# Development of a new algorithm for automatic decay tree reconstruction of Belle II events

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 2018 at the SuperKEKB asymmetric electron-positron collider facility, which targets the highest ever reached instantaneous luminosity of $6\times10^{35}$ $cm^{-2}.s^{-1}$. Such luminosity will allow Belle II to record during the next decade a unique data set exceeding 50 billion $e^+e^-\rightarrow b\bar{b}, c\bar{c}$, $\tau^+\tau^-$ processes.

The collisions detected by Belle II present the unique feature that they produce pairs of particle and anti-particle, which decay in a relatively small amount of final particles. This specificity is exploited as a powerful tool to identify rare decays with or without missing energy (when neutrinos are present in the final state). In particular, automatic algorithms based on artificial intelligence can already identify final states with a few percent efficiency.
Current algorithms mostly use kinematic information of the final particles. However, the Belle II detector benefits from an excellent vertex detector, which performance might even improve in a few years thanks to an upgrade program under development. The detector precision allows to decide with great accuracy whether two tracks are actually coming from the same secondary vertex or not. Using this information recursively leads to the reconstruction of the entire decay tree for part of the collisions. Initial estimation showed that this method could reconstruct a significant fraction of the events (beyond the current few percent).

During this internship, the student will start implementing a first version of an algorithm based on reconstructed vertices to recognize the decay trees present in the event. This initial version will not use artificial intelligence in order to understand which type of vertices are well reconstructed and which are difficult to identify. The algorithm will be developed and tested on simulated data, focusing first on $e^+e^-\rightarrow b\bar{b}$ events. The first goal of the internship is to estimate the potential of this new method, even with a basic algorithm.
In addition, performance comparison of the algorithm with the current vertex detector geometry and with an upgraded geometry will be performed. The second internship goal is to understand how much such an algorithm based on vertices would benefit from an upgraded vertex detector.

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Name and title of supervisor: **Jérôme BAUDOT, professor**
Phone : **+33 (0)3 88 10 66 32**
Email :jerome.baudot@iphc.cnrs.fr

Team members:
**Varghese BABU (postdoc. CNRS), Jérôme BAUDOT (PR Unistra), Giulio DUJANY (CR CNRS), Tristan FILLINGER (PhD student CNRS), Christian FINCK (CR-HDR CNRS), Lucas MARTEL (PhD student Unistra), Isabelle RIPP-BAUDOT (DR CNRS, group leader).**

Lab direcor: **Sandrine COURTIN**
Lab name and adress: **Institut Pluridisciplinaire Hubert Curien (IPHC)**
**23 rue du Loess,  BP 28 – 67037 STRASBOURG CEDEX 2**