National Central University & RIKEN

June 16th, 2024 INTT meeting



INTT vertex Z reconstruction

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Vertex Z - procedures

- 1. Update the cluster ϕ and radius based on the reconstructed average vertex XY
- 2. Loop over all the inner and outer cluster pairs, keep the pairs which pass the $\Delta \phi$ cut and DCA cut (proto-tracklets)
- 3. Move to the Z-Radius plane. For each proto-tracklets, the full strip lengths of the two clusters (inner and outer) are considered. Project the **possible vertex Z*** to the Z axis (radius = 0)
- 4. Fill all the **possible vertex Zs*** of all the proto-tracklets into the histogram
- 5. Fit the distribution with **Gaussian function + offset** to determine the reconstructed vertex Z for single event (fit parameter and fit range tunable)

Possible vertex Z^{*}: the shapes are different based on the methods INTT meeting









- Suggestion given by Akiba san
- i.e., weighting the entry by (1./"possible vertex Z range")

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3 Sigma 1.81223e+00 3.67564e-02 1.70493e-05 1.71654e-02	F
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2 Mean 3.38231e-02 1.91429e-02 5.48619e-07 -2.23329e-04	
3 Sigma 1.84386e+00 2.77961e-02 -4.67244e-06 5.17198e-03	-
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2 Mean -2.01406e-01 3.01065e-02 2.74847e-05 -1.25034e-03	

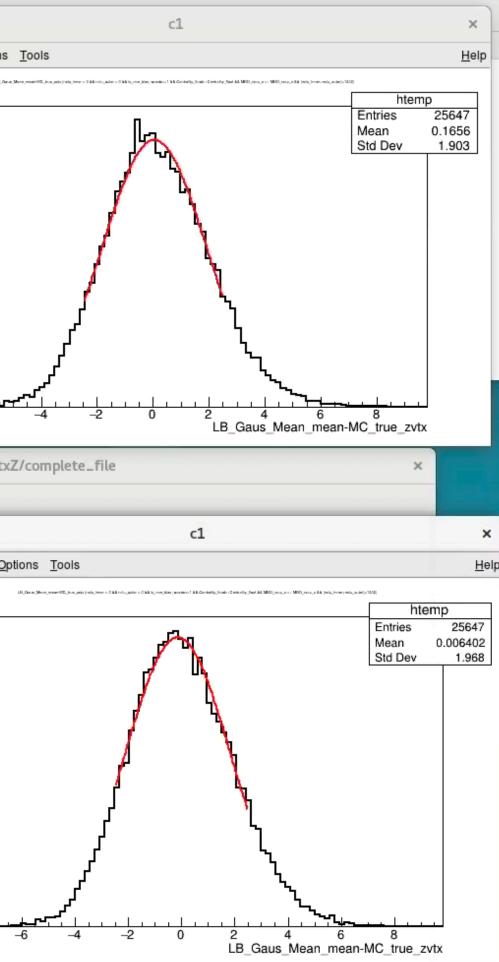
2.02799e+00 5.45754e-02 -8.71696e-06 -3.11292e-04 3 Sigma FitResultPtr) <nullptr TFitResult> >ot [9] htemp->Fit("gaus","","",-2.5,2.5) 400 CN=31.3958 FROM MIGRAD STATUS=CONVERGED 68 CALLS 69 TOTAL EDM=1.38919e-08 STRATEGY= 1 ERROR MATRIX UNCERTAINTY 3.5 per cent EXT PARAMETER STEP FIRST 200 NAME ERROR SIZE DERIVATIVE NO. VALUE 9.62338e+02 9.47119e+00 8.28067e-02 2.37302e-05 1 Constant 2 Mean -1.48302e-01 2.08696e-02 -2.11826e-05 -4.23607e-03 1.95373e+00 3.12570e-02 -5.09078e-05 4.01835e-02 3 Sigma FitResultPtr) <nullptr TFitResult>

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.a+ [101 □
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• Idea: the weight of each combination filled into the 1D histogram should be the same,



