B decays – portal to Physics Beyond the Standard Model (flavour anomalies)

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UJ PARTICLE PHYSICS PHENOMENOLOGY AND EXPERIMENTS SEMINAR 31.05.2021

OUTLINE

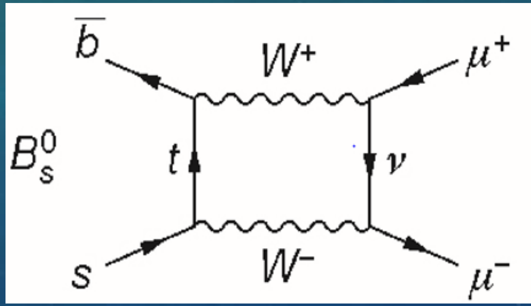
23 March 2021: Improved measurement of $B_s^0 \rightarrow \mu^+\mu^-$ decays LHCB-PAPER-2021-007-001.

23 March 2021: **Test of lepton universality in beauty-quark decays** CERN-EP-2021-042 ; LHCB-PAPER-2021-004

LHCb results and interpretation of flavour anomalies
in b to sll transitions

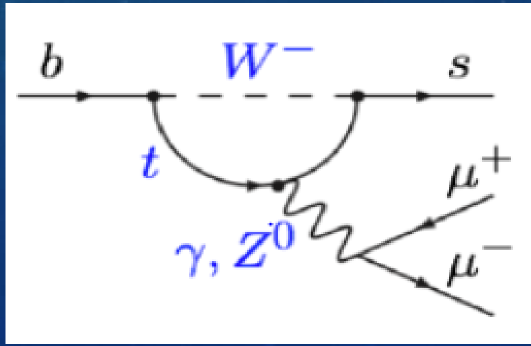
$$B_s^0 \rightarrow \mu^+\mu^-$$

- Purely leptonic flavour-changing neutral current mediated decay
- Clean probe of new physics



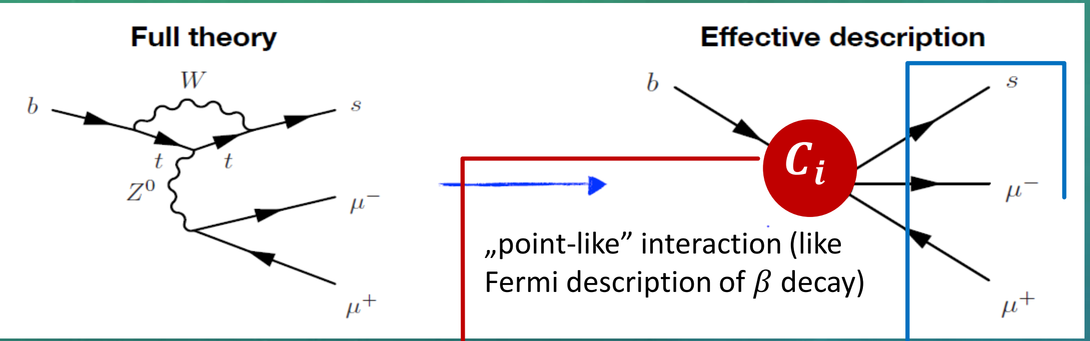
$$B^+ \rightarrow K^+ l^+ l^-$$

- Includes hadronic corrections



Effective theory for rare B decays

$b \to s l^+ l^-$ (FCNC) can be described with an „Effective Hamiltonian" where high- and low-energy contributions are factorised ($M_b \ll M_W$)



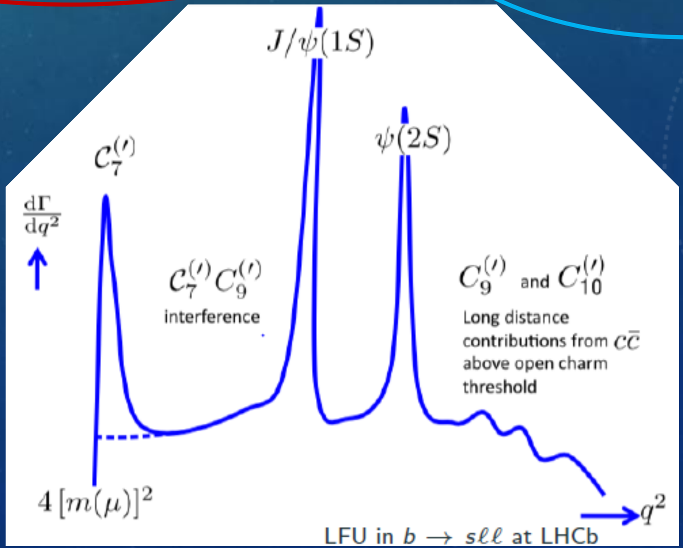
$$H_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_i [\mathcal{C}_i(\mu)\mathcal{O}_i(\mu) + \mathcal{C}'_i(\mu)\mathcal{O}'_i(\mu)]$$

left handed — right handed (suppressed in the SM)

Wilson coefficient (short-distance), evaluated in perturbation theory

Local operators (long distance), lattice calculations

Wilson Coefficient		Operator
γ-penguin	$\mathcal{C}_7^{(\prime)}$	$(\bar{s}\sigma_{\mu\nu} P_{R(L)} b) F^{\mu\nu}$
vector	$\mathcal{C}_9^{(\prime)}$	$(\bar{s}\gamma_\mu P_{R(L)} b)\bar{\mu}\gamma^\mu \mu$
axial-vector	$\mathcal{C}_{10}^{(\prime)}$	$(\bar{s}\gamma_\mu P_{R(L)} b)\bar{\mu}\gamma^\mu \gamma_5 \mu$
scalar	$\mathcal{C}_S^{(\prime)}$	$\bar{s} P_{R(L)} b \bar{\mu}\mu$
pseudo-scalar	$\mathcal{C}_P^{(\prime)}$	$\bar{s} P_{R(L)} b \bar{\mu}\gamma_5 \mu$

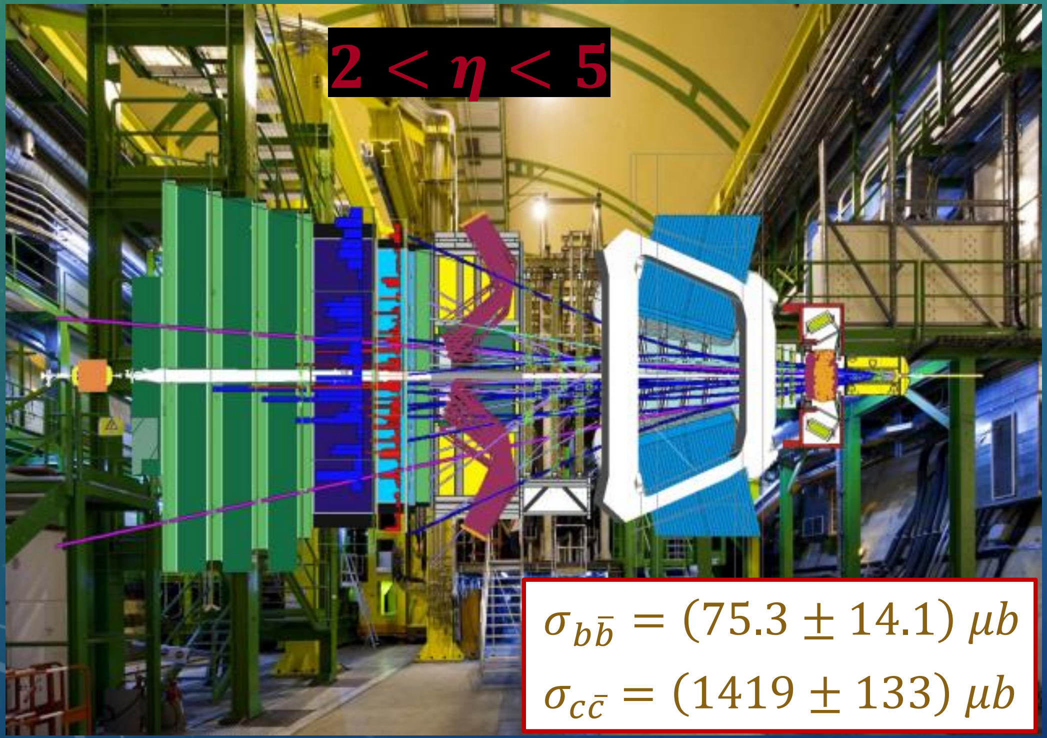


LHCb SPECTROMETER

LHCb JINST 3 (2008) S08005
LHCb performance IJMPA 30 (2015) 1530022

Physics program:

- CP Violation and rare decays of beauty and charm meson
- …
- …
- QCD, electroweak, exotica …



Excellent performance:

- 3 fb^{-1} accumulated in RUN I, 3.26 fb^{-1} in Run II;
- Tracking system with momentum resolution $\Delta p/p \sim 0.5 - 1\%$ (from 2 to 200 GeV);
- Excellent time (50 fs) resolution;
- Precise vertexing: $\sigma(IP) = (15 + 29/p_T[GeV])\ \mu m$
- Efficient hadronic identification (2-100 GeV/c):

$$\mathcal{E}(K \to K) \sim 95\%$$

$$\text{misID } \mathcal{E}(\pi \to K) \sim 5\%$$

- Calorimeters ECAL, HCAL, $\Delta E/E = 1\% + 10\%/\sqrt{E[GeV]}$ for ECAL
- HeRSChel detector: scintillator counters covering high rapidity region to veto detector activity

Improved measurement of $B^0_{(s)} \to \mu^+\mu^-$ decays

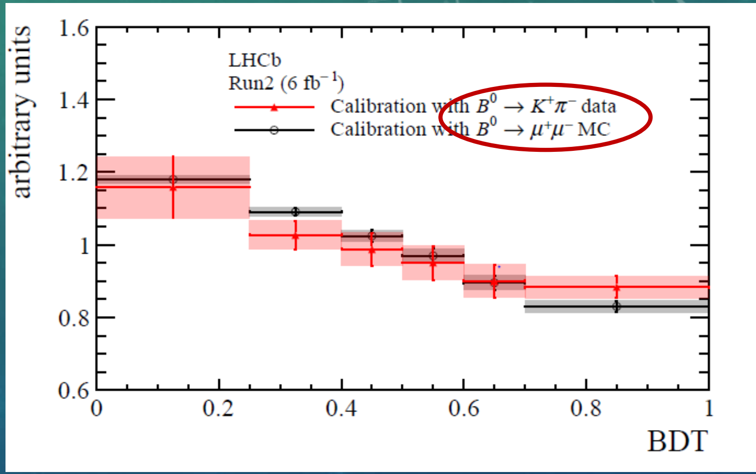
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

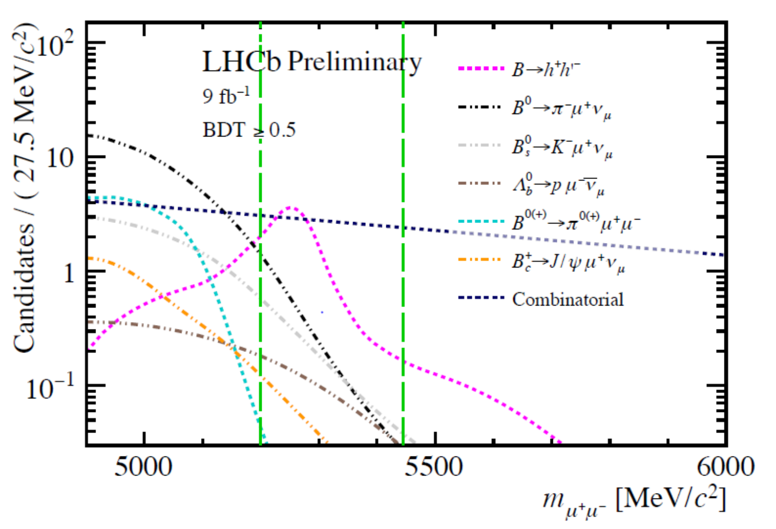
To be submitted to Phys. Rev. Lett.

