Summer Student Programme 2024

Detector layout optimisation for electron-track reconstruction at FCC-ee

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Overview

01

Introduction

Goal

Study **electron track** reconstruction in the CLD detector for FCC-ee.

How

Run the full Key4hep **simulation** and **reconstruction** chain and **analyse** the produced data.

Why

Accurate electron track reconstruction is crucial for the FCC-ee physics program.

Challenges

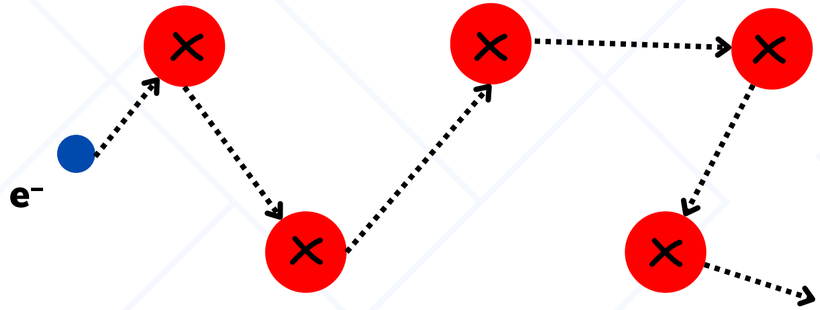
High **material interaction** probability of electrons.

02

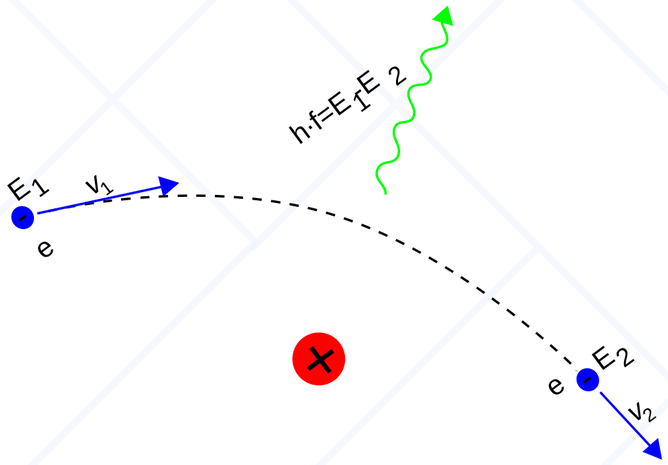
Interaction of $e^{\pm}$ with matter

Due to their small mass, electrons undergo **violent accelerations** and **abrupt changes in direction** during collisions with nuclei

Multiple Scattering



Bremsstrahlung



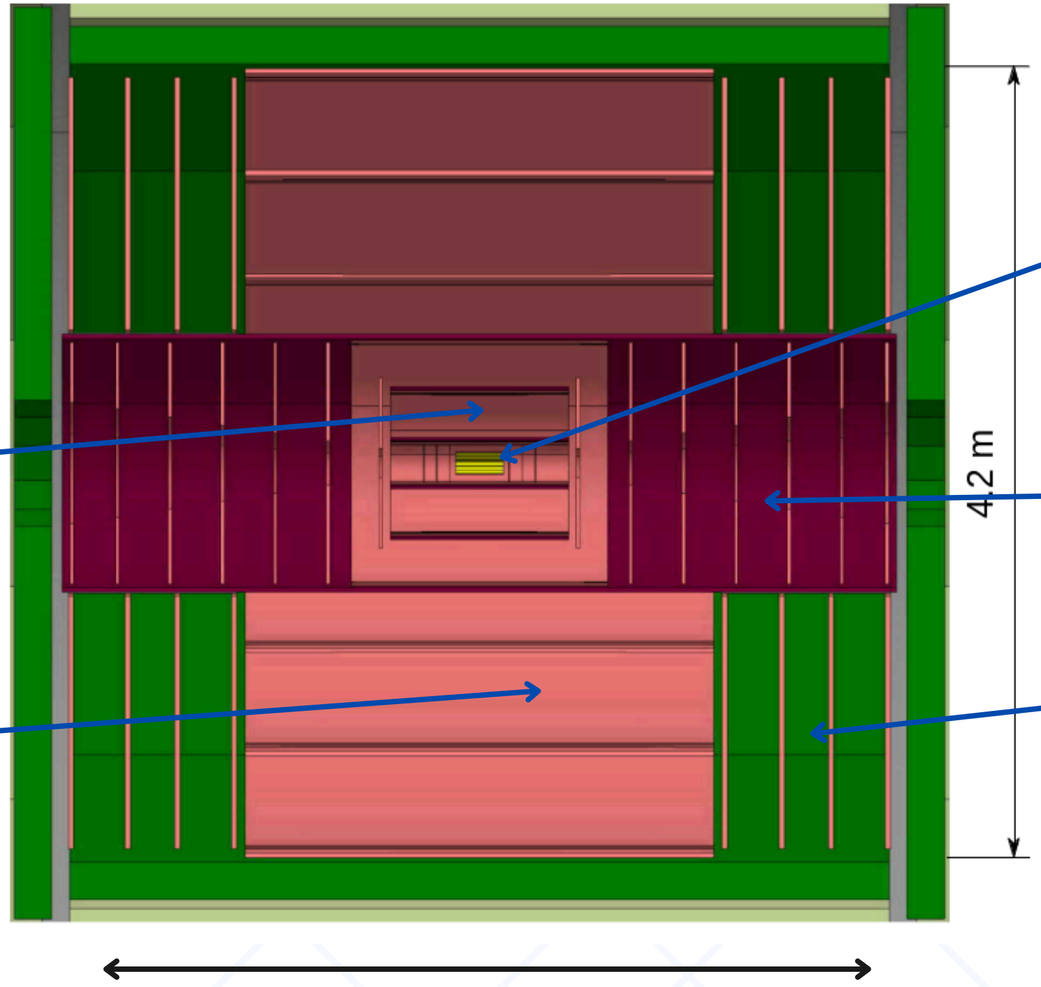
02

CLD Tracking system

All-silicon vertex and tracking system with a 2T magnetic field

3 Inner Tracker Barrels

3 Outer Tracker Barrels



3 Vertex Double-Barrels and 3 Vertex Double-Discs

7 Inner Tracker Discs

4 Outer Tracker Discs

Overall layout of the CLD tracking system [01]

