PROCEEDINGS OF SCIENCE

Rare decays at LHCb

Thomas Long[a,*] **on behalf of the LHCb collaboration**

[a] *Cavendish Laboratory, University of Cambridge, J J Thomson Avenue, Cambridge, United Kingdom*

E-mail: thomas.long@cern.ch

Rare decays, mediated by flavour-changing neutral currents (FCNCs), are highly suppressed in the standard model (SM) and are consequently sensitive probes of physics beyond the SM. The LHCb experiment has produced a broad range of rare decays measurements, setting important constraints on new physics (NP). These proceedings summarise three recent representative results: a comprehensive analysis of the decay $B^0 \to K^{*0}\mu^+\mu^-$ which reinforces existing tensions with SM predictions in both branching fractions and angular observables, a search for the lepton flavour violating (LFV) decay $B^0 \to K^{*0}\tau^\pm e^\mp$ setting the most stringent limits to date on $b \to s\tau e$ transitions, and a test of lepton flavour universality (LFU) using $B_s^0 \to \phi\ell^+\ell^-$ decays which is the first LFU test with rare B_s^0 decays and includes the first observation of $B_s^0 \to \phi e^+e^-$. These analyses demonstrate the precision and reach of the LHCb rare decays programme which is setting increasingly stringent limits on NP.

The 17th International Conference on Heavy Quarks and Leptons (HQL 2025)
15-19 September, 2025
Peking University, Beijing, China

*Speaker

https://pos.sissa.it/

PoS(HQL2025)084

1. Introduction

Searches for physics beyond the Standard Model (SM) can be performed either directly or indirectly. In direct searches, new particles are produced on-shell at high energies. Such searches are limited by the centre-of-mass energy $\sqrt{s}$ of the collisions, meaning that new physics (NP) remains inaccessible if the mass scale lies beyond experimental reach. In contrast, indirect searches probe the virtual effects of heavy particles through precise measurements of low-energy processes. Even when new states cannot be produced directly, they can contribute via higher-order interactions, leading to deviations from SM predictions. Indirect searches therefore provide a complementary approach to direct searches, extending sensitivity to NP.

Rare decays of heavy flavoured hadrons are amongst the most powerful tools for indirect searches. These processes are mediated by flavour-changing neutral currents (FCNCs) which are forbidden at tree-level in the SM and occur only through higher-order electroweak loops. As a result, their branching fractions are highly suppressed, typically of order 10^{-5} or less. This suppression enhances their sensitivity to contributions from new heavy particles, which can modify decay rates, angular distributions, and asymmetries.

Rare decays can be described with model-independent effective theory. In this formalism, the effects of heavy degrees of freedom are encoded in local operators $O_i^{(\prime)}$ and their corresponding Wilson coefficients $C_i^{(\prime)}$, which capture short-distance physics. In $b \to s\ell^+\ell^-$ transitions, the key operators include $O_7^{(\prime)}$, $O_9^{(\prime)}$, and $O_{10}^{(\prime)}$, associated respectively with electromagnetic, vector, and axial-vector interactions. Different effective couplings sensitive to NP scenarios dominate in different regions of the dilepton invariant mass squared (q^2) which motivates measuring observables in bins of q^2 [1].

Rare decays can be probed experimentally through two key types of observables: branching fractions and angular distributions. Branching fractions measure the probability for a particle to decay into a specific final state, typically determined relative to a well-measured control mode to reduce systematic uncertainties. Recent measurements of differential branching fractions as a function of q^2 have shown tensions with SM predictions in several decay modes, including $B^0 \to K^{*0}\mu^+\mu^-$ and $B_s^0 \to \phi\mu^+\mu^-$ [3, 5]. Such anomalies could hint at modifications to relevant $C_i^{(\prime)}$ coefficients, and hence to potential NP contributions.

Angular analyses of rare decays provide additional and complementary sensitivity. Angular distributions encode correlations amongst the final-state particles that reflect the spin structure and short-distance dynamics. The differential decay rate can be decomposed into spherical harmonics, yielding angular coefficients that serve as key observables. By forming linear combinations of these coefficients, so-called optimised observables such as P_5' can be constructed, which cancel leading-order hadronic uncertainties and provide cleaner probes of short-distance dynamics.