CERN-EP-2021-xxx
LHCb-PAPER-2021-007
March 3, 2021

Analysis strategy:

- Legacy measurement of LHCb on the full Run 1 and Run 2 data (9 fb^{-1})
- Improvement of strategy from 2017.
- Rejection of combinatorial background:
  - BDT with blinded signal region
  - Calibrated on data-corrected simulation
  - Cross-checked on $B^0 \to K^+\pi^-$
- Mass shape is calibrated on control channels $B^0 \to K^+\pi^-$, $B^0_s \to K^+K^-$
- To measure the branching fraction, luminosity and cross-section uncertainties are avoided by computing the ratio to a well-known channels: $B^+ \to J/\psi(\to \mu^+\mu^-)K^+$, $B^0 \to K^+\pi^-$
- Remaining background is modelled

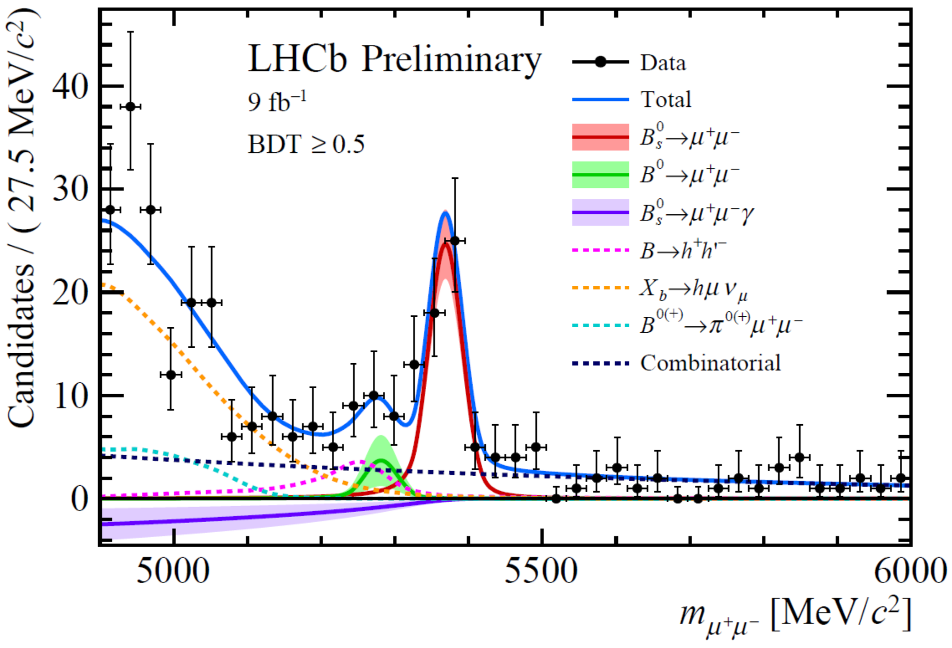


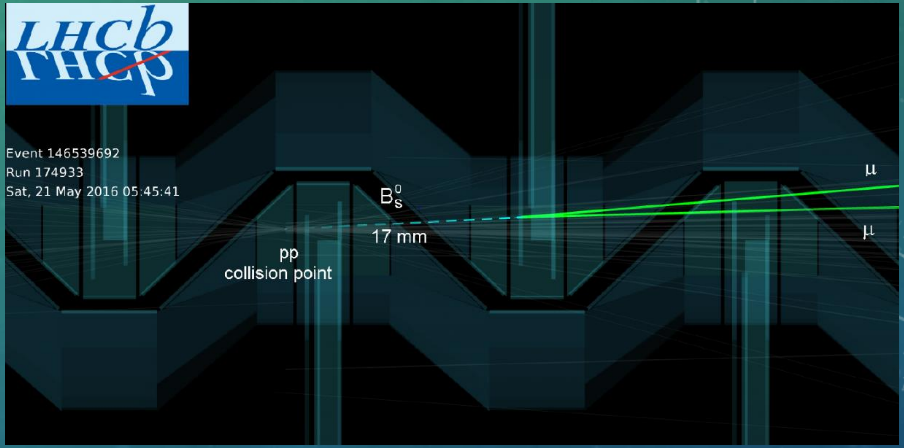


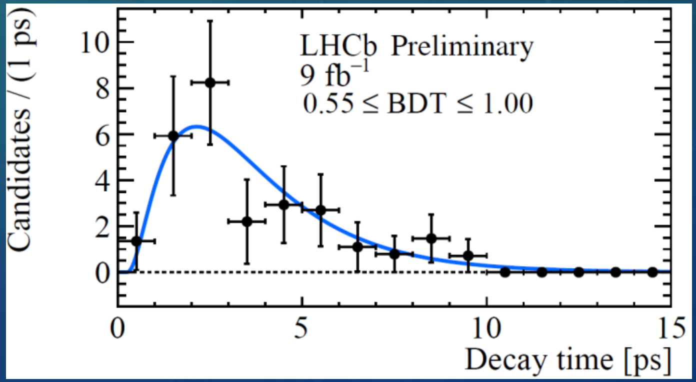
Remarkable impact of data-driven techniques!

Improved measurement of $B^0_{(s)} \to \mu^+\mu^-$ decays

In the SM, only the heavy and longer-lived B^0_s eigenstate decays to the $\mu^+\mu^-$ final state.







$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \left(3.09^{+0.46}_{-0.43}\ {}^{+0.15}_{-0.11}\right) \times 10^{-9}\ \ (10.8\sigma)$$

$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 2.6 \times 10^{-10}\ (1.7\sigma)$$

$$\tau_{eff} = 2.07 \pm 0.29 \pm 0.03\ \text{ps}$$

consistent with both the heavy and light mass eigenstate

Improved measurement of $B^0_{(s)} \to \mu^+\mu^-$ decays

- Important milestone for LHCb and a crucial input for the "flavour anomalies”
- Achieved the most precise single-experiment measurement of $\mathcal{B}(B^0_s \to \mu^+\mu^-)$
- Very clean prediction in the SM:

$$\mathcal{B}(B^0_s \to \mu^+\mu^-)_{SM} = (3.66 \pm 0.14) \times 10^{-9}$$

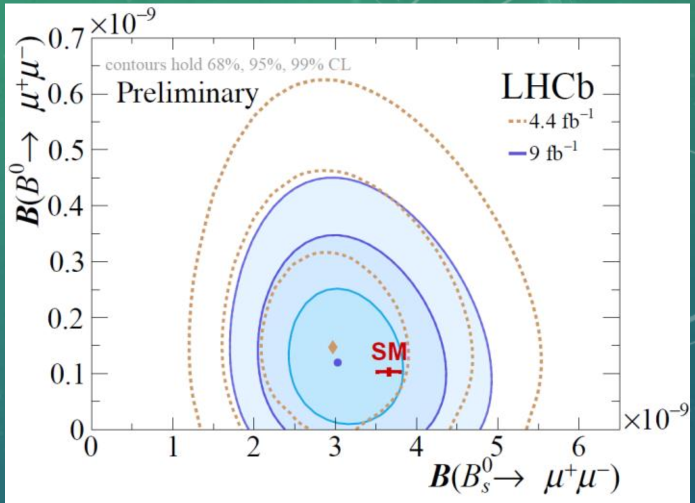
$$\mathcal{B}(B^0 \to \mu^+\mu^-)_{SM} = (1.03 \pm 0.05) \times 10^{-10}$$

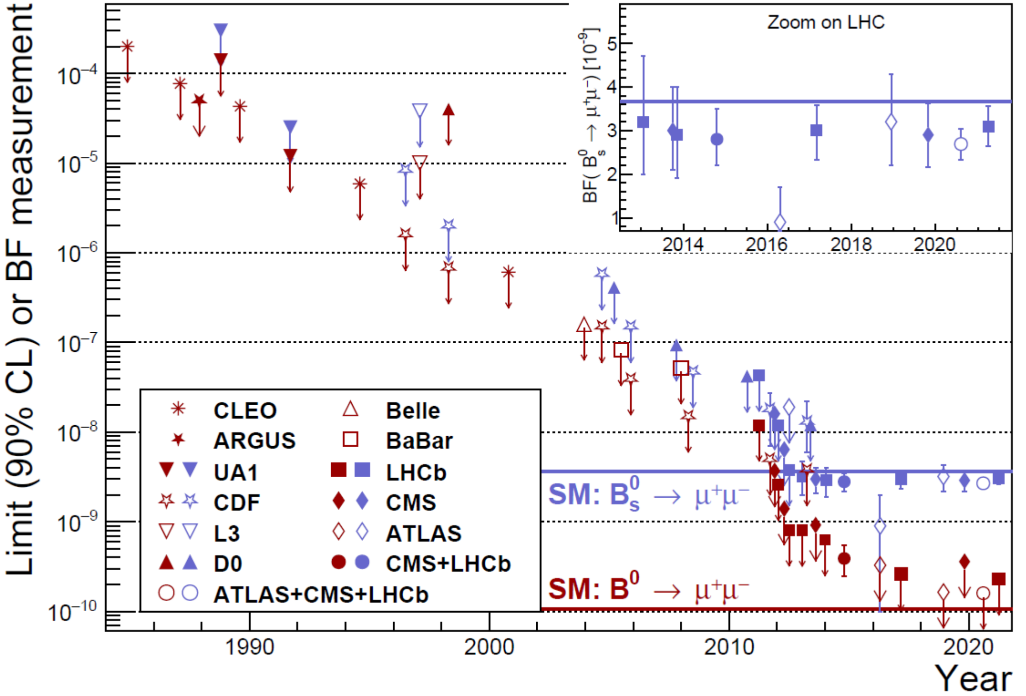
- BF prediction includes single Wilson coefficient C_{10} and a single hadronic constant
- 2020 combination of ATLAS, CMS, LHCb:

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \left(2.69^{+0.37}_{-0.35}\right) \times 10^{-9}$$

2.1σ away from SM

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \left(3.09^{+0.46}_{-0.43}\ {}^{+0.15}_{-0.11}\right) \times 10^{-9} \text{ (LHCb only)}$$





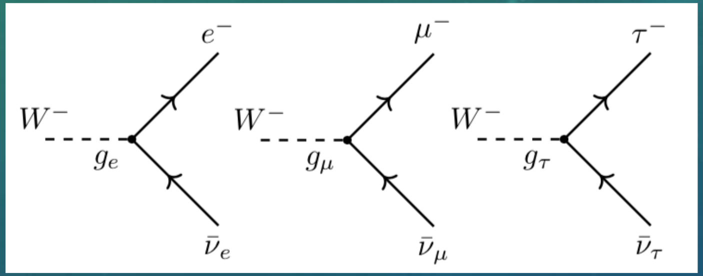
Lepton universality – direct measurements @ LEP 2000

Physics Reports
Volume 532, Issue 4, 30 November 2013, Pages 119-244

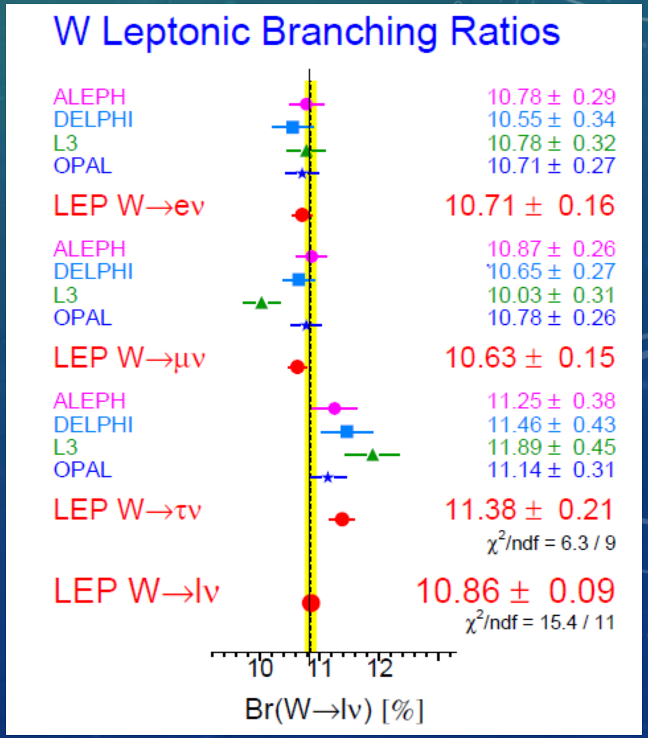
Electroweak measurements in electron–positron collisions at W-boson-pair energies at LEP

The ALEPH Collaboration, The DELPHI Collaboration, The L3 Collaboration, The OPAL Collaboration, The LEP Electroweak Working Group [1]

- SM couplings of charged leptons to gauge bosons are identical
- Very clean and precise measurement at electron collider

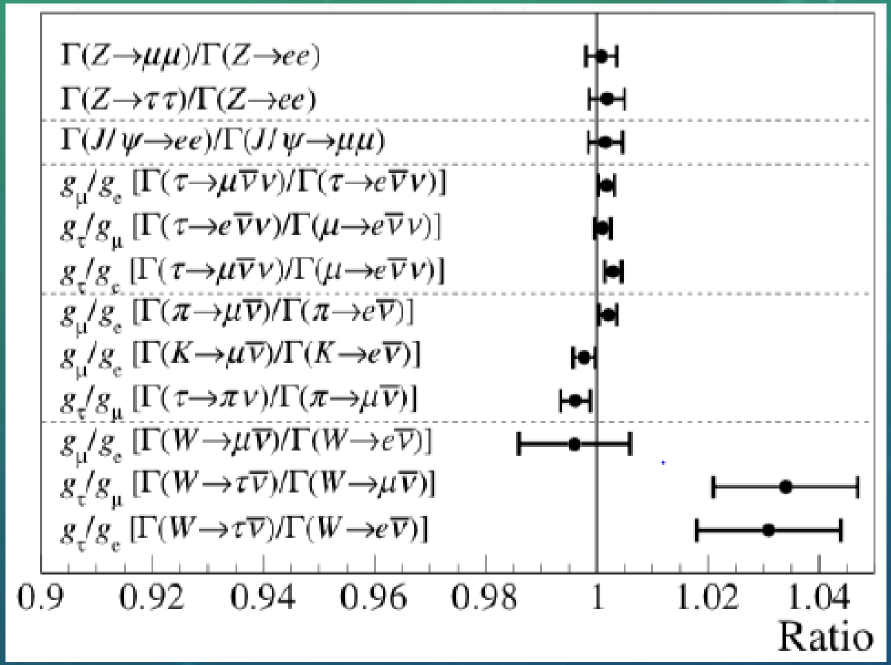


$$\mathcal{B}(\mathrm{W} \to \mu\overline{\nu}_\mu) \,/\, \mathcal{B}(\mathrm{W} \to \mathrm{e}\overline{\nu}_\mathrm{e}) = 0.993 \pm 0.019\,,$$
$$\mathcal{B}(\mathrm{W} \to \tau\overline{\nu}_\tau) \,/\, \mathcal{B}(\mathrm{W} \to \mathrm{e}\overline{\nu}_\mathrm{e}) = 1.063 \pm 0.027\,,$$
$$\mathcal{B}(\mathrm{W} \to \tau\overline{\nu}_\tau) \,/\, \mathcal{B}(\mathrm{W} \to \mu\overline{\nu}_\mu) = 1.070 \pm 0.026\,.$$

