Silicon Tracking Simulation

CLIC09
October 15, 2009

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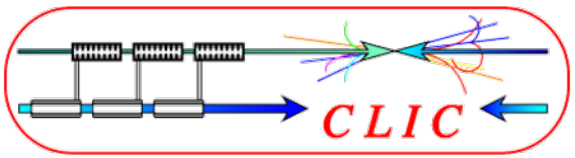

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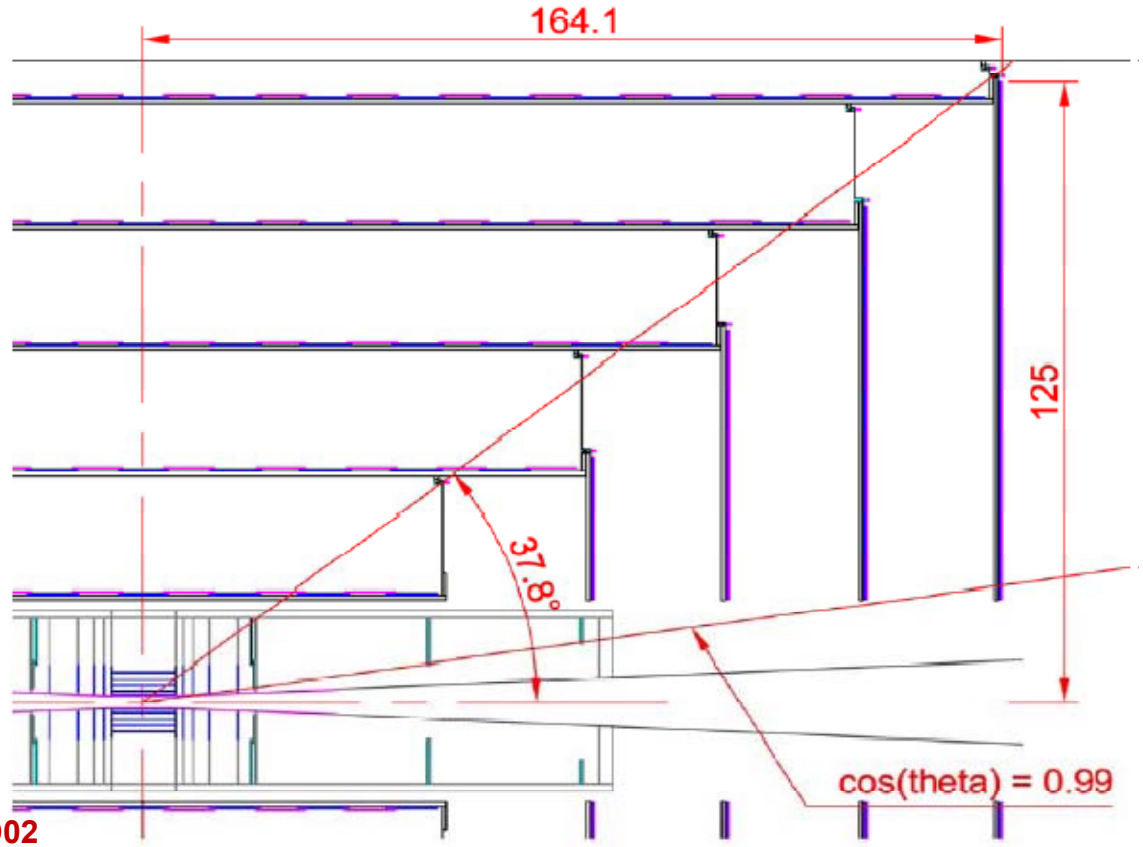
Outline

- Layout of full silicon tracker
- Tracking simulation & track finding
- Tracking efficiency studies
- Outlook

