sPHENIX INTT - Vertex

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National Central University, Taiwan

INTT meeting

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國立中央大學 National Central University

Event by event vertex XY - quadrant method

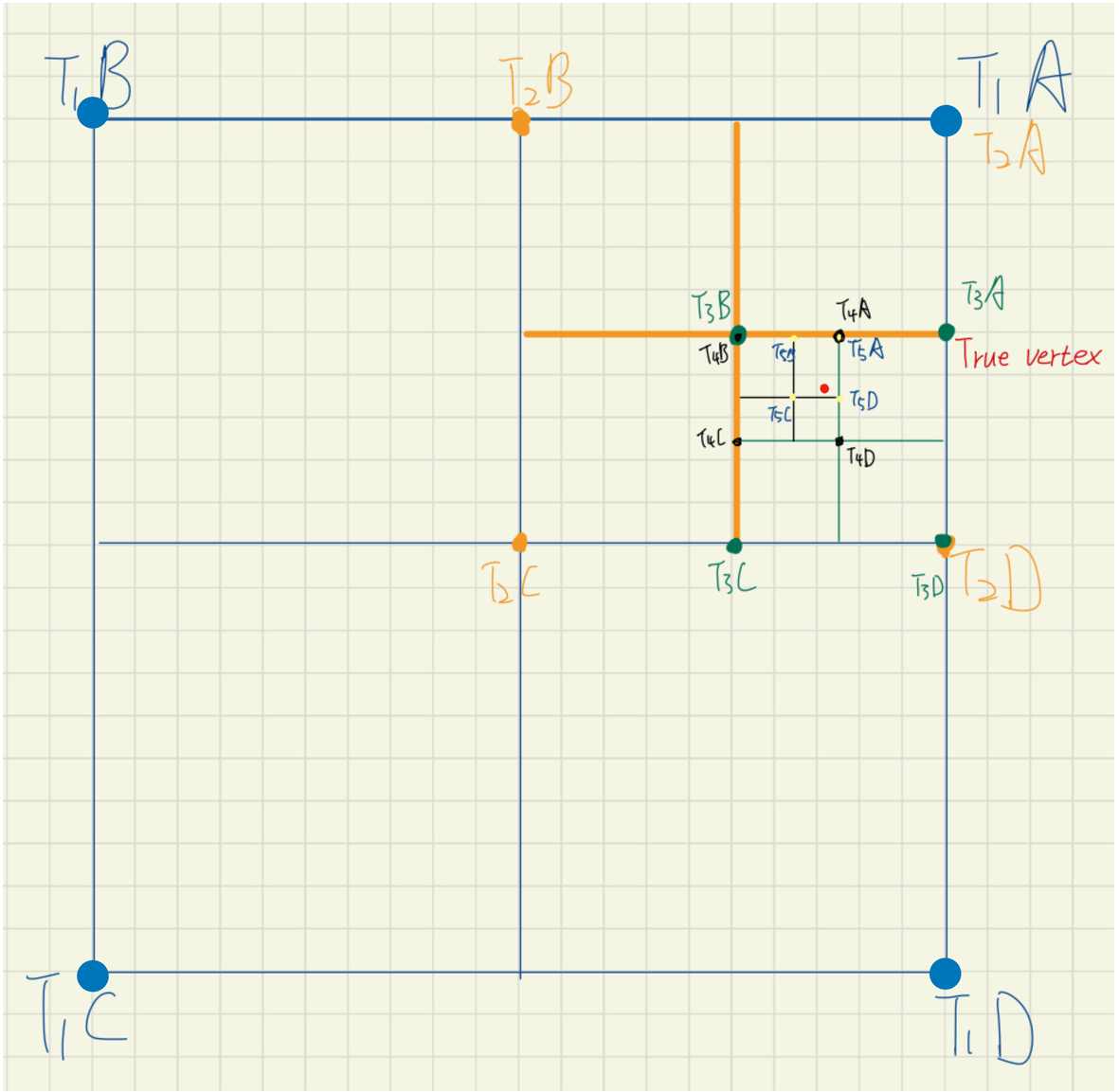
- **Procedures**
  - In each test, try with 4 vertices
  - Narrow the searching window half and move to the quadrant that gives better performance
  - Iteration, test the 4 new vertices

- **Concern**
  - How to determine the “good” vertex ?
  - Once it moves to wrong quadrant, it will never come back

- **Original plan of improvement**
  - Double check the quadrant performance with vertices on the axes (T_1U, D, R, L)

  →It simply doesn’t work. It isn’t sensitive enough to detect the discrepancy b/w reco and true

The area inside the INTT barrel



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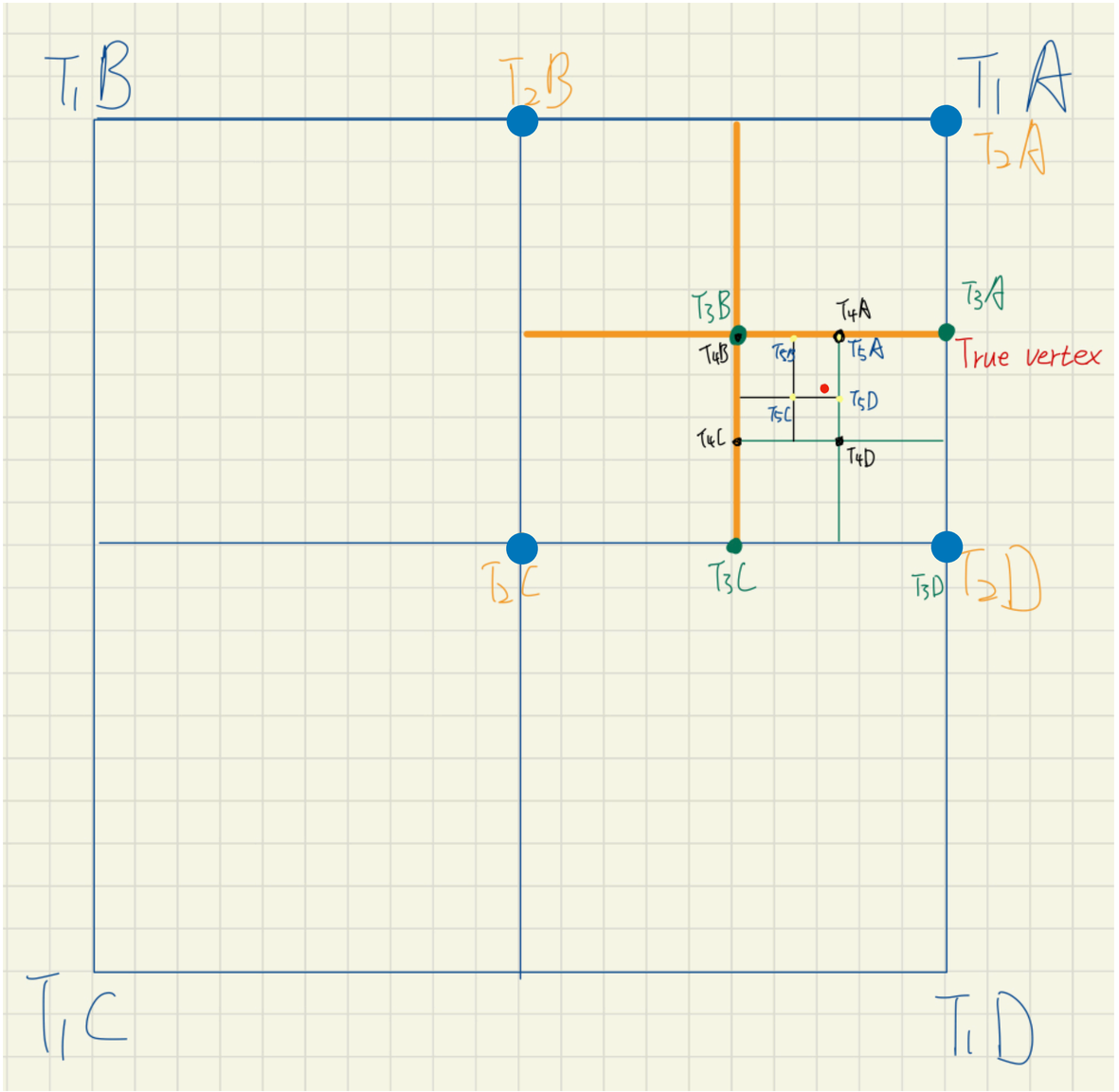