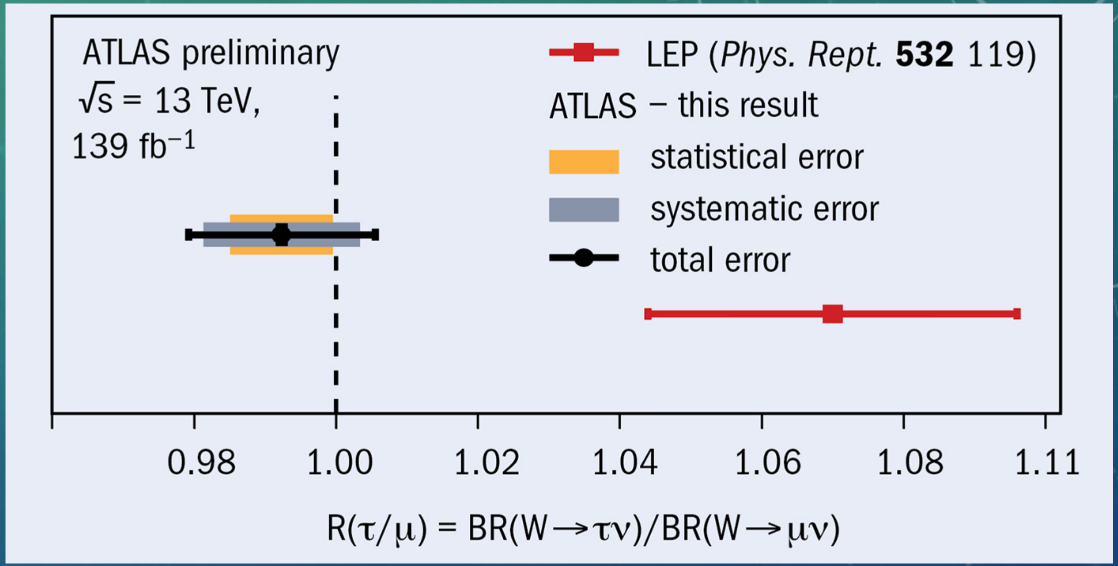


Lepton universality – direct measurements @ LHC 2020

- Extensively probed with $Z^0 \rightarrow l^+l^-$ and $J/\psi \rightarrow l^+l^-$ to sub percent level



ATLAS Collaboration 2020 ATLAS-CONF-2020-014



R(τ/μ) = 0.992 ± 0.013 [± 0.007 (stat) ± 0.011 (syst)]

$$R_K^{(*)} = \frac{\mathcal{B}(B\rightarrow K^{(*)}\mu^+\mu^-)}{\mathcal{B}(B\rightarrow K^{(*)}e^+e^-)} \cong 1 \text{ in SM}$$

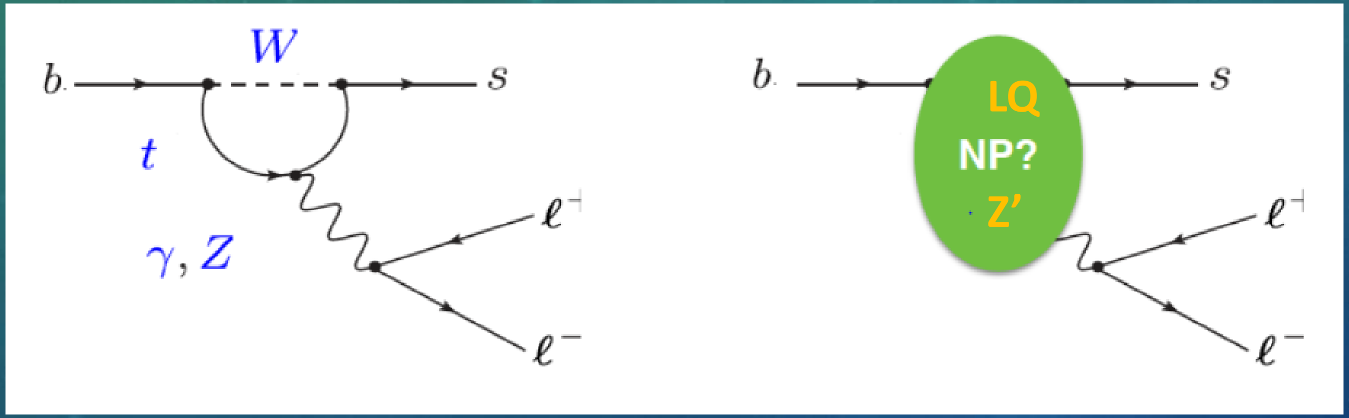
Any significant deviation is a smoking gun for New Physics

The power of indirect searches

Precision measurements to unveil new particles indirectly:

- 1970 charm quark as an explanation of the suppression of $K^0 \to \mu^+\mu^-$ (before direct discovery of J/ψ)
- 1973 prediction of 3x3 CKM matrix for explanation of CPV in kaons
- 1987 top mass limit from loop contribution in $B^0 - B^0$ mixing

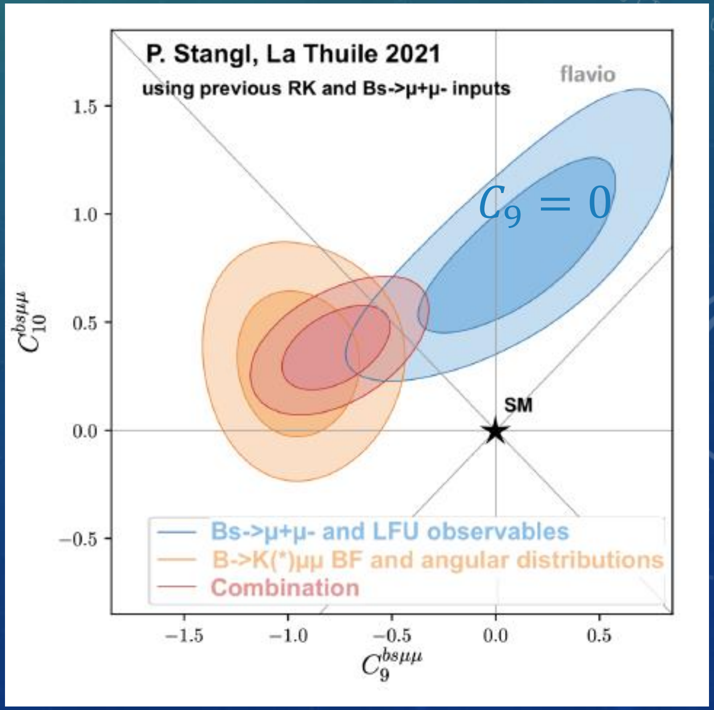
Large mass of b quark and rare decays of B mesons offer a rich phenomenology for **indirect searches of New Physics**



$b \to sl^+l^-$ are **FCNC** processes – only loop diagram in SM,

$BF < 10^{-6}$

Observables are sensitive **to new (virtual) particles**



Flavour Anomalies in $b \to sl^+l^-$

Over the past decade we have observed a coherent set of tensions with SM predictions:

- Branching Fractions:

  $B^0 \to K^*\mu^+\mu^-$, $B_s^0 \to \phi\mu^+\mu^-$, $\Lambda_b \to \Lambda\,\mu^+\mu^-$

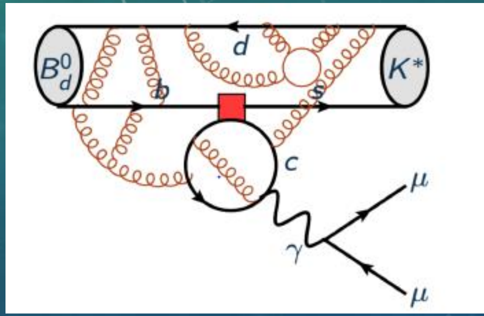
- Angular Analyses:

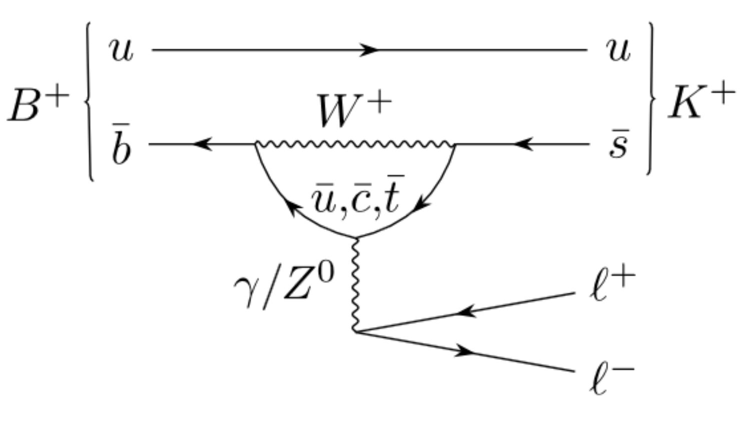
  $B^0 \to K^*\mu^+\mu^-$, $\Lambda_b \to \Lambda\,\mu^+\mu^-$

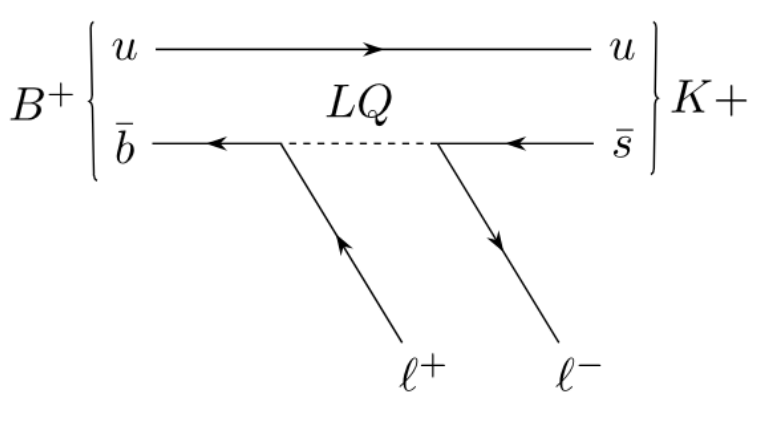
- Lepton Flavour Universality with e/μ ratios:

  $B^0 \to K^*l^+l^-$, $B^+ \to K^+l^+l^-$

Hadronic uncertainties!







BUT
strong force does not couple directly to leptons so decays $B^+ \to K^+\mu^+\mu^-$ and $B^+ \to K^+e^+e^-$ are identical.
SM predictions with $\mathcal{O}(1\%)$

$b \to sl^+l^-$ contains $b \to s$ transition with a hadron and offer multitude of observables complementary to $B_s^0 \to \mu^+\mu^-$

Test of lepton universality in beauty-quark decays

arXiv:2103.11769
CERN-EP-2021-042
LHCb-PAPER-2021-004
23 March 2021
Nature Physics

The direct observable in rare decays is hardly measurable: $R_K^{(*)} = \frac{\mathcal{B}(B \to K^{(*)}\mu^+\mu^-)}{\mathcal{B}(B \to K^{(*)}e^+e^-)}$

Double ratio normalises the rare BF ratio with a control BF ratio:

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

$$= \frac{N(B \to K^{(*)}\mu^+\mu^-)}{N(B \to K^{(*)}J/\psi(\to \mu^+\mu^-))} \times \frac{\mathcal{E}(B \to K^{(*)}J/\psi(\to \mu^+\mu^-))}{\mathcal{E}(B \to K^{(*)}\mu^+\mu^-)} \times \frac{N(B \to K^{(*)}J/\psi(\to e^+e^-))}{N(B \to K^{(*)}e^+e^-)} \times \frac{\mathcal{E}(B \to K^{(*)}e^+e^-)}{\mathcal{E}(B \to K^{(*)}J/\psi(\to e^+e^-))} =$$

$$= 1 \pm \mathcal{O}(10^{-3})$$

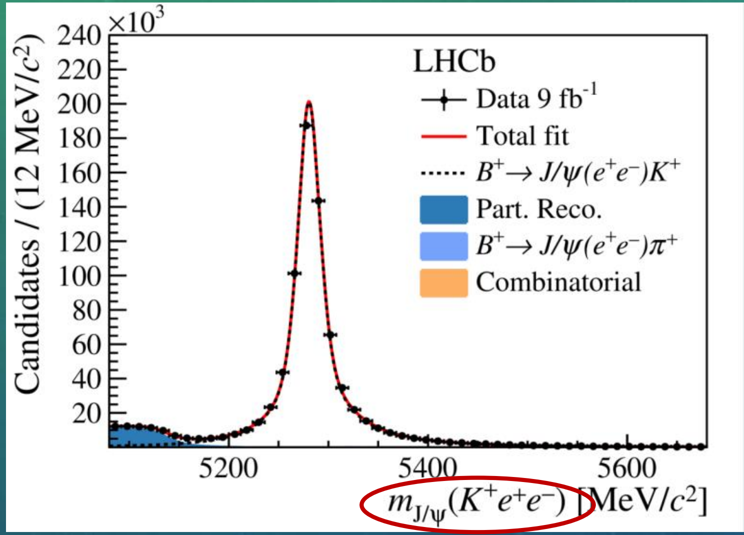
- Experimentally clean: most systematic uncertainties cancel due to double ratio, but controlling efficiencies is vitally important.
- Theoretically clean: hadronic uncertainties cancel, QED effects are small.
- The J/ψ sits in a different q^2 region, but is otherwise identical.

