SiD Tracking Performance at 3 TeV in Presence of Beam Background

LCWS Beijing
March 29, 2010

Christian Grefe
CERN, Bonn University

- Introduction
  - Detector concept for CLIC
  - Beam induced background
- Overlaying background
- Tracking efficiency
- Momentum resolution
- Performance of tracking algorithm

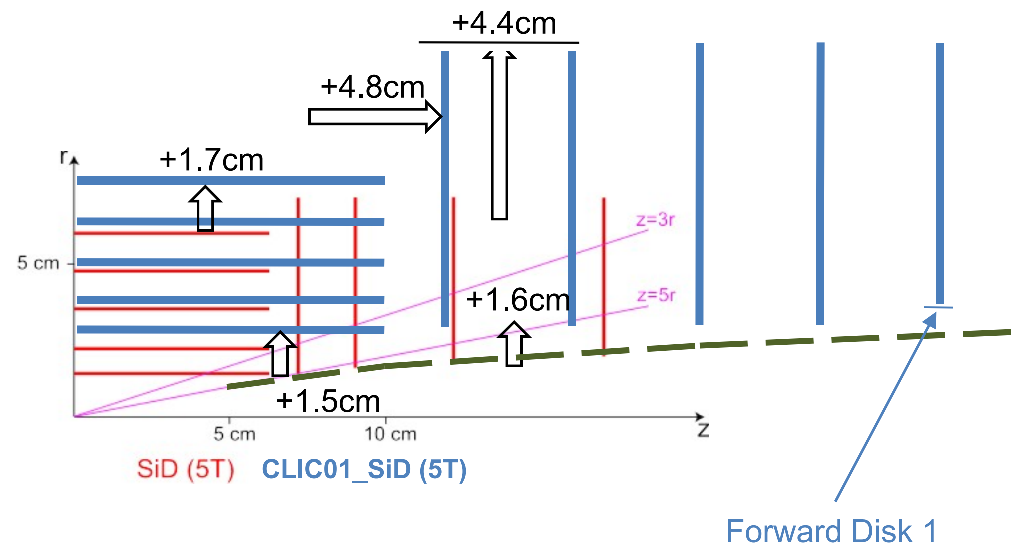
- Precision instrument for e^+e^- collisions
- Optimized concept for 3 TeV
- Detector will be operated at 500 GeV in a first stage

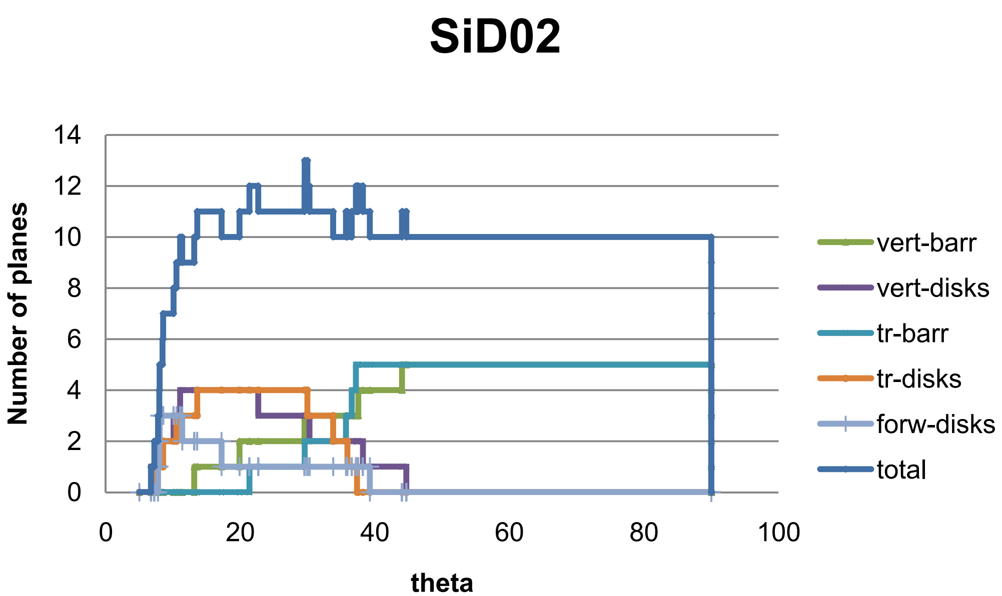
→ Start from existing ILC detector concepts and modify where necessary

