Commissioning, Performance, and Alignment of the sPHENIX Tracking Detectors

Supported by DE-SC0023491

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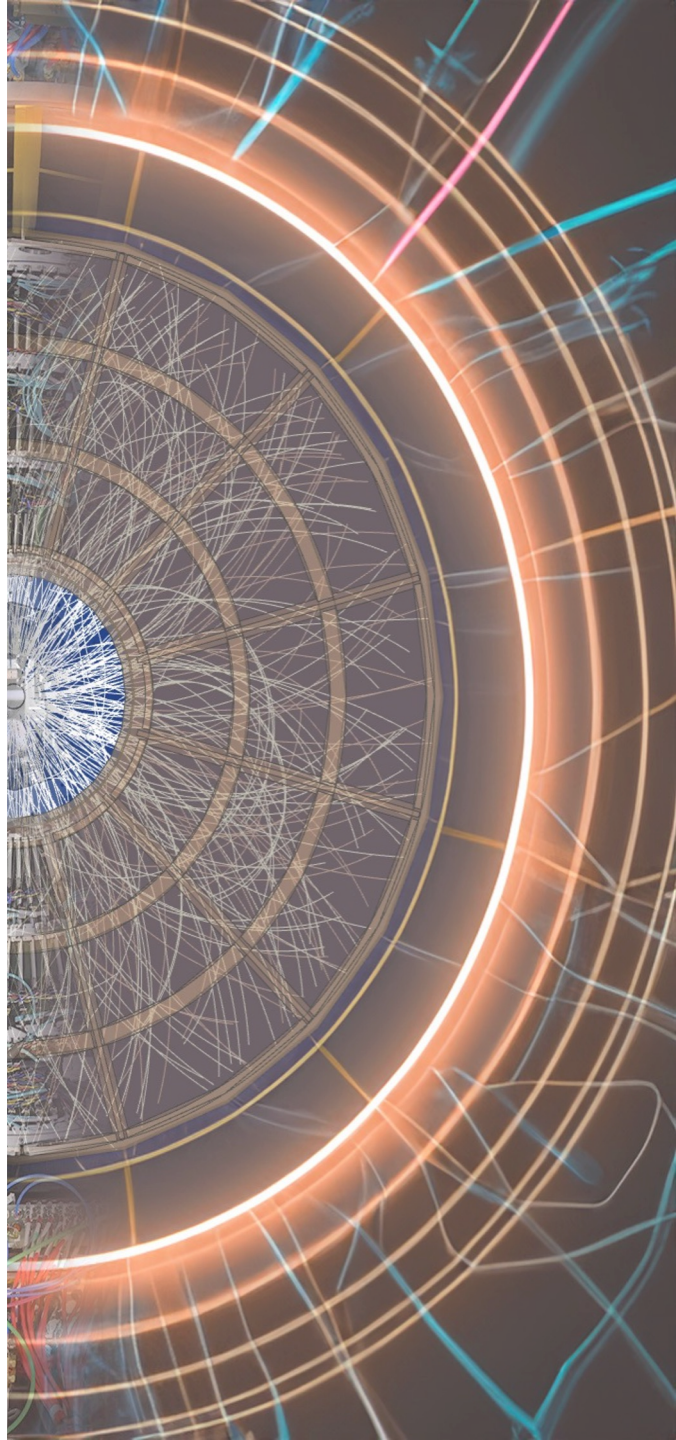
- ✓Performance Plots



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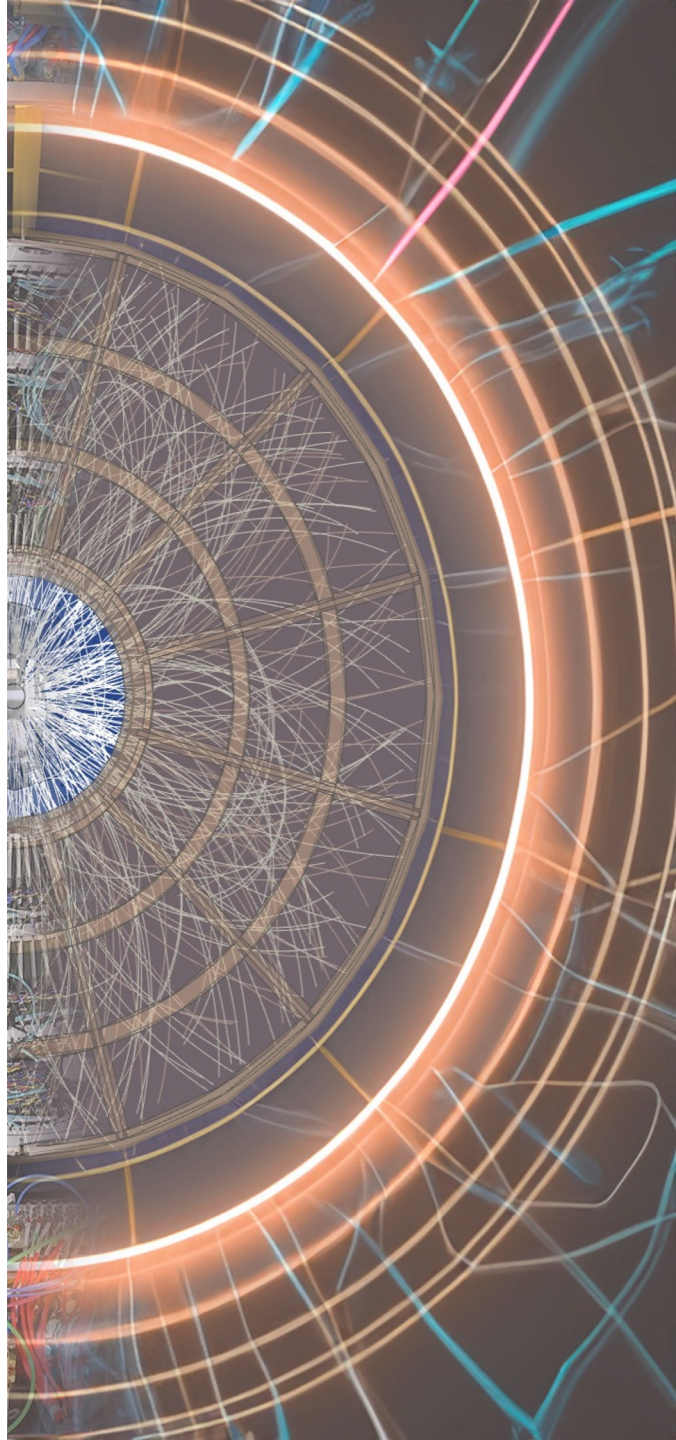
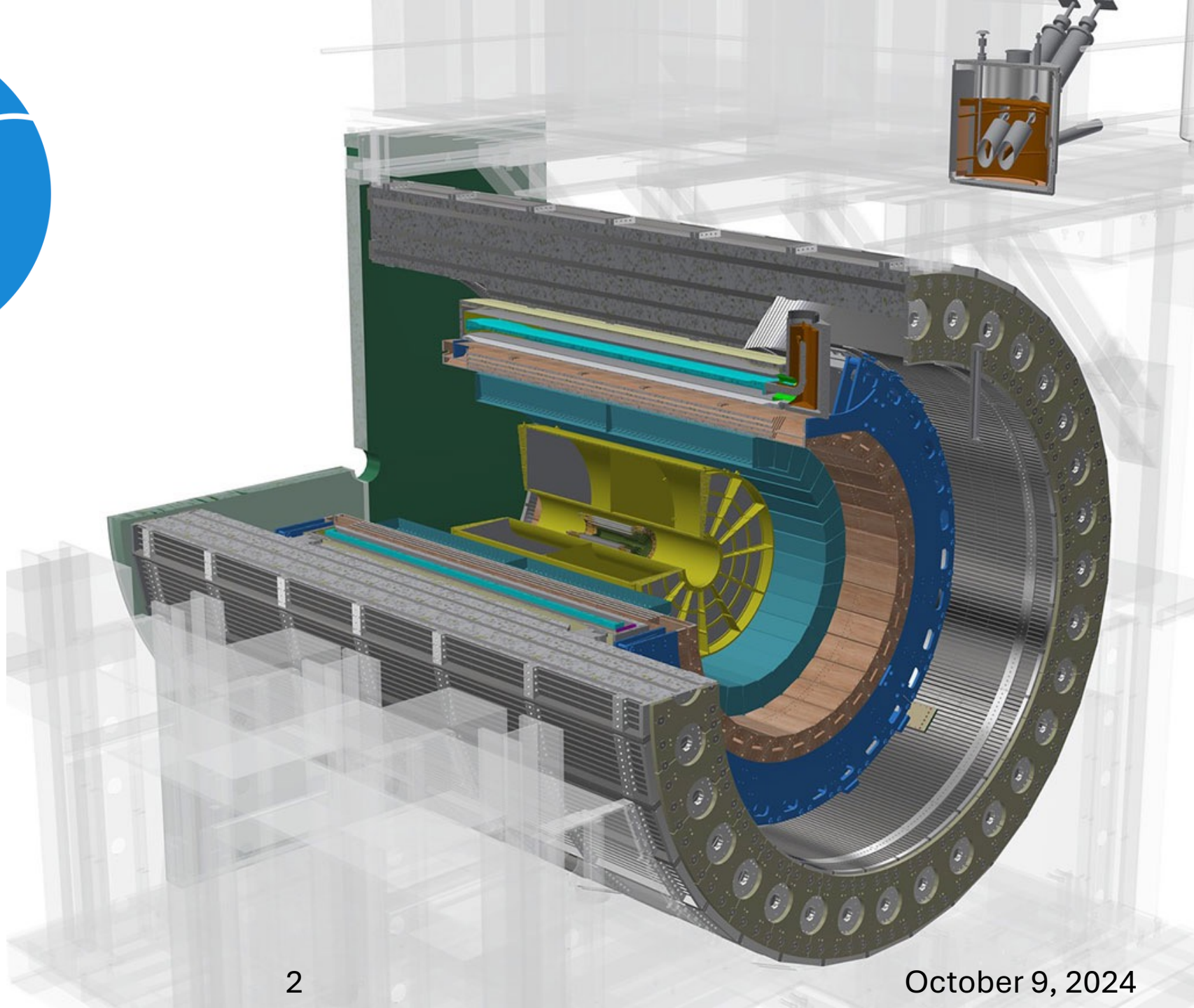


