Searches for Lepton Flavour Violation at LHCb

Andreas Güth, Jan-Marc Basels, Christoph Langenbruch, Stefan Schael
I. Physikalisches Institut B, RWTH Aachen

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Jahrestreffen der deutschen LHCb-Gruppen, Rostock

Lepton Flavour Violation at LHCb - Introduction

Why search for lepton flavour violation (LFV)?

- Lepton flavour conservation is an accidental symmetry in the SM ($m_\nu = 0$)
- Normalized rates of LFV processes involving charged leptons are tiny $\mathcal{O}(10^{-55}) - \mathcal{O}(10^{-40})$ in the SM
  $\Rightarrow$ LFV hadron decays would be a striking signature of new physics
- (Possible) Connection between violation of lepton flavour universality (LFU) and LFV

  $\Rightarrow$ Current interest in LFV in the light of observed LFU anomalies R_K, R_{K^*}, R_D, R_{D^*}

Selective overview of upper bounds on cLFV observables (status 2017)

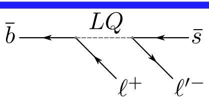
Riv. Nuovo Cimento, Vol. 41 (2018) 71

Reaction	Present limit	C.L.	Experiment	Year
$\mu^+ \to e^+\gamma$	$< 4.2 \times 10^{-13}$	90%	MEG at PSI	2016
$\mu^+ \to e^+e^-e^+$	$< 1.0 \times 10^{-12}$	90%	SINDRUM	1988
$\mu^-\mathrm{Ti} \to e^-\mathrm{Ti}$ †	$< 6.1 \times 10^{-13}$	90%	SINDRUM II	1998
$\mu^-\mathrm{Pb} \to e^-\mathrm{Pb}$ †	$< 4.6 \times 10^{-11}$	90%	SINDRUM II	1996
$\mu^-\mathrm{Au} \to e^-\mathrm{Au}$ †	$< 7.0 \times 10^{-13}$	90%	SINDRUM II	2006
$\mu^-\mathrm{Ti} \to e^+\mathrm{Ca}^*$ †	$< 3.6 \times 10^{-11}$	90%	SINDRUM II	1998
$\mu^+e^- \to \mu^-e^+$	$< 8.3 \times 10^{-11}$	90%	SINDRUM	1999
$\tau \to e\gamma$	$< 3.3 \times 10^{-8}$	90%	BaBar	2010
$\tau \to \mu\gamma$	$< 4.4 \times 10^{-8}$	90%	BaBar	2010
$\tau \to eee$	$< 2.7 \times 10^{-8}$	90%	Belle	2010
$\tau \to \mu\mu\mu$	$< 2.1 \times 10^{-8}$	90%	Belle	2010
$\tau \to \pi^0 e$	$< 8.0 \times 10^{-8}$	90%	Belle	2007
$\tau \to \pi^0 \mu$	$< 1.1 \times 10^{-7}$	90%	BaBar	2007
$\tau \to \rho^0 e$	$< 1.8 \times 10^{-8}$	90%	Belle	2011
$\tau \to \rho^0 \mu$	$< 1.2 \times 10^{-8}$	90%	Belle	2011
$\pi^0 \to \mu e$	$< 3.6 \times 10^{-10}$	90%	KTeV	2008
$K_L^0 \to \mu e$	$< 4.7 \times 10^{-12}$	90%	BNL E871	1998
$K_L^0 \to \pi^0\mu^+e^-$	$< 7.6 \times 10^{-11}$	90%	KTeV	2008
$K^+ \to \pi^+\mu^+e^-$	$< 1.3 \times 10^{-11}$	90%	BNL E865	2005
$J/\psi \to \mu e$	$< 1.5 \times 10^{-7}$	90%	BESIII	2013
$J/\psi \to \tau e$	$< 8.3 \times 10^{-6}$	90%	BESII	2004
$J/\psi \to \tau\mu$	$< 2.0 \times 10^{-6}$	90%	BESII	2004
$B^0 \to \mu e$	$< 2.8 \times 10^{-9}$	90%	LHCb	2013
$B^0 \to \tau e$	$< 2.8 \times 10^{-5}$	90%	BaBar	2008
$B^0 \to \tau\mu$	$< 2.2 \times 10^{-5}$	90%	BaBar	2008
$B \to K\mu e$ ‡	$< 3.8 \times 10^{-8}$	90%	BaBar	2006
$B \to K^*\mu e$ ‡	$< 5.1 \times 10^{-7}$	90%	BaBar	2006
$B^+ \to K^+\tau\mu$	$< 4.8 \times 10^{-5}$	90%	BaBar	2012
$B^+ \to K^+\tau e$	$< 3.0 \times 10^{-5}$	90%	BaBar	2012
$B_s^0 \to \mu e$	$< 1.1 \times 10^{-8}$	90%	LHCb	2013
$\Upsilon(1s) \to \tau\mu$	$< 6.0 \times 10^{-6}$	95%	CLEO	2008
$Z \to \mu e$	$< 7.5 \times 10^{-7}$	95%	LHC ATLAS	2014
$Z \to \tau e$	$< 9.8 \times 10^{-6}$	95%	LEP OPAL	1995
$Z \to \tau\mu$	$< 1.2 \times 10^{-5}$	95%	LEP DELPHI	1997
$h \to e\mu$	$< 3.5 \times 10^{-4}$	95%	LHC CMS	2016
$h \to \tau\mu$	$< 2.5 \times 10^{-3}$	95%	LHC CMS	2017
$h \to \tau e$	$< 6.1 \times 10^{-3}$	95%	LHC CMS	2017