03 Tracking efficiency

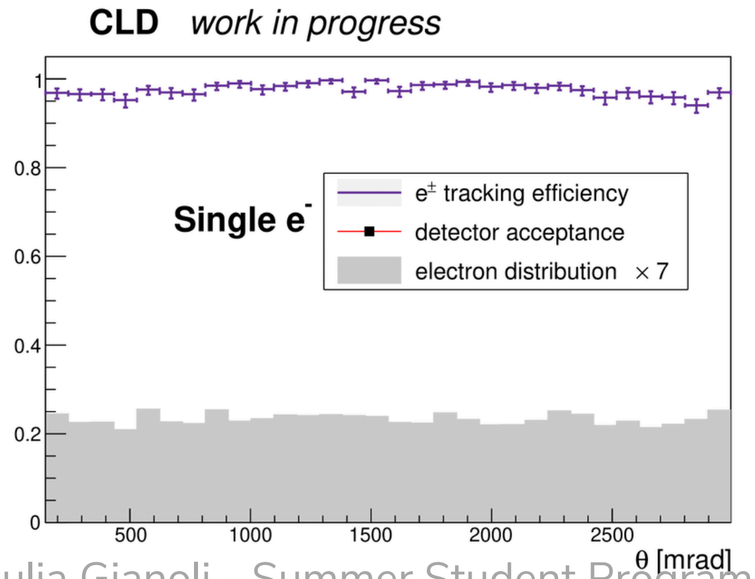
Definition:

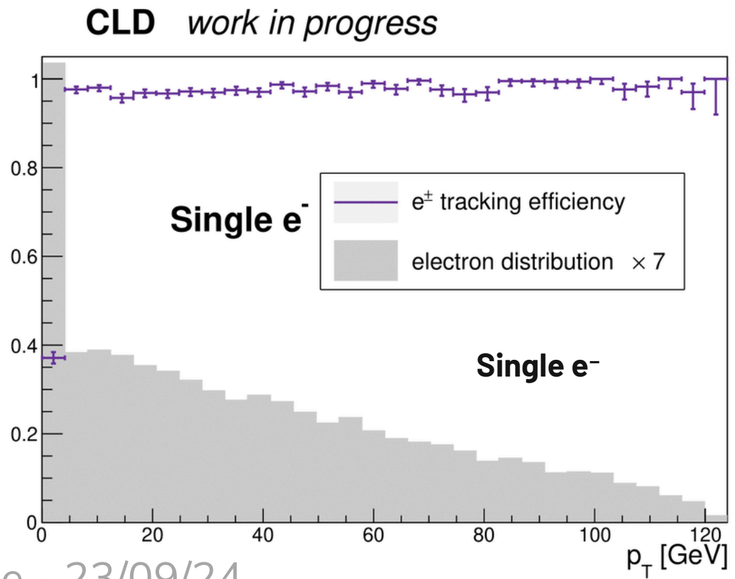
Fraction of the reconstructable **Monte Carlo particles** that have been **reconstructed** (stable at generator level, ≥ 4 unique hits, p_t >100 MeV)

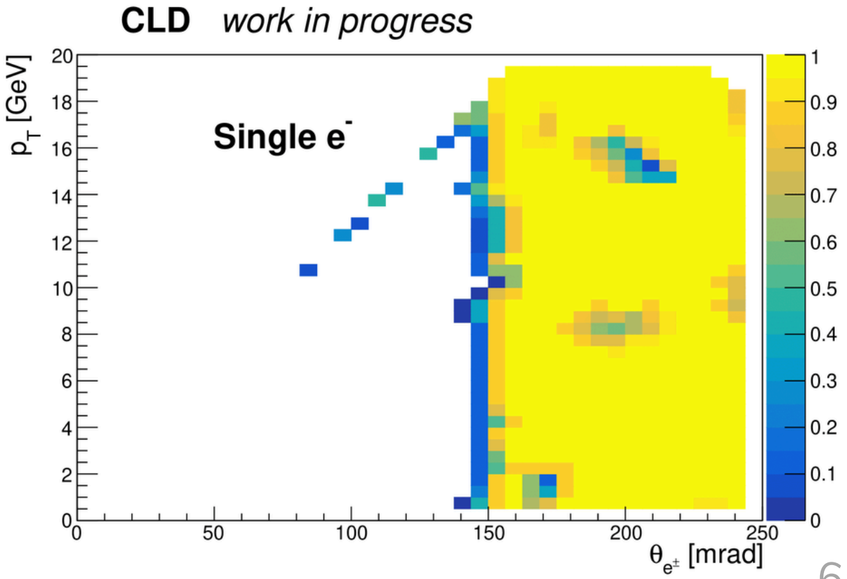
Simulation:

10000 events (single e^-)
Energies ranging from **0 to 124 GeV** (uniform distribution)

