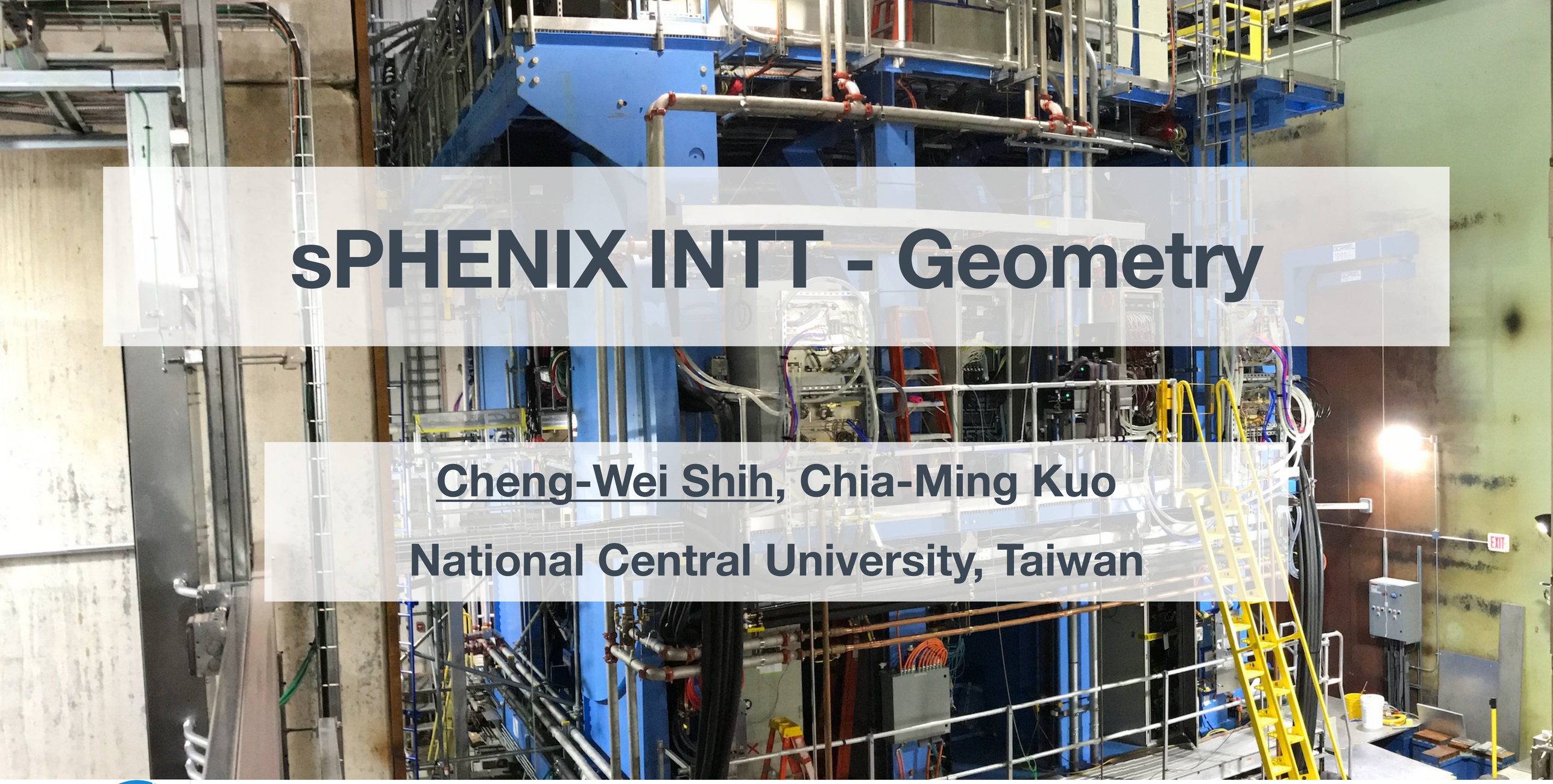


sPHENIX INTT - Geometry

Cheng-Wei Shih, Chia-Ming Kuo

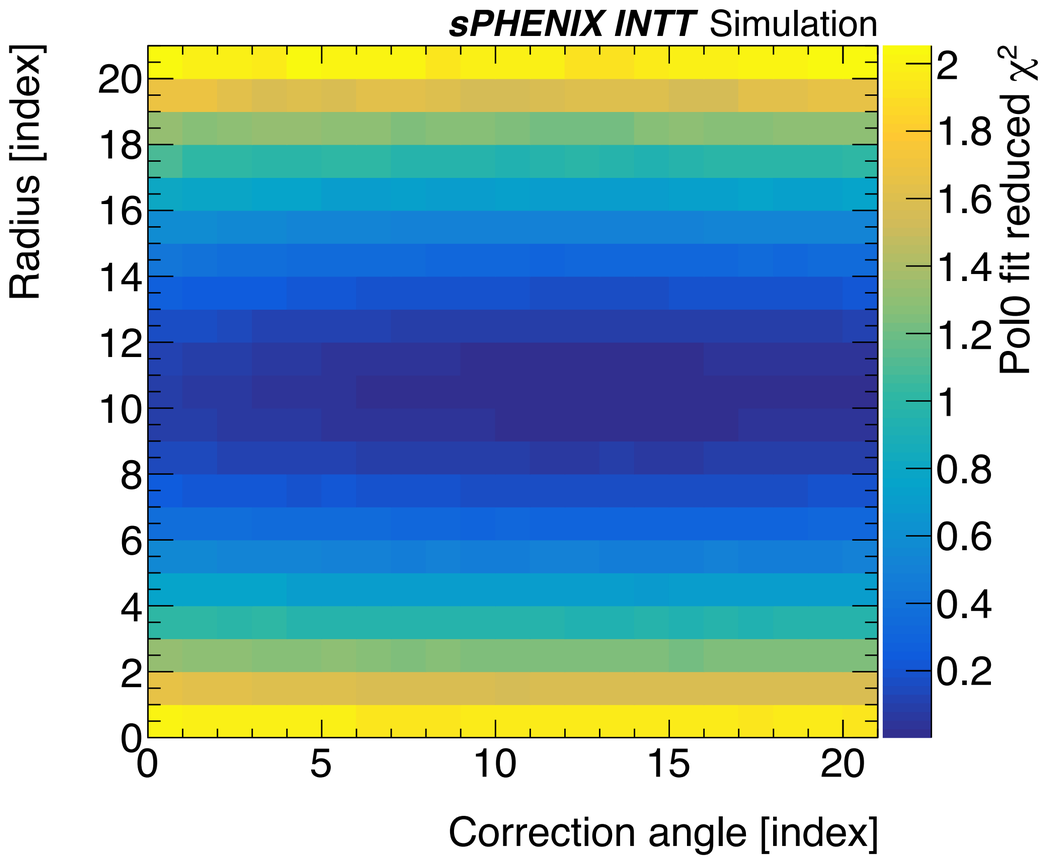
National Central University, Taiwan

INTT meeting

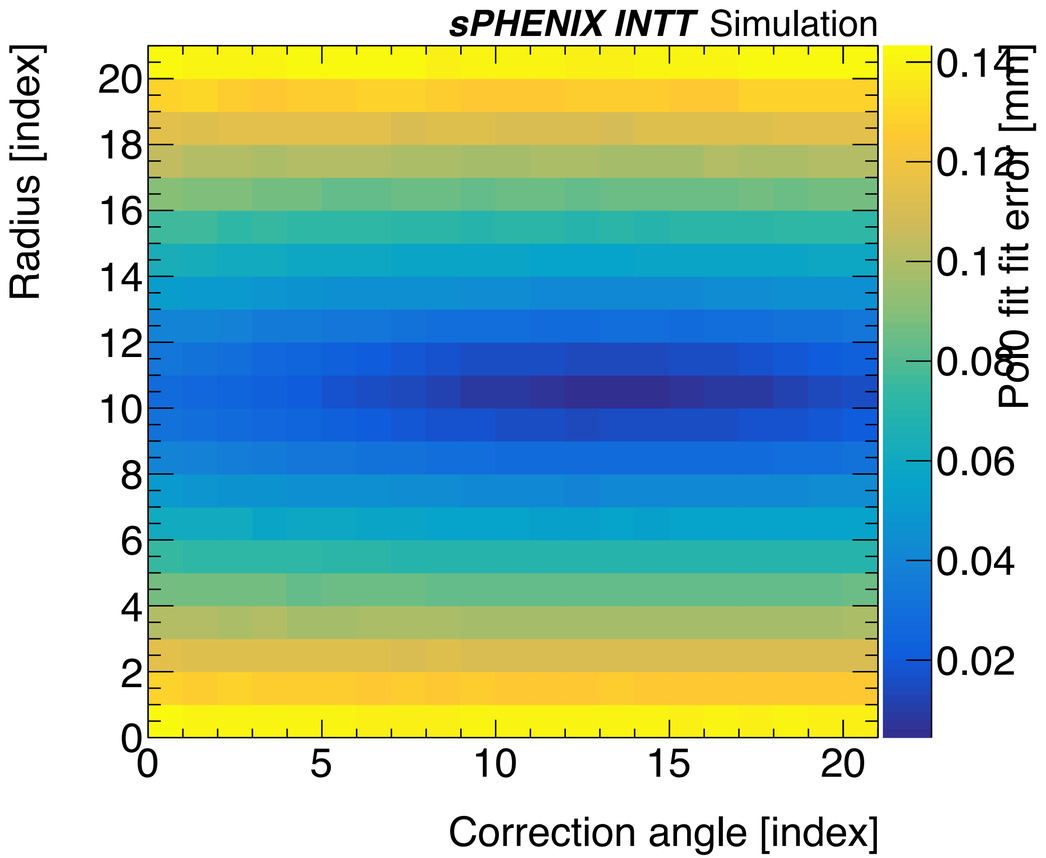
December 27th 2023

Vertex XY determination by INTT

