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Studying the beauty mesons structure with radiative leptonic decays at the LHCb experiment

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The rare radiative leptonic decay $B^+ \rightarrow \ell^+ \nu_\ell \gamma$, with $\ell = \mu, e$, is considered a golden channel to probe the internal structure of the B meson through its Light-Cone Distribution Amplitude (LCDA). Predicted by the Standard Model with a Branching Ratio (BR) of $\mathcal{O}(10^{-6})$, it has not yet been observed. The most stringent upper limit on its BR has been set by the Belle experiment, while a search at a hadron collider such as LHC was long deemed unfeasible. A novel approach has been developed at the LHCb experiment, which exploits photons that convert to e^+e^- pairs in the material of the VERTex LOCator (VELO), allowing to extract the secondary B -vertex. Again, since the information on the final-state neutrino is lost, the corrected mass of the $\ell^+e^+e^-$ system serves as the main observable. A crucial aspect of the strategy is the modelling of backgrounds, dominated by the neutral meson decays $\pi^0 \rightarrow \gamma\gamma$ and $\eta \rightarrow \gamma\gamma$. The LHCb dataset also provides sensitivity to the analogous B_c^+ decay modes. The ongoing search for the decay $B^+ \rightarrow \mu^+ \nu_\mu \gamma$ with Run 2 data shows promising sensitivity, and a parallel analysis using Run 3 data has started. Benefiting from the latest detector upgrade and improved trigger efficiencies, the current Run 3 study targets both muon and electron channels with the aim of getting to the first observation of these $B_{(c)}^+$ decays, or at least of significantly constraining the existing upper limits on their BRs.

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