Branching ratios and angular observables can also be combined into tests of lepton flavour universality (LFU). In the SM, the couplings of charged leptons to gauge bosons are identical, neglecting minor corrections due to lepton masses and QED effects. This leads to precise predictions in the ratios of branching fractions and angular observables between analogous decay modes with different lepton generations in the final state. A significant deviation from unity in these ratios would constitute evidence of NP. Moreover, these ratios are largely insensitive to hadronic form-factor uncertainties, making them particularly robust observables for experimental tests.

PoS(HQL2025)084

The LHCb experiment has produced a range of results in the study of rare decays, particularly in $b \to s\ell^+\ell^-$ transitions. These proceedings focus on three recent representative analyses: a comprehensive analysis of the decay $B^0 \to K^{*0}\mu^+\mu^-$, a search for lepton flavour violation (LFV) in the decay $B^0 \to K^{*0}\tau^\pm e^\mp$ and a test of LFU using $B^0_s \to \phi\ell^+\ell^-$ decays (denoted R_ϕ).

2. A comprehensive analysis of $B^0 \to K^{*0}\mu^+\mu^-$

The decay $B^0 \to K^{*0}\mu^+\mu^-$ is one of the decays involving $b \to s\ell^+\ell^-$ transitions which have shown tensions with SM predictions. The tension for $B^0 \to K^{*0}\mu^+\mu^-$ has not just been observed at LHCb but also at CMS, with measurements of observables such as P'_5 and the forward backward asymmetry A_{FB} showing consistent deviations [4–6]. These results lead to global fits which show a preference for non-SM values of effective couplings.

LHCb has recently released a comprehensive analysis of $B^0 \to K^{*0}\mu^+\mu^-$ that reinforces the observed tensions [7]. These results supersede the previous LHCb analysis [5], almost doubling the dataset ($\mathcal{L}_{\mathrm{int}} = 8.4\ \mathrm{fb}^{-1}$) and retuning the selection to improve the signal efficiency and background rejection. An extensive set of observables are extracted: the analysis simultaneously measures CP-averaged and CP-violating observables, it measures all $\mathcal{S}$-wave and interference observables and it completes a model-independent measurement of the differential branching fraction. The analysis also considers the effects of lepton mass which is particularly important at low q^2, and widens the $K\pi$ invariant mass ($m(K\pi)$) window which increases the sensitivity to the $\mathcal{S}$-wave contribution.

The measurements are extracted with a 5D simultaneous fit in bins of q^2 to the invariant mass of the final state particles $m(K\pi\mu\mu)$, $m(K\pi)$, and the three decay angles θ_ℓ, θ_K, and ϕ. Multiple fit configurations are used to extract different sets of observables, including configurations in the optimised versus non-optimised observable basis, CP-averaged versus CP-asymmetric and nominal (eight) versus finer (16) q^2 bins.

As illustrated in Fig. 1, the measured differential branching fraction (left) is found to be consistently below SM predictions, and compatible with previous $B^0 \to K^{*0}\mu^+\mu^-$ results. The dominant uncertainty is associated with the normalisation mode. Tensions in A_{FB} and P'_5 persist,

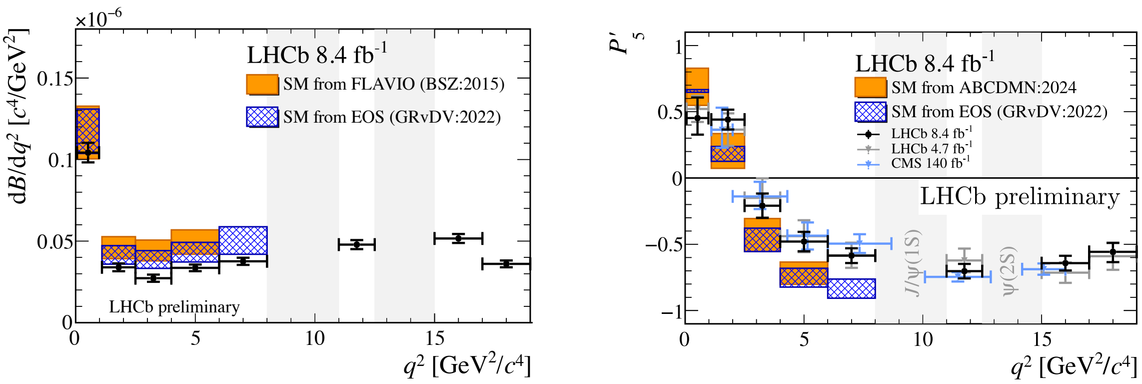

Figure 1: Differential branching fraction of $B^0 \to K^{*0}\mu^+\mu^-$ (left) and the optimised observable P'_5 (right) as a function of q^2 [7]. Both measurements are in tension with SM predictions, and are consistent with previous measurements.