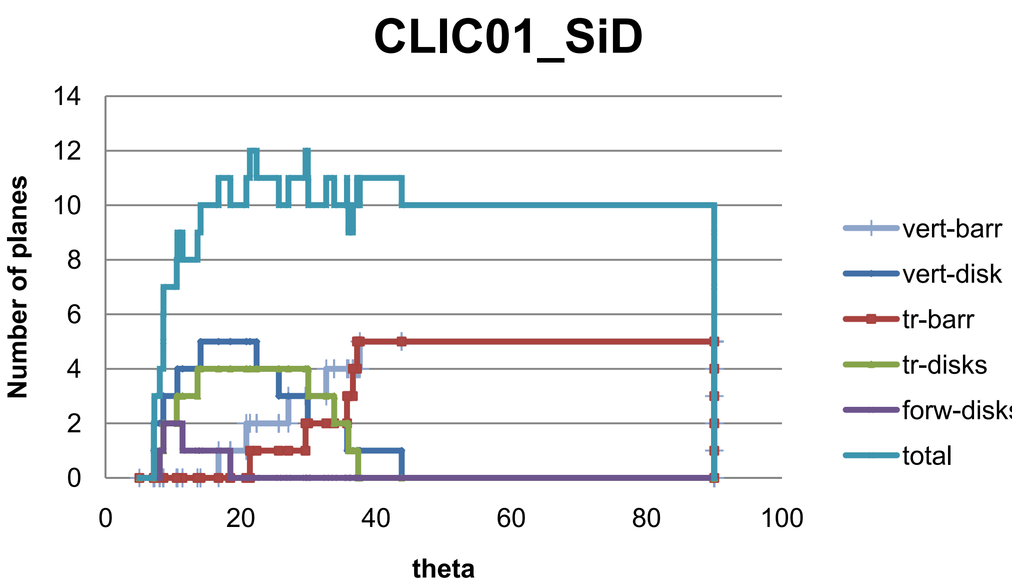
- Main differences from the detectors point of view:
  - Higher Energy (more jet energy, higher density within jets, …)
  - Higher beam induced background (high occupancy esp. in vertex)
  - Less time between bunches (time stamping / time slicing)
  - Less time between trains (power pulsing?)

Modified SiD Tracker

- Vertex and forward tracker:
  - 5 barrel layers and 7 disks of 20 x 20 µm² Si-pixels
  - Modified layout to avoid pair background
- Main Tracker:
  - 5 barrel layers and 4 disks of 9 cm x 25 µm Si-strip