DCA distance reduced χ^2



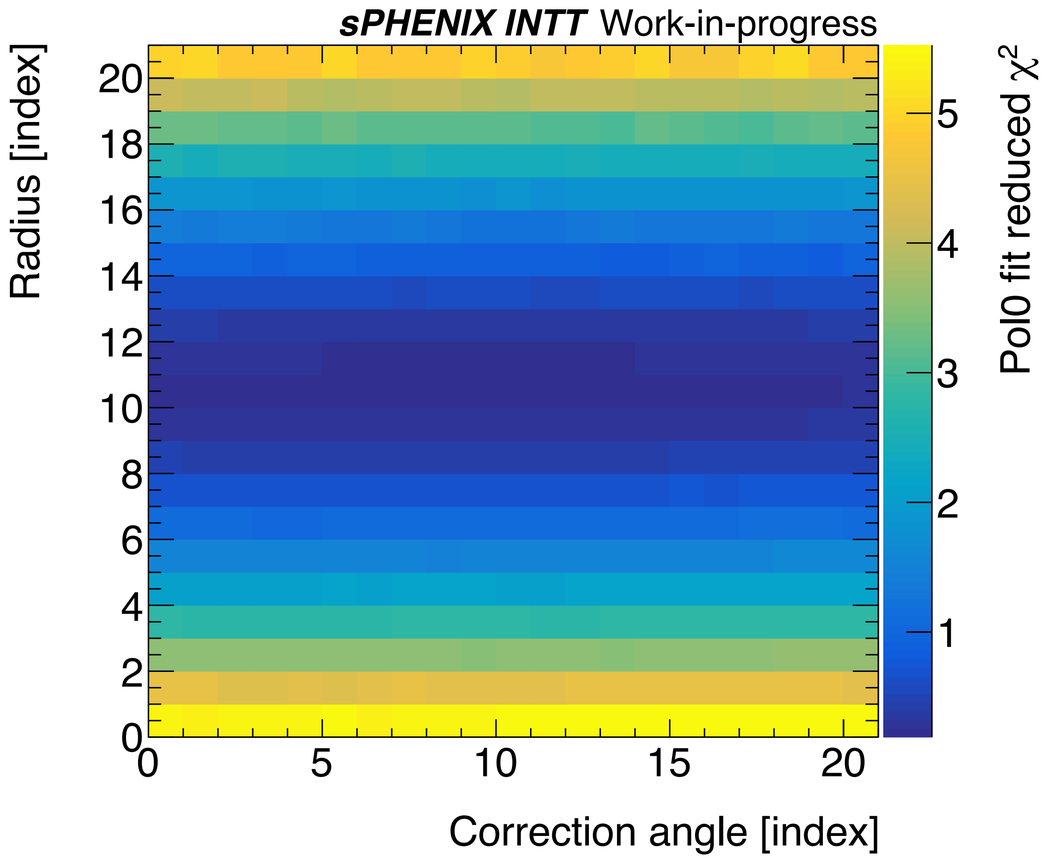
DCA distance fit error



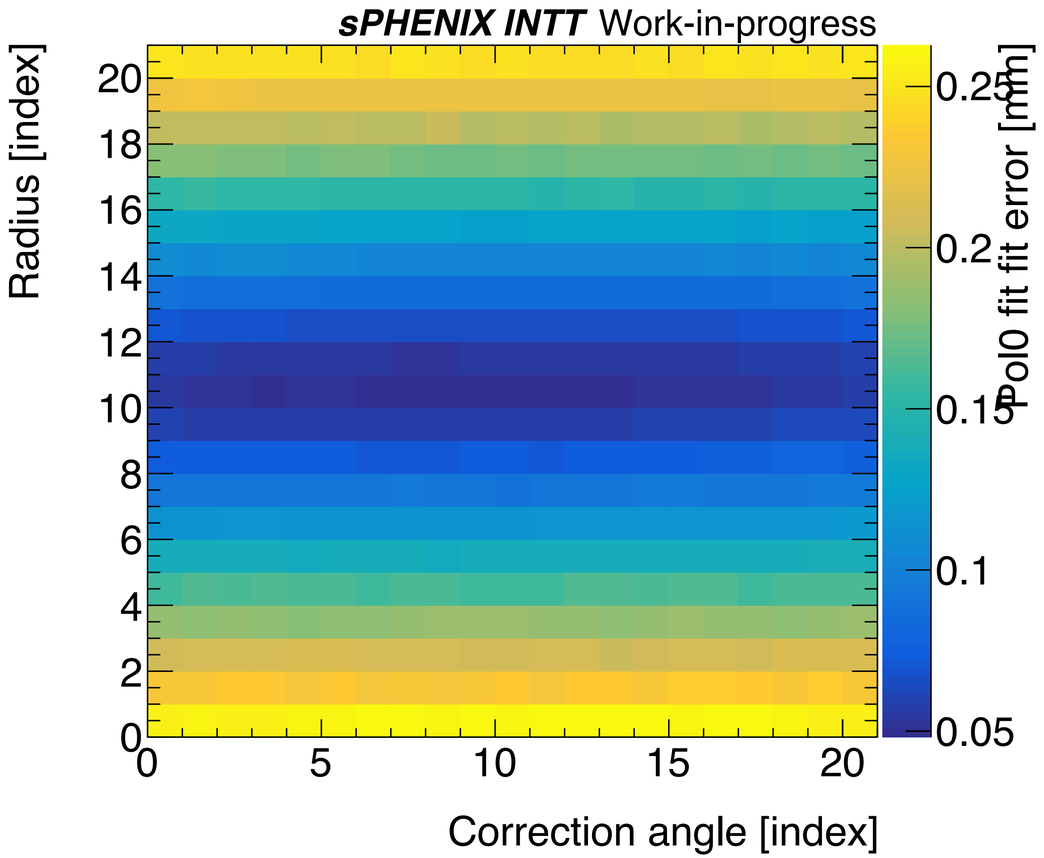
The fit error seems to be more sensitive (if the radius is given correctly)
Will implement this method with data soon