in particular in low to intermediate q^2 bins ($1.1 < q^2 6.0\ \mathrm{GeV}^2/c^4$), where P_5' is consistently above SM predictions and A_{FB} is consistently below.

3. Search for LFV with $B^0 \to K^{*0}\tau^\pm e^\mp$ decays

Lepton flavour is conserved at tree level in the SM and this conservation arises as an accidental global symmetry, meaning it is not enforced by any underlying principle. However, it is known that lepton flavour is violated in the neutrino sector from neutrino oscillations [10–17]. In the charged sector, predictions for LFV rates are immeasurably small at $O(10^{-54})$ [18]. Many NP scenarios that violate LFU, for instance through Z' bosons or leptoquark mediators, can enhance LFV decay rates [19].

Many LFV searches have been performed at flavour physics facilities. LHCb has conducted searches with μe [20–22] and $\tau\mu$ [23–26] final states. However, until recently decays with τe have only been explored at BaBar and Belle [27–35]. The most stringent limit on $b \to s\tau e$ transitions was set by Belle with the $B^+ \to K^+\tau^\pm e^\mp$ decay which was $\mathcal{B}(B^+ \to K^+\tau^\pm e^\mp) < 1.5 \times 10^{-5}$ at the 90% confidence level [36].

This analysis is the first search for the cLFV decay $B^0 \to K^{*0}\tau^\pm e^\mp$ and was carried out using the Run 2 dataset ($\mathcal{L}_{\mathrm{int}} = 5.4\ \mathrm{fb}^{-1}$) recorded by LHCb [38]. The decay modes $B^0 \to K^{*0}\tau^+ e^-$ and $B^0 \to K^{*0}\tau^- e^+$ are treated independently. These decays have different background considerations and are affected differently by extensions to the SM [37]. The $K^*(892)^0$ meson is reconstructed through its decay into a kaon and a pion, while the τ is reconstructed through the decays $\tau^\mp \to \pi^\mp\pi^\pm\pi^\mp\nu_\tau$ and $\tau^\mp \to \pi^\mp\pi^\pm\pi^\mp\pi^0\nu_\tau$, where the ν_τ and π^0 are not reconstructed. Missing energy from the unreconstructed particles results in the invariant mass of final state particles not peaking at the B^0 mass. Therefore, a kinematic fit to the decay chain which imposes constraints on the vertices and the τ mass is used. In addition, this analysis makes use of a dedicated trigger selection and multi-stage BDT selection targetting backgrounds from random track combinations and physical backgrounds. Together with the constrained kinematic fit, these elements lead to improved sensitivity relative to similar LFV searches [25]. The decay $B^0 \to D^-(\to K^+\pi^-\pi^+)D_s^+(\to K^+K^-\pi^+)$ is used as the normalisation channel.

Upper limits are set on the branching fractions for both decay modes at the 90(95%) confidence level as $\mathcal{B}(B^0 \to K^{*0}\tau^+ e^-) < 4.9(5.9) \times 10^{-6}$ and $\mathcal{B}(B^0 \to K^{*0}\tau^- e^+) < 5.9(7.1) \times 10^{-6}$, which are the most stringent limits on $b \to s\tau e$ transitions to date. These results are obtained assuming a phase-space model for the signal decays. Similar limits were obtained considering two NP models.

4. Test of LFU with $B_s^0 \to \phi\ell^+\ell^-$ decays (R_ϕ)

The branching fraction of $B_s^0 \to \phi\mu^+\mu^-$ has previously been measured by LHCb to be $\mathcal{B}(B_s^0 \to \phi\mu^+\mu^-) = (8.14 \pm 0.21 \pm 0.16 \pm 0.03 \pm 0.39) \times 10^{-7}$ and belongs to the group of branching fraction measurements in tension with the SM, with the measurement being systematically below theoretical predictions [3]. The LFU ratio R_ϕ denotes the ratio of branching fractions between $B_s^0 \to \phi e^+e^-$ and $B_s^0 \to \phi\mu^+\mu^-$. This analysis is the first test of LFU using B_s^0 decays.