Impact of efficiency on LU measurements

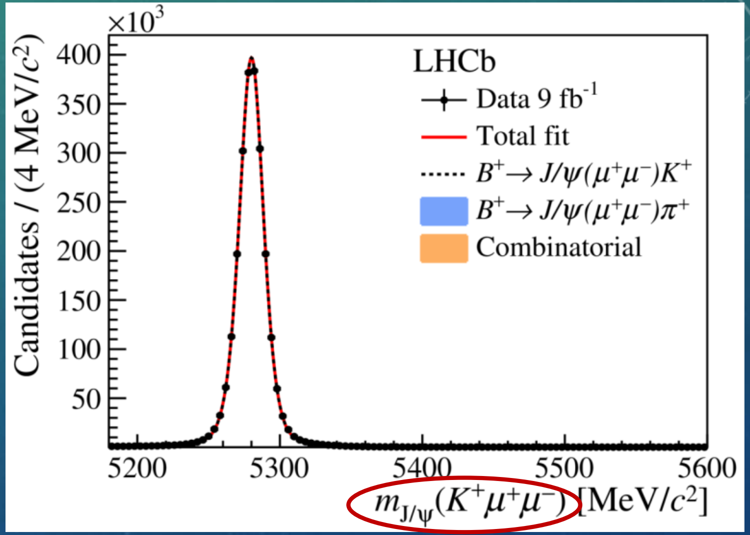
$$r_{J/\psi} = \frac{\mathcal{B}(B^+ \to K^+ J/\psi(\to \mu^+\mu^-))}{\mathcal{B}(B^+ \to K^+ J/\psi(\to e^+e^-))} = 1$$

BUT

electrons and muons exhibits very different detection efficiency:



Yields ≠



Controlling efficiencies means takes into account:

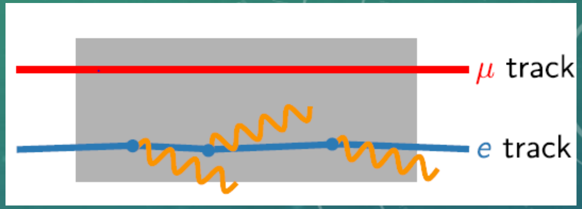
- bremsstrahlung
- L0 trigger
- Lepton identification

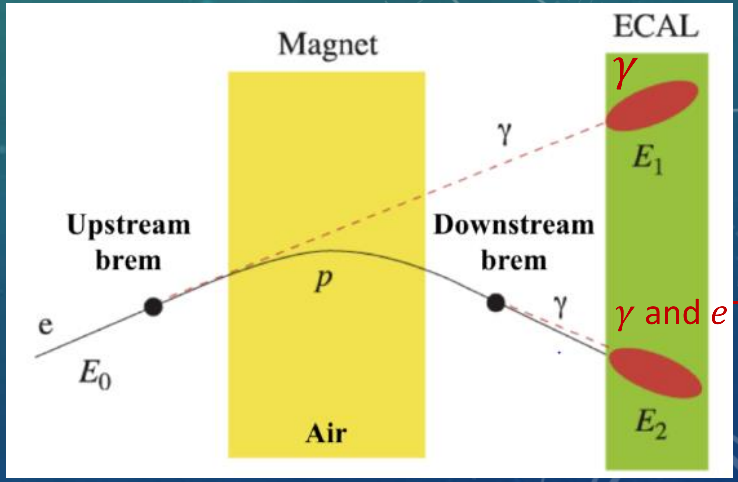
The complexity of this analysis is mostly driven by the differences between muon and electron detection and reconstruction

LHCb-PAPER-2021-004

Bremsstrahlung

- Electron suffer heavy losses from bremsstrahlung (compared to μ) – significantly broader resolution of electron final states.
- Deficit of Energy (up to 20%) is corrected by combining energy deposits from photons (E_T>75 MeV) in small region in the ECAL extrapolated from e track from before the magnet (momentum of matching γ is added to electron track).
- Even after the bremsstrahlung recovery electrons still have degraded mass and q^2 resolution.





L0 Trigger

- L0 calo trigger requires higher thresholds than L0 muon trigger – three exclusive trigger categories are used for e^+e^-

Particle ID

- PID and tracking efficiency larger for muons than electrons.

Efficiences

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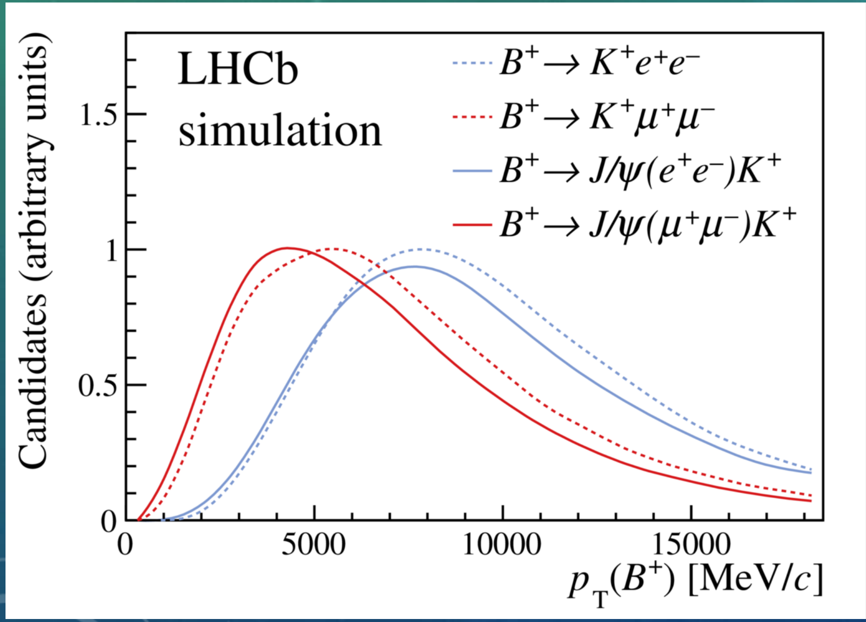
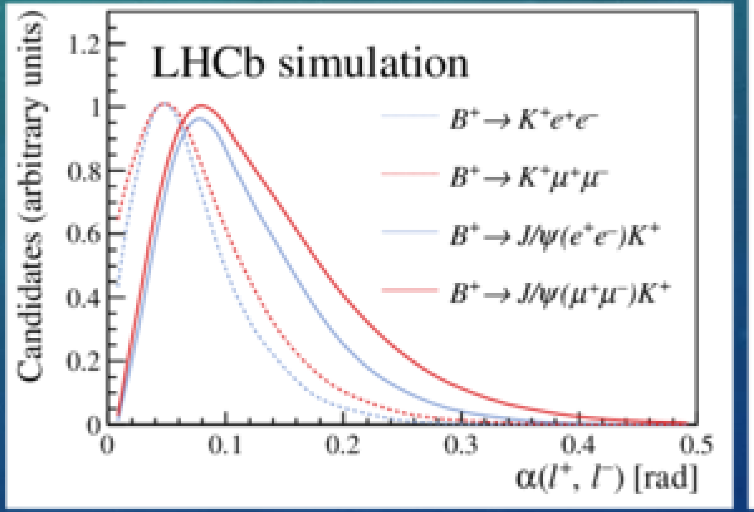
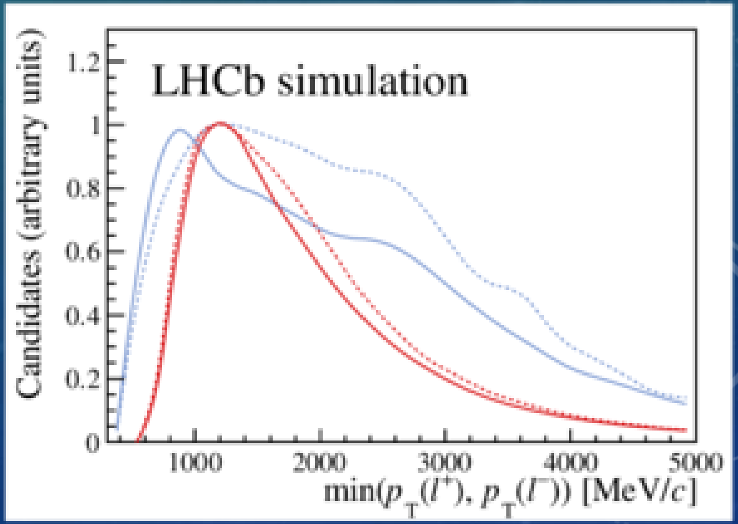
- Efficiencies are computed using simulation with control channel from real data
- Trigger $\mathcal{E}$ obtained from control mode real data
- PID $\mathcal{E}$ determined from high statistic control samples
- Mass of $(K^+e^+e^-)$ and q^2 resolution and kinematics from control mode

Verified procedure through host of cross-checks (at % -level)







Cross-checks

LHCb-PAPER-2021-004

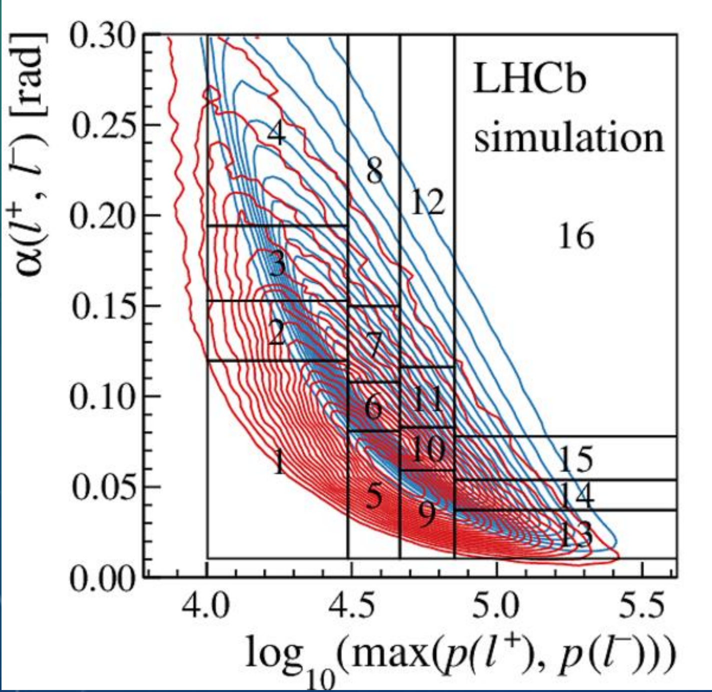
$$r_{J/\psi} = \frac{\mathcal{B}(B^+ \to K^+ J/\psi(\to \mu^+\mu^-))}{\mathcal{B}(B^+ \to K^+ J/\psi(\to e^+e^-))} = 1$$

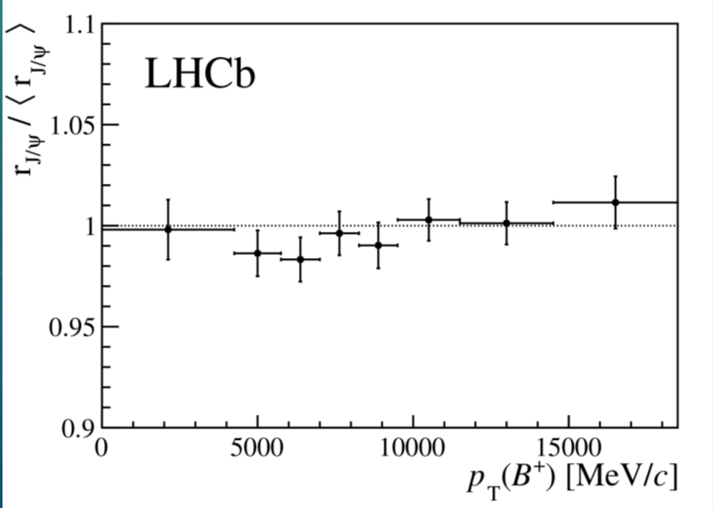
- Very stringent test of the efficiencies via measurement of $r_{J/\psi}$

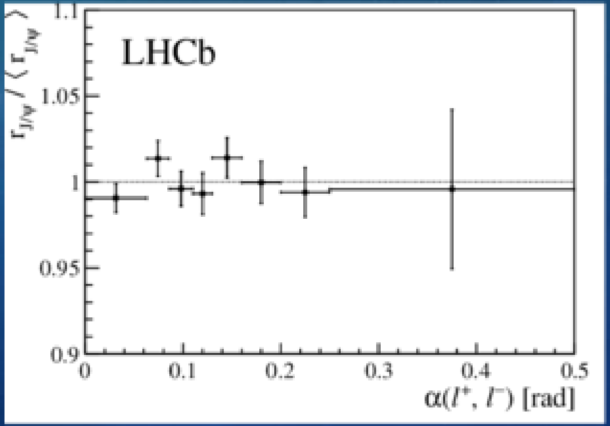
$$r_{J/\psi} = 0.981 \pm 0.020 \text{ (stat+syst)}.$$

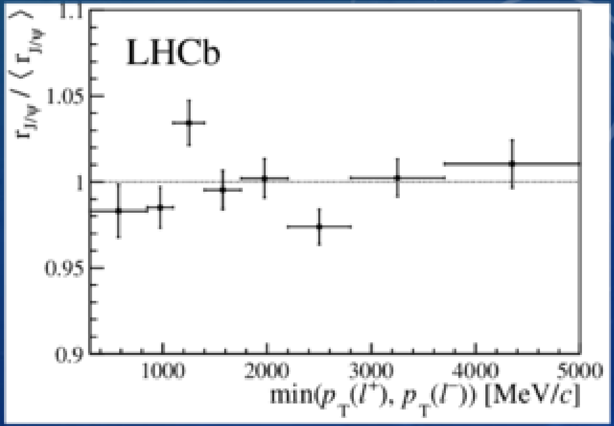
- Test of efficiency across all kinematic regions:
  - plenty of variables checked if distributions are flat in all 16 regions

