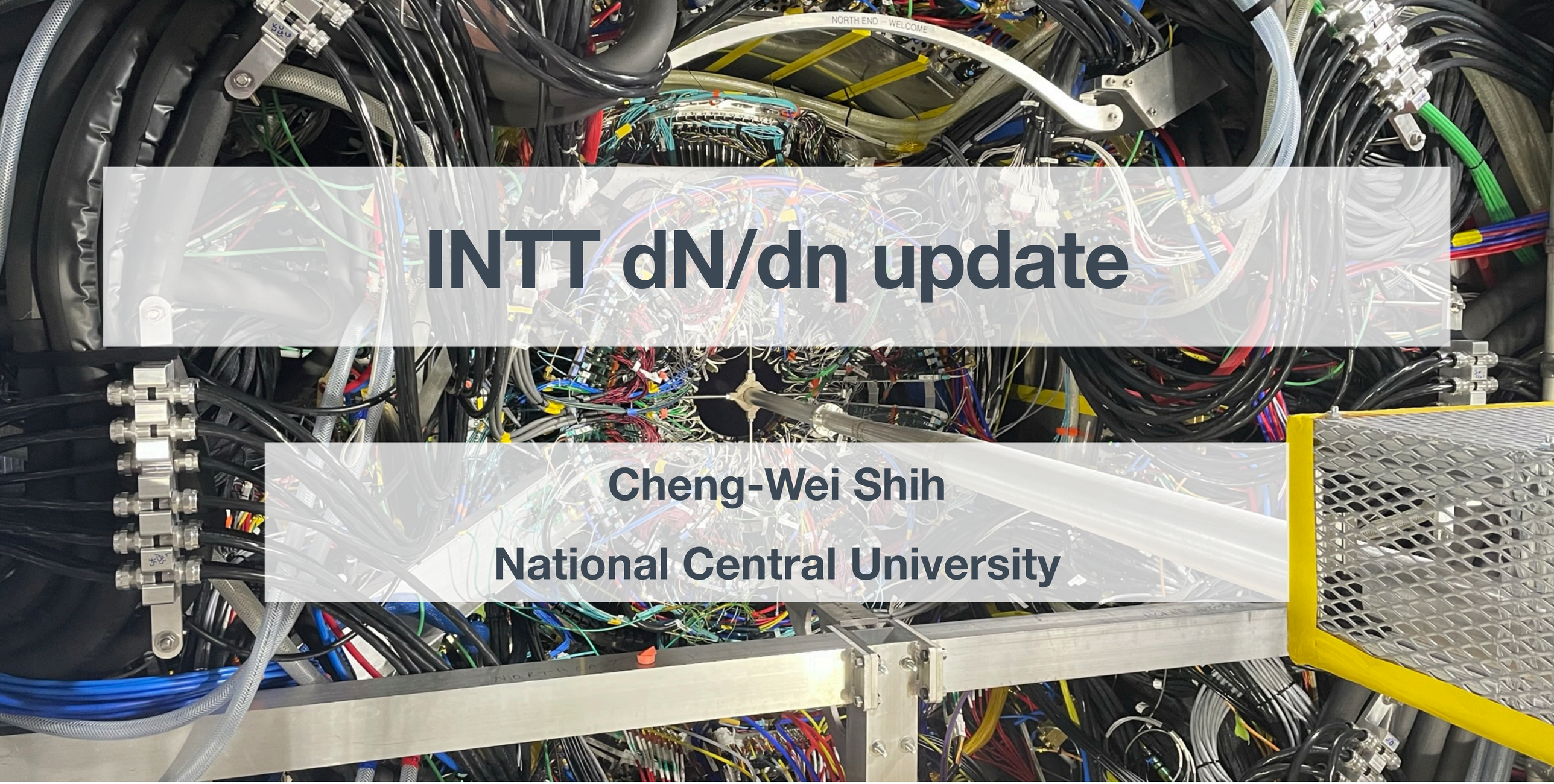


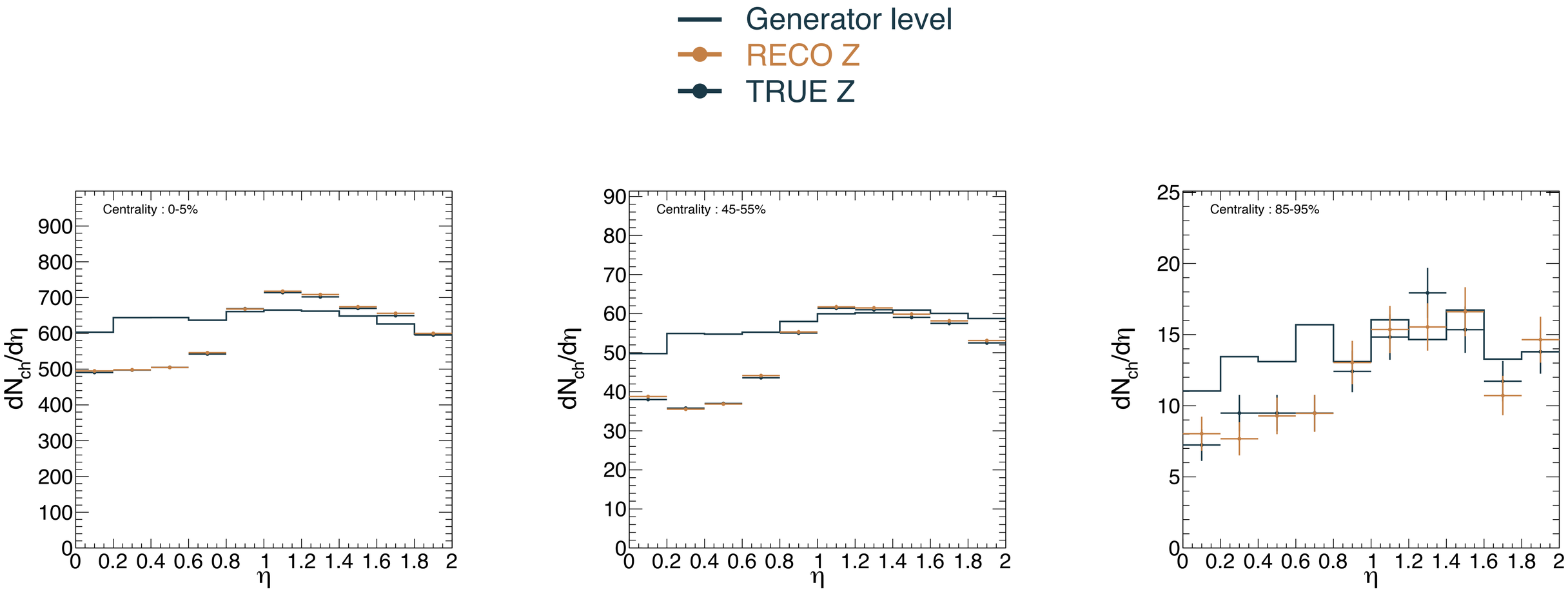
INTT dN/dη update

Cheng-Wei Shih

National Central University

March 6th, 2024
INTT meeting

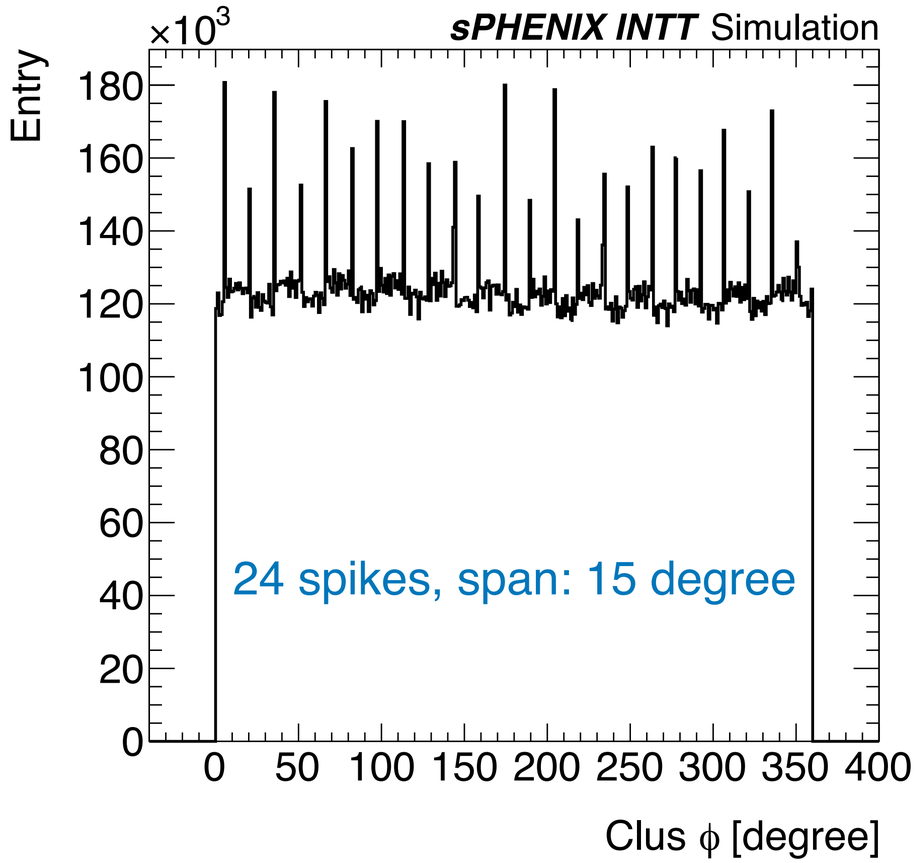
Tracklet counting with reco/true zvtx



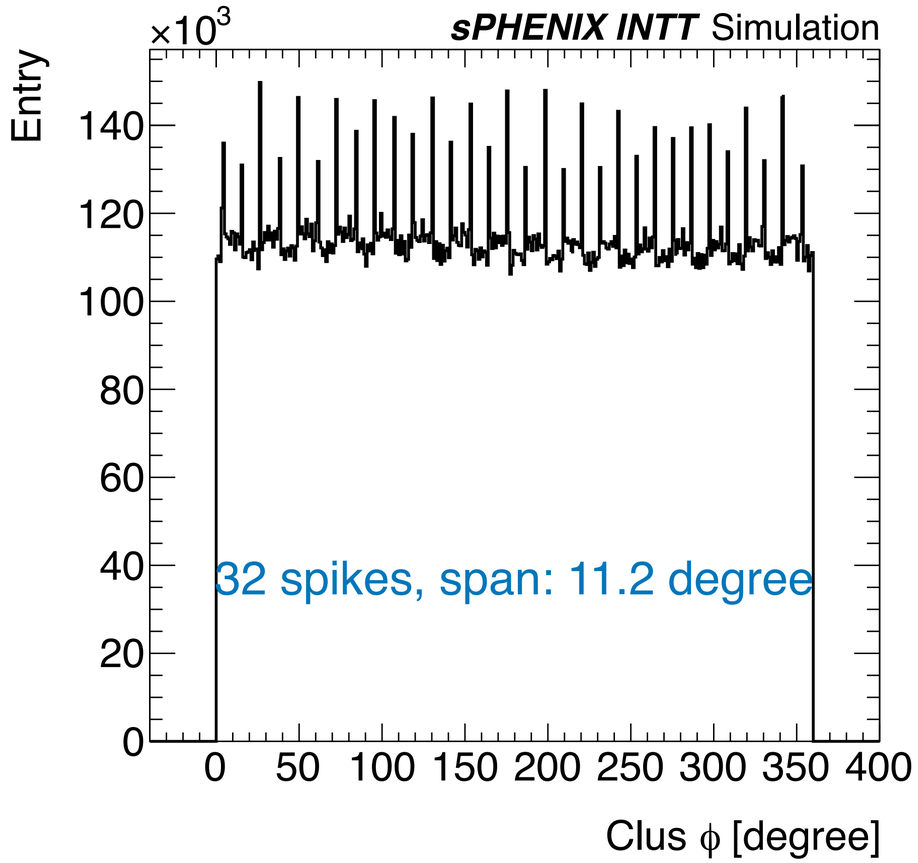
Z resolution seems not to affect the final counting too much (even in low multiplicity)

Cluster ϕ distribution

Inner barrel



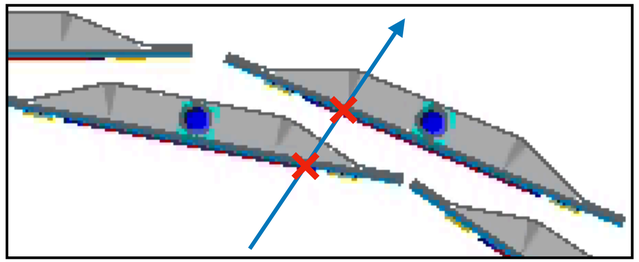
Outer barrel



Spikes: the overlap region in INTT due to the design

Mega (3/4-cluster) track finder

- Correct the cluster ϕ and radius based on the vertex XY
- 4-cluster track → 4-nested loops
  - One cluster in each sub layer (INTT: two sub-layers for each barrel)
  - Same Z strip index for the clusters in each INTT barrel
  - Searching window $|\Delta\phi| < 2$ degrees for each next-nest loop
  - The pair of innermost-sub-layer and outermost-sub-layer clusters links to the zvtx
  - Fit the pair with polynomial 0 in R-θ plane
  - Keep the proto-4-cluster track for the further selection after looping



- 3-cluster track → 3-nested loops
  - Two cases: 2 inner + 1 outer or 1 inner + 2 outer
  - One cluster in each sub layer
  - Same Z strip index for the clusters in each INTT barrel
  - Searching window $|\Delta\phi| < 2$ degrees for each next-nest loop
  - The pair of relatively inner sub-layer and relatively outer sub-layer clusters links to the zvtx
  - Fit the pair with polynomial 0 in R-θ plane
  - Keep the proto-3-cluster track for the further selection after looping

