Title: Upgrade and performance of the ATLAS tracking detector and R&D on CMOS detectors for the new experiments at the Future Circular Collider

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Equipe: ATLAS

Description:

The ATLAS experiment is one of the four main detectors installed at the Large Hadron Collider (LHC) hosted by the CERN[1] laboratory, close to Geneva, Switzerland.
The data collected during Run1 (2010-2012) and Run2 (2015-2018) allowed to observe a Higgs boson (H) of a mass of about 125 GeV, first in bosonic final states and then in fermionic ones. Run3 started in 2022, and should last till 2025, with the goal to integrate by that date about 450 fb^{-1} of data, doubling those collected at the end of Run2.
In parallel upgrades are taking place to transform the LHC into a high luminosity machine (HL-LHC); the final goal is to integrate data between 2029 and 2040 arriving at 3000-4000 fb^{-1}, to fully exploit the potential of the machine. This will allow to perform high precision measurements of Standard Model (SM) parameters and test several Beyond SM scenarios.
To achieve this goal in a reasonable timespan not only the LHC will see its instantaneous collision rate increasing by a factor 5-7, but also several detectors of the ATLAS experiment will be upgraded. In particular, the actual tracking and vertexing detector will not be able to sustain the high fluxes of particles of HL-LHC, nor the accumulation of radiation damage to its silicon sensors correlated with that, a factor 10 larger than today.

For these reasons a new Inner Tracker (ITk[2]) is being developed; the ITk detector will consist of pixels detectors in its innermost part and microstrips in the outer part. According to the current plans ITk should be ready for data-taking in 2029 when collisions will resume.

To understand the Higgs boson even better, an e+e- "Higgs factory" has been set as the priority for the European particle physics community after the LHC. Such Higgs factory could be the Future Circular Collider (FCC) project, which will use e+e- collisions in its first phase (FCC-ee). Detectors with excellent particle reconstruction and identification performance will be needed to achieve a precision better than 1% on the different couplings of the Higgs boson. Currently several R&D projects[3] to develop detectors that can provide the necessary performance are underway.

The APC ATLAS group has been strongly involved in silicon pixels R&D for ITk since many years, contributing to the studies on pixel sensors design, simulation, test, performance modeling and pre-production of ITk pixels modules. We are also engaged in R&D on CMOS detectors aimed at the FCC-ee. The plan is to test CMOS prototypes in laboratory and on beam, comparing the results with precise TCAD (Technology Computer Assisted Design) and MonteCarlo simulations.

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[1] cern.ch
[2] https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ITkPublicResults
[3] e.g. DRD3 group

The candidate will participate to the efforts of the pixel detector modules for ITk, by measuring them on beam in European laboratories (CERN, DESY[4]). The results will be compared to precise TCAD and MonteCarlo simulations to tune radiation damage models that later will be used to extrapolate detector performance in different data-taking conditions (voltage, radiation fluence). The candidate will also give a contribution in understanding the performance of the actual ATLAS pixel detector with the accumulation of radiation damage, a preparatory work for the ITk pixels part of the project.

The candidate will also participate to tests in laboratory and on beam of prototypes of monolithic pixels detectors developed in the 65nm CMOS technology, in collaboration with CERN, DESY and several other European research institutes. The work will be completed by precise TCAD and MonteCarlo simulations.

Working place: APC, Paris

Mobility: regular trips to CERN and DESY for testbeams. Presentation at an international conference and participation in a summer school in high energy physics.

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[4] desy.de