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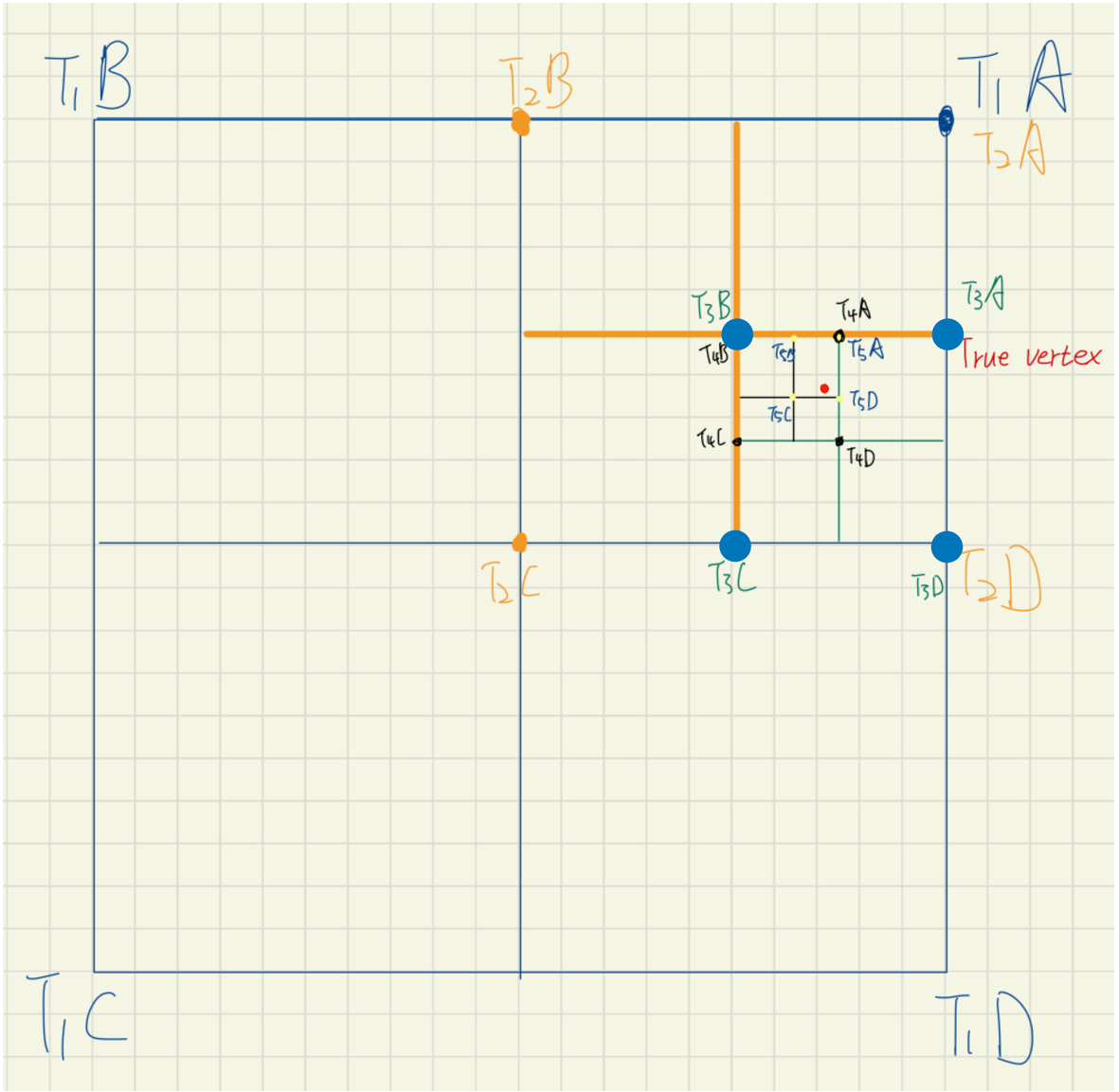

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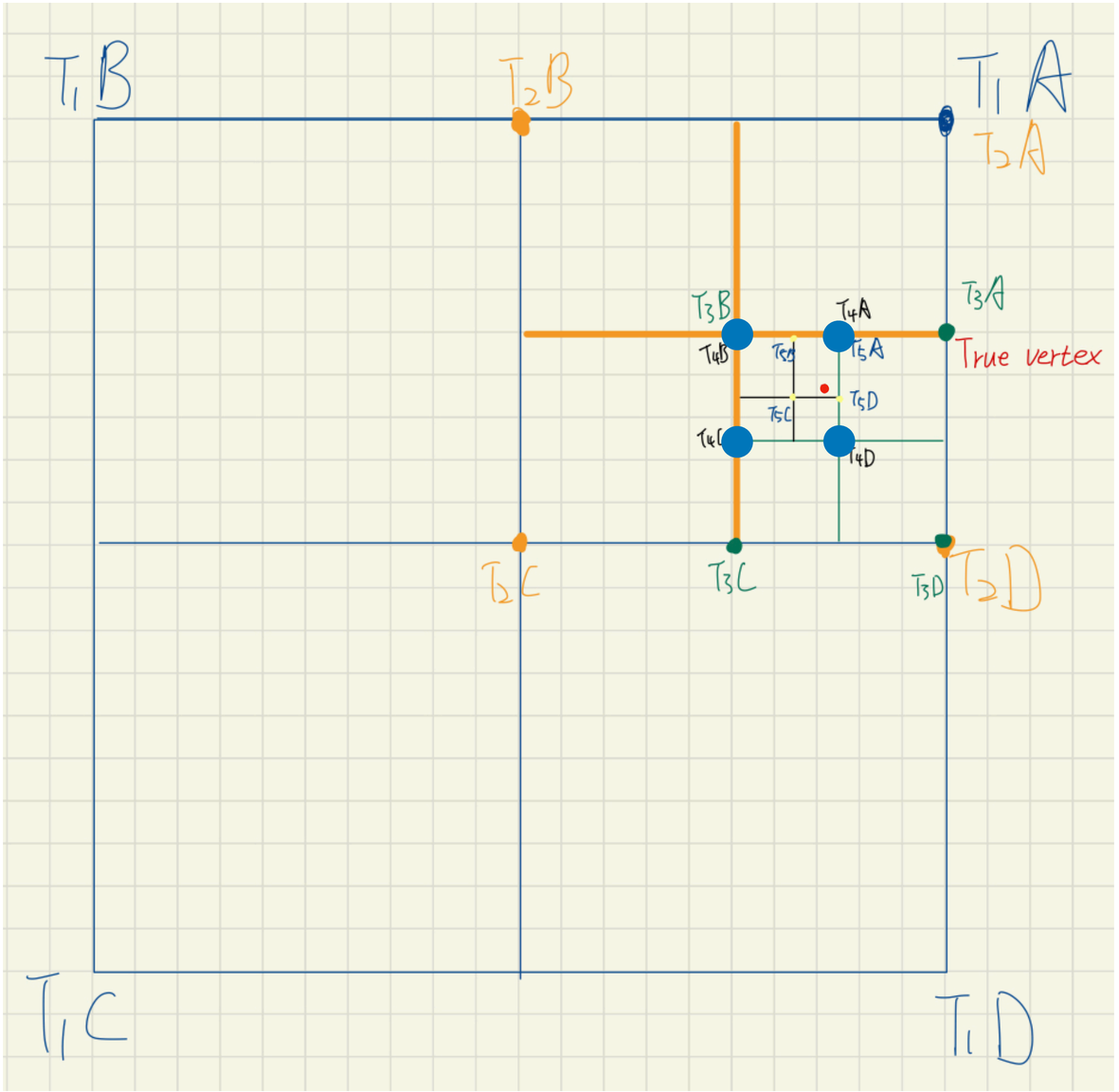

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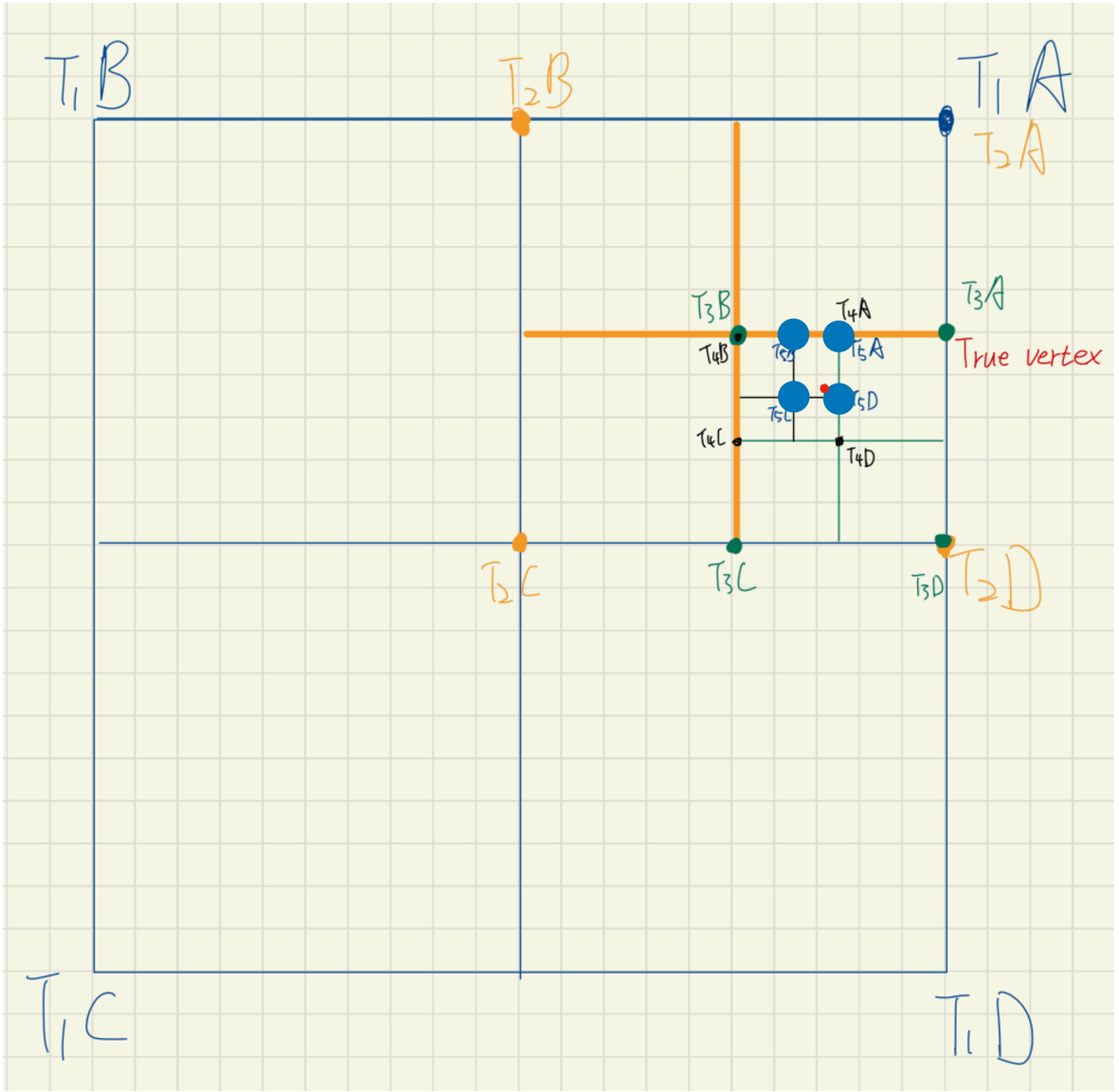