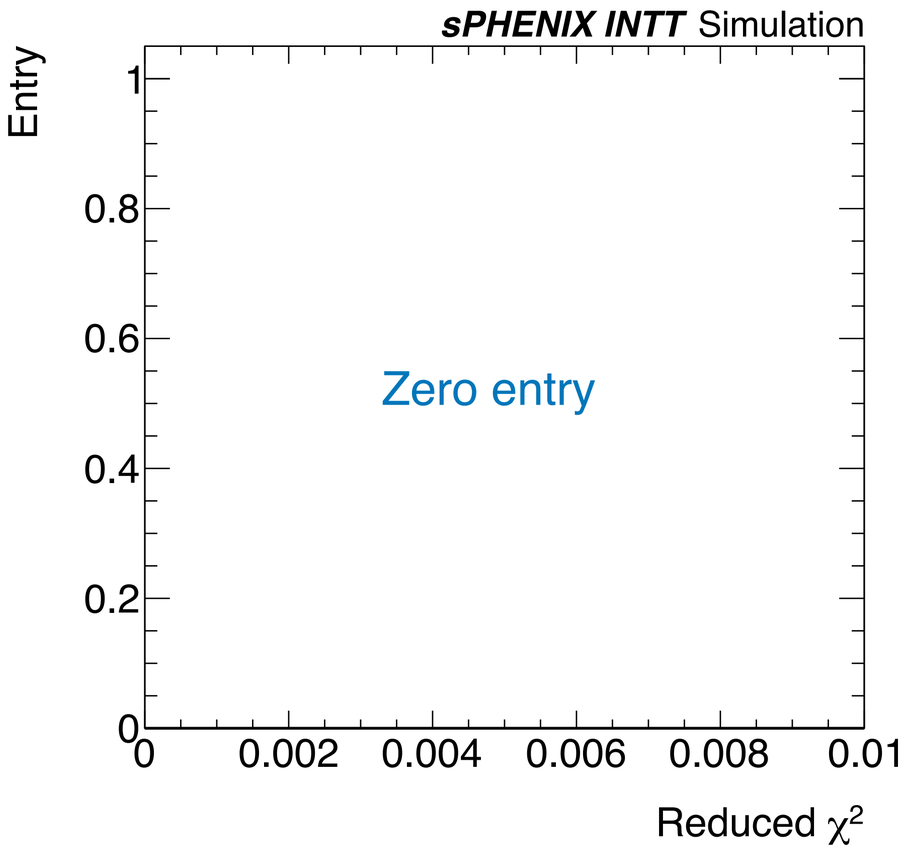
Mega (3/4-cluster) track finder

- Beginning with 4-cluster track (More tight selection)
  - Sort over the proto-4-cluster tracks based on the fit reduced χ^2
  - Start from the best one, if the reduced χ^2 < **certain cut value** → one 4-cluster track found. Mark the 4 clusters as used
  - Move to the next track. Skip the track as long as there is one cluster marked as used

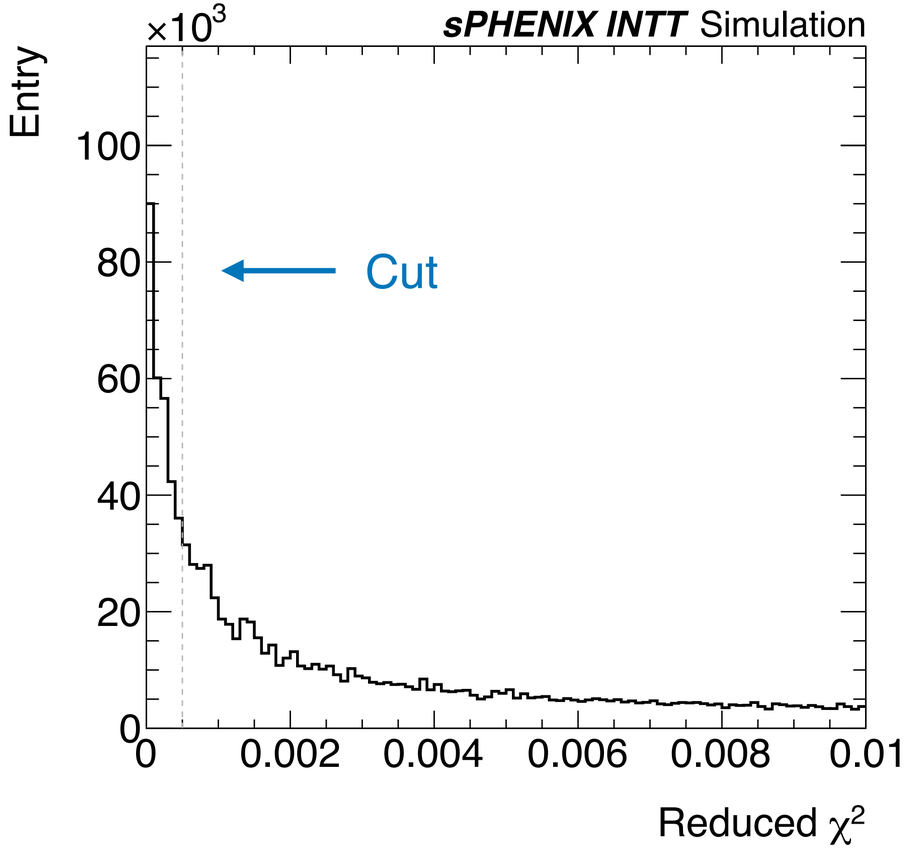
- Check the 3-cluster track with the **same cluster-mark map**
  - Combine two cases when checking
  - Same procedures as that of 4-cluster track