sPHENIX

2π coverage in azimuth

$$-1.1 \leq \eta \leq 1.1$$



MVTX

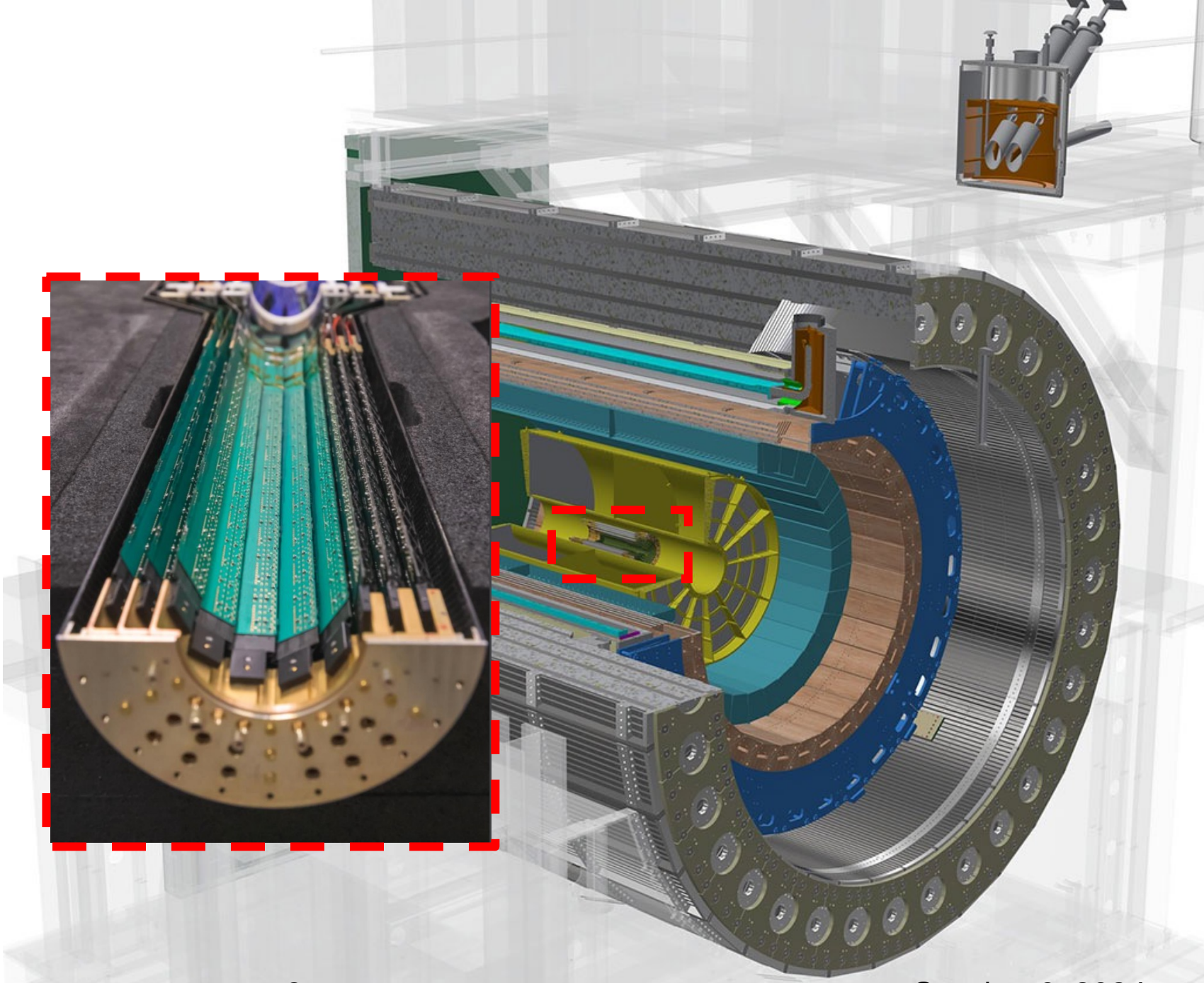
Monolithic Active Pixel Sensors (MAPS) Vertex Detector

Located near beampipe for high precision primary and secondary vertex measurements

Consists of 3 layers of silicon pixel staves within $\sim 1 < r < 5$ cm

~5-micron precision in $r\phi, z$

$10\ \mu s$ integration time



INTT

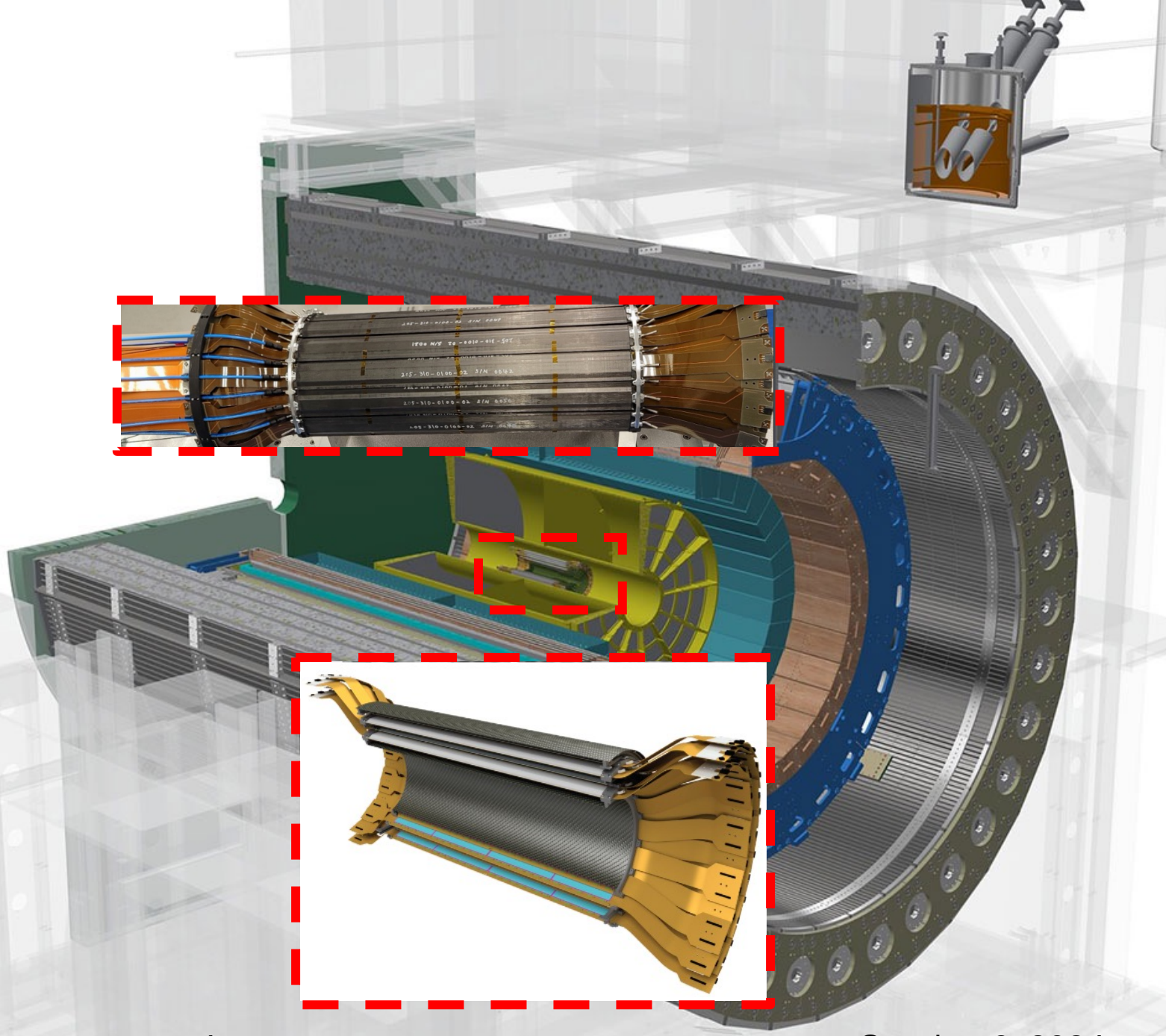
Intermediate Tracker Detector

Timing resolution allows us to separate pileup events in the TPC in high multiplicity heavy ion collisions

Consists of 2 layers of silicon strip detectors within $\sim 7 < r < 11$ cm

~25-micron precision in $r\phi$, 1 cm in z

Fast $\sim 60\ ns$ integration time compared to $106\ ns$ RHIC bunch crossing spacing