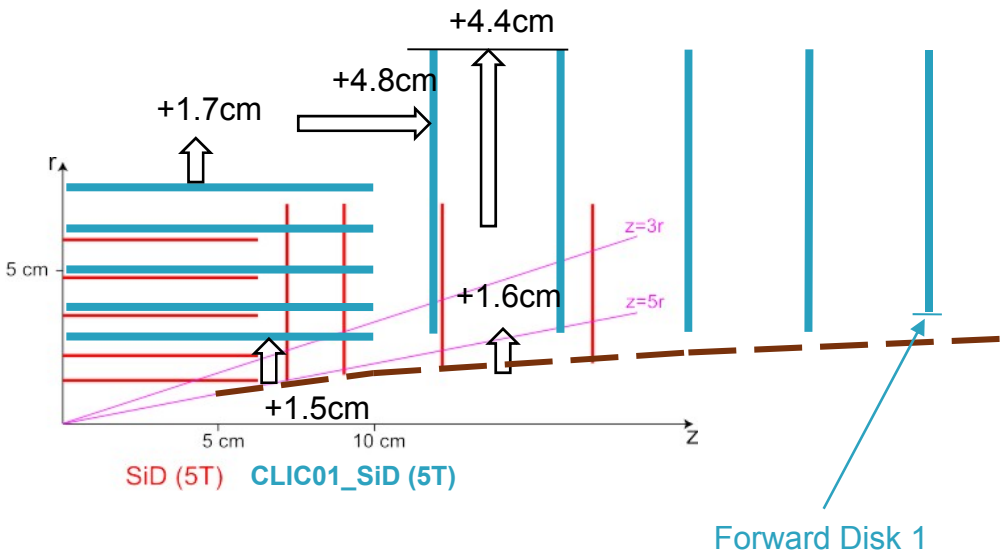
Work in progress

- Based on the SiD concept – all silicon tracking
  - Vertex and forward: 5 barrel + 7 disk detectors (20 x 20 μm² pixels)
  - Outer tracker: 5 barrel (axial strip) + 4 disk (stereo strip) detectors (9 cm x 25 μm)
  - ~ 10 precise hits per track



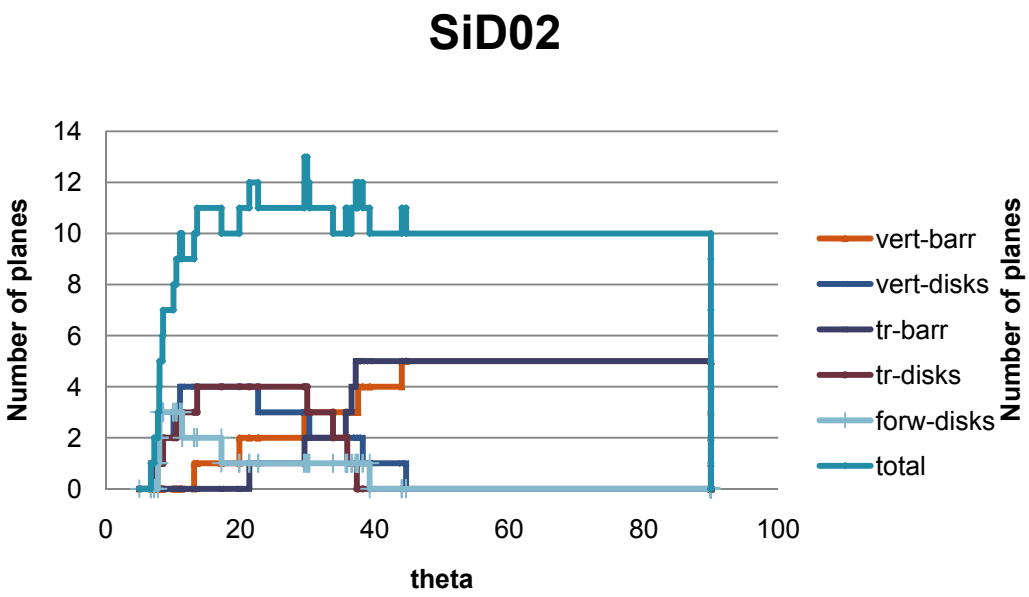
Changes to Vertex Detector

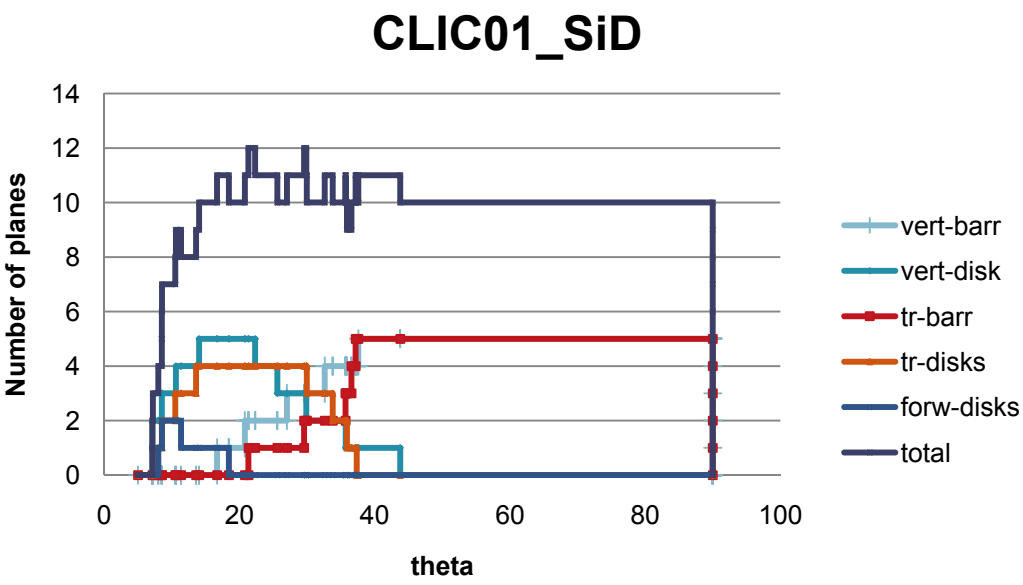
- Higher beam-induced background requires larger inner radius of vertex tracker (30mm instead of 15mm)
- Changes to achieve similar angular coverage
  - Longer barrel region
  - Larger disk detectors
  - Moved disks closer together (including first forward disk)



