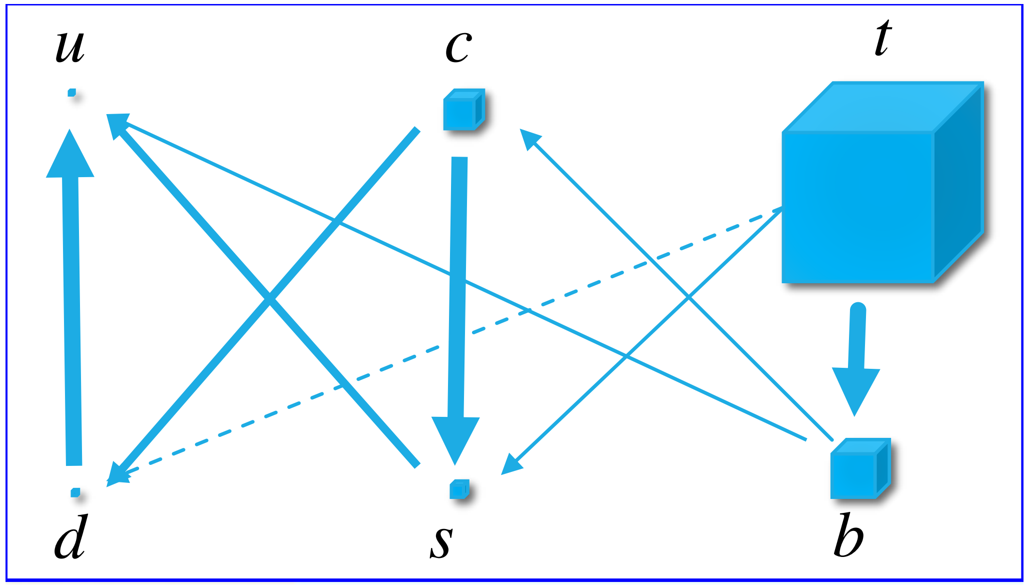
New results on flavour anomalies from LHCb

A. Mauri
on the behalf of the LHCb collaboration

Interpreting the LHC Run 2 data and Beyond
27-31 May 2019, Trieste

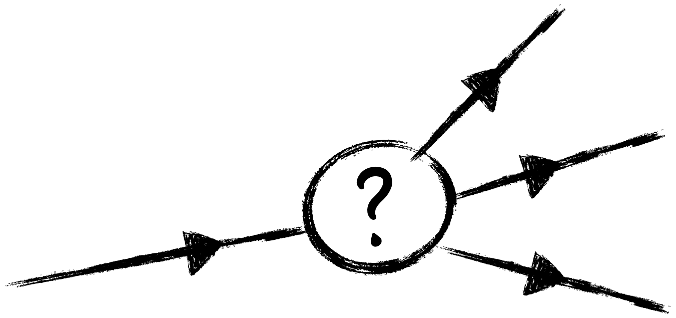
Why study flavour?

- *Flavour puzzle*
  - 20 free parameters in the flavour sector
    - only 5 to characterize gauge interaction and boson masses
  - why 3 generations?
  - what is the origin of their mass hierarchy?
- V_{CKM} hierarchical and nearly diagonal



Indirect searches in Flavour Physics

- precise measurements of ***b*, *c*** **decays**
- sensitive to **new virtual particles**
- probe **higher energy** scales than direct searches

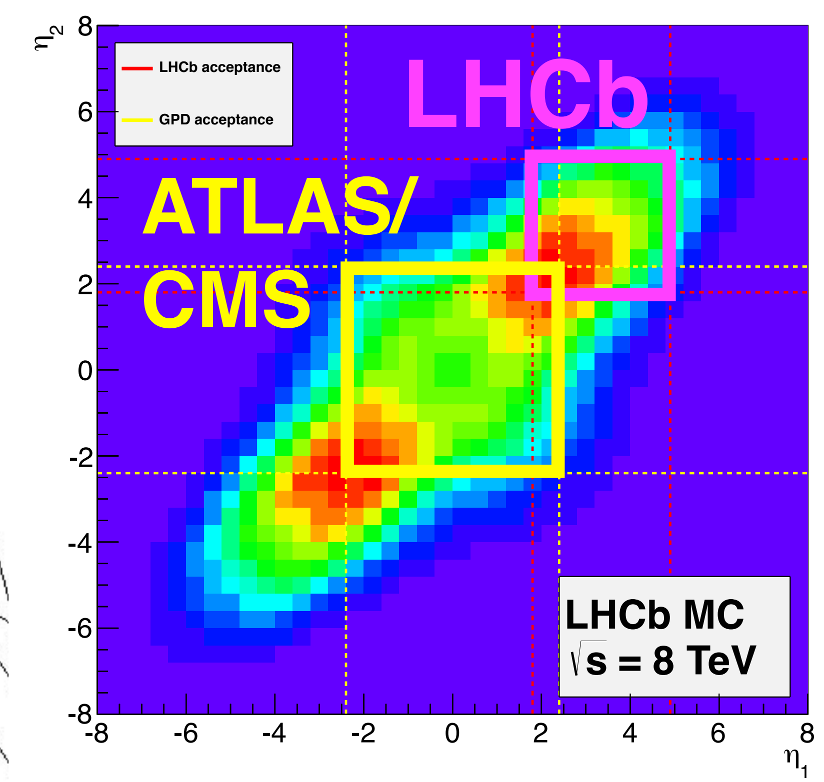


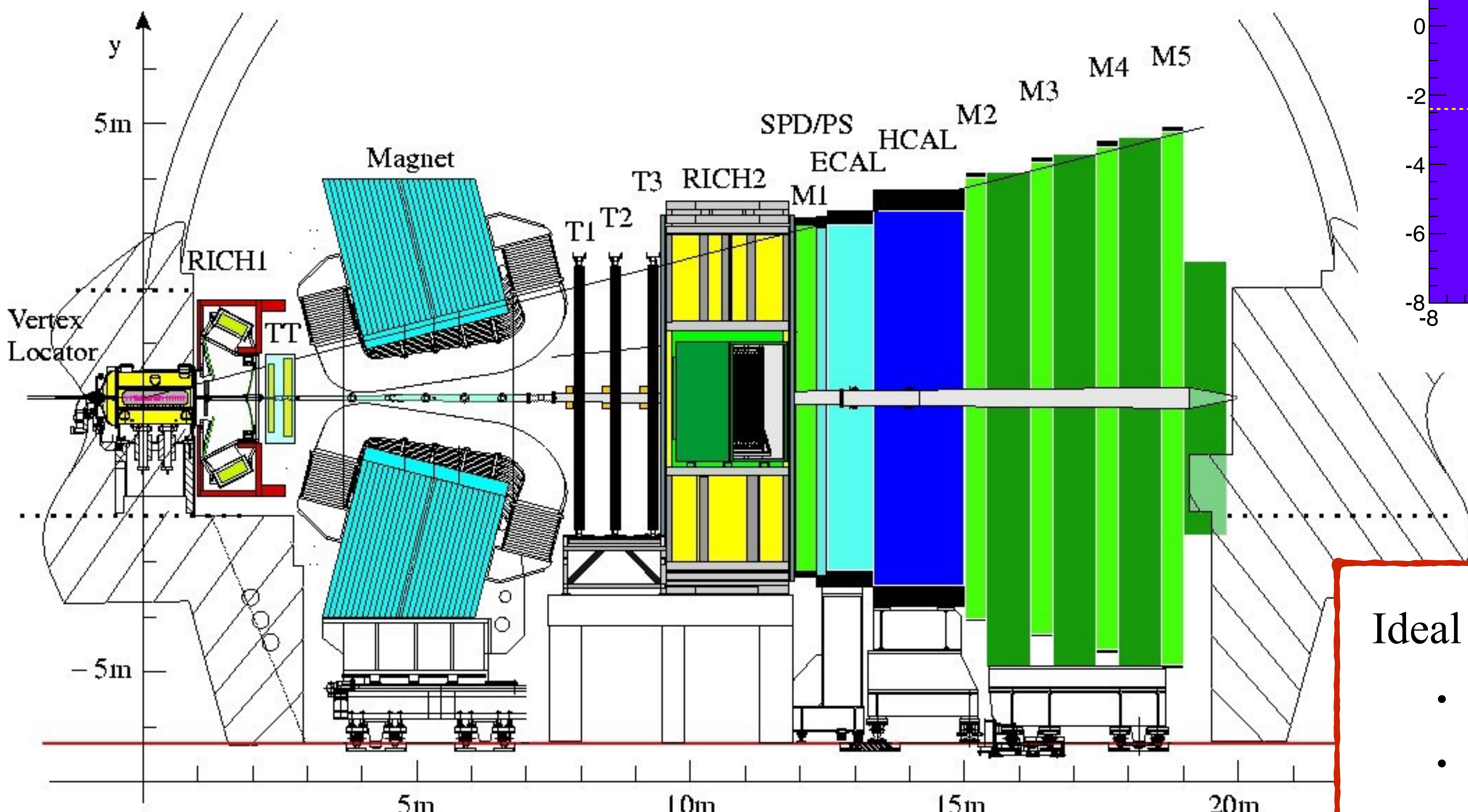
The LHCb detector

LHCb is a forward spectrometer placed at LHC

- Pseudorapidity range: $2 < \eta < 5$
- focused on the study of *b* and *c* decays
  - $O(10^5)$ $b\bar{b}$ pairs produced every second
  - $\sigma(pp \to H_b X) = 144 \pm 1 \pm 21\,\mu b$ in acceptance

$pp \to b\bar{b}$ cross section



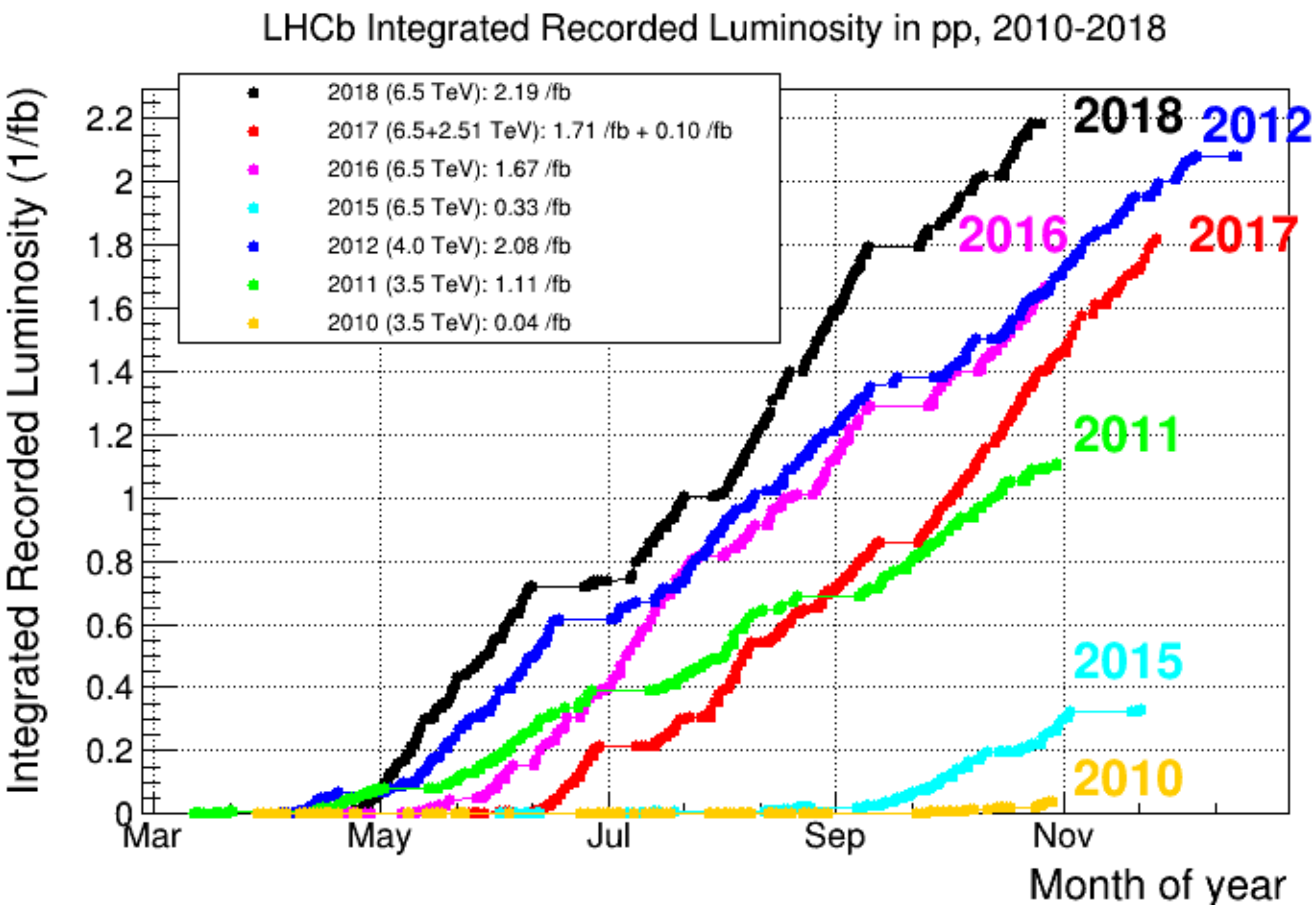


Ideal place for studying b and c decays:

- excellent vertex resolution
- excellent momentum resolution
- excellent particle identification

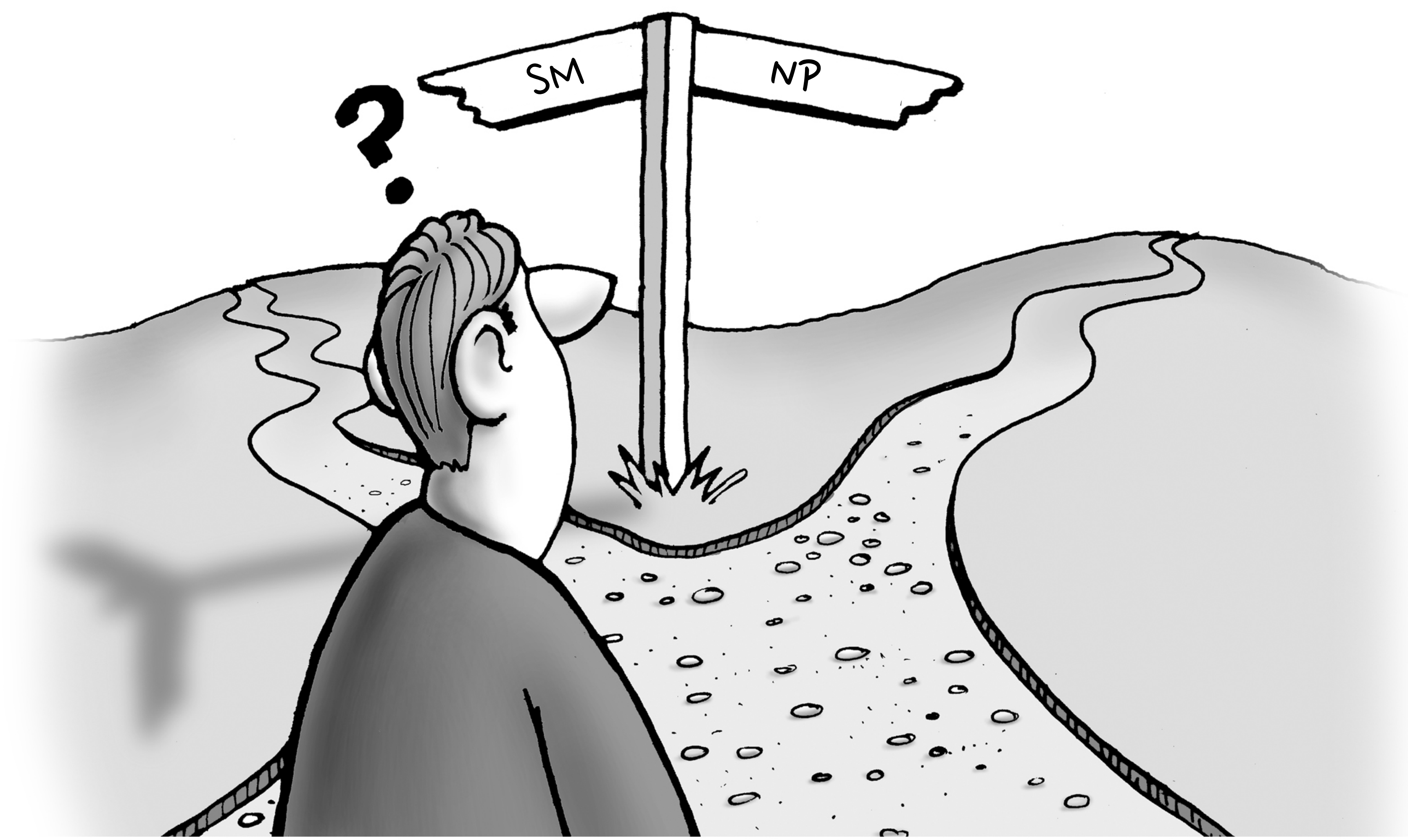
JINST 3 (2008) S08005 IJMPA 30 (2015) 1530022

Collected datasets



- **Run1** LHCb collected **1+2 fb^{-1}** of data in **2011+2012**
- **Run2** LHCb collected **6 fb^{-1}** of data between **2015** and **2018** (roughly twice b-meson per fb-1 due to **increased $\sqrt{s}$**)

The flavour anomalies...

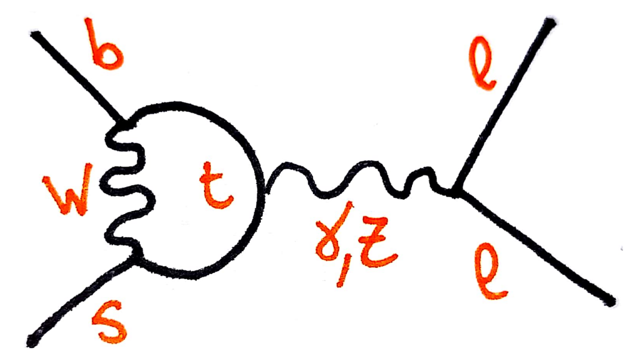


Flavour anomalies

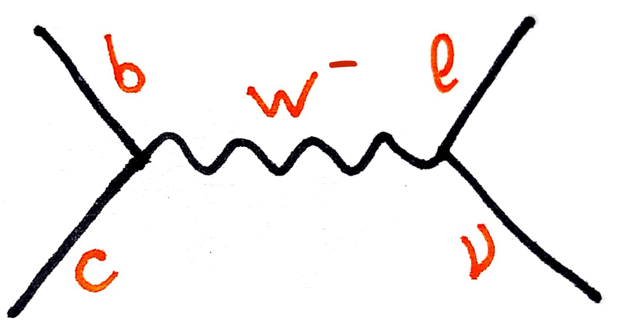
1. $b \to s\ell\ell$ processes
   - Rate and angular distributions of exclusive $b \to s\mu^+\mu^-$ decays
   - Relative rates of $b \to s\mu^+\mu^-$ and $b \to se^+e^-$ decays ($\mathrm{R_{K^{(*)}}}$)

2. $b \to c\tau^-\bar{\nu}_\tau$ decays
   - Relative rates of $b \to c\tau^-\bar{\nu}_\tau$ versus decays with e/μ ($\mathrm{R_{D^{(*)}}}$)

NEUTRAL CURRENT

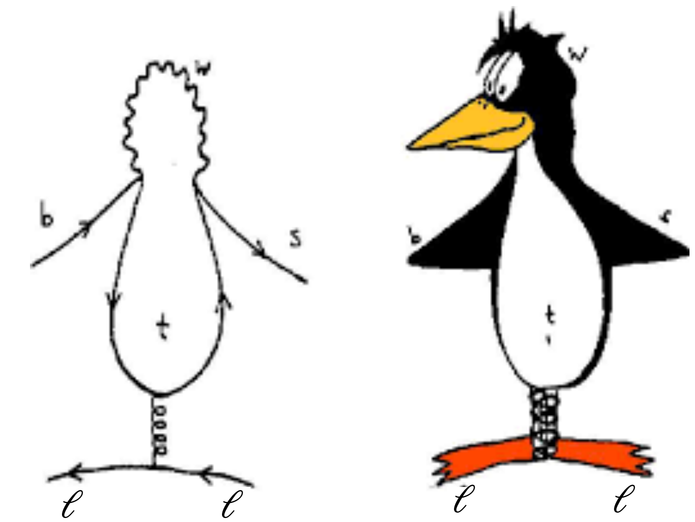


CHARGED CURRENT

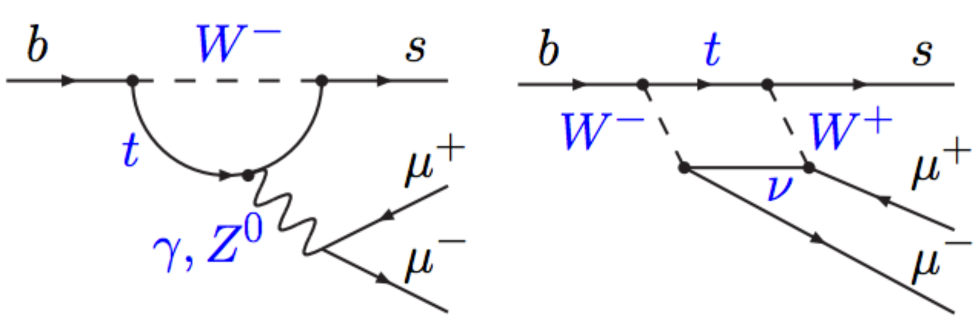


Why rare b decays?

