STAR Forward Tracking System Simulation

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With inputs from Te-Chuan Huang, James Brandenburg

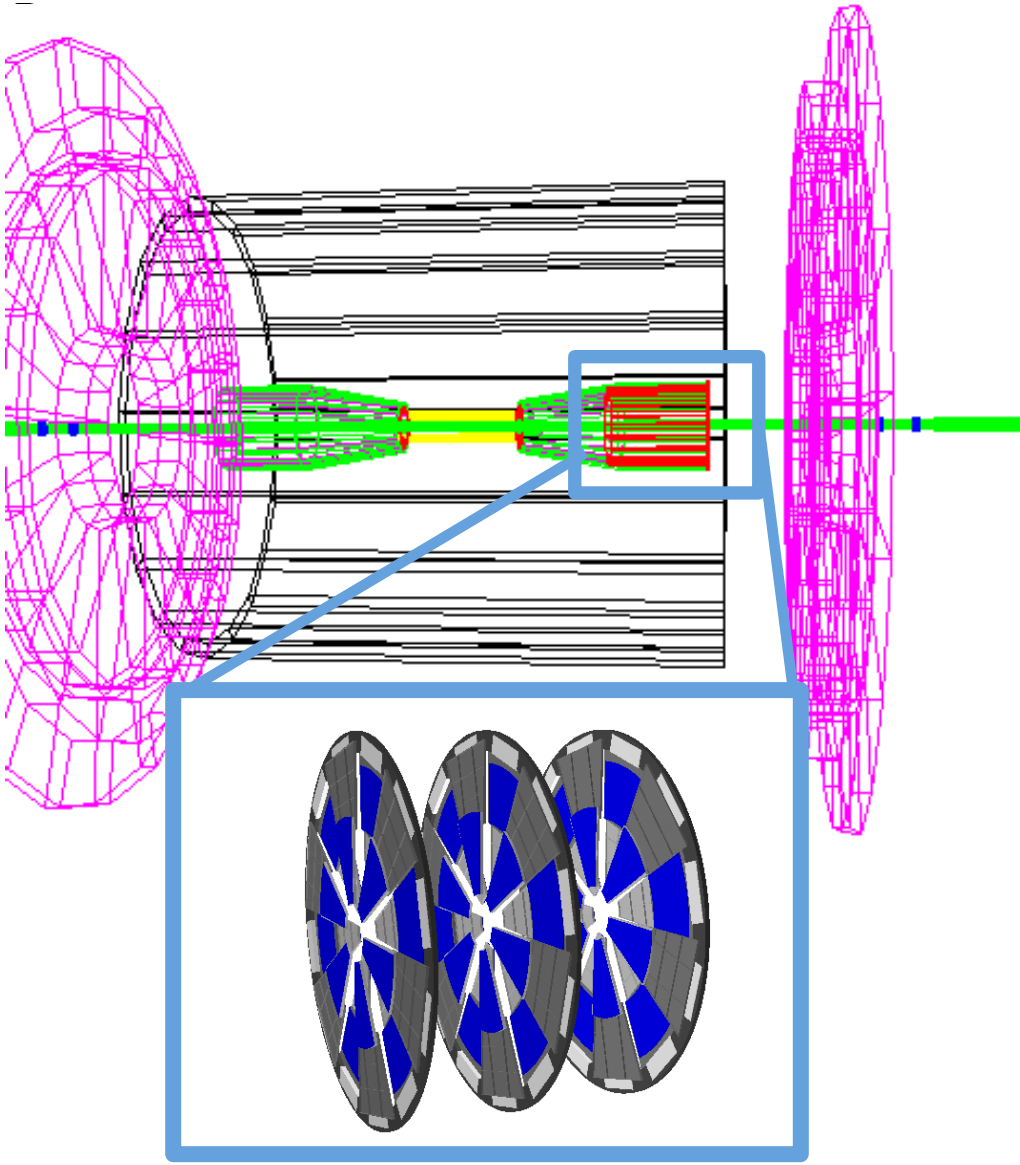
Outline

1. Detector geometry
2. Hit reconstruction
3. Tracking performance
4. New tracking algorithm development
5. Known issues and future work

Detector geometry

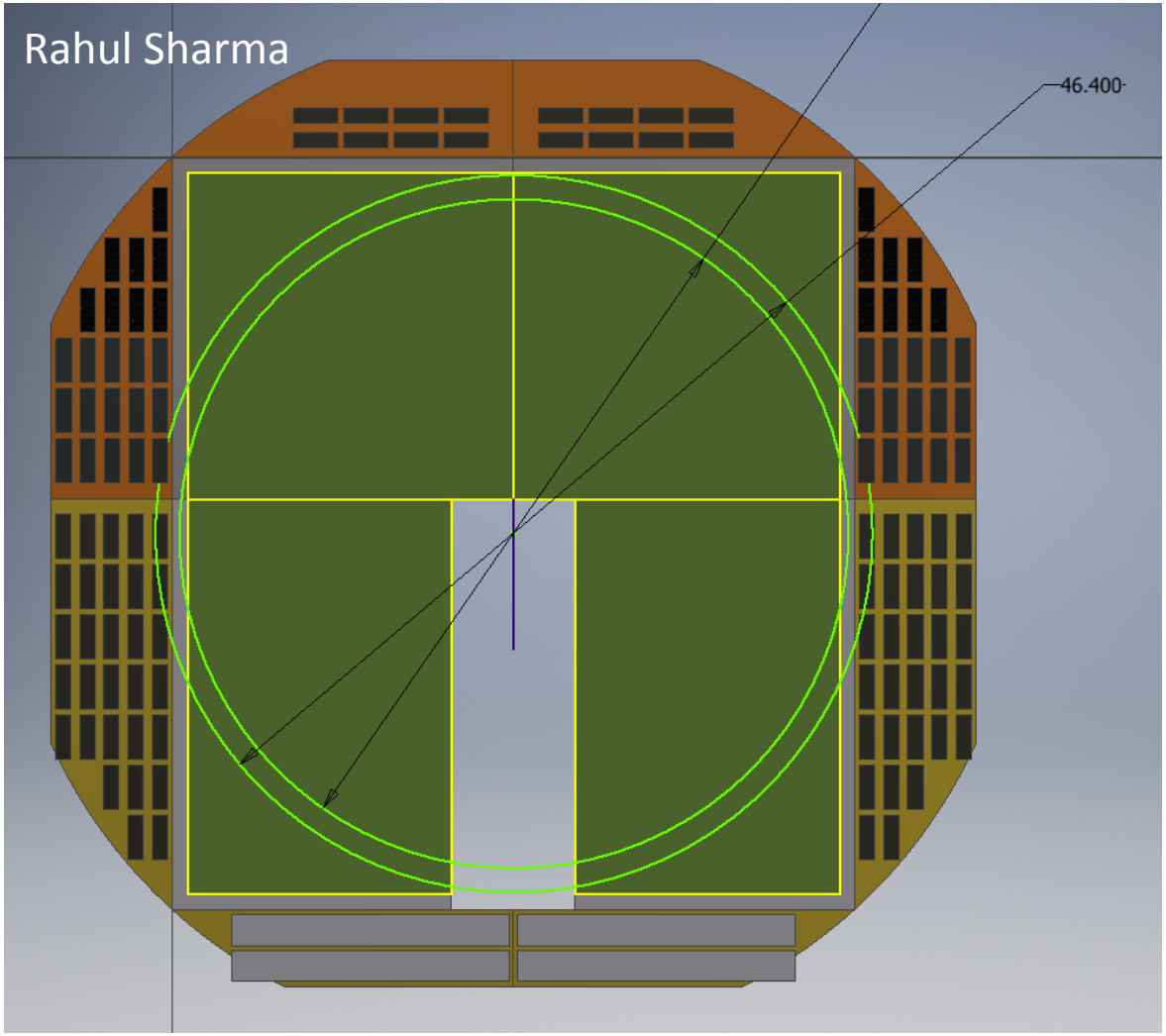
Detail silicon tracker geometry

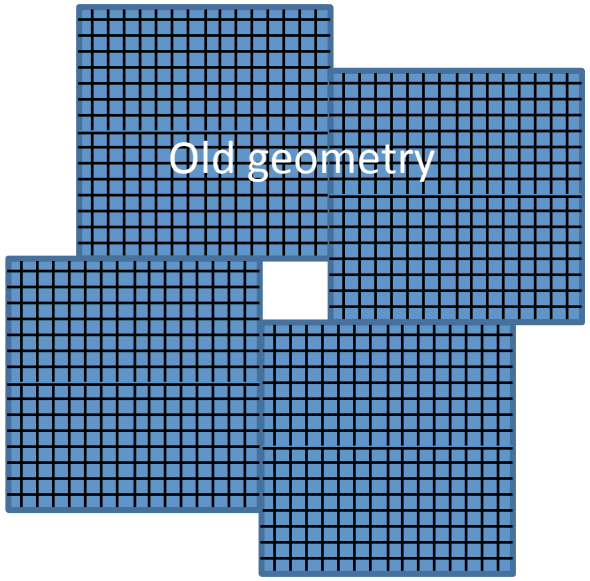
| —- Supporting (ABS)
| —- Disk (Air)
|—- Half ring (Air)
| |—- Solid part (aluminium)
| |—- vacuum part (Air)
|
|—- Wedge (Air)
|—- Inner wedge (Air)
| |—- Mechanical (PEEK)
| |—- Hybrid (Kapton)
| |—- Silicon (Silicon)
|
|—- Outer wedge (Air)
|—- Mechanical (PEEK)
|—- Hybrid (Kapton)
|—- Silicon (Silicon)



Credit: Te-Chuan Huang

New sTGC geometry





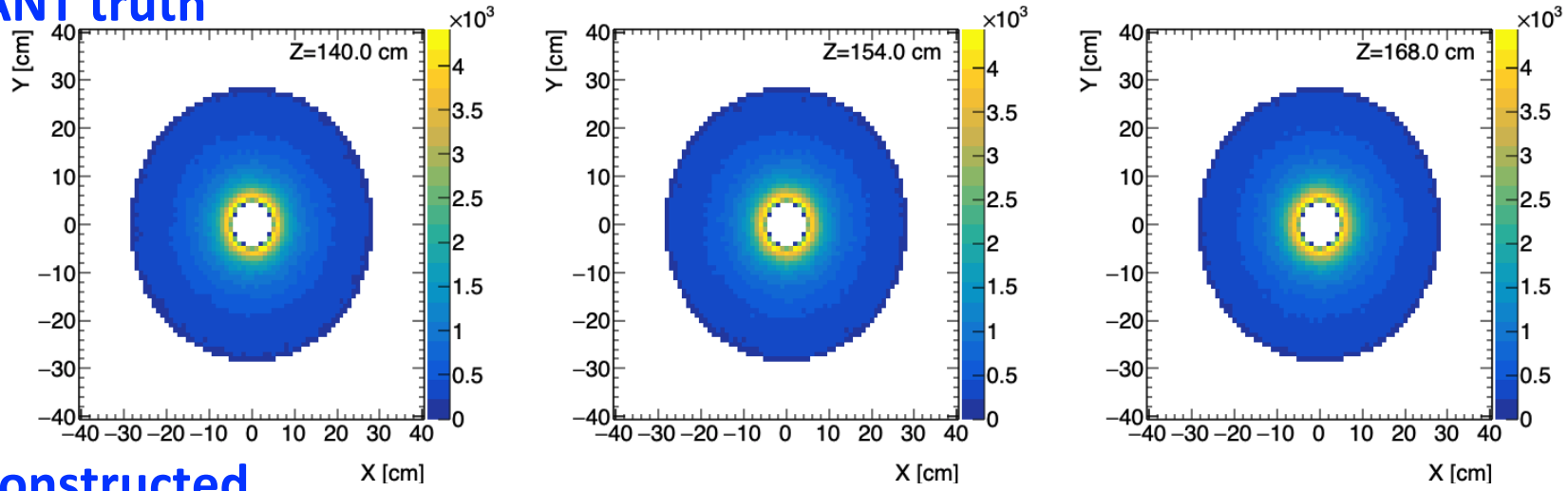
sTGC geometry change in order to:

- Fit in pole-tip with FEE and RDO
- Leave space to lift and move pole-tip

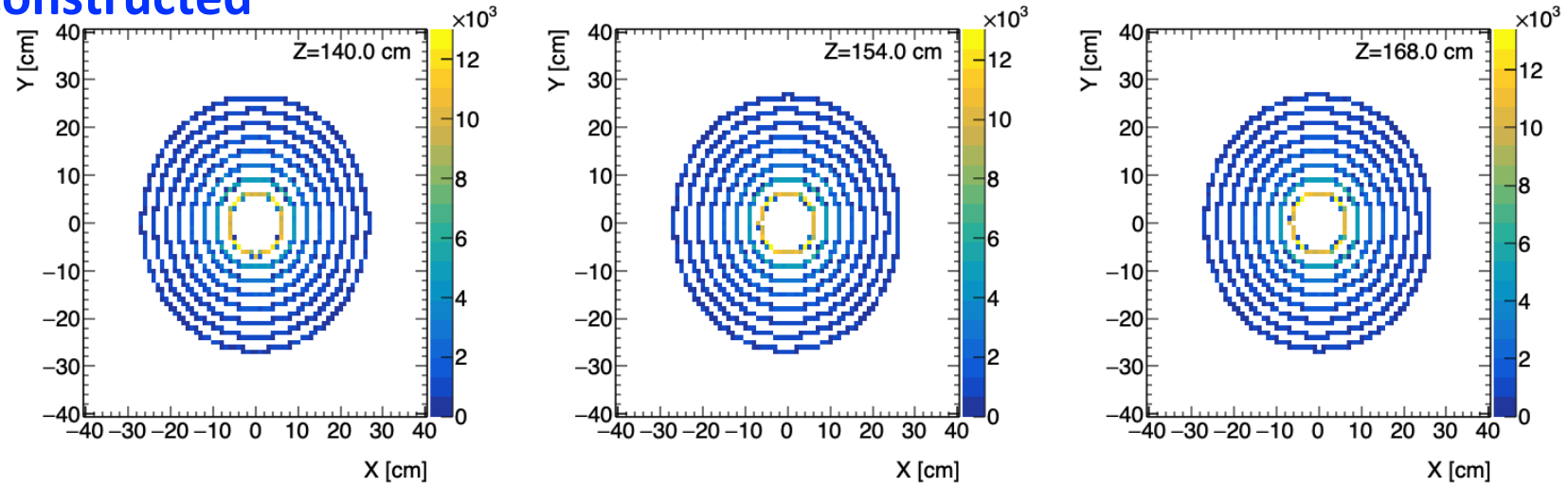
Hit Reconstruction

Silicon hit reconstruction

GEANT truth



Reconstructed

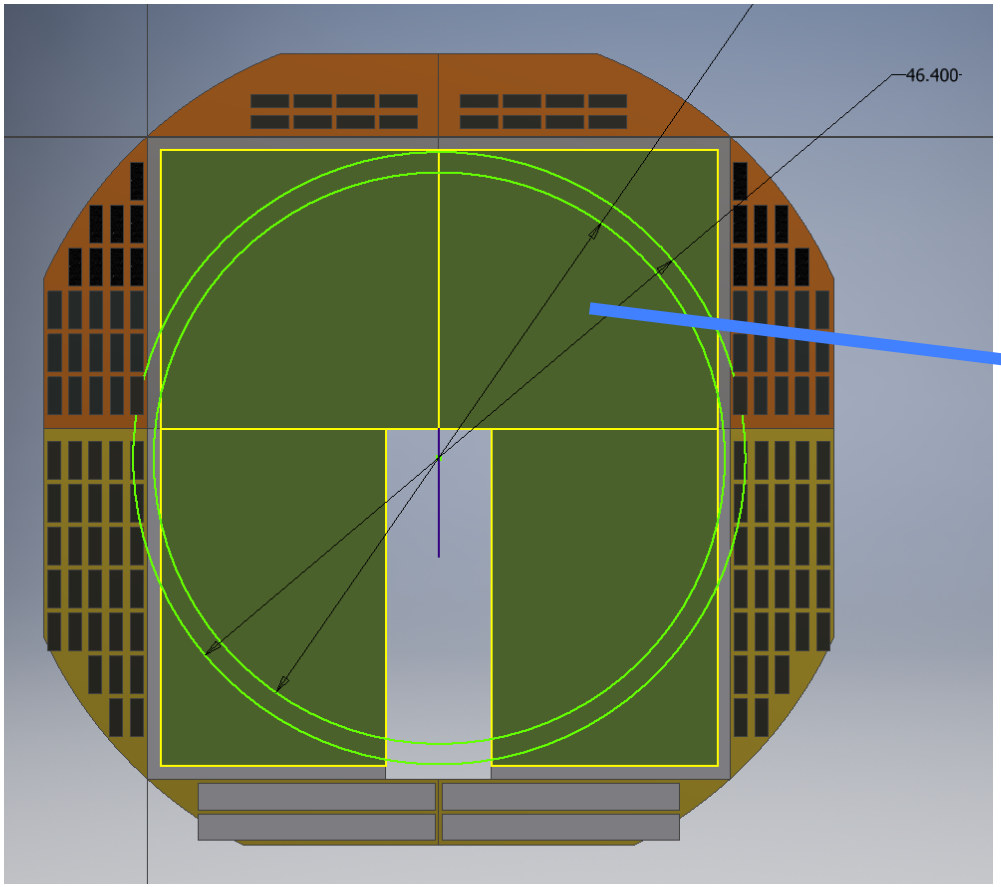


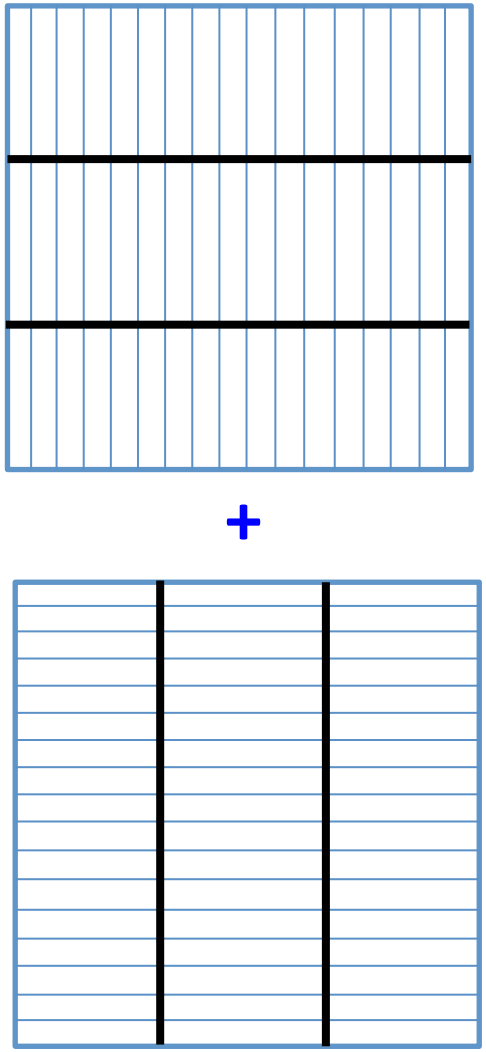
Fine phi resolution

R position reconstructed at center of segments

Credit: Te-Chuan Huang

sTGC hit reconstruction





Strip width = 0.32 cm; x, y resolution 100 μm

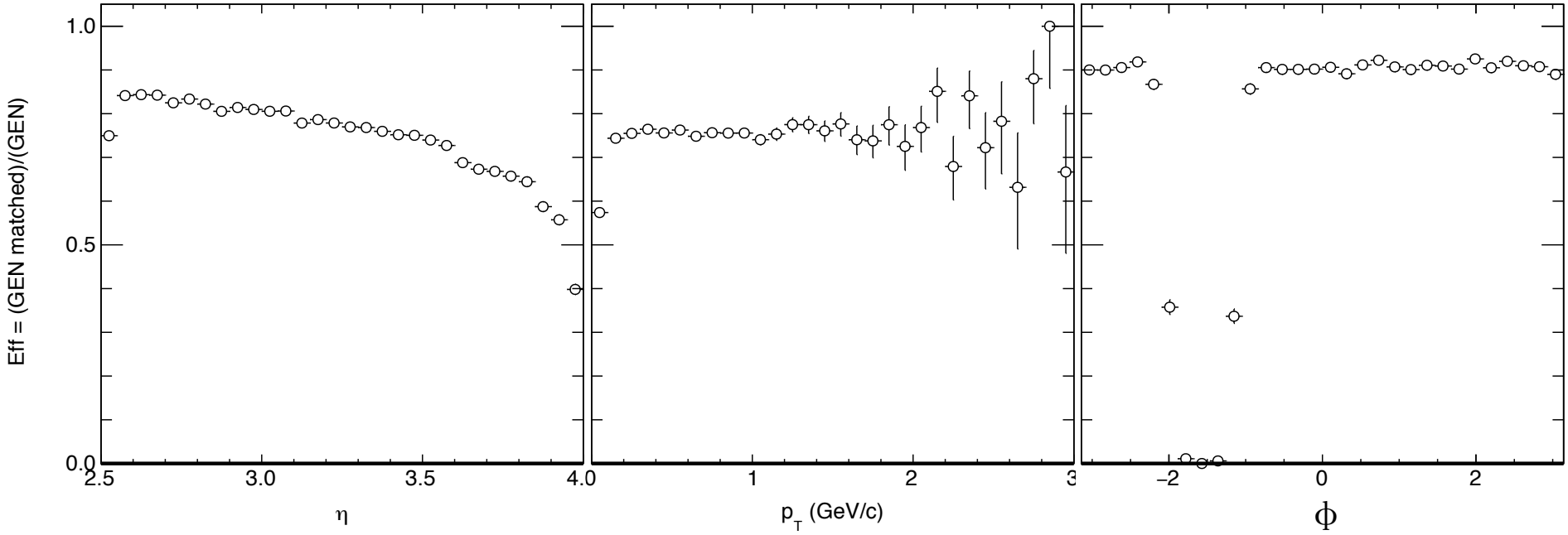
Total channel # for entire sTGC = 14,780

# of channel for each chamber <= 512

Tracking performance

Tracking performance – PP

$\langle mult_{GEN}^{foward} \rangle \approx 5$

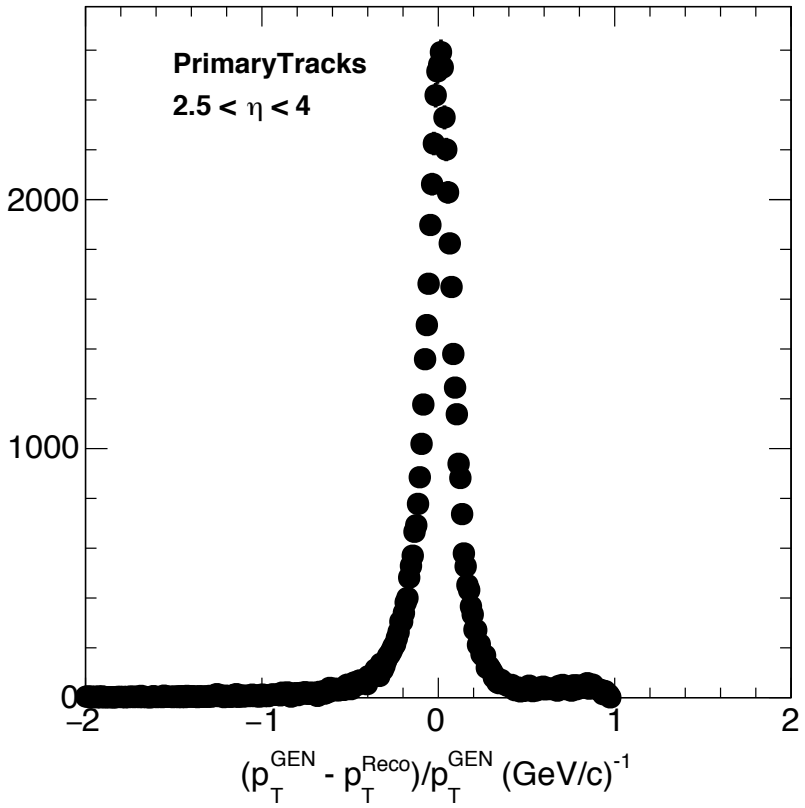


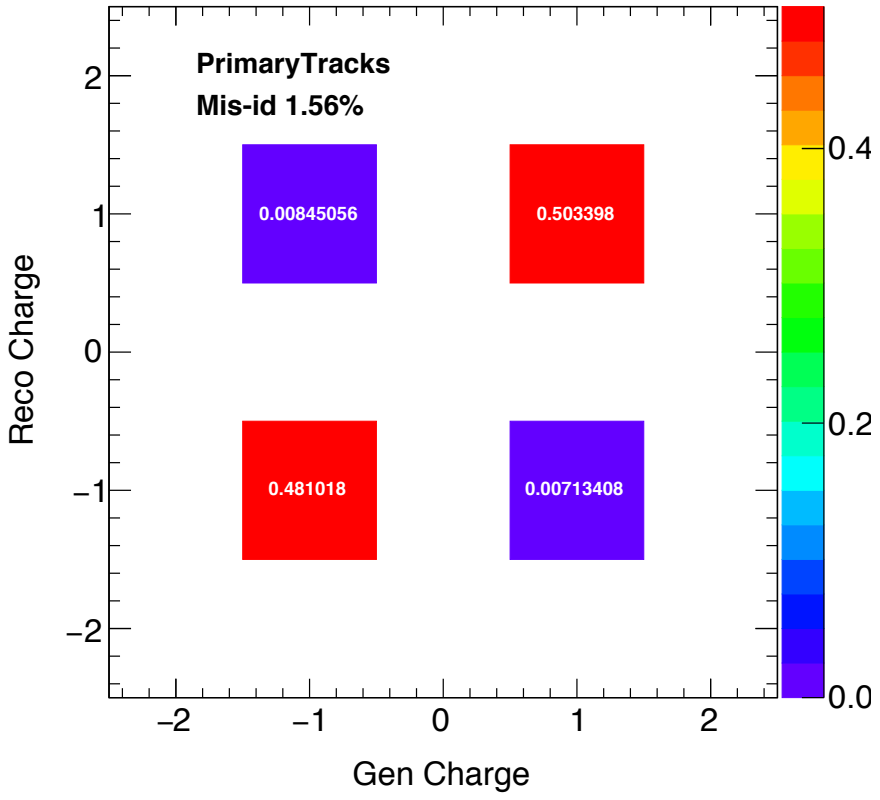
80% efficiency flat over pT & drops at high eta