Entries weighted Fit mean : 3.382e-02 Fit width : 1.8439e+00

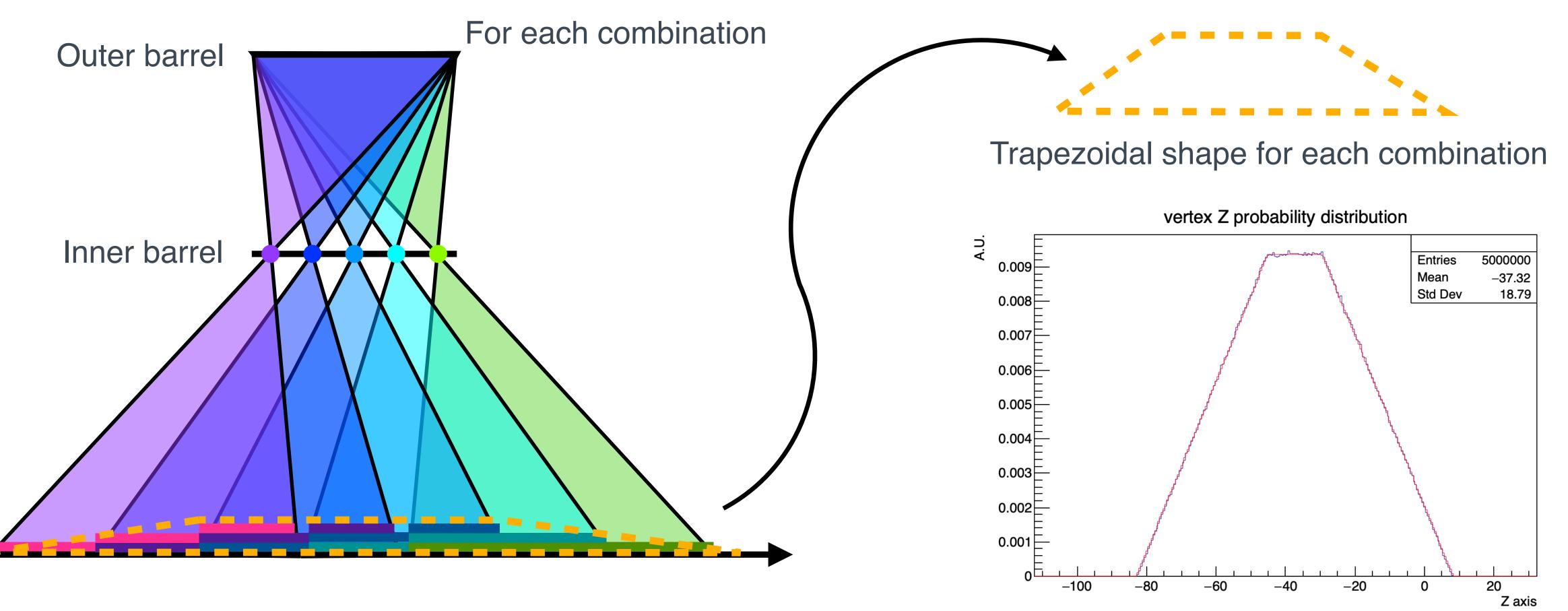
Original Fit mean : -1.483e-01 Fit width : 1.9537e+00

~6% improvements

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Vertex Z improvement - trapezoidal



Caveat: for each combination in single event, have to have the shape, and fill that into histogram, not trivial... Not easy, but still have the way to make it happen

