Performance of a Full Silicon Tracker at CLIC

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Outline

1. Introduction

2. Track Reconstruction Algorithm

3. Performance

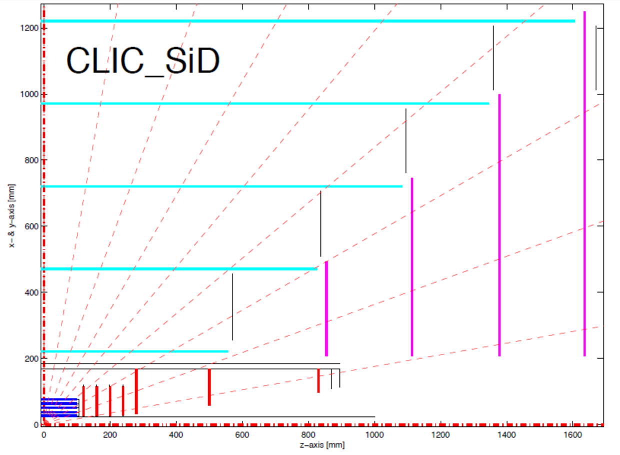
4. Conclusions

CLIC_SiD Detector Concept

- Detector concept based upon the SiD detector design for ILC:
  - Full silicon tracker.
  - 5 T magnetic field.
- Reoptimized to operate at 3 TeV. Relevant differences for tracking:
  - Higher energy collisions:
    ↪ Higher energy particles.
    ↪ Higher density in jets.
    ↪ Higher forward region occupancy.
  - Higher beam induced background:
    ↪ Vertex detector: inner radius increased from 13 mm to 27 mm.
  - Higher bunch crossing and bunch train rates:
    ↪ Time stamping challenge...
- We need to assess performance of the new design.

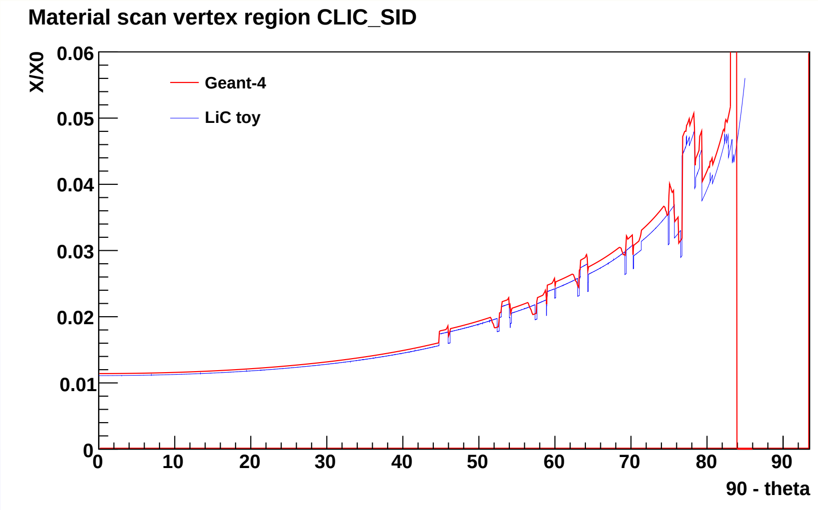
Full Silicon Tracker

Main Tracker
5 barrel layers + 4 endcap stereo-disks
10 cm × 25 μm Si strips (50 μm pitch digital readout)



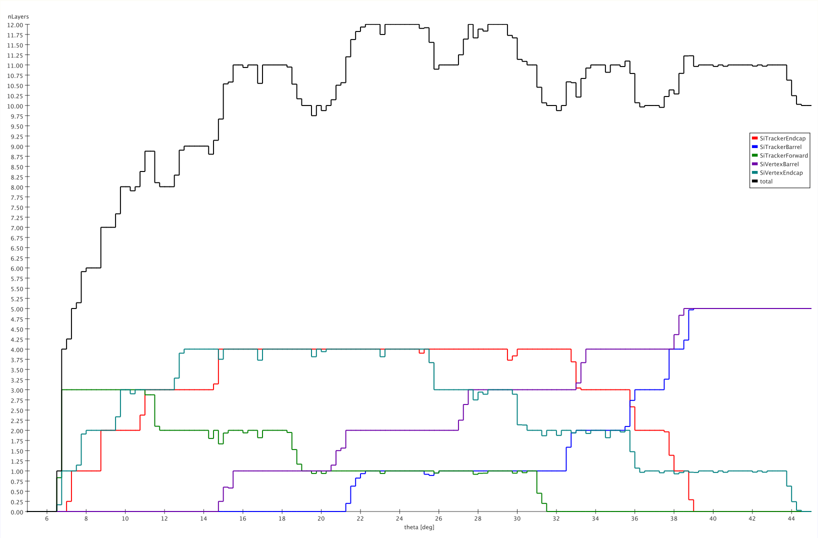
Vertex Detector
5 barrel layers + 7 disks
$(20\ \mu\text{m})^2$ Si pixels
(digital readout)