150 mrad < θ< 2π*1000 mrad-150 mrad

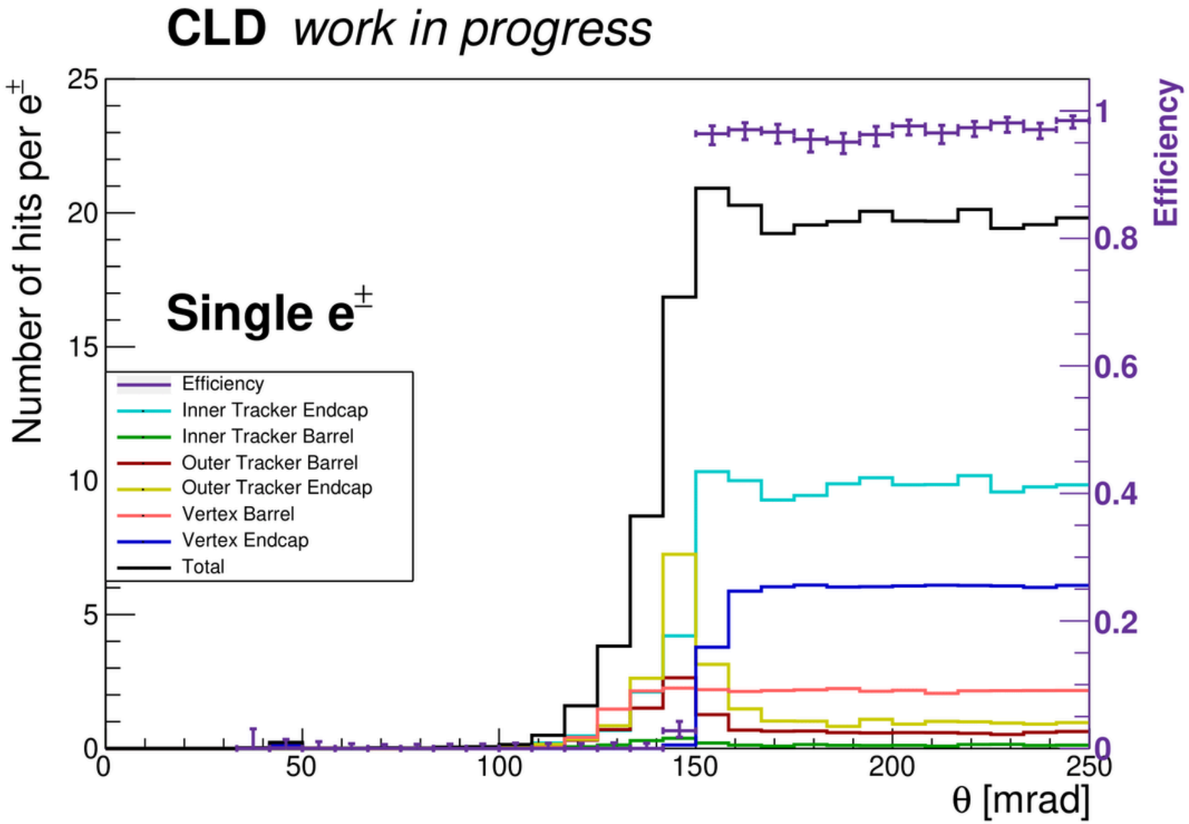


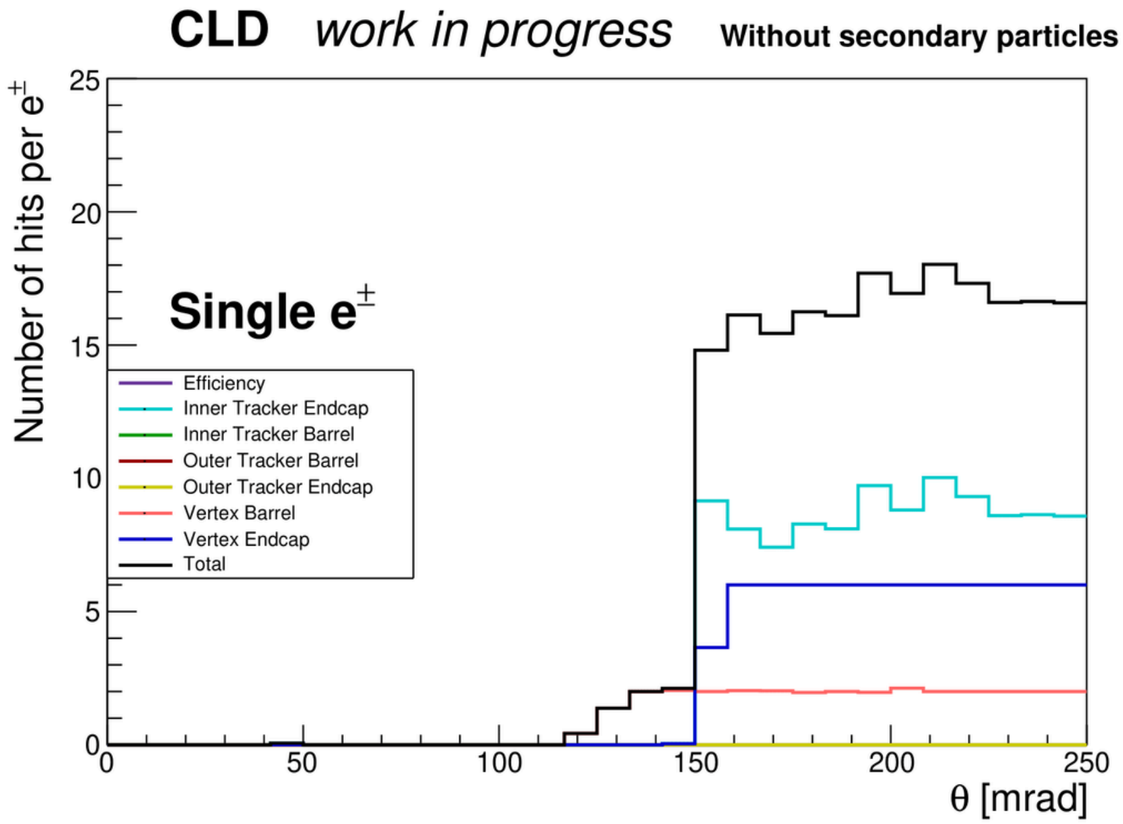




03 Tracking efficiency

Number of **SimTrackerHit** per e^- for different parts of the tracking system



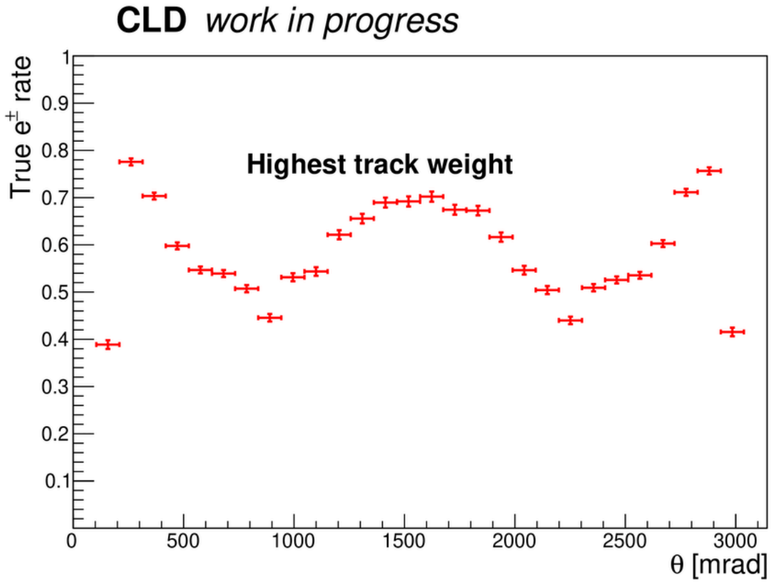


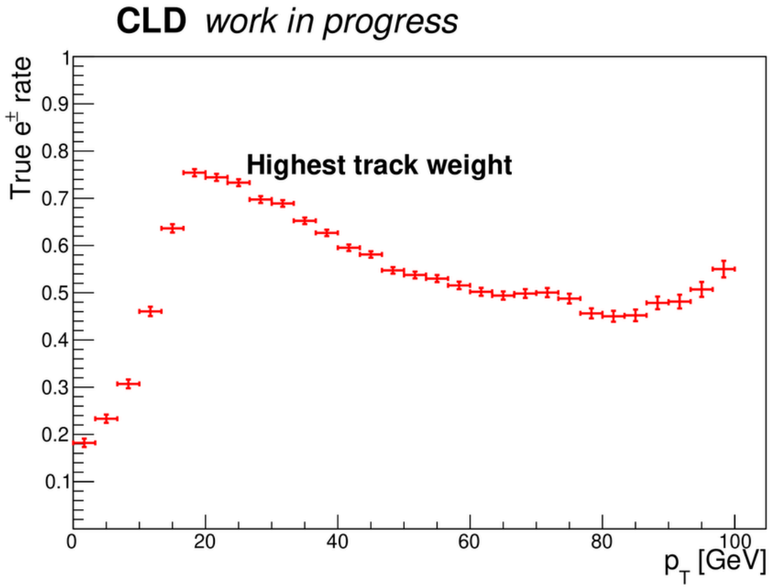