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Idea given by Akiba san. For each combination, take into account of the distribution of the possible vertex Z range, and normalize the distribution, and fill into the histogram. (Used to assume the Uniform distribution of the vertex Z)

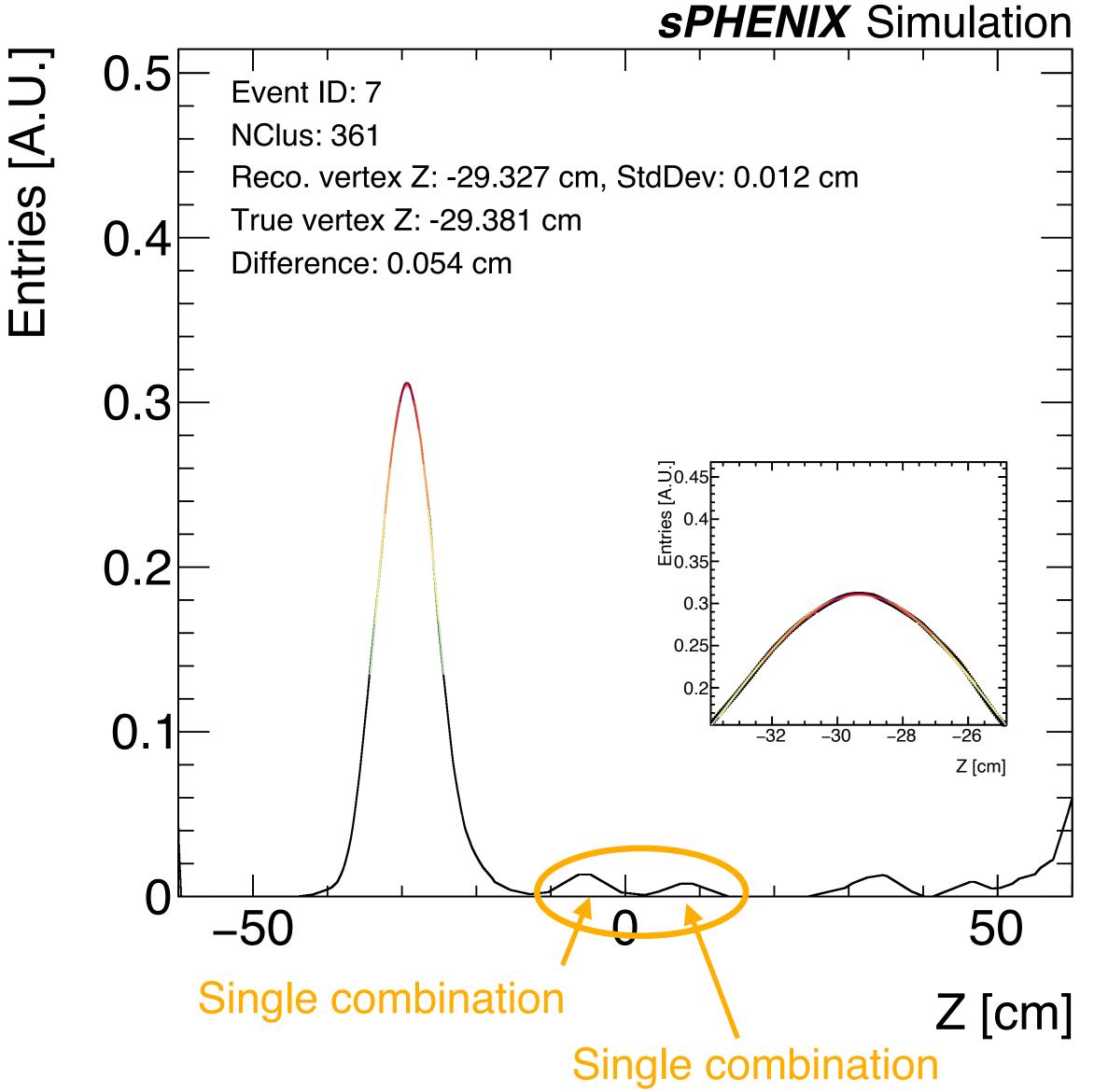
Justification of using possible vertex Z range / sqrt(12): The region with higher probability is presumably selected