Quick trial with data run20869

DCA distance reduced χ^2



DCA distance fit error



The correlations seem to be more flat than that of MC (The true geometry is not yet understood well)

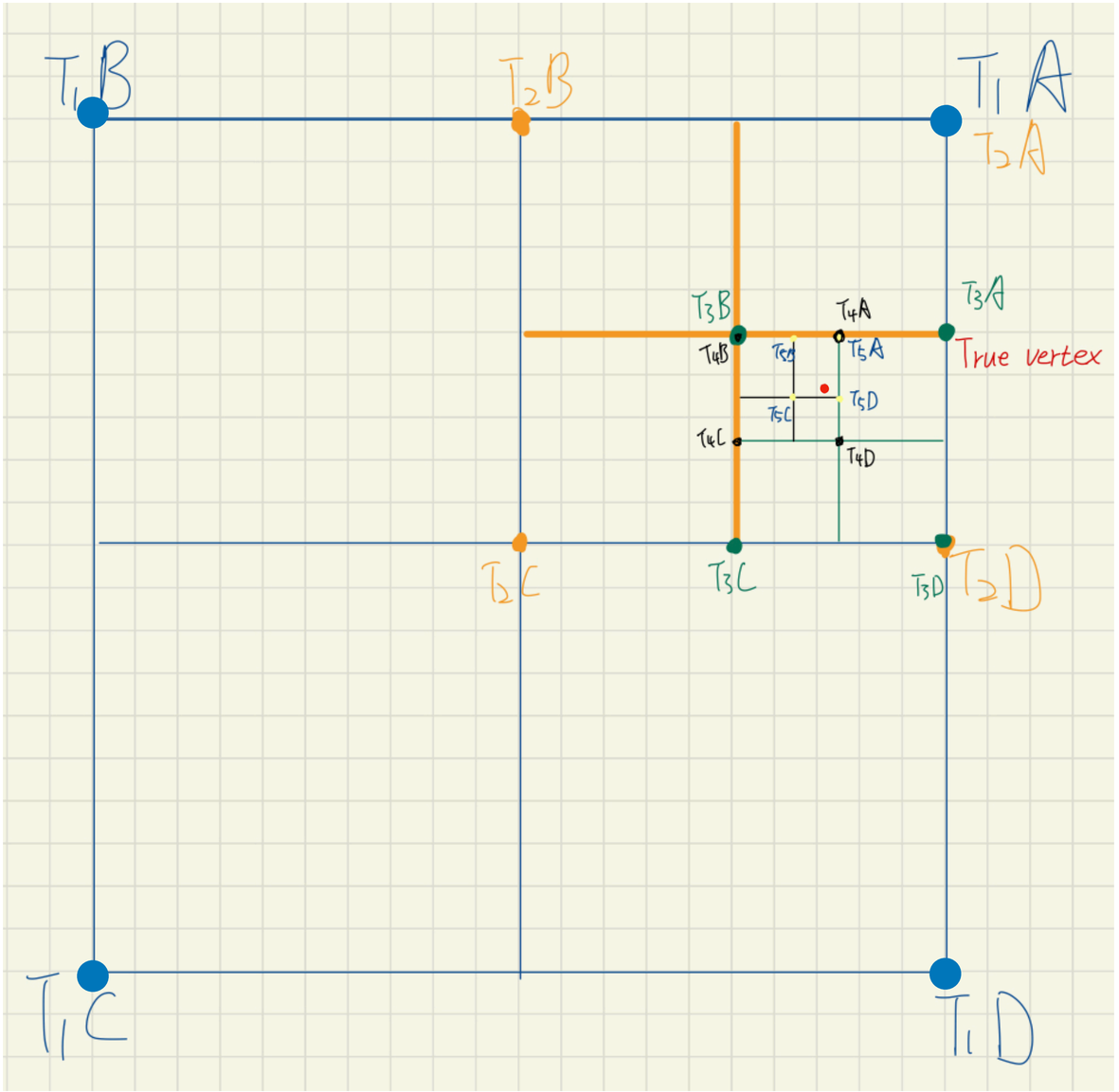
Vertex XY determination by INTT

- Another scan method, quoted from Hao-Ren
  - In each test, try with 4 vertices
  - Move to the quadrant that gives smaller DCA
  - Half the searching window
  - Move to the next test, try with 4 vertices

