UNIVERSITÉ Clermont Auvergne

Chimie Mathématiques Sciences de l'Univers Physique

Ecole Doctorale des Sciences Fondamentales

Title: Study of rare baryonic-radiative decays of B mesons with LHCb

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Summary:

The Standard Model of Particles Physics (SM), successfully confronted to five decades of experimental tests, describes with precision 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 collection 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, radiative decays of b-hadrons proceed via Flavor-Changing Neutral Current, $b \to q\gamma$ ($q=s$ *or* d), that occurs through loop-mediated transitions. The dynamics of those FCNC transitions is particularly sensitive to the possible NP spectrum allowed to propagate inside the virtual loops.
With a decay rate of few 10^{-5} at most, radiative decays are relatively rare. Several of the dominant modes mediated by the $b \to s\gamma$ transition, such as $B^0 \to K^+\pi^-\gamma$, $B_s \to K^+K^-\gamma$, $B^+ \to K^+\pi^+\pi^-\gamma$ or $\Lambda_b \to pK^-\gamma$, have extensively been (and are still being) studied at LHCb. The full statistics of Run1-Run2, and the increasing Run3 dataset, now allows to explore some of the suppressed modes mediated by the $b \to d\gamma$ transition with a typical decay rate of few 10^{-7}, like $B^0 \to \pi^+\pi^-\gamma$ or $B_s \to K^{*0}\gamma$.
The LHCb group at LPCA is involved in several ongoing searches for these rare decay modes.

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The main purpose of this doctoral project is the search and the study of the yet unobserved radiative decays of the B mesons involving of pair of baryons in the final states, like $B^+\to p\Lambda^*(\to pK^+)\gamma$ ($b\to s\gamma$ transition) or, even more suppressed, $B^0\to pp\gamma$ ($b\to d\gamma$ transition). These baryonic-radiative decays, potentially accessible with the current statistics at LHCb, could provide interesting information about the di-baryon mass spectrum and possibly on the polarization structure of the emitted photons. Other rare and/or unobserved mesonic decays with a similar topology, such as $B^+\to K^+K^-K^+\gamma$, $B^+\to K^+K^-\pi^+\gamma$, or $B^+\to\pi^+\pi^-\pi^+\gamma$, will also be studied.

The retained PhD candidate will exploit the large LHCb dataset to explore these challenging topologies. He or she will develop the signal selection and study the different backgrounds that potentially contaminate the signal region. Due to the difficult hadronic environment and the expected large background contamination, multivariate tools will have to be setup. A detailed invariant-mass model describing the signal and the remaining backgrounds, will be built to isolate the signal and to further explore its dynamics.

The main experimental signature of the radiative decays at LHCb is driven by the high-energy photon in the final-state. The Electromagnetic Calorimeter that identifies the photon and reconstructs its momentum, plays a major role in the reconstruction and the selection performance. Technical developments related to the reconstruction and the identification of neutral objects for the Run 3 and future LHCb upgrade are foreseen.

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