Cut value determination

4-cluster track



3-cluster track

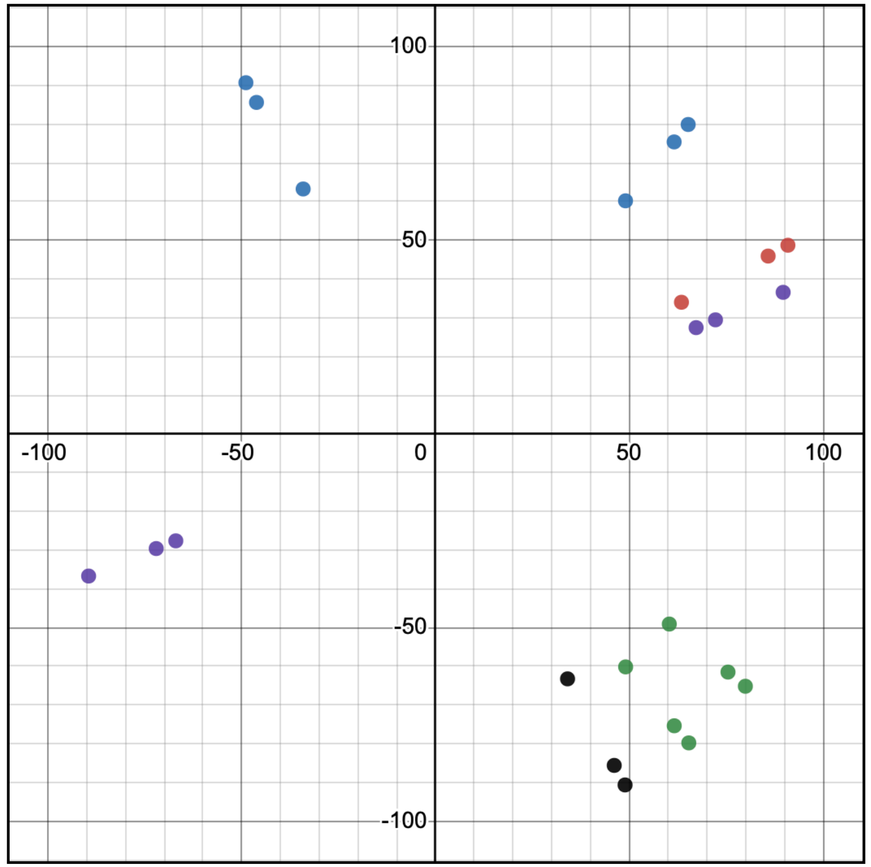


Cut value for 3-cluster track: 0.0005

Event display of 3-cluster track

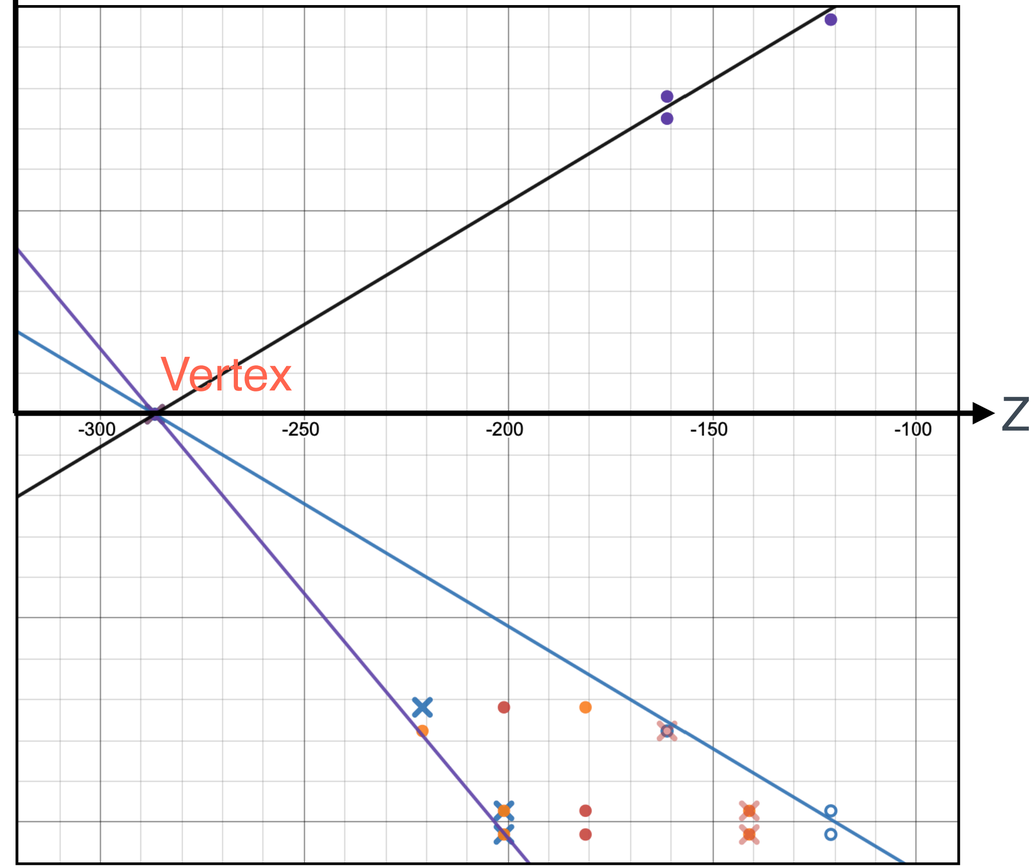
Color no correspondence b/w two plots

X-Y plane



Radius

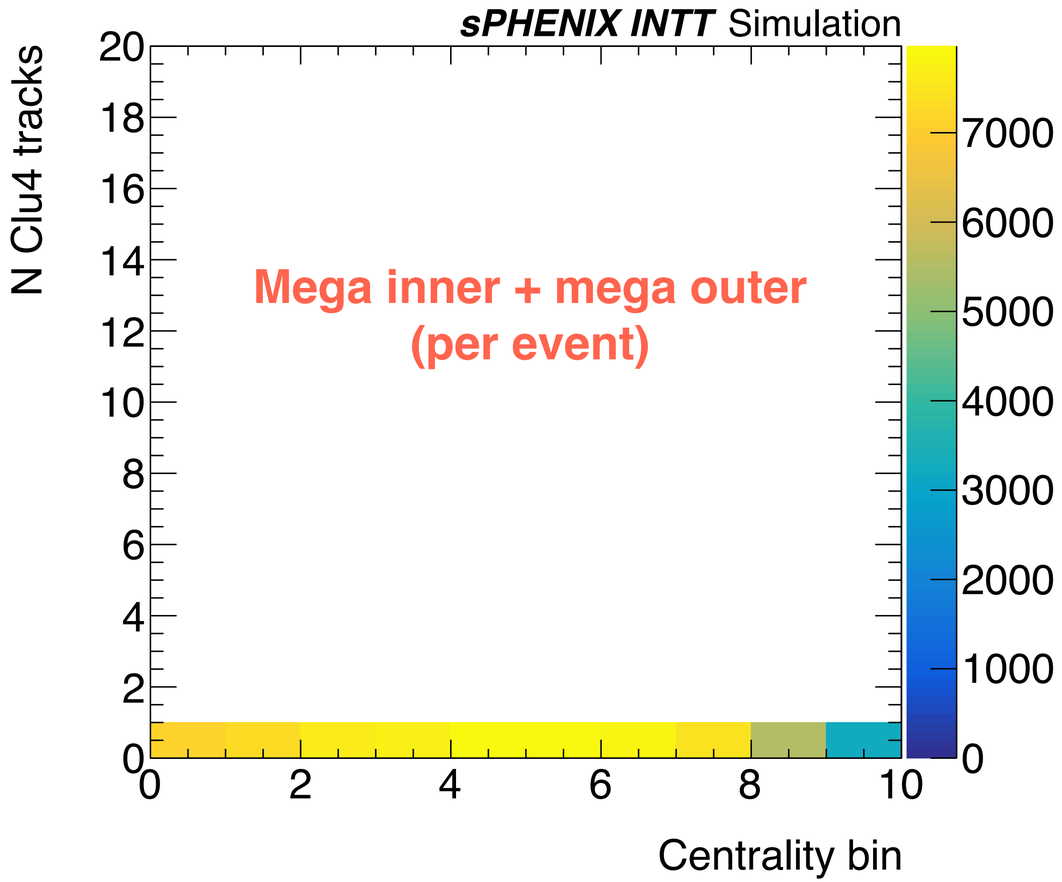
Z-radius plane



Negative radius: track with two outer clusters

The 4-cluster track

80k MC events
True zvtx with 0.5 mm dummy error, selected Z range: full range

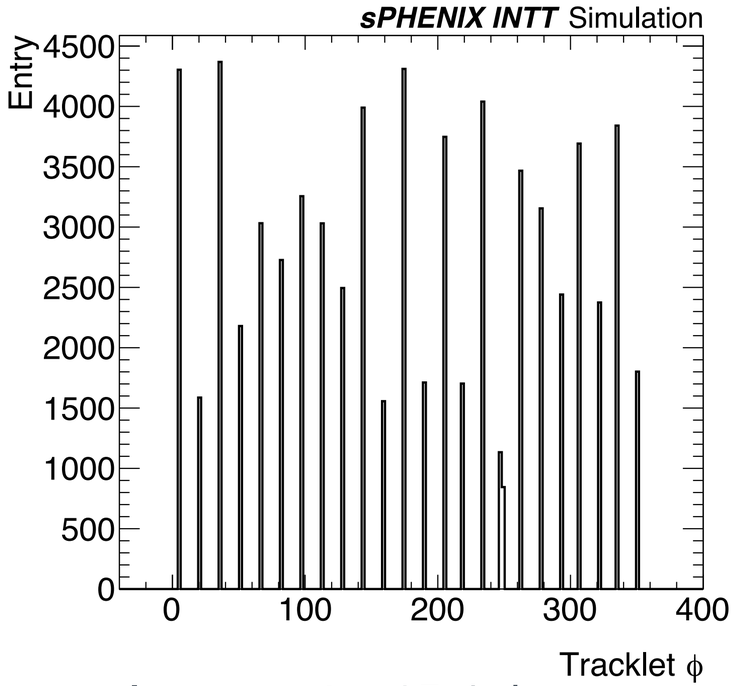