Vertex Z improvement - trapezoidal



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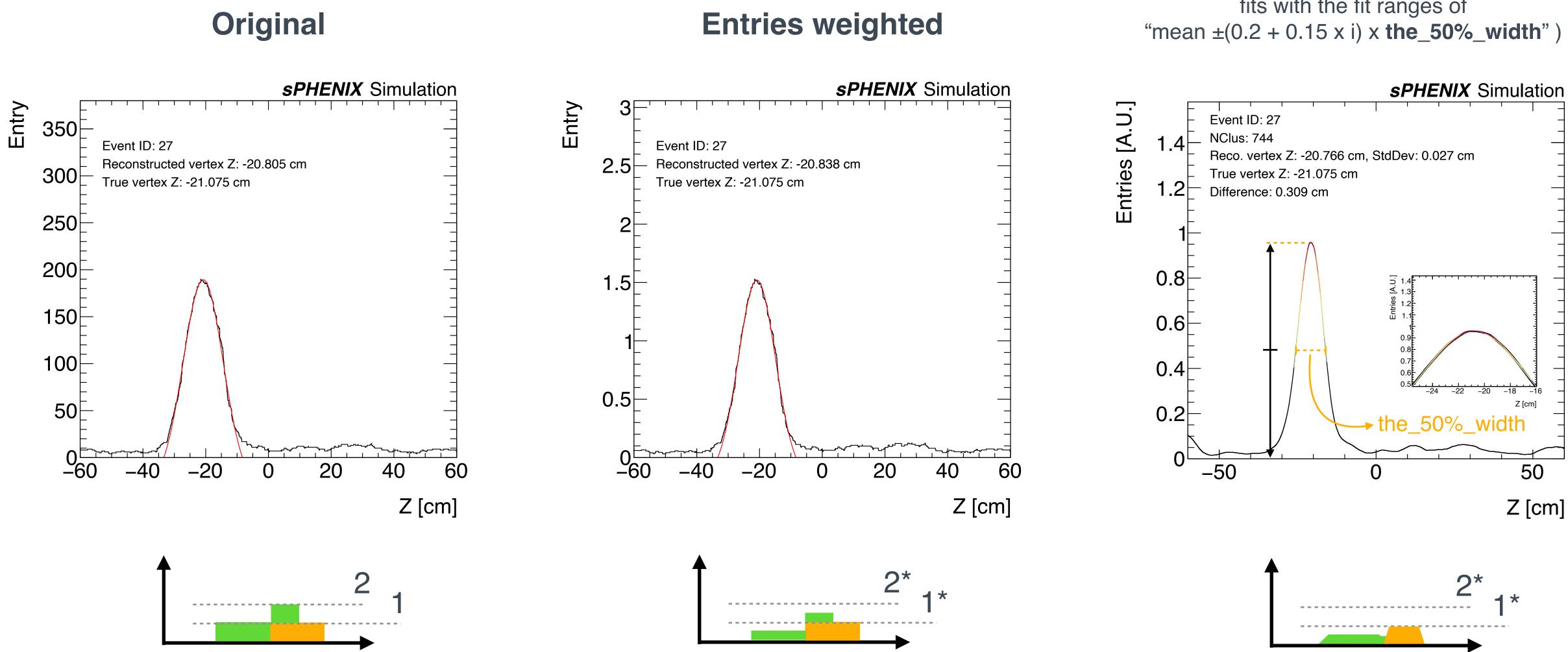
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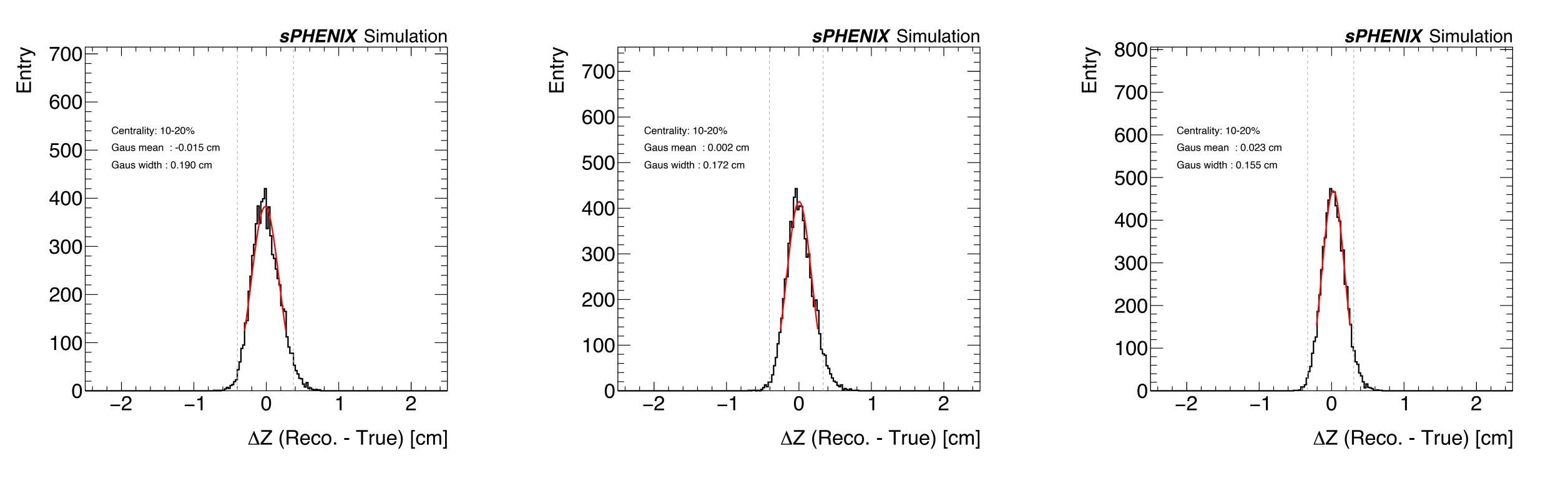
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Trapezoidal