Angular Coverage

- Outer tracker unchanged
- Overall angular coverage sustained
- ~10 hits down to low angles



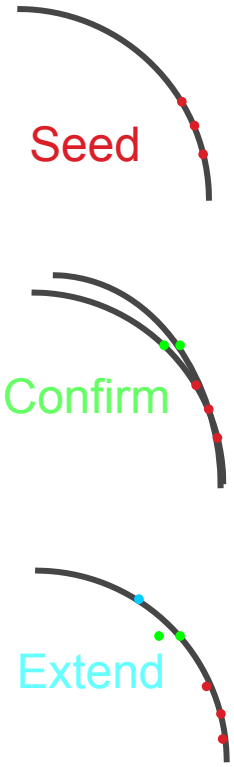


Sandro Palestini

Tracking Simulation

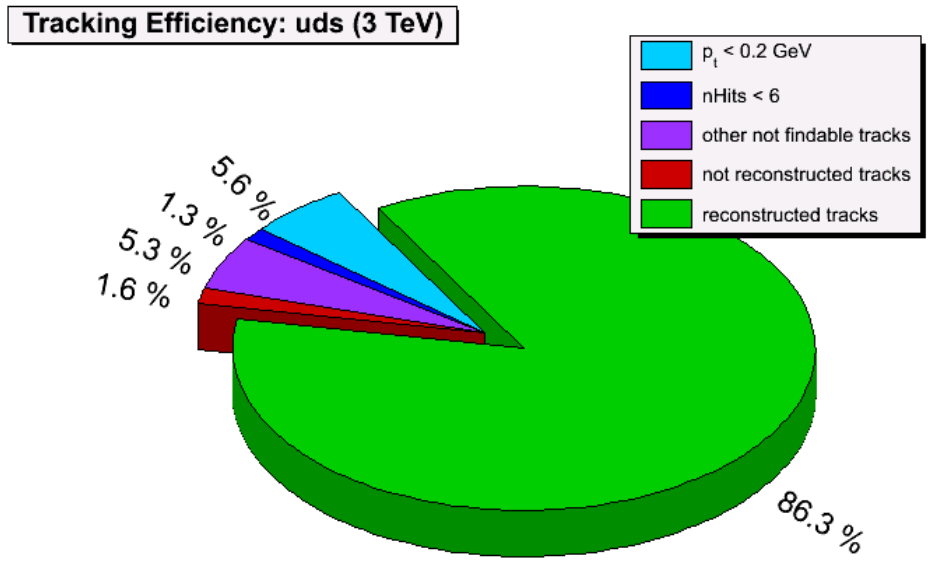
- Full simulation using GEANT4 (slic)
- Modeled tracker using cylinders and disks (like SiD LOI)
- “Virtual segmentation” to divide disks and cylinders into individual sensors after simulation
- Digitization and reconstruction using Java-based org.lcsim framework
- Track finding code (SeedTracker) using default SiD02 strategies
- Simulated di-jet events at several energies
  - Presented here are results for light quark (uds) events for E_{cm} = 3 TeV

- Track finding begins by forming all possible 3 hit track seeds in the three “Seed Layers”
  - Brute force approach to finding all possible track seeds
- Require the presence of a hit in a “Confirmation Layer”
  - Significantly reduces the number of candidate tracks to be investigated
- Add hits to the track candidate using hits on the “Extension Layers”
  - Discard track candidates with fewer than 7 hits (6 hits for barrel only tracks)
  - If two track candidates share more than one hit, best candidate is selected
- Upon each attempt to add a hit to a track candidate, a helix fit is performed and a global χ^2 is used to determine if the new track candidate is viable



