

Mid-rapidity Tracking Simulations

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for the STAR Collaboration

Outline

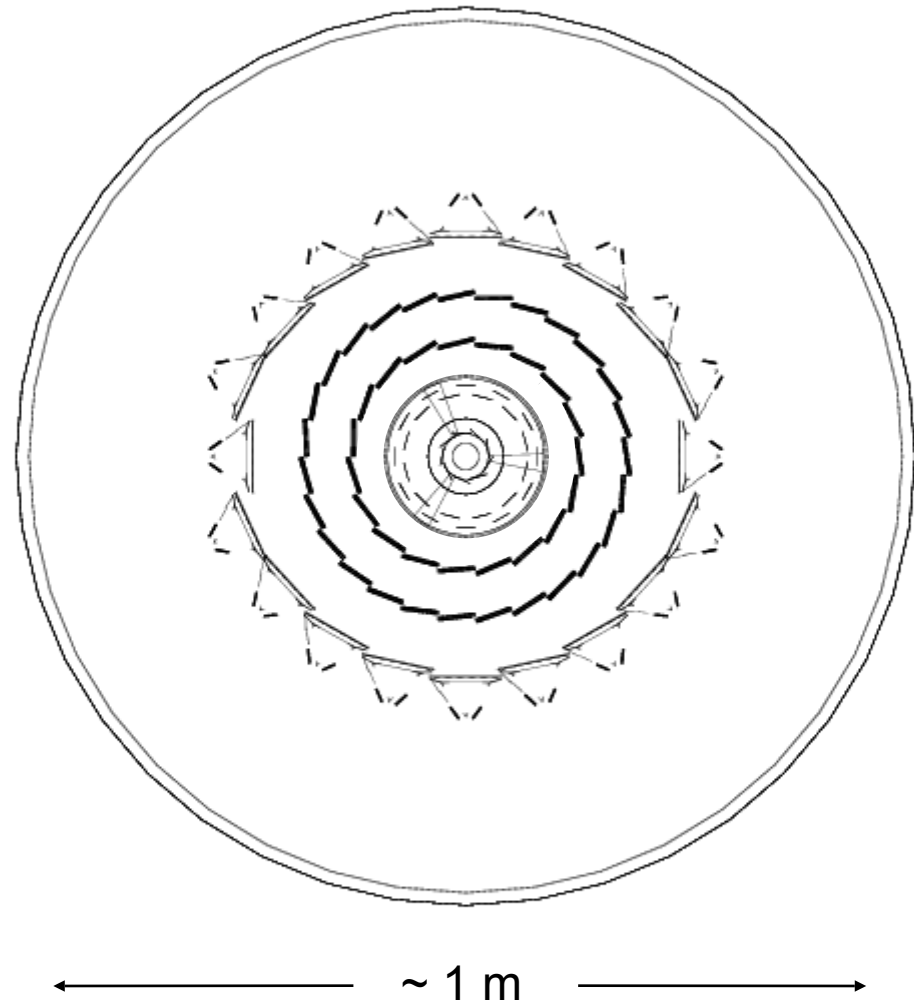
- D^0 reconstruction from baseline configuration
- Presented here:
 - Geometry layout in simulation
 - Occupancy as a function of radius
 - pointing resolution of system to outer HFT
 - D^0 efficiency, expected $S/(S+B)$
- Results from the most extreme multiplicities
 - secondary vertex tagging in central Au+Au
 - high density in all trackers
 - Multiple collision pileup in HFT during readout

Wherever possible, use both analytic and MC results

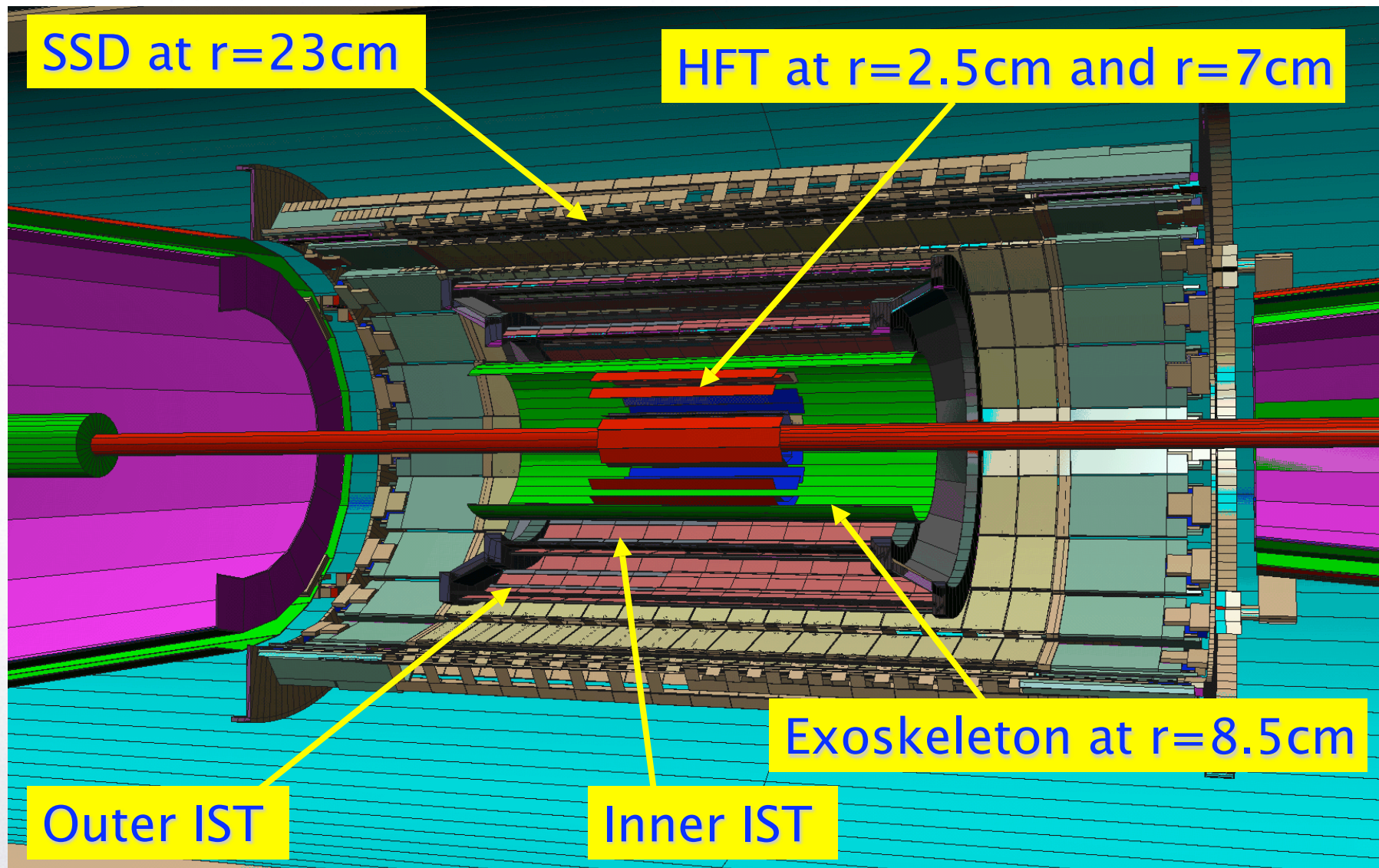
Graded Resolution

- Goal: graded resolution from the outside \rightarrow in
- TPC – SSD – IST – HFT
- TPC pointing resolution at the SSD is ~ 1 mm
- SSD pointing at the IST is ~ 300 μm
- IST pointing at the HFT is ~ 200 μm
- HFT pointing at the VTX is ~ 50 μm