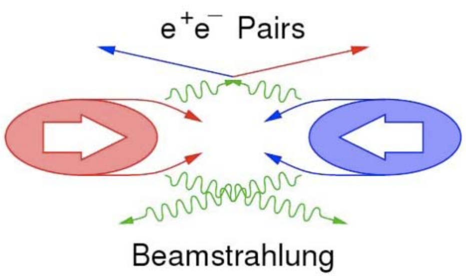


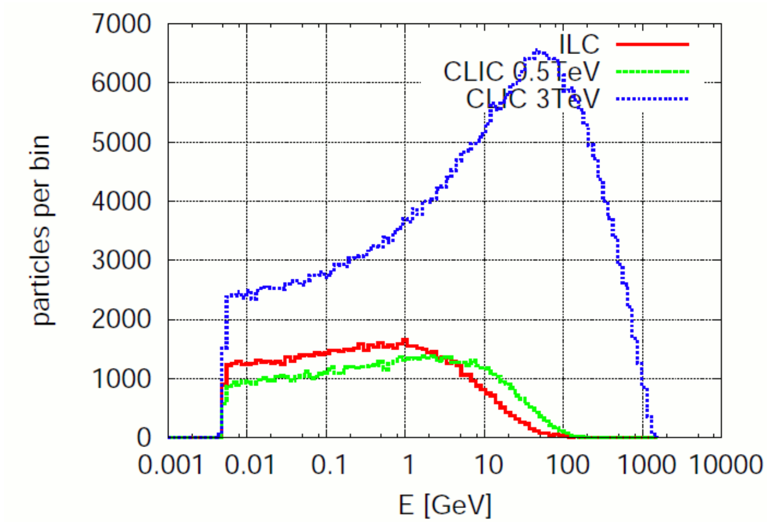


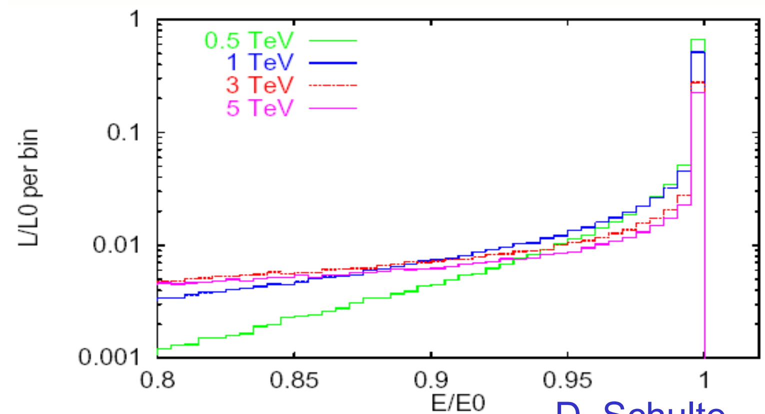
Beam Induced Background

- Beamstrahlung:
  - Oppositely charges bunches attract each other and create γ ($\Delta E/E = 29\%$ @ 3 TeV)
- Coherent pairs (3.8×10^{8} / BX)
  - Very low angles, mostly disappear in the beampipe
- Incoherent pairs (3.0×10^{5} / BX)
  - Higher angles, need to be suppressed by solenoid field, problematic for VTX
- $\gamma\gamma \rightarrow$ hadrons (~3 / BX)
  - "mini jets" spoiling the physics
- Beamspectrum:
  - Only 1/3 of luminosity in top 1% of energy

→ For now: only $\gamma\gamma \rightarrow$ hadrons in sim & reco







D. Schulte

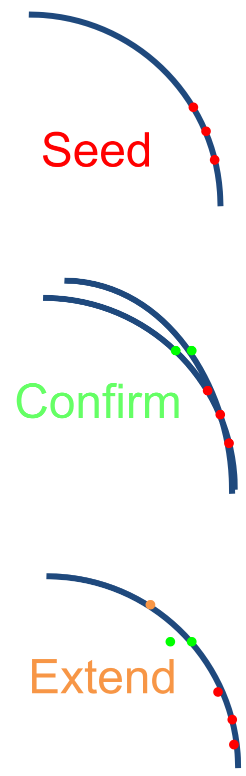
Overlaying LCIO Files

- Implemented lcsim driver
  - Define input LCIO files (no limit)
  - Each LCIO can contribute different number of its events to the overlayed event
  - Set which collections to merge (i.e. no need to merge calo hits for tracking studies)
  - Feedback appreciated: lcsim-contrib/Grefe/overlayEvents

- Procedure
  - Simulate signal and background (1 BX per event) separately
  - Merge desired amount of BX with signal LCIO
  - Run reconstruction

