LFV+LFU in neutral-current b and c decays at LHCb

Lepton flavour violation and lepton universality violation in meson and baryon decays

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outline

Anomalies

LUV and LFV

Where we saw the anomalies

LHCb detector

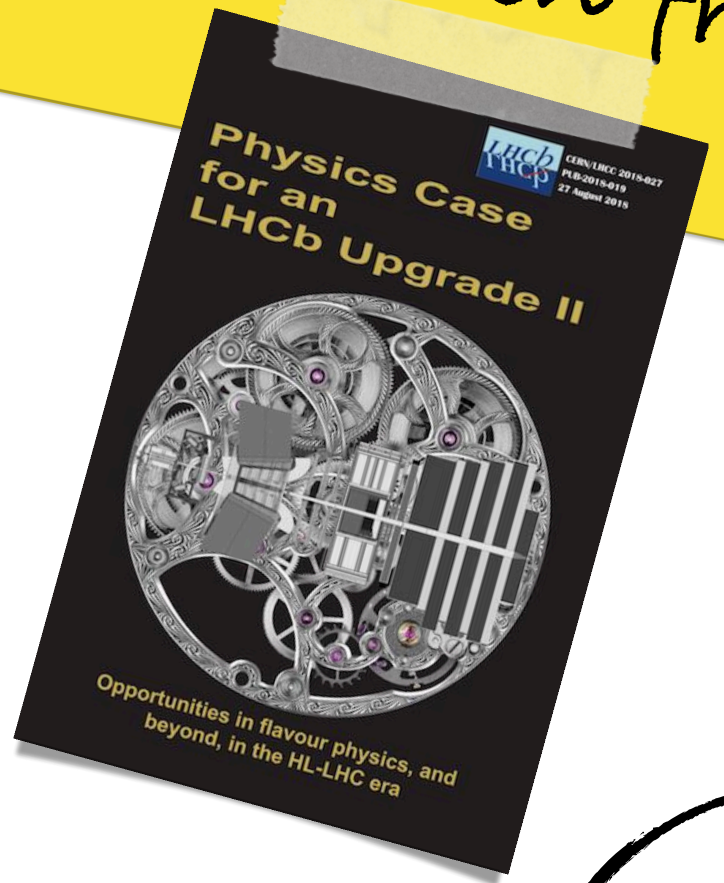
LHCb upgrades

Measurement and prospects

Disclaimer

Some projections are not official

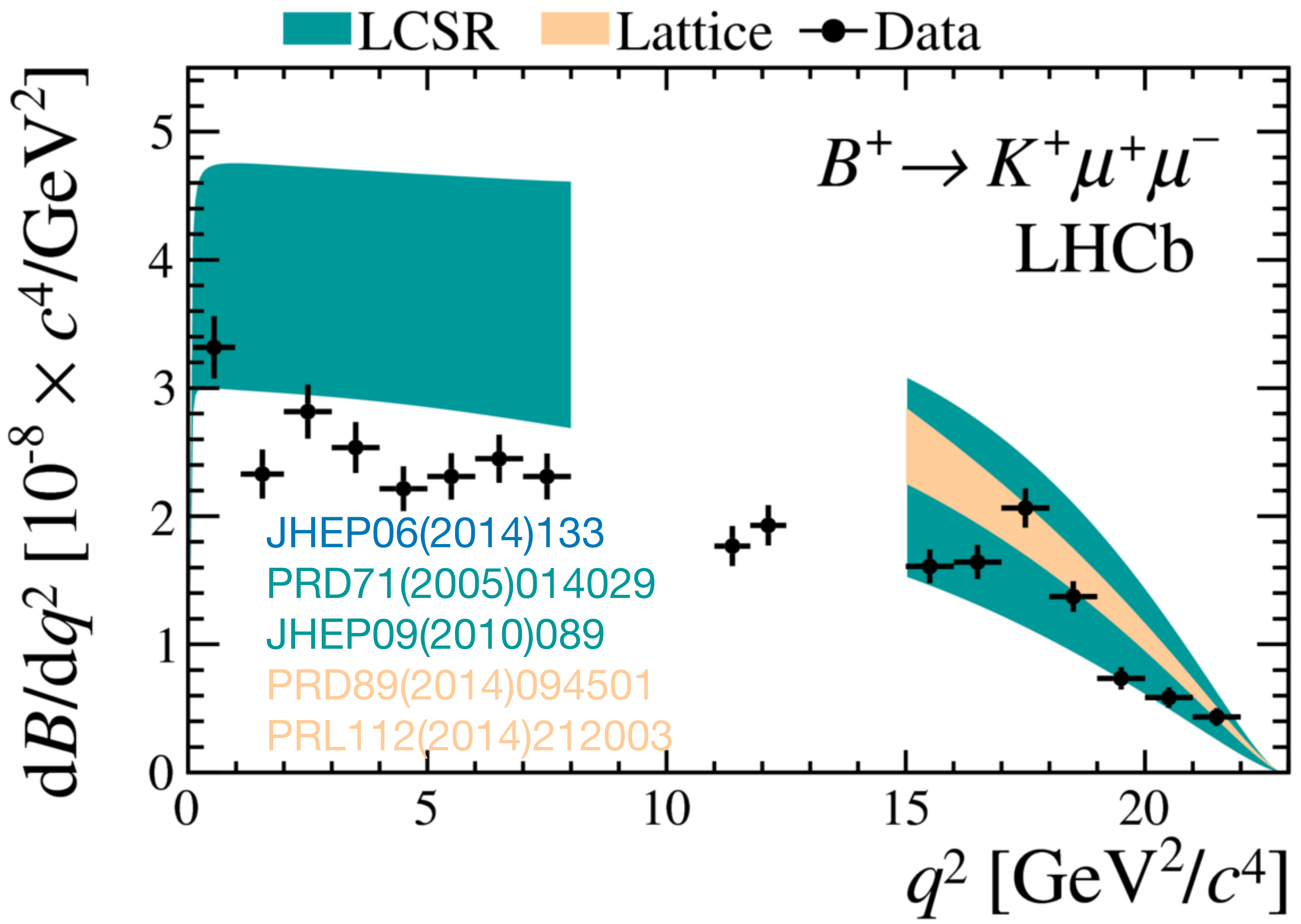
other taken from

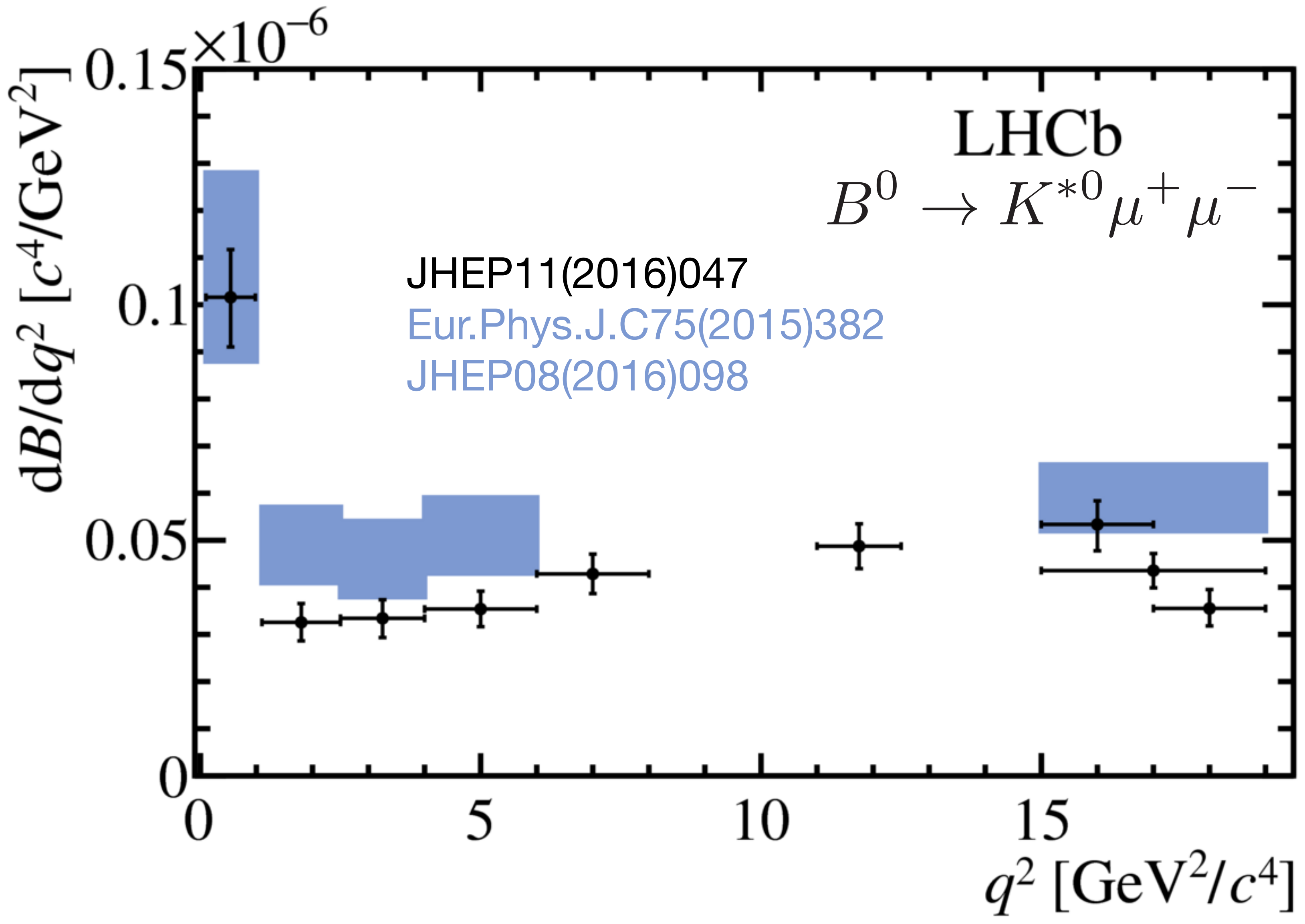


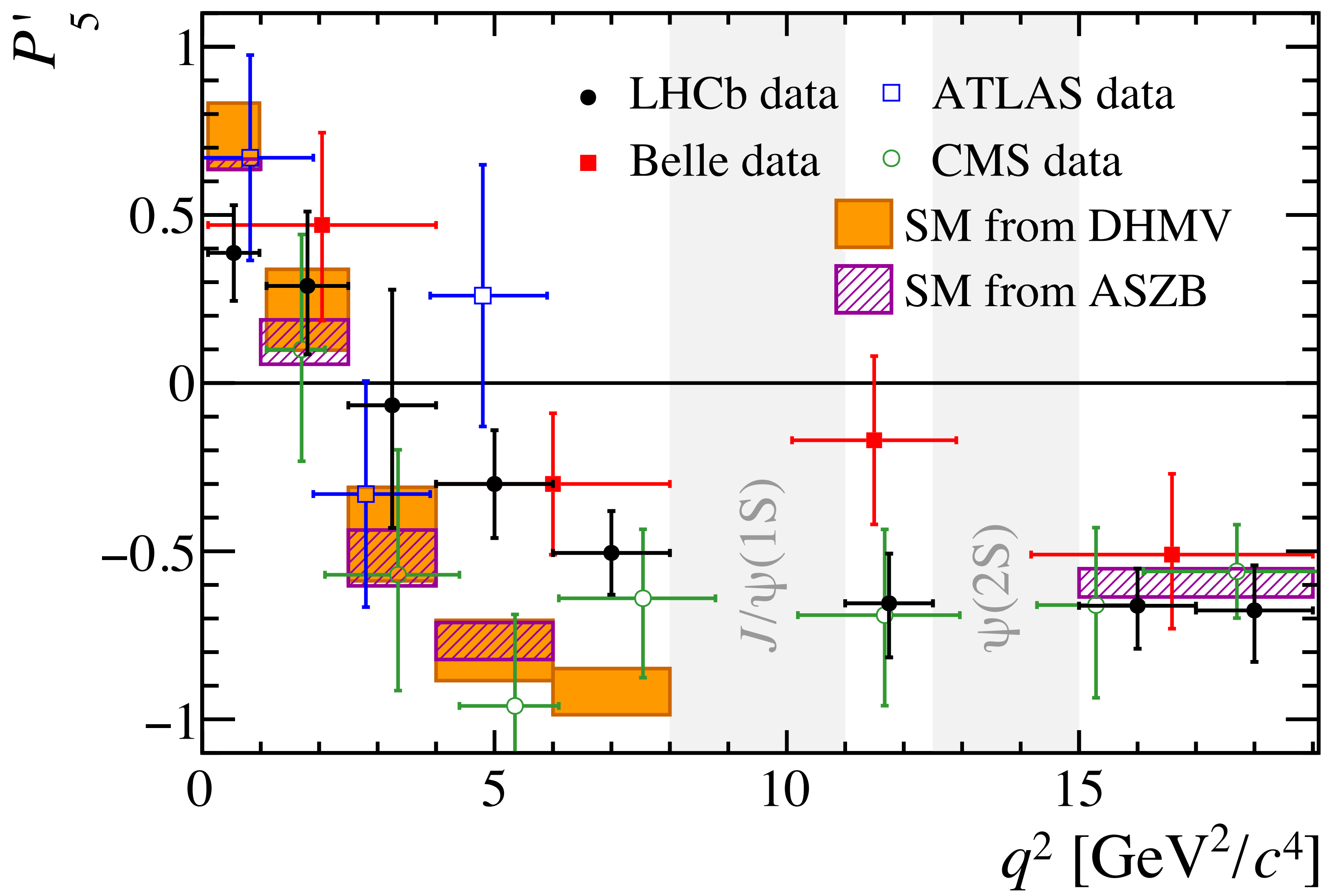
Anomalies

- Several electroweak penguin decays measurements showed anomalous deviation from the expected SM value (in semileptonic decays too, see Manuel's talk tomorrow)
- Large theory uncertainty from hadronic form factors
- Global fit of Wilson coefficients seems to indicate a coherent pattern!

LHCb, JHEP 02 (2016) 104,
Belle, PRL 118 (2017) 111801,
CMS-PAS-BPH-15-008,
ATLAS-CONF-2017-023
Eur.Phys.J.C75(2015)382
JHEP08(2016)098
PRD89(2014) 094501



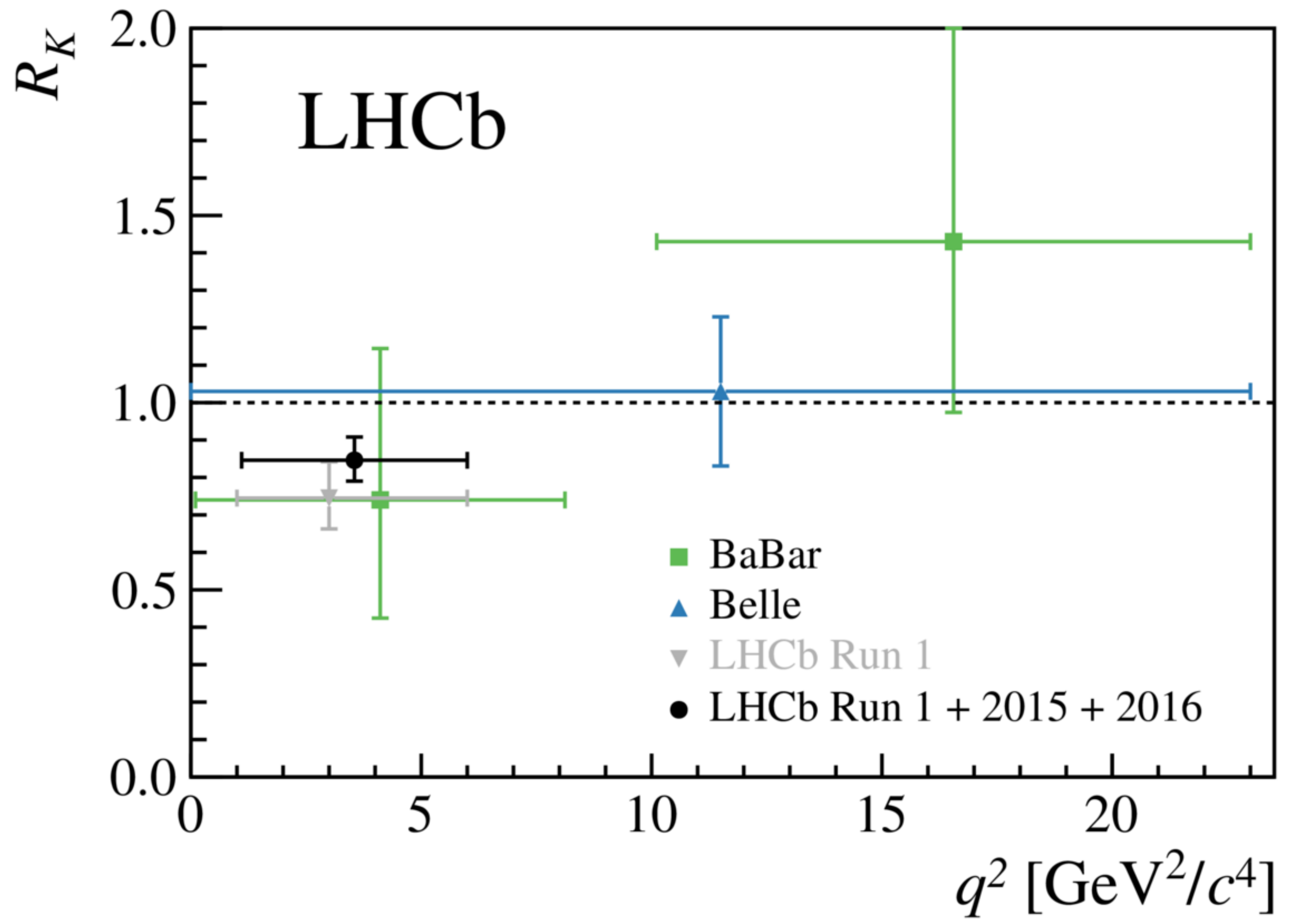


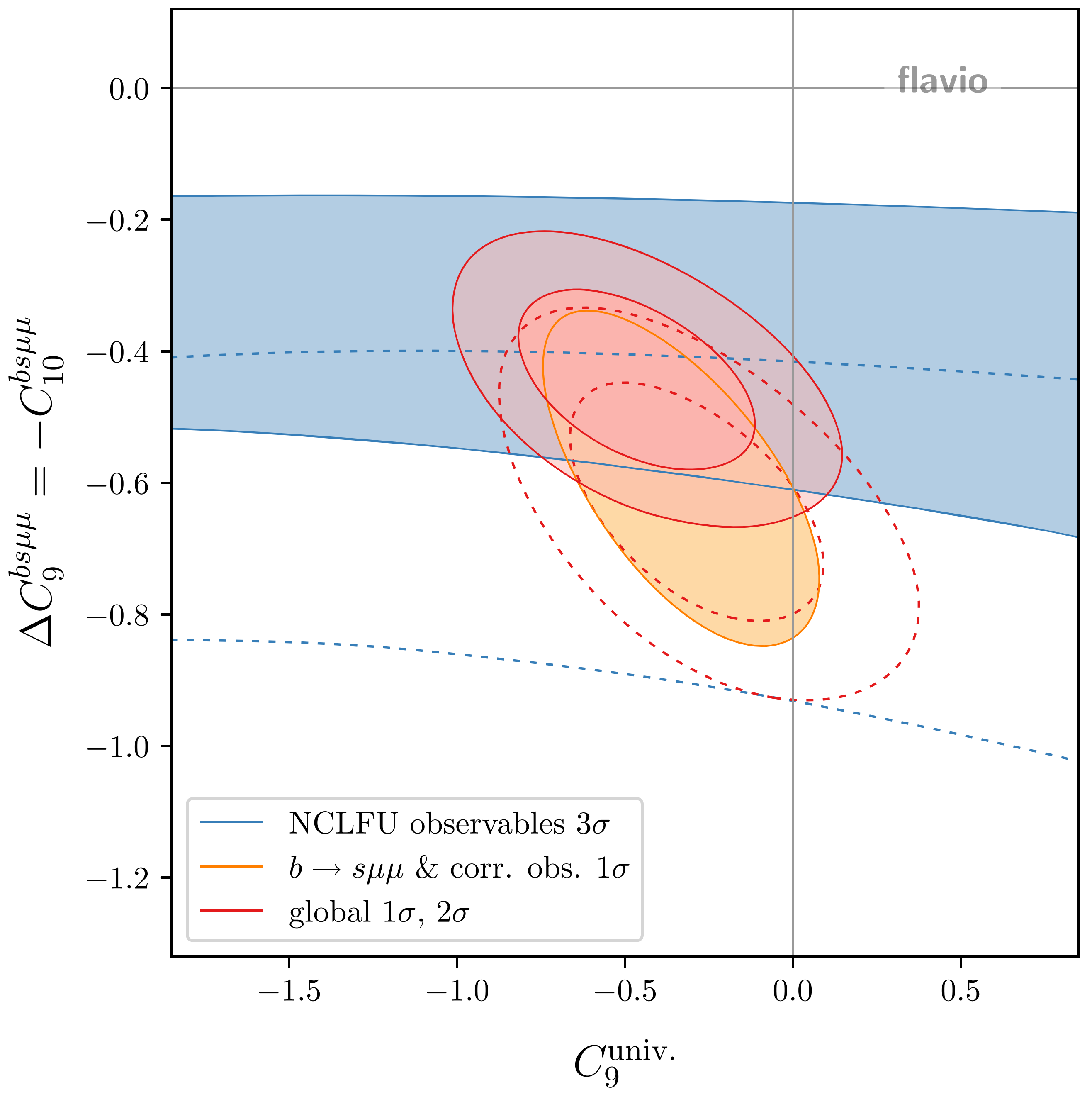


LFU and consequences

- Lepton Flavour Universality (LFU): couplings with gauge bosons of all leptons are equal
- QCD uncertainties completely cancel in the ratio
- Cleaner observables can be used to probe NP effects
- Hints of deviation from LFU test consistent with $b \to s\mu\mu$ BF and angular analyses if NP only in μ
- Possible Lepton Flavour Violation (LFV) as possible consequence

Phys. Rev. Lett. 122 (2019) 191801



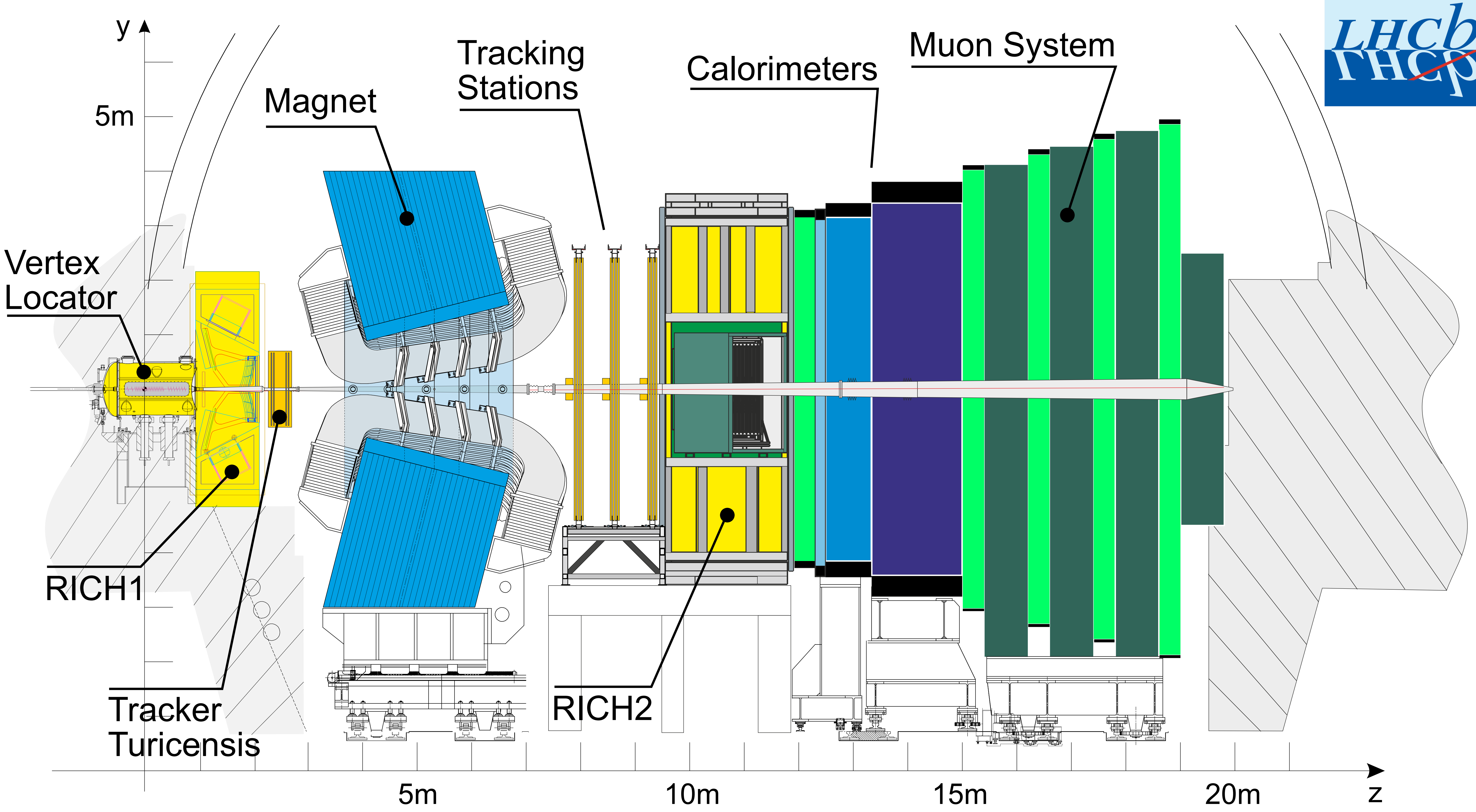


Aebischer et al, Eur. Phys. J. C (2020) 80:252

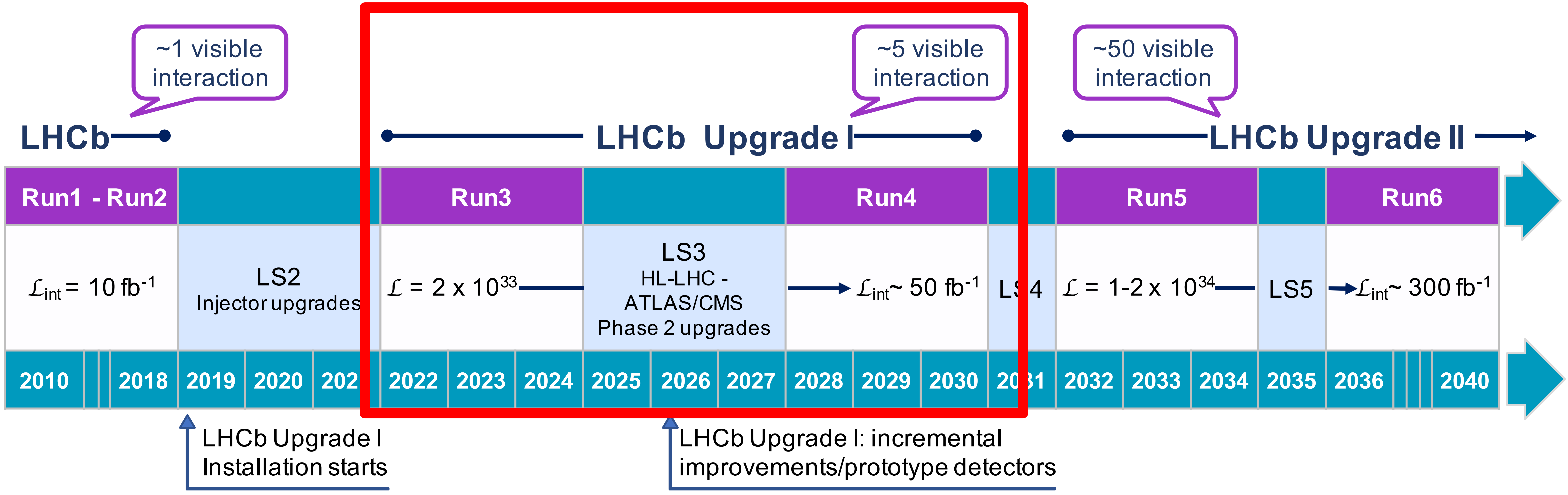
LHCb detector

- Excellent vertex and IP resolution:
  $\sigma(IP) \simeq 24\mu m$ at $p_T = 2GeV$
- Good momentum resolution:
  $\sigma(p)/p \simeq 0.4\text{-}0.6\%$ for $p \in (0,100) GeV/c$