Inside the TPC

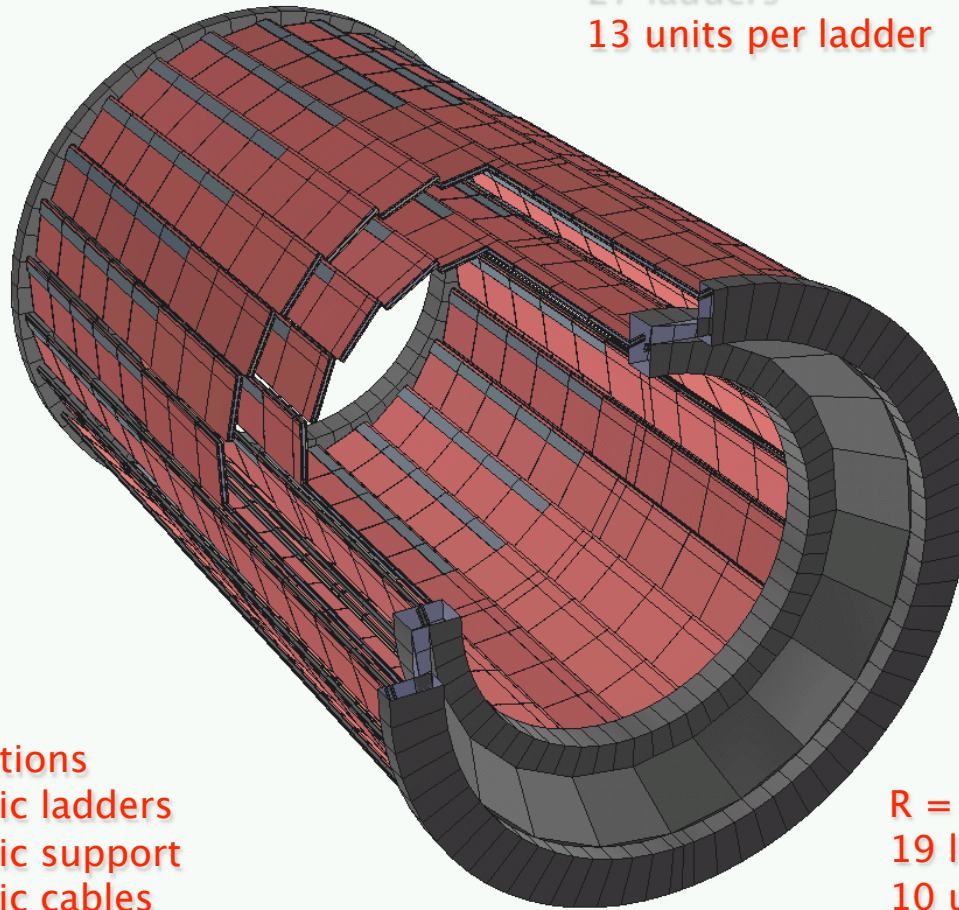


Tracker Layout



IST Layout

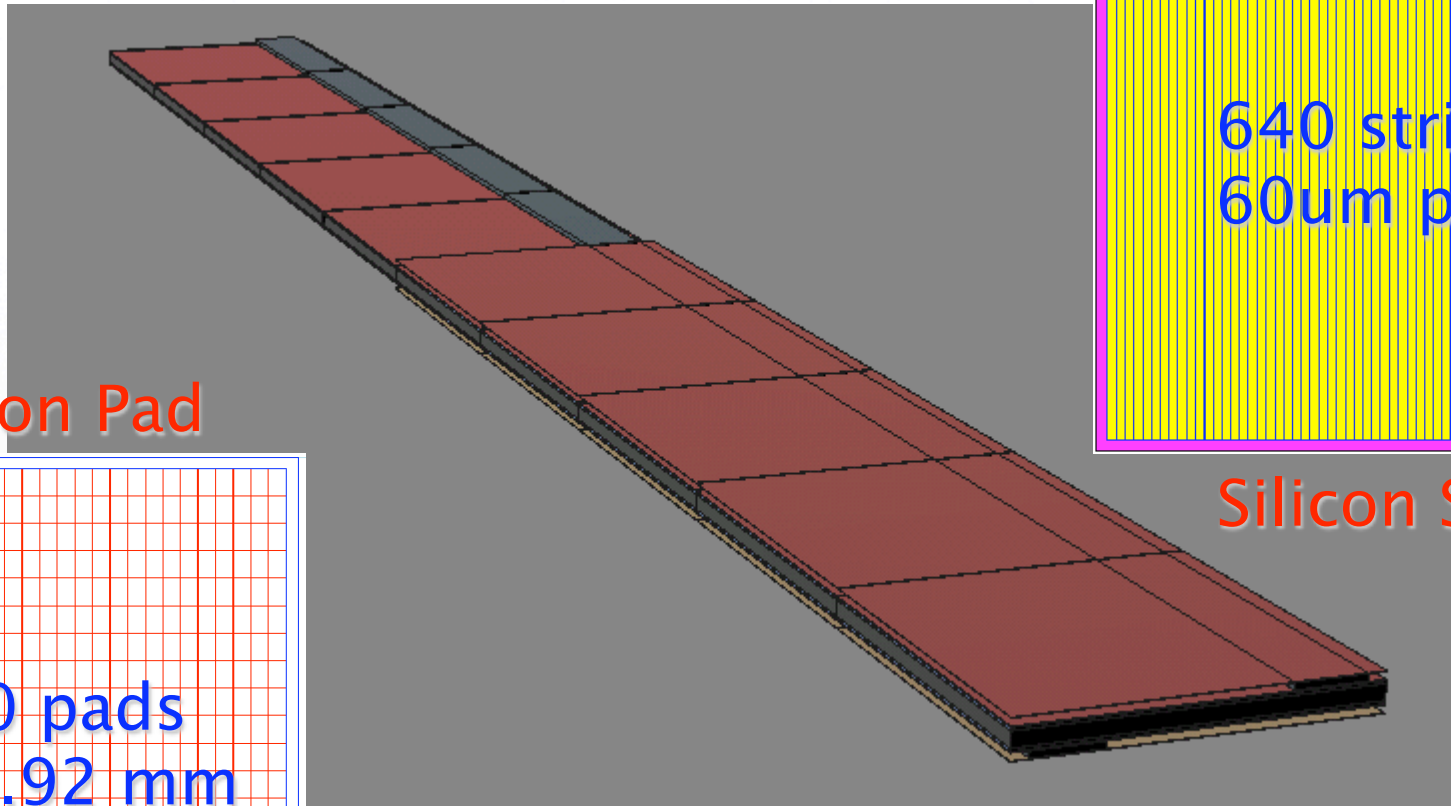
R = 17 cm
27 ladders
13 units per ladder



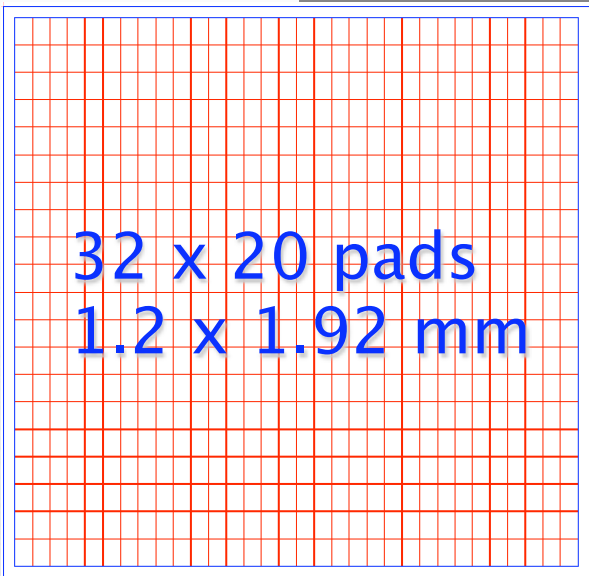
Simulations
Realistic ladders
Realistic support
Realistic cables
No utilities yet