LFU and LFV

Possible connection between LFU and LFV: They appear alongside each other in many models of new physics, $b \to s\ell^+\ell'^-$ transitions particularly interesting

Example: Leptoquarks



$$\mathcal{B}(B \to K\mu^\pm e^\mp) \sim 3 \cdot 10^{-8} \left(\frac{1-R_K}{0.23}\right)^2, \quad \mathcal{B}(B \to K(e^\pm,\mu^\pm)\tau^\mp) \sim 2 \cdot 10^{-8} \left(\frac{1-R_K}{0.23}\right)^2$$

$$\frac{\mathcal{B}(B_s \to \mu^+ e^-)}{\mathcal{B}(B_s \to \mu^+\mu^-)_{\mathrm{SM}}} \sim 0.01 \left(\frac{1-R_K}{0.23}\right)^2, \quad \frac{\mathcal{B}(B_s \to \tau^+(e^-,\mu^-))}{\mathcal{B}(B_s \to \mu^+\mu^-)_{\mathrm{SM}}} \sim 4 \left(\frac{1-R_K}{0.23}\right)^2.$$

JHEP12(2016)027

$\Rightarrow$ Observable rates for LFV processes in models for LFU anomalies

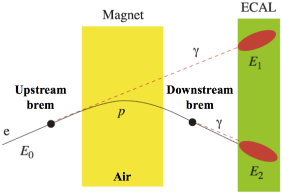
- $e\mu$ pair in the final state:
  - $\mathcal{B}(\mathrm{B_s^0} \to \mathrm{e}^\pm\mu^\mp)$ up to 10^{-11} Hiller, Loose, Schönwald JHEP 12 (2016) 027
  - $\mathcal{B}(\mathrm{B} \to \mathrm{K}^{(*)}\mathrm{e}^\pm\mu^\mp)$ up to 10^{-8}
- $\tau\mu$ pair in the final state:
  - $\mathcal{B}(\mathrm{B_s^0} \to \tau^\pm\mu^\mp)$ up to 10^{-4} Bordone et al., JHEP 1810 (2018) 148
  - $\mathcal{B}(\mathrm{B} \to \mathrm{K}^{(*)}\tau^\pm\mu^\mp)$ up to 10^{-5}

Common challenges in searches for LFV

- Extremely rare decays $\rightarrow$ Large samples of B^0_d, B^0_s decays needed ✓
- Understanding of backgrounds crucial
  - Semileptonic cascades with B, D decays
  - $B \rightarrow J/\psi(\rightarrow \ell^+\ell^-)X$ decays with mis-identification
- Two different lepton flavours $\rightarrow$ Additional challenge e/τ reconstruction:

Final state with $e\mu$ pair

- Electron's bremsstrahlung losses degrade $\sigma(m_B)$, effects mitigated by brem photon recovery in electron reconstruction



- Hardware trigger E_T^e thresholds higher than for p_T^μ

Final state with $\tau\mu$ pair

- τ reconstructed through its decays

Leptonic:
- $BR(\tau^- \rightarrow \mu^- \nu\nu) = 17.41 \pm 0.04$ %
- $BR(\tau^- \rightarrow e^- \nu\nu) = 17.83 \pm 0.04$ %