[Dominik Dannheim]



Vertex detector material budget (Fast simulation and Geant4 scan)

[Dominik Dannheim]



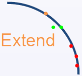
Silicon Tracker Coverage Angular dependence of number of tracker planes *seen* by a particle.

Track Reconstruction: the SeedTracker Algorithm

How it works

1. Form all possible 3 hit track in three defined *seed layers*.

2. Require the presence of a hit in a *confirmation layer*, to highly reduce possible combinations.



3. Add hits to the track on the *extension layers*.

4. Final selection of tracks
   - Tracks are required to have a minimum number of hits (strategy dependent).
   - A helix fit is performed, and a cut on its χ^2 is applied to select good tracks.
   - Finally, if two tracks share more than one hit, the best candidate is selected.

[Richard Partridge]

Track Reconstruction: the SeedTracker Algorithm

Strategies

- A full set of strategies is needed to cover all possible combinations of *seed layers*.
- An *automatic strategy builder* is used to ensure that all possible combinations of layers are taken into account.
- 5, 6 and 7 hit strategies will be shown for comparison.

Example: 7 hit strategy.

- Requires at least 7 hits per track.
- $p_t > 0.2$ GeV.
- Impact parameter cuts: $|d_0| < 0.5$ cm and $|z_o| < 1$ cm.
- Quality of fit: $\chi^2 < 50$.

Definitions

- **Efficiency:**

$$\text{eff} = \frac{\#\text{reconstructed tracks matching truth}}{\#\text{final state MC particles}}$$

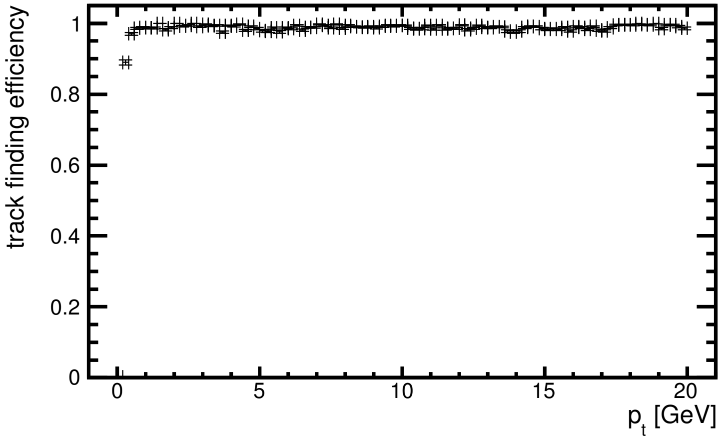
- **Purity:**

$$\text{pur} = \frac{\#\text{hits in a reconstructed track matching truth}}{\#\text{total hits}}$$

Samples

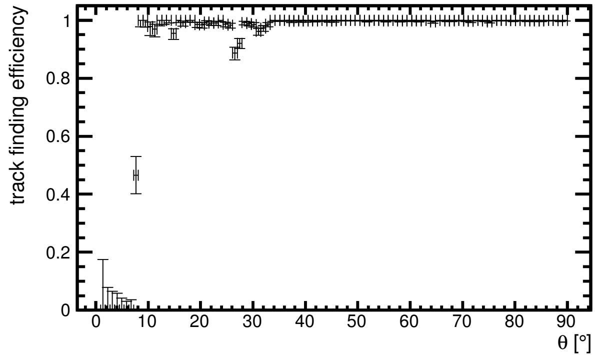
- Single muons, shot at different angles and energies.
- $e^+e^- \rightarrow Z \rightarrow qq$ (uds) events (3 TeV).

Performance: single muons



Track finding efficiency versus transverse momentum ($\theta > 8^\circ$).

