HINTS OF NEW PHYSICS IN RARE BEAUTY-HADRON DECAYS

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01 INTRODUCTION

Does the Standard Model (SM) start to show its shortcomings? The LHCb experiment at CERN sees hints of different behaviour between electrons and muons, which could hint at possible new particles or interactions beyond the Standard Model. Multiple recent LHCb analyses studying this 'lepton- flavour universality' see tensions with the SM predictions [1,2]. An example decay is shown in Fig. 1.

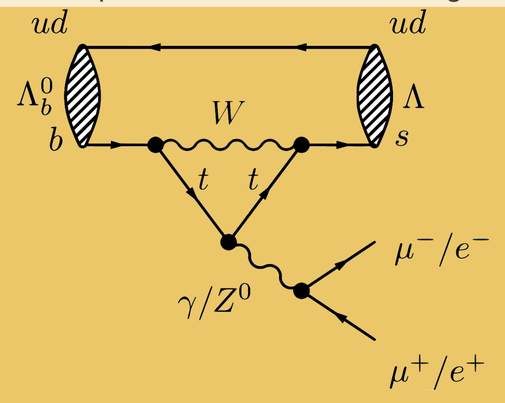
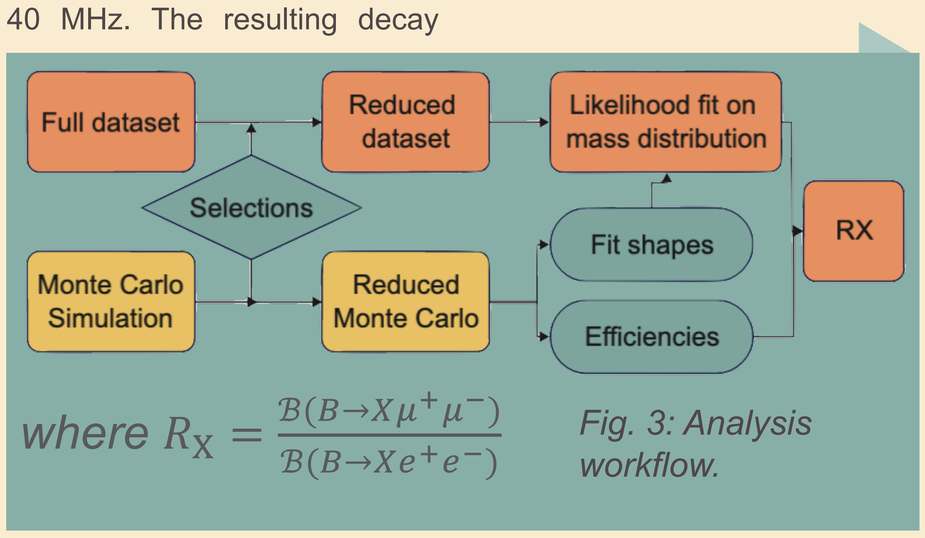


Fig. 1: Feynman diagram of $\Lambda_b^0 \to \Lambda l^+ l^-$ decay

02 THE LHCb DETECTOR AND DATA ANALYSIS

LHCb is one of the four major Large Hadron Collider experiments at CERN studying the interactions of particles through high-energy proton-proton collisions happening at 40 MHz. The resulting decay products are reconstructed using multiple subdetectors to measure their energy and particle type (Fig. 2). Fig. 3 shows the data analysis flow that is followed in the analyses.



where $R_X = \frac{\mathcal{B}(B \to X\mu^+\mu^-)}{\mathcal{B}(B \to Xe^+e^-)}$

Fig. 3: Analysis workflow.