- Thought: the last option, which doesn't find the vertex by the geometry

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

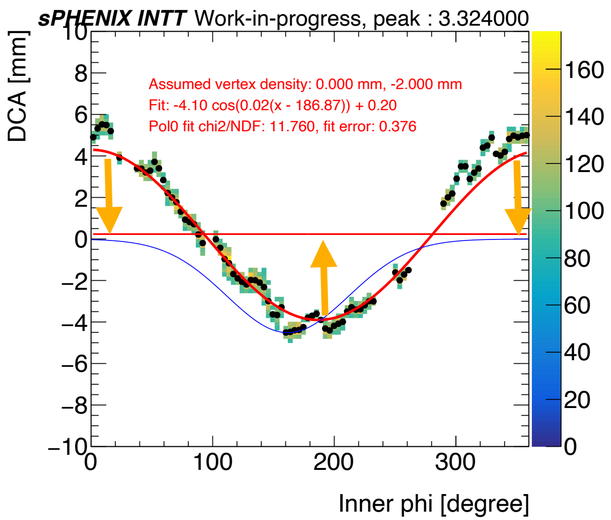
The area inside the INTT barrel

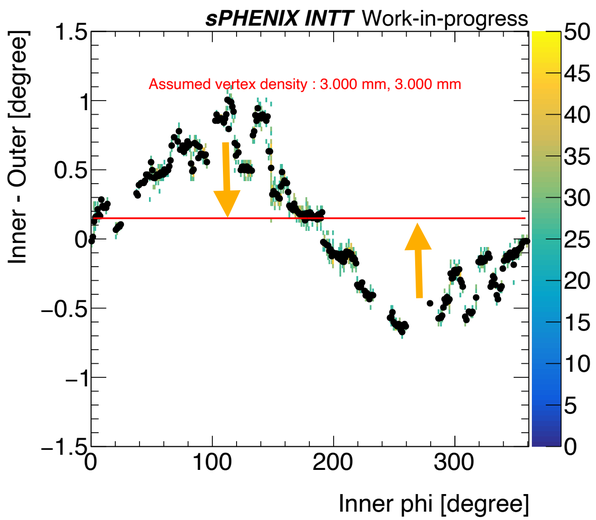


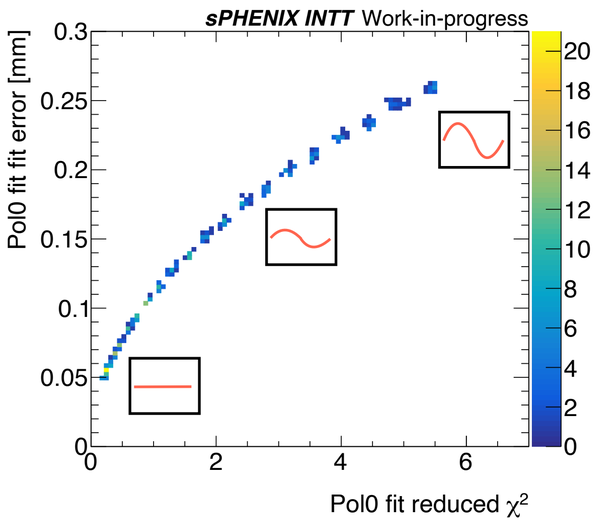
Choice of quantities

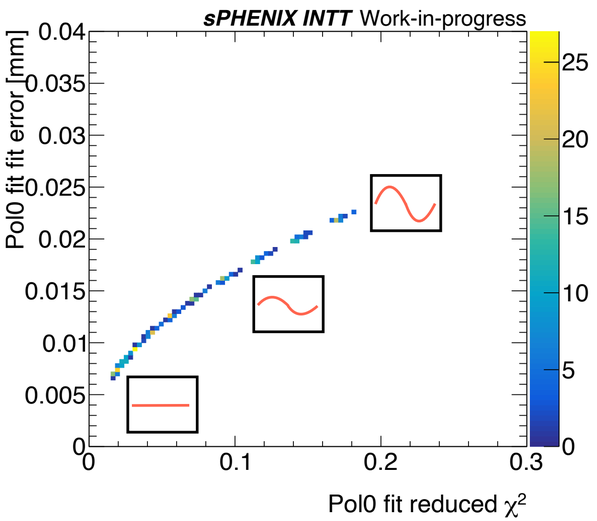
- What quantities are good choices to quantify the performance of the given vertex?
  - If the given vertex is getting closer to the true vertex:
    - DCA - inner ϕ and Δϕ - inner ϕ correlations become flat
    - Δϕ 1D distribution becomes concentrated

Background removed and fit with pol0









In the case of modulation correlation, Pol0 fit error seems to be more sensitive in the region with small amplitude
Currently better fit errors of DCA-inner ϕ and Δϕ-inner ϕ are required

Determine the vertex via two ways

Full scan method

Scan step of radius: 0.3 mm and angle: 0.4 degree

			desired X [mm]	desired Y [mm]	radius [mm]	phi [degree]
Inner	DCA	Fit error	-0.194	2.498	2.506	94.441
		Reduced chi2	-0.194	2.498	2.506	94.441
	Δϕ	Fit error	-0.320	2.491	2.511	97.320
		Reduced chi2	-0.320	2.491	2.511	97.320
Outer	DCA	Fit error	-0.226	2.497	2.507	95.172
		Reduced chi2	-0.226	2.497	2.507	95.172
	Δϕ	Fit error	-0.194	2.498	2.506	94.441
		Reduced chi2	-0.289	2.493	2.510	96.613

Quadrant scan method

Scan area ±3 mm in X and Y, scan 9 times → final window size ±0.0117 mm in X and Y

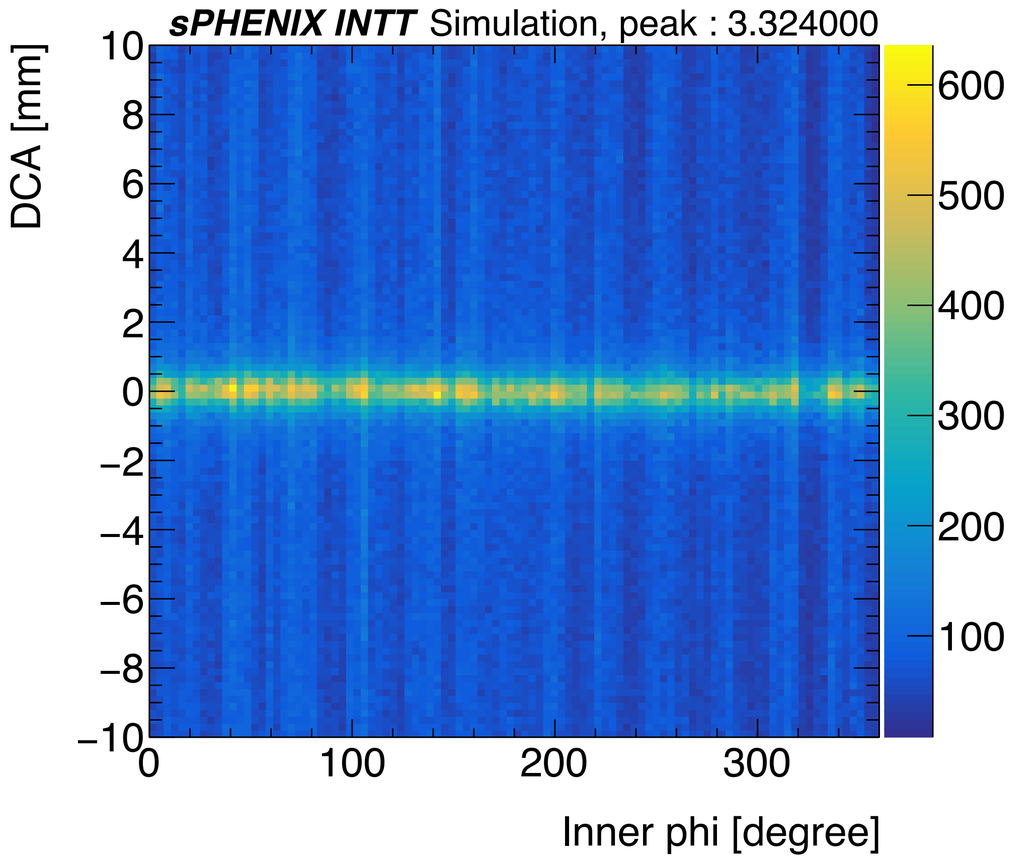
	vtx X [mm]	vtx Y [mm]	radius [mm]	phi [degree]
Best vertex	-0.1875	2.5078	2.5148	94.2759
Corresponding origin	-0.1992	2.4961	2.5040	94.5628