R = 12 cm
19 ladders
10 units per ladder

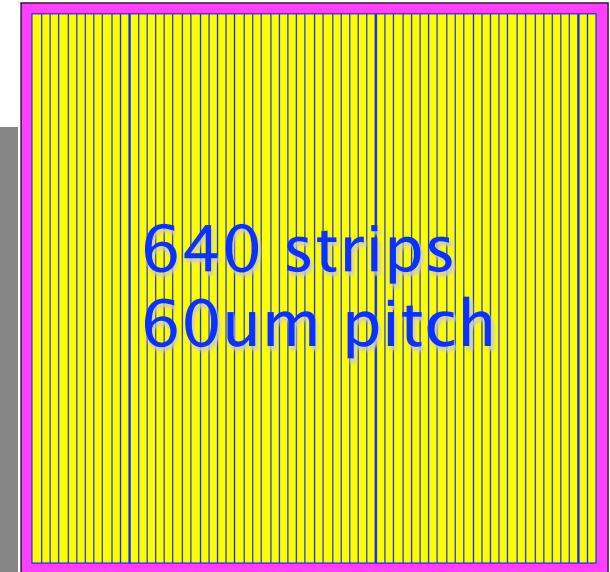
IST Ladder Layout



Silicon Pad



32 x 20 pads
1.2 x 1.92 mm

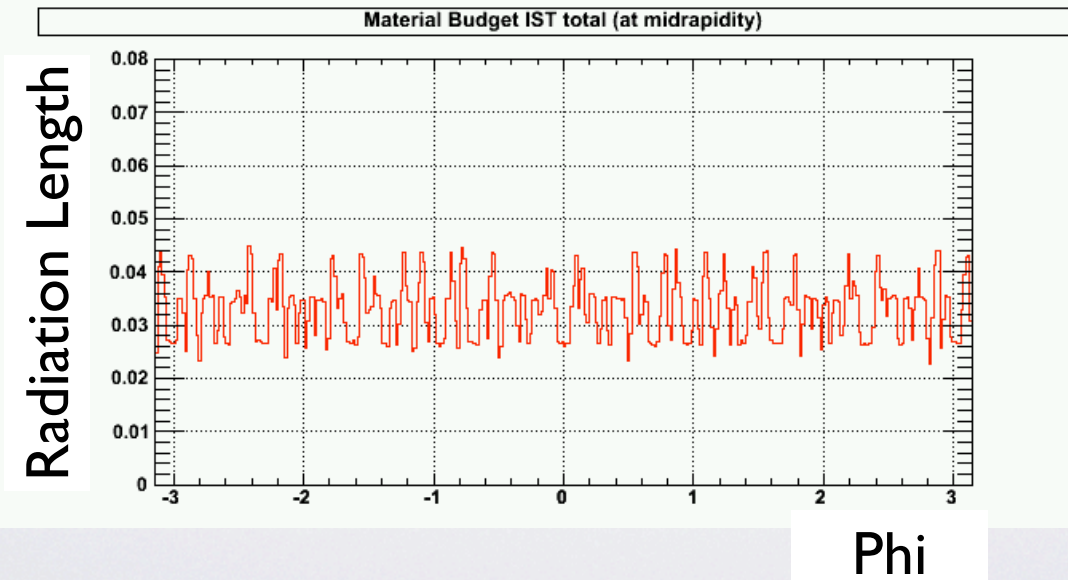
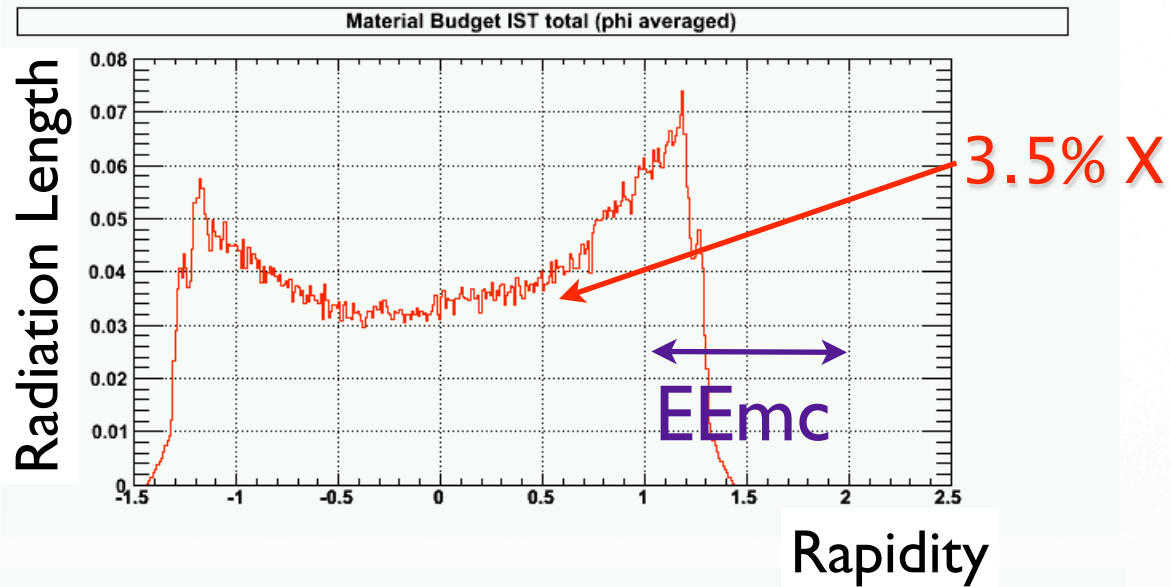


640 strips
60um pitch

Silicon Strip

Pad readout identical to strip sensors:
640 channels each

Total IST Material Budget



Explicit level of detail in simulations

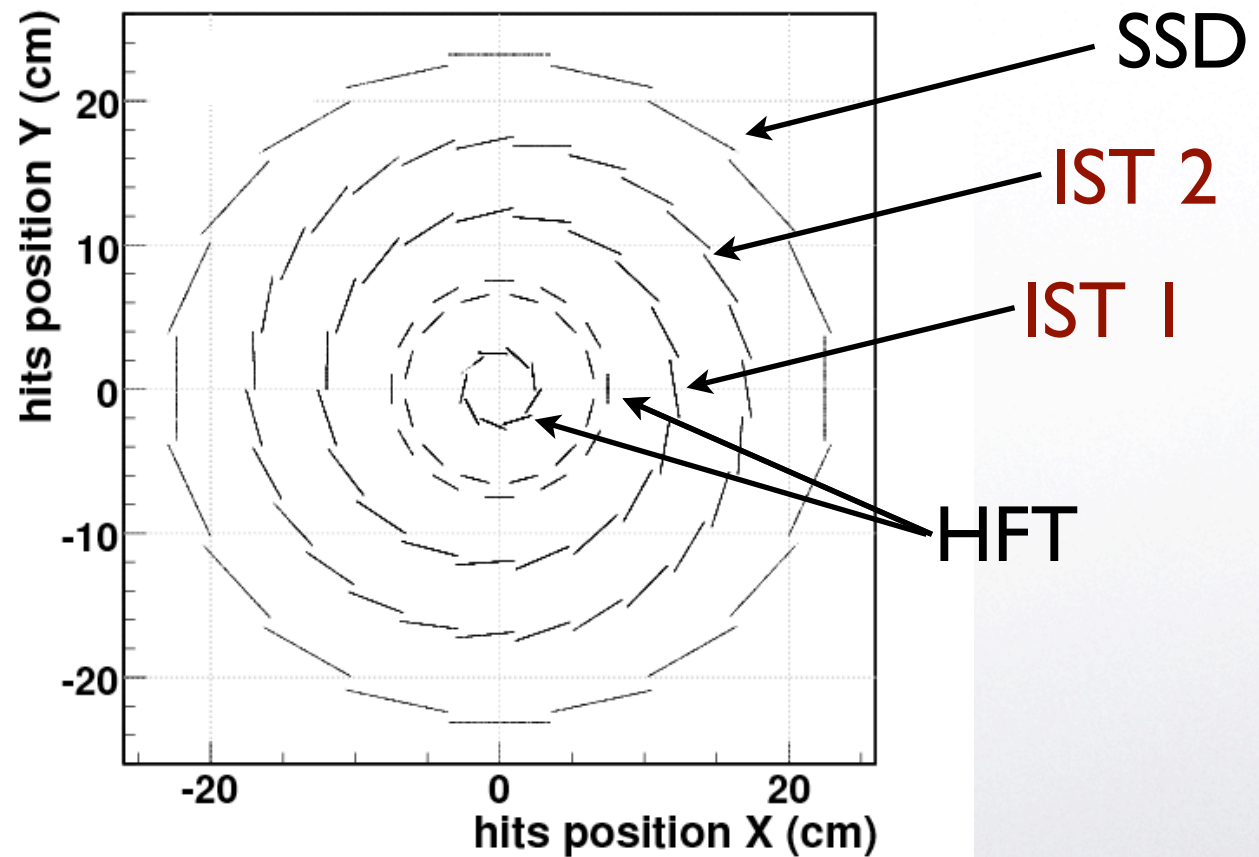
Simulation Sample

- Unless otherwise stated:
 - Central Hijing Au+Au ($b < 6$ fm)
 - 20 Minbias Hijing events mixed in HFT for pileup
 - $L = 1 \times 10^{27} \text{ cm}^{-2}\text{s}^{-1}$
 - Detailed Geant3 representation
 - Standard STAR Kalman tracker
 - baseline configuration for both IST layers
- Assumptions
 - HFT Pileup included
 - Combinatoric ghosting in the IST not included

