dN/dη updates

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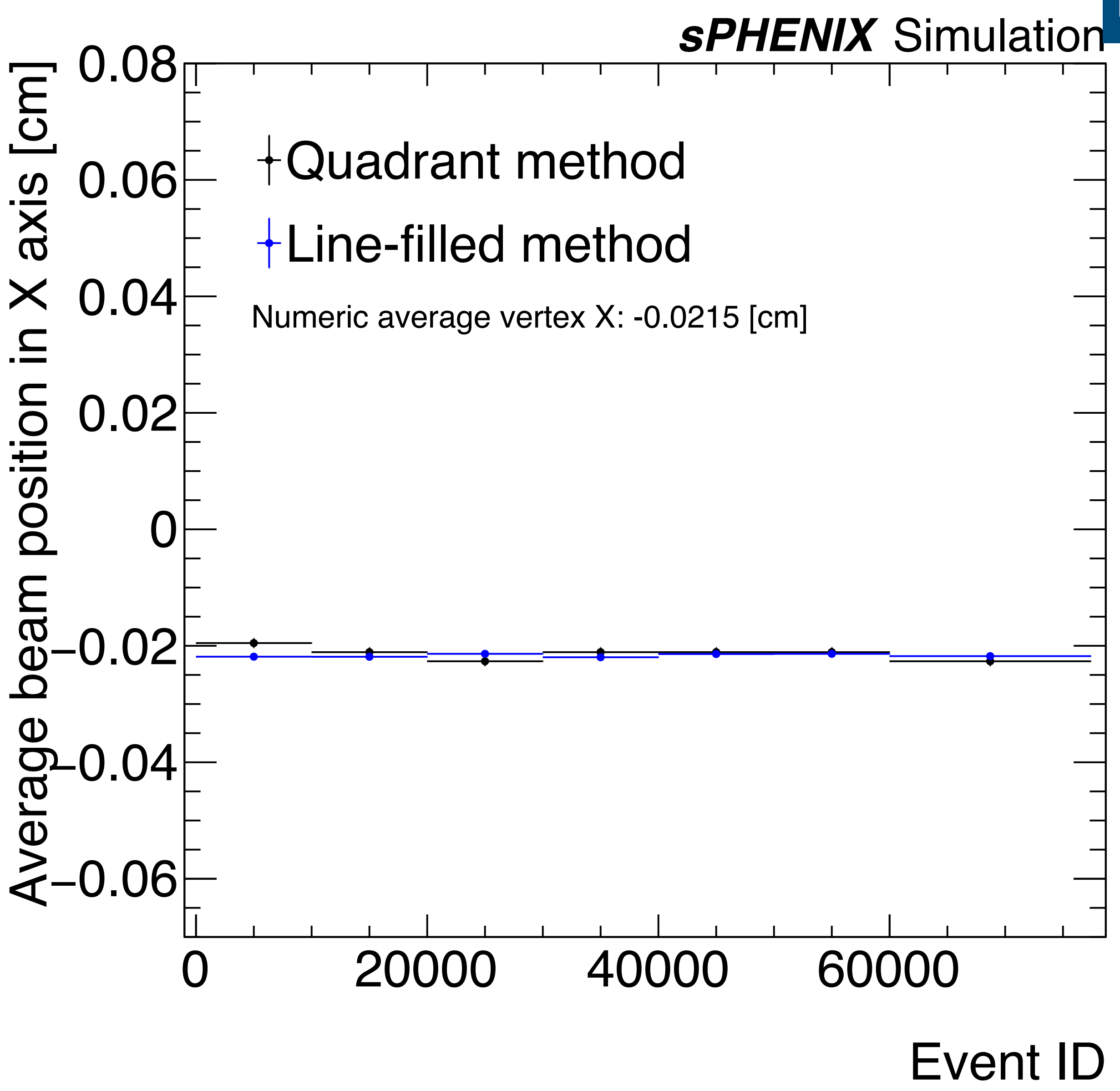
National Central University/RIKEN

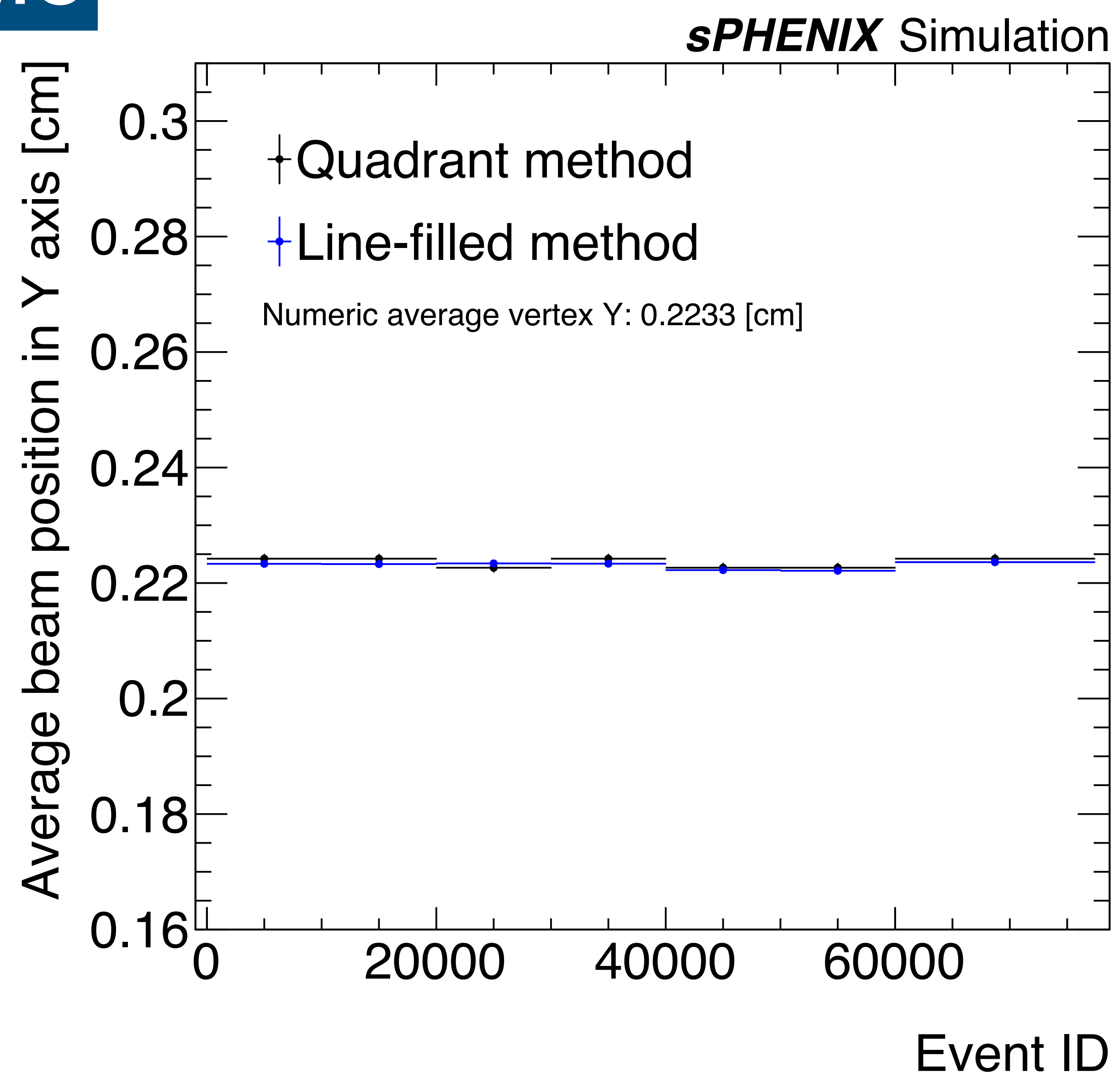
Jan 17th, 2025
RBRC exp. monthly meeting

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

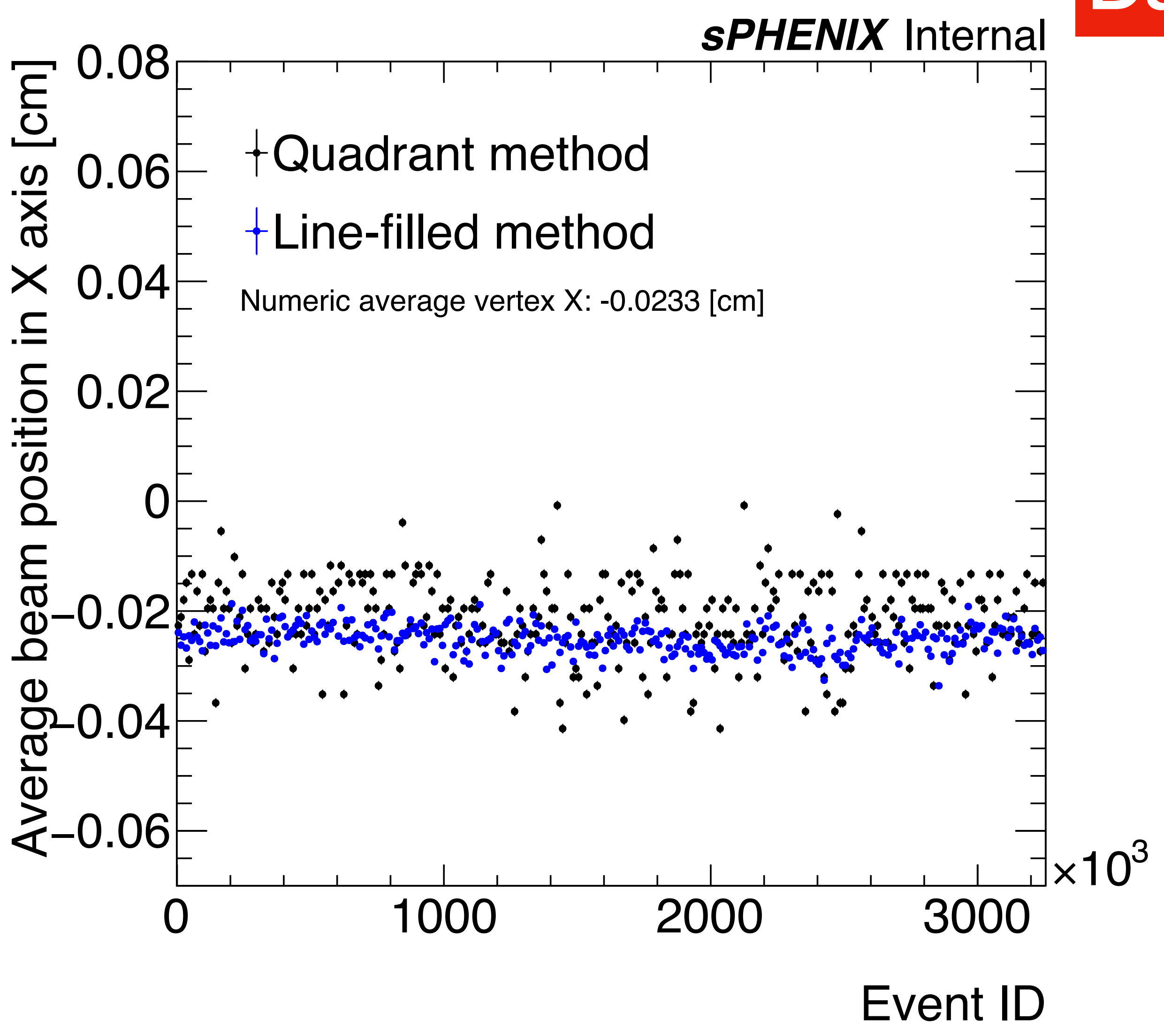
Average vertex XY

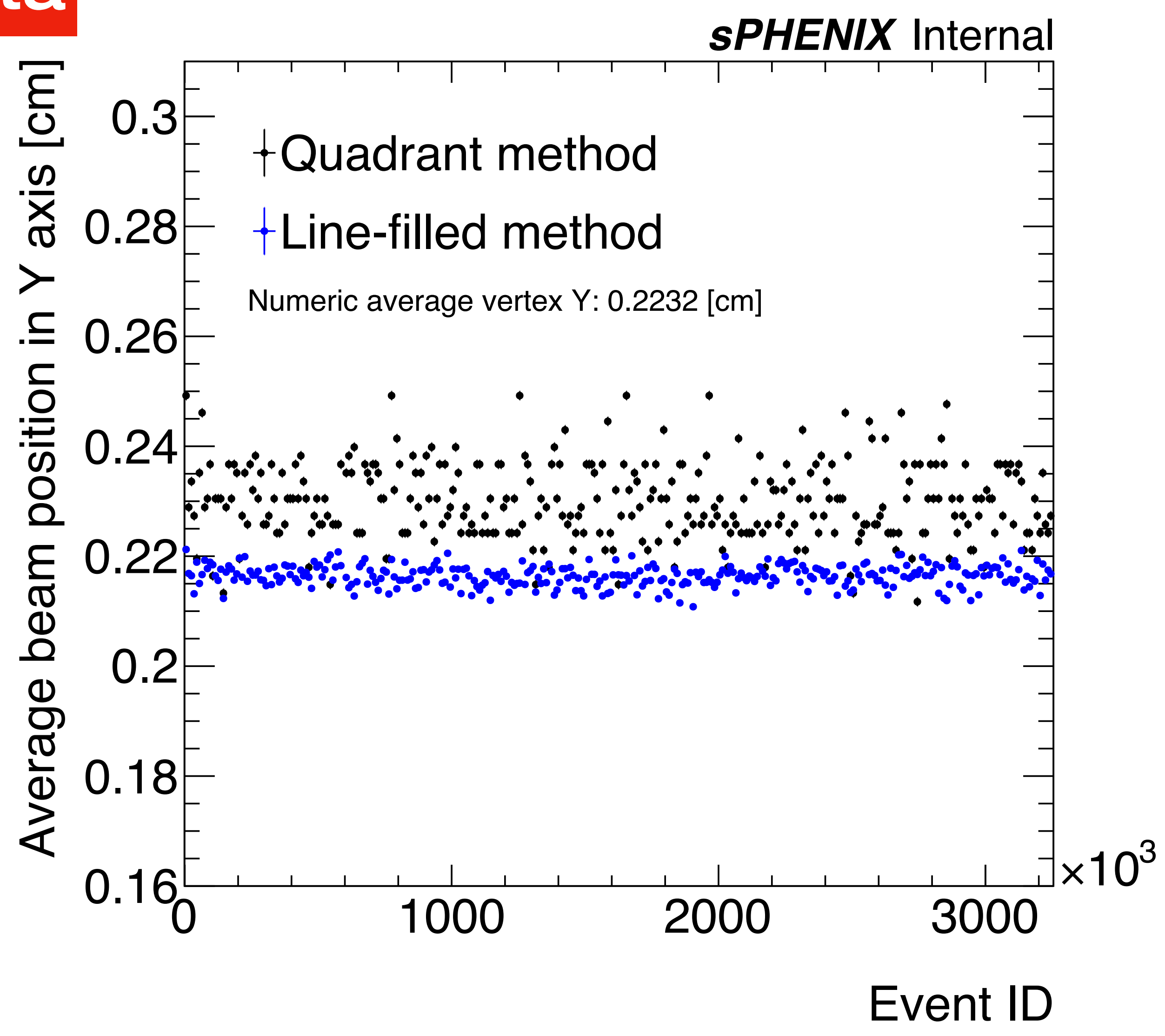
MC





Data





unit : [cm]
final average vertex XY should be used :
line filled X : -0.0216673 +/- 0.000264715
line filled Y : 0.223049 +/- 0.000601275
quadrant X : -0.021317 +/- 0.00107823
quadrant Y : 0.223549 +/- 0.000835191
avg: {-0.0214921, 0.223299} [cm]
Fit avg: {-0.0216742, 0.223105} [cm]

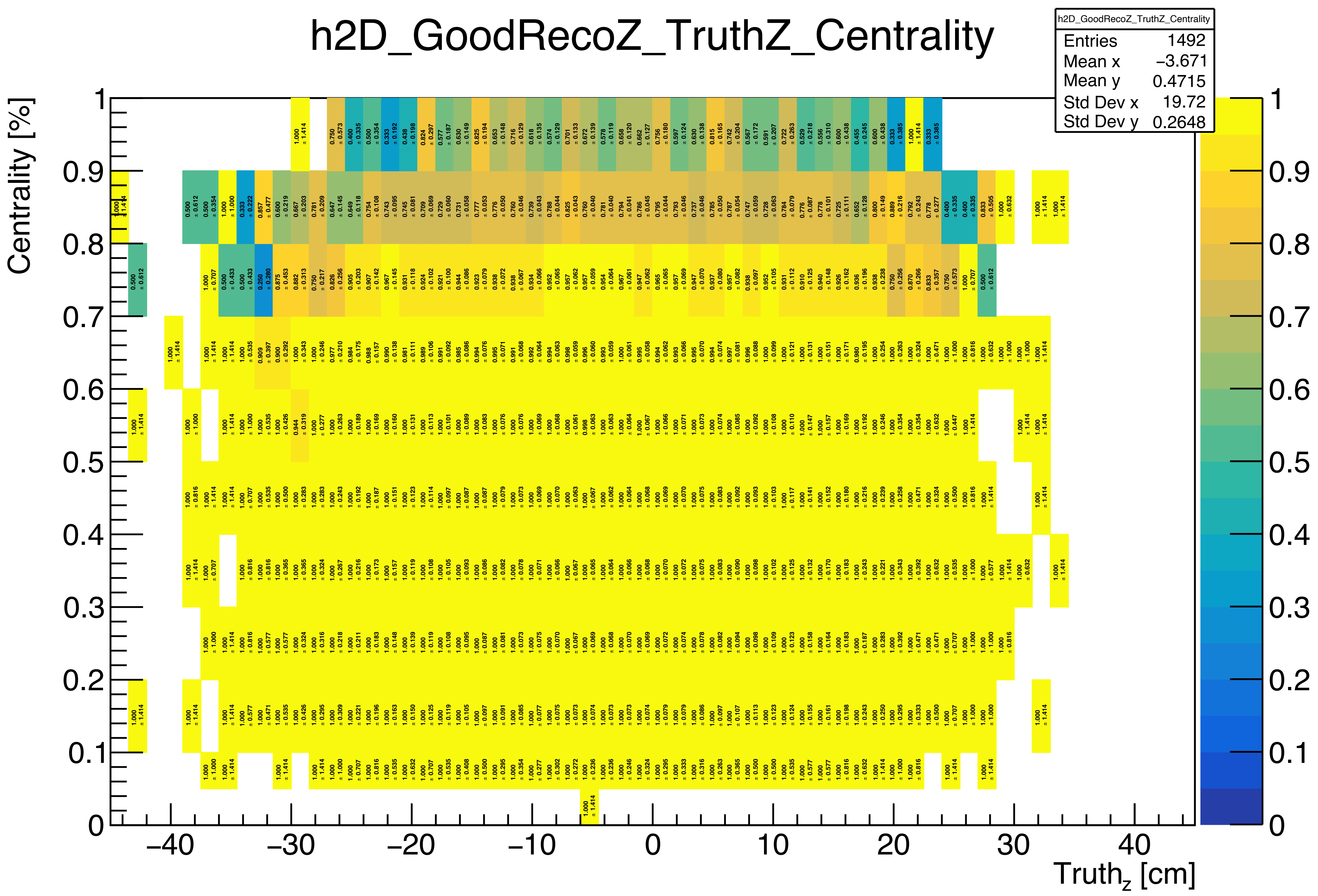
Truth: {-0.02204, 0.2229 cm}

unit : [cm]
final average vertex XY should be used :
line filled X : -0.0251217 +/- 0.00243517
line filled Y : 0.216403 +/- 0.00190794
quadrant X : -0.0214217 +/- 0.0071013
quadrant Y : 0.229943 +/- 0.00691613
avg: {-0.0232717, 0.223173} [cm]
Fit avg: {-0.0251361, 0.216375} [cm]

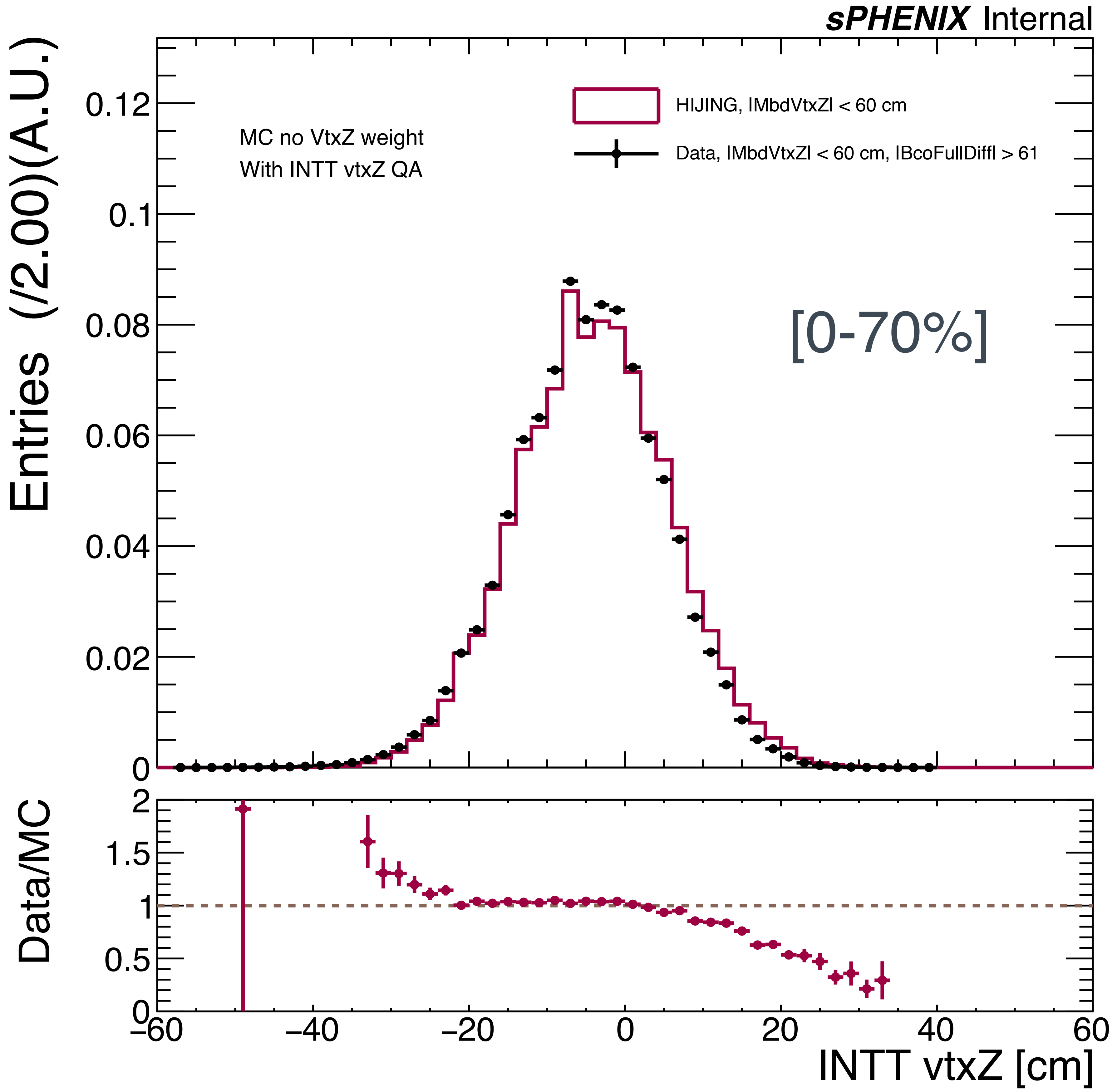
Diff in two methods in Y: 134 μm

PerEvent vertex Z

INTT Vertex Z reconstruction with VtxZQA cut



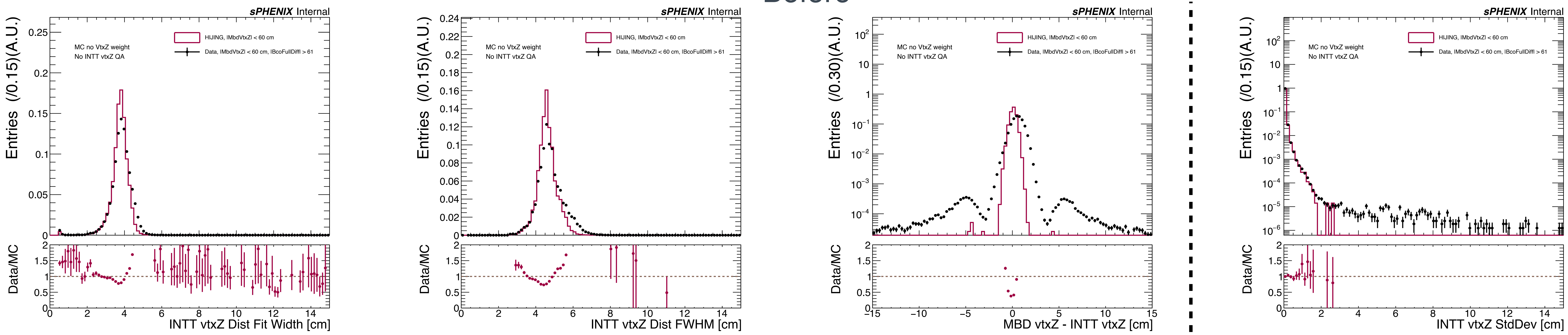
fabs(reco. vtxZ - truth) <= 1 cm



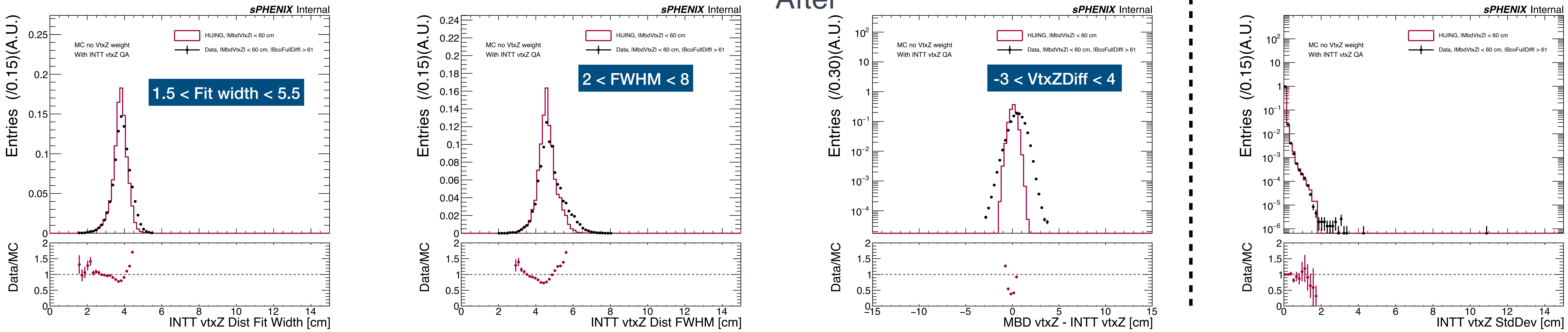
VtxZ reweighing factors

INTT vertex Z QA (Data-MC comp)

Before



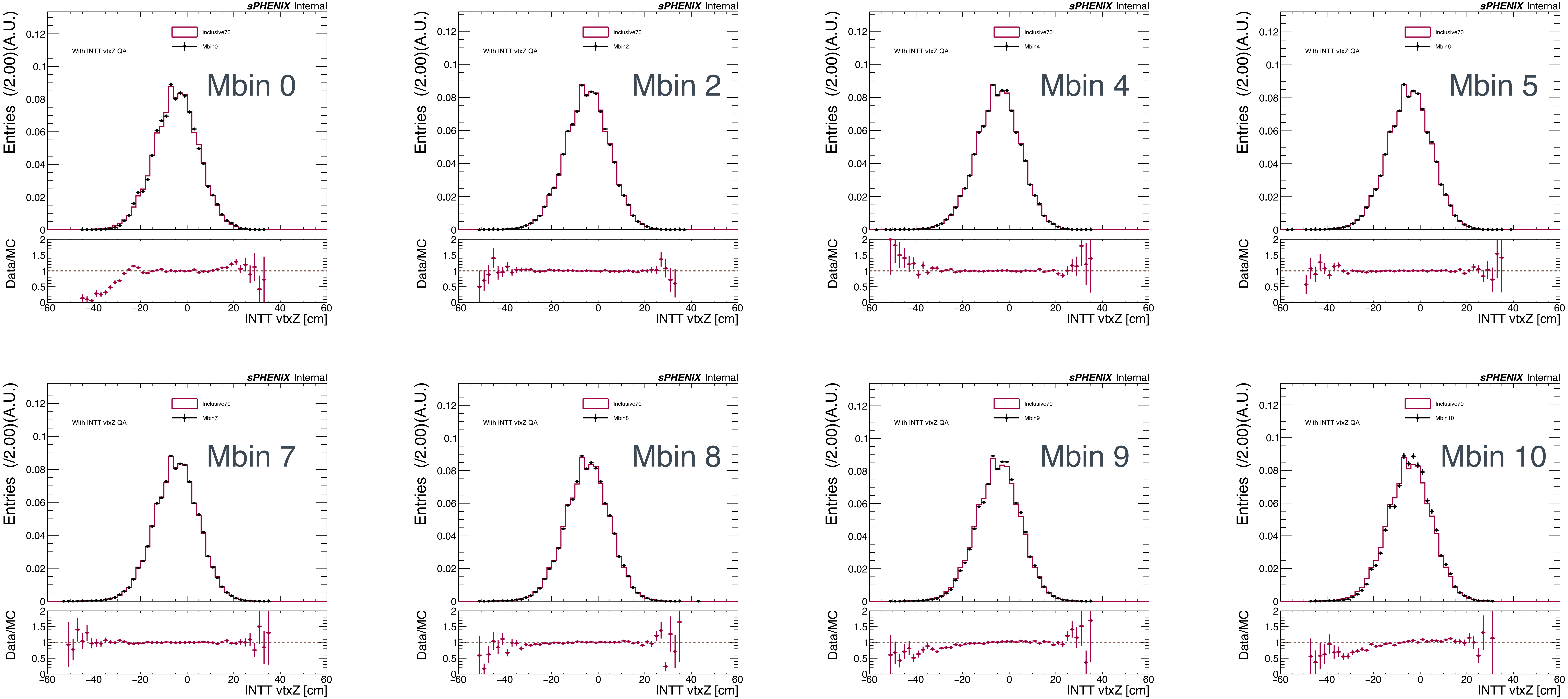
After



Three selections are considered for the INTT vtxZ QA. Good agreement in INTT VtxZ StdDev post selection

Vertex Z distribution, self comparison

Data only, with vtxZ QA, comparing with Inclusive70

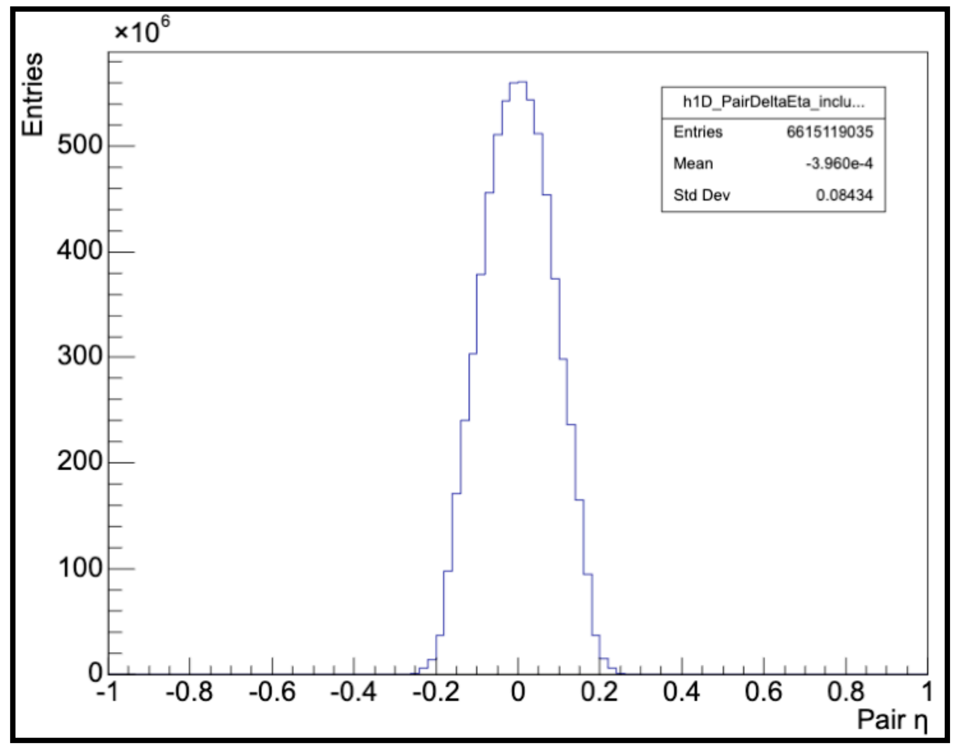


We maybe able to do 0% - 80% ? But now stick with [0-70%]

Tracklet approach

Data

- Procedures:
  - Prepare the Δϕ distribution for each {Centrality-bin x Eta-bin x vtxZ-bin x isRotated x isTypeA}
    - Pairs are required to link to the reco. vertex Z (corresponding to |Δη| ≦ 0.25)
  - Stack up the Δϕ histograms based on the selected vtxZ and Centrality ranges
  - Determine the background by
    - ~~Fitting (Polynomial 2) {signal region exclusion}~~: Not used
      - Large-scattering tracks and the decay products of primary particles decaying in flight contribute to the fit
    - Count entries of the rotated case (Inner barrel rotated 180 degrees in ϕ)



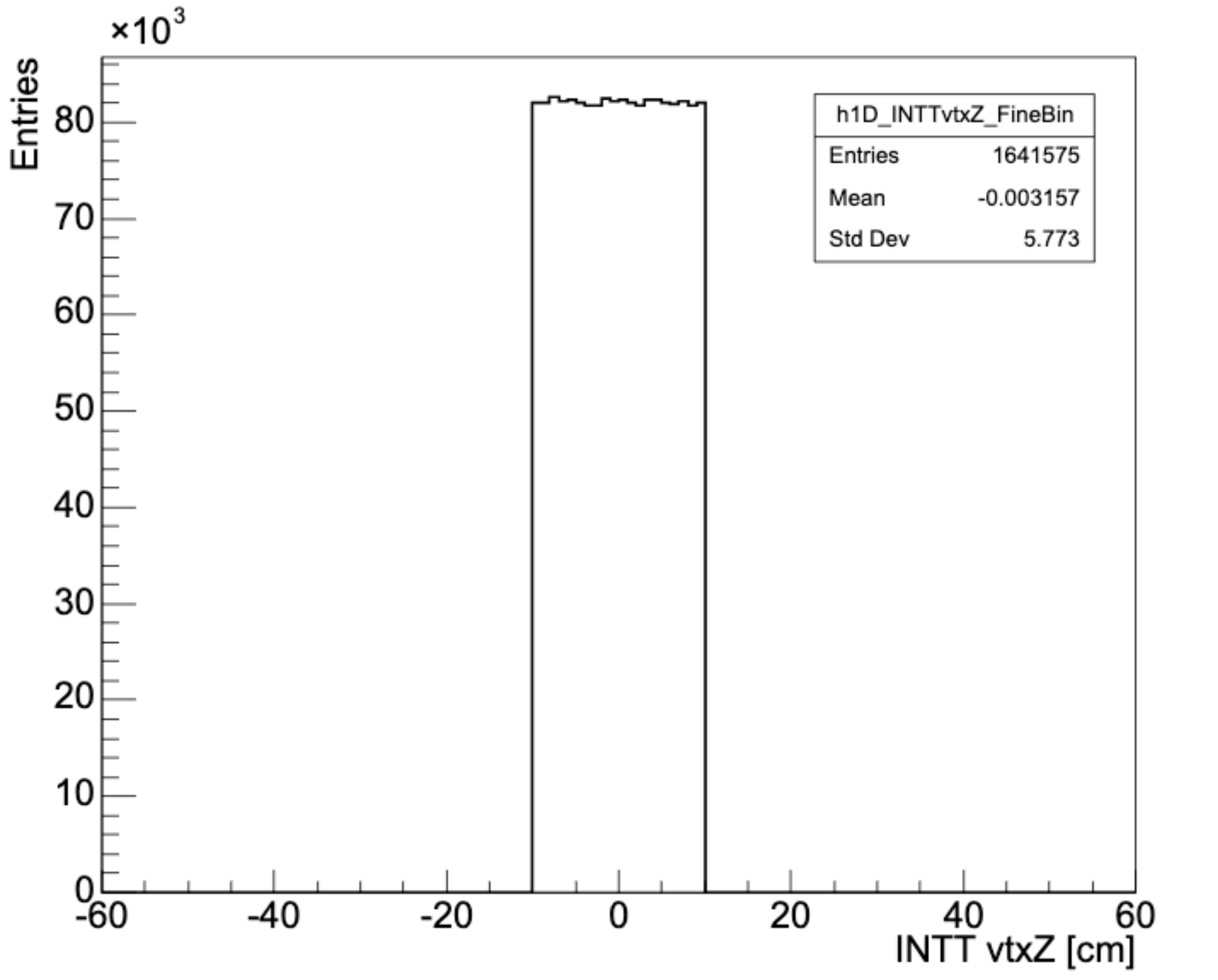
Centrality [0-70%], vertex Z [-10 cm - 10 cm], Eta [0.3 - 0.5]