(final vertex Z given by average of 7 gaussian fits with the fit ranges of







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Very central events

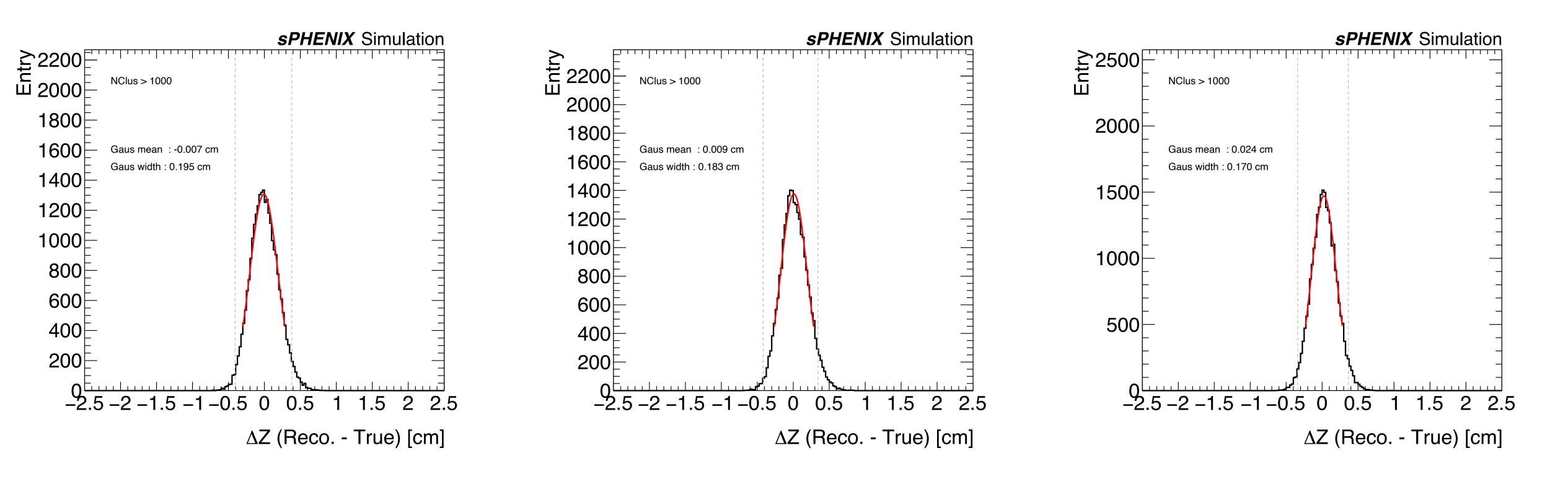
9.5% improvement

18.4% improvement





Number of valid clusters > 1000



Valid clusters: cluster adc > 35 && cluster phi size < 6

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6.2% improvement

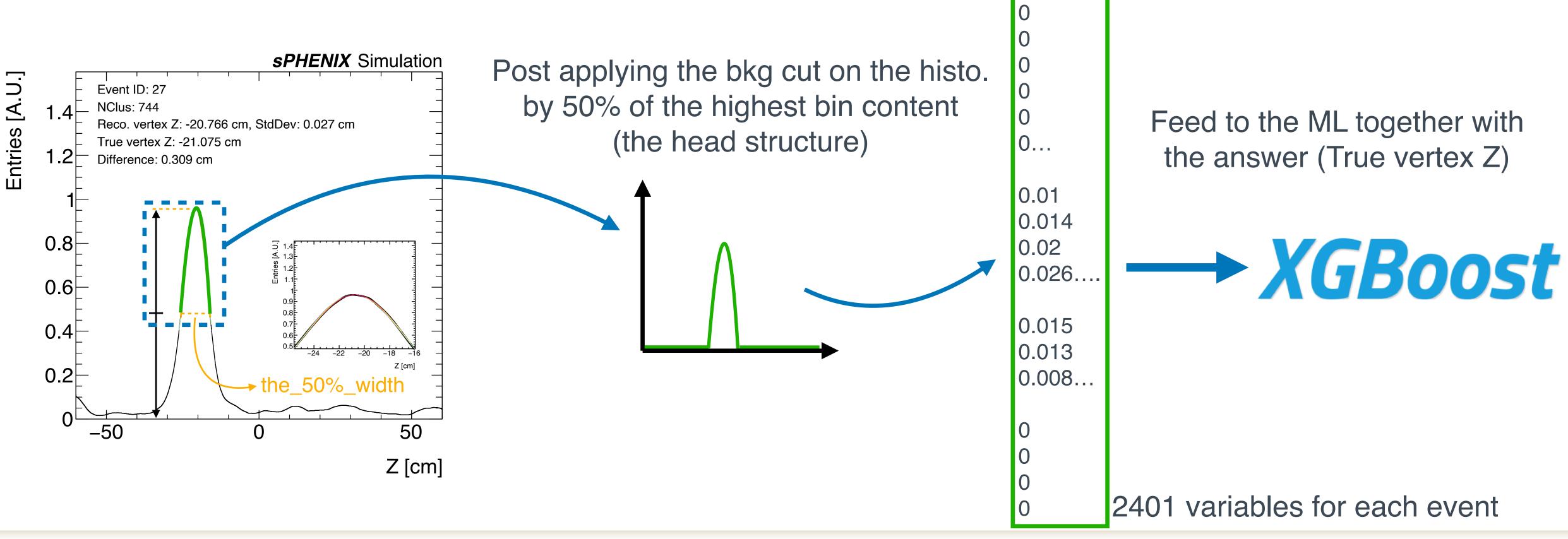
12.8% improvement





Determining the vertex Z from the histogram SPHENX

- New trial: after having the histograms made of possible vertex Z ranges, use ML (XGBoost) to do the final vertex Z determination
- Training variables: the content of each bin of the histogram post the 50% entry cut (2401 variables currently, corresponding to the number of bins of histogram)
- Total MC events: 80k (80% training, 20% testing)



