CLD detector model overview

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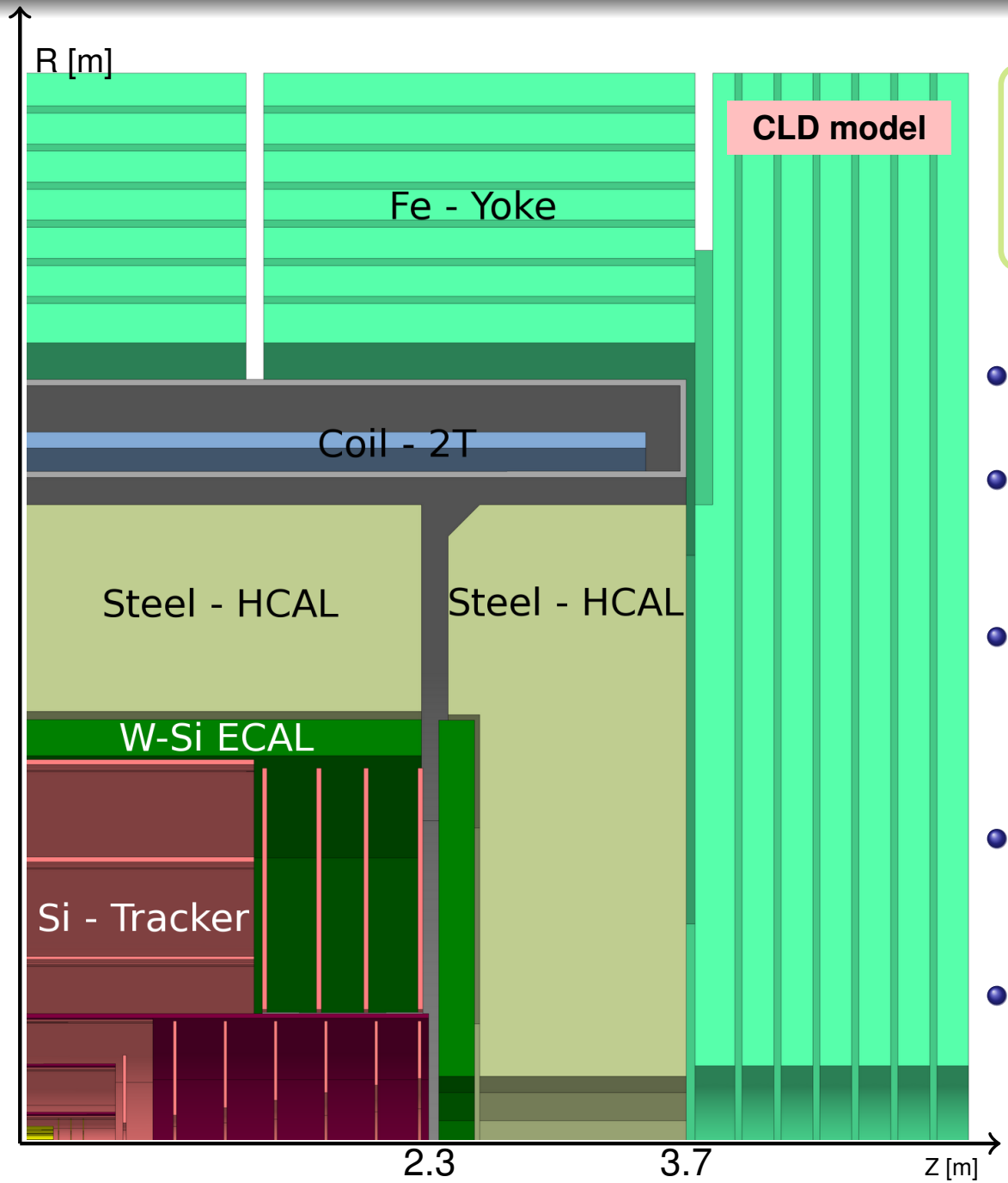
CLD Detector Model

CLD detector model



CLD detector model is inspired by detectors for CLIC and ILC and optimized for FCC-ee conditions

- Full silicon tracking system - provides $\geqslant$12 hits per track
- 2 T magnetic field (constrains from the machine) $\rightarrow$ 2.1 m large tracker radius
- Fine-grained ECAL and HCAL optimised for particle flow reconstruction
- Superconducting solenoid is outside of calorimeter
- Forward detector region: MDI region $<$ 150 mrad (accommodates LumiCal)

Simulation and reconstruction software tools

- For performance study of theCLD detector for FCC-ee one can benefit from the fully functional and well tested iLCSoft software used by the CLIC and ILC community.

- Detector geometry description and event simulation: DD4hep
- Event Reconstruction: Marlin

- Track Pattern recognition: TruthTracking or ConformalTracking
- Particle Flow Reconstruction: PandoraPFA