By design, we shouldn't see any 4-cluster tracklet

The 3-cluster track

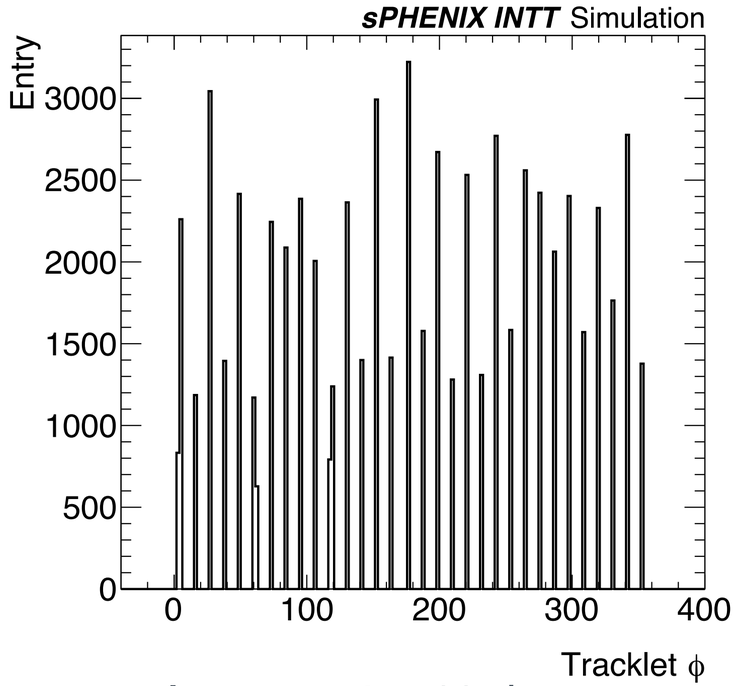
80k MC events
True zvtx with 0.5 mm dummy error, selected Z range: full range

Mega inner + single outer (in total)



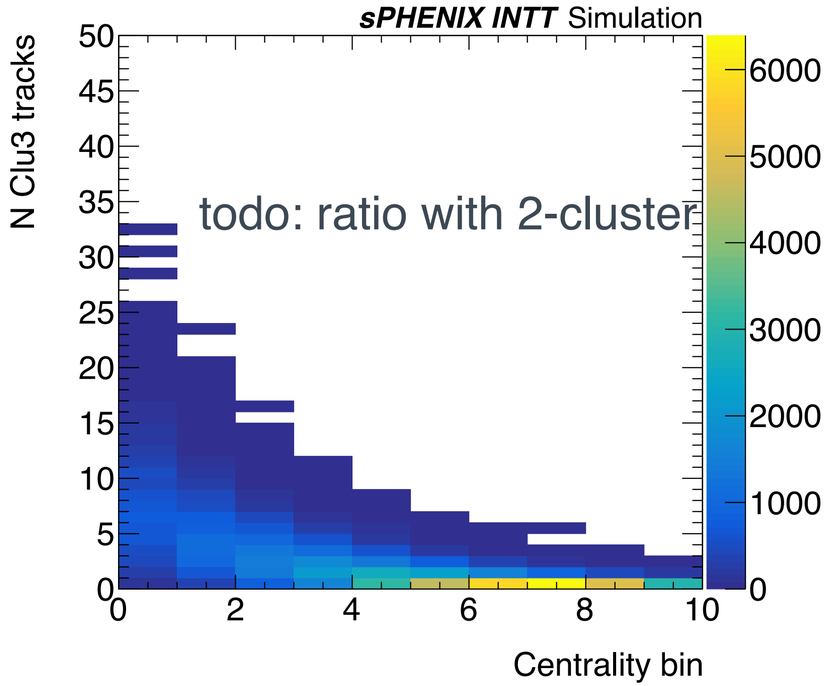
Increment: ~15.4 degrees

Single inner + mega outer (in total)



Increment: ~11 degrees

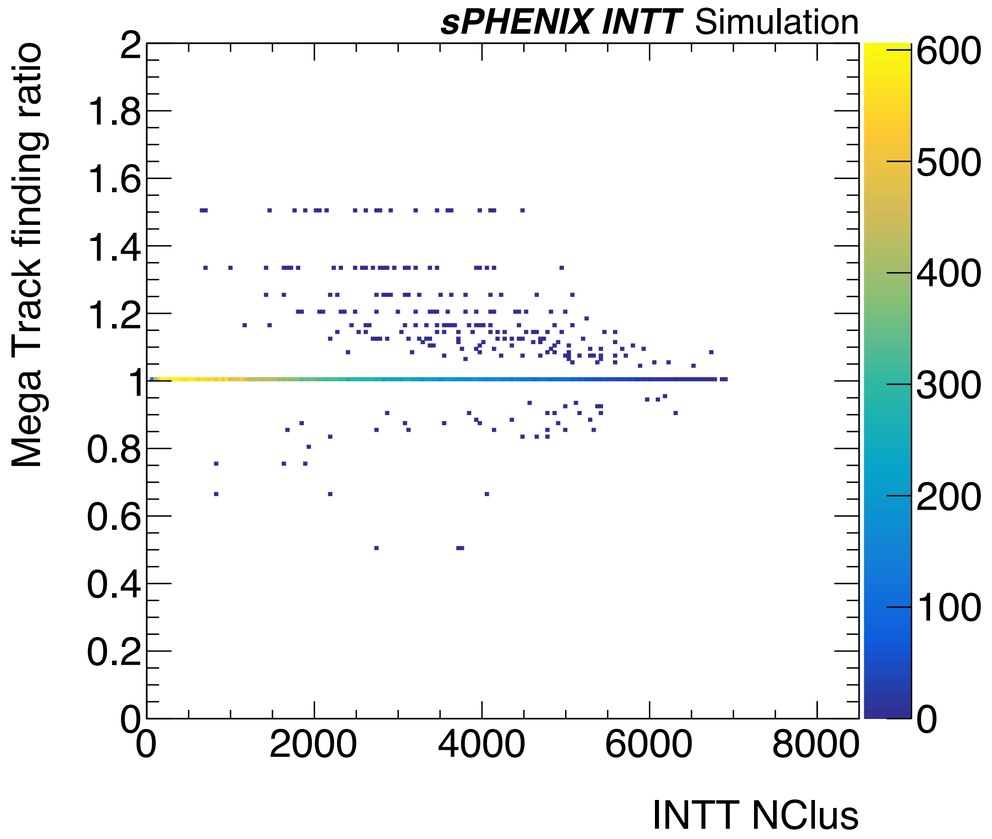
Combine (per event)



Equal increment → geometry effect
The 3-cluster tracklets are visible by design, but not so many