The sTGC hole introduce a sharp efficiency valley in phi

Tracking performance – PP

$\langle mult_{GEN}^{foward} \rangle \approx 5$

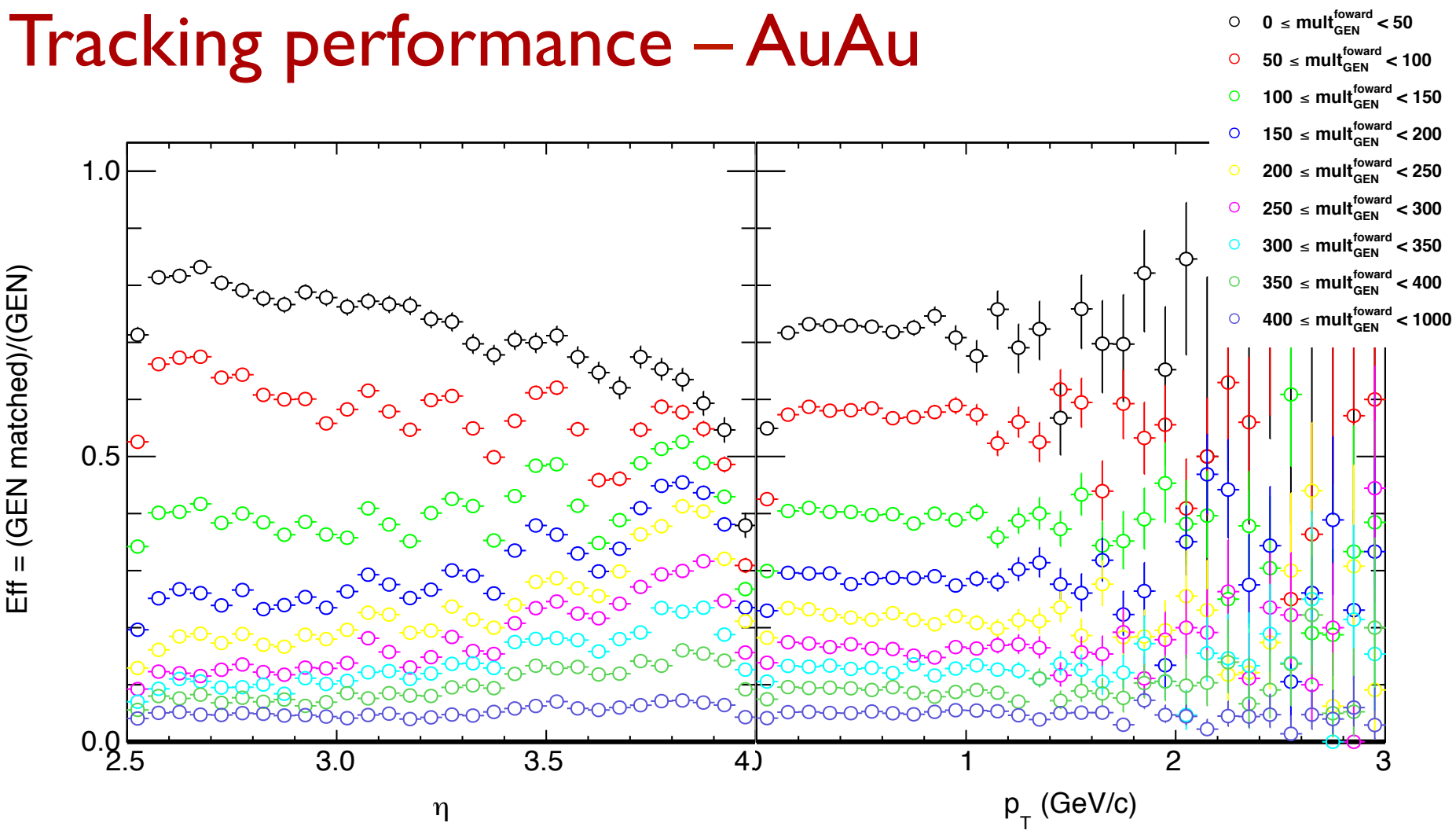




Good pT resolution and charge identification

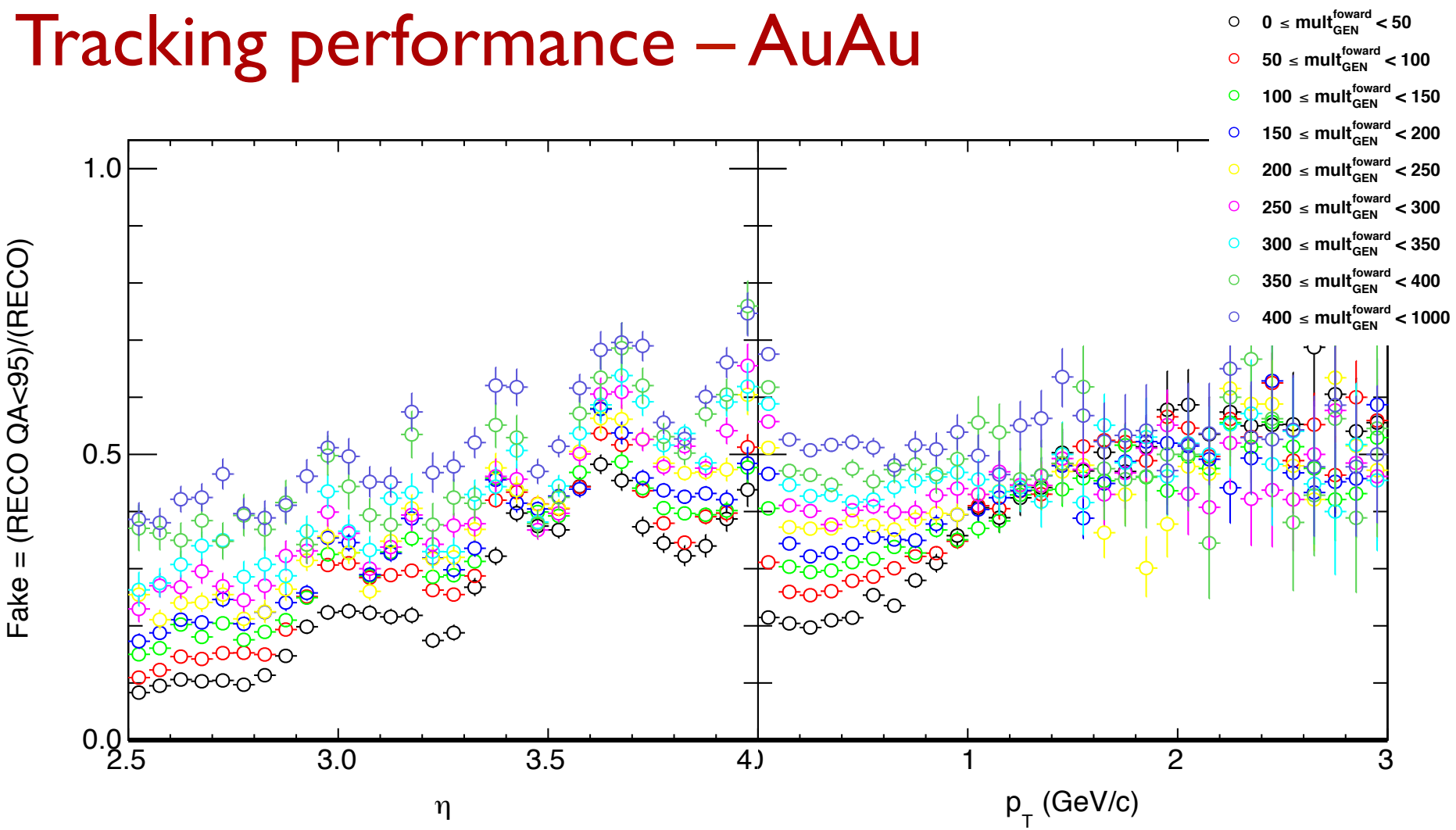
Meet the requirement for Cold QCD program