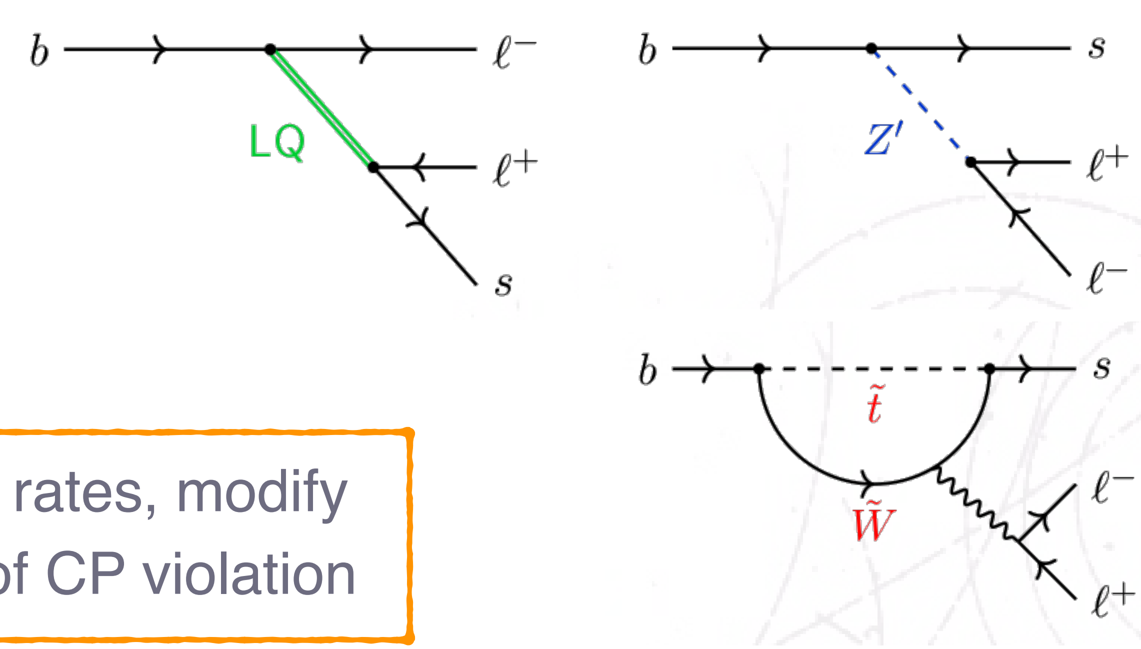
- $b \to s\ell\ell$ transitions are powerfull probes of New Physics
  - FCNC proceeding via loop diagrams only (“penguin" or box)
  - suppressed in the SM, more sensitive to New Physics



SM



NP



New particles could enhance/suppress decay rates, modify angular distributions, introduce new sources of CP violation

Theory formalism

- Low-energy processes (B decays) can be described by an **effective theory:**

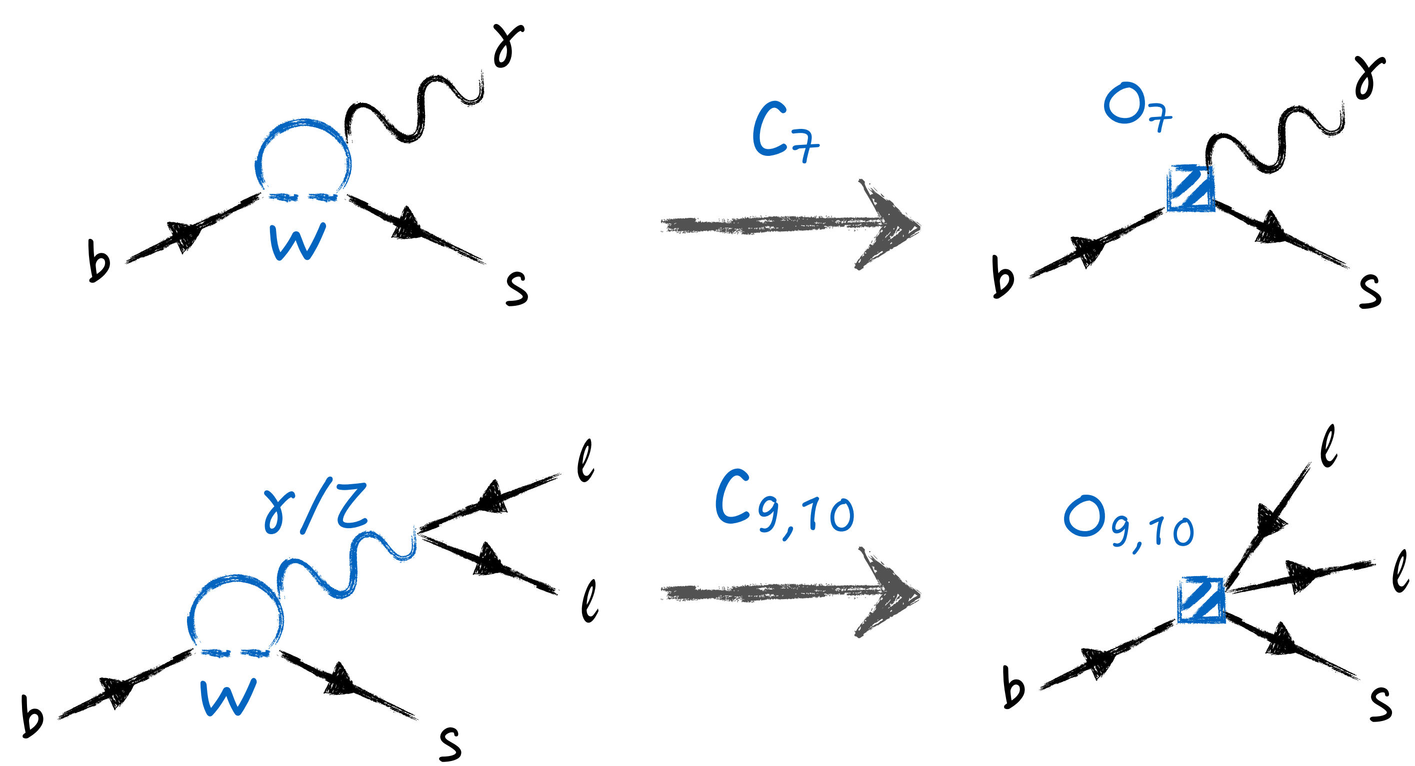
$$\mathcal{H}_{eff} = \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^{*} \sum_i \mathcal{C}_i \mathcal{O}_i$$

Wilson coefficients (*effective couplings*) → $\mathcal{C}_i$

Local operators → $\mathcal{O}_i$

- New Physics can contribute to different Wilson coefficients (or introduce new operators) depending on its Lorentz structure

$$\mathcal{C}_i = \mathcal{C}_i^{\mathrm{SM}} + \mathcal{C}_i^{\mathrm{NP}}$$



$B_{s,d} \to \mu^+\mu^-$ decays

- One of the golden channel to look for NP
  - helicity suppressed
  - $\mathcal{B}(B_s^0 \to \mu^+\mu^-) \propto |C_{10} - C'_{10}|^2$

> - Precise SM prediction
>
>   **C. Bobeth et al. PRL 112, 101801 (2014)**
>
> $$BR(B_s \to \mu^+\mu^-)_{SM} = (3.65 \pm 0.23) \times 10^{-9}$$
>
> $$BR(B^0 \to \mu^+\mu^-)_{SM} = (1.06 \pm 0.09) \times 10^{-10}$$

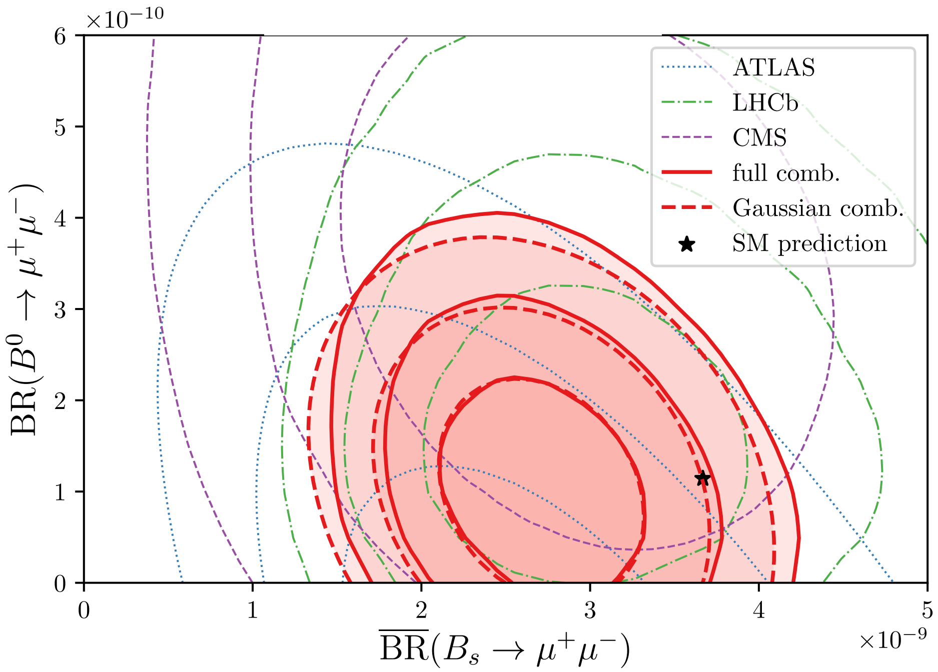
- Latest LHCb result uses Run1 + (Run2) 1.4 fb^{-1}

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.0 \pm 0.6\,^{+0.3}_{-0.2}) \times 10^{-9} \quad \textbf{7.8}\boldsymbol{\sigma}$$

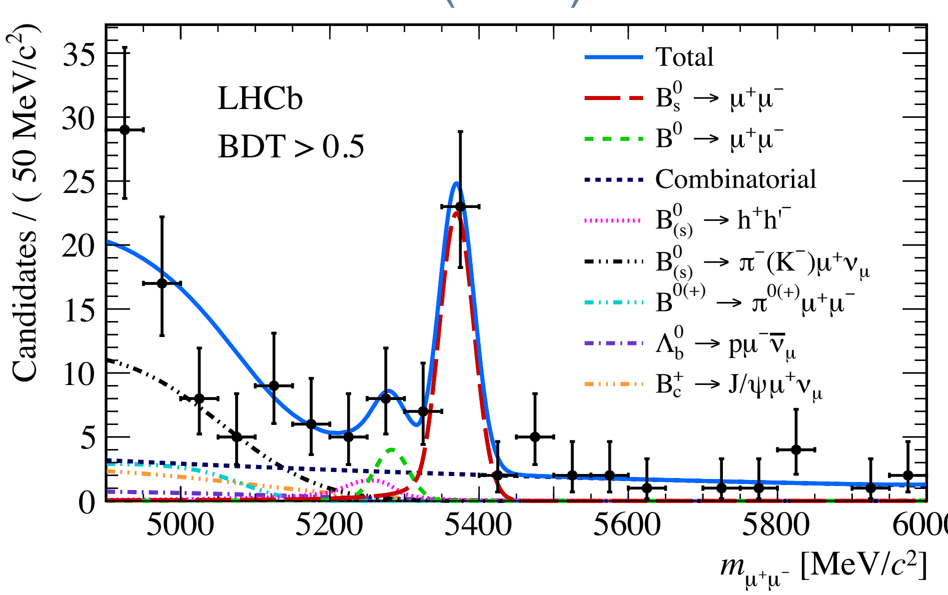
$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 3.4 \times 10^{-10} \text{ at 90\% CL} \quad \textbf{1.9}\boldsymbol{\sigma}$$

  - Compatible with SM prediction

arXiv:1903.10434



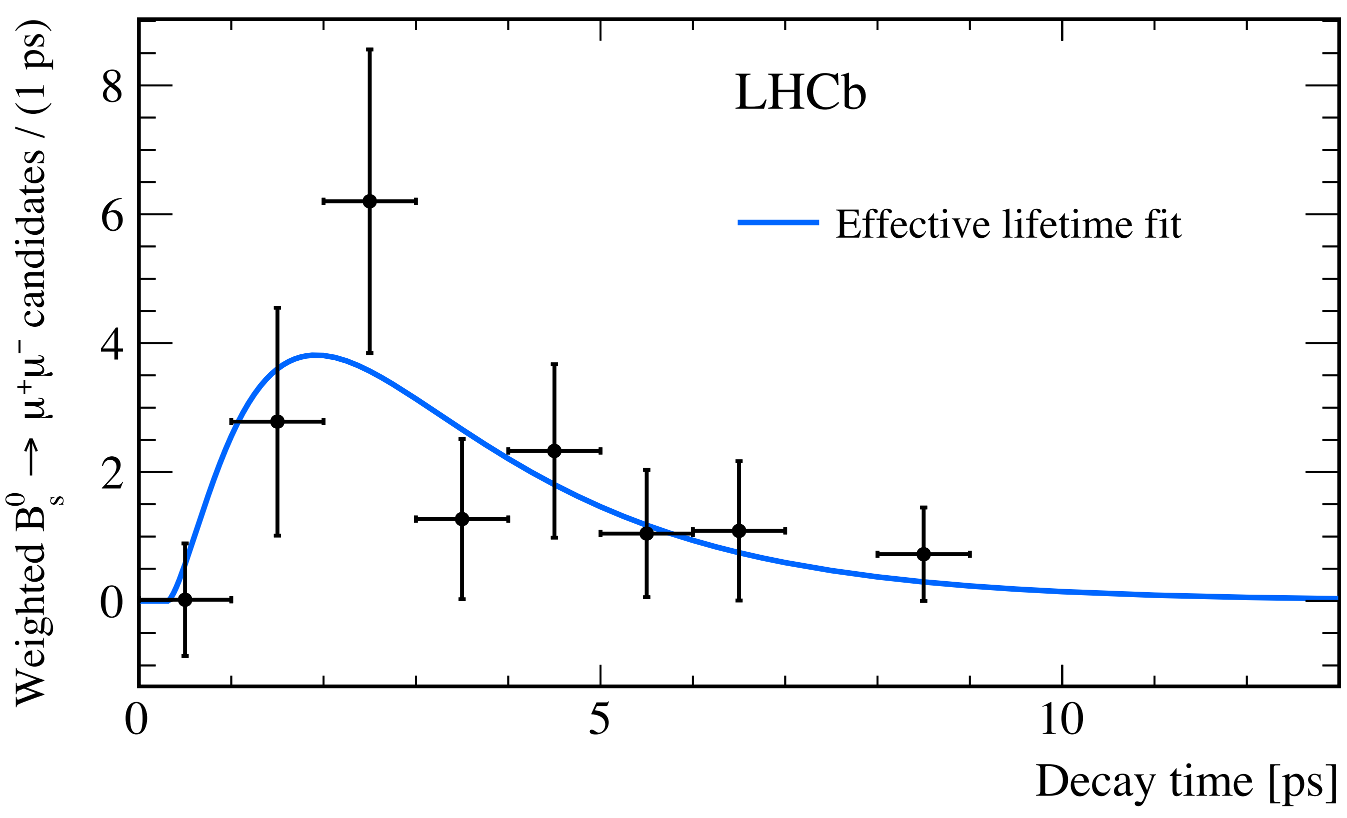
PRL 118 (2017) 191801



$B_{s,d} \to \mu^+\mu^-$ effective lifetime

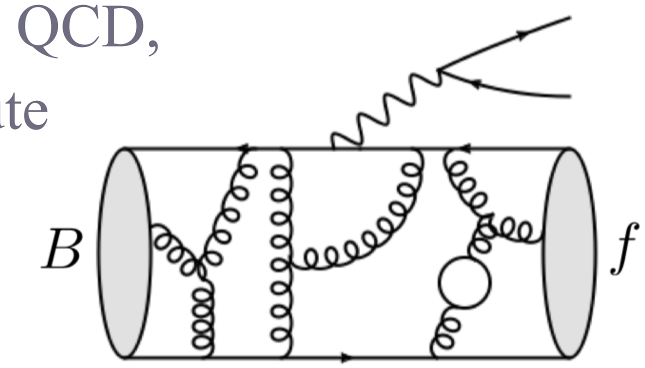
- First measurement of the effective lifetime
  - provides complementary constraints on NP models
  - $\tau_{eff}(B_s^0 \to \mu^+\mu^-) = (2.04 \pm 0.44 \pm 0.05)$ ps

PRL 118 (2017) 191801



Great variety of observables

- Observe hadronic decay, not the quark-level transition
  - $b \to s\ell\ell \longrightarrow B^+ \to K^+\ell\ell$, $B^0 \to K^{*0}\ell\ell$, $B_s \to \phi\ell\ell$, etc.
- Needs to compute hadronic matrix elements
  - Non-perturbative QCD, difficult to compute