MVTX

INTT

TPC

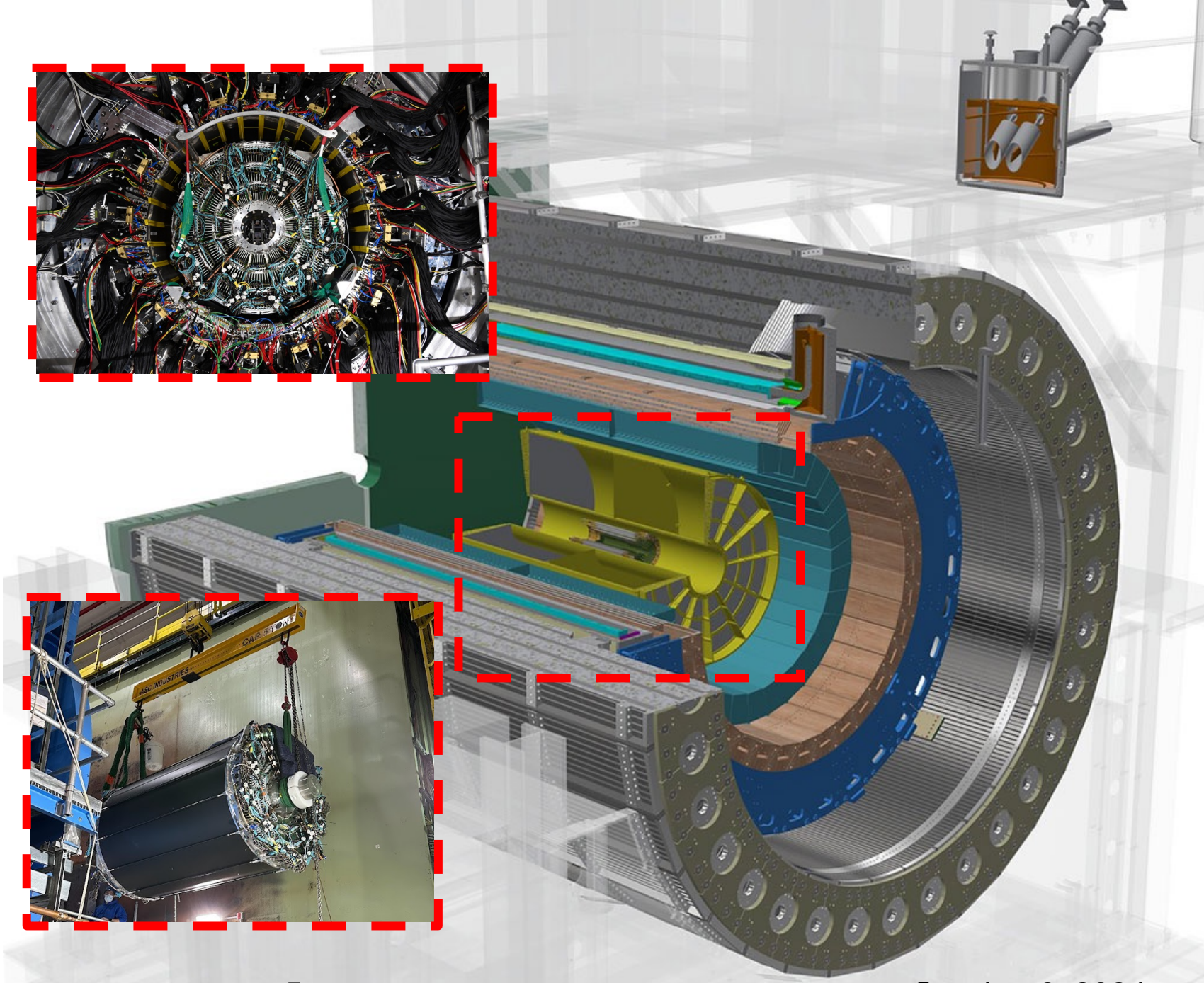
Time Projection Chamber

High resolution momentum measurements of charged particles

Gaseous volume contained within ~80 cm outer radius

~150-micron precision

Long ~15 μs drift time



MVTX

INTT

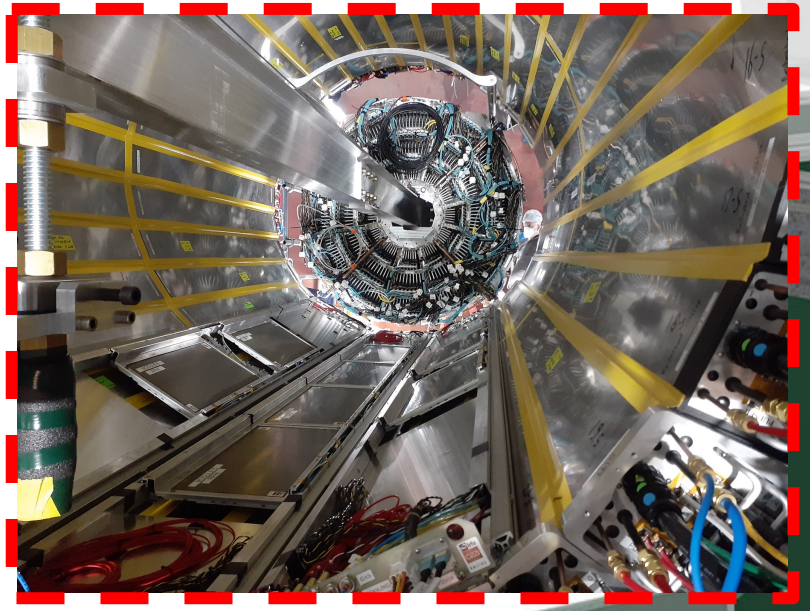
TPC

TPOT

TPC Outer Tracker

Located outside of the TPC

Corrects for TPC distortions by providing an additional precision data point



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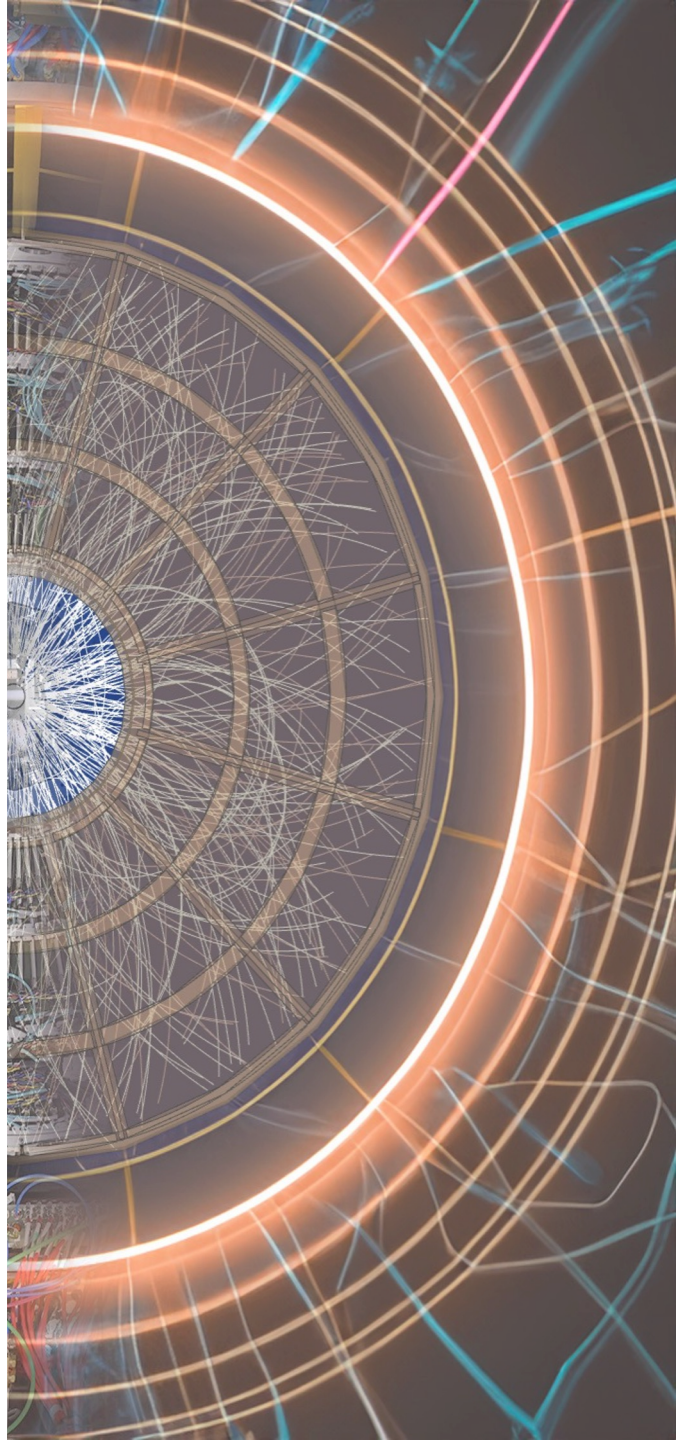
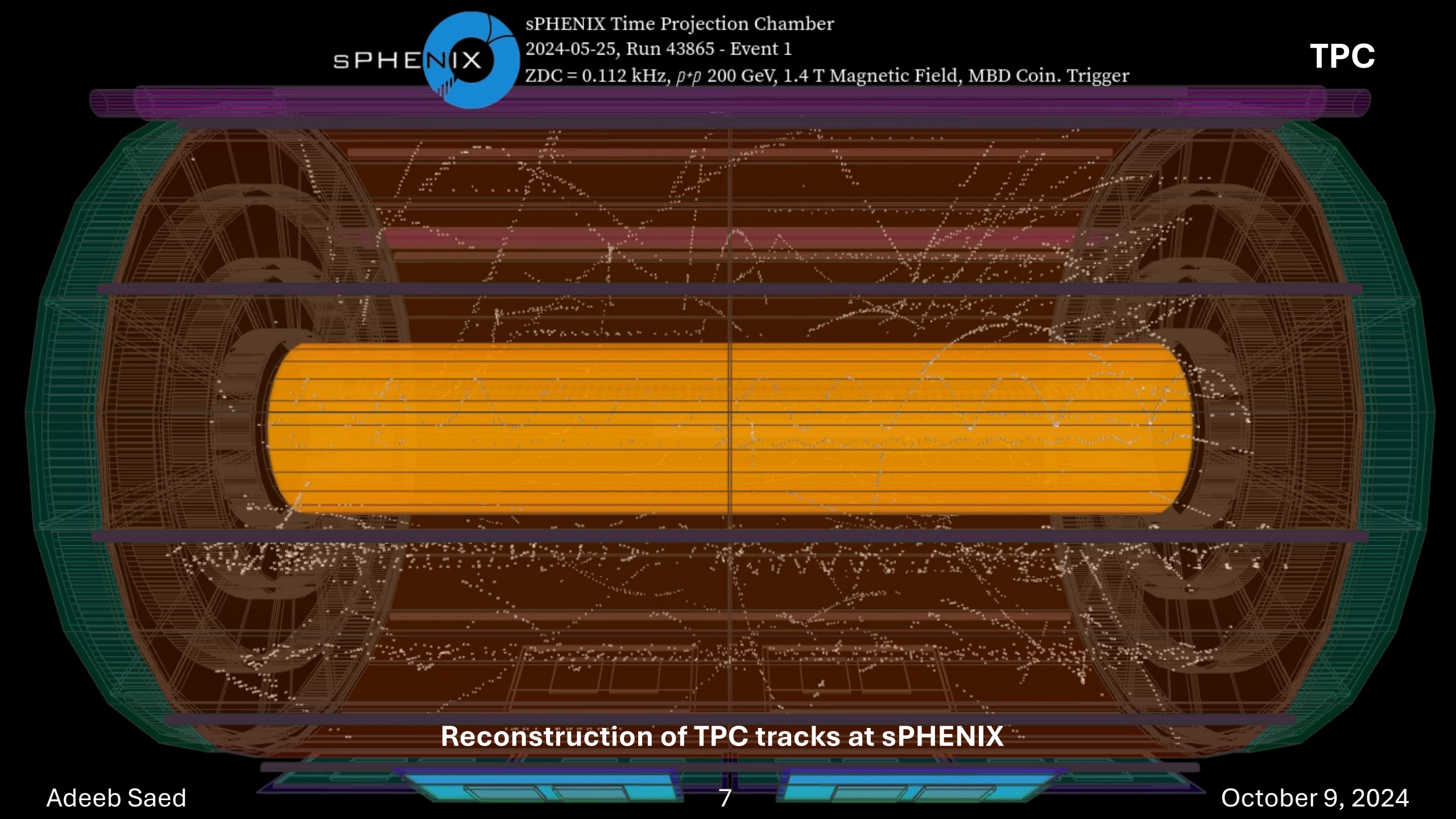
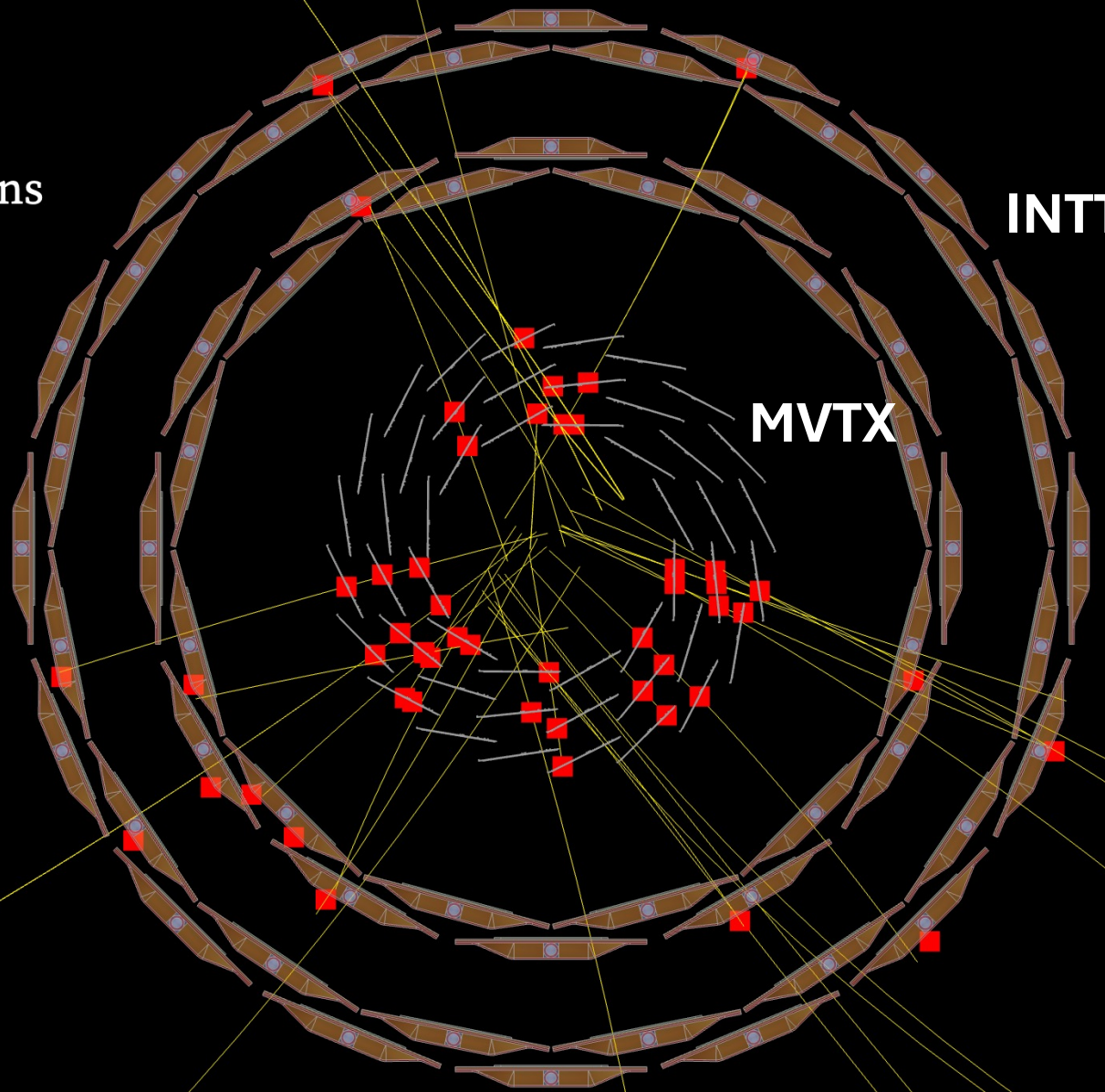