Tracking performance – AuAu



Efficiency drops at high multiplicity & high eta

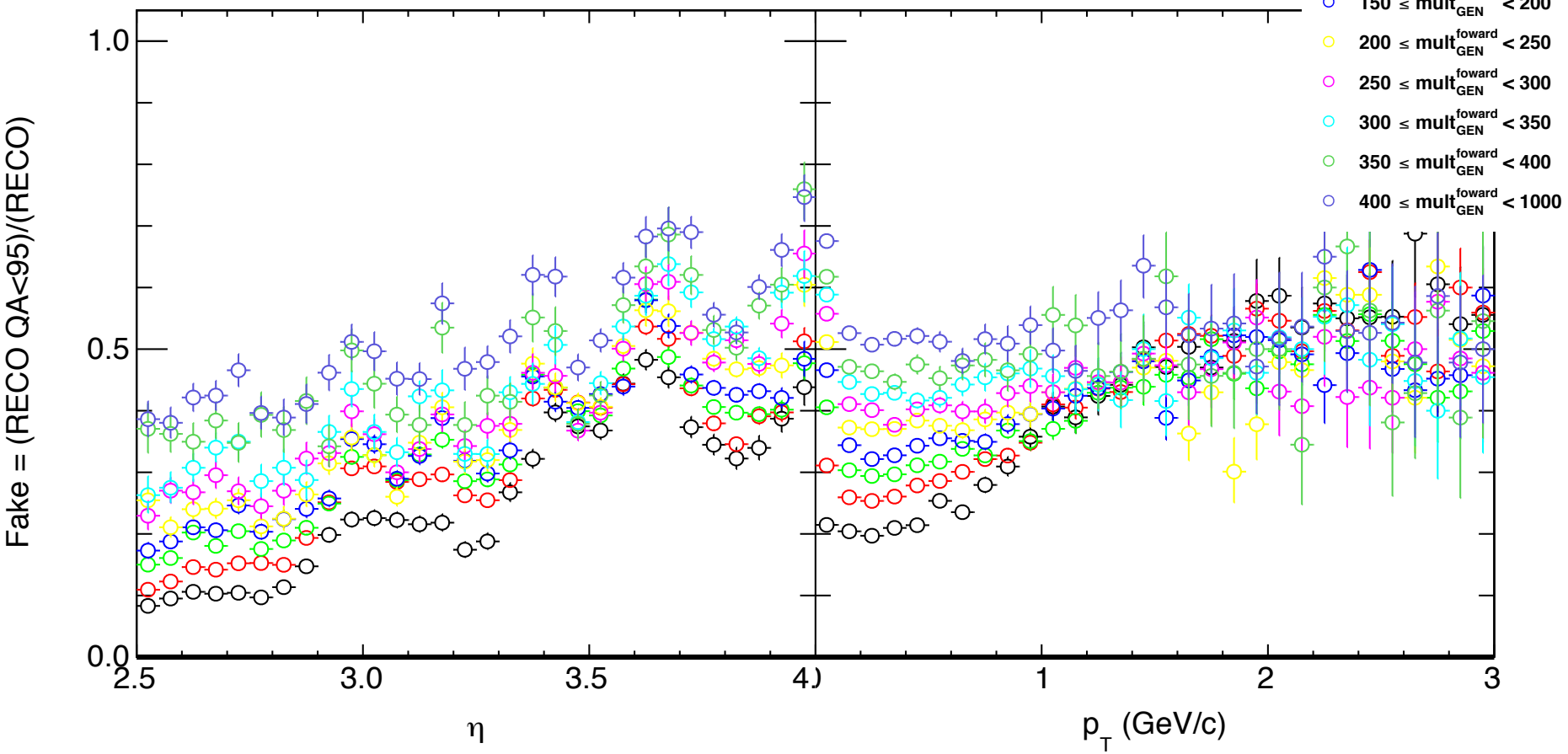
Tracking performance – AuAu



Efficiency drops at high multiplicity & high eta

Fake rate increase at high multiplicity & high eta/pt

Tracking performance – AuAu

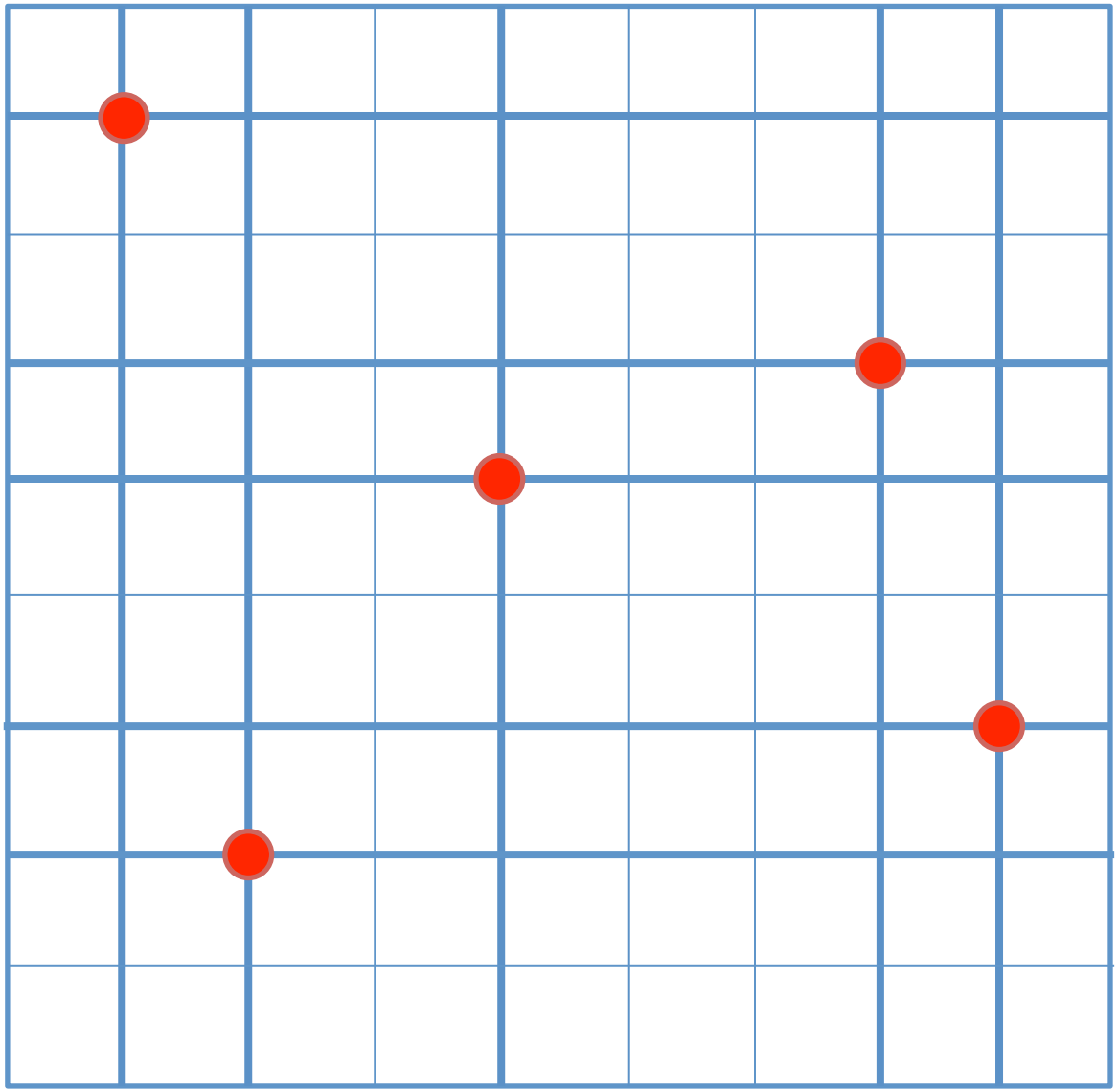


Efficiency drops at high multiplicity & high eta

Fake rate increase at high multiplicity & high eta/pt

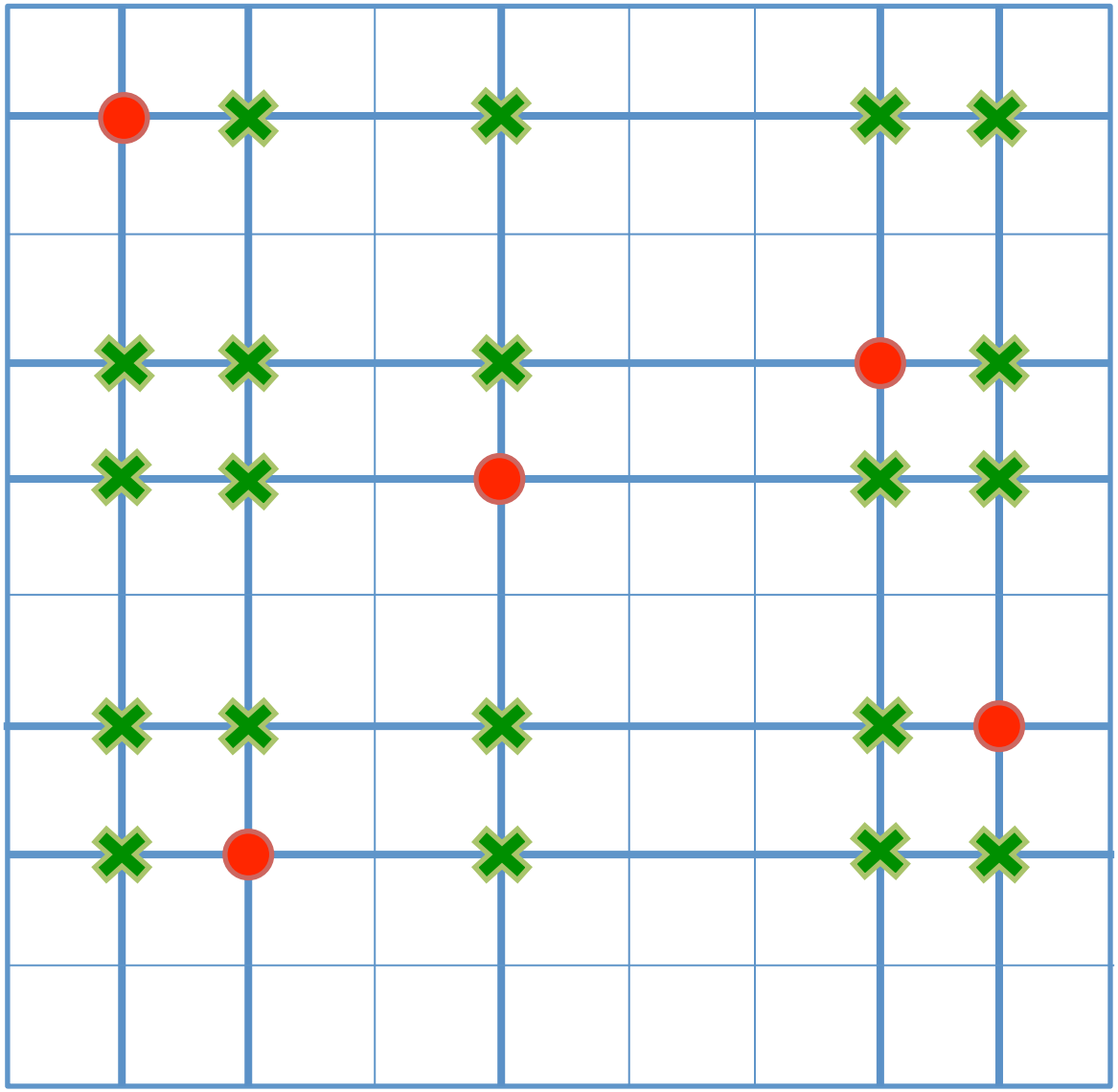
Ways to improve?

sTGC ghost hits



Real Hit

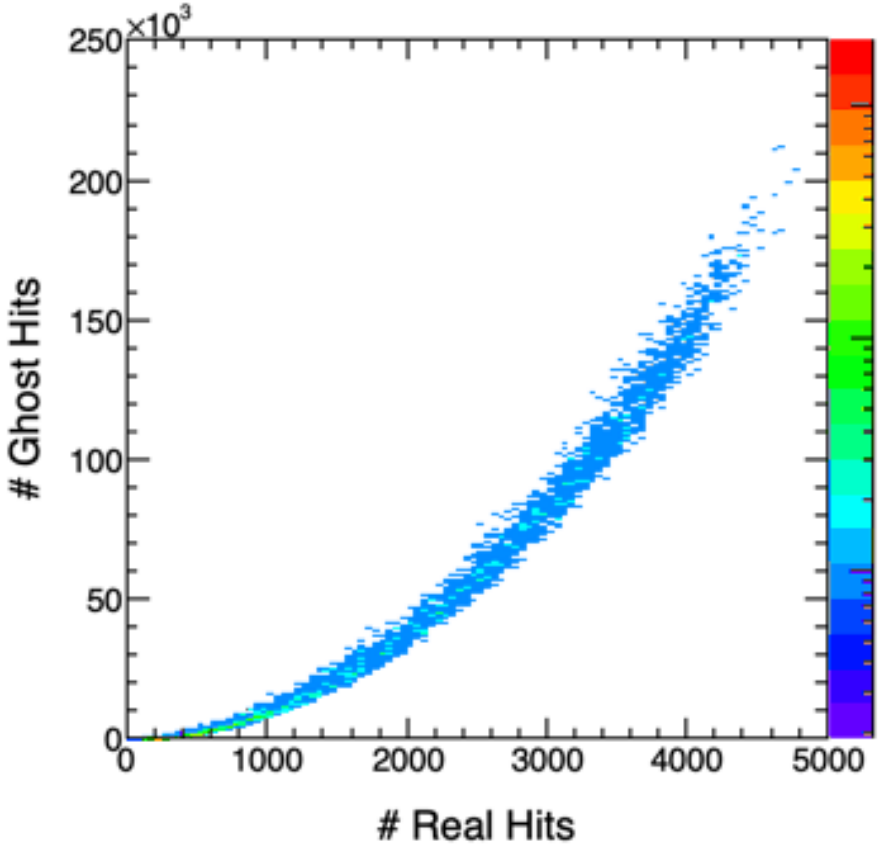
sTGC ghost hits



Real Hit

Ghost Hit

sTGC ghost hits

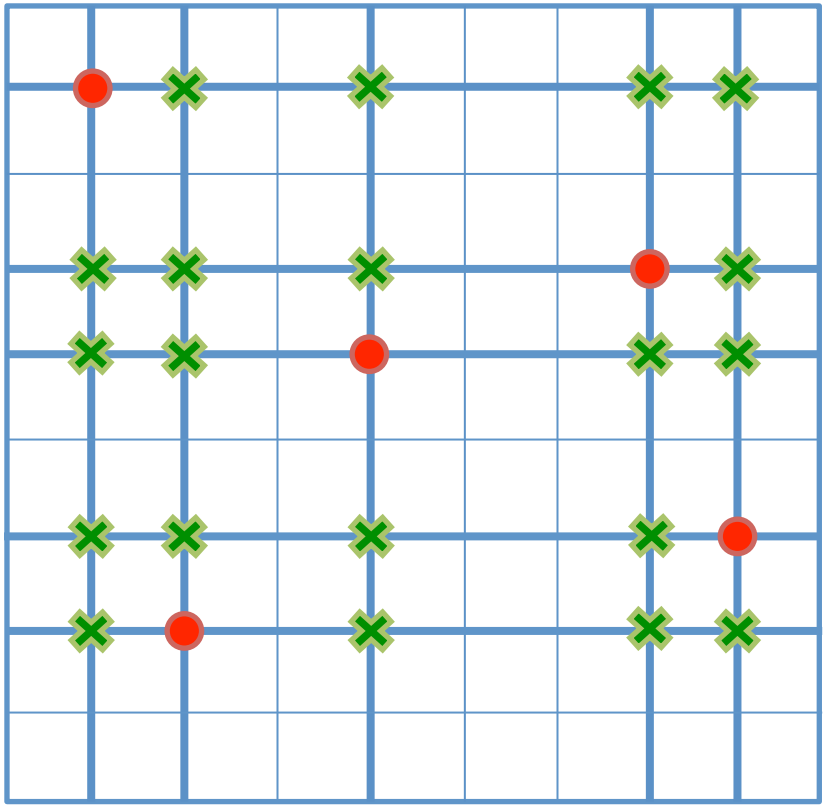


Ghost hits increase as N^2!

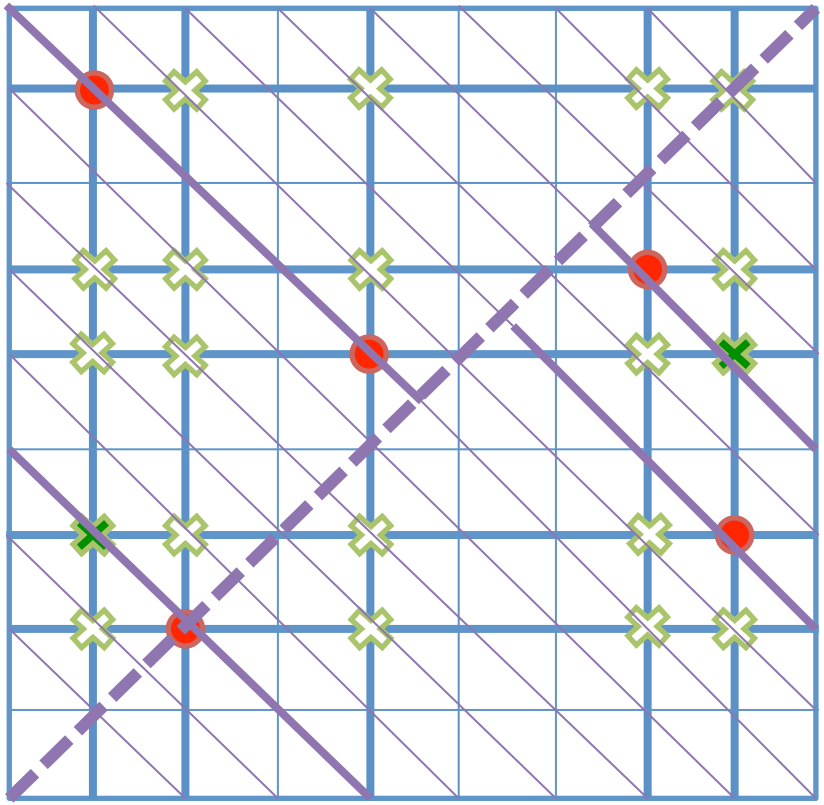
Large impact on track reconstruction at high occupancy