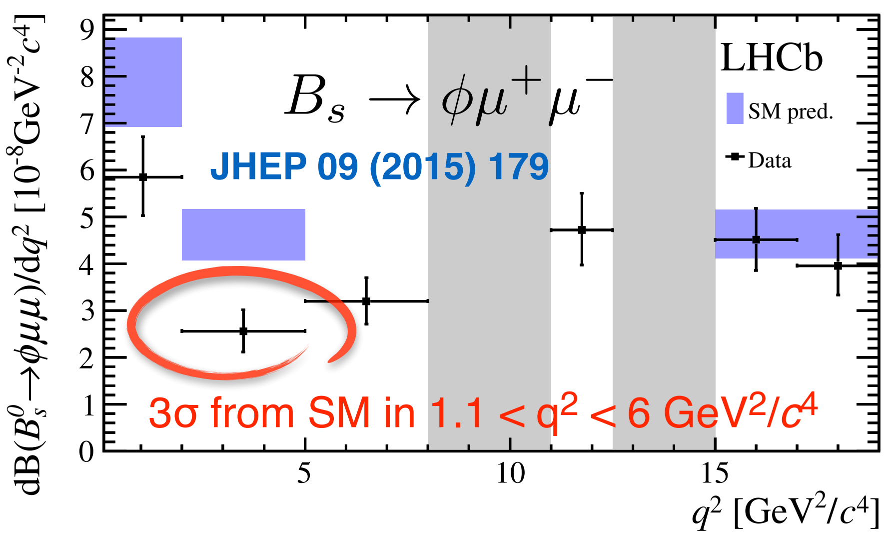
DIRTY

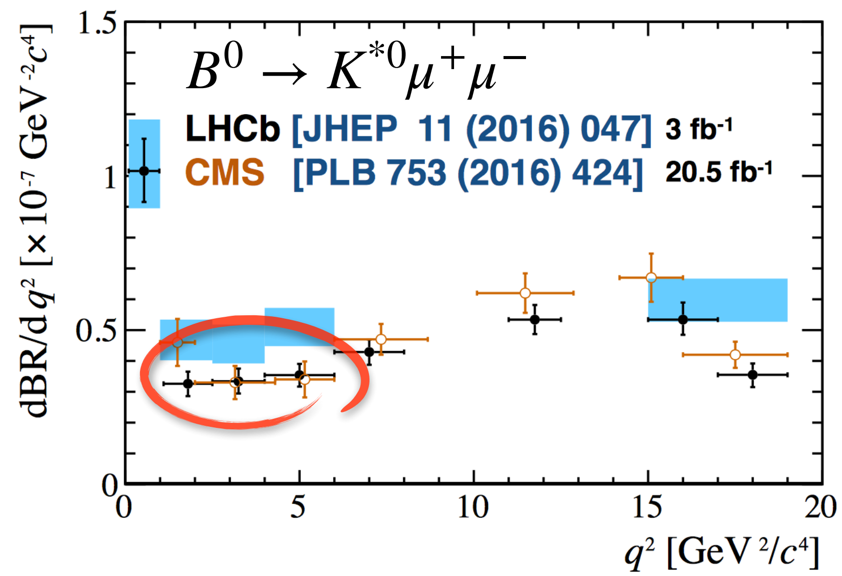
- Branching ratios: **large** theory uncertainties
- Angular observables: **reduced** theory uncertainties
- Lepton Flavour Universality tests (ratio of BR, etc.): **clean**, uncertainties cancels

CLEAN

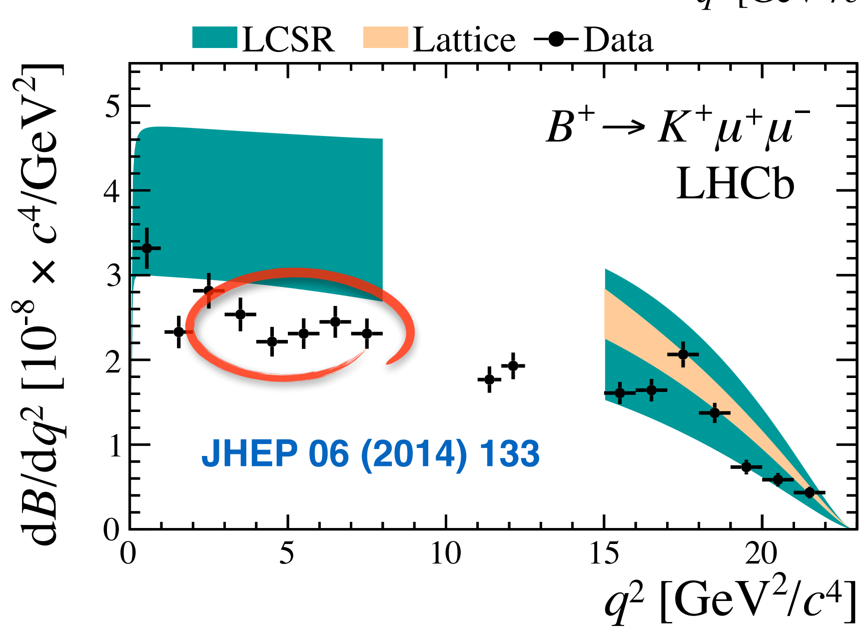
Branching fractions too low in $b \to s\mu^+\mu^-$?

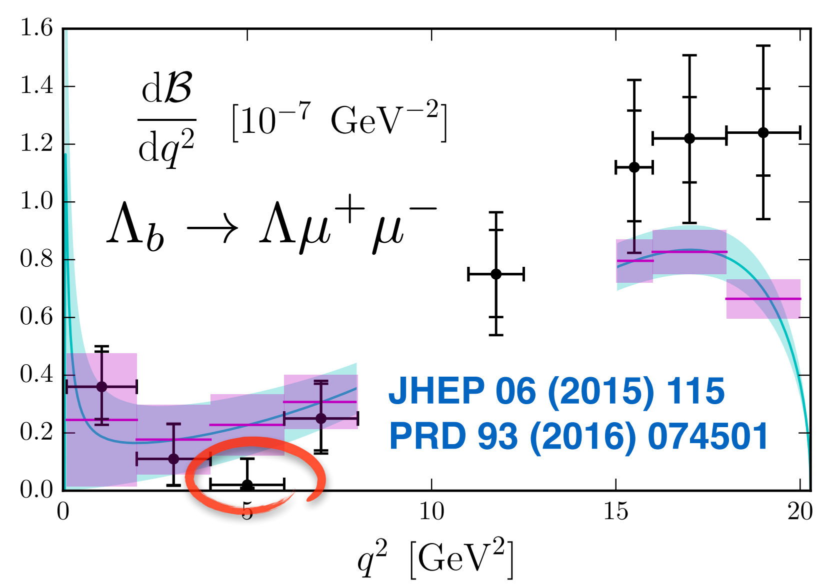
Measured BR are consistently lower than predicted in SM





q^2: squared di-lepton invariant mass

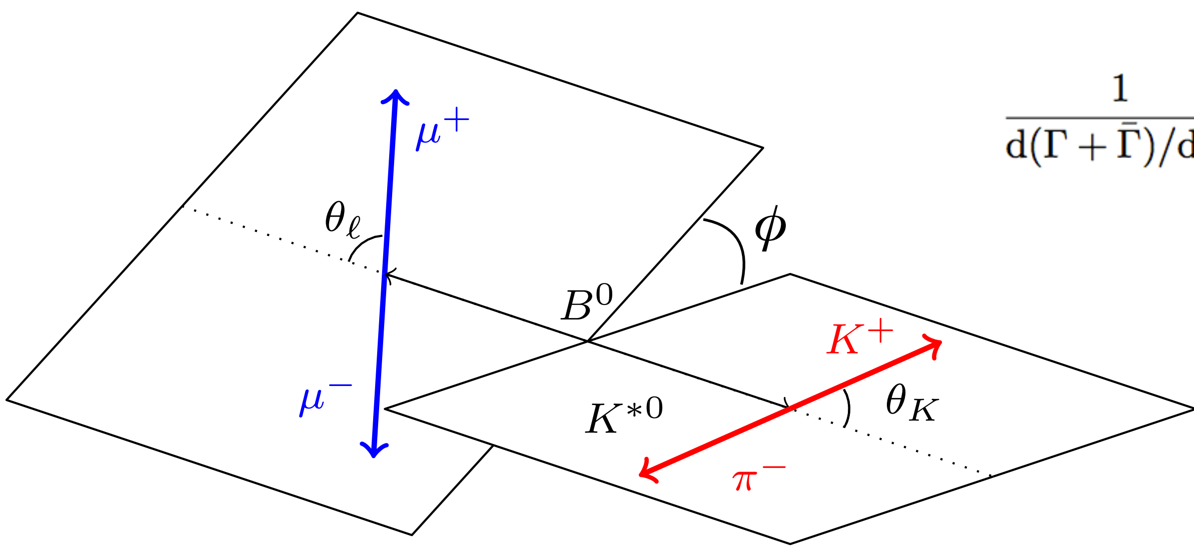




though SM suffers from large uncertainties…

$B \to K^* \mu\mu$ angular analysis

* Study the angular distribution of the 4 final state particles ($\cos\theta_\ell, \cos\theta_K, \phi$) in $B^0 \to K^{*0}\mu\mu$



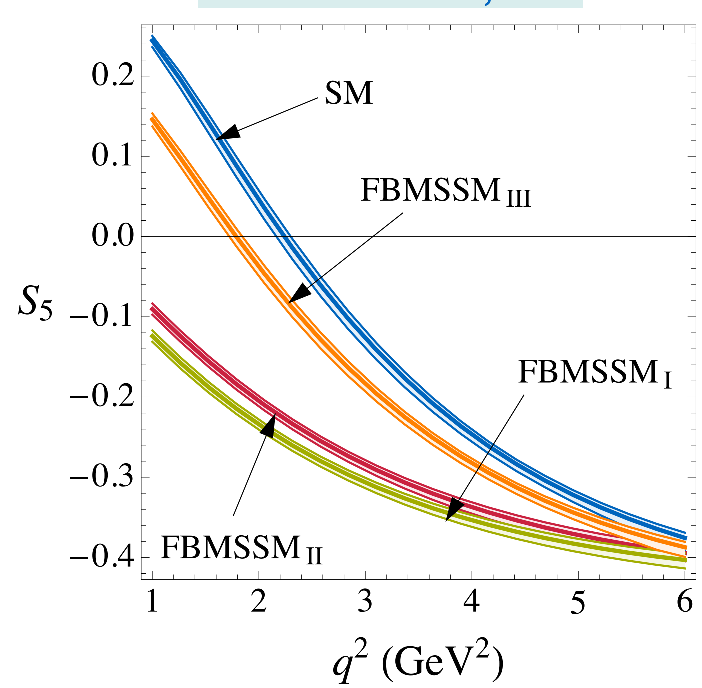
$F_{\rm L}$: fraction of longitudinal polarization of the K*

$$
\begin{aligned}
\frac{1}{\mathrm{d}(\Gamma+\bar{\Gamma})/\mathrm{d}q^2}\frac{\mathrm{d}^4(\Gamma+\bar{\Gamma})}{\mathrm{d}q^2\,\mathrm{d}\vec{\Omega}} = \frac{9}{32\pi}\Big[&\frac{3}{4}(1-F_{\rm L})\sin^2\theta_K + F_{\rm L}\cos^2\theta_K \\
&+\frac{1}{4}(1-F_{\rm L})\sin^2\theta_K\cos 2\theta_l \\
&-F_{\rm L}\cos^2\theta_K\cos 2\theta_l + S_3\sin^2\theta_K\sin^2\theta_l\cos 2\phi \\
&+S_4\sin 2\theta_K\sin 2\theta_l\cos\phi + S_5\sin 2\theta_K\sin\theta_l\cos\phi \\
&+\frac{4}{3}A_{\rm FB}\sin^2\theta_K\cos\theta_l + S_7\sin 2\theta_K\sin\theta_l\sin\phi \\
&+S_8\sin 2\theta_K\sin 2\theta_l\sin\phi + S_9\sin^2\theta_K\sin^2\theta_l\sin 2\phi\Big]
\end{aligned}
$$

$A_{\rm FB}$: forward-backward asymmetry of the dilepton system

* A lot of information contained in the angular distributions

JHEP 0901:019,2009



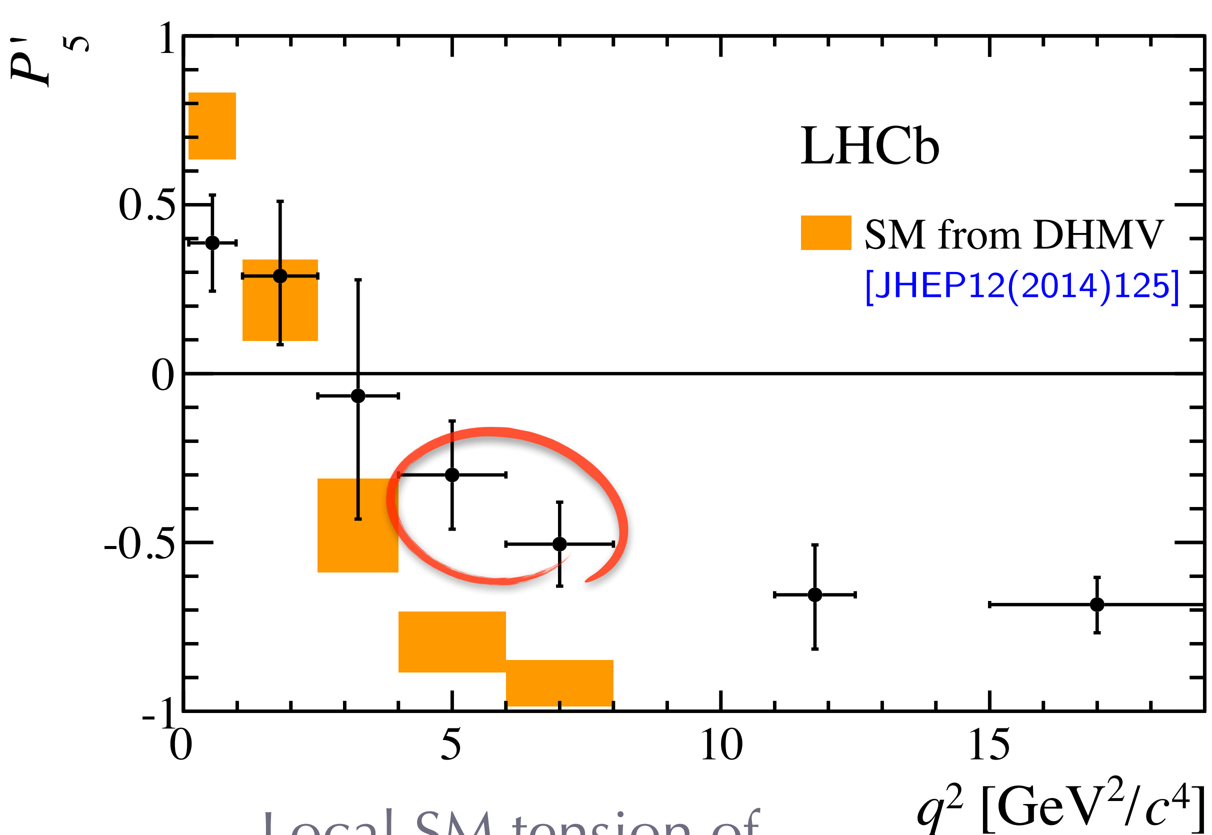
Form factor “free” observables

Optimized basis

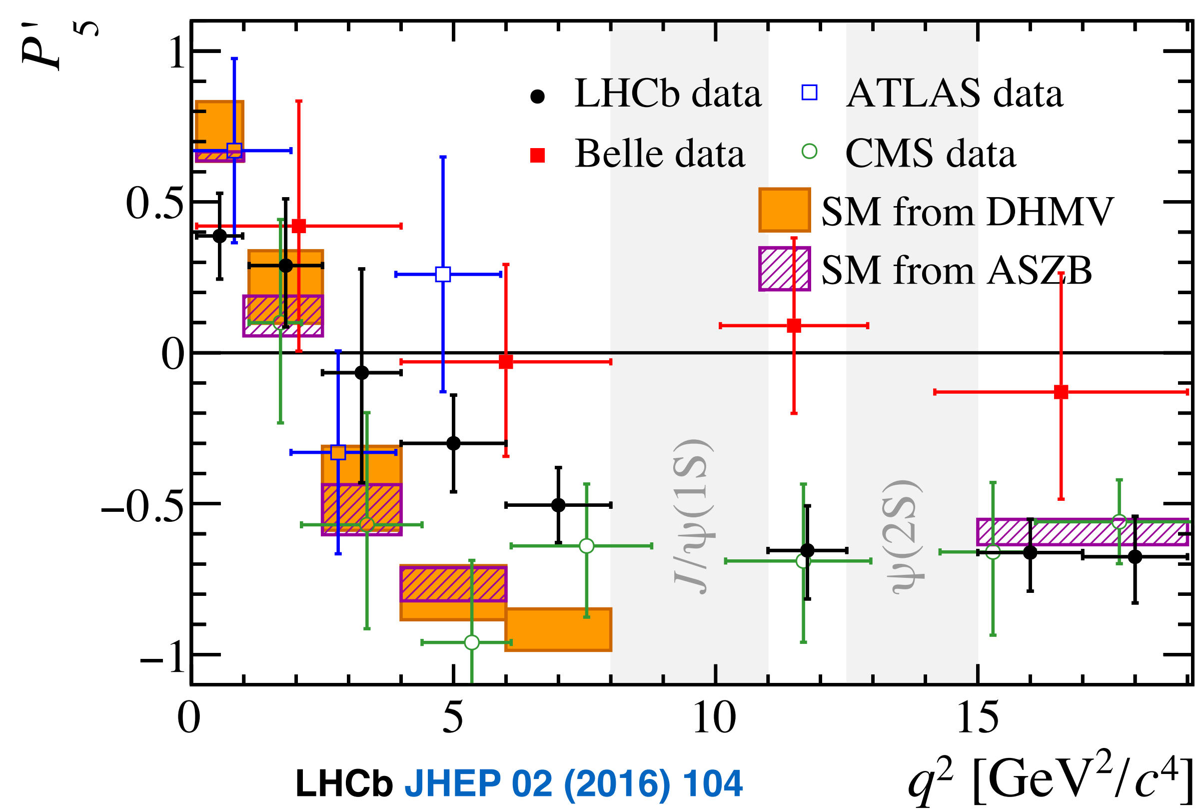
$$P'_5 = \frac{S_5}{\sqrt{F_L(1-F_L)}}$$

→ reduced theoretical uncertainty

Descotes-Genon et al. [JHEP 04 (2012) 104]



Local SM tension of
2.8 and 3.0 σ
Global → 3.4 σ

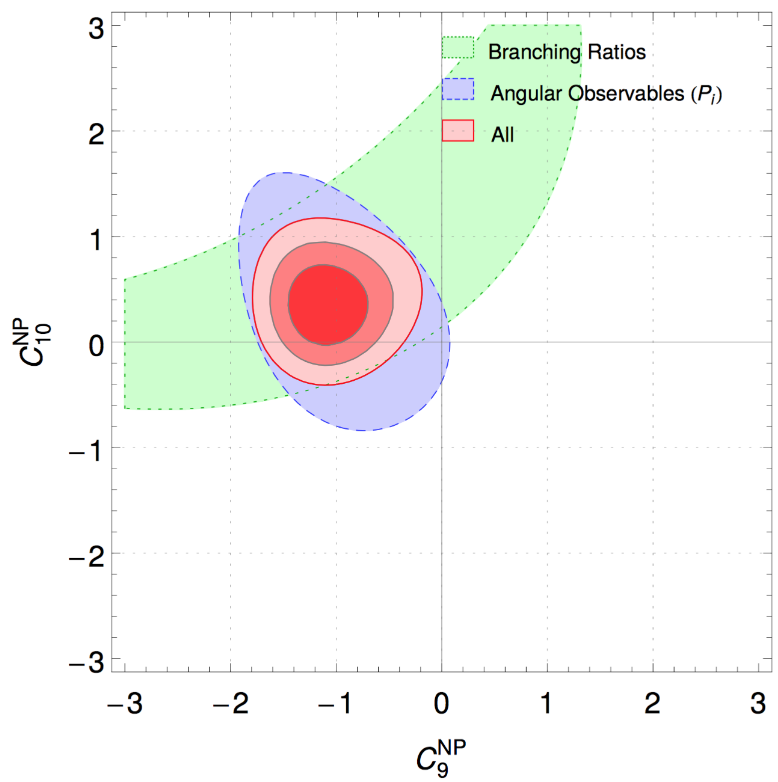


LHCb JHEP 02 (2016) 104
BELLE PRL 118 (2017)
ATLAS ATLAS-CONF-2017-023
CMS PLB 781 (2018) 517541

Theory uncertainty

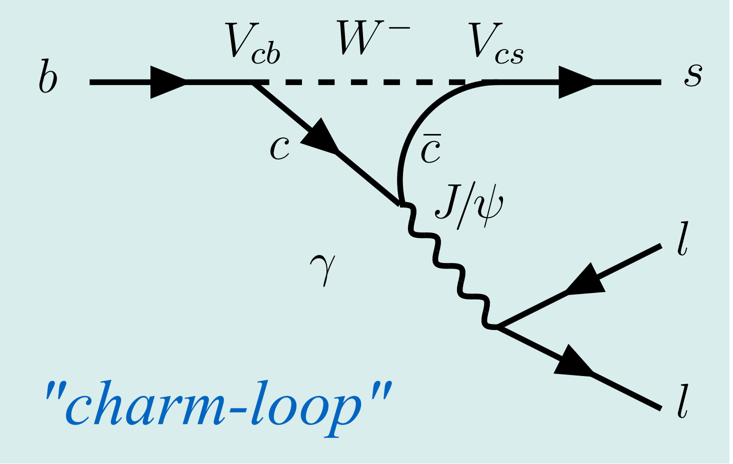
JHEP 05, 043 (2013)
PRD 93, 014028 (2016)
JHEP 06, 116 (2016)