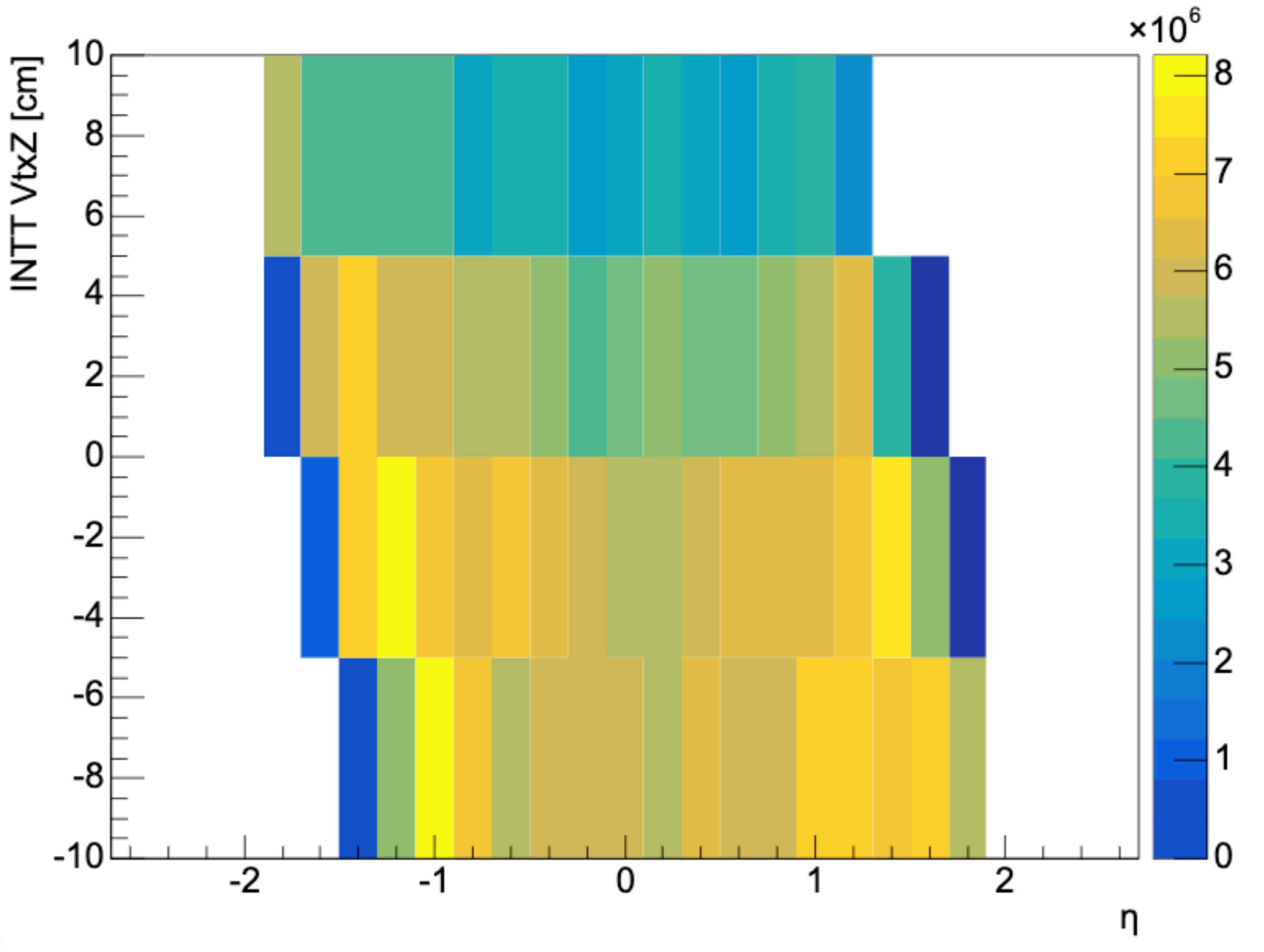
Signal determined by counting (|Δϕ| ≦ 0.021) instead of fitting as the distribution doesn't follow Gaussian distribution

Geometry acceptance correction

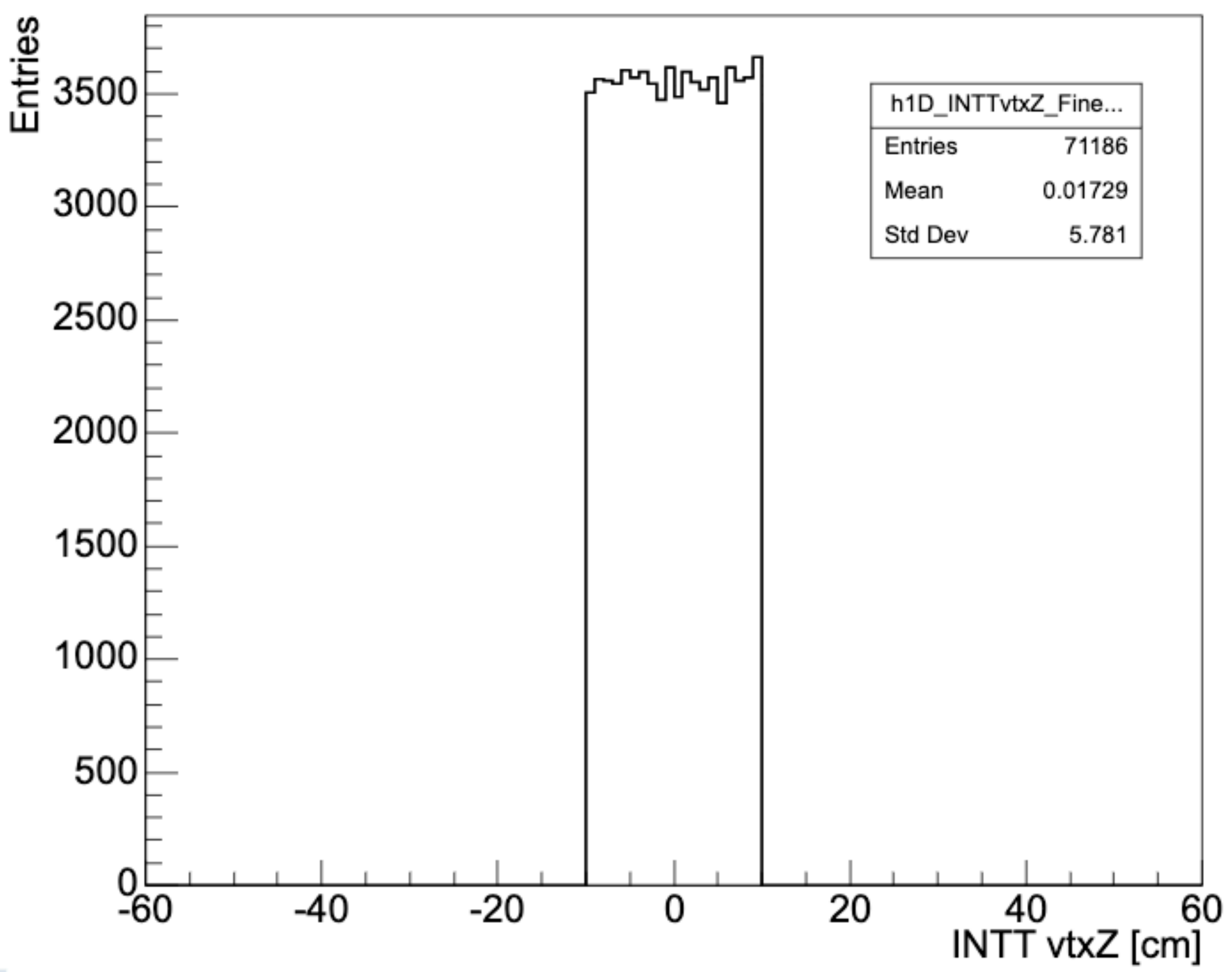
- INTT vertex Z given by Uniform(-10 cm, 10 cm). Centrality region: [0-70%]. Vertex Z weight applied in MC
- Reconstruct the number of tracklets as a function of η (width 0.2) and INTT vtxZ (width 5 cm)
- Each Z bin is scaled by the un-weighted vertex Z distribution to cancel the random fluctuation
- Normalize the 2D histograms and take the ratio between data and MC
- Currently only selecting the bins with ratios within 0.9 ~ 1.1

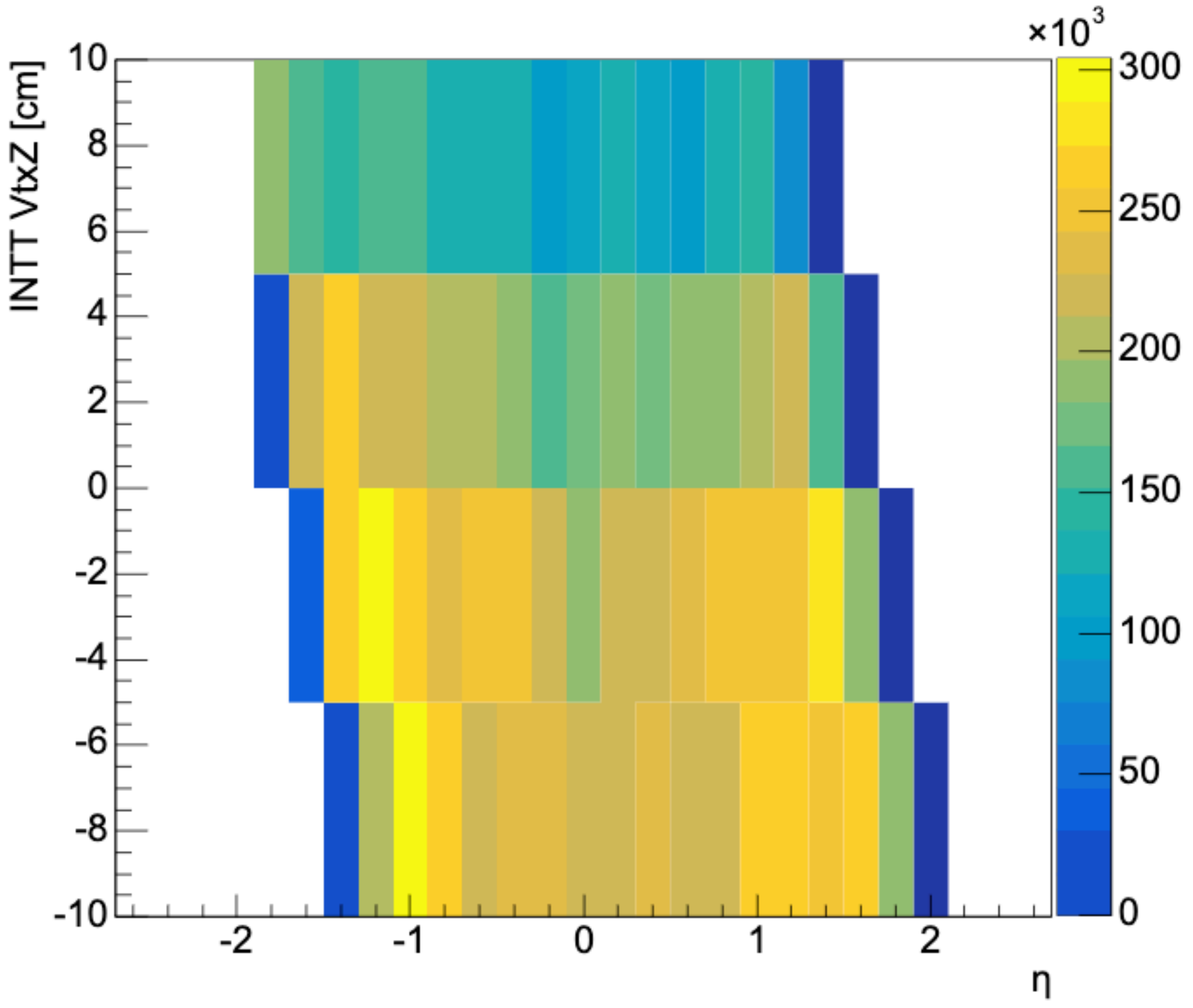
Data





MC





The way how this is evaluated may be incorrect, as it can be strongly model dependent, modification is ongoing

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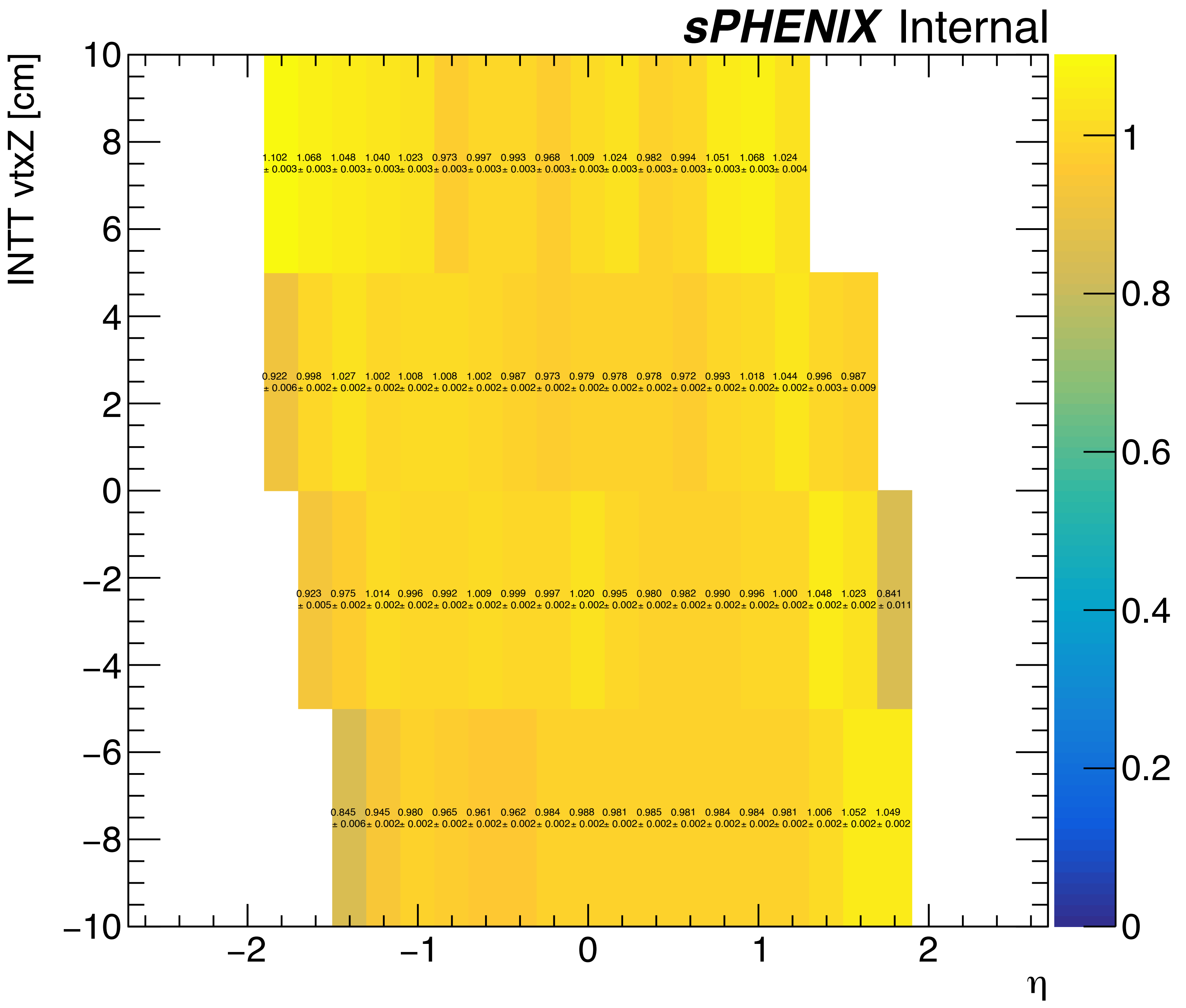
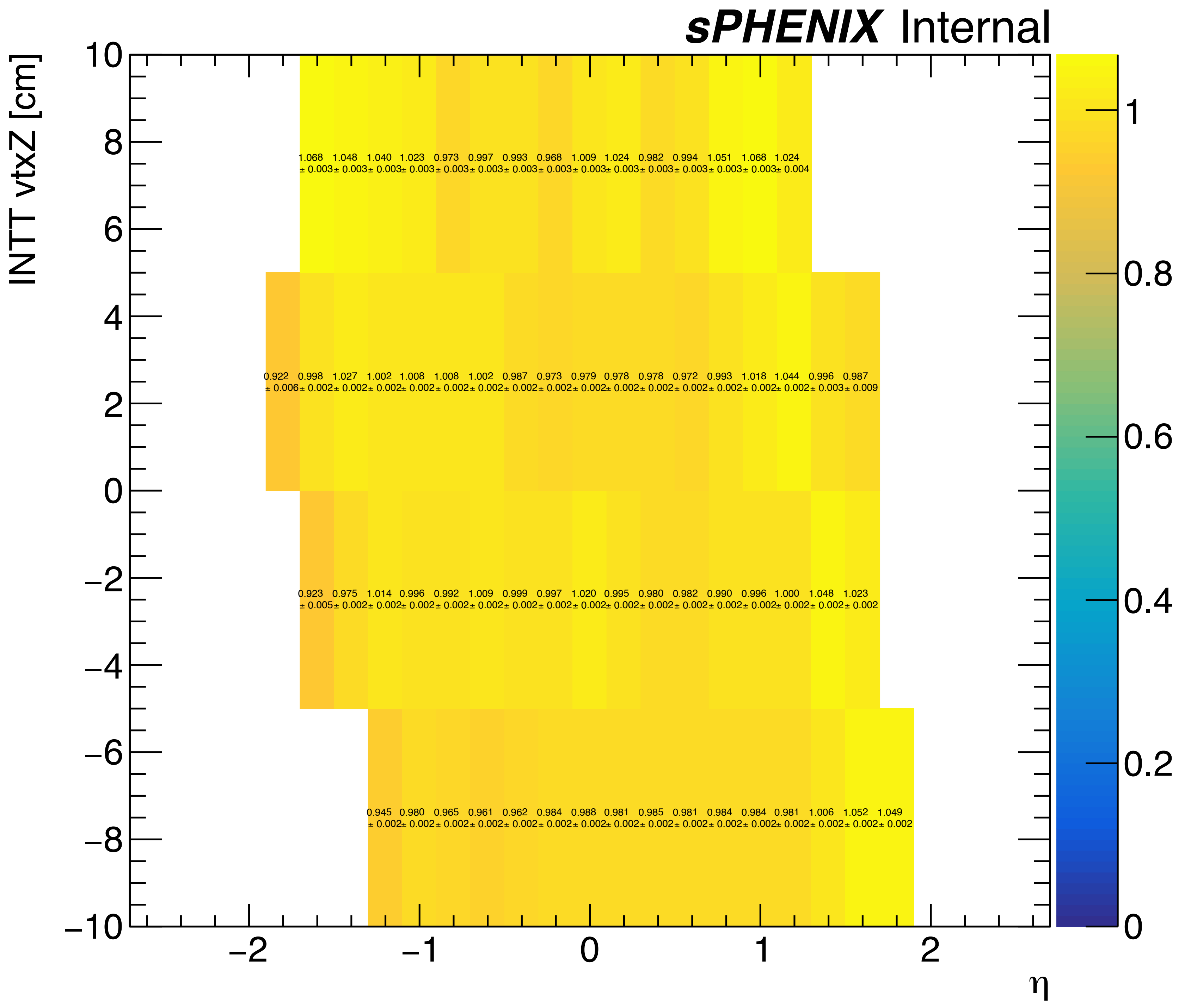


Final map

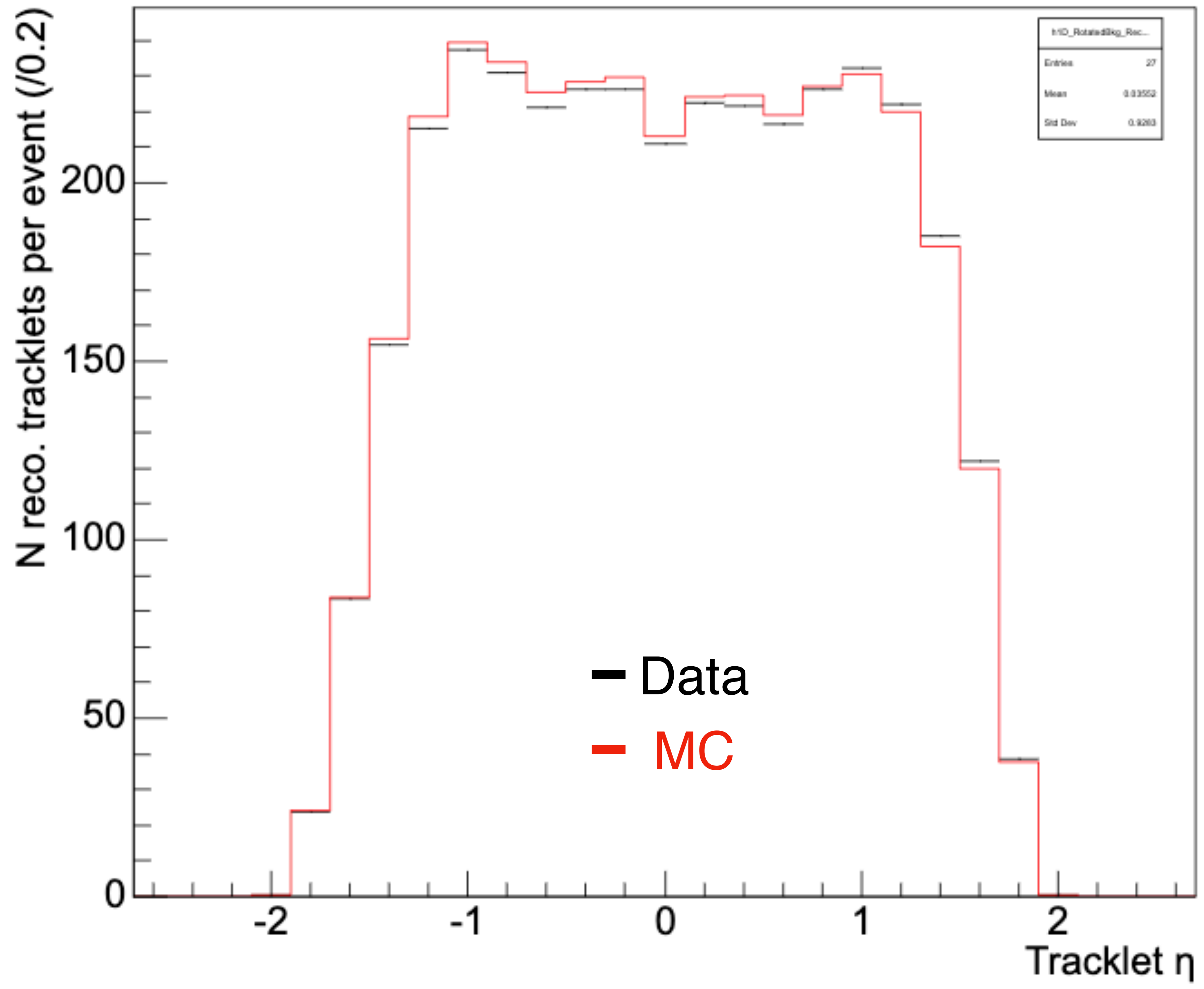


Currently, the Geometry acceptance correction is applied to MC first and then the alpha correction is derived

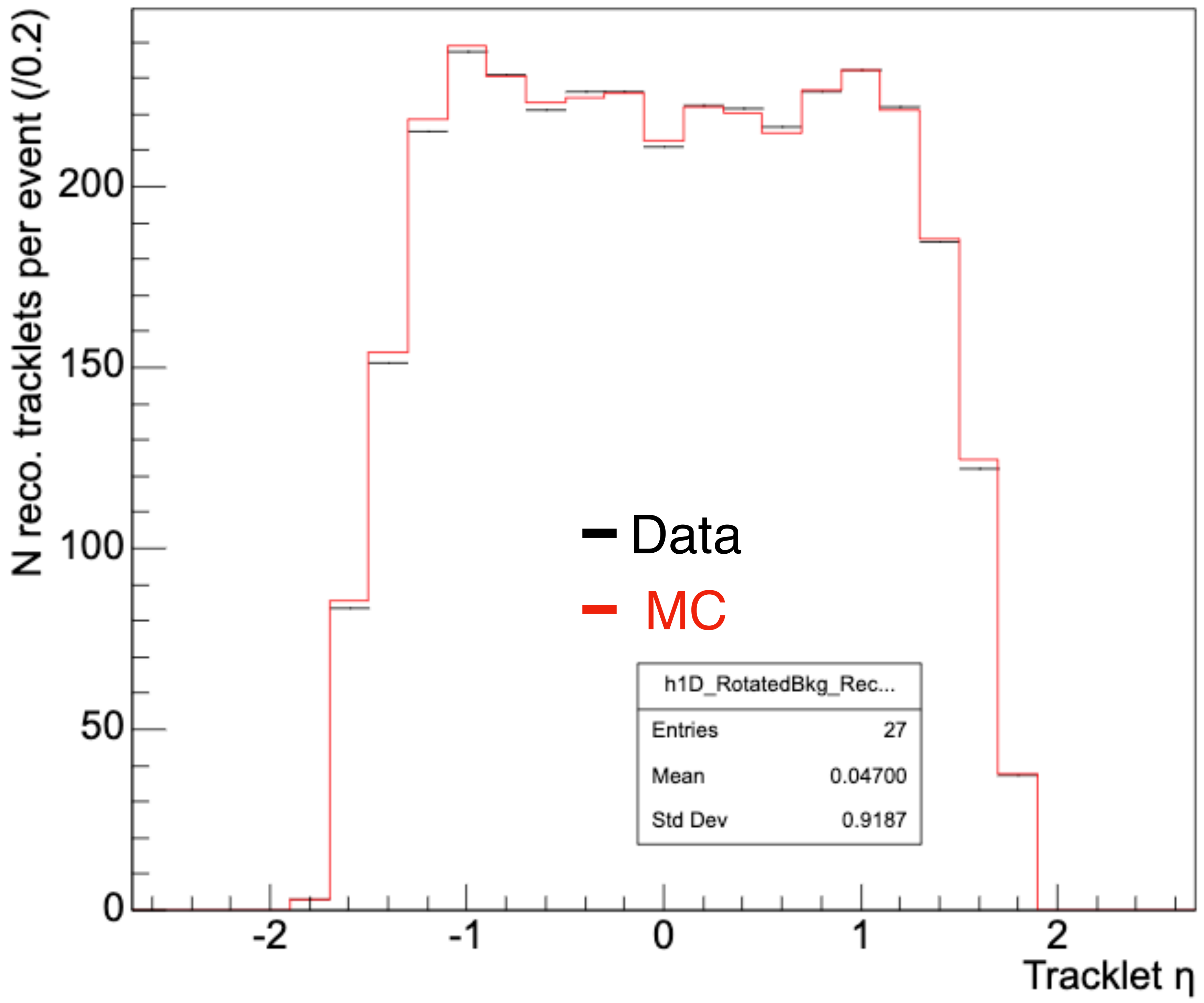
N reco. tracklets per event

vtxZ [-10 cm ~ 10 cm], Centrality [0-70%], vtxZ reweighing applied in MC

Before GeoAccCorr



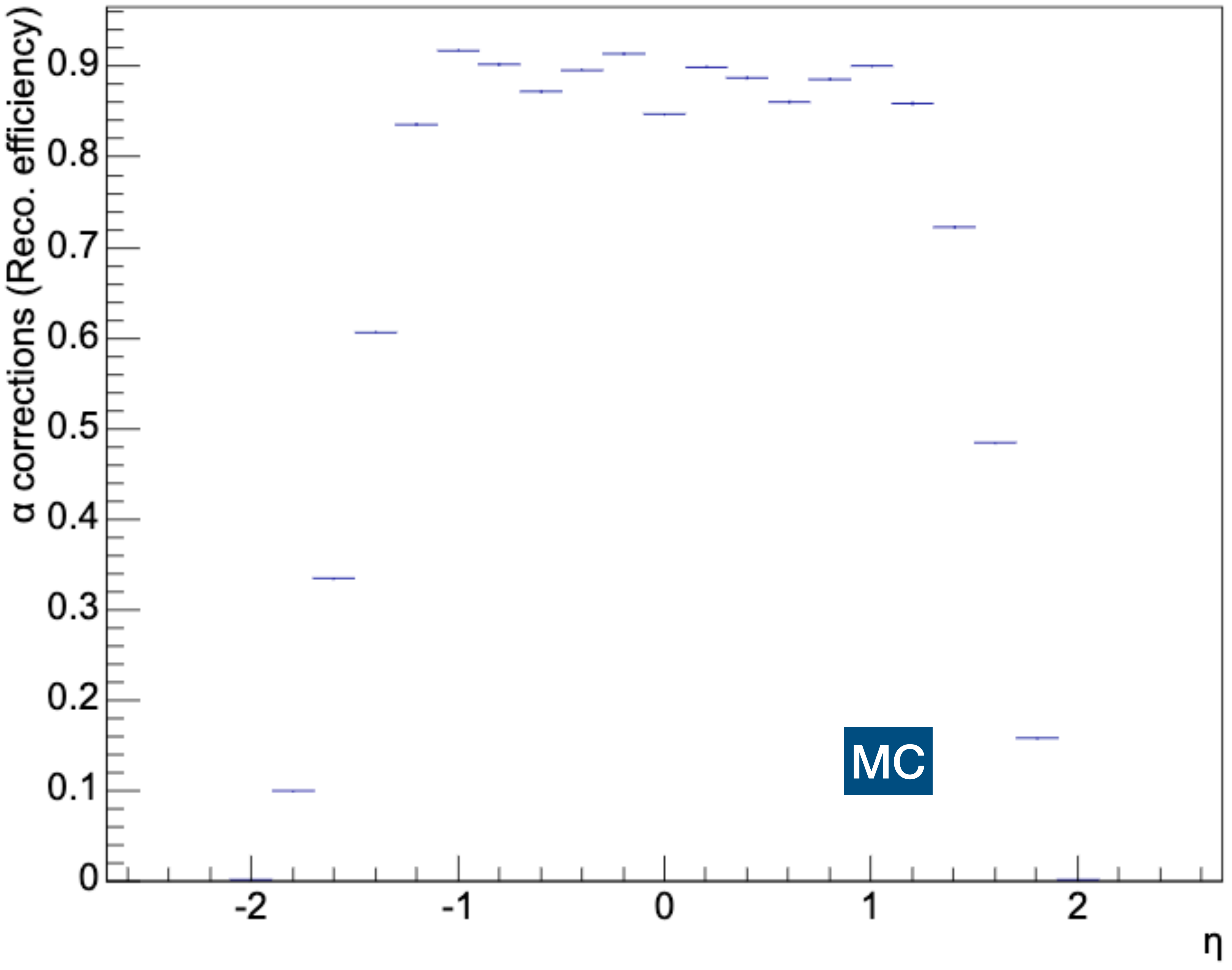
Post GeoAccCorr



The way how this is evaluated may be incorrect, as it can be strongly model dependent, modification is ongoing

Alpha corrections

The ratio is [reco tracklets / Truth]
Currently prefer to present in this way as it tells the reconstruction efficiency