Location & Orientation

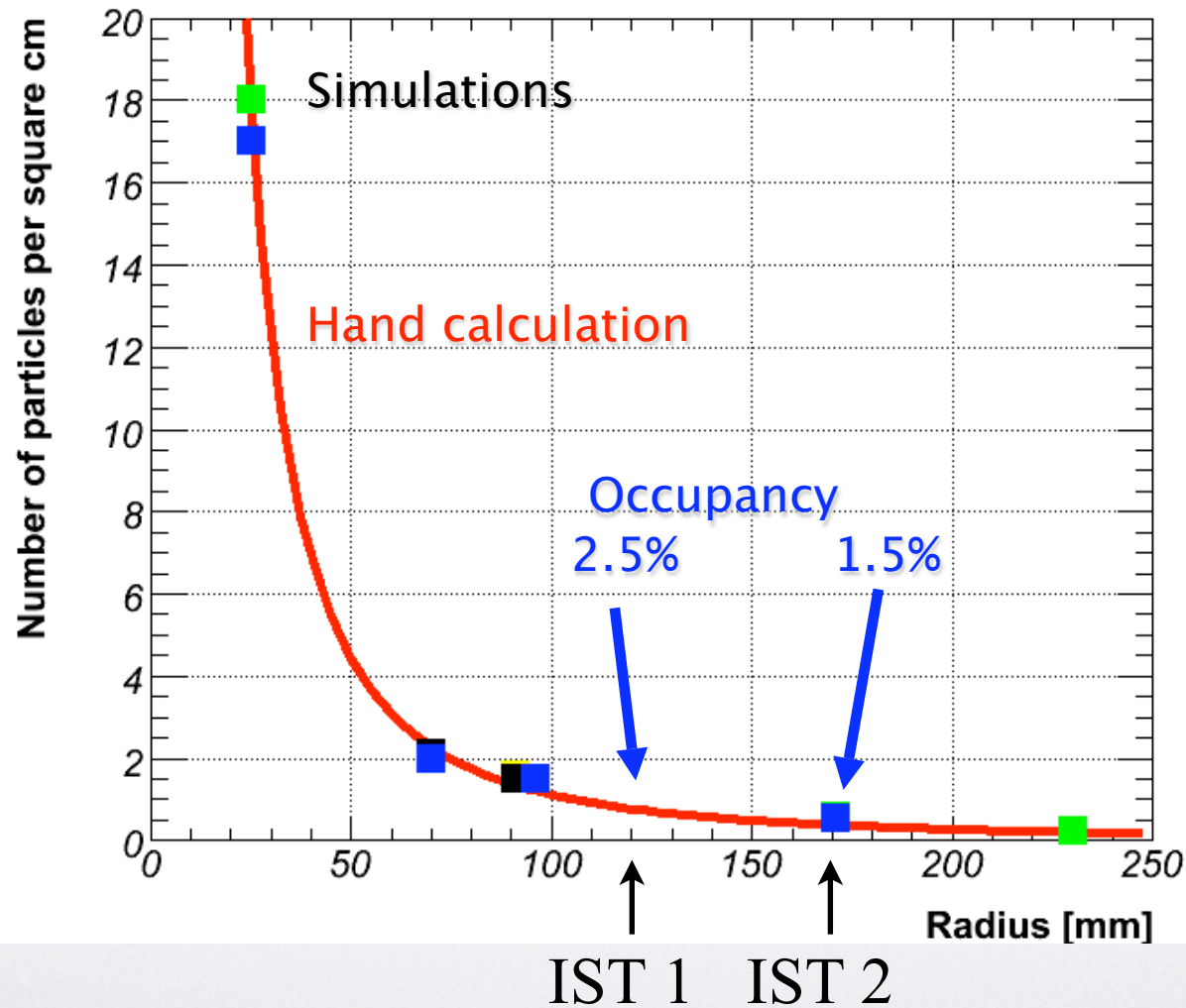
- Improve both r/ϕ and z resolution of TPC/SSD projection
- IST2 strips perpendicular to beam line
- IST1 strips parallel to beam line

TPC starts @ 50 cm



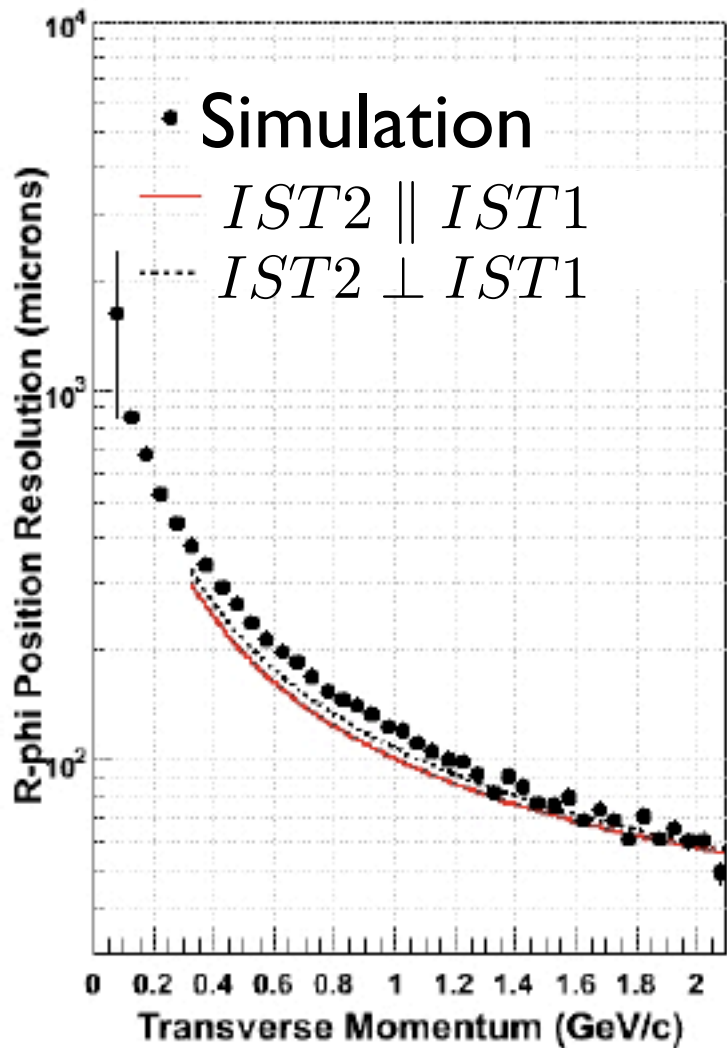
Expected Occupancies

Particle Density for Central Au+Au@200 GeV (700/unitrap)