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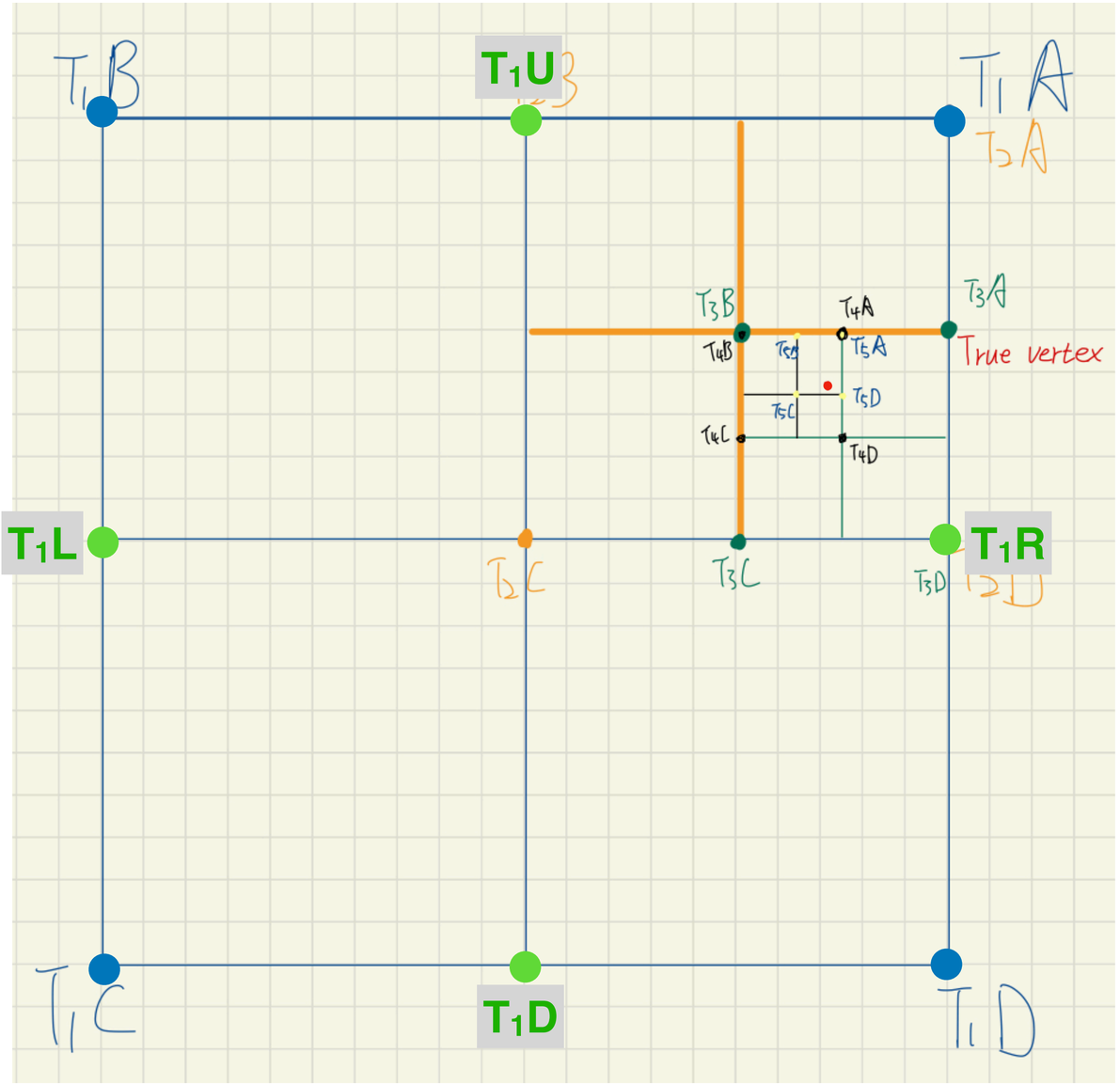
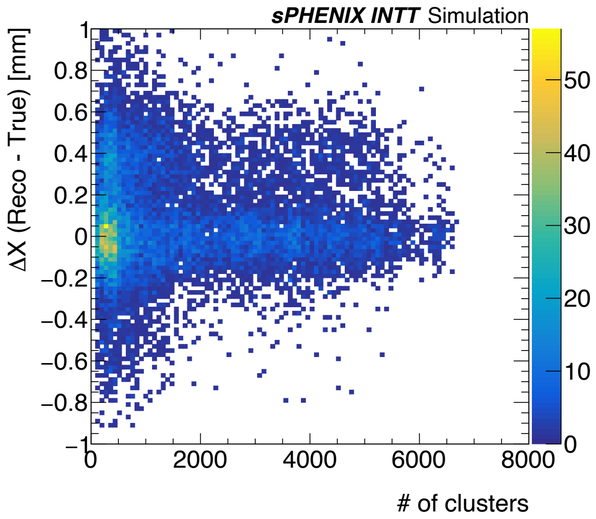


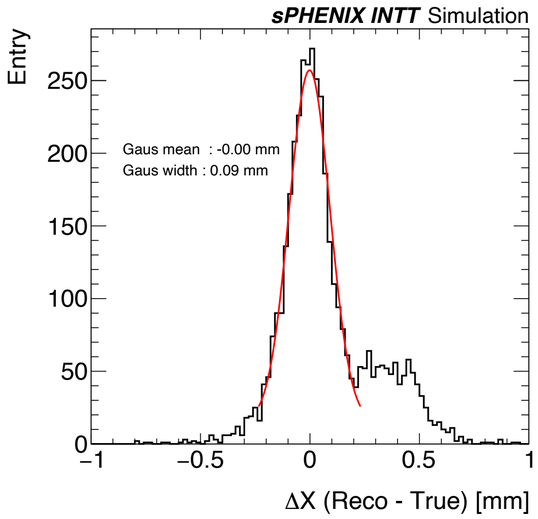
Event by event vertex XY - quadrant method

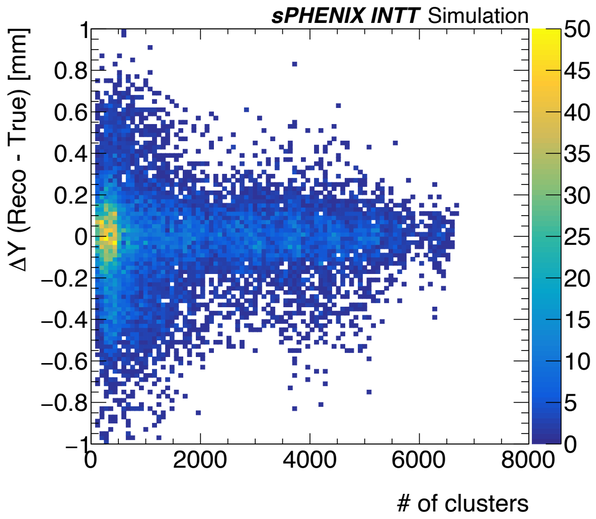
- Search starts from origin (0,0) with 8 mm x 8 mm square and 10-time iterations
- Z vertex included as an additional constrain to pure the tracklet selection

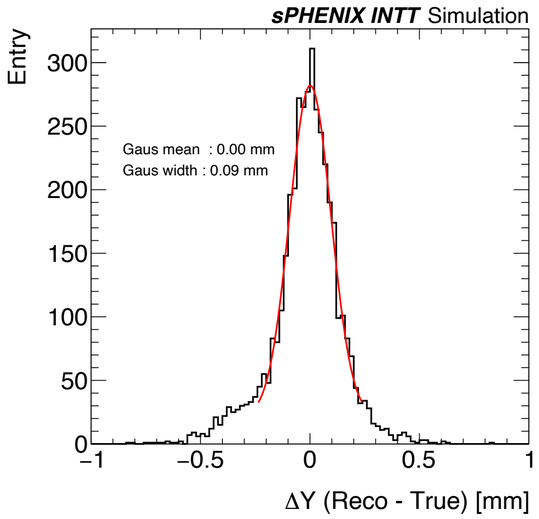
- True Z vertex was used (Feasibility study with MC)
- Number cluster > 2500

Test with MC 388.000









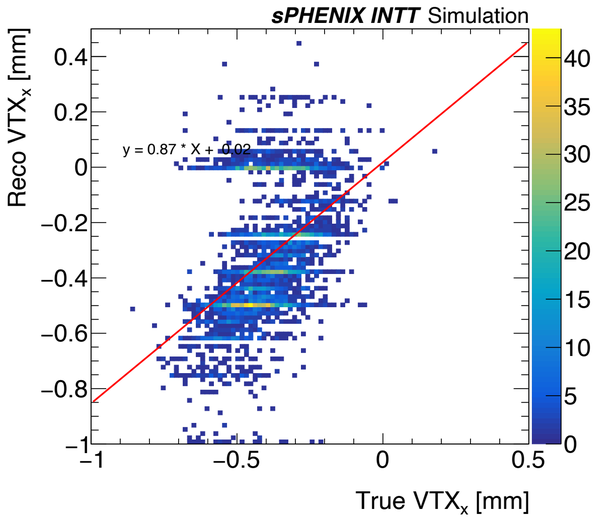
Hard to tell the functionality of event-by-event XY vertex reconstruction by this method