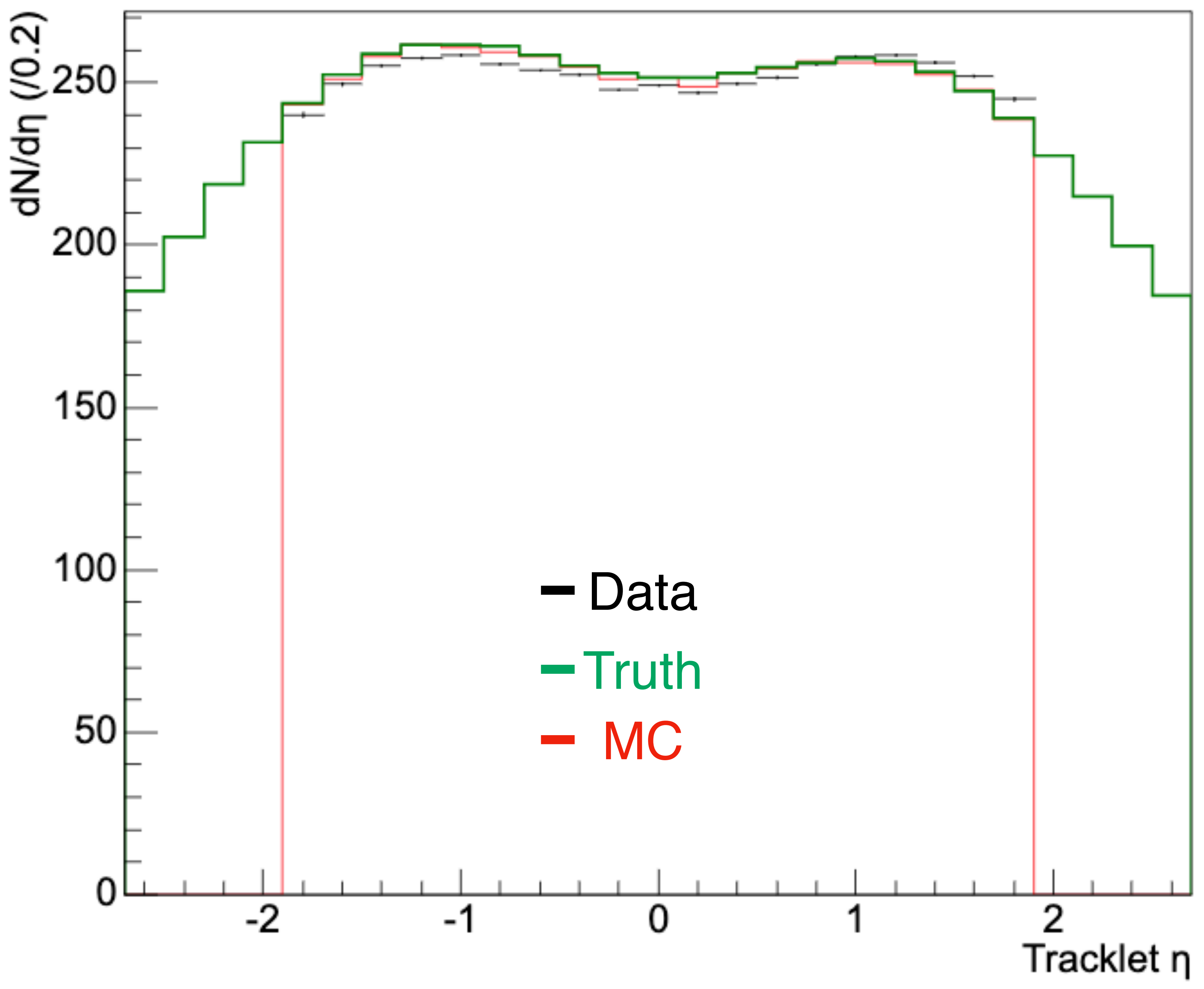


General speaking, 90% efficiency in the mid-rapidity

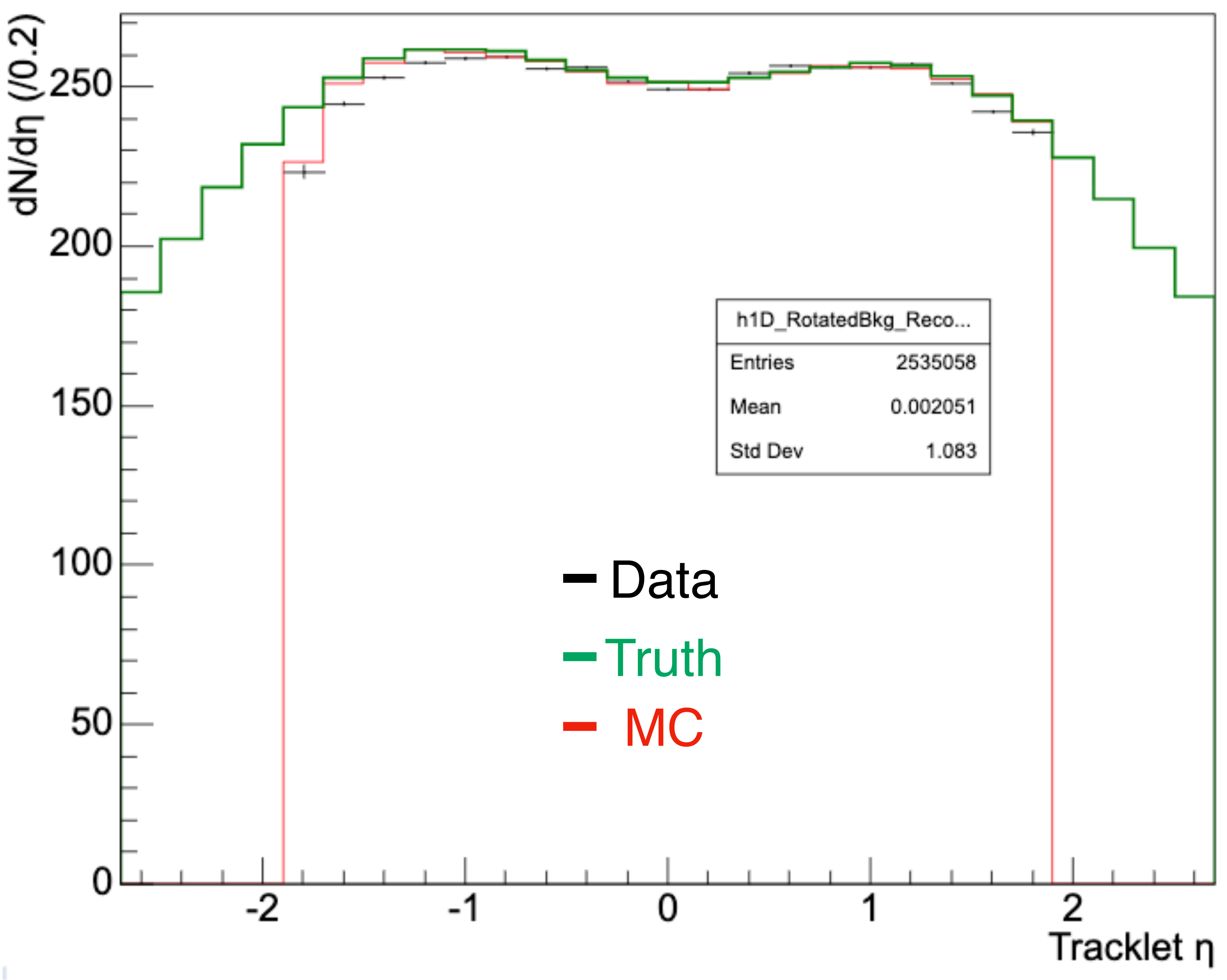
dN/dη

vtxZ [-10 cm ~ 10 cm], Centrality [0-70%], vtxZ reweighing applied in MC
| Eta region | ≦ 1.9 included

No GeoAccCorr



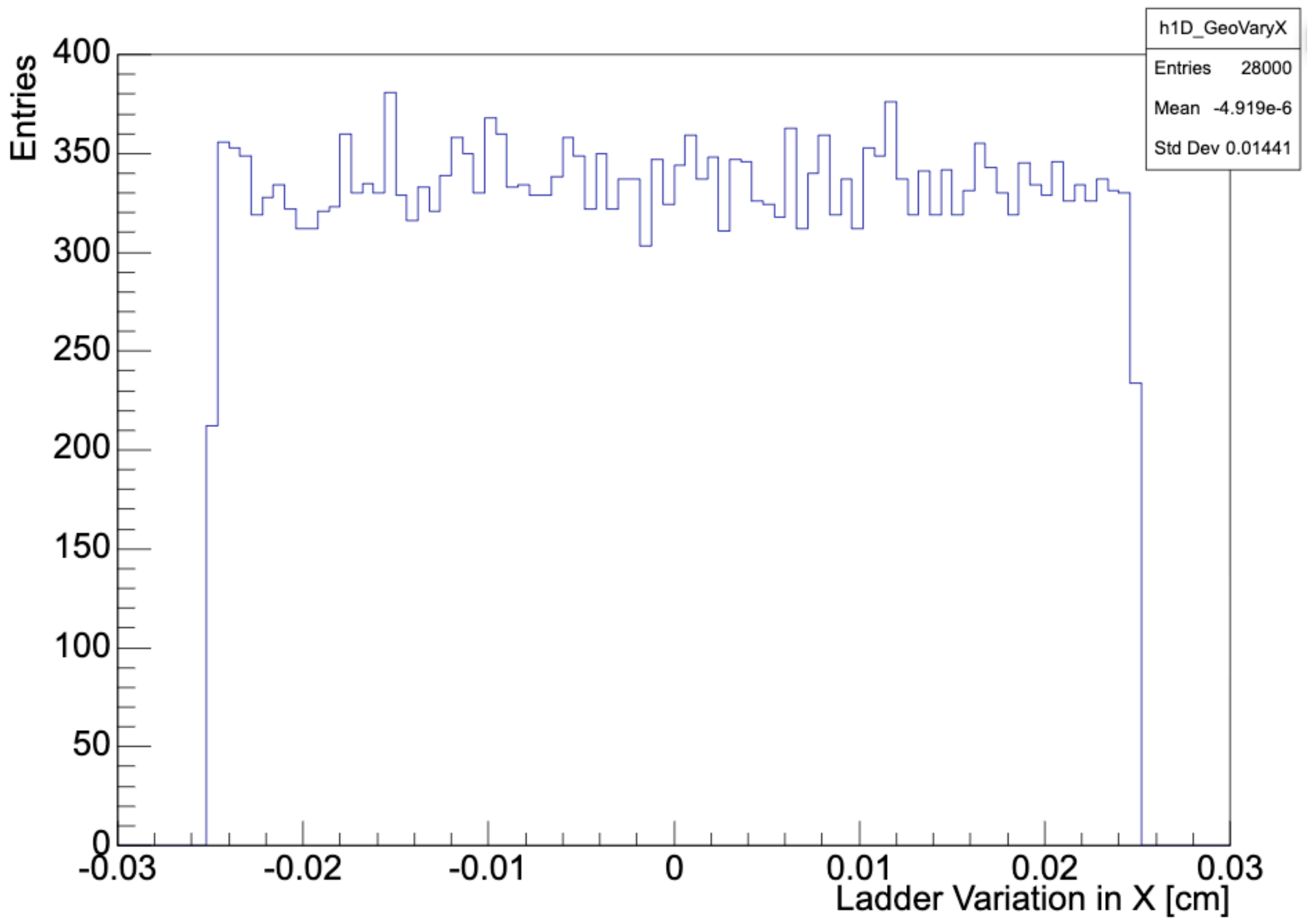
With GeoAccCorr

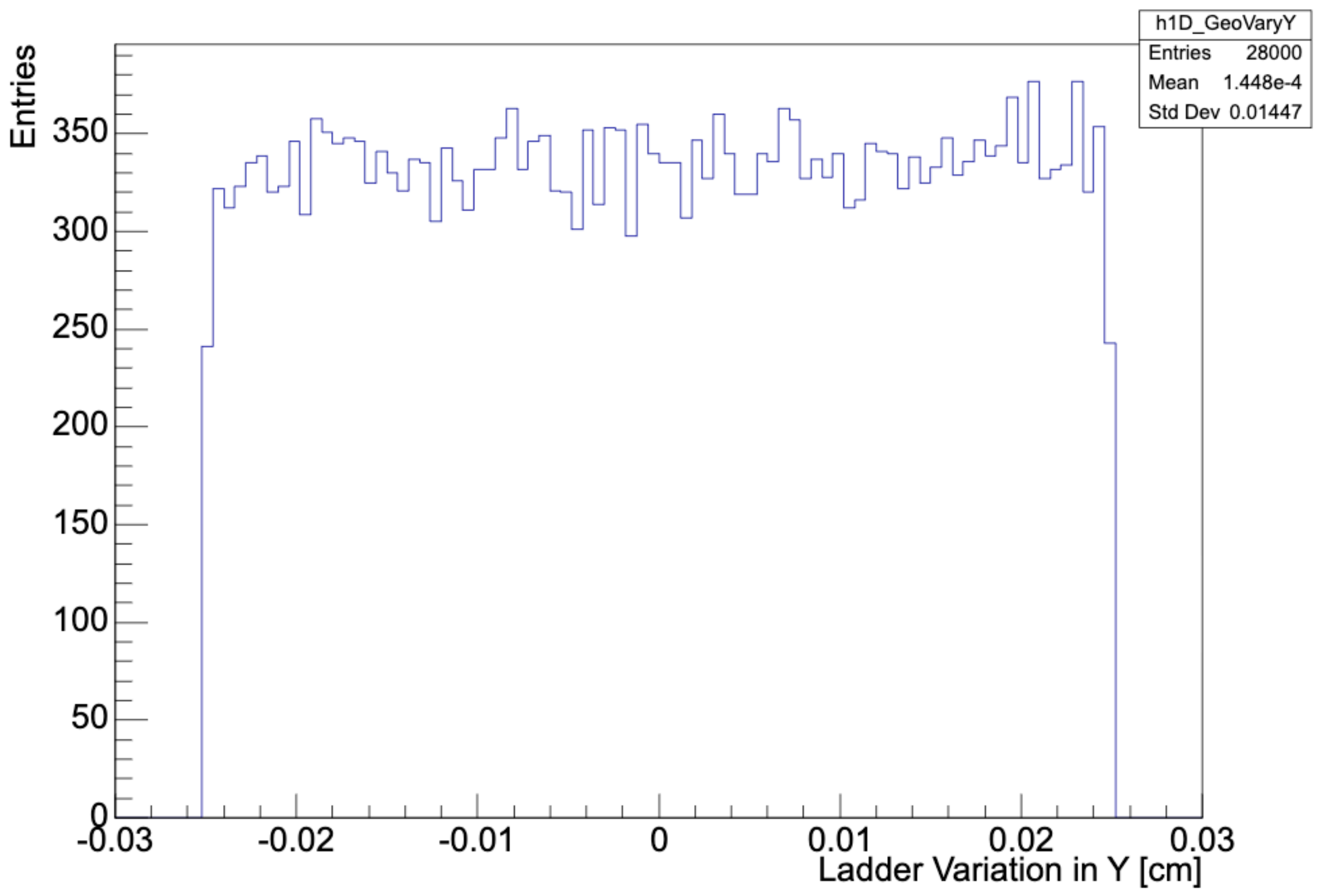


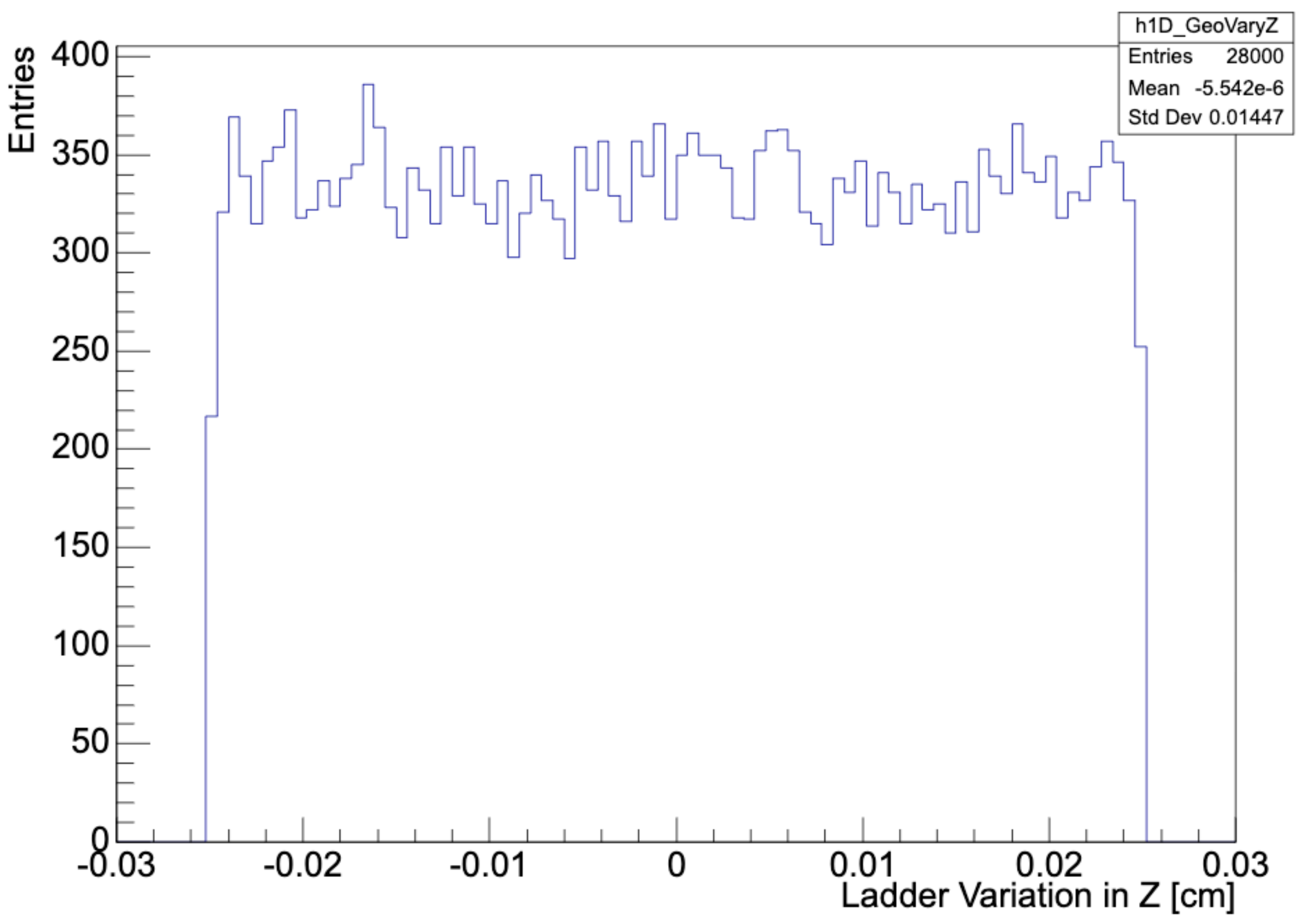
Geometry offset test v1

- In the offline and in MC, introduce the random offsets in 3 dimensions for each ladder by `Uniform(-0.025, 0.025)`, ±250 μm

Run 500 trials

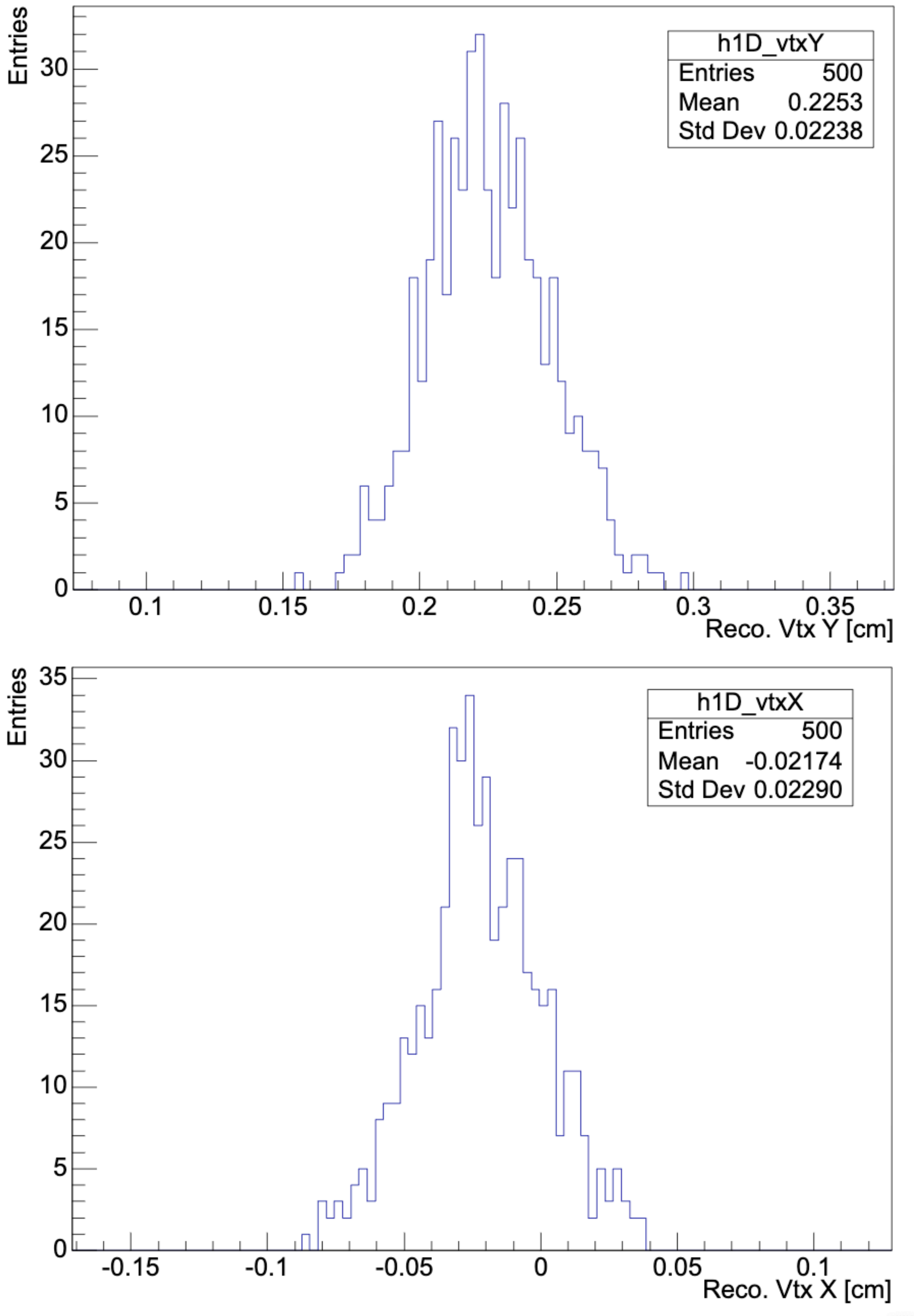






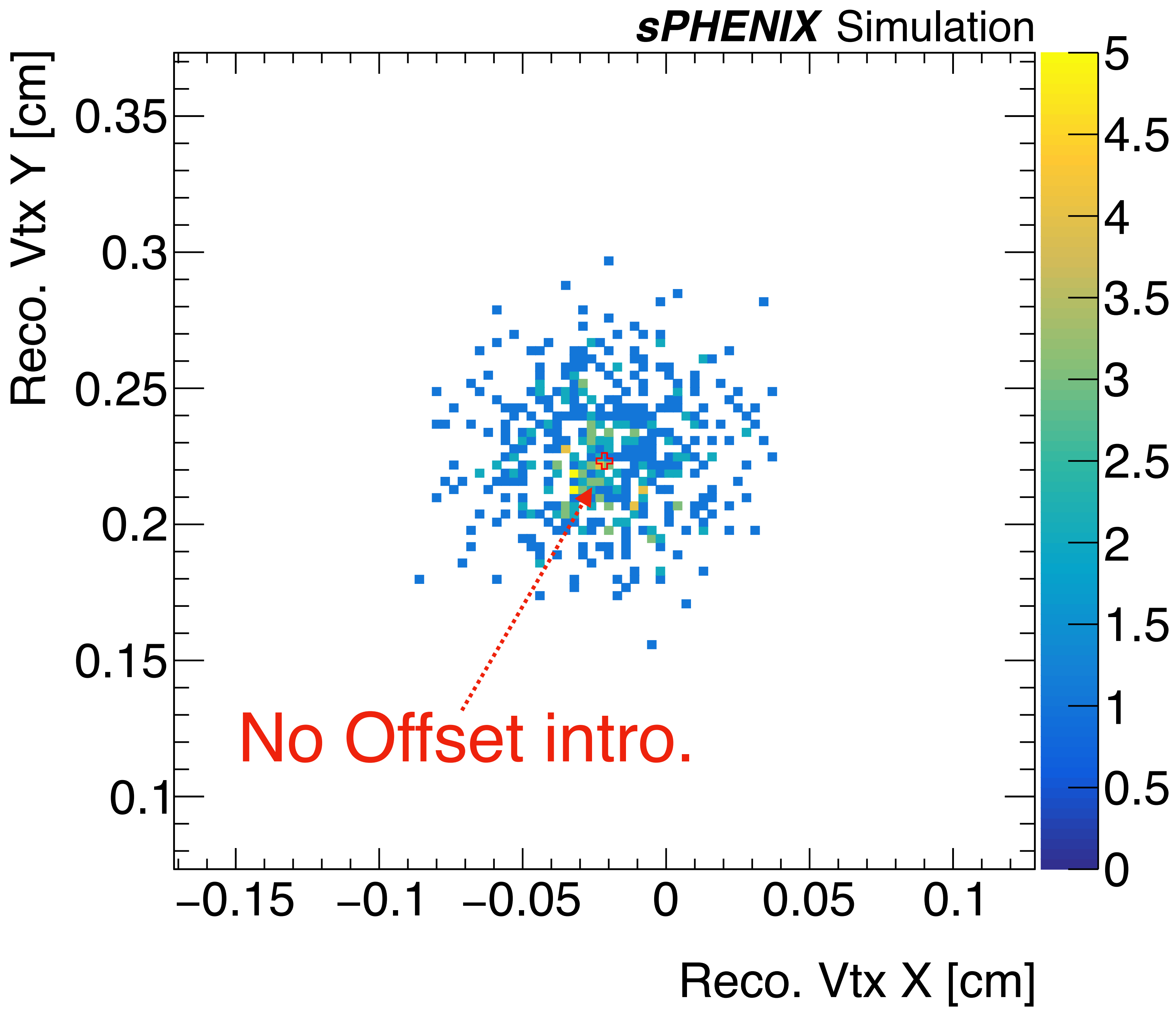
Geometry offset test v1 - vertex

- In the offline and in MC, introduce the random offsets in 3 dimensions for each ladder by `Uniform(-0.025, 0.025)`, ±250 μm

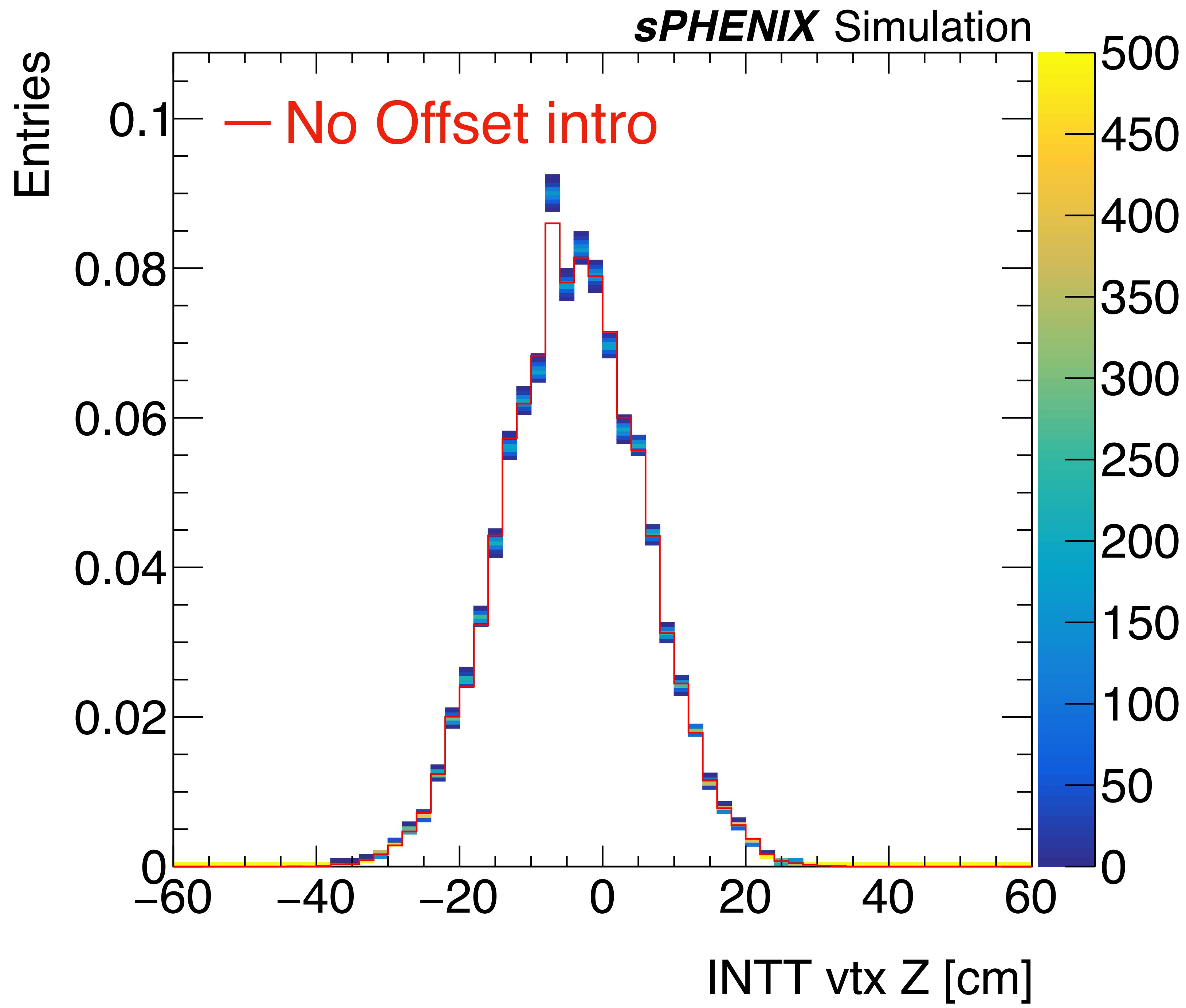


Deviation: ~230 μm

Run 500 trials (each is with 30k events)