Hadronic:
- $BR(\tau^- \rightarrow \pi^- \nu) = 10.83 \pm 0.06$ %
- $BR(\tau^- \rightarrow \pi^- \pi^0 \nu) = 25.52 \pm 0.09$ %
- $BR(\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu) = 9.30 \pm 0.11$ %
- $BR(\tau^- \rightarrow \pi^- \pi^+ \pi^- \nu) = 9.31 \pm 0.06$ %
- $BR(\tau^- \rightarrow \pi^- \pi^+ \pi^- \pi^0 \nu) = 4.62 \pm 0.06$ %

- ν : Missing momentum degrades $\sigma(m_B)$
- τ decay vertex cannot always be reconstructed

$B^+ \to K^+ \mu^\pm e^\mp$: Introduction / Selection

New Result
arXiv:1909.01010

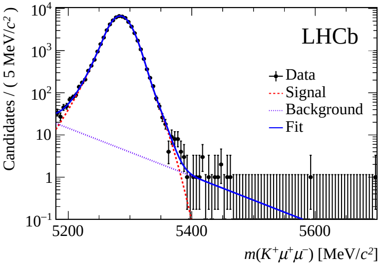
Analysis essentials

- LHCb Run I data, $\mathcal{L}_{int} = 3\ \mathrm{fb}^{-1}$
- Signature:
  Muon provides highly efficient trigger
  3 tracks forming secondary vertex

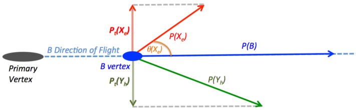
Selection

- Significant background from semileptonic cascades $B^+ \to \overline{D}^0(\to K^+\ell'^-\bar{\nu}_{\ell'}h')\ell^+\nu_\ell h$
  $\Rightarrow D^0$ veto $m(K^+\ell^-) > 1885$ MeV
- Topological BDT against combinatorial
- 2nd BDT including m_B^{HOP} variable against semileptonic cascades
- Tight PID cuts on kaon and leptons

Normalization channel:
$B^+ \to J/\psi(\to \mu^+\mu^-)K^+$

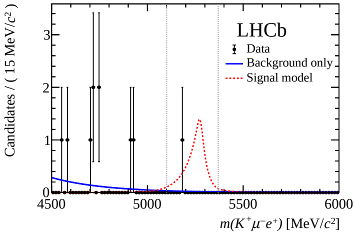


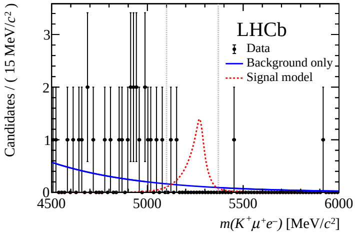
m_B^{HOP}: Correct $\vec{p}^{\,e}$ for $p_\perp^e / p_\perp^{K\mu}$ imbalance



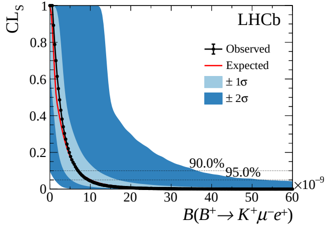
$B^+ \to K^+ \mu^\pm e^\mp$: Results

Analysis split by charge of the $\mu^\pm e^\mp$ pair

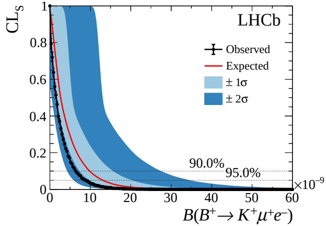




$\mathcal{B}(B^+ \to K^+ \mu^- e^+) < 9.5 \cdot 10^{-9}$ at 95% CL



$\mathcal{B}(B^+ \to K^+ \mu^+ e^-) < 8.8 \cdot 10^{-9}$ at 95% CL



Systematic uncertainties in the limit $<$7%

Improving former most stringent limit from BaBar by one order of magnitude

Starting to probe interesting range of parameter space for LFU+LFV models

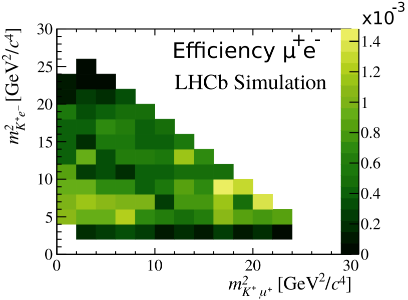
$B^+ \to K^+\mu^\pm e^\mp$: Signal model / (Re-)Interpretation

