Proposition de sujet de stage M2 (2020) à l'Institut de Pluridisciplinaire Hubert Curien (IPHC)

Tracker geometry optimization and tracking performance at the Future Circular Collider at CERN

Until now, the largest particle accelerator ever build is the Large Hadron Colliders (LHC). It accelerates particles (protons or heavy ions) up to an energy of 6.5 TeV per beam, yielding to most energetic collisions ever achieved. Thanks to its high energy and large beam intensity, the LHC allowed to improve our understanding of the SM and to push forward the boundaries of new physics. The discovery of the Higgs boson is the most famous example of the impact of the LHC. To probe more deeply the Standard Model (SM) of particle physics, and to search more intensively signs of new particles, the LHC will be upgraded to achieved even greater luminosity (High-Luminosity LHC or HL-LHC). While the construction of the HL-LHC is currently being prepared, with a start of operation being scheduled in 2027, it is already important to start thinking of the next generation of accelerators, now. Indeed, the development of new accelerators and detectors require a long term investment of time and effort.

Once the physics reach of the HL-LHC has been fulfilled, scientists think that the next accelerators should be an electron-positron collider. While lower energies and luminosities are usually achievable at lepton colliders, the clean environment and the perfect knowledge of the initial states allows to perform measurements of extreme precisions. This is particularly important for measuring the properties of the newly discovered Higgs boson, among other particles and processes, and to search for tiny deviations compared to SM predictions, that would be hint of contributions of new physics.

Different kind of leptonic accelerators are being explored. Linear colliders, such as ILC and CLIC, can reach high energies, while circular colliders such as CEPC and FCC can reach high instantaneous luminosities more easily. Furthermore, the tunnel of circular colliders can be used to install a next-to-next proto-proton collisions at extremely high energies (100 TeV in the centre of mass).

While ILC and CLIC options have been studied extensively in the past, the CEPC and FCCee options should be more deeply investigated. In the last case, recent decisions of the European Strategy for particle physics gave the green light for exploring more concretely the FCC option. In particular, the design of the detector has to be optimized to match the specificities of e+e- collisions in a circular collider. Inner most parts of detectors are usually constituted of layers sensitive to charged particles. Such sub-detector, named trackers, allows to measure very precisely the path followed by charged particles through the sensors. In the presence of a magnetic field, the reconstructed trajectories of charge particles (tracks) allows to measure precisely their momenta and electric charges. Thus, the resolution and performances of tracking detectors has a crucial role of the capabilities of a detector to achieve ambitious physics reaches.

In this internship, we plan to study the impact of the tracker geometry on the detector performances in the context of the FCCee accelerator. Various detector geometries, in particular of the vertex detector, will be simulated with the TkLayout packages. Different options of module size and intrinsic resolutions can also be studied. The corresponding tracking performances (resolution, efficiency) will be estimated and compared with different scenarios. The outcome of the studies will potentially serve as a base for the design of a future tracker. The internship will take place within the Picsel group of IPHC.

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