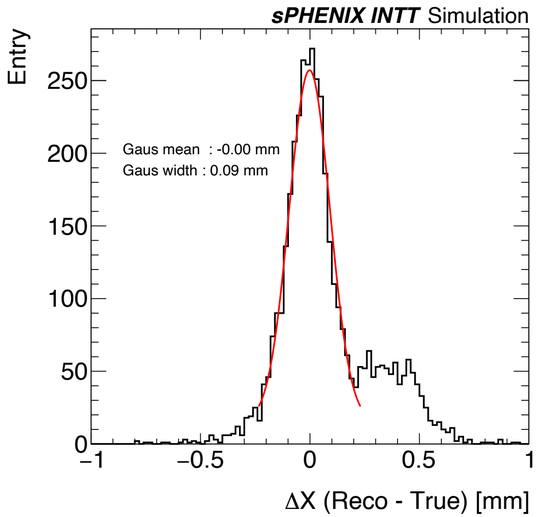
Event by event vertex XY - quadrant method

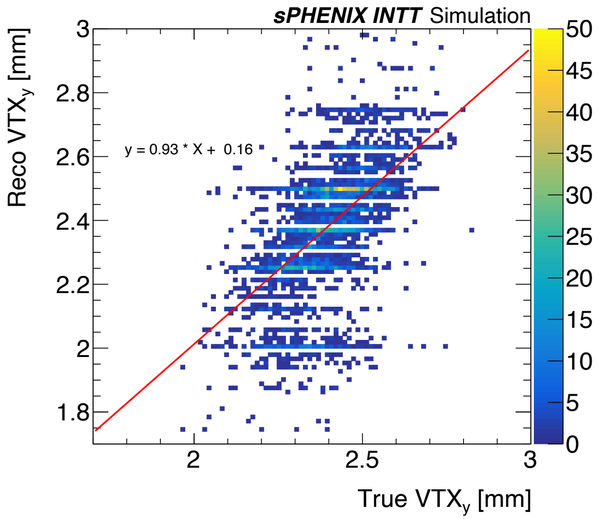
- Search starts from origin (0,0) with 6 mm x 6 mm square and 9-time iterations
- Z vertex included as an additional constrain to pure the tracklet selection

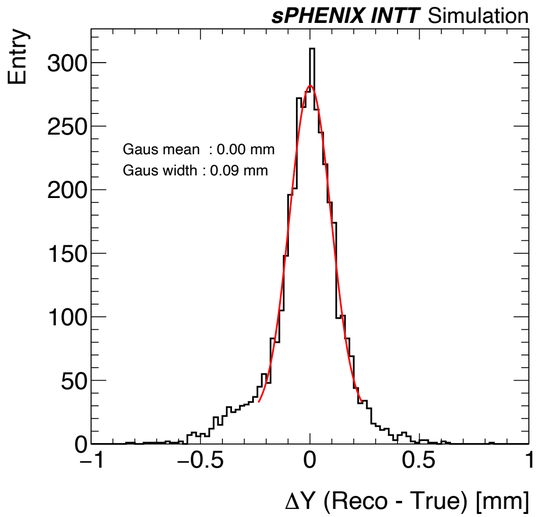
- True Z vertex was used (Feasibility study with MC)
- Number cluster > 2500

Test with MC 388.000







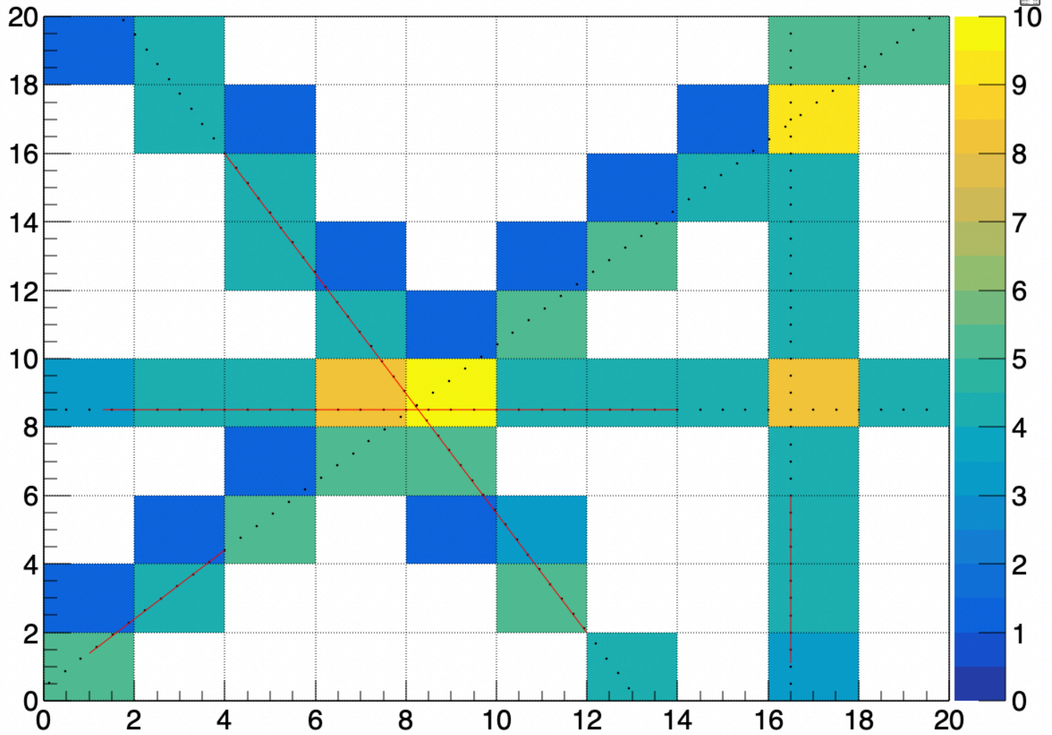


The quadrant method could bot determine the event-by-event XY vertex well
The current good vertex determination method easily went to the wrong quadrant

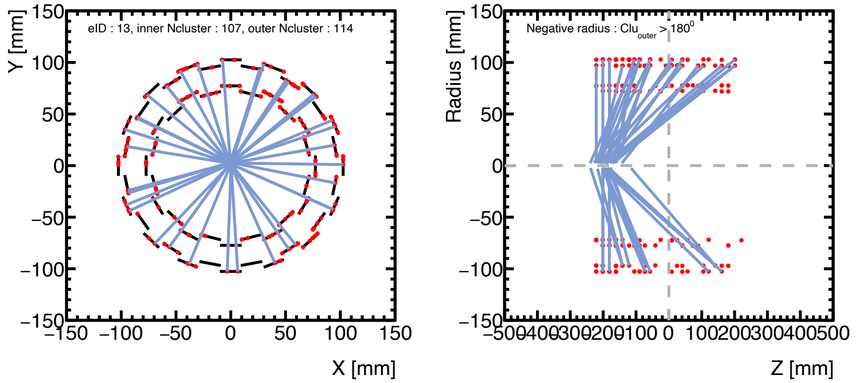
New method of xy vertex reconstruction

- Fill the tracklets in the 2D histogram
  - Sample the tracklet with given segmentation (line into points), and fill the points in histogram
  - Remove the background
  - Calculate the mean of each axis

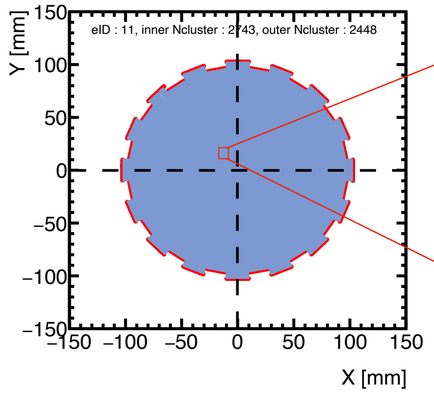
- Histogram size: ±1.5 mm for both axes with the center set at reco vertex XY of whole run
- Cell size: 30 μm
- Line segmentation : 1 μm