- Muon identification:
- $\varepsilon_\mu = 98\%$, $\varepsilon_{K\to\mu} = 0.6\%$, $\varepsilon_{\pi\to\mu} = 0.3\%$
- Trigger efficiency:
  $\varepsilon_\mu = 90\%$ for selected B decays



Upgrade and plans



- Preparing the upgrade for Run3 and Run4 during LS2
  - Full software trigger and new readout system, all detector at 40MHz (32 Tbps throughput)
  - Replace tracking detectors + PID + VELO, $\mathscr{L} = 2 \times 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
  - Consolidate PID, tracking and ECAL during LS3
- Phase-II upgrade during LS4:
  - New detector technologies, $\mathscr{L} = 1.5 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$

Detector upgrade I

Detector upgrade II

RICH with new photon detectos $\sigma_t < 100$ ps/photon, TORCH detector

ECAL with finer segmentation and timing with $\sigma_t \sim 20 - 50$ ps

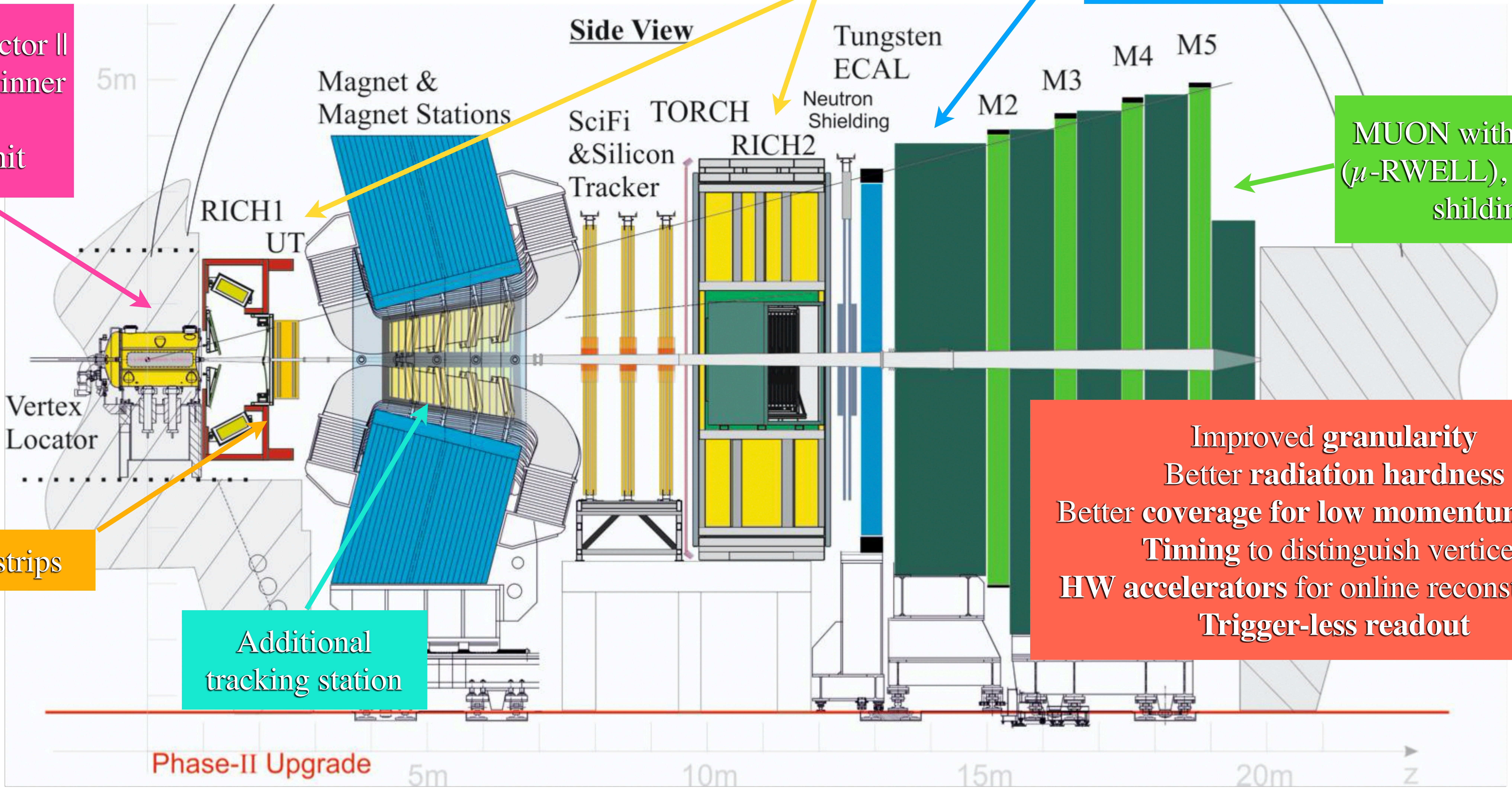
New Vertex Detector ll smaller pixels, thinner sensors, $\sigma_t < 200$ ps/hit

MUON with MPGD (μ-RWELL), modified shilding

Si-strips

Additional tracking station

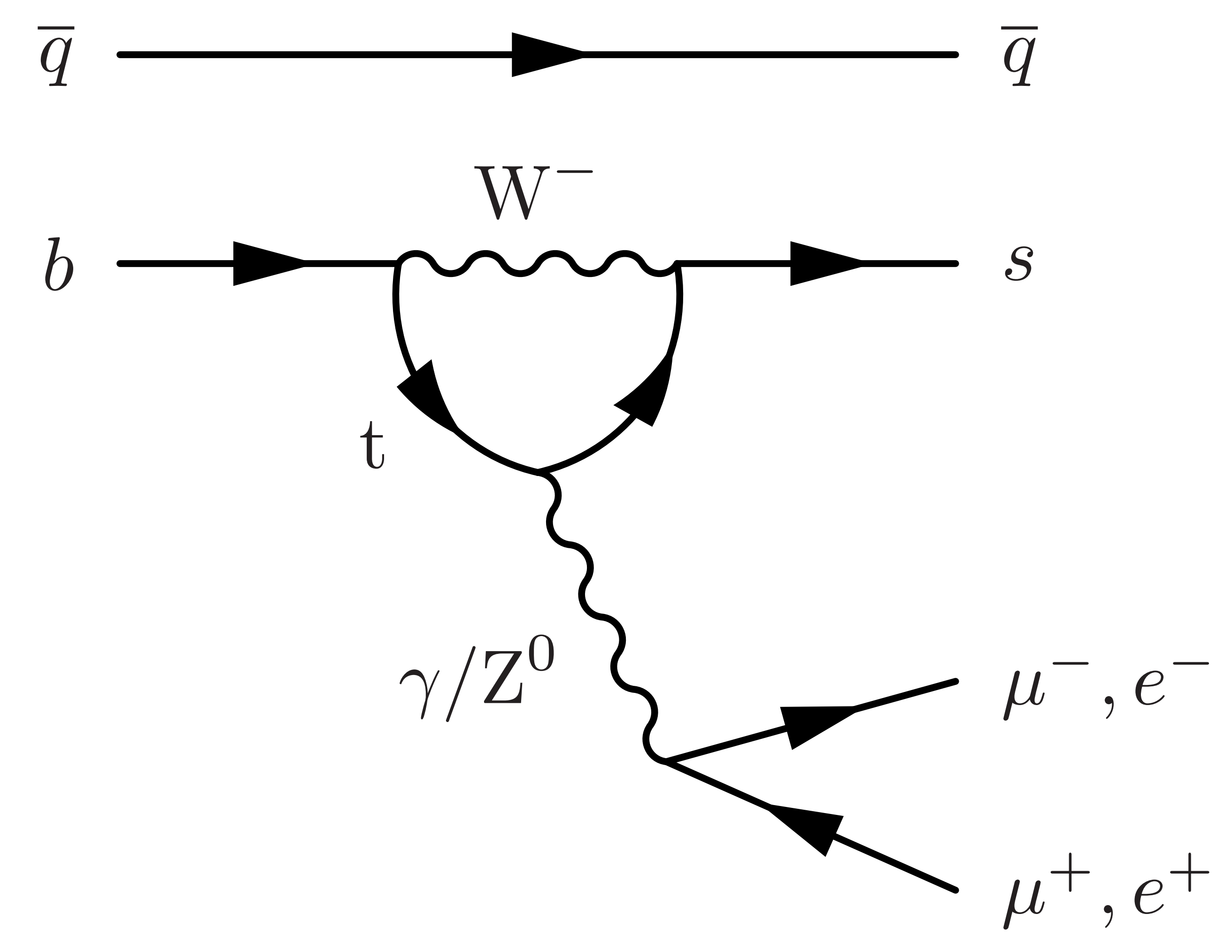
Improved **granularity**
Better **radiation hardness**
Better **coverage for low momentum** tracks
Timing to distinguish vertices
HW accelerators for online reconstruction
Trigger-less readout



Lepton Flavour Universality tests

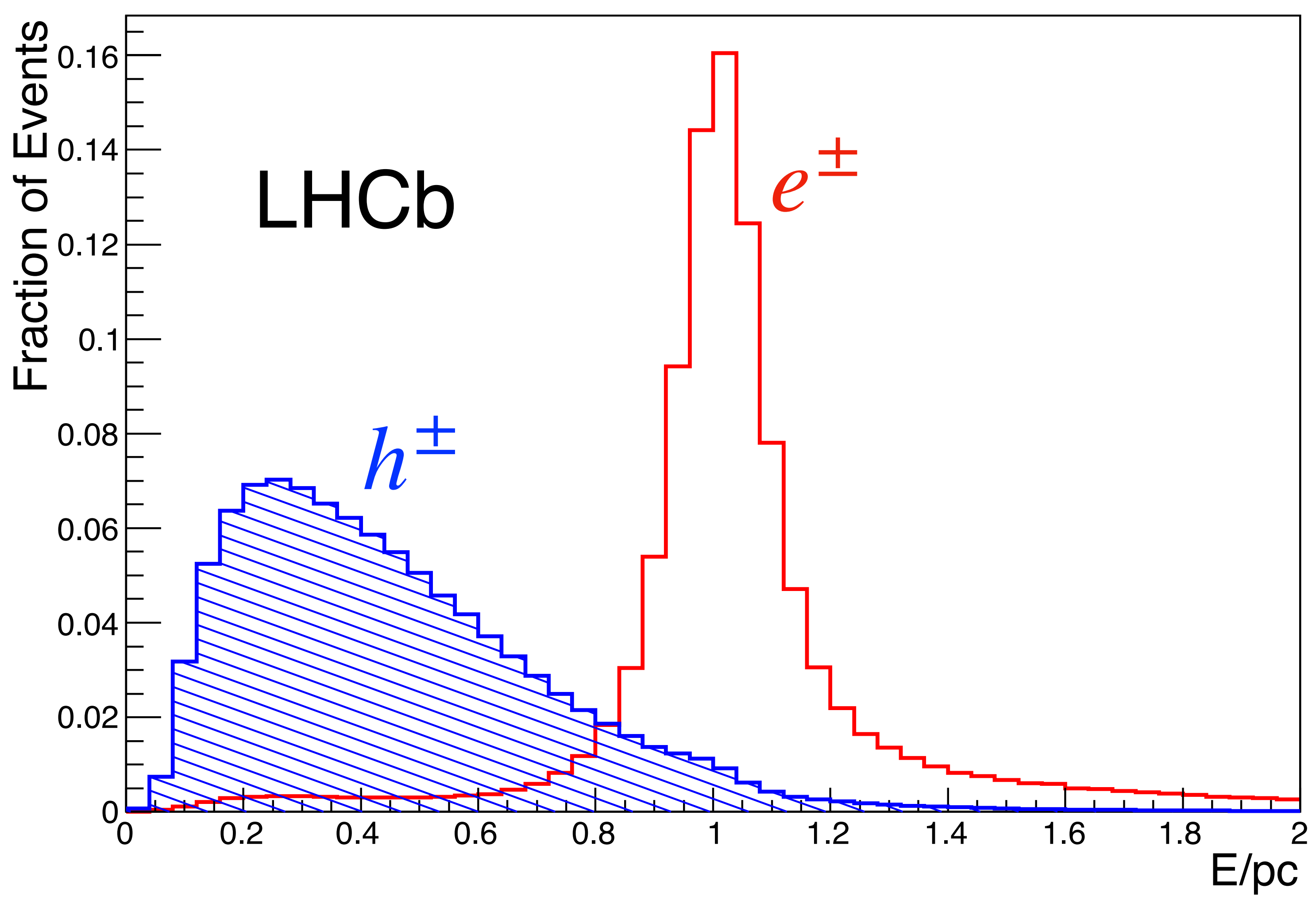
- $b \to s\ell\ell$ processes excellent probe to test for LUV effects
- $R_{K^{(*)}}$ is close to unity in SM, with very small uncertainties
- Extremely clean test:
    - cancellation of hadronic form-factors uncertainties in predictions
    - Possible deviation from QED corrections ~1% below $c\bar{c}$ resonance Bordone, Isidori, Pattori EPJC(2016)76:440
- Electrons are very challenging @LHCb!

$$R_H = \frac{\int_{q^2_{\min}}^{q^2_{\max}} \frac{\mathrm{d}\Gamma[B \to H\mu^+\mu^-]}{\mathrm{d}q^2}\mathrm{d}q^2}{\int_{q^2_{\min}}^{q^2_{\max}} \frac{\mathrm{d}\Gamma[B \to He^+e^-]}{\mathrm{d}q^2}\mathrm{d}q^2}$$

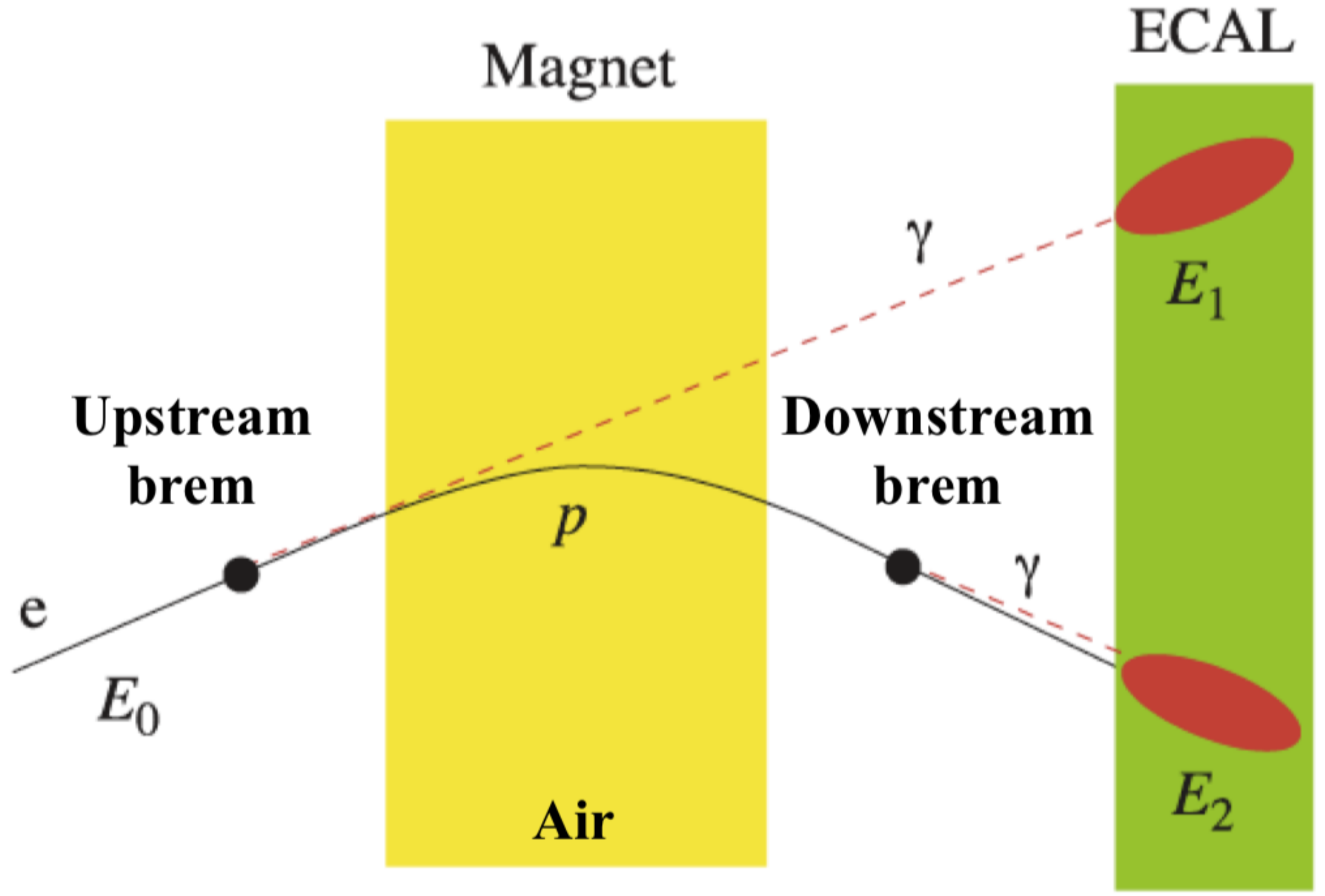


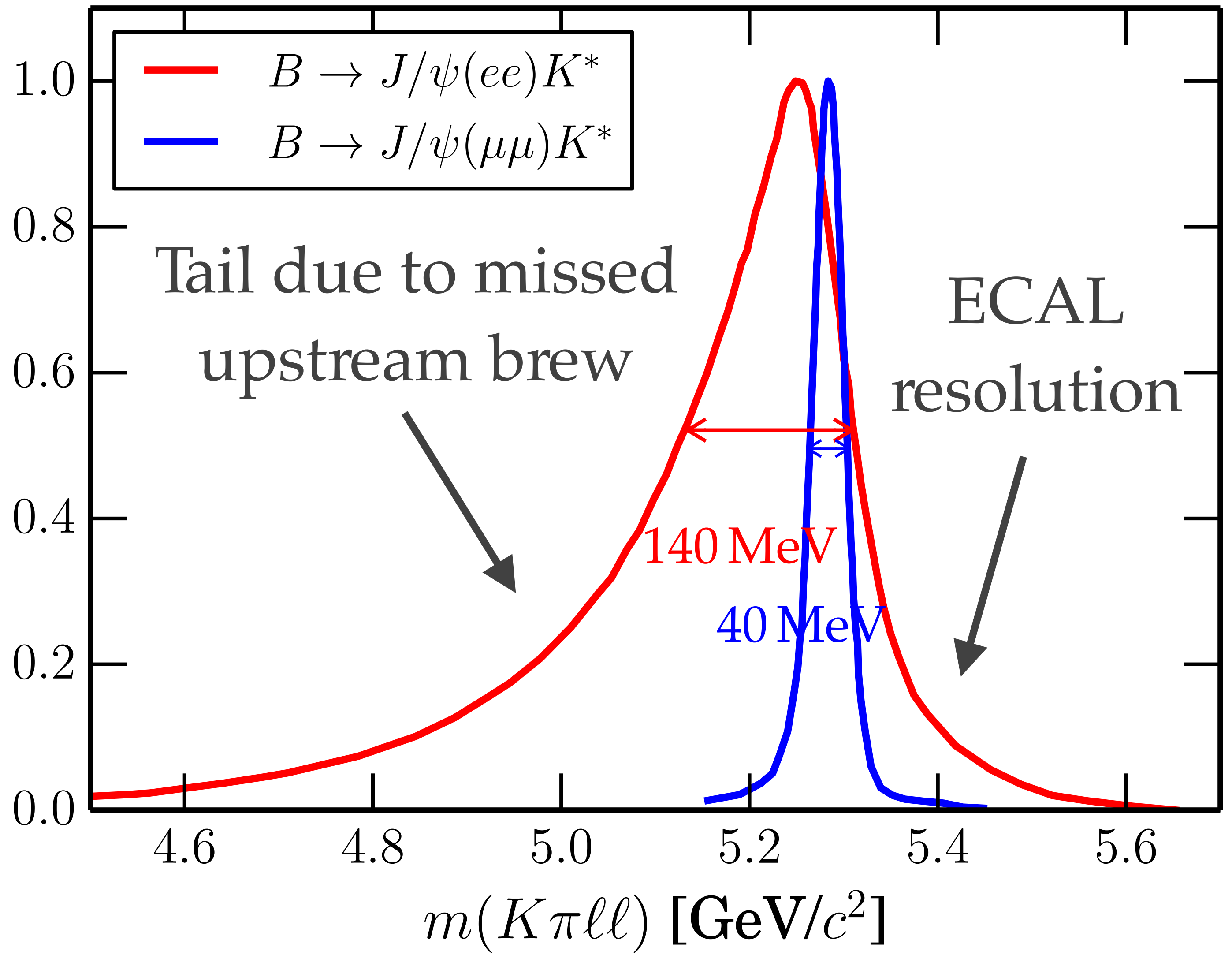
Electrons

Int.J.Mod.Phys. A 30, 1530022 (2015)



- Triggered on large energy deposit on calorimeter
- Electron ID based on calorimetric information
- Selection is a factor ~3 less efficient than muons
- Boosted *b*-hadrons from LHC collision: most electron emit hard bremsstrahlung photon
  - momentum resolution heavily affected.