Both methods more and less agree each other

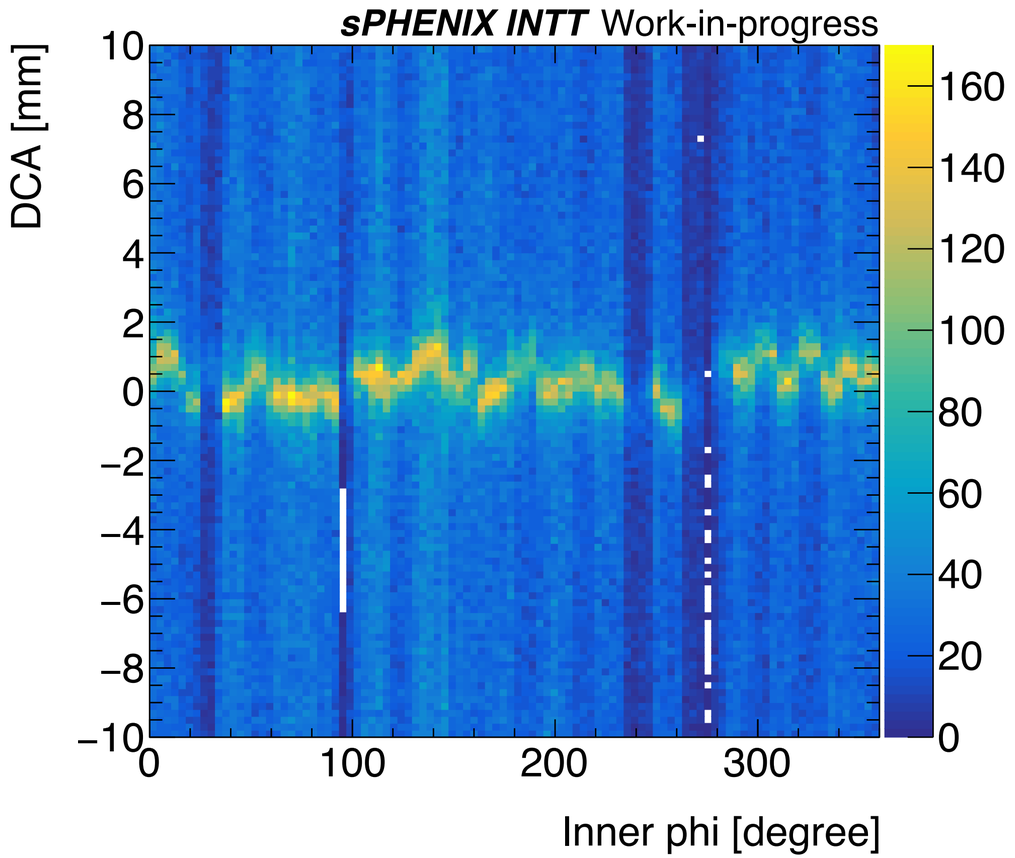
Reminder about the difference b/w data and MC

Same vertex finding algorithm

MC



Data



Studying on the geometry may be the only way to tackle it

Some thoughts on the geometry correction

- INTT: **2** sensors x **2** sides for each ladder x **56** ladders on barrel = **224** sensors
- 224 sensors x 6 degrees of freedom (x, y, z and 3 dimensional rotation) = 1344
- Each sensor has 13 possible correction attempts (±x, ±y, ±z, ±α, ±β, ±ɣ, don't move)
- TMath::Power(13,224) = 3.3366520e+249 → too a lot 😅 😅

- Try to do approximated geometry correction and factorize the combinations
  - Fix z, α, β, ɣ (Assume the effects of rotation is small, and it's hard to correct Z)
  - First focus on the sensors of south side type B (south-most sensor)
  - With beam (two points for each tracklet), first focus on B0L0 and B1L0 sub-layers

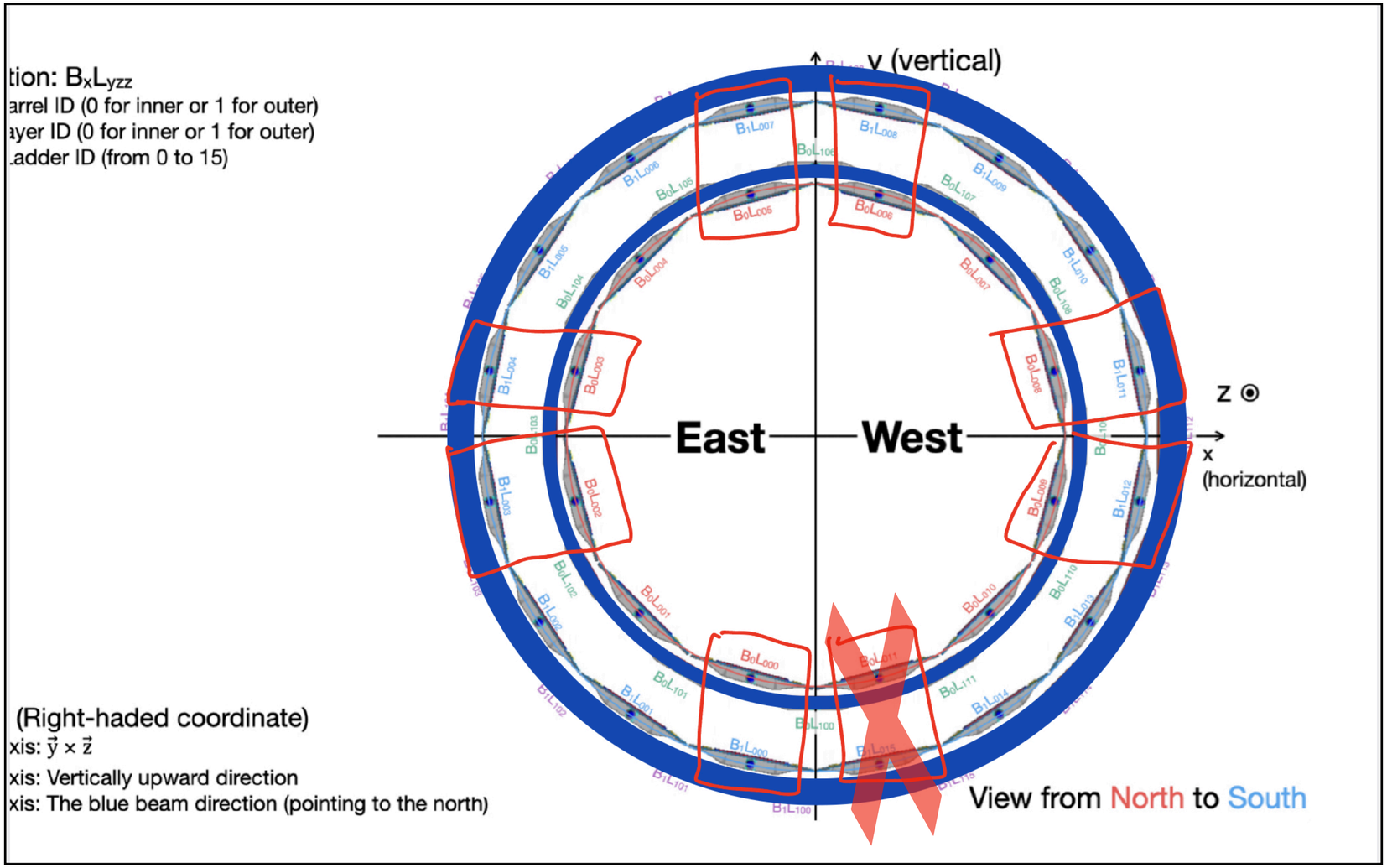
  → 28 sensors with 2 degrees of freedom (5 possible correction attempts)

  →Only 14 ladders overlap with others

  →Math::Power(5,14) = 6.1035156e+09 → still a lot 😅 but let's try to start with this

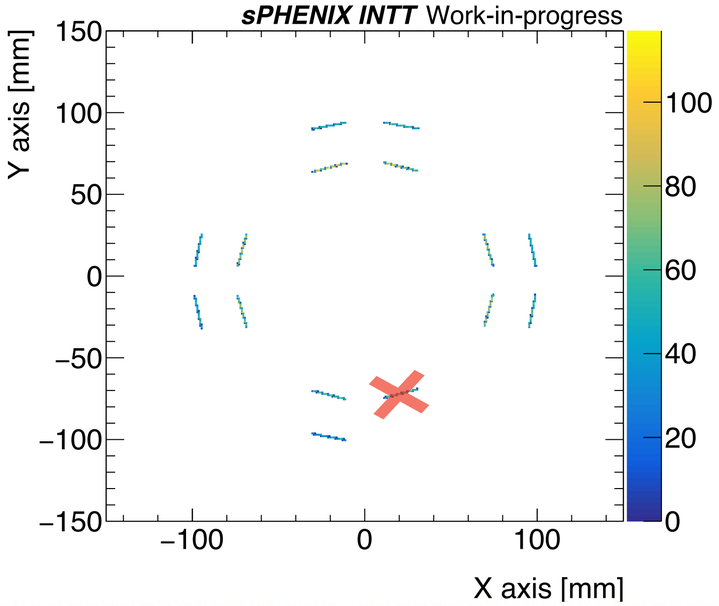
- So it may then be a sequential correction method (start with / have some references first!)