03

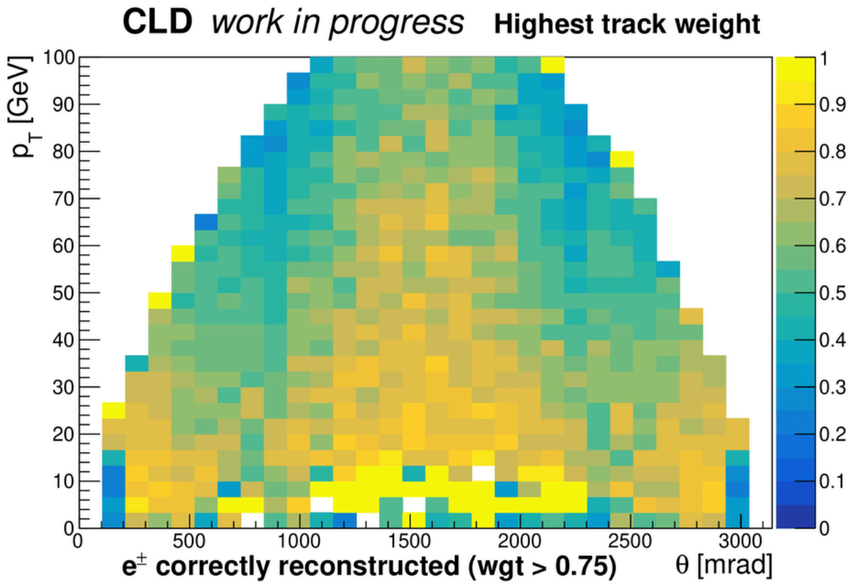
True electron rate

Definition:

True electron rate: Fraction of reconstructable Monte Carlo particles which have been reconstructed as **pure tracks** (track weight > 75%).
Track weight: percentage of hits in a track that belong to the same MC particle.