sTGC ghost hits rejection

Nominal



Diagonal strip

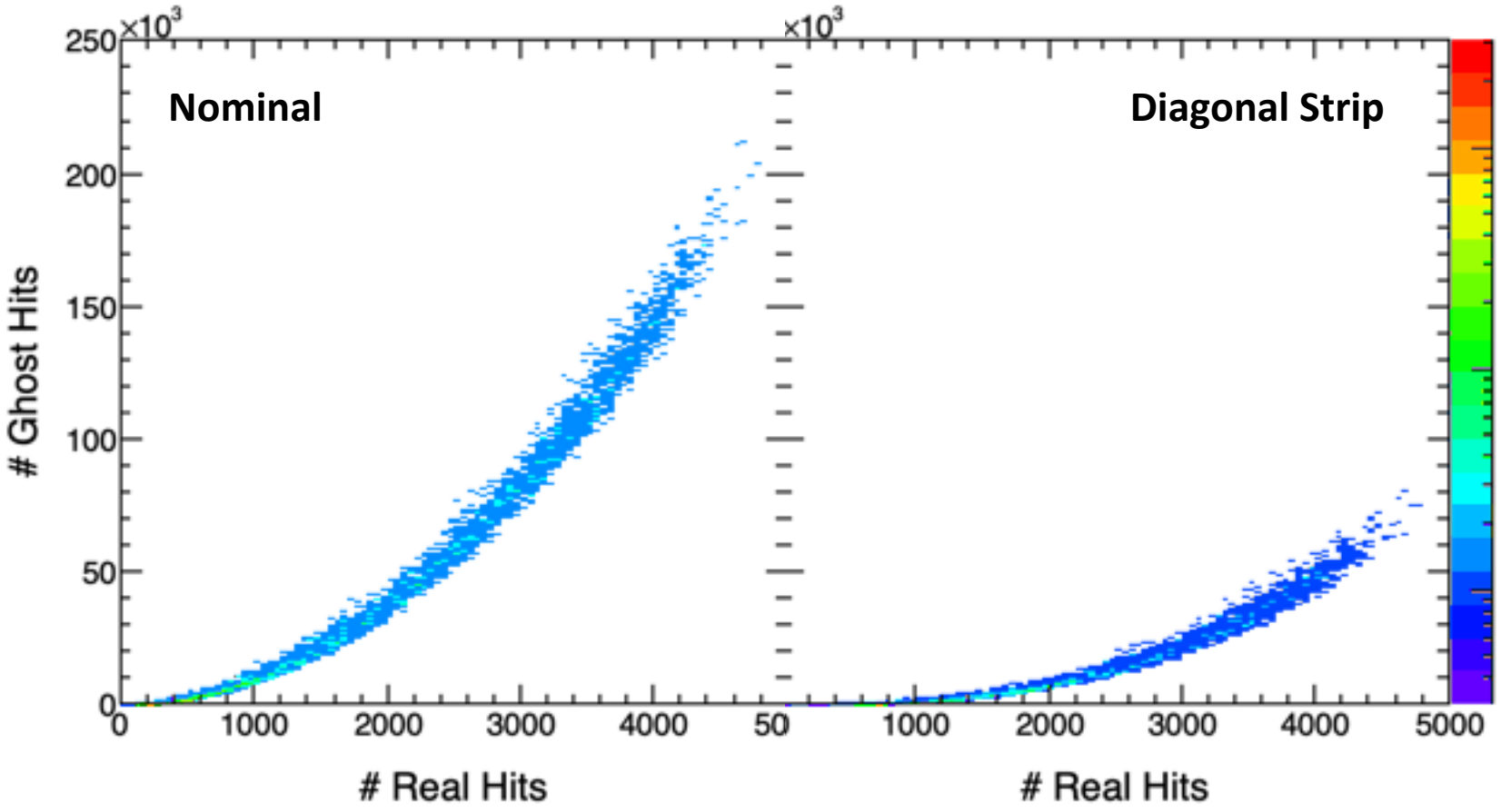


Add diagonal strips with 3.2mm width

Add **6,992** channels

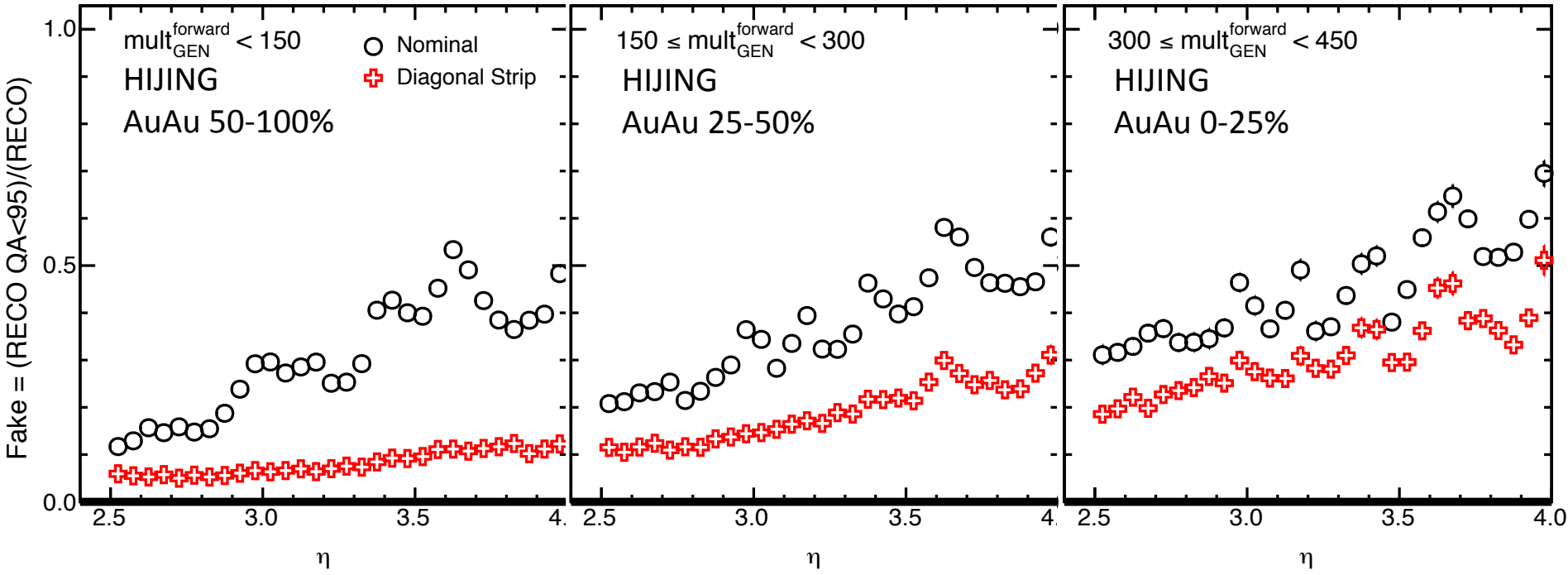
channel each chamber <= 512

sTGC ghost hits rejection



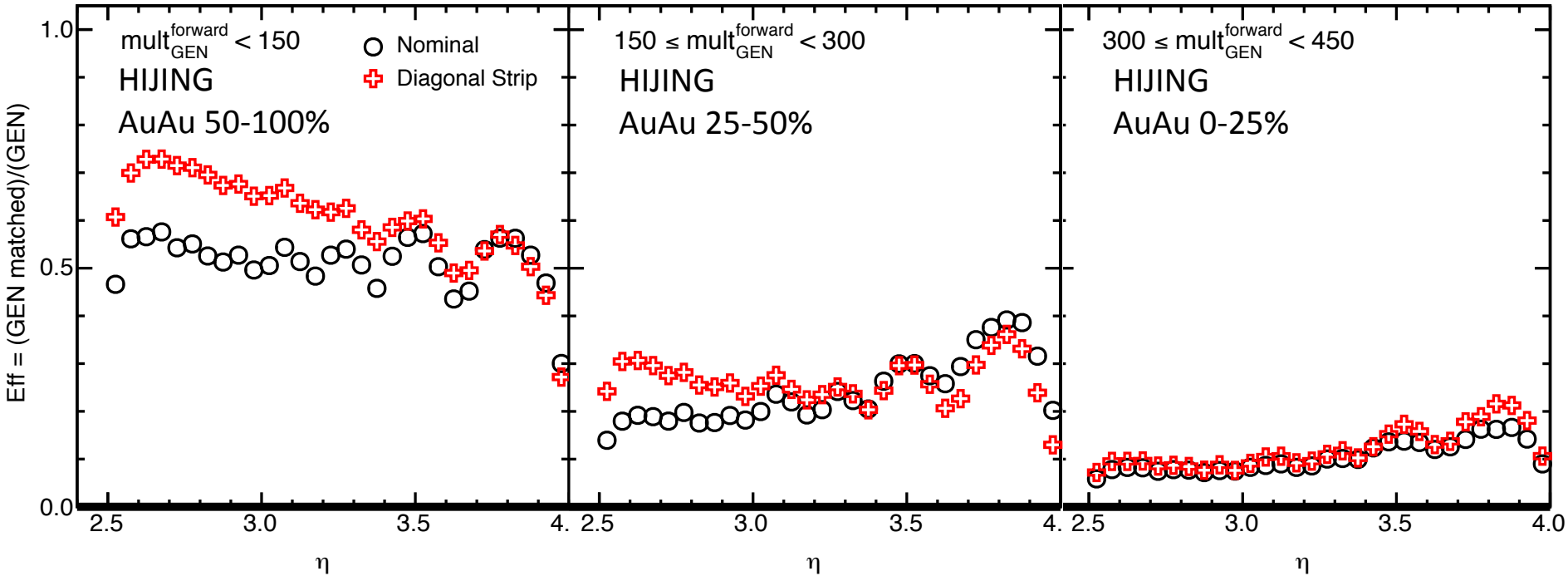
Significant reduction of ghost hits

sTGC ghost hits rejection



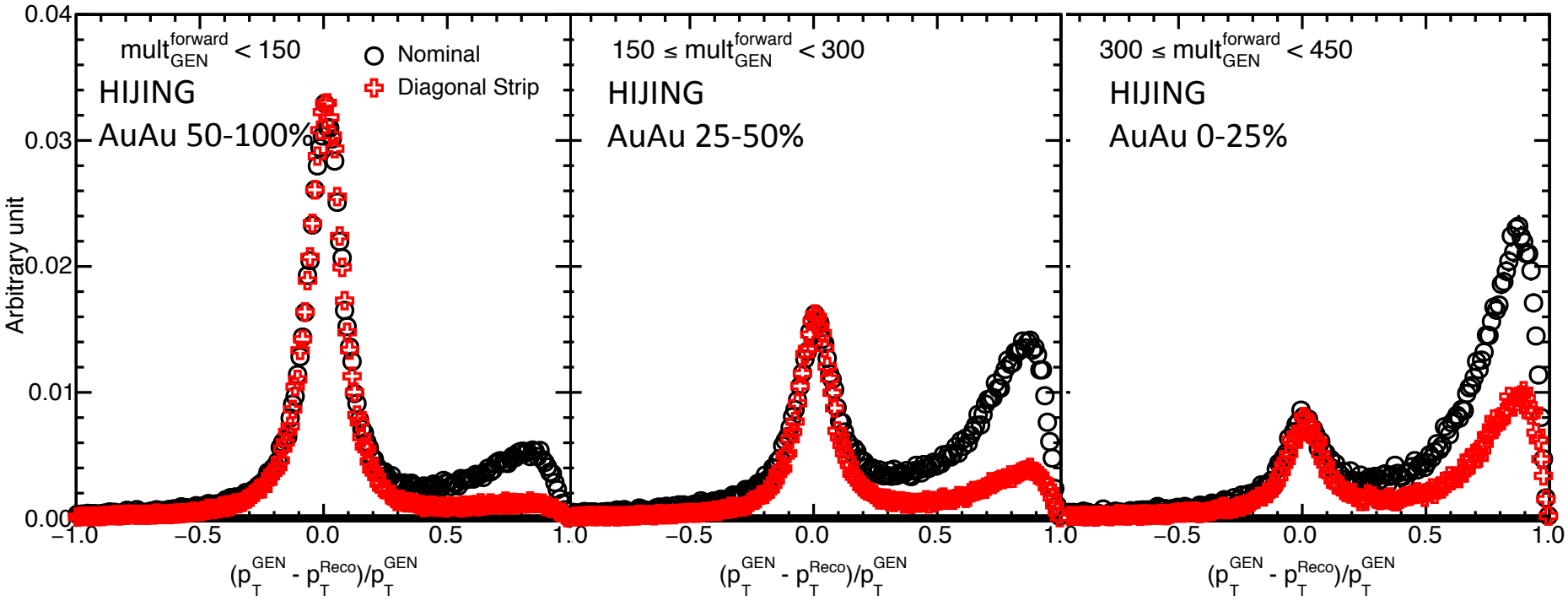
Significant improvement of fake rate

sTGC ghost hits rejection



Significant improvement of efficiency for peripheral & mid-central

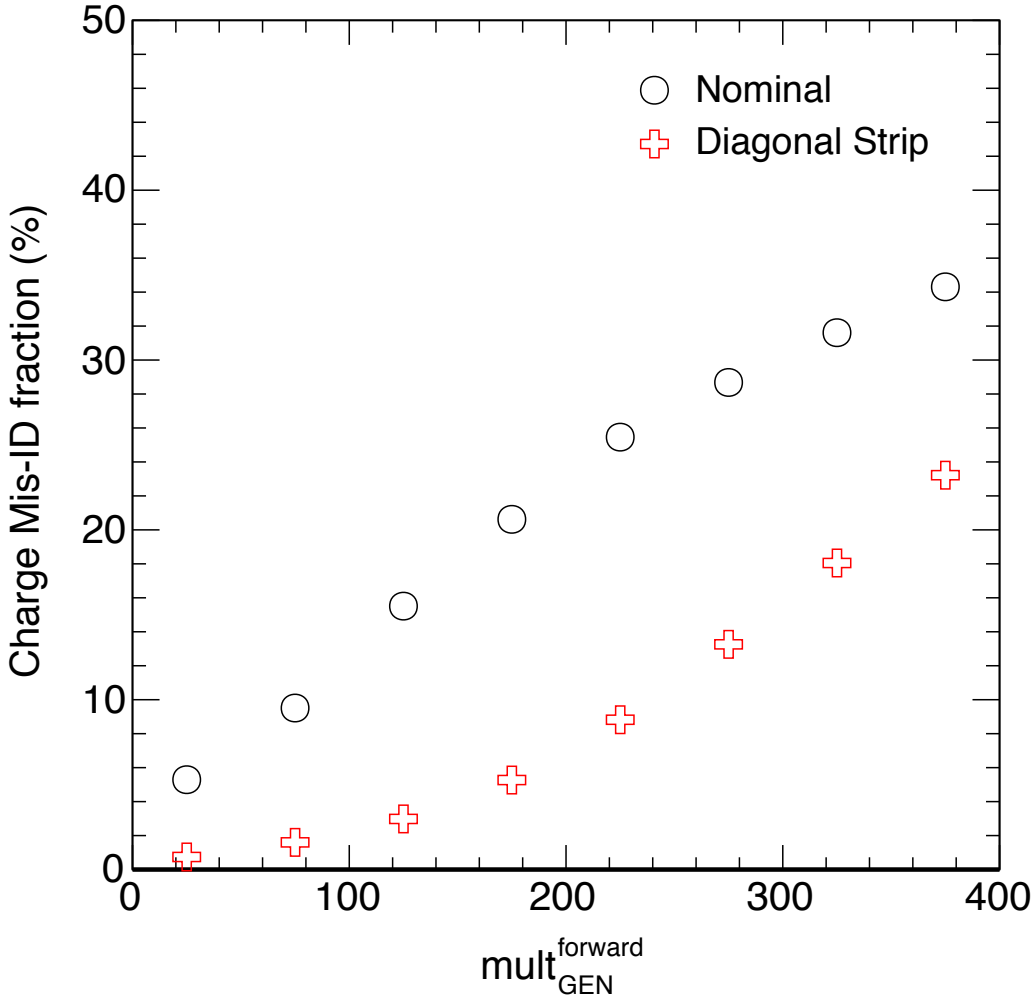
sTGC ghost hits rejection



No big improvement for pT resolution

Significant improvement for wrong-pT tracks