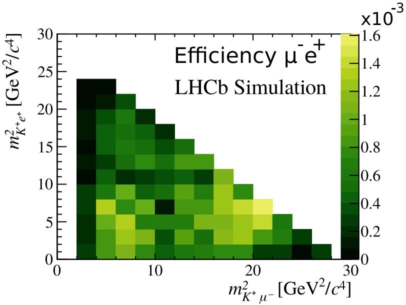
Analysis split according to charge combination of the $\mu^\pm e^\mp$ pair:

$B^+ \to K^+\mu^+e^-$ $\qquad\qquad$ $B^+ \to K^+\mu^-e^+$

(BSM) Model independent approach:

- Phase space decay model used for signal decay
- Efficiency maps provided over the Dalitz plane
  $\to$ Re-weighting allows for re-interpretation of exclusion limits in terms of a specific signal





$B_d^0 \to K^*(892)\mu^\pm e^\mp$, $B_s^0 \to \phi(1020)\mu^\pm e^\mp$

Goal: Cover in one analysis

$B_d^0 \to K^*(892)(\to K^+\pi^-)\mu^\pm e^\mp$

$\mathcal{B} < 1.8 \times 10^{-7}$ (90% CL) [Belle, Phys. Rev. D 98, 071101 (2018)]

$B_s^0 \to \phi(1020)(\to K^+K^-)\mu^\pm e^\mp$

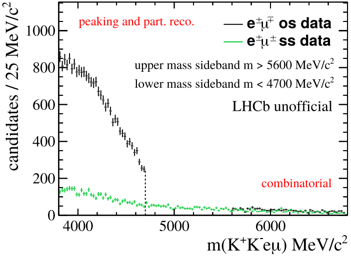
No limit in the literature

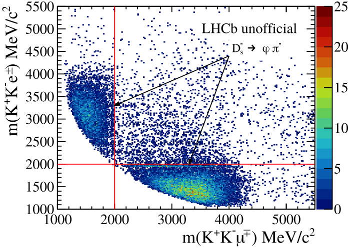
Analysis essentials $\phi\mu^\pm e^\mp$

- Normalization channel: $B_s^0 \to J/\psi(\to \mu^+\mu^-)\phi(1020)$
- Using same-sign data to model background
- Tight cut on $|m(K^+K^-)\text{-}m(\phi)| < 12$ MeV
- Veto $m(K^+K^-\ell^\pm) < 2000$ MeV targeting semilept. cascades $B_s^0 \to D_s^-(\to \phi\ell'^-\bar{\nu}_{\ell'})\ell^+\nu_\ell$
- Topological BDT against combinatorial
- Currently studying remaining exclusive backgrounds and efficiencies

Work in progress!

$B_s^0 \to \phi(1020)\mu^\pm e^\mp$, Run I data





Preliminary estimate of expected limit (Run I data only):

$\mathcal{B}(B_s^0 \to \phi(1020)\mu^\pm e^\mp) < 4 \times 10^{-8}$ (90% CL)

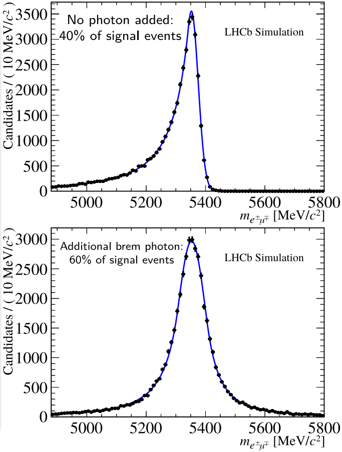
$B^0_{s,d} \to e^{\pm}\mu^{\mp}$: Introduction

Search for LFV with purely leptonic final state, electron reconstruction challenging