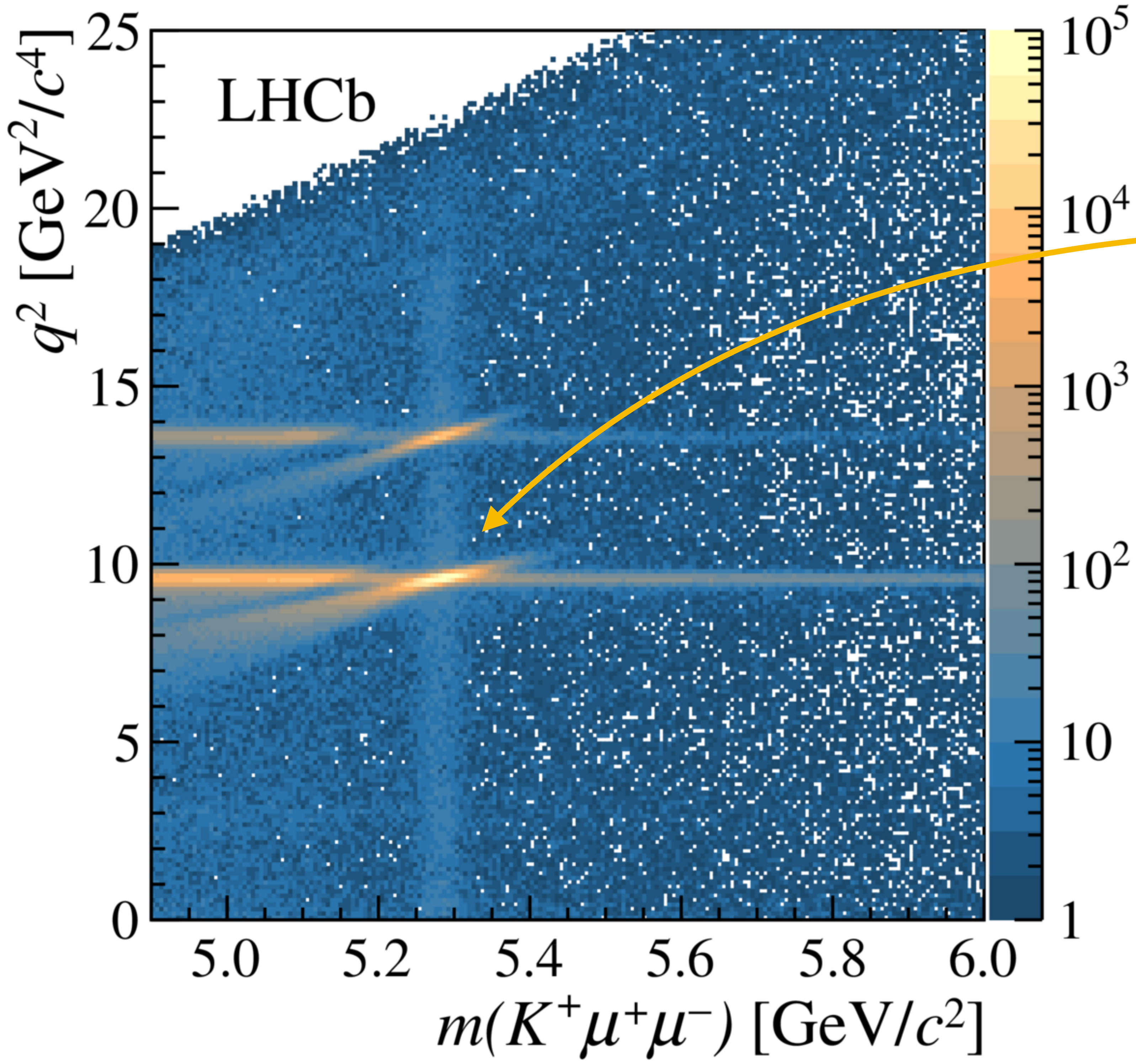


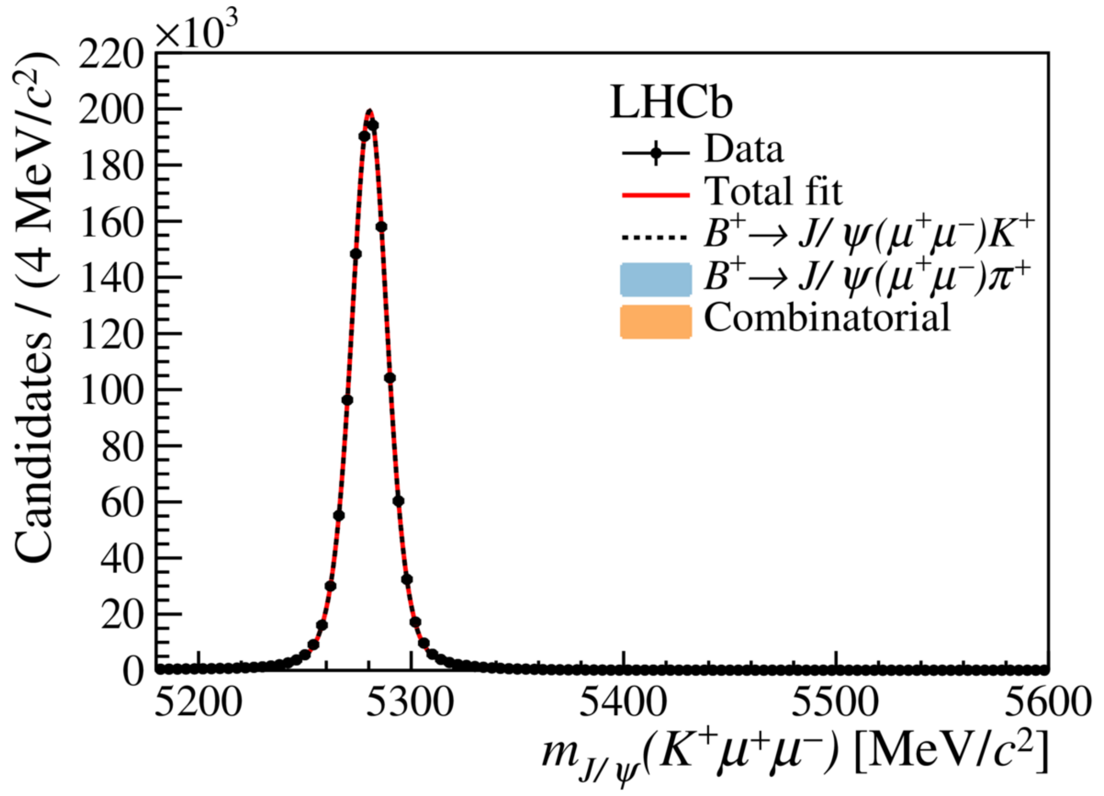
$B^+ \to K^+\ell^+\ell^-$ LFU tests

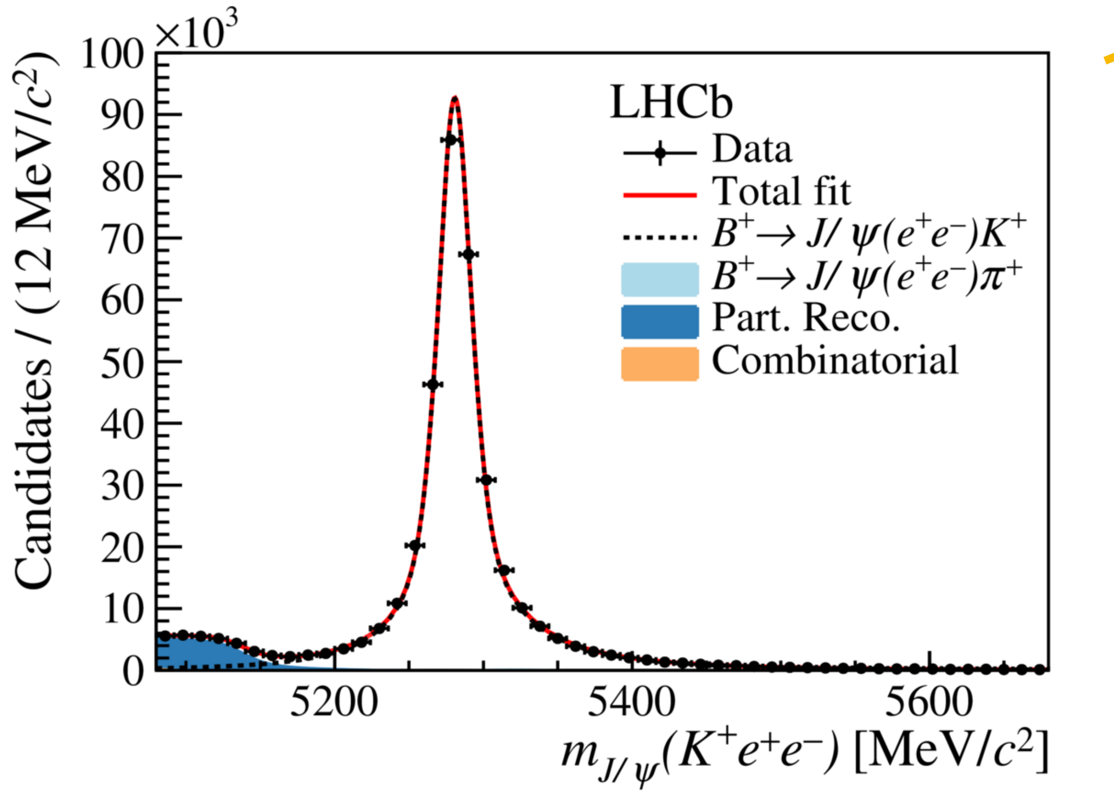
Phys. Rev. Lett. 122 (2019) 191801

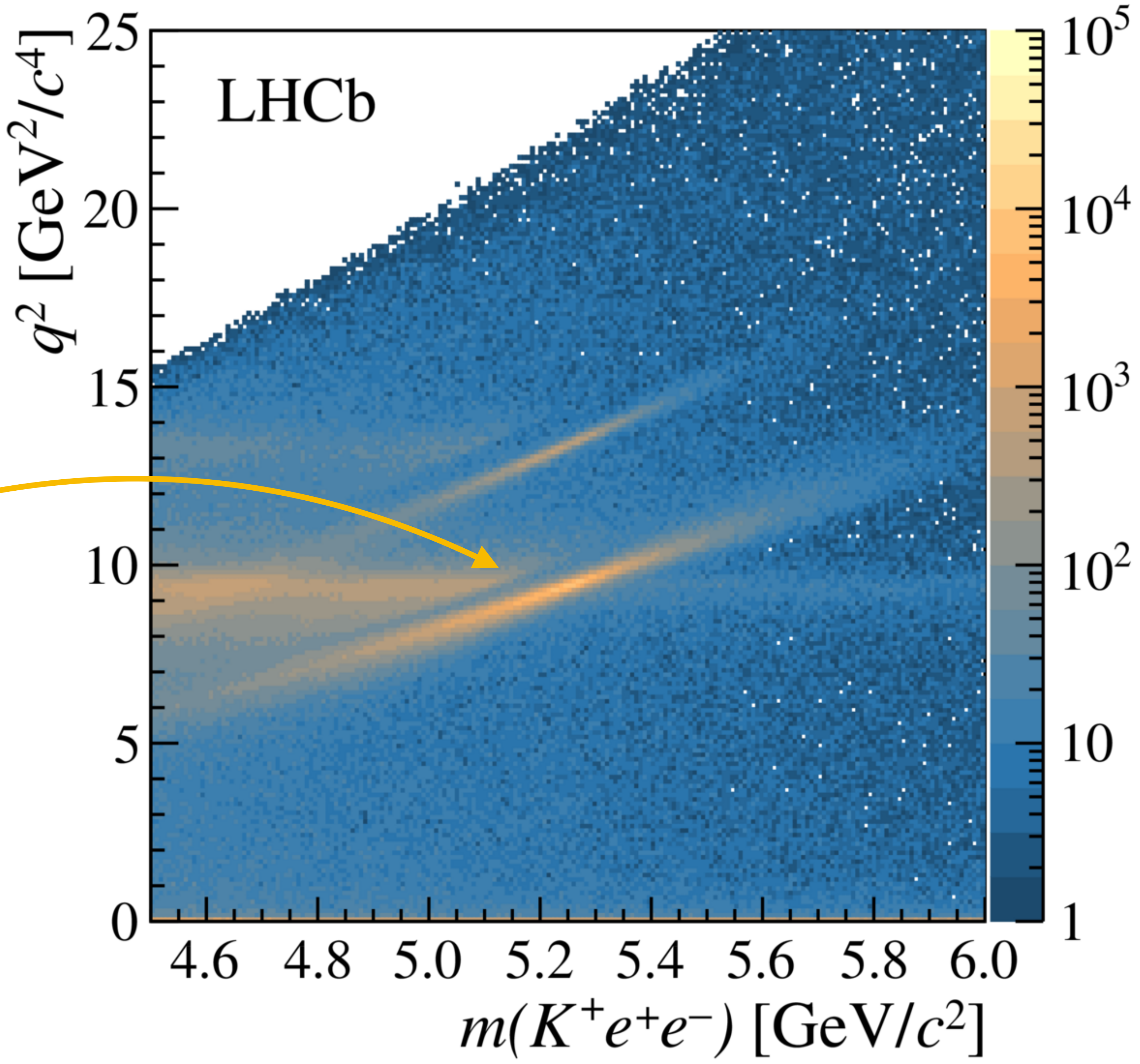
- Use of double ratio to further reduce systematics:

$$R_K = \frac{\mathcal{B}(B^+ \to K^+\mu^+\mu^-)}{\mathcal{B}(B^+ \to J/\psi\,(\to \mu^+\mu^-)K^+)} \Bigg/ \frac{\mathcal{B}(B^+ \to K^+e^+e^-)}{\mathcal{B}(B^+ \to J/\psi\,(\to e^+e^-)K^+)}$$







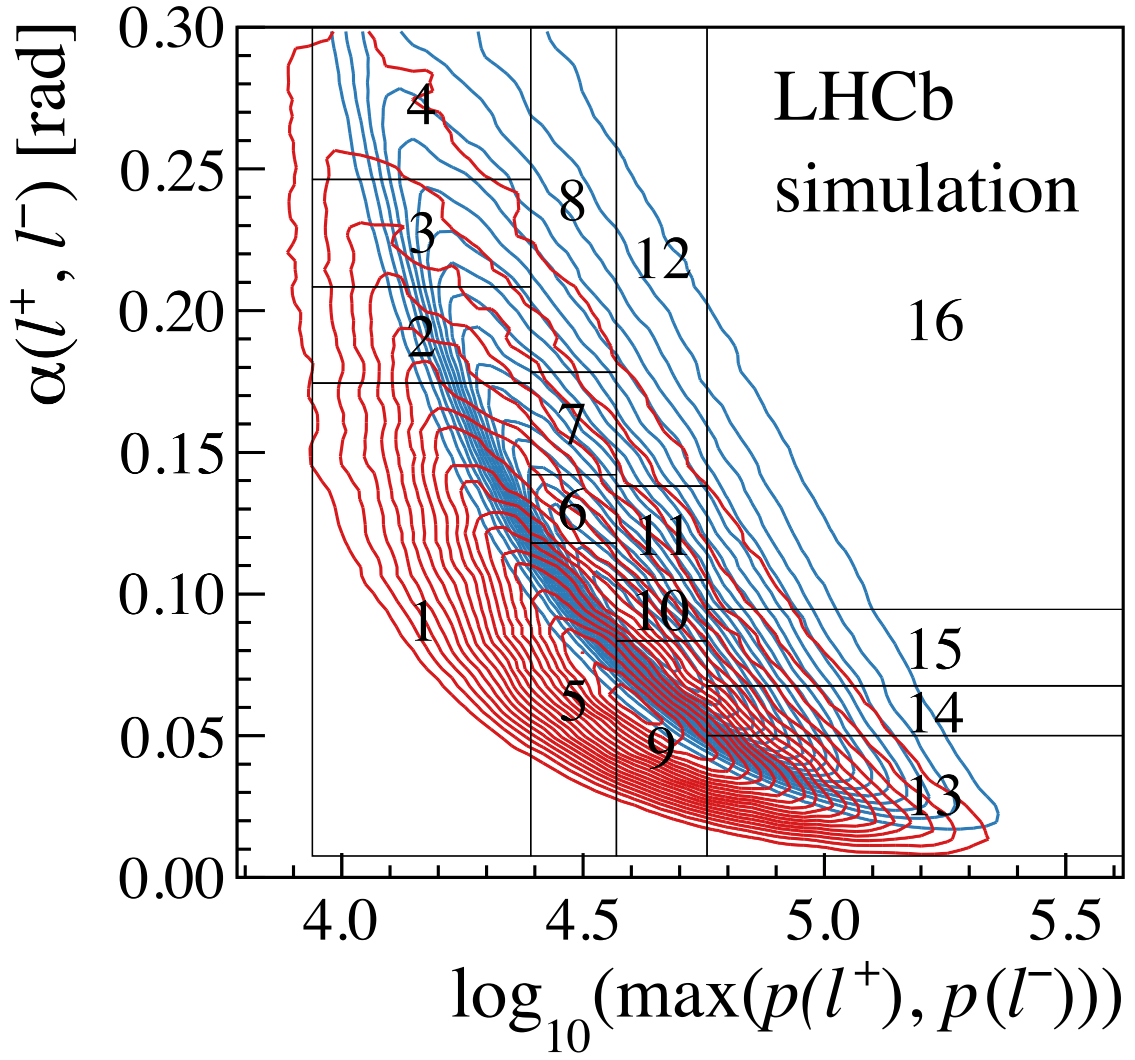


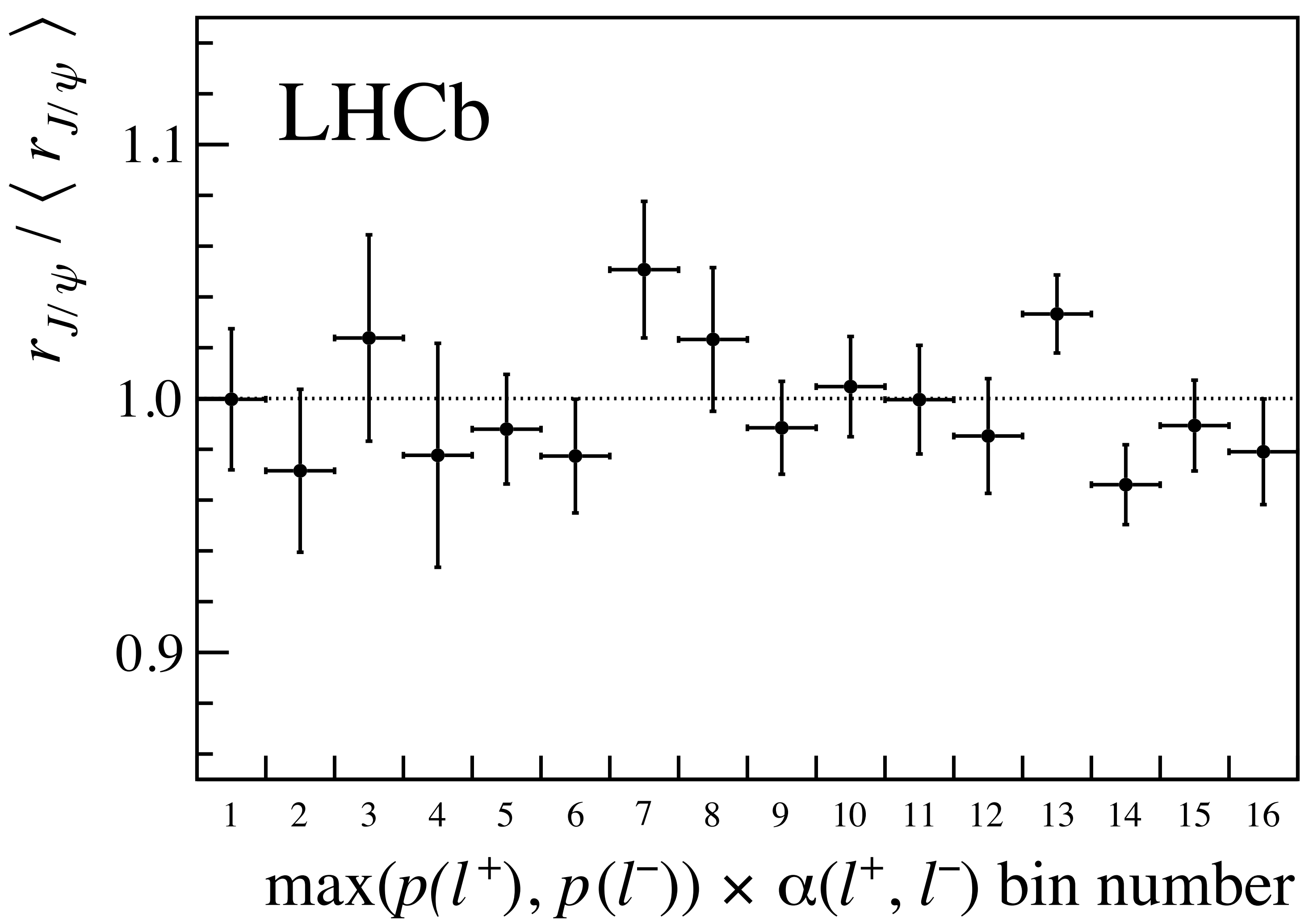
$B^+ \to K^+\ell^+\ell^-$ crosschecks

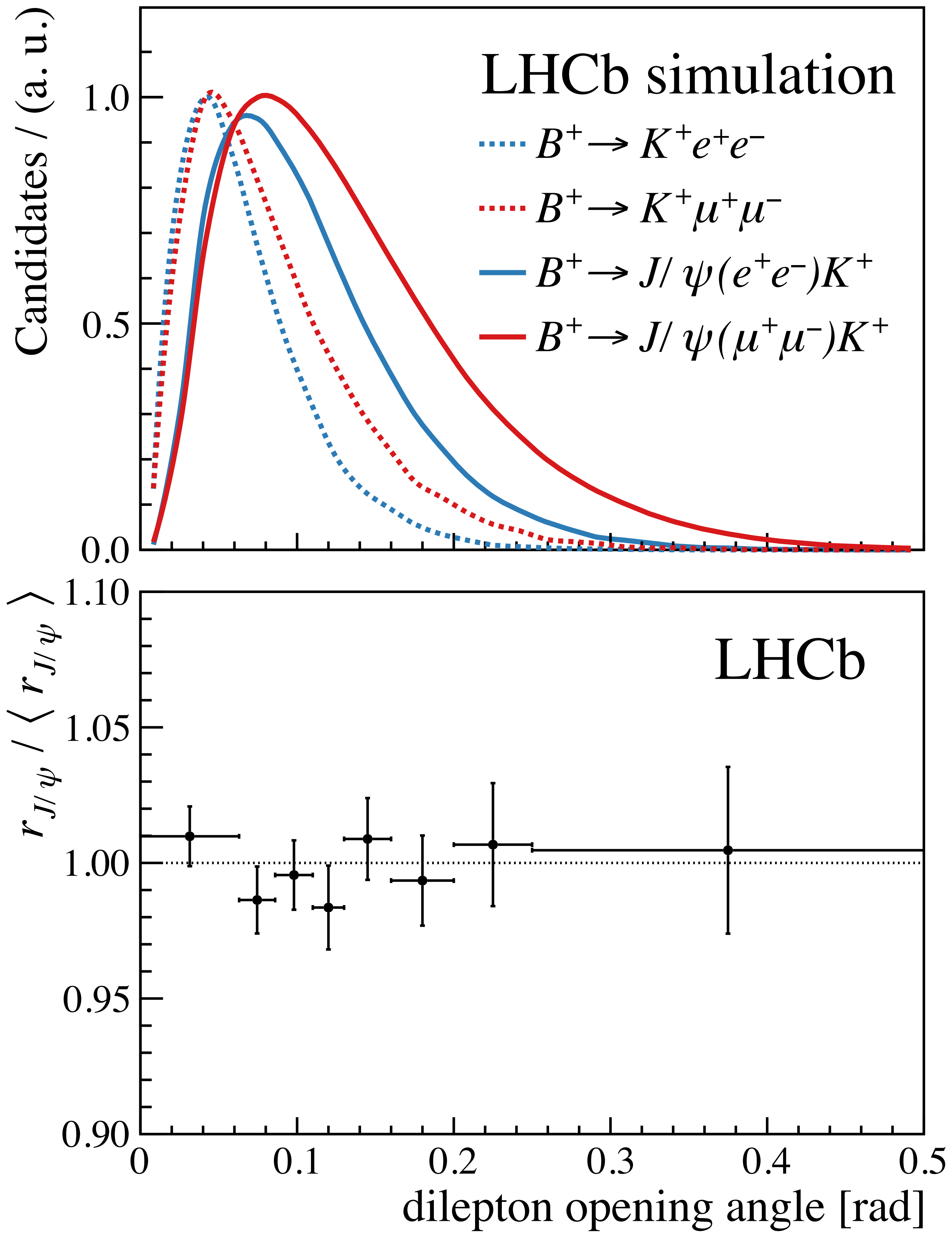
Phys. Rev. Lett. 122 (2019) 191801

- Crosschecks universality in $c\bar{c}$ resonances in all kinematic regions

$$r_{J/\psi} = \frac{\mathcal{B}(B^+ \to J/\psi(\to \mu^+\mu^-)K^+)}{\mathcal{B}(B^+ \to J/\psi(\to e^+e^-)K^+)} = 1$$







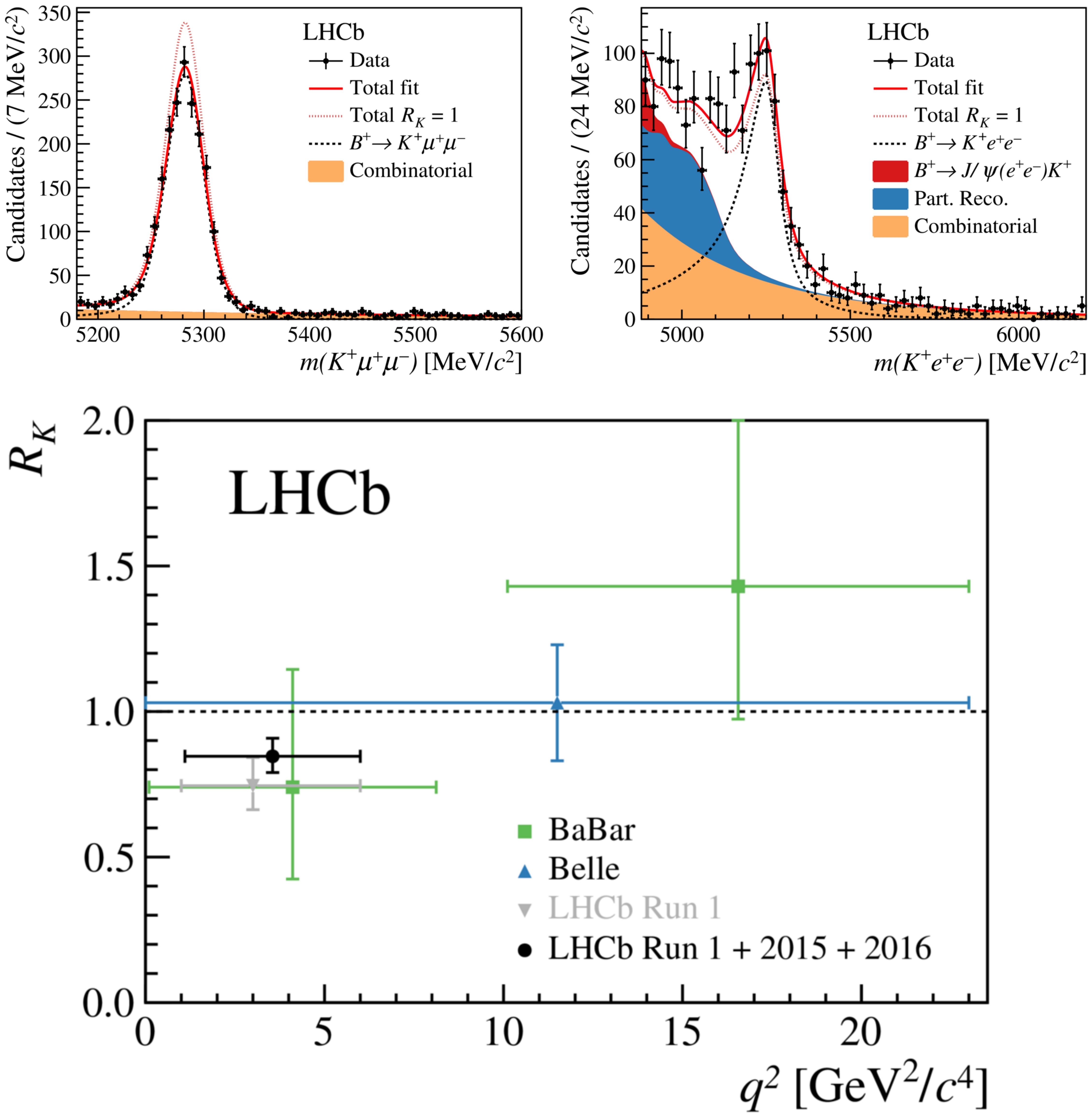
- Can also test that R_K measured at the $\psi(2S)$ is 1

$$R_{\psi(2S)} = \frac{\mathcal{B}(B^+ \to K^+\psi(2S)(\mu^+\mu^-))}{\mathcal{B}(B^+ \to K^+J/\psi(\mu^+\mu^-))} \Bigg/ \frac{\mathcal{B}(B^+ \to K^+\psi(2S)(e^+e^-))}{\mathcal{B}(B^+ \to K^+J/\psi(e^+e^-))} = 0.986 \pm 0.013\ (\mathrm{stat} + \mathrm{syst})$$

$B^+ \to K^+\ell^+\ell^-$ LFU tests

Phys. Rev. Lett. 122 (2019) 191801

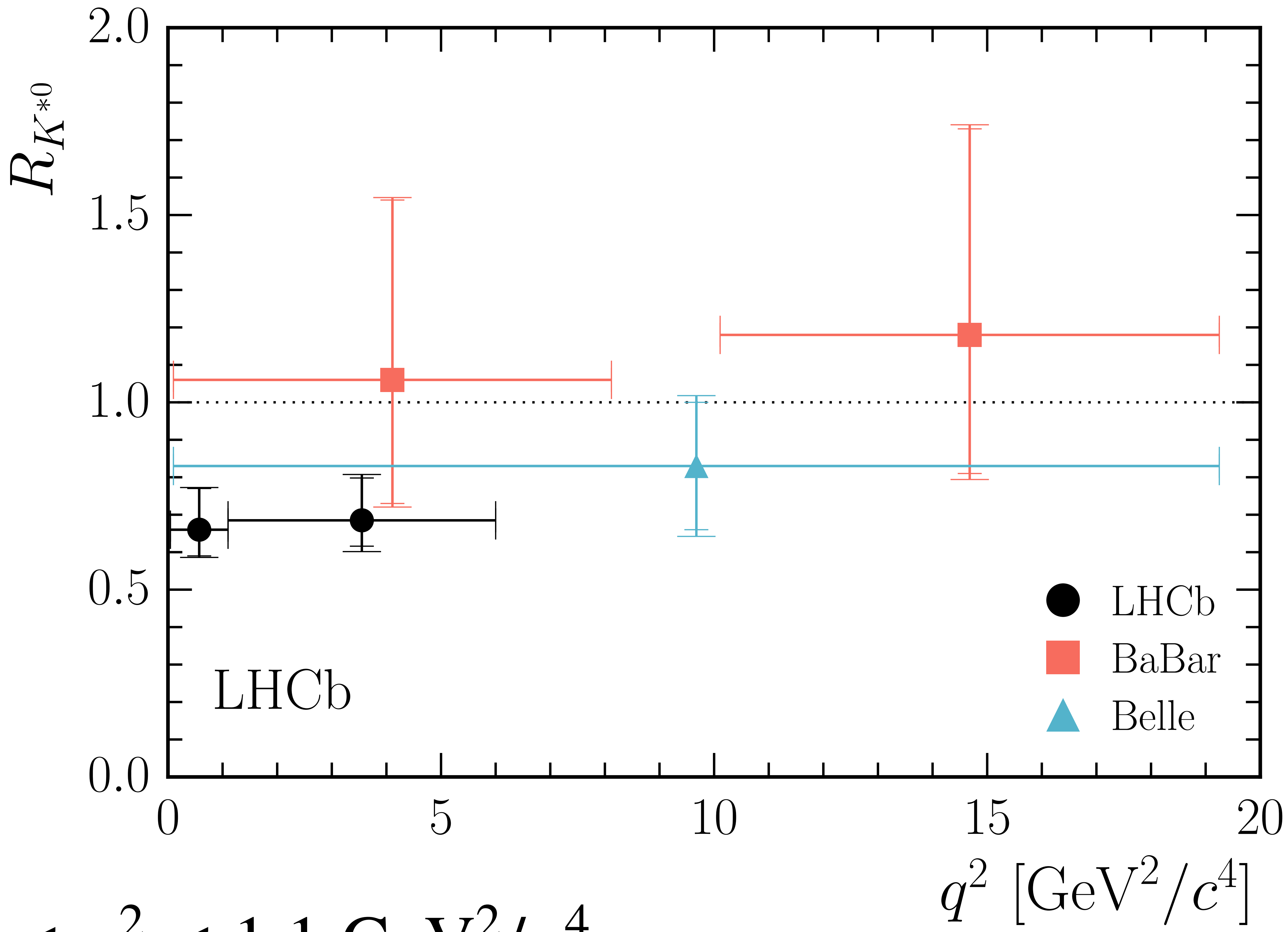
- Measurement with 2011-2016 (~5 fb^{-1} at $\sqrt{s}$ = 7,8 and 13 TeV) in central q^2 bin [1-6]GeV^2
  - $R_K = 0.846^{+0.060+0.016}_{-0.054-0.014}$
- Yield of ~766 $B^+ \to K^+e^+e^-$ events vs ~1943 $B^+ \to K^+\mu^+\mu^-$ driving the total uncertainty:
  - 7% statistical error vs 2% systematic
- R_K is found to be lower than 1 by ~15%
  - Still compatible with the SM at 2.5σ level!