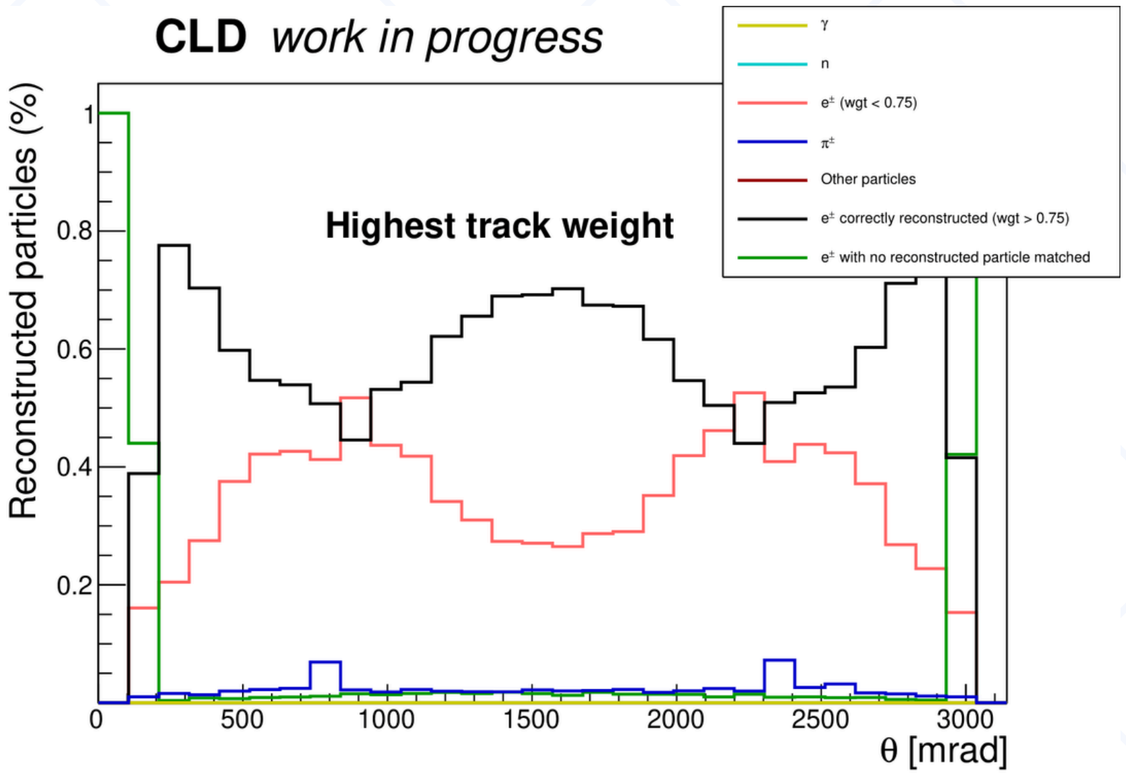
03

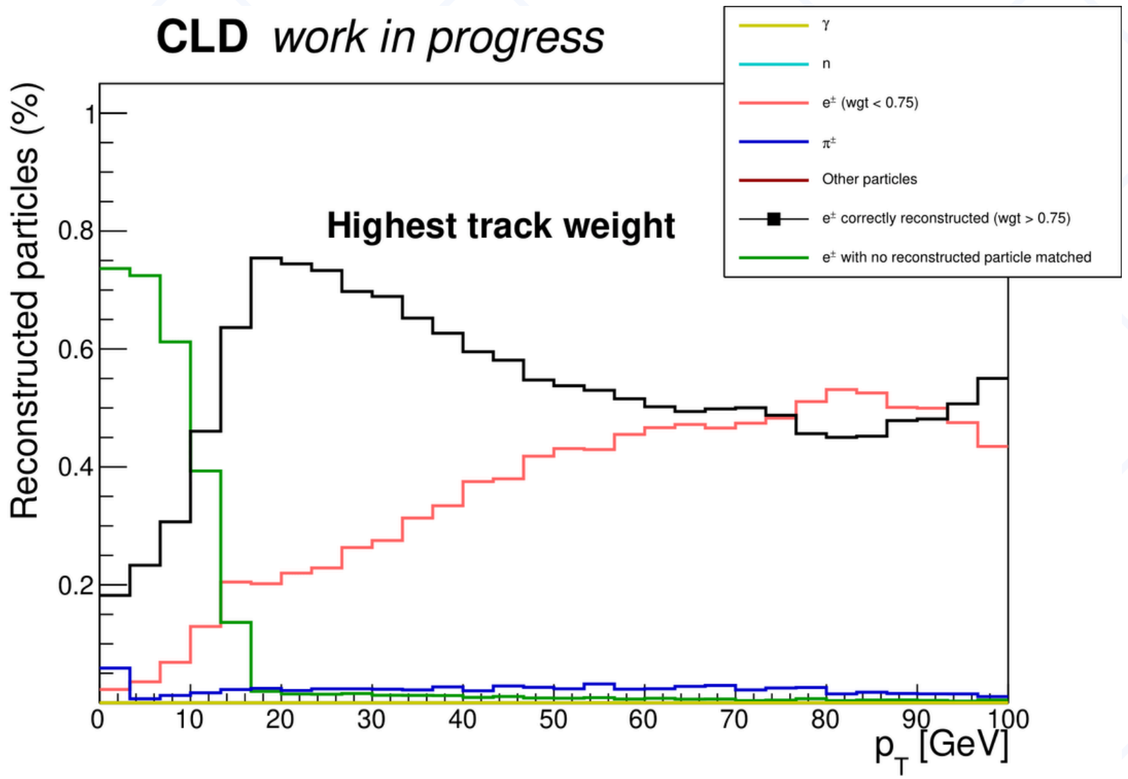
True electron rate

Considerations:

Particles are never reconstructed as n or γ

Mainly are **electrons with weight < 75%**





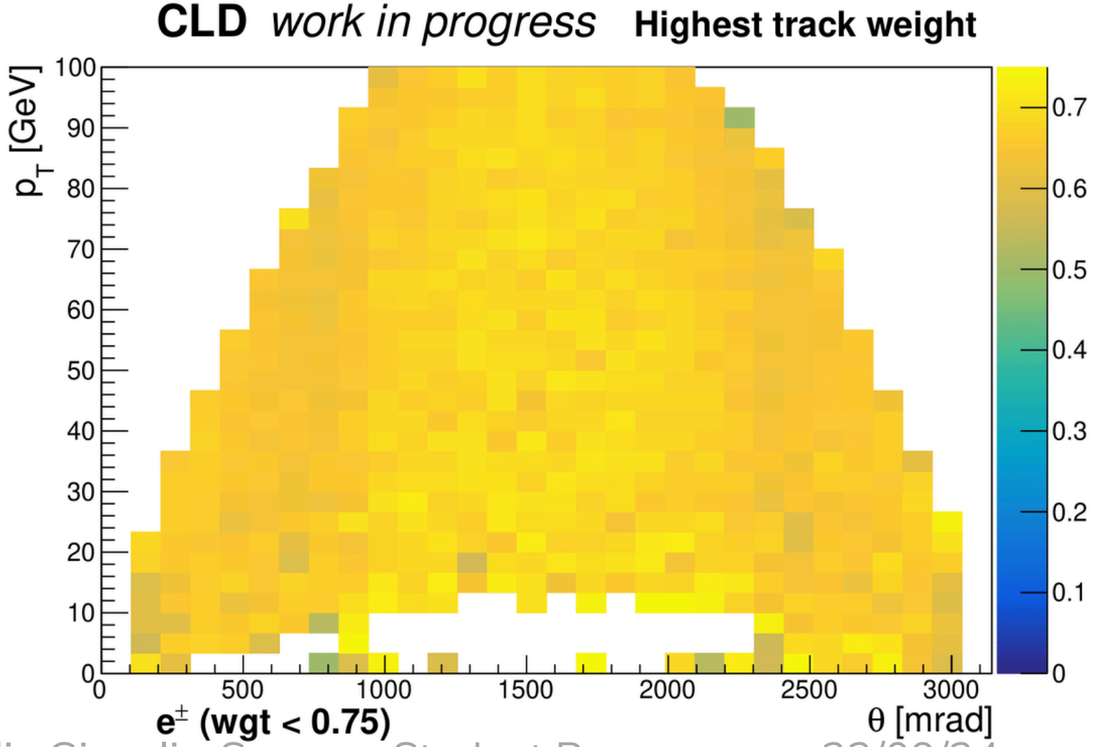
03

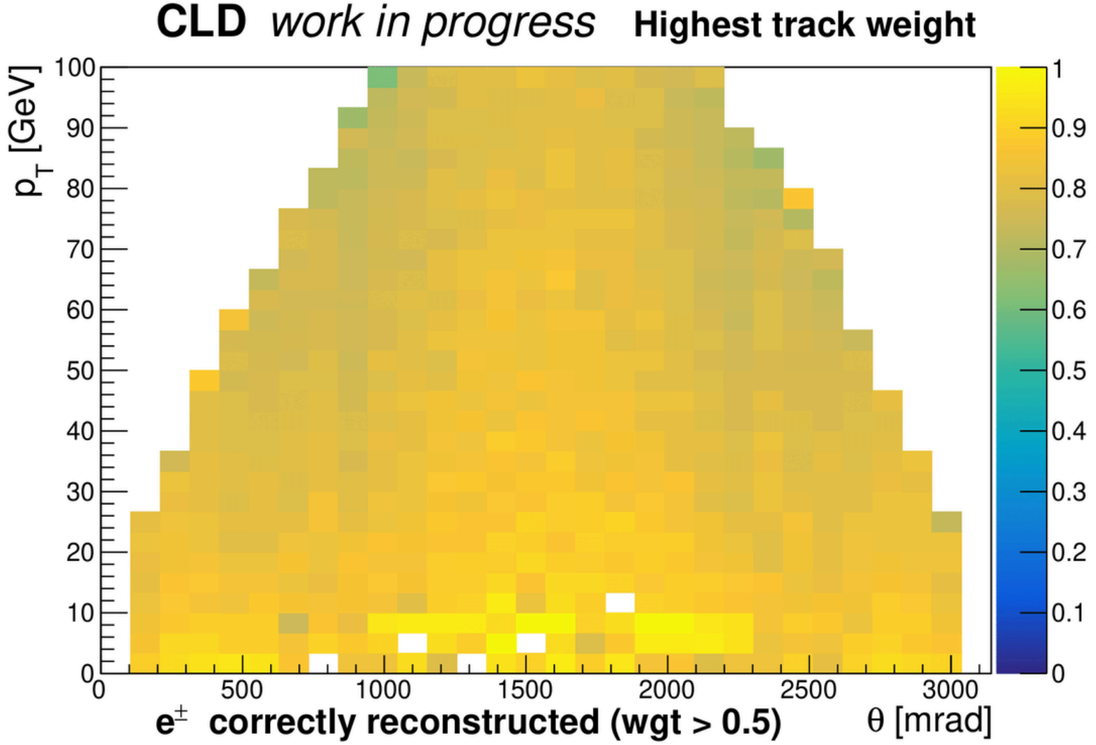
True electron rate

Considerations:

Weight of the electrons not reconstructed correctly **> 0.5**

Threshold of 0.5: **at least 70%** of the tracks are correctly reconstructed.