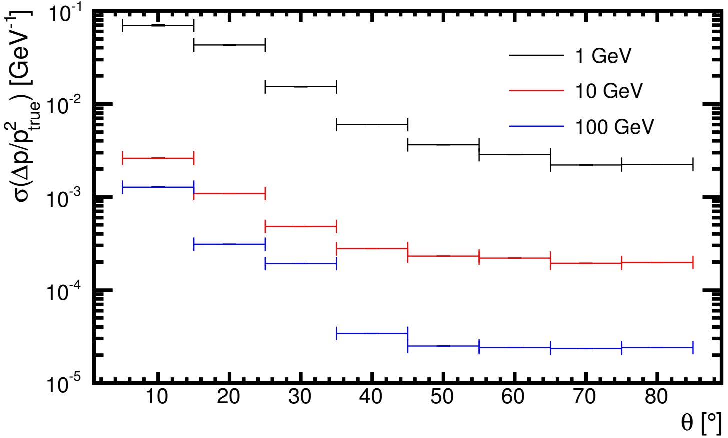
Performance: single muons



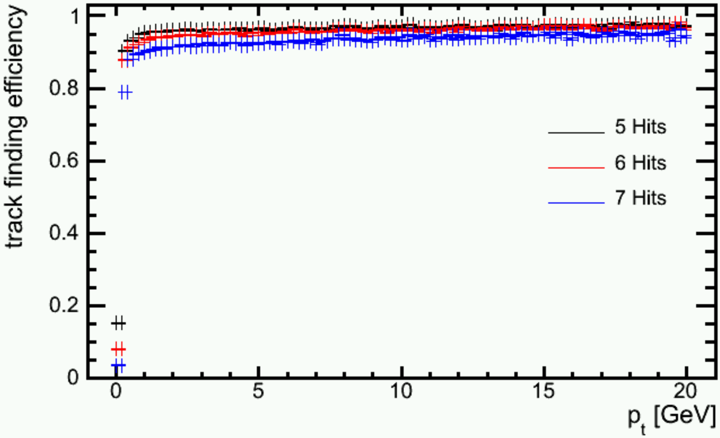
Track finding efficiency versus angle ($p_t > 0.25$ GeV).

- Dip at $\theta \simeq 28^\circ \rightarrow$ Seems to be related to transition region between barrel and endcap in the vertex detector.
- Forward region ($\theta \lesssim 32^\circ$): unefficiency not well understood.

Performance: single muons

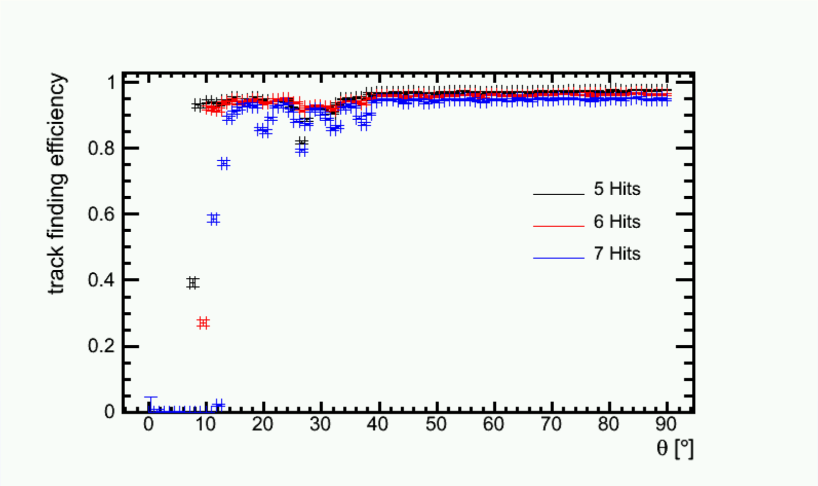


Momentum resolution, $\sigma(1/p)$ (1/GeV), versus angle and momentum.



Track finding efficiency versus transverse momentum ($\theta > 8°$). Color: different strategies.

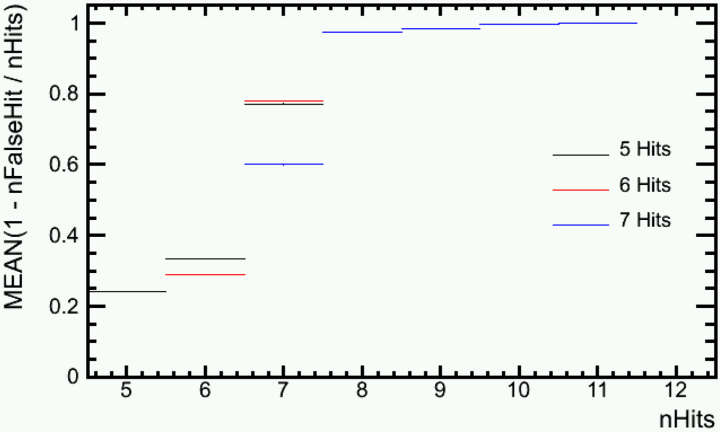
Performance: dijets



Track finding efficiency versus angle ($p_t > 0.25$ GeV). Color: different strategies.