$B^0 \to K^{*0}\ell^+\ell^-$ LFU tests

JHEP 08 (2017) 055

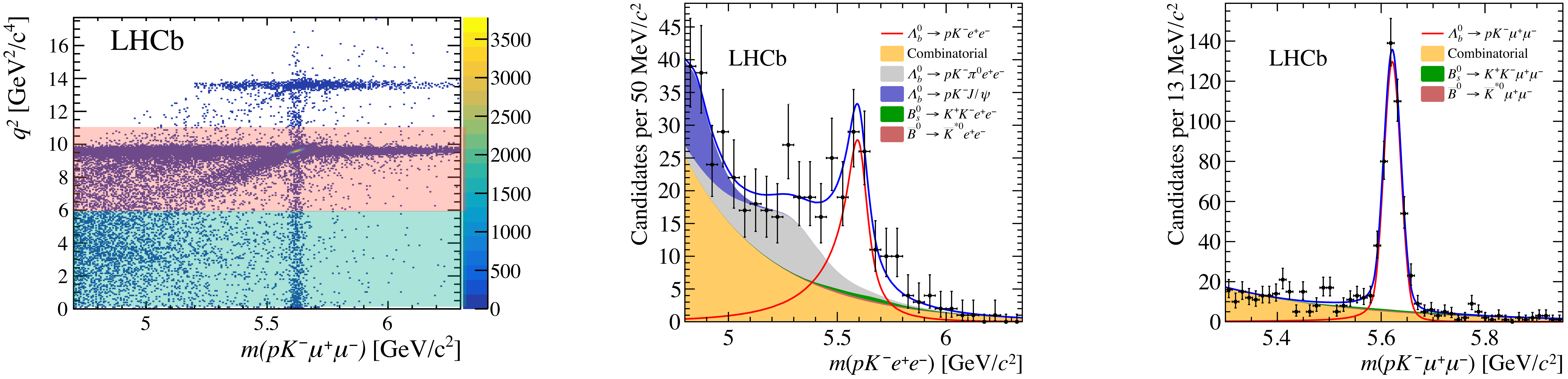
- Results use Run1 data ~3fb^{-1} of integrated luminosity
- Precision of ~17% in both bins, statistically dominated
- Upcoming Run1+Run2 analysis expected to reduce uncertainty by a factor ~2



$$R_{K^*} = \begin{cases} 0.66^{+0.11}_{-0.07}\,(\text{stat})\,^{+0.03}_{-0.05}\,(\text{syst}) & \text{for } 0.045 < q^2 < 1.1\ \text{GeV}^2/c^4 \\ 0.69^{+0.11}_{-0.07}\,(\text{stat})\,^{+0.05}_{-0.05}\,(\text{syst}) & \text{for } 1.1 < q^2 < 6.1\ \text{GeV}^2/c^4 \end{cases}$$

LFU test with baryons

JHEP 05 (2020) 040



- First test of LU with b-baryons, using $\Lambda_b^0 \to pK\ell^+\ell^-$ decays, analogous to $R(K^{(*)})$, expected to be unity in the SM [Fuentes-Martin et al.]
- Analysis performed using Run1 + 2016 dataset
- Region considered for the measurement: $m(pK^-) < 2.6$ GeV$/c^2$ and $0.1 < q^2 < 6$ GeV$^2/c^4$
- Efficiency crosschecked with resonant J/ψ component in $6 < q^2 < 11$ GeV$^2/c^4$

LFU test with baryons

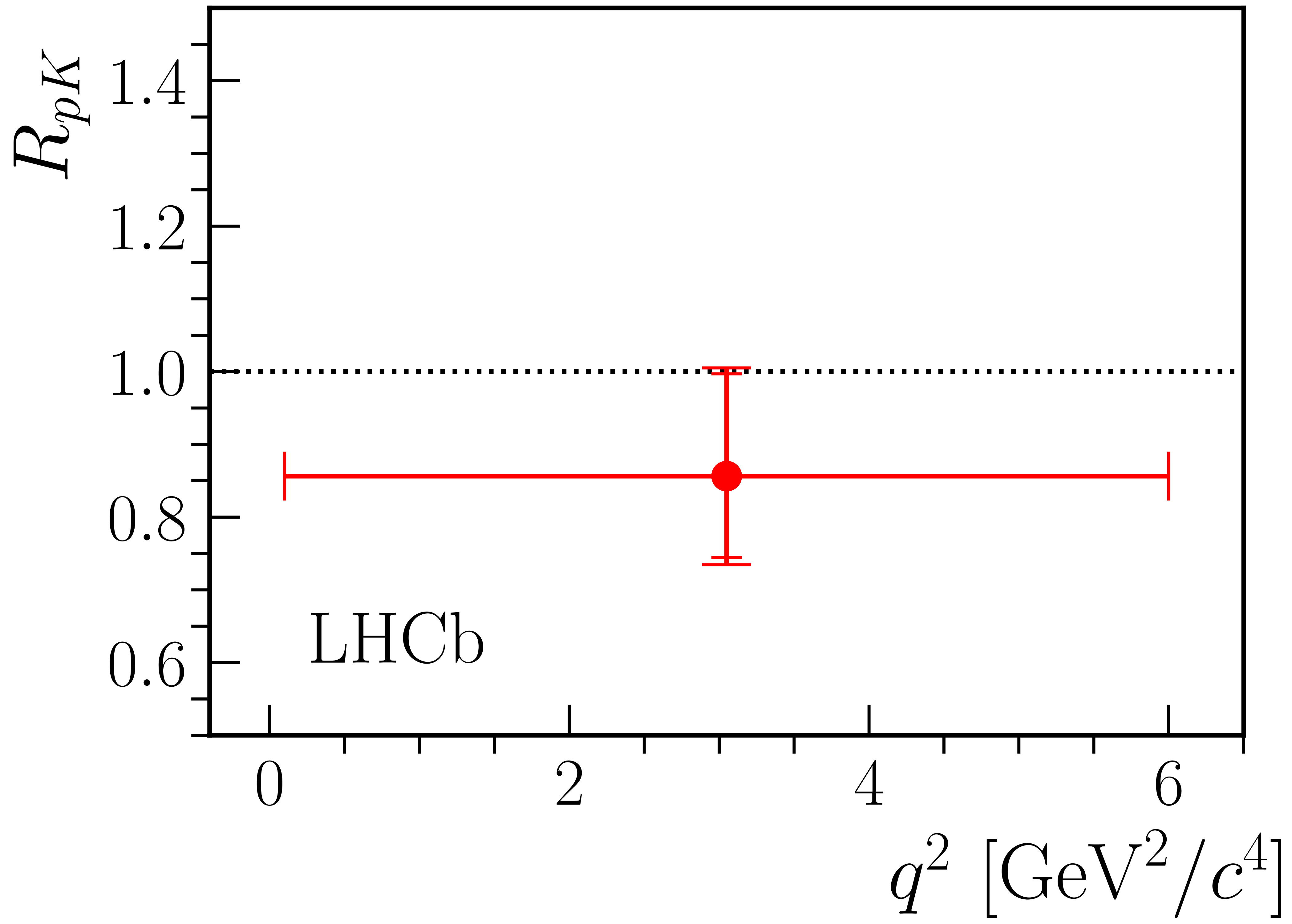
JHEP 05 (2020) 040

- First observation of $\Lambda_b^0 \to pKe^+e^-$ with more than 7σ

$$\mathscr{B}(\Lambda_b^0 \to pKe^+e^-)\Big|_{0.1<q^2<6\mathrm{GeV}^2/c^4} = (3.1 \pm 0.4 \pm 0.2 \pm 0.3 \pm^{0.4}_{0.3}) \times 10^{-7}$$

$$\mathscr{B}(\Lambda_b^0 \to pK\mu^+\mu^-)\Big|_{0.1<q^2<6\mathrm{GeV}^2/c^4} = (2.65 \pm 0.14 \pm 0.12 \pm 0.29 \pm^{0.38}_{0.23}) \times 10^{-7}$$

$$R_{pK}\Big|_{0.1<q^2<6\mathrm{GeV}^2/c^4} = 0.86^{+0.14}_{-0.11} \pm 0.05$$



Prospects for R_X measurements in LHCb

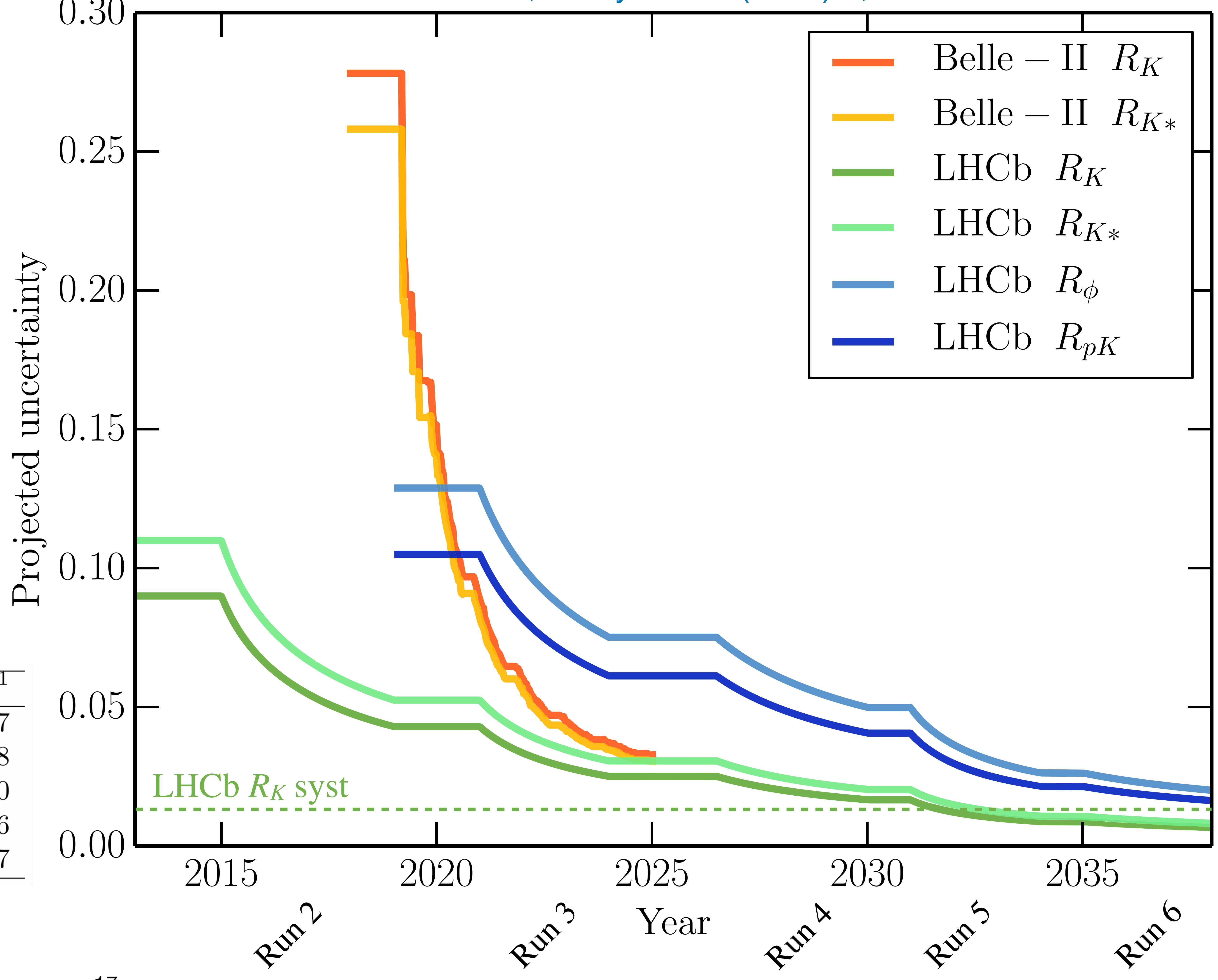
- Precision driven by the electron mode and projection based on the current performances

- R_K hitting QED uncertainty during Run 6

- **Higher statistics will give access to additional observables such as R_π**

R_X precision	Run 1 result	9 fb^{-1}	23 fb^{-1}	50 fb^{-1}	300 fb^{-1}
R_K	$0.745 \pm 0.090 \pm 0.036$ [274]	0.043	0.025	0.017	0.007
$R_{K^{*0}}$	$0.69 \pm 0.11 \pm 0.05$ [275]	0.052	0.031	0.020	0.008
R_ϕ	–	0.130	0.076	0.050	0.020
R_{pK}	–	0.105	0.061	0.041	0.016
R_π	–	0.302	0.176	0.117	0.047

Bifani et al, J.Phys.G 46 (2019) 2, 023001



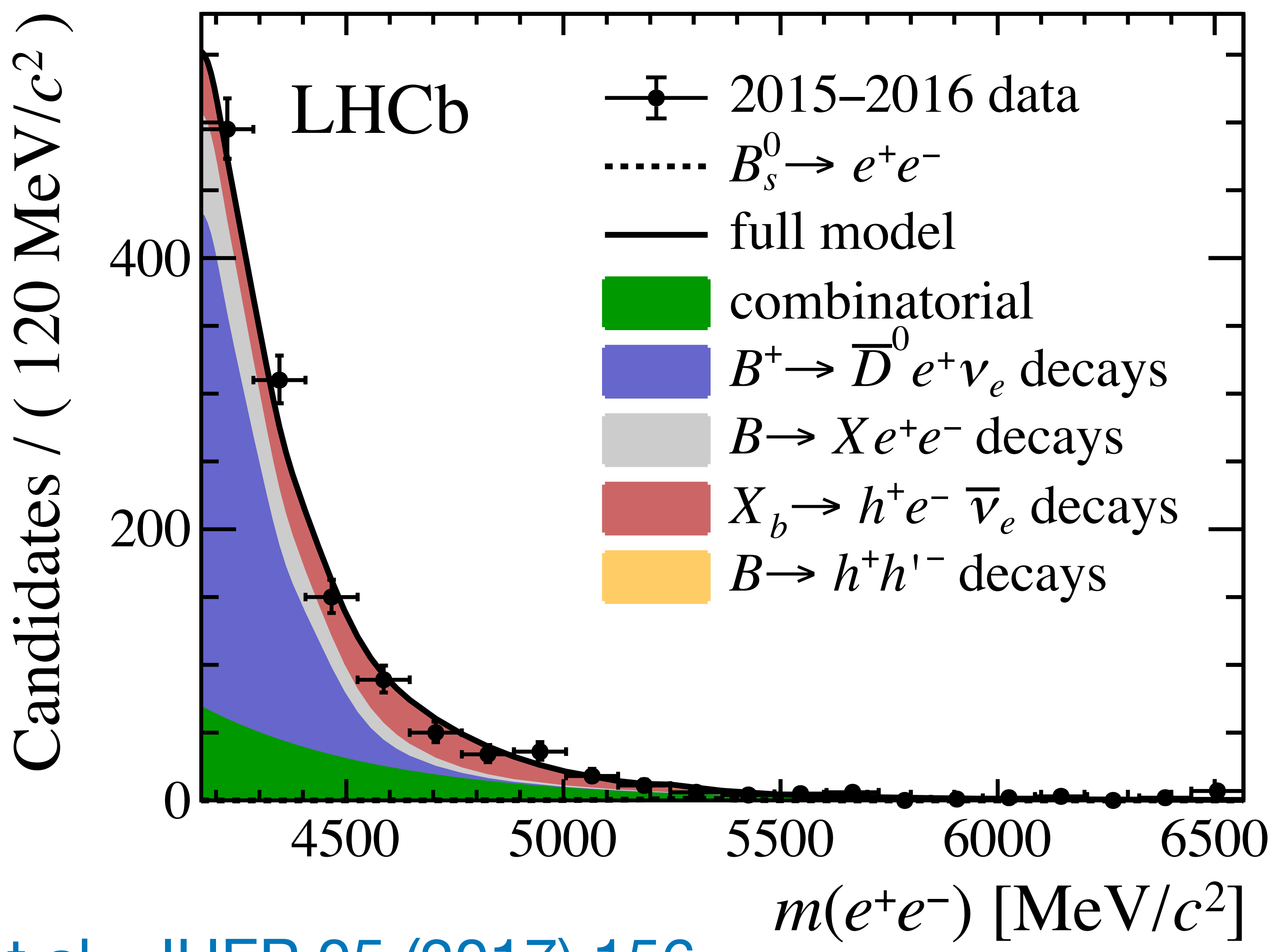
Test of LFU with $B^0_{(s)} \to e^+e^-$ decays

- Helicity suppressed by $\mathcal{O}(10^{-4})$ relative to $B^0_{(s)} \to \mu^+\mu^-$
- $\mathcal{B}(B^0_s \to e^+e^-) = (8.35 \pm 0.39) \times 10^{-14}$
- $\mathcal{B}(B^0 \to e^+e^-) = (2.39 \pm 0.14) \times 10^{-15}$

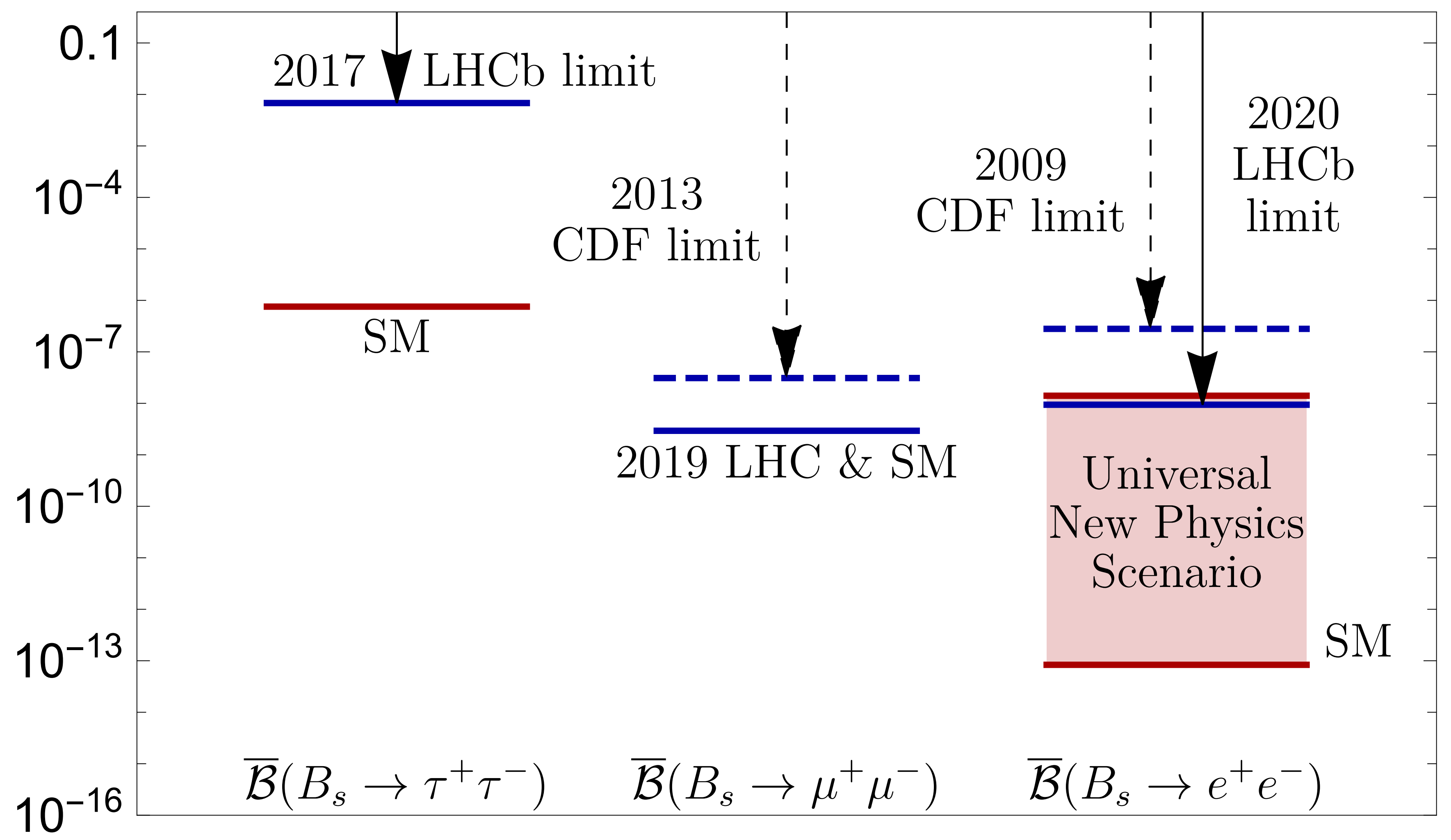
M. Beneke et al. JHEP 10 (2019) 232

- NP effects could increase BFs by $\mathcal{O}(10^6)$
- Current analysis performed on Run1+2015+2016 data
- Signal extracted from UML fit on $m_{e^+e^-}$
  - $\mathcal{B}(B^0_s \to e^+e^-) < 11.2 \times 10^{-9}$ at 95 % CL
  - $\mathcal{B}(B^0 \to e^+e^-) < 3.0 \times 10^{-9}$ at 95 % CL

Phys. Rev. Lett. 124 (2020) 211802



Fleischer et al., JHEP 05 (2017) 156



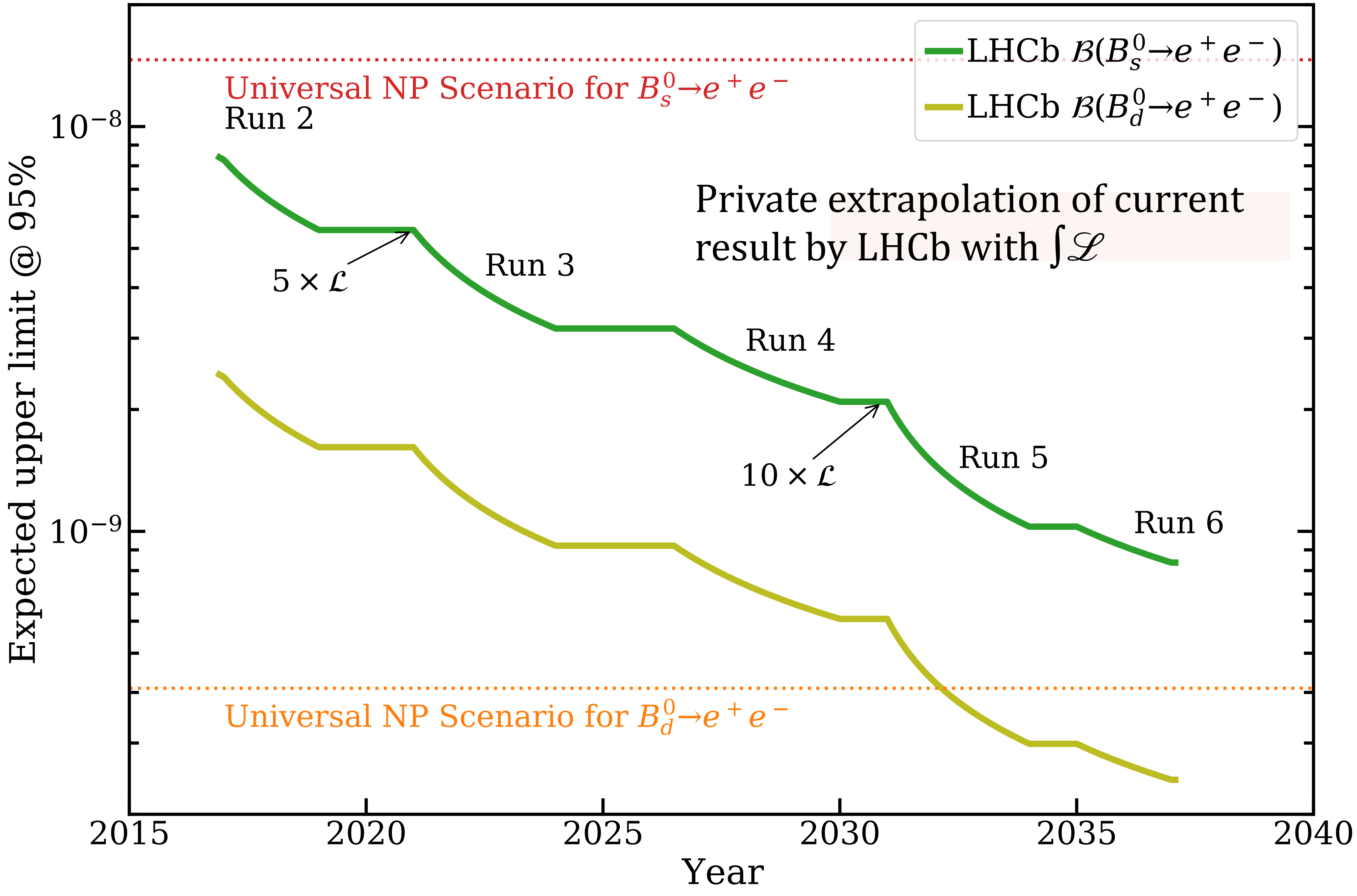
Prospects

- $B_s^0 \to e^+e^-$ already probing possible LUV scenarios
- Potential backgrounds like $B_s^0 \to e^+e^-\gamma$ might become relevant with larger statistics
- Electron reconstruction/PID unknown after UpgradeII
- Also $B_{(s)}^0 \to \tau^+\tau^-$ even if far from SM expectations still powerful tool to constraint NP Leptoquark models

  Phys. Rev. D 94, 115021 (2016)
- Run1:

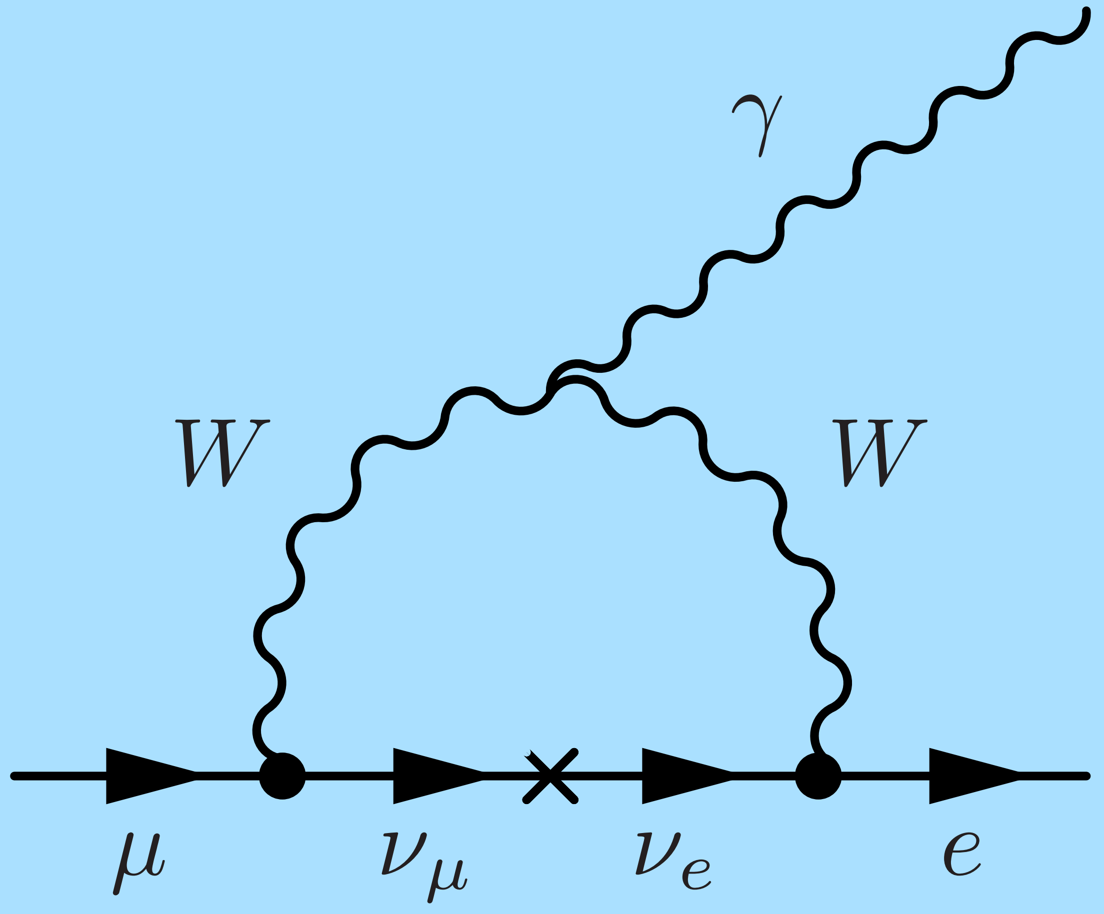
  $\mathcal{B}(B_{(s)}^0 \to \tau^+\tau^-) < 6.8 \times 10^{-3}$ @ 95 % CL
- 300 fb–1:

  $\mathcal{B}(B_{(s)}^0 \to \tau^+\tau^-) < 2.6 - 5 \times 10^{-4}$ @ 95 % CL



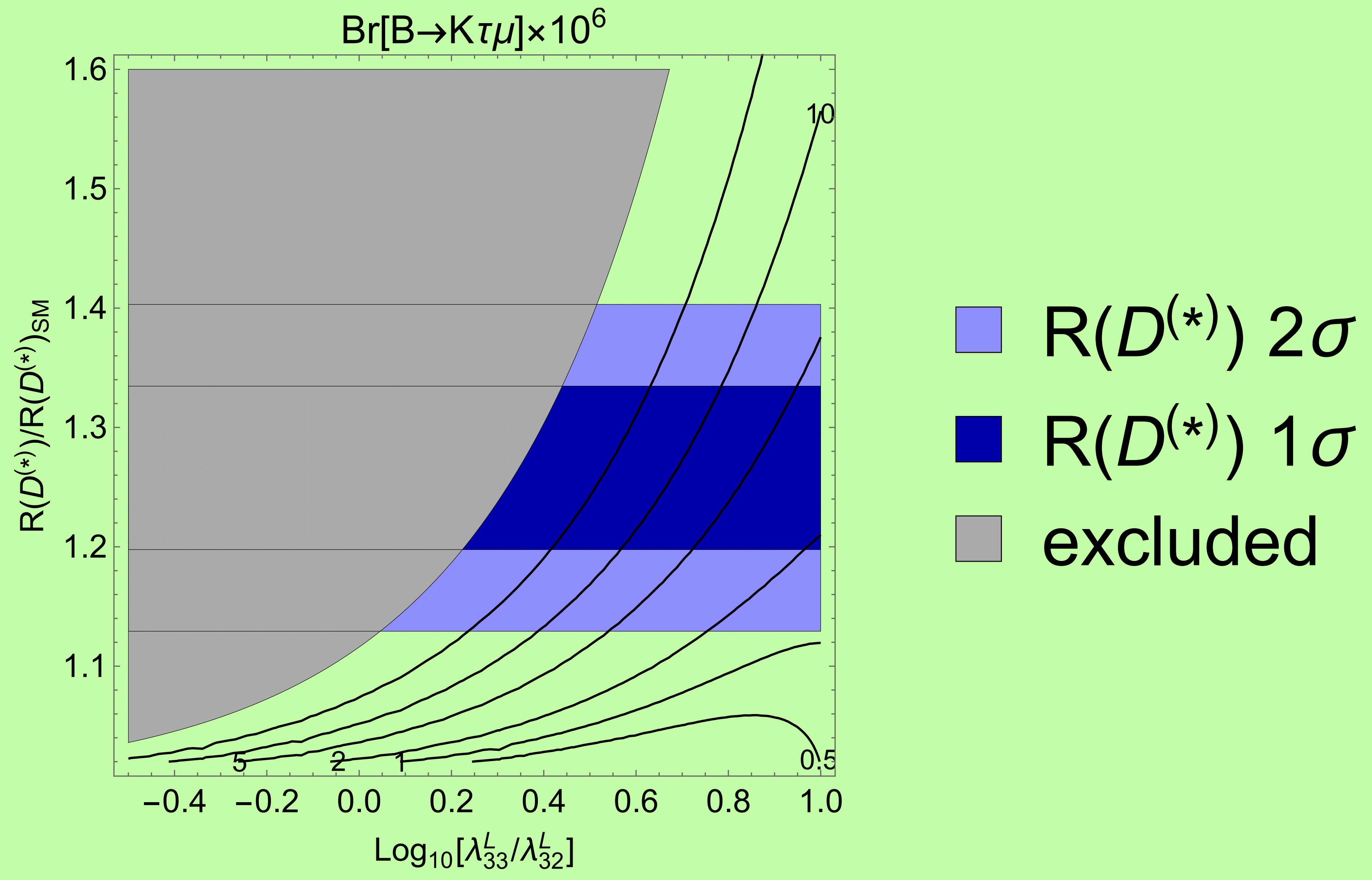
Lepton flavour violations measurements

- Lepton Flavour Violation forbidden in the SM
- Observation of neutrino oscillation → evidence of LFV in the neutral sector. However no observation of LFV in the charged sector so far



$$\mathscr{B}(\mu \to e\gamma) < 10^{-50}$$

- If LFUV confirmed



➡Interesting correlation with $b \to s\tau\mu$ and $b \to s\mu e$ LFV processes in several BSM models

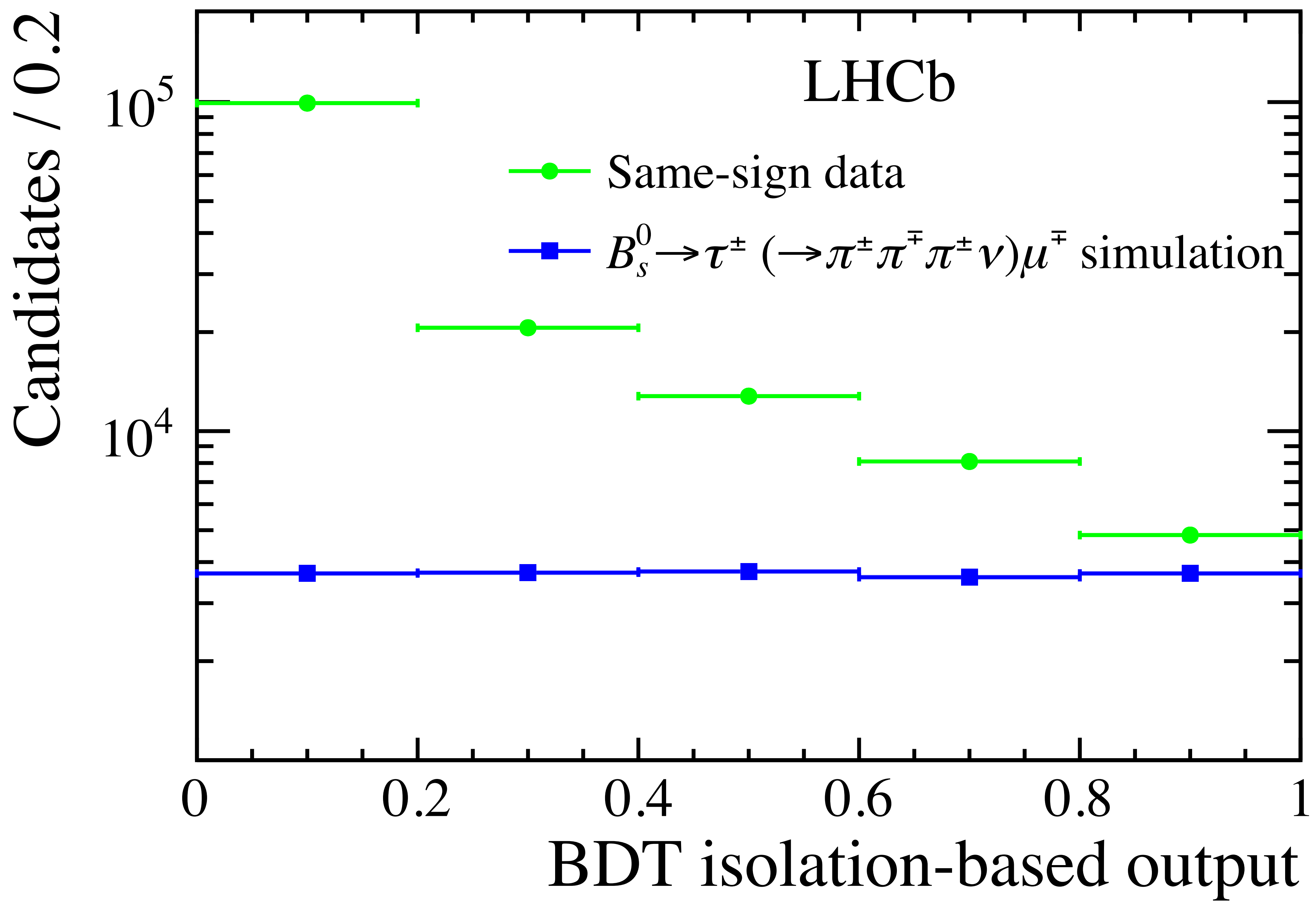
Crivellin, Mueller, Ota JHEP09(2017)040

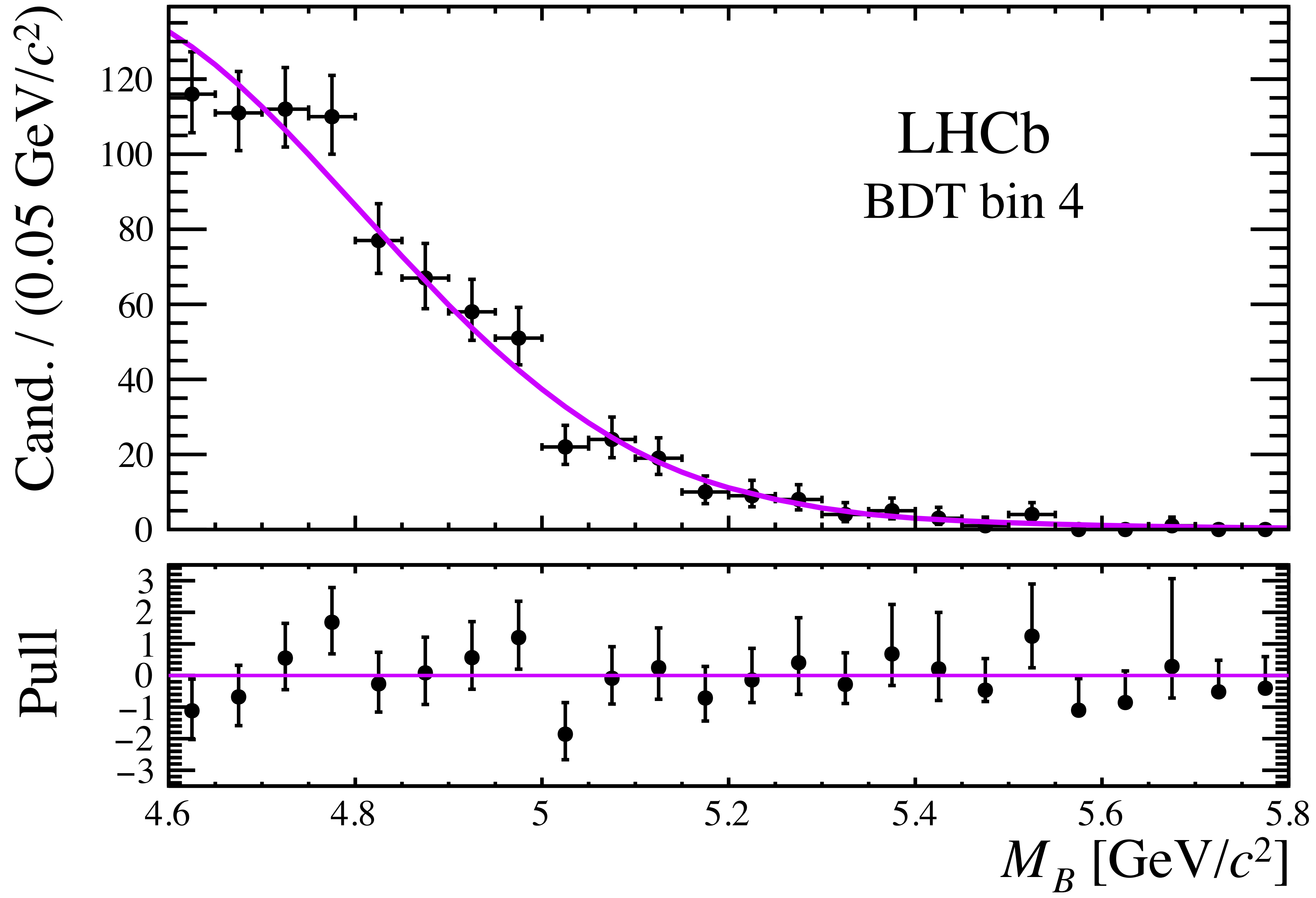
$B^0_{(s)} \to \tau^{\pm}\mu^{\mp}$

Phys. Rev. Lett. 123 (2019) 211801

- BF can be ~O(10–5) in some models with Z'/ leptoquarks [JHEP 11 (2016) 035]
- LHCb analysis with Run1 data (3 fb-1)
- Reconstruct $B^0_{(s)} \to \tau^{\pm}\mu^{\mp}$ candidates using the 3-prong τ decays
- Events classified with multivariate operator and invariant mass (kinematically constrained)

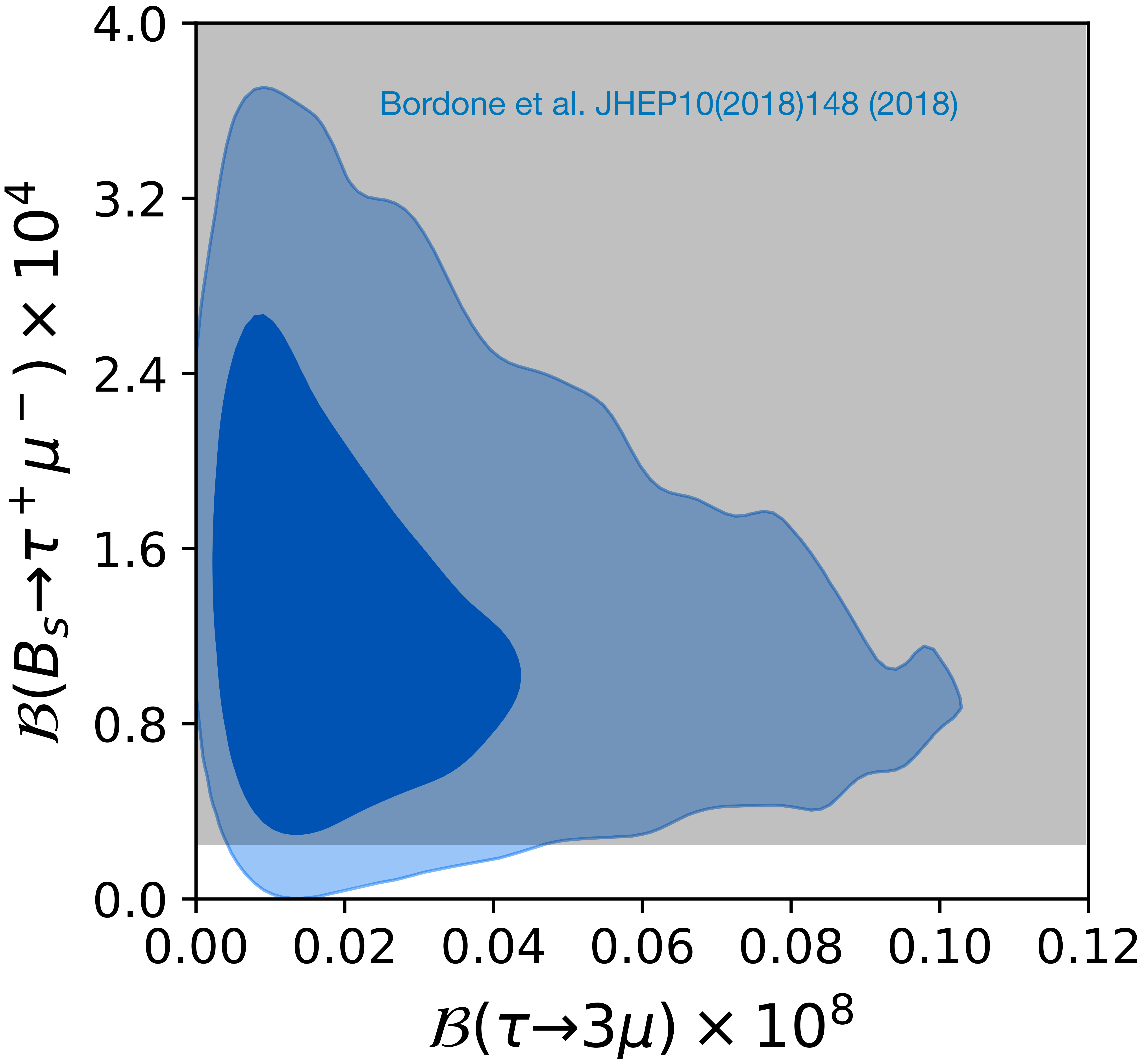
Mode	Limit	90% CL	95% CL
$B^0_s \to \tau^{\pm}\mu^{\mp}$	Observed	3.4×10^{-5}	4.2×10^{-5}
	Expected	3.9×10^{-5}	4.7×10^{-5}
$B^0 \to \tau^{\pm}\mu^{\mp}$	Observed	1.2×10^{-5}	1.4×10^{-5}
	Expected	1.6×10^{-5}	1.9×10^{-5}





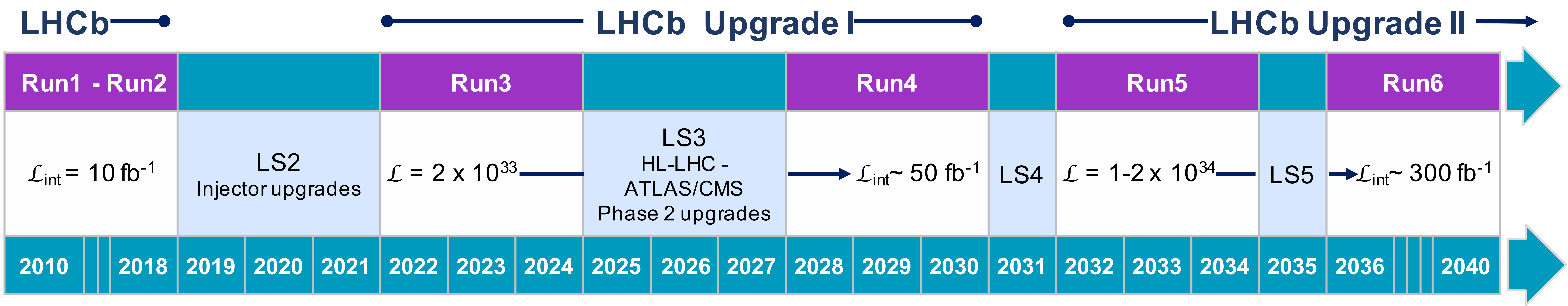
$B^0_{(s)} \to \tau^\pm \mu^\mp$

- Already very effective in constraining BSM models such Pati-Salam extensions
- Complementary to cLFV searches with τ



$B \to \ell\ell'$ prospects

CERN-LHCC-2018-027



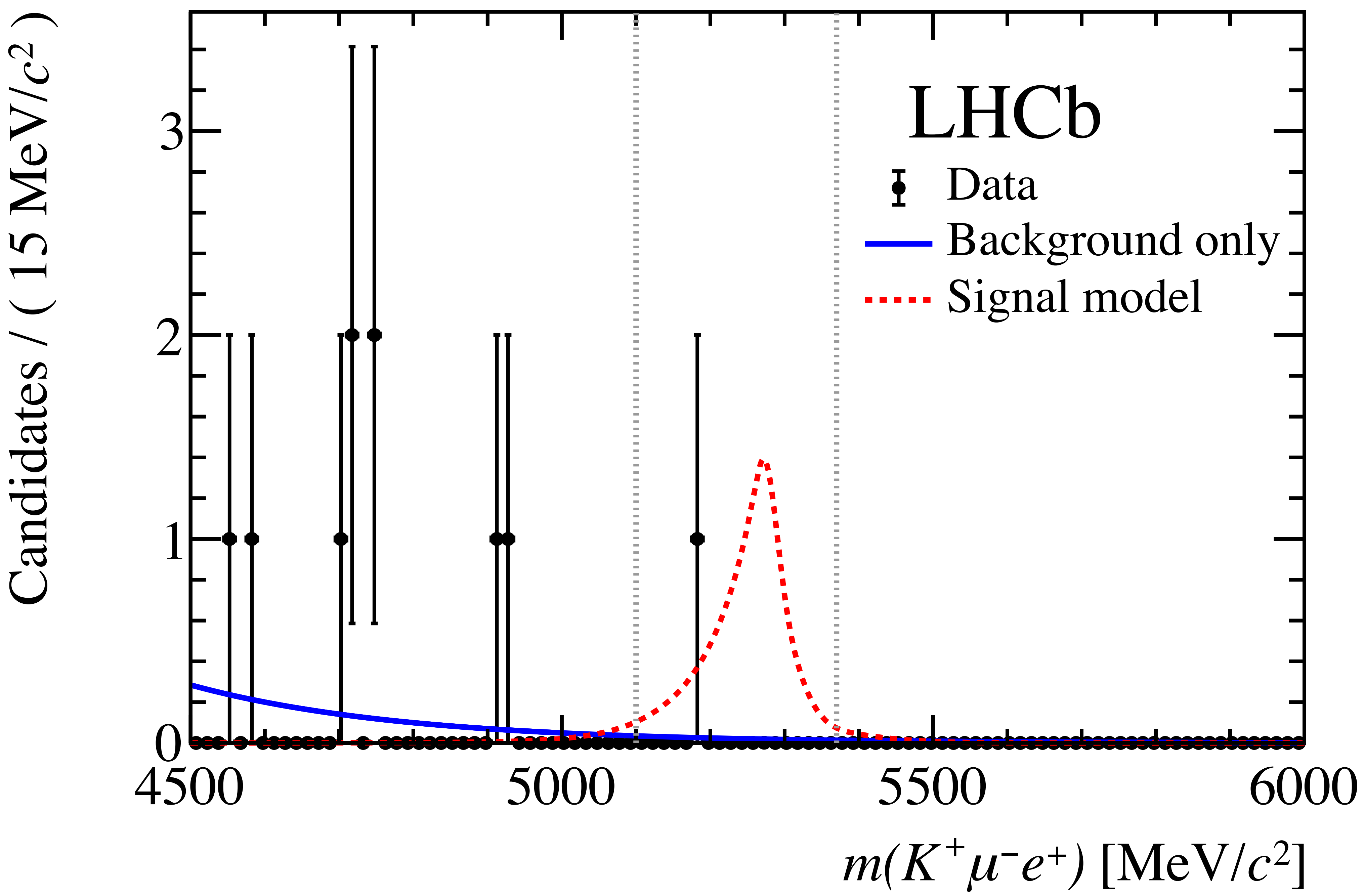
	LHCb Run1	Upgrade I	Upgrade II
$\mathscr{B}(B^0 \to e^\pm\mu^\mp)$	$< 1.3 \times 10^{-9}$	$< 2 \times 10^{-10}$	$< 9 \times 10^{-11}$
$\mathscr{B}(B_s^0 \to e^\pm\mu^\mp)$	$< 6.3 \times 10^{-9}$	$< 8 \times 10^{-10}$	$< 3 \times 10^{-10}$
$\mathscr{B}(B^0 \to \tau^\pm\mu^\mp)$	$< 1.4 \times 10^{-5}$	–	$< 3 \times 10^{-6}$

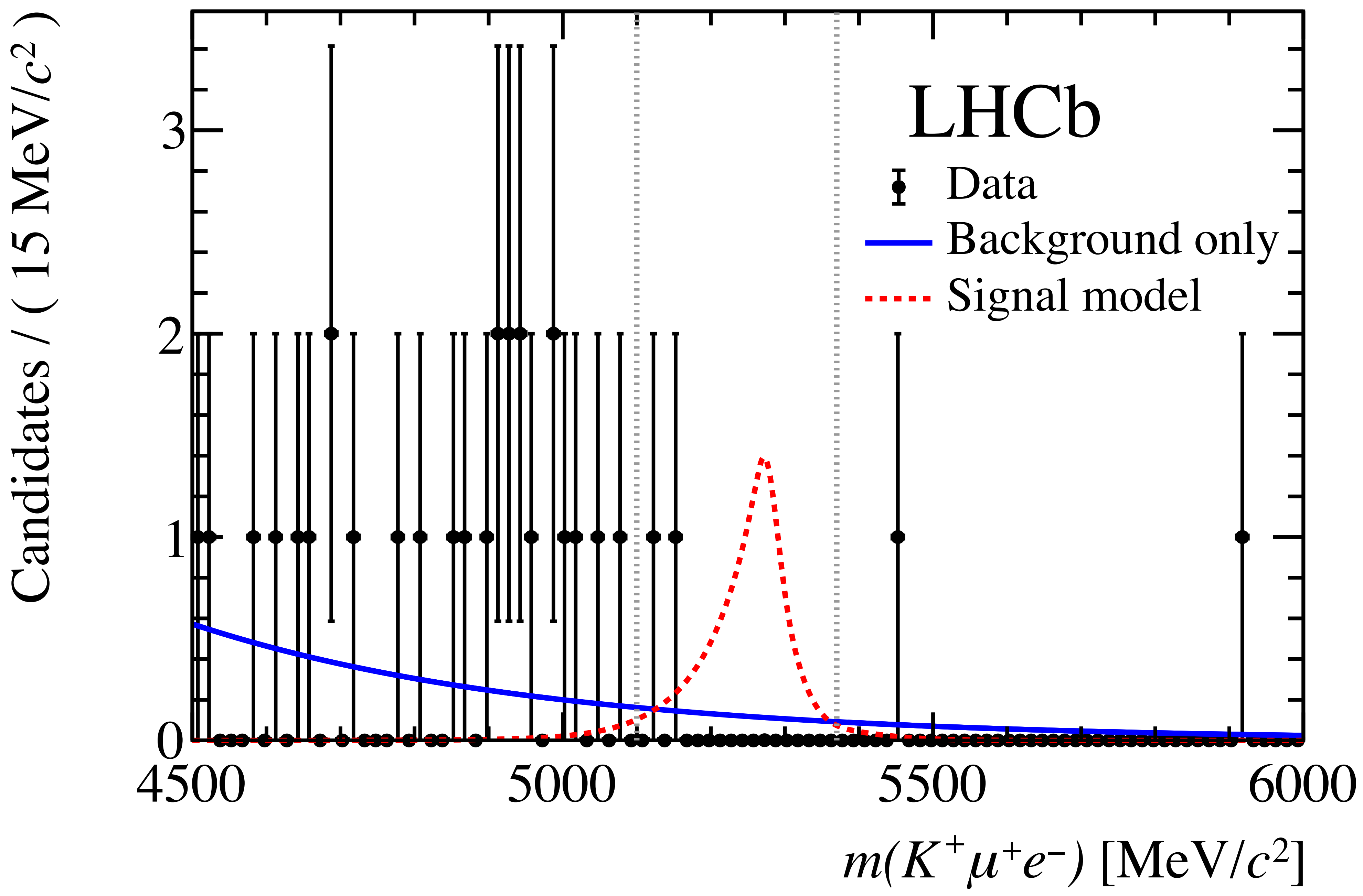
projections @95% CL

Phys. Rev. Lett. 123 (2019) 241802

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

- Leptoquark/Z' scenario: $\mathscr{B} \sim \mathscr{O}(10^{-9} - 10^{-8})$
  - Leptoquarks: [PRD 97 (2018) 015019, JHEP 06 (2015) 072, JHEP 12 (2016) 027]
  - Z': [PRD 92 (2015) 054013]
- Search for $B^+ \to K^+\mu^\pm e^\mp$ performed with Run1 ($3fb^{-1}$)
  - $\mathscr{B}(B^+ \to K^+\mu^+e^-) < 8.8 \times 10^{-9}$ @95 % CL
  - $\mathscr{B}(B^+ \to K^+\mu^-e^+) < 9.5 \times 10^{-9}$ @95 % CL