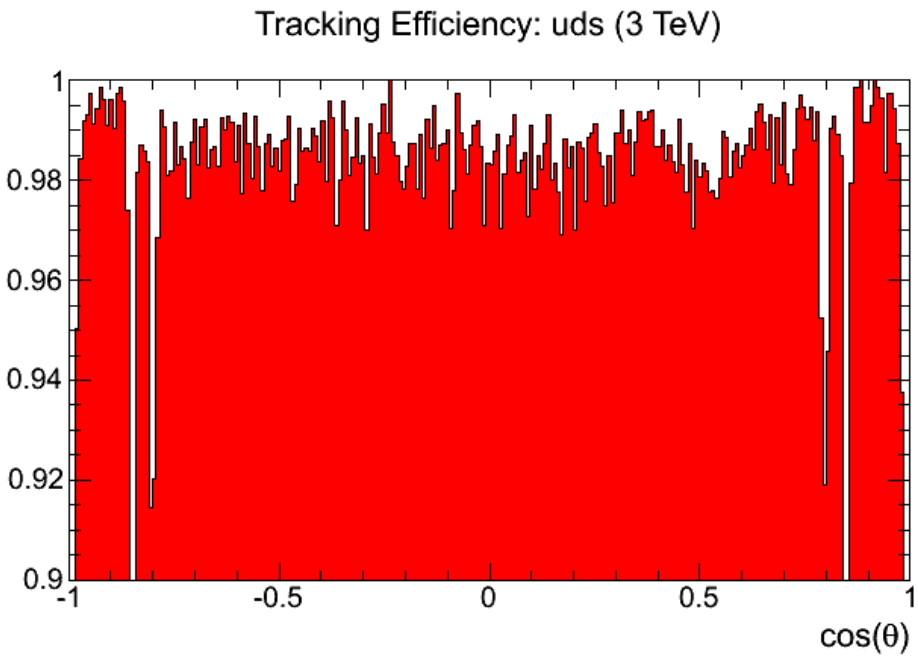
Richard Partridge

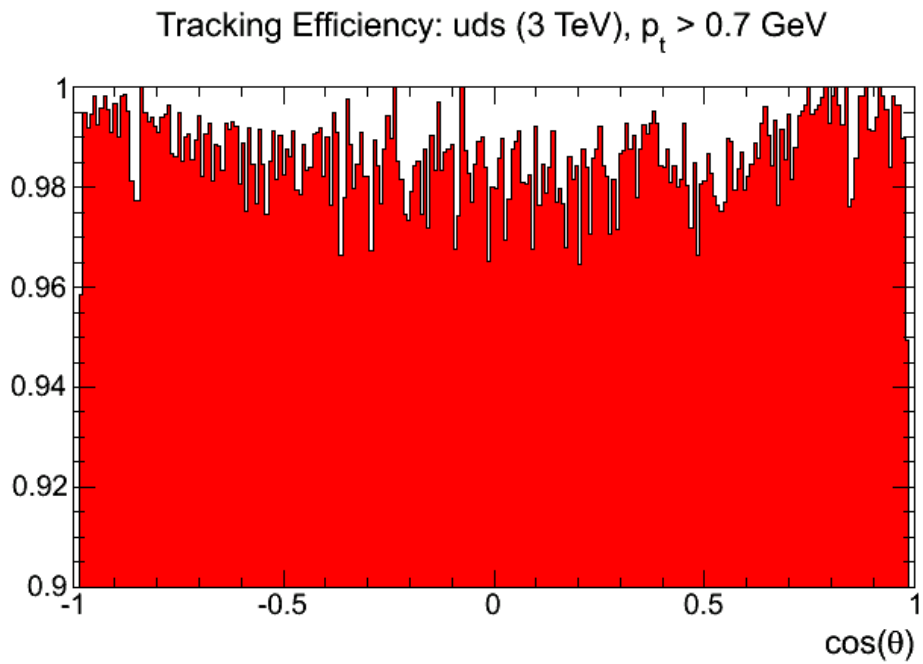
- Strategy requirements
  - At least 7 hits on the track
    - Only 1 hit per layer
    - Special barrel only strategy with 6 hits used to pick up low-p_T particles in the central region
  - $p_T > 0.2$ GeV
  - r - ϕ and s - z impact parameter cuts $|d_0| < 1$ cm and $|z_0| < 1$ cm
  - $\chi^2 < 50$ ($\chi^2 < 25$ for 6-hit barrel only strategy)
- Findable tracks
  - Tracks that pass strategy requirements
- On the following slides: tracking efficiency defined as nReconstructed / nFindable



Tracking Efficiency vs. cos(θ)