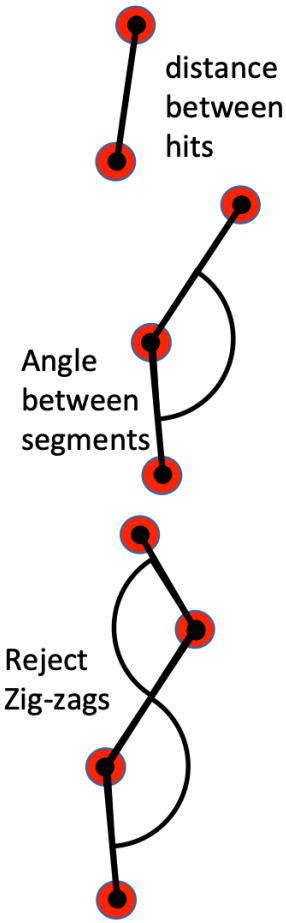
sTGC ghost hits rejection



Significant improvement for charge mis-ID

New Tracking Algorithm

New tracking algorithm



Unsorted hits from Si + sTGC (real tracks, background and ghost hits)

Sort hits, build geometry maps

2-hit Segments Finder
Filters on hit distance and neighboring stations

3-hit Segments Finder
Filter on angle, distance min&max

CA state evolution

Track Candidate Segments

Resolve Conflicts
(Hopfield neural network)

Track Candidates

Track Fitting

Primary Vertex Finding

Hit removal

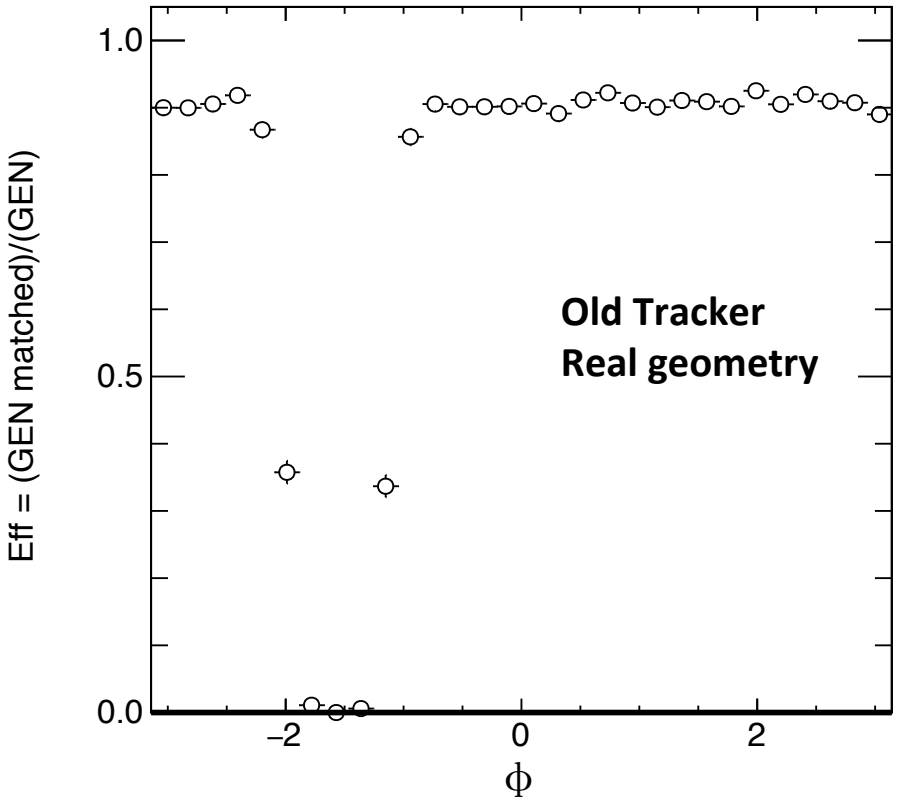
Charge / Momentum

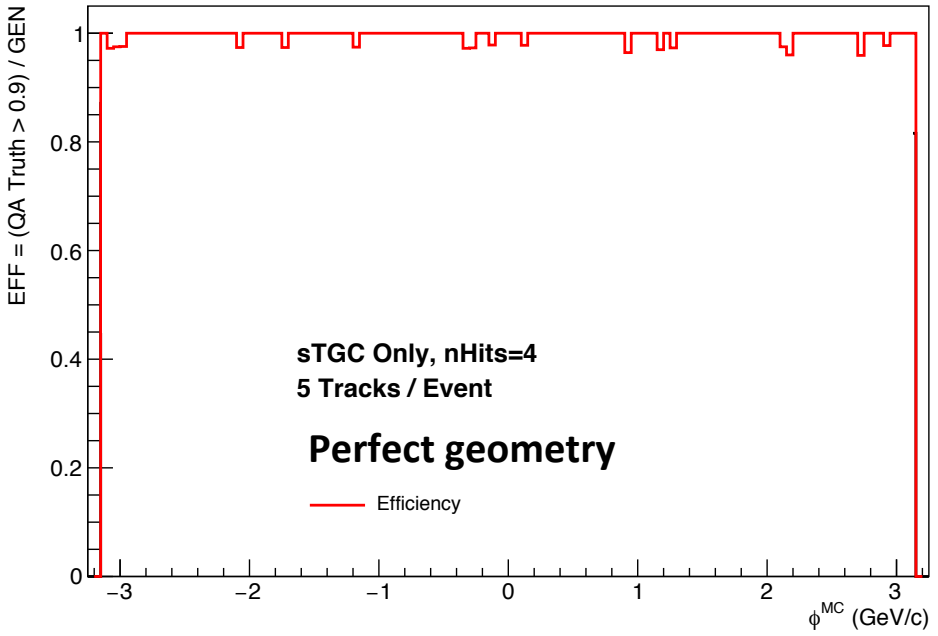
Based on iterative tracking and Cellular Automaton (CA)