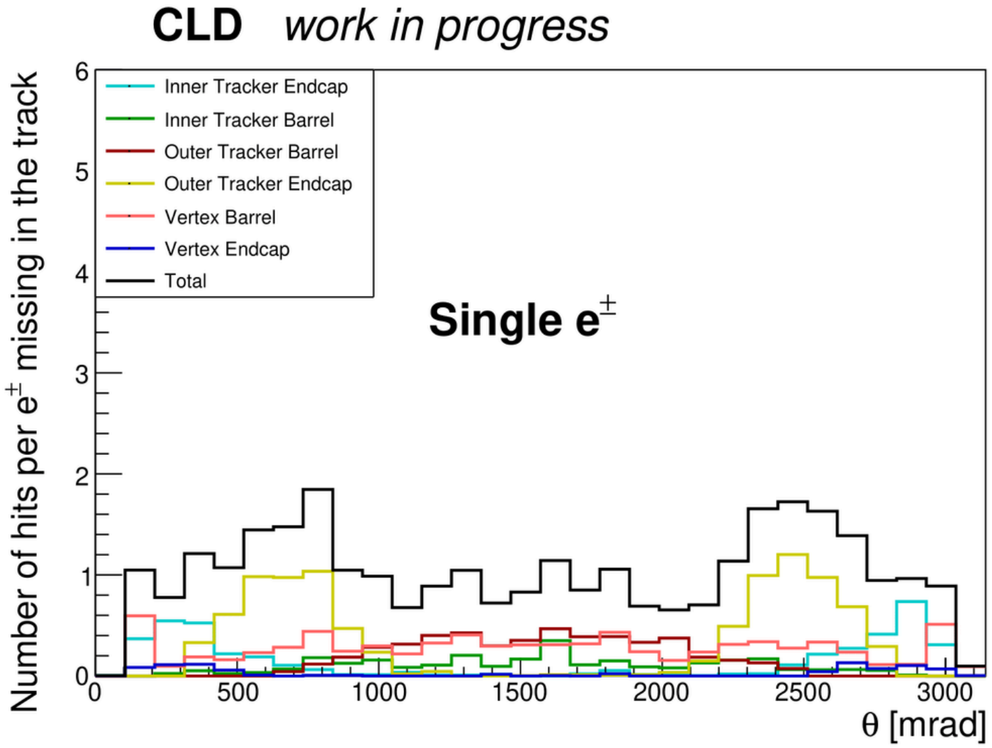


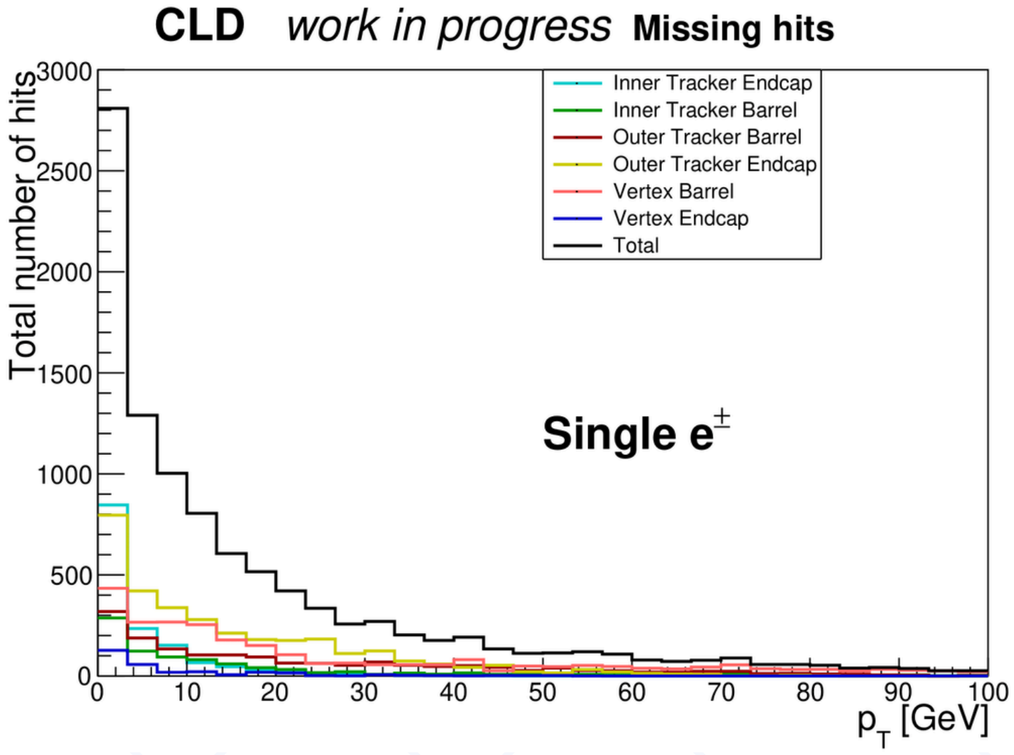
03

Missing hits

Definition:

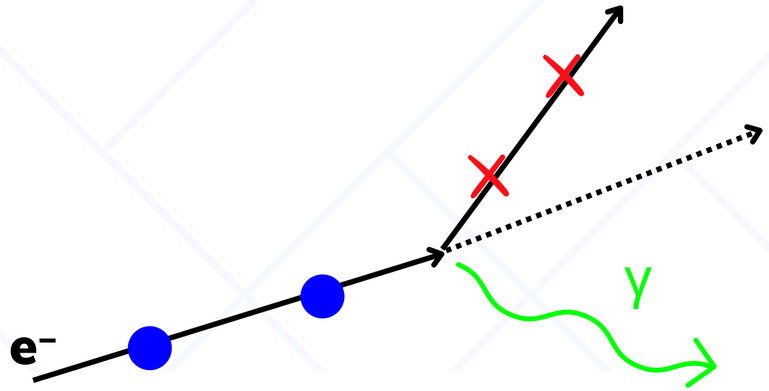
Simulated hits that are **not** reconstructed **in the track**