Starting point of geometry correction

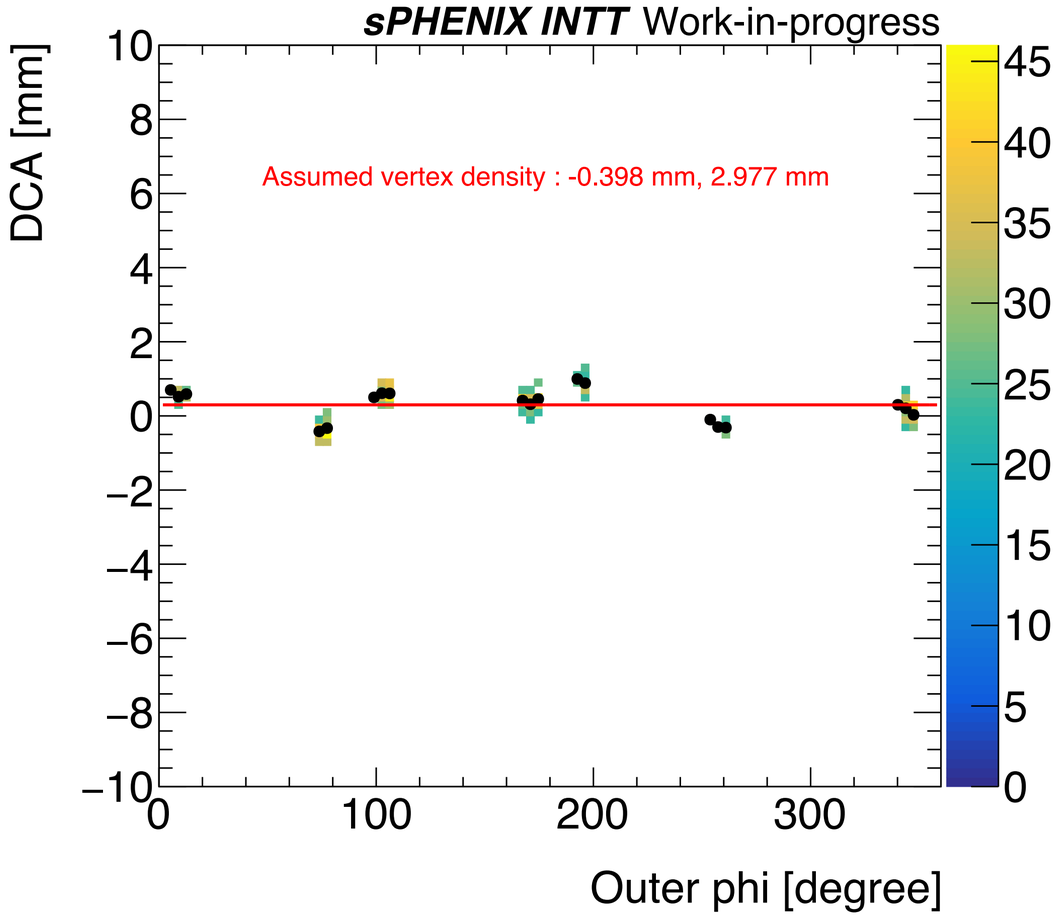


With the consideration of B0L0 and B1L0 only, there are 16 ladder overlapping with others

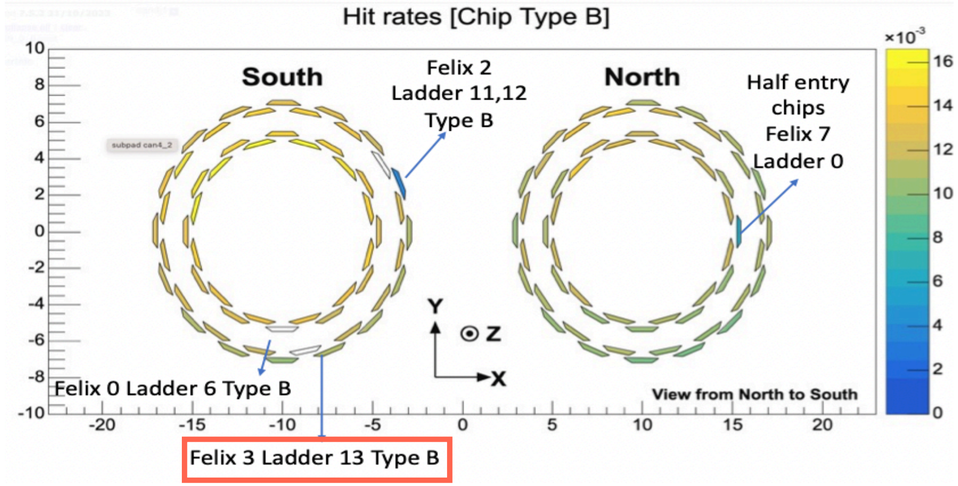
Implementation!