Tracking system

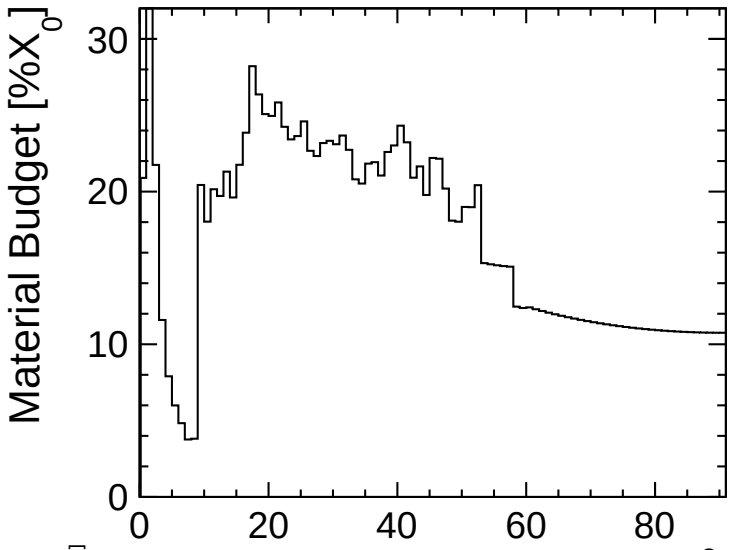
Vertex detector

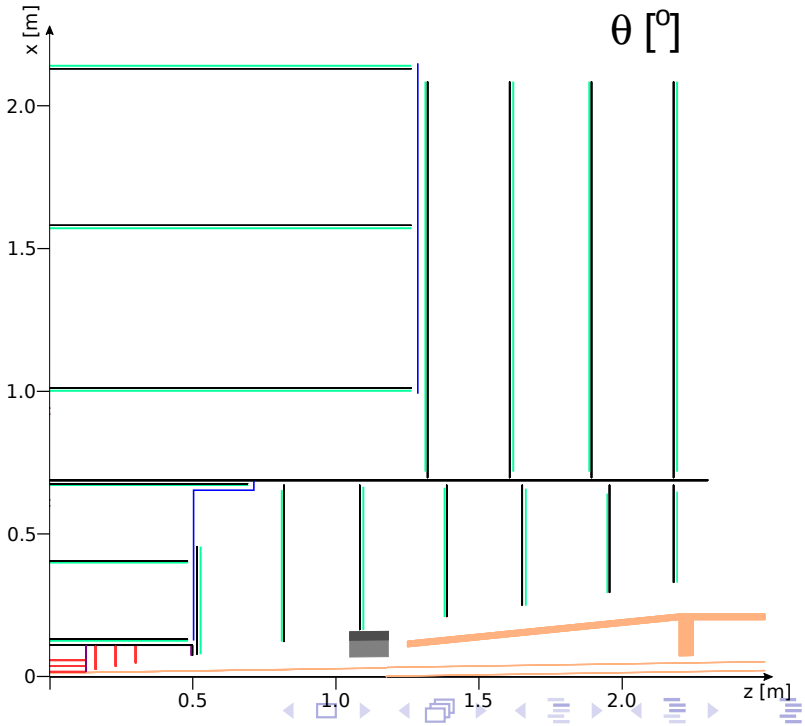
- Silicon pixels: 25x25μm
- Single-point resolution: 3 μm
- 3 double layers in barrel: 17-57 mm
- 3 double endcap disks per side: 160 - 300 mm
- Material budget: 0.3% X_0 per layer

Tracker detector

- Silicon pixel and microstrips detector
- Inner Tracker:
  - 3 barrel layers, 5 disks
- Outer Tracker:
  - 3 barrel layers, 4 disks
- Single-point resolution:
  - everywhere: 7 μm x 90 μm
  - 1st disk: 5 μm x 5 μm
- Material budget:
  - barrel: 1.1-1.2% X_0 per layer
  - disks: 1.4-1.6% X_0 per layer

VTX + Tracker + Beampipe Material Budget





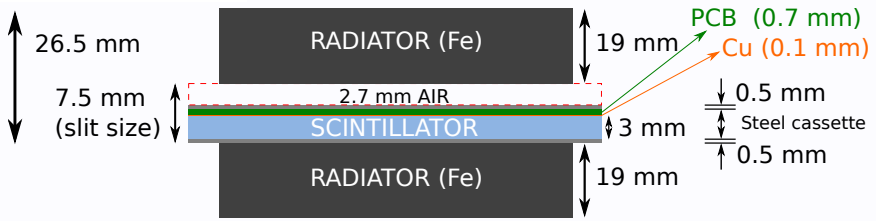
Electromagnetic Calorimeter

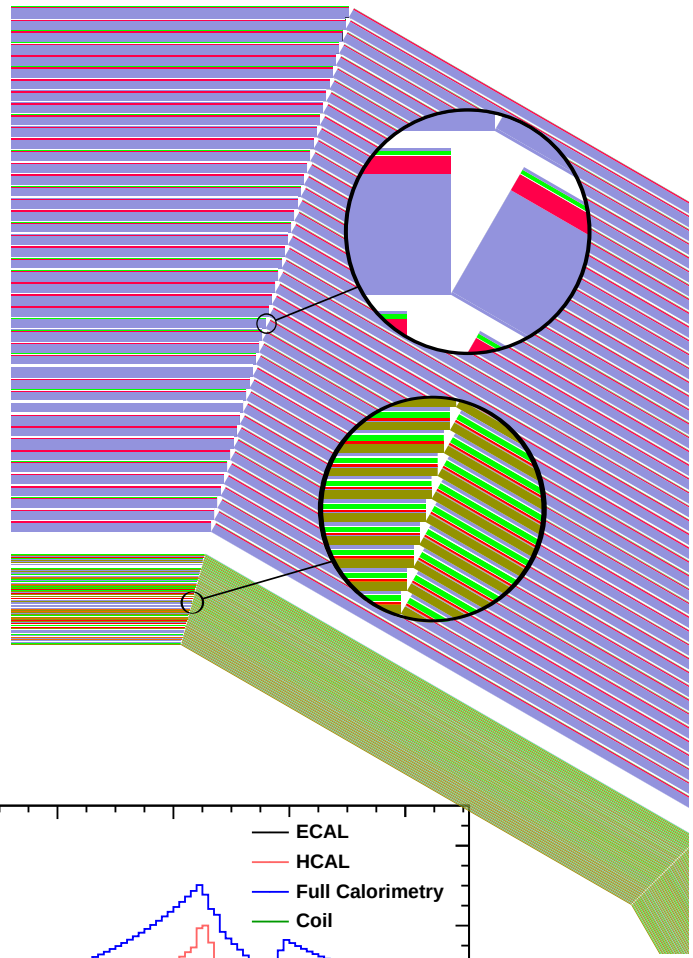
- Si-W sampling calorimeter
- cell size 5 x 5 mm 2
- 40 layers (1.9mm thick W plates)
- 22 X_0