The analysis is completed with the full Run 1 and Run 2 dataset ($\mathcal{L}_{\mathrm{int}} = 9\ \mathrm{fb}^{-1}$) collected by LHCb [39]. The measurement is performed in three bins of q^2: $0.1 < q^2 < 1.1\ \mathrm{GeV}^2$ (low),

Table 1: Measurements of R_ϕ^{-1} and $\mathrm{d}\mathcal{B}(B_s^0 \to \phi e^+e^-)/\mathrm{d}q^2$ in the low-, central- and high-q^2 bins [39]. The first uncertainty is statistical, while the remaining are systematic. The third and fourth uncertainty on the differential branching fraction are due to the experimental uncertainty on the ratio $\mathrm{d}\mathcal{B}(B_s^0 \to \phi\mu^+\mu^-)/\mathrm{d}q^2/\mathcal{B}(B_s^0 \to J/\psi\phi)$ [3] and $\mathcal{B}(B_s^0 \to J/\psi\phi)$ [41, 42], respectively.

q^2 [GeV^2/c^4]	R_ϕ^{-1}	$\mathrm{d}\mathcal{B}(B_s^0 \to \phi e^+e^-)/\mathrm{d}q^2$ [10^{-7} GeV^{-2}c^4]
$0.1 < q^2 < 1.1$	$1.57^{+0.28}_{-0.25} \pm 0.05$	$1.38^{+0.25}_{-0.22} \pm 0.04 \pm 0.19 \pm 0.06$
$1.1 < q^2 < 6.0$	$0.91^{+0.20}_{-0.19} \pm 0.05$	$0.26 \pm 0.06 \pm 0.01 \pm 0.01$
$15.0 < q^2 < 19.0$	$0.85^{+0.24}_{-0.23} \pm 0.10$	$0.39 \pm 0.11 \pm 0.04 \pm 0.02 \pm 0.02$

$1.1 < q^2 < 6.0$ GeV^2 (central), and $15 < q^2 < 19$ GeV^2 (high). The analysis exploits the narrow $\phi \to K^+K^-$ width which helps reduce background contributions and facilitates including the high q^2 bin for the first time at LHCb. Particle identification requirements reduce $B^0 \to K^{*0}(\to K\pi)\ell\ell$ and $\Lambda_b^0 \to pK\ell\ell$ decays to negligible levels. $B_s^0 \to D_s^-(\to \phi\pi^-)\ell\nu_\ell$ decays, where the π^- is mistakenly identified as a lepton, are rejected by removing candidates if the $\phi\ell^-$ mass is consistent with that of a D_s^- meson after the pion mass has been assigned to the lepton. This veto also removes potential background from $B_s^0 \to D_s^-(\to \phi\pi)\pi$ decays with double misidentification. Combinatorial backgrounds are suppressed with a BDT classifier and a dedicated BDT for high-q^2 is trained to deal with leakage from $B_s^0 \to J\psi\phi$ decays. Yields are extracted from unbinned extended maximum-likelihood fits to the invariant mass distributions in each q^2 bin.

Together with [41], this is the first observation of $B_s^0 \to \phi e^+e^-$ at low and central-q^2. The differential branching fraction $\mathrm{d}\mathcal{B}(B_s^0 \to \phi e^+e^-)/\mathrm{d}q^2$ and R_ϕ^{-1} measurements in each q^2 bin are shown in Tab. 1. The measurement of R_ϕ is consistent with the SM expectation. As implied by the values obtained for R_ϕ, $\mathrm{d}\mathcal{B}(B_s^0 \to \phi e^+e^-)/\mathrm{d}q^2$ is consistent with that of the $B_s^0 \to \phi\mu^+\mu^-$ decay and lies below the central value of the SM prediction in the central- and high-q^2 bins. These results are statistically limited with the largest systematic uncertainty attributed to modelling of the signal and background in the likelihood fits.