Run through the vertex find macro



Slide from Jaein



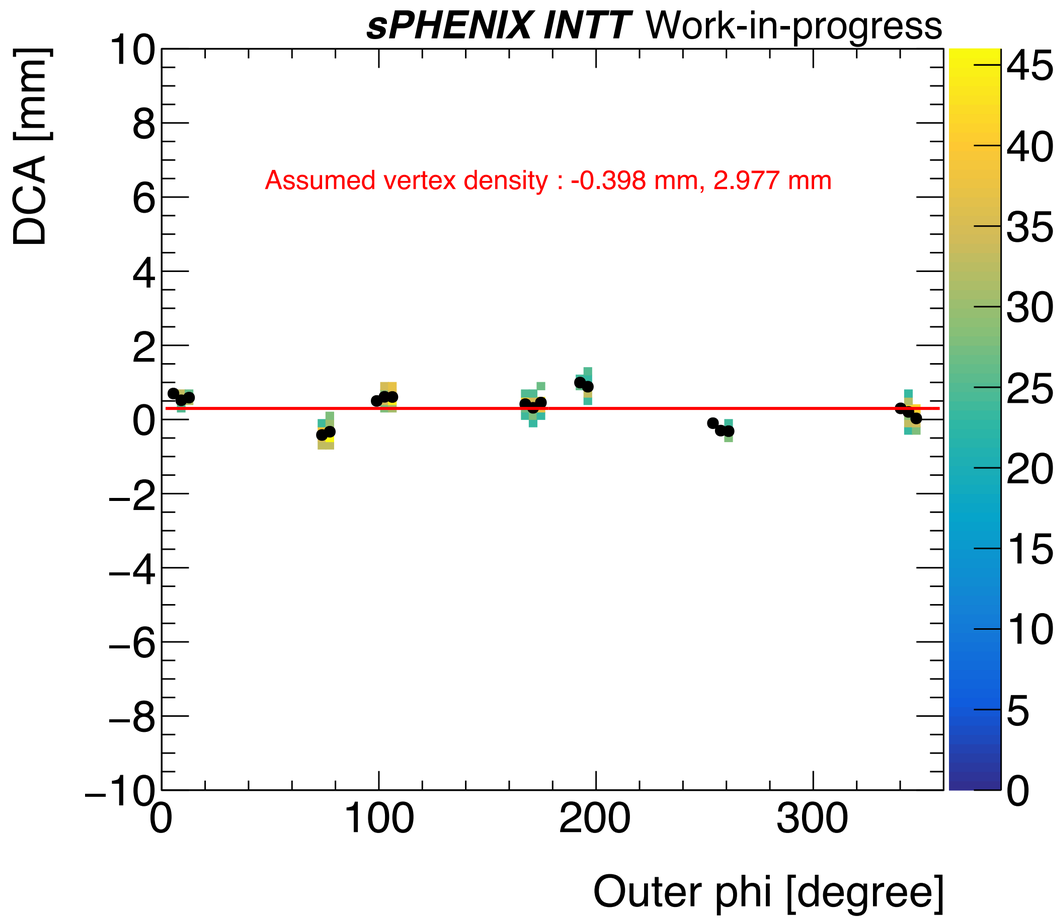
Try to first work on the alignment test with 7 pairs

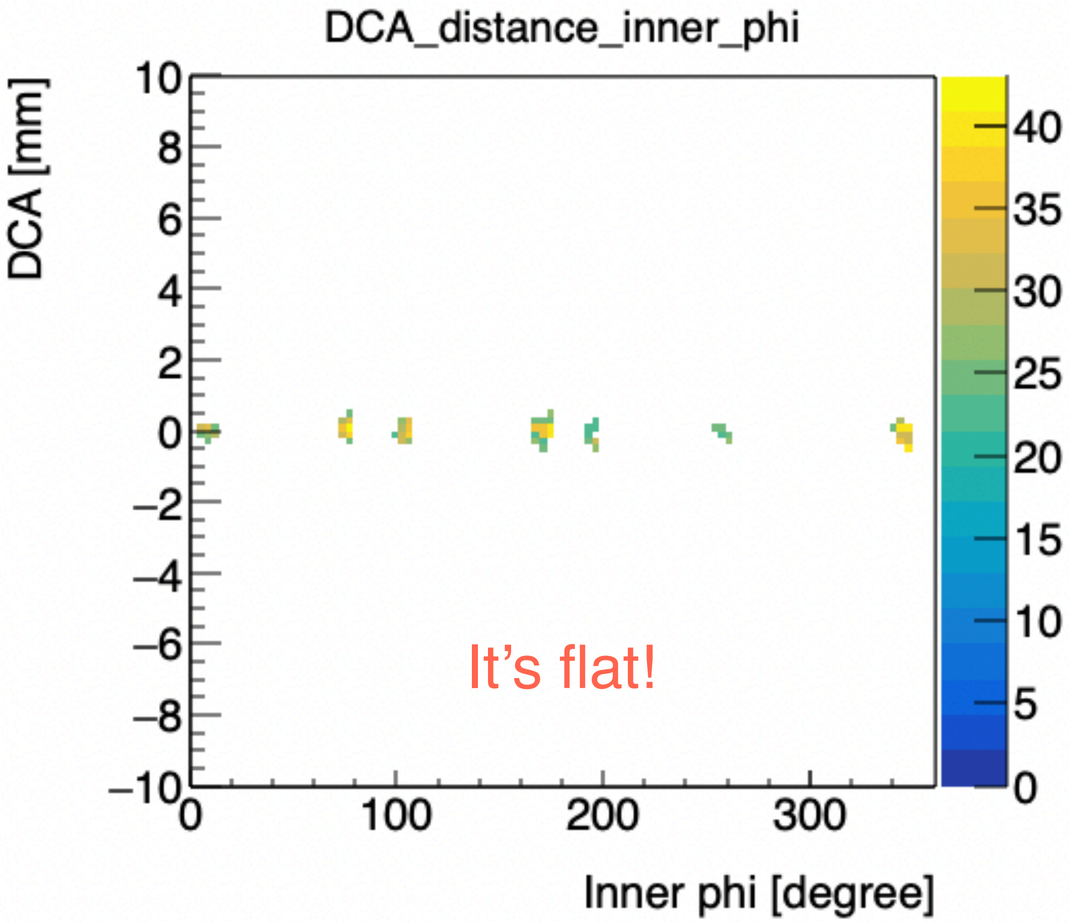
Implementation - procedures

- Random Gaussian with the range ±0.2 mm for each axis, for each sensor
- Run through the vertex finding algorithm
- Fit the correlations with Pol0 → check the fit error and fitting line position
  - Perfect geometry should have minimal fit error and fitting line lying on zero
- 🤞🏽🤞🏾 to hit the jackpot ! or at least try to find any tendencies
- First attempt: 3,000,000 trials

Current status

One of the best cases



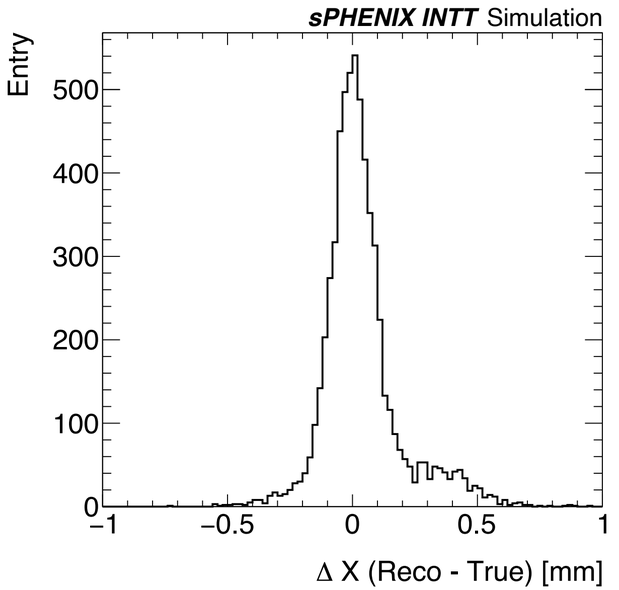


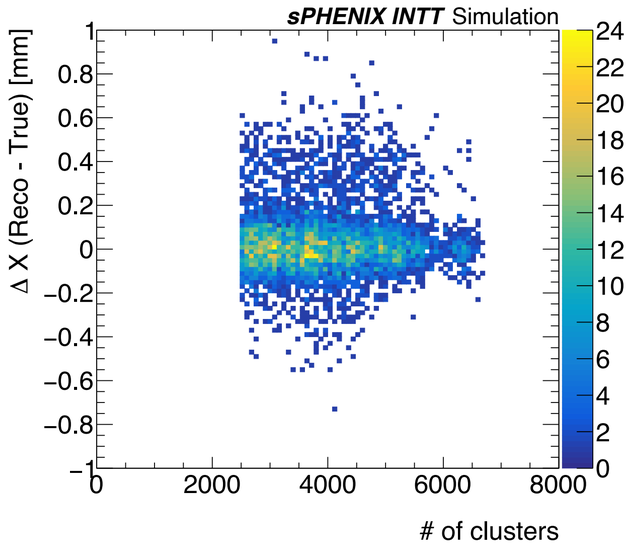
Further confirmation is needed, vertex position, cosmic ray, etc.