- Both branching ratios and P_5' discrepancies can be explained with a shift in C_9 (or C_9 and C_{10})



[JHEP06 (2016) 092]

Be aware of long-distance effects



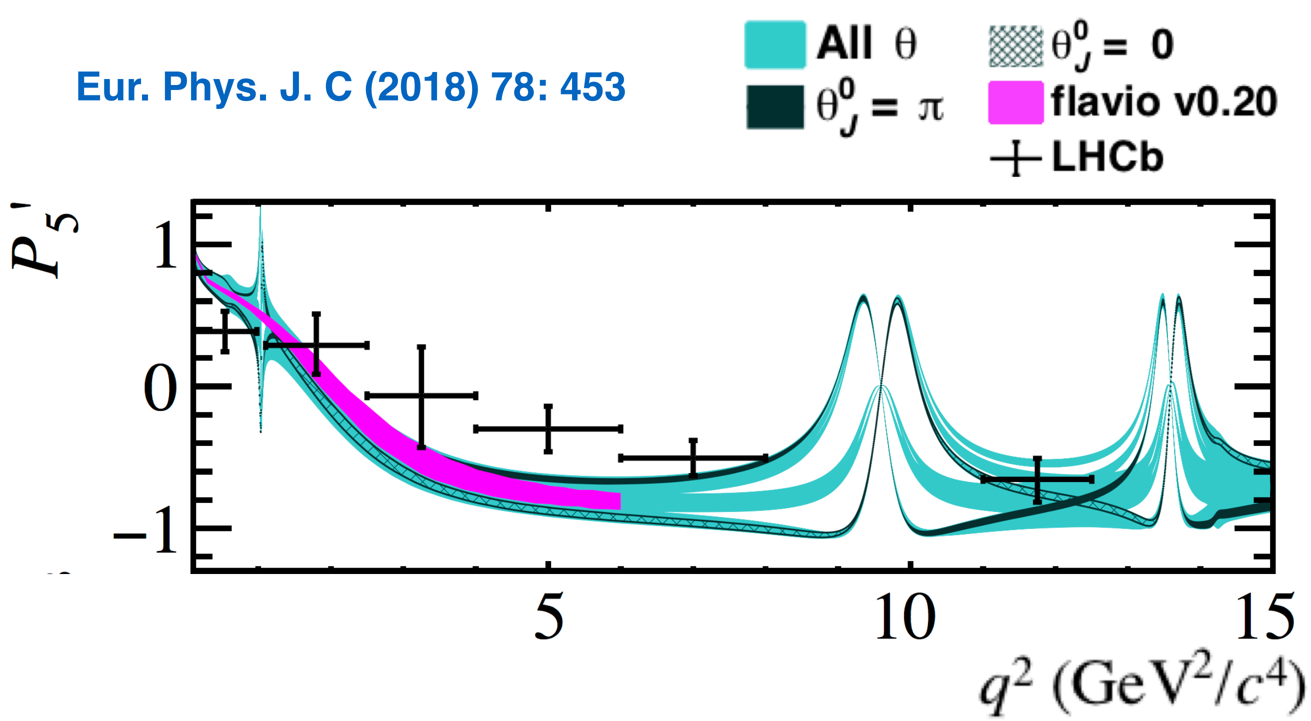
✓ removed by mass cuts
✗ interferes elsewhere
✗ difficult to access reliably

- Long debate in the community if these effect can be interpreted as NP or must be attributed to charm loop

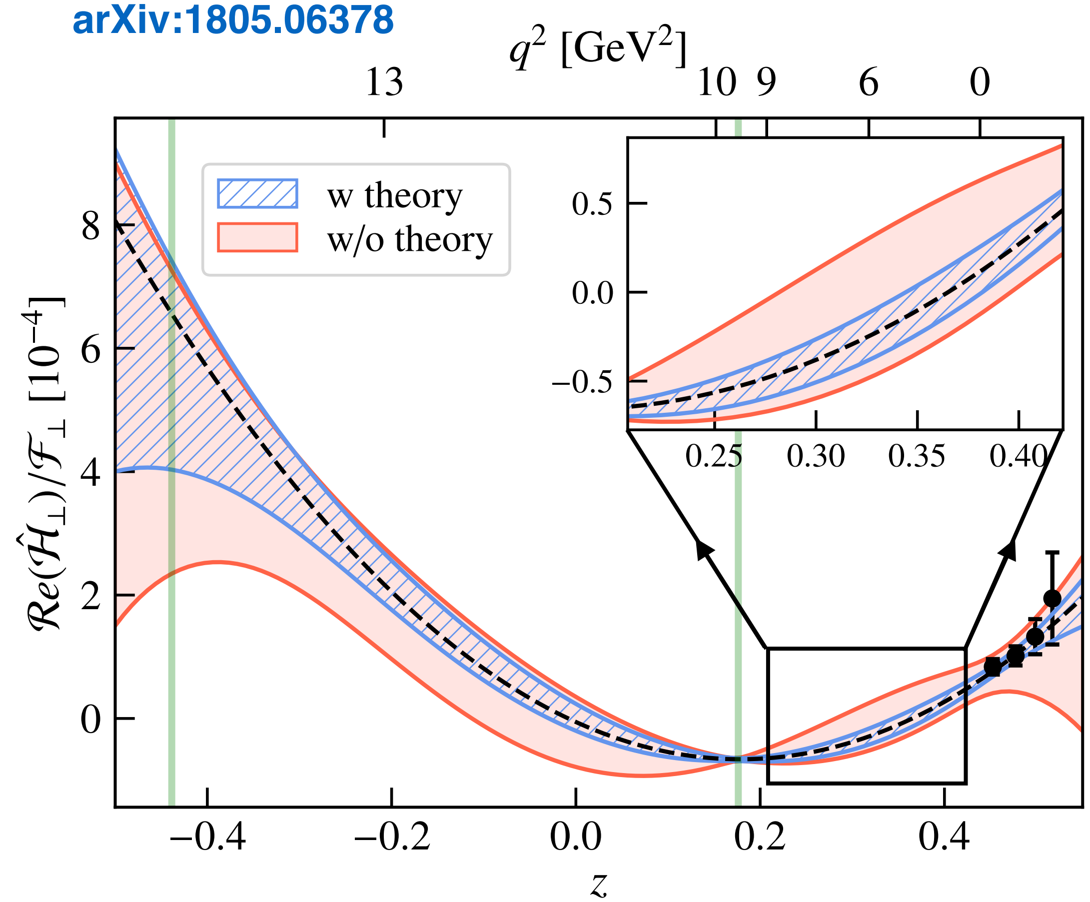
Fighting the charm loop at experimental level

- Several attempts to disentangle short-distance (WCs) from long-distance (cham loop) contributions
  - Parametrizing charmonia resonances as sum of Breit-Wigner
    - including tails away from resonances, each with magnitude and phases
  - Parametrizing charmonia resonances as polynomials

Eur. Phys. J. C (2018) 78: 453

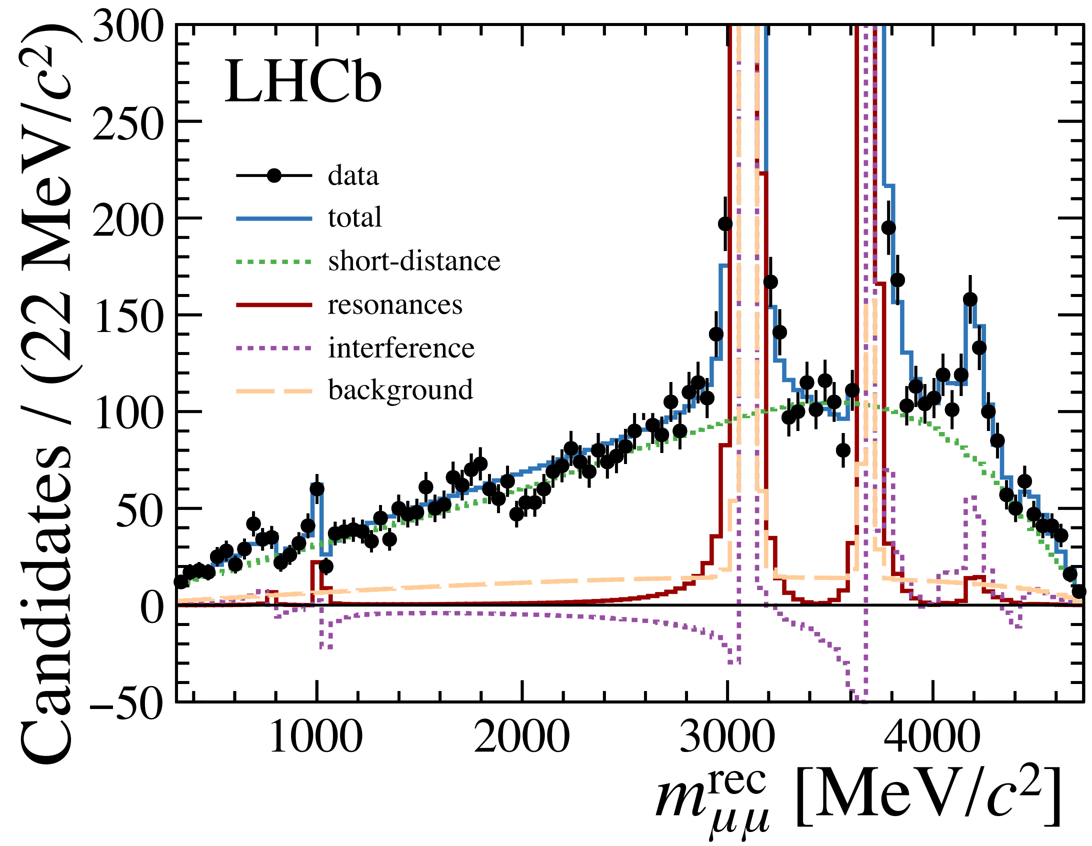


arXiv:1805.06378

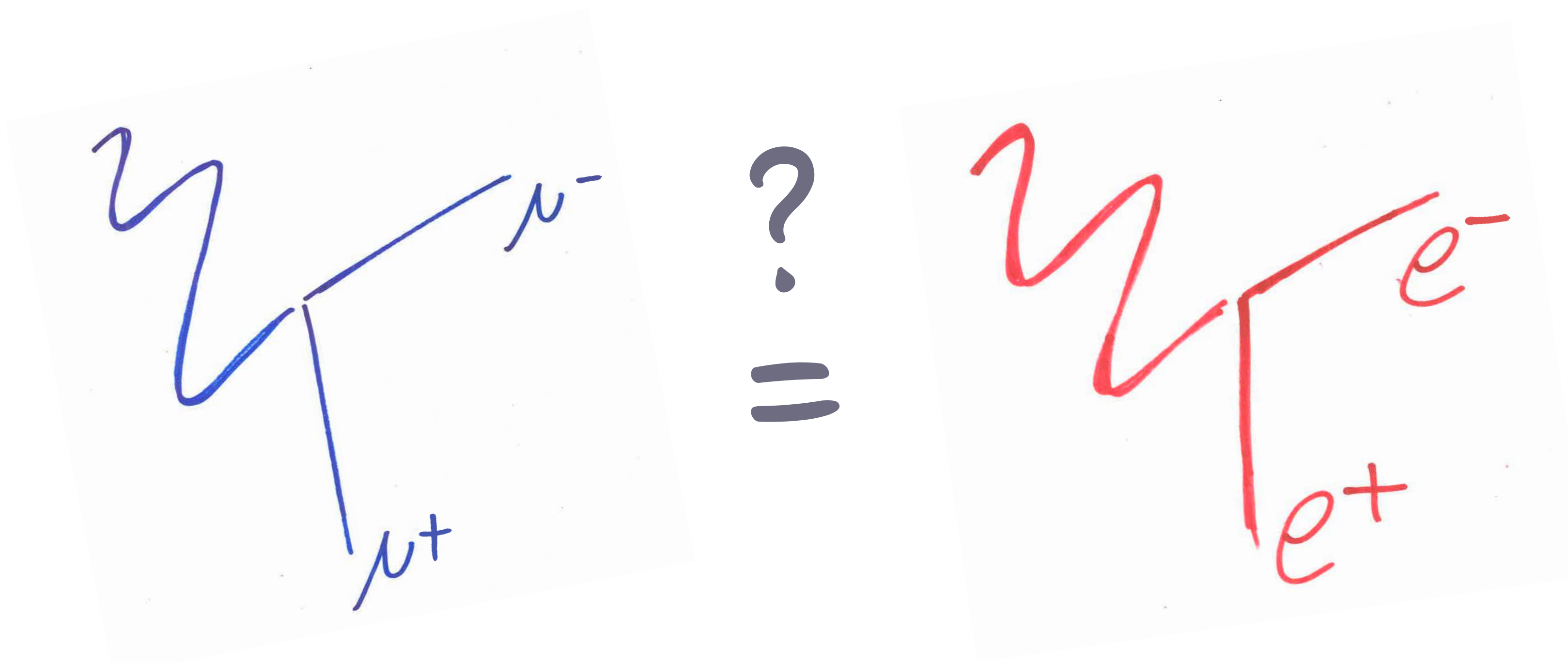


Phases in $B^+ \to K^+\mu\mu$

- $B^+ \to K^+\mu\mu$ decays present simpler phenomenology compared to $B^0 \to K^{*0}\mu\mu$ (K^+ is a scalar)
- Fit to m($\mu\mu$) to determine the interference between "rare mode" and resonances
- 4 solutions equally compatible with data
  - J/ψ-"rare mode" phase difference compatible with ±π/2
  - interference far from the pole mass is small



Lepton Flavour Universality (LFU) test in rare decays



LFU in rare decays

- SM implies ***Lepton Flavour Universality***
  - Different lepton generations **couple identically** to SM processes
  - Only difference mass → phase space
- Ratios of the form

$$R_{K^{(*)}} = \frac{\mathcal{B}(B \to K^{(*)}\mu^+\mu^-)}{\mathcal{B}(B \to K^{(*)}e^+e^-)} \overset{\text{SM}}{=} 1 \pm \mathcal{O}(10^{-2})$$

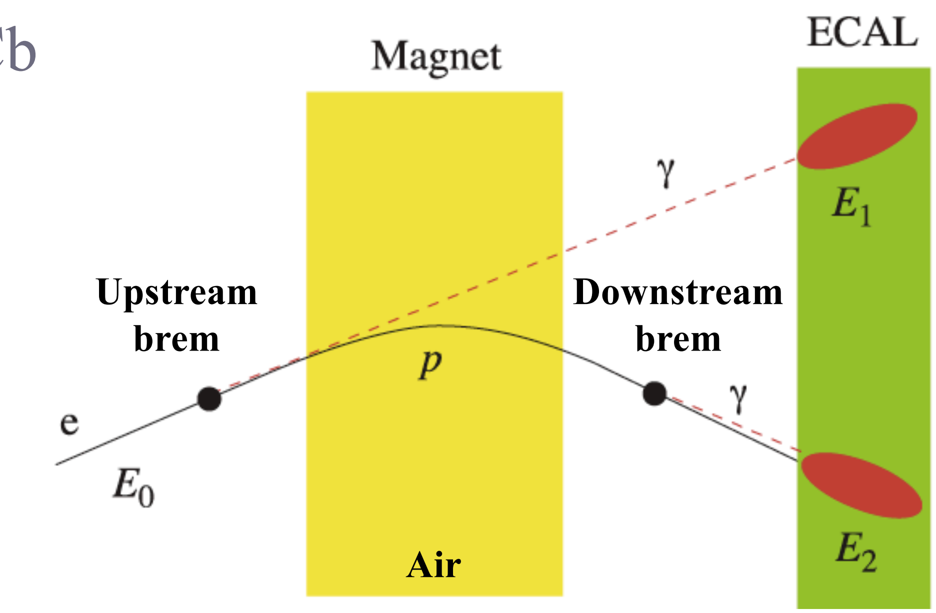
EPJ C76 (2016) 8 440

→ Free from QCD uncertainties

Lepton non-universality would be a clear sign of NP

Experimental double ratio

- Electrons and muons behave very differently in LHCb due to large Bremsstrahlung radiation for electrons:
  - worse B mass and q^2 resolution
  - low reconstruction efficiency
  - selected in 3 different trigger categories (electron, hadron, TIS)



- LFU experimentally measured as double ratio:

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

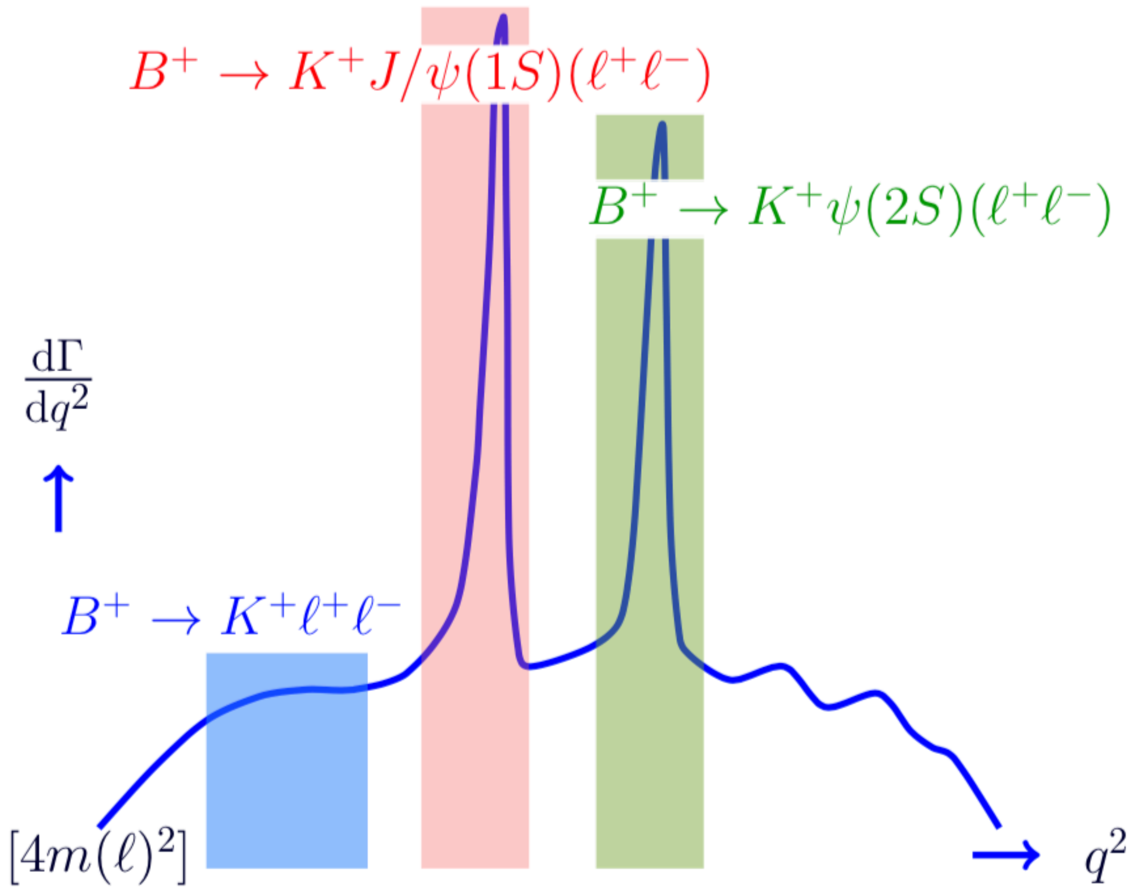
most of the systematics cancel out

- Current LHCb status (pre-Run2):
  - $R_K = 0.745^{+0.090}_{-0.074}\,(\text{stat}) \pm 0.036\,(\text{syst})$ ← Updated with 2015 & 2016 datasets (roughly double the statistics)
  - $R_{K^{*0}} = \begin{cases} 0.66^{+0.11}_{-0.07} \pm 0.03 & \text{for } 0.045 < q^2 < 1.1 \text{ GeV}^2 \\ 0.69^{+0.11}_{-0.07} \pm 0.05 & \text{for } 1.1 < q^2 < 6.0 \text{ GeV}^2 \end{cases}$

Efficiency calibration

- Key ingredients:
  - Yields determined from a fit to the invariant mass
  - Efficiency computed with MC simulation calibrated on control channels in data

- Efficiency calibration makes extensive use of $B^+ \to K^+ J/\psi(\ell^+\ell^-)$ and $B^+ \to K^+\psi(2S)(\ell^+\ell^-)$ decays
  - resonant and non-resonant modes are separated in q^2
  - however, good overlap in the variables relevant for detector response



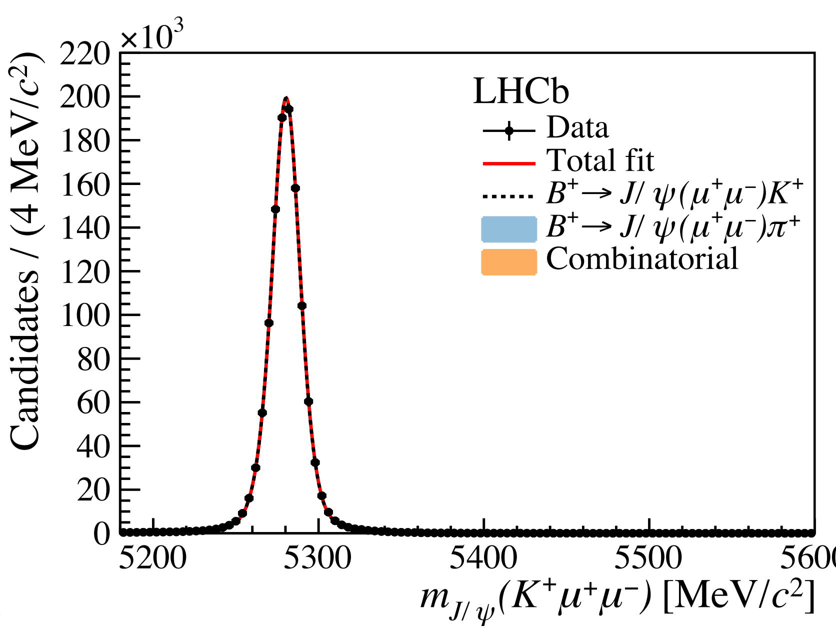
Cross-check #1: $r_{J/\psi}$

- To ensure efficiencies are under control, check $r_{J/\psi} = \dfrac{\mathcal{B}(B^+ \to K^+ J/\psi(\mu^+\mu^-))}{\mathcal{B}(B^+ \to K^+ J/\psi(e^+e^-))} = 1$
  - Very stringent check:
    - Single ratio ⟶ direct control of efficiencies

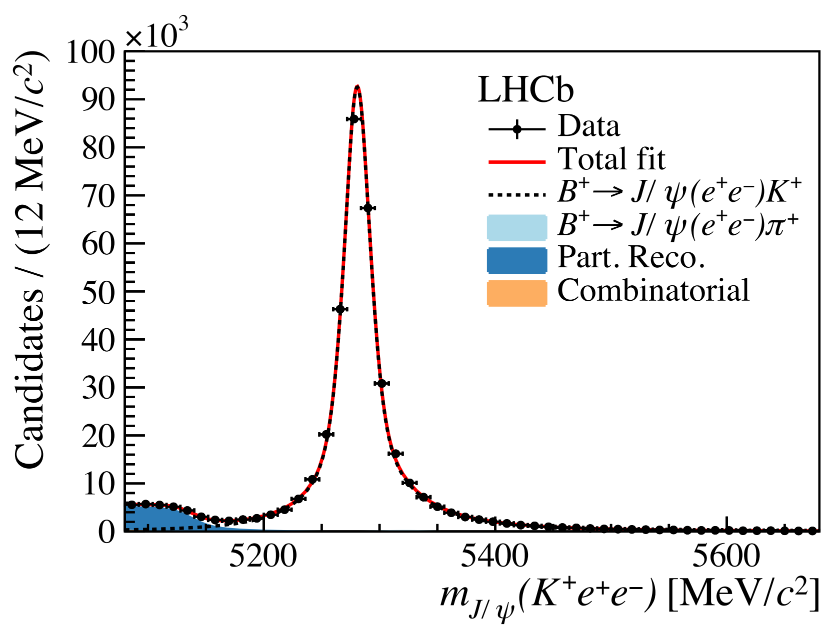
$$r_{J/\psi} = 1.014 \pm 0.035 \text{ (stat+syst)}$$

Checked compatibility of $r_{J/\psi}$=1 for both Run1 and Run2, and in all trigger category

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



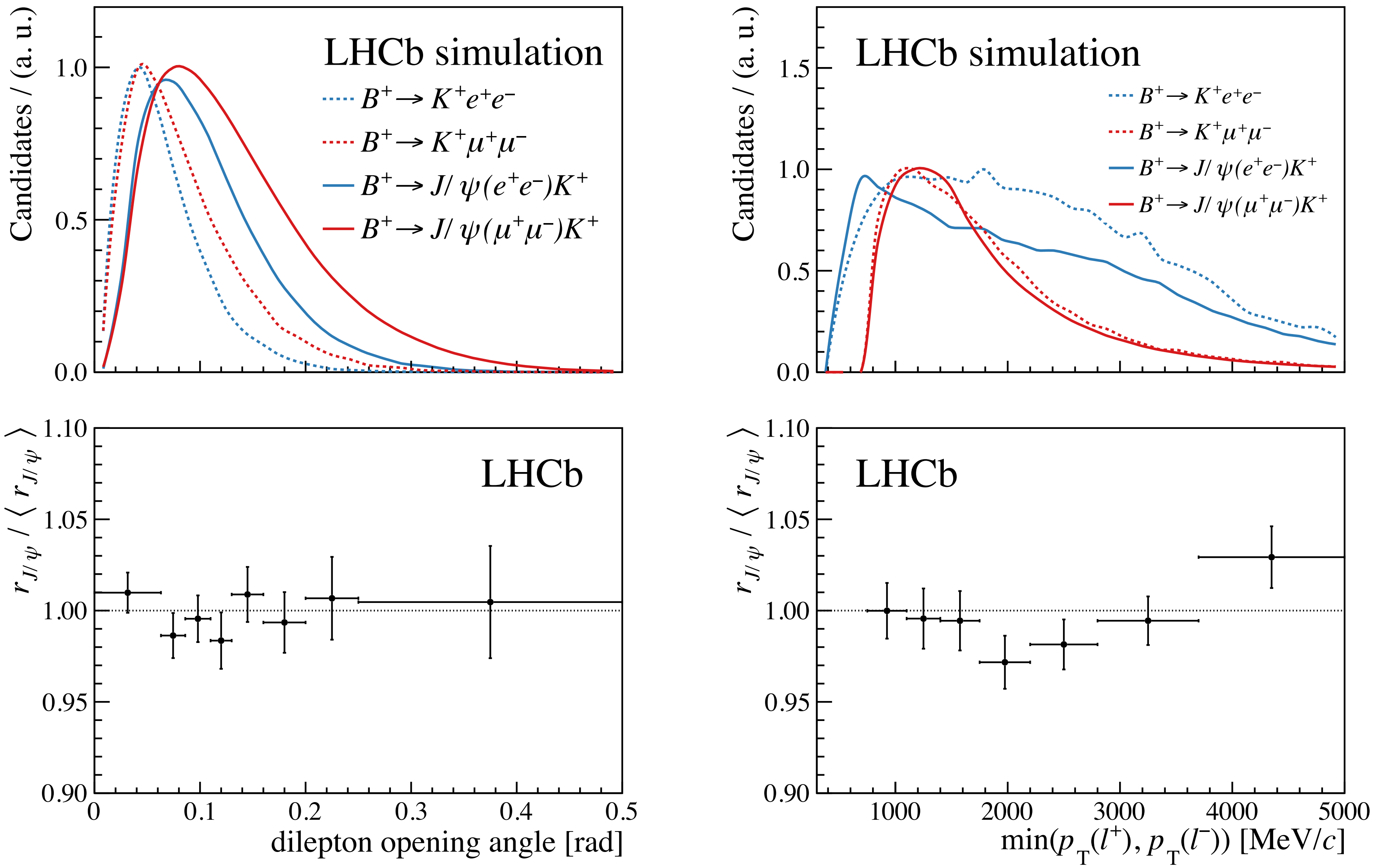
$B^+ \to K^+ J/\psi(\to e^+e^-)$



Phys. Rev. Lett. 122, 191801 (2019)

Cross-check #2: differential $r_{J/\psi}$

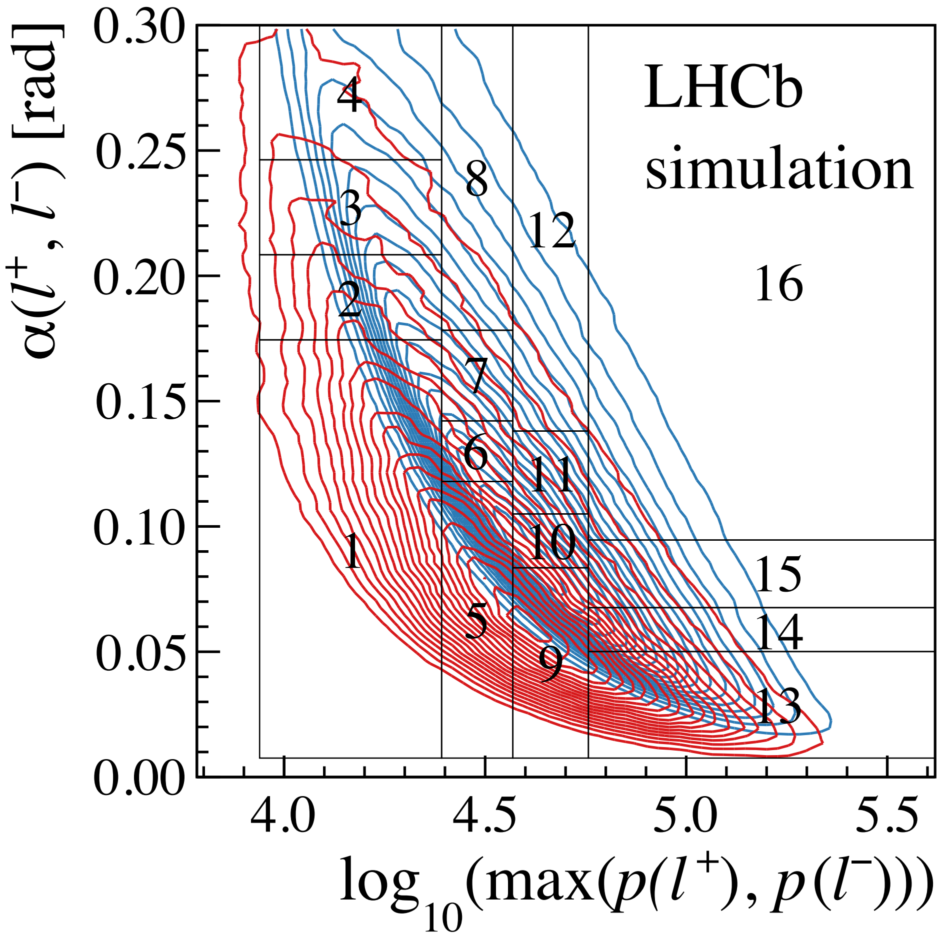
- Cross-check efficiency is well understood in all kinematic region
  - Ensure $r_{J/\psi}$ is flat for all variables examined



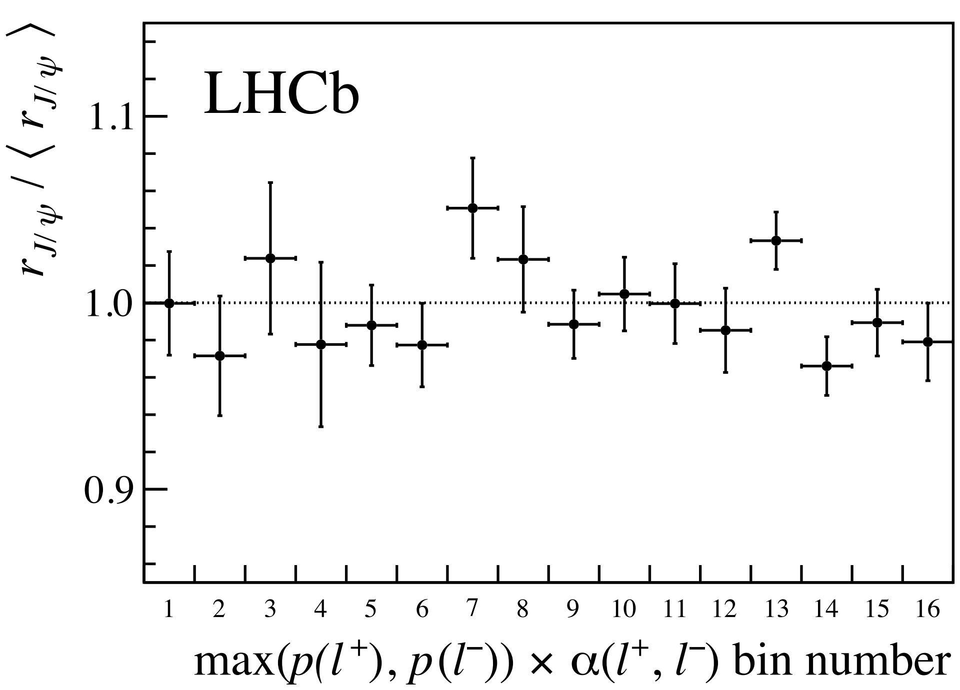
Phys. Rev. Lett. 122, 191801 (2019)

Cross-check #2(b): 2D-differential $r_{J/\psi}$

- Cross-check for possible correlated effects in kinematic variables



Phys. Rev. Lett. 122, 191801 (2019)



Flatness gives confidence that efficiencies are understood in the entire phase space!

Cross-check #3: $R_{\psi(2S)}$

- Test double ratio cancellation on $B^+ \to K^+\psi(2S)(\ell^+\ell^-)$ decays

Phys. Rev. Lett. 122, 191801 (2019)

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

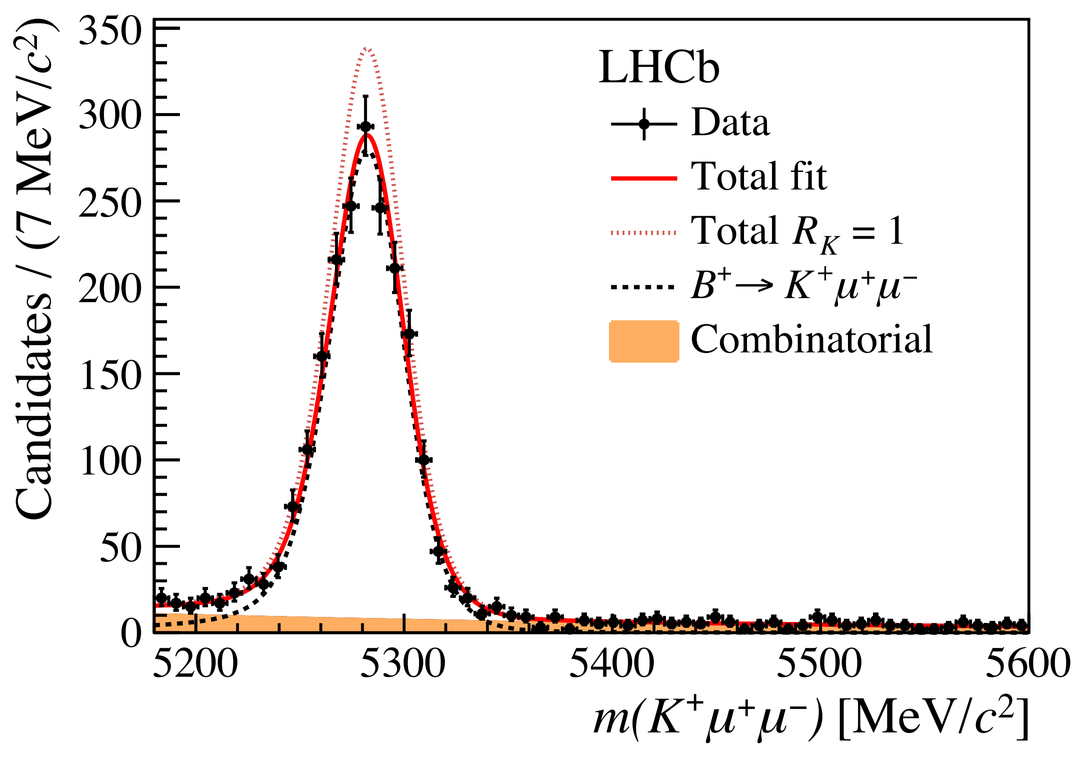
R_K measurement

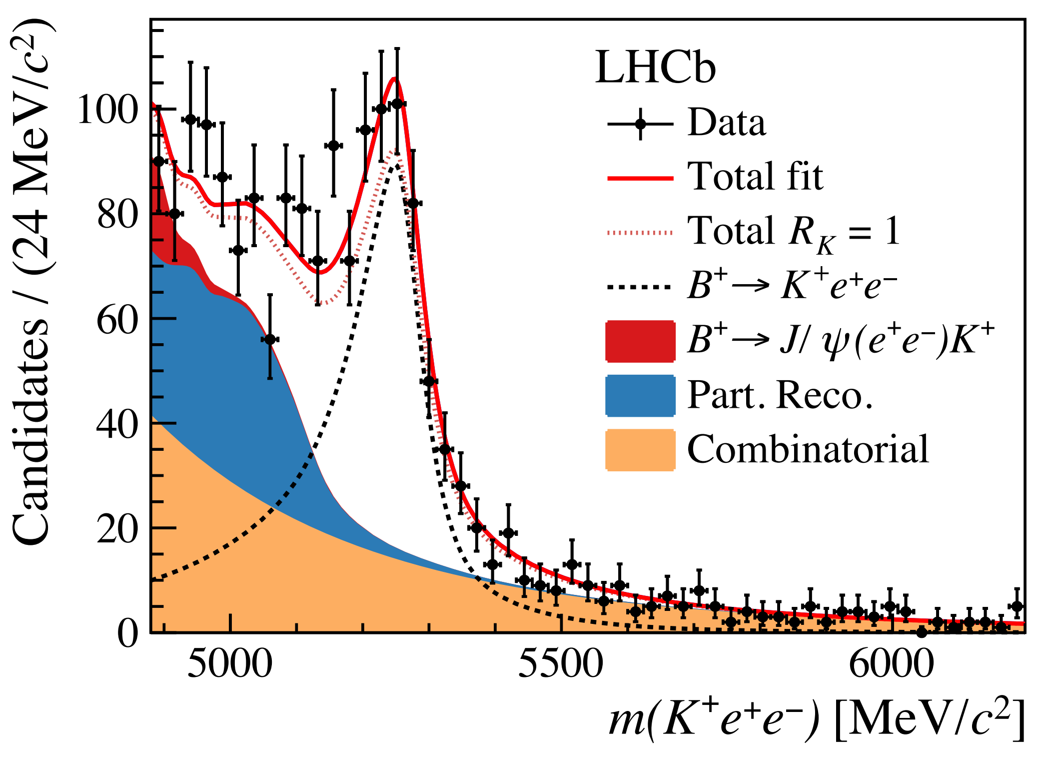
- Simultaneous fit to m($K\mu\mu$) and m(Kee) to extract R_K