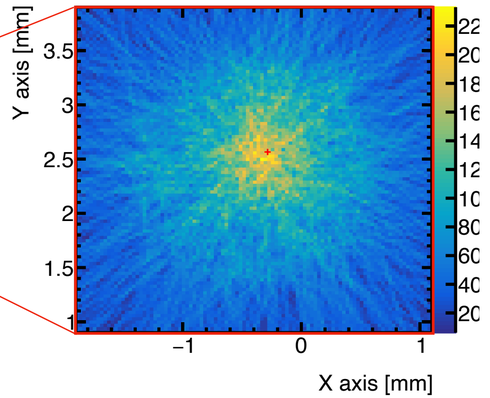


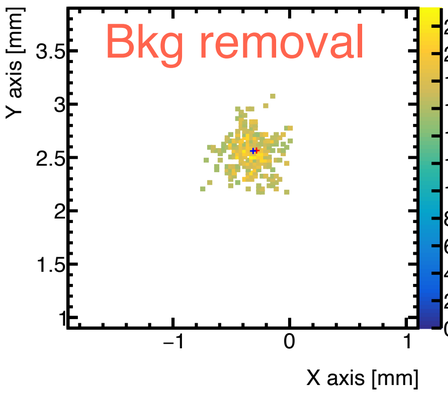
Low multiplicity event



High multiplicity event







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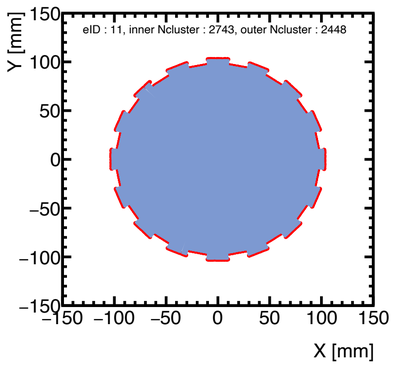
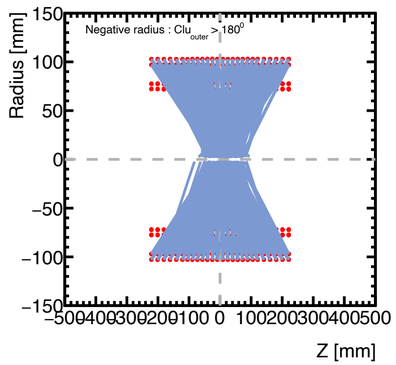
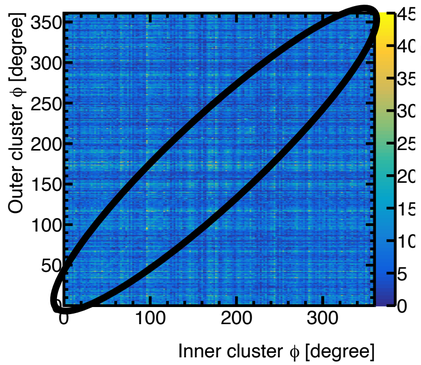
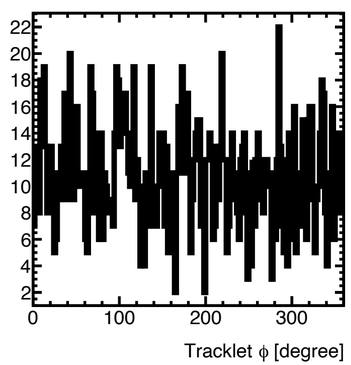
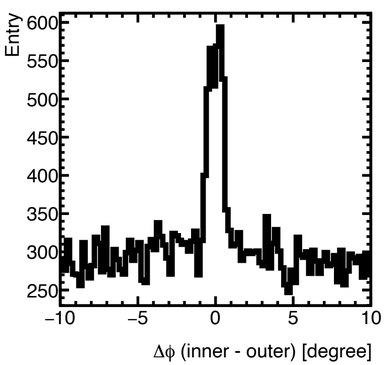
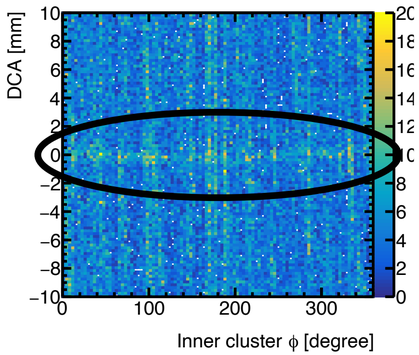


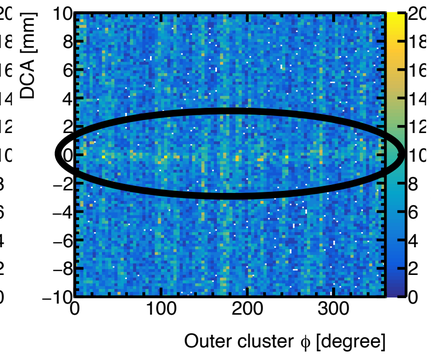


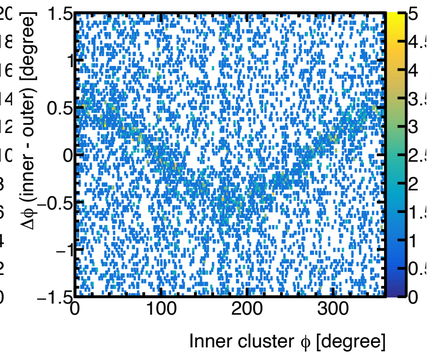


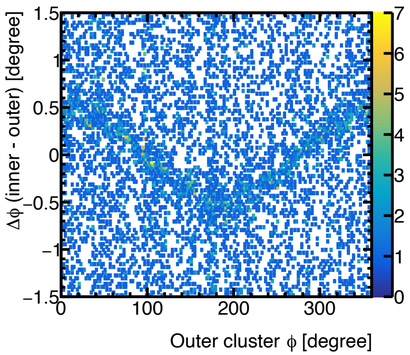


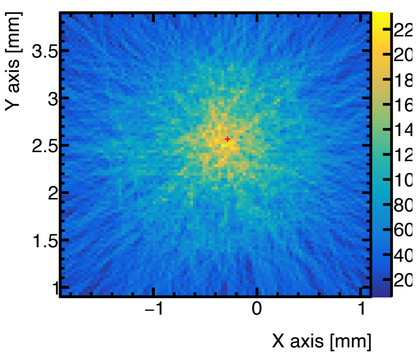


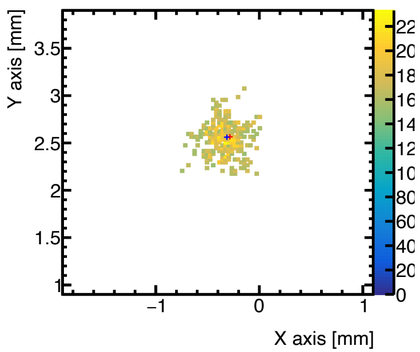








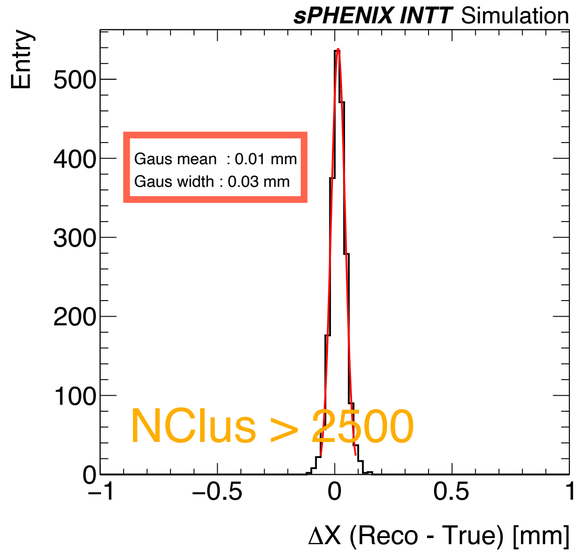


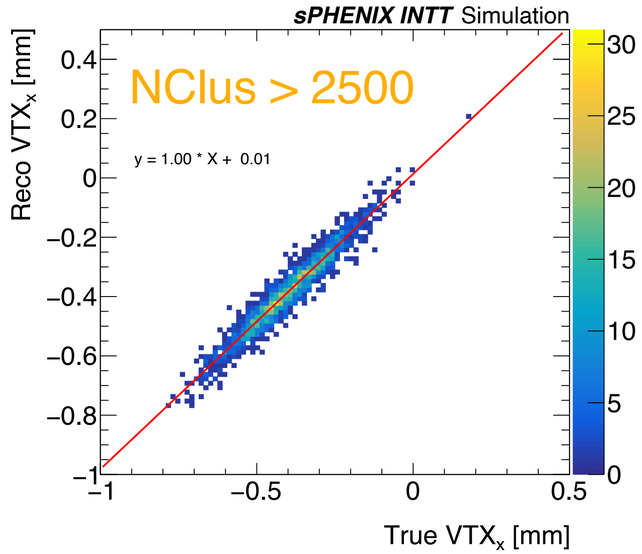


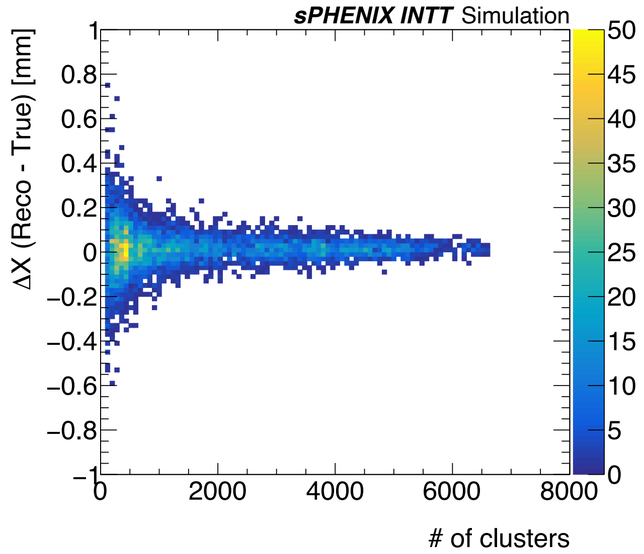
Some correlation can be easily see.
The additional Z constraint indeed improves the tracklet selection up to some level