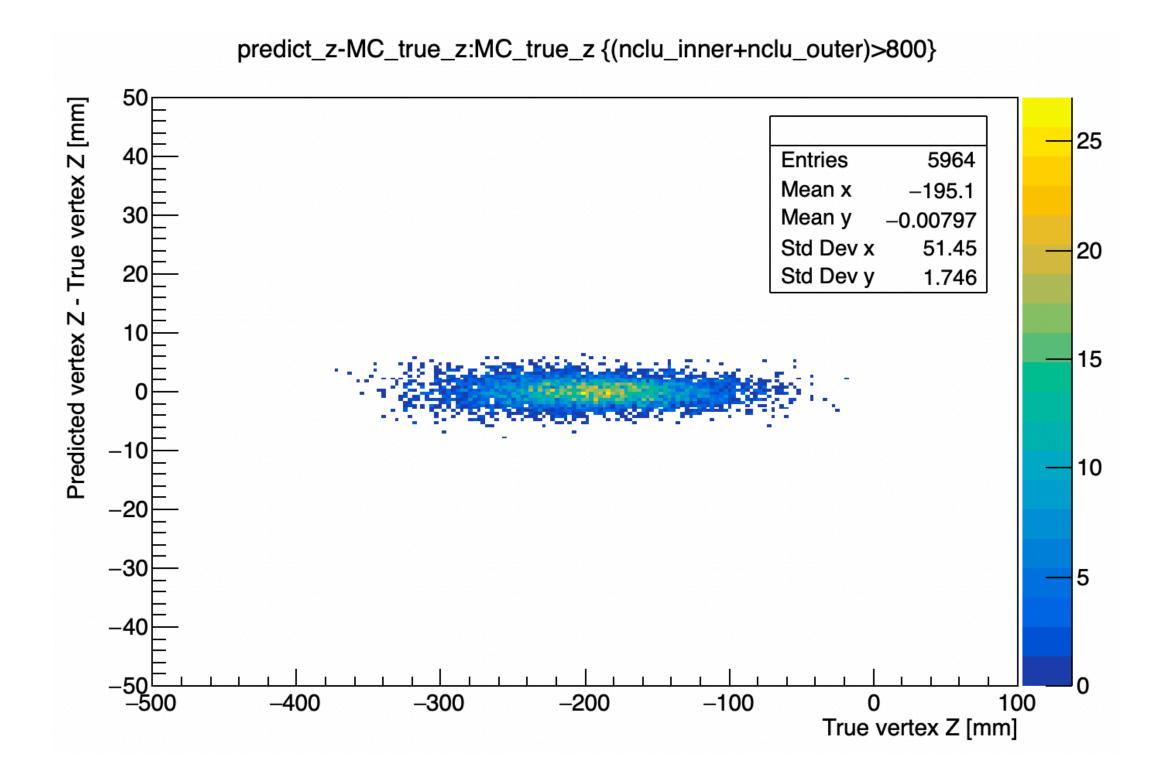




Determining the vertex Z from the histogram SPHENX

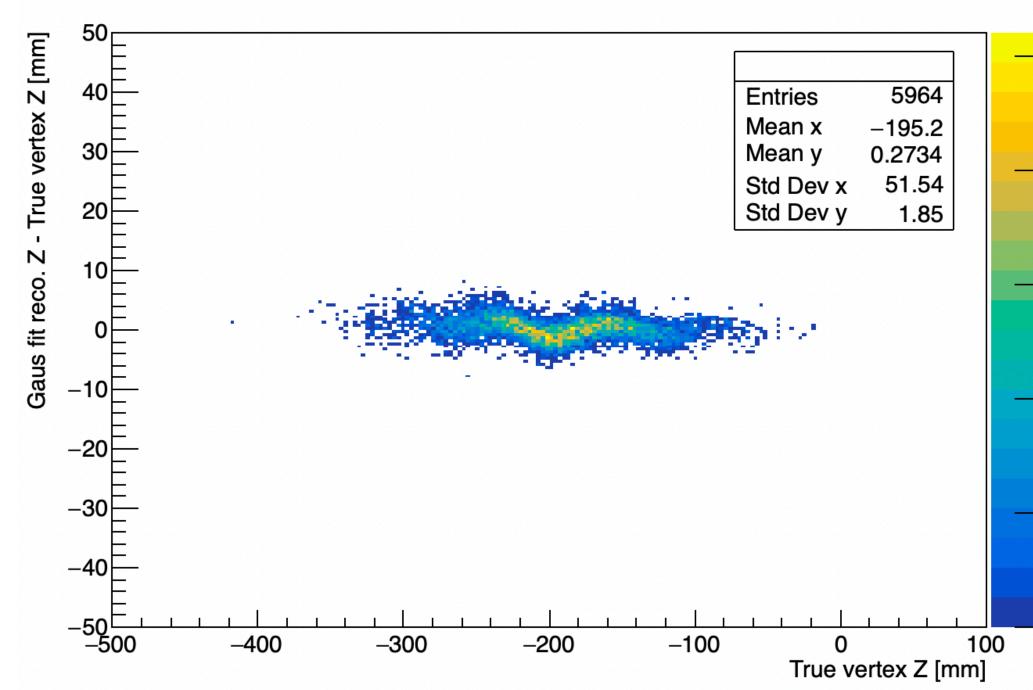
The test sample 20% of the total MC events