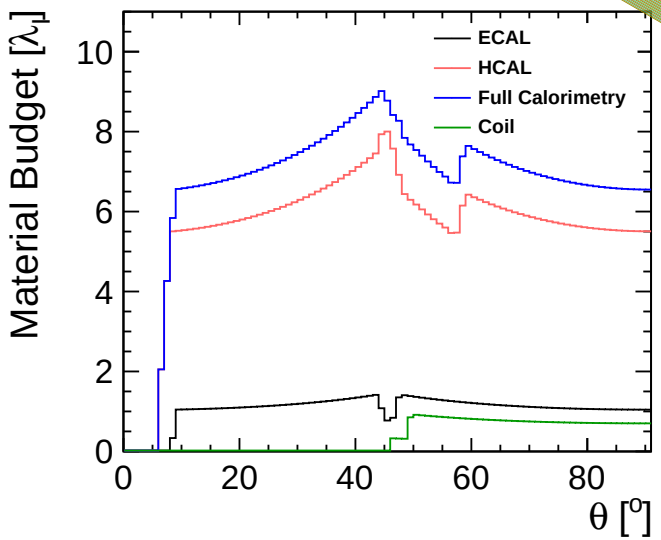
Hadronic Calorimeter

- Scintillator-steel sampling calorimeter
- cell size 30 x 30 mm 2
- 44 layers (19mm thick steel plates)
- 5.5 λ_I

HCAL layer







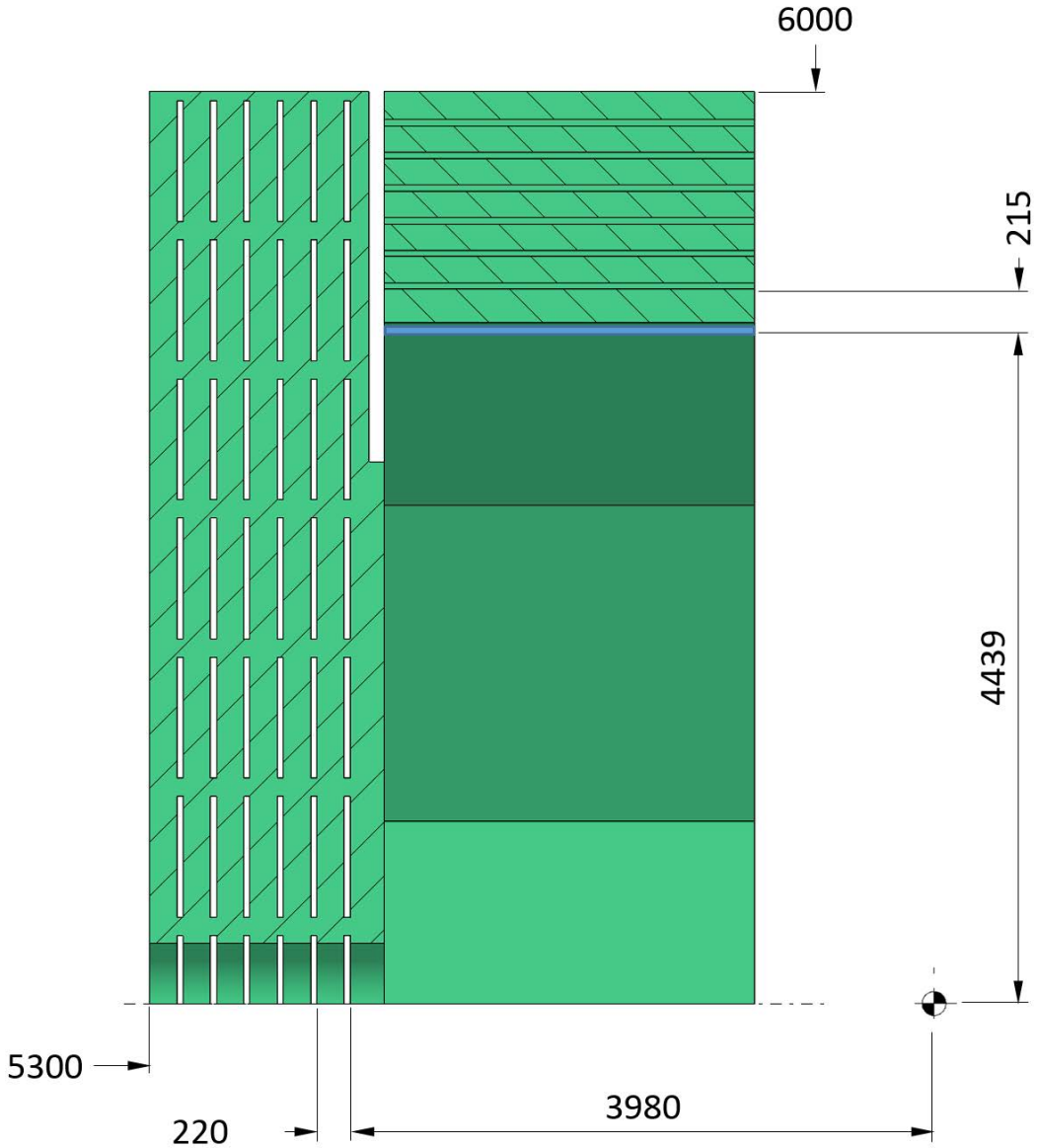
The magnet and muon system

The magnet system

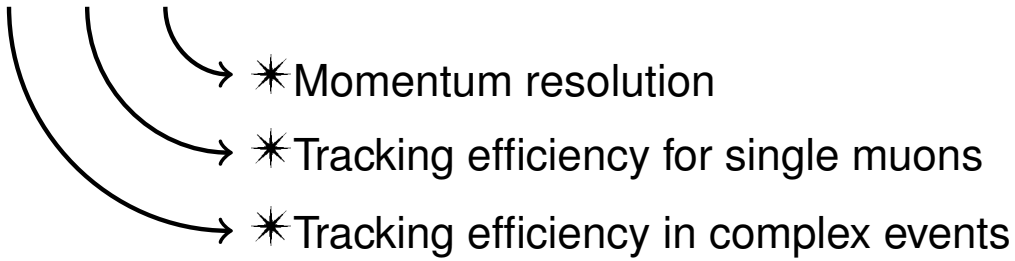
- 2T superconducting coil outside calorimeter
- Return yoke:
  - Barrel: 1T field
  - Endcap: no field in the simulation

