# Student session 2

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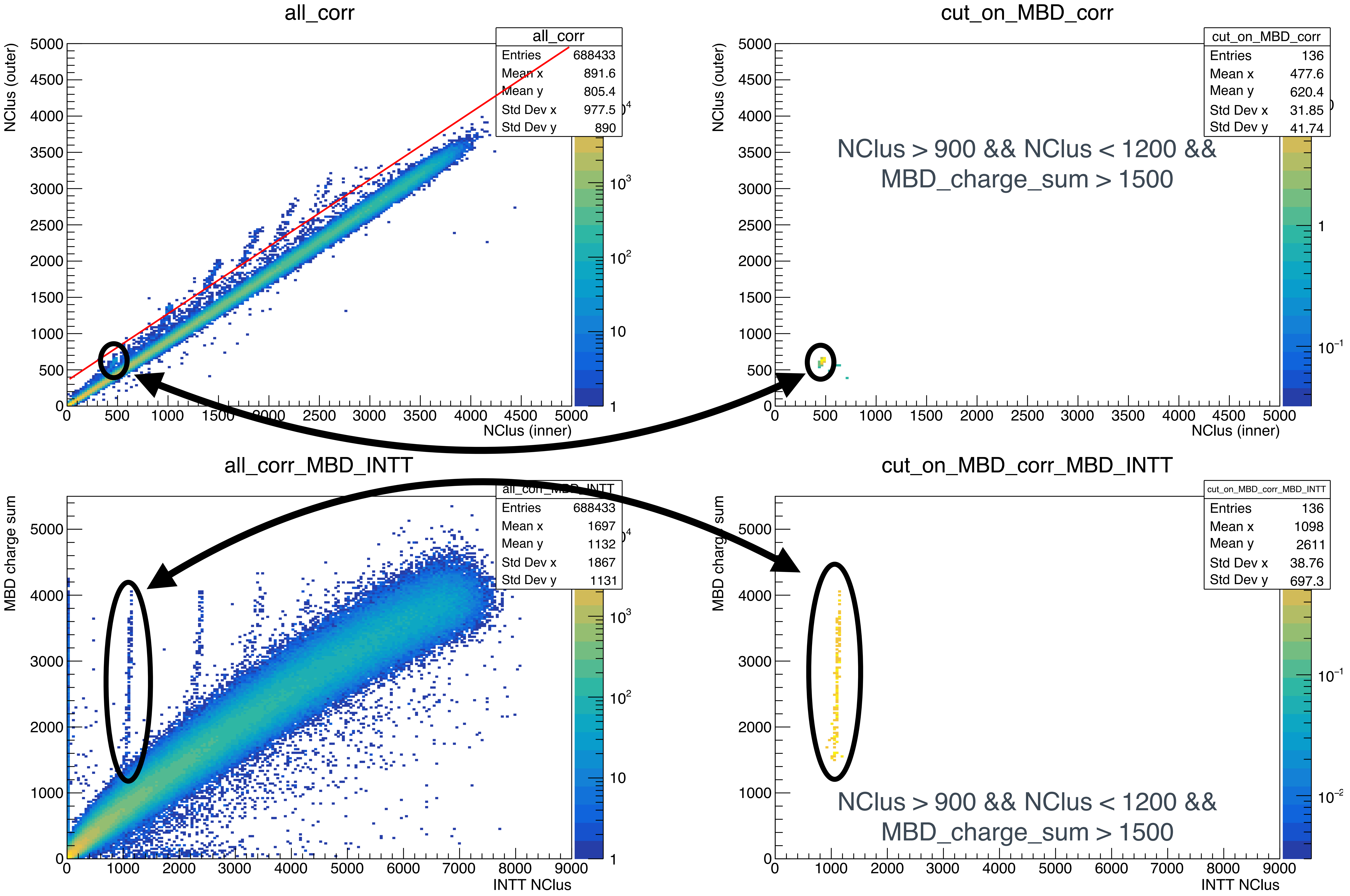
INTT workshop at KU

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

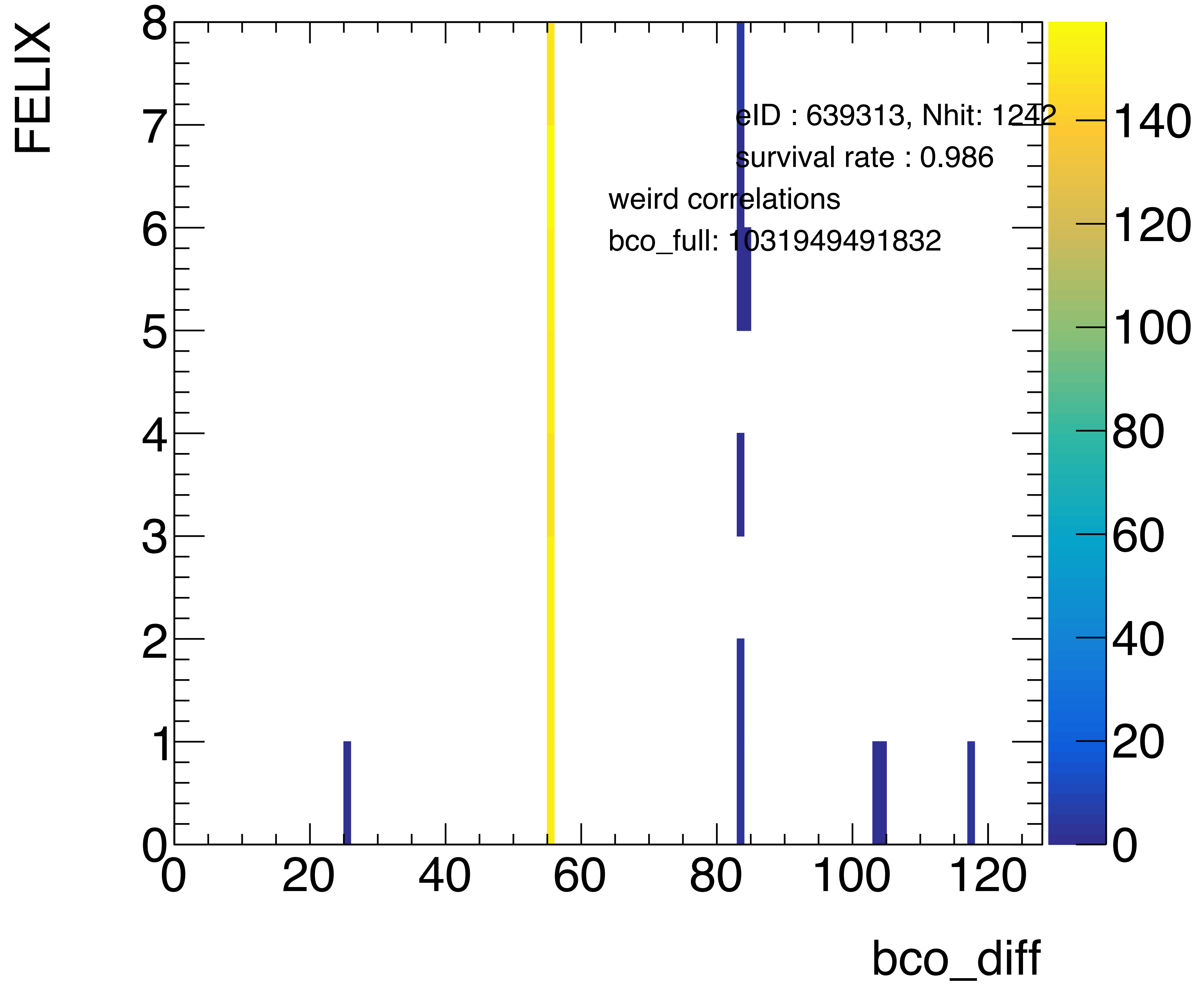
Global :
MBD_charge_sum > 10 &&
MBD_z_vtx > -10 && MBD_z_vtx < 10