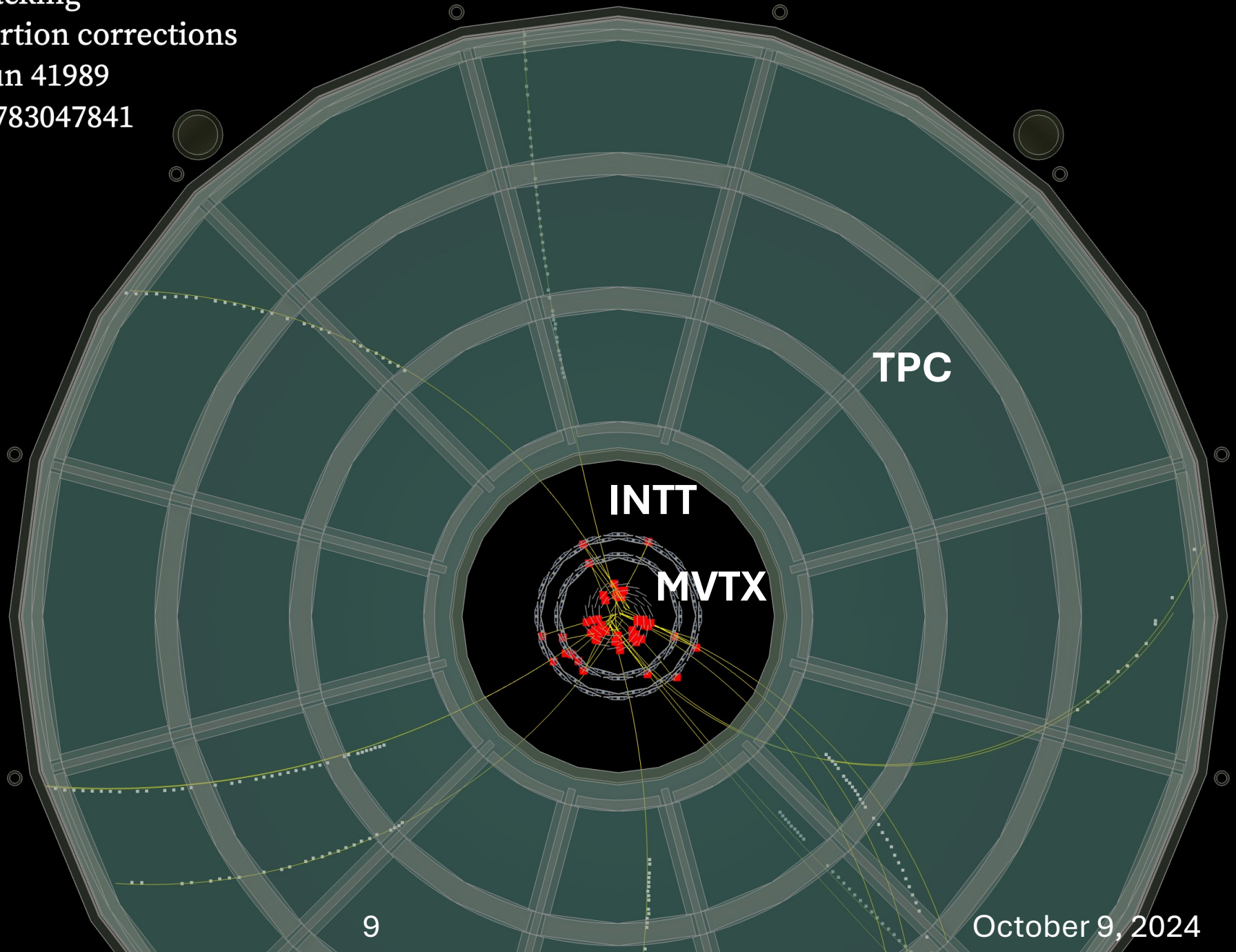
Reconstruction of TPC tracks at sPHENIX

sPHENIX Tracking
No TPC distortion corrections
2024-6-12, Run 41989
BCO: 401966783047841
200 GeV p+p

Reconstruction of tracks in the silicon layers



sPHENIX Tracking
No TPC distortion corrections
2024-6-12, Run 41989
BCO: 401966783047841
200 GeV p+p



Ability to match tracks in the silicon layers to the TPC

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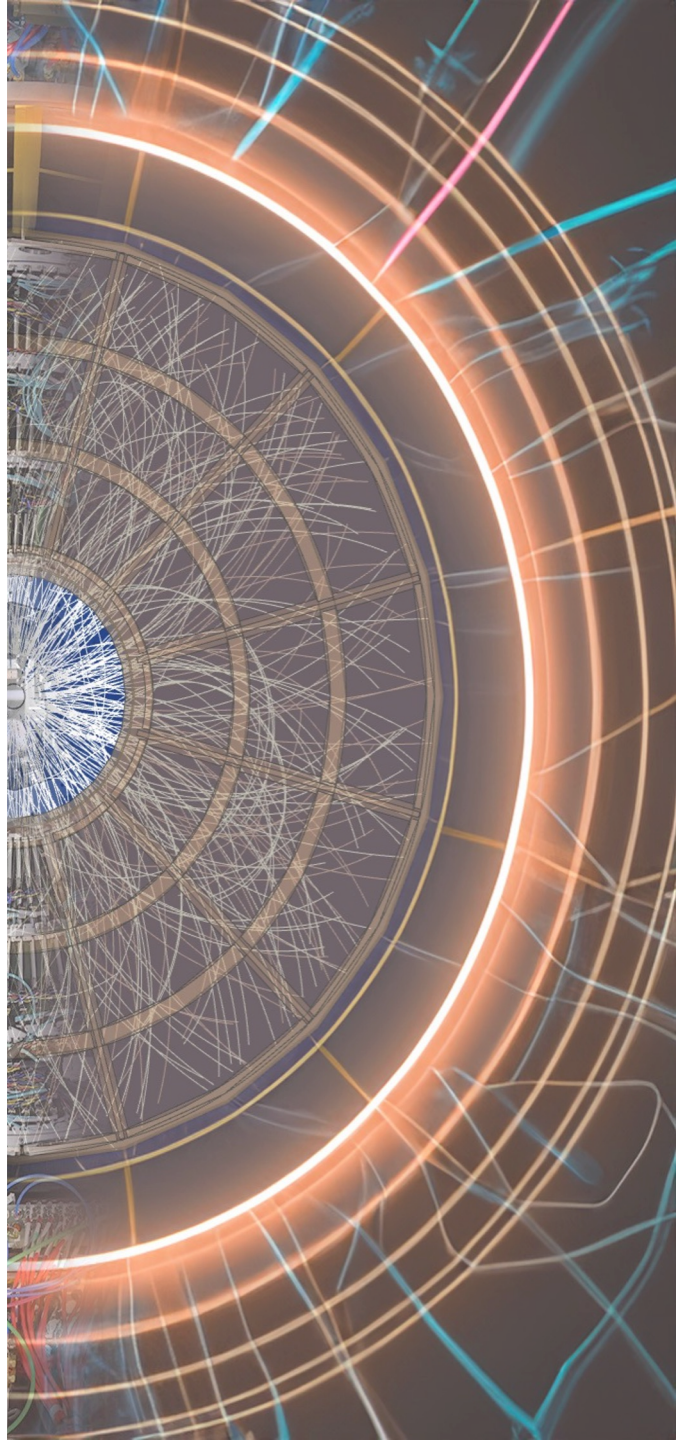
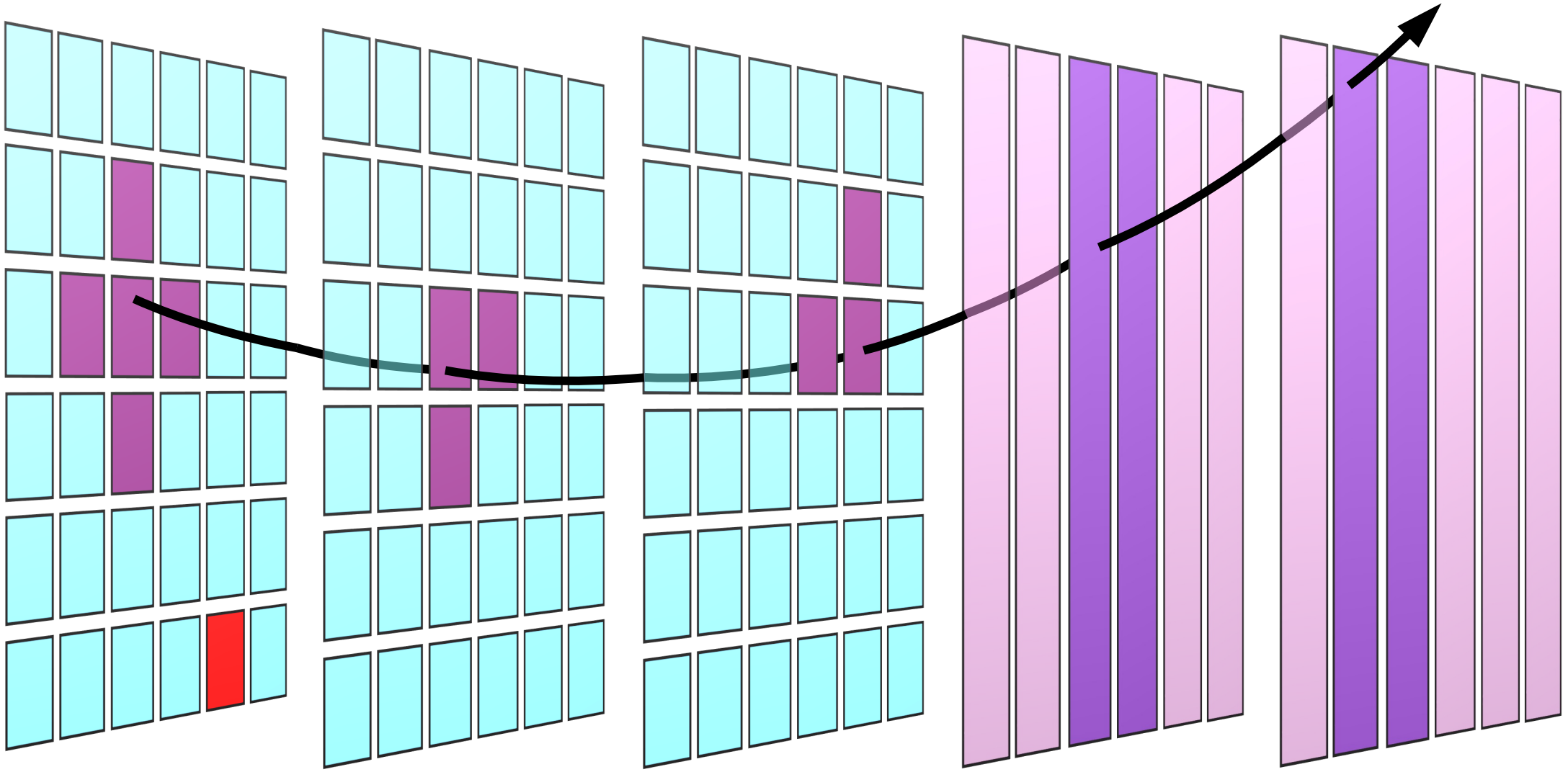