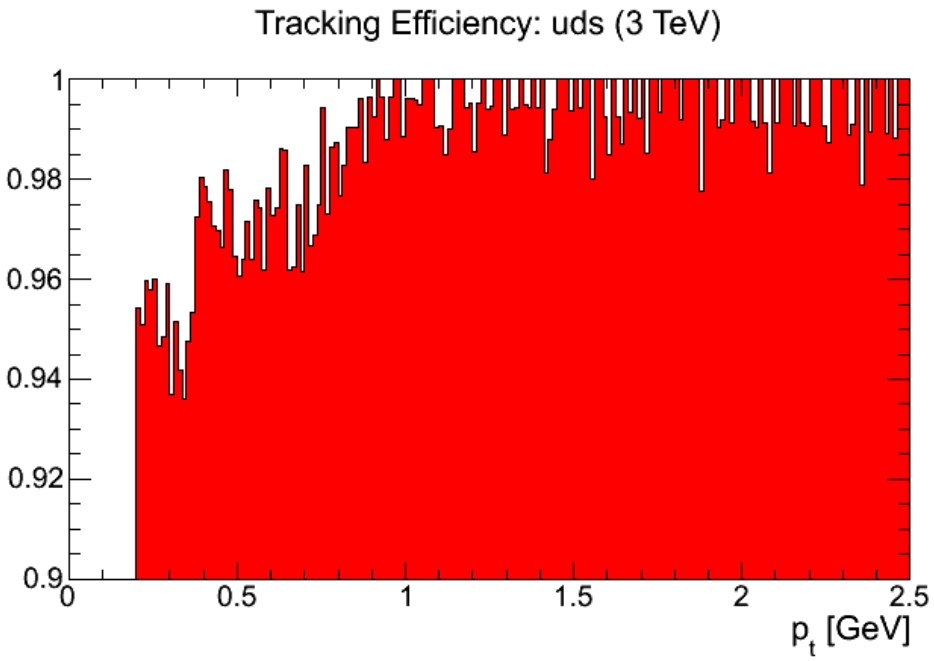
- Dips of barrel-endcap transition for vertex and main tracker clearly visible
- Only affects low p_t tracks
- Need to align vertex and main tracker transitions

