Search for the rare radiative transitions $b \to d\gamma$ at LHCb.

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The Standard Model of Particle Physics (SM), successfully confronted to four decades of experimental tests, well describes all 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. In particular, LHCb has recorded the largest amount of radiative decays $X_b \to X_s\gamma$ where X_b represents a beautiful hadron, B^0, B^+, B_s or Λ_b, and X_s a strange hadron.

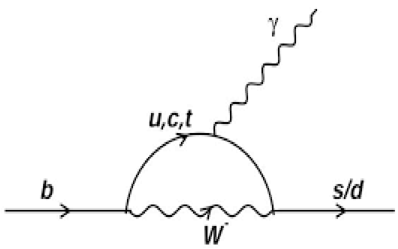

Figure 1: Diagramme pingouin radiatif dominant la transition $b \to q\gamma$.

With a branching ratio of about 10^{-5} the radiative B decays are rare. The SM accounts for this flavour-changing neutral transition $b \to s\gamma$ through loop-mediated currents, as illustrated on the above figure. The dynamics of the transition is particularly sensitive to the possible NP spectrum allowed to propagate inside the virtual loops.
The flavour transition $b \to d\gamma$ is even rarer because of the CKM suppression $|\frac{V_{td}}{V_{ts}}|^2$ that further reduces the branching ratio by a factor almost 4%. Such transitions have only been observed in the $B^{0,\pm} \to \rho^{0,\pm}\gamma$ exclusive modes by the Babar and Belle experiments operating during the 2000-2010 decade. Few tens of candidates have been recorded leading to a signal statistical significance of about 6 standard deviations for each of the two experiments.

The huge amount of data collected by LHCb should permit to reconstruct the exclusive $B^0 \to (\rho^0 \to \pi^+\pi^-)\gamma$ decays with a statistics at least one order of magnitude larger and, thus, to significantly improve its branching ratio measurement. A selection of $(\pi^+\pi^-)\gamma$ candidates is being developped in the LHCb group of the Laboratoire de Physique de Clermont (LPC). The main challenge of this analysis is to deal with the large background contaminations that may contribute to the reconstructed final-state. Several sources of background are involved: combinatorial backgrounds, mis-identification of charged hadrons in the final-state , partially reconstructed B decays, ...
The proposed internship will consist in the study and the modelisation of the various sources of backgrounds. A mass model will be designed accordingly, aiming at measuring the actual $B^0 \to (\pi^+\pi^-)\gamma$ signal contribution. In a second step, an amplitude analysis of the $(\pi^+\pi^-)$ hadronic system will be set-up to evaluate the exclusive $B^0 \to \rho^0(\to \pi^+\pi^-)\gamma$ signal component and to search for possible additional contributions from orbitally excited mesonic resonances, unobserved so far in such decay.

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