5. Conclusion and Outlook

The LHCb experiment continues to deliver world-leading results in studies of rare decays, as highlighted in these proceedings. The comprehensive analysis of the decay $B^0 \to K^{*0}\mu^+\mu^-$ reinforces long-standing tensions in branching fractions and angular observables, with new measurements exhibiting improved precision, and consistency with previous deviations. The first search for the LFV decay $B^0 \to K^{*0}\tau^\pm e^\mp$ sets the most stringent limits to date on $b \to s\tau e$ transitions, extending the experimental coverage of LFV channels at LHCb into previously unexplored modes. The test of LFU with $B_s^0 \to \phi\ell^+\ell^-$ decays, constituting the first test of LFU with B_s^0, finds results consistent with previous $B_s^0 \to \phi\ell^+\ell^-$ studies and includes the first observation of the $B_s^0 \to \phi e^+e^-$ in low- and central-q^2 bins. Together, these results exemplify the breadth and precision of rare decay studies at LHCb and their continued potential to reveal signs of NP. Looking ahead, the Run 3 dataset will enable new searches, first observations, and increasingly stringent tests of the SM thanks to the novel trigger system and unprecedented integrated luminosity.

PoS(HQL2025)084

References

[1] W. Altmannshofer, P. Ball, A. Bharucha, A. J. Buras, D. M. Straub and M. Wick, *Symmetries and Asymmetries of $B \to K^{*}\mu^{+}\mu^{-}$ decays in the Standard Model and beyond*, *JHEP* **01** (2009) 019, doi:10.1088/1126-6708/2009/01/019, arXiv:0811.1214 [hep-ph].

[2] LHCb Collaboration, *Differential branching fraction and angular analysis of the decay $B^{0} \to K^{*0}\mu^{+}\mu^{-}$*, *JHEP* **08** (2013) 131, doi:10.1007/JHEP08(2013)131, arXiv:1304.6325 [hep-ex].

[3] LHCb Collaboration, *Branching Fraction Measurements of the Rare $B_{s}^{0} \to \phi\mu^{+}\mu^{-}$ and $B_{s}^{0} \to f_{2}^{\prime}(1525)\mu^{+}\mu^{-}$ Decays*, *Phys. Rev. Lett.* **15** (2021) 127, doi:10.1103/PhysRevLett.127.151801, arXiv:2105.14007 [hep-ex].

[4] LHCb Collaboration, *Angular analysis of the $B^{0} \to K^{*0}\mu^{+}\mu^{-}$ decay using 3 fb^{-1} of integrated luminosity*, *JHEP* **02** (2016) 104, doi:10.1007/JHEP02(2016)104, arXiv:1512.04442 [hep-ex].

[5] LHCb Collaboration, *Measurement of CP-averaged observables in $B^{0} \to K^{*0}\mu^{+}\mu^{-}$ decay*, *Phys. Rev. Lett.* **125** (2020) 011802, doi:10.1103/PhysRevLett.125.011802, arXiv:2003.04831 [hep-ex].

[6] CMS Collaboration, *Angular analysis of the $B^{0} \to K^{*}(892)^{0}\mu^{+}\mu^{-}$ decay in proton-proton collisions at $\sqrt{s} = 13$ TeV*, *Phys. Lett. B* **864** (2025) 139406, doi:10.1016/j.physletb.2025.139406, arXiv:2411.11820 [hep-ex].

[7] LHCb collaboration, *A comprehensive analysis of the decay $B^{0} \to K^{*0}\mu^{+}\mu^{-}$*, LHCB-PAPER-2025-041-001 in preparation (2025).

[8] B. Capdevila, A. Crivellin and J. Matias, *Review of semileptonic B anomalies*, *Eur. Phys. J. Spec. Top.* **233** (2023) 2, 409-428, doi:10.1140/epjs/s11734-023-01012-2, arXiv:2309.01311 [hep-ex].

[9] LHCb Collaboration, *Differential branching fractions and isospin asymmetries of $B \to K^{(*)}\mu^{+}\mu^{-}$ decays*, *JHEP* **6** (2014) 133, doi:10.1007/jhep06(2014)133, arXiv:1403.8044 [hep-ex].

[10] Super-Kamiokande Collaboration, Y. Fukuda *et al.*, *Evidence for oscillation of atmospheric neutrinos*, *Phys. Rev. Lett.* **81** (1998) 1562, doi:10.1103/PhysRevLett.81.1562, arXiv:hep-ex/9807003.