Phys. Rev. Lett. 122, 191801 (2019)

$B^+ \to K^+\mu^+\mu^-$ ($N_{sig} \sim 1940$)

$B^+ \to K^+e^+e^-$ ($N_{sig} \sim 760$)

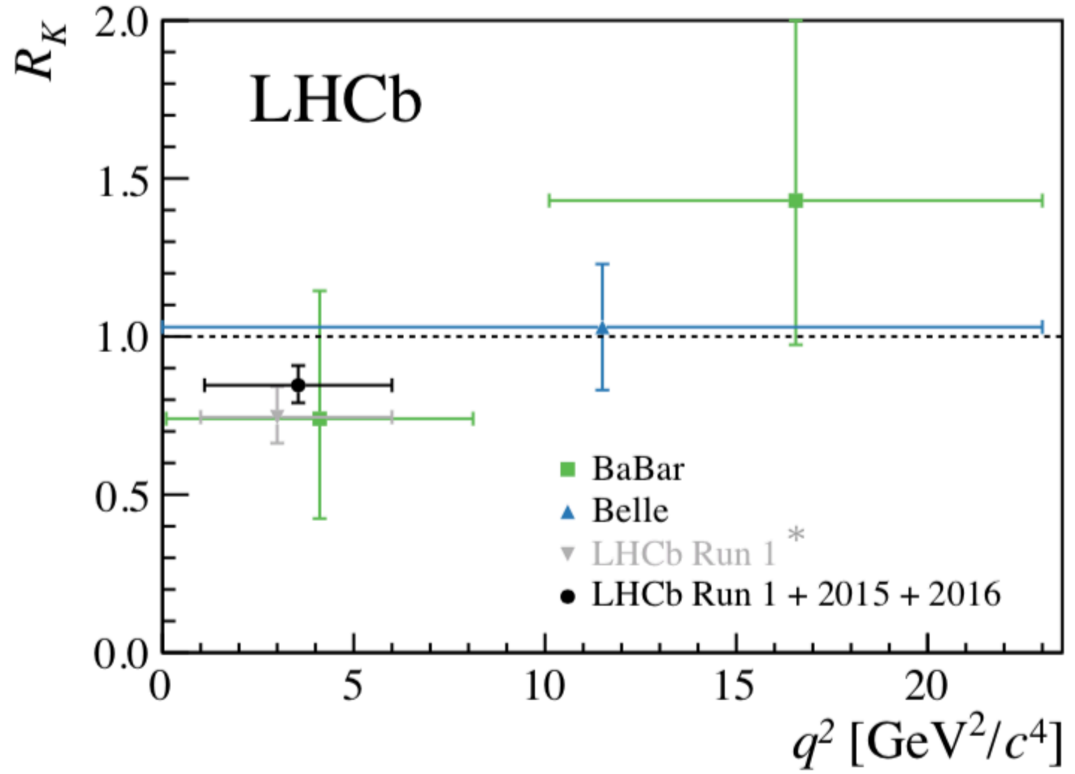




$$R_K = 0.846\,^{+0.060}_{-0.054}\,\text{(stat)}\,^{+0.014}_{-0.016}\,\text{(syst)}$$

R_K measurement: overview

- LHCb updated R_K measurement
  - re-analysing 2011-2012 data
  - adding 2015-2016 data



$$R_{K\ \mathrm{Run1}}^{\mathrm{new}} = 0.717\ ^{+0.083}_{-0.071}\,(\mathrm{stat})\ ^{+0.017}_{-0.016}\,(\mathrm{syst})$$

$$R_{K\ \mathrm{Run2}} = 0.928\ ^{+0.089}_{-0.076}\,(\mathrm{stat})\ ^{+0.020}_{-0.017}\,(\mathrm{syst})$$

$$\longrightarrow\ R_K = 0.846\ ^{+0.060}_{-0.054}\,(\mathrm{stat})\ ^{+0.014}_{-0.016}\,(\mathrm{syst})$$

1.9 sigma compatibility between Run1 and Run2

Combined 2.5 sigma from SM prediction

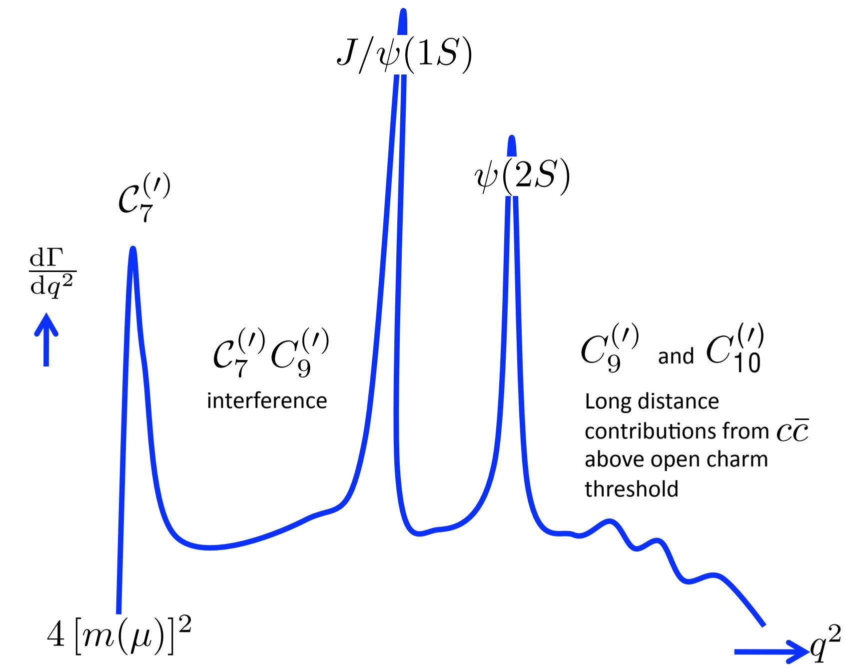
- $\mathcal{B}(B^+ \to K^+ e^+ e^-)$ compatible with SM for all years

LFU test in $B^0 \to K^*\ell^+\ell^-$ decays

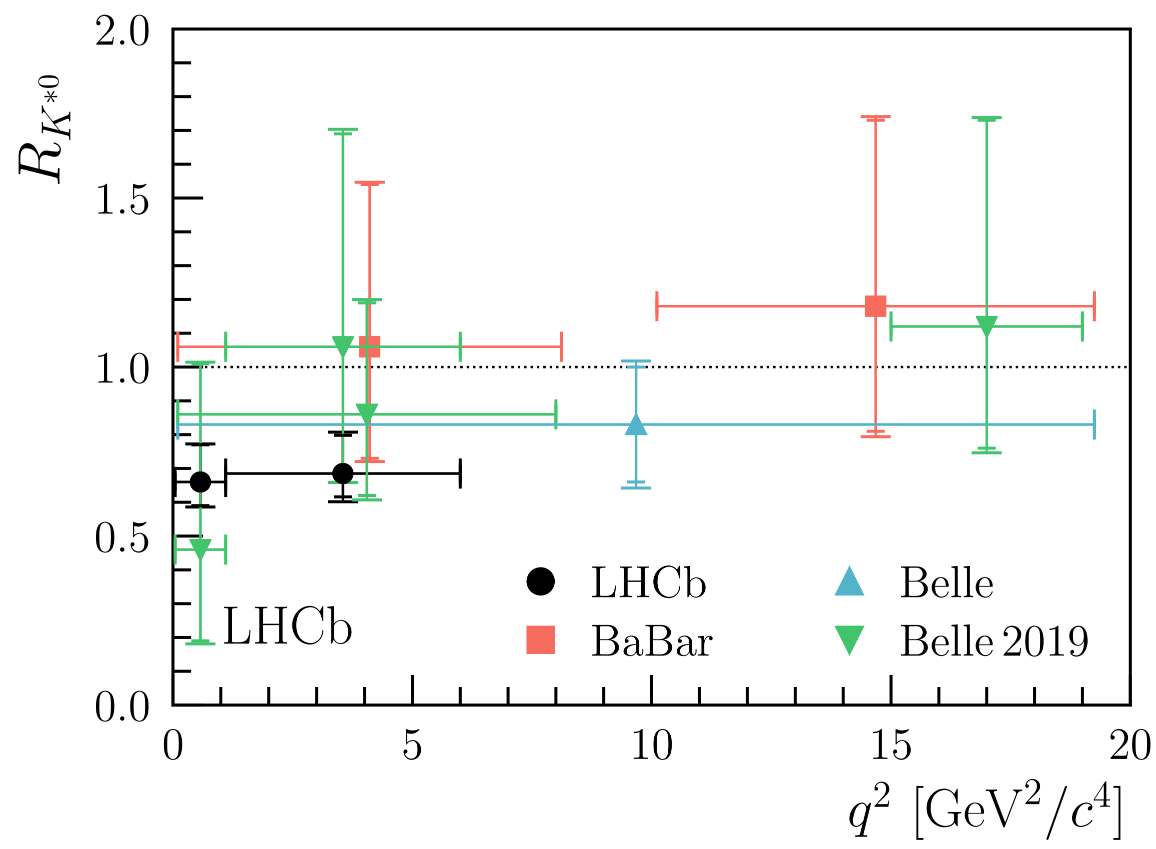
- LHCb Run 1: [JHEP 08 (2017) 055]

$$R_{K^{*0}} = \begin{cases} 0.66^{+0.11}_{-0.07} \pm 0.03 & \text{for } 0.045 < q^2 < 1.1 \ \text{GeV}^2 \\ 0.69^{+0.11}_{-0.07} \pm 0.05 & \text{for } 1.1 < q^2 < 6.0 \ \text{GeV}^2 \end{cases}$$

  - 2.1 (2.4) σ tension with the SM

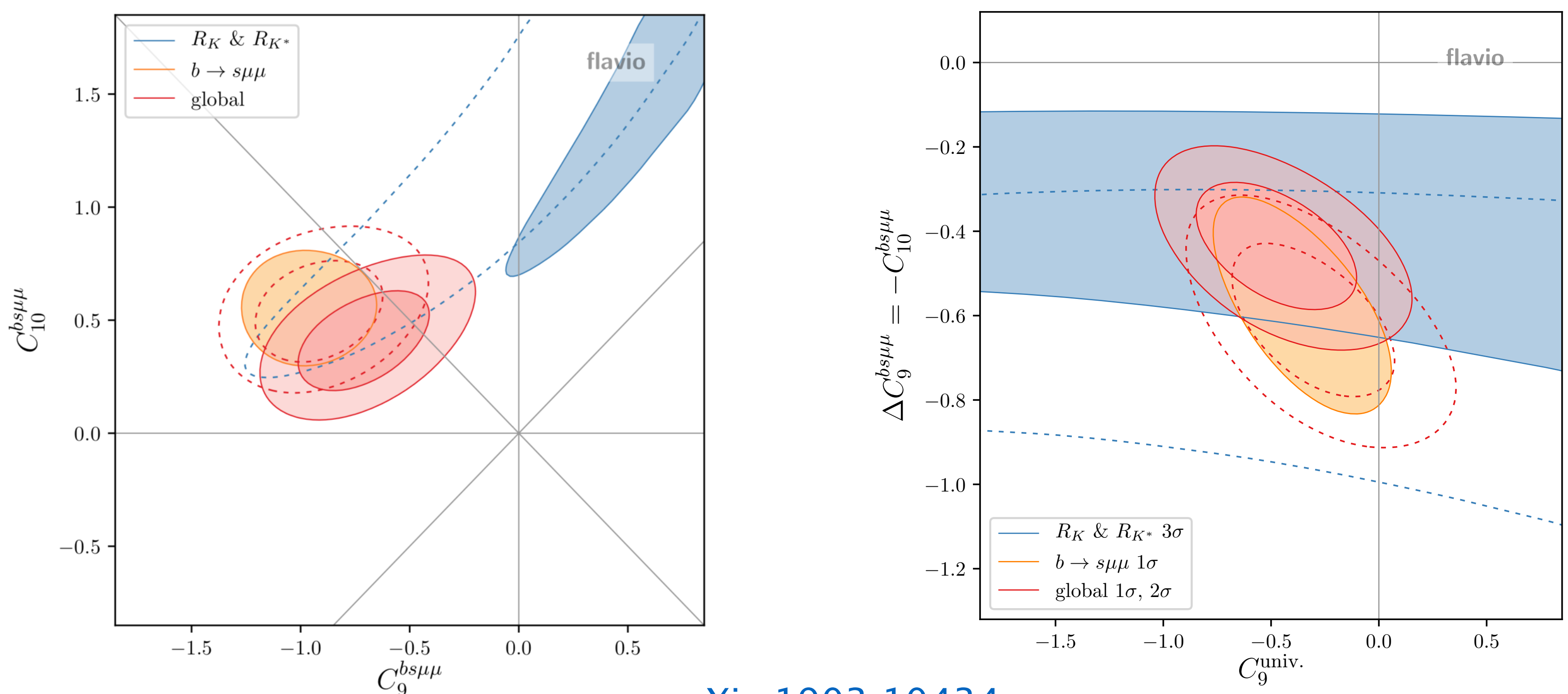


- Belle recently updated measurement of R_{K^*} [arXiv:1904.02440]



Impact on global fits

- After R_K update LFU measurements slightly moved away from common solution with *b*→*sll* anomalies
  - NP universal contribution to C_9…?

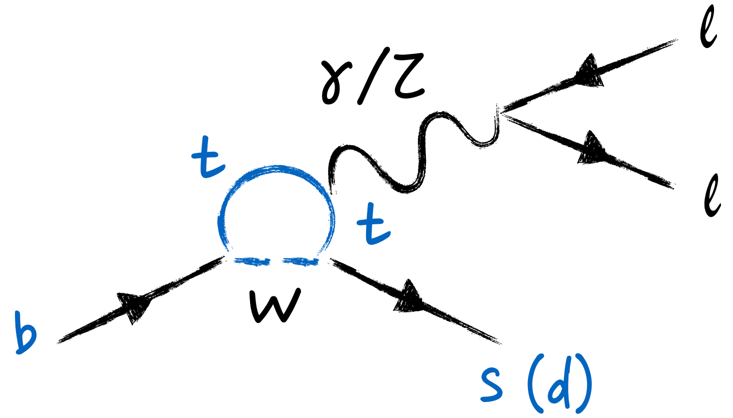


arXiv:1903.10434

See next talk for theory interpretation…

What about $b \to dll$ transitions?

- $b \to dll$ is **Cabibbo suppressed** respect to $b \to sll$ (~25 times smaller)
- Similar but **complementary** information
  - allow V_{td} / V_{ts} measurement
  - test Minimal Flavour Violation hypothesis
- **Very rare processes**, on the brink of observation

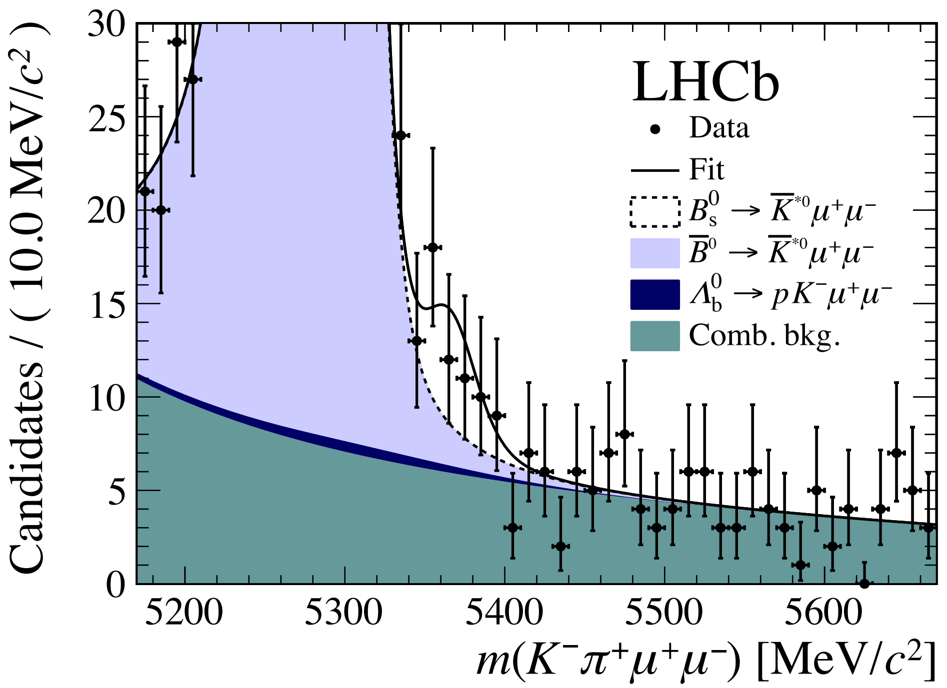


Evidence for the decay $B_s^0 \to \overline{K}^{*0} \mu^+\mu^-$

- equivalent to $B^0 \to K^* \mu^+\mu^-$
- **First evidence: 3.4σ with 4.6 fb^{-1}**
  - 38 ± 12 candidates (4200 $B^0 \to K^* \mu^+\mu^-$)
- $\mathcal{B} = (2.9 \pm 1.0 \pm 0.2 \pm 0.3) \times 10^{-8}$