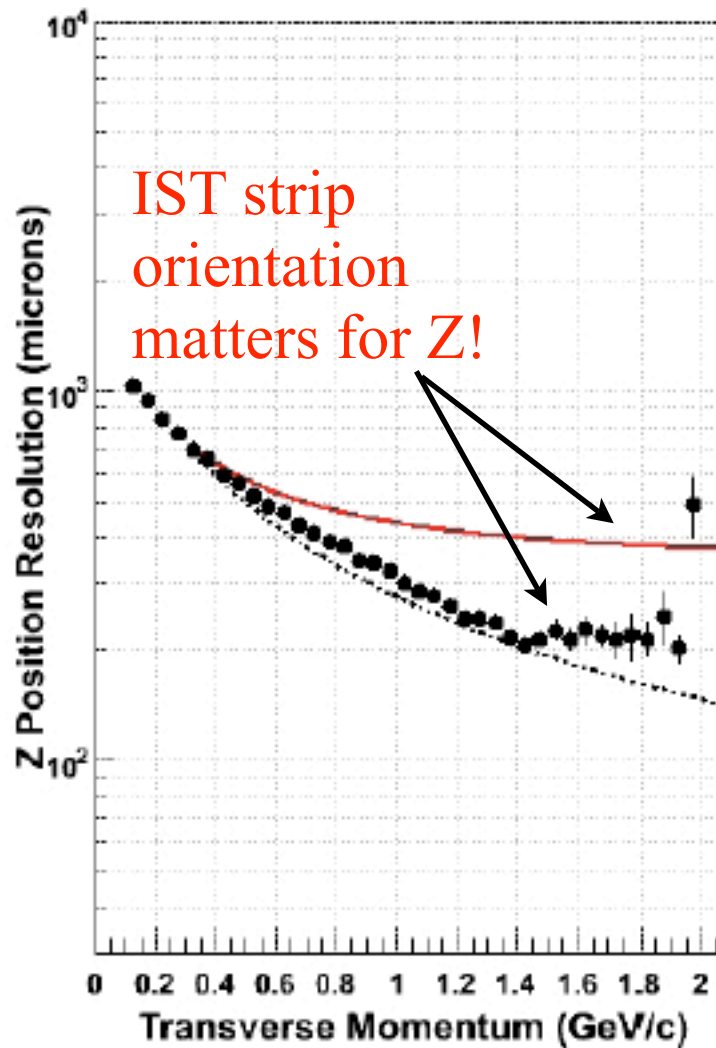


12 cm inner IST limits ghosting to < 7%

Pointing Resolution @HFT2



$$\sigma_{r\phi}(700 \text{ MeV}) = 170 \mu\text{m}$$



$$\sigma_z(700 \text{ MeV}) = 430 \mu\text{m}$$

$$\pi \sigma_{r\phi} \sigma_z \sim 0.23 \text{ mm}^2$$

compare to

$$\# \text{hits} / 0.23 \text{ mm}^2 \text{ is} \\ < 0.01$$

(200 μs readout
@ $90 \times 10^{26} \text{ cm}^{-2}\text{s}^{-1}$)

Probability to add correct hit $> 94\%$

D^0 Simulations

Input: central hijing (0-6fm) event + 10 D^0 + 10 Λ

100% decay $D^0 \rightarrow K^- \pi^+$ $\Lambda_c^+ \rightarrow p K^- \pi^+$

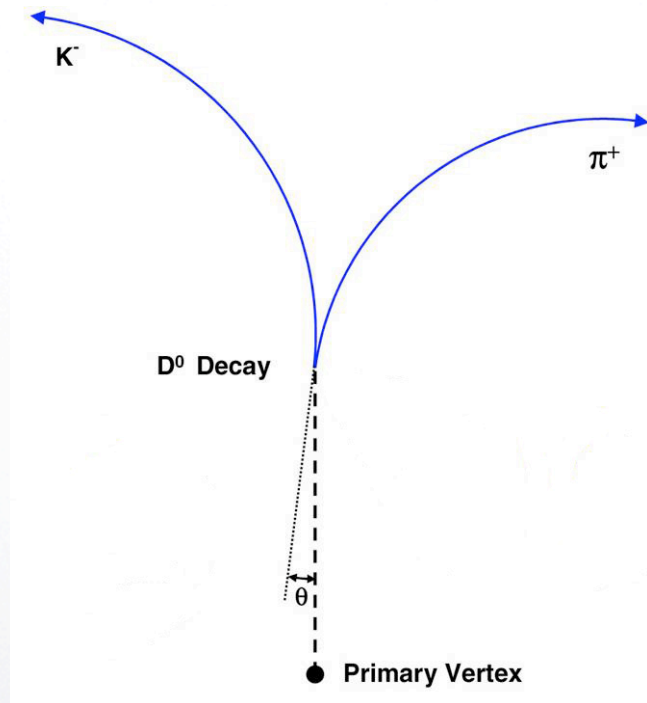
Hijing vertex: Gaussian, $\sigma=5\text{cm}$

D^0 , Λ_c : from hijing vertex

p_T (0.2, 10.0) flat, eta (-1.1, 1.1) flat, phi

~15 K good events used

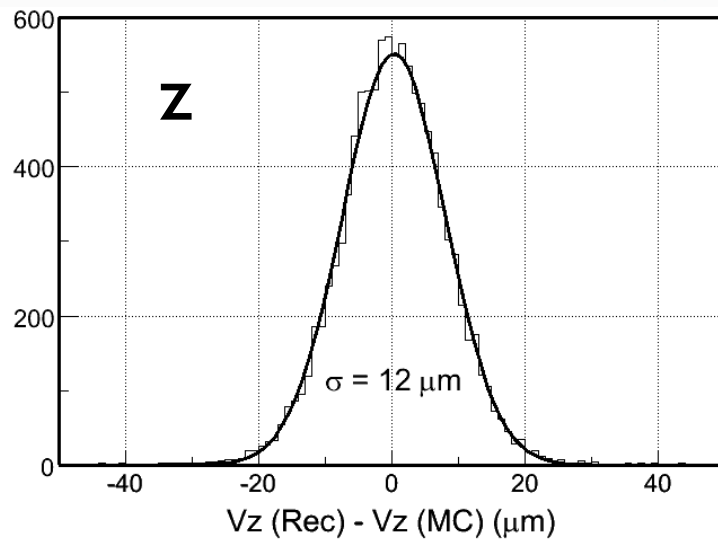
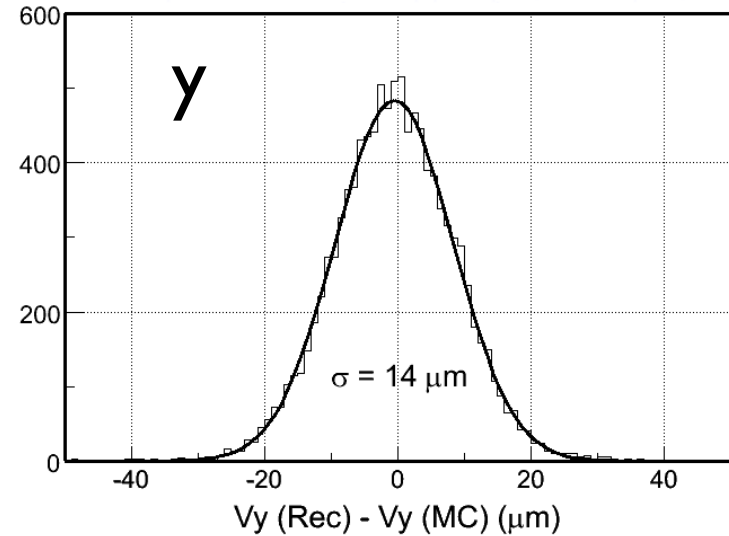
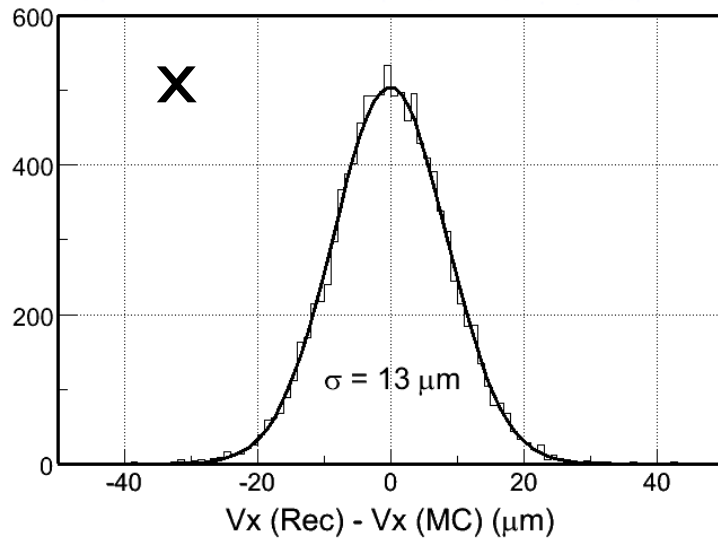
D⁰ Simulations



- k/pi V0 combinations
- V0 points to primary vertex
- Decay displaced from primary vertex

