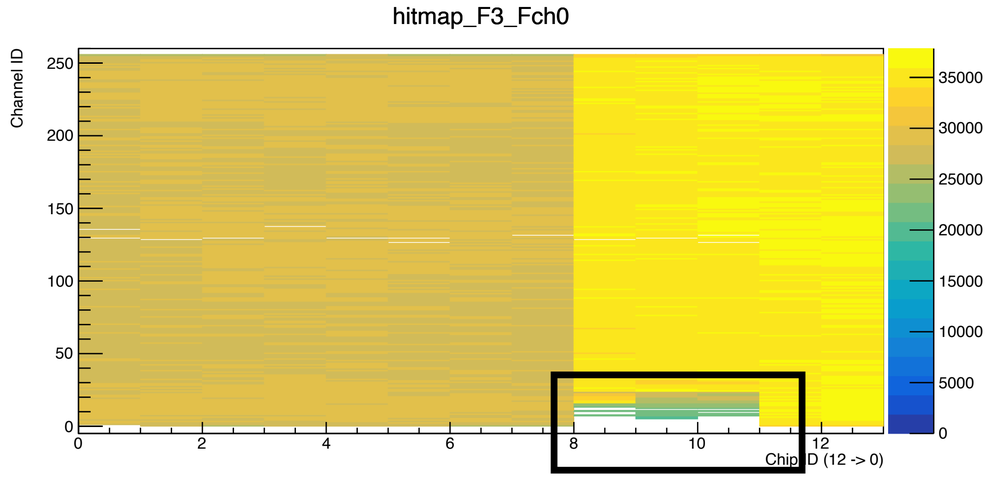


Hitmap module for checking bad channel map

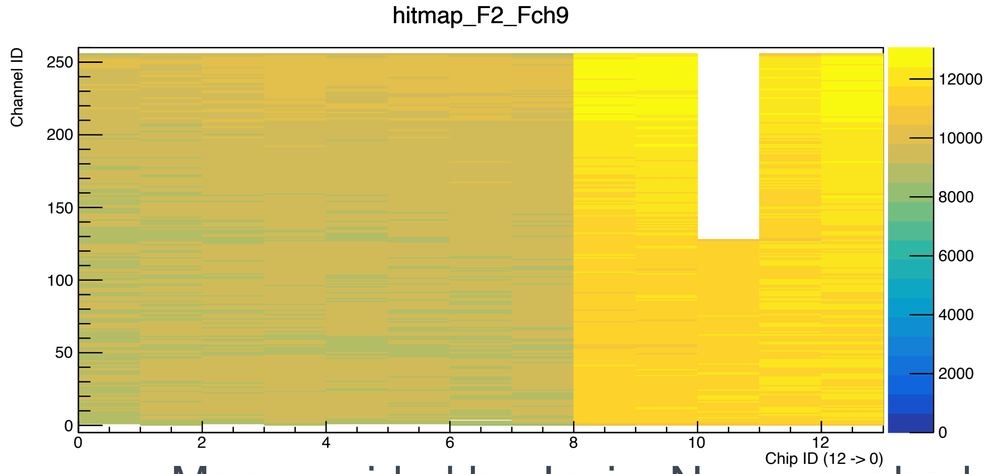
Map provided by Jaein

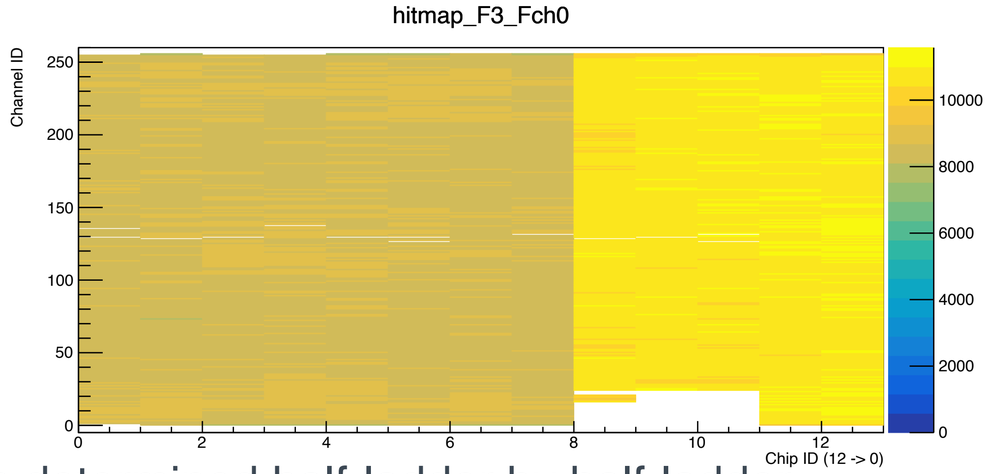
Old map: /sphenix/user/jaein213/macros/inttcalib/hotmap_cdb_1031/hotmap_run_00054280.root





New map: /sphenix/user/jaein213/macros/inttcalib_fee/hotmap_cdb/hotmap_cdb_54280_100000_DST_1114.root (Also in CDB)



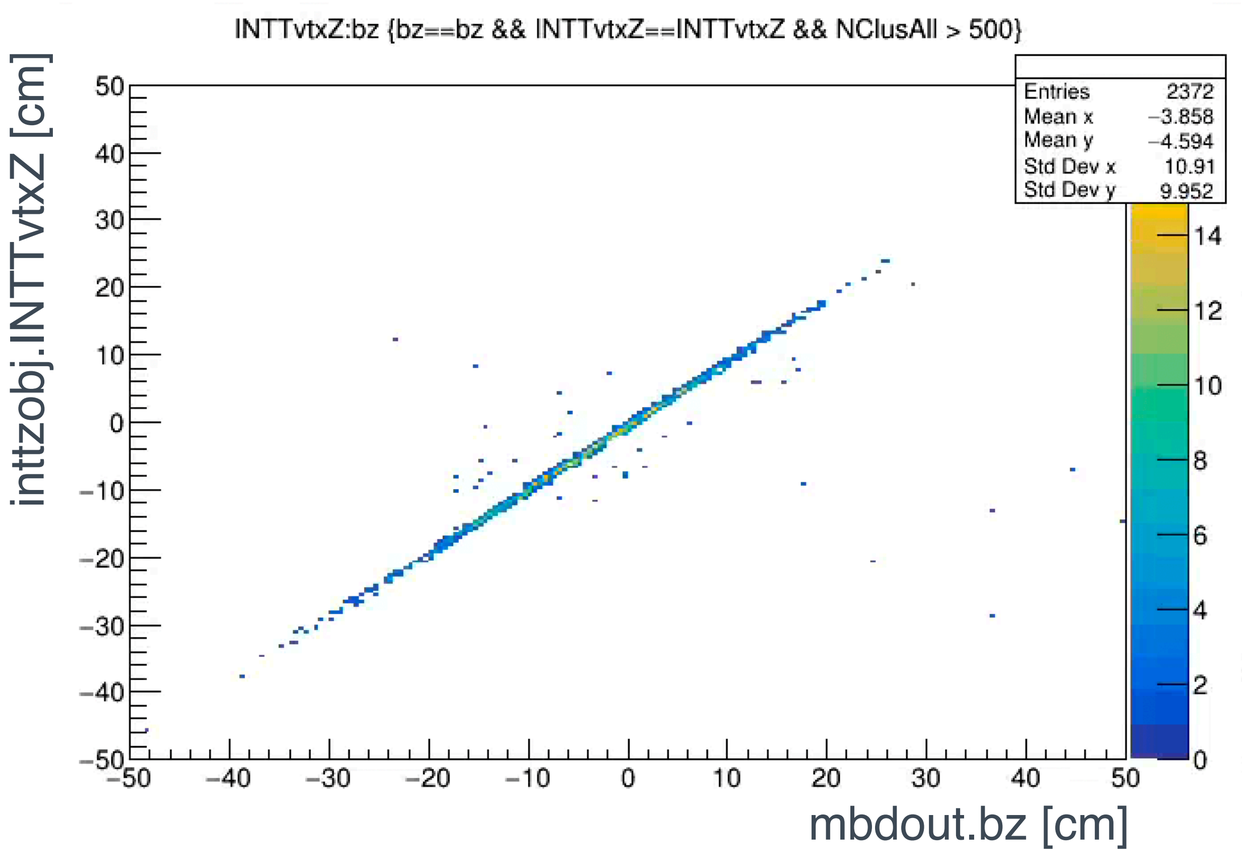


Map provided by Jaein. New map: bad channels determined half-ladder by half-ladder

