Master Thesis proposal :

Study of charmless b-hadron decays with the LHCb spectrometer
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Flavour tagging with advanced deep machine learning techniques

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The **LHCb experiment** , operating at the Large Hadron Collider at **CERN**, has successfully recorded proton collisions during the LHC Run 1 and 2 before undergoing a major upgrade before the restart of the LHC in 2022 for Run 3, allowing the detector to accumulate high quality data at a rate increased by a factor ~ 5. Thanks to a robust and flexible trigger system, the integrated luminosity at the end of Run 2 reached the level of $9\,\text{fb}^{-1}$, with a target of $\sim 50\,\text{fb}^{-1}$ by 2033. The Physics objectives of the LHCb experiment consists in the high **precision studies of rare decays and CP violation phenomena** in the heavy flavours (b, c, and τ) sector.

The charged current quark flavour transitions are described in the **Standard Model (SM)** by the **Cabibbo-Kobayashi-Maskawa (CKM) matrix**, which relates the quark mass eigenstates to the electroweak eigenstates. This is **intimately linked to the spontaneous symmetry breaking** of the electroweak symmetry. The existence of a non vanishing phase in that matrix is the unique source of CP violation in the SM and most of what we can learn experimentally on this quantity is brought by the observables belonging to the b-hadron decays and mixing phenomena.

The LHCb experiment started at the moment when the B-factories experiments (BaBar and Belle) completed their Physics program. The science produced at these facilities is simply impressive. The **KM paradigm** is actually established as the **main source of CP violation at the electroweak scale**. Yet, there are strong indications (mostly driven by cosmological observations) that **new sources of CP violation must exist**. The LHCb experiment is expected to **improve the precision on CKM parameters** in particular (it already did in some respects) and constrain further if not unravel these new CP violation sources. The Physics analyses developed in our group belong to this framework.

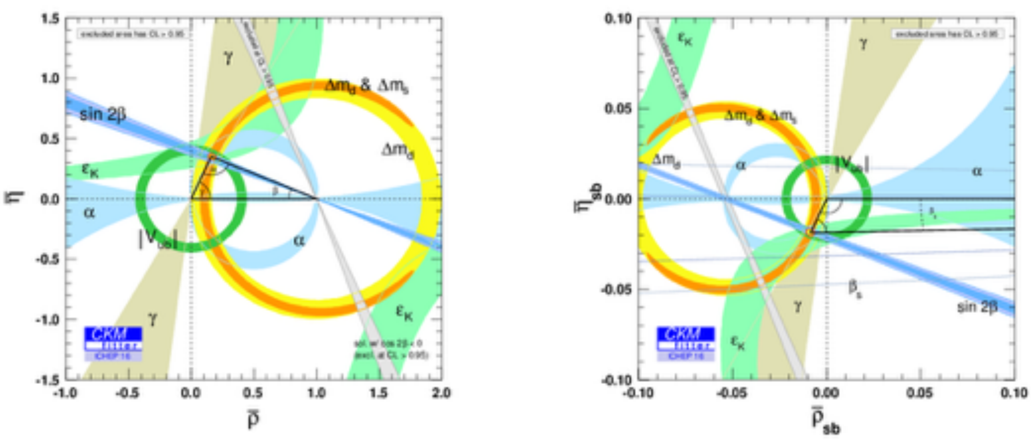

FIGURE 1 – Unitarity triangles related to β (left) and β_s (right).

Our team aims at measuring the weak phases which govern the amplitudes of the B^0_d and B^0_s mixing phenomena, which can be identified in the SM with the CKM angles β and β_s(Fig. 1). This can be realized by means of **Dalitz plane analyses of the charmless 3-body decays** of these mesons, including a K_S^0 in the final state. These measurements are requiring advanced techniques of the **decay amplitudes determination** as well as **flavour tagging (FT)**. The latter is a **key ingredient for all CP and mixing analysis** performed in LHCb as it is essential for the determination of the flavour of the decaying neutral B meson. The precision on the measured physics parameters are ultimately directly linked to the FT performances. **Advanced Deep Machine Learning techniques** appear promising to improve the FT performances, which would have a major impact on a wide range of measurements performed in the LHCb collaboration. Depending on the selected applicant preferences, the Master Thesis will either focus in installing the latter techniques OR in contributing to the Dalitz plane analysis framework we've developed, relying on the last developments reported on the thesis defended in our group.

The internship's subject can be **prolonged towards a PhD. program**.

Keywords : LHCb, LHC, ElectroWeak Standard Model, CP violation, B Mesons Mixing, Flavour Tagging, Deep Machine Learning