Primary Vertex Resolution

- Vertex resolution: central Au+Au w/ HFT pileup

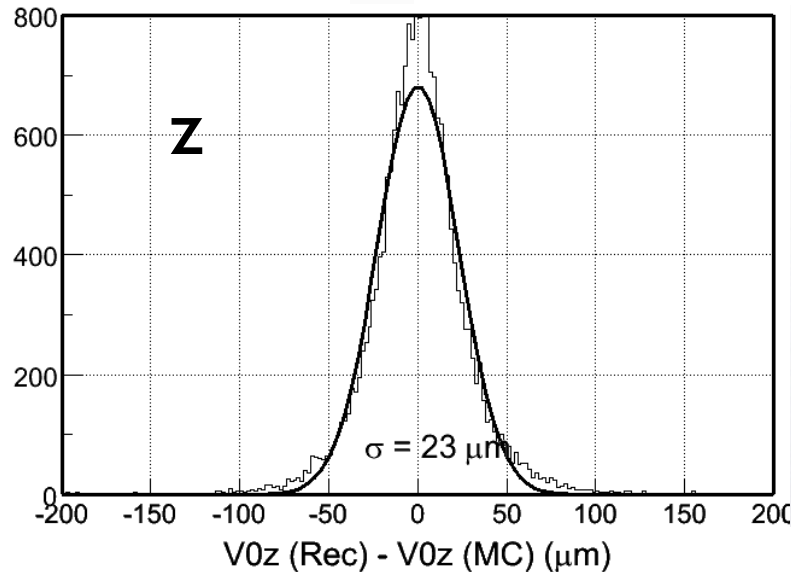
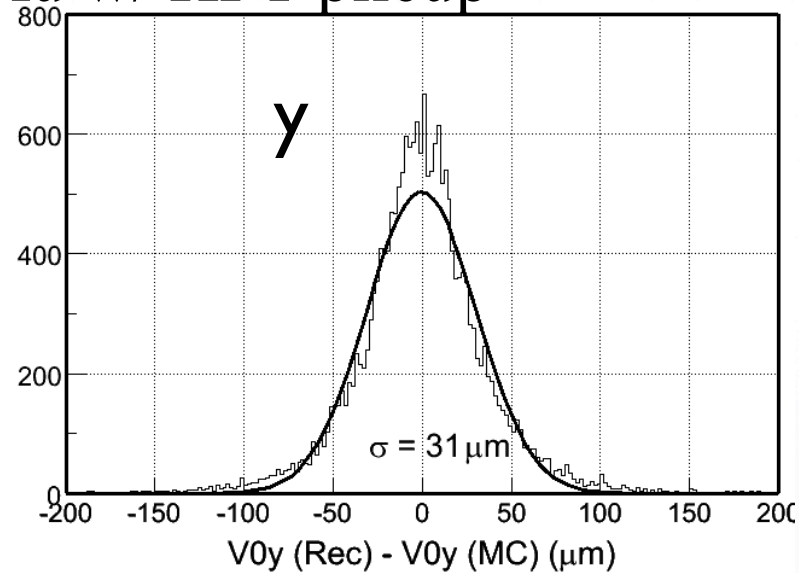
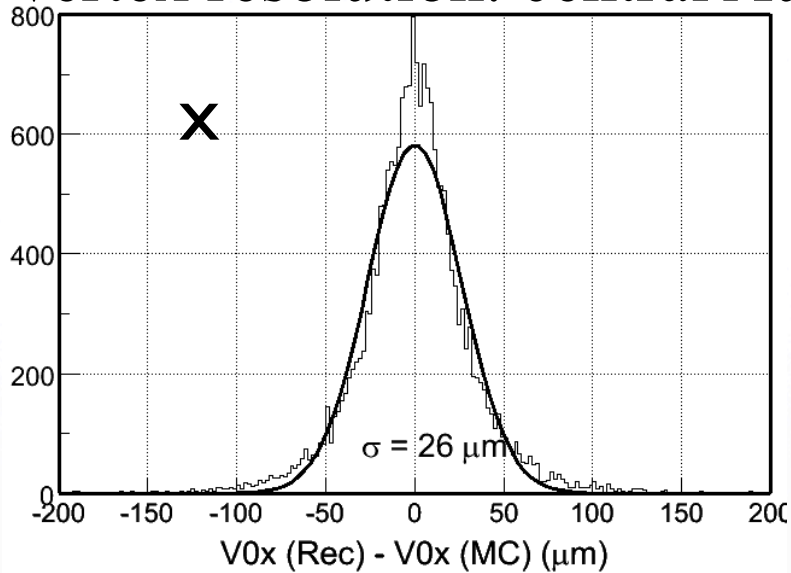