Reco. vertex Z predicted by training model



Reco. vertex Z by 7 Gaus fittings

fit_reco_z-MC_true_z:MC_true_z {(nclu_inner+nclu_outer)>800}



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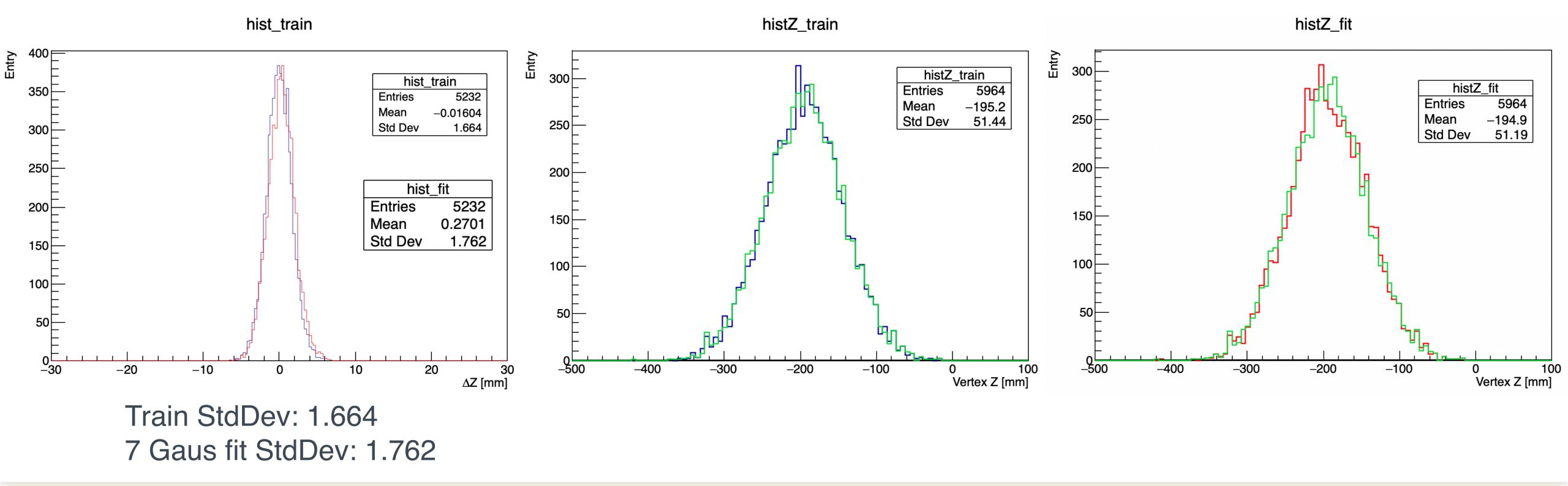


Determining the vertex Z from the histogram SPHENX

The test sample 20% of the total MC events







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- Reco. vertex Z predicted by training model
- Reco. vertex Z by 7 Gaus fittings
 - Number of cluster* > 800



Summary and thoughts

- With the trapezoidal describing the shapes of the possible vertex Z range for each combination and the entry normalization involved, (I think) we are really touching the limit of the vertex Z determination by INTT standalone data, which is good!
- IMHO, the avg_7_Gaus_fit is already very optimal, but nevertheless, just thinking out loud, giving the ML a try
- It seems that the ML does not improve the resolution "that much", (I think) which indicates that, again, we are touching the limit
- But ML seems to have the capability to mitigate the wiggling structure at the vertex Z around -20 cm, which makes this approach promising (maybe not the run24 needs to worry about), but more check is needed for sure (retrain with higher statistic, etc)
- Concern: data/MC discrepancy, model overtrain. For data, can possibly (only) be validated by cross check study with MBD vertex Z