Total bad channels: 14702 → 4% of INTT channels

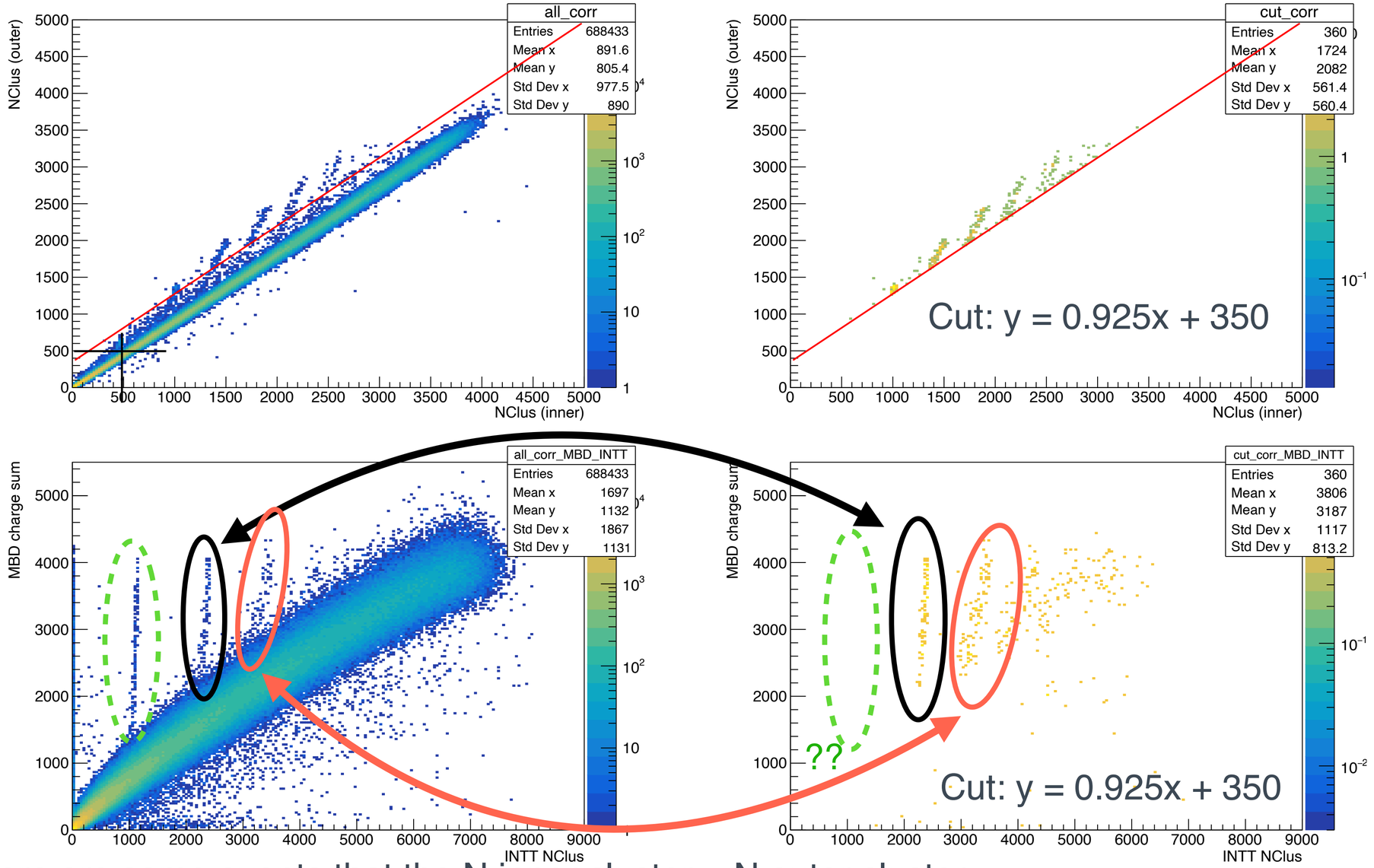
Vertex reconstruction module

```
  InttZVertexFinderTrapezoidal(
    const std::string &name = "InttZVertexFinderTrapezoidal",
    std::pair<double, double> vertexXYIncm_in = {0, 0}, // note : in cm
    bool IsFieldOn_in = false,
    bool IsDCACutApplied_in = true,

    std::pair<std::pair<double,double>,std::pair<double,double>>
DeltaPhiCutInDegree_in = {{-1,1},{-1000.,1000.}}, // note : in degree

    std::pair<std::pair<double,double>,std::pair<double,double>>
DCAcutIncm_in = {{-1,1},{-1000.,1000.}}, // note : in cm

    int ClusAdcCut_in = 35,
    int ClusPhiSizeCut_in = 8,
    bool PrintRecoDetails_in = false
  );
```



- A F4A module (GitHub Link) prepared to save the INTT reconstructed vertex Z into DST for the MBD timing calibration
  - Have informed Mickey
- Todo:
  - Replace the current one in the coresoftware/offline/package/intt
  - Optimize the module to handle multiple collisions in one strobe length (and even in one bunch crossing)
  - Take a look the vertex XY reconstruction module as well

The spikes in multiplicity correlation

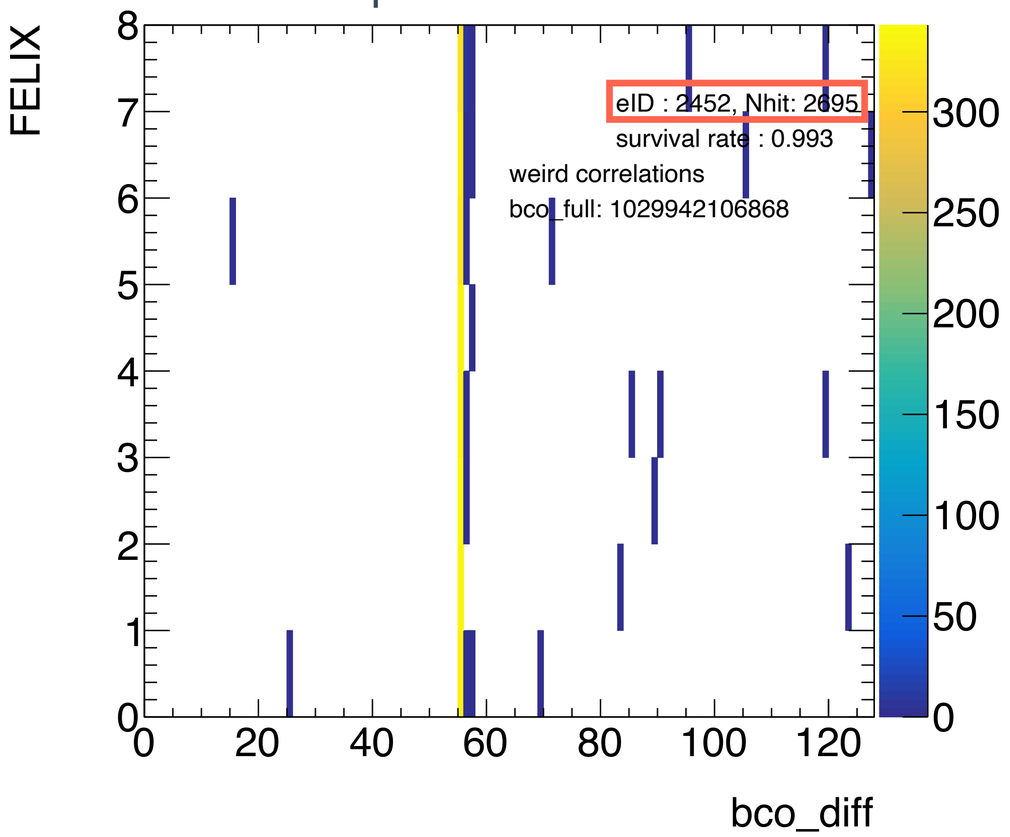


There are some events that the N inner cluster < N outer cluster

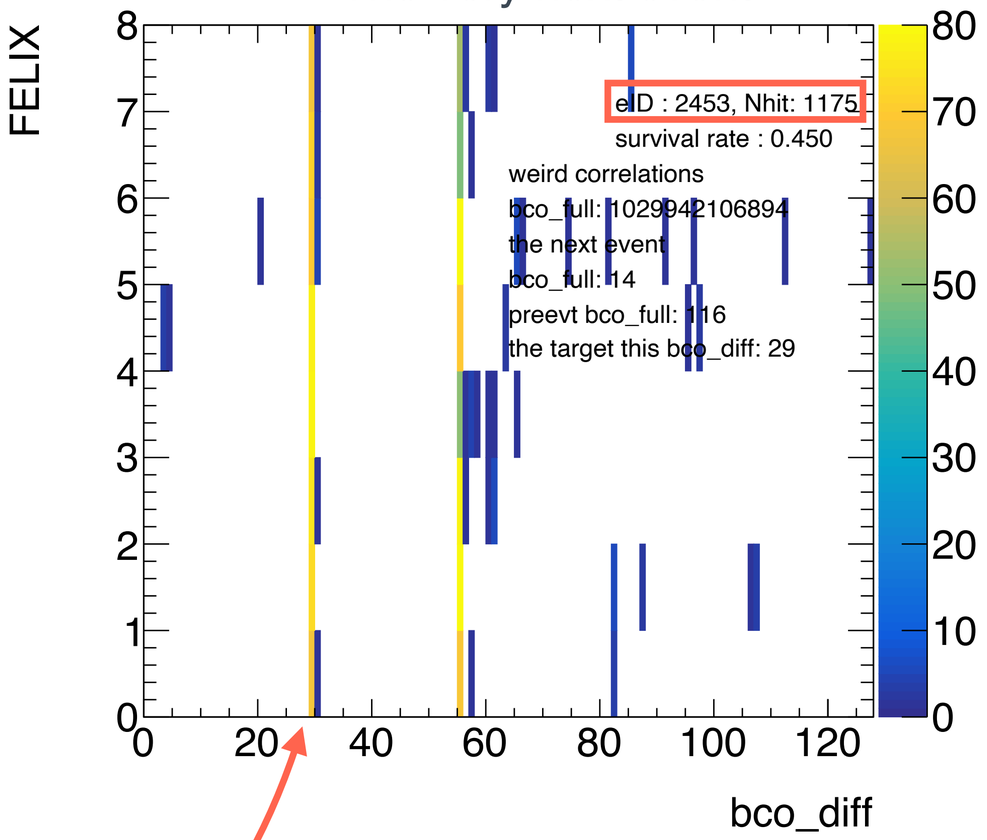
The outliers are correlated to the outlier groups in the MBD-INTT multiplicity correlation