$$\sigma_{3D} \approx \sqrt{3} \times 13 \mu\text{m}$$

Excellent primary vert resolution in all dimensions

Secondary Vertex Resolution

□ Vertex resolution: central Au+Au w/ HFT pileup

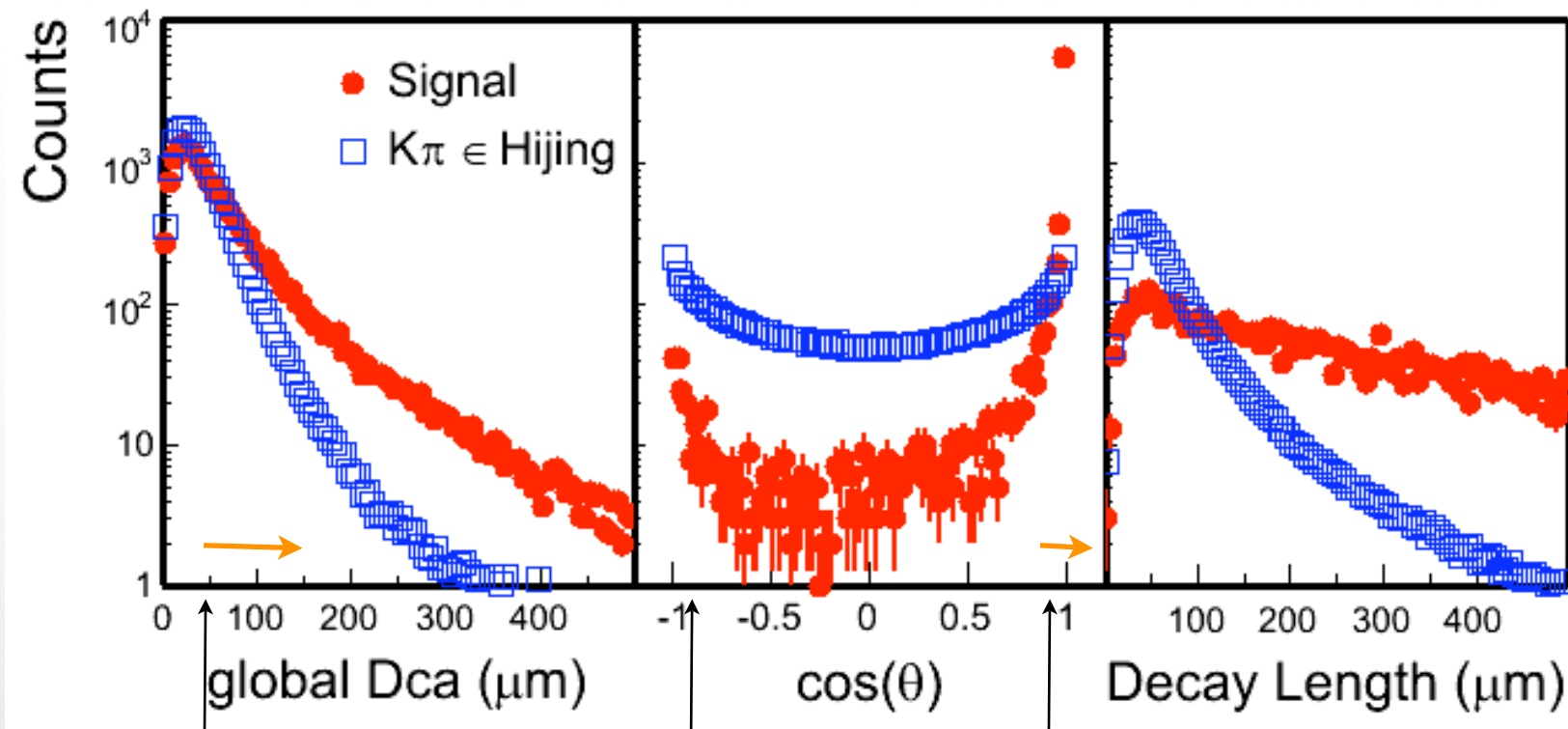


$$\sigma_{3D} \approx \sqrt{3} \times 26 \mu\text{m}$$

Excellent secondary vert resolution in all dimensions

Decay Distributions

- Kinematic Distributions: central Au+Au w/ HFT pileup

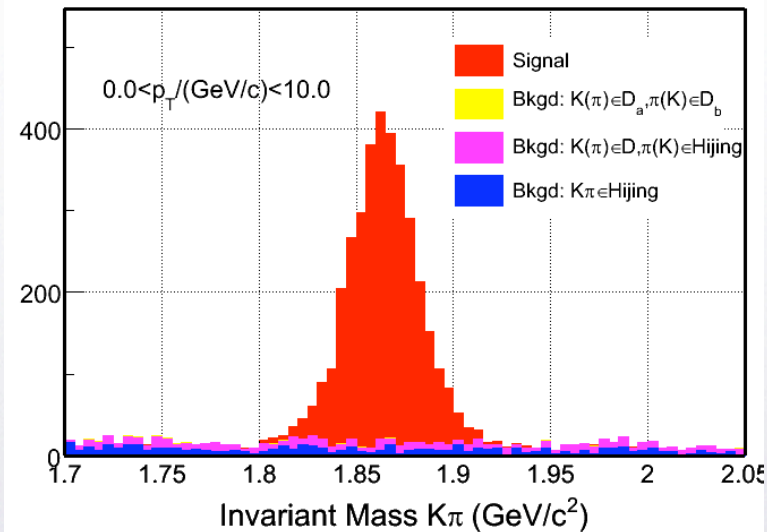
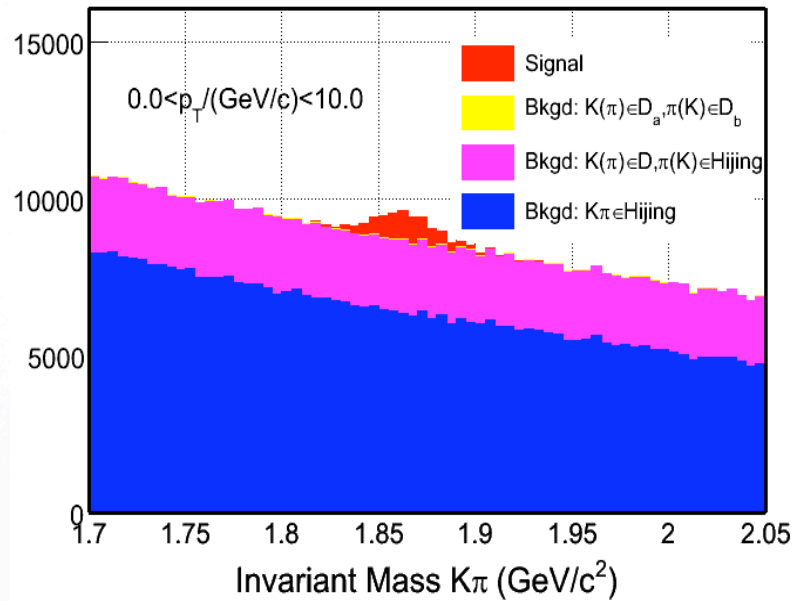


Signal to Background

All (K, π) combinations



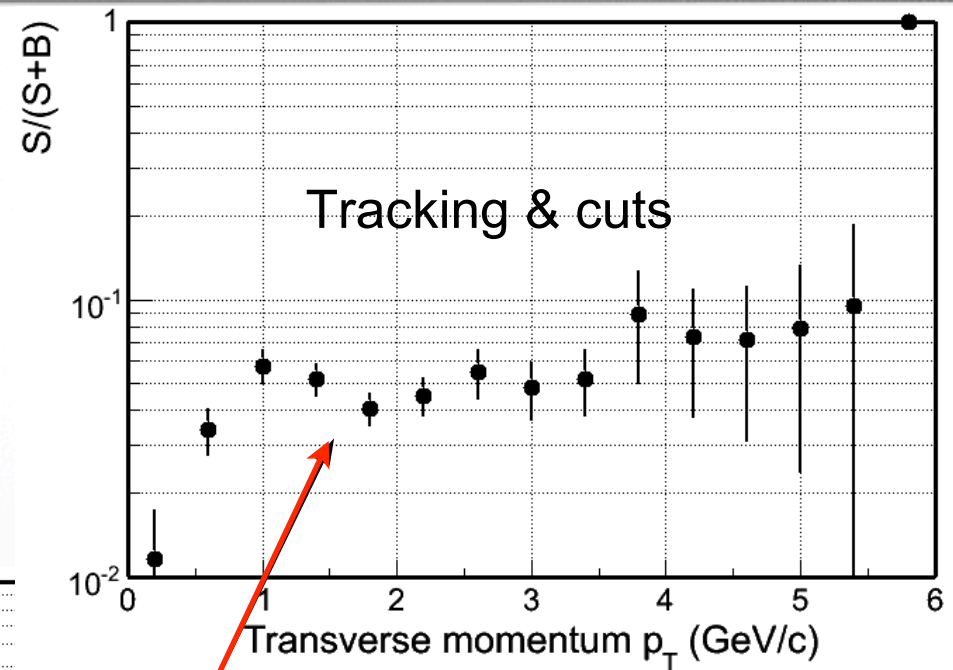
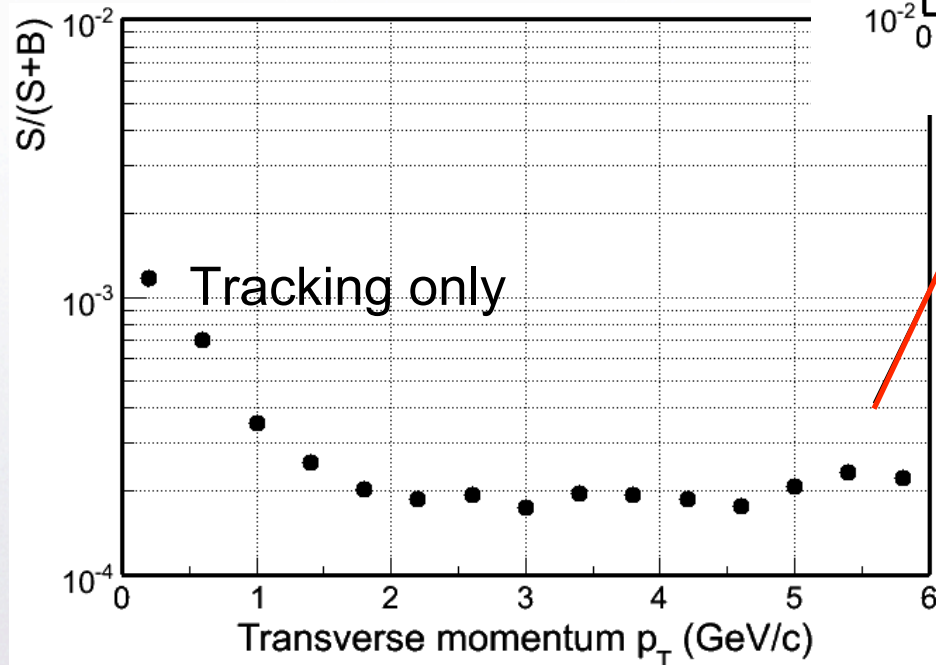
$gDca > 50\mu\text{m}$
 $\cos\theta > 0.98$