SeedTracker Algorithm

- 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

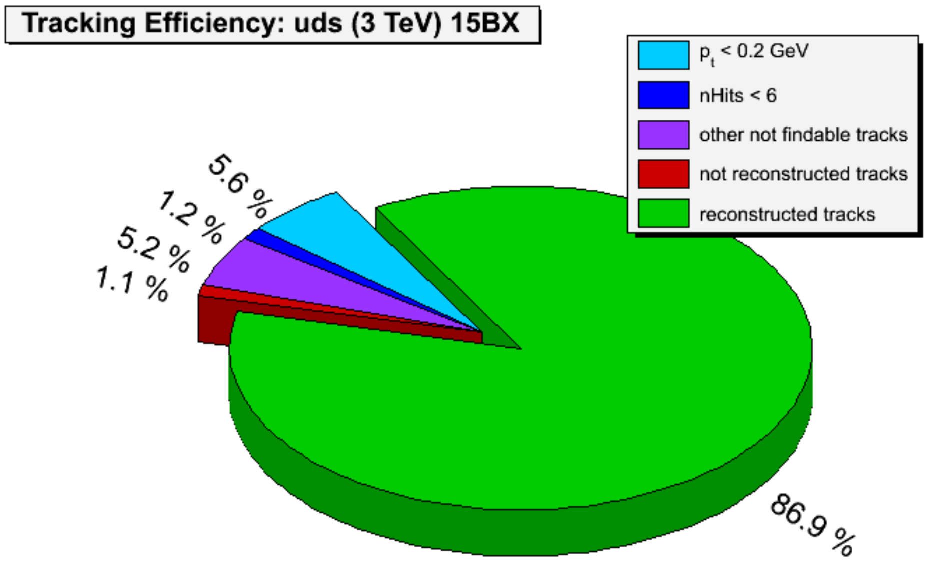


Richard Partridge

Tracking Efficiency

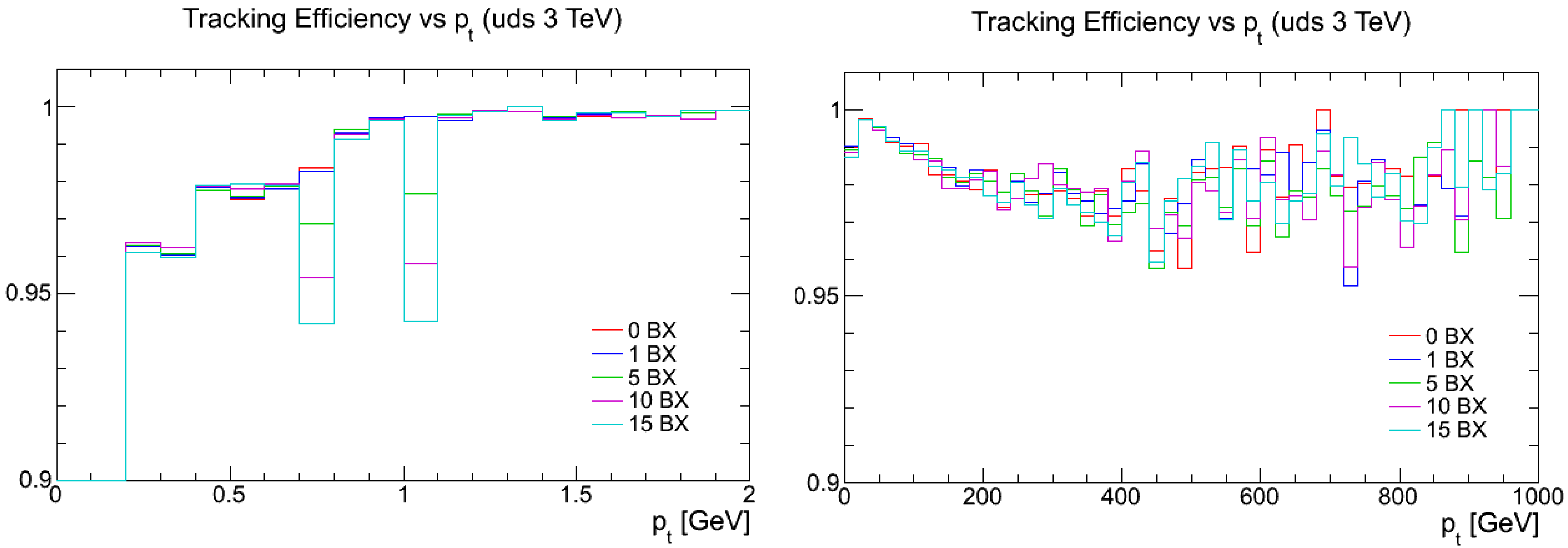
- Strategy requirements from SiD
  - At least 7 hits on the track
    - Only 1 hit per layer
    - Special barrel only strategy with 6 hits used to pick up low-p_t particles in the central region
  - $p_T > 0.2$ GeV
  - r - ϕ and s - z impact parameter cuts $|d_0| < 1$ cm and $|z_0| < 1$ cm
  - $\chi^2 < 50$ ($\chi^2 < 25$ for 6-hit barrel only strategy)

- A "findable track" fulfills these cuts
- Define tracking efficiency as nReconstructed / nFindable
- Only consider final state MCPs from the signal event for calculating efficiency