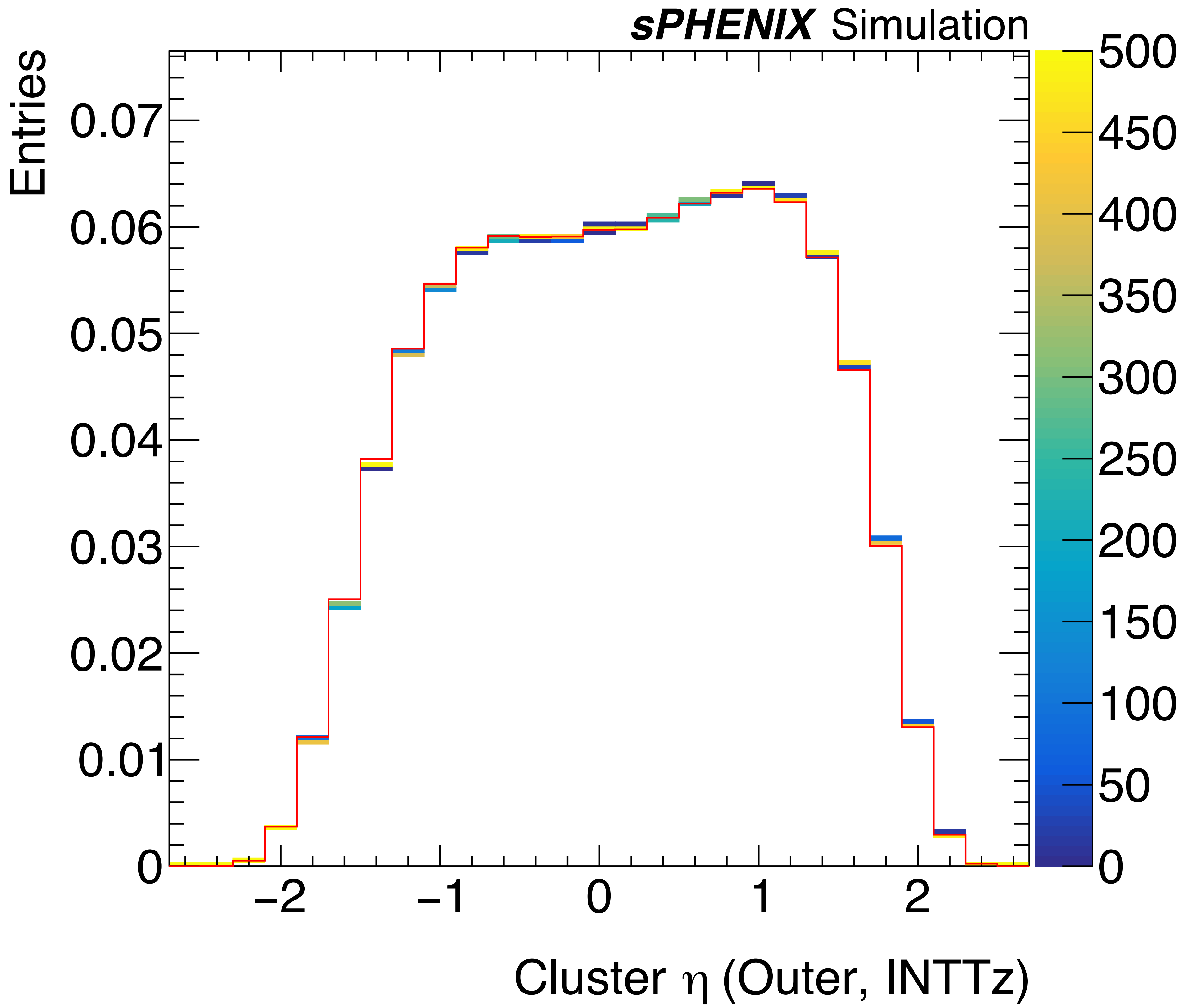


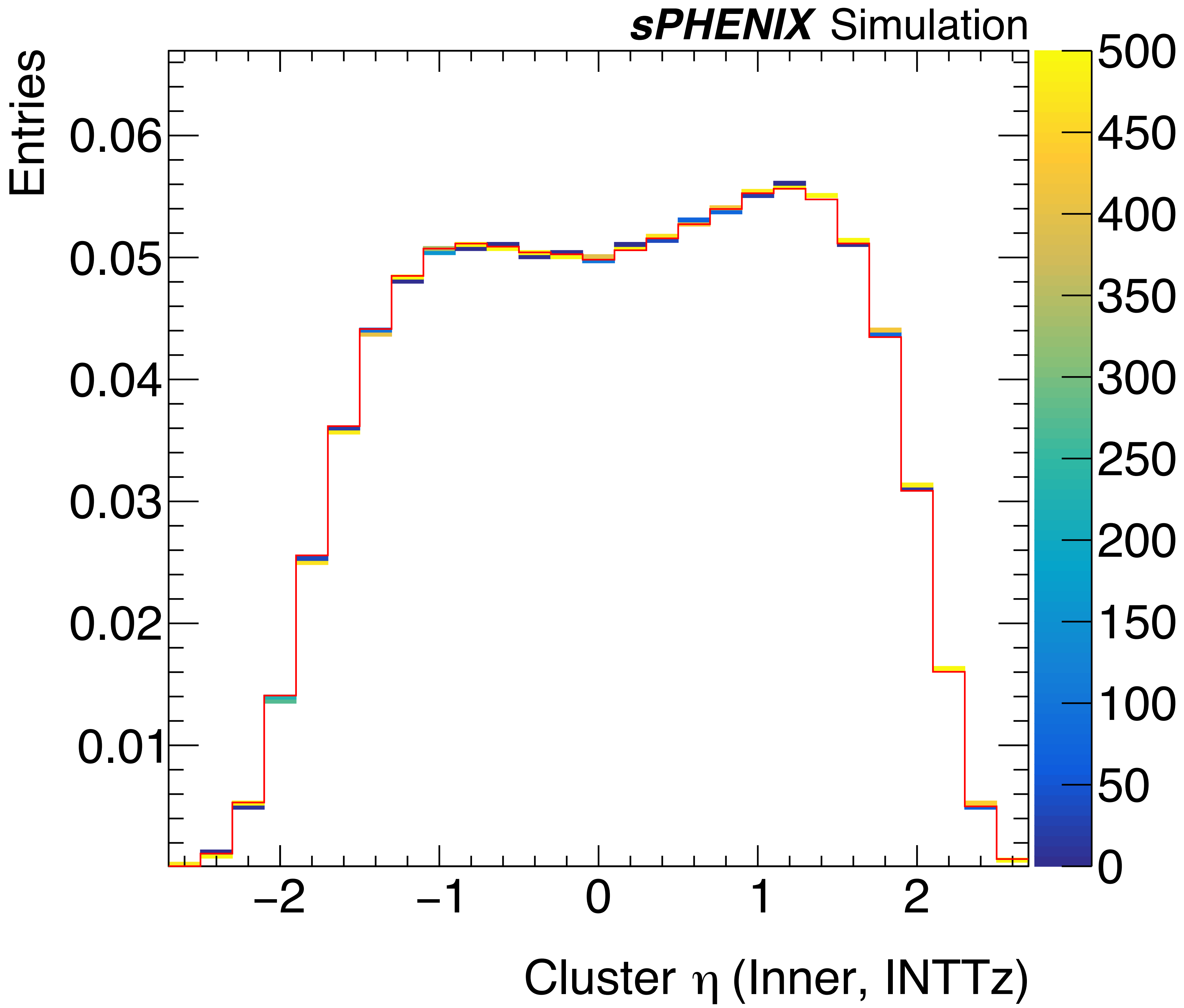
No vtxZ re-weighting



Geometry offset test v1 - ClusEta_INTTz

MC self-comparison, no vtxZ re-weighting

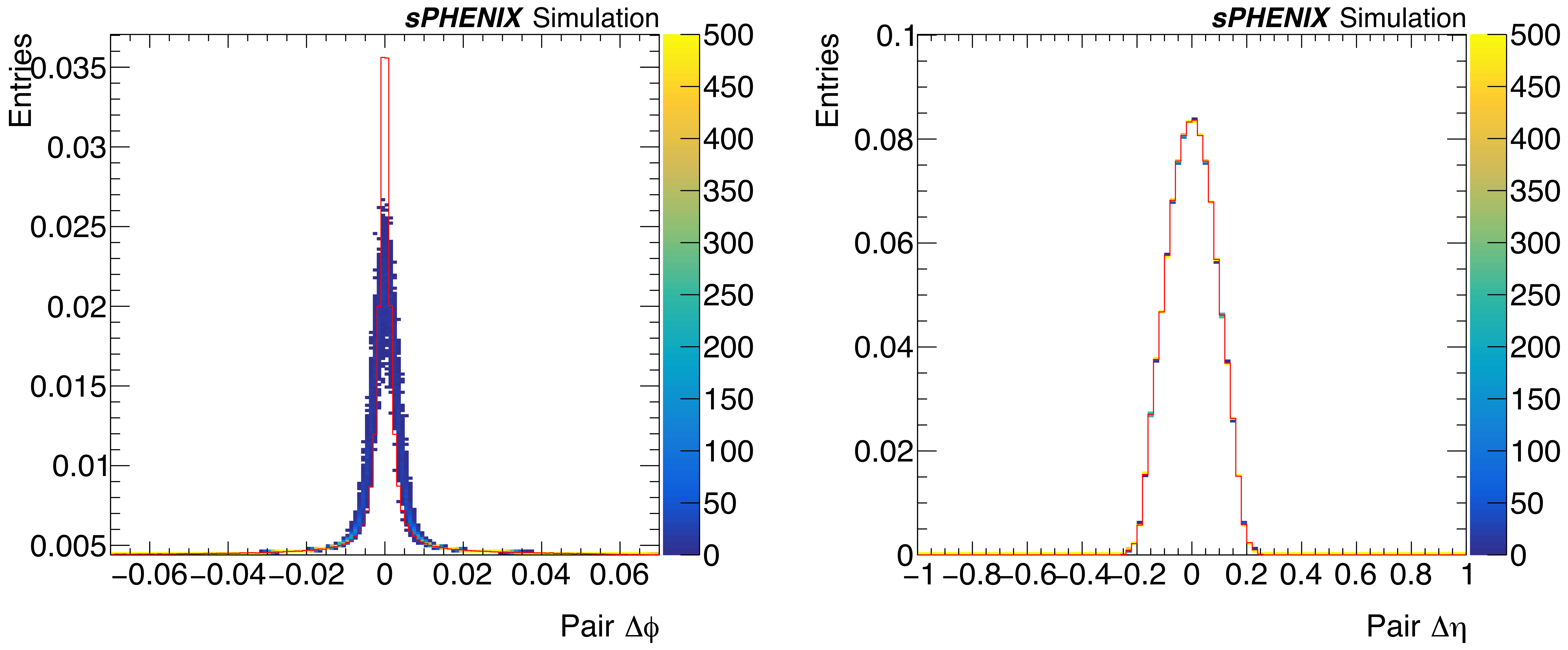




Not much variation in cluster η

Geometry offset test v1 - Cluster pair

MC self-comparison, no vtxZ re-weighting

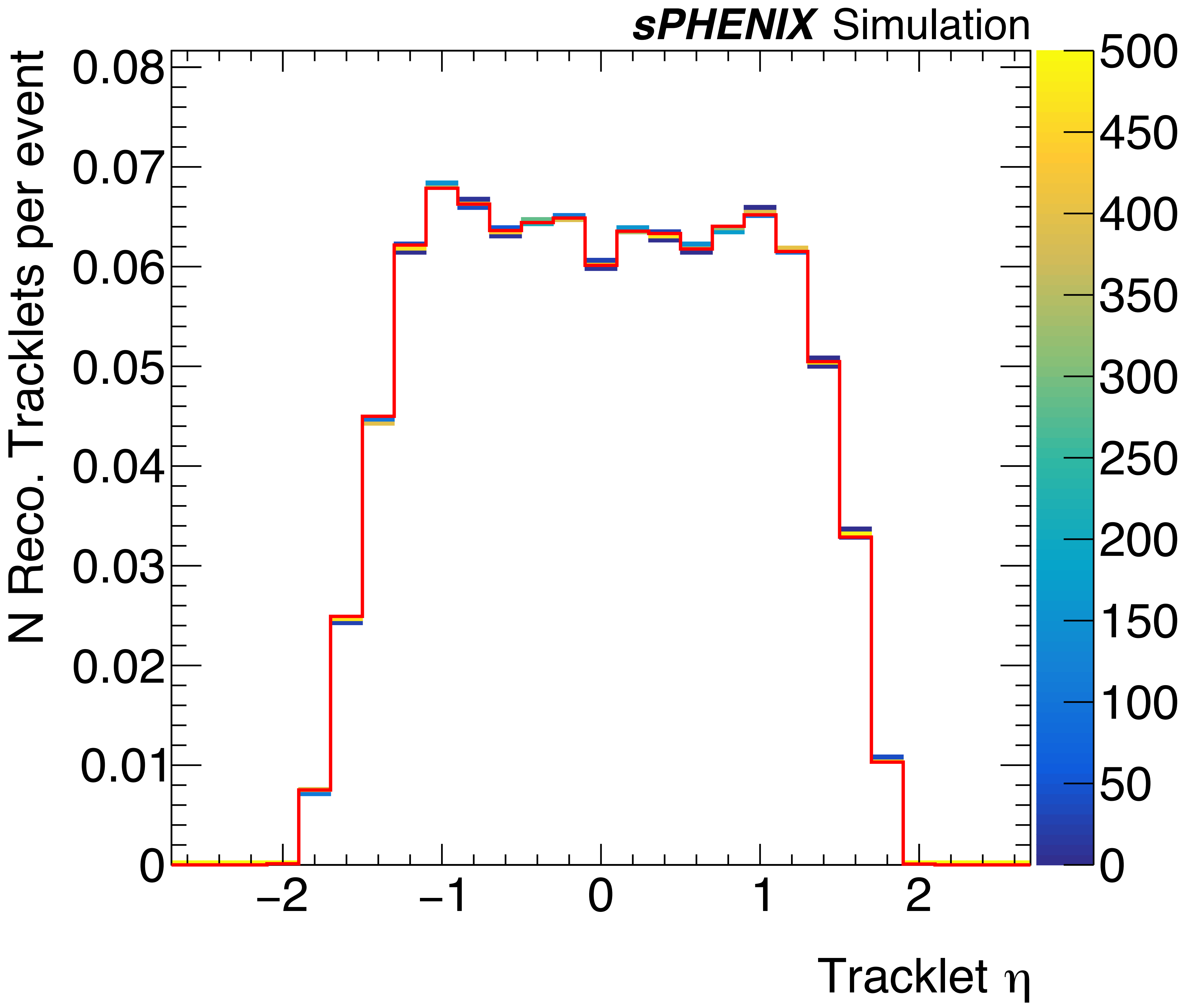


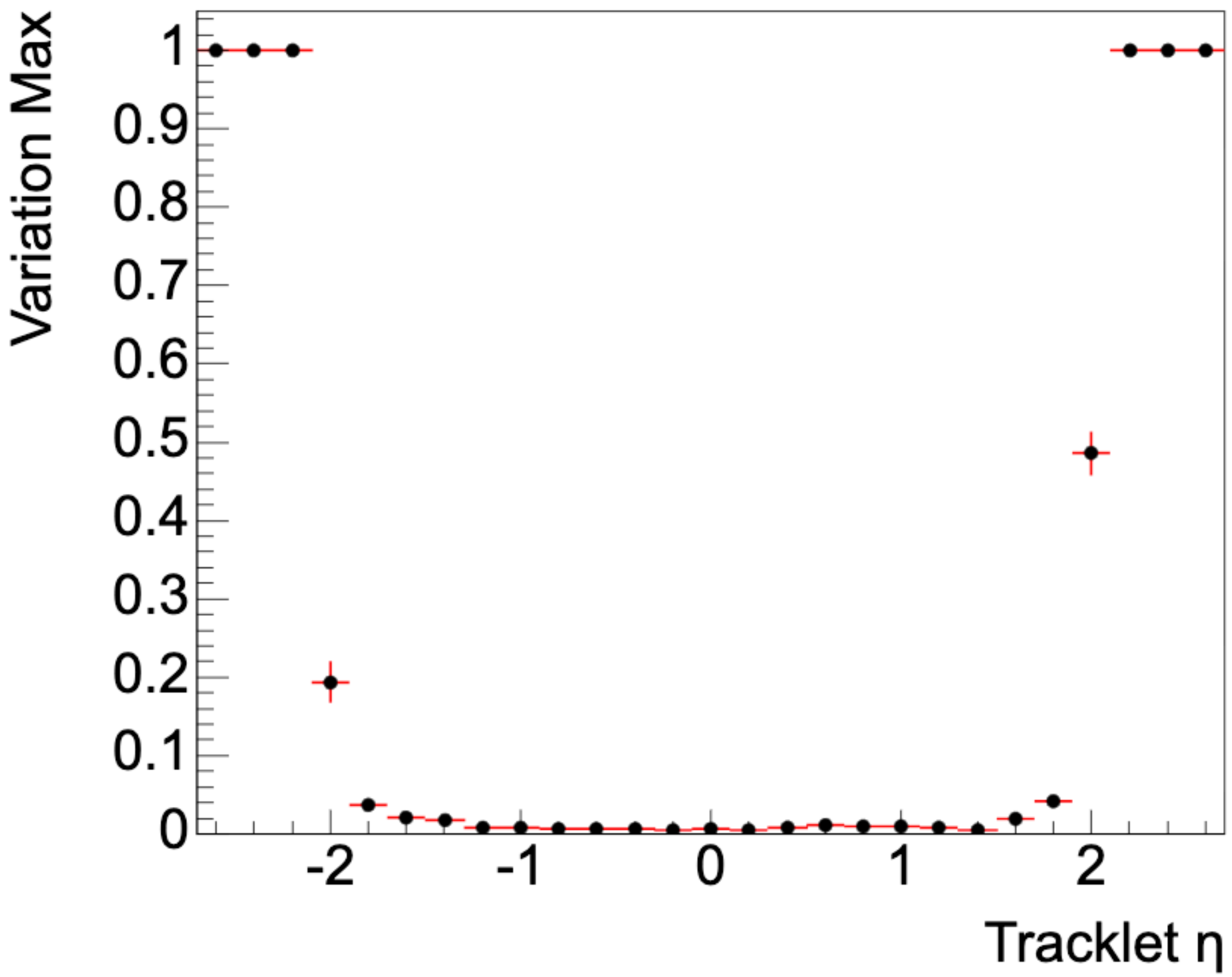
The Δϕ distribution is wider once the geo. offsets are introduced, which is in line with what we seen in the data
Not much variation seen in the Δη distribution as supported by the cluster η distributions

Reconstructed tracklet distribution

MC self-comparison, no vtxZ re-weighting

PHOBOS Approach
(Bkg. estimated by Rotating inner barrel)



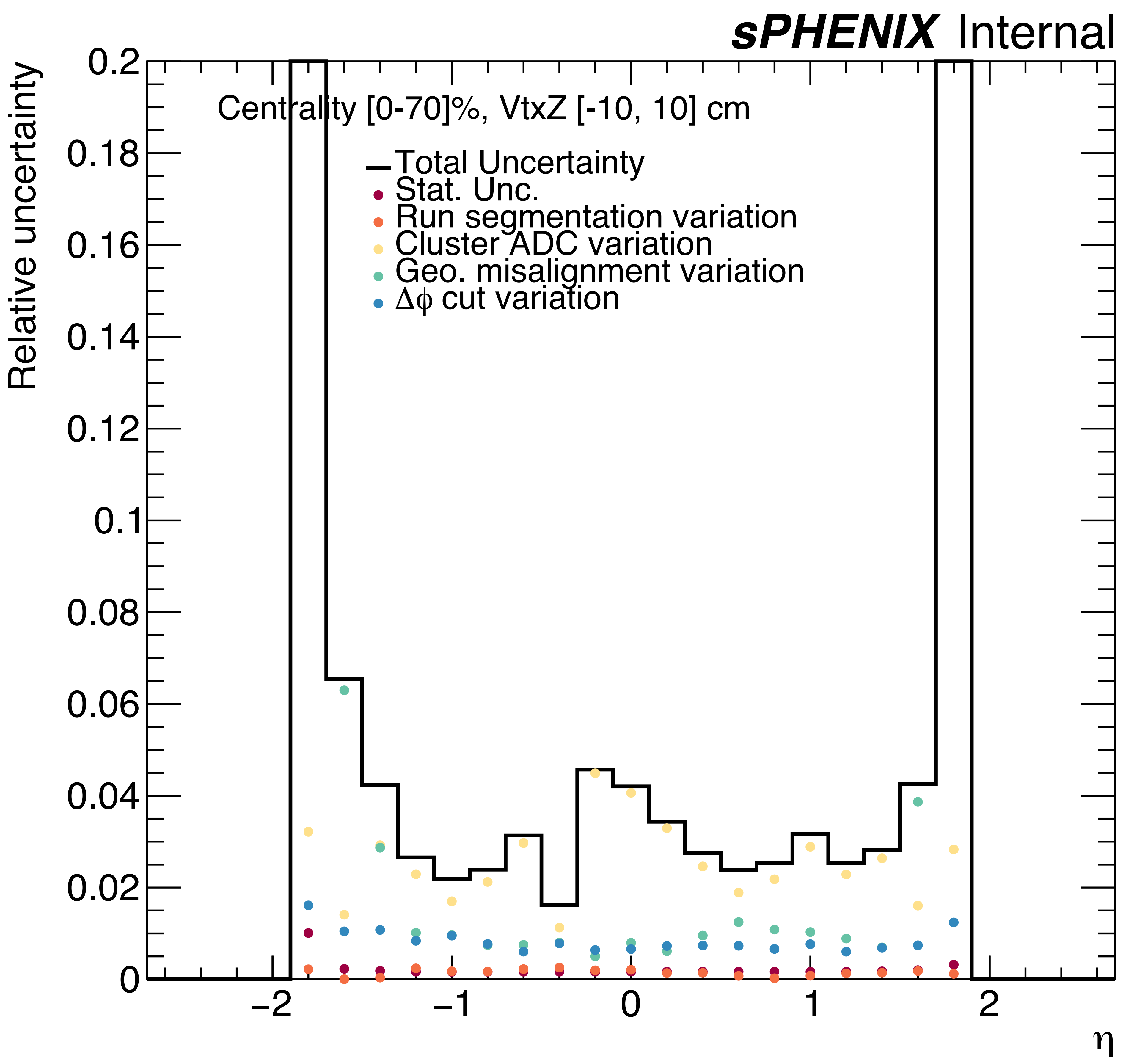


- Assuming what we measured is at either the lower or upper bounds, 1σ can cover the truth

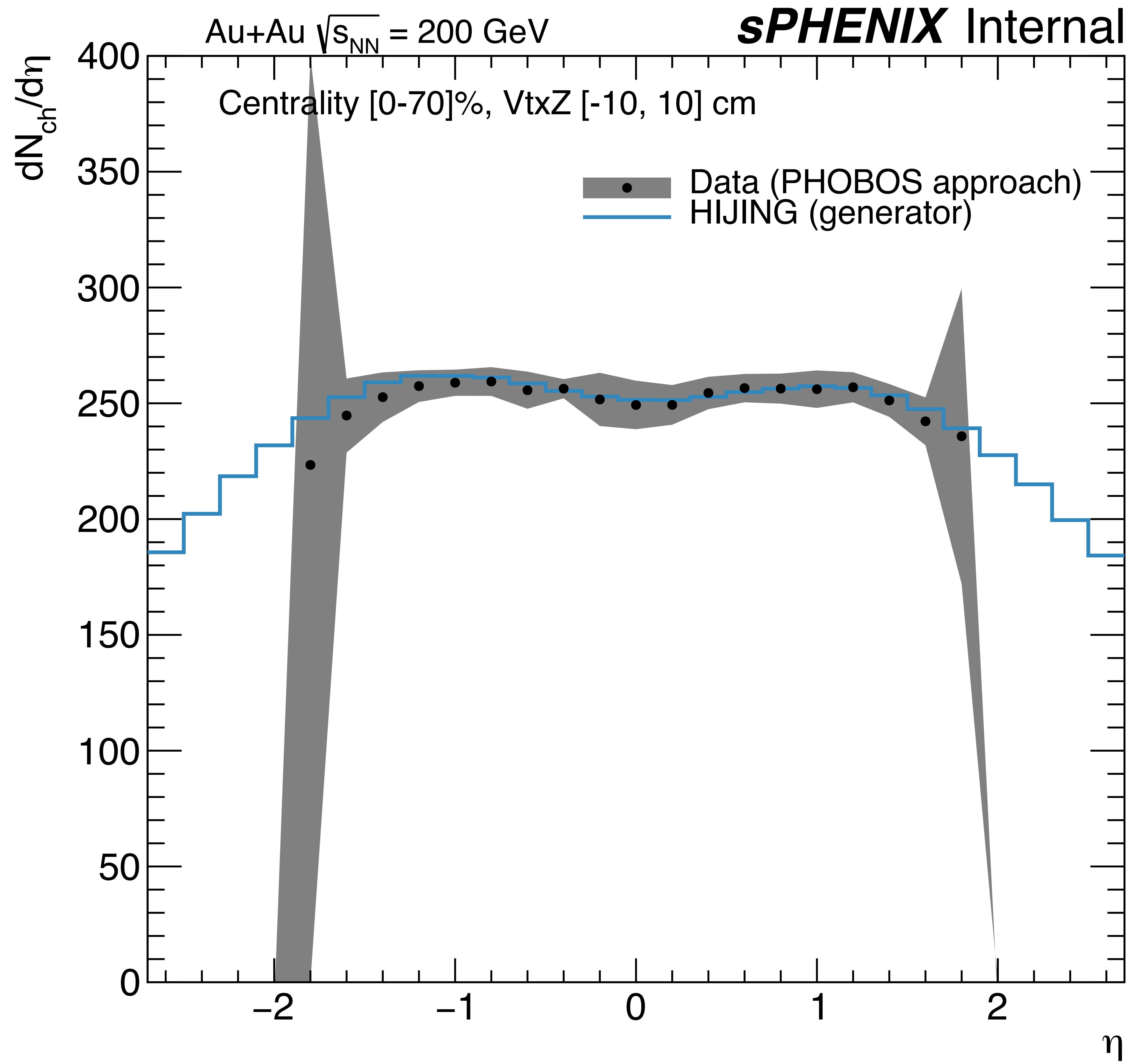
Systematic uncertainties

- Statistical uncertainty
- ADC cut [0, 35]
- $\Delta\phi$ cut [0.018 rad, 0.021 rad, 0.024 rad]
- Run segmentation [first 1.5M, second 1.5M, All]
- Geometry offset [Assigning offsets in 3 dimensions for each ladder] {derived purely from MC}

- Todo:
  - Need to re-consider the correction and re-run the analysis to provide you the new syst. unc.



Currently Result (w/ Syst. unc.)



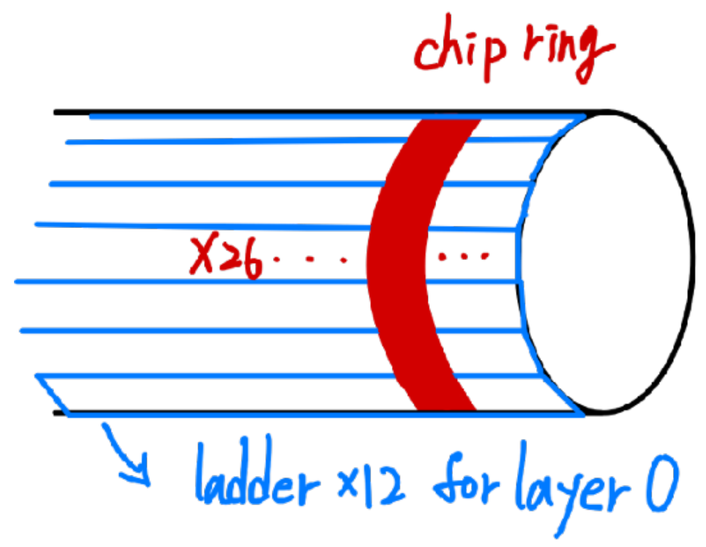
Analysis flow update

- The Geometry Acceptance Corrections in CMS approach are divided into three parts
  - Confirm the column multiplicity consistency (data-MC comp.)
  - Confirm the geometry acceptance (data-MC comp.)
  - Estimate the misalignment effect in MC

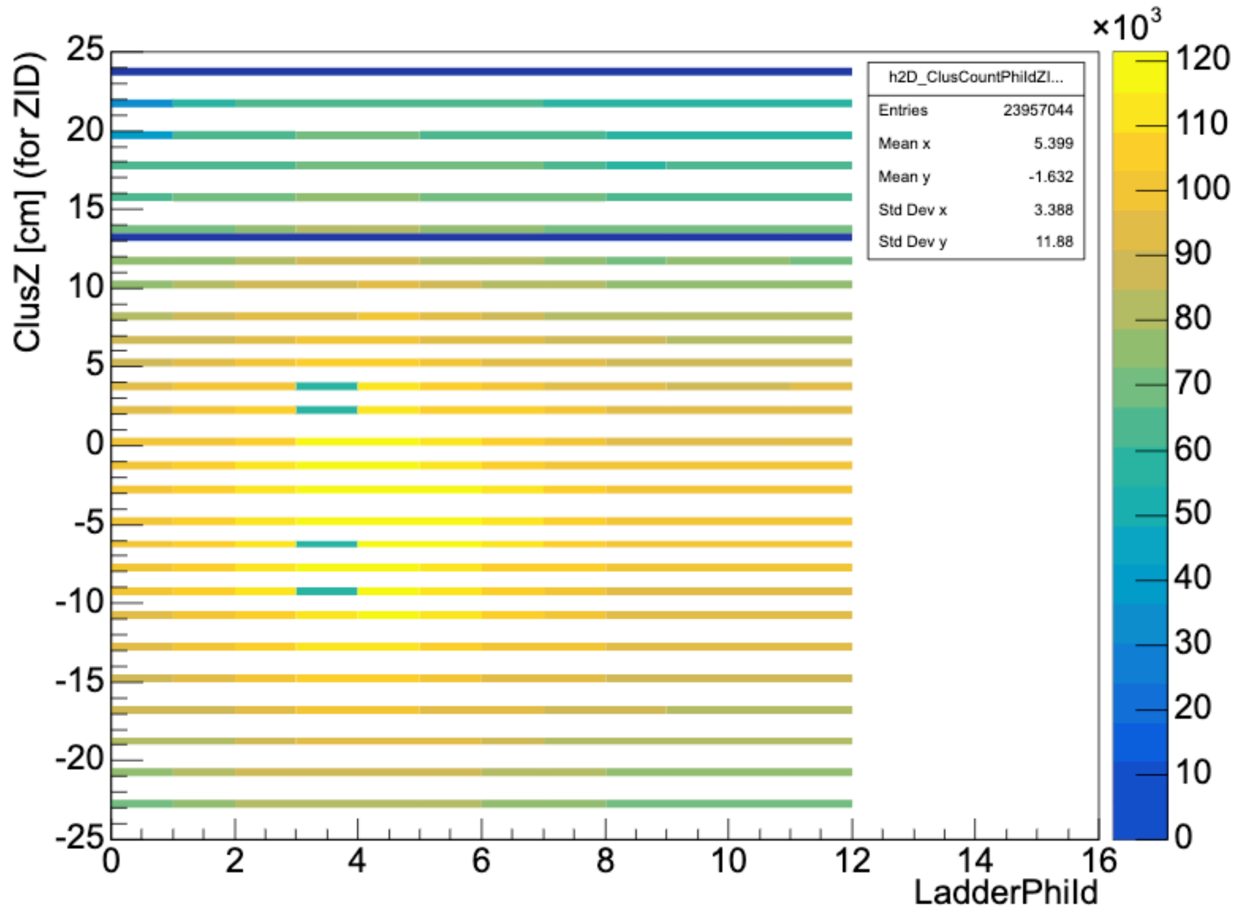
- Avg VtxXY
- Per event VtxZ
- Multiplicity Ratio map -> New
- Tracklet reconstruction
- Geo Acceptance map -> New
- dNdEta (Efficiency (Alpha) correction)
  - Misalignment effect considered in the systematic uncertainty

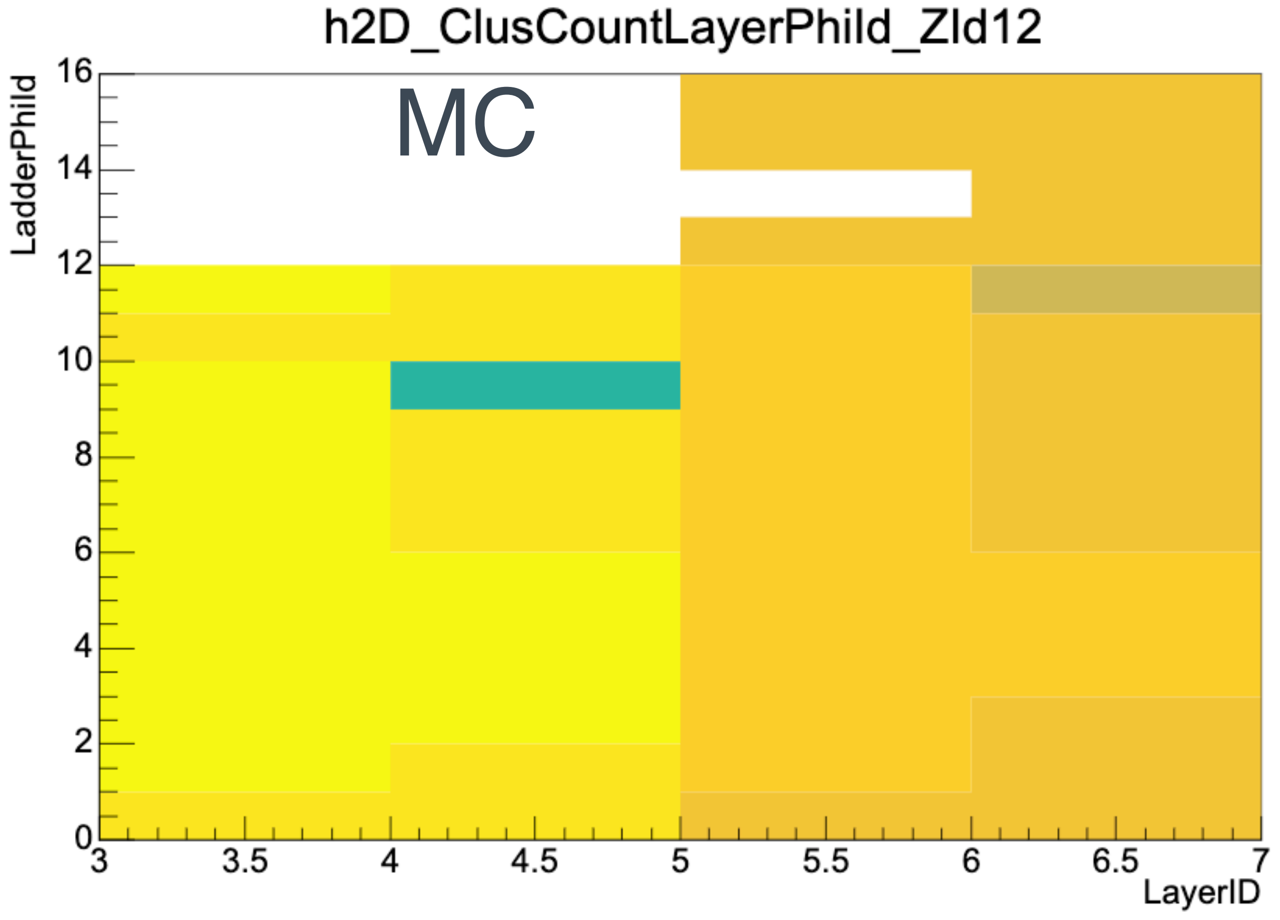
Multiplicity Ratio mask

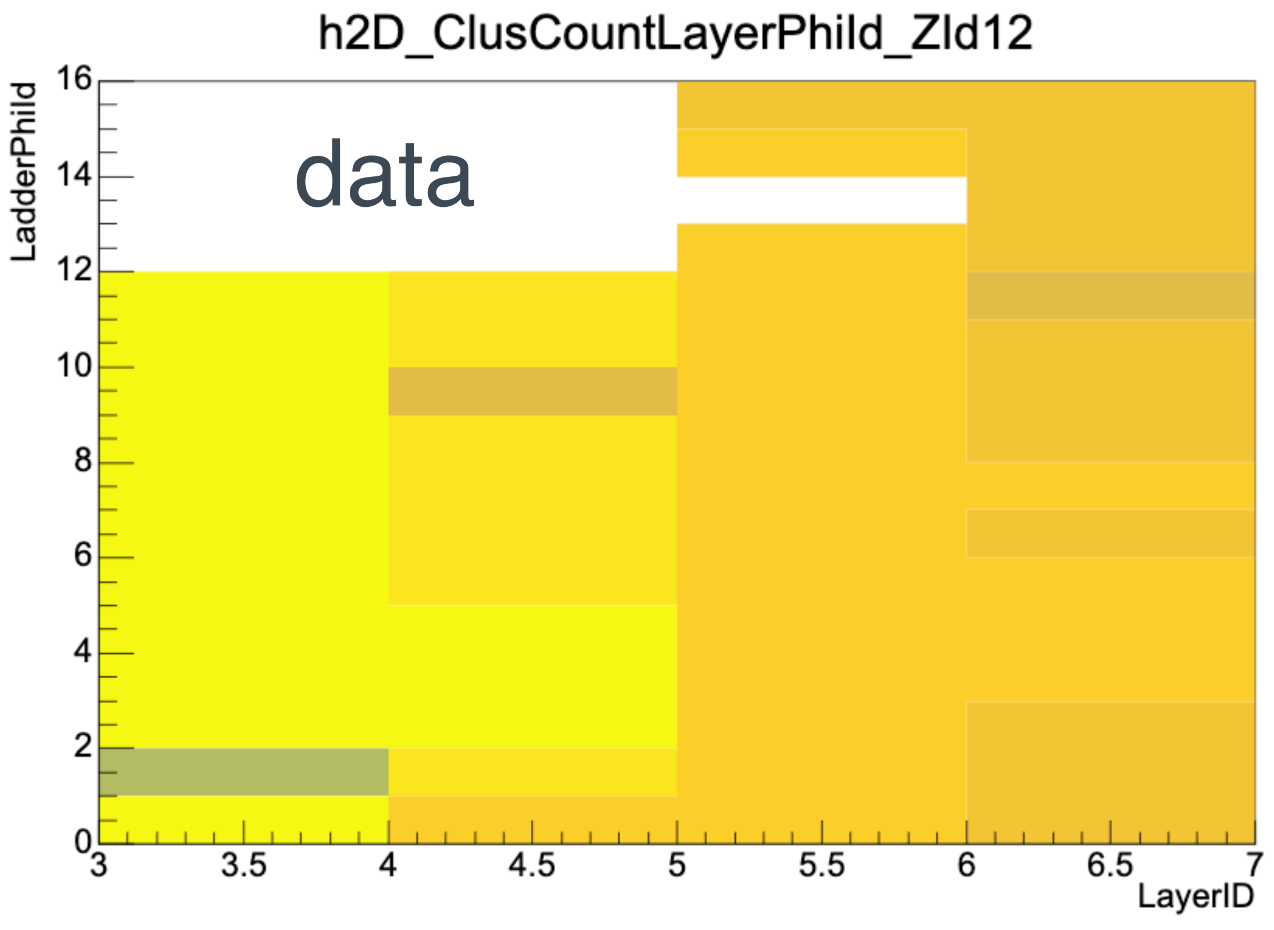
- To account for the different column multiplicity (can be due to unmarked cold channel, etc)
- In Data and MC, count the number of clusters for each {LadderPhiID, ColumnID, LayerID}
  - The count of each column is normalized by strip length and ϕ coverage
- In each ring (INTT: 26 rings), scale the the counts by the Maximal count
- Take the ratio by Data_Ring_Map / MC_Ring_Map
  - Check is done ring by ring, therefore, free from vtxZ distribution and truth particle Eta distribution
- The cells with 0.8 < ratio < 1.2 are used in the following analysis
  - Not a correction, just mask the columns in both data and MC