Too little data to say anything about q^2 or angular distributions

JHEP07(2018)020



Near future for rare decays

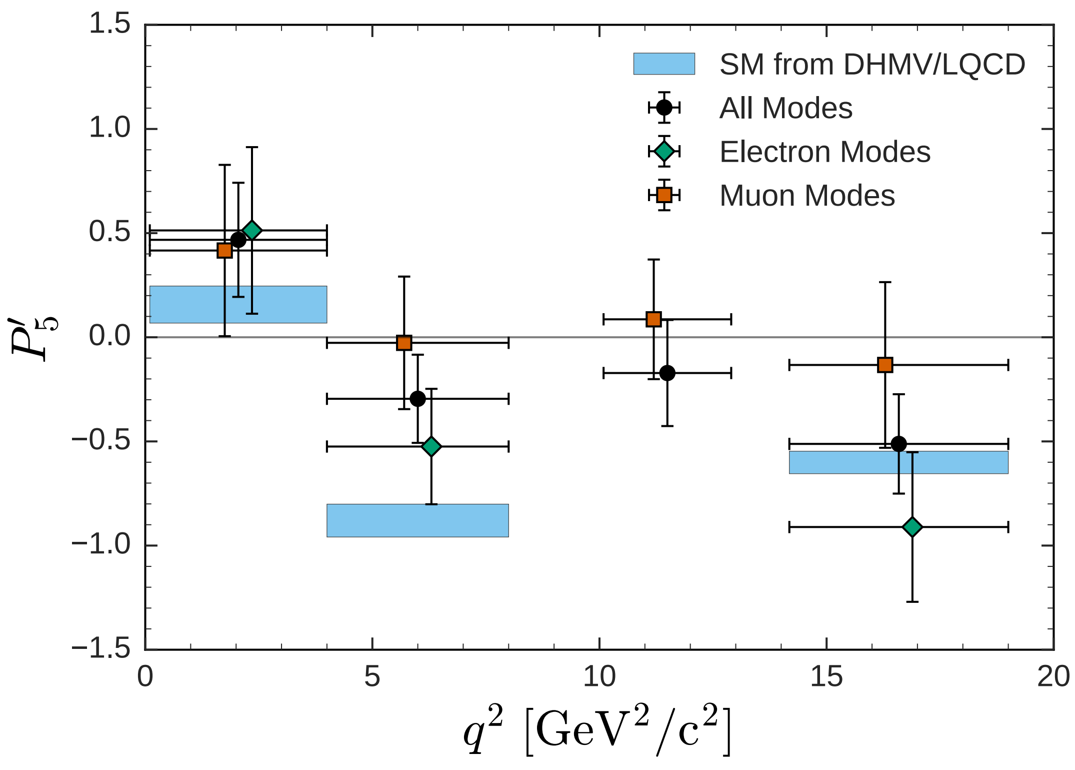
Updates of:

- R_{K^*} (+ Run2)
- R_K (+ 2017 & 2018)
- $B^0 \to K^*\mu^+\mu^-$ angular analysis

New measurements:

- New ratios: $R_{(K\pi\pi)}$, R_φ, etc.
- $B^0 \to K^*e^+e^-$ angular analysis
  - non-LFU angular asymmetries $\Delta P'_i$
- Direct measurements of Wilson coefficients (C_9 & C_{10}) from data
  - via amplitude analysis of $B^0 \to K^*\mu^+\mu^-$

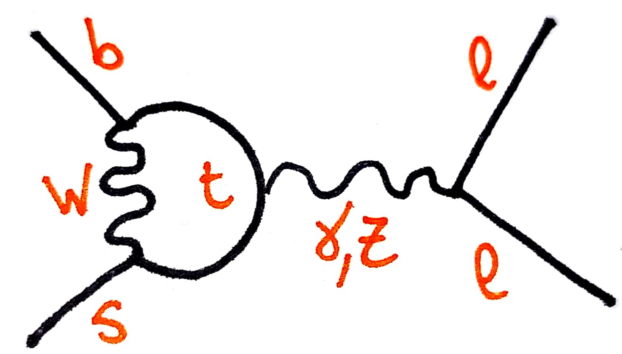
Belle - PRL 118 (2017) 11 111801



Flavour anomalies

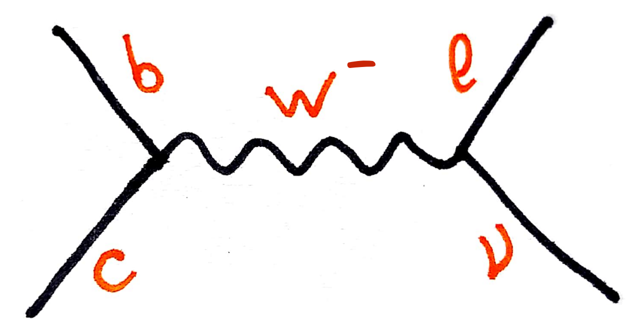
NEUTRAL CURRENT

1. $b \to s\ell\ell$ processes
   - Rate and angular distributions of exclusive $b \to s\mu^+\mu^-$ decays
   - Relative rates of $b \to s\mu^+\mu^-$ and $b \to se^+e^-$ decays ($\mathrm{R_{K^{(*)}}}$)



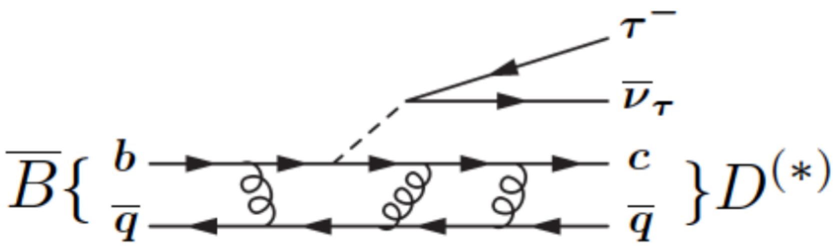
CHARGED CURRENT

2. $b \to c\tau^-\bar{\nu}_\tau$ decays
   - Relative rates of $b \to c\tau^-\bar{\nu}_\tau$ versus decays with μ ($\mathrm{R_{D^{(*)}}}$)



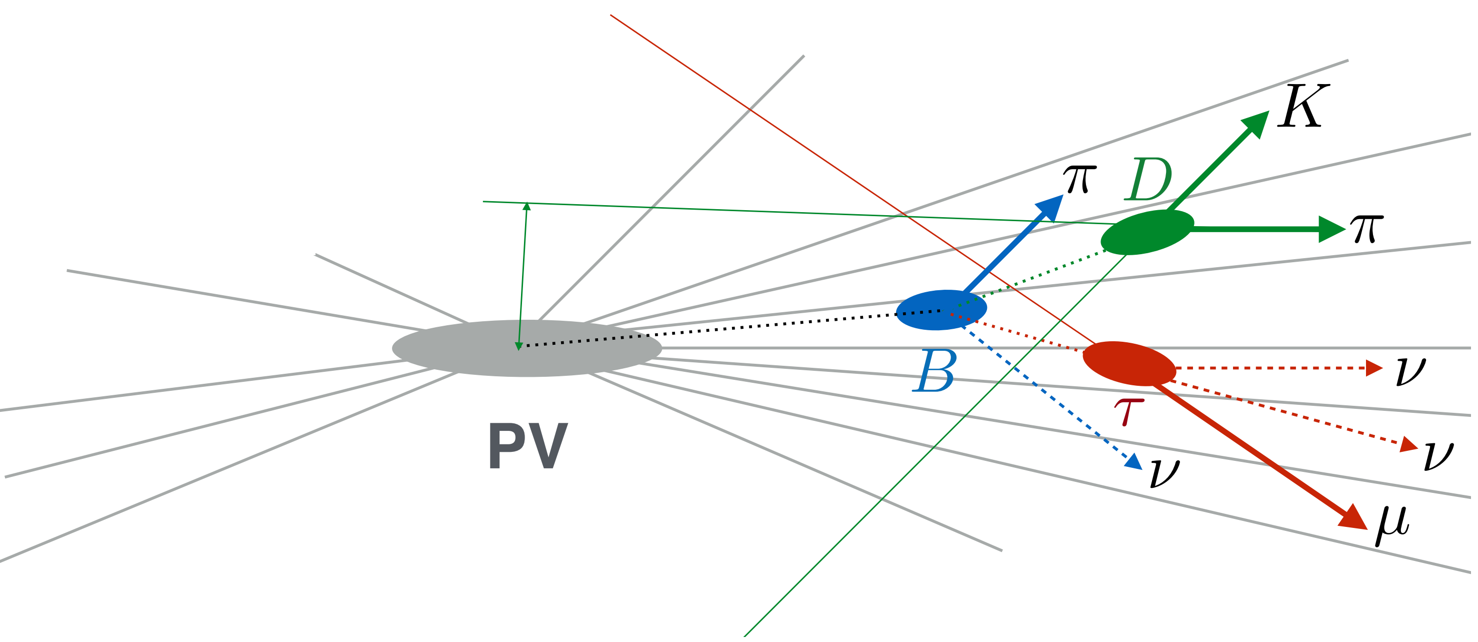
Lepton universality in $b \to cl\nu$ decays

- $b \to c\ell\nu$ are **tree level** decays
  - abundant at LHC and B factories
    - B-factories have **cleaner** events
    - LHCb **more statistics**
- Complicated experimentally by **missing energy** in the final-state from multiple **missing neutrinos**



LFU ratio

$$R_{D^{(*)}} = \frac{\mathcal{B}(B \to D^{(*)}\tau\nu)}{\mathcal{B}(B \to D^{(*)}\mu\nu)}$$



Theoretically clean (hadronic uncertainties and $|V_{cb}|$ cancel)

- $R_D^{SM} = 0.299 \pm 0.03$
- $R_{D*}^{SM} = 0.258 \pm 0.05$

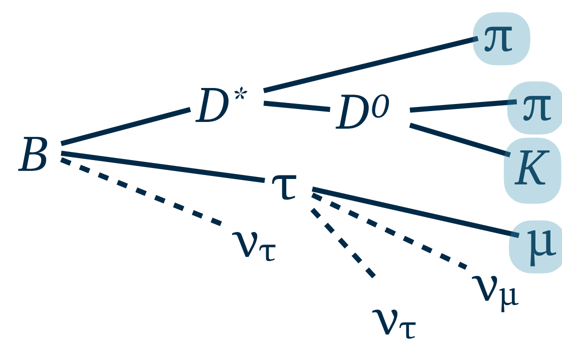
PRD 94 (2016) 094008, PRD 85 (2012) 094025

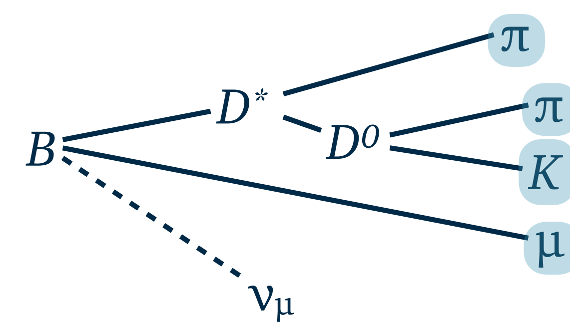
τ reconstruction

- **Leptonic**: Br ~17 %
  - $\tau \rightarrow \mu\, \nu_\mu\, \nu_\tau$
  - $\tau \rightarrow e\, \nu_e\, \nu_\tau$ → only at *B* factories

Signal and normalization have the same visible final state

→ Part of the systematic cancels in the ratio!





- **Hadronic**

Decay	$\mathcal{B}$ (%)
$\tau^- \rightarrow \pi^-\pi^0\, \nu_\tau$	25.49 ± 0.09
$\tau^- \rightarrow \pi^-\, \nu_\tau$	10.82 ± 0.05
$\tau^- \rightarrow \pi^-\pi^+\pi^-\, \nu_\tau$	9.02 ± 0.05
$\tau^- \rightarrow \pi^-\pi^+\pi^-\pi^0\, \nu_\tau$	4.49 ± 0.05

1-prong decays (first two rows), only at *B* factories

3-prong decays (last two rows), only at LHCb

  - requires an other decay channel with similar final state, e.g. $B \rightarrow D^*\pi\pi\pi$

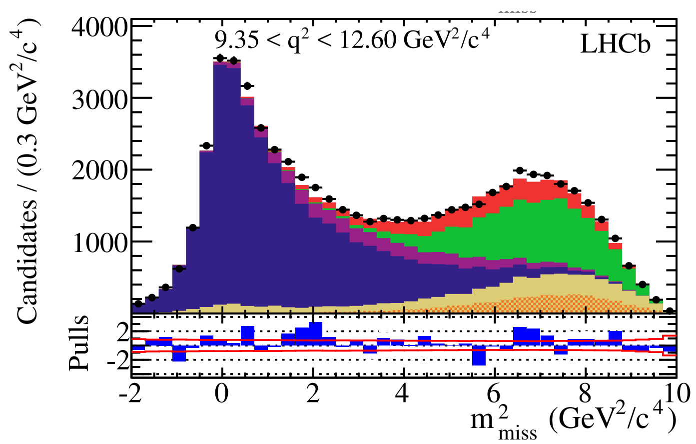
Run I data

“Muonic” VS “hadronic” R_{D^*}

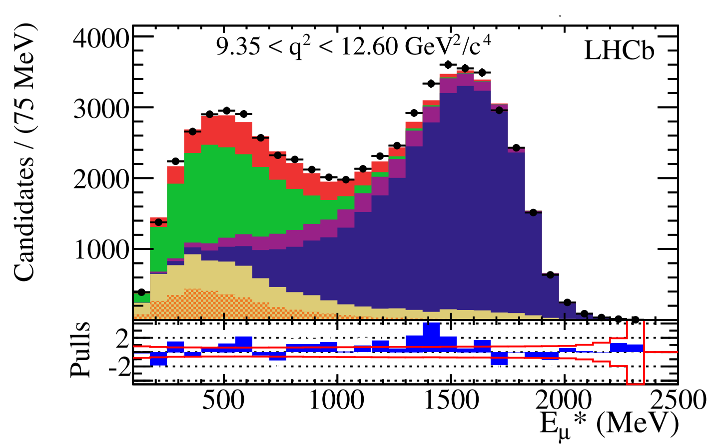
muonic

Set of variables

- E_μ
- q^2
- m^2_{miss}



Projection in one of the four q^2 bins



PRL 115 (2015) 111803

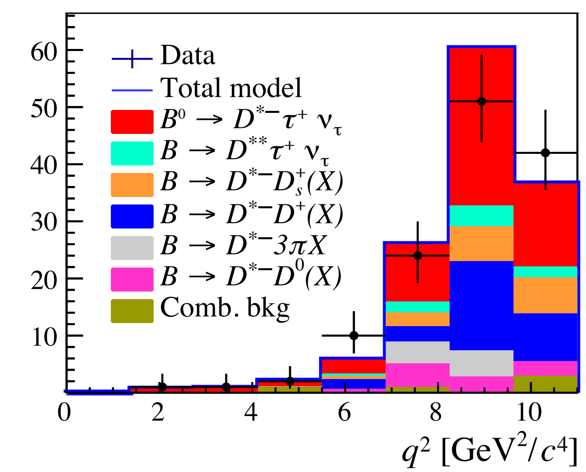
$$R(D^*) = 0.336 \pm 0.027 \pm 0.030$$

2.1σ greater than SM

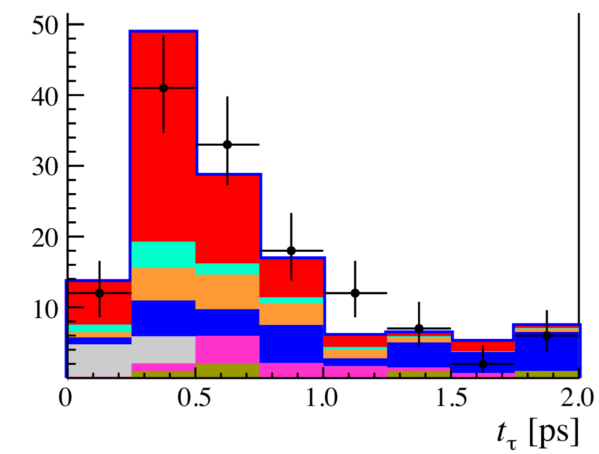
hadronic

Set of variables

- t_τ
- q^2
- BDT output



Projection in one bin of BDT response



PRD 97 (2018) 072013

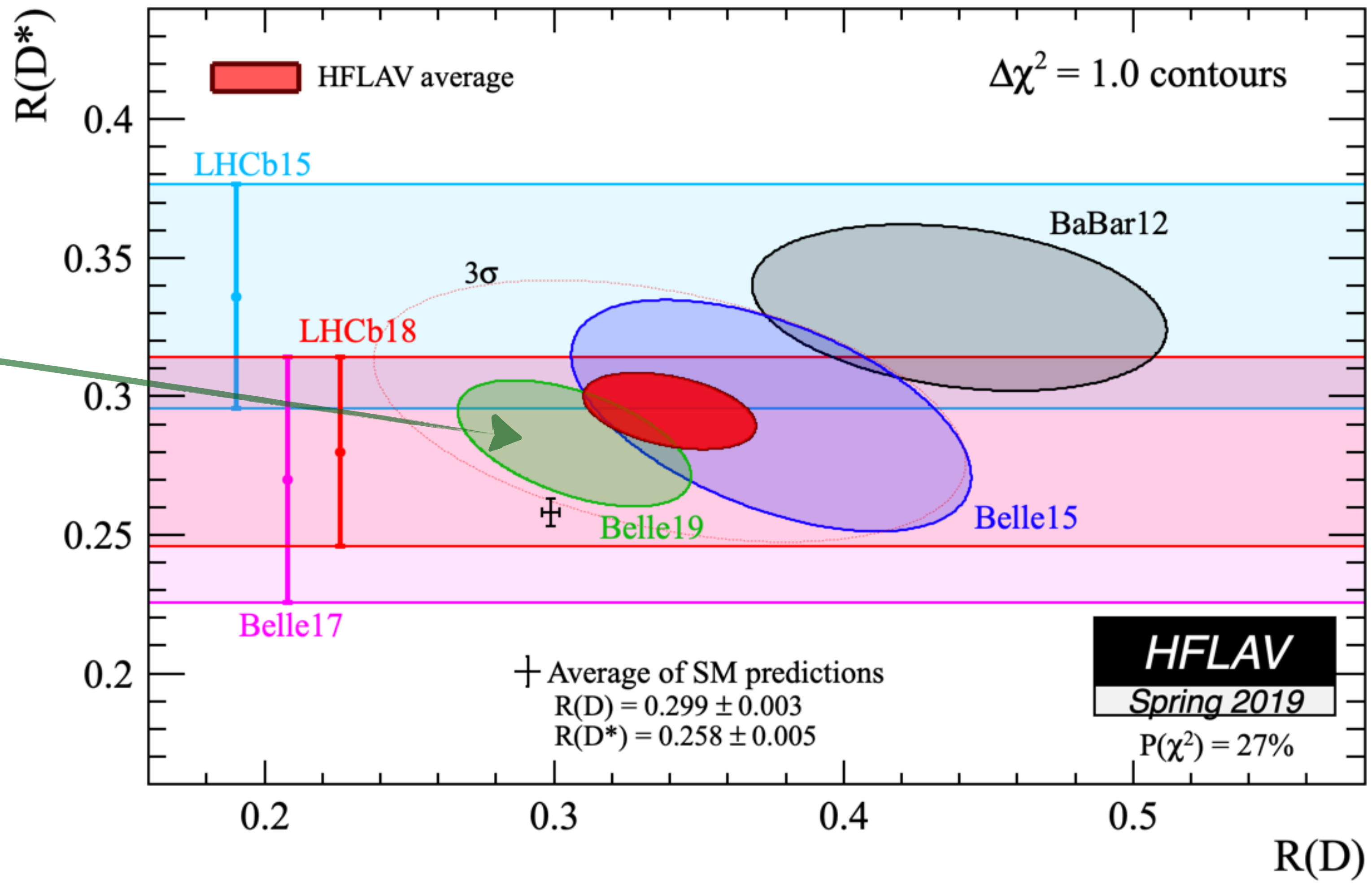
$$\mathcal{R}(D^*) = 0.291 \pm 0.019 \pm 0.026 \pm 0.013$$

1σ above the SM

$R_{D^{(*)}}$ combination

- After Moriond 2019 tension with SM is reduced from 3.8 to 3.1 σ

New measurement from Belle!