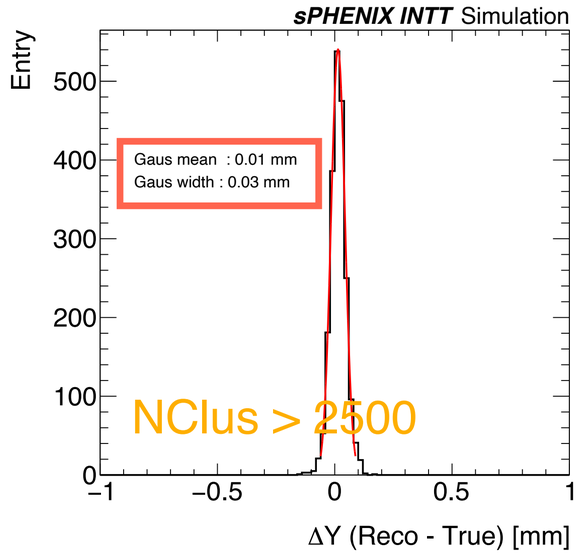
New method of xy vertex reconstruction

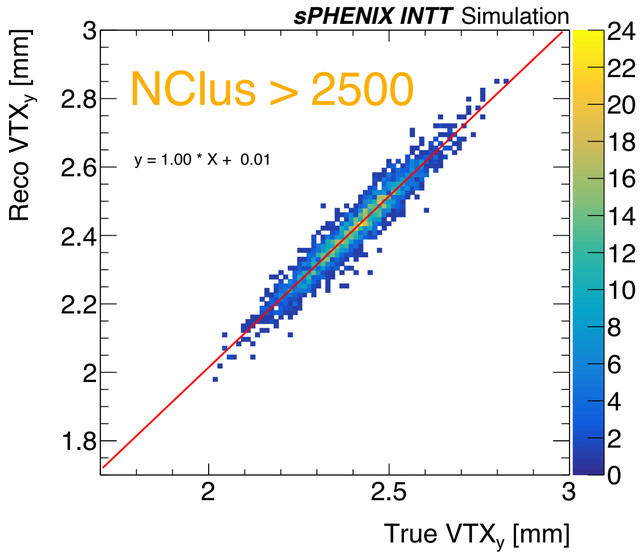
Test with MC 388.000

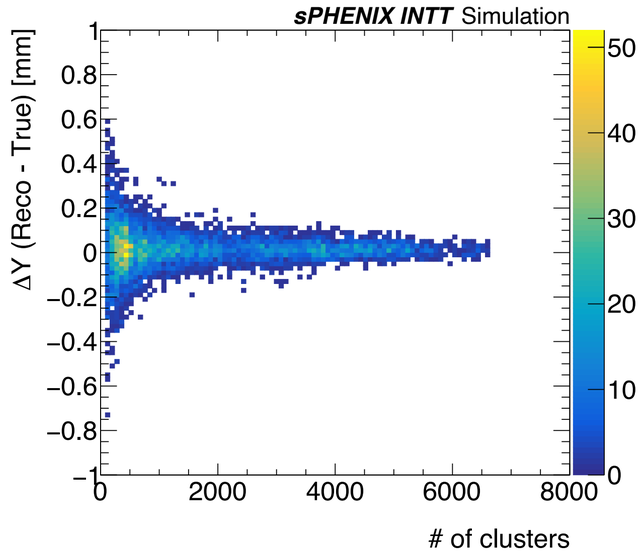












True Z vertex was used (Feasibility study with MC). The new method can perform XY vertex reconstruction well!

A full test of vertex reconstruction

Tested with MC 388.000

Procedures

1. Find the first vertex XY for the whole run by the quadrant method
   - Low multiplicity, ±4 mm window & 10 iterations
   - Determine the Δϕ and DCA cut value
2. Find the second vertex XY for the whole run by the line-filled method
   - Center of window given by step 1
   - ± 1.5 mm window with cell size 30 μm
   - Line segmentation 1 μm
3. Reconstruct the event-by-event Z vertex by the line-filled method
   - Run XY vertex given by step 1 and 2

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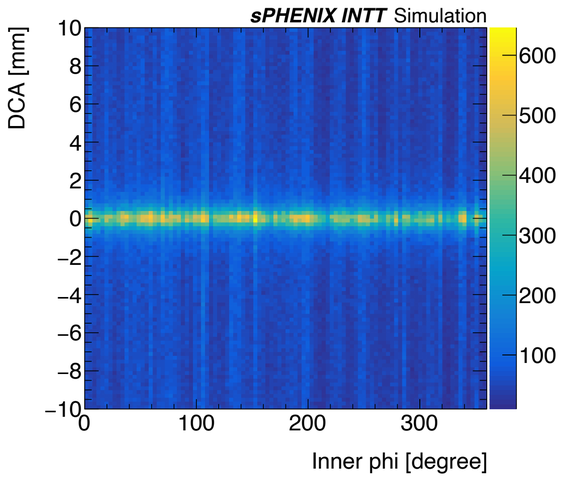

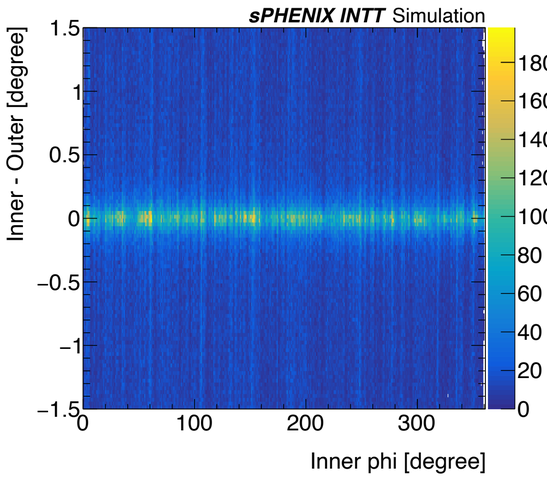

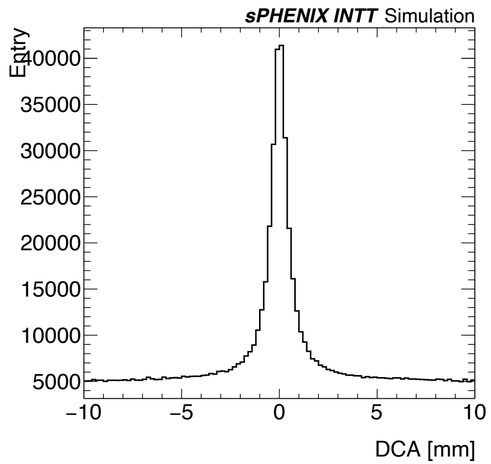

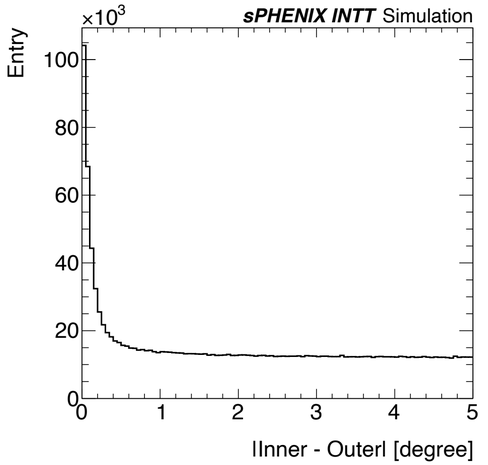

Vertex (-0.375, 2.41406), origin (-0.386719, 2.40234)

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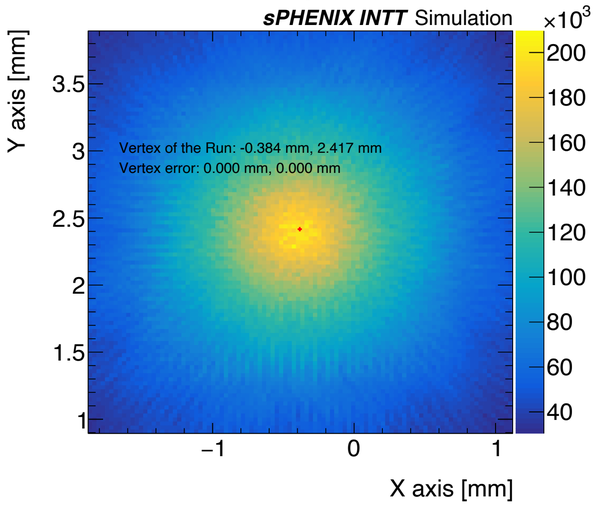
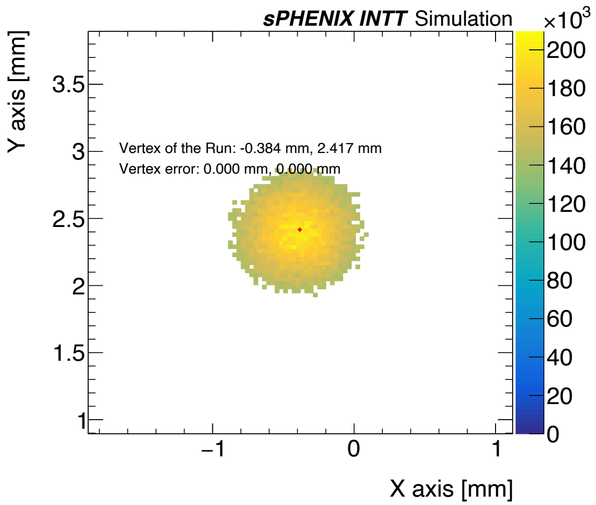
3. Reconstruct the event-by-event Z vertex by the line-filled method
   - Run XY vertex given by step 1 and 2

Step 2





Final run XY vertex = (step_1 + step_2)/2.
→ (-0.381 mm, 2.406 mm)