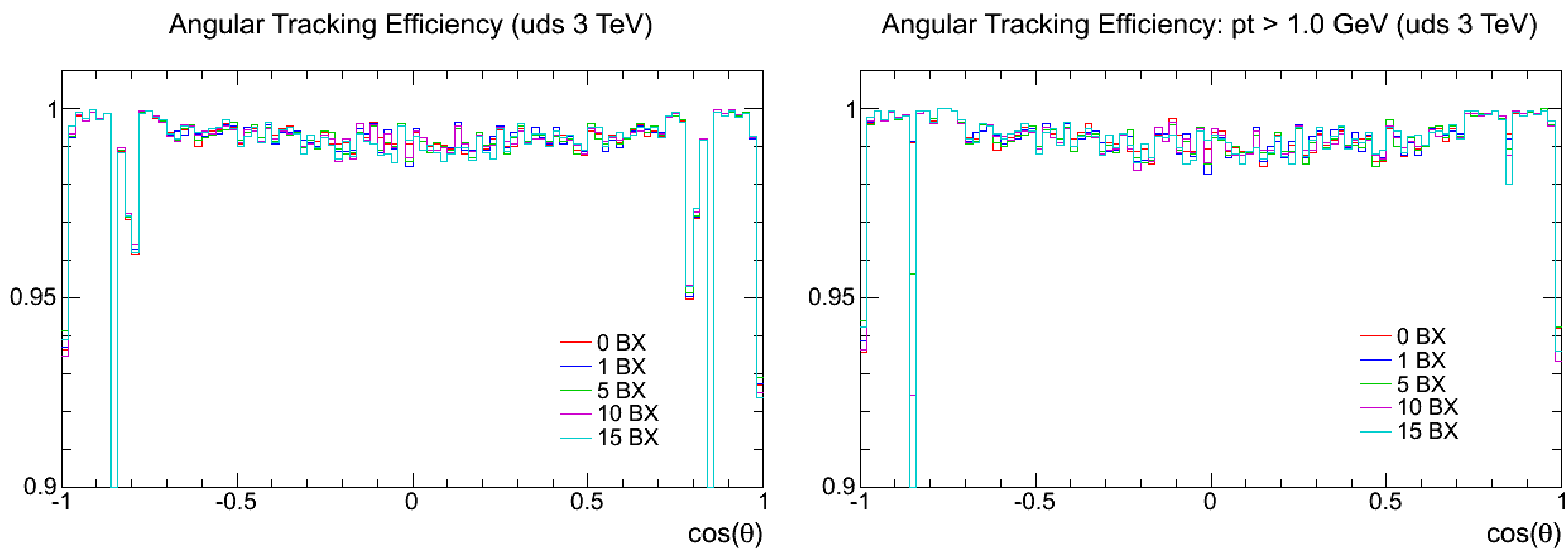
Tracking Efficiency vs. p_t

- Cut-off by algorithm for $p_t < 0.2$ GeV
- Lose some tracks for $p_t < 1$ GeV and $p_t > 100$ GeV



- No difference when adding background (except for dips at 0.7 GeV and 1.0 GeV → needs to be understood)

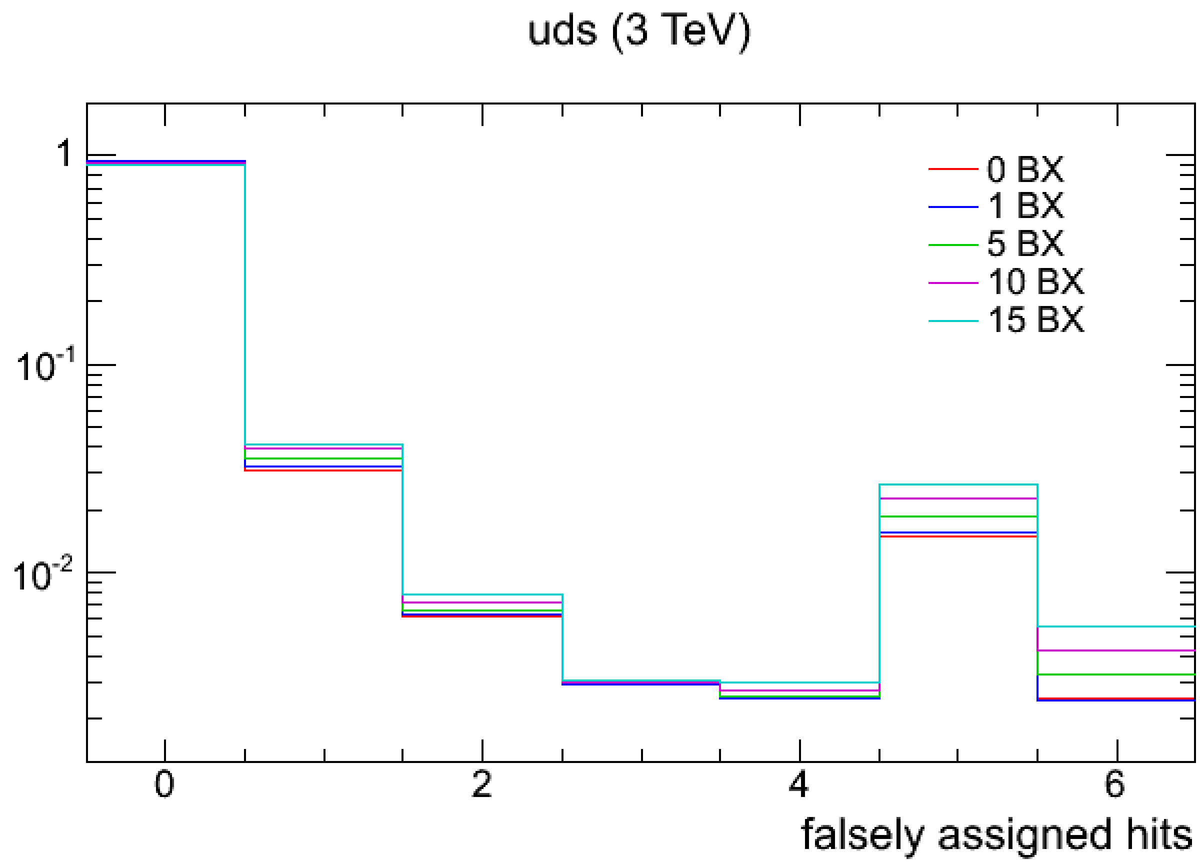
- Dips in efficiency at barrel-endcap-transitions for VTX and main tracker
- Only low p_t tracks affected