Displaced Vertex + $\cos(\theta)$ yields clean D0 signal

Signal to Background

Cuts increase $S/(S+B)$ by factor of ~ 300

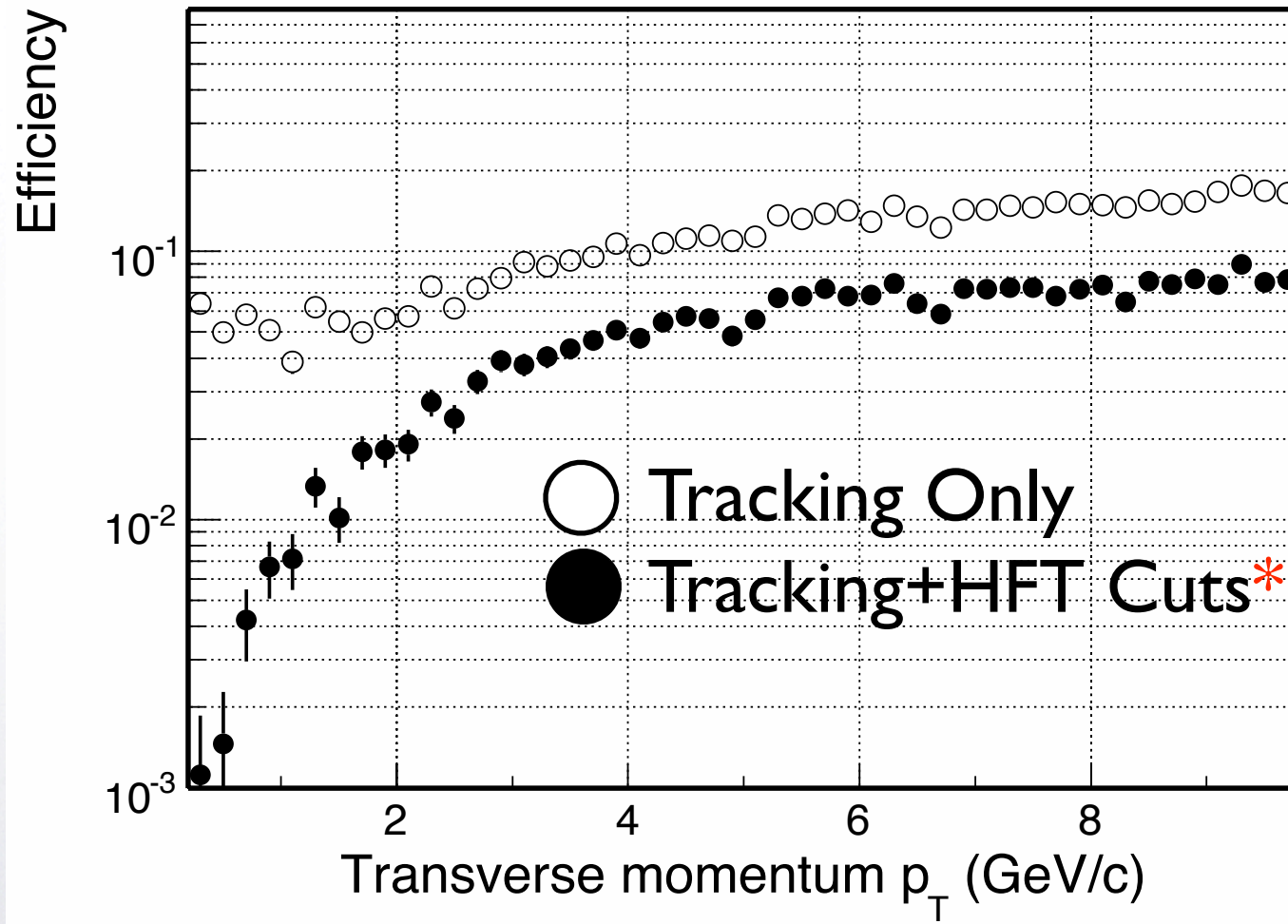


Then require
 $gDca > 50 \mu\text{m}$
 $\cos\theta > 0.98$

Displaced Vertex + $\cos(\theta)$ yields clean D0 signal

D0 Efficiencies

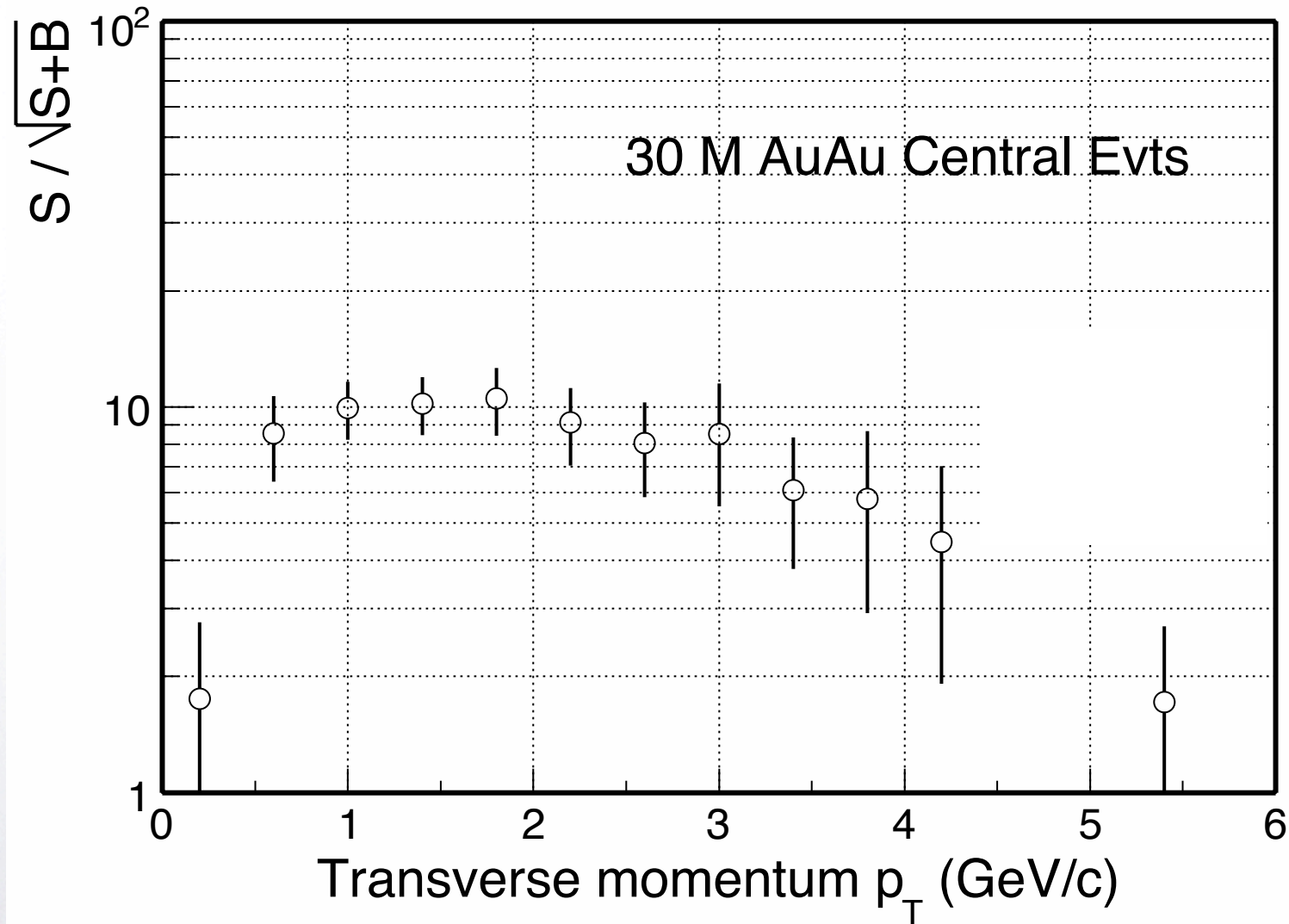
- D⁰ Reconstruction: central Au+Au w/ HFT pileup



$gDca > 50\mu m$
 $\cos\theta > 0.98$

Sufficient to meet D⁰ physics goals

Expected Significance



~10 sigma significance in 30M central AuAu events

Baseline Performance

- Baseline configuration works
- Acceptable occupancy with IST1 @ 12 cm
- Sufficient pointing resolution to HFT2
 - realistic HFT pile-up
 - central Au+Au
- D^0 reconstruction
 - cuts yield clean sample
 - efficiency, signal/background meet specifications

And p+p?

- Full p+p simulations underway
- Expectations
 - IST (APV25) designed for high rate acquisition
 - Multiplicity \ll central Au+Au
 - Fewer tracks to define primary vertex
- Quick estimate
 - $\sigma_{\text{displaced}}(\text{AuAu}) \sim \sigma_{\text{displaced}}(\text{pp})$
 - $\sigma_{\text{displaced}}(\text{AuAu}) \sim \sigma_{\text{primary}}(\text{pp}) \sim 45 \mu\text{m}$ (3-d)
- Must clearly demonstrate with simulations, but no fundamental obstacles