The spikes in multiplicity correlation

The problematic event



The very next event



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

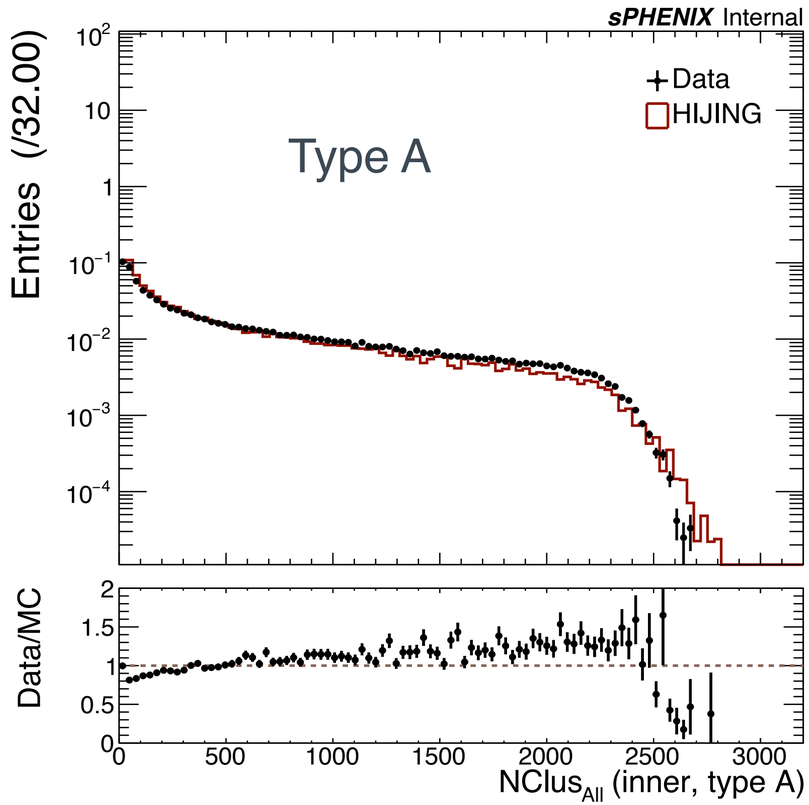
Current conclusion: the hits are carried over to the next event

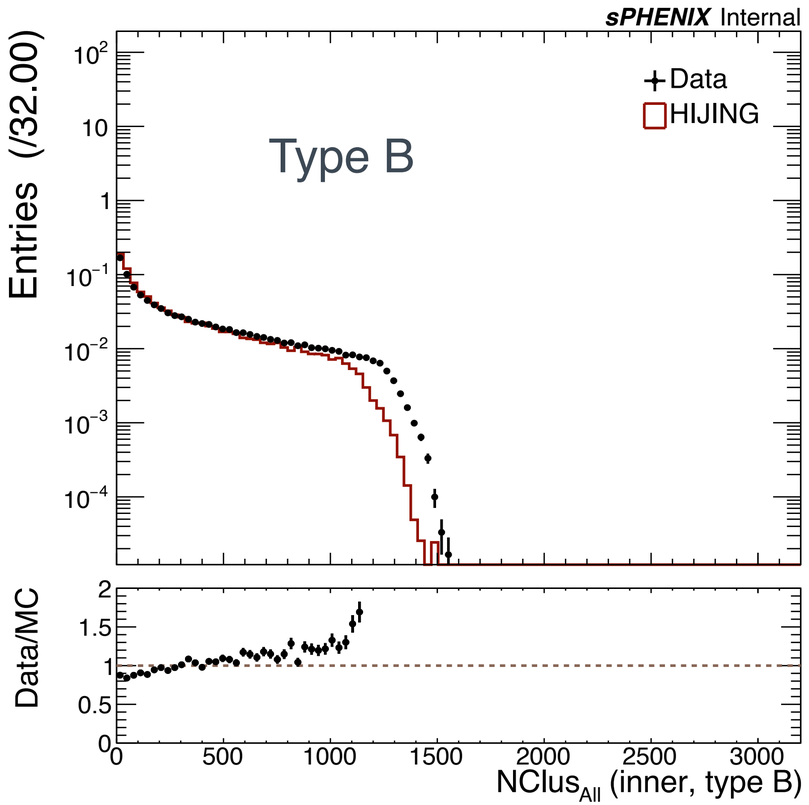
Direct evidence of hits been carried over

Sensor by sensor check

Run 54280 (run24)

- |MBD vertex Z| ≦ 10 cm
- MC entries vertex Z reweighing applied



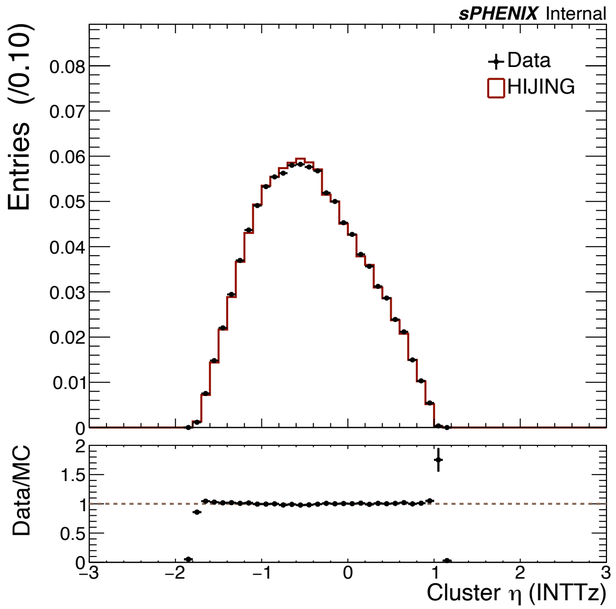


The data suggests a more investigation in type B sensors

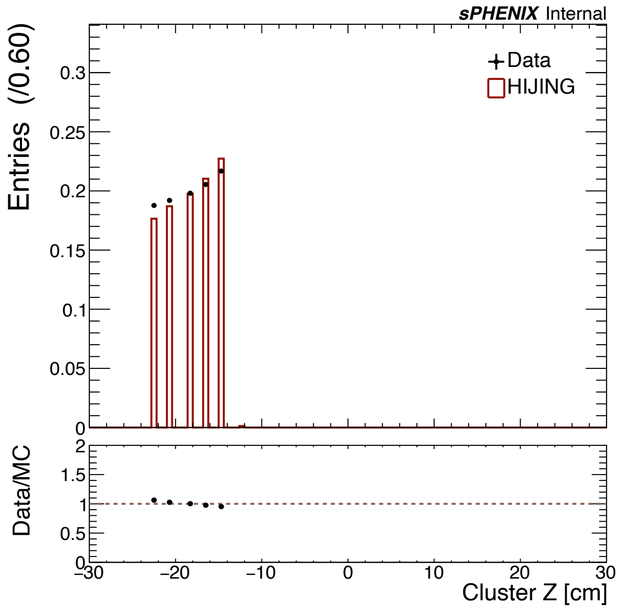
Sensor by sensor check

Sensor-by-sensor check in (NClus, Clusη, ClusZ): /sphenix/user/ChengWei/INTT/INTT_dNdeta_repo/DST_MC/PrepareDistribution/Dist_compare/Comp_SensorCheck_INTTvtxZQA_vtxZDiff_vtxReweightINTT_RangeMBDzM10p0to10p0/sensor_check

