Charmless and Radiative transitions of B mesons with LHCb.

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The Standard Model of Particle Physics (SM), successfully confronted to five decades of experimental tests, well describes the current quarks and leptons data. Though, fundamental open questions still remain that justify the search for New Physics (NP) phenomena beyond the SM predictions. Among the four experiments installed on the Large Hadron Collider (LHC) at CERN, Geneva, two of them, Atlas and CMS, are performing direct searches of new particles. The purpose of the LHCb experiment is to conduct indirect searches of new phenomena through accurate measurements in the heavy quarks sector.
During its first campaigns of data taking (run1: 2010-2013 and run2 : 2015-2018) LHCb has collected an unprecedently large statistics of B hadron decays, paving the way for studying rare and very rare transitions. After a three-year shutdown and an important update of the detector, the LHCb experiment has now entered in its third period of data taking (run3), aiming at increasing the collected statistics by a factor four in the coming years.

In the SM, the charmless transitions of the b quark to u, d or s lighter quarks proceed via the flavour-changing charged current, $b \to u$, or via the neutral current, $b \to s(d)$. While the charged transition is allowed at the tree-level in the SM, with the emission of a charged W^- boson, the flavour-changing neutral current (FCNC) can only occur through loop-mediated transitions, as illustrated on the figure below for a radiative decay. The dynamics of those FCNC transitions is particularly sensitive to the possible NP spectrum allowed to propagate inside the virtual loops.

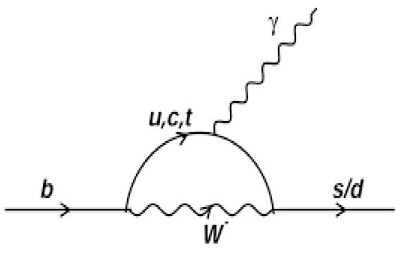

Figure 1: Penguin diagram dominating the FCNC $b \to q\gamma$ transition (q=s or d).

With a typical decay rate of few 10^{-5} the charmless decay modes of B mesons are relatively rare. Due to presence of light quarks, u or d, many interesting decays are producing one or several neutral pions in the final-state. The main signature of neutral pions is a pair of photons detected within the Electromagnetic Calorimeter system (Ecal) of the experiment. Similarly, the radiative decays are experimentally constrained by the high-energy radiated photon. Due to this singular electromagnetic signature, the reconstruction of the corresponding final-states are in general experimentally complicated. Nevertheless, many decay modes with one neutral pion or with an high-energy radiated photon have already been observed and explored at LHCb: $B_d/B^+/B_s/\Lambda_b \to (X_h)\gamma$, $B^0 \to (X_h)\pi^0$, ... where (X_h) generically represents a two- or three-body system of light hadrons. The LHCb group at LPC has been intensively engaged in the reconstruction of calorimetric objects and the related physics analysis. Several specific analysis are currently in progress in that sector and many possible developments and analysis extension can arise from them:

- charmless $B \to \rho\rho$ four-body final-states with one or two neutral pions: $B^+ \to \rho^+(\pi^+\pi^0)\rho^0(\pi^+\pi^-)$, $B^0 \to \rho^+(\pi^+\pi^0)\rho^-(\pi^-\pi^0)$ and similar topologies in the b-hadrons decays: $\Lambda_b \to ph^+h^-\pi^0$
- Unexplored radiative decays with neutral pions: $B^0 \to (h^+h^-\pi^0)\gamma$, $B_s \to \phi(\pi^+\pi^-\pi^0)\gamma$, $B^+ \to K^+\omega^0(\pi^+\pi^-\pi^0)\gamma$.
- Rare or yet unobserved radiative modes with neutral kaons: $B^0 \to (K_s^0K^+K^-)\gamma$, $B_s \to (K_s^0K^\pm\pi^\mp)\gamma$

The proposed internship will consist in identifying and exploring the most promising topologies, in term both of physics outcome and of experimental relevance. The retained candidate will contribute to the final-state reconsruction and to the definition of the signal selection.

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