Optimisation of a deep graph neural network to reconstruct a generic B decay at Belle II

The Belle II experiment, located near Tokyo in Japan, is a large international particle physics experiment, aiming to discover physics processes beyond the Standard Model of particle physics. Belle II operates since 2019 at the SuperKEKB asymmetric electron-positron collider facility, which targets the highest ever reached instantaneous luminosity of 6×10^{35} $cm^{-2}.s^{-1}$. Such luminosity will allow Belle II to record during the next decade a unique data set exceeding 50 billion $e^+e^-\rightarrow$bb, cc, $\ell\ell$ processes.

Decays with neutrinos in the final state are among the most promising to look for physics processes beyond the Standard Model of particle physics. Tantalising deviations from the Standard Model have recently been reported in the b → c l nu and b → s l l transitions. If the source of these anomalies is indeed new physics then also b → s nu nubar and b → tau tau transitions should be affected.

Belle II will remain in the foreseeable future the best experiment allowing to observe decays with neutrinos in the final state. In this experiment pairs of B mesons are produced in electron-positron collisions. As neutrinos from the signal are undetected the full event must be reconstructed to constrain their kinematic and correctly identify the signal decay. This requires to be able to reconstruct generically one of the two B mesons from one of its thousands of possible decay modes. Currently this task is performed by the Full Event Interpretation (FEI) algorithm. This consists of a hierarchical approach based on shallow classifiers in which final state particles are combined through several stages to form intermediate particles and finally the B candidate. In this approach the decay modes considered are explicitly defined and the total efficiency of the algorithm is a few percents.

The generic reconstruction of a B meson decay is a complex but hierarchical problem, with analogies to machine vision and other fields where deep learning brought tremendous improvements. In the framework of the FIDDLE ANR project we are developing a deep graph neural network to reconstruct a generic B decay directly from its final state particles without the need to explicitly define the possible decay modes. Preliminary studies shown that this algorithm can obtain a factor two improvement of the efficiencies at constant background.

During this internship, the student will optimise this deep graph neural network. He.she will studying which are the best variables to use as input and he.she will optimise the hyper-parameters of the model to obtain the best performance.

Nom, prénom et grade du responsable de stage : **Giulio DUJANY, CRCN et Jacopo CERASOLI, postdoc**
Téléphone : **03.88.10.62.28**
Email :giulio.dujany@iphc.cnrs.fr

Composition de l'équipe :
Varghese BABU (postdoctorant CNRS), Jérôme BAUDOT (PR Unistra), Jacopo CERASOLI (postdoctorant CNRS/ANR), Giulio DUJANY (CR CNRS), Christian FINCK (CR-HDR CNRS), Lucas MARTEL (doctorant Unistra), Isabelle RIPP-BAUDOT (DR CNRS, responsable du groupe), Petros STAVROULAKIS (doctorant Unistra).

Nom du responsable et intitulé du laboratoire d'accueil : **Sandrine COURTIN**
Adresse : **Institut Pluridisciplinaire Hubert Curien (IPHC)**
23 rue du Loess, BP 28 – 67037 STRASBOURG CEDEX 2