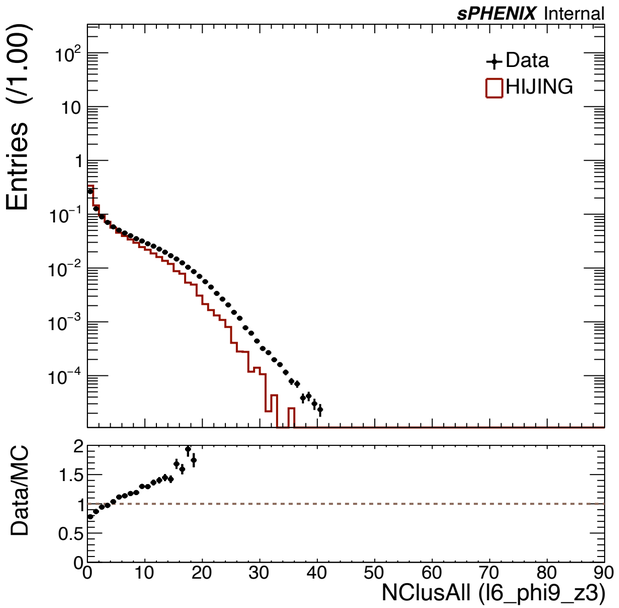
Type A
l3_phi0_z0



Type B
l3_phi6_z1

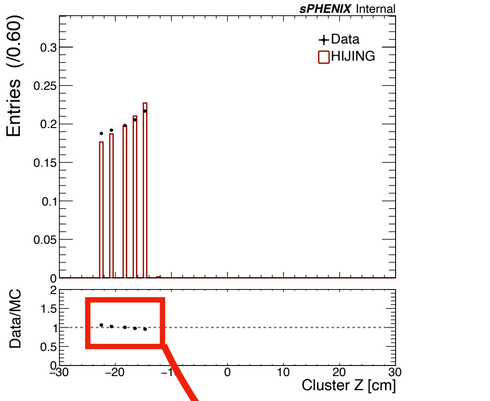


Type B
l6_phi9_z3

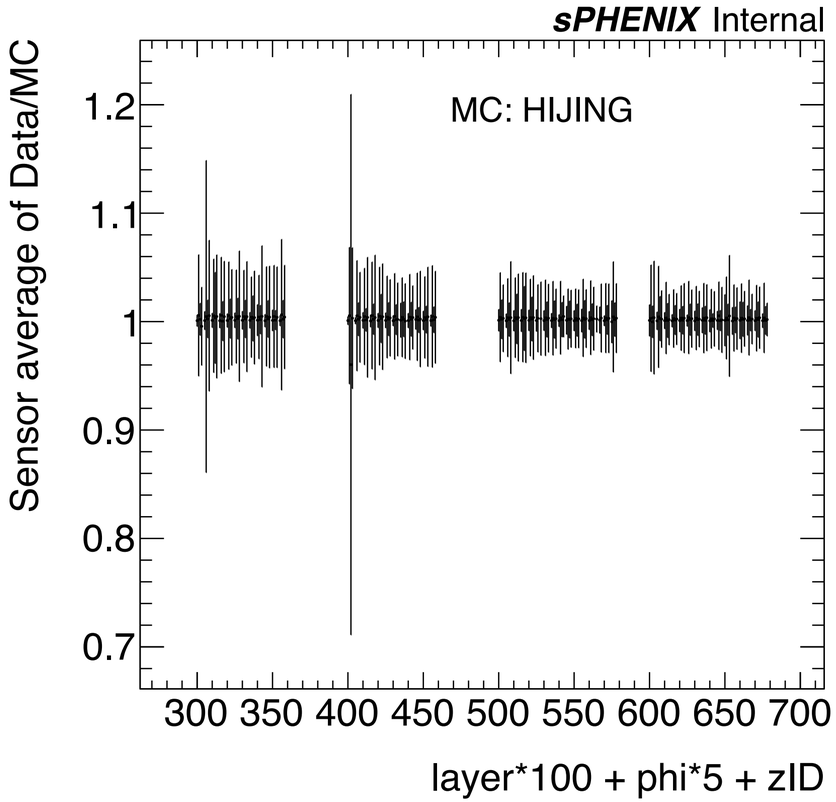


Overall speaking, all type A sensors have relatively better agreements
No particular type B sensor with distinct behavior, all are with rather large discrepancies → more checks needed

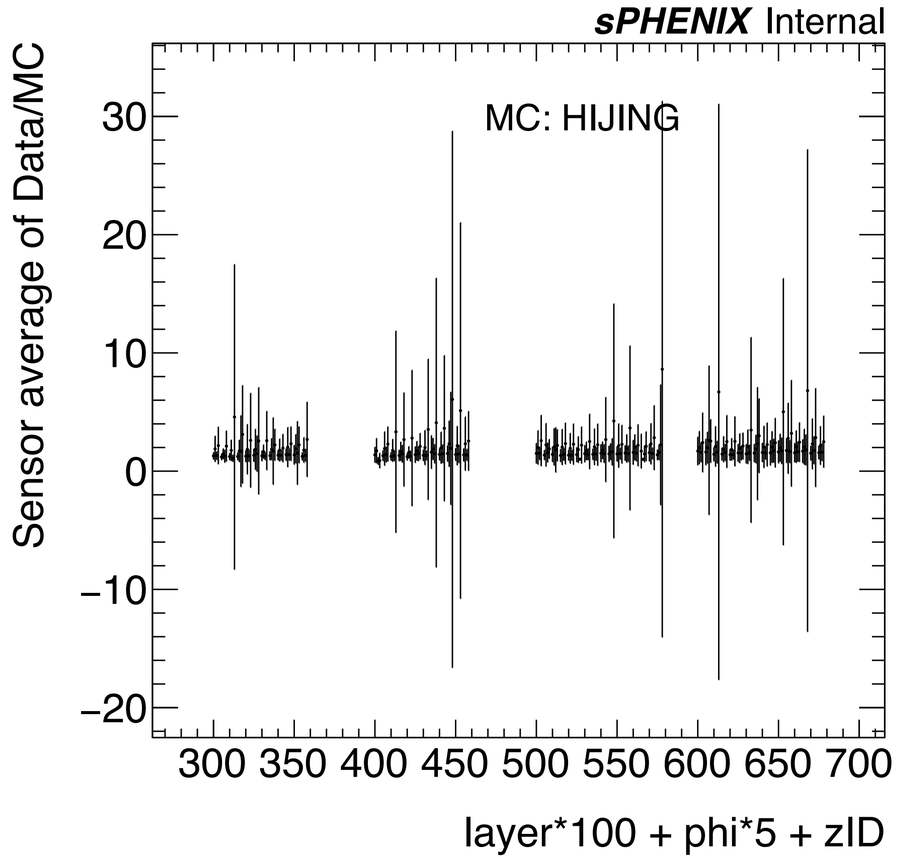
Sensor by sensor check



cluster Z

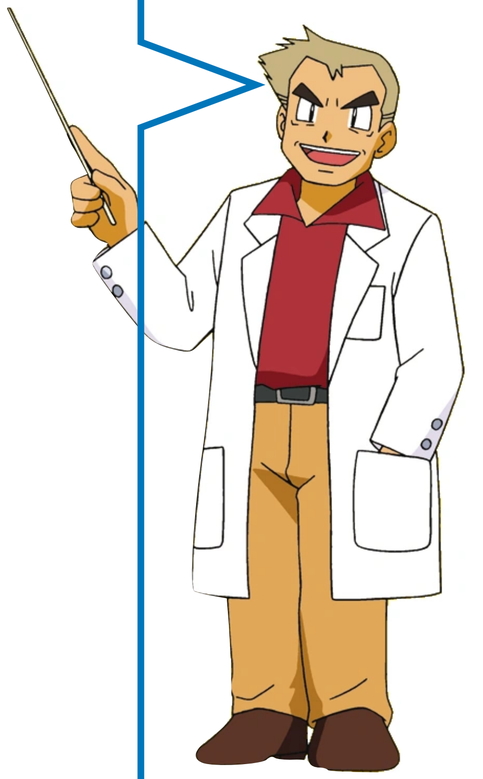


NclusAll



Was trying to have quantity for each sensor, need more work
Point: the mean value of the ratios, error bars: the standard deviation of the ratios

Comments from Doctor Okido



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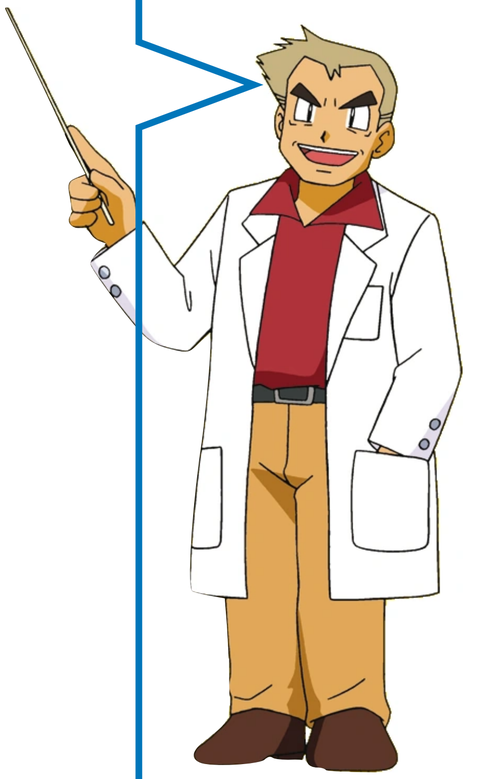
Comments from Doctor Okido

- As of today, I think it's fair to say that INTT group understands the INTT detector much better than the MVTX/TPC groups understanding their detectors
  - It may be a unfair statement to them. But the takeaway is that INTT group has been working hard on the optimization of INTT operation, and understanding the detector



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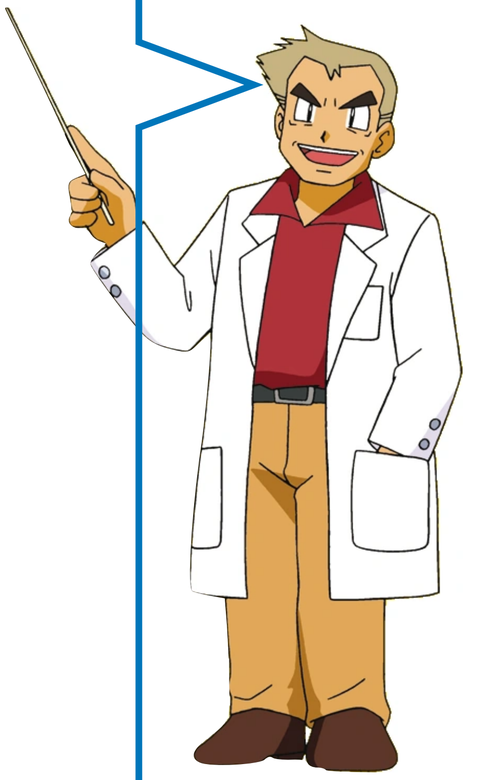
- As of today, the understanding on INTT detector is in the ballpark, say ~97% level?