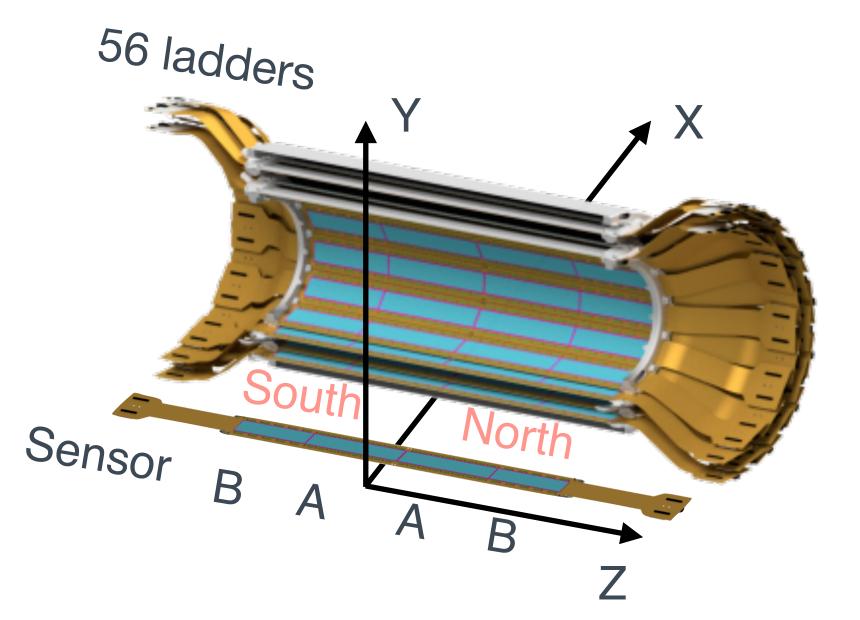


Back up

INTT geometry

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

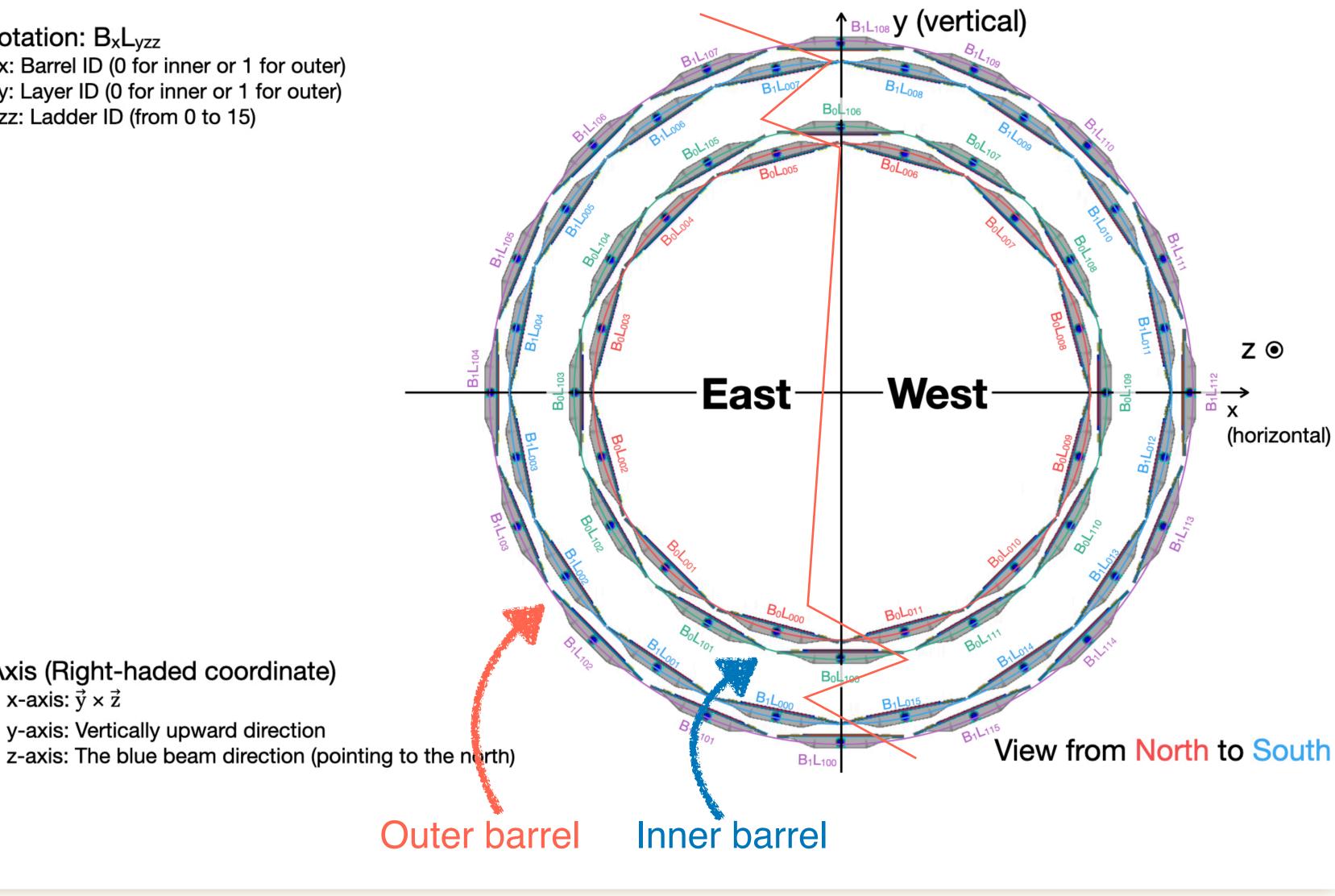
Notation: B_xL_{yzz} x: Barrel ID (0 for inner or 1 for outer) y: Layer ID (0 for inner or 1 for outer) zz: Ladder ID (from 0 to 15)



Axis (Right-haded coordinate) x-axis: $\vec{y} \times \vec{z}$ y-axis: Vertically upward direction

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