More measurement

- What about B_c decays?
  - test of LFU in $b \to c\ell\nu$ decays with different spectator quark

$$R_{J/\psi} = \frac{\mathcal{B}(B_c \to J/\psi\tau\nu)}{\mathcal{B}(B_c \to J/\psi\mu\nu)} \overset{\text{SM}}{=} [0.25, 0.28]$$

Large interval due to form factor uncertainties

$$R_{J/\psi}^{\text{LHCb}} = 0.71 \pm 0.17 \pm 0.18$$

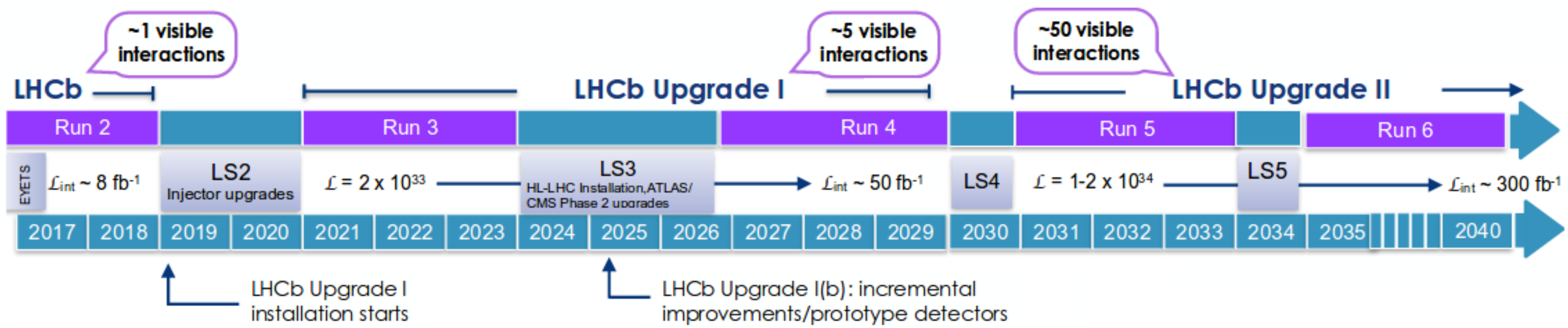
PRD 120 (2018) 121801

2σ above the SM

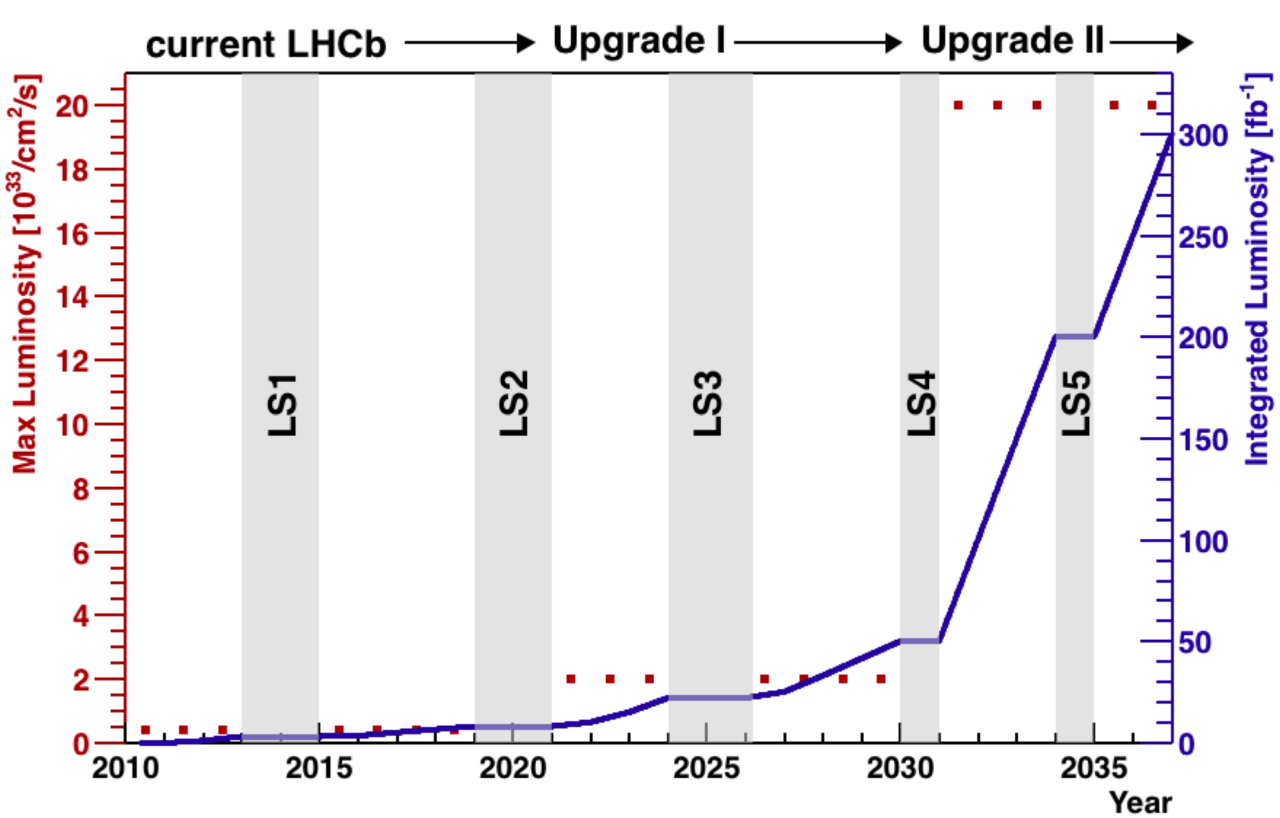
Near future → several measurement in the pipeline:

- Simultaneous measurements of R(D*) & R(D^0) and R(D*) & R(D^+)
- New measurement of R(Λ_c), R(D_s), etc.
- Updates with Run2

LHCb Upgrades

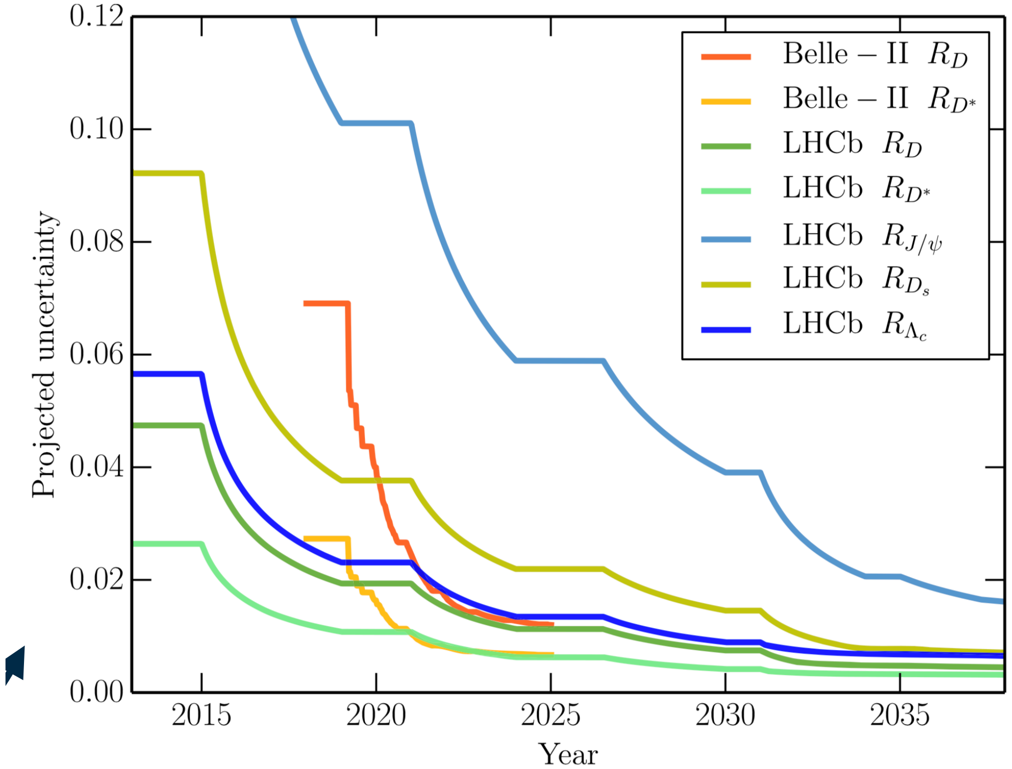


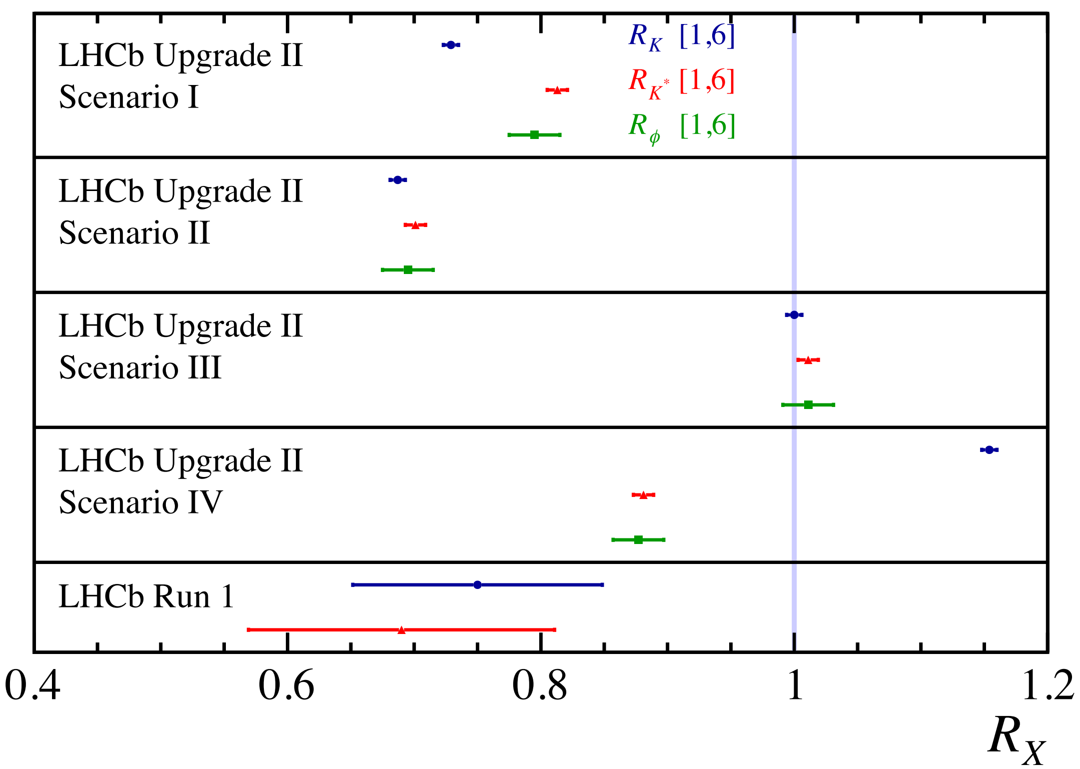
- Upgrade of the LHCb detector during LS2
  - All trigger decision software
  - Expect to collect 50 fb^{-1}
- LHCb phase-II
  - Further major upgrade in LS4 to profit from the HL-LHC program
  - Increase dataset up to 300 fb^{-1}



New era of precision measurements

- Projected sensitivity for various LFU ratios for LHCb future upgrades

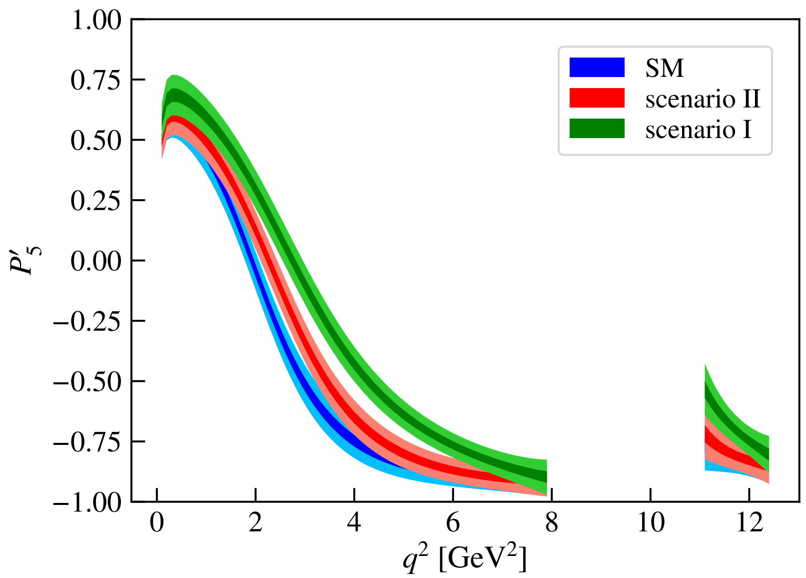




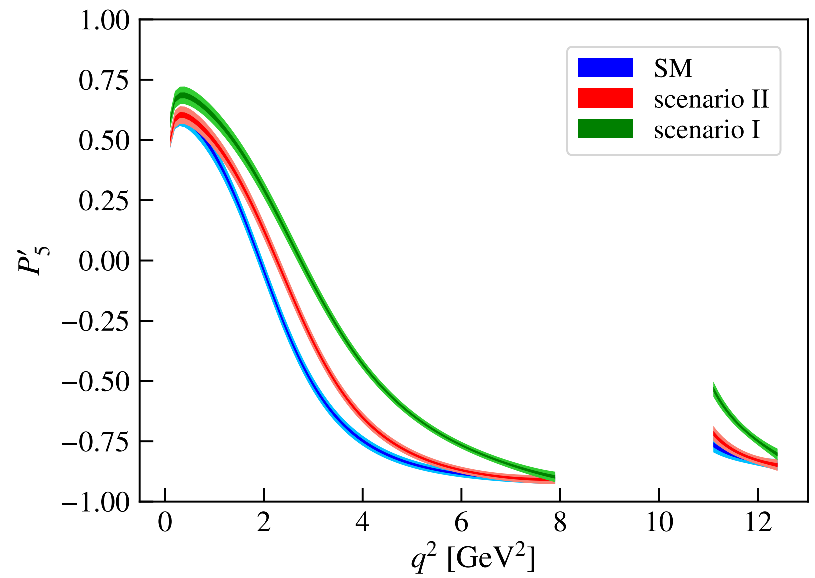
Physics of the HL-LHC, WG4 Flavour [arXiv:1812.07638]

New era of precision measurements

Run 3

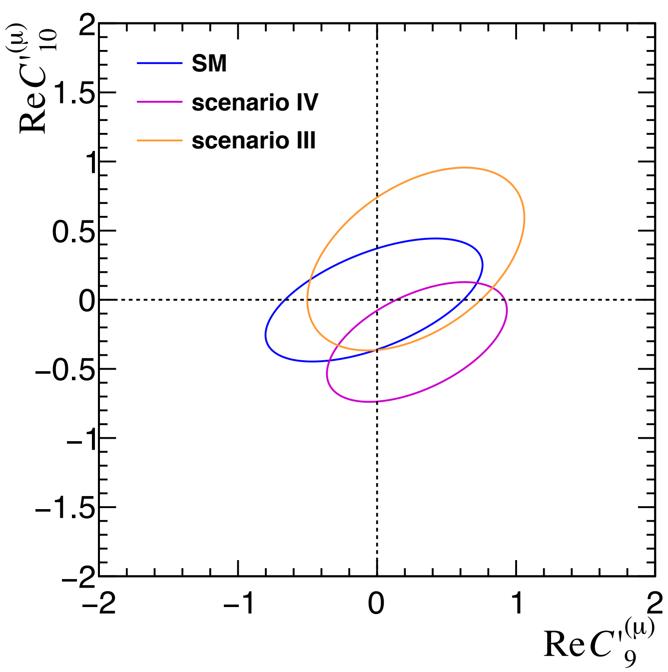


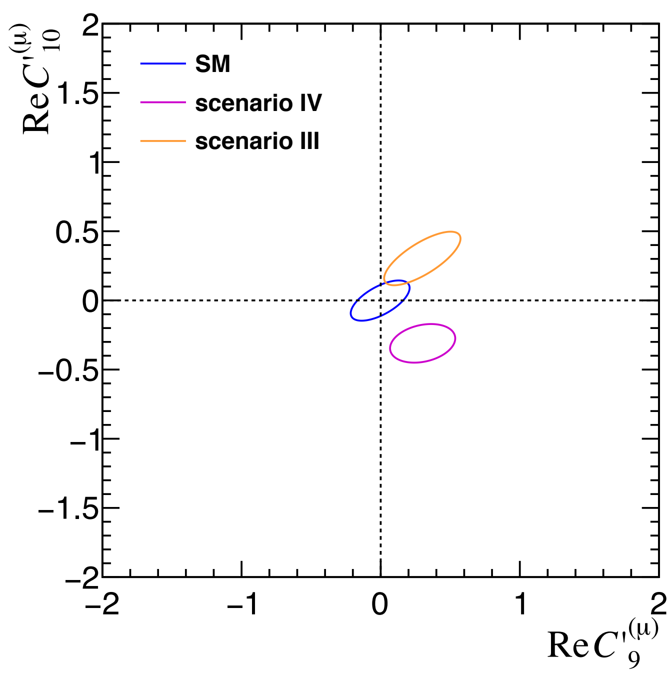
Upgrade II



Precise (unbinned) determination of angular observables

Scenario	ΔC_9	ΔC_{10}
SM	0	0
I	-1.4	0
II	-0.7	+0.7



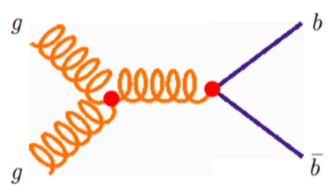


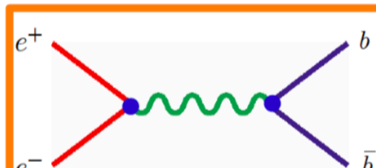
Right-handed Wilson coefficients

Scenario	C'_9	C'_{10}
SM	0	0
III	+0.3	+0.3
IV	+0.3	-0.3

Physics of the HL-LHC, WG4 Flavour [arXiv:1812.07638]

Belle II and LHCb Upgrades





- Time dependent B_s physics
  - CPV in $B_s \to J/\psi\, \phi$, $B_s \to \phi\phi$
- $B_s \to \mu^+\mu^-$
- CKM angle γ
- CPV in B_d
- $B \to X_s\, \ell^+\ell^-$ (exclusive) → **LFU**
- $B \to X_s\, \gamma$ (exclusive)
- Charm physics
- Semileptonic B decays
- $B \to D\, \tau^-\, \nu$, $B \to D^*\, \tau^-\, \nu$
- Dark matter
- τ – physics: LFV
- $B \to \tau^-\, \nu$, $B \to \mu^-\, \nu$
- $B \to K^*\, \nu\nu$, $B \to \nu\nu$
- $B \to X_s\, \ell^+\ell^-$ (inclusive)
- $B \to X_s\, \gamma$ (inclusive)

"B_s & charged tracks"

Important overlap: sporty competition!

"inclusive & neutrals "

J. Albrecht Portoroz 2019

Conclusion

Intriguing pattern of anomalies in neutral and charged currents transitions

- measurements by LHCb, Babar and Belle
- still need larger statistics to understand if these anomalies are genuine sign of physics beyond the SM
- more results will come from LHCb Run2 analyses

Thank you!