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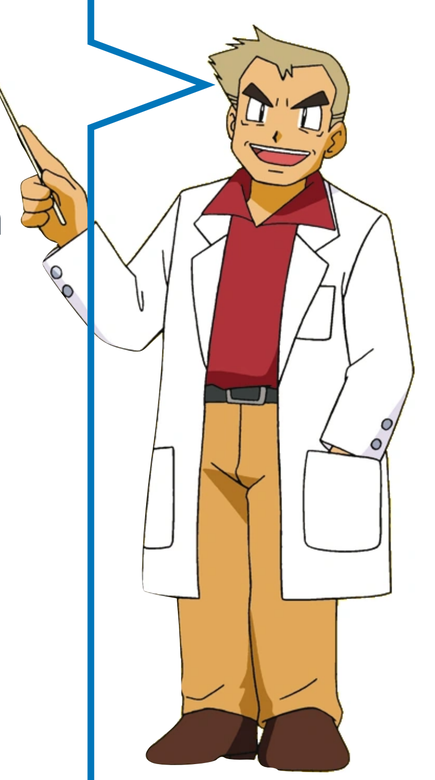
- In addition, the members of INTT group are in the stage of pushing the physics results out based on this detector (predominantly/partially)
  - Flow v2, dNdEta, silicon-seeding & EMCal matching for several topics, etc



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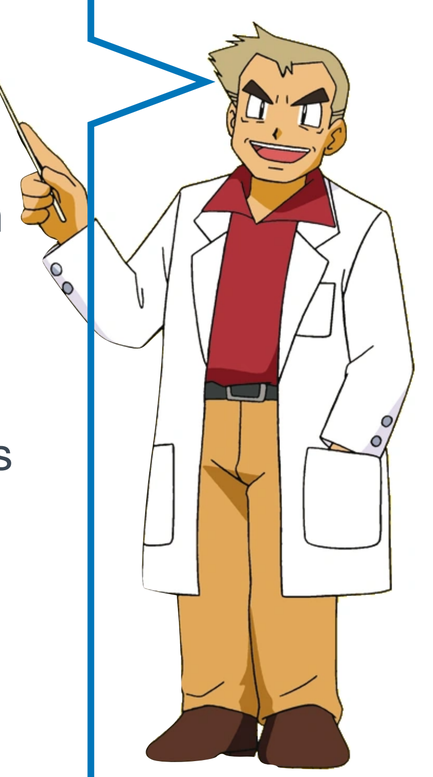

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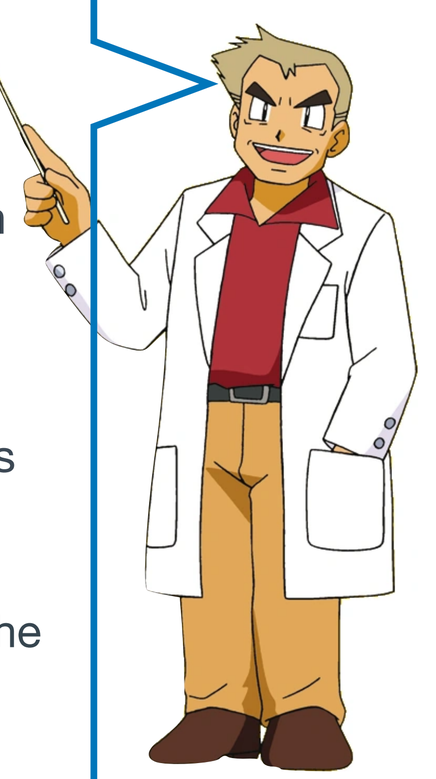

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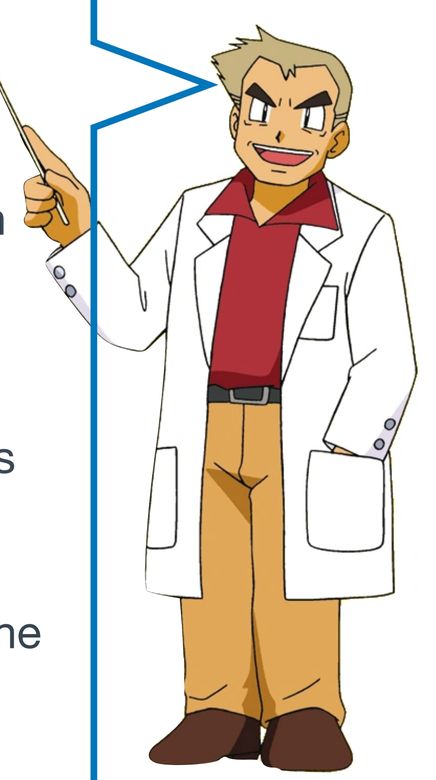
  - **We would need people to work on those service tasks**



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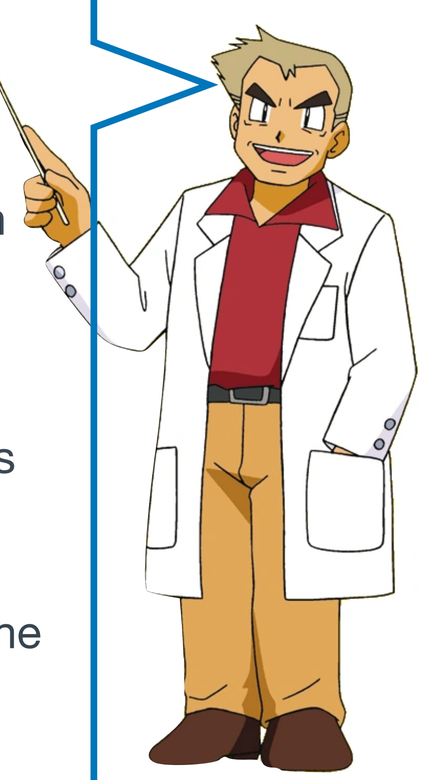
- **I would like to re-iterate and urge more people to, in addition to the development of the codes for the physics results, look into the data!**



Doctor Okido

The open questions remained to INTT

- INTT timing resolution (It's just not 1, so, how much?)
- INTT chip timing (the chip timing can shift, is it a severe issue ?)
  - Impact: cold-QCD analyses, charged hadron, inclusive photon, photon-jet
- INTT good run list
  - Impact: cold-QCD analyses, charged hadron, inclusive photon, photon-jet, all sPHENIX physics analyses
- Coarse delay scan practice (Find the way to find the best coarse-delay for data taking)
  - Impact: run 2025 data taking
- INTT carried-over hits (New way check?, automation, correlation b/w mix-up hits and opentime & ncollision)
- Threshold setting of run 2025 (We under-estimated the real edep spectrum in run23 and 24)
  - Impact: run 2025 data taking
- Spikes at 43 and 46 of cluster phi size distribution (Can we have the way to reject them?)
  - Impact: V2 measurement & dN/dEta with cluster approach, and tracking efficiency study
- The discrepancy between INTT and MC
  - Impact: basically all the physics analyses, dN/dEta with cluster approach, and tracking efficiency study
- INTT radiation damage
  - Impact: run 2025 data taking
- INTT geometry optimization
  - Impact: All analyses, V2 measurement, dN/dEta, streaming-calo match

The brief description can be found in google doc

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If you questioned "what don't you do the service tasks also"?

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- INTT good run list
  - Impact: cold-QCD analyses, charged hadron, inclusive photon, photon-jet, all sPHENIX physics analyses
- Coarse delay scan practice (Find the way to find the best coarse-delay for data taking)
  - Impact: run 2025 data taking
- INTT carried-over hits (New way check?, automation, correlation b/w mix-up hits and opentime & ncollision)
- Threshold setting of run 2025 (We under-estimated the real edep spectrum in run23 and 24)
  - Impact: run 2025 data taking
- Spikes at 43 and 46 of cluster phi size distribution (Can we have the way to reject them?)
  - Impact: V2 measurement & dN/dEta with cluster approach, and tracking efficiency study
- The discrepancy between INTT and MC
  - Impact: basically all the physics analyses, dN/dEta with cluster approach, and tracking efficiency study
- INTT radiation damage
  - Impact: run 2025 data taking
- INTT geometry optimization
  - Impact: All analyses, V2 measurement, dN/dEta, streaming-calo match

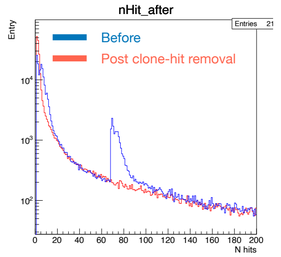
The brief description can be found in google doc

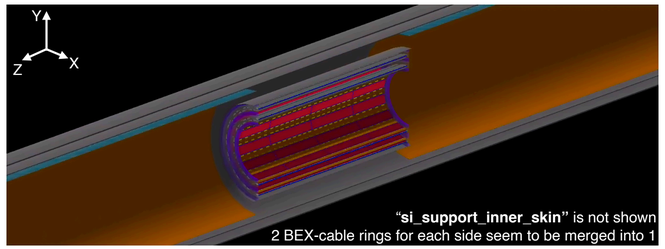
If you questioned "what don't you do the service tasks also"?

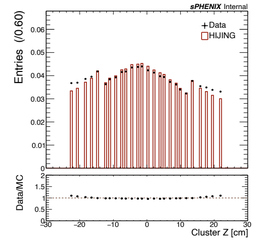
Ans. "I was, am and will be working on it"

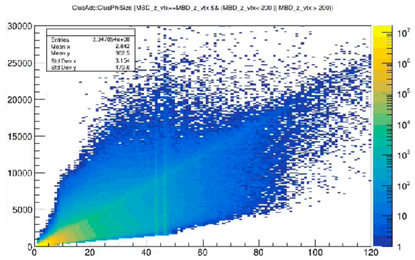
INTT relevant service tasks I've worked on

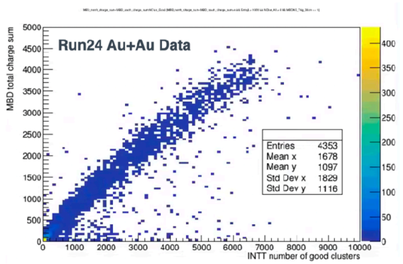
1. Clone hit
2. Geant4 survey geometry implementation
3. G4Step → G4Hit type B sensor bug fix
4. Streaming - calophysics event matching (both run23 and run24)
5. Beam background study
6. Carried-over hits (event mixed-up)
7. Calibration cross check
    1. INTT timing (chip time_bucket issue, INTT timing resolution, event-by-event peak)
    2. Justification of bco_diff cut
    3. Bad channel map check
8. INTT vertex Z module
9. Cluster phi size distribution
10. INTT radiation damage
11. Criterion of clustering in Z