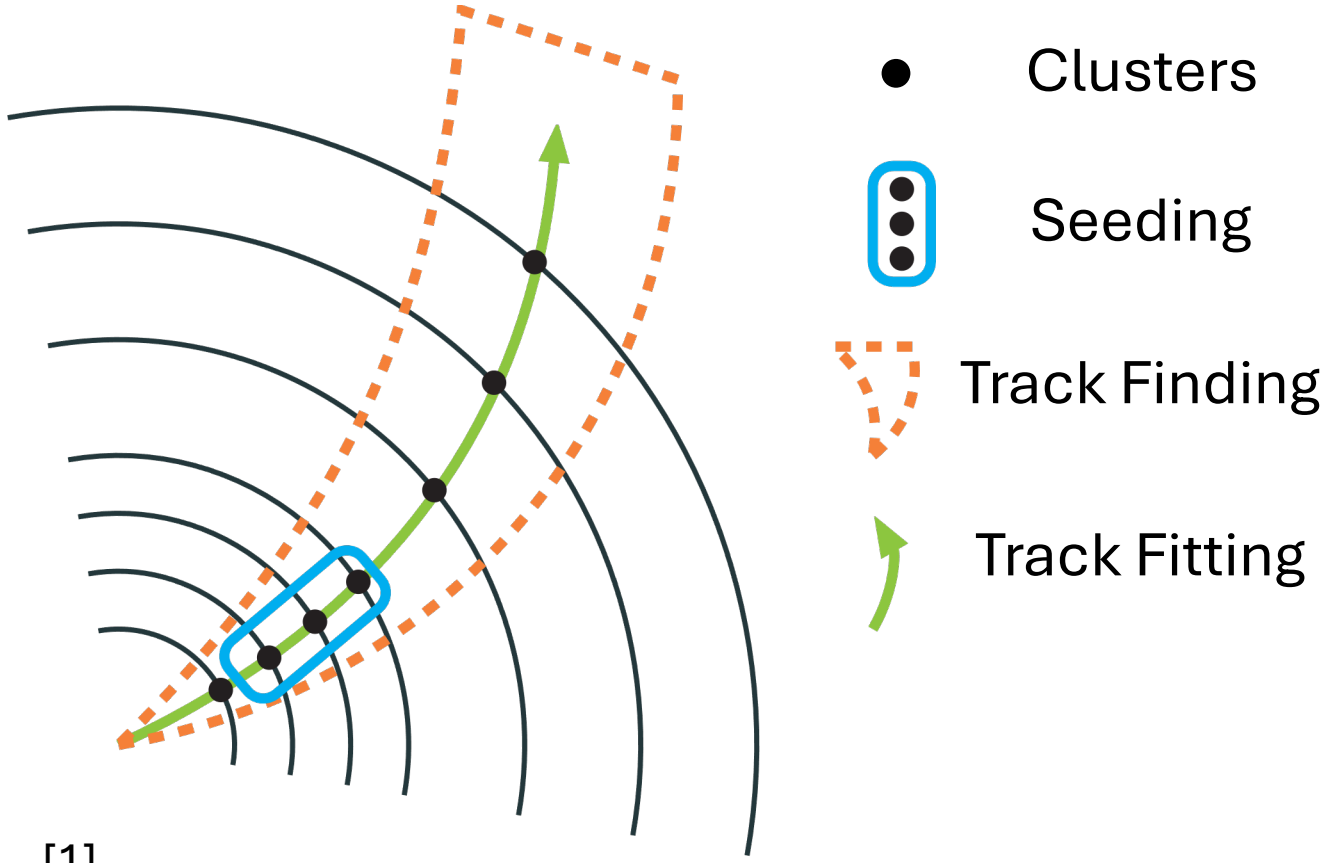
1. Clustering algorithm combines **raw hits** into **clusters**.

2. Seeding algorithm combines **clusters** across silicon layers. A silicon **seed** is a potential track candidate.

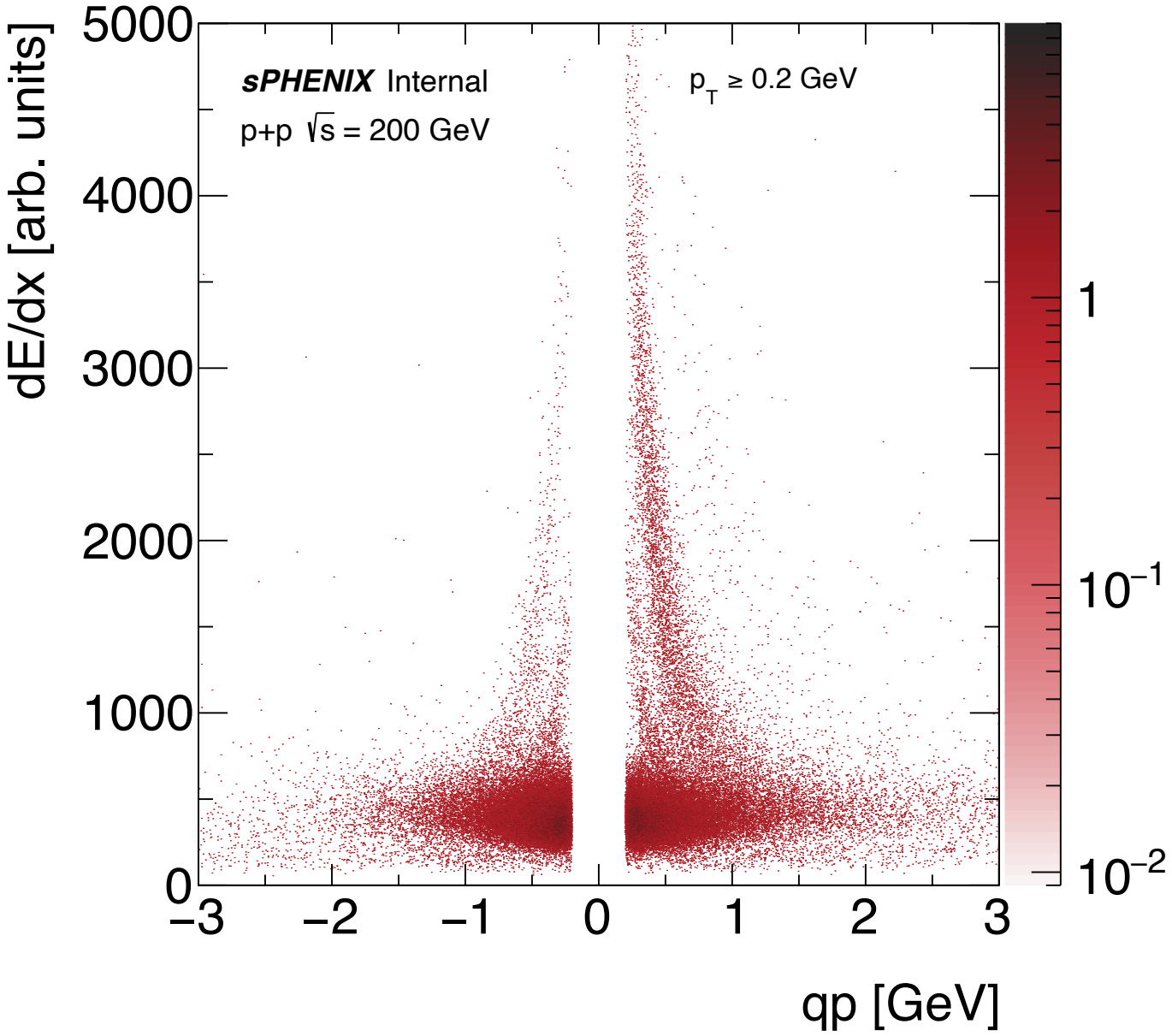
3. A separate seeding algorithm is performed across the TPC layers.

4. Geometrically, silicon and TPC seeds are associated into a **combined seed** based on η, ϕ, and DCA to the beamline. The collision bunch crossing is determined from the INTT cluster time.

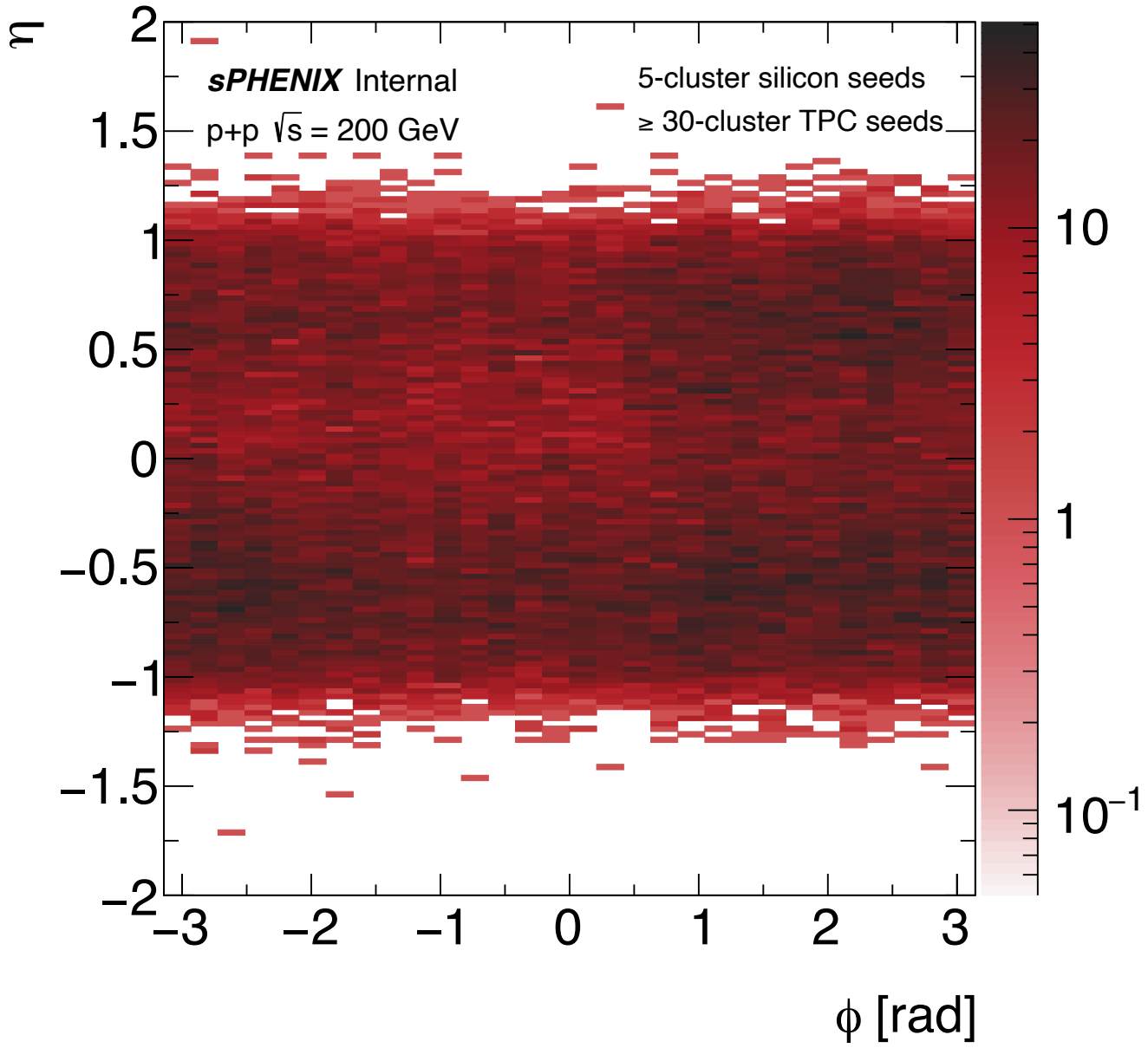
5. With a **Kalman Filter**, the combined seed is fit to extract the track parameters.



