SIMULATIONS AND PHYSICS ANALYSIS FOR A VERTEX DETECTOR OPTIMIZATION OF A FUTURE HIGGS FACTORY (FCCEE/ILC): FROM HEAVY FLAVOR TAGGING TO LONG LIVED PARTICLES SEARCHES.

DIRECTEURS DE THESE : AUGUSTE BESSON ET ZIAD EL BITAR
GROUPE PICSEL,
INSTITUT PLURIDISCIPLINAIRE HUBERT CURIEN, DÉPARTEMENT RECHERCHE SUBATOMIQUE,
23 RUE DU LOESS - BP28 67037 STRASBOURG CEDEX 2
TEL : 03 88 10 68 01 ; E-MAIL : ABESSON@IN2P3.FR ET ZIAD.ELBITAR@IPHC.CNRS.FR

The PhD will be welcomed by the PICSEL group (Physics with Integrated Cmos Sensors and ELectron machines) which works closely with the microelectronic platform of IPHC. The PICSEL group has been engaged in a long-term effort to equip vertex detectors in e+e- machines with CMOS pixels sensors, and in particular in the future Higgs factory, considered as the highest priority next collider beyond LHC. There are 4 Higgs factory projects (ILC, FCCee, CEPC, CLIC) that could start in the 2030s. All of them contain a very rich Higgs physics program by producing (e+e- -> Z H) with a center of mass energy around sqrt(s) = 250 GeV.

The physics program of the Higgs factories will cover a wide spectrum, including studying the Higgs boson and measuring its properties very precisely but also top physics, electroweak physics and searches beyond the Standard Model. The expected precision of the measurements in the Higgs sector will be typically at the per mil level, improving significantly the HL-LHC measurements. This will allow constraining or excluding unambiguously the different theories beyond the Standard Model.

To accomplish this ambitious program, the foreseen detectors will have to reach unprecedented performances. The vertex detector, probably equipped with CMOS pixels sensors, will have to allow an impact parameter measurement resolution on the vertex of the order of 5 microns with a material budget below ~ 0.15% X0 per layer while being able to cope with the data flow governed by the beam background. The vertex detector will play a crucial role to tag heavy flavors (b and c quarks, tau leptons), to allow jet charge measurements and to reconstruct low momentum tracks.

The main goal of the PhD will be to perform a complete physics analysis using full simulation tools which will allow optimizing the vertex detector and the tracking system. The proposed physics benchmark which will be the core of the thesis consists in studying the long-lived particles (LLP) production in the golden channel (e+e- -> h + Z). Many Beyond Standard Model theories predict the existence of a long-lived particle which can have different signatures. The PhD program will focus on models where the LLP is relatively light and has relatively short flying distance before its decay (typically less than 1 meter). The Higgs boson may then decay into a pair of LLPs (such as Higgs boson coupled to BSM scalars) which will therefore decay somewhere inside the tracking detector. These very peculiar signatures will allow testing the inner tracking capabilities to reconstruct displaced vertex far from the interaction point.