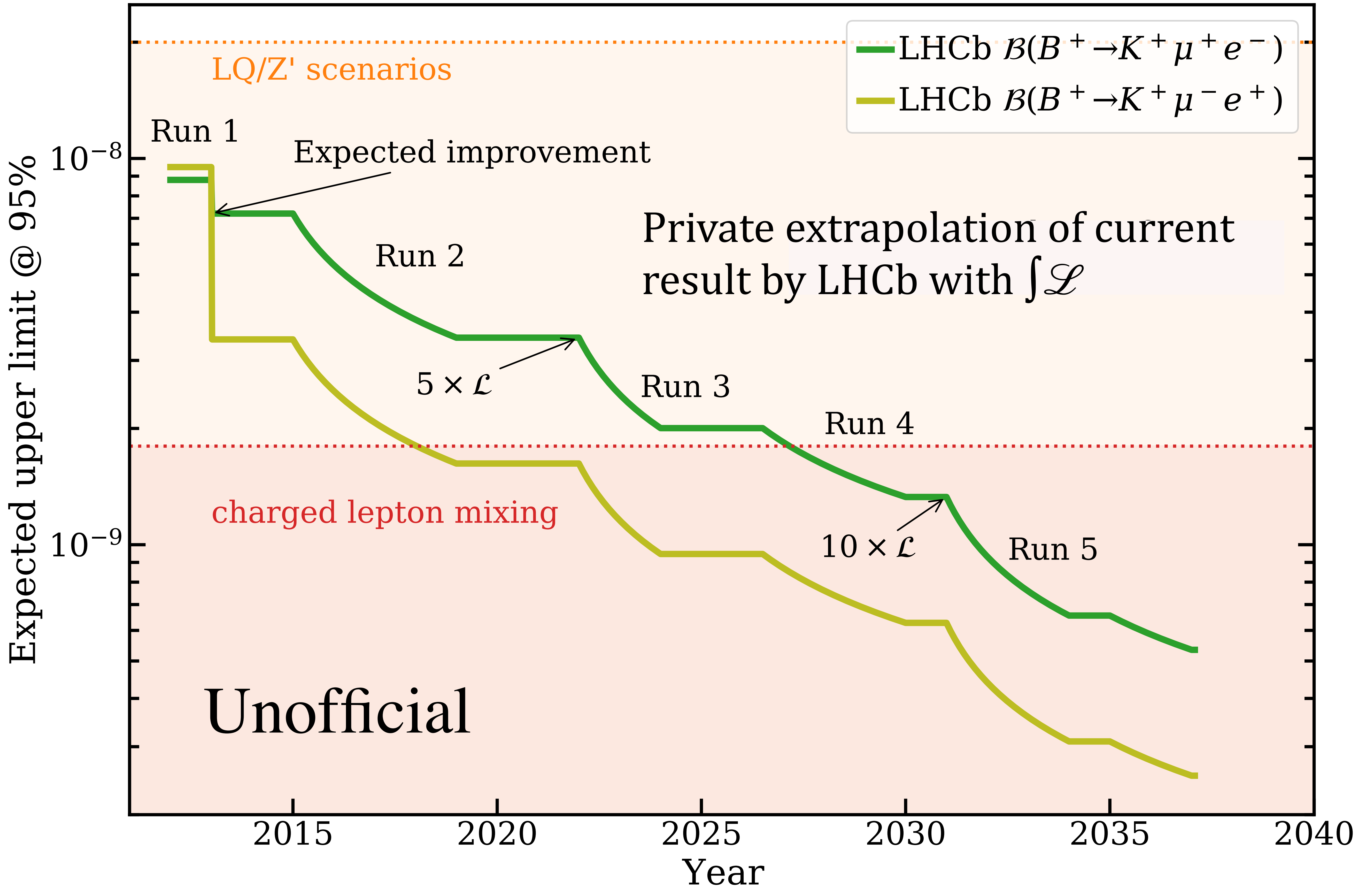




Projections

- Expected upper limit scales with $\sqrt{\mathscr{L}}$
- Selection improvement gains quite a bit
- Strongly constraining New Physics predictions
- Potential backgrounds like $B^+ \to K^+\pi^+\pi^-$ might become relevant with larger statistics

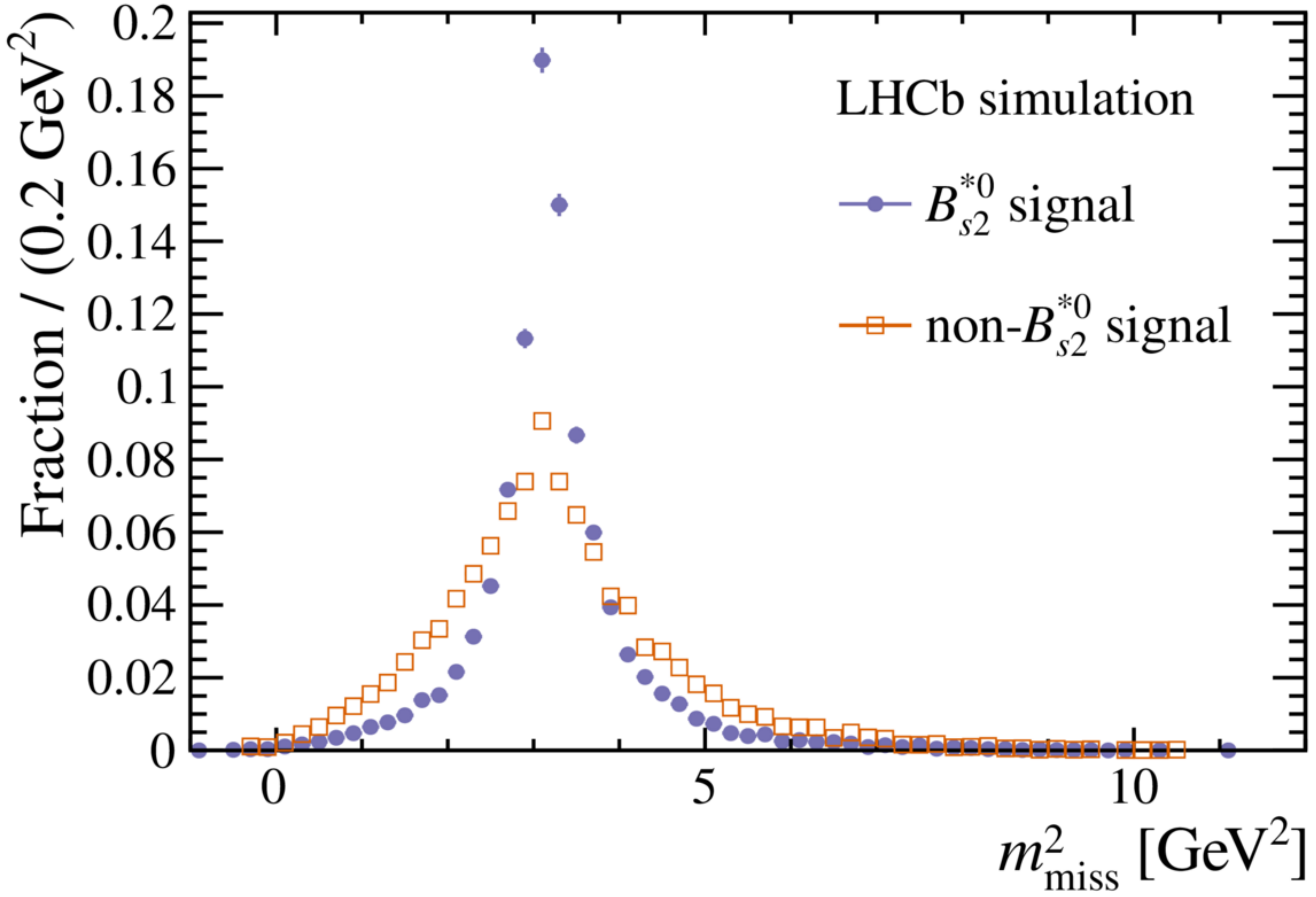
LQ: PRD 97 (2018) 015019, JHEP 06 (2015) 072, JHEP 12 (2016) 027]
Z': PRD 92 (2015) 054013
CPV: PLB 750 (2015) 367

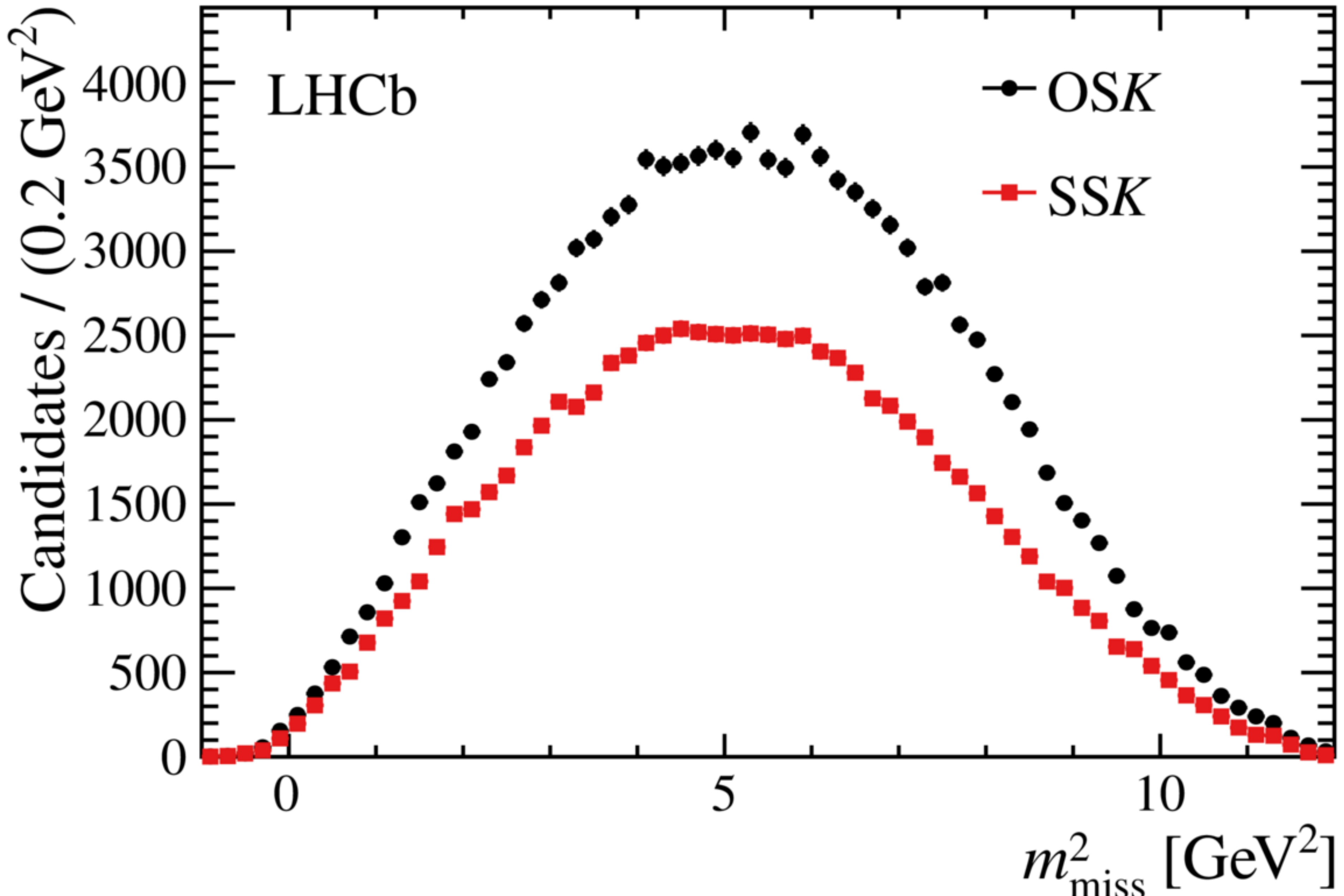


$B^+ \to K^+\mu^-\tau^-$

- BSM models predict to have large enhancement:
  - PS[3] model predicts BF ~ 10^{-5}
- Best experimental limit from BaBar
  - $\mathscr{B}(B^+ \to K^+\mu^-\tau^+) < 2.8 \times 10^{-5}$ @ 90 % CL
- Analysis performed on Run1 and Run2 data
- τ four-momentum fully reconstructed using $B_{s2}^{*0} \to B^+K^-$ decays (~1% of B+ production)
  - kinematic constraint to reconstruct missing mass m_τ

JHEP 06 (2020) 129





$B^+ \to K^+\mu^-\tau^-$

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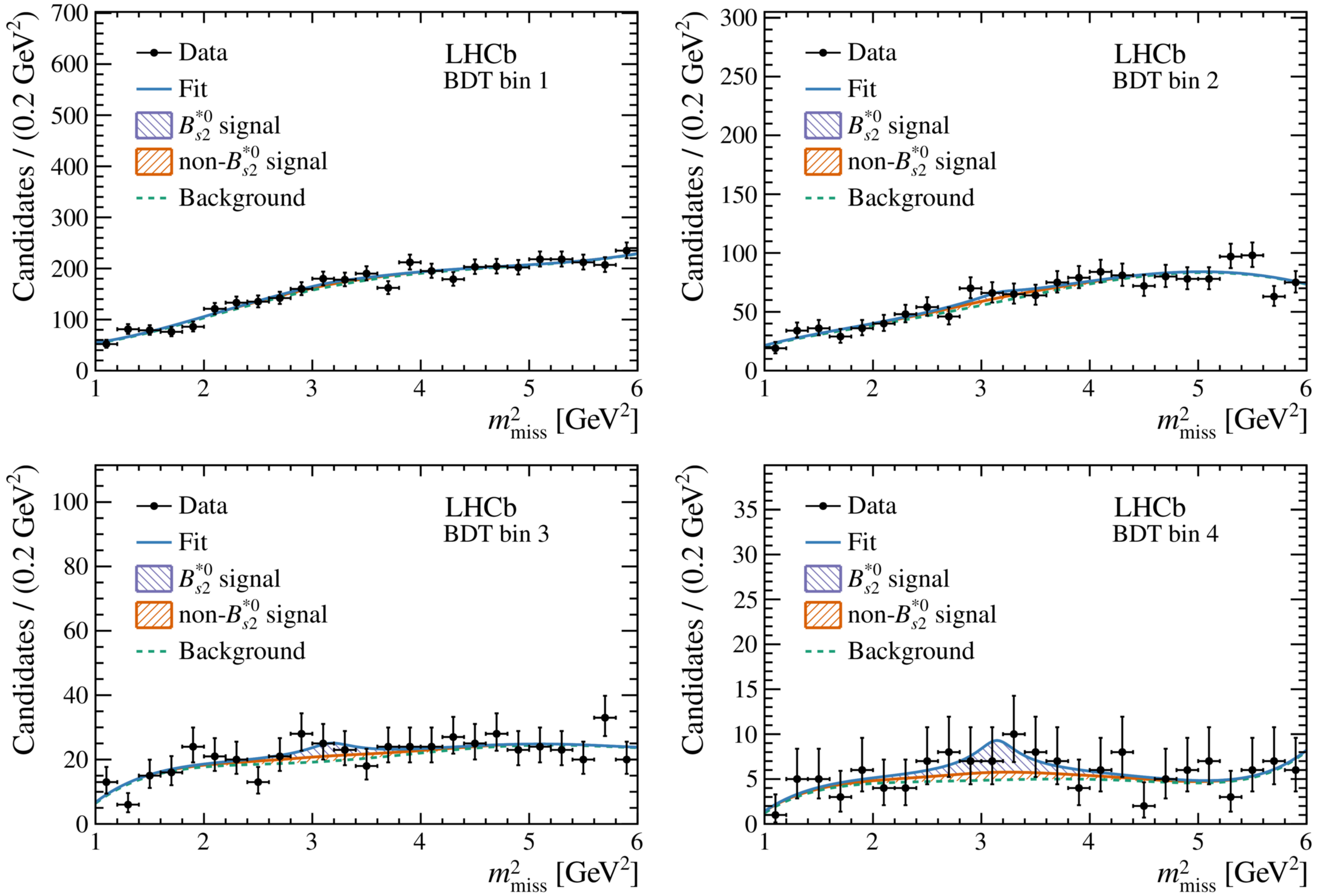
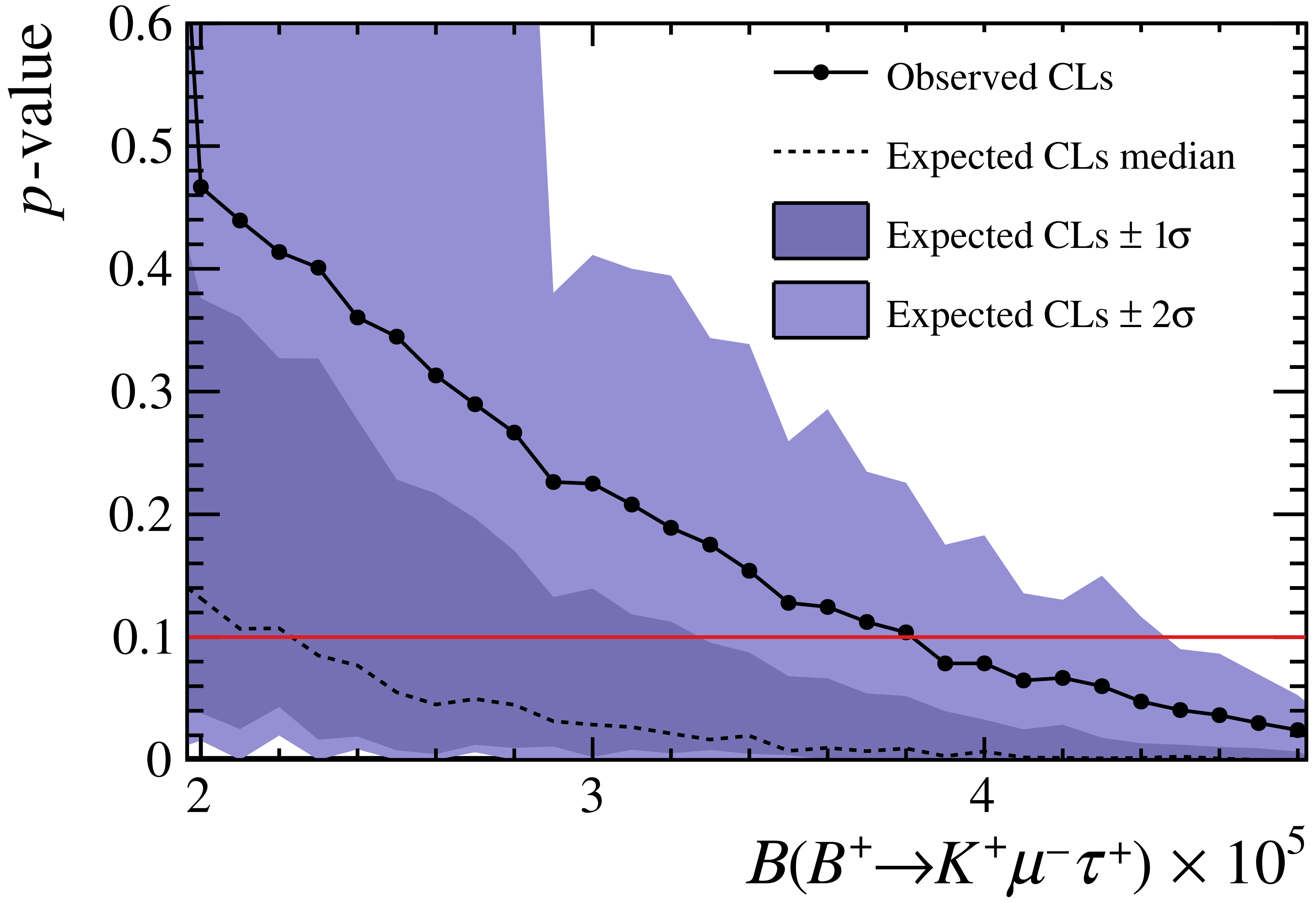


- Simultaneous fit in four bins of BDT:
  - background shape from same-sign kaon sample
  - No excess of events observed
  - CLs method used to set the limit:
  - $\mathscr{B}(B^+ \to K^+\mu^-\tau^+) < 3.9(4.5) \times 10^{-5}$ @90 % (95%) CL

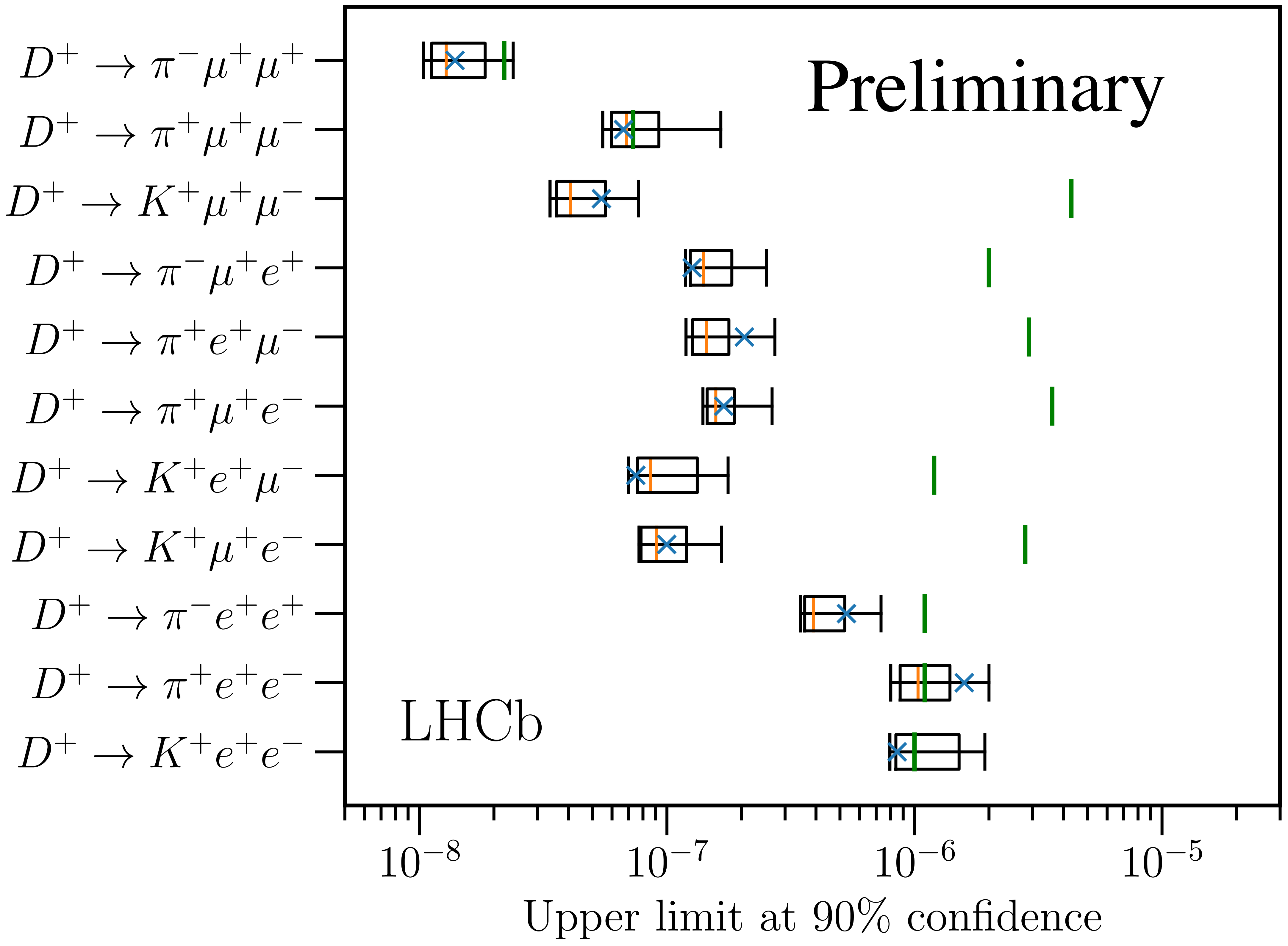


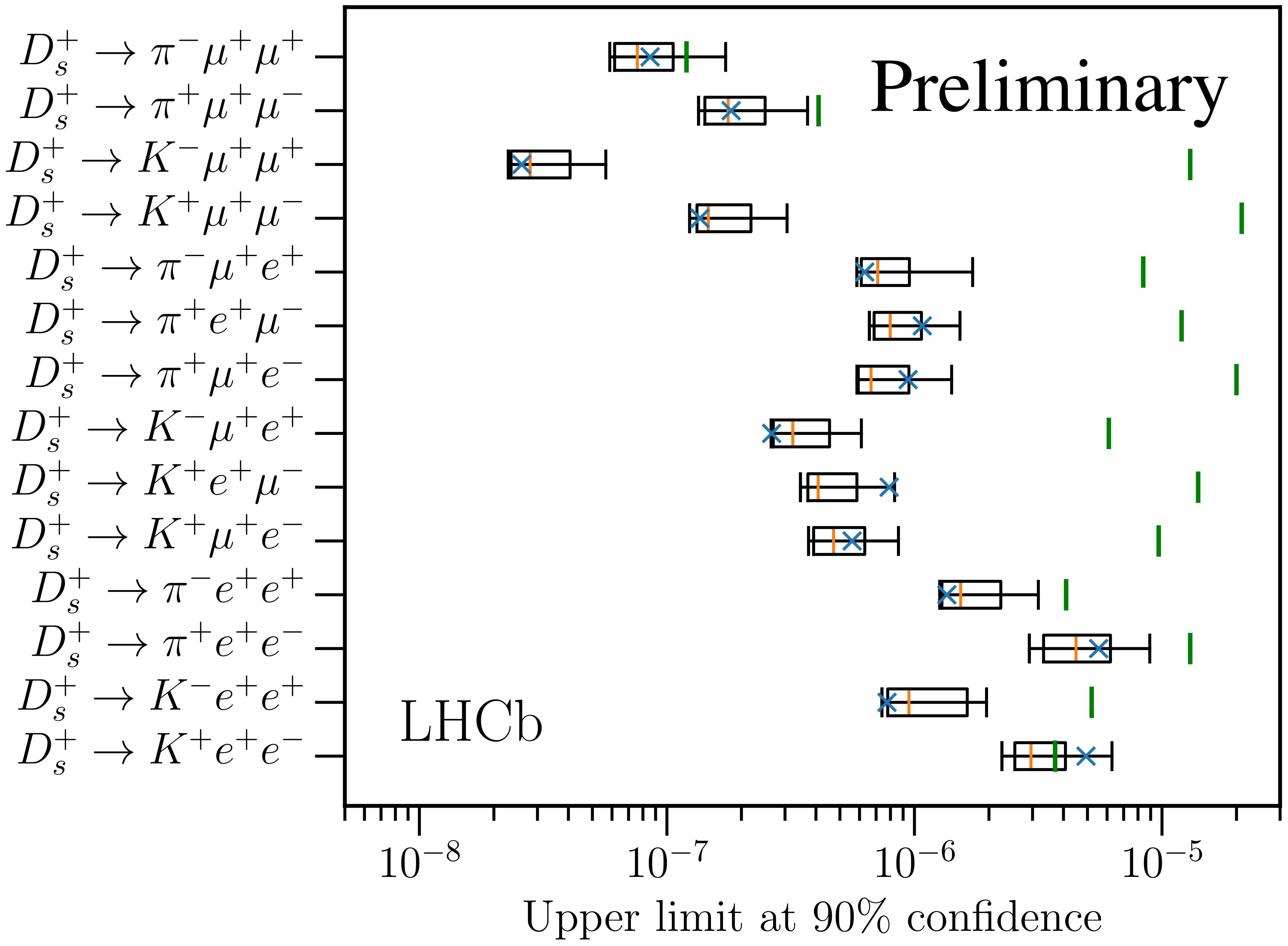
- Promising analysis using three-prong τ decays

LFV in the charm sector

- Searches for 25 new charm rare/LFV/LNV
- preliminary results compatible with bkg-only hypothesis

LHCb-PAPER-2020-007

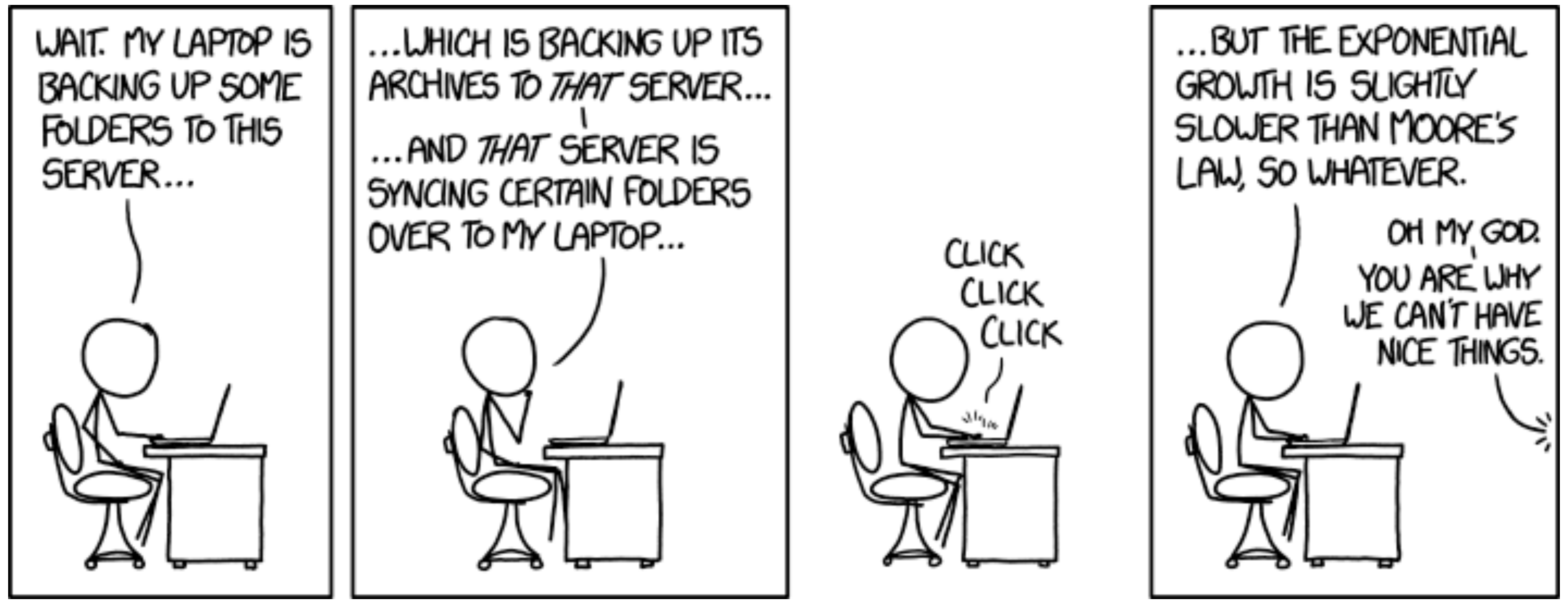




~~Conclusions~~ Summary

- FCNC is a powerful tool to probe for NP effects
- Current anomalies in $b \to s\ell\ell$ processes suggest possible NP. Update of LFU can possibly show an evidence of NP already with full Run2 data.
- Additional decays can be exploited (Baryons) for the search for BSM effects.
- LFV searches with the LHCb detector can strongly constraints the parameters space of several BSM models.
- LHCb upgrades will provide the statistical power to discriminate between NP models, and provide access to additional observables.