[11] SNO Collaboration, Q. R. Ahmad *et al.*, *Measurement of the rate of $\nu_{e} + d \to p + p + e^{-}$ interactions produced by ^{8}B solar neutrinos at the Sudbury Neutrino Observatory*, *Phys. Rev. Lett.* **87** (2001) 071301, doi:10.1103/PhysRevLett.87.071301, arXiv:nucl-ex/0106015.

[12] OPERA Collaboration, N. Agafonova *et al.*, *Observation of a first ν_{τ} candidate in the OPERA experiment in the CNGS beam*, *Phys. Lett. B* **691** (2010) 138, doi:10.1016/j.physletb.2010.06.022, arXiv:1006.1623 [hep-ex].

[13] T2K Collaboration, K. Abe *et al.*, *Evidence of electron neutrino appearance in a muon neutrino beam*, *Phys. Rev. D* **88** (2013) 032002, doi:10.1103/PhysRevD.88.032002, arXiv:1304.0841 [hep-ex].

[14] NOvA Collaboration, P. Adamson *et al.*, *First measurement of muon-neutrino disappearance in NOvA*, *Phys. Rev. D* **93** (2016) 051104, doi:10.1103/PhysRevD.93.051104, arXiv:1601.05037 [hep-ex].

[15] Double Chooz Collaboration, Y. Abe *et al.*, *Indication of reactor $\bar{\nu}_e$ disappearance in the Double Chooz experiment*, *Phys. Rev. Lett.* **108** (2012) 131801, doi:10.1103/PhysRevLett.108.131801, arXiv:1112.6353 [hep-ex].

[16] Daya Bay Collaboration, F. P. An *et al.*, *Observation of electron-antineutrino disappearance at Daya Bay*, *Phys. Rev. Lett.* **108** (2012) 171803, doi:10.1103/PhysRevLett.108.171803, arXiv:1203.1669 [hep-ex].

[17] RENO Collaboration, J. K. Ahn *et al.*, *Observation of reactor electron antineutrino disappearance in the RENO experiment*, *Phys. Rev. Lett.* **108** (2012) 191802, doi:10.1103/PhysRevLett.108.191802, arXiv:1204.0626 [hep-ex].

[18] S. Davidson, B. Echenard, R. H. Bernstein, J. Heeck and D. G. Hitlin, *Charged Lepton Flavor Violation*, arXiv:2209.00142 [hep-ex].

[19] W. Altmannshofer and J. Zupan, *Snowmass White Paper: Flavor Model Building*, arXiv:2203.07726 [hep-ph].

[20] LHCb collaboration, R. Aaij et al., *Search for the lepton-flavour violating decays $B^0_{(s)} \to e^\pm\mu^\mp$*, *JHEP* **03** (2018) 078, arXiv:1710.04111.

[21] LHCb collaboration, R. Aaij et al., *Search for the lepton-flavour violating decays $B^+ \to K^+\mu^\pm e^\mp$*, *Phys. Rev. Lett.* **123** (2019) 231802, arXiv:1909.01010.

[22] LHCb collaboration, R. Aaij et al., *Search for the lepton-flavour violating decays $B^0 \to K^{*0}\mu^\pm e^\mp$ and $B^0_s \to \phi\mu^\pm e^\mp$*, *JHEP* **06** (2023) 073, arXiv:2207.04005.

[23] LHCb collaboration, R. Aaij et al., *Search for the lepton-flavour-violating decays $B^0_s \to \tau^\pm\mu^\mp$ and $B^0 \to \tau^\pm\mu^\mp$*, *Phys. Rev. Lett.* **123** (2019) 211801, arXiv:1905.06614.

[24] LHCb collaboration, R. Aaij et al., *Search for the lepton flavour violating decay $B^+ \to K^+\mu^-\tau^+$ using B^{*0}_{s2} decays*, *JHEP* **06** (2020) 129, arXiv:2003.04352.

[25] LHCb collaboration, R. Aaij et al., *Search for the lepton flavour violating decay $B^0 \to K^{*0}\tau^\pm\mu^\mp$*, *JHEP* **06** (2023) 143, arXiv:2209.09846.