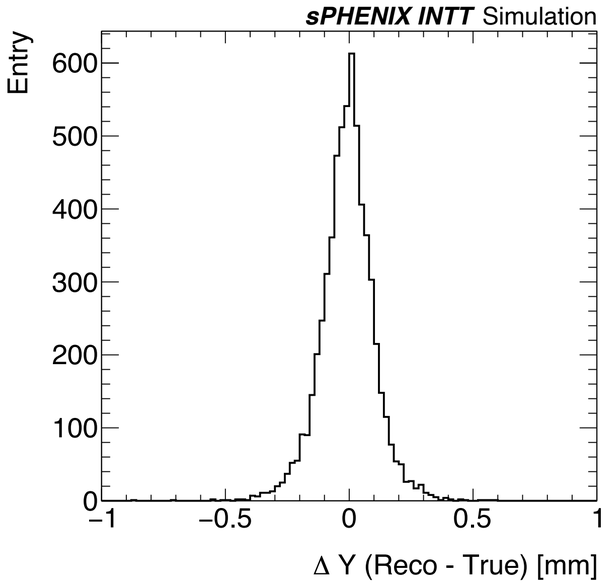
Event by event vertex XY

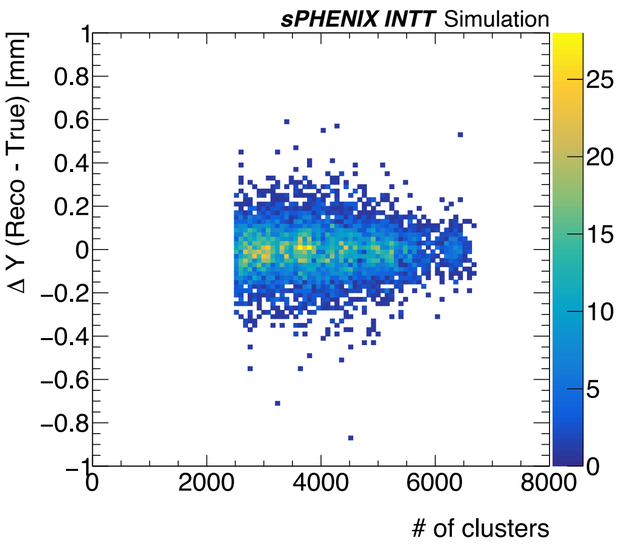
- Performed after the Z vertex finding as an additional constraint
  - Pure the tracklet selection
- Quadrant method with the origin (0,0) and 6 mm x 6 mm square
  - 9-time iteration

- Feasibility study with MC (true z vertex was used)
- Number cluster > 2500









It’s possible to measure the VTXxy event by event. A relatively poor resolution is expected

Summary

- Multiple ways for vertex XY determination were developed. All are working well with MC
  - Not sure about the performance with data
  - Could be caused by the un-corrected geometry

- Having the approximated “perfect” geometry has high priority!
  - The factorization method was attempted which tries to reduce the degrees of freedom
  - Within the first 3M trials, several combinations can provide flat correlation
  - Further confirmation is needed with vertex checking, cosmic ray

- It may be feasible to achieve the 3D vertex event by event
  - Relatively poor resolution in XY which may be expected

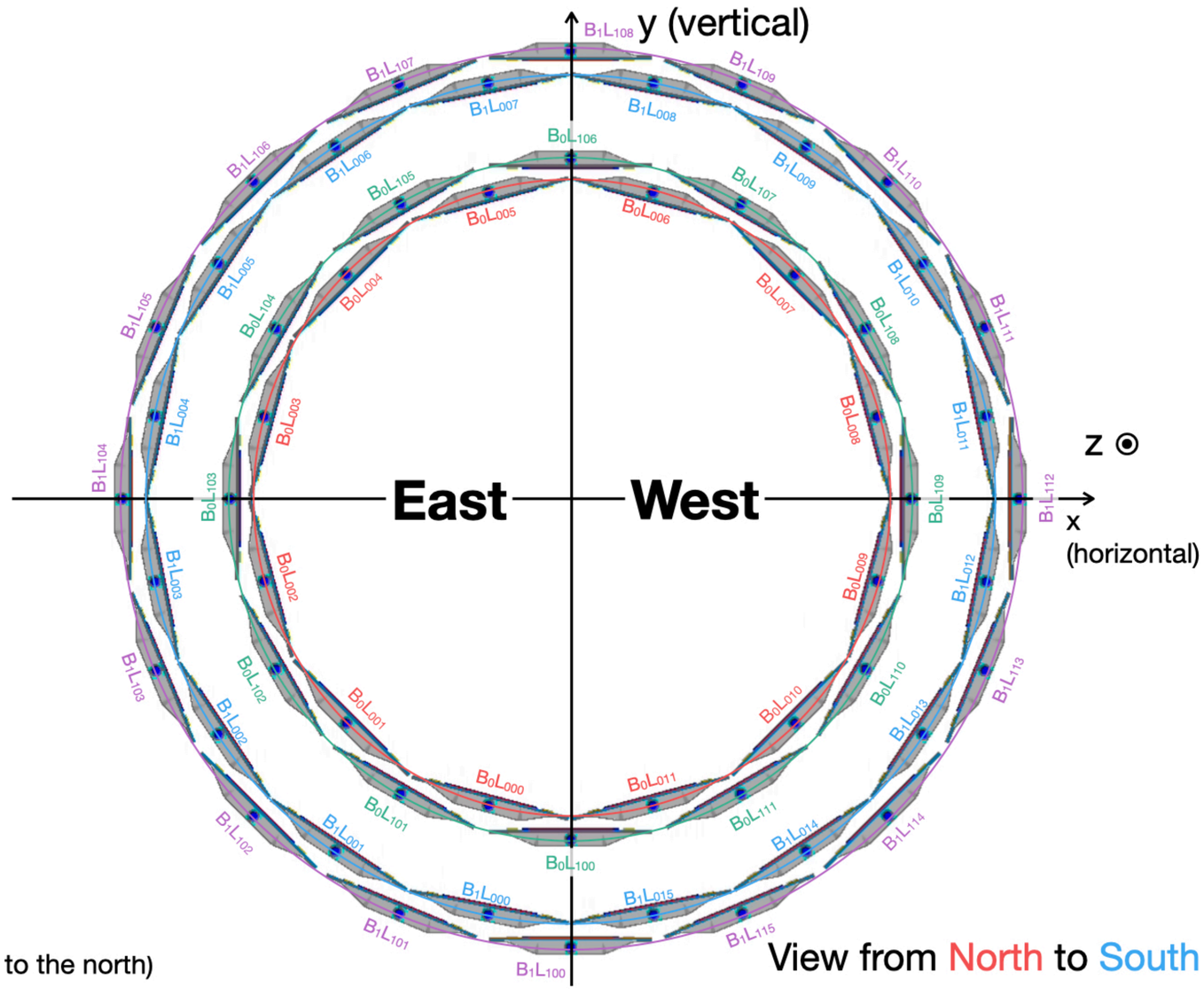
Short-term todo list

- Attempt of geometry fine tuning
- Implementation of vertex event by event
- Analysis note of beam test 2021, (review the results during the writing)

Back up

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)