The muon system

- 6 RPC muon chambers
- Cell size: 30 x 30 mm

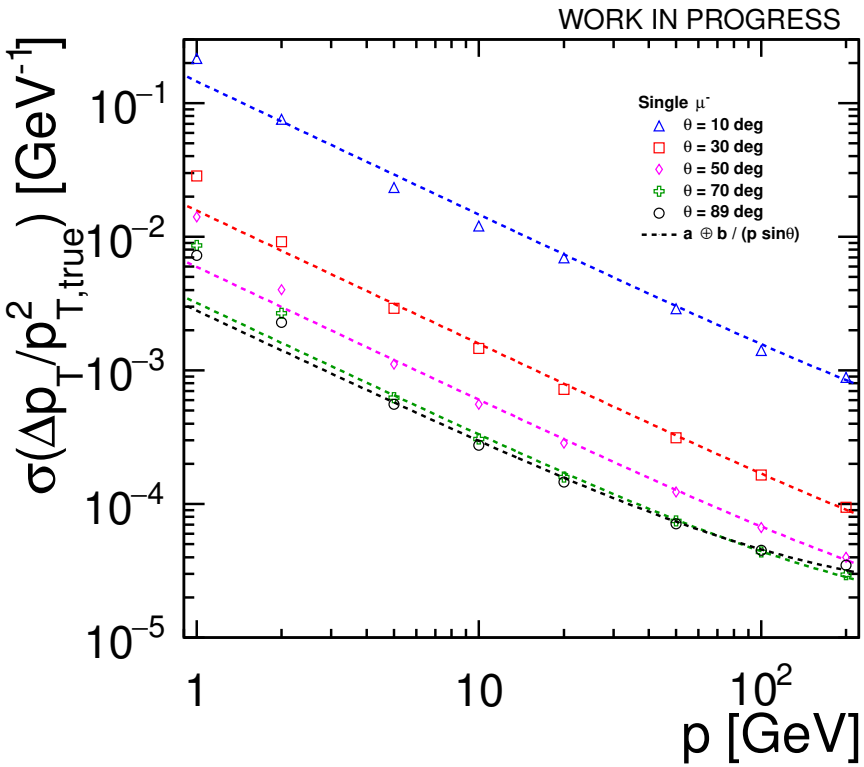


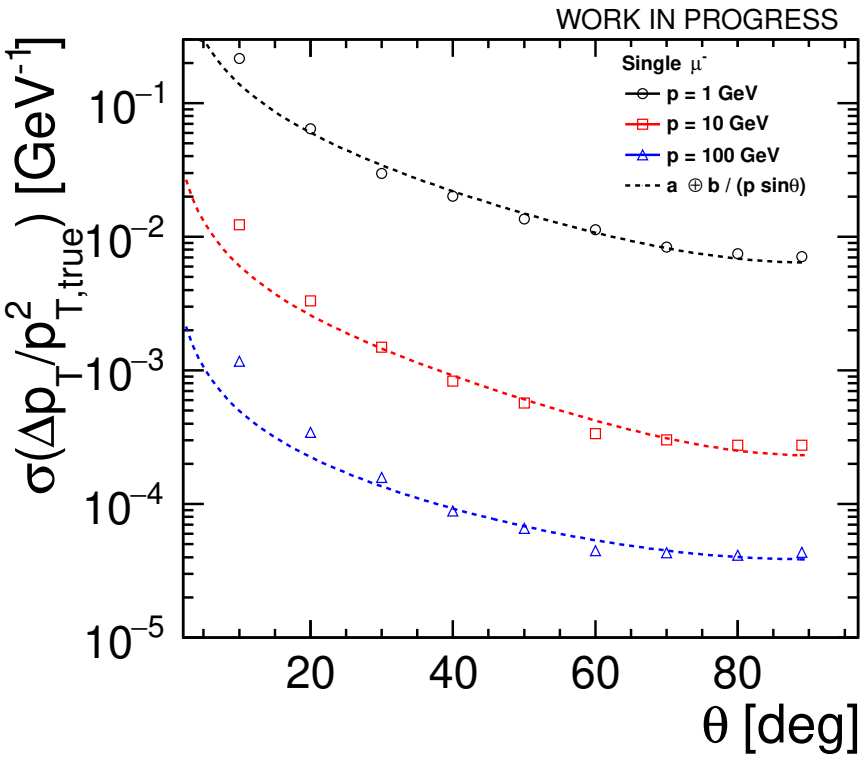
Tracking performance



Momentum Resolution

- Statistics used: 10k single muons at fixed energy and θ for each datapoint

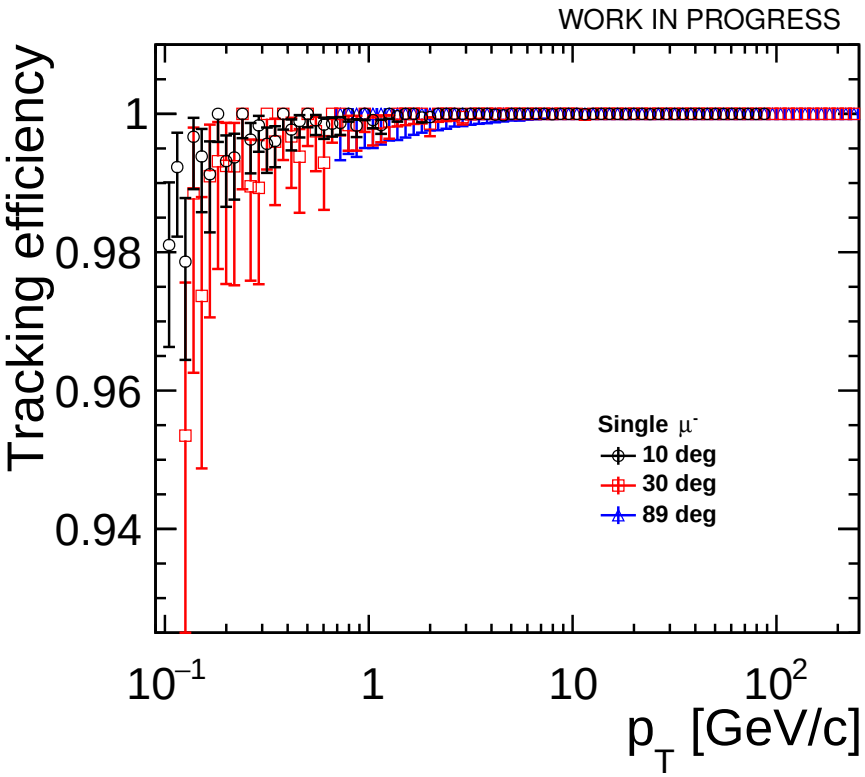


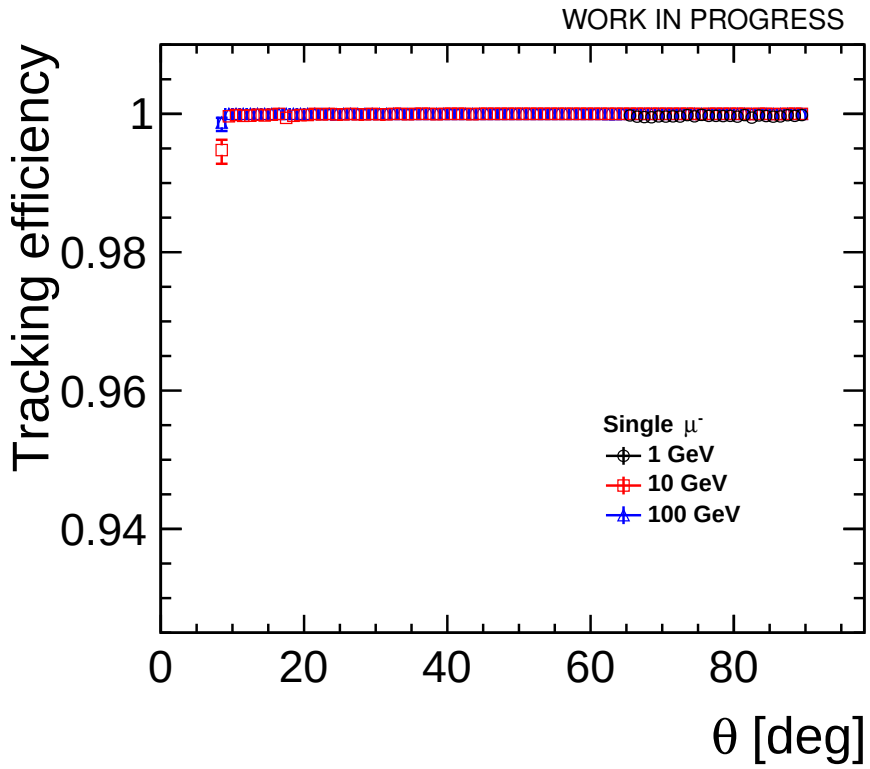


- Achieved momentum resolution of 4x10^{-5} GeV^{-1} for 100GeV muons in the barrel

Tracking efficiency for single muons

- Efficiency = fraction of reconstructed particles out of the reconstructable MC particles
- Reconstructable particles: stable MC particles with $p_T > 0.1$ GeV/c and $|\cos(\theta)| < 0.99$ which left at least 4 unique hits in tracking system
- Statistics used: 2M single muons for each dataset