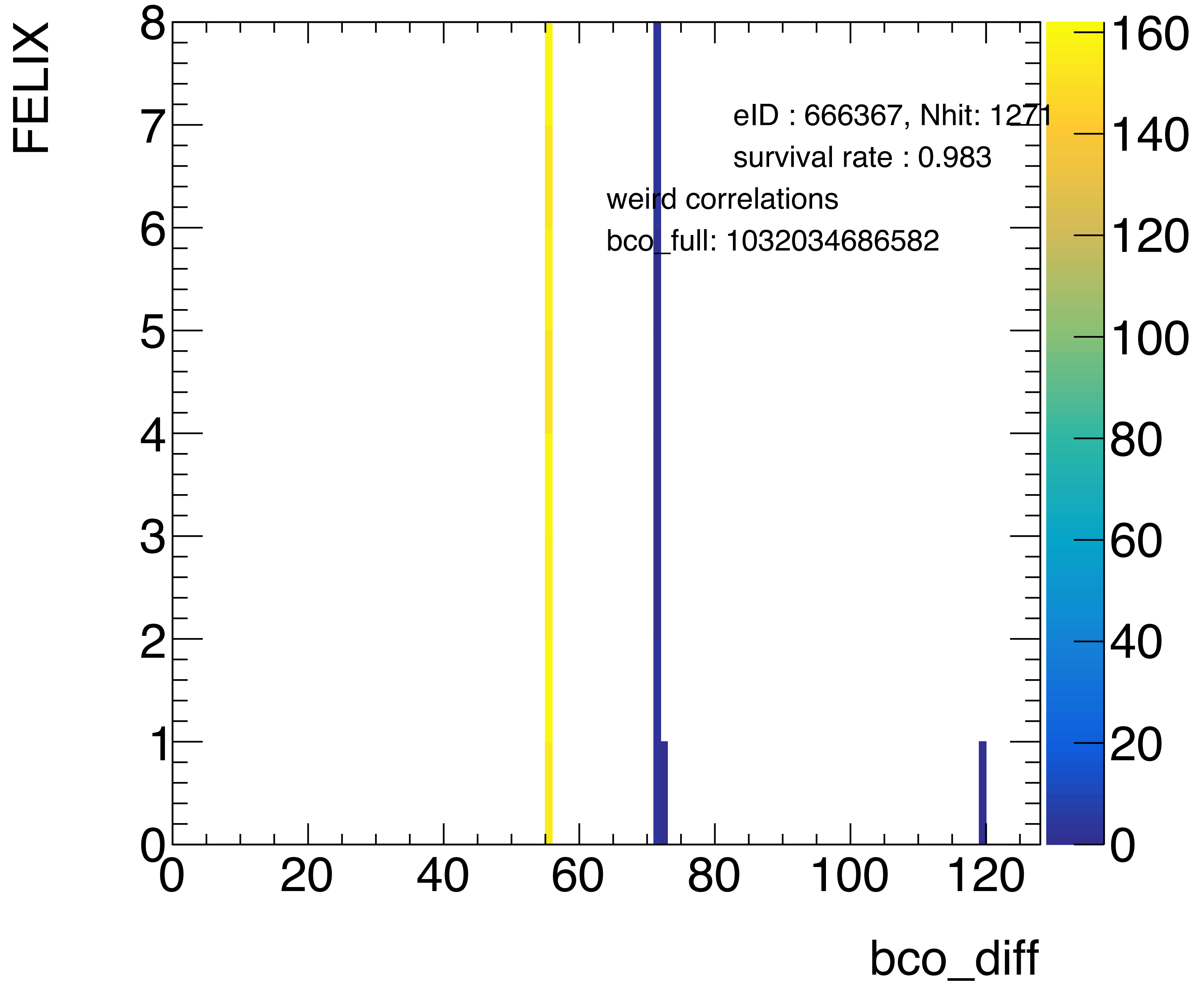


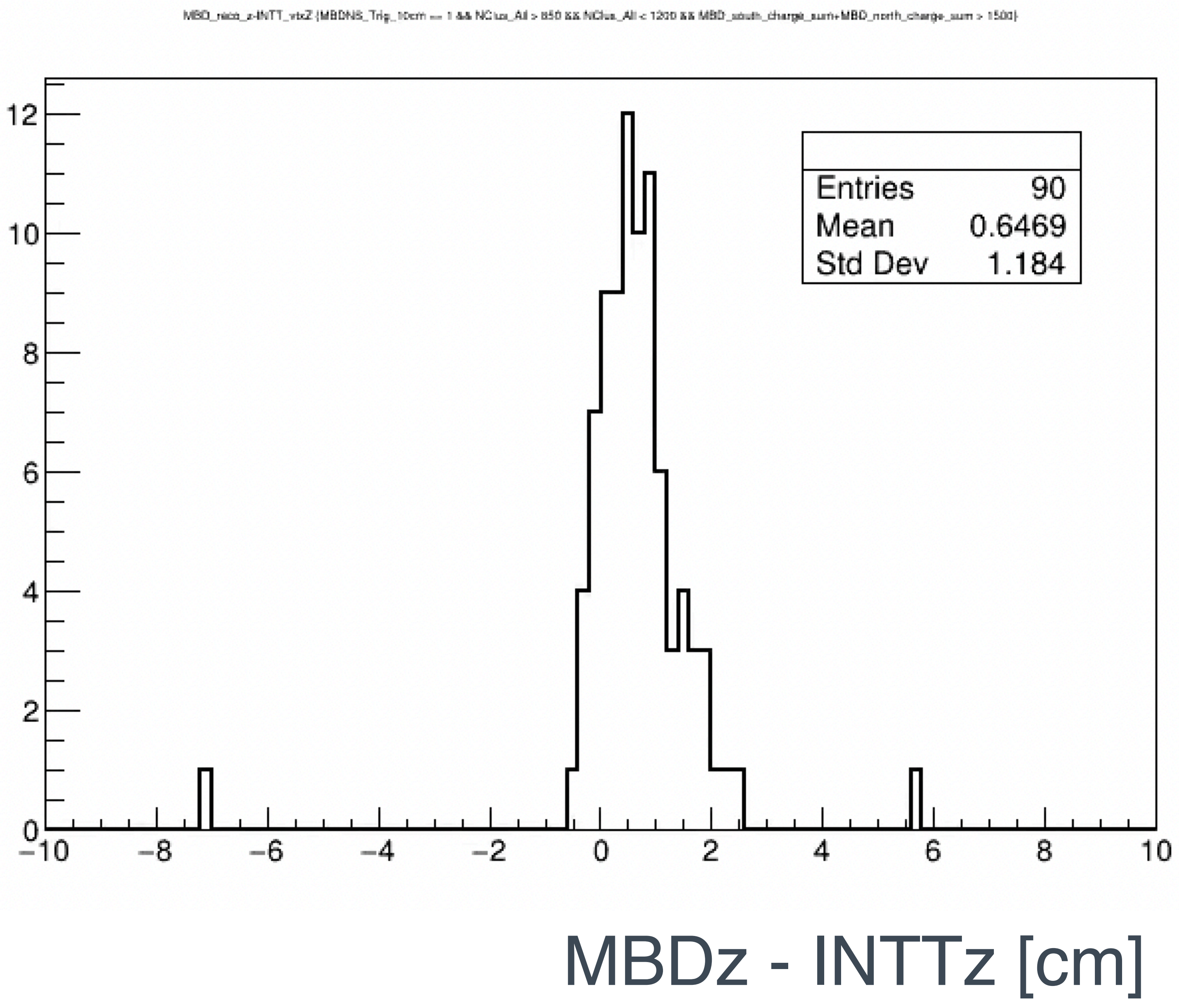
NClus > 900 && NClus < 1200 &&
MBD_charge_sum > 1500

