Measurements of $B \to \mu^+\mu^-$ decays using the LHCb Experiment

Hannah Mary Evans

Abstract

This dissertation documents a study of very rare B-meson decays at the LHCb experiment, using data taken during the first experiment run ofthe Large Hadron Collider (LHC) and during the second experiment run until September 2016.

The LHCb experiment was designed to test the Standard Model of particle physics and to search for New Physics effects that go beyond the scope of the Standard Model through the decay of b hadrons produced in high energy proton-proton collisions at the LHC. The measurements described in this dissertation are made using data samples of proton-proton collisions with integrated luminosities of 1.0, 2.0 and 1.4 fb^{-1}, collected at centre-of-mass energies of 7, 8 and 13 TeV, respectively.

The branching fractions of the very rare $B^0 \to \mu^+\mu^-$ and $B_s^0 \to \mu^+\mu^-$ decays and the effective lifetime of $B_s^0 \to \mu^+\mu^-$ decays are precisely predicted by the Standard Model and are sensitive to effects from New Physics. New Physics processes could influence the $B_s^0 \to \mu^+\mu^-$ branching fraction and effective lifetime independently, and therefore the two observables are complementary.

The $B_s^0 \to \mu^+\mu^-$ decay is observed with a statistical significance of 7.8σ and the branching fraction is measured to be $\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.0 \pm 0.6^{+0.3}_{-0.2}) \times 10^{-9}$. The $B_s^0 \to \mu^+\mu^-$ effective lifetime is measured for the first time as $2.04 \pm 0.44 \pm 0.05$ ps. The $B^0 \to \mu^+\mu^-$ branching fraction is measured as $\mathcal{B}(B^0 \to \mu^+\mu^-) = (1.5^{+1.2+0.2}_{-1.0-0.1}) \times 10^{-10}$ with a statistical significance of 1.6σ. An upper limit is set for the branching fraction of $\mathcal{B}(B^0 \to \mu^+\mu^-) < 3.4 \times 10^{-10}$ at the 95% confidence level. All results are consistent with the predictions of the Standard Model.

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Declaration

This dissertation is the result of my own work, except where work done in collaboration with others is specified in the text. No part of it has been submitted for another qualification at this or any other University. Finally, this dissertation does not exceed the word limit set by the respective Degree Committee.

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