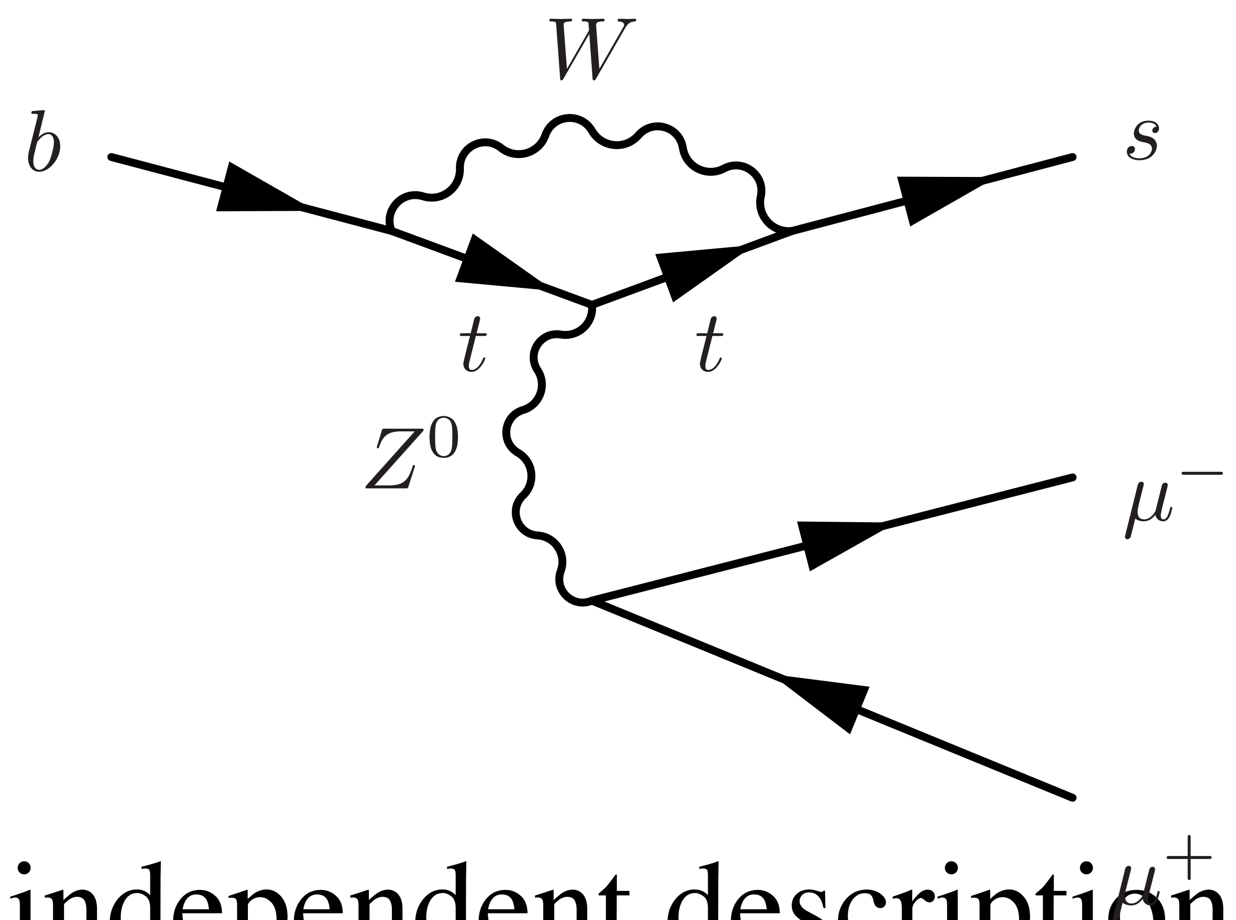
Backup


WAIT. MY LAPTOP IS BACKING UP SOME FOLDERS TO THIS SERVER...
...WHICH IS BACKING UP ITS ARCHIVES TO *THAT* SERVER...
...AND *THAT* SERVER IS SYNCING CERTAIN FOLDERS OVER TO MY LAPTOP...
CLICK
CLICK
CLICK
...BUT THE EXPONENTIAL GROWTH IS SLIGHTLY SLOWER THAN MOORE'S LAW, SO WHATEVER.
OH MY GOD.
YOU ARE WHY WE CAN'T HAVE NICE THINGS.

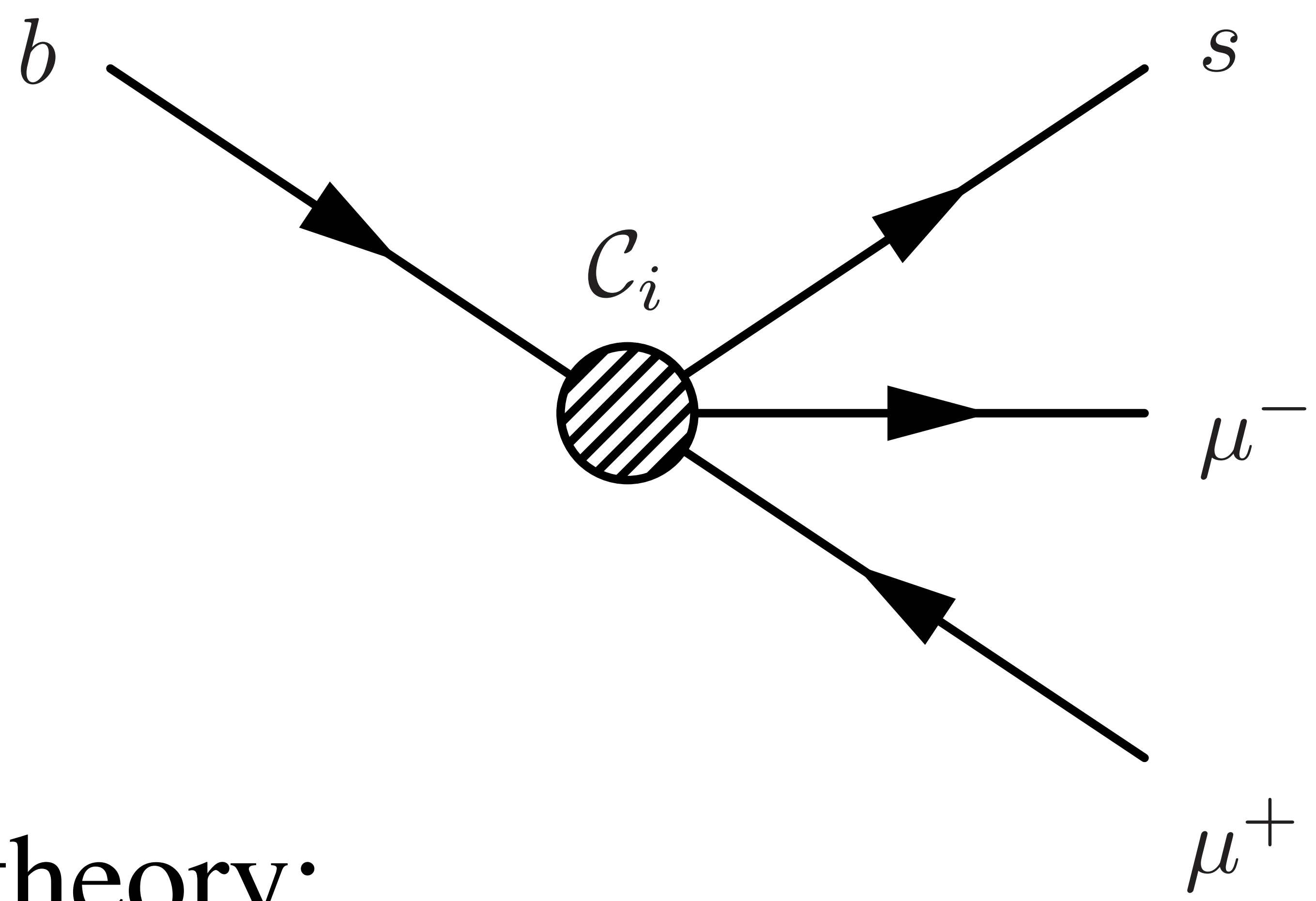
Effective theory

- Similarly to the β-decay we can integrate out the heavy field of the SM

Full theory



Effective description

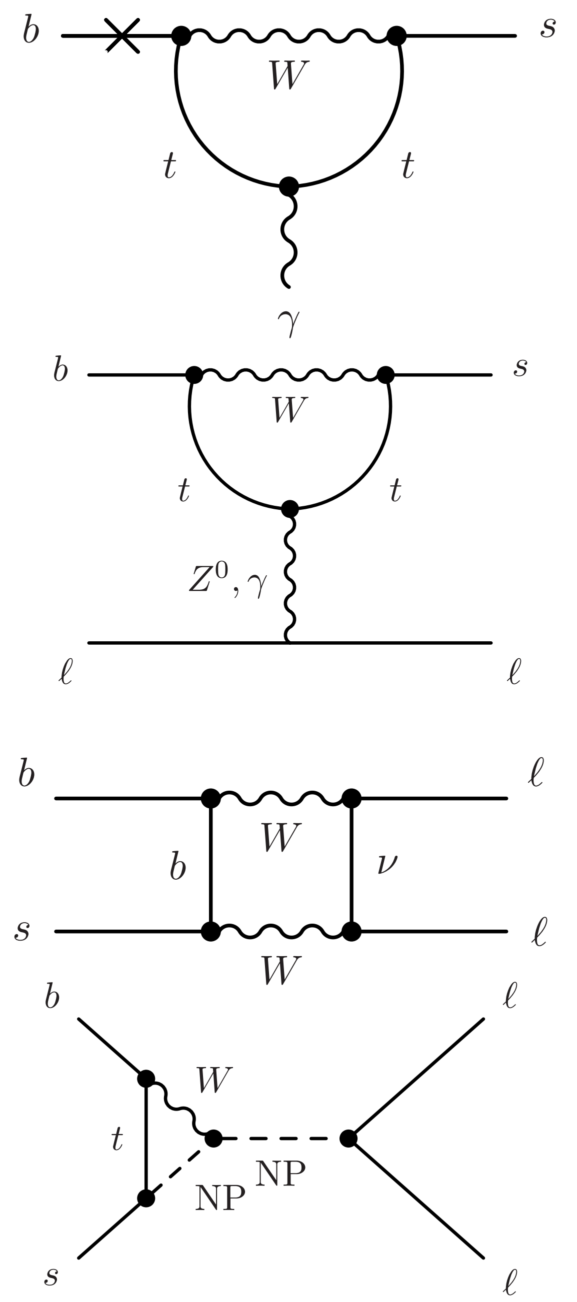


- Model independent description in effective field theory:

- $$\mathcal{H}_{eff} = -\frac{4G_{\mathrm{F}}}{\sqrt{2}\pi} V_{ts}^* V_{tb} \sum_i \left[C_i \mathcal{O}_i + C_i' \mathcal{O}_i' \right]$$

  - Ci Wilson coefficients encoding info of the short distance physics
  - Oi four-fermion operators

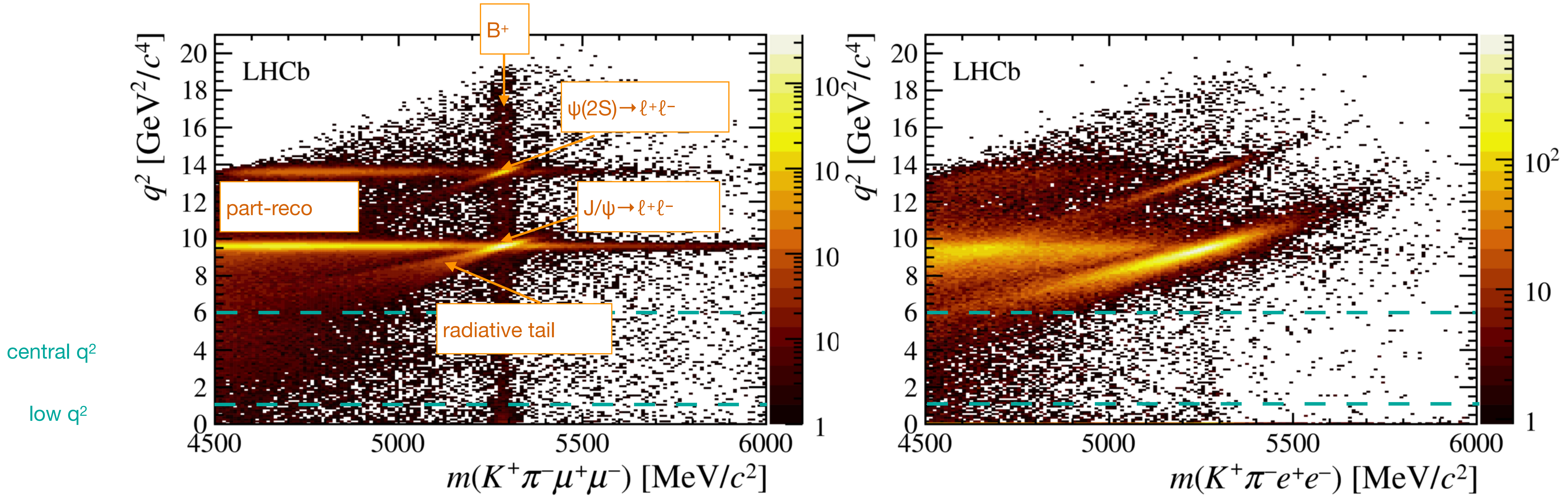
Possible terms



		$b \to s\ell\ell$	$B^0_{(s)} \to \ell^+\ell^-$	$b \to s\gamma$
O_7(')	$(m_b/e)(\bar{s}\sigma^{\mu\nu}P_R b F_{\mu\nu})$	x		x
O_9(')	$(\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \ell)$	x		
O_{10}(')	$(\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu\gamma_5 \ell)$	x	x	
O_S('),O_P(')	$(\bar{s}P_R b)(\bar{\ell}\ell)$		x	
	$(\bar{s}P_R b)(\bar{\ell}\gamma_5\ell)$			

$B^0 \to K^{*0}\ell^+\ell^-$ LFU tests

- Results use Run1 data ~3fb–1 of integrated luminosity
- Measure the double ratio with the resonant mode B→ K*J/ψ(→ℓ+ℓ–)
- Fit B mass in two q2 regions: low [0.045-1.1] GeV2/c4 and central [1.1-6.0] GeV2/c4



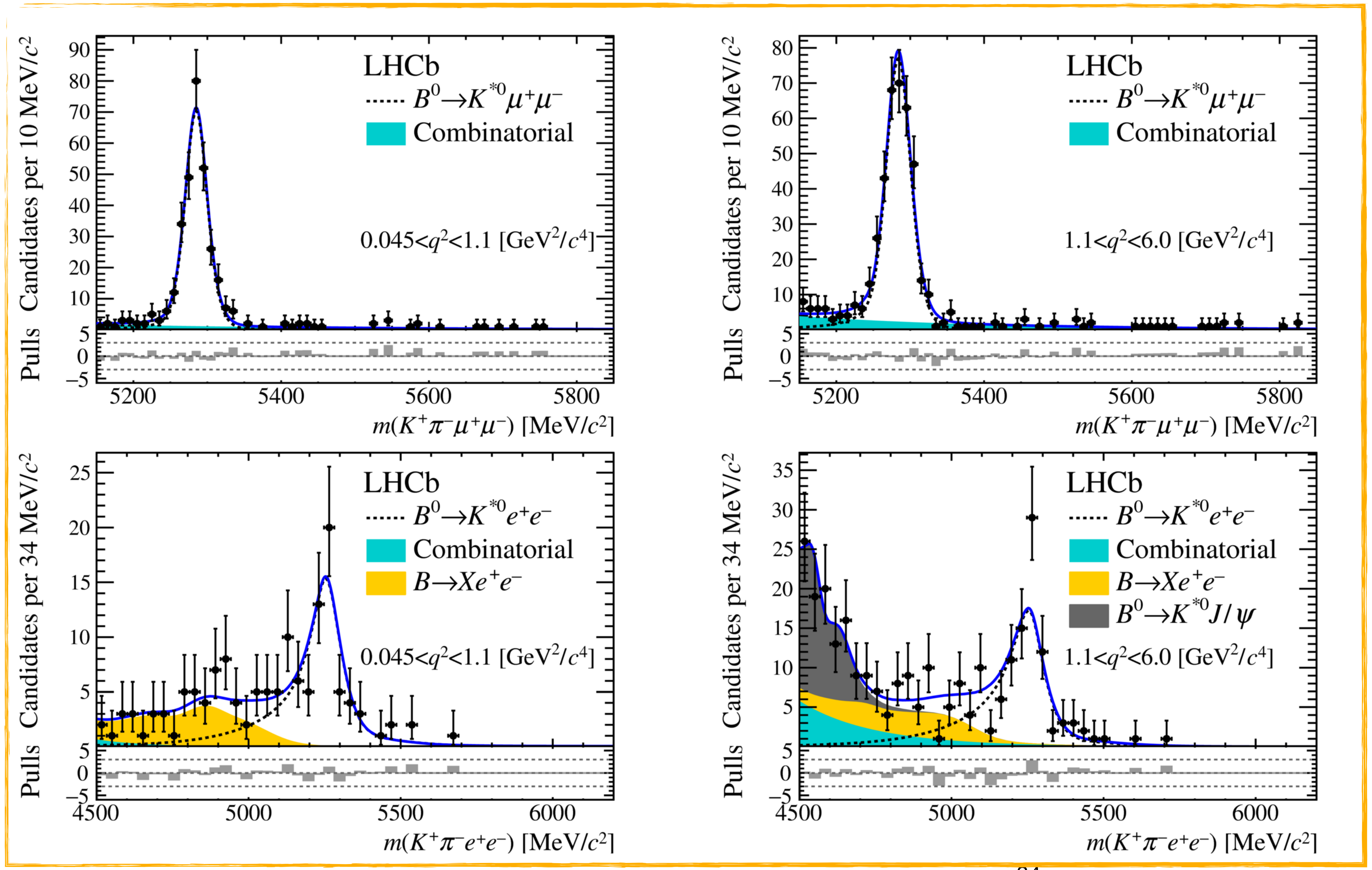
[JHEP 08 (2017) 055]