NClus > 900 && NClus < 1200 &&
MBD_charge_sum > 1500

# The outliers in the multiplicity correlation





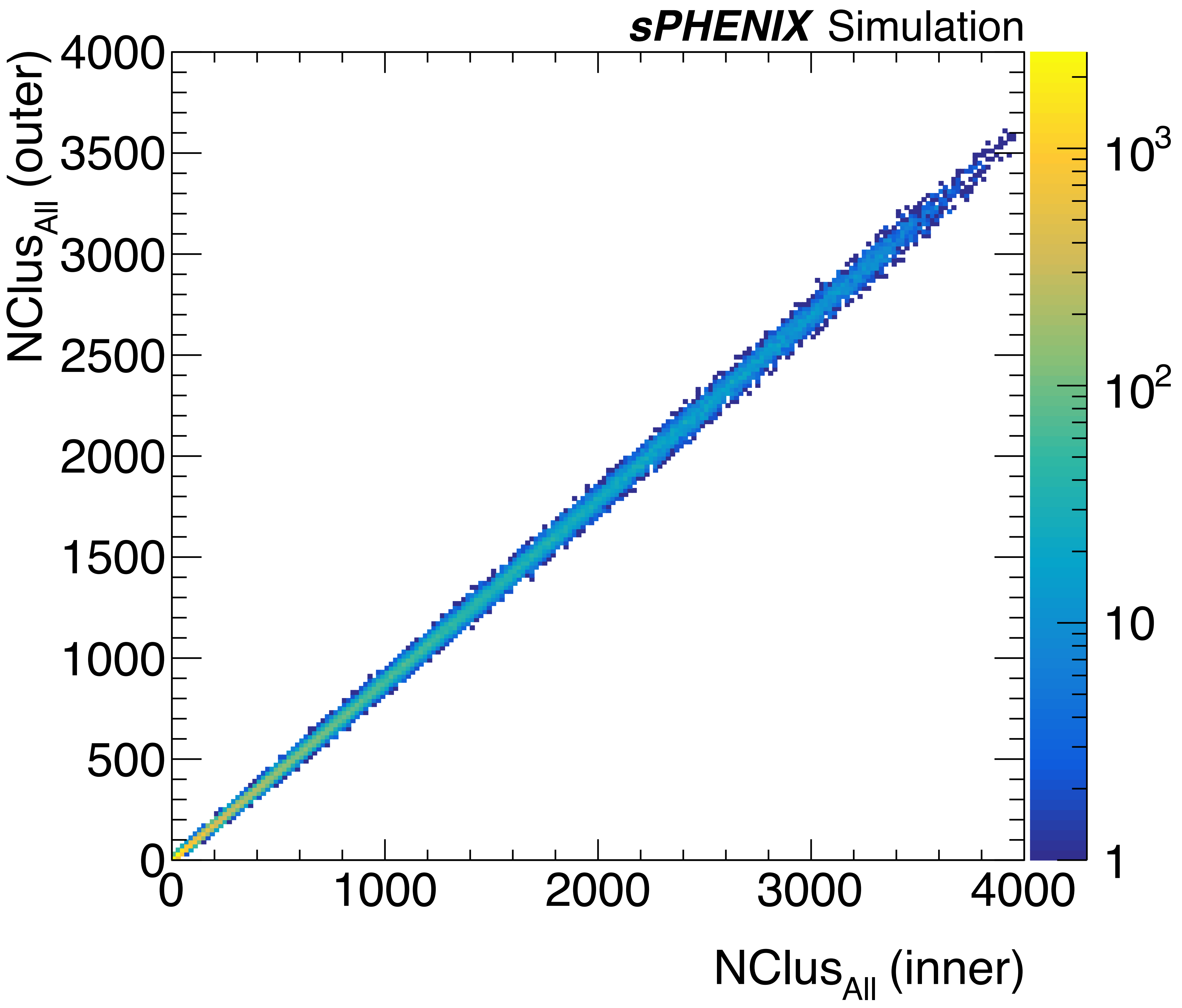


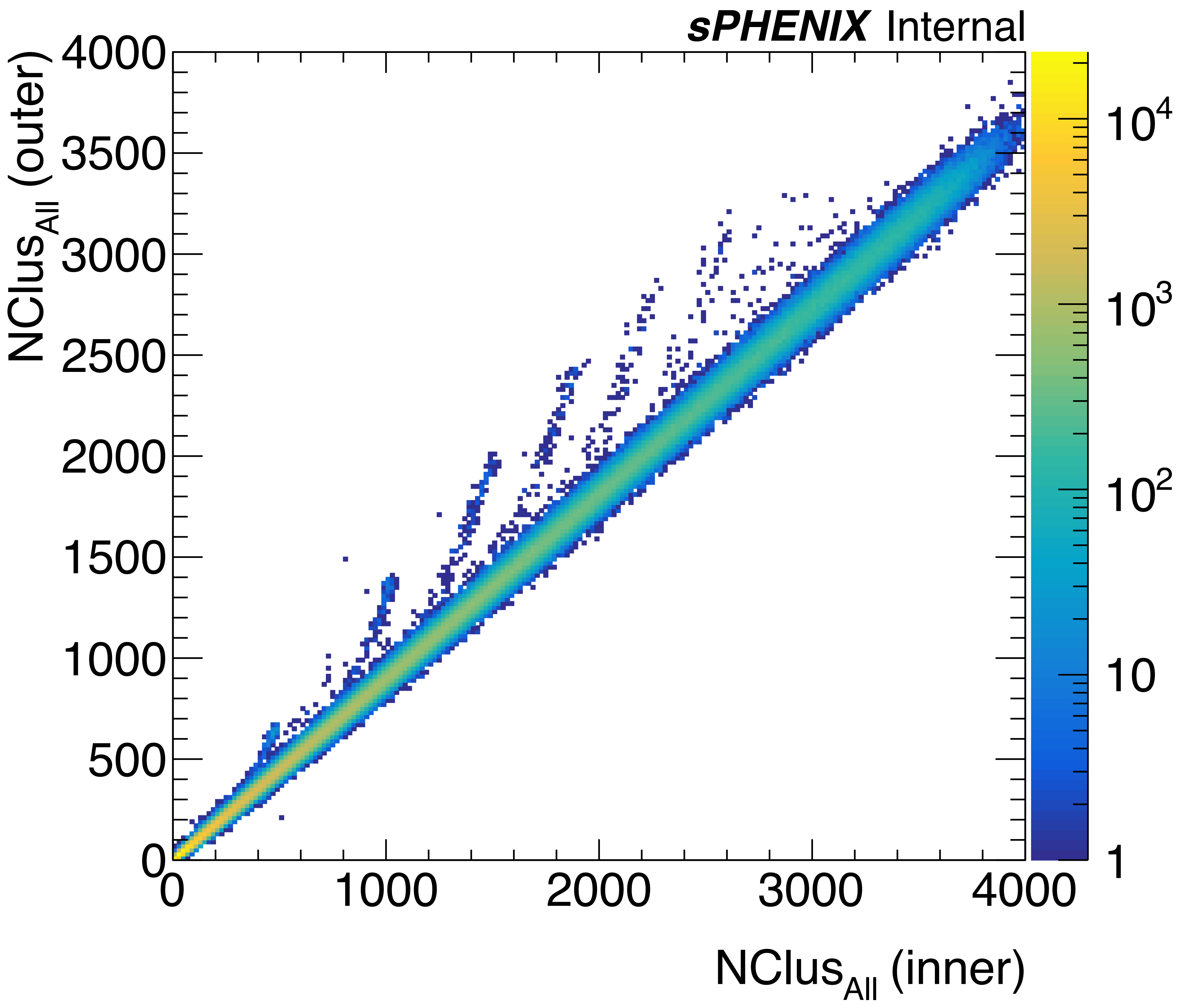
The bco_diff looks correct
The hit maps were also checked, no obvious problem found

It's very weird that the vertex Z are correlated, which means the events are matched
More investigation needed…