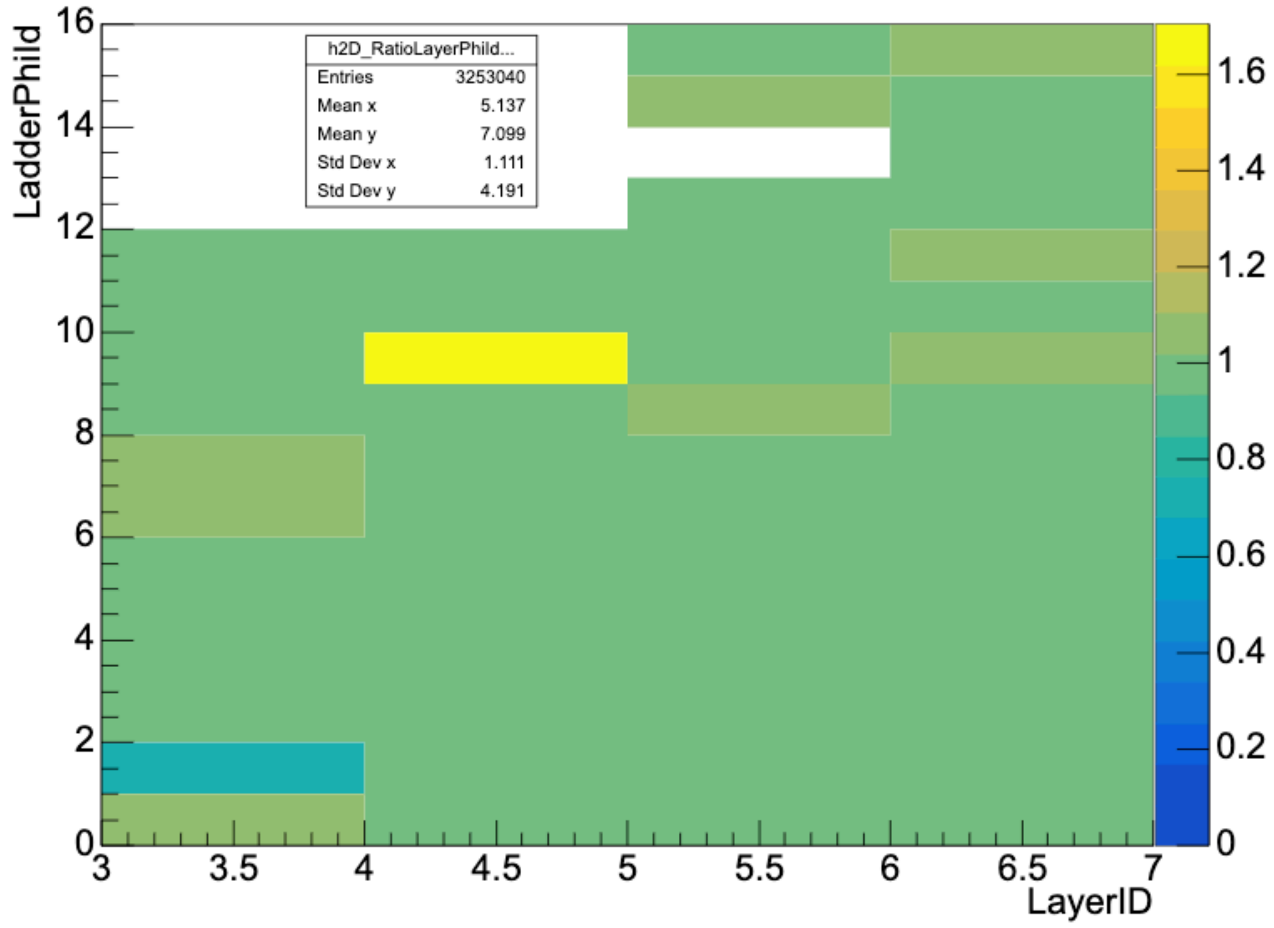
MC







data / MC



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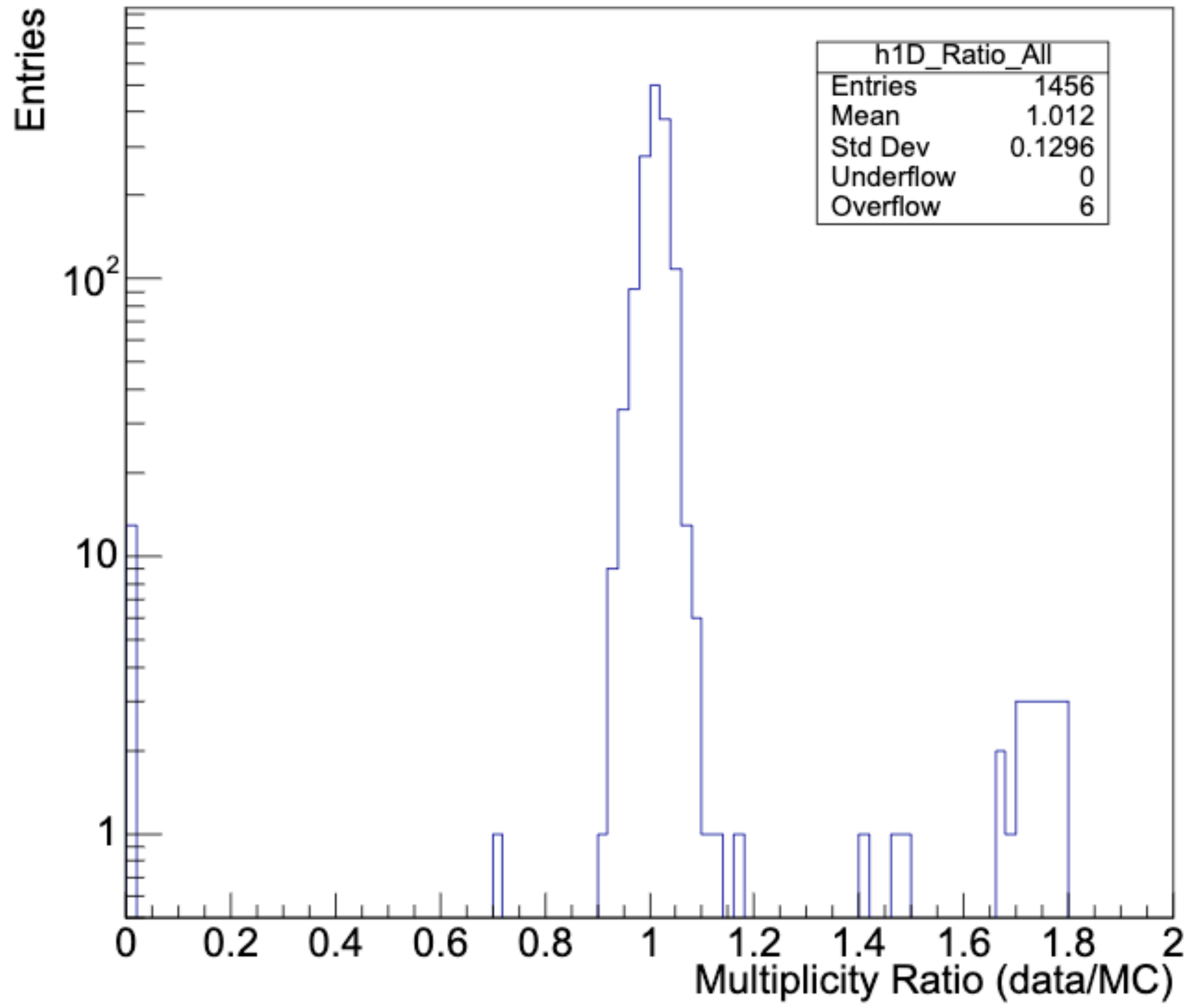
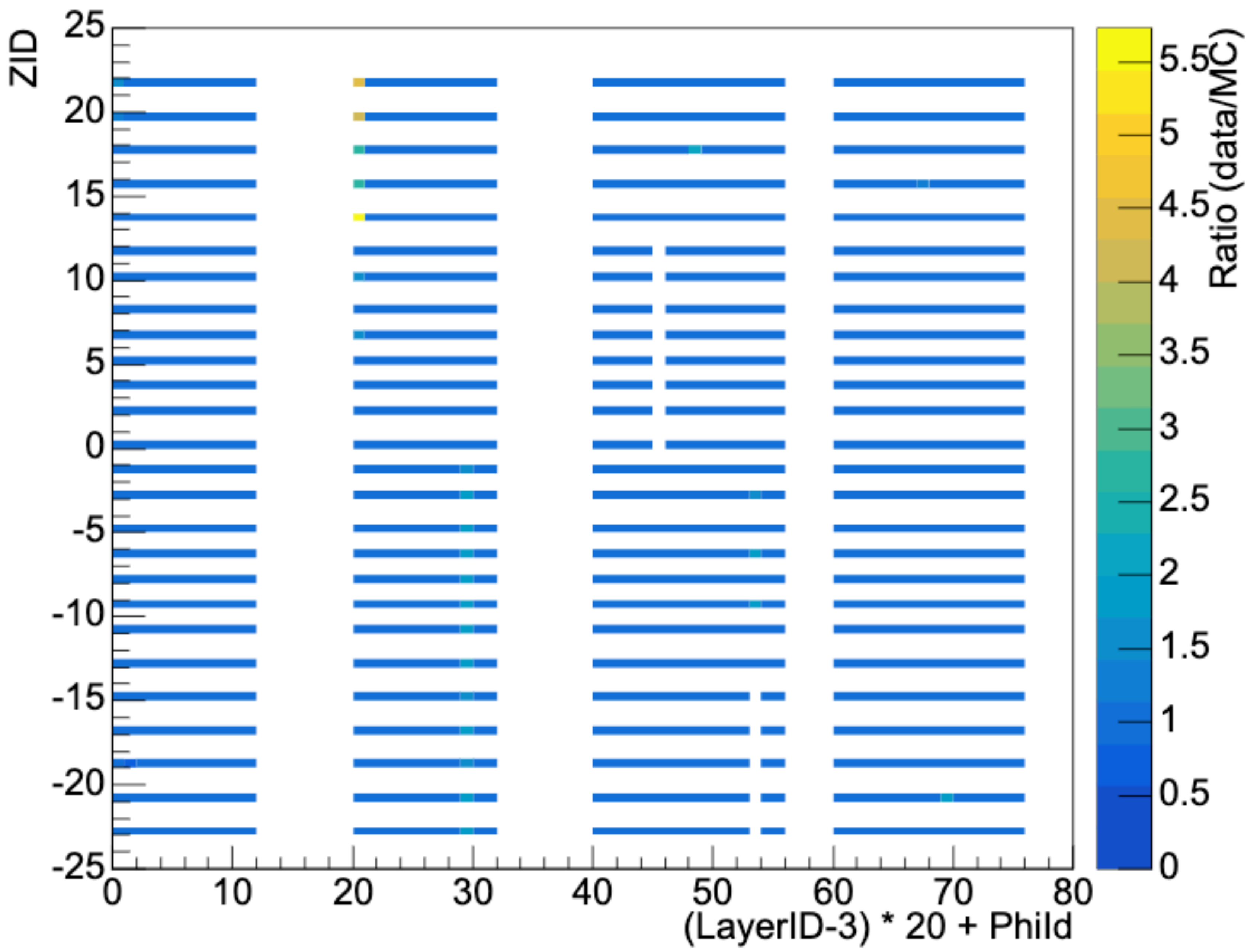
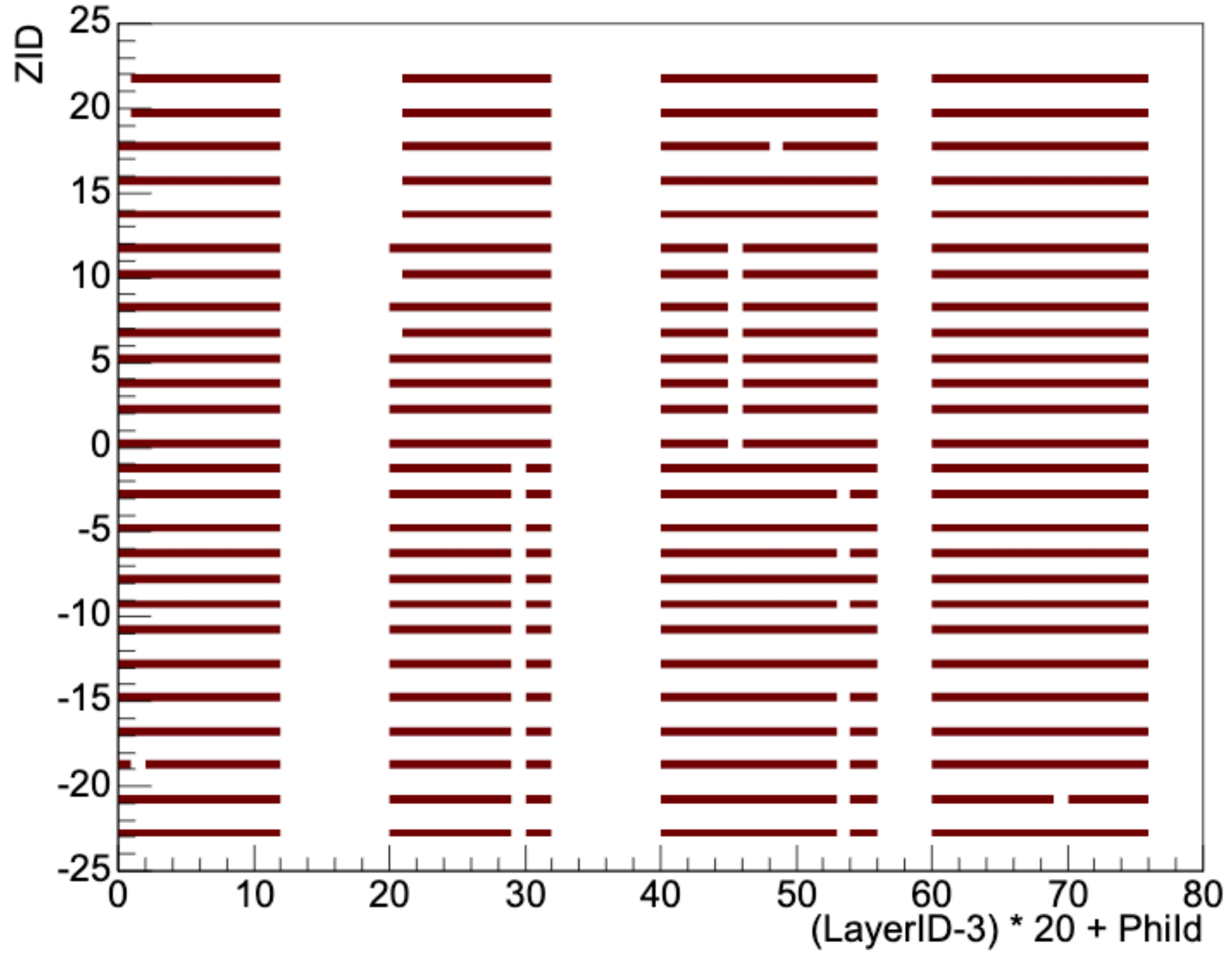




Final Map
Used in the following analysis



Geometry acceptance map

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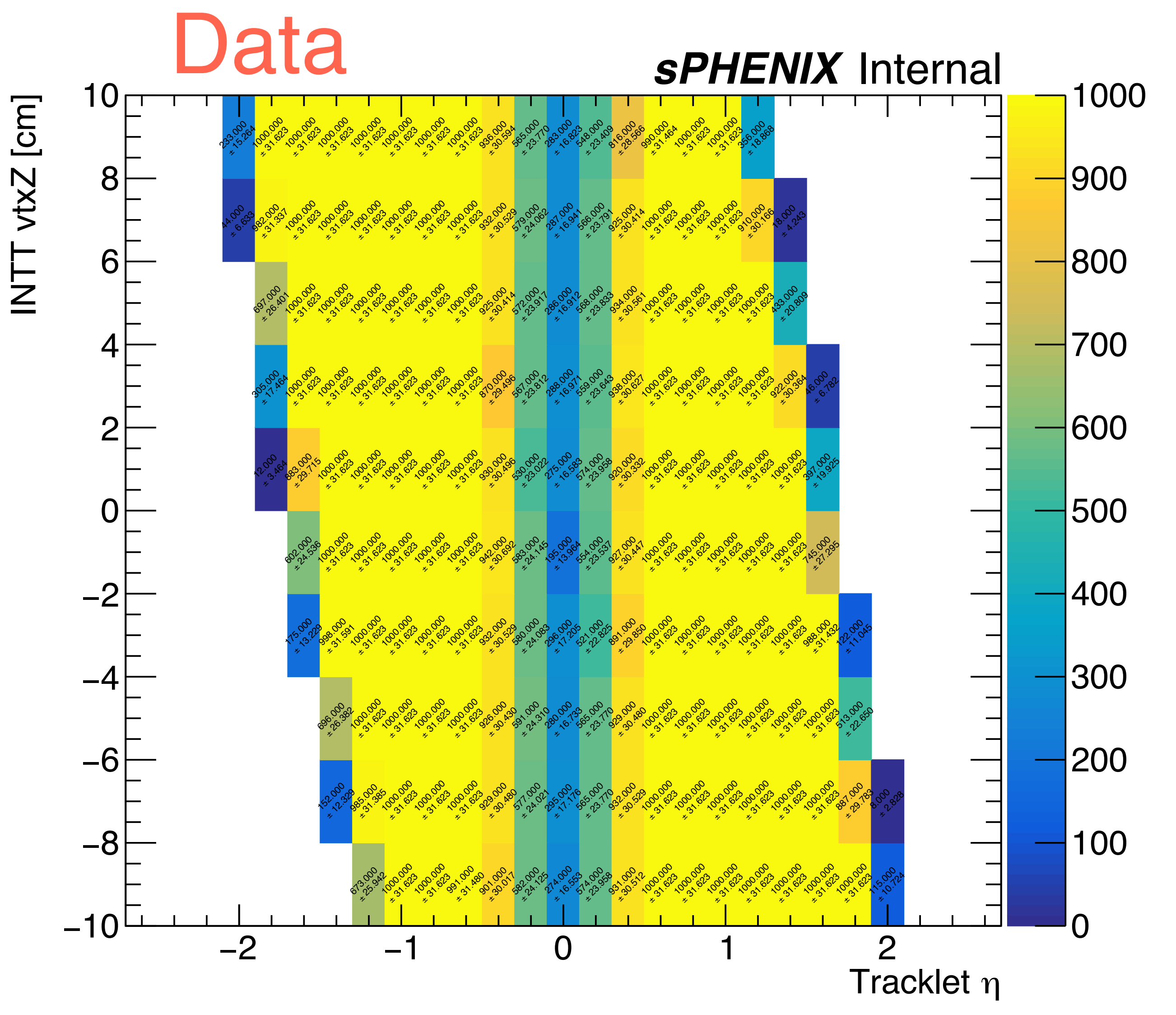
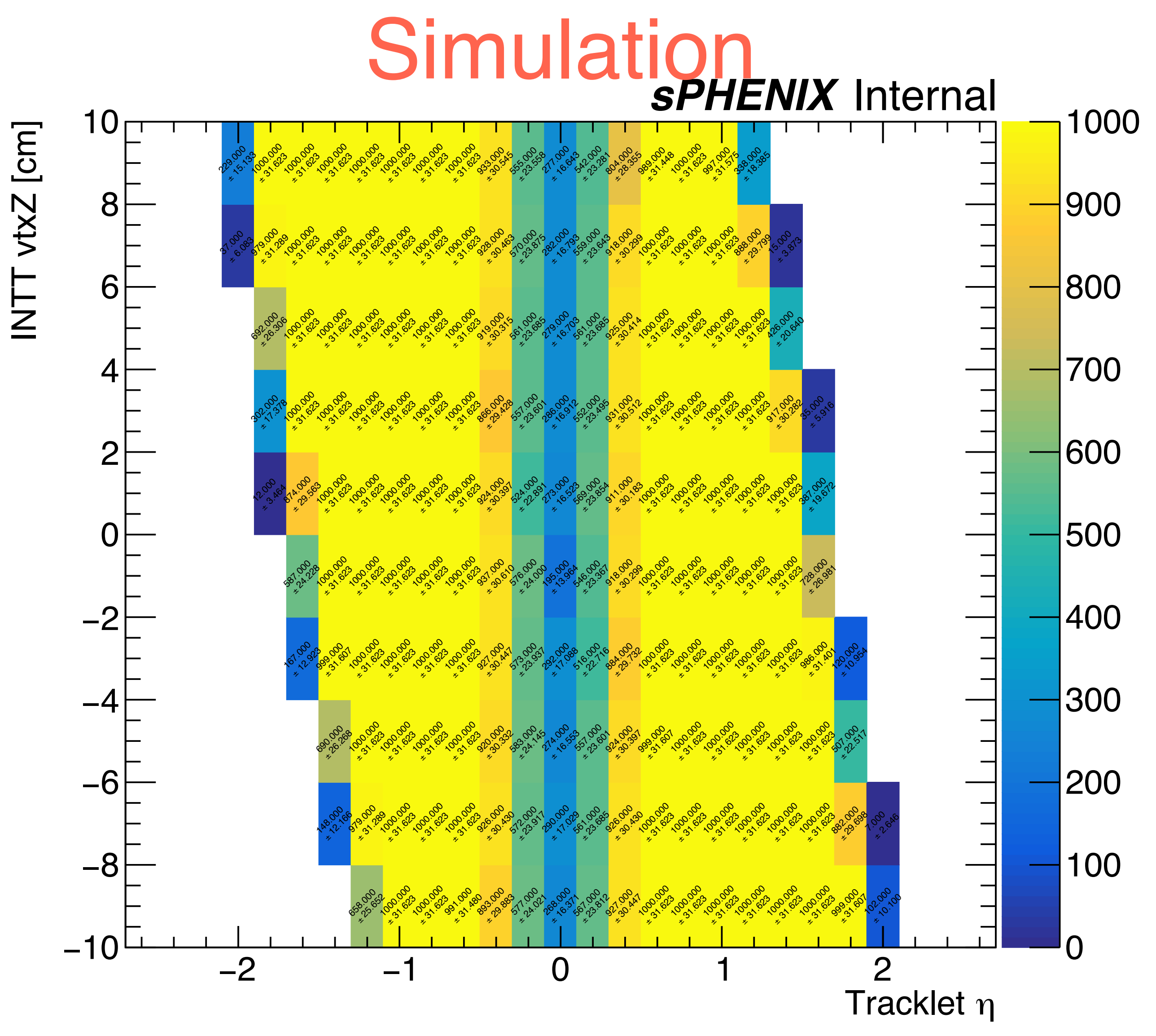
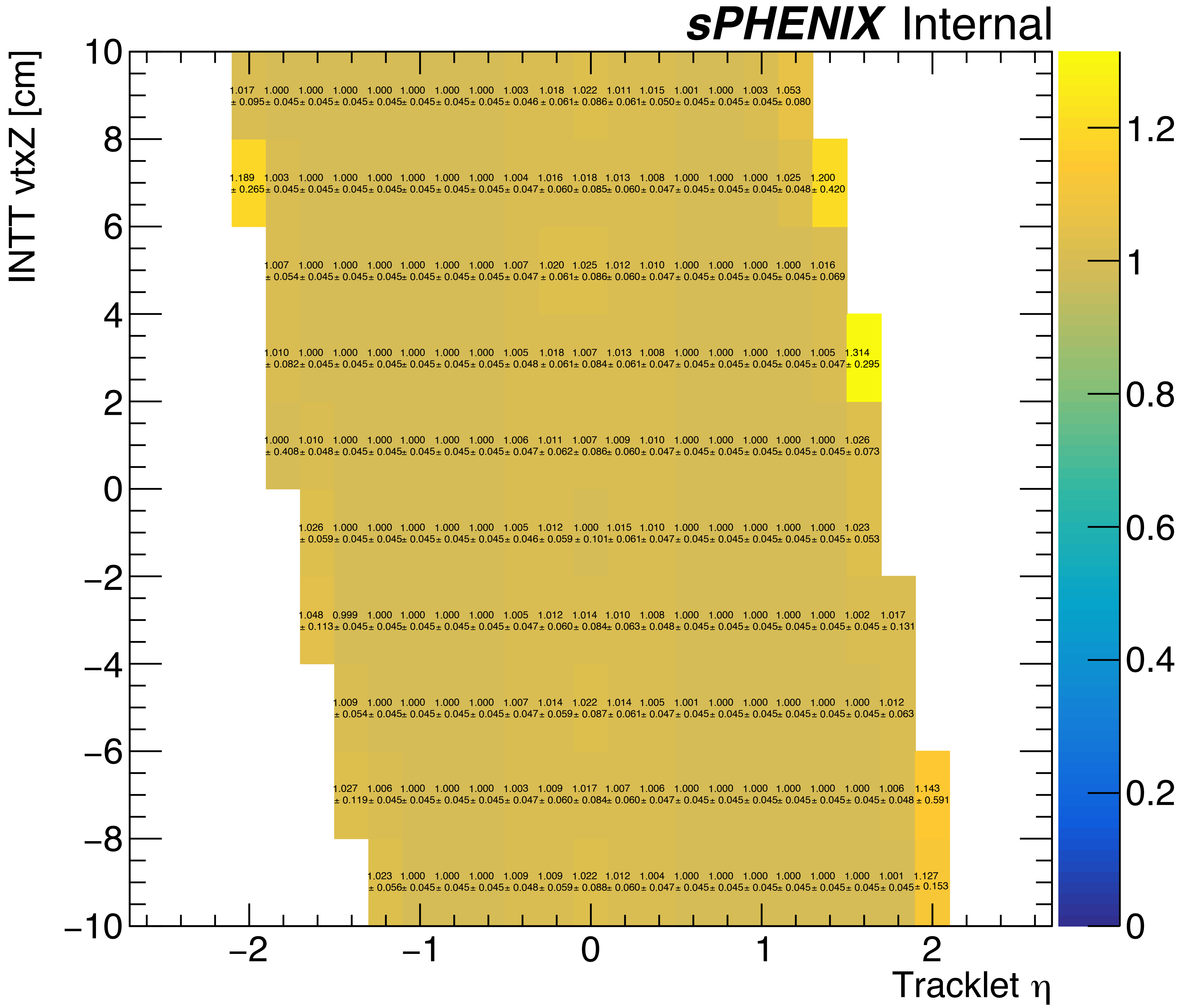
- Reconstruction the tracklets by the best pair method and filled the valid tracklets in the fine-binning 2D histogram (Eta bin 0.01, vtxZ bin 0.04 [cm])
  - Same requirements as the original method in DeltaEta and DeltaPhi
- Normalize the cell content (only check the acceptance)
  - Content >= 1 → set to 1
  - Otherwise → set to 0
- Rebin the histograms (Eta bin 0.2, vtxZ bin 2 [cm])
- Take the ratio (data/MC)
- Only select the region in the analysis where the difference is < 10%
- Apply the map in both data and MC
  - It's a map, not a correction







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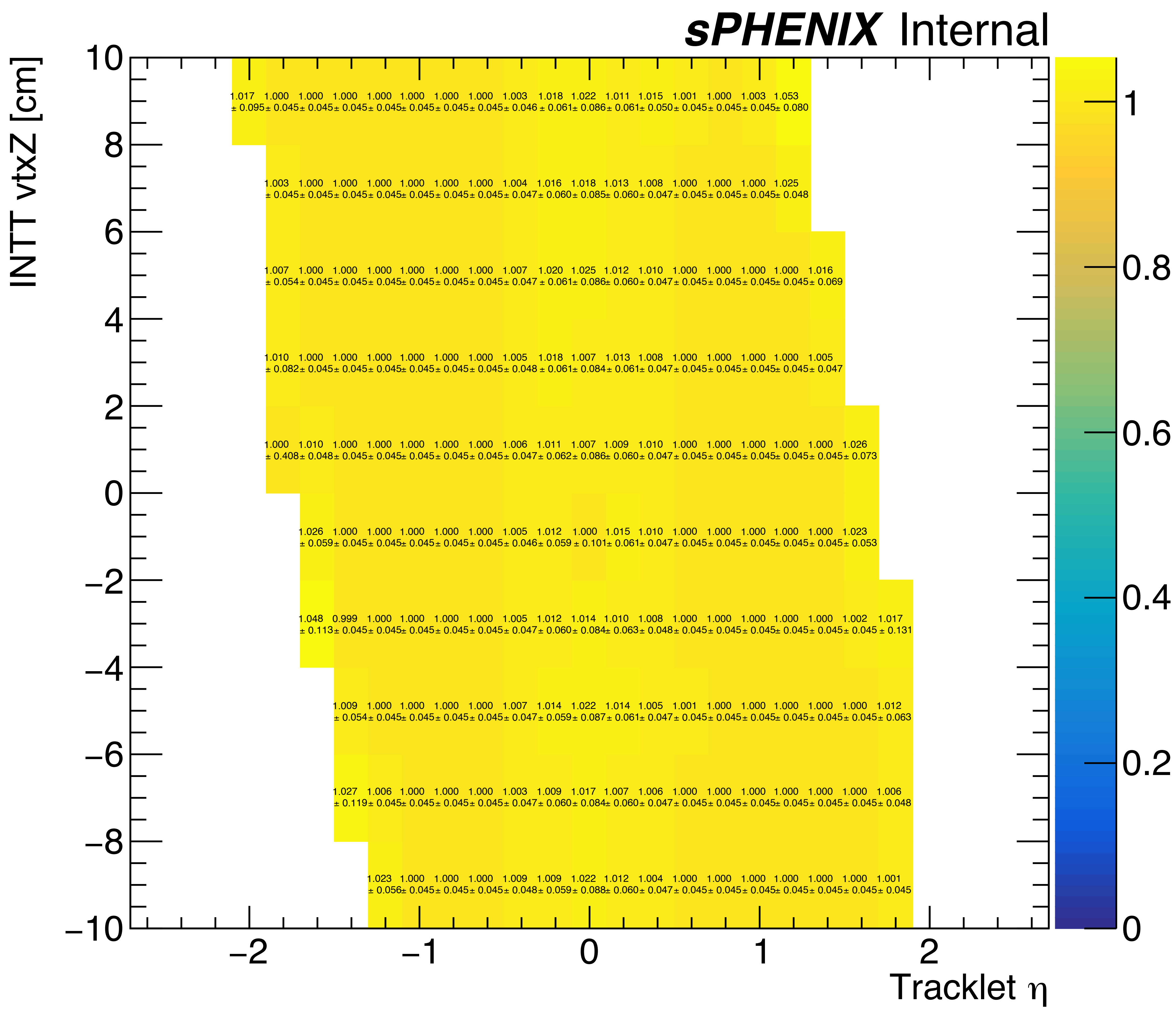
Final map



Summary

- The whole analysis flow of dNdEta is re-run

- The effect of the geometry misalignment is studied
  - Vertex XY can vary ~ 220 μm, vtxZ dist. varies slightly
  - $\Delta\phi$ becomes wider which is similar to that of the current data
  - Relatively small variation in the reco. tracklet in mid-rapidity

- The first round of $dN_{ch}/d\eta$ result is presented
  - Vertex Z re-weighting, geometry and efficiency corrections are included
  - Some of the systematic uncertainties are evaluated
  - The data agrees with the generator-level distribution
  - Some more work on re-considering the corrections is in progress

- The cluster approach and CMS approach (in backup) are also checked (as the supporting doc.)

dNdEta, Cluster approach

MC: HIJING

[0-70%], ClusAdc > 35, |vtxZ| ≦ 10 cm, α corrections only

Supporting Doc.

MC1 - MC2 comp before corr. | MC1 - MC2 comp | Data - MC2 comp before corr. | Data - MC2 comp post corr.

- In the MC, the numbers of clusters in both layers are more than the number of charged hadrons
- The per-event number of clusters in data is more than that of in MC.

INTT remaining tasks

Google slide

The open questions of INTT what require people to look into

- Important — Fraction of hits moved to next of BCO bin (Due to the imperfect coarse/fine delay)
- Important — INTT chip timing stability (the chip timing can shift, is it a severe issue ?)
- Coarse delay scan practice (Have some data with different coarse-delay settings aiming at improving the INTT timing resolution, we will need to practice it for the run 2025 preparation)
- INTT good run list (streaming first, then triggered for p+p)
- Important — INTT hit-carried-over issue (in AuAu and p+p, and mitigation strategy)
- Threshold setting of run 2025 (the current one underestiamtes real spectrum)
- Hit saturation in Run 2025
- Calibration data analysis (artificial charge injection to chips)
- Important — Understanding the INTT overflow tag behavior

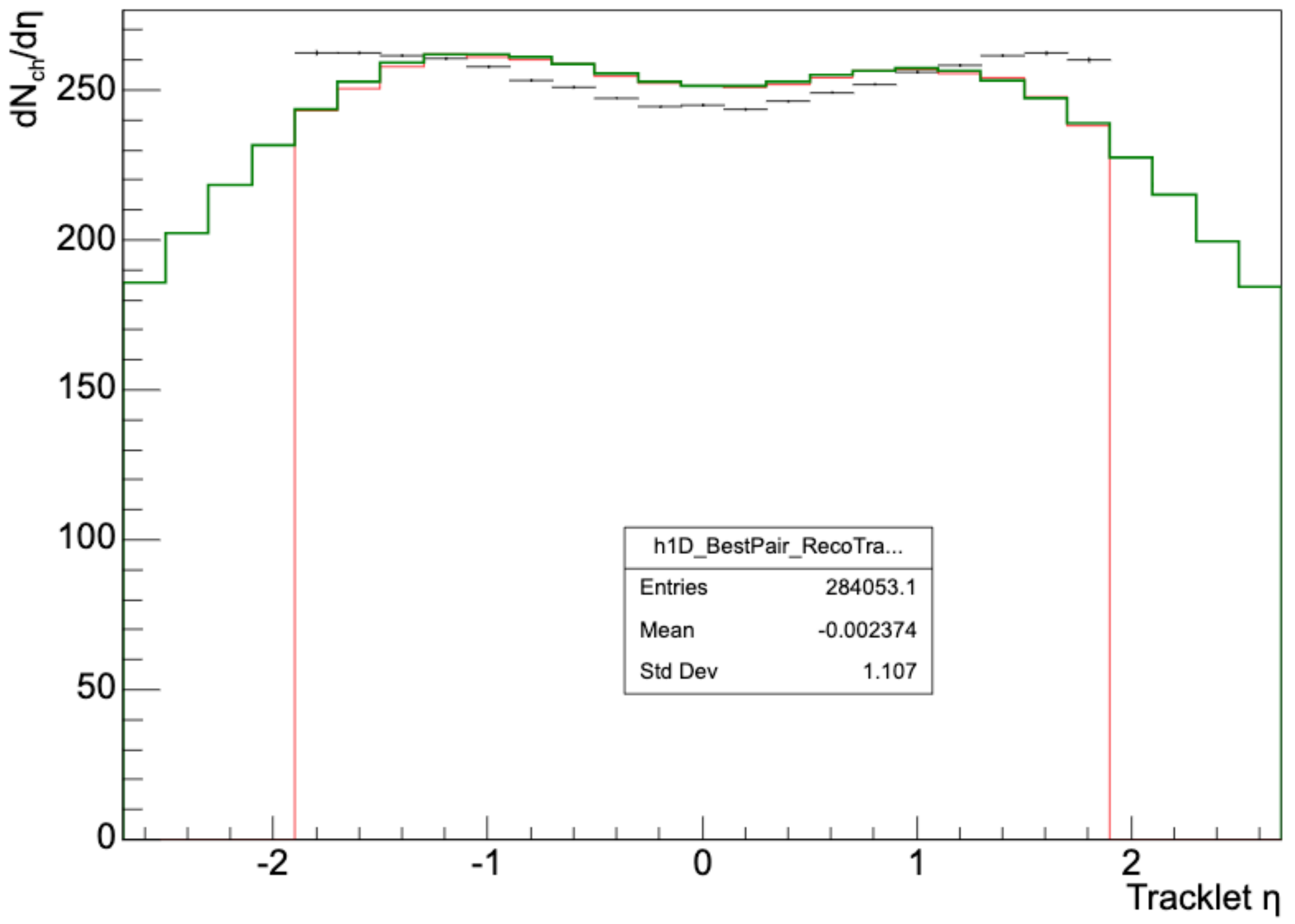
- The discrenapcy between data and MC (Simulation optimization)
- INTT radiation damage
- INTT geometry optimization

- (Sort like closed)
  - Spikes at 43 and 46 of cluster phi size distribution
  - hit saturation issue

2

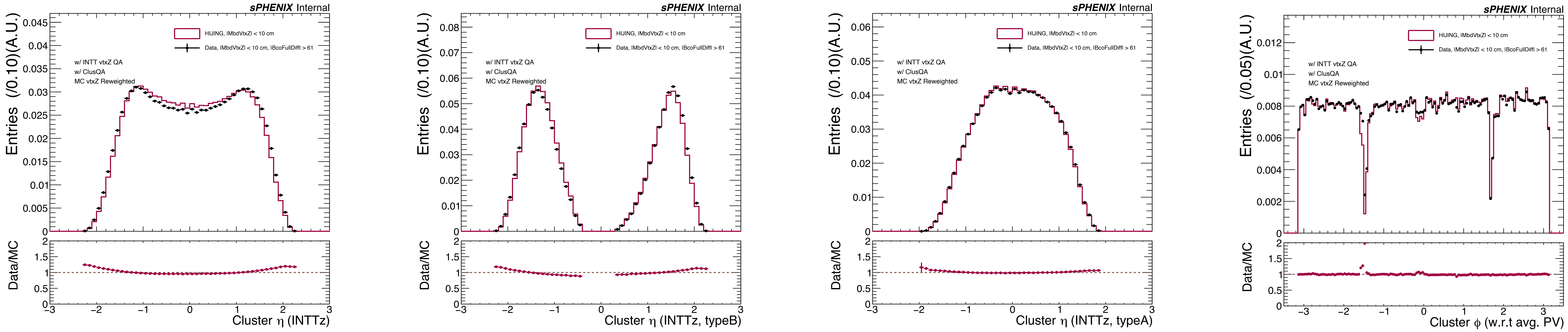
Back up

vtxZ [-10 cm ~ 10 cm], Centrality [0-70%], vtxZ reweighing applied in MC, alpha correction applied
| Eta region | ≦ 1.9 included



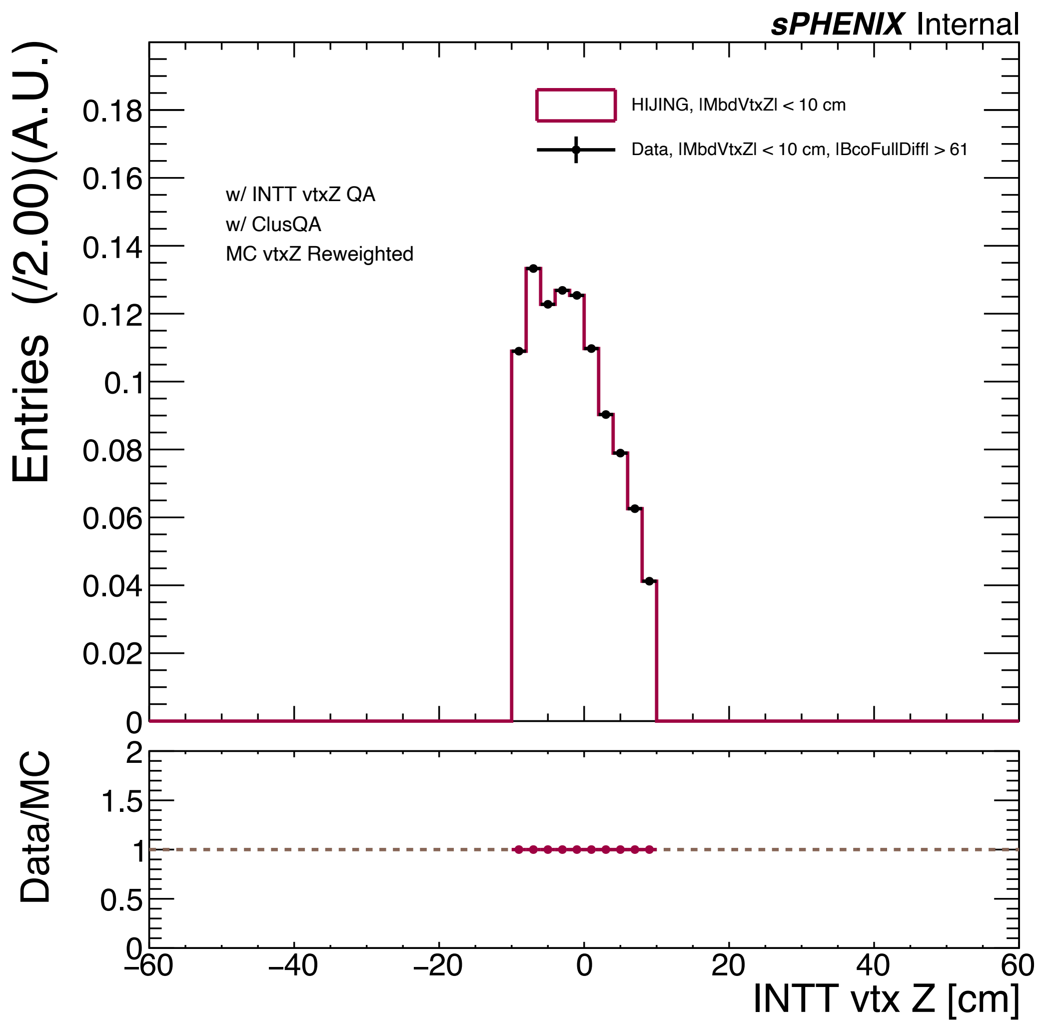
Cluster Eta and Phi

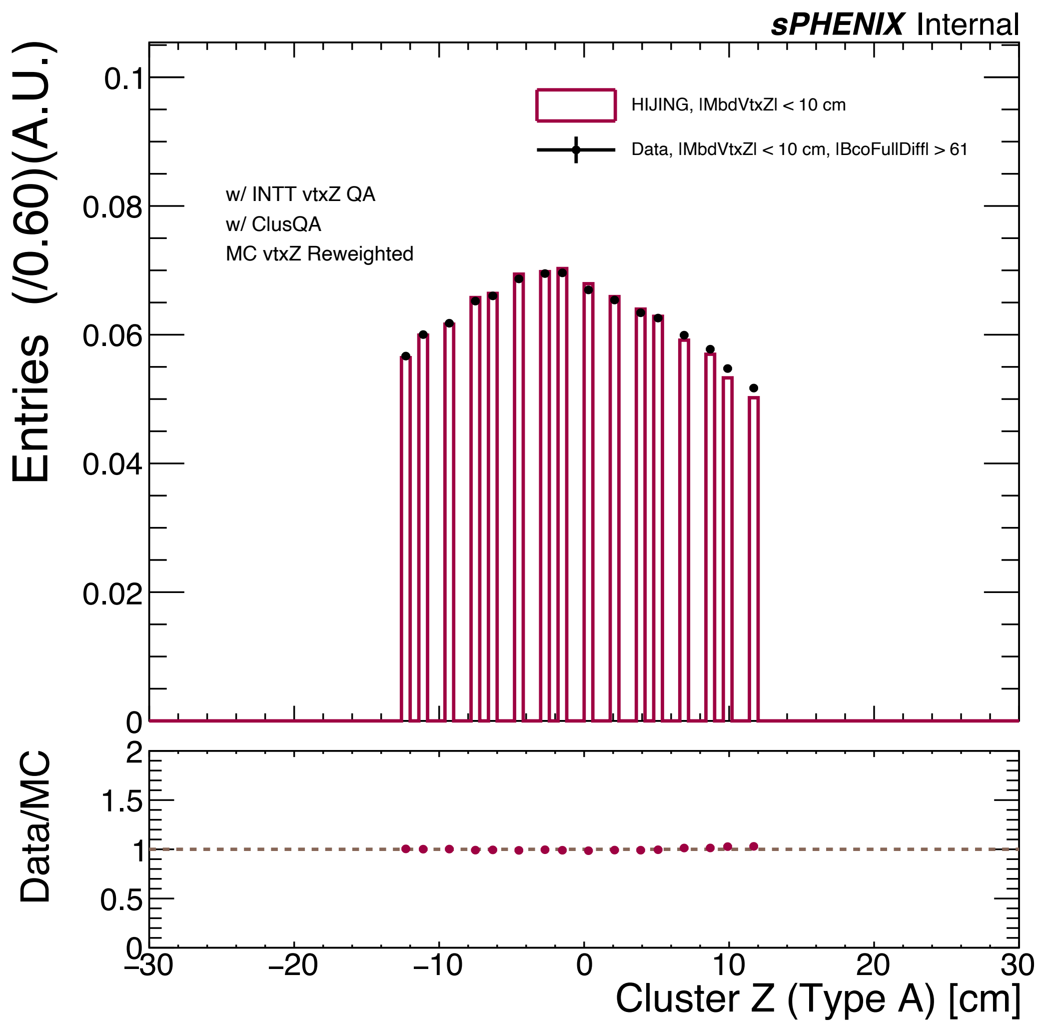
Supporting Doc.