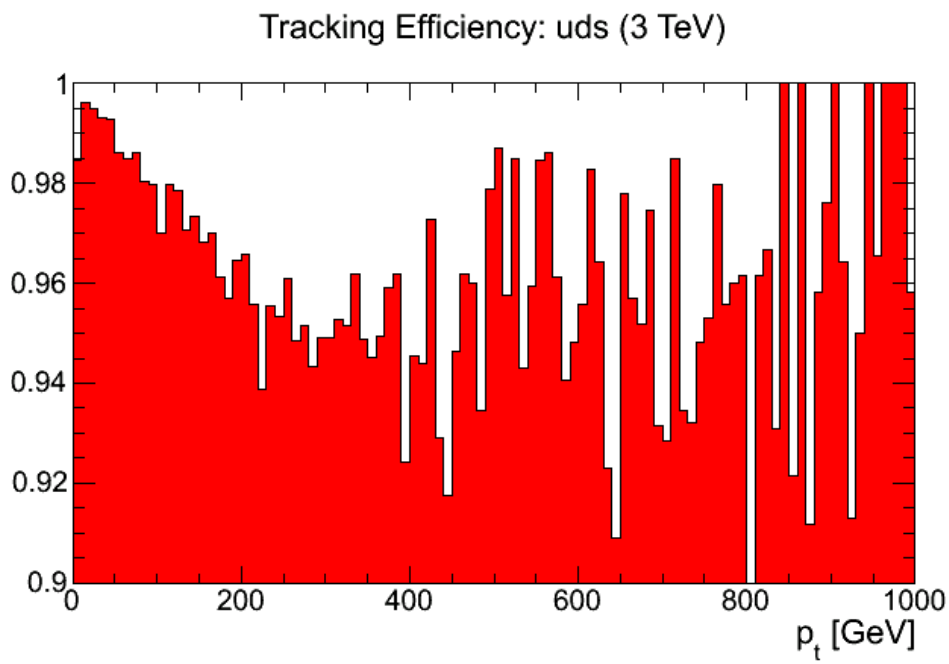




Tracking Efficiency vs p_t

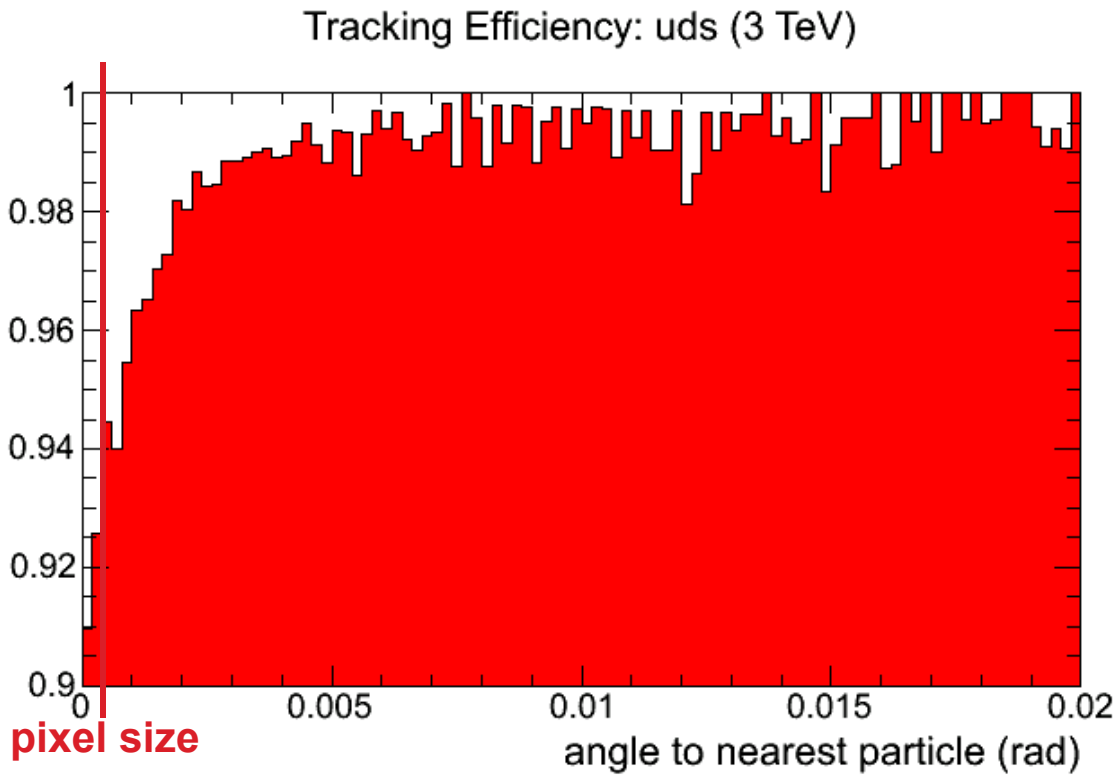
- Drop of efficiency for low p_t
- Significant drop in efficiency already at ~100 GeV – algorithm fails in dense environments