- Again no difference when adding background

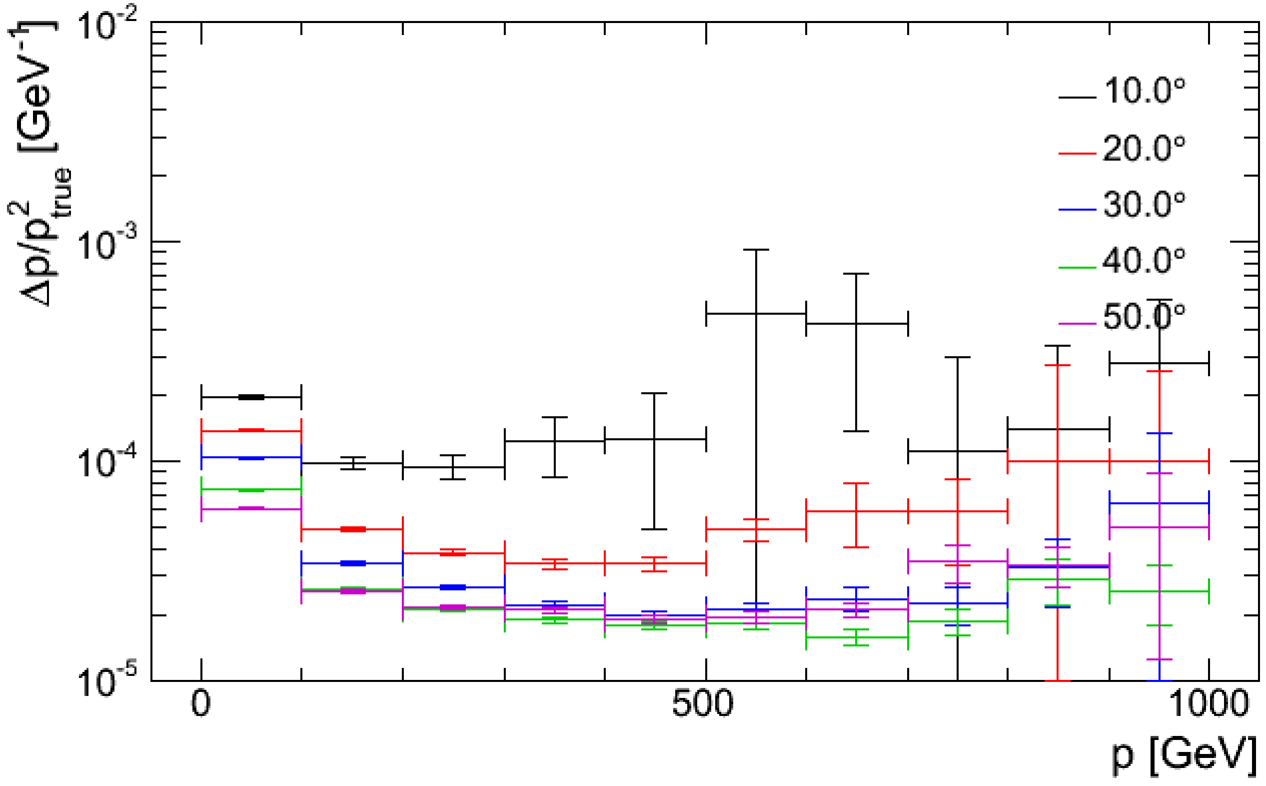
Fake Track Rate

- Define MC particle contributing majority of hits to reco track as true MCP
- More background leads to more confusion
  - 3% of reco tracks have 5 falsely assigned hits with 15 BX overlayed