JHEP 1803 (2018) 078

Analysis essentials

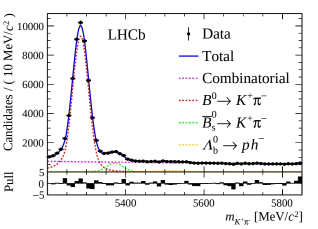
- LHCb Run I data, $\mathcal{L}_{int} = 3\ \text{fb}^{-1}$
- Signature:
  - Efficient trigger: both muon/electron triggers
  - Secondary vertex formed by $e^{\pm}\mu^{\mp}$ candidates fulfilling tight PID requirements
- Recovery of bremsstrahlungs photons in e reco
  $\Rightarrow$ Analysis split into brem/no brem categories
  Separate evaluation of ϵ_{sig}, mass shape
- 2 normalization channels:
  - $B^0_d \to K^+\pi^-$ (topology)
  - $B^+ \to J/\psi K^+$ (high yield, similar triggers)

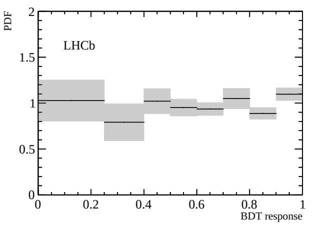


$B^0_{s,d} \to e^\pm \mu^\mp$: Selection

Selection and background

- Topological BDT targeting combinatorial
  Uniform response for signal $\to$ Flatness checked using $B^0_d \to K^+\pi^-$ selected data





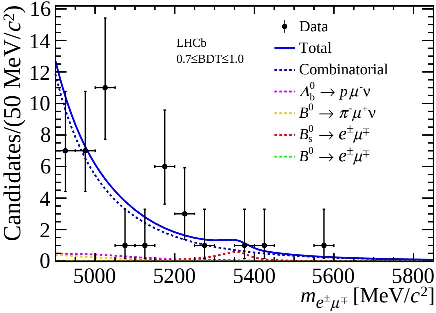
- Peaking bkg $B^0 \to h^+h'^-$ reduced to ~ 0.1 events by tight PID requirements
- Remaining exclusive background contribution dominated by partially reconstructed processes $B^0 \to \pi^-\mu^+\nu_\mu$ and $\Lambda_b \to p\ell^-\bar{\nu}_\ell$ is modelled in the fit

Signal efficiencies obtained from simulation except for trigger and PID efficiencies

$$\epsilon^{tot}_{sel}(B^0_d \to e^\pm\mu^\mp) = (2.22 \pm 0.05)\% \quad , \quad \epsilon^{tot}_{sel}(B^0_s \to e^\pm\mu^\mp) = (2.29 \pm 0.05)\%$$

$B^0_{s,d} \to e^{\pm}\mu^{\mp}$: Results

Simultaneous fit of $m(B^0_{s,d})$ in 14 brem$\times$BDT bins

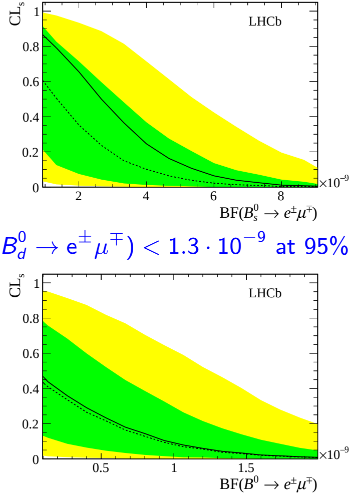


3 scenarios considered in the interpretation:
$B^0_d \to e^{\pm}\mu^{\mp}$; $B^0_{sH} \to e^{\pm}\mu^{\mp}$, $B^0_{sL} \to e^{\pm}\mu^{\mp}$

Impact of systematic uncertainties on expected limit $< 5\%$

$\mathcal{B}(B^0_{sH} \to e^{\pm}\mu^{\mp}) < 6.3 \cdot 10^{-9}$ at 95% CL

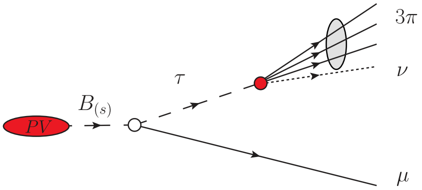
$\mathcal{B}(B^0_d \to e^{\pm}\mu^{\mp}) < 1.3 \cdot 10^{-9}$ at 95% CL



Improving former most stringent limit on $\mathcal{B}(B^0_d \to e^{\pm}\mu^{\mp})$ (LHCb, $\mathcal{L}_{int} = 1\ \mathrm{fb}^{-1}$) by almost a factor 3