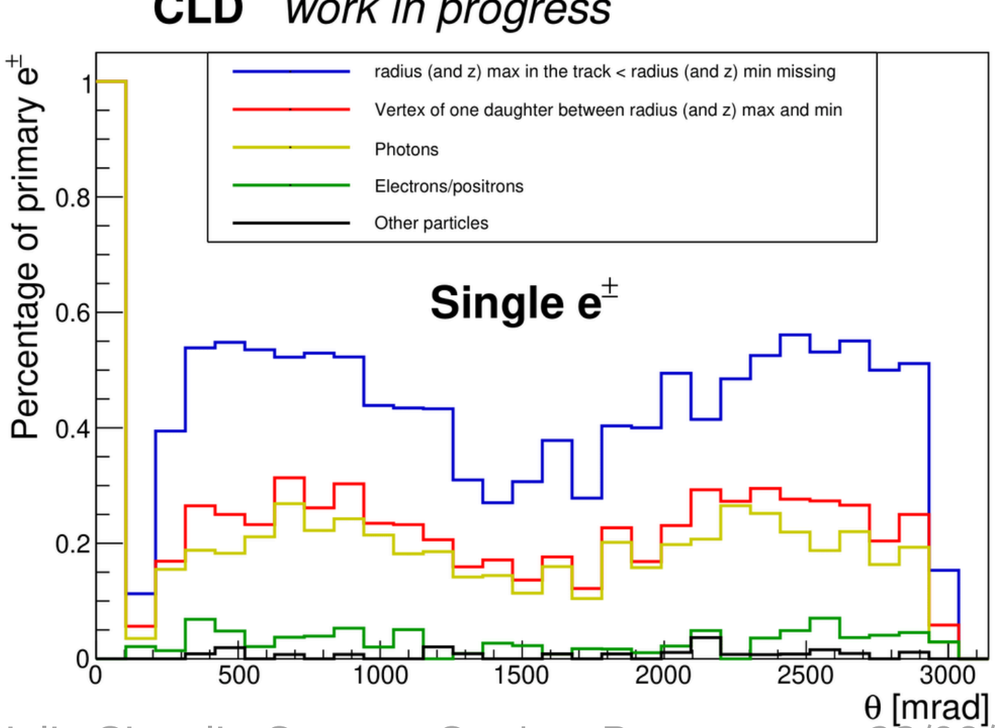


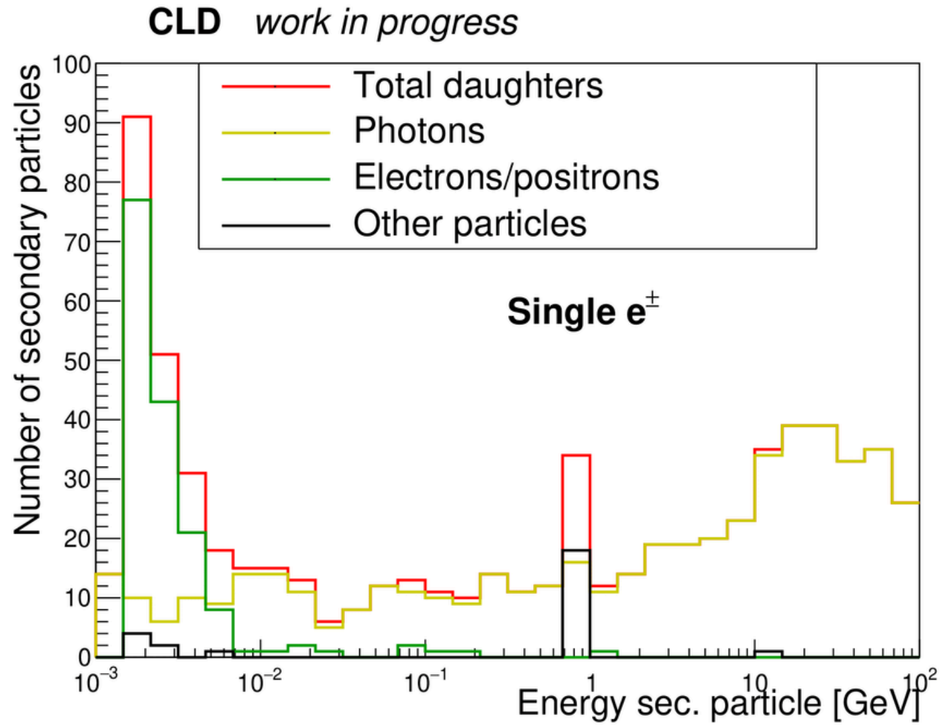
03

Missing hits



- Hits in the track
- Missing hits

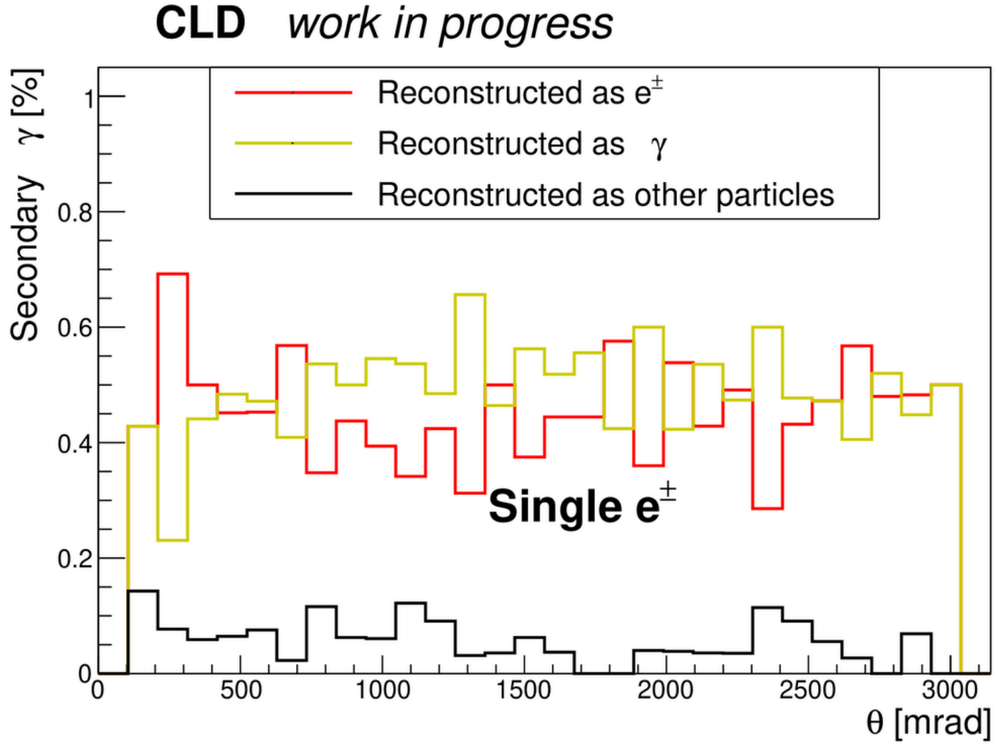


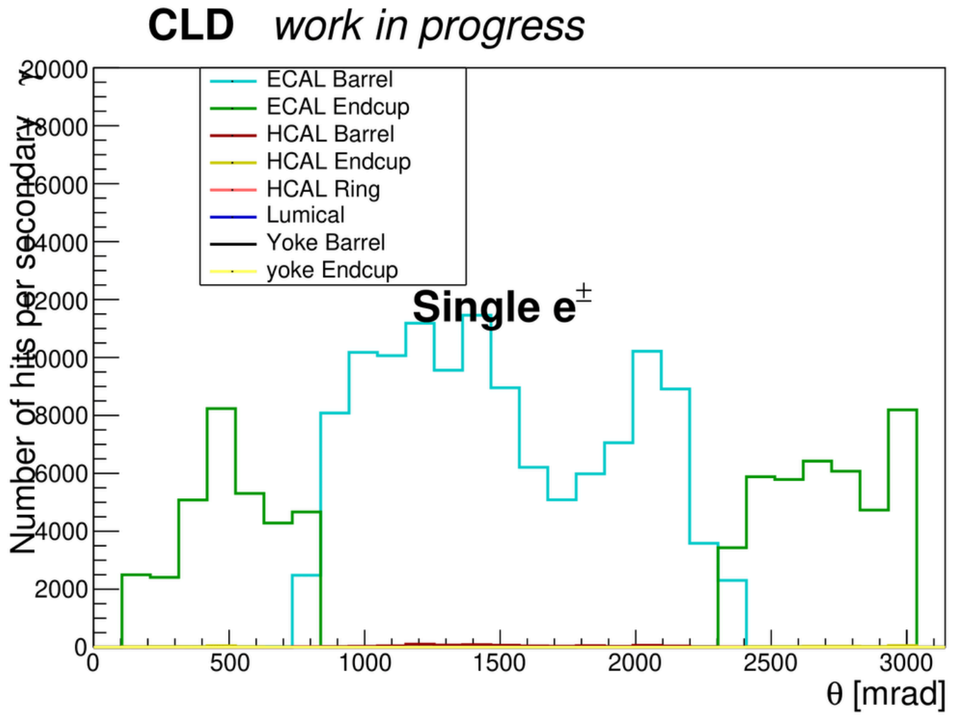


03

Missing hits

What happens to the **secondary photons** emitted by electrons ?





04

Conclusion

01 **Low efficiency** for electrons with $\theta < 150$ mrad and $p_t < 5$ GeV

02 **True electron rate**: lowering the threshold to 50% gives 70% correctly reconstructed tracks

03 **Missing hits** largely due to Bremsstrahlung.

04 **Photon misidentification**: many secondary photons are reconstructed as electrons.

04

Outlook

01 **Optimize detector geometry** for low θ and p_t electrons.

02 Improve reconstruction algorithms to handle **Bremsstrahlung effects.**

03 **Enhance particle identification** to reduce photon-electron misidentification.

04 Test performance with **more complex event simulations**.

Thank You!

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My offices mates, in particular Katerina and Enrico, for the great times we spent together.

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Reference

01 N. Bacchetta et al. *CLD – A Detector Concept for the FCC-ee*. 2019. arXiv: 1911.12230 [physics.ins-det]. URL: https://arxiv.org/abs/1911.12230.

02 URL: *https://edm4hep.web.cern.ch/*