# Run 54280, multiplicity correlation

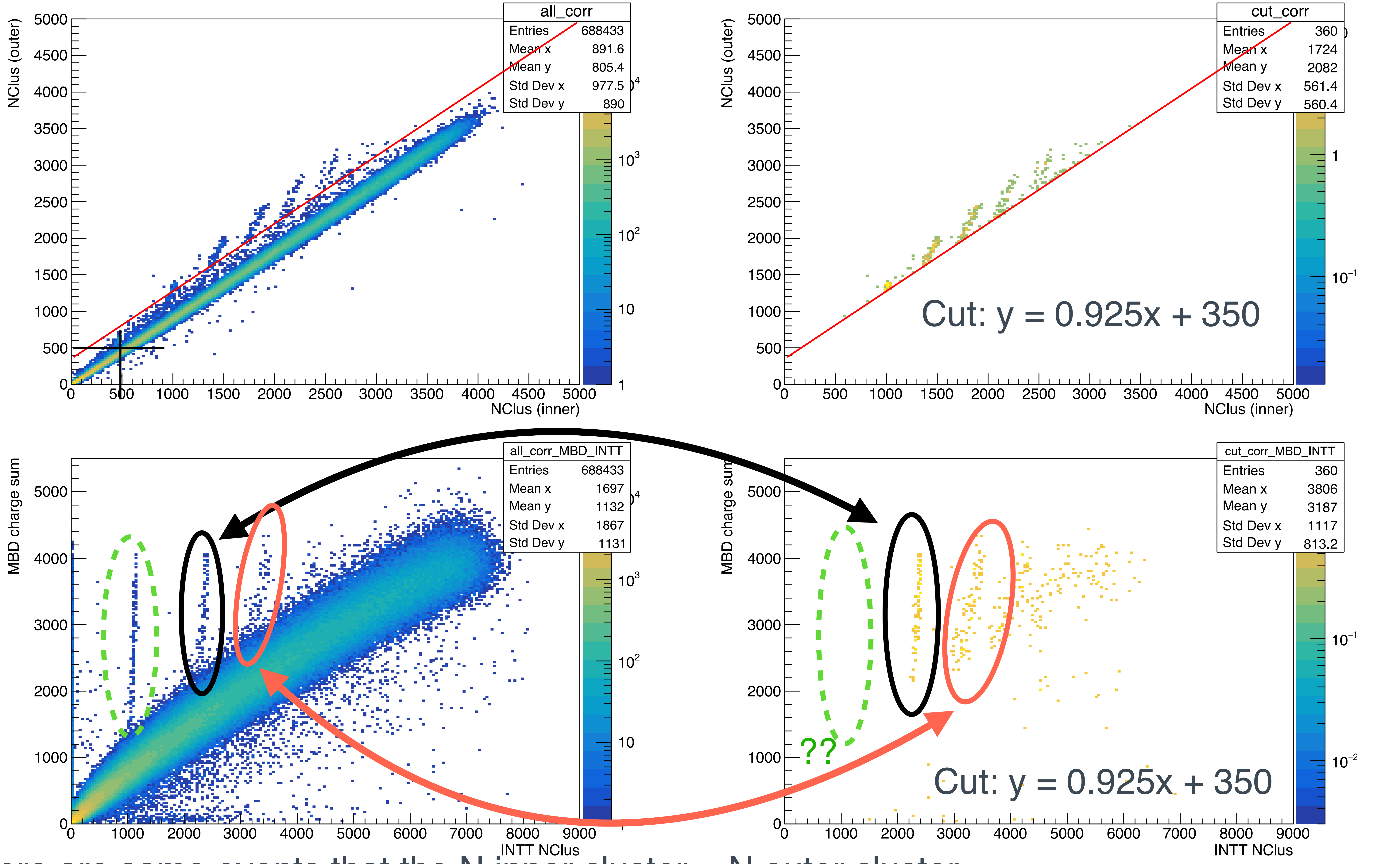
w/ MBD Vertex Z within ±10 cm





Somehow outliers in the internal correlation found

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



| all_corr | |
|---|---|
| Entries | 688433 |
| Mean x | 891.6 |
| Mean y | 805.4 |
| Std Dev x | 977.5 |
| Std Dev y | 890 |

| cut_corr | |
|---|---|
| Entries | 360 |
| Mean x | 1724 |
| Mean y | 2082 |
| Std Dev x | 561.4 |
| Std Dev y | 560.4 |

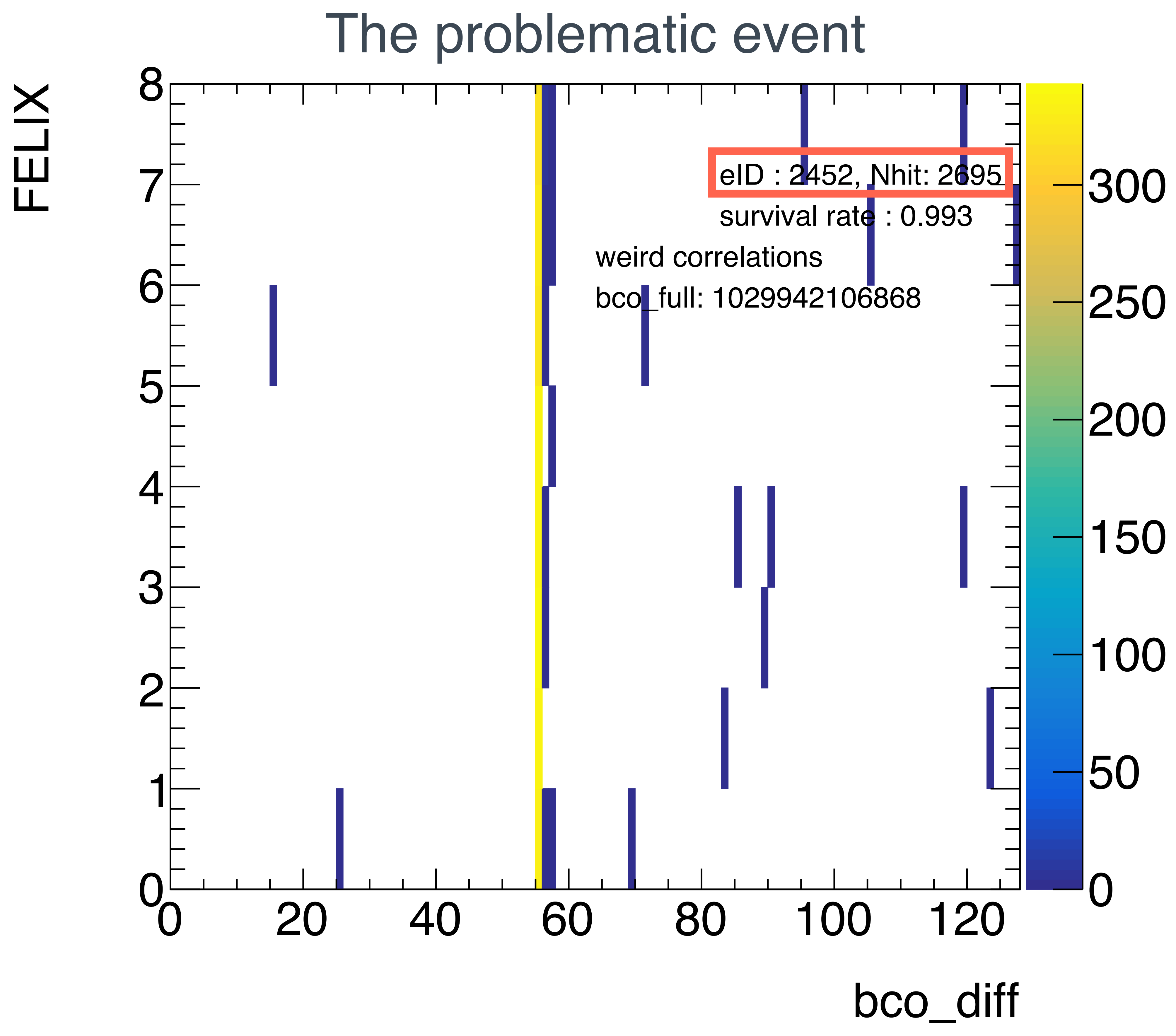
Cut: y = 0.925x + 350

| all_corr_MBD_INTT | |
|---|---|
| Entries | 688433 |
| Mean x | 1697 |
| Mean y | 1132 |
| Std Dev x | 1867 |
| Std Dev y | 1131 |

| cut_corr_MBD_INTT | |
|---|---|
| Entries | 360 |
| Mean x | 3806 |
| Mean y | 3187 |
| Std Dev x | 1117 |
| Std Dev y | 813.2 |