$B^0_{s,d} \to \tau^{\pm}\mu^{\mp}$: Introduction

First search for LFV with a τ lepton in the final state by LHCb arXiv:1905.06614



Analysis essentials

- LHCb Run I data, $\mathcal{L}_{int} = 3\ \mathrm{fb}^{-1}$
- τ reconstructed in 3-prong channel
  $\tau^{\pm} \to \pi^{\pm}\pi^{\mp}\pi^{\pm}\nu$
  $\mathcal{B}(\tau^{\pm} \to \pi^{\pm}\pi^{\mp}\pi^{\pm}\nu) = 9.31 \pm 0.06\%$
- Normalization channel:
  $\mathrm{B^0_d} \to \mathrm{D}^{-}(\to \mathrm{K}^{+}\pi^{-}\pi^{-})\pi^{+}$
- Same-sign data $\tau^{\pm}\mu^{\pm}$ used to model background

Signal toplogy & selection basics

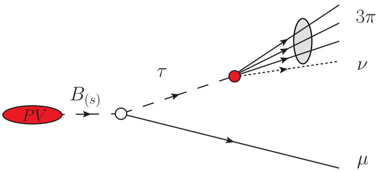
- Muon provides efficient L0/HLT1 triggers
- τ decay vertex reconstruction
  $\Rightarrow$ Reconstruction of p_{ν}, $m(B^0_{s,d})$
- τ decays via intermediate resonances
  $\tau^{\pm} \to a_1^{\pm}(1260)\nu \to \rho(770)\pi^{\pm}\nu$
  $\to \pi^{\pm}\pi^{\mp}\pi^{\pm}\nu$
  $\Rightarrow$ Rejection of low $m(\pi^{+}\pi^{-})$ bkgs

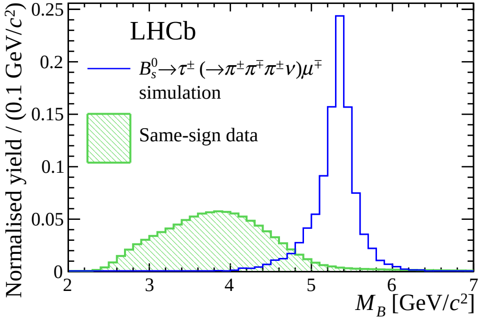
$\epsilon^{tot}_{sel}(\mathrm{B^0_s} \to \tau^{\pm}\mu^{\mp}) \approx 1.6 \cdot 10^{-4}$

$B^0_{s,d} \to \tau^\pm \mu^\mp$: $m(B^0_{s,d})$ calculation

$m(B^0_{s,d})$ calculation

Available information for kinematic constraints:
Muon & pion tracks, primary vertex, τ decay vertex, m_τ
$\Rightarrow$ $m(B^0_{s,d})$ determined analytically up to a 2-fold ambiguity
$m(B^0_{s,d})$ solution with best discrimination power and corresponding p_ν chosen

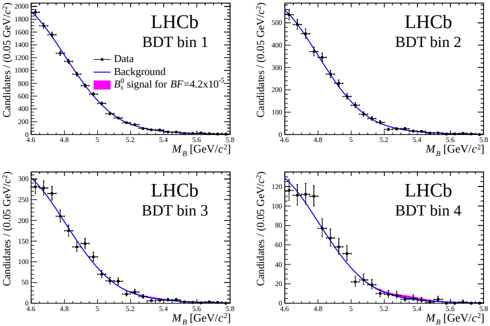




Refit of the decay tree with the inferred neutrino momentum performed
Fit parameters and their uncertainties used in the selection

$B^0_{s,d} \to \tau^\pm\mu^\mp$: Results

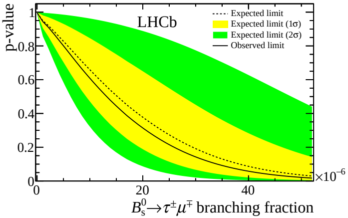
Simultaneous fit of $m(B^0_{s,d})$ in 4 BDT bins



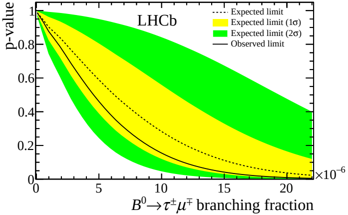
Two scenarios considered: $B^0_{s,d} \to \tau^\pm\mu^\mp$