[26] LHCb collaboration, R. Aaij *et al.*, *Search for the lepton-flavor violating decay $B^0_s \to \phi\mu^\pm\tau^\mp$*, *Phys. Rev. D* **110** (2024) 7, arXiv:2405.13103.

PoS(HQL2025)084

[27] BaBar collaboration, B. Aubert et al., *Measurements of branching fractions, rate asymmetries, and angular distributions in the rare decays $B \to K\ell^+\ell^-$ and $B \to K^*\ell^+\ell^-$*, *Phys. Rev. D* **73** (2006) 092001, arXiv:hep-ex/0604007.

[28] BaBar collaboration, B. Aubert et al., *Search for the rare decay $B \to \pi\ell^+\ell^-$*, *Phys. Rev. Lett.* **99** (2007) 051801, arXiv:hep-ex/0703018.

[29] Belle collaboration, O. Seon et al., *Search for lepton-number-violating $B^+ \to D^-\ell^+\ell'^+$ decays*, *Phys. Rev. D* **84** (2011) 071106, arXiv:1107.0642.

[30] BaBar collaboration, J. P. Lees et al., *A search for the decay modes $B^\pm \to h^\pm\tau^\pm\ell^\mp$*, *Phys. Rev. D* **86** (2012) 012004, arXiv:1204.2852.

[31] BaBar collaboration, J. P. Lees et al., *Search for lepton-number violating $B^+ \to X^-\ell^+\ell^+$ decays*, *Phys. Rev. D* **89** (2014) 011102, arXiv:1310.8238.

[32] Belle collaboration, S. Choudhury et al., *Test of lepton flavor universality and search for lepton flavor violation in $B \to K\ell\ell$ decays*, *JHEP* **03** (2021) 105, arXiv:1908.01848.

[33] Belle collaboration, H. Atmacan et al., *Search for $B^0 \to \tau^\pm\ell^\mp$ ($\ell = e, \mu$) with a hadronic tagging method at Belle*, *Phys. Rev. D* **104** (2021) L091105, arXiv:2108.11649.

[34] Belle collaboration, S. Watanuki et al., *Search for the lepton flavour violating decays $B^+ \to K^+\tau^\pm\ell^\mp$ ($\ell = e, \mu$)*, *Phys. Rev. Lett.* **130** (2023) 261802, arXiv:2212.04128.

[35] Belle collaboration, L. Nayak et al., *Search for $B^0_s \to \ell^\pm\tau^\mp$ with the semi-leptonic tagging method at Belle*, *JHEP* **08** (2023) 178, arXiv:2301.10989.

[36] Belle Collaboration, *Search for the lepton flavour violating decays $B^+ \to K^+\tau^\pm\ell^\pm$ ($\ell = \mu, e$) at Belle*, *JHEP* **130** (2023) 261802, doi:10.1103/PhysRevLett.130.261802, arXiv.2212.04128 [hep-ex].

[37] M. Bordone, O. Catà and T. Feldmann, *Effective theory approach to new physics with flavour: general framework and a leptoquark example*, *JHEP* **01** (2020) 067, arXiv:1910.02641.

[38] LHCb Collaboration, *Search for the lepton-flavour-violating decays $B^0 \to K^{*0}\tau^\pm e^\mp$*, arXiv.2506.15347 [hep-ex].

[39] LHCb Collaboration, *Test of lepton flavour universality with $B^0_s \to \phi\ell^+\ell^-$ decays*, *Phys. Rev. Lett.* **134** (2025) 121803, doi:10.1103/PhysRevLett.134.121803, arXiv:2410.13748 [hep-ex].

[40] LHCb Collaboration, *Angular analysis of the decay $B^0_s \to \phi e^+e^-$*, *JHEP* **07** (2025) 069, doi:10.1007/JHEP07(2025)069, arXiv:2504.06346 [hep-ex].

[41] LHCb collaboration, *Constraints on the photon polarisation in $b \to s\gamma$ transitions using $B^0_s \to \phi e^+e^-$ decays*, *JHEP* **03** (2025) 047, doi:10.1007/JHEP03(2025)047.

[42] Particle Data Group collaboration, *Review of Particle Physics*, *Phys. Rev. D* **110** (2024) 030001, doi:10.1103/PhysRevD.110.030001.

PoS(HQL2025)084