Cut: y = 0.925x + 350

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



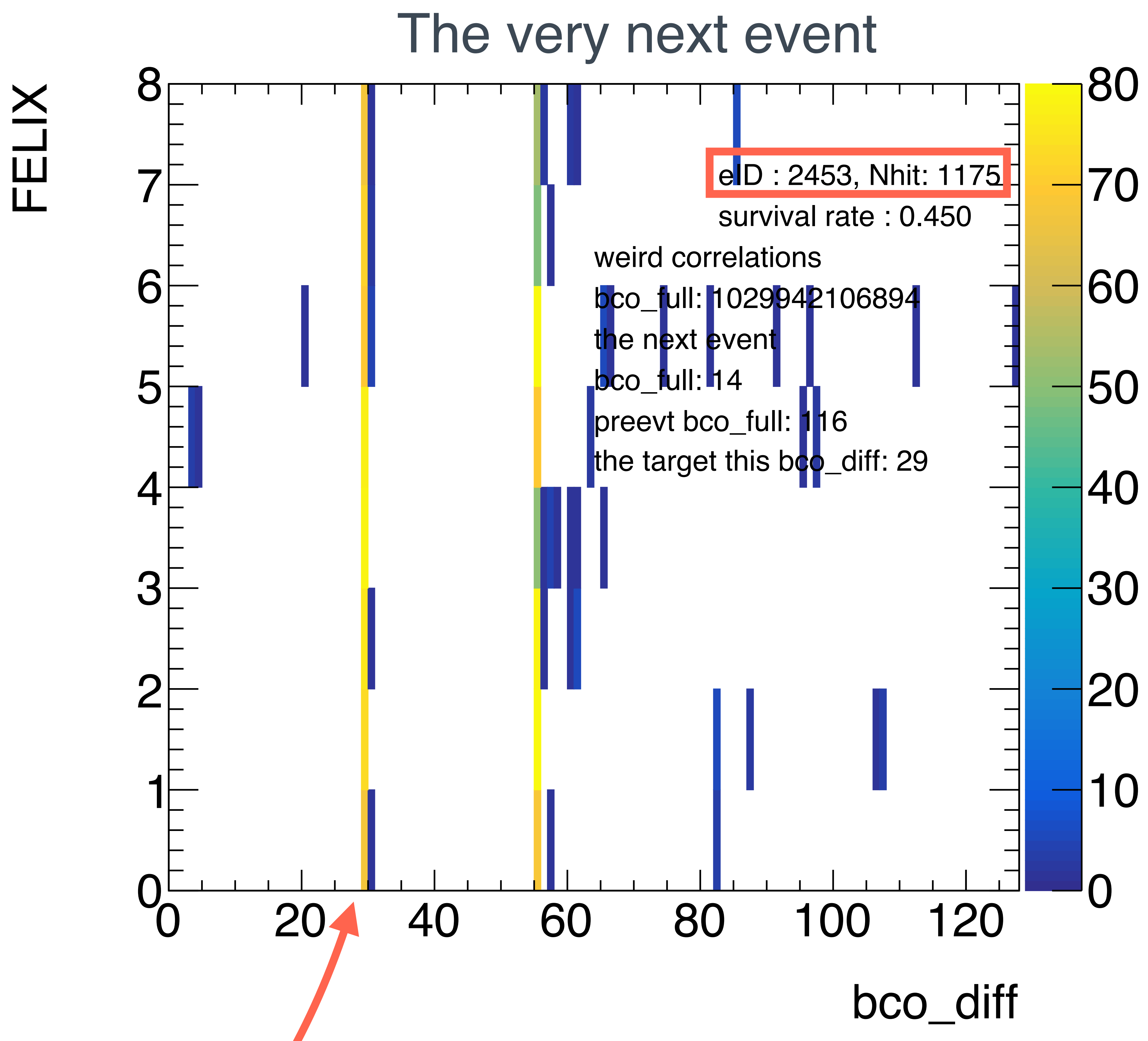
The problematic event

eID : 2452, Nhit: 2695

survival rate : 0.993

weird correlations

bco_full: 1029942106868



The very next event

eID : 2453, Nhit: 1175

survival rate : 0.450

weird correlations

bco_full: 1029942106894

the next event

bco_full: 14

preevt bco_full: 116

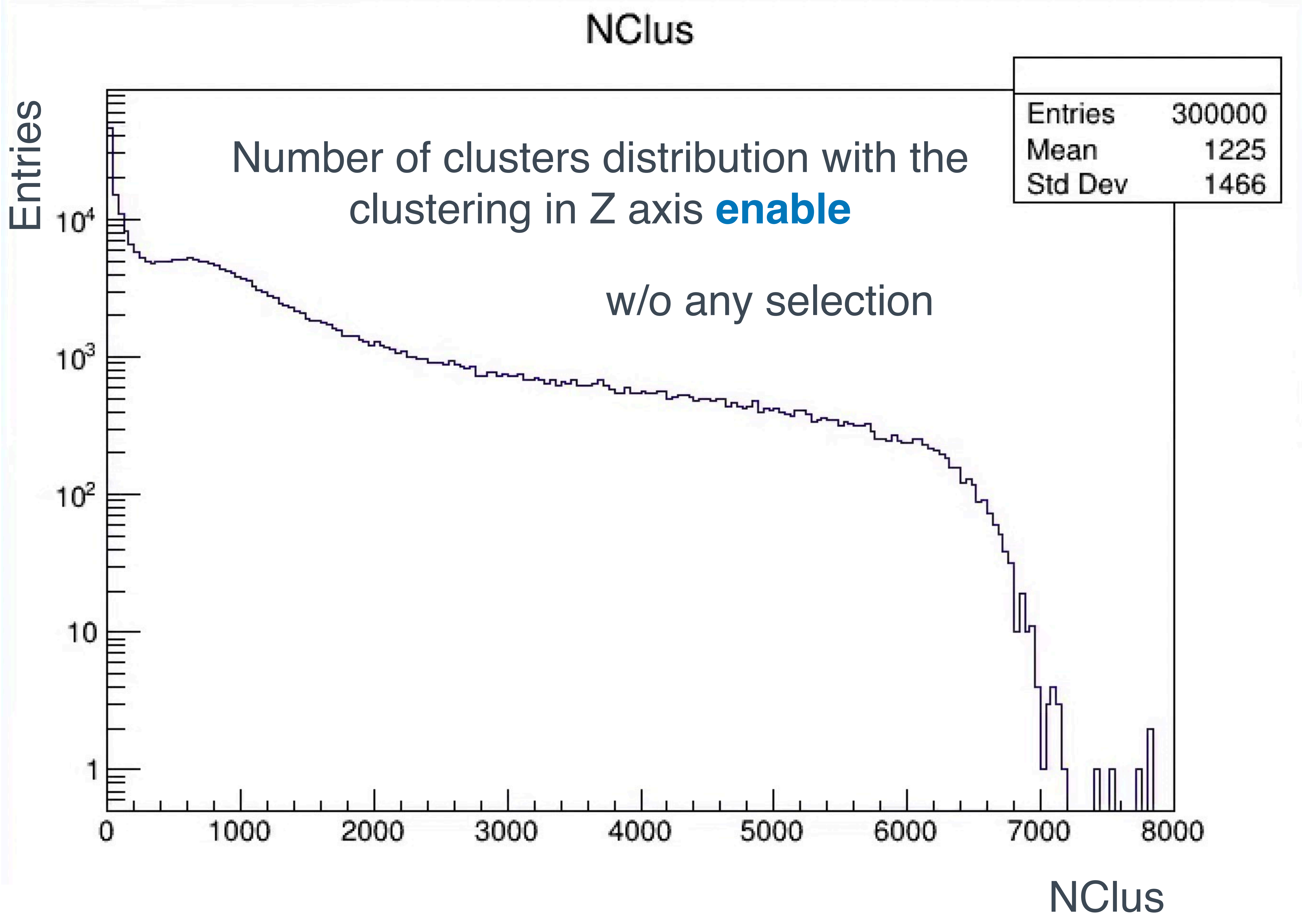
the target this bco_diff: 29

| | | |
|---|---|---|
| (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

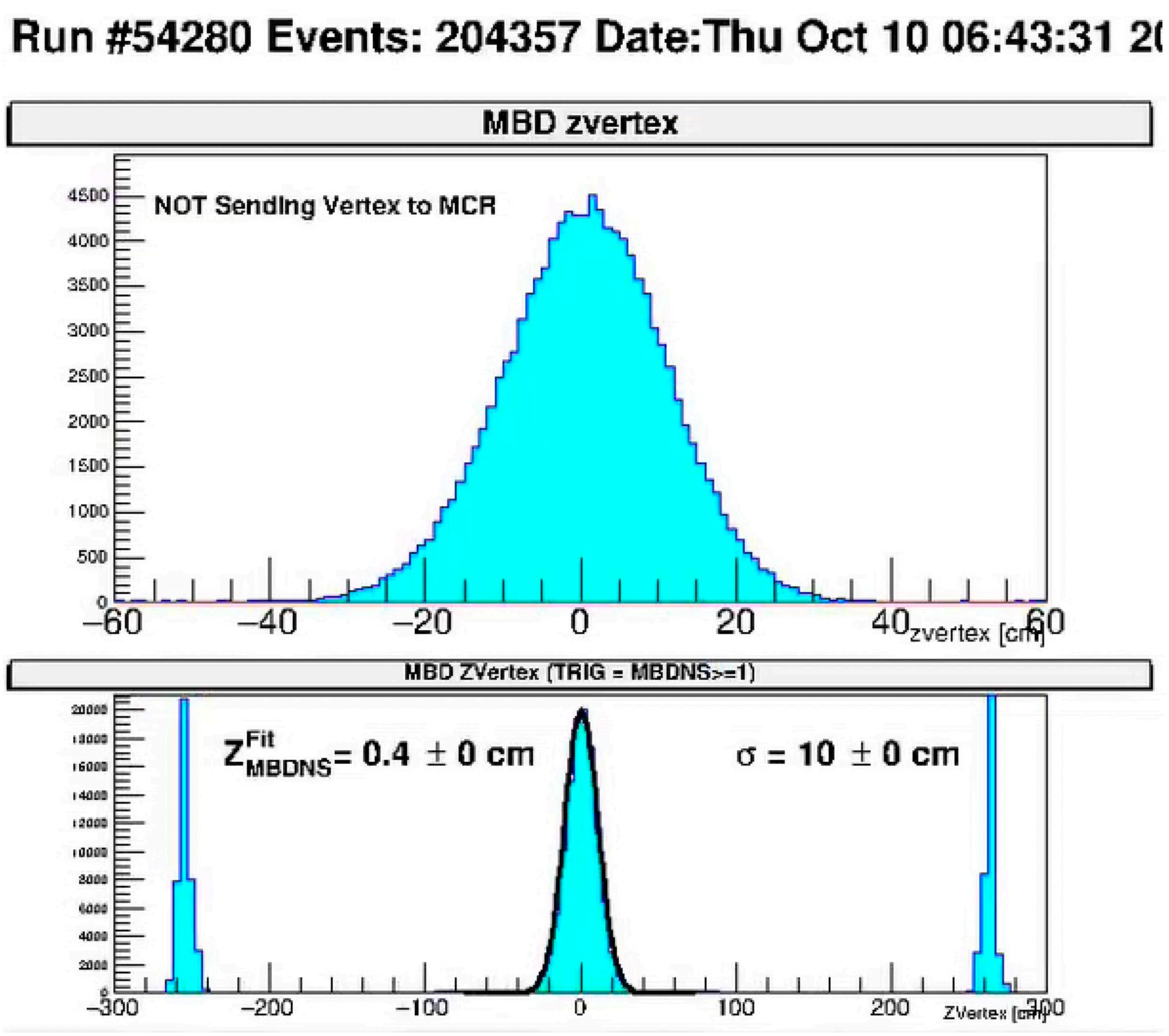
# Abnormal structure of NClus distribution