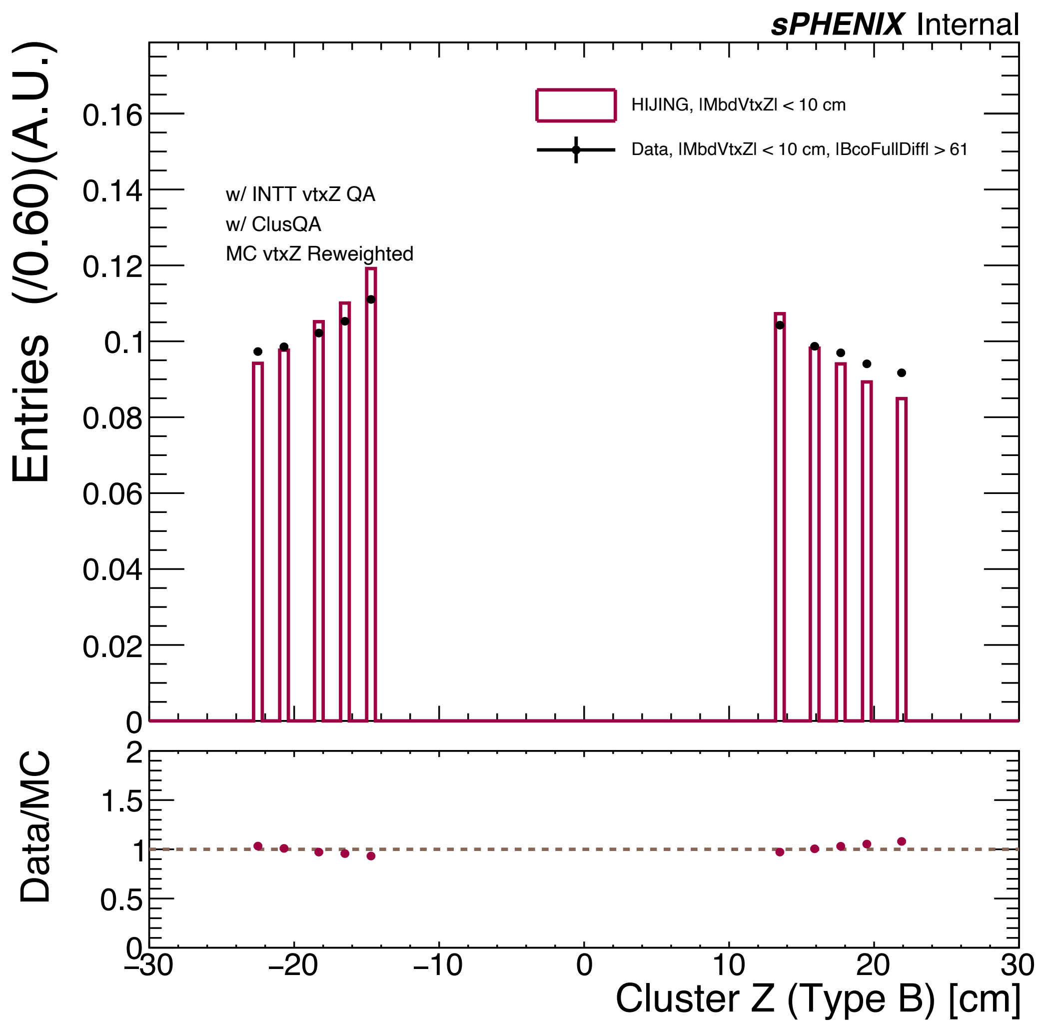


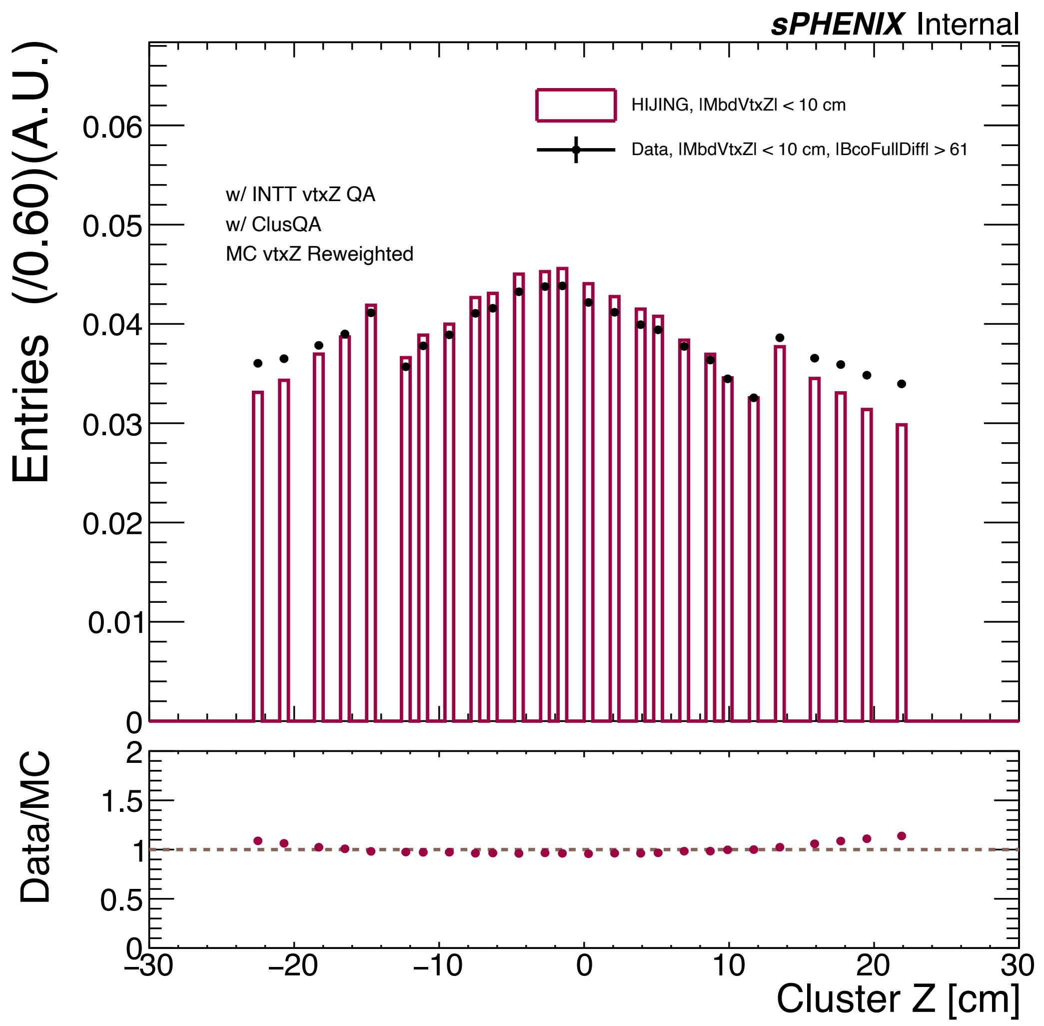
Supporting Doc.

VtxZ comparison
for confirmation



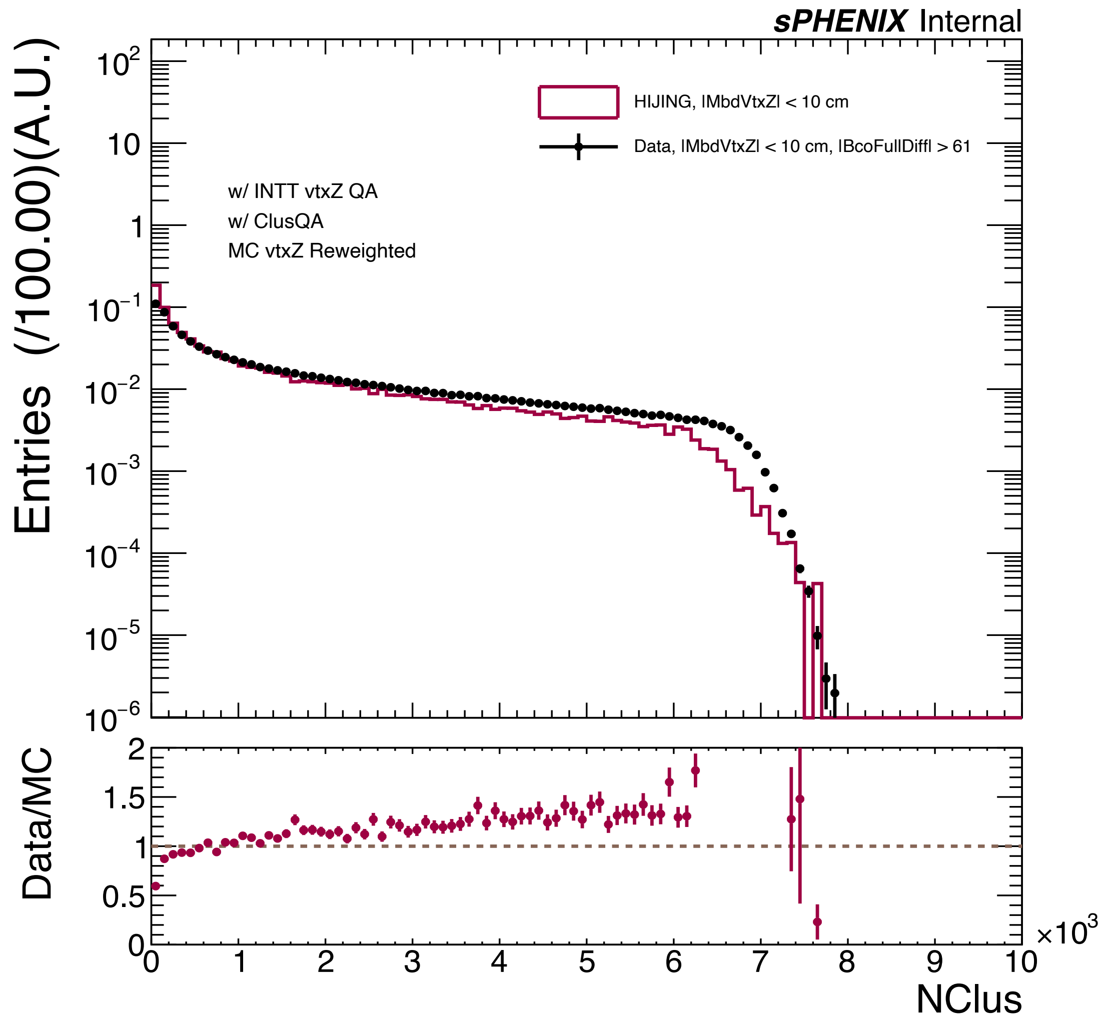


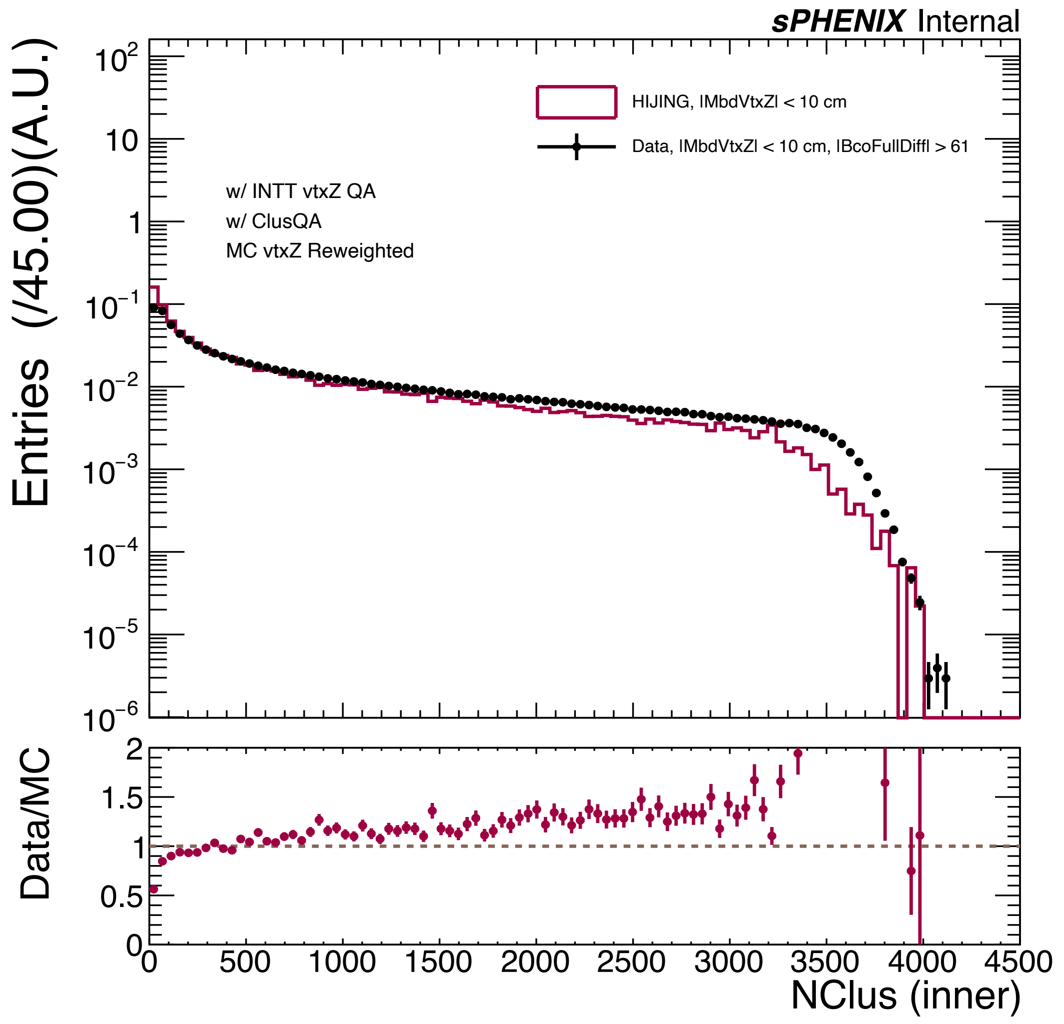


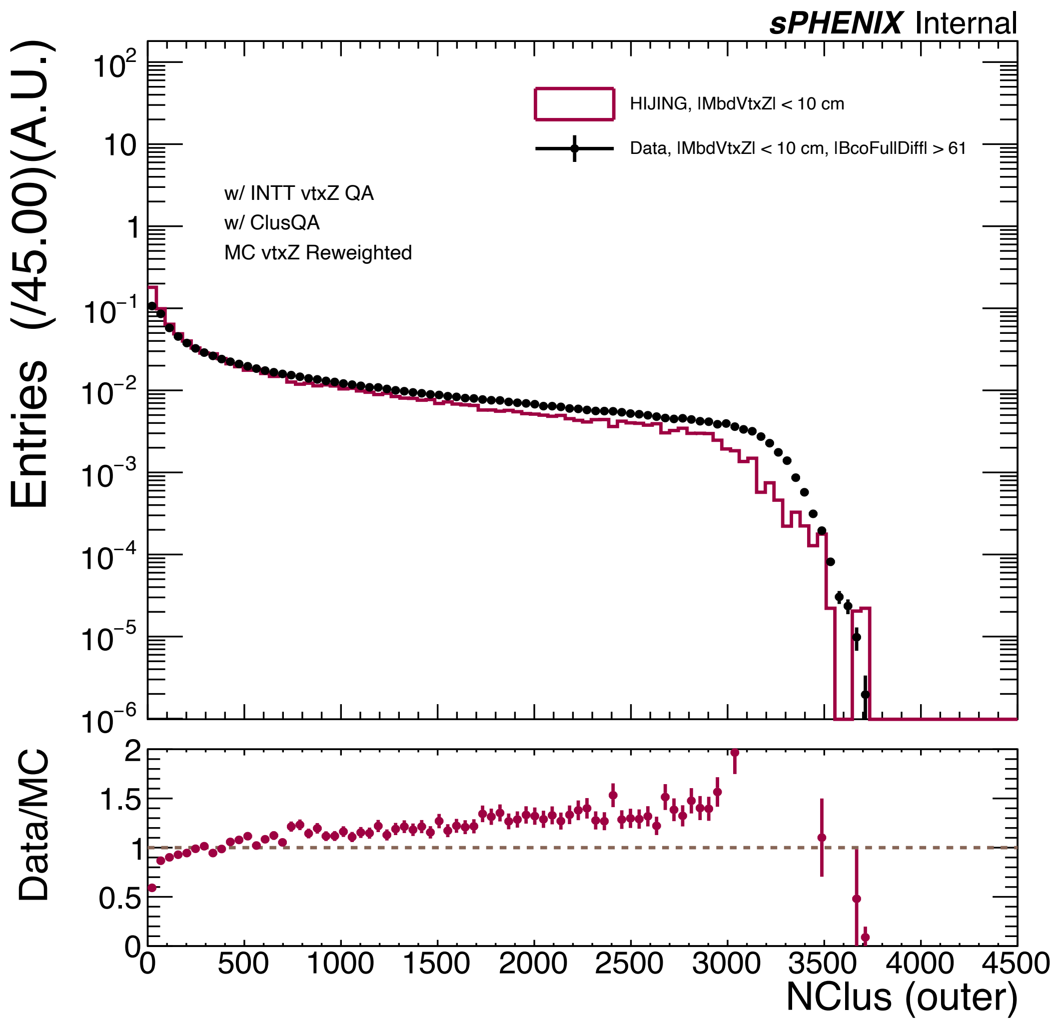


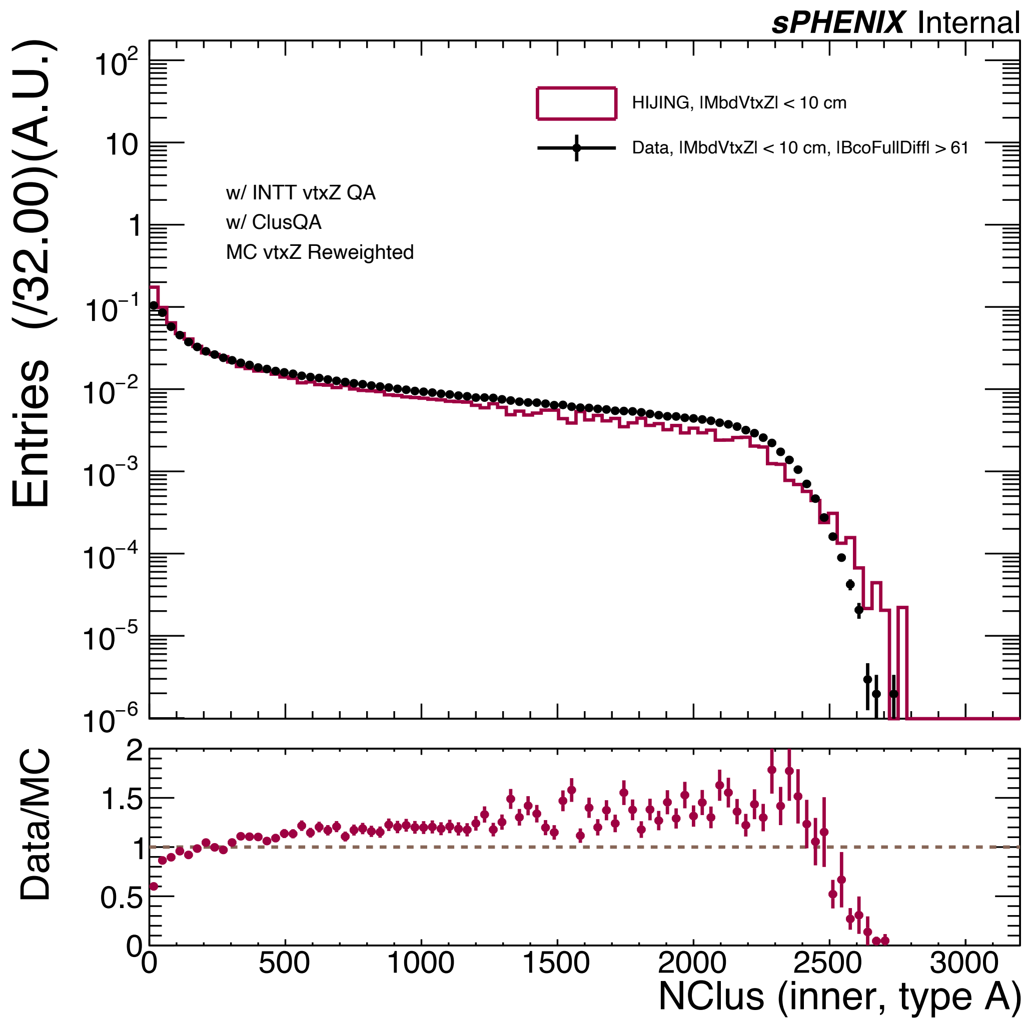
NClus with different selections

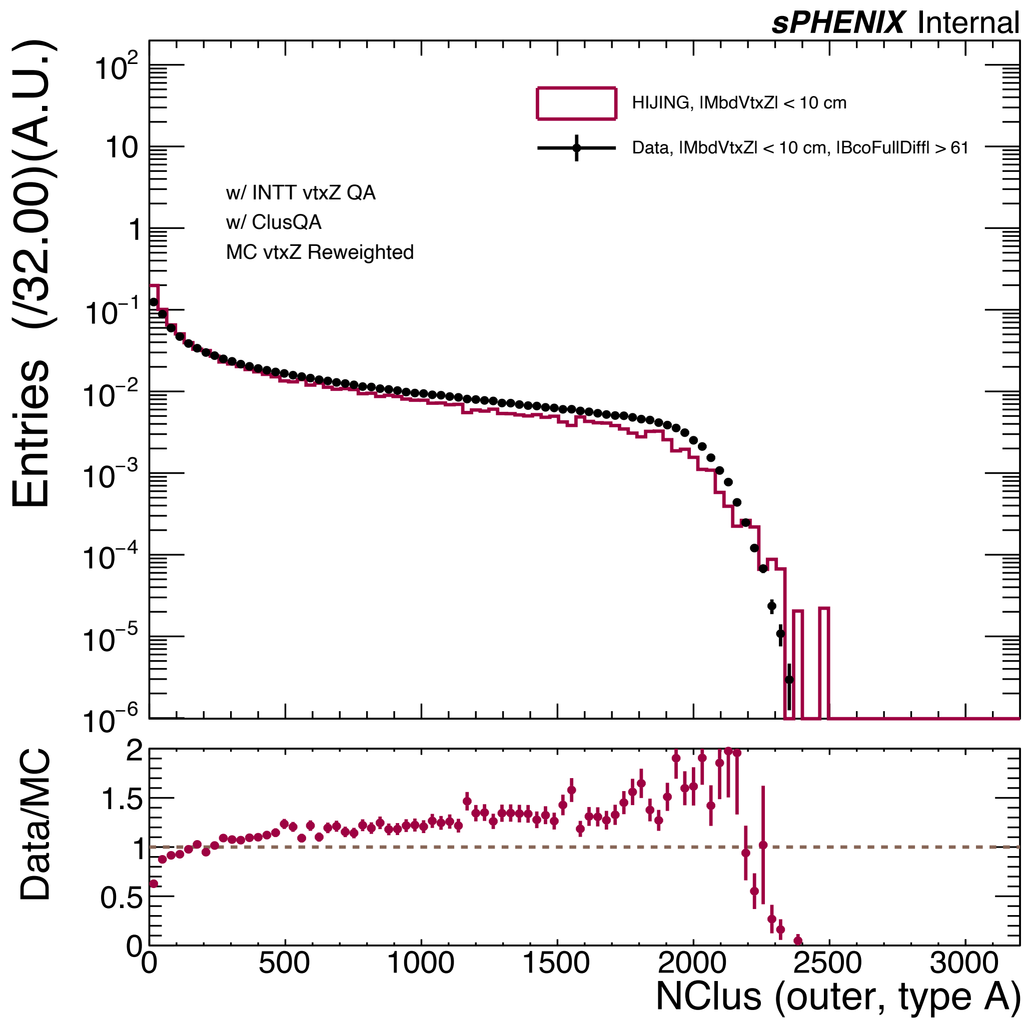
Supporting Doc.