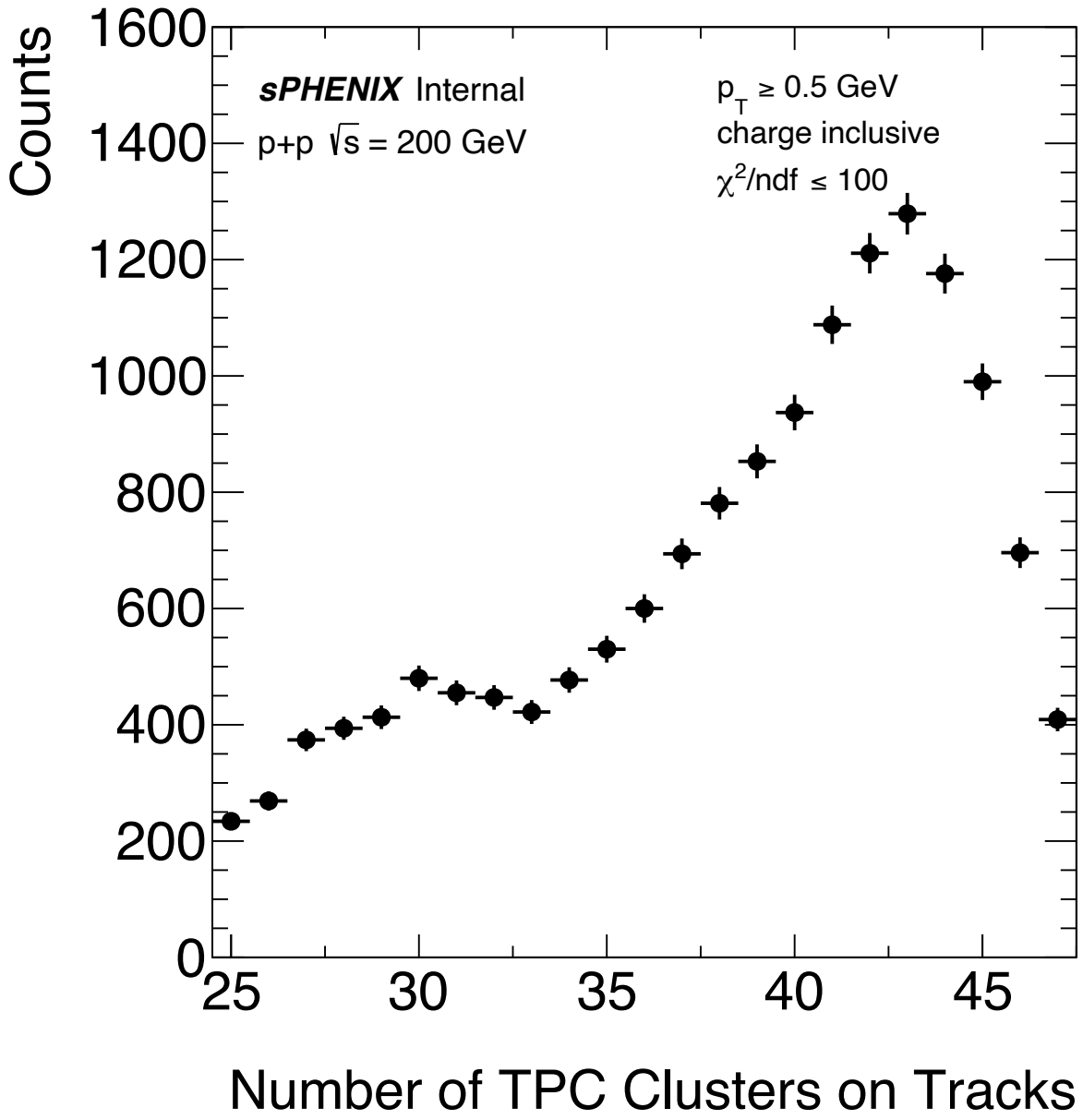
[1]



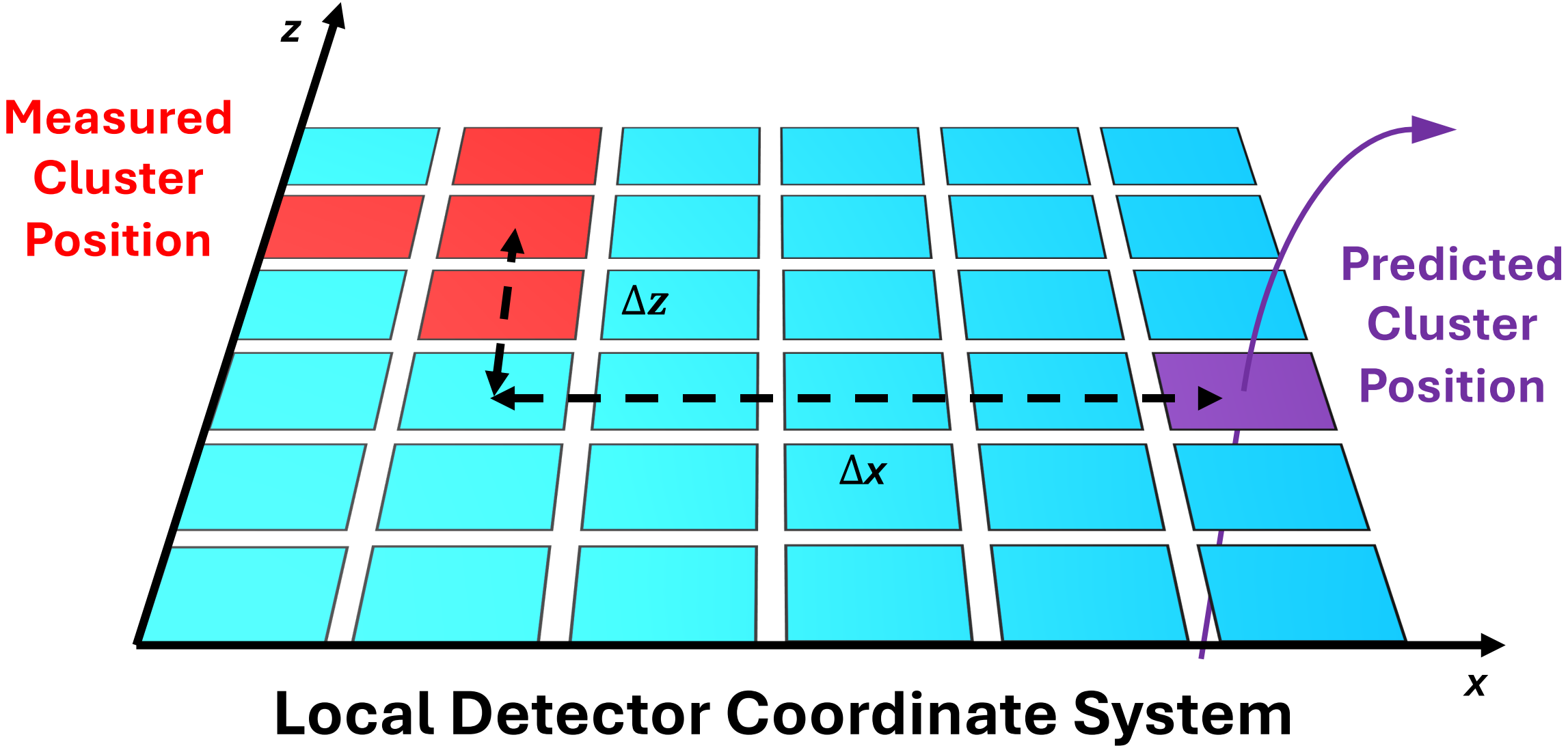
- ~5000 events
- Bands from particle species (pions, kaons, protons)
- Indicative of full MIP (Minimally Ionizing Particle) efficiency of TPC
- Full coverage in the reconstruction



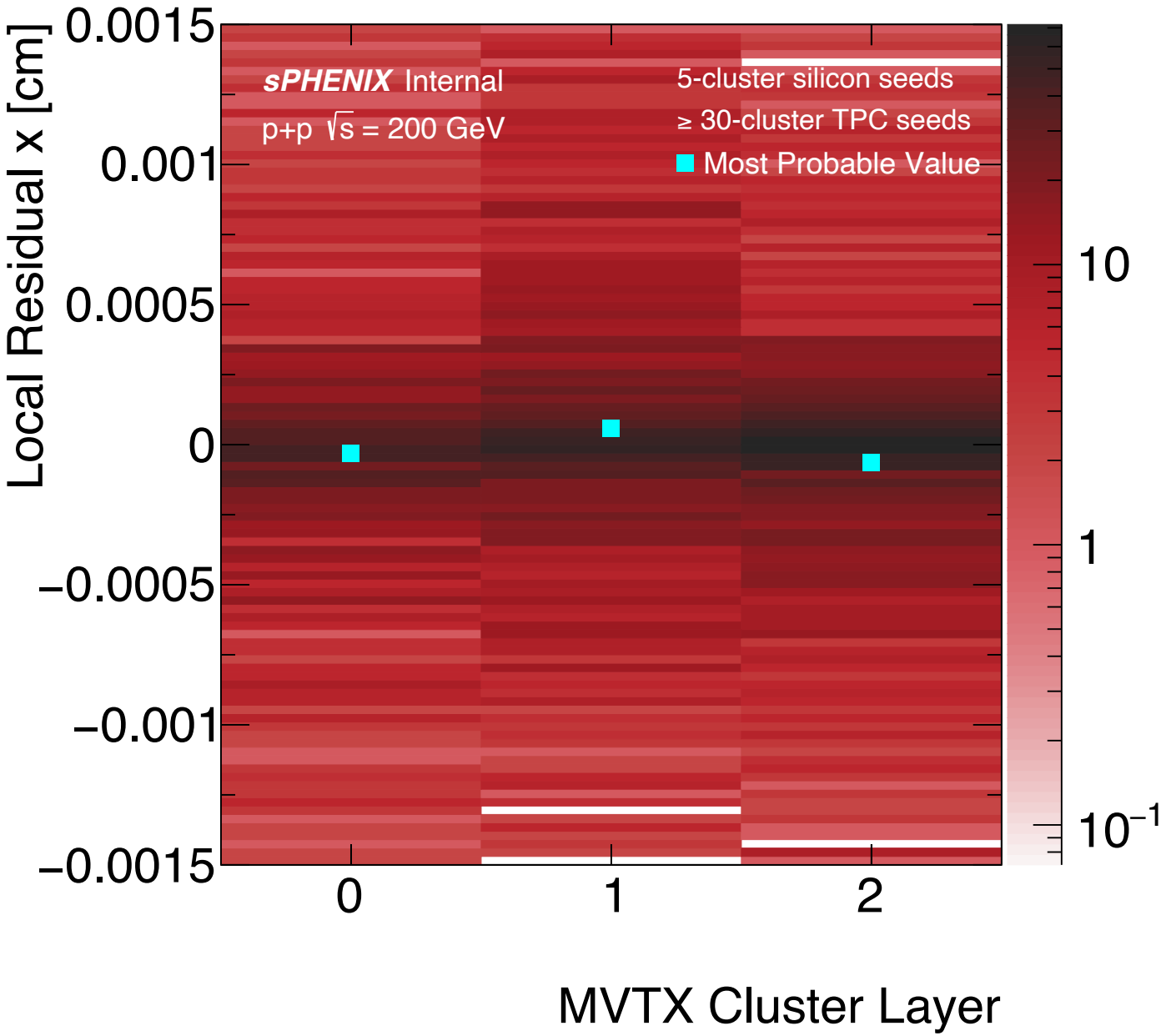
- No efficiency corrections, raw distribution
- Full reconstruction of track seeds across both η and ϕ acceptance