$B^+ \to K^+ J/\psi(\to e^+e^-)$
$B^+ \to K^+ e^+e^-$



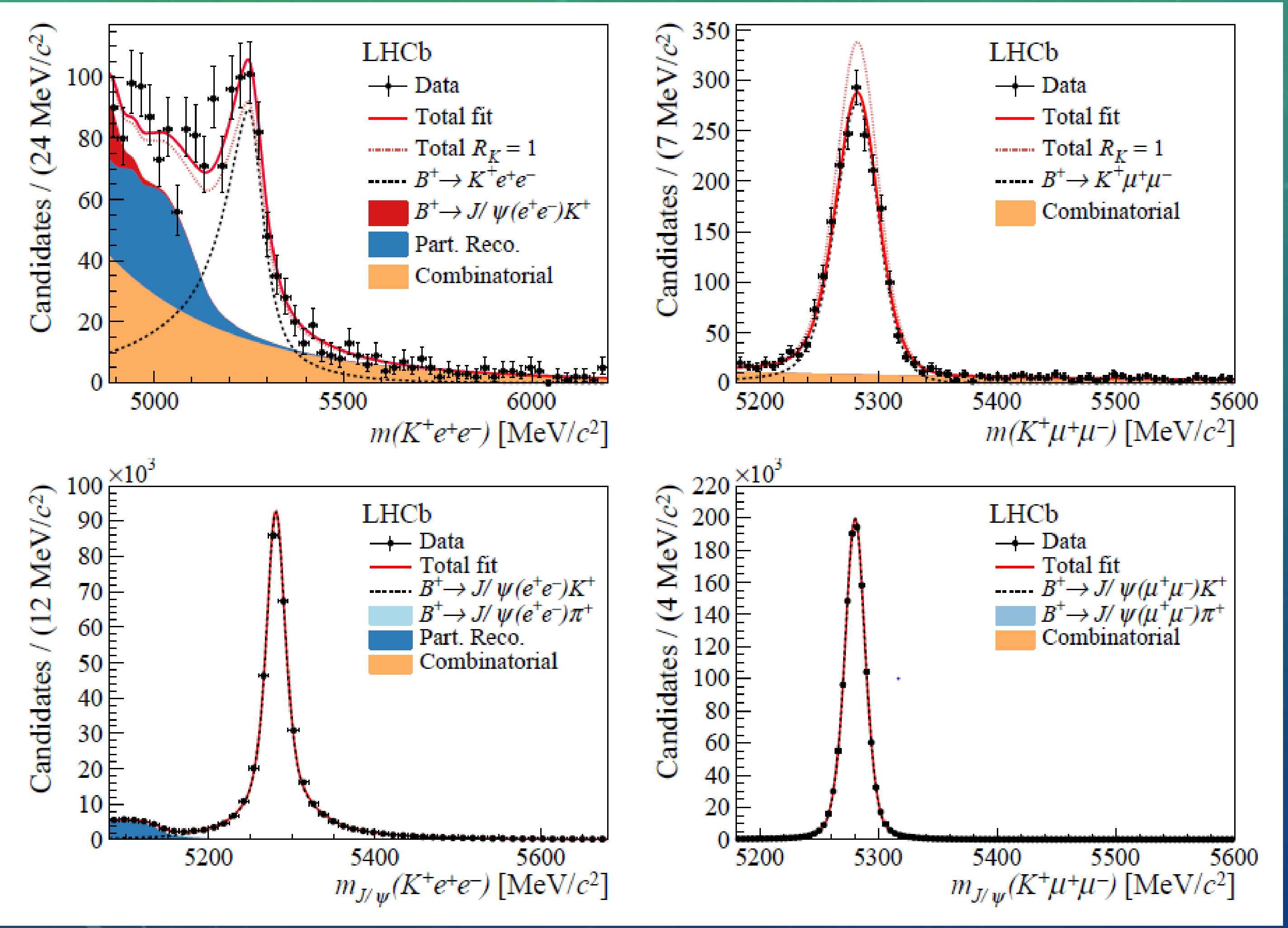






Yields $B^+ \to K^+ l^+ l^-$ (2019)

CERN-EP-2019-043
LHCb-PAPER-2019-009
22 March 2019



Decay Mode	Event Yield
$B^+ \to K^+ e^+ e^-$	766 ± 48
$B^+ \to K^+ \mu^+ \mu^-$	$1\,943 \pm 49$
$B^+ \to J/\psi\,(\to e^+ e^-) K^+$	$344\,100 \pm 610$
$B^+ \to J/\psi\,(\to \mu^+ \mu^-) K^+$	$1\,161\,800 \pm 1\,100$

$$R_K = \frac{\int_{1.1\,\mathrm{GeV}^2}^{6.0\,\mathrm{GeV}^2} \frac{\mathrm{d}\mathcal{B}(B^+ \to K^+ \mu^+ \mu^-)}{\mathrm{d}q^2}\mathrm{d}q^2}{\int_{1.1\,\mathrm{GeV}^2}^{6.0\,\mathrm{GeV}^2} \frac{\mathrm{d}\mathcal{B}(B^+ \to K^+ e^+ e^-)}{\mathrm{d}q^2}\mathrm{d}q^2}$$

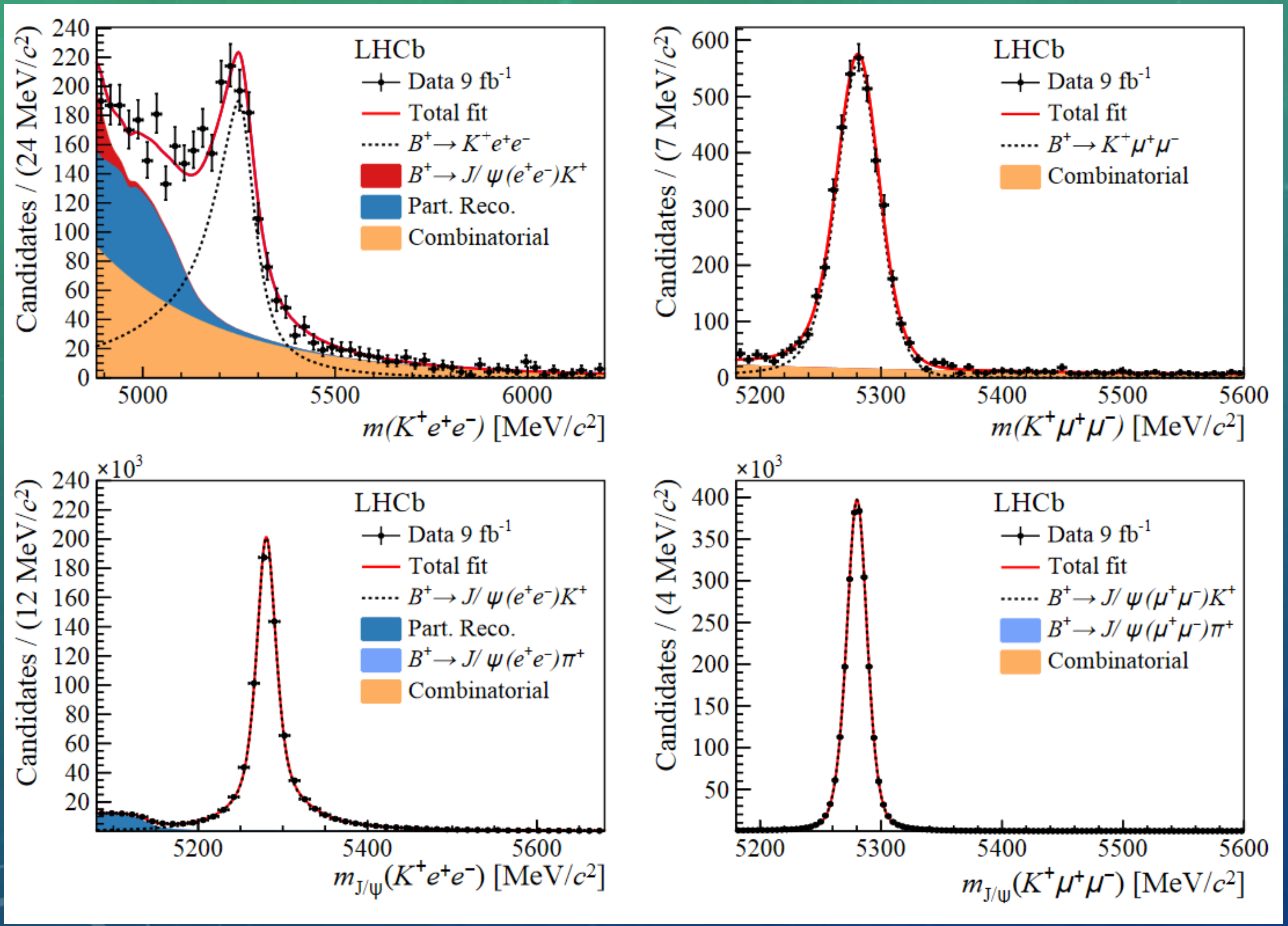
$$R_K = 0.846\,^{+0.060}_{-0.054}\,^{+0.016}_{-0.014}$$

Yields $B^+ \to K^+ l^+ l^-$ (2021)

LHCb-PAPER-2021-004

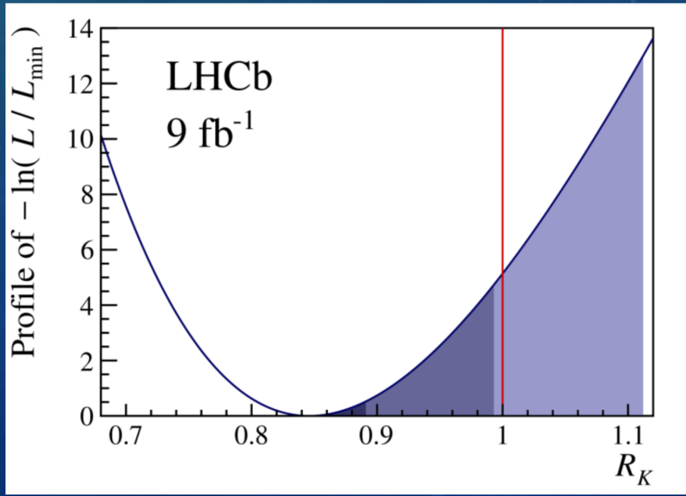
CERN-EP-2021-042
LHCb-PAPER-2021-004
23 March 2021

Nature Physics



Decay mode	Yield
$B^+ \to K^+ e^+ e^-$	$1\,640 \pm 70$
$B^+ \to K^+ \mu^+ \mu^-$	$3\,850 \pm 70$
$B^+ \to J/\psi\,(\to e^+ e^-)K^+$	$743\,300 \pm 900$
$B^+ \to J/\psi\,(\to \mu^+ \mu^-)K^+$	$2\,288\,500 \pm 1\,500$

$$R_K(1.1 < q^2 < 6.0\,\mathrm{GeV}^2/c^4) = 0.846\,^{+0.042}_{-0.039}\,^{+0.013}_{-0.012}$$



Systematic uncertanties

LHCb-PAPER-2021-004

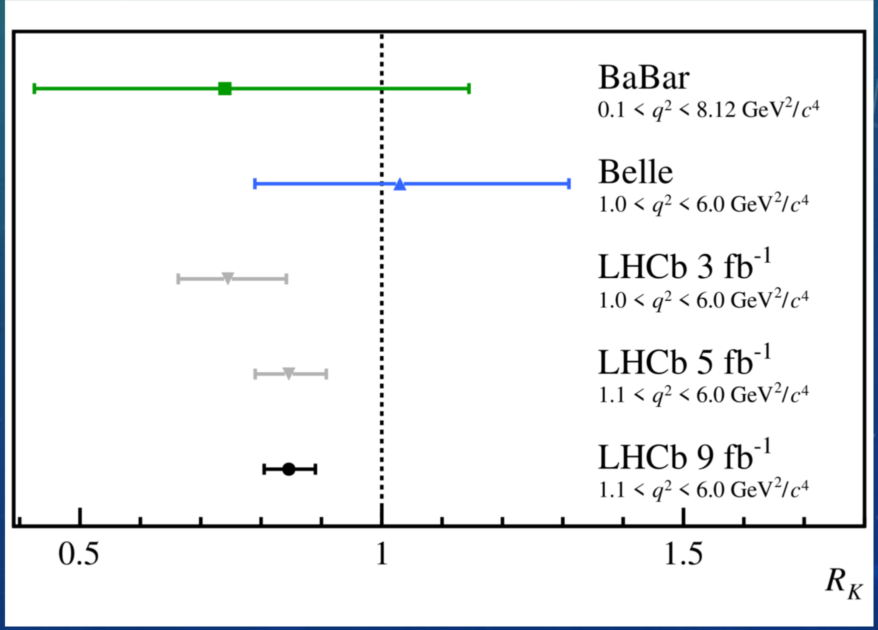
- Dominant sources ($\sim 1\%$):

  Fit model (signal and partially reconstructed background shape), statistic of calibration samples.

- Other sources:

  efficiency

- Total relative systematic is 1.5% in the final R_K measurement.