Impact of systematic uncertainties on expected limit: 35%

$\mathcal{B}(B^0_s \to \tau^\pm\mu^\mp) < 4.2 \cdot 10^{-5}$ at 95% CL



$\mathcal{B}(B^0_d \to \tau^\pm\mu^\mp) < 1.4 \cdot 10^{-5}$ at 95% CL



Improving the former most stringent limit on $\mathcal{B}(B^0_d \to \tau^\pm\mu^\mp)$ (BaBar) by a factor 2

First limit on $\mathcal{B}(B^0_s \to \tau^\pm\mu^\mp)$, in the range of interest of models for LFU anomalies

Searches for LFV (+LNV/BNV) in LHCb

Published searches for LFV using (parts of) LHCb Run I data

Decay	Publication	Year	Type	Limit $\mathcal{B}$ (95% CL) Strongest limit in lit.
$B^+ \to K^+ e^\pm \mu^\mp$	arXiv:1909.01010 submitted to PRL	2019	LFV	8.8×10^{-9}
$B^0 \to \tau^\pm \mu^\mp$	arXiv:1905.06614 submitted to PRL	2019	LFV	1.4×10^{-5}
$B^0 \to e^\pm \mu^\mp$	JHEP 1803 (2018) 078	2018	LFV	1.3×10^{-9}
$D^0 \to e^\pm \mu^\mp$	PLB 754 (2016) 167	2016	LFV	1.6×10^{-8}
$\tau^- \to \mu^+ \mu^- \mu^-$	JHEP 02 (2015) 121	2015	LFV	5.6×10^{-8}
$\tau^- \to p^+ \mu^- \mu^-$	PLB 724 (2013) 36	2013	BNV+LNV	5.7×10^{-7}
$B^- \to \pi^+ \mu^- \mu^-$	PRL 112 (2014) 131802	2014	LNV	4.0×10^{-9}
$D^- \to \pi^+ \mu^- \mu^-$	PLB 724 (2013) 203	2013	LNV	2.5×10^{-8}

Work on Run I+II update (adding almost 4× Run I statistics) started

More searches for LFV working towards publication, Run I+II

τμ: $B^+ \to K^+ \mu^- \tau^+$ (B^*_{s2}-tagged and τ 3-prong), $B^0_d \to K^* \mu^- \tau^+$, $B^0_s \to \phi \mu^- \tau^+$

eμ: $B^0_d \to K^* e^- \mu^+$ + $B^0_s \to \phi e^- \mu^+$, $\Lambda_b \to \Lambda e^- \mu^+$

Searches for LFV are becoming a cornerstone of the LHCb physics program

Searches for LFV - A Glimpse into the future

Decay	Max. NP LFU models	Best Limit 90% CL	Exp.	LHCb '19	LHCb Upgrade I	Belle II 50 ab^{-1}
$B_d^0 \to e\mu$		1.0×10^{-9}	LHCb	Run I	2×10^{-10}	-
$B_s^0 \to e\mu$	10^{-11}	5.4×10^{-9}			8×10^{-10}	-
$B^+ \to K^+ e\mu$	10^{-8}	6.4×10^{-8}	LHCb	Run I	few $\times 10^{-9}$	-
$B^+ \to K^+ \tau\mu$	10^{-5}	4.8×10^{-5}	BaBar	ongoing	$\sim 10^{-6}$	3.3×10^{-6}
$B_d^0 \to K^* \tau\mu$	10^{-5}	-	-	ongoing	$\sim 10^{-6}$	few $\times 10^{-6}$
$B^+ \to K^+ \tau e$		3.0×10^{-5}	BaBar	-	-	2.1×10^{-6}

Official LHCb expectations from arXiv:1808.08865 in blue
Official Belle II expectations from arXiv:1808.10567 in orange
Guess from similar channels or extrapolation for luminosity in grey

Tests of charged lepton flavour conservation will benefit from LHCb / Belle II competition and complementarity in the coming years

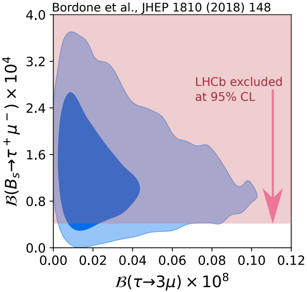
Summary

- LHCb has a strong program of searches for LFV hadron (and τ) decays
  In the light of the LFU anomalies, the LFV effort has recently been intensified