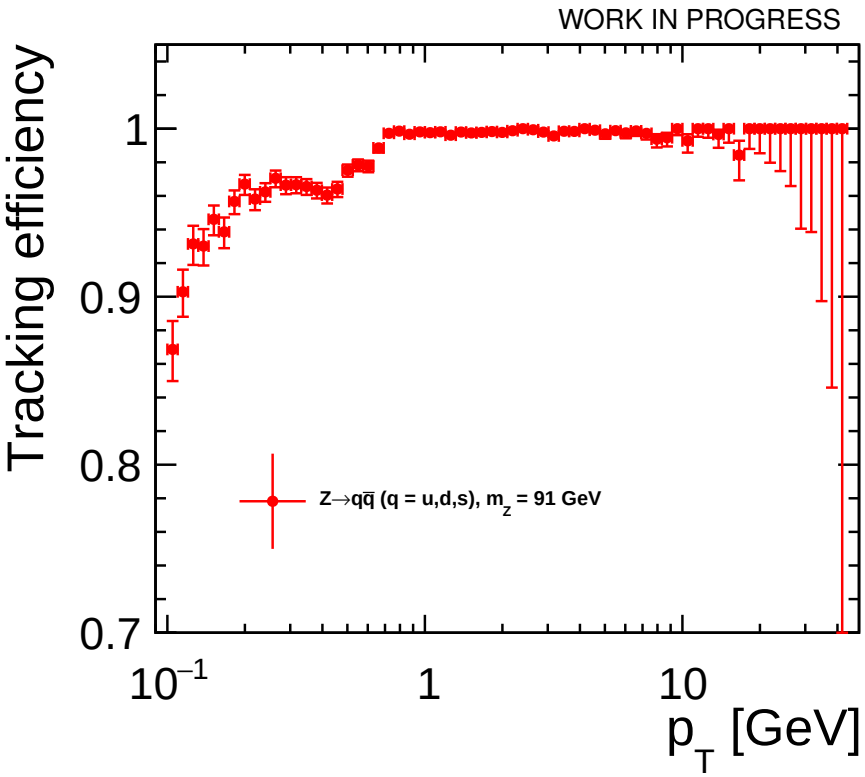


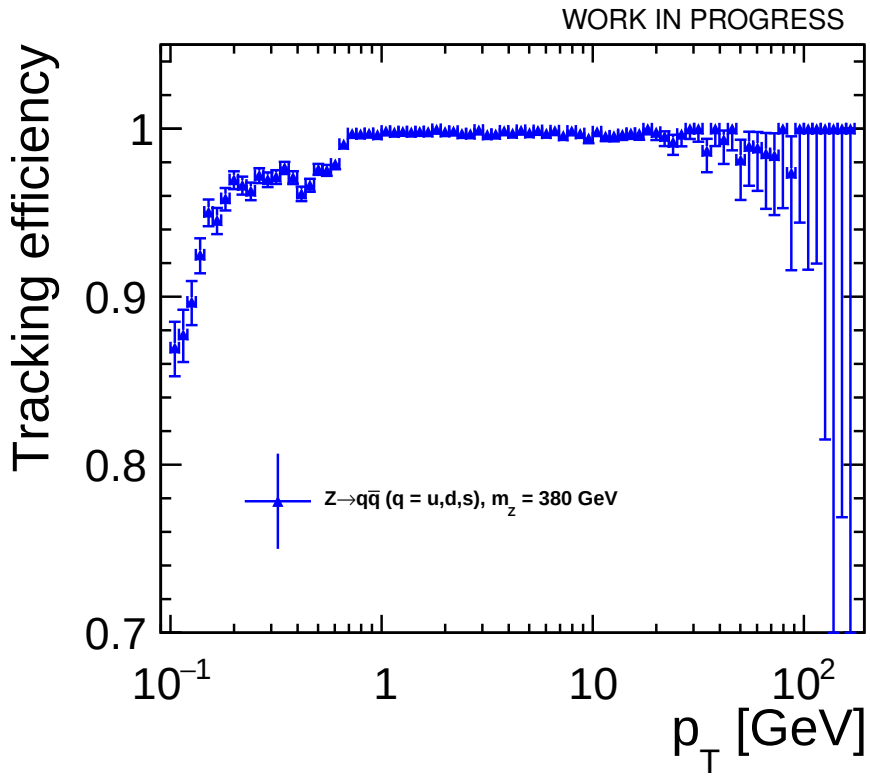


- Fully efficient tracking from 1 GeV

Tracking efficiency for Z-like boson events decaying at rest into light quarks

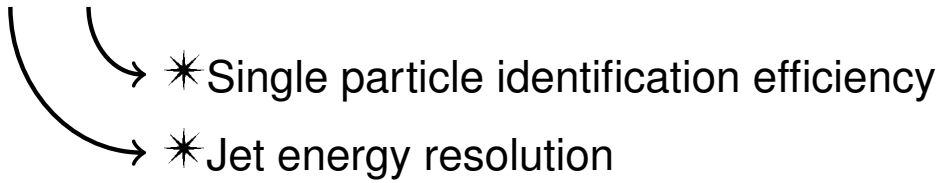
- Efficiency = fraction of pure reconstructed particles out of the reconstructable MC particles
- Pure reconstructed particles: 75% of hits from track are associated to the simulated MC particle