A full test of vertex reconstruction

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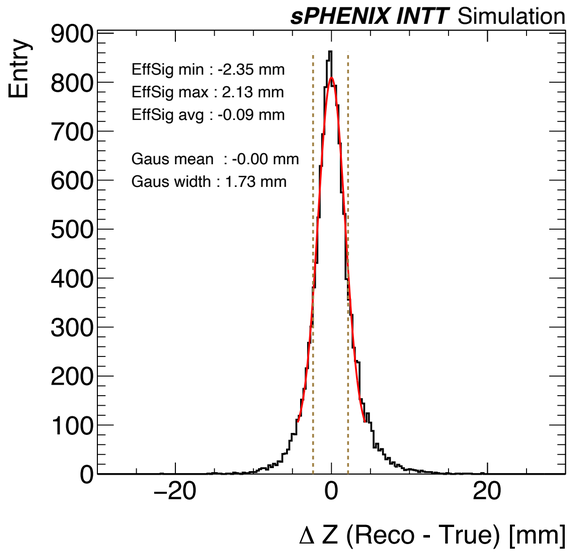
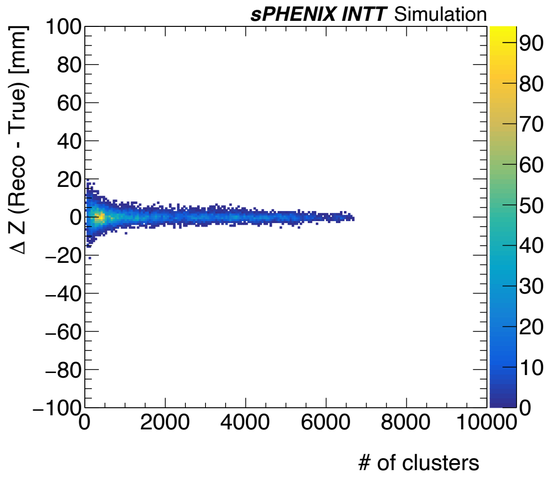
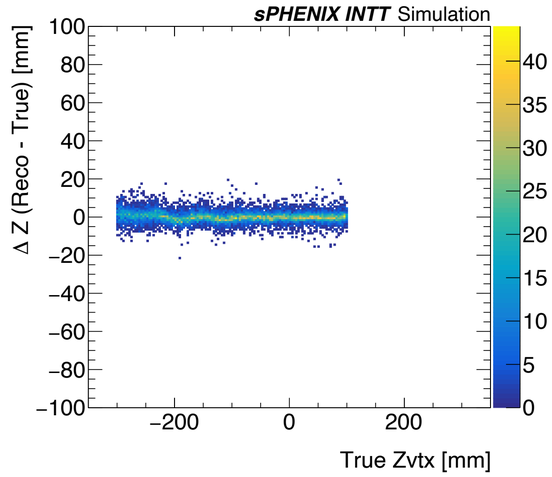
Step 3







A full test of vertex reconstruction

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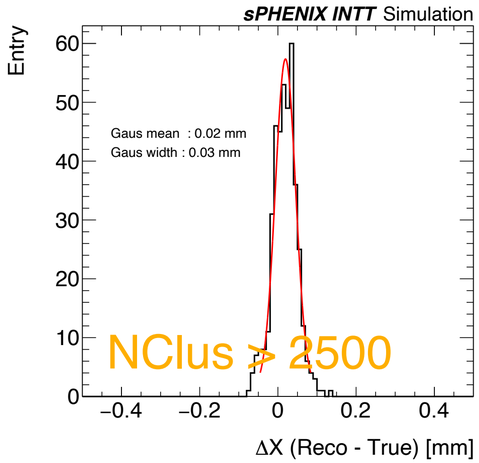
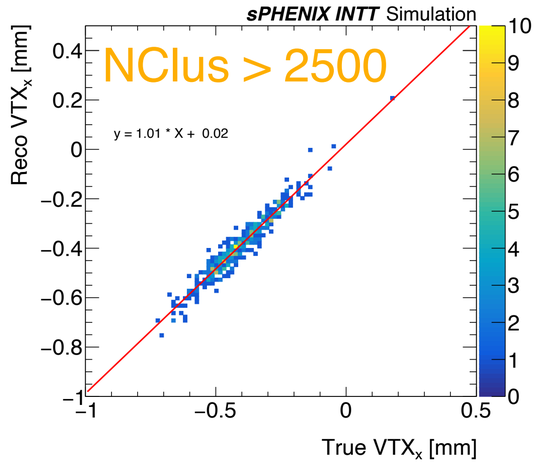
Procedures

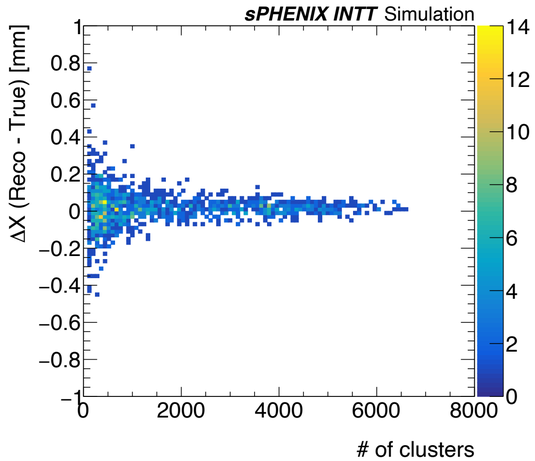
4. Reconstruct the event-by-event XY vertex by the line-filled method

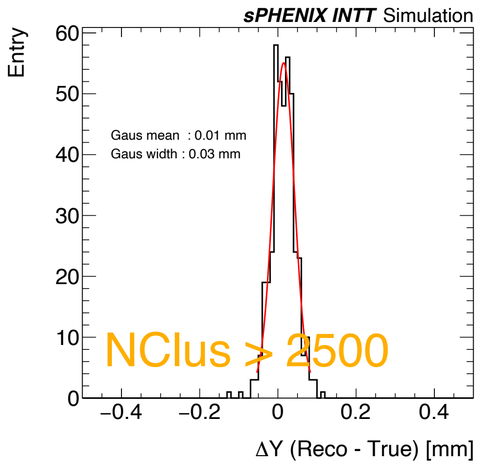
First 2k events shown

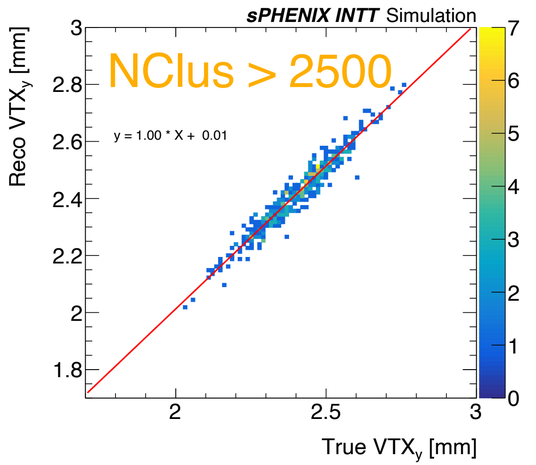
Step 4

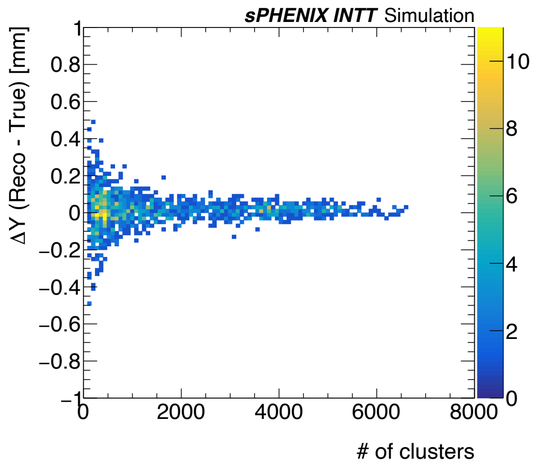












It’s promising that INTT can perform event-by-event 3D vertex measurement!

Summary

- With the current reconstruction method, it's promising that INTT can perform the event-by-event 3D vertex reconstruction up to some reasonable resolution! 🥳😆🥳

- The cut selection (Δϕ and DCA) can affect the final result

- The procedures to have the 3D vertex event by event with the standalone INTT data:
  1. Search the XY vertex for the whole run by quadrant method
  2. Find the XY vertex for the whole run by line-filled method with the window center given by the quadrant method
  3. Reconstruct the Z vertex event by event, by the 1D line-filled method
  4. Reconstruct the XY vertex event by event, by the 2D line-filled method

Short-term todo list

- Attempt of alignment study
  - Feasibility of alignment with Millipede-II package (famous and official)
  - Feasibility of alignment with ML (works with MVTX)