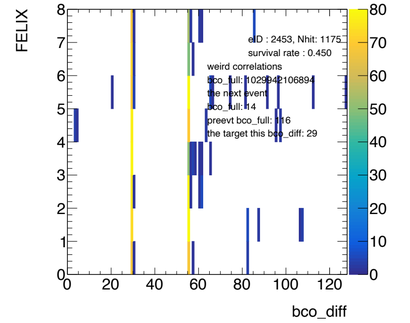


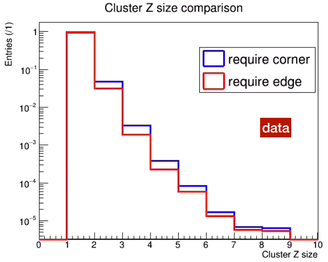


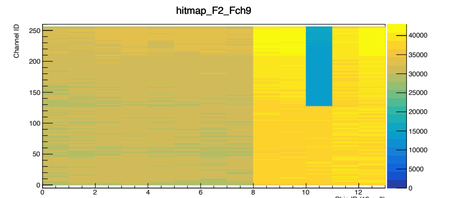


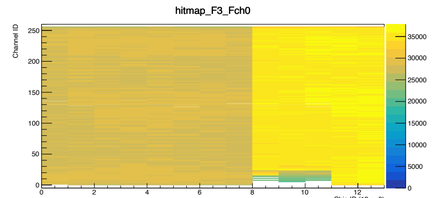


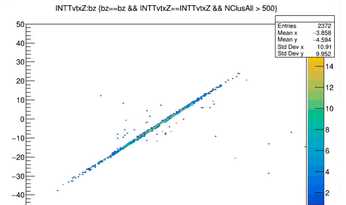


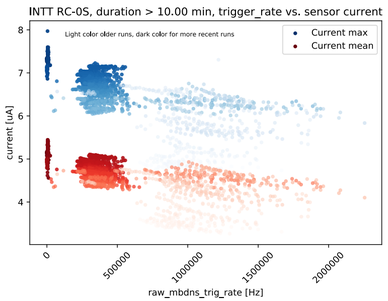


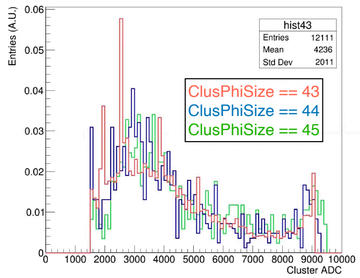


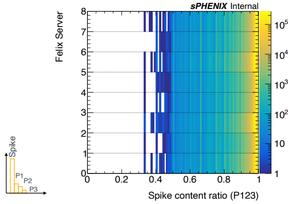




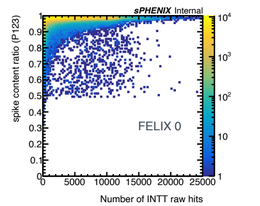








$$\text{Ratio\_P123} = \frac{C_{55}}{C_{55} + C_{56} + C_{57} + C_{58}}$$

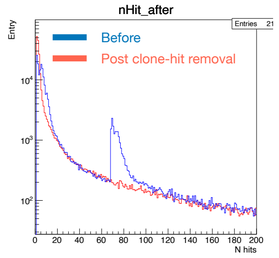


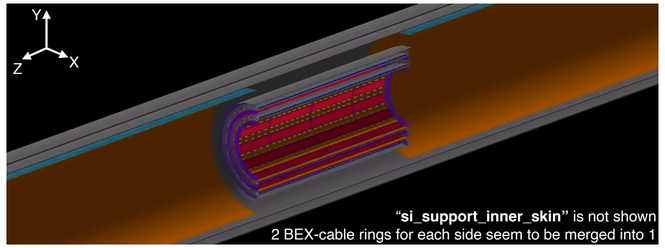
- spike_content_ratio_P123 Mean: 0.980138, StdDev: 0.0309565
- spike_content_ratio_PM123 Mean: 0.979865, StdDev: 0.0316666

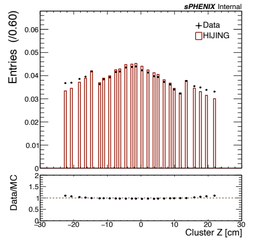
This number can be used for timing scan analysis

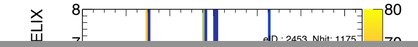
INTT relevant service tasks I’ve worked on

1. Clone hit
2. Geant4 survey geometry implementation
3. G4Step → G4Hit type B sensor bug fix
4. Streaming - calophysics event matching (both run23 and run24)







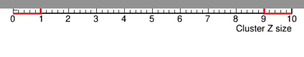


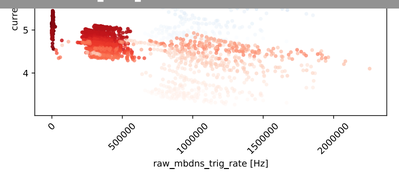
Frankly speaking, the physics analysis is one of the motivations for myself to look into some of topics I’ve been working on

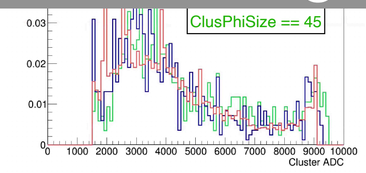
However, these service tasks provide benefits beyond my own physics analysis

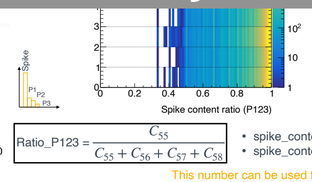
Given that we now have more people expressing interest and actually engaging in physics analyses (dNdEta, flow v2 and track-EMCal matching), it would be highly beneficial for those involved to also participate in the associated service tasks, as this fosters a collaborative and balanced approach to advancing our objectives.

10. INTT radiation damage
11. Criterion of clustering in Z









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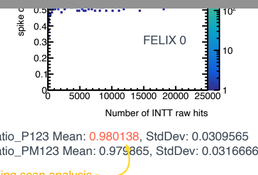


- spike_content_ratio_P123 Mean: 0.980138, StdDev: 0.0309565
- spike_content_ratio_PM123 Mean: 0.979865, StdDev: 0.0316666

This number can be used for timing scan analysis

Summary

- Time goes faster than what I expected. It's the end of the INTT 2024 workshop at KU

- 3 + 1 modules are available for the public usage
  - INTTHitMap / INTTHitMapEvt / INTTvtxZTrapezoidal / TH2INTT

- The performance of the new bad channel map has been checked. No major issue found for the run 54280. Thanks Jaein!

- Outlier groups found in the correlations b/w INTT and MBD multiplicity, and INTT inner-outer multiplicity
  - The time_bucket and hitmap look just fine
  - Those events are well matched with MBD events
  - Tentative conclusion: the hits are somehow carried over to the next events

- Sensor-by-sensor behaviors have been checked to investigate the discrepancies b/w data and MC in type B sensors
  - No major discovery, all the type B sensors are having similar behaviors and with the rather large discrepancy when comparing with the MC

- **Thank for everyone's hard work very much that the INTT can be running well and our knowledge of INTT is in the ballpark!**
  - **It would be highly beneficial for more people to participate in the associated service tasks, to push the best physics results out**

Back up

Comments from our collaborators

My two cents…

- There have been occasions where removing events was suggested due to unexpected behaviors in data or to recover data-simulation agreements. While I understand the rationale behind these suggestions, I believe that such measures should be considered a last resort. It is crucial that we first thoroughly investigate and understand the root causes of these issues rather than resorting to ad-hoc cutoffs that may obscure underlying problems
- Issues should be transparent and disclosed to the collaboration (the daily tracking meeting would be the most relevant venue for discussing issues of tracking detectors). Every subsystem is vital to the experiment, and maintaining the integrity and quality of data is the foundation of the success of the physics program
- Please let me know if you disagree, and I am open to discuss further offline