Mega track finding ratio

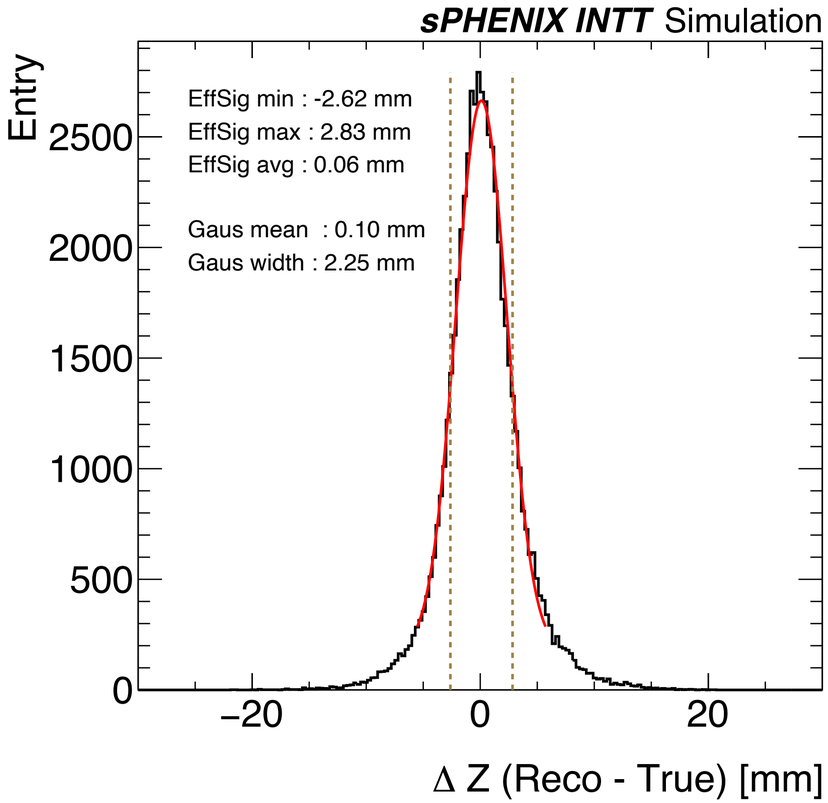
Mega Track finding ratio: N_{recoZ} / N_{trueZ}
True Z: with 0.5 mm dummy error
recoZ: Z resolution corresponding to the centrality bin



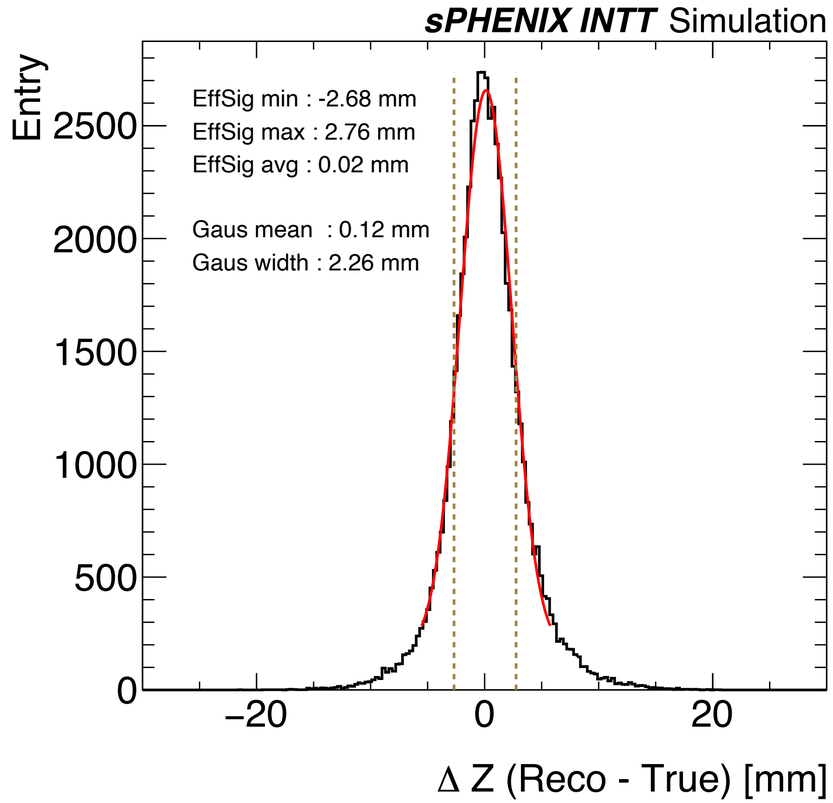
The mega track finding efficiency is quite high

Z resolution check

Without mega tracklet removal



Mega track removal prior to the zvtx reconstruction
(True zvtx with dummy error 0.5 mm)

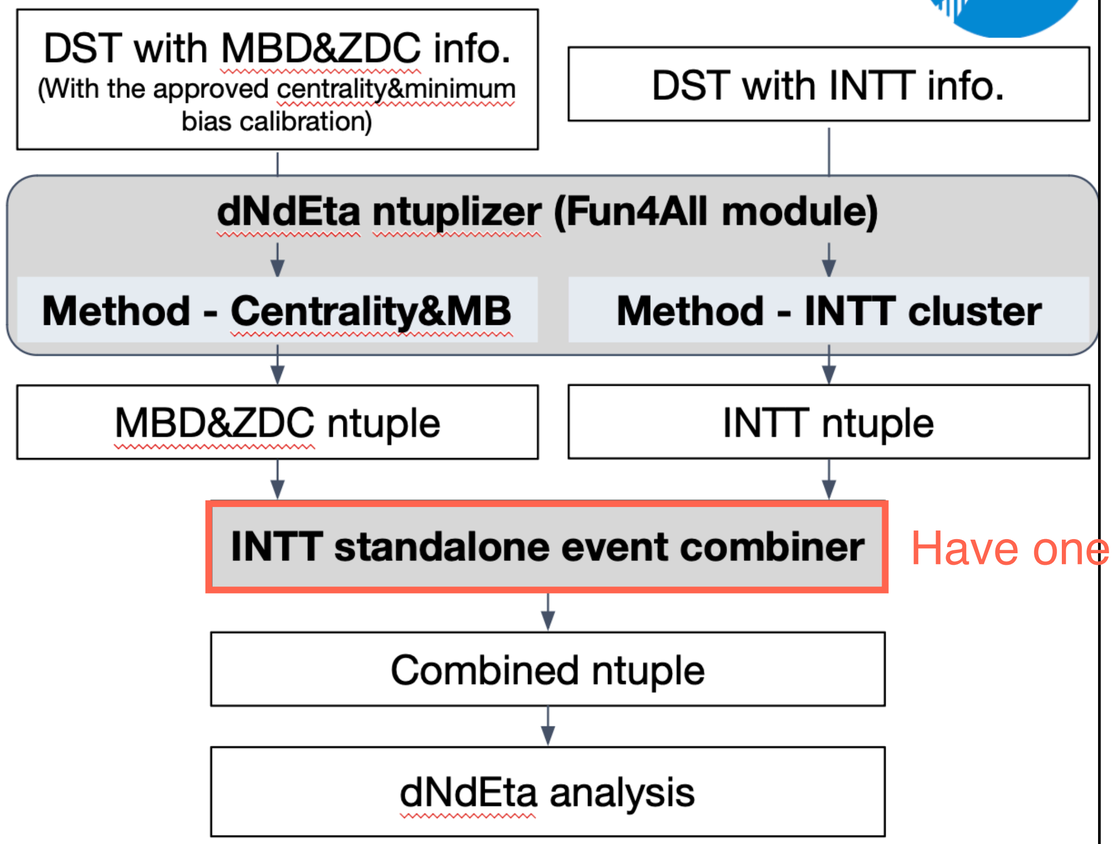


The mega tracks (INTT design) barely affects the Z vertex resolution

Workflow of event combiner

Analysis workflow

- A modified workflow is developed, shown on RHS
  - We would like to confirm with the physics&analysis coordination and TG conveners that this workflow, specifically for Run23 data, complies with the publication guideline