$B^0 \to K^{*0}\ell^+\ell^-$ LFU tests

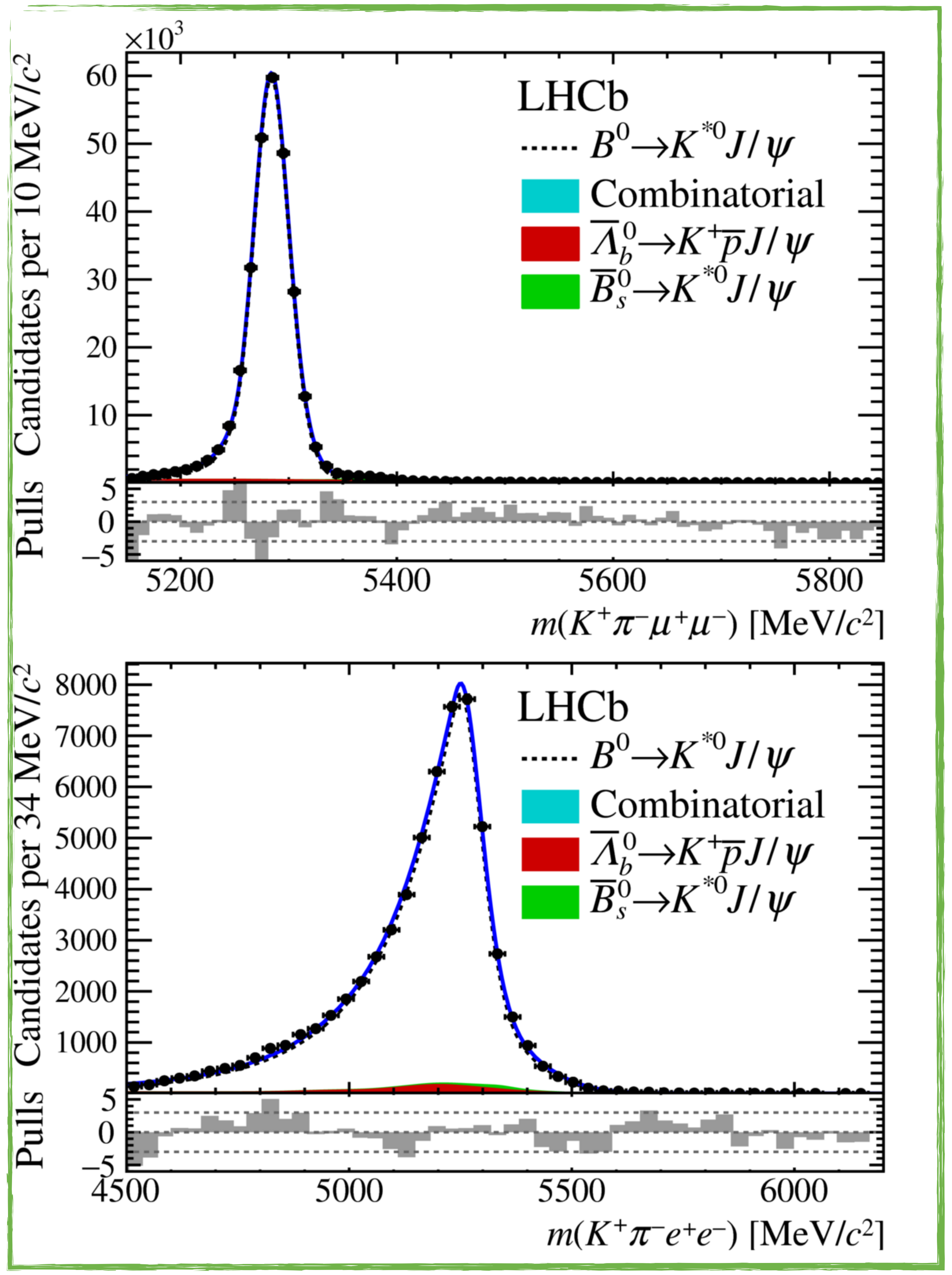
JHEP 08 (2017) 055

- Similar deviation observed in R_{K*} analysis on Run1 data ~3fb^{-1}

$0.045 < q^2 < 1.1\ \mathrm{GeV}^2/c^4$ | $1.1 < q^2 < 6.0\ \mathrm{GeV}^2/c^4$

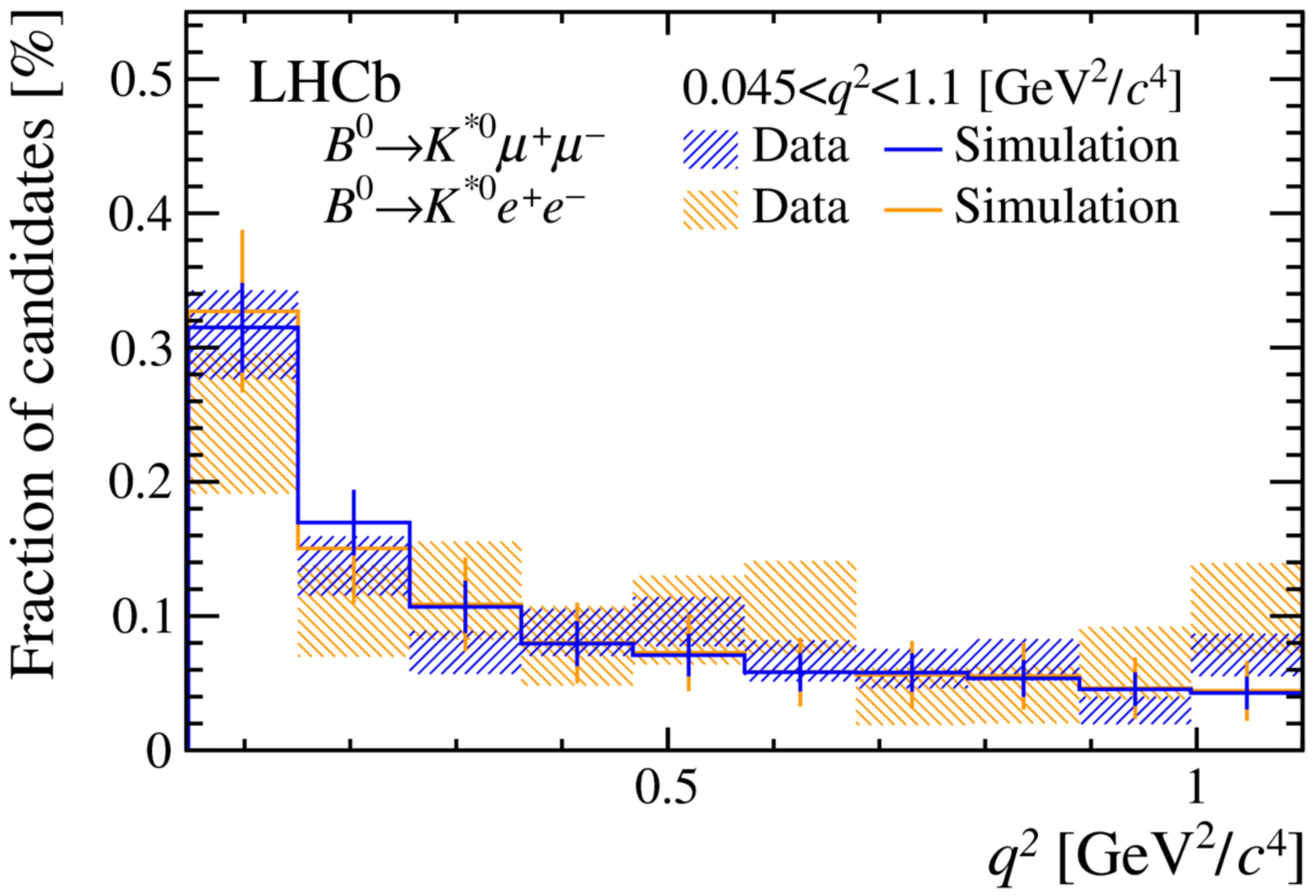


J/ψ mode



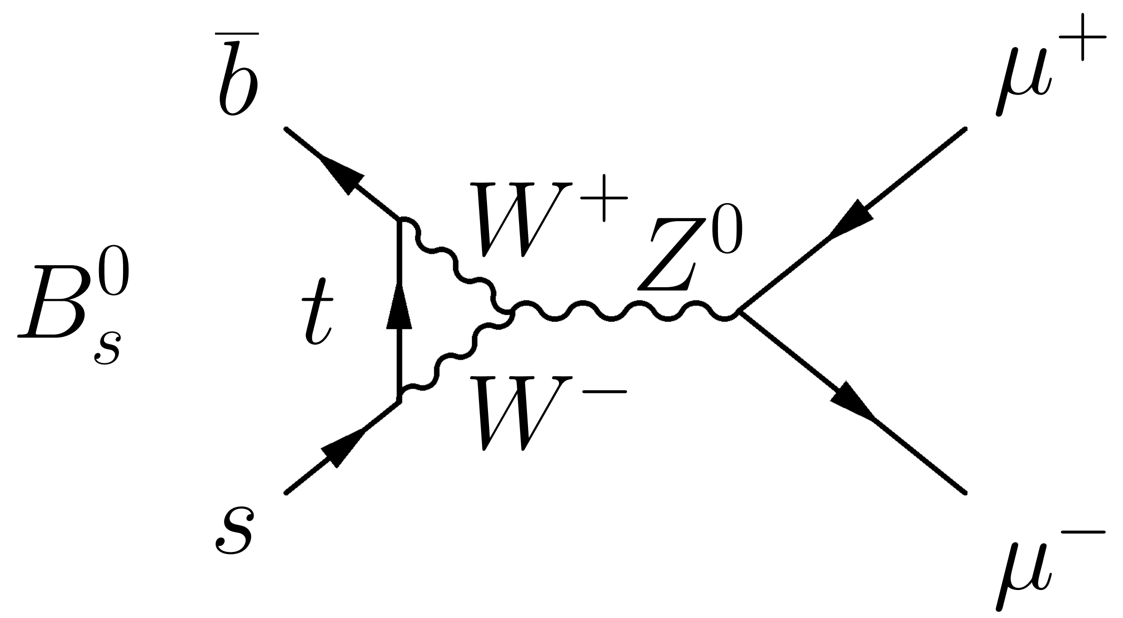
R_{K^*} crosschecks

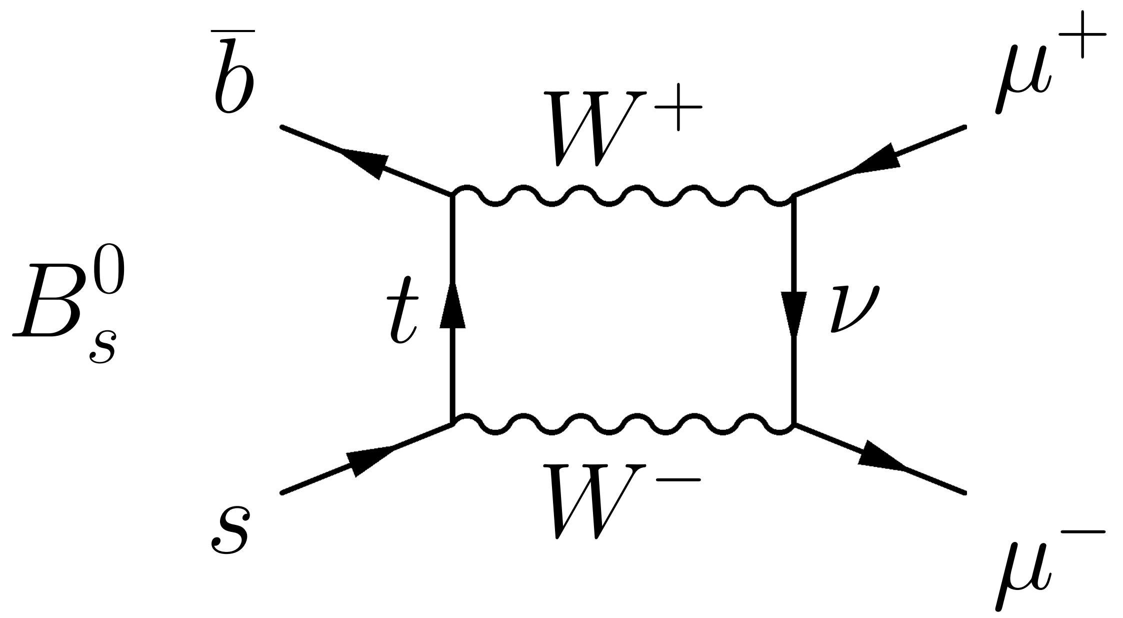
- Measure single ratio for the J/ψ mode to control absolute scale of the efficiencies:
- $$r_{J/\psi} = \frac{\mathcal{B}(B^0 \to K^{*0} J/\psi(\to \mu^+\mu^-))}{\mathcal{B}(B^0 \to K^{*0} J/\psi(\to e^+e^-))} = 1.043 \pm 0.006(\text{stat}) \pm 0.045(\text{syst})$$
- Additional cross-check from measurement of the ratio:
- $$R_{\psi(2S)} = \frac{\mathcal{B}(B^0 \to K^{*0}\psi(2S)(\to \mu^+\mu^-))}{\mathcal{B}(B^0 \to K^{*0} J/\psi(\to \mu^+\mu^-))} \Bigg/ \frac{\mathcal{B}(B^0 \to K^{*0}\psi(2S)(\to e^+e^-))}{\mathcal{B}(B^0 \to K^{*0} J/\psi(\to e^+e^-))}$$
- measured with 2% precision compatible with 1 within 1σ
- Splot technique used to statistically subtract background from data → good agreement between data and simulation



Physics Motivation

- $B^0_{(s)} \to \mu^+\mu^-$ decays only proceed through FCNC processes and are highly suppressed in SM (Loop + helicity)
- **An excellent probe to look for NP.**
- What to measure:
  - **Branching fractions**: $B^0_s \to \mu^+\mu^-$ may start to enter precision regime, while first evidence of $B^0 \to \mu^+\mu^-$ might emerge.
  - **Effective lifetime**: only the heavy B_s state can decay into $\mu\mu$ in the SM; different composition of states may be allowed by NP.





- SM predictions:
- $\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.66 \pm 0.14) \times 10^{-9}$
- $\mathcal{B}(B^0 \to \mu^+\mu^-) = (1.03 \pm 0.05) \times 10^{-10}$
- $\tau_{\mu\mu} = 1.609 \pm 0.010$ ps

M. Beneke et al JHEP 10 (2019) 232

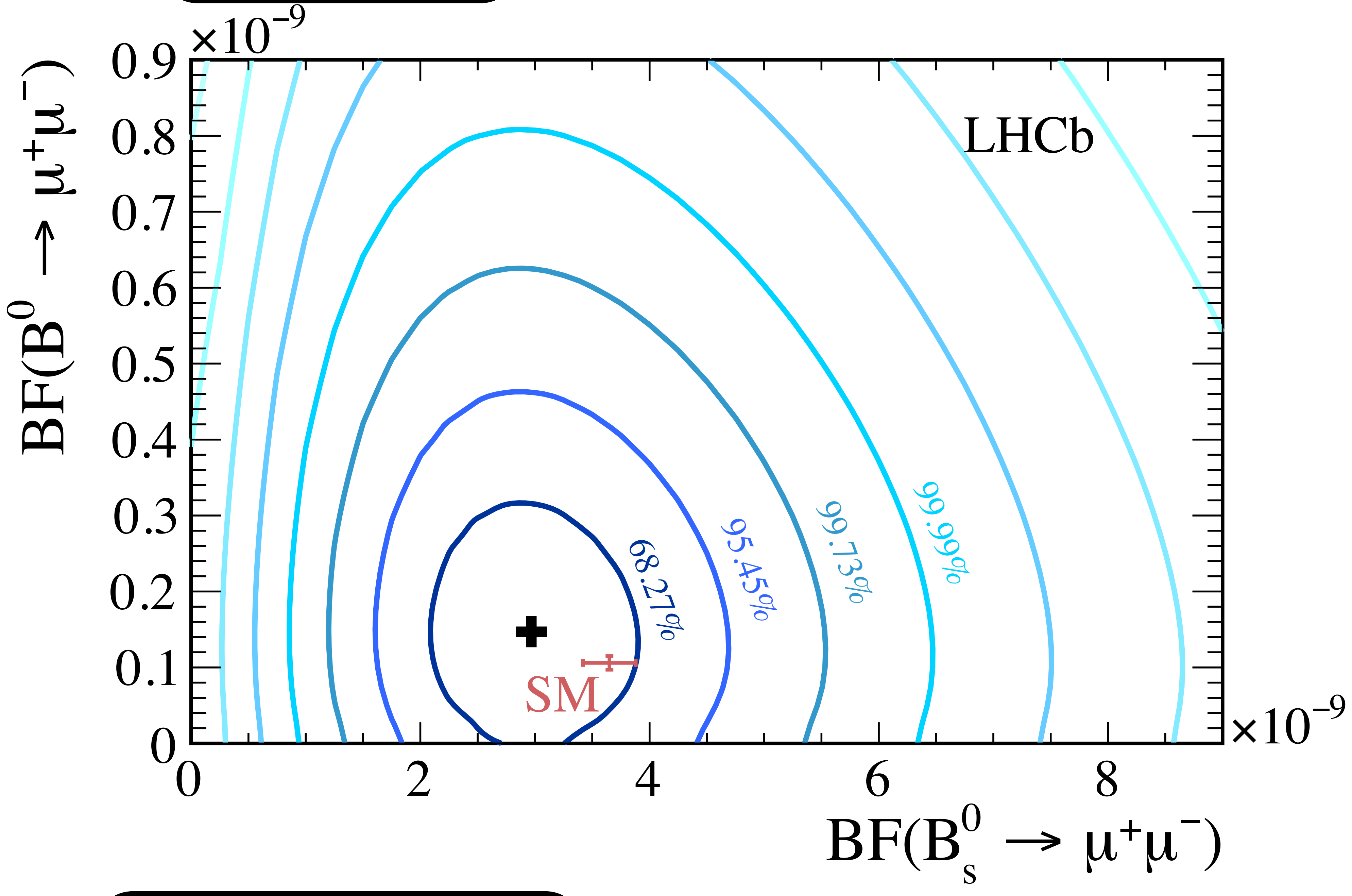
HFLAV, Y. Amhis et al., Eur. Phys. J. C 77 (2017) 895

LHCb Results

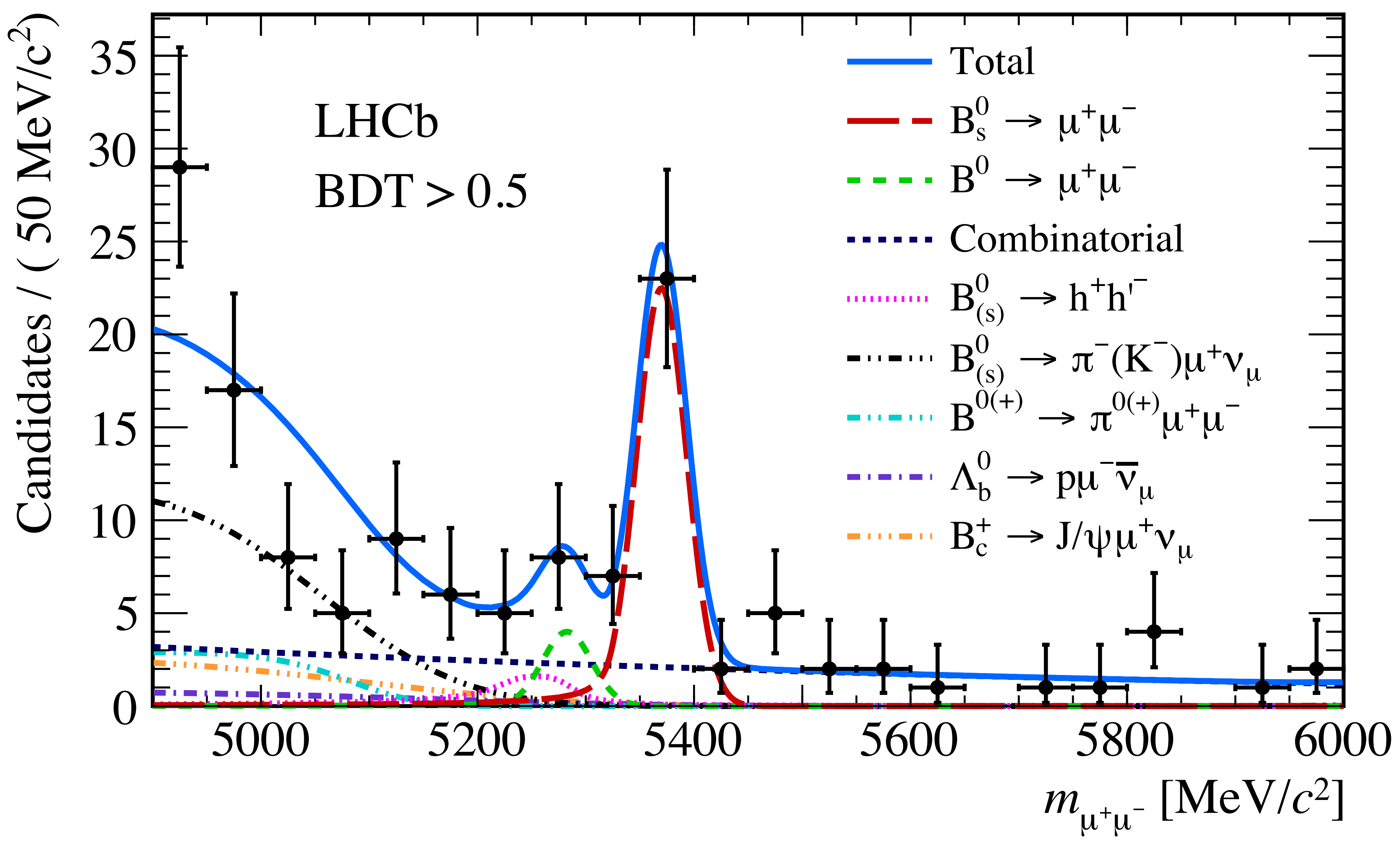
Ref: LHCb PRL 118, 191801 (2017)

- Analysis uses Run1 + 1.4fb^{-1} of Run2 data:
  - $\mathscr{B}(B_s^0 \to \mu^+\mu^-) = (3.0 \pm 0.6(\text{stat})^{+0.3}_{-0.2}(\text{syst})) \times 10^{-9}$
  - $\mathscr{B}(B^0 \to \mu^+\mu^-) < 3.4 \times 10^{-10}$ @ 95 % CL
- Signal significance of 7.8σ and 1.6σ

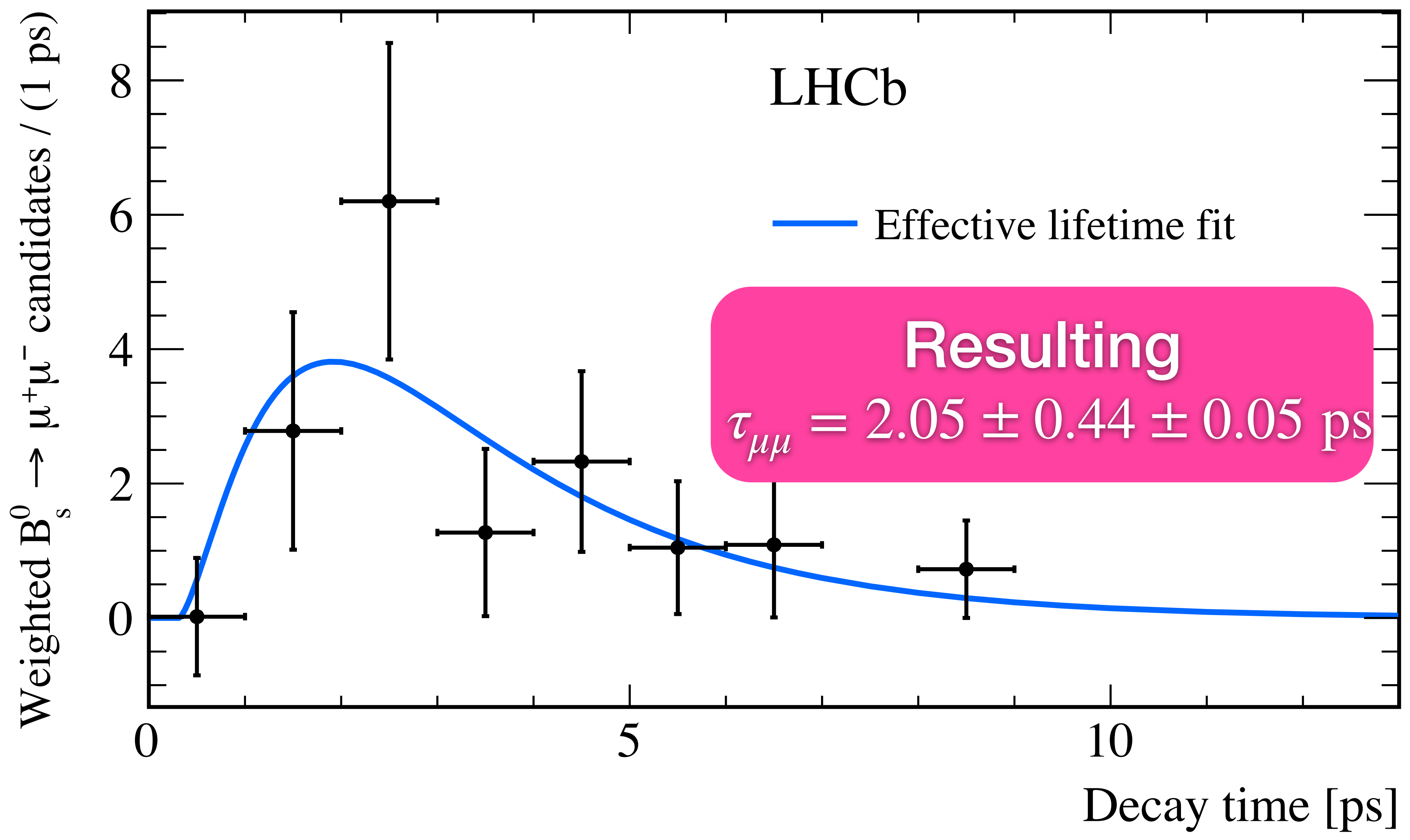
2D contours



High BDT mass projection



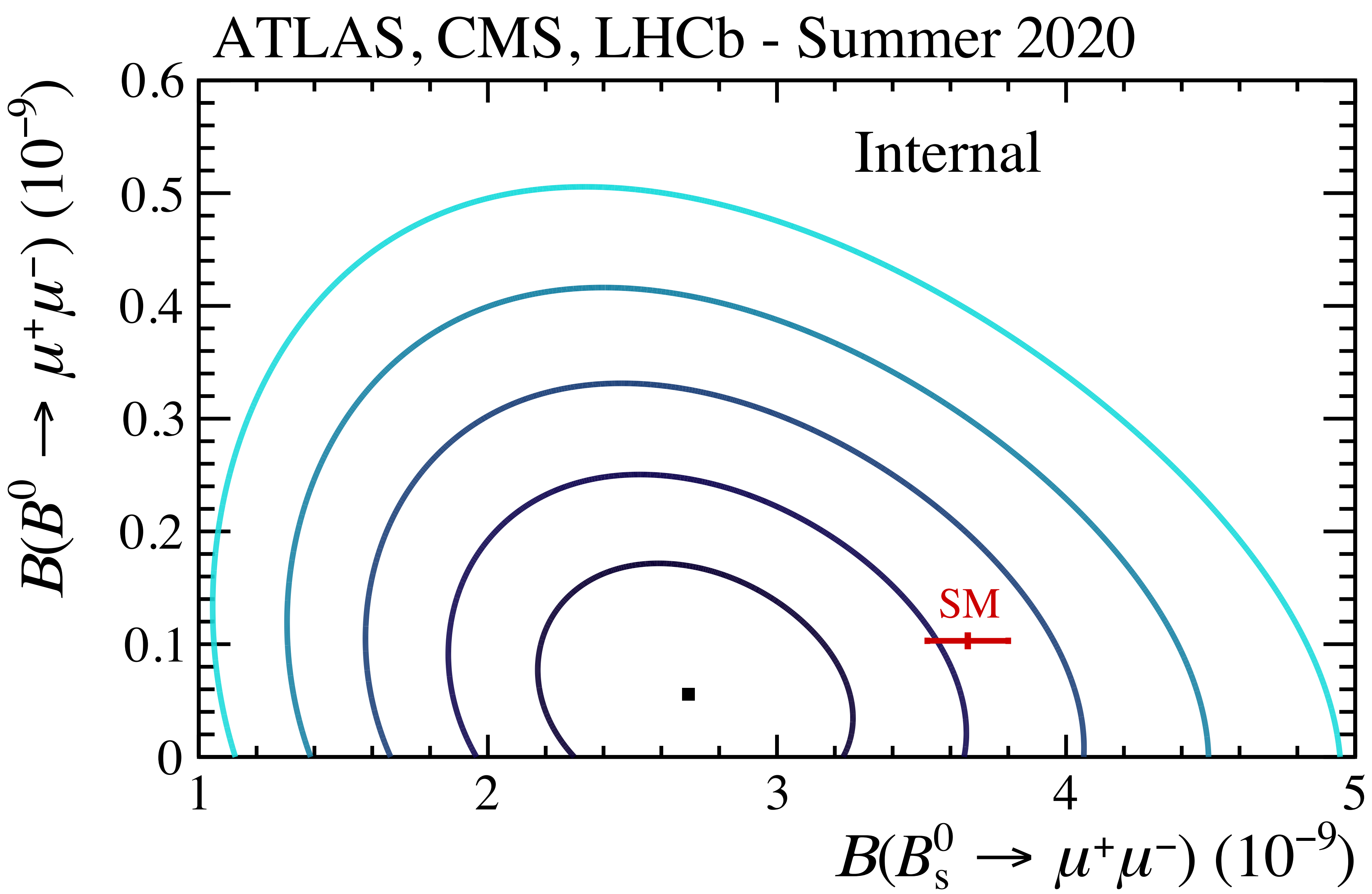
Decay time sPlot

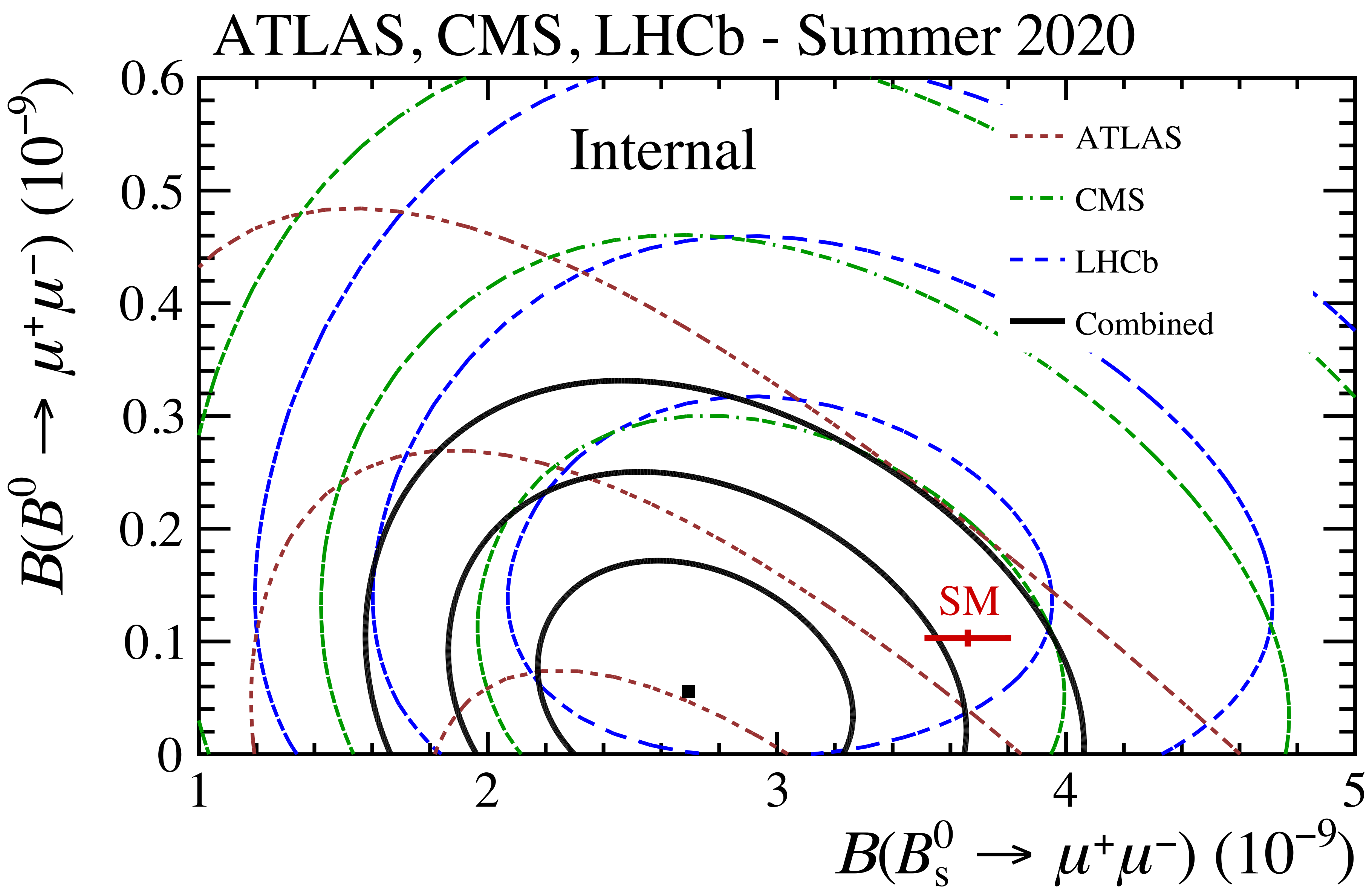


Resulting
$\tau_{\mu\mu} = 2.05 \pm 0.44 \pm 0.05$ ps

Results: Combined 2D Contours

- The 3 binned log-likelihoods are summed + shifted to zero.
- Apply the analytic model on the **combined 2D likelihood histogram** to obtain the combined branching fractions.
- Results:
  - $\mathscr{B}(B_s^0 \to \mu^+\mu^-) = (2.69\,^{+0.37}_{-0.35}) \times 10^{-9}$
  - $\mathscr{B}(B^0 \to \mu^+\mu^-) = (0.6 \pm 0.7) \times 10^{-10}$
- **Compatibility with the SM in 2D: 2.1σ**





Results: Combined 1D Likelihood Curves

- Profile 1D likelihoods for one of the branching fractions, and the ratio $\mathscr{R} = \mathscr{B}(B^0 \to \mu^+\mu^-)/\mathscr{B}(B_s^0 \to \mu^+\mu^-)$, as obtained from the 2D contours:
  - $\mathscr{B}(B^0 \to \mu^+\mu^-) < 1.6\,(1.9) \times 10^{-10}$ @ 90 % (95%) CL
  - $\mathscr{R} < 0.052\,(0.060) \times 10^{-10}$ @ 90 % (95%) CL
- Compatibility with SM for $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$: 2.4σ and 0.6σ