Number of clusters distribution with the clustering in Z axis enable



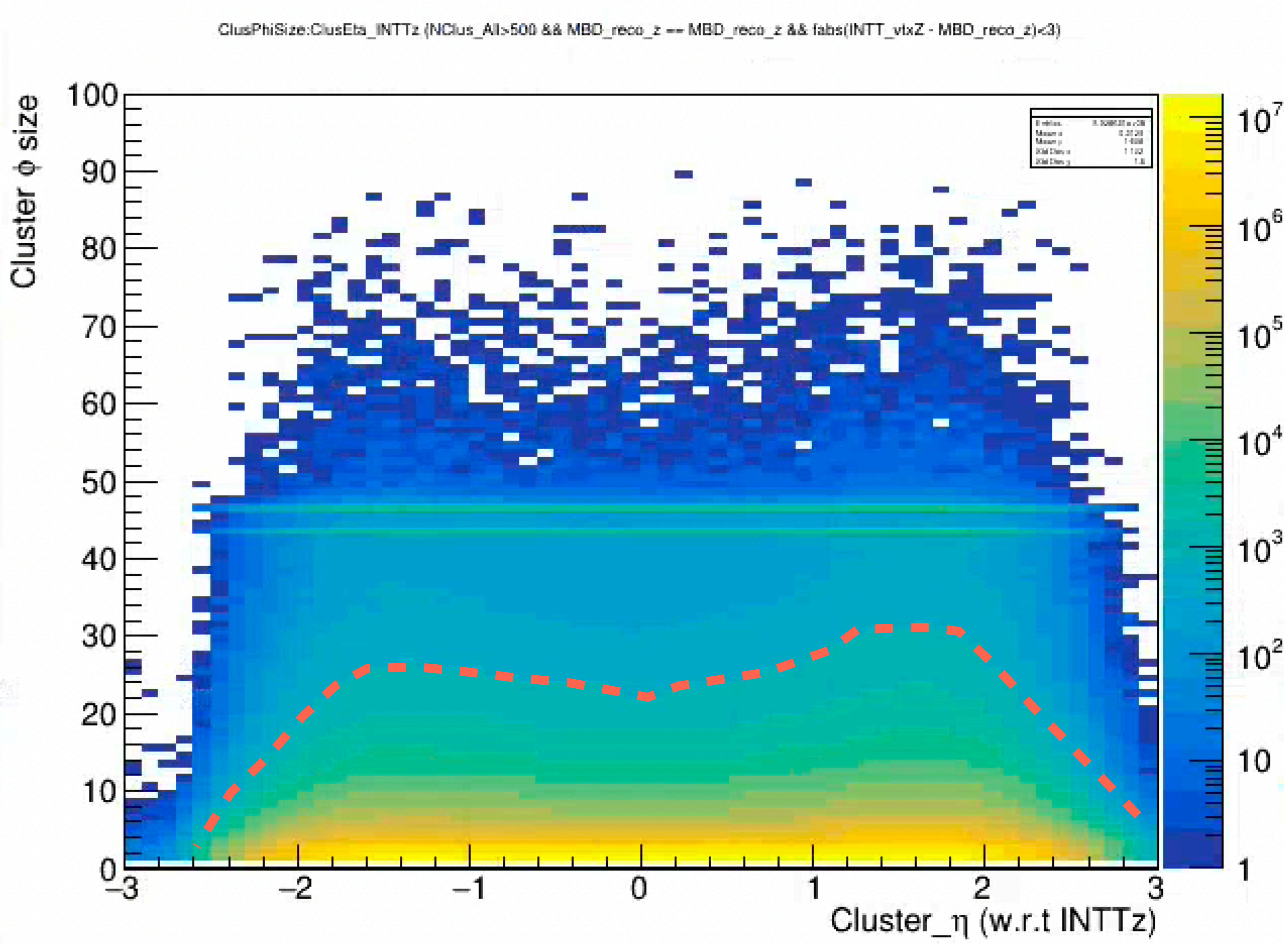
Number of clusters distribution with the clustering in Z axis **enable**

w/o any selection



The bump at NClus ~1000 is from the "no-collision" events

# A quick check of cluster phi size behavior



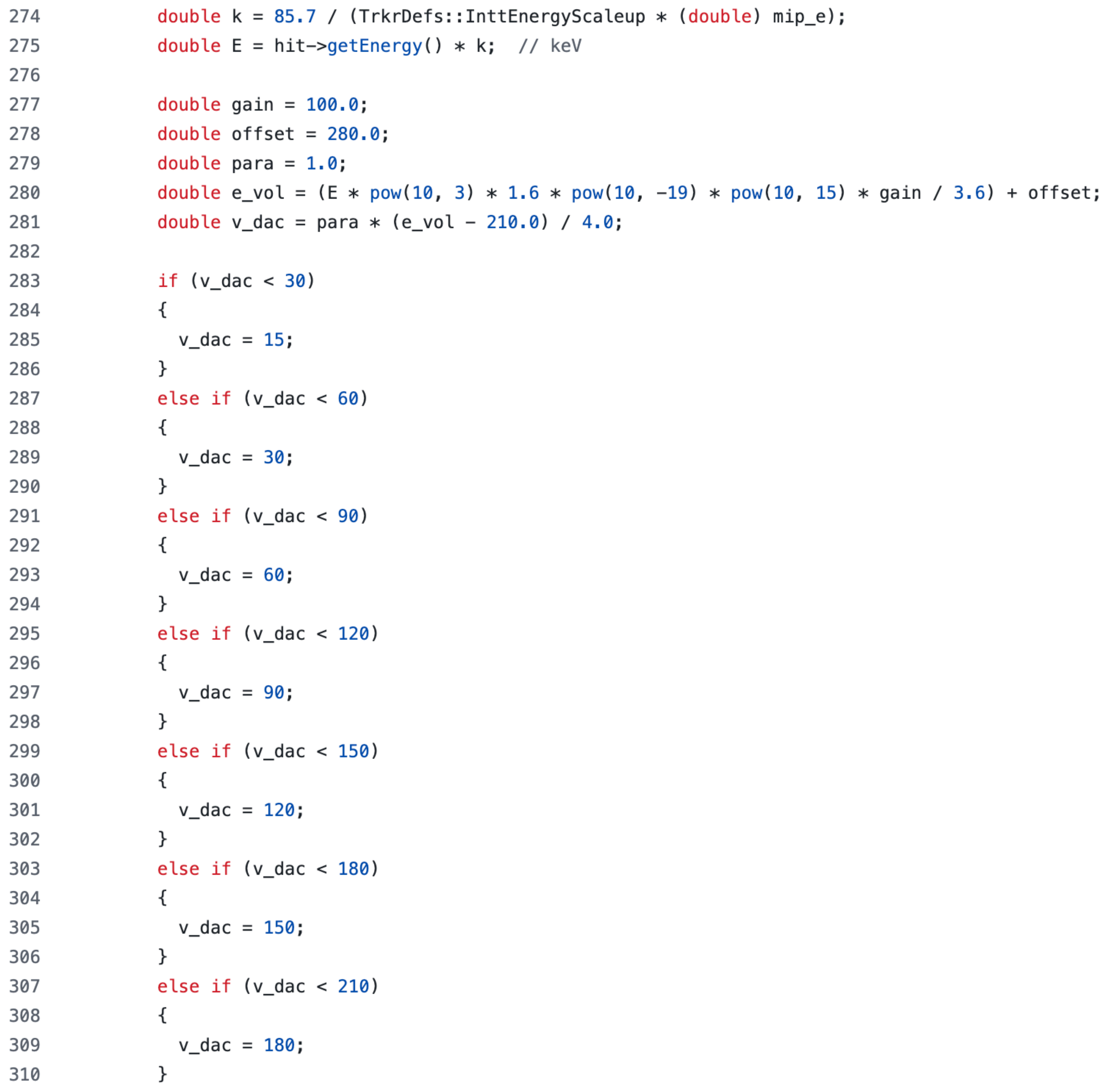
You can see the contour, it seems to be reasonable