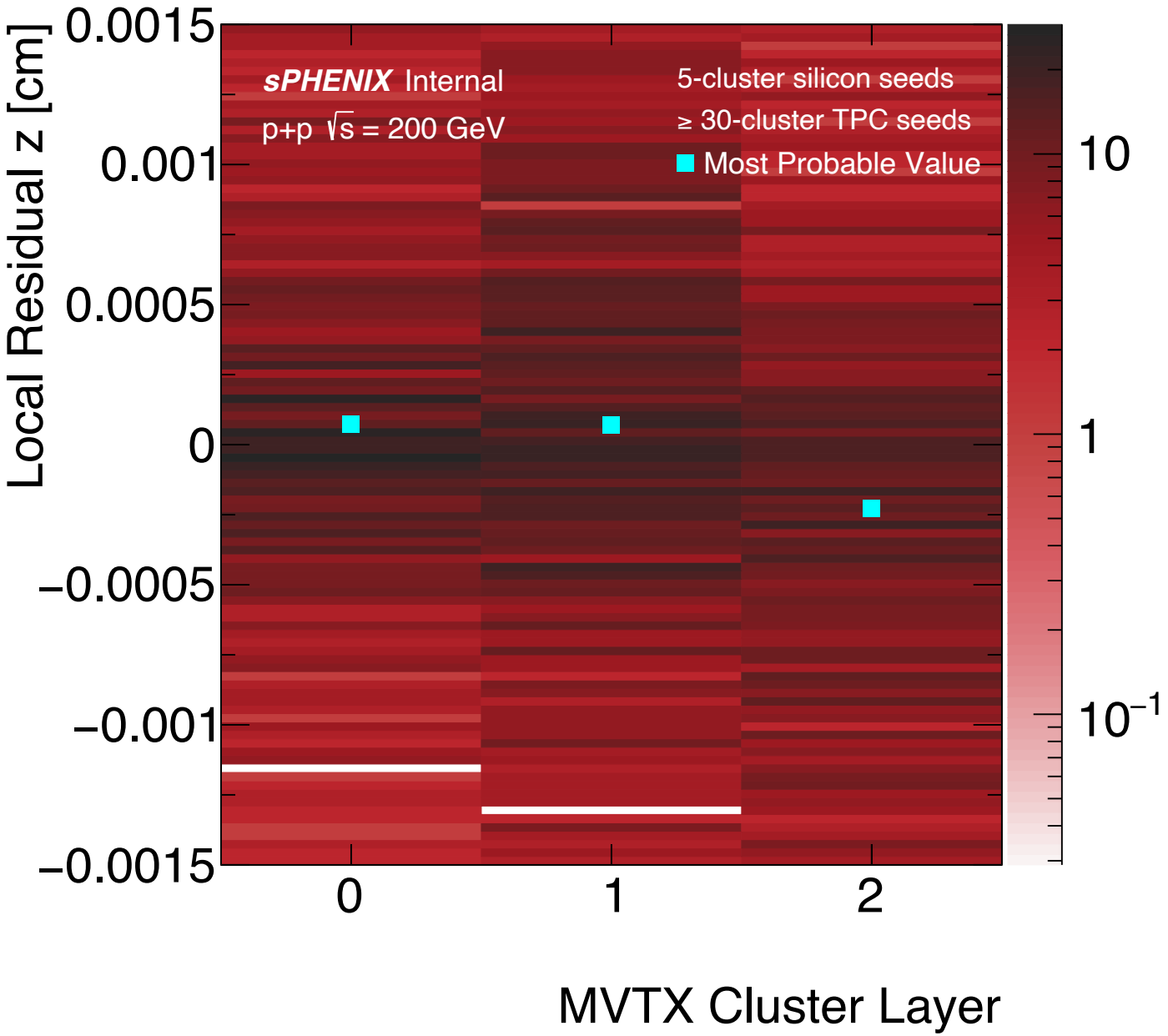
- Reconstruction of many tracks across all 48 layers of the TPC
- Cut on track quality to select for well-reconstructed tracks across silicon and TPC



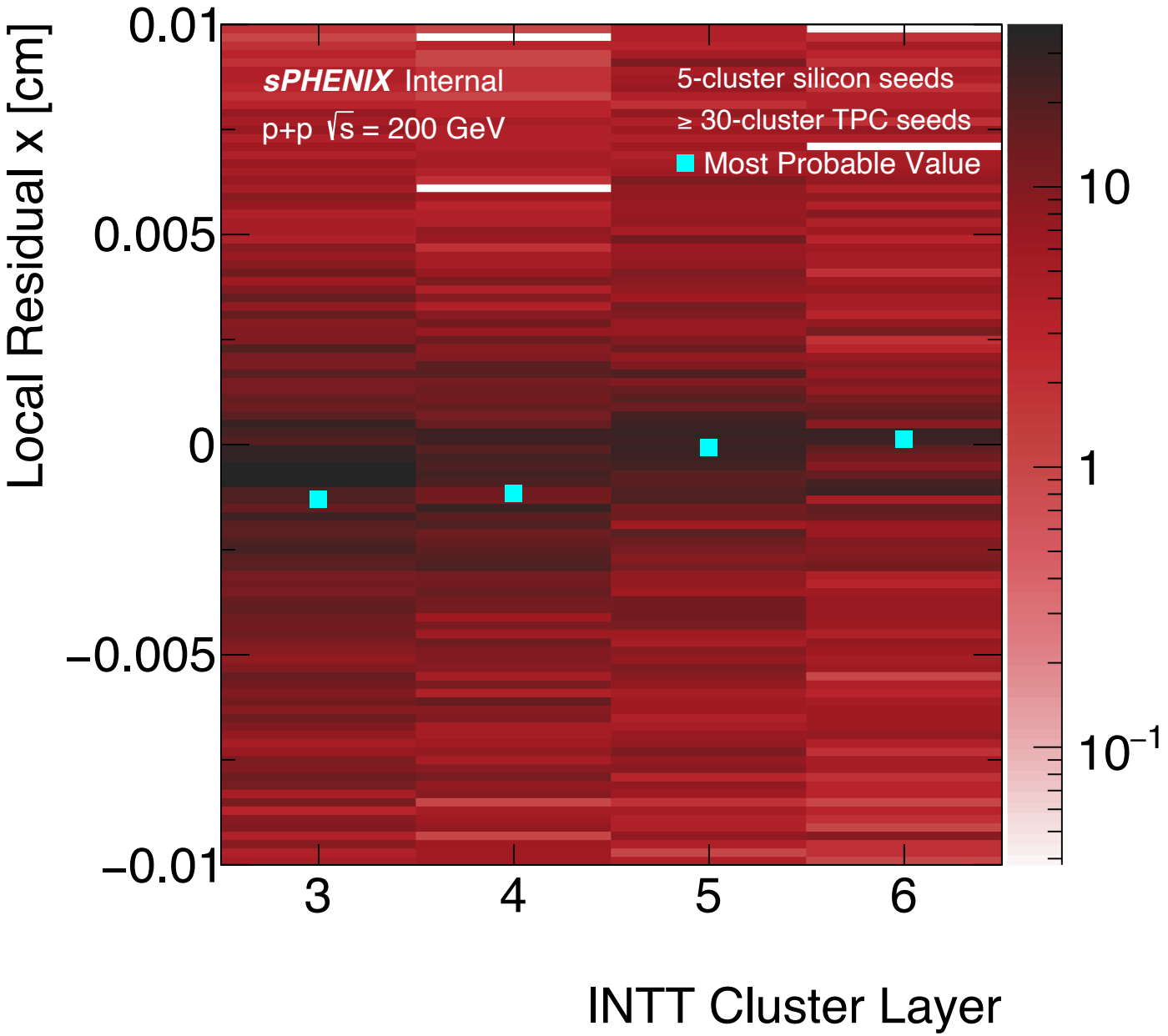
Residual = (Measured Cluster Position) – (Intersection of Track Fit with Physical Detector Surface)



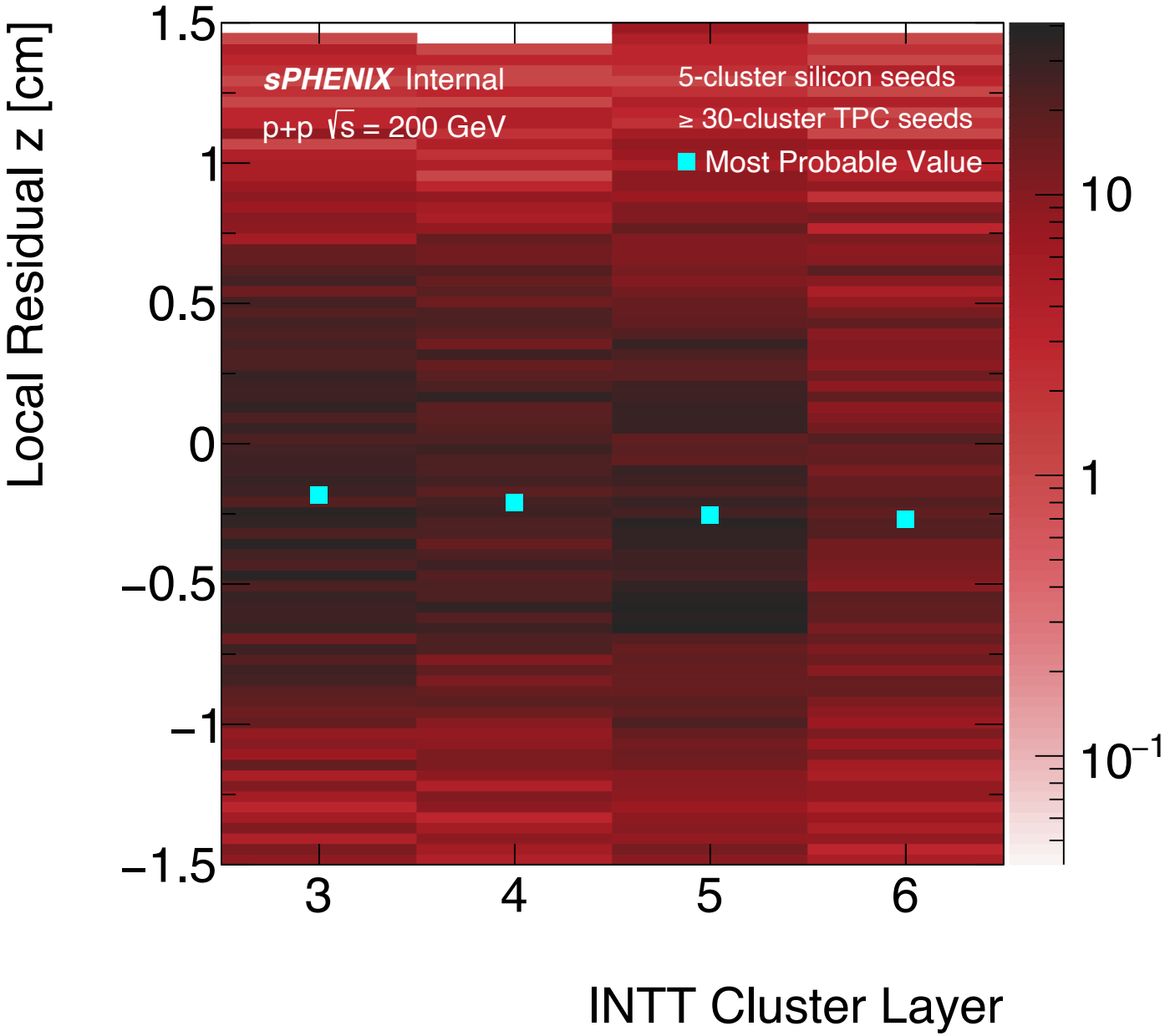
- Crude silicon alignment and no TPC distortion corrections
- Small residuals in x-direction across **MVTX** layers for high quality tracks (micron level)
- Residuals biased by high resolution of the MVTX (~5-micron precision in $r\phi$)
- Reflects mechanical internal alignment of the MVTX