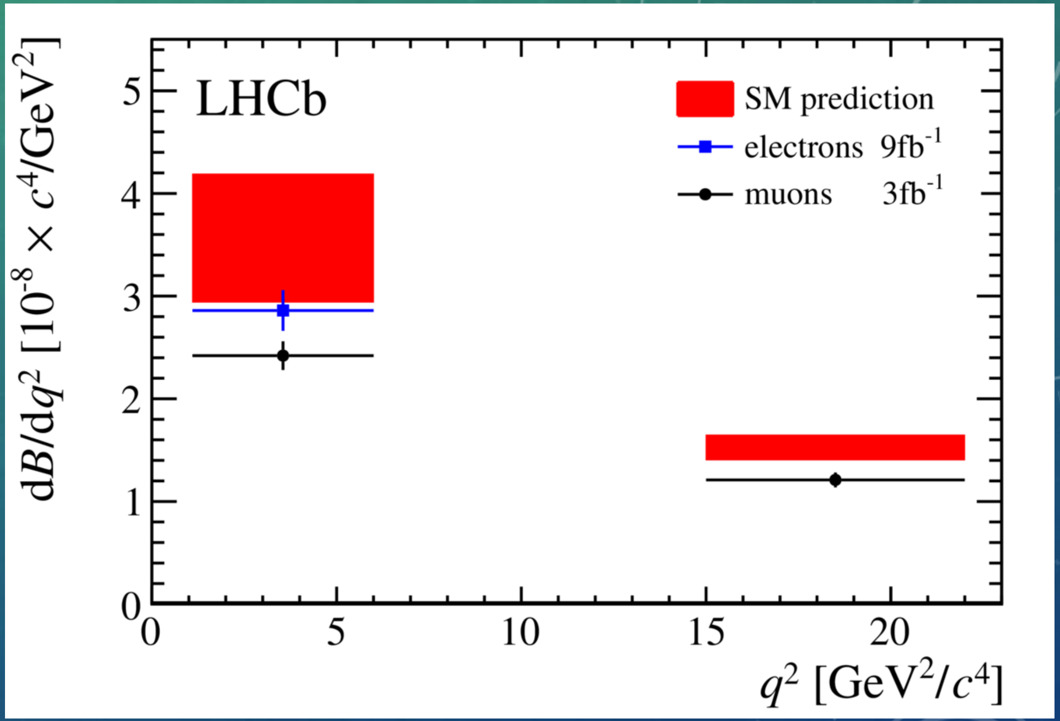
LHCb-PAPER-2021-004

Results

$$R_K = 0.846 \ ^{+0.042}_{-0.039} \ (stat) \ ^{+0.013}_{-0.012} \ (syst)$$

p-value under SM hypothesis: 0.0010

evidence of LFU violation at 3.1σ

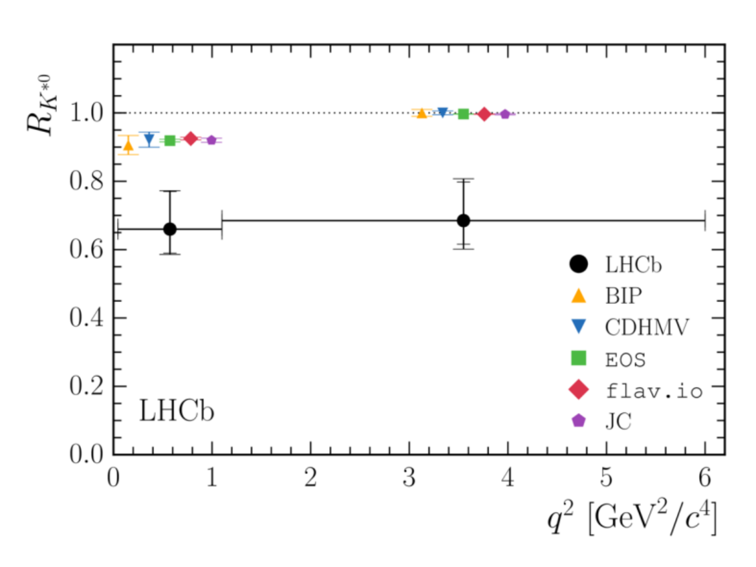


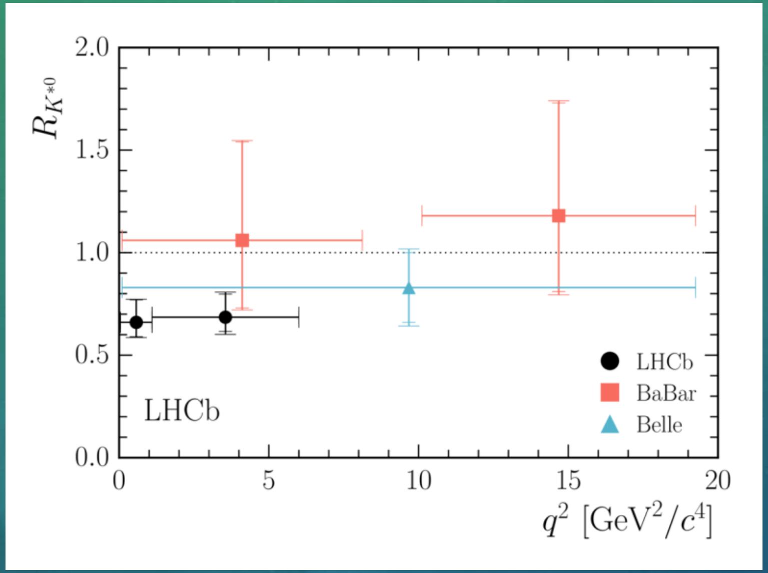
When combining with $\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$, which is below SM [JHEP 06 (2014) 133]:

$$\frac{d\mathcal{B}(B^+ \to K^+e^+e^-)}{dq^2} = \left(28.6 \ ^{+1.5}_{-1.4} \ (stat) \pm 1.4(syst)\right) \times 10^{-9} \ (GeV/c^2)^{-1}$$

it seems that electrons are more SM-like than muons.

R_K^* results from $B^0 \to K^{*0} l^+ l^-$ (2017, 2020)



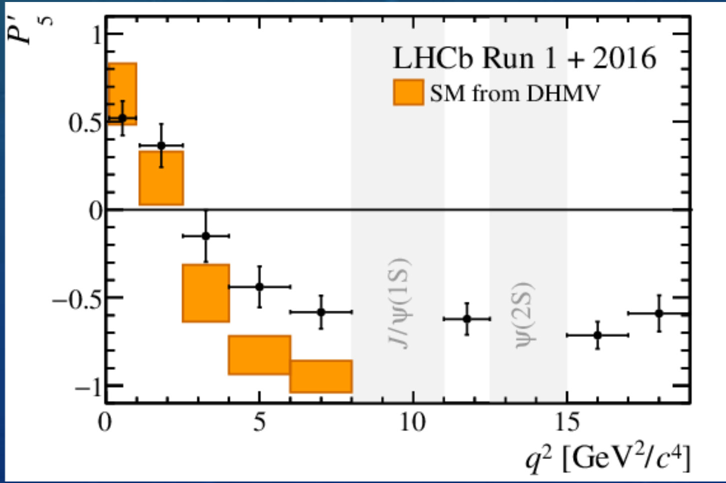


q^2 range [GeV$^2/c^4$]	$R^{SM}_{K^{*0}}$
[0.045, 1.1]	0.906 ± 0.028
	0.922 ± 0.022
	$0.919^{+0.004}_{-0.003}$
	0.925 ± 0.004
	$0.920^{+0.007}_{-0.006}$
[1.1, 6.0]	1.000 ± 0.010
	1.000 ± 0.006
	$0.9968^{+0.0005}_{-0.0004}$
	0.9964 ± 0.005
	0.996 ± 0.002

models

JHEP 08 (2017) 055

	low-q^2	central-q^2
$R_{K^{*0}}$	$0.66^{+0.11}_{-0.07} \pm 0.03$	$0.69^{+0.11}_{-0.07} \pm 0.05$
95.4% CL	[0.52, 0.89]	[0.53, 0.94]
99.7% CL	[0.45, 1.04]	[0.46, 1.10]



SM compatibility: ~2.2σ , ~2.5σ in central q^2

Phys. Rev. Lett. 125 (2020) 011802

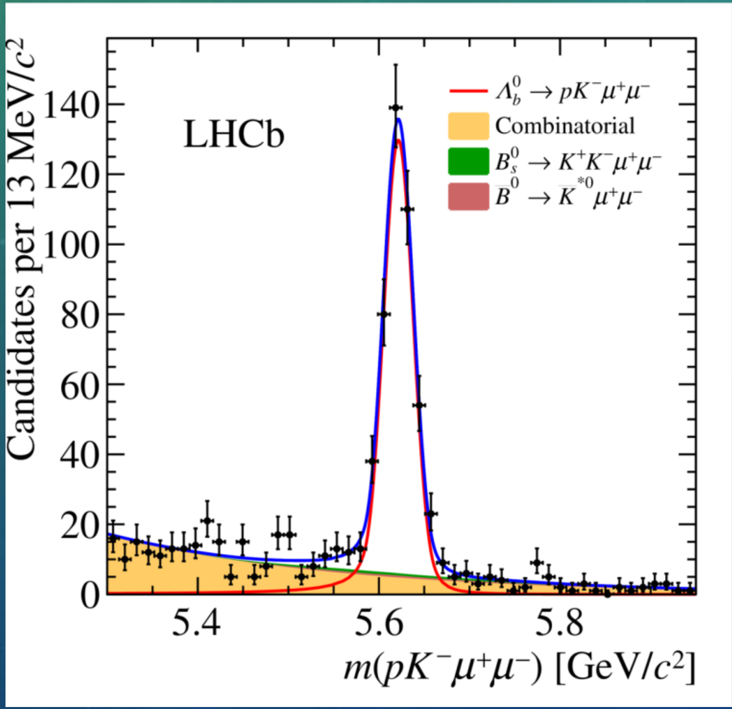
Yields $\Lambda_b \to pK^- l^+ l^-$ (2019)

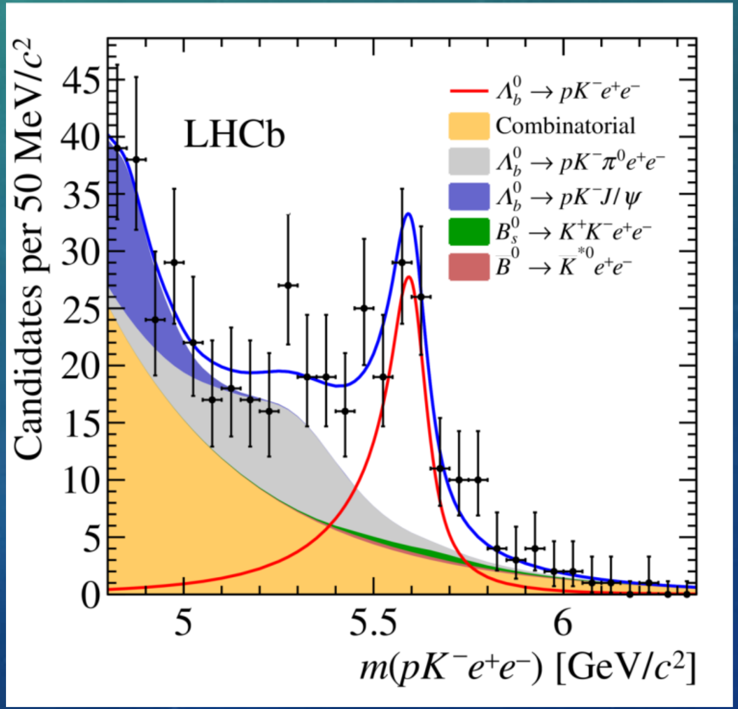
JHEP 2020 (2020) 40

First LFU measurement using B-bayrons and first observation of $\Lambda_b \to pK^-\ell\ell$ - sensitive to different exp. uncertainties than B-meson LFU measurement $\to$ highly complimentary .

$N(\Lambda_b \to pK^- ee) = 122 \pm 17$

$N(\Lambda_b \to pK^- \mu\mu) = 444 \pm 23$



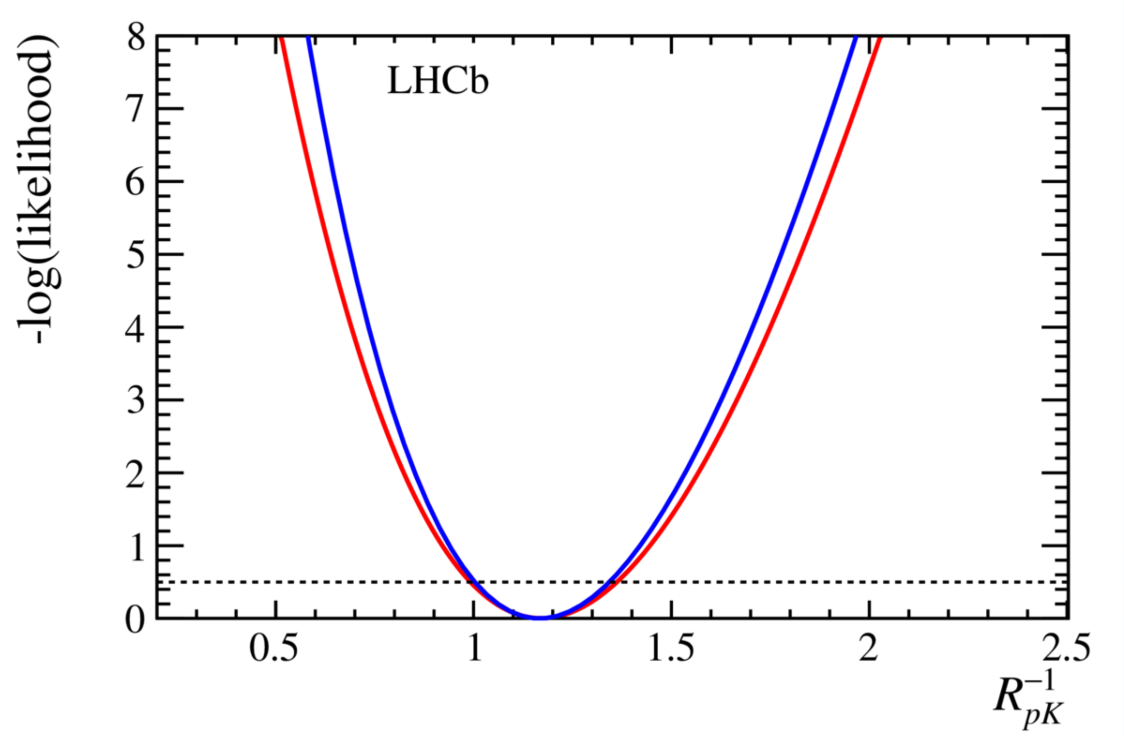


R_{pK} results in $\Lambda_b \to pK^- l^+ l^-$ (2019)