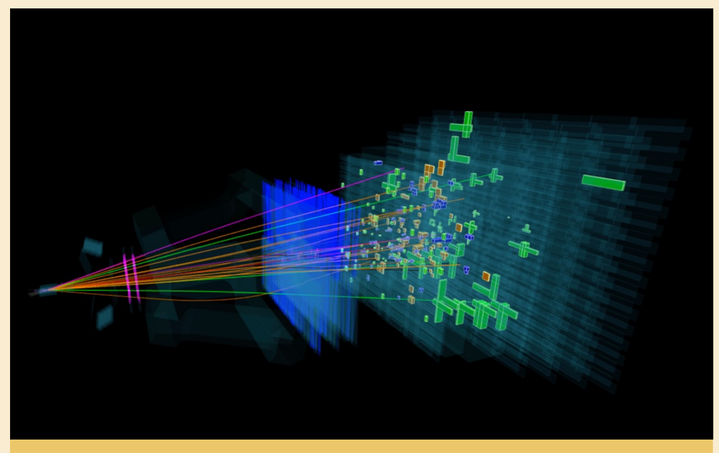


Fig. 2: Event display [6] of a proton-proton collision in the LHCb detector. For an online interactive visualisation, scan the QR code.

03 RESULTS

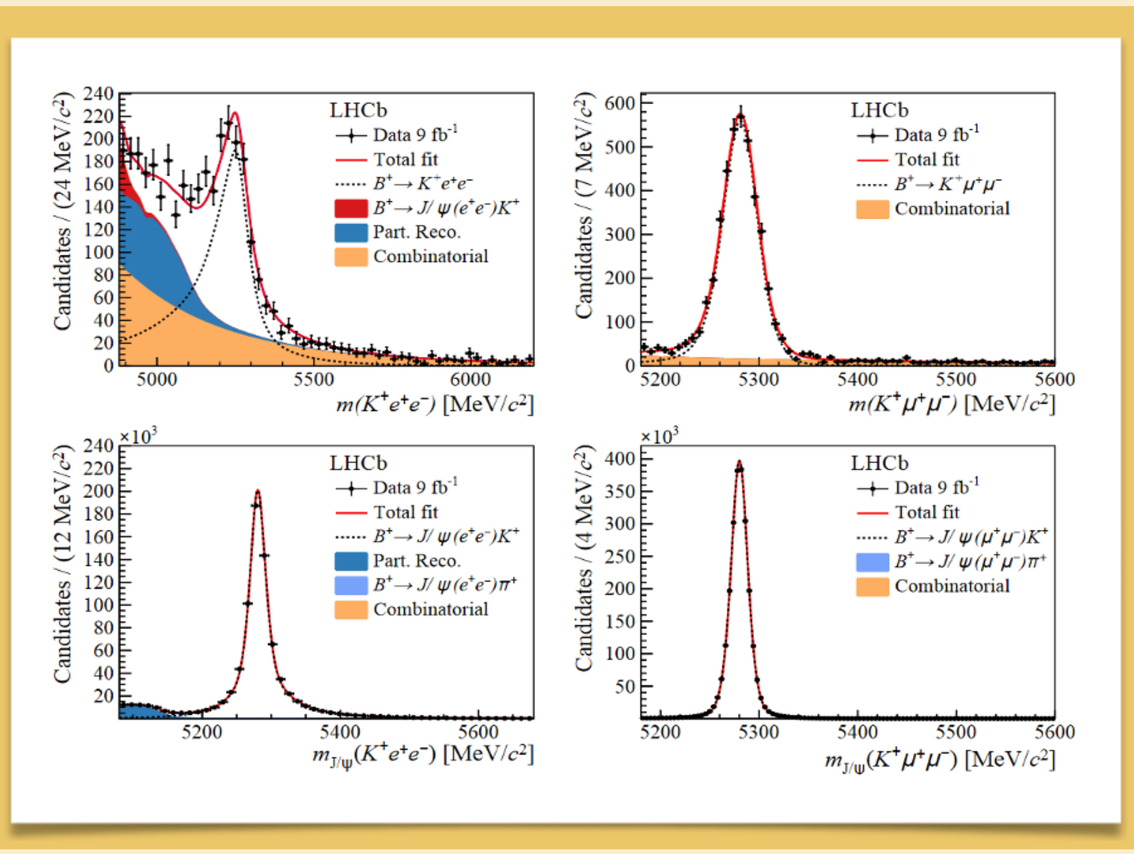


Fig. 4: Signal decays are identified through their invariant mass. The invariant mass of the reconstructed particles for signal $B^\pm \to K^\pm \ell^+ \ell^-$ and $B^\pm \to K^\pm J/\psi(\to \ell^+ \ell^-)$ control mode decays after all selections using the full LHCb dataset are shown on the left [1].