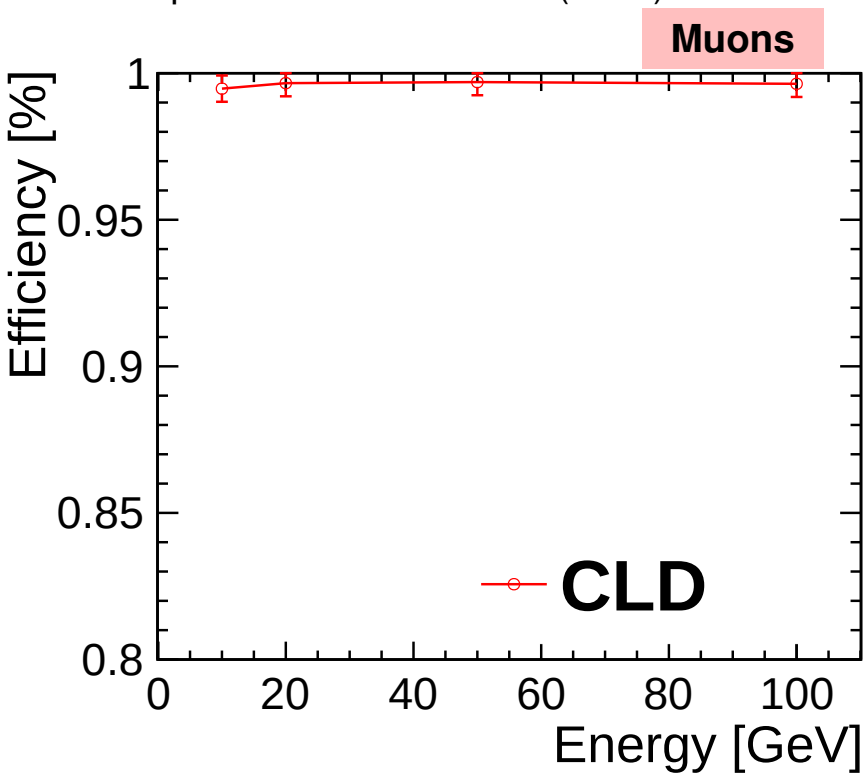
- Fully efficient tracking from 1 GeV

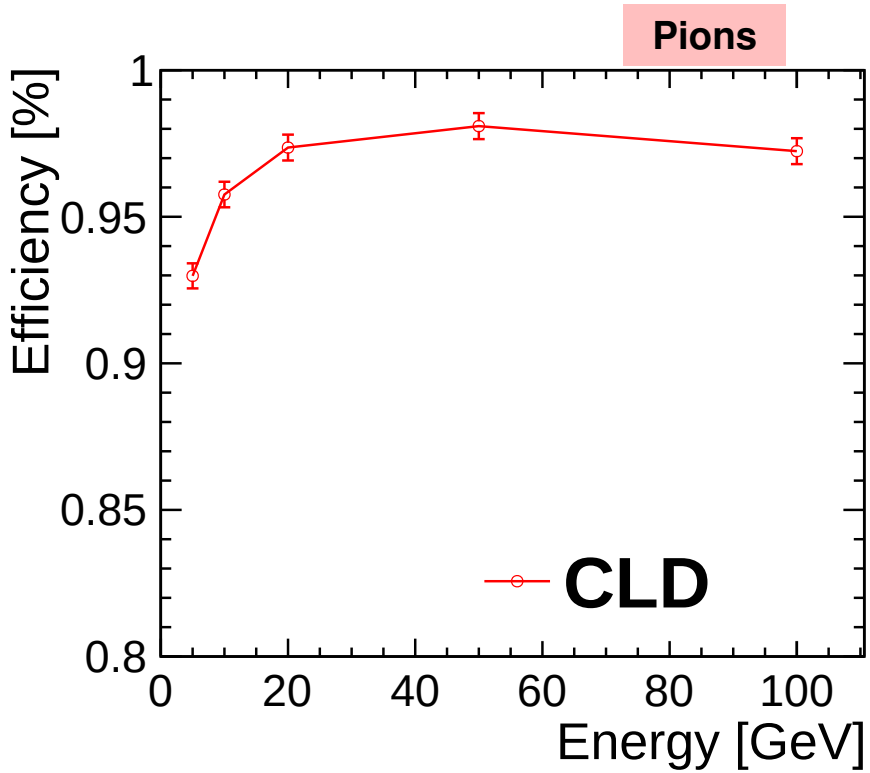
Calorimetry performance



Single particle identification efficiency

- Efficiency = fraction or matched reconstructed particles out of the simulated MC particles:
  - reconstructed particle of the same type as simulated MC particle
  - angular matching: $\Delta\theta < 0.01$rad and $\Delta\phi < 0.02$rad
  - energy matching:
    - charged particles: $|p_T^{truth} - p_T^{PFO}| < 5\%\ p_T^{truth}$
    - photons: $\Delta E < 5 \times \sigma(\text{ECal}) \approx 0.75 \times \sqrt{E}$