JHEP 2020 (2020) 40

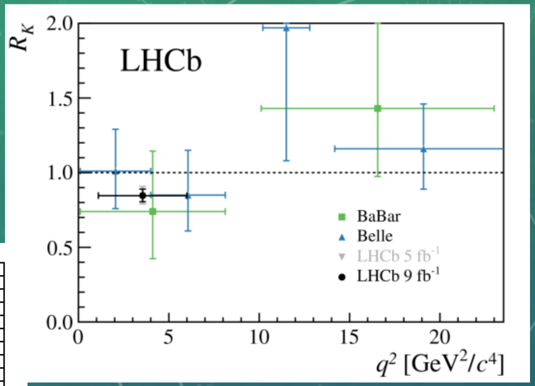
$$R_{pK}^{-1} = 1.17\,^{+0.18}_{-0.16} \pm 0.07$$
$$R_{pK} = 0.86\,^{+0.14}_{-0.11} \pm 0.05$$

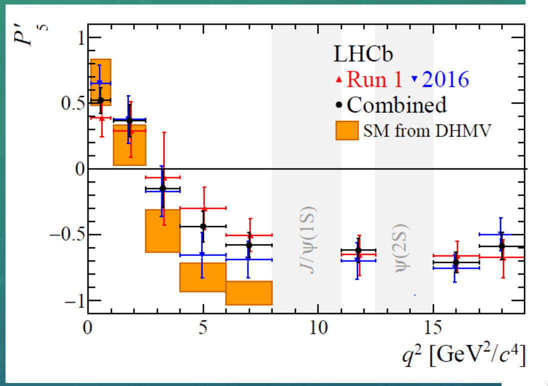
- Result compatible with the SM to one standard deviation
- Also in agreement with R_K and R_K^* where μ modes occur at lower rates than e modes



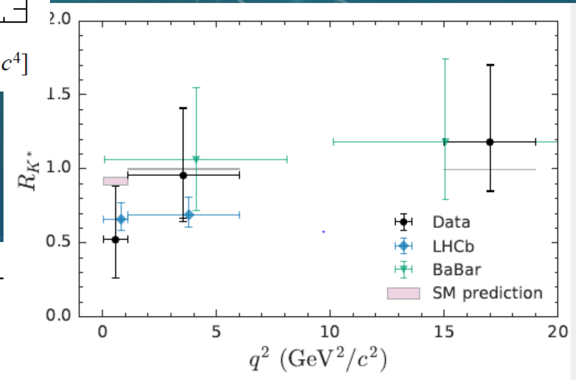
What next? Task for for theorist

- Updated R_K measurement with a 3.1σ departure from LFU!
- Several LHCb measurements deviate from SM by 2-3 σ
- Start-up of the discussion on flavour anomalies

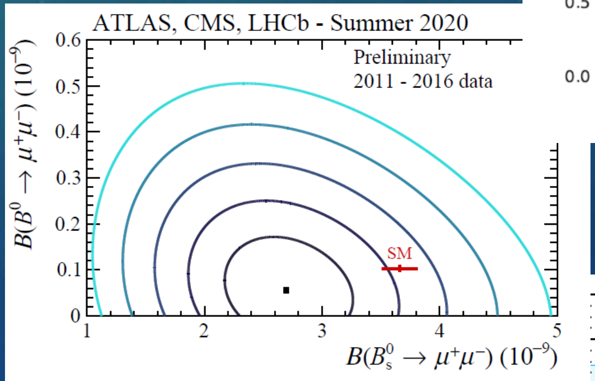




To combine of all LFU observables

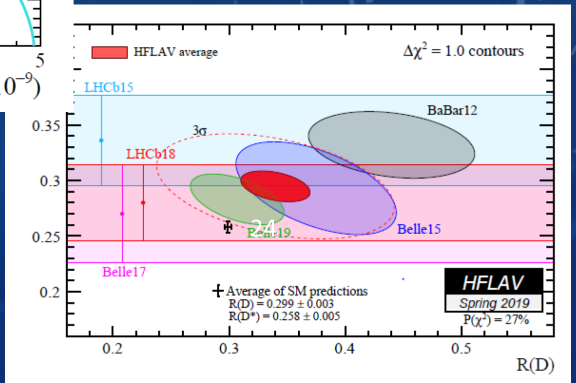


Emerging patterns of New Physics with and without Lepton Flavour Universal contributions:
M. Alguero et al. *Eur.Phys.J.C* 79 (2019) 8, 714
Addendum: Eur. Phys. J. C (2020) **80**: 511



J. Aebischer et al., B-decay discrepancies after Moriond 2019, arXiv:1903.10434
M. Alguero Moriond QCD: Global fits to $b \to sll$ data, link

La Thuile 2021 - Les Rencontres de Physique de la Vallée d'Aoste, 10 March 2021:
P. Stangl *Flavour fits*



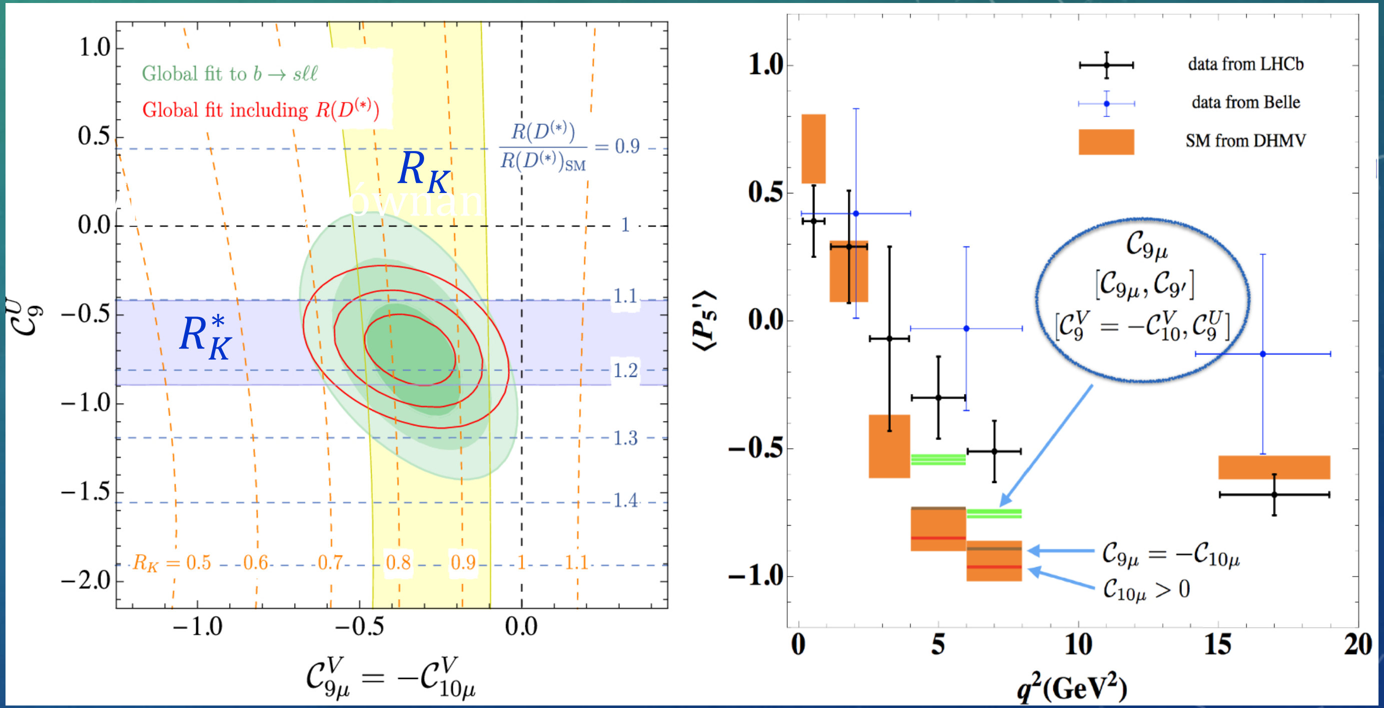
in one model for New Physics interpretation

The model setup

Global likelihood from **smelli** python package for comparing theory predictions to experimental data:

M. Alguero et al. *Eur.Phys.J.C* 79 (2019) 8, 714

J.Aebischer, J.Kumar, P.Stangl, D.M. Straub
A Global Likelihood for Precision Constraints and Flavour Anomalies,
arXiv:1810.07698



- New Physics scenarios:

  Weak Effective Theory (WET): NP Wilson coefficients C'_i

  Standard Model Effective Theory (SMEFT) at scale of 4 TeV: NP particles (LQ, Z')

246 obs (Global) + 22 obs (LFUV) from LHCb, Belle, ATLAS, CMS

The model: one Wilson coeficient or more?

Emerging patterns of New Physics with and without Lepton Flavour Universal contributions:
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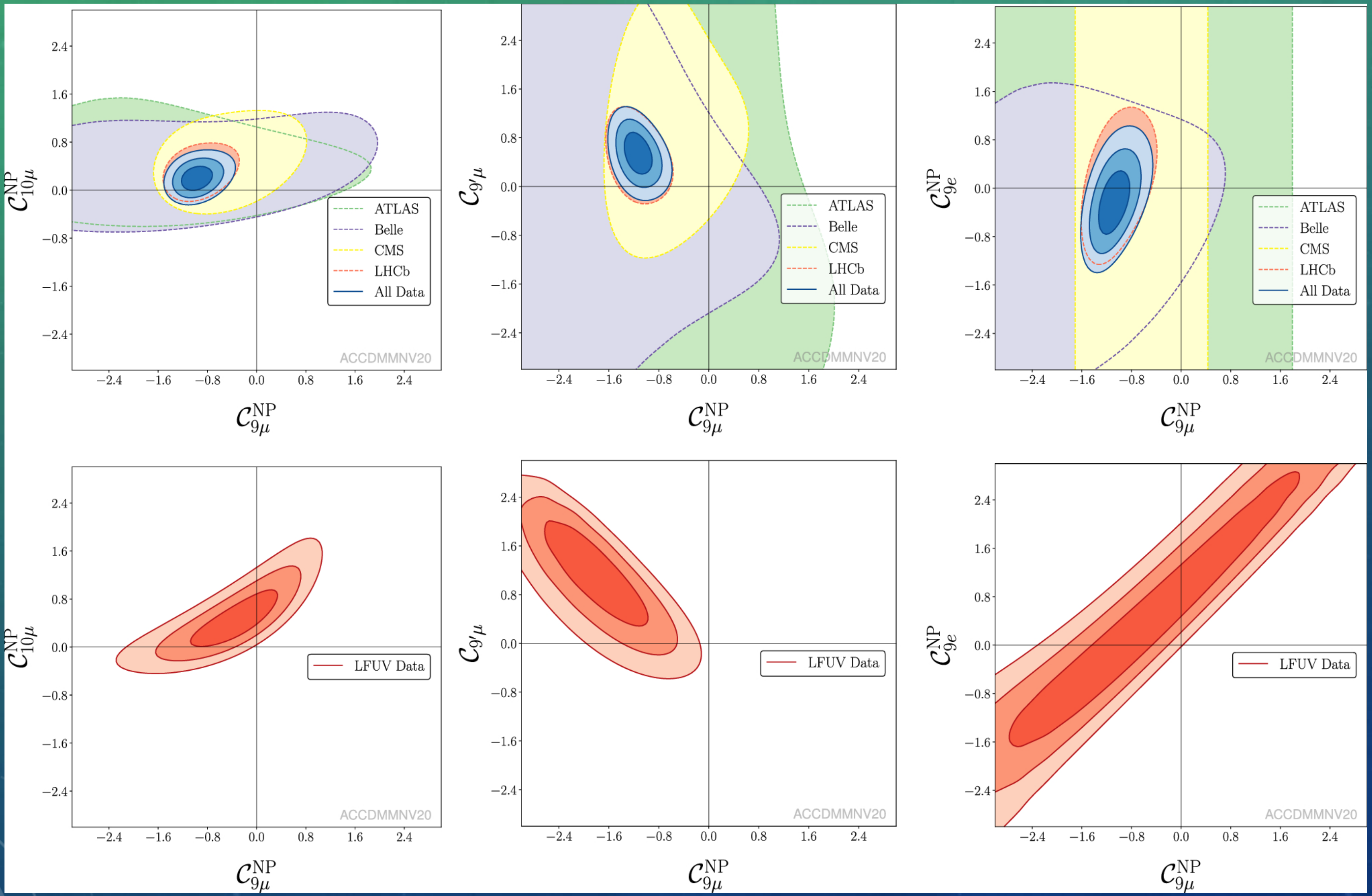
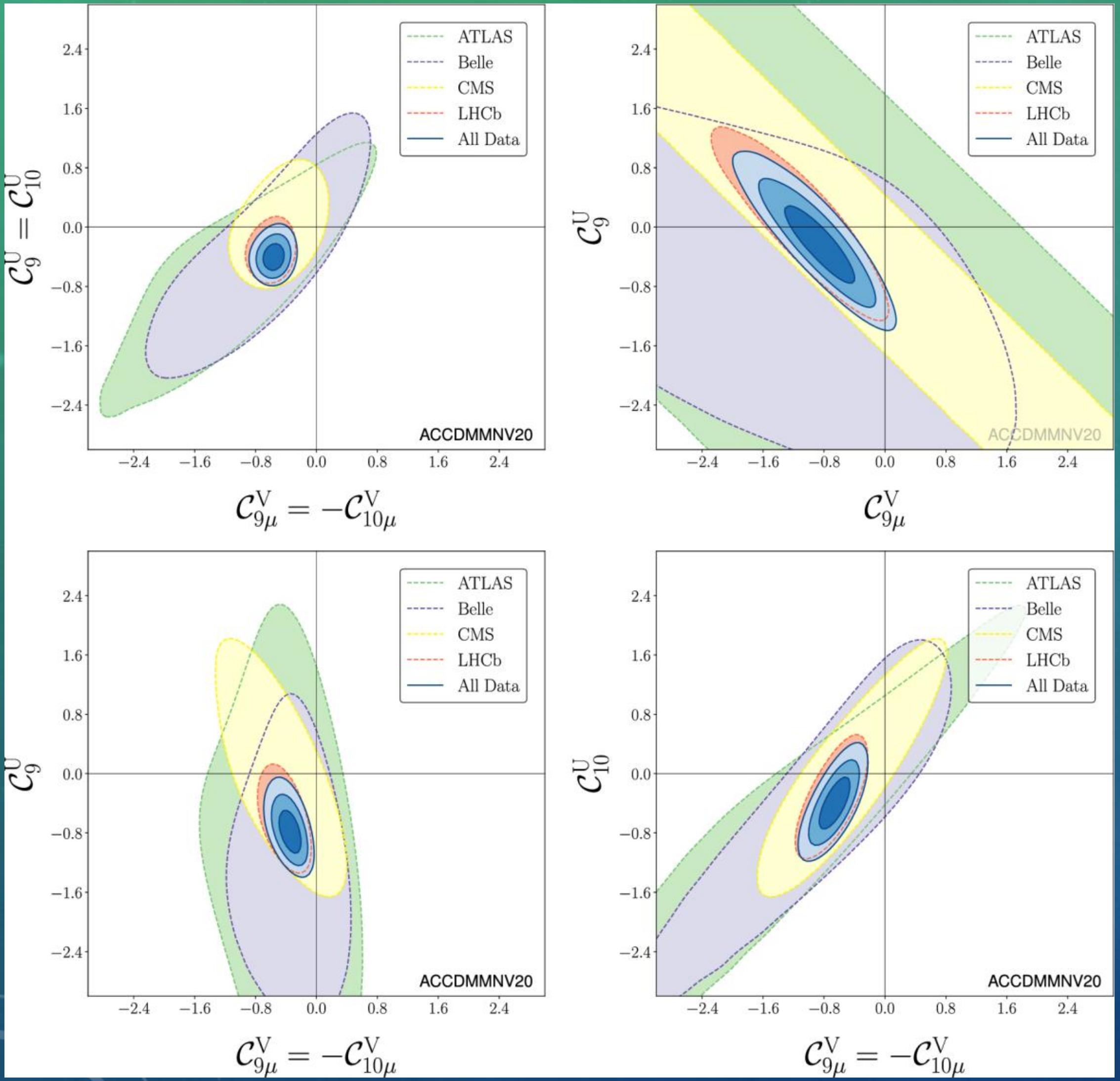


