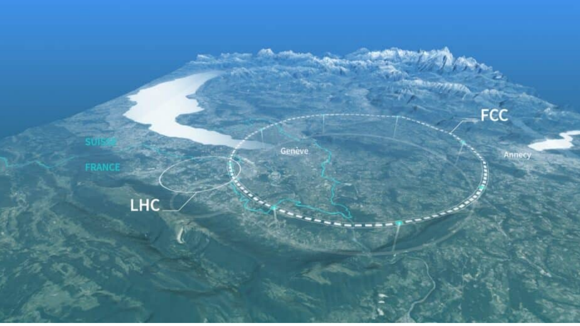

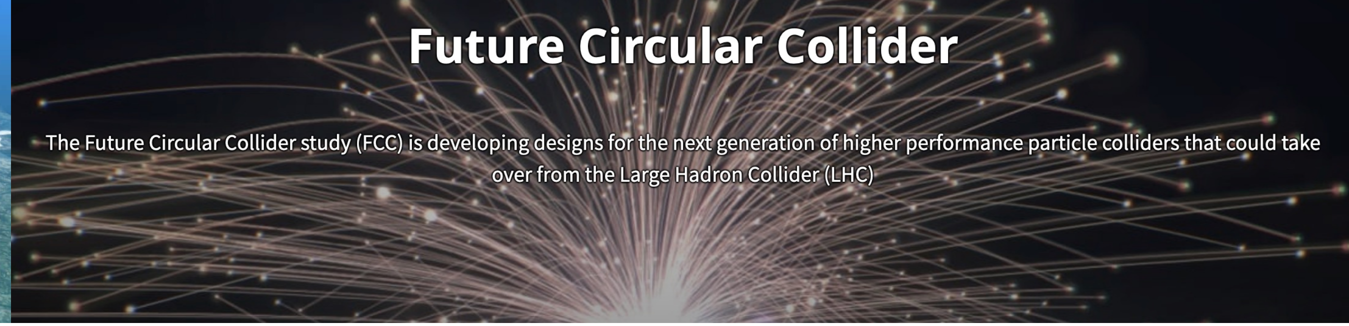

IDEA detector concept: full simulation and performance note

Nicola De Filippis
Politecnico and INFN Bari

FCC Detector Full Sim Working meeting, October 2, 2023

European network for developing new horizons for RIs

Goals

Scope:

- document the state-of-the-art of the IDEA full simulation
- would include status of simulation of IDEA geometry (DD4HEP and Geant4) with a advanced level of details
- would include simulation of hits, digis
- would include local/global reconstruction algorithms, at least the strategy
- would include perfomance plots at different levels

The NOTE has to be an enough comprehensive document

  - to be used by software user and developer community as a base for more advanced studies
  - to be used as a reference for full simulation-based physics analyses studies
  - to collect the effort of several people and groups

Draft

Note at link:
https://www.overleaf.com/project/641b1d37a489ea46a68e6f25

IDEA detector concept Full Simulation description and performance

First Author[1,2*], Second Author[2,3†] and Third Author[1,2†]

[1*]Department, Organization, Street, City, 100190, State, Country.
[2]Department, Organization, Street, City, 10587, State, Country.
[3]Department, Organization, Street, City, 610101, State, Country.

*Corresponding author(s). E-mail(s): iauthor@gmail.com;
Contributing authors: iiauthor@gmail.com; iiiauthor@gmail.com;
†These authors contributed equally to this work.

1 Introduction

Both the European Strategy for particle physicsand the Snowmass Community Planning Exercisepointed to an electron-positron Higgs factory as top priority after the LHC. The preferred option for a future collider at CERN is the Future Circular Collider (FCC), a collider with an integrated programme to push both intensity and energy frontiers [?]. The FCC program at CERN combines in the same 100 km infrastructure an electron-positron high luminosity Higgs/Electroweak factory, followed by a 100 TeV proton-proton collider.

The IDEA (Innovative Detector for an Electron–positron Accelerator) detector proposal for an experiment along the electron-positron collider, is designed to provide:

- the state-of-the-art momentum and angular resolution for charged particles, especially at low momentum, for precision electroweak physics at the Z pole and flavor physics;
- a suitable vertex resolution to separate g, c, b, τ final states;
- a suitable jet-jet invariant mass resolution to separate W, Z and Higgs bosons giving two jets;
- Good π^0 identification for τ and heavy flavor reconstruction;
- particle identification capability to classify final states and flavor tagging.

IDEA includes a silicon pixel detector in the innermost part, an ultralight drift chamber as the main tracking device, a silicon wrapper, a magnet, a preshower, a dual readout calorimeter and a muon system. The option of using a crystal electromagnetic calorimeter to improve the electron/photon energy resolution is also inspected. This document describes the full simulation of the IDEA subdetectors and the relevant performance.

2 Software framework and tools

Here quick intro to Geant, key4hep, DD4hep. Reference to other documents.

3 Vertex detector

3.1 Inner tracker

3.2 Medium and outer tracker

4 Drift Chamber

4.1 Geometry simulation

4.2 Local reconstruction

4.3 Cluster counting technique for PID

The IDEA drift chamber is designed to provide efficient tracking, a high-precision momentum measurement and excellent particle identification by exploiting the application of the cluster counting technique. To investigate the potential of the cluster counting techniques on physics events, a simulation of the ionization cluster generation is needed, therefore we developed algorithms that can use the energy deposit information provided by the Geant4 toolkit to reproduce, in a fast and convenient way, the cluster number and cluster size distributions. Indeed, the ionization of matter by charged particles is the primary mechanism used for particle identification (dE/dx), but the large uncertainties in the total energy deposition represent a limit to the particle separation capabilities. The cluster counting technique (dN/dx) takes advantage of the primary ionization Poissonian nature and offers a more statistically significant way to infer the mass information [1].

4.3.1 Principles of cluster counting techniques

In general, the drift chambers can provide a measurement of the energy loss along the particle trajectory, that, if associated with a measurement of the momentum, allows for the derivation of the mass of an ionizing particle (the traditional dE/dx method). However, the large and inherent uncertainties in the total energy deposition, described by the Landau function, represent a serious limit to the particle identification

Next step: we need to identify the editor of each section