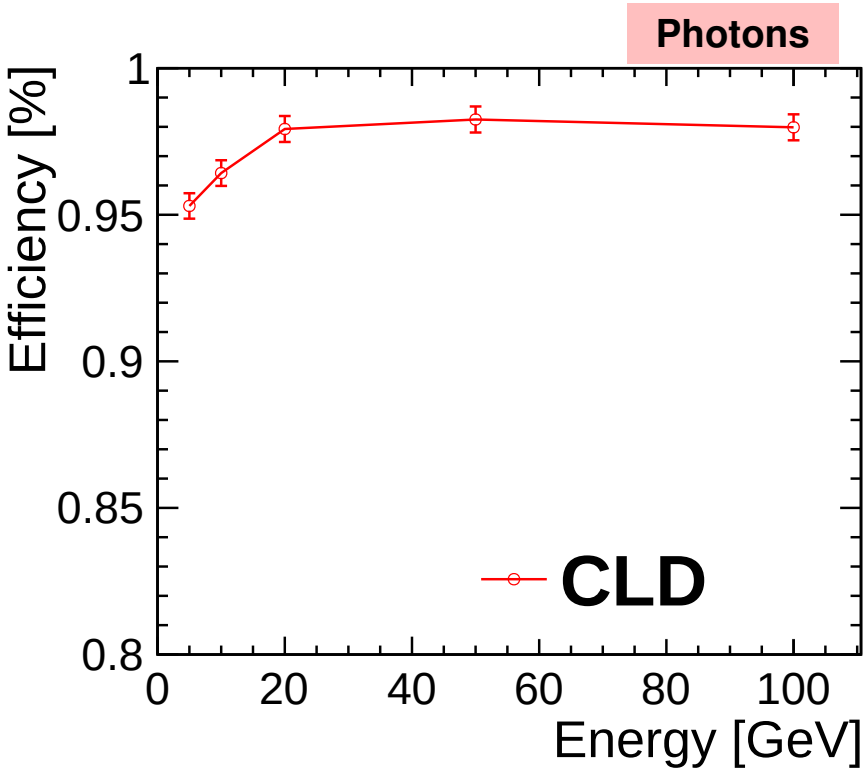


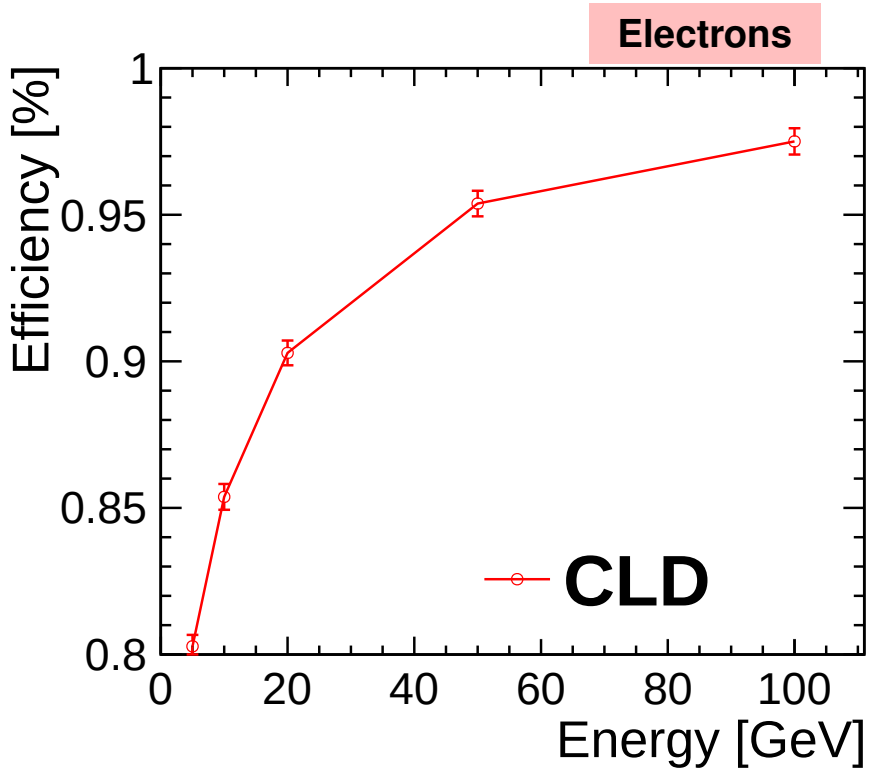


- 99% muon efficiency and $>$ 95% pion efficiency

Single particle identification efficiency

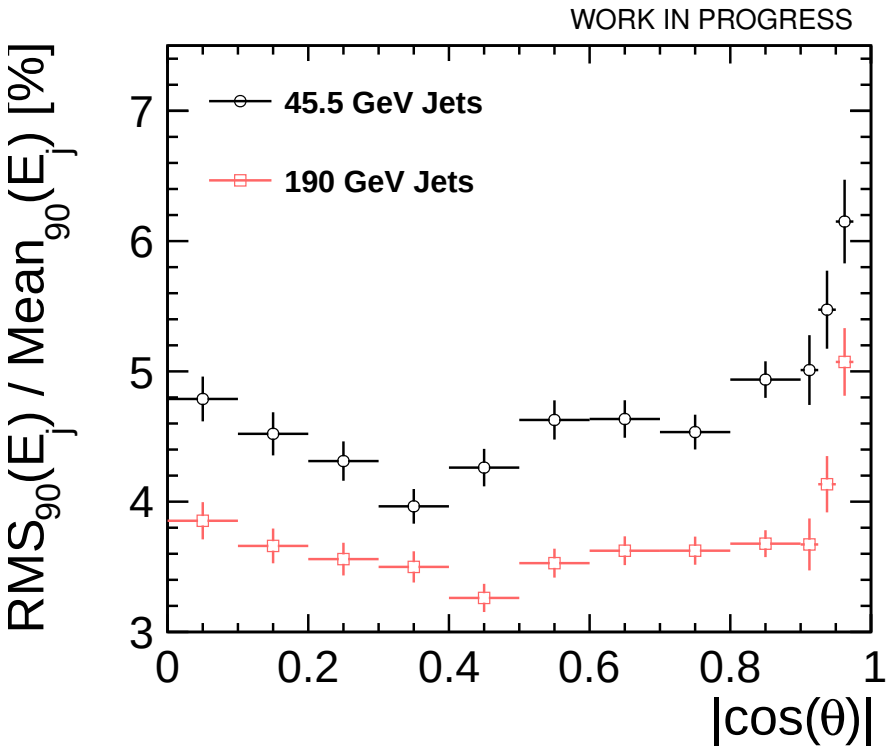
- Photon merging procedure is used to recover inefficiency due to photon conversion
- Pandora parameters were retuned in order to recover electron inefficiency due to Bremsstrahlung

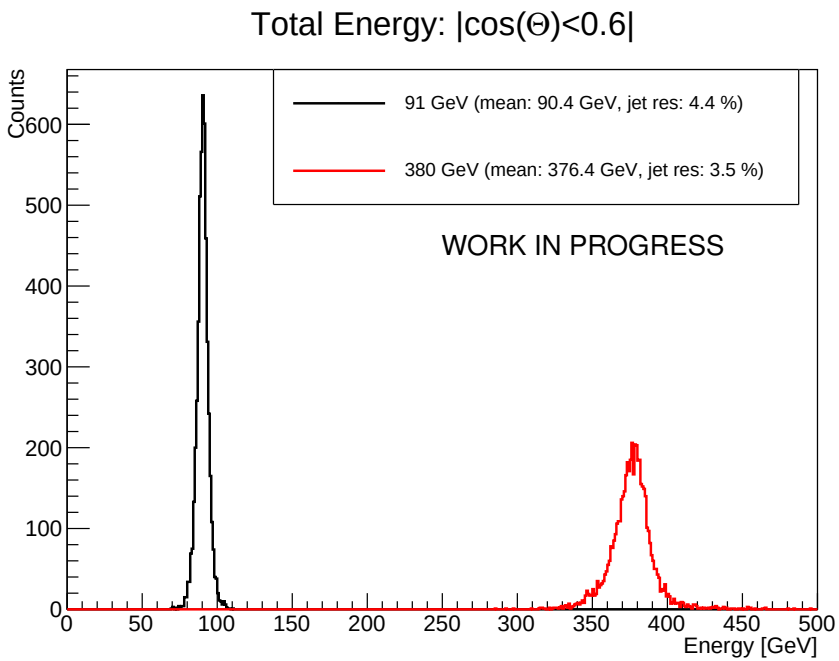




- $>$ 95% photons and electron efficiency [TODO electron plot will be updated]

Jet Energy Resolution





- Jet energy resolution in barrel region:
  - 45.5 GeV jets: 4-5 %
  - 190 GeV jets: 3-4 %
- Total energy is reconstructed with 1% accuracy:
  - 91 GeV: 90.4 GeV
  - 380 GeV: 376.4 GeV
- comparable resolution with the CLIC detector

Jet energy (E_j) is measured as a half of total energy (E_{jj}) of $Z \rightarrow$ uds di-jet event

$$\frac{\mathrm{RMS}_{90}(E_j)}{\mathrm{mean}_{90}(E_j)} = \frac{\mathrm{RMS}_{90}(E_{jj})}{\mathrm{mean}_{90}(E_{jj})}\sqrt{2}$$

arXiv:1209.4039

Summary

The CLD design is finalized for the CDR

- Overall dimensions settled

Detector performances is studied in full simulation

- Tracking performance
  - Momentum resolution and track reconstruction efficiency
- Calorimetry performance
  - Single particle ID efficiency
  - Jet energy resolution

Thank you for your attention!

Possible additional plots

- Tracking performance:
  - Angular, d_0, z_0 resolutions
- Plots with background overlaid:
  - tracking efficiency
  - signle particle ID efficiency
  - jet energy resolution

BACKUP