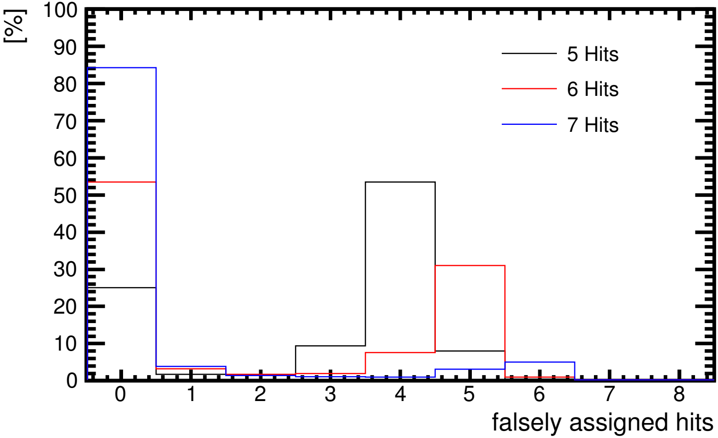
- Same effects already observed with single muons.

Performance: dijets



Track purity Fraction of true hits per track versus total number of hits assigned to track. Color: different strategies.

Performance: dijets



Histogram: percentage of tracks having n false hits assigned. Color: different strategies.

Conclusions

Acceptance

- Tracker acceptance down to $\sim 7^\circ$.
- Track reconstruction in good shape down to $\sim 9^\circ$.

Performance

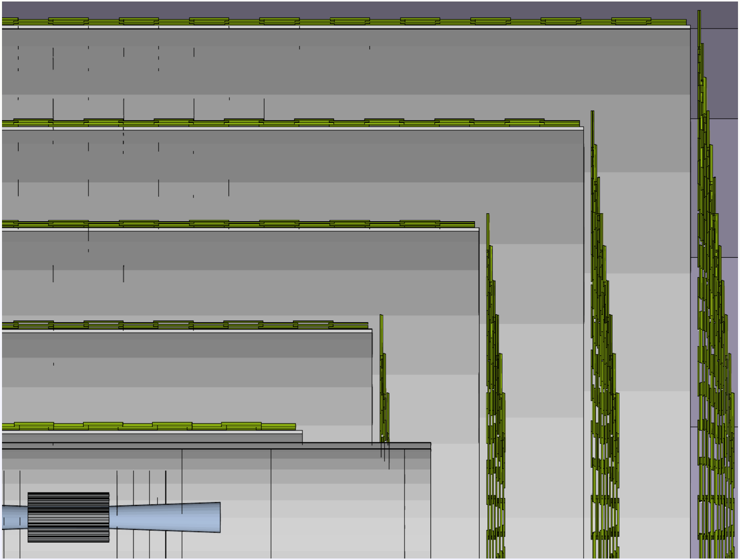
- Physics requirements fulfilled by *momentum resolution*:
$$\frac{\Delta p}{p^2} \sim 10^{-5}\ \mathrm{GeV}^{-1}$$
- Robustness against machine induced background has been proven on previous version (CLIC_SiD_01). Has to be verified.

Open issues

- Tracking in the forward region: non-understood unefficiencies and *dip*.
- Impact parameter resolution not yet well understood.

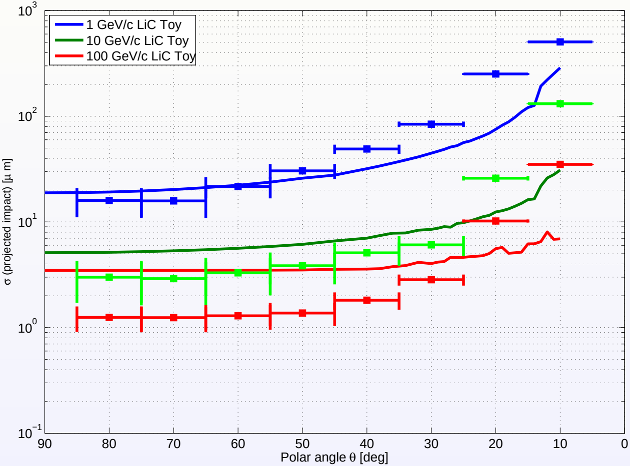
Backup Slides

Tracker Layout (old)



Tracker layout: side view.

Performance: single muons



Impact parameter resolution (D0) versus angle and momentum (fast and full simulations).

[Dominik Dannheim]