Only sTGC hits used and no track fitting at this momemt

Credit: James Brandenburg

New tracking algorithm

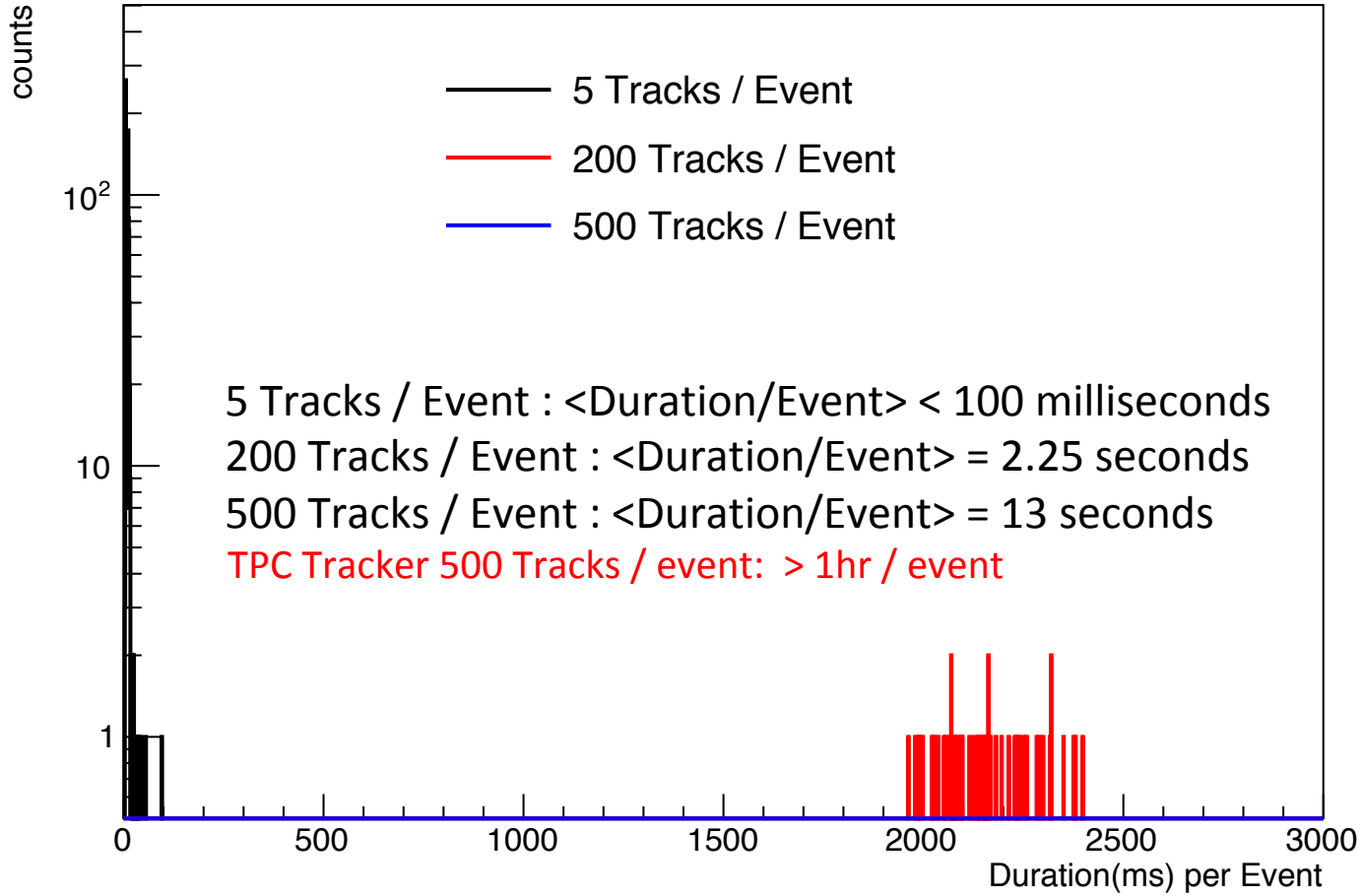




Good efficiency for track candidates
Remain to see after final track fitting

Credit: James Brandenburg

New tracking algorithm

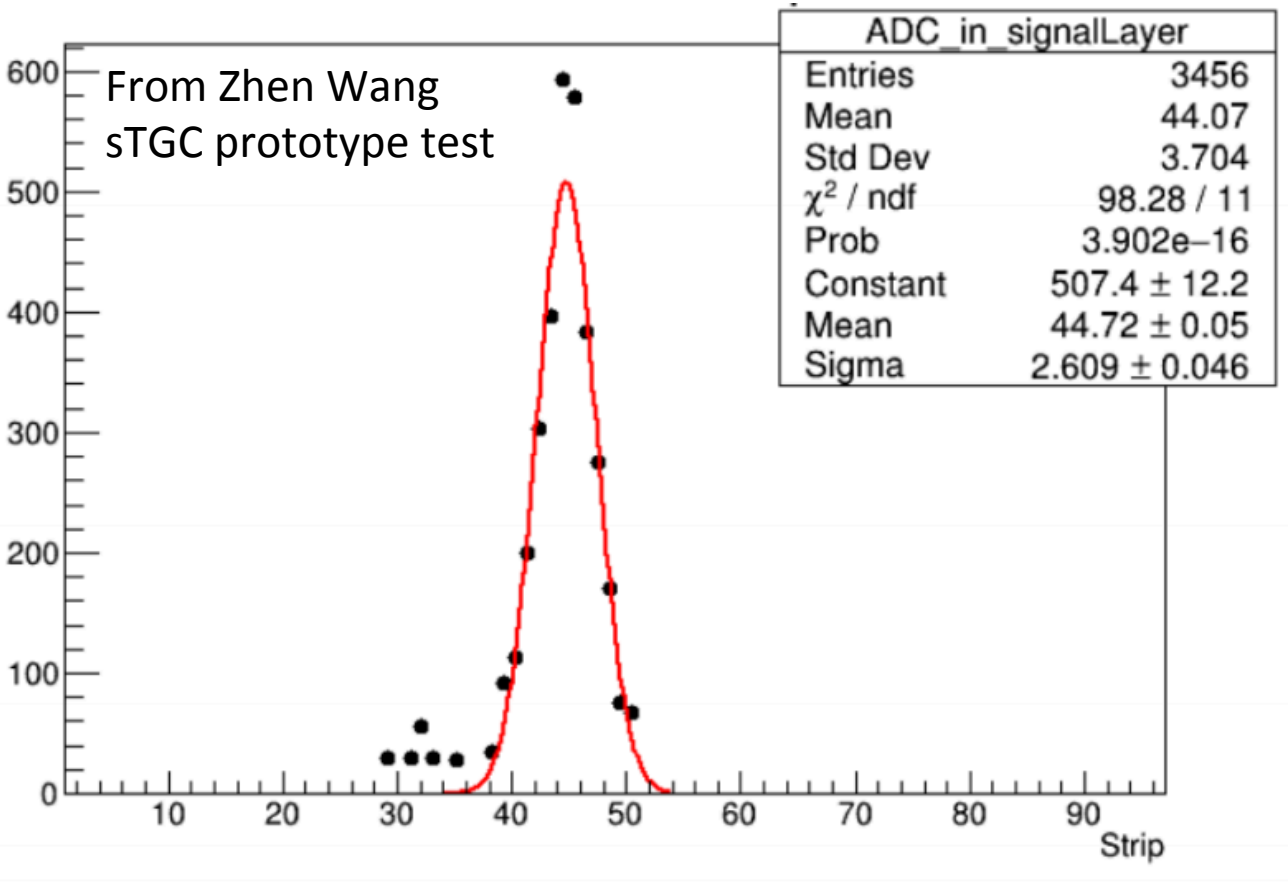


Way faster than TPC tracking algorithm
Including track fitting triple the timing

Credit: James Brandenburg

Known issues and future work

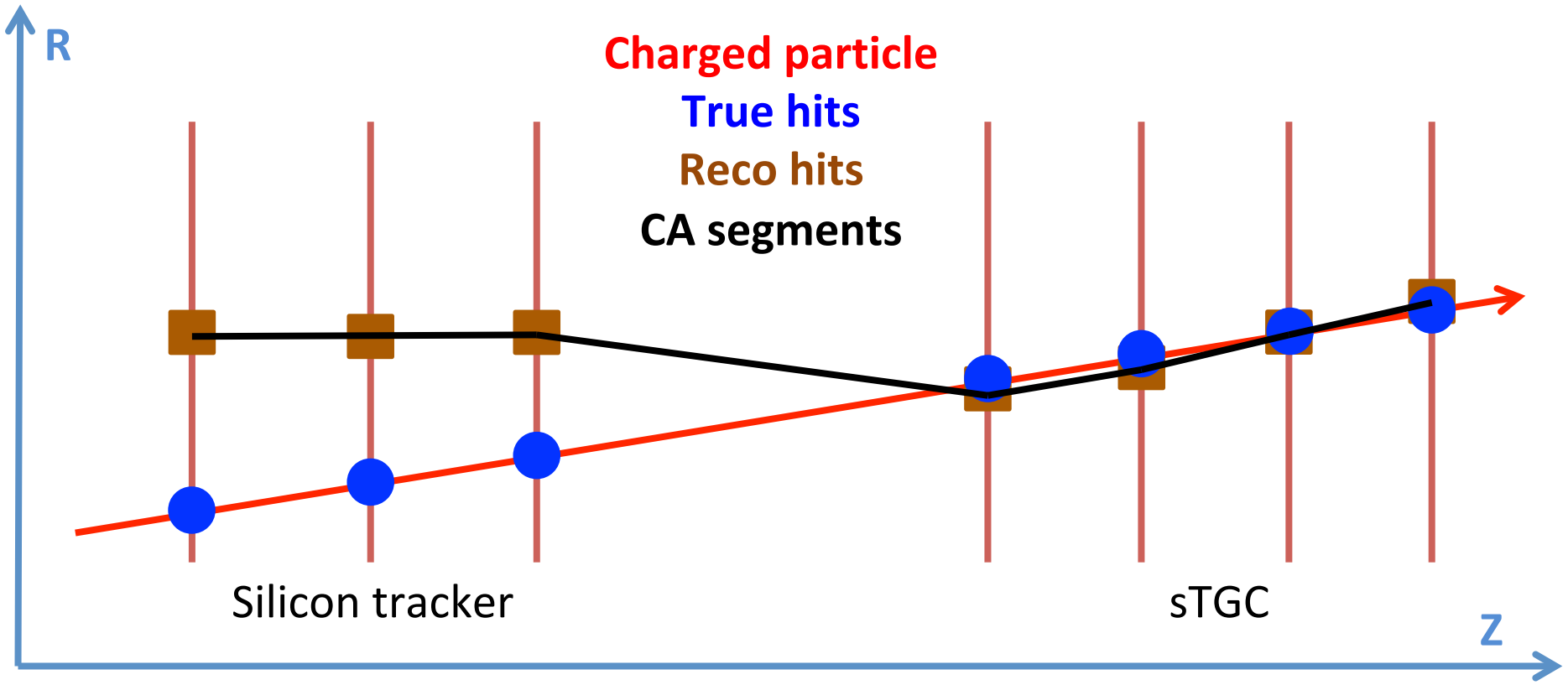
sTGC cluster size



Overlapping clusters harm detector resolution & ghost rejection

Cluster shape depends on gas & voltage - simulation on the way

Silicon hits for tracking



Silicon hit reconstruction in R direction might confuse CA

One solution is to use sTGC only for track seeds

Then propagate to silicon with Kalman filter

Summary

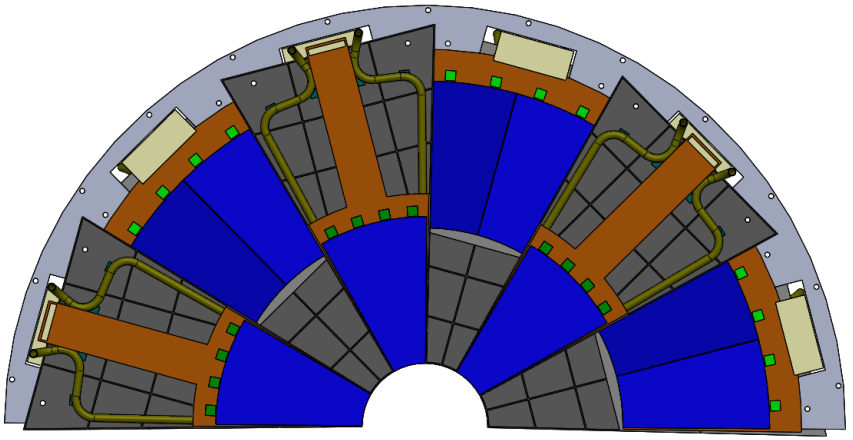
- New geometry has been implemented for FTS simulation
- Performance in PP meet Cold QCD program requirement
- Performance in AuAu plagued by ghost hits
  - Ghost rejection design with diagonal strips can significantly improve the situation
- Indication of room for improvement in tracking algorithm

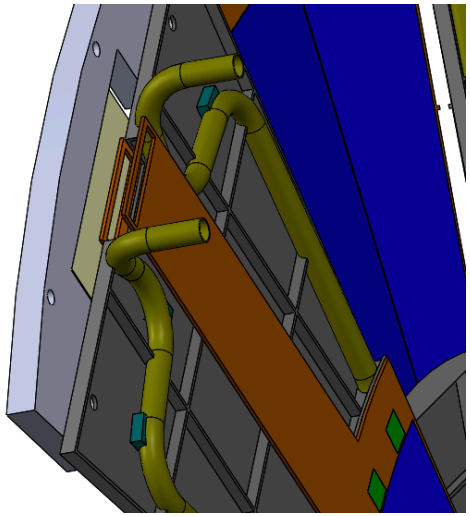
- Known issues and future work
  - Impact of sTGC cluster size
  - Optimal way to use silicon hits in tracking

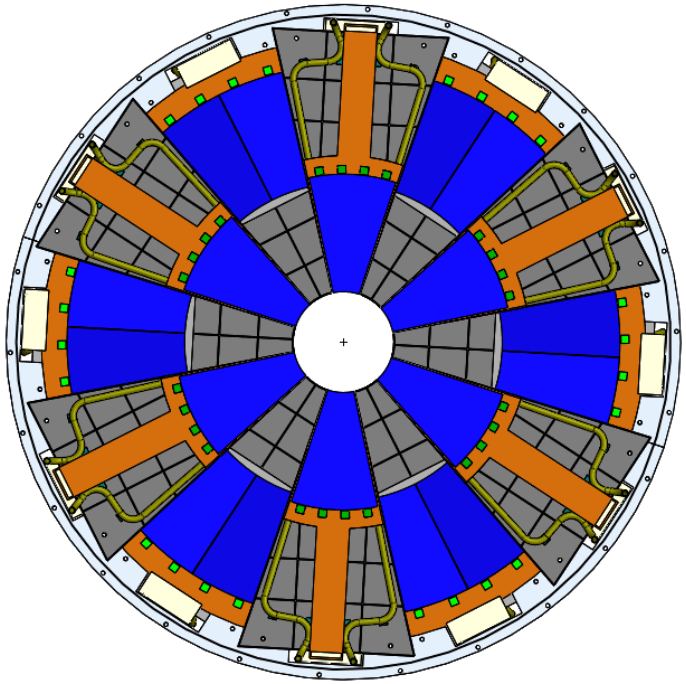
Back up

Basics of building a new geometry

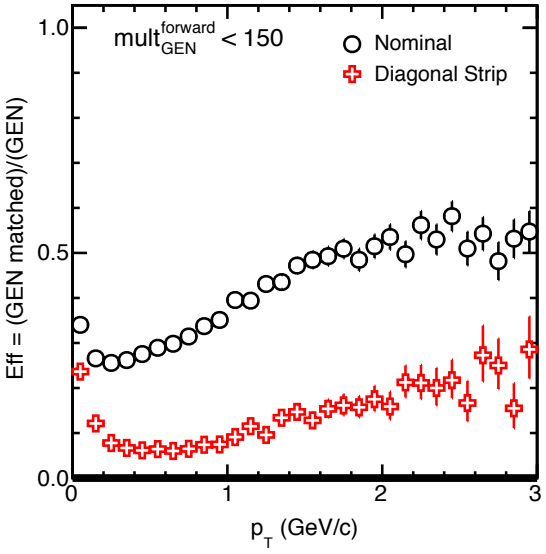
- Main disk (x3)
  - Rings (x2)
  - *T-boards* (x12)
  - Wedges (x12)
    - Outer wedges
      - Outer support
      - Outer silicons
      - *Outer chips*
      - *Cooling tube*
      - *Outer hybrid*
    - Inner wedge
      - Inner suport
      - Inner silicon
      - *Inner chips*
      - *Inner hybrid*