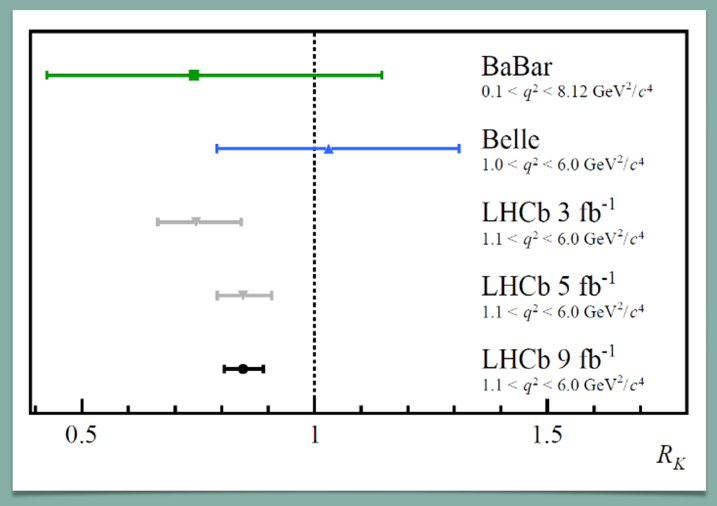


Fig. 5: Measured R_K values by BaBar, Belle, and LHCb [1]. The SM value, 1, is shown with the dotted vertical line.

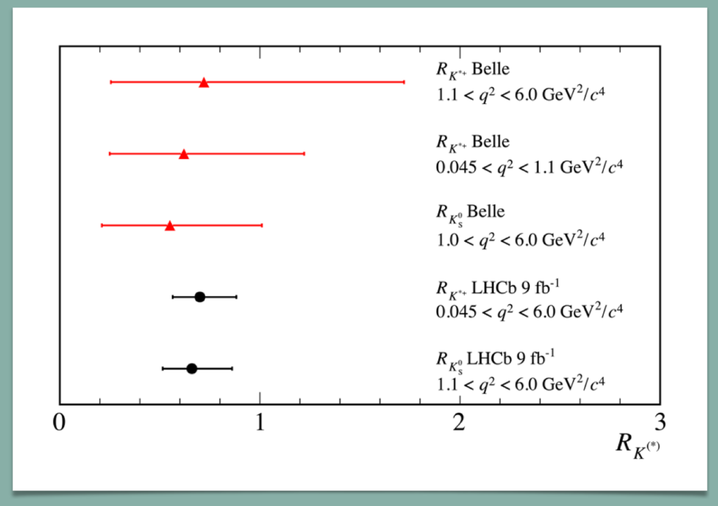


Fig. 6: Measured $R_{K_S^0}$ and $R_{K^{*+}}$ values by Belle and LHCb [2].

04 DISCUSSION

- The obtained results potentially indicate a reduction in the muon branching fraction.
- The R_K measurement [1] (Fig. 4 and 5) has the lowest uncertainty and shows a deviation of 3.1 std. dev. away from its SM value of 1.
- The $R_{K_S^0}$ *and* $R_{K^{*+}}$ measurements [2] (Fig. 6) also show a deviation in the same direction, although with a lower significance due to higher statistical uncertainties.
- Multiple New Physics models have been proposed to explain these anomalies, among which a new Z' boson or a leptoquark [4,5].
- We are currently working on an analysis using rare Λ_b^0 decays as an independent baryonic crosscheck to the presented mesonic results.

05 CONCLUSION

The LHCb experiment at the LHC at CERN has performed multiple 'lepton flavour universality' tests, and sees a pattern of deviations to lower values than the expected Standard Model prediction of 1. The current R_K measurement is 3.1 std. dev. removed from the SM value. These 'anomalies' could potentially be explained by the existence of leptoquarks or a Z' boson. Further analyses and an upgraded LHCb detector will hopefully be able to determine if there is New Physics in $b \to sl^+l^-$ decays.

References

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[6] https://www.nikhef.nl/~mvegh/eventdisplay/

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