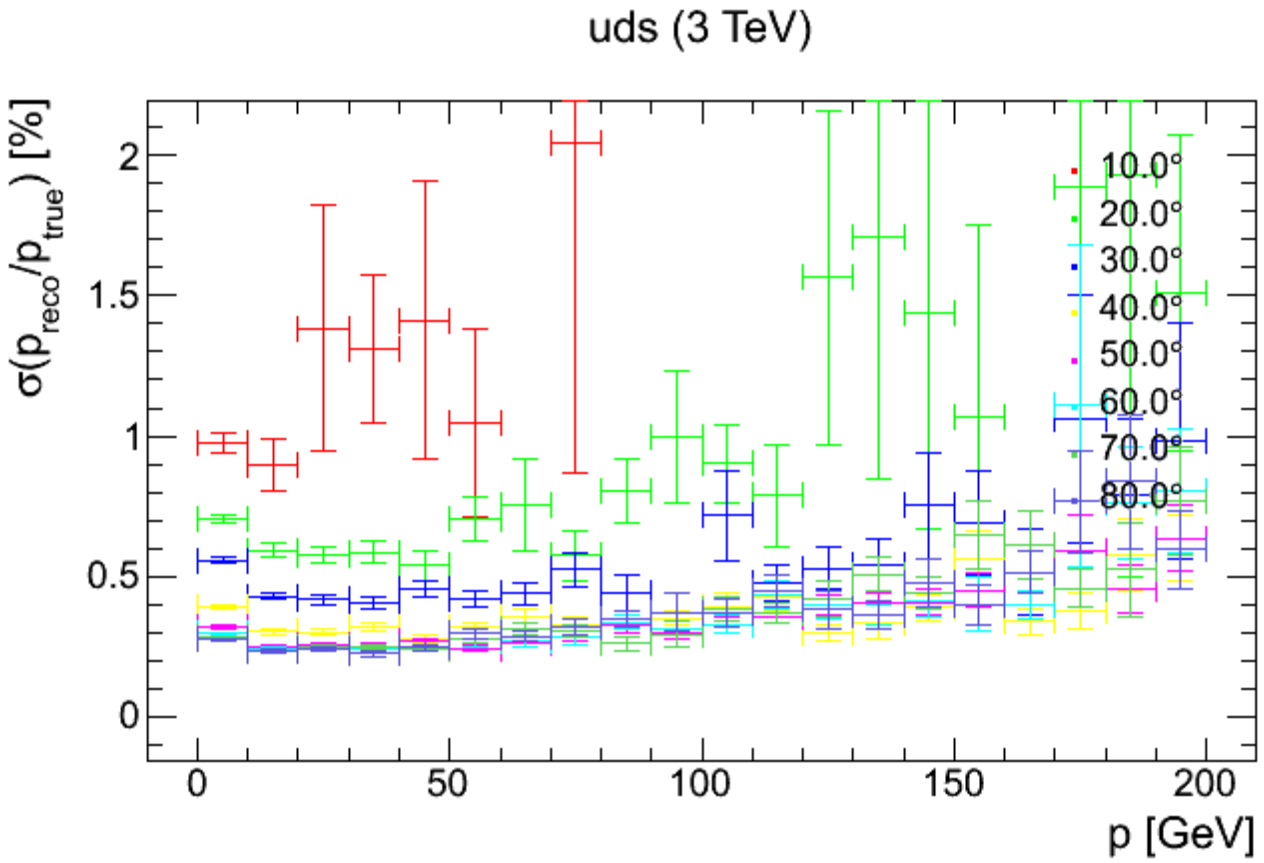


Tracking Efficiency in Dense Jets

- Vertex resolution is limiting factor for dense tracks
- Loosing only some VTX hits is fatal – need 6 of 10 possible hits
- Will be worse when overlaying background in Vertex
- Need to extend tracking algorithm – main tracker should be sufficient for high p_t track reconstruction

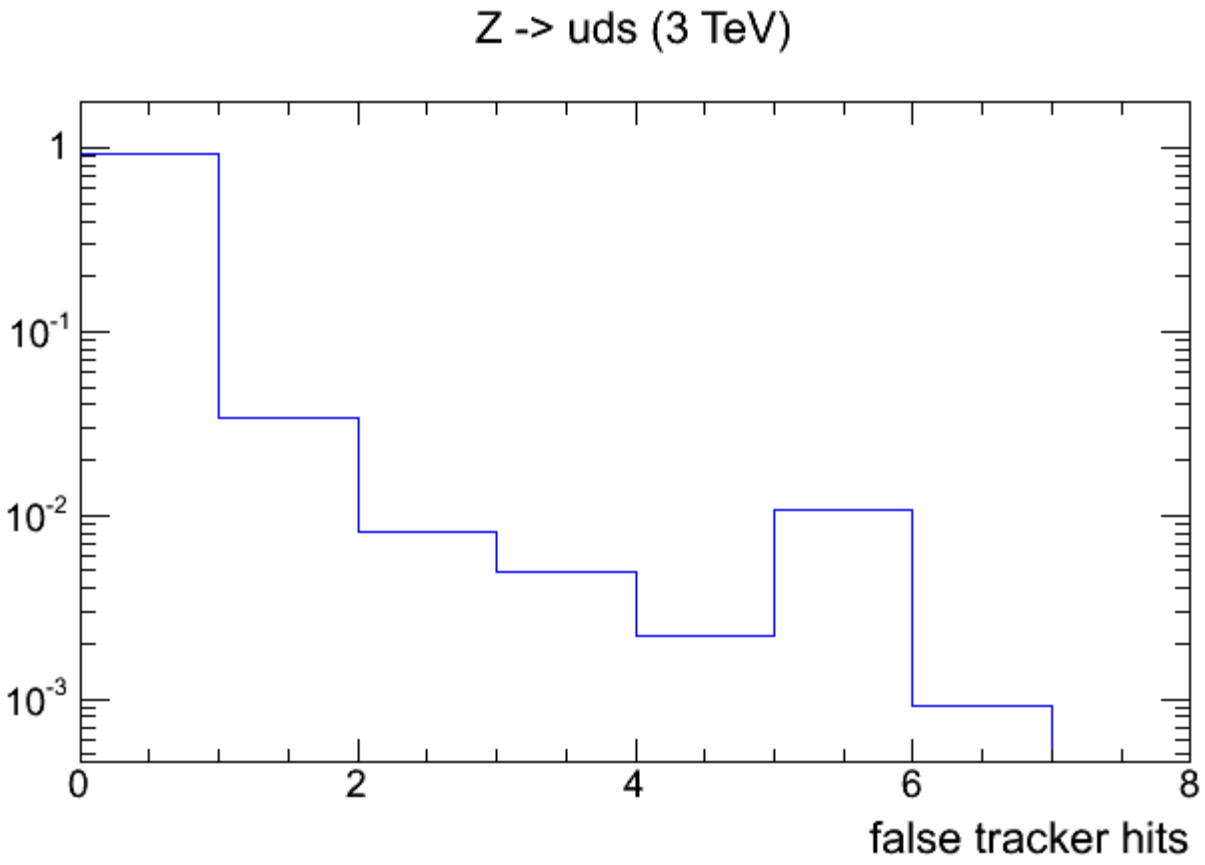


- Momentum resolution fulfills requirement of $\sigma_p/p \approx 5*10^{-5}$ 1/GeV for angles greater than 20°