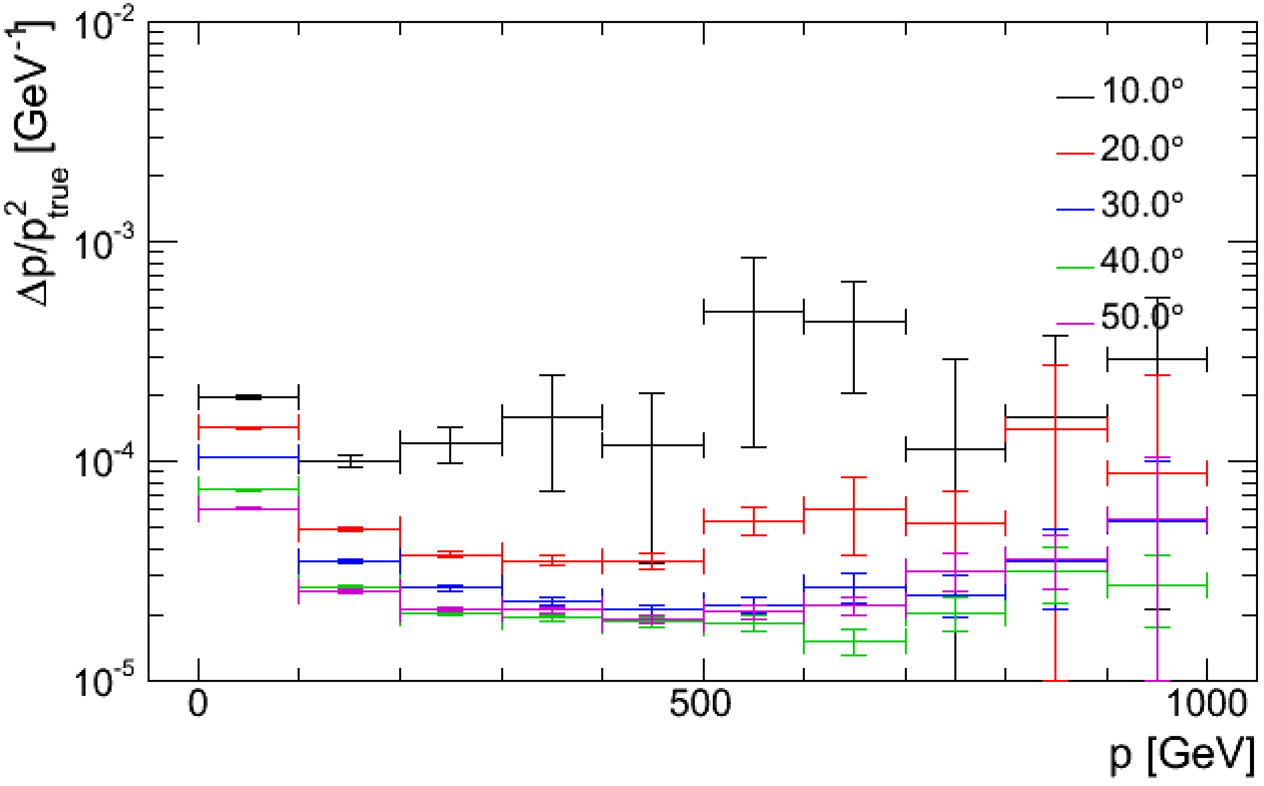
Momentum Resolution

- Design goal for CLIC (and ILC): $\Delta p/p^2 \approx 2 \cdot 10^{-5}$ GeV^{-1}
  - Driven by physics requirements, i.e. $e^+e^- \rightarrow \nu\nu H^0 \rightarrow \nu\nu\mu^+\mu^-$
- Fulfilled for angles > 20°
- Loss of resolution for high p (should be flat)