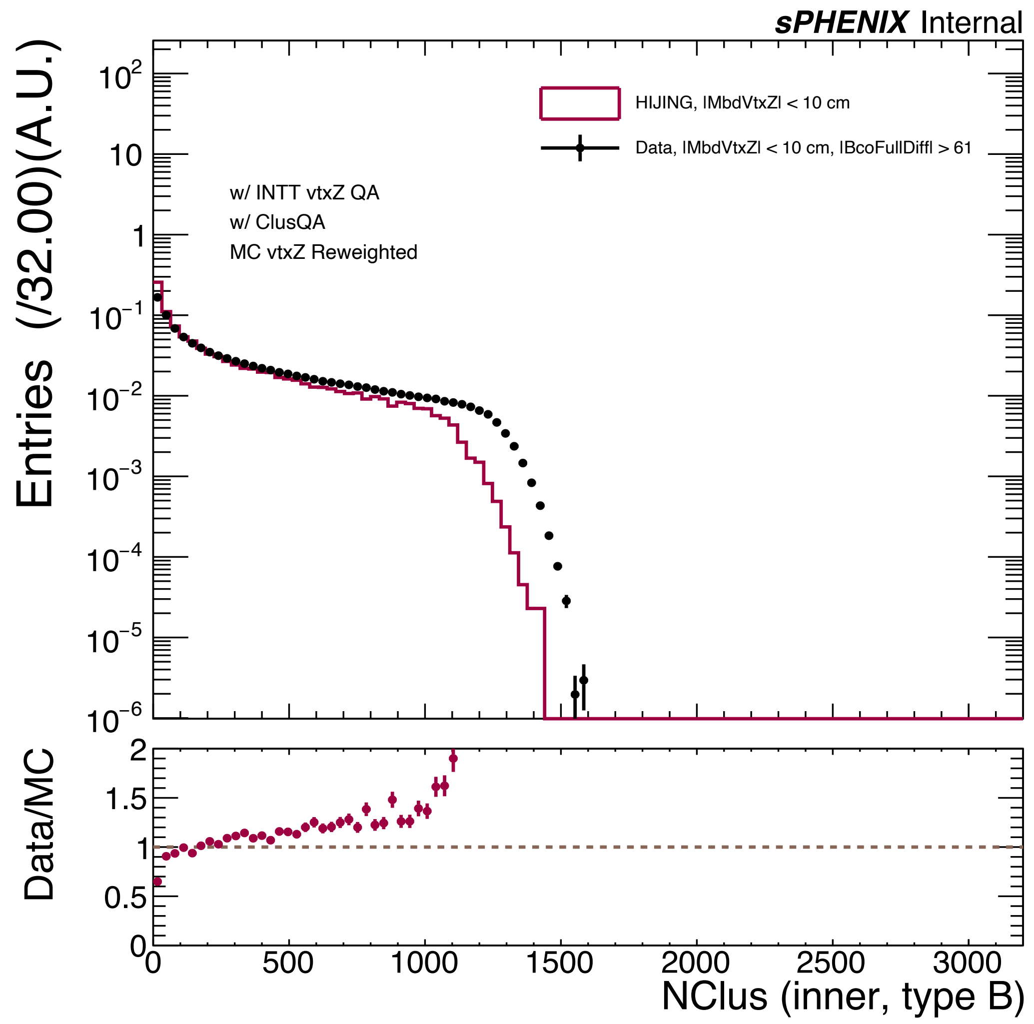


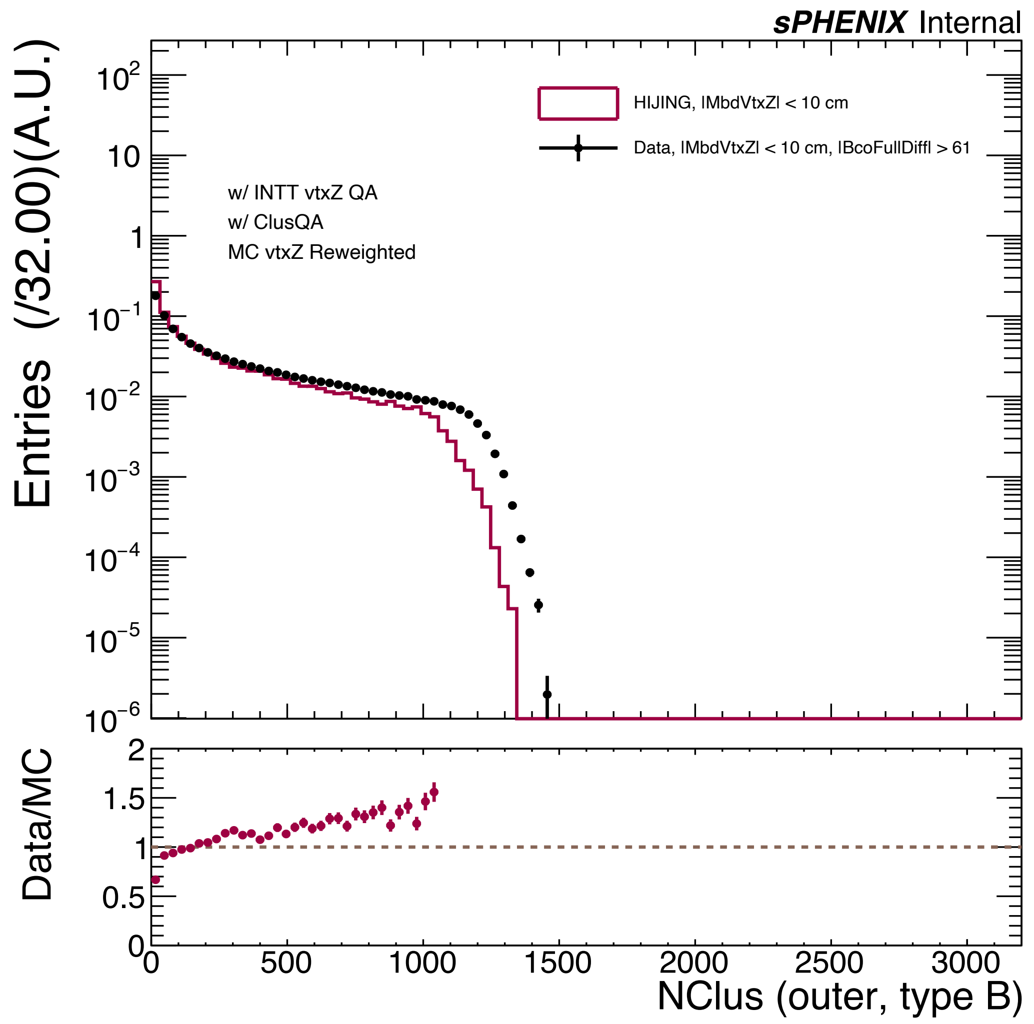






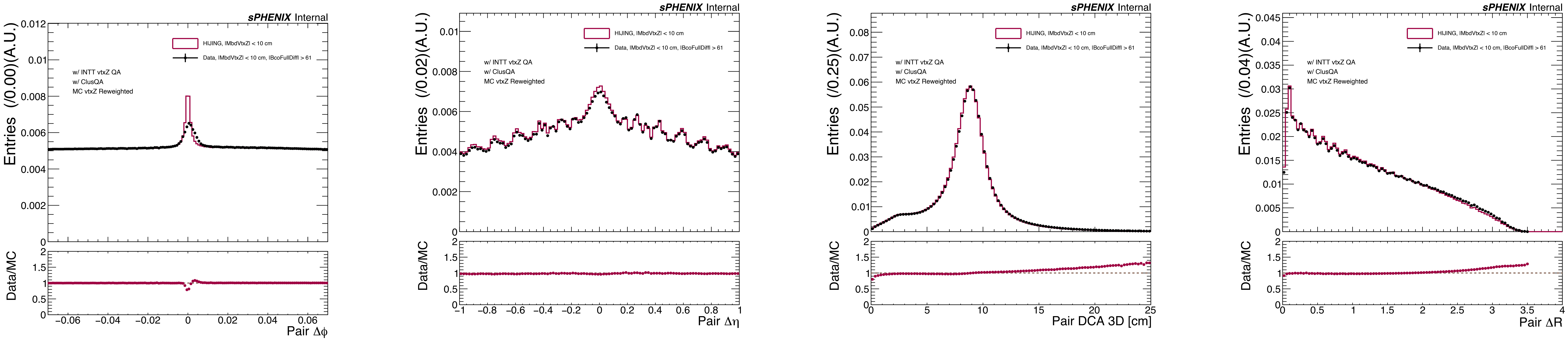






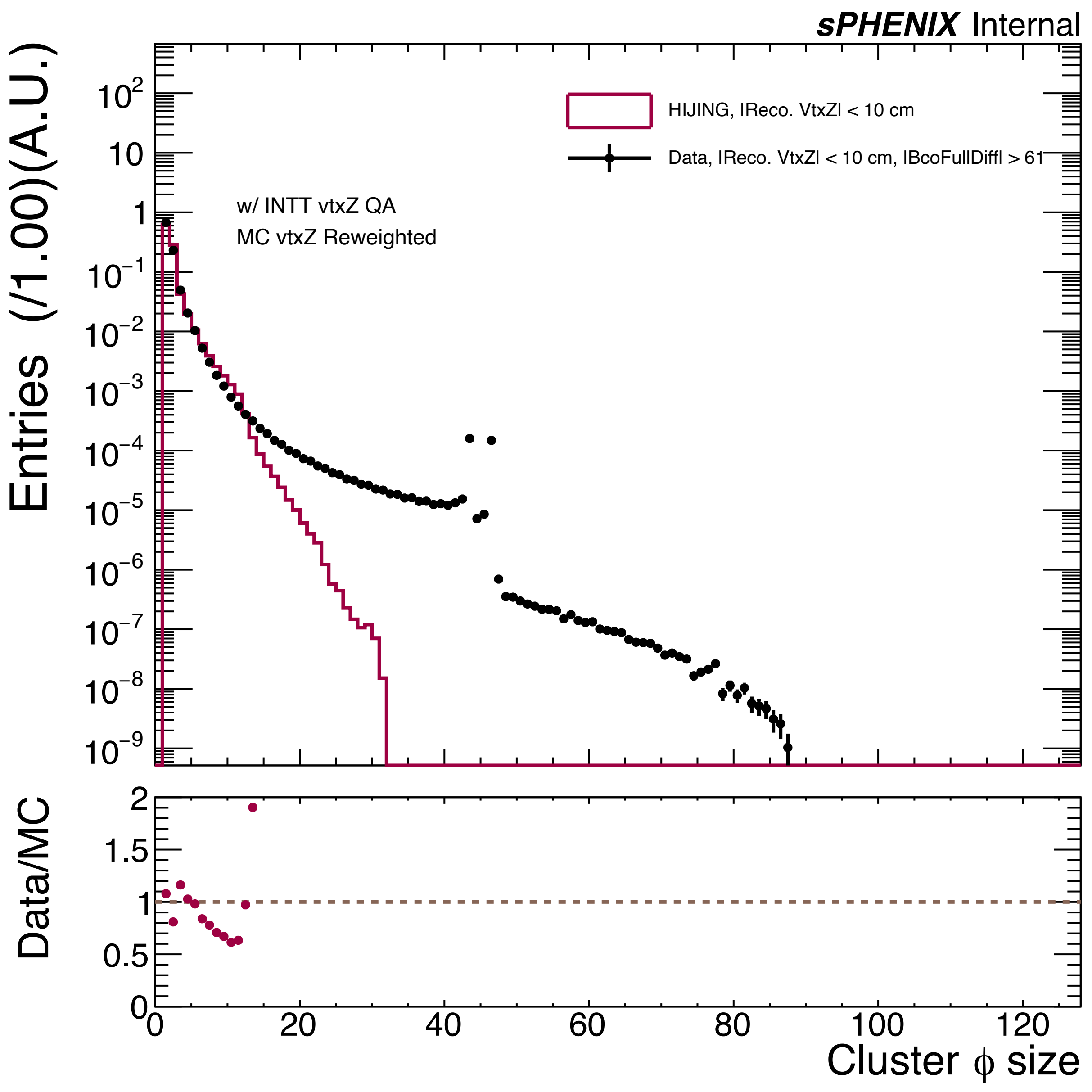
Tracklet distributions

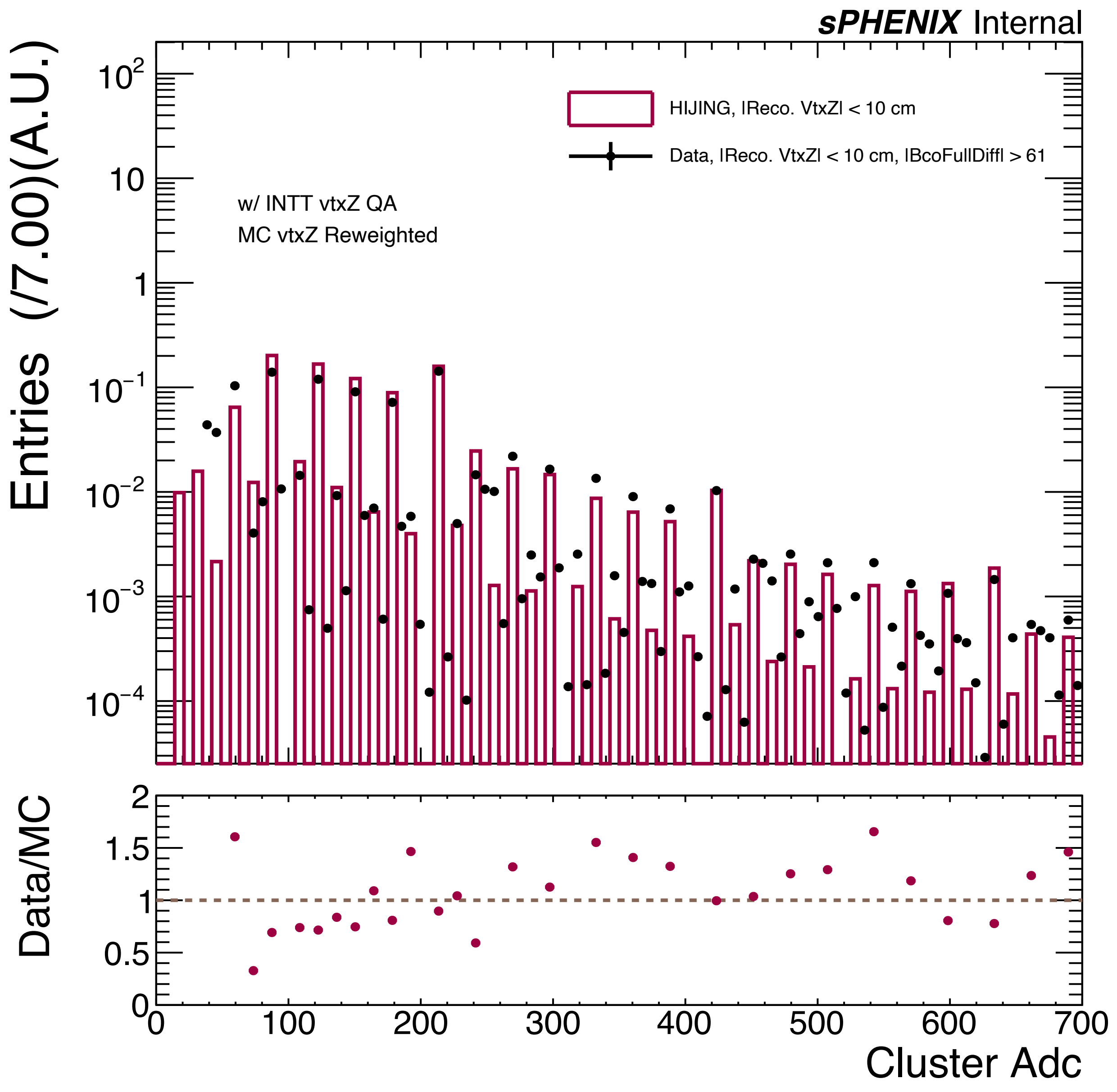
Supporting Doc.

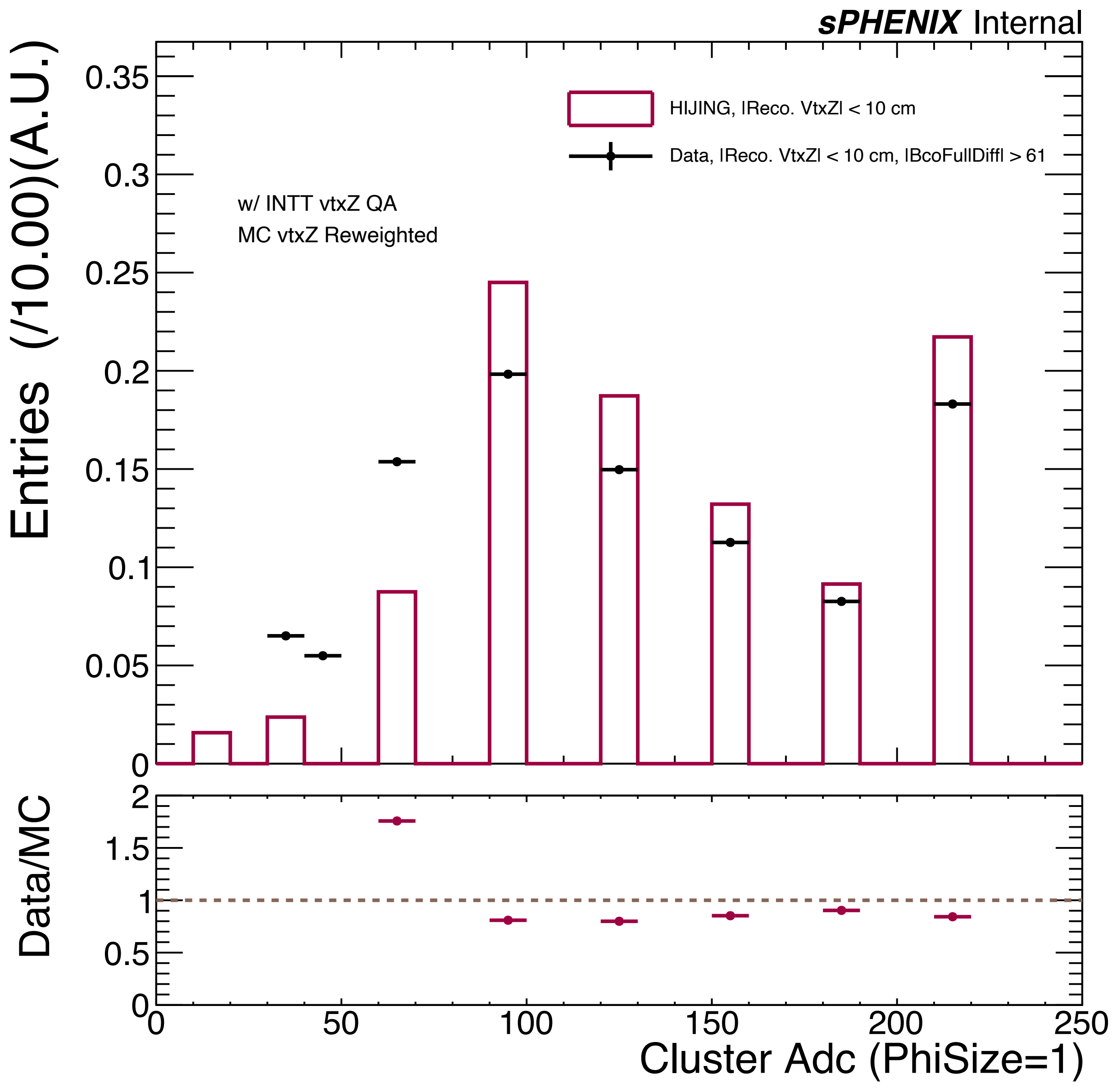


Cluster ϕ size and cluster ADC

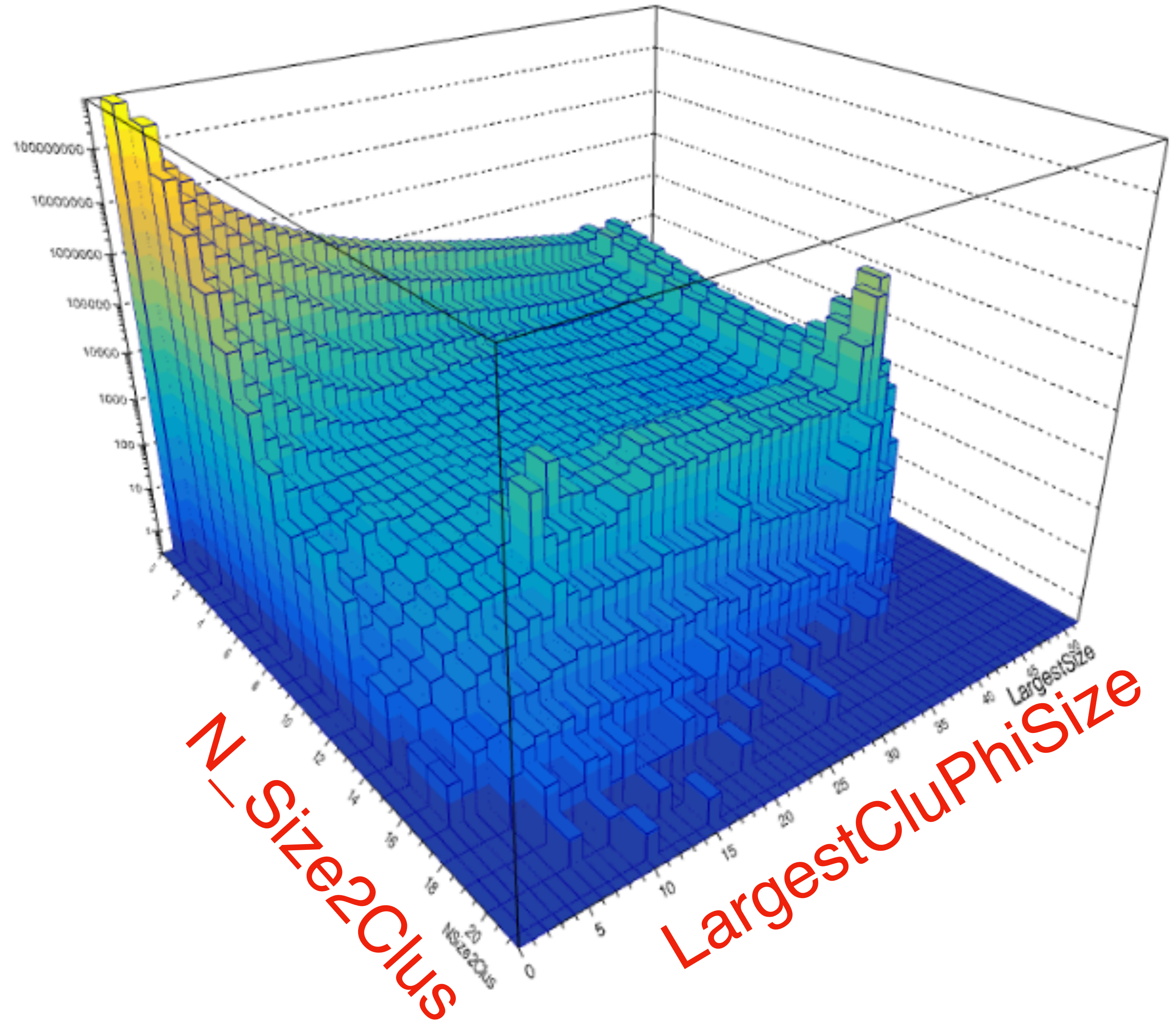
Supporting Doc.