- Geometry correction…

Back up

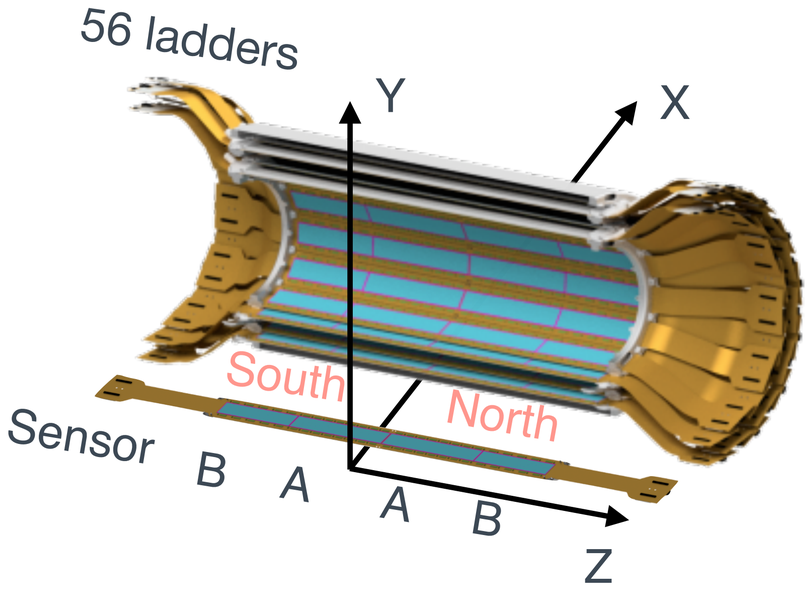
Appendix for the full reco trial

The Quadrant 0 won the competition

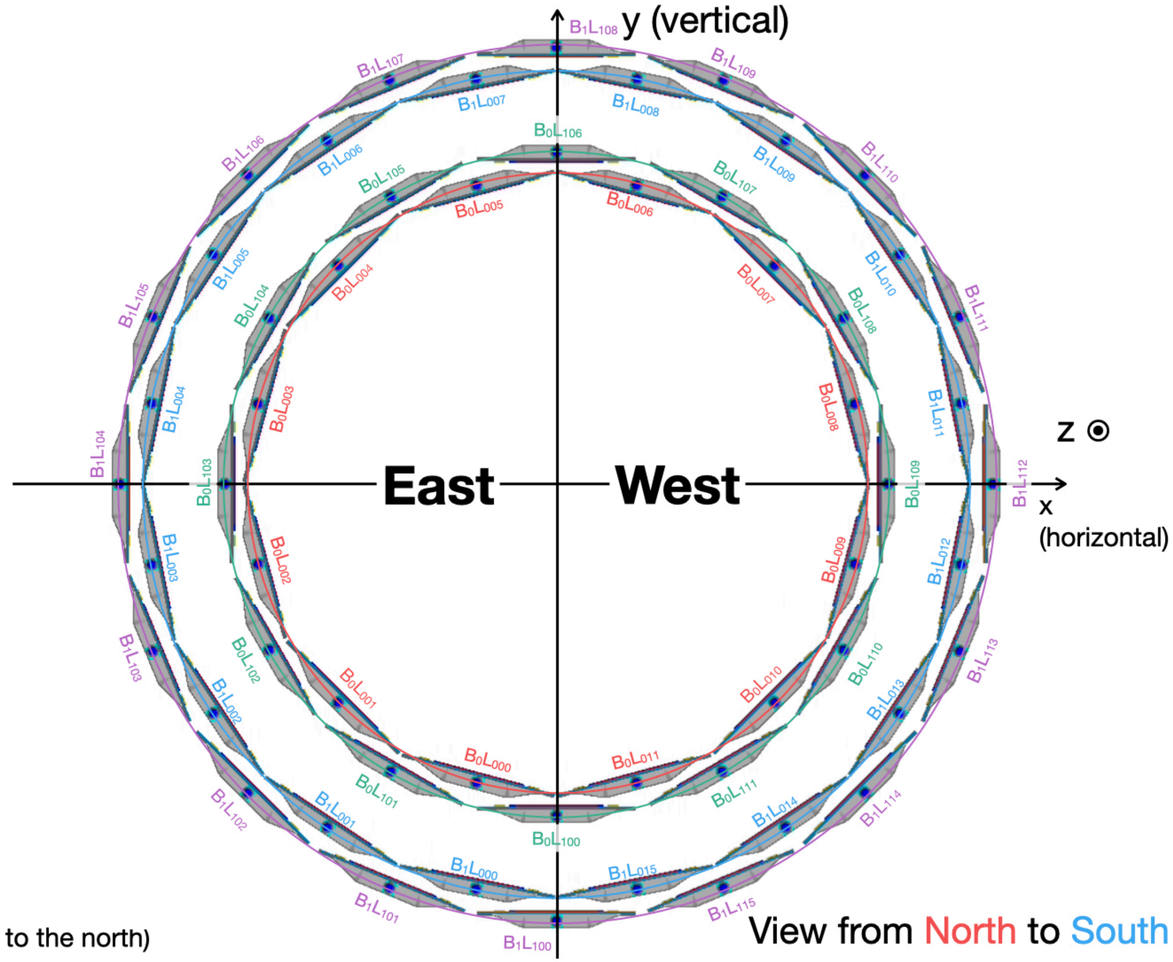
The best vertex throughout the scan: -0.375 2.41406

The origin during that scan: -0.386719 2.40234

INTT geometry



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)



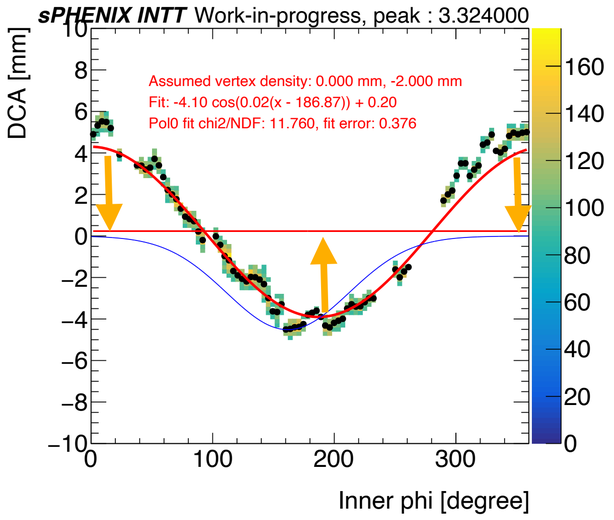
Axis (Right-haded coordinate)
- x-axis: $\vec{y} \times \vec{z}$
- y-axis: Vertically upward direction
- z-axis: The blue beam direction (pointing to the north)

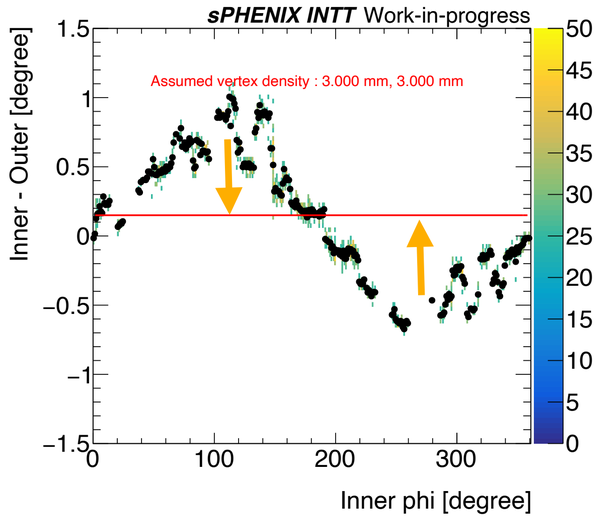
Choice of quantities

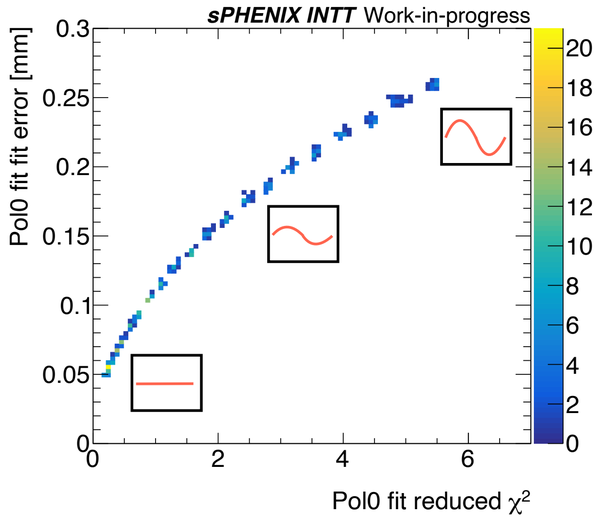
- What quantities are good choices to quantify the performance of the given vertex?
  - If the given vertex is getting closer to the true vertex:
    - DCA - inner ϕ and Δϕ - inner ϕ correlations become flat
    - Δϕ 1D distribution becomes concentrated

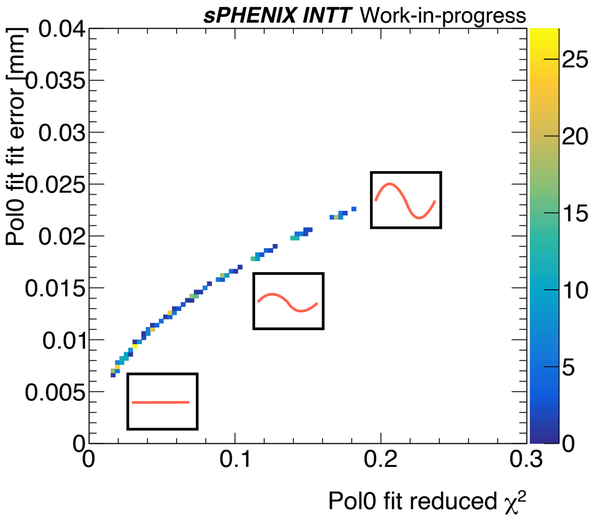
Background removed and fit with pol0

Each trial vertex gives you the following plots









In the case of modulation correlation, Pol0 fit error seems to be more sensitive in the region with small amplitude

Currently fit errors of DCA-inner ϕ and Δϕ-inner ϕ are required

2024 Travel plan - Cheng-Wei

- Plan A
  - First stay: Feb 17 to Mar 19 (28 days)
    → Two-week **owl** shift + two weeks working for maybe INTT
  - Second stay: May 19 to Aug 11 (85 days) (Start time depends on the stay in JP)
    → Full stay for spin operation + one week **night** shift (possibly July 2 - July 9)
  - (Potential third stay in BNL with 9-day period)
  - Total stay : 28 + 85 + 9 = 122 days

- Plan B
  - First stay: Feb 18 to Mar 6 (18 days)
    → Two-week **owl** shift only
  - Second stay: May 19 to Aug 11 (85 days) (Start time depends on the stay in JP)
    → Full stay for spin operation + one week **night** shift (possibly July 2 - July 9)
  - Third stay in BNL (19 day, possibly from the beginning of September)
    - Full stay for spin operation
  - Total stay : 18 + 85 + 19 = 122 days