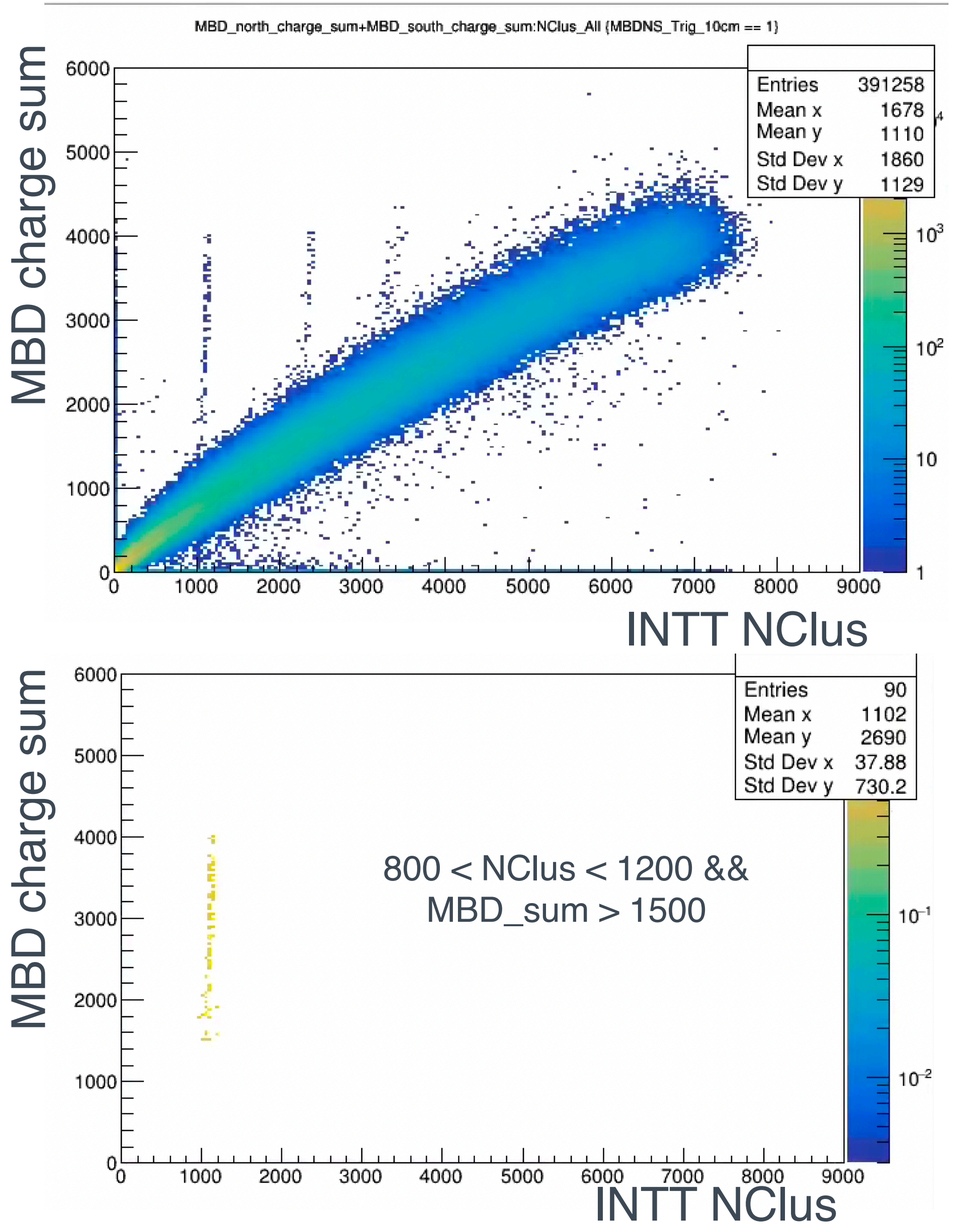
Regarding the INTT MC optimization

- As far as I checked, the diffusion radius is a constant, which means all the G4Steps become the tubes with the same radii (charge_diffusion radius)
  - It should in principle be a distribution (Gaussian, as an example)
- Tentative strategy:
  - We should probably use the cluster phi distribution from the beam test data as the reference to tune the diffusion radius (much simpler environment)
  - I should be able to have the distributions before the end of this week

- Relevant items
  - hard coded threshold setting
  - no hit rejection if the hit_adc is below threshold
  - edep distribution discrepancy b/w data and MC
  - cluster phi size discrepancy
  - non-optimized diffusion radius model and parameters

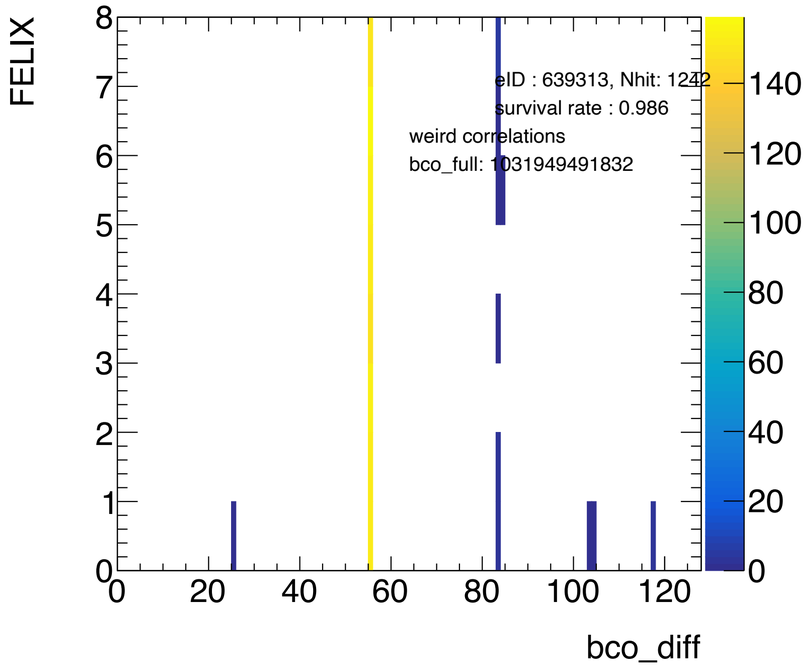
- More need to be address
  - `siinactive_volume` is called by `si_glue_box`
  - Incorrect ZID assignment

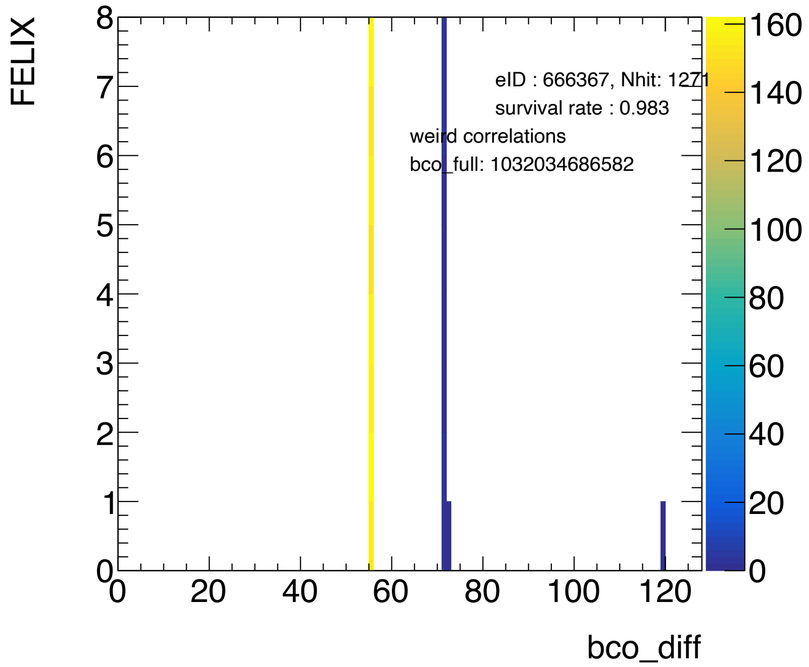
The spikes in multiplicity correlation

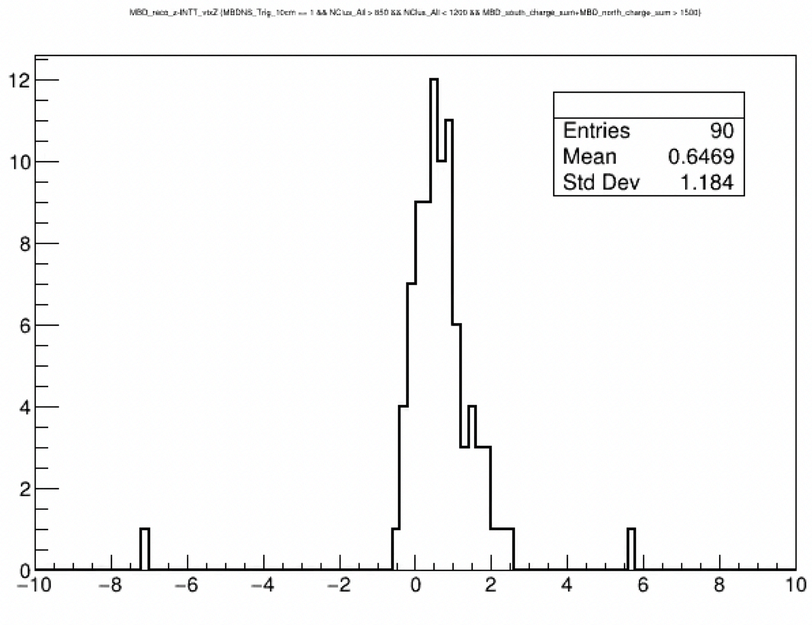


	MBD Charge Sum	NClus	INTT bco_full
619409 *	2974.55108642578125 *	1134 *	1031886808862 *
639301 *	2164.0875244140625 *	1104 *	1031949491832 *
666355 *	3472.1243896484375 *	1138 *	1032034686582 *
669663 *	2737.6702880859375 *	1120 *	1032045024480 *
690588 *	1799.94366455078125 *	983 *	1032110953424 *
698626 *	1576.2518310546875 *	1055 *	1032136641664 *
712580 *	4007.536376953125 *	1146 *	1032181036098 *
714328 *	1614.93585205078125 *	1047 *	1032186640088 *
719051 *	3642.686279296875 *	1113 *	1032201606278 *
720282 *	3576.748046875 *	1107 *	1032205373512 *
727168 *	2304.62249755859375 *	1076 *	1032227313124 *
728861 *	2372.64794921875 *	1104 *	1032232570308 *
729104 *	3592.4307861328125 *	1132 *	1032233305902 *
730482 *	1508.58889770507812 *	1039 *	1032237745096 *
734431 *	2682.98760986328125 *	1090 *	1032250319960 *
750448 *	2974.711669921875 *	1114 *	1032300071972 *
754445 *	3278.87939453125 *	1126 *	1032312835370 *
777019 *	2078.91387939453125 *	1059 *	1032383446818 *
779231 *	3104.60675048828125 *	1114 *	1032390326522 *
785253 *	2558.194091796875 *	1092 *	1032409663066 *
785364 *	2584.3201904296875 *	1086 *	1032409984570 *
804463 *	3537.193115234375 *	1144 *	1032470095194 *
805209 *	2580.93499755859375 *	1085 *	1032472469496 *
822955 *	2451.635009765625 *	1111 *	1032529038484 *
845952 *	3648.367431640625 *	1135 *	1032600608210 *