$B_s \to \mu^+\mu^-$

$C_{10\mu} = C_{10\mu}^{SM} + C_{10\mu}^{NP}$

Emerging patterns of New Physics with and without Lepton Flavour Universal contributions:
M. Alguero et al. *Eur.Phys.J.C* 79 (2019) 8, 714
Addendum: Eur. Phys. J. C (2020) **80**: 511

The model: one Wilson coeficient or more?



New Physics coefficients:

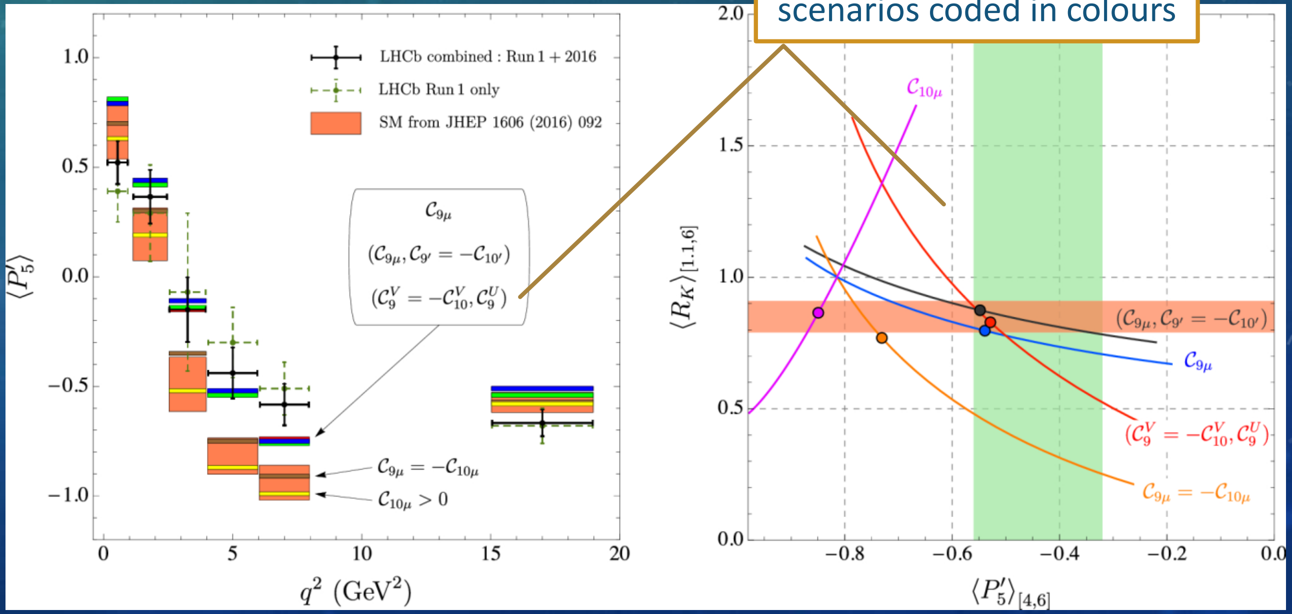
- Electrons with flavour Universality (U)
- Muons with flavour Universality Violation (UV)

$$C_{ie}^{\rm NP} = C_i^{\rm U}$$

$$C_{i\mu}^{\rm NP} = C_{i\mu}^{\rm V} + C_i^{\rm U}$$

New Physics in muon sector only!

scenarios coded in colours



Try it yourself

test your model with global results:
https://github.com/smelli/

jupyter nbviewer

JUPYTER FAQ

Step 1: EFT and basis

Execute this cell and select an EFT and basis

```
In [ ]: widgets.HBox([widget_eft, widget_basis])
```

Step 2: likelihood

execute this cell to initialize the likelihood. This will only take a moment.

```
In [ ]: gl = smelli.GlobalLikelihood(eft=select_eft.value, basis=select_basis.value)
```

Step 3: Wilson coefficients

select a point in EFT parameter space by entering in the text field Wilson coefficient values in the form `name: value`, one coefficient per line (this format is called YAML). The allowed names in the chosen basis can be found in the PDF file linked below.

Example in the SMEFT Warsaw basis:

```
lq1_2223: 1e-9
lq1_3323: 1e-8
lq3_3323: 1e-8
```

```
In [ ]: widgets.VBox([out_basispdf, widgets.HBox([ta_wc, t_scale])])
```

Step 4: parameter point

execute this cell to intialize the `GlobalLikelihoodPoint` object

```
In [ ]: glp = gl.parameter_point(read_yaml(ta_wc.value), float(t_scale.value))
```

Step 5: results!

inspect the likelihood by looking at the numerical value ...

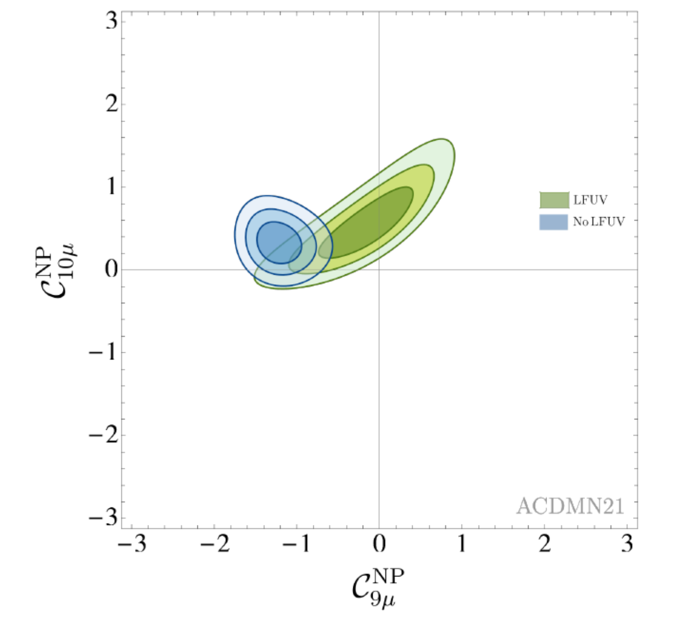
```
In [ ]: glp.log_likelihood_global()
```

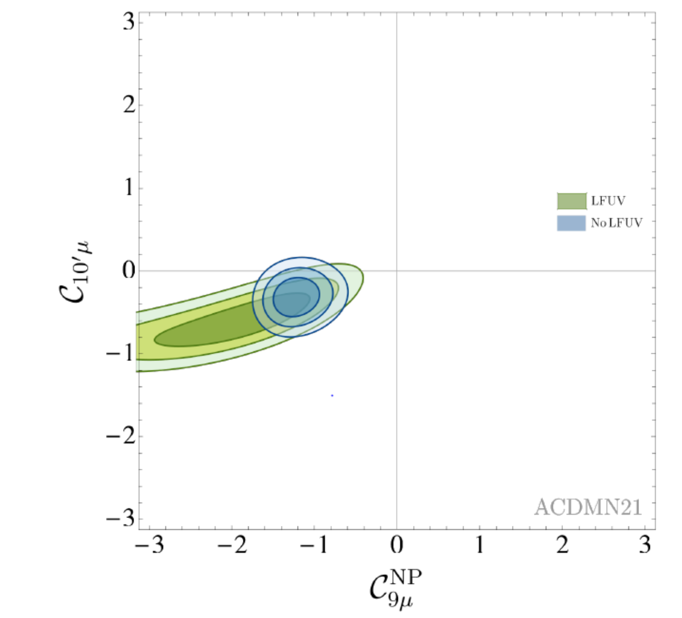
... or inspecting the table of observables

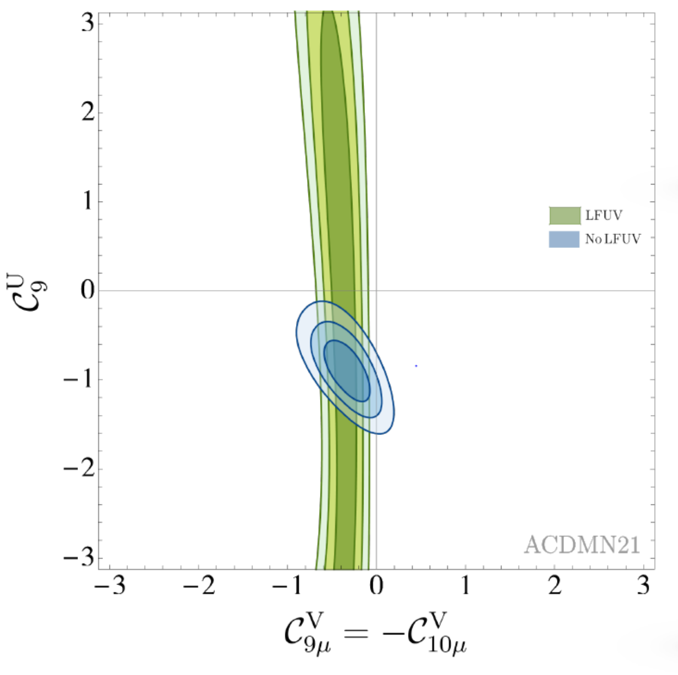
Try it yourself

test your model with global results: https://github.com/smelli/

new fits to $b \to sll$ (Moriond 2021)







M. Alguero et al. *Eur.Phys.J.C* 79 (2019) 8, 714
Addendum: Eur. Phys. J. C (2020) **80**: 511

Summary

- New result on R_K with more statistic & more precision.
- Increased tension with SM in $B^+ \to K^+ l^+ l^-$ and $B_s^0 \to \mu^+\mu^-$ as a sign of flavour anomalies in $b \to sll$
- R_K is uncorrelated with previous parameters
- Plenty of scenarios with similar significances:
  - Right-Handed Currents $C'_{10\,\mu}$ can explain both $\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ and R_K with $C'_{10\,\mu} \neq 0$
  - The scenario LFU with coefficients: $\{C_{9\mu}^V = -C_{10\mu}^V, C_9^U\}$ is reinforced and explains tensions between $C_{9\mu}^{NP}$
  - and LFUV fit with $C_{9\mu}^{NP} = -C_{10\mu}^{NP}$
  - $Q_5 = P'_{\mu 5} - P'_{e5}$ new candidate for a discriminator between preferred scenarios
- A consistent model-independent interpretation is possible via modification of $b \to s$ coupling with additional heavy neutral boson or with leptoquarks.
- Other SM extensions: SUSY, Higgs sectors, extra dimensions are also considered.