Have one version ready

The structure of available ntuplizer

- Directoy: /gpfs/mnt/gpfs02/sphenix/user/cdean/software/analysis/dNdEta_Run2023/macros/intt_run20869.root (centrality_run20869.root)

MBD/ZDC/centrality/EP part

```
event                = 3
clk                  = 58491
femclk               = 58462
is_min_bias          = 1
MBD_centrality       = 0.66
MBD_z_vtx            = -13.4907
MBD_south_charge_sum = 2.39753
MBD_north_charge_sum = 96.5587
MBD_charge_sum       = 98.9563
MBD_charge_asymm     = -0.951544
```

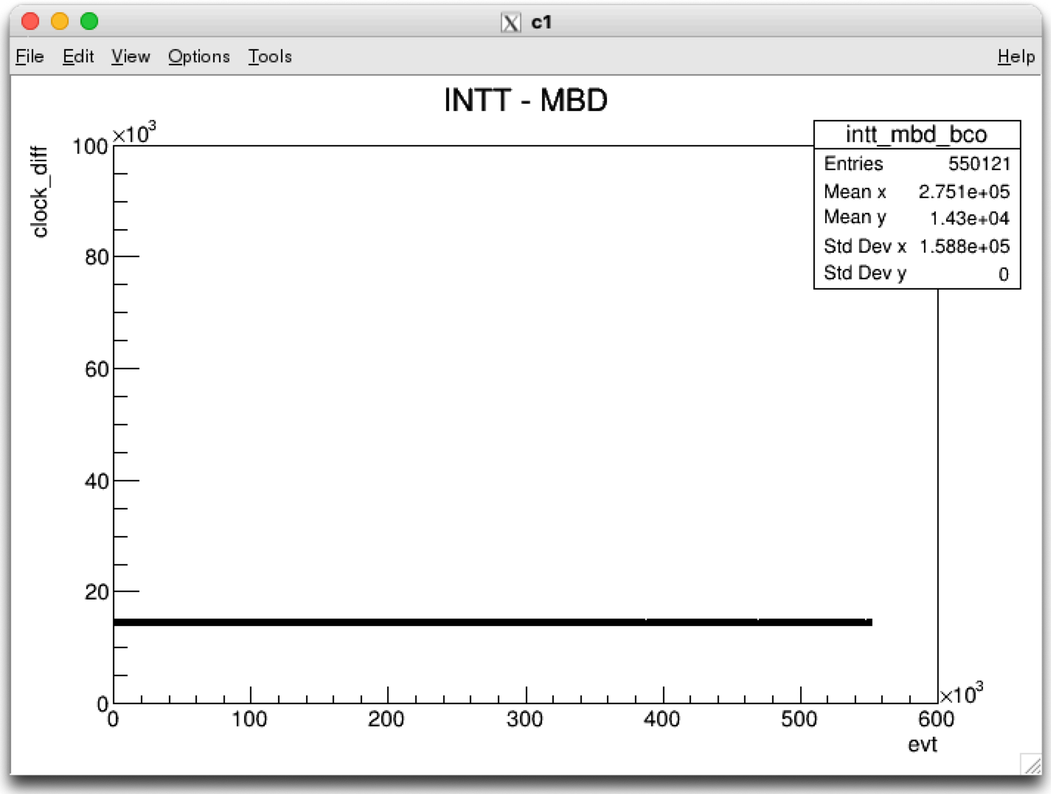
INTT part (data)

```
event_counter    = 1
INTT_BCO         = 727877790848
NClus_Layer1     = 356
NClus            = 669
ClusLayer        = (vector<int>*)0x3240140
ClusX            = (vector<float>*)0x38dddf0
ClusY            = (vector<float>*)0x3237130
ClusZ            = (vector<float>*)0x3171df0
ClusR            = (vector<float>*)0x26222c0
ClusPhi          = (vector<float>*)0x2e02d20
ClusEta          = (vector<float>*)0x324a640
ClusAdc          = (vector<unsigned int>*)0x2ac6dc0
ClusPhiSize      = (vector<float>*)0x32434f0
ClusZSize        = (vector<float>*)0x277c260
ClusLadderZId    = (vector<unsigned char>*)0x3266640
ClusLadderPhiId  = (vector<unsigned char>*)0x3929a40
ClusTrkrHitSetKey = (vector<unsigned int>*)0x245b960
ClusTimeBucketId = (vector<int>*)0x316fd70
```