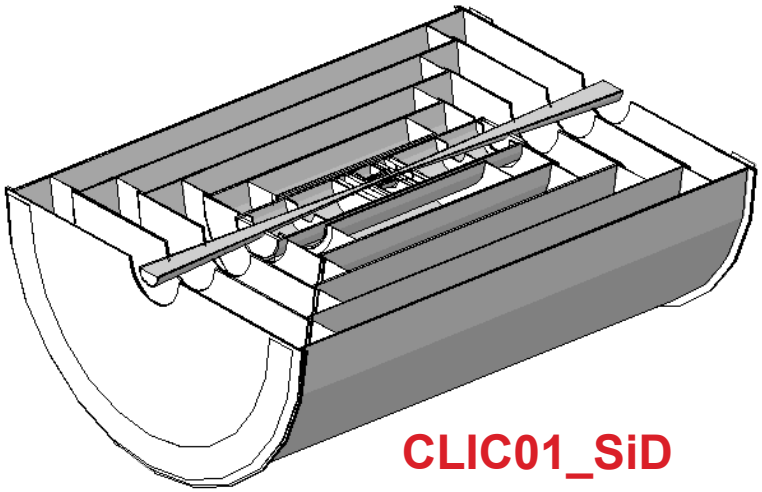


Fake Track Rate

- Comparison with MC truth after track reconstruction
  - Count hits which are associated with different MC particles
  - >99% have less than 2 falsely assigned hits
  - Very low fake track rate



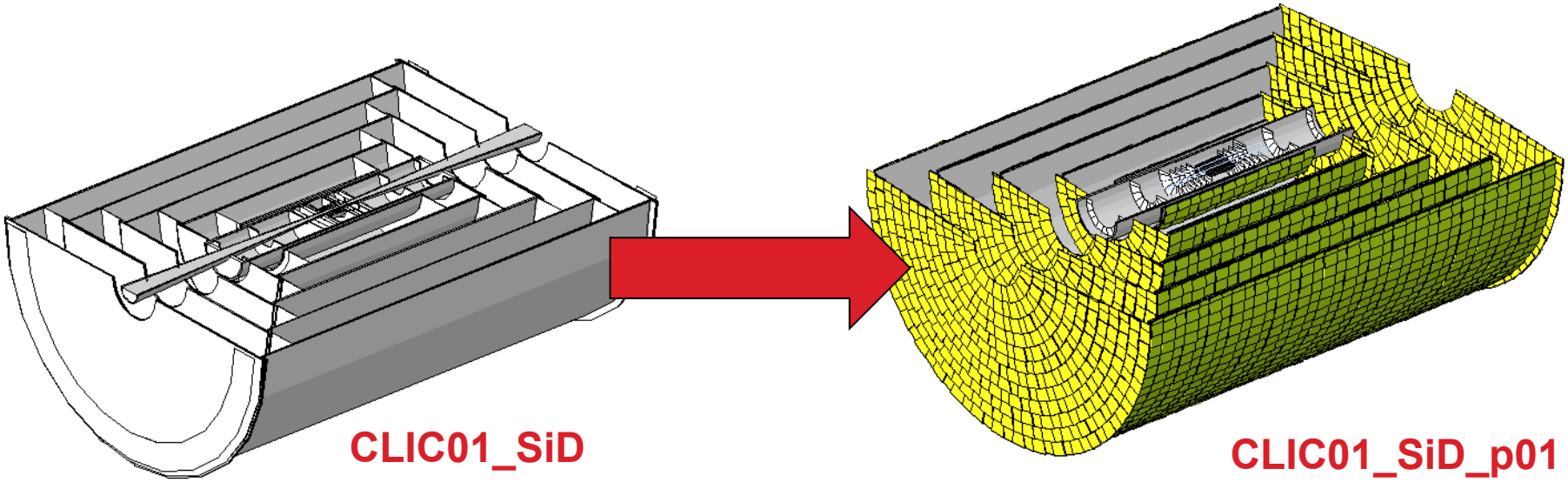
- First model uses cylinders and disks for tracker



CLIC01_SiD

Realistic Tracker Geometry

- First model uses cylinders and disks for tracker
- Updated geometry uses individual tiles
  - Realistic overlaps, realistic angles



- Geometry ready → starting simulations soon

Conclusion & Outlook

- Used SiD tracker layout with modified vertex and forward region
- SiD tracking software working out of the box
- Initial tracking performance studies done, some improvements needed
  - Align vertex detector and main tracker barrel-endcap transition
  - Efficiency for high p_t has to be improved (use adapted strategies)
  - Investigate impact of pixel size
- Future plans
  - Investigate impact of beam-induced background
  - Time-stamping requirements?
  - Impact of planar trackers (increased material budget)