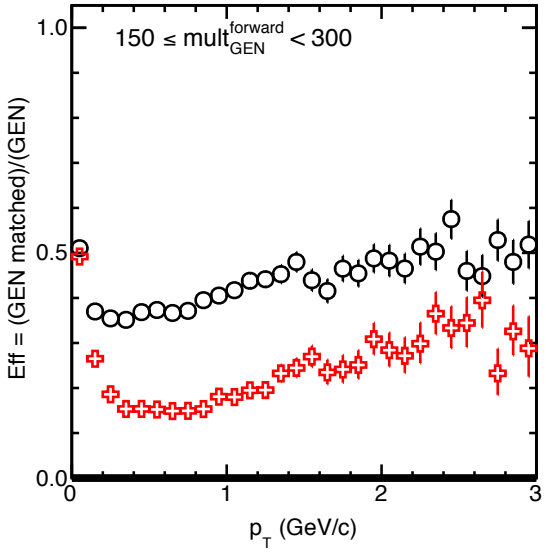


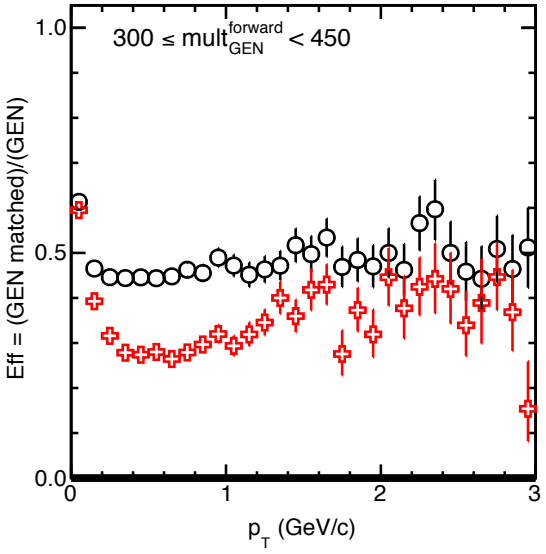




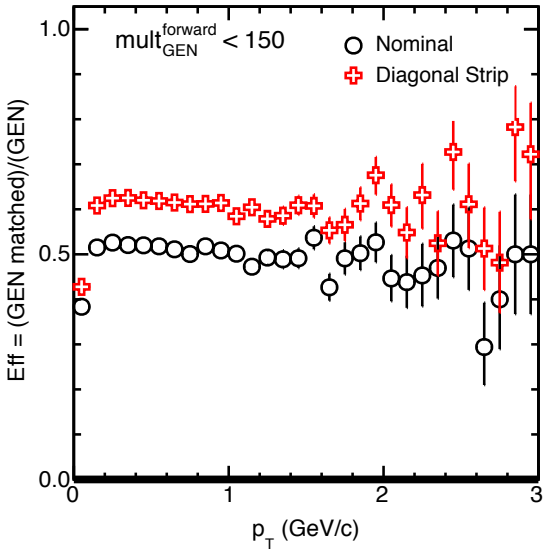
sTGC ghost hits rejection

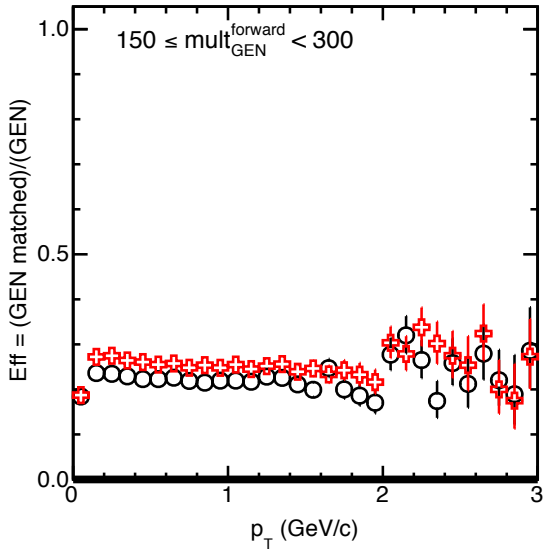


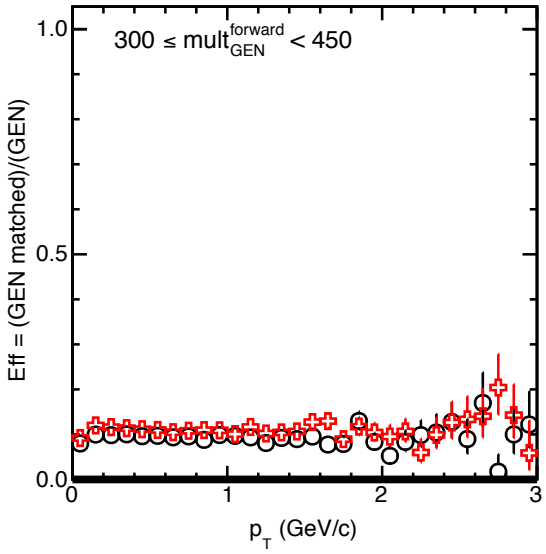




sTGC ghost hits rejection

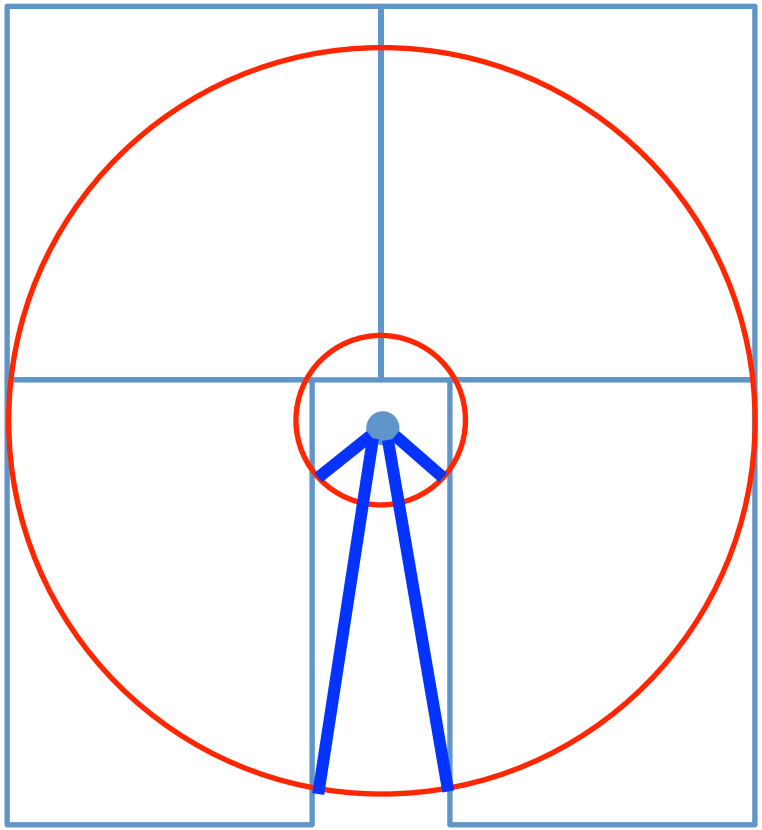




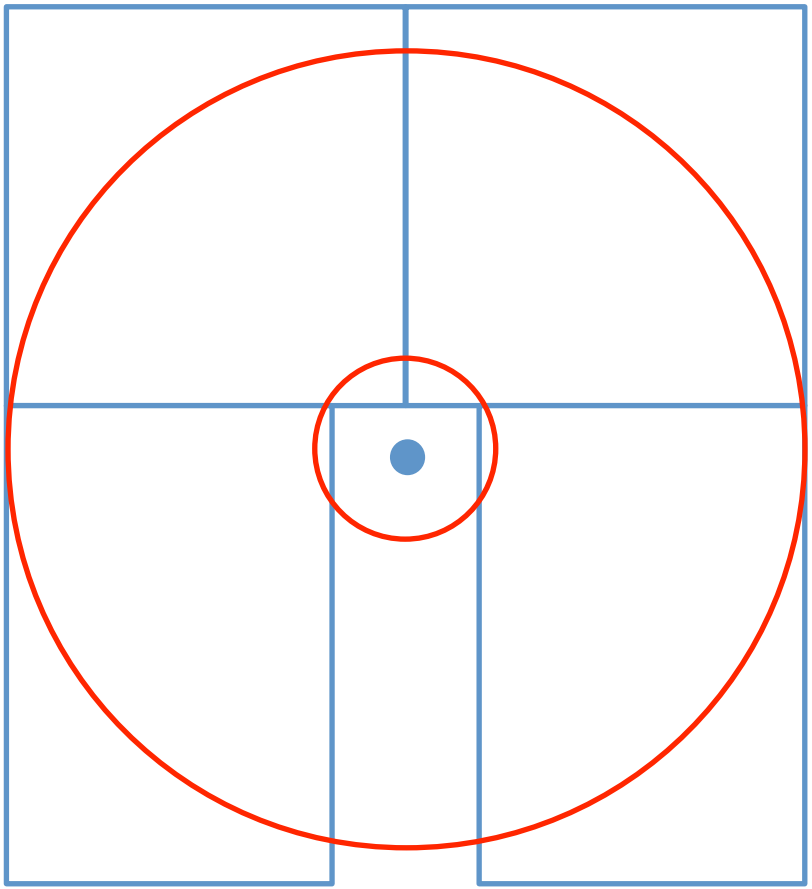


The new sTGC acceptance

Disk 1,2 (z = 280,304cm)



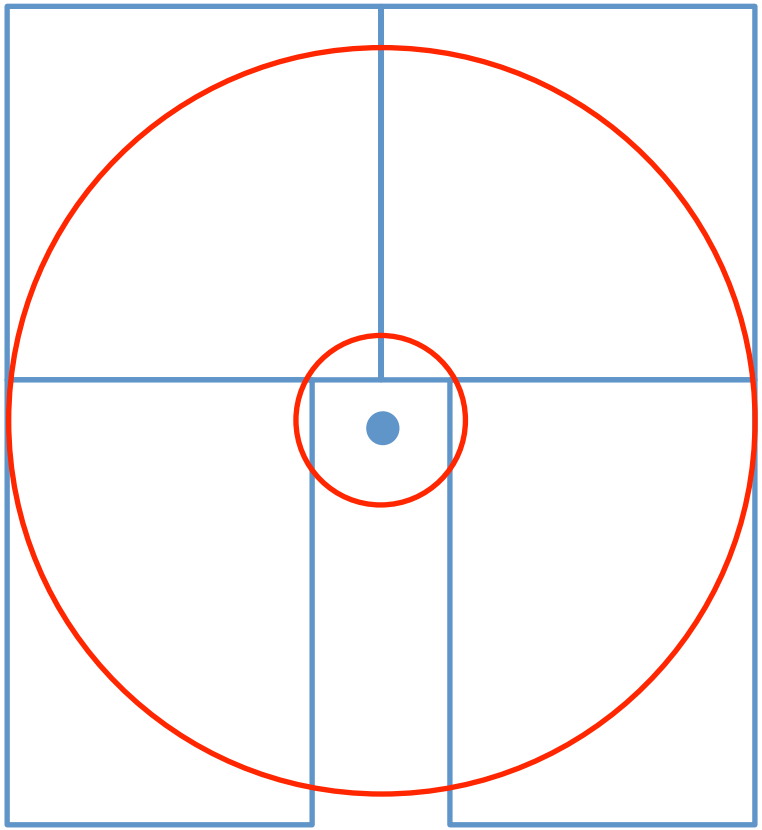
Disk 3,4 (z = 327,349cm)



The hole results in larger acceptance loss in ϕ at larger eta

The new sTGC acceptance

Disk 1,2 (z = 280,304cm)



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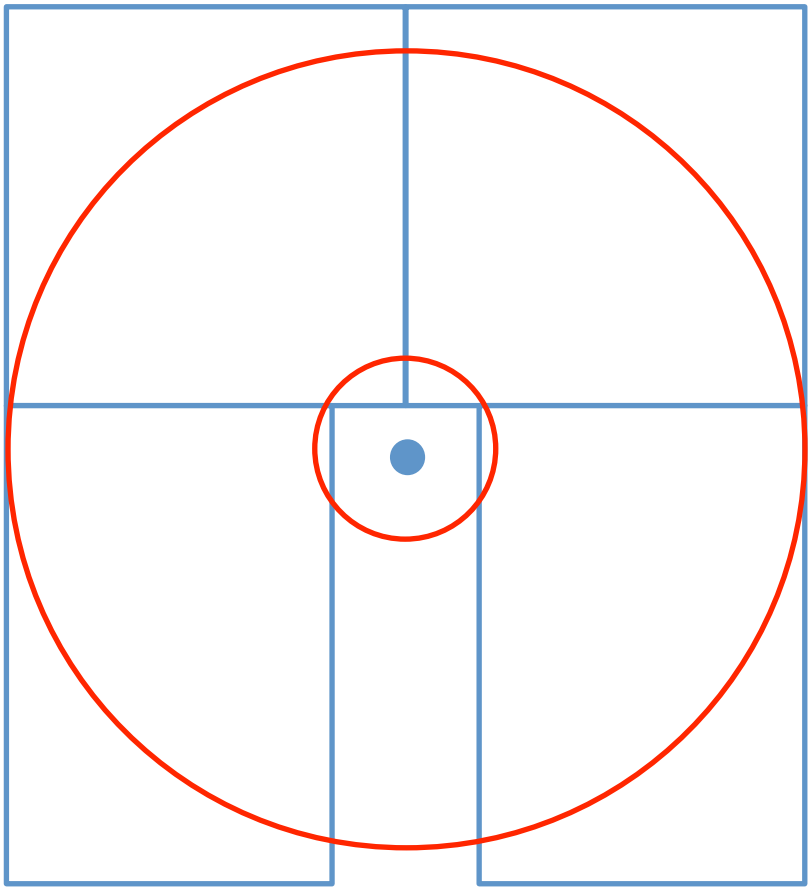

Full azimuthal coverage (besides the hole)

Disk 1: $2.5 < \eta < 3.9$

Disk 2: $2.6 < \eta < 4.0$

Disk3: $2.5 < \eta < 4.0$

Disk4: $2.6 < \eta < 4.1$