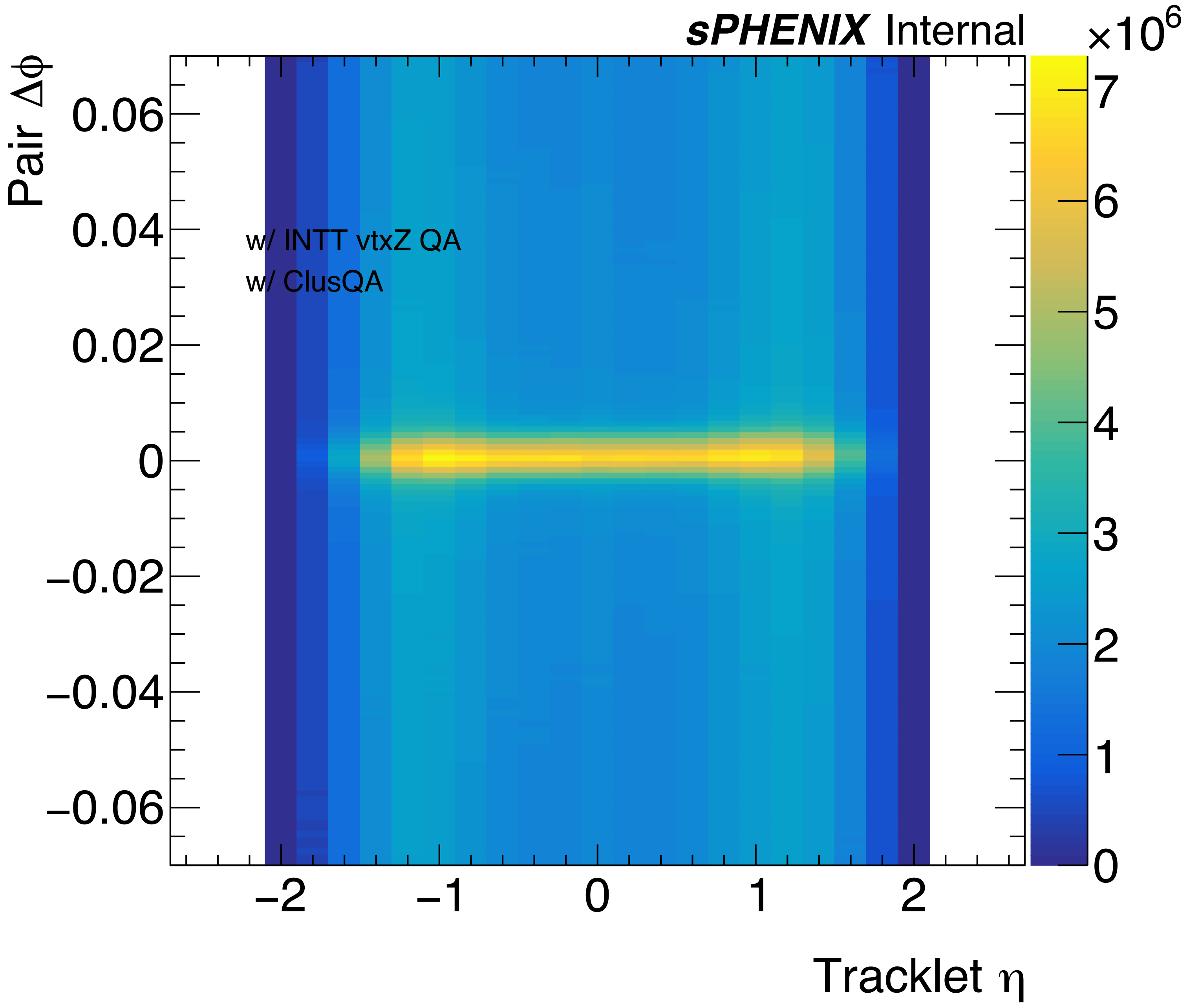


Further study of the chip saturation

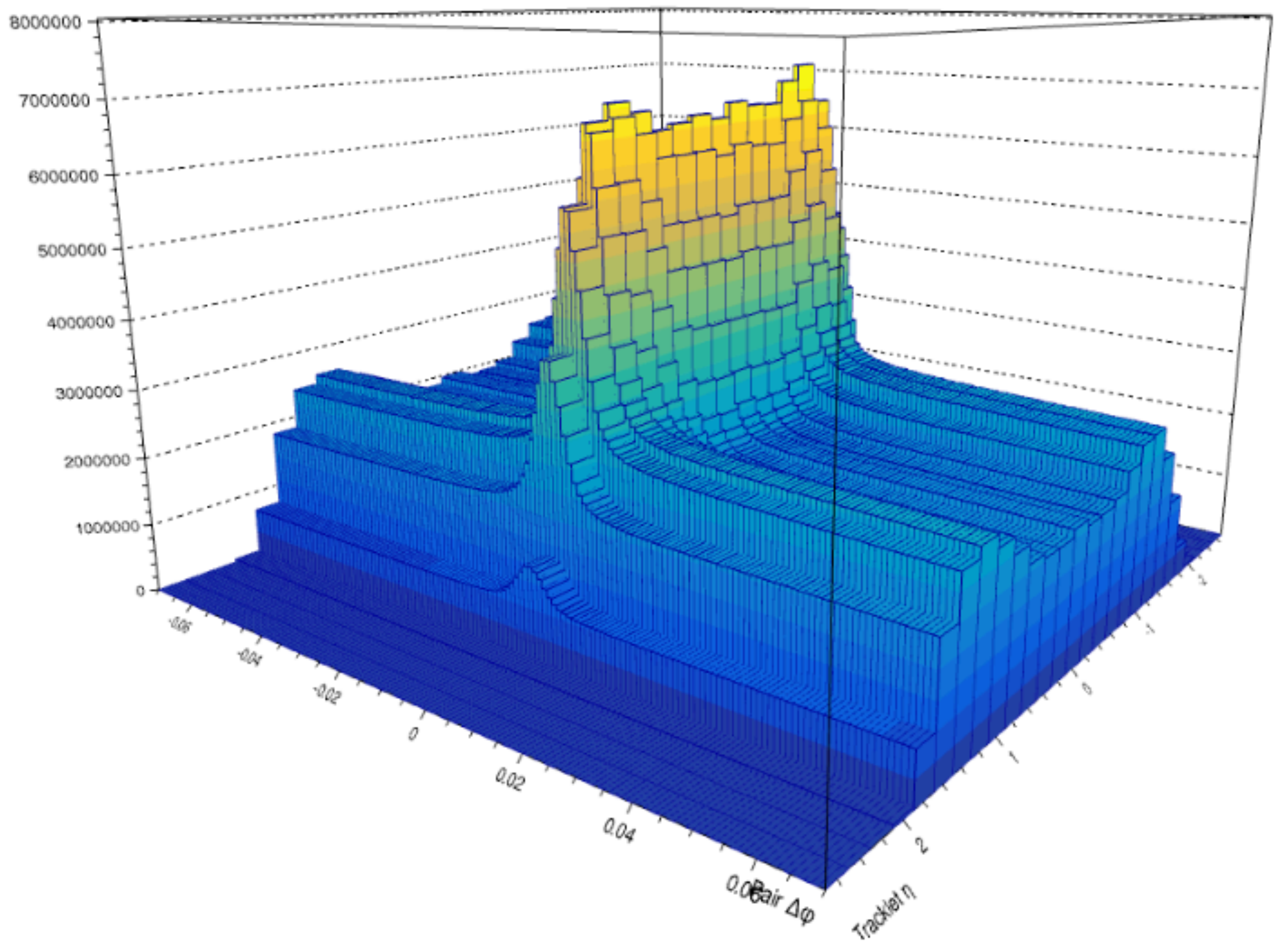


Tracklet Δφ as a function of tracklet η

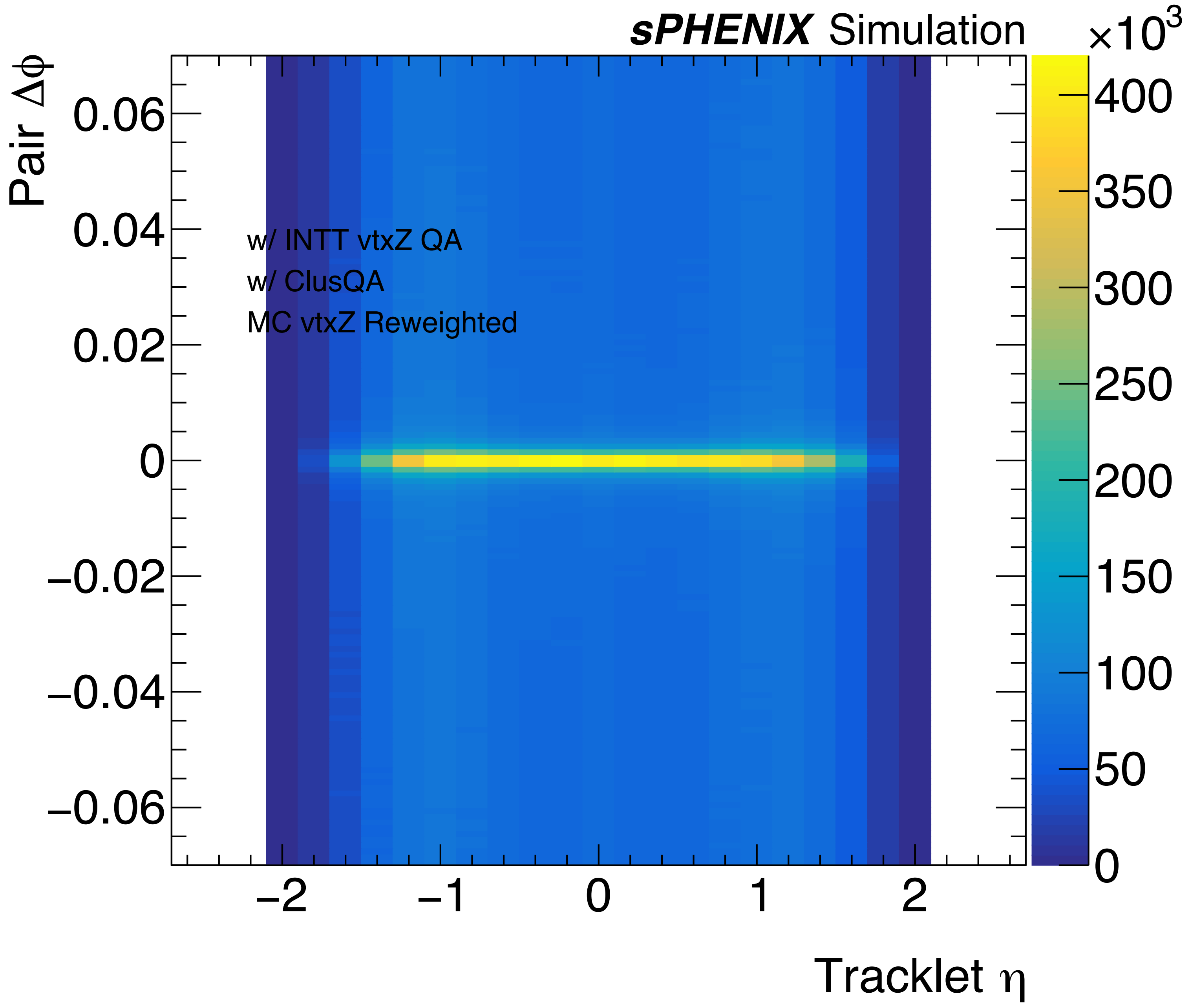
Data



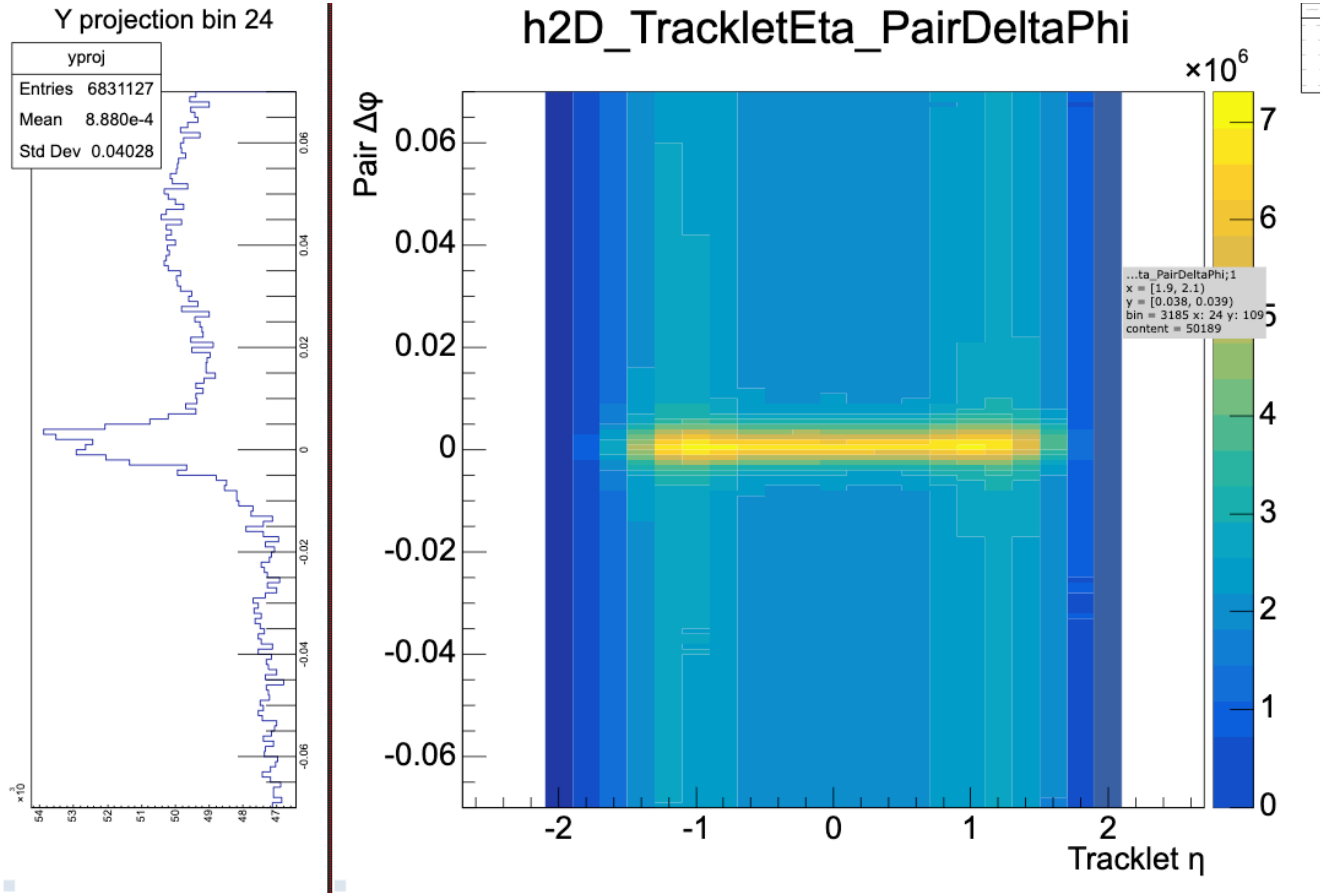
Data



MC

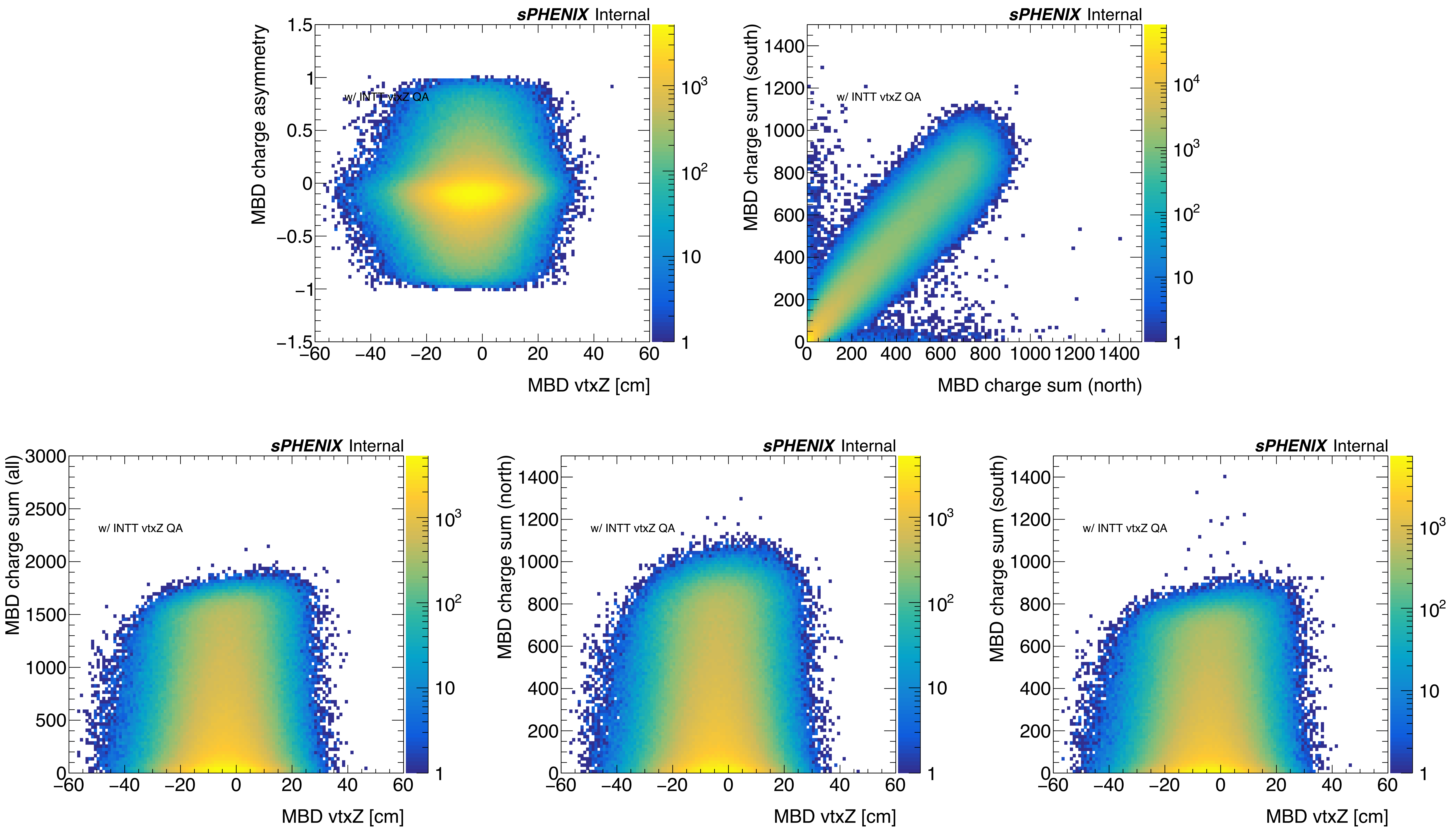


Tracklet Δϕ as a function of tracklet η



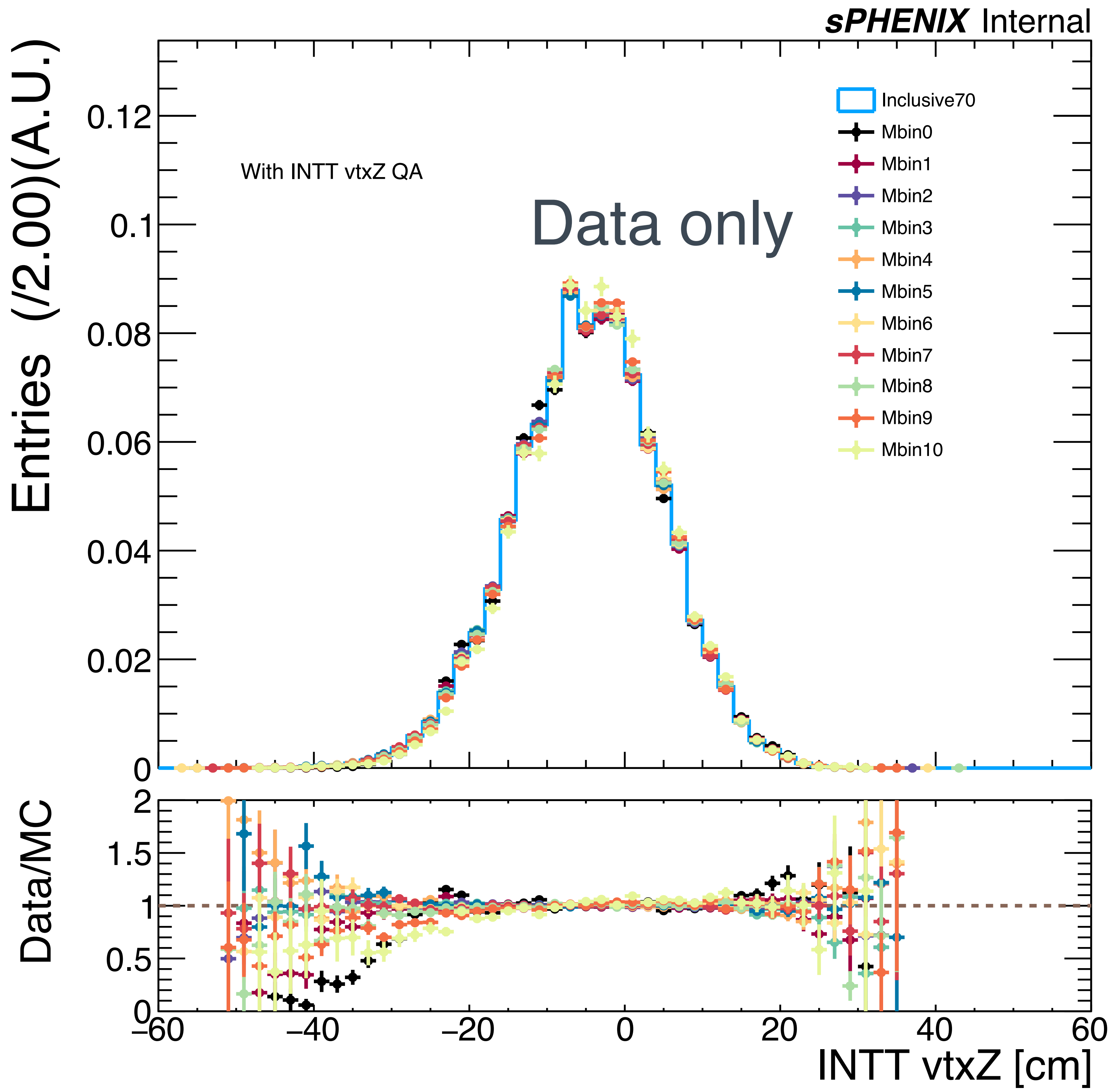
MBD behaviors

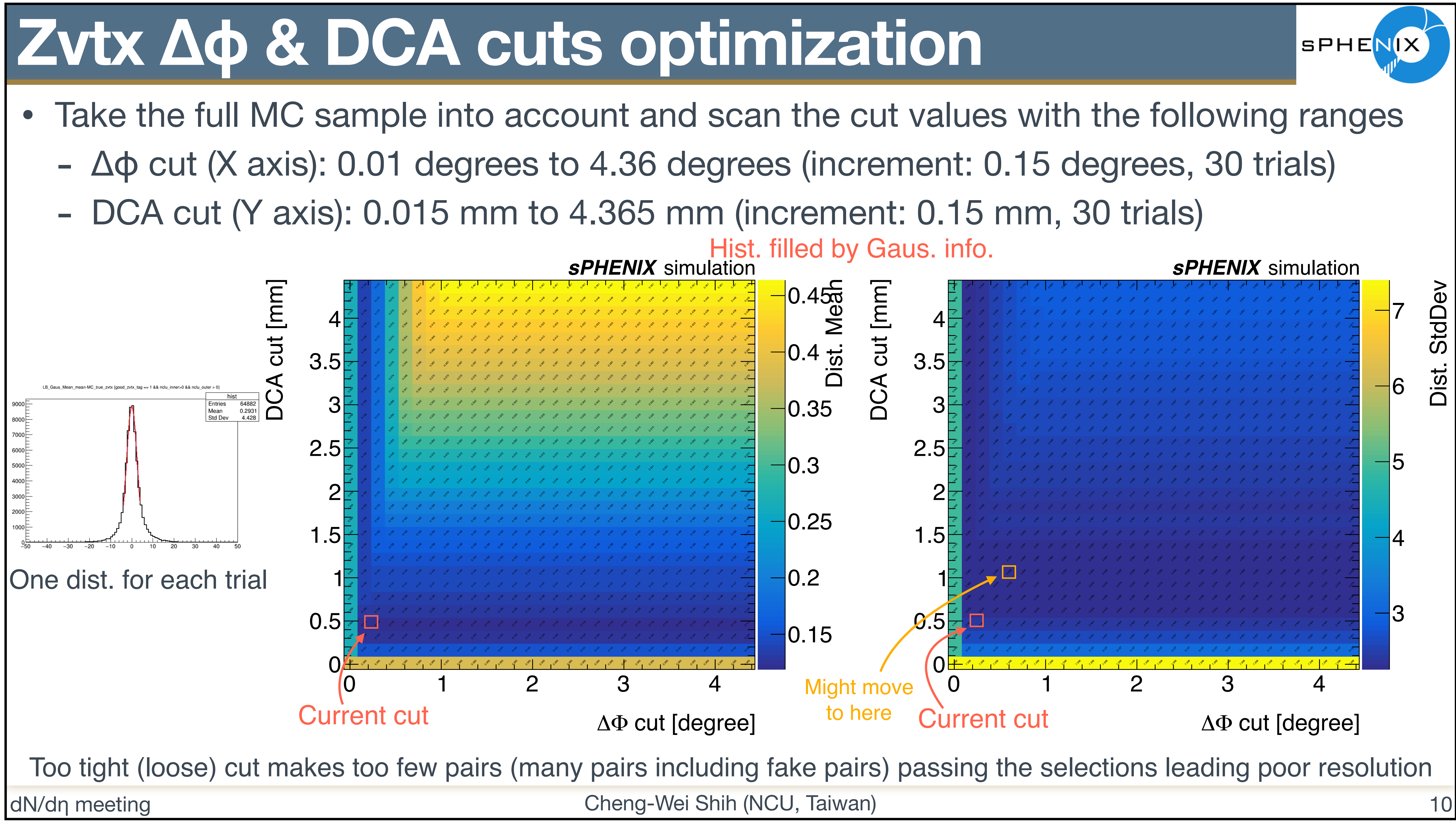
Run 54280, first 3M



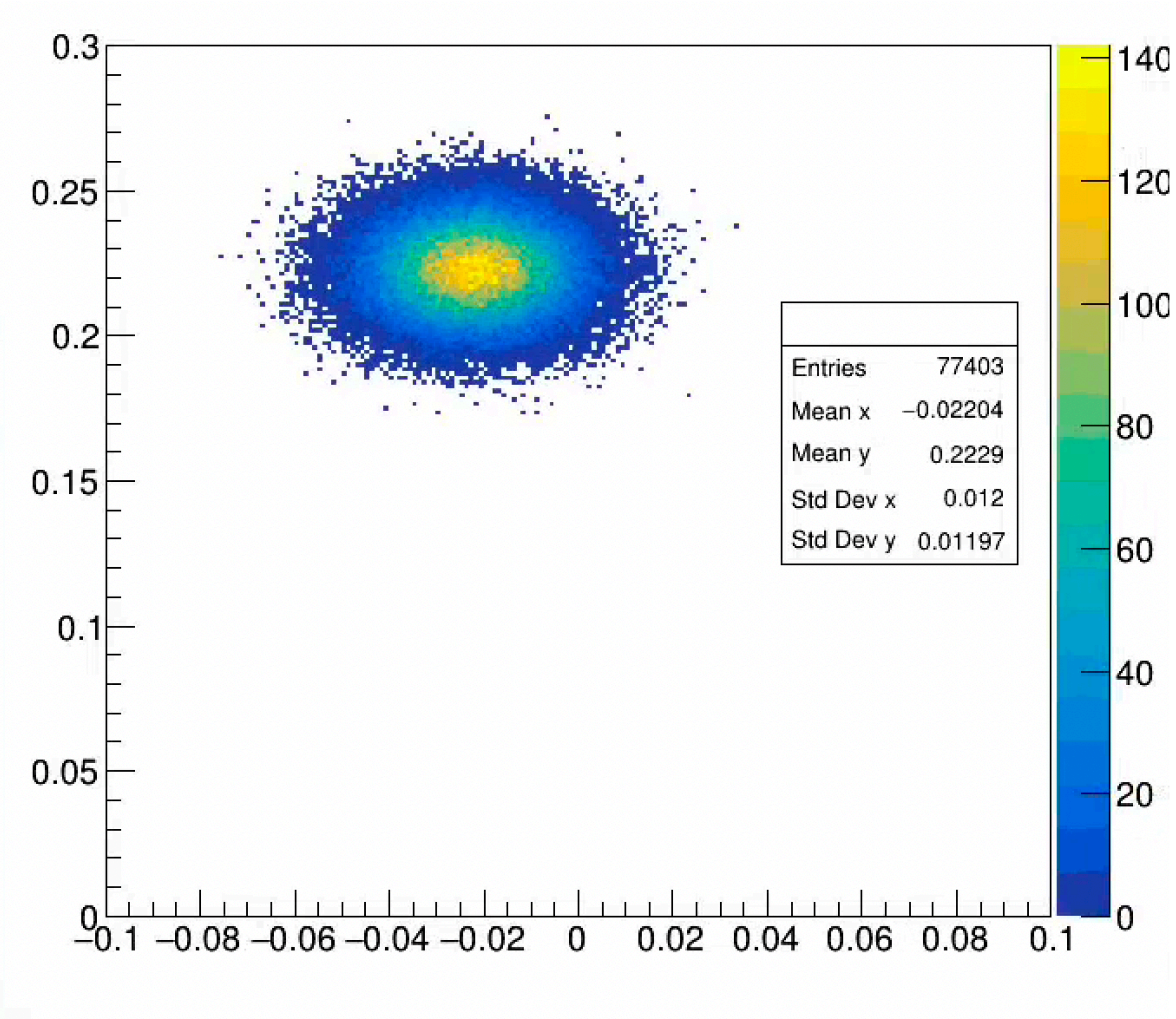
PerEvent vertex Z

Current cut: DCA: 0.1 cm && DeltaPhi: 0.6 degrees (supported by the previous scan study)



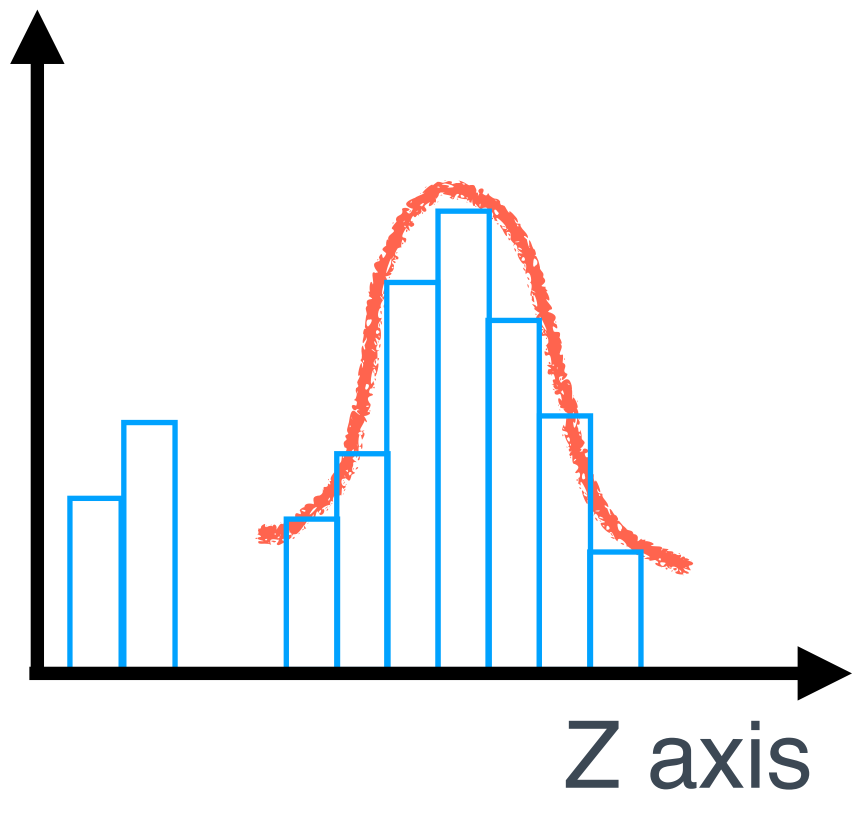


True vertex XY of this MC



INTT vtx Z QA, cut intro

“gaus + offset” fit width

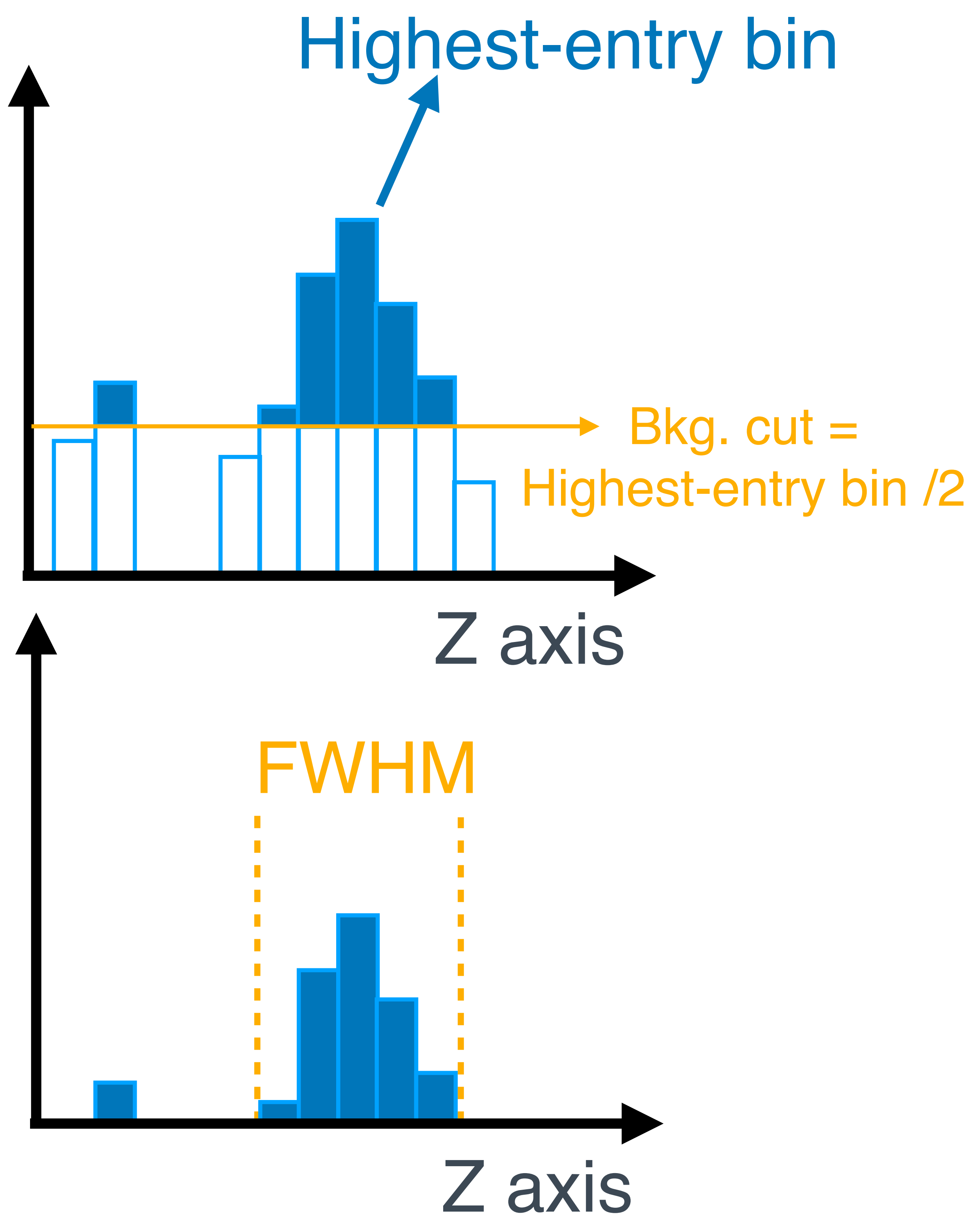


MC

Data

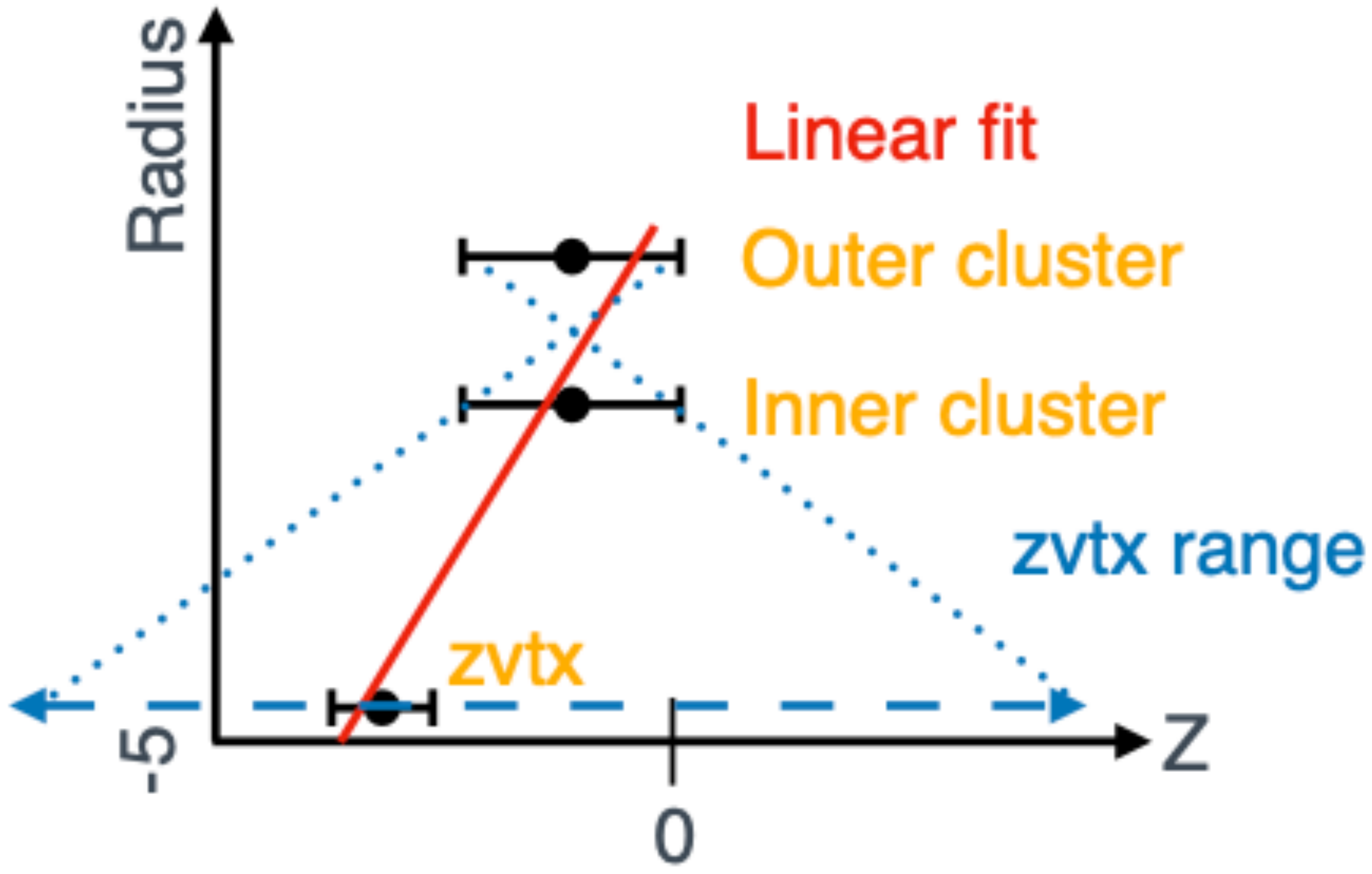
MC

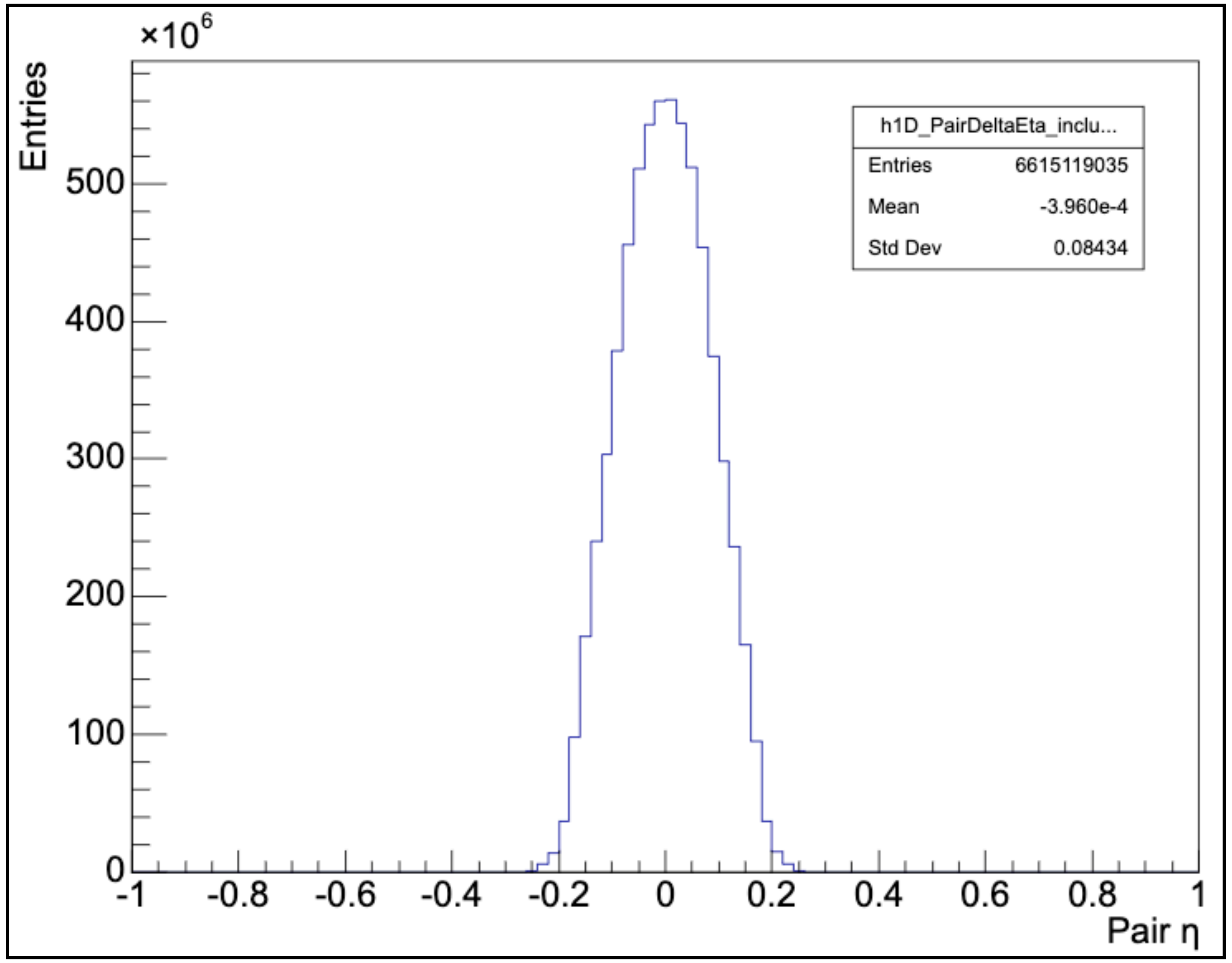
Data



Pair selection for PHOBOS approach

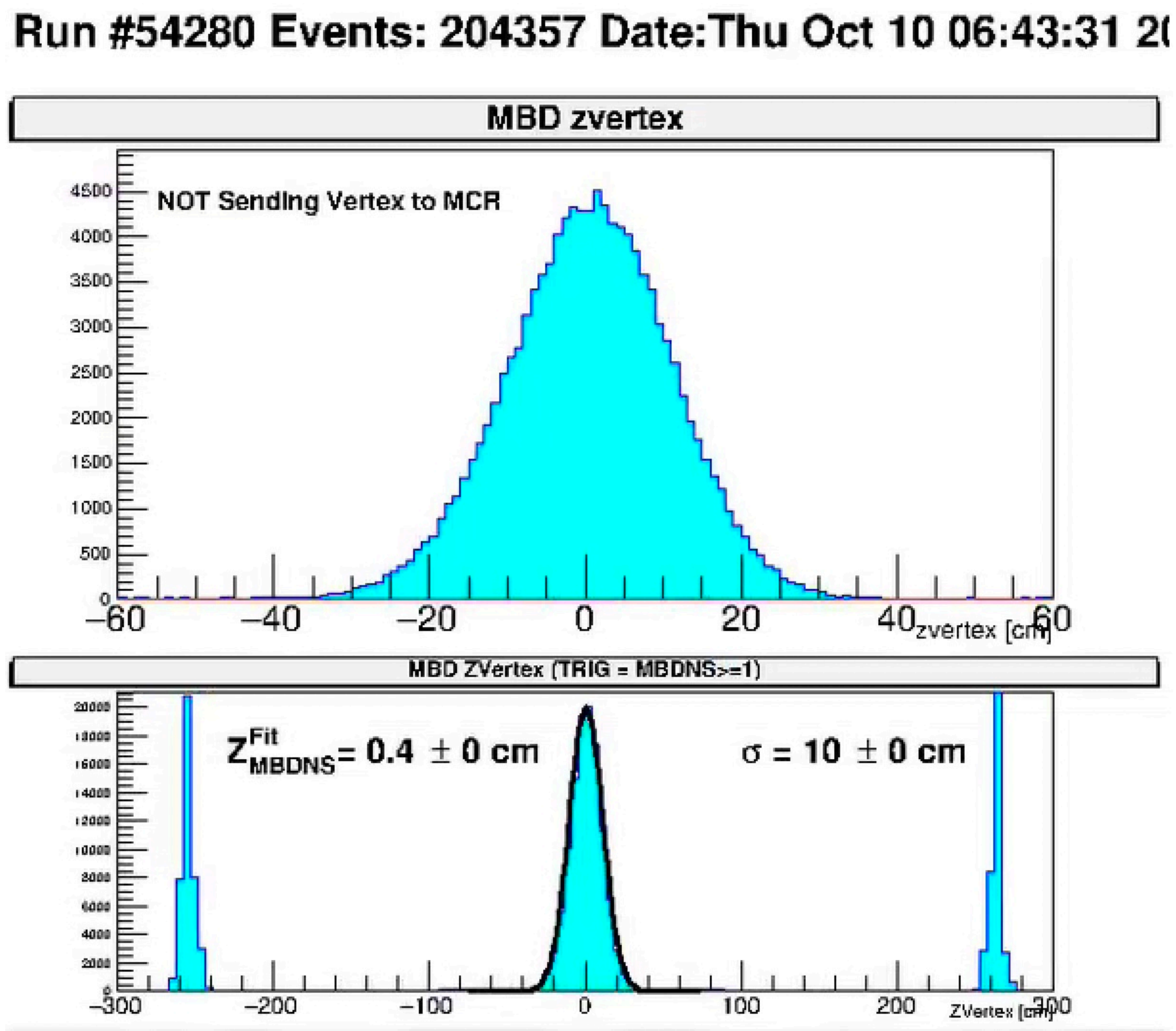
Pairs link to the vertex Z





Run description - 54280

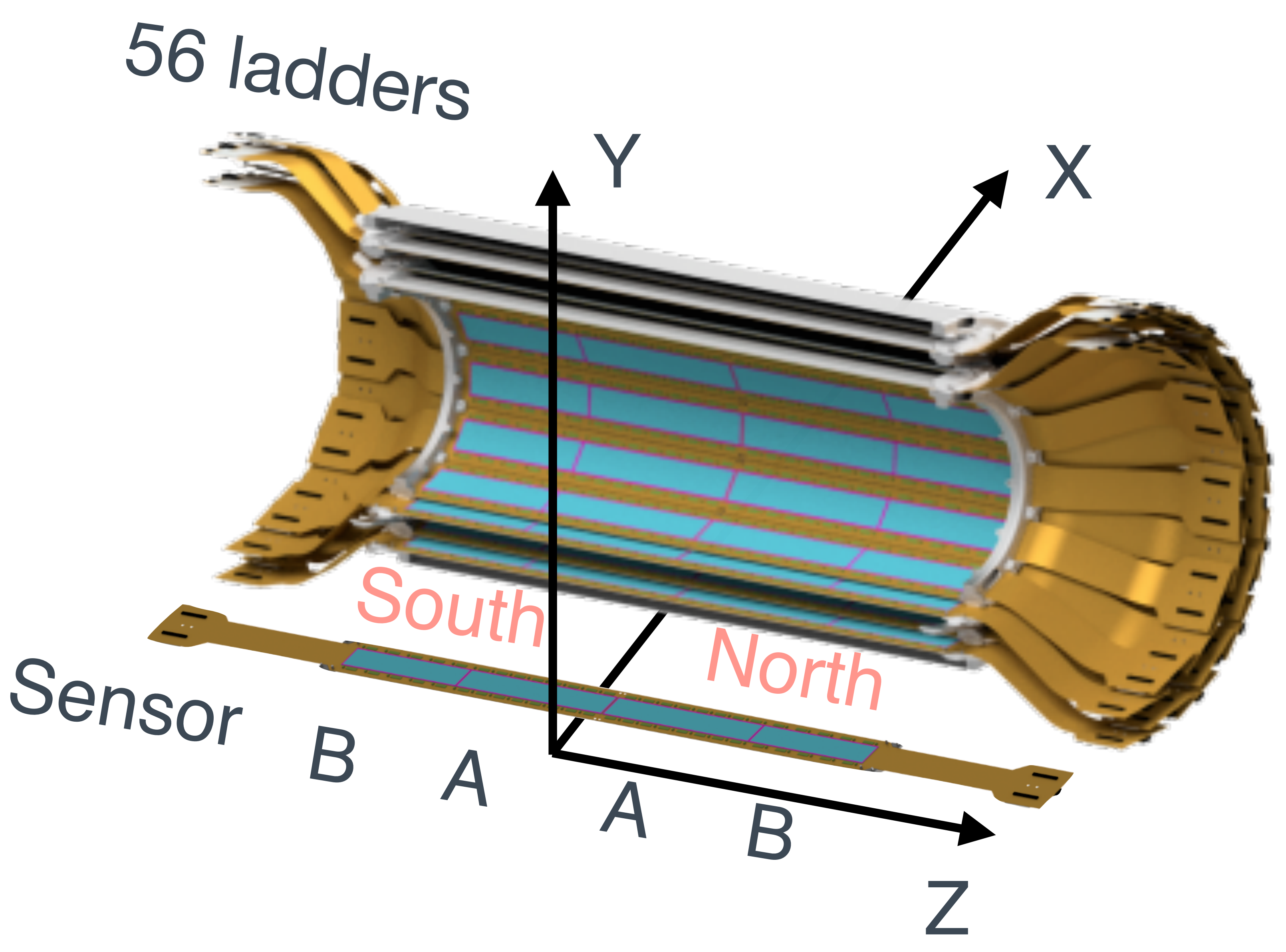
- Spike appears at each end of MBD
- The mini-bias definition is not yet available (as far as I know)
- Live trigger available to constraint the MBD vertex Z



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

INTT geometry

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

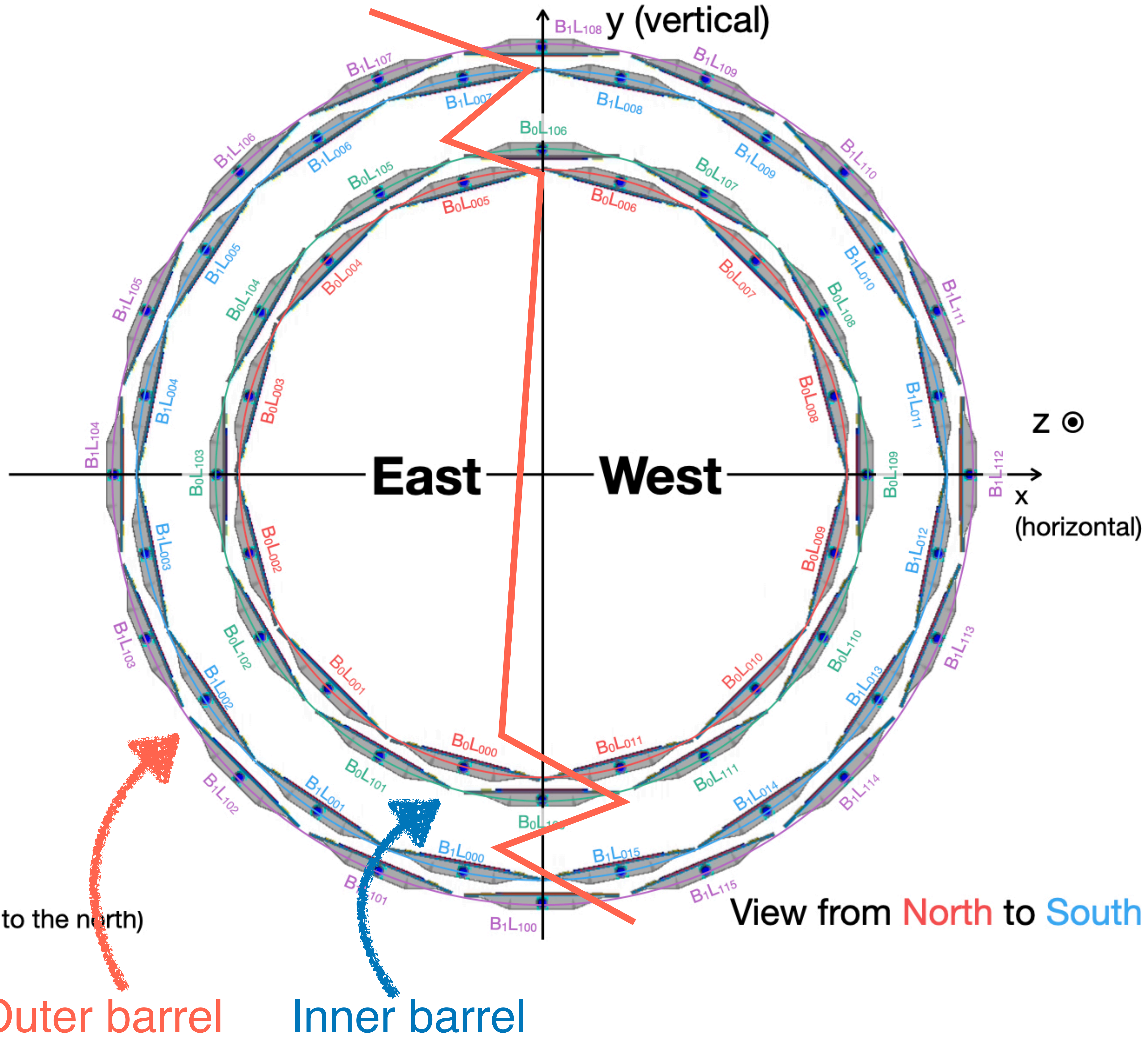


Notation: B_xL_{yzz}

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)