The spikes in multiplicity correlation





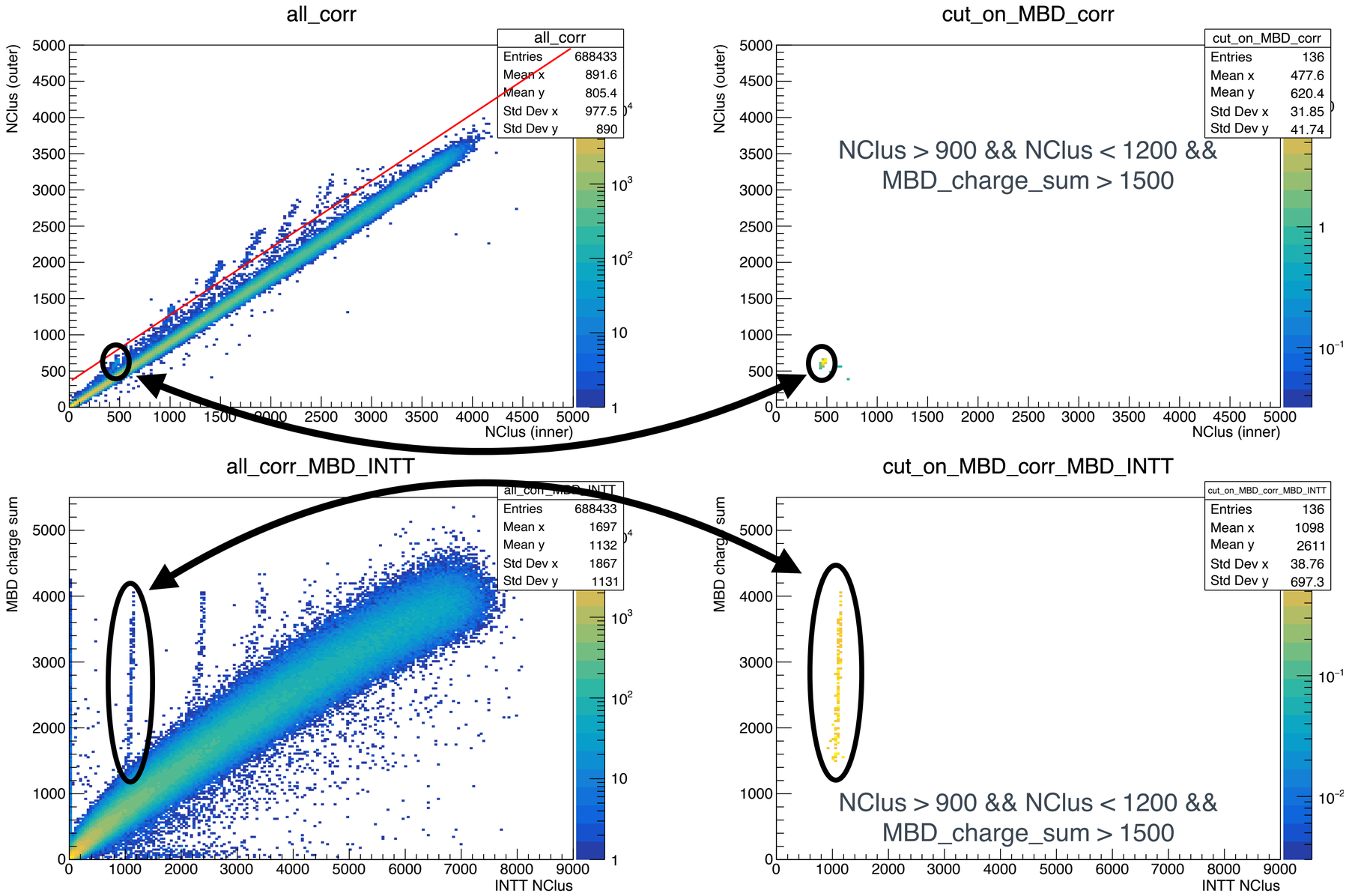


The bco_diff looks correct
The hit maps were also checked, no obvious problem found

Time_bucket (bco_diff) looks just fine & no obvious issue spotted in the hit map
Can have the vertex Z matched → not caused by the event mis-matched

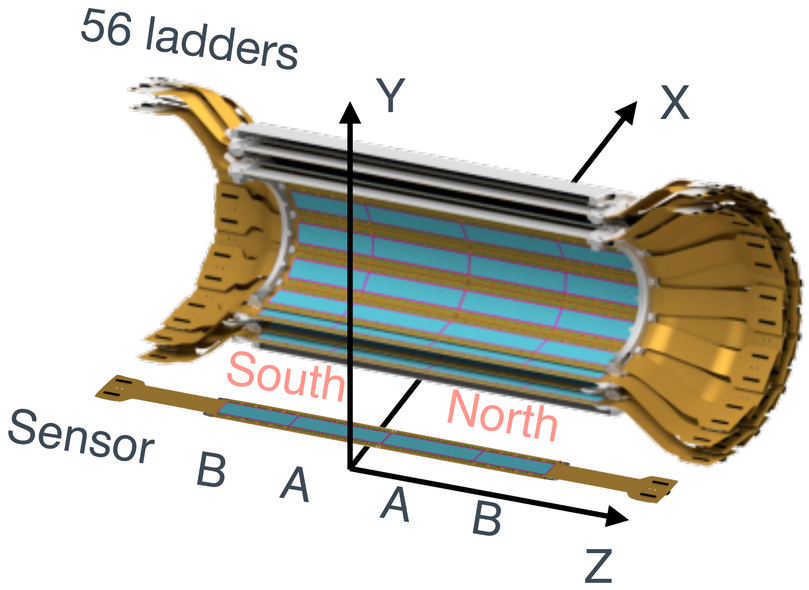
The spikes in multiplicity correlation

Global :
MBD_charge_sum > 10 &&
MBD_z_vtx > -10 && MBD_z_vtx < 10

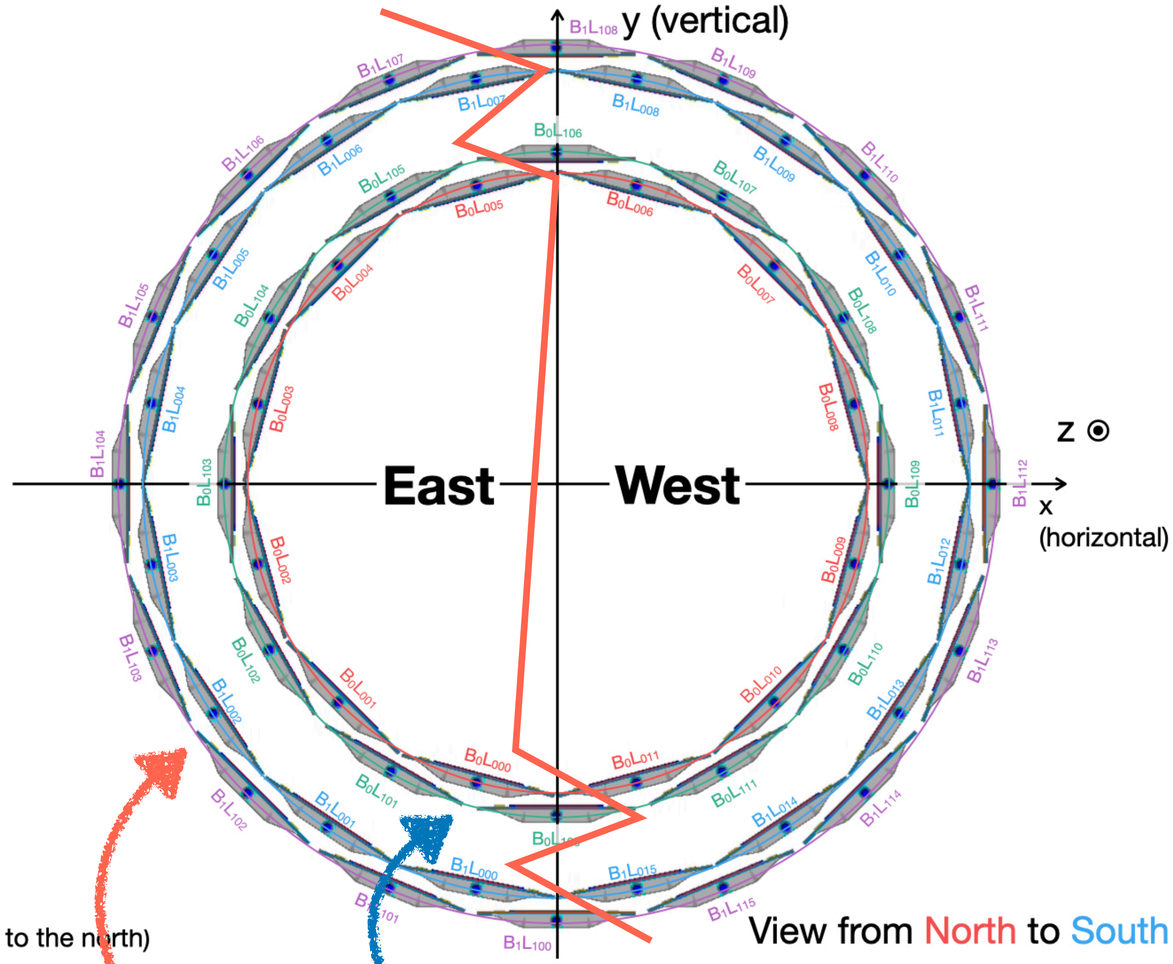


INTT geometry

INTT: 2 sensors X 2 sides of half-ladders X 56 ladders = 224 sensors



Notation: B_xL_{yzz}
- x: Barrel ID (0 for inner or 1 for outer)
- y: Layer ID (0 for inner or 1 for outer)
- zz: Ladder ID (from 0 to 15)



Axis (Right-haded coordinate)
- x-axis: $\vec{y} \times \vec{z}$
- y-axis: Vertically upward direction
- z-axis: The blue beam direction (pointing to the north)