- LHCb has demonstrated its capability to push the sensitivity of searches for LFV in 2- and 3-body decays with $e\mu$ and $\mu\tau$ pairs

Current sensitivities: $\mathcal{O}(10^{-9})$ for $\mathcal{B}(\mathrm{B} \to X\, e\mu)$
$\mathcal{O}(10^{-5})$ for $\mathcal{B}(\mathrm{B} \to X\, \tau\mu)$

Probing interesting regions in parameter space of several BSM models for LFU anomalies



Stay tuned for the next round of results of LFV searches covering new decay channels and Run I+II updates of published Run I searches

- LHCb (Upgrade I) and Belle II will allow for further improvement of these sensitivities by about one order of magnitude in the coming years

BACKUP

Searches for LFV - A Glimpse into the Future

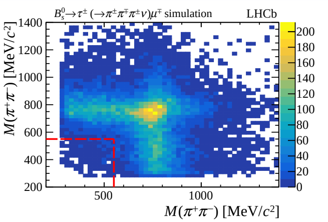
Decay	Max. NP	Best 90% CL	Publication	Exp.	LHCb '19	LHCb Upg. I	Belle II '27
$B_d^0 \to e\mu$	10^{-11}	1.0×10^{-9}	JHEP1803078	LHCb	Run I	2×10^{-10}	-
$B_s^0 \to e\mu$	10^{-11}	5.4×10^{-9}				8×10^{-10}	-
$B^+ \to K^+ e^- \mu^+$	10^{-8}	6.4×10^{-8}	1909.01010	LHCb	Run I	2×10^{-9}	-
$B_d^0 \to K^* e\mu$	10^{-8}	1.8×10^{-7}	PRD98071101	Belle	ongoing	$\sim 10^{-9}$	$\sim 2 \times 10^{-8}$
$B_s^0 \to \phi e\mu$	-	-	-	-	ongoing 4×10^{-8}	-	-
$B_d^0 \to \tau\mu$	10^{-5}	1.2×10^{-5}	1905.06614	LHCb	Run I	3×10^{-6}	1.3×10^{-5}
$B_s^0 \to \tau\mu$	10^{-5}	3.4×10^{-5}				9×10^{-6}	10^{-5}
$B^+ \to K^+ \tau\mu$	10^{-5}	4.8×10^{-5}	PRD86012004	BaBar	ongoing	10^{-6}	3.3×10^{-6}
$B_d^0 \to K^* \tau\mu$	10^{-5}	-	-	-	ongoing	10^{-6}	$\sim 10^{-6}$
$B_d^0 \to \tau e$		2.8×10^{-5}	PRD77091104	BaBar	-	-	1.6×10^{-5}
$B^+ \to K^+ \tau e$	-	3.0×10^{-5}	PRD86012004	BaBar	-	-	2.1×10^{-6}

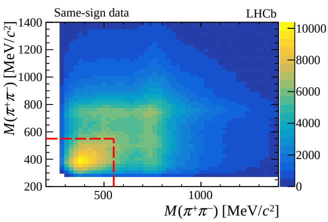
Official LHCb expectations from arXiv:1808.08865 in blue
Official Belle II expectations from arXiv:1808.10567 Guess from similar channels or extrapolation for luminosity in grey
(adapted from presentation by F. Polci, $b \to s\ell\ell$ 2019 Workshop, Lyon)

$B^0_{s,d} \to \tau^{\pm}\mu^{\mp}$: Selection

Preselection

- Cut-based preselection using resonance structure of the τ decay

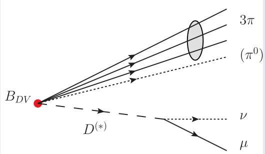




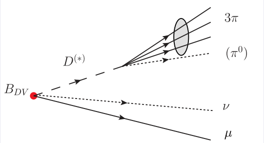
- BDT combining 7 isolation variables

Selection targeting specific bkgs

- BDT against combinatorial bkg
- $\tau_\tau/\sigma(\tau_\tau) > 1.8$
  Rejection of 'reverse topology'



- Remaining background dominated by 'signal topology'. modelled in the fit



- Final BDT, $m(B^0_{s,d})$ fit in 4 BDT bins

$$\epsilon^{tot}_{sel}(\mathrm{B^0_s} \to \tau^{\pm}\mu^{\mp}) \approx 1.6 \cdot 10^{-4}$$