INTT-MBD event combiner

- Code: Github
- Same files for testing, All events included

clock_diff as a function of event ID



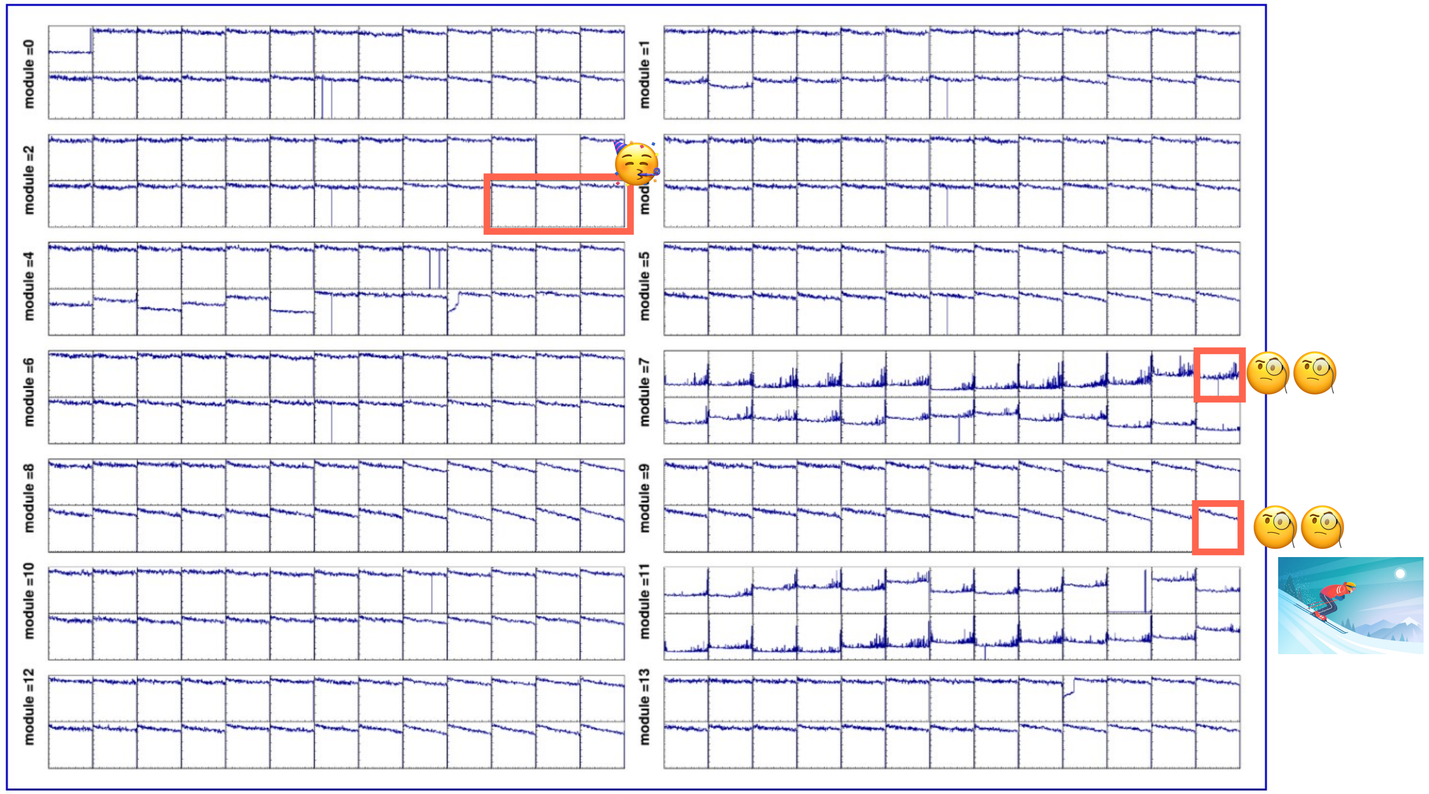
Tree structure posit merge

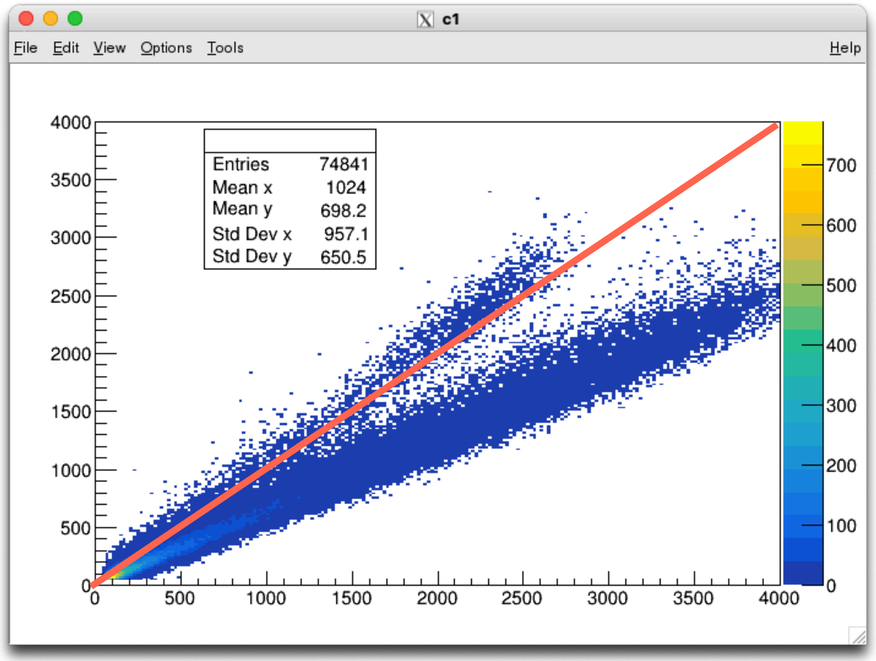
```
root [2] EventTree->Show(1)
======> EVENT:1
 event_counter    = 1
 INTT_BCO         = 727877790848
 NClus_Layer1     = 356
 NClus            = 669
 ClusLayer        = (vector<int>*)0x26228d0
 ClusX            = (vector<float>*)0x1a60aa0
 ClusY            = (vector<float>*)0x2054040
 ClusZ            = (vector<float>*)0x11797d0
 ClusR            = (vector<float>*)0x268af40
 ClusPhi          = (vector<float>*)0x2849140
 ClusEta          = (vector<float>*)0x284a160
 ClusAdc          = (vector<unsigned int>*)0x2848640
 ClusPhiSize      = (vector<float>*)0x2855660
 ClusZSize        = (vector<float>*)0x2855cd0
 ClusLadderZId    = (vector<unsigned char>*)0x285dc40
 ClusLadderPhiId  = (vector<unsigned char>*)0x20dd530
 ClusTrkrHitSetKey = (vector<unsigned int>*)0x283fda0
 ClusTimeBucketId = (vector<int>*)0x210d030
 event            = 3
 clk              = 58491
 femclk           = 58462
 is_min_bias      = 1
 MBD_centrality   = 0.66
 MBD_z_vtx        = -13.4907
 MBD_south_charge_sum = 2.39753
 MBD_north_charge_sum = 96.5587
 MBD_charge_sum   = 98.9563
 MBD_charge_asymm = -0.951544
```

To understand the INTT data

We are in the half way toward fully understand the INTT data

Very nice website (plot database for all years) made by Genki





Idea: expand the capability of the website to check the data in more aspects
(ladder dependency, before/post hot channel masking, etc.)
Benefit: not only for the run23 analyses, but also toward the run24 data finalization

Summary

- The O(mm) z resolution seems not to affect the cluster counting too much
- New algorithm of mega tracklet finderwas implemented
  - Mega tracks: second-order effect on the track counting, first order on zvtx reconstruction
- 3-cluster tracks are visible by INTT simply because of its design
  - No 4-cluster tracks
- The more central the collision is, the higher probability to have mega tracks
- The effects on the zvtx reconstruction seems to be really minor
- One version of the INTT-MBD event combiner is ready
- We are in the half way toward fully understand the INTT data

Todo list

- Data quality check
- To check how the residual affects the resolution of vtx XY and Z
- Beam width XY
- PCM meeting this Friday

Back up

Tracklet, two methods

- Proto-tracklets: $|\Delta\phi| \leqq 3.5$ degrees, and pair links to zvtx ($|\Delta\eta| < \sim 0.25$)
- Reco tracklet η: 3-point track (zvtx, inner and outer clusters)

1. Loose (inclusive) :
   - Single cluster is allowed to be involved in multiple proto-tracklets
   - Have the result for the whole run
   - Signal extraction by the background subtraction
2. Tight:
   1. Keep all the qualified proto-tracklets
   2. Beginning with the pair with smallest $|\Delta\phi|$, and marked the clusters as “used”
   3. Pair discarded as long as one cluster is the “used” one
   4. $|\Delta\phi|$ up to 1 degree
   - Counting method → can be event by event

- reco zvtx resolution w/ mega cluster finder (use true z to pick up)
- reco zvtx resolution w/o mega cluster finder

- mega cluster finder efficiency true z / with reco z without mega cluster finder

- Tracklet counting with true zvtx / reco Z without mega cluster finder
- Method inclusive background study with reco Z without mega cluster finder

- True Z
  - tracklet counting w/ and w/o mega cluster finder

- TrackCounting_TrueZ_NoMegatrackRemoval
- TrackCounting_RecoZ_NoMegatrackRemoval
- TrackCounting_RecoZ_NoMegatrackRemoval_BKGStudy_InnerPhiRotation

- RecoEvtZ_noMegaTrackRemoval
- RecoEvtZ_withMegaTrackRemoval_TrueZGiven

- Mega track finding effi
- Ttrackcounting_recoZ_withMegatrackremoval?

- TrackCounting_TrueZ_NoMegatrackRemoval
- TrackCounting_RecoZ_NoMegatrackRemoval_BKGStudy_InnerPhiRotation

- RecoEvtZ_noMegaTrackRemoval
- RecoEvtZ_withMegaTrackRemoval_TrueZGiven

- 3/4-cluster finder
- True/Reco zvtx, N tracklet counting
- Reco zvtx, background/signal overlap
- 3-cluster tracklet -> how it affects the XY and zvtx

- Residual study -> zvtx
- Official F4A module for the INTT zvtx

2787 nhits : 17170 N_clu_south : 2385 N_clu_north : 2446 Nclu inner : 2302 Nclu outer : 2529