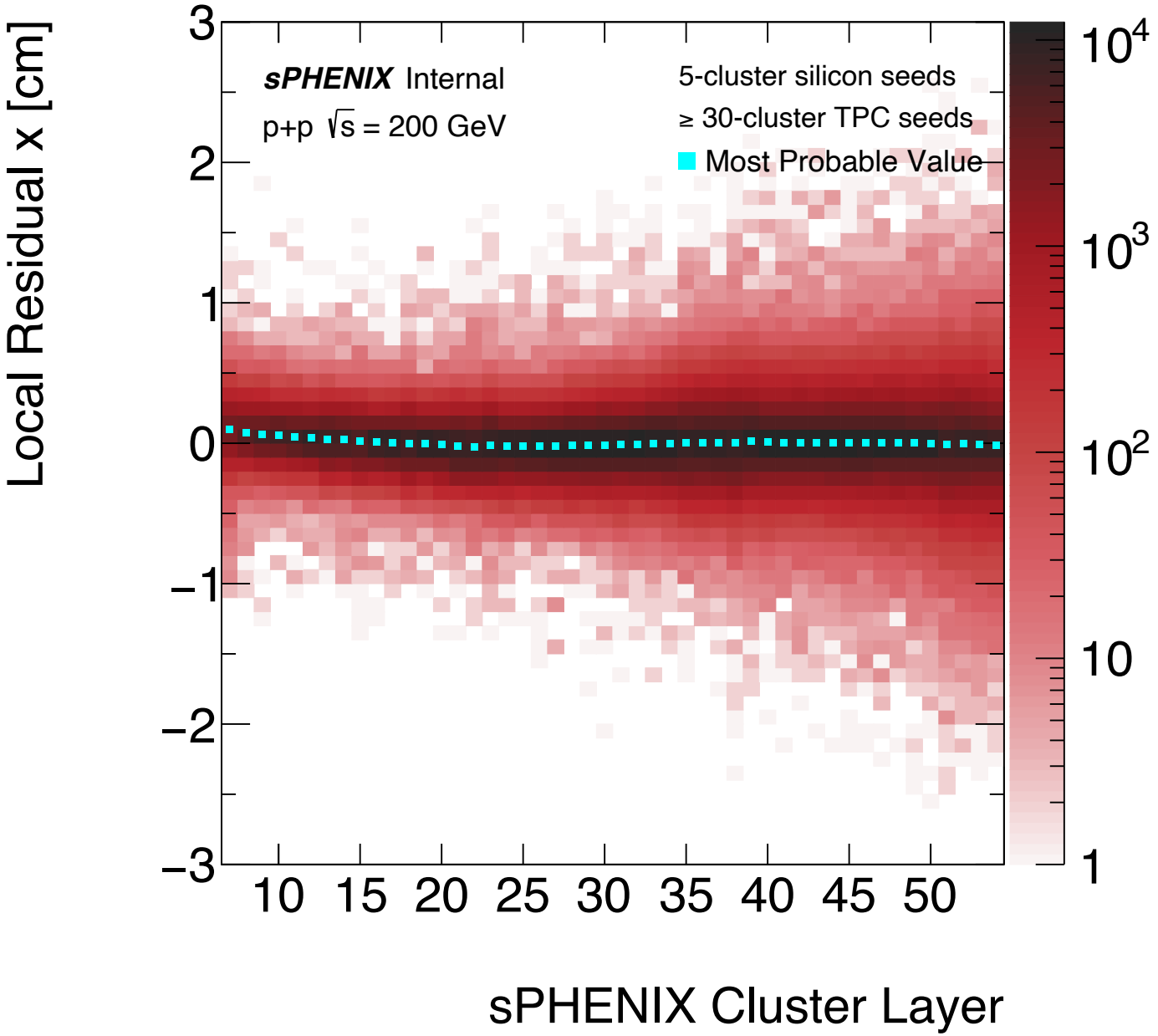
- Crude silicon alignment and no TPC distortion corrections
- Crude silicon alignment was derived with the INTT, which has poor z resolution
  - For tracks with both INTT and MVTX clusters, there is a slight difference in x- and z- residuals of MVTX
- Small residuals in z-direction across **MVTX** layers for high quality tracks (micron level)



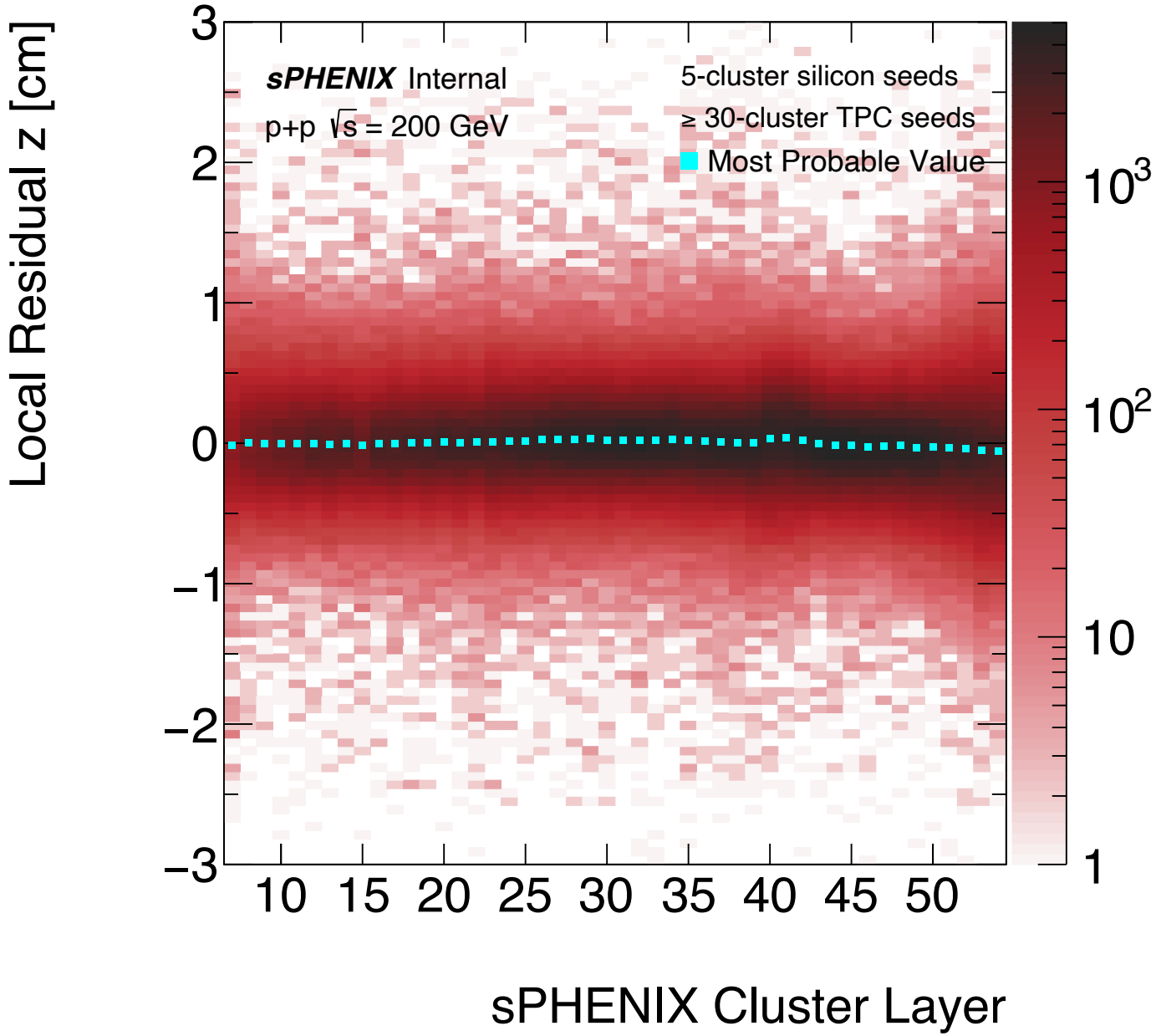
- Crude silicon alignment and no TPC distortion corrections
- Small residuals in x-direction across **INTT** layers for high quality tracks (tens of microns)
- $\sim$25-micron precision in $r\phi$ in INTT



- Crude silicon alignment and no TPC distortion corrections
- Small residuals in z-direction across **INTT** layers for high quality tracks given poor z resolution
- Residuals are comparable to the dimensions of INTT strips



- Crude silicon alignment and no TPC distortion corrections
- Small residuals in x-direction across **TPC** layers for high quality tracks
- Uniform, symmetric distribution across layers



- Crude silicon alignment and no TPC distortion corrections
- Small residuals in z-direction across **TPC** layers for high quality tracks
- Uniform, symmetric distribution across layers

Conclusion

- Promising tracking performance given commissioning phase of experiment
- Further work on silicon alignment and applying TPC distortion corrections
- Goals:
  - Heavy-flavor quarkonia as probes of the QGP
  - Achieving momentum resolution to distinguish between Upsilon states
  - Open heavy flavor decay reconstruction
  - Track substructure in jets

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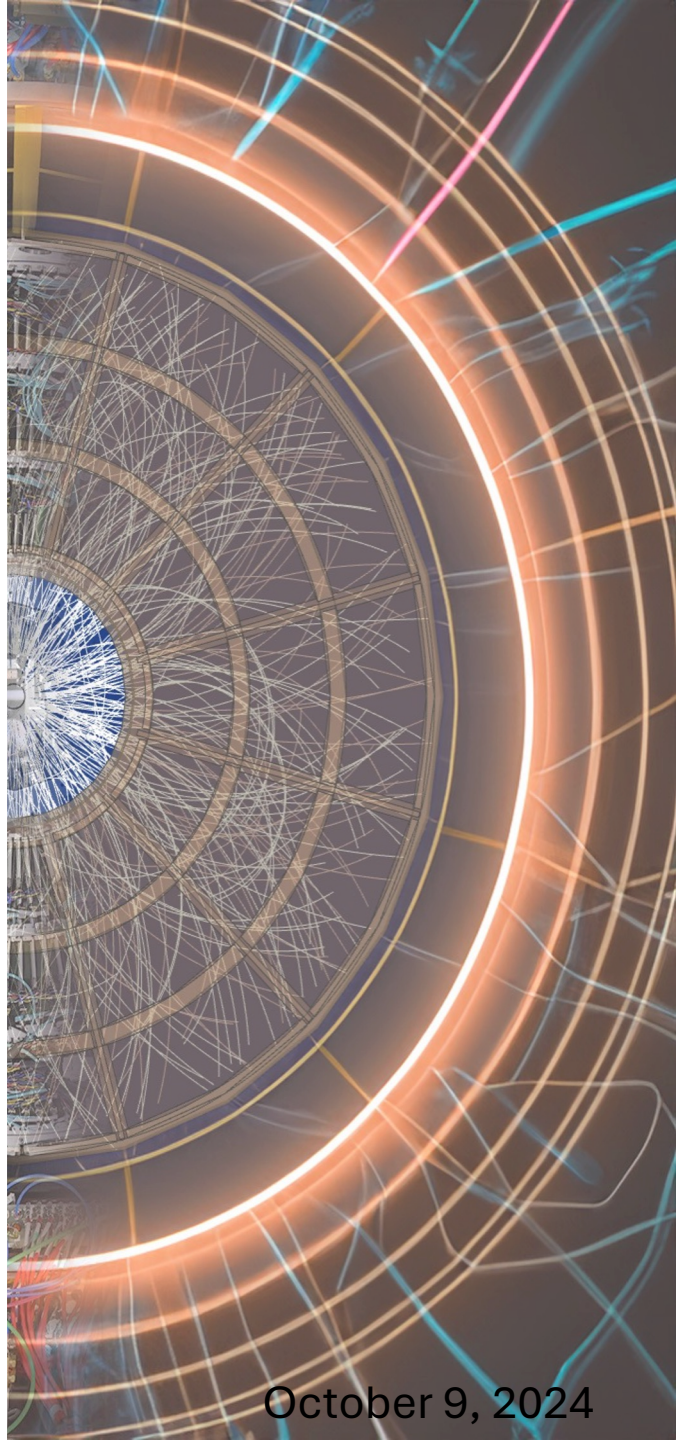

Citations

[1] *Osborn, Joseph & Collaboration, for. (2021). Implementation of ACTS into sPHENIX track reconstruction. 10.48550/arXiv.2103.06703.*