# Strategy of optimizing the INTT simulation

PHG4InttDigitizer.cc

Hard coded threshold setting

Seems to be no hit rejection



```
        double k = 85.7 / (TrkrDefs::InttEnergyScaleup * (double) mip_e);
        double E = hit->getEnergy() * k;  // keV

        double gain = 100.0;
        double offset = 280.0;
        double para = 1.0;
        double e_vol = (E * pow(10, 3) * 1.6 * pow(10, -19) * pow(10, 15) * gain / 3.6) + offset;
        double v_dac = para * (e_vol - 210.0) / 4.0;

        if (v_dac < 30)
        {
          v_dac = 15;
        }
        else if (v_dac < 60)
        {
          v_dac = 30;
        }
        else if (v_dac < 90)
        {
          v_dac = 60;
        }
        else if (v_dac < 120)
        {
          v_dac = 90;
        }
        else if (v_dac < 150)
        {
          v_dac = 120;
        }
        else if (v_dac < 180)
        {
          v_dac = 150;
        }
        else if (v_dac < 210)
        {
          v_dac = 180;
        }
```

# Strategy of optimizing the INTT simulation

- 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)

- 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
  - edep distribution discrepancy b/w data and MC
  - cluster phi size discrepancy
  - non-optimized diffusion radius model and parameters

# Summary

- In run 54280, the outliers in the multiplicity correlation between INTT and MBD correlate with the that of in the multiplicity correlation between INTT inner and outer barrel

- As far as I checked, we could have the direct evidence of hits carried over to the next event

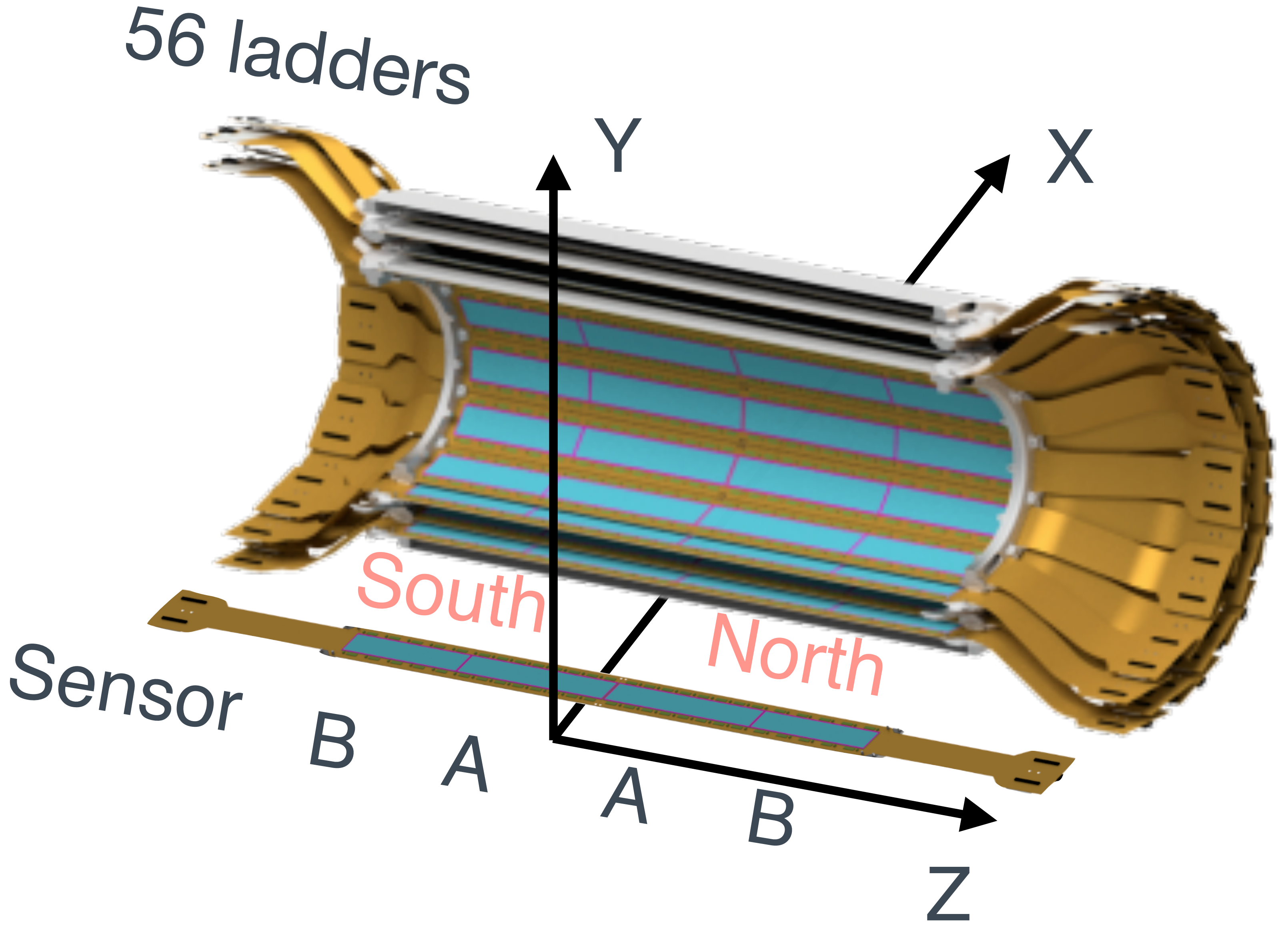
- It seems that for the case of INTT, we can reject most of the beam background by the event selection of MBDNS_Trig_30cm

- The cluster phi size distribution seems to be from the beam background and seems to be really from physics
    - We really need someone senior to work on the MC optimization