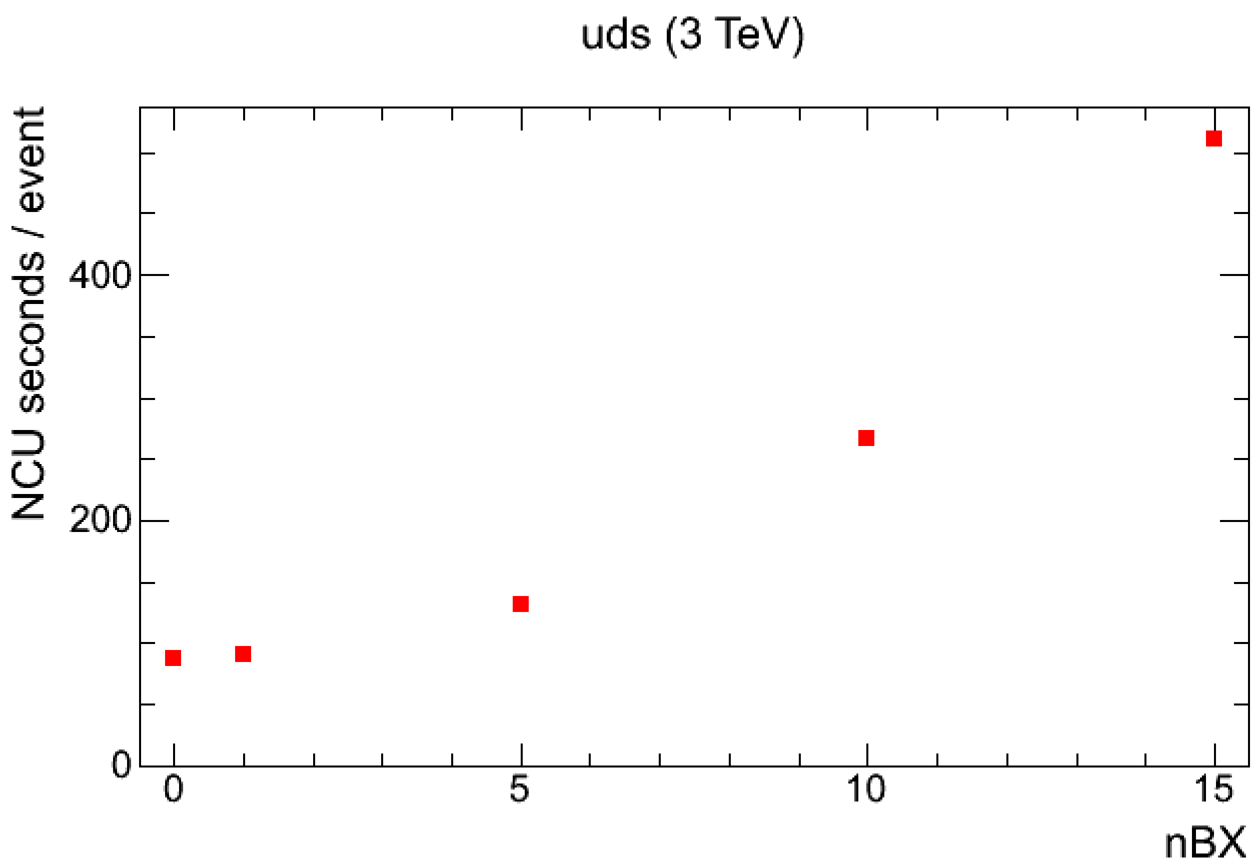


Momentum Resolution

- Only marginal changes in resolution when adding background



- Computing performance does not scale when adding background



Conclusion & Outlook

- Modifed geometry of SiD02 → CLIC01_SiD
- Implemented flexible driver for overlaying LCIO files
- Simulation and reconstruction for z → qq (uds) @ 3 TeV, including up to 15 BX of γγ → hadrons background:
  - Tracking efficiency: OK
  - Momentum resolution: OK
  - Computing performance: does not scale

→ Need to understand high p behavior

- Future Plans:
  - Overlay pair background as well
  - Add more BX, see if efficiency breaks down