# Back up

# 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)

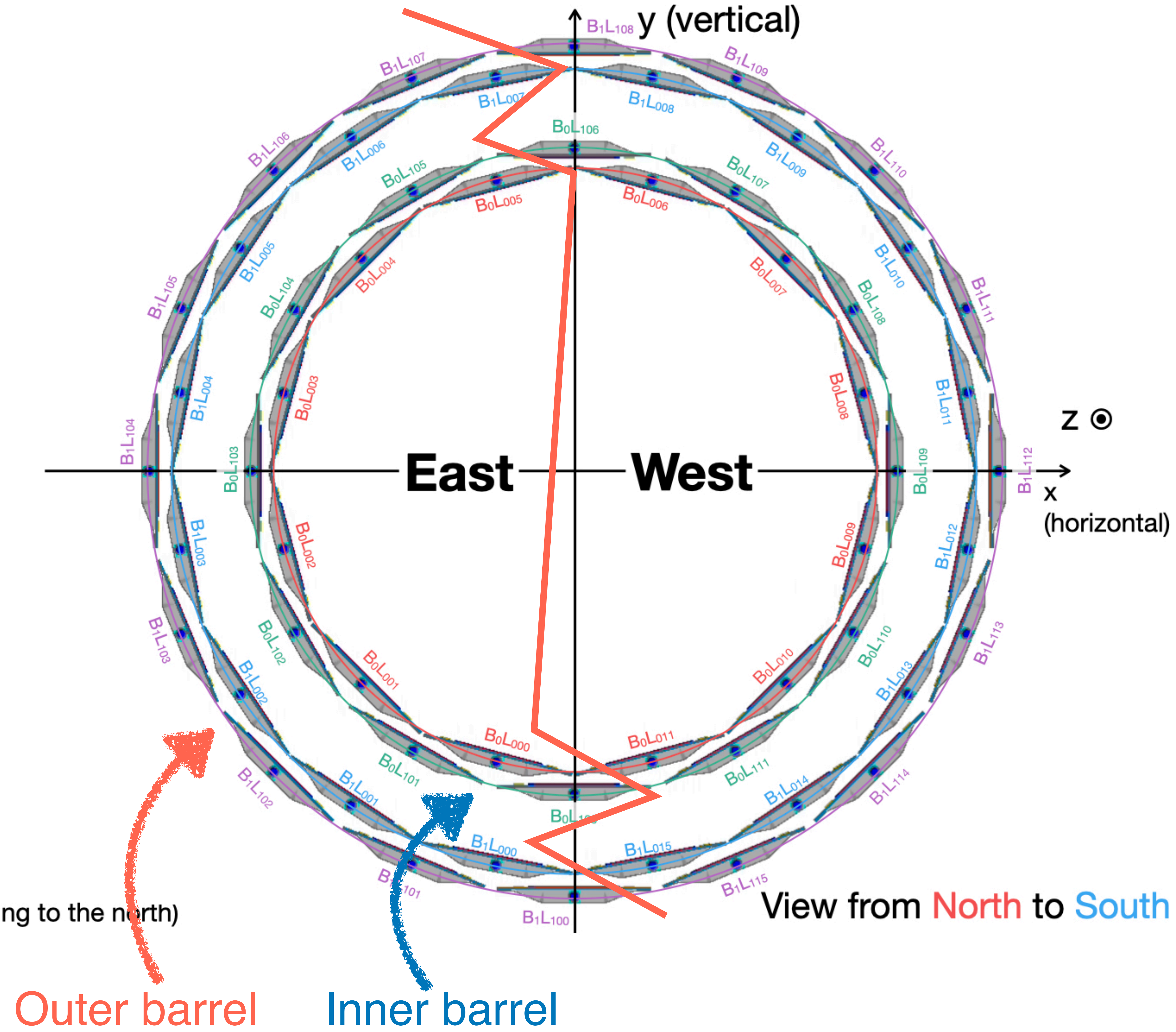
zz: Ladder ID (from 0 to 15)

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)



View from North to South

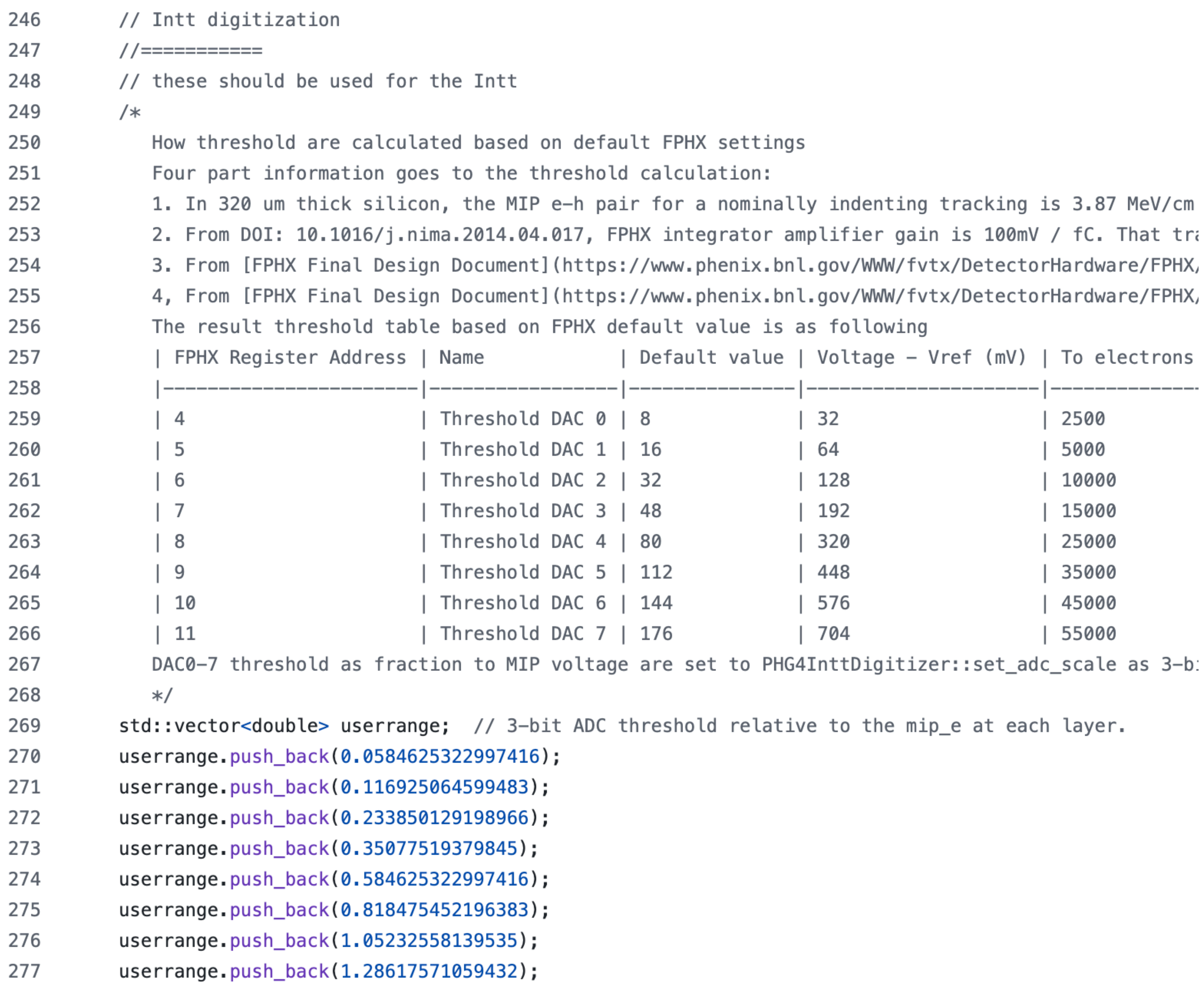
Outer barrel

Inner barrel

# Strategy of optimizing the INTT simulation

In G4_TrkrSimulation.C

Maybe not be used for the conversion calculation



```
// Intt digitization
//===========
// these should be used for the Intt
/*
   How threshold are calculated based on default FPHX settings
   Four part information goes to the threshold calculation:
   1. In 320 um thick silicon, the MIP e-h pair for a nominally indenting tracking is 3.87 MeV/cm
   2. From DOI: 10.1016/j.nima.2014.04.017, FPHX integrator amplifier gain is 100mV / fC. That tra
   3. From [FPHX Final Design Document](https://www.phenix.bnl.gov/WWW/fvtx/DetectorHardware/FPHX/
   4, From [FPHX Final Design Document](https://www.phenix.bnl.gov/WWW/fvtx/DetectorHardware/FPHX/
   The result threshold table based on FPHX default value is as following
   | FPHX Register Address | Name            | Default value | Voltage - Vref (mV) | To electrons
   |-----------------------|-----------------|---------------|---------------------|-------------
   | 4                     | Threshold DAC 0 | 8             | 32                  | 2500
   | 5                     | Threshold DAC 1 | 16            | 64                  | 5000
   | 6                     | Threshold DAC 2 | 32            | 128                 | 10000
   | 7                     | Threshold DAC 3 | 48            | 192                 | 15000
   | 8                     | Threshold DAC 4 | 80            | 320                 | 25000
   | 9                     | Threshold DAC 5 | 112           | 448                 | 35000
   | 10                    | Threshold DAC 6 | 144           | 576                 | 45000
   | 11                    | Threshold DAC 7 | 176           | 704                 | 55000
   DAC0-7 threshold as fraction to MIP voltage are set to PHG4InttDigitizer::set_adc_scale as 3-bi
   */
std::vector<double> userrange;  // 3-bit ADC threshold relative to the mip_e at each layer.
userrange.push_back(0.0584625322997416);
userrange.push_back(0.116925064599483);
userrange.push_back(0.233850129198966);
userrange.push_back(0.35077519379845);
userrange.push_back(0.584625322997416);
userrange.push_back(0.818475452196383);
userrange.push_back(1.05232558139535);
userrange.push_back(1.28617571059432);
```