Lepton Flavour Universality in Rare B decays

Paula Álvarez Cartellle

Heavy Flavour 2023 - Quo Vadis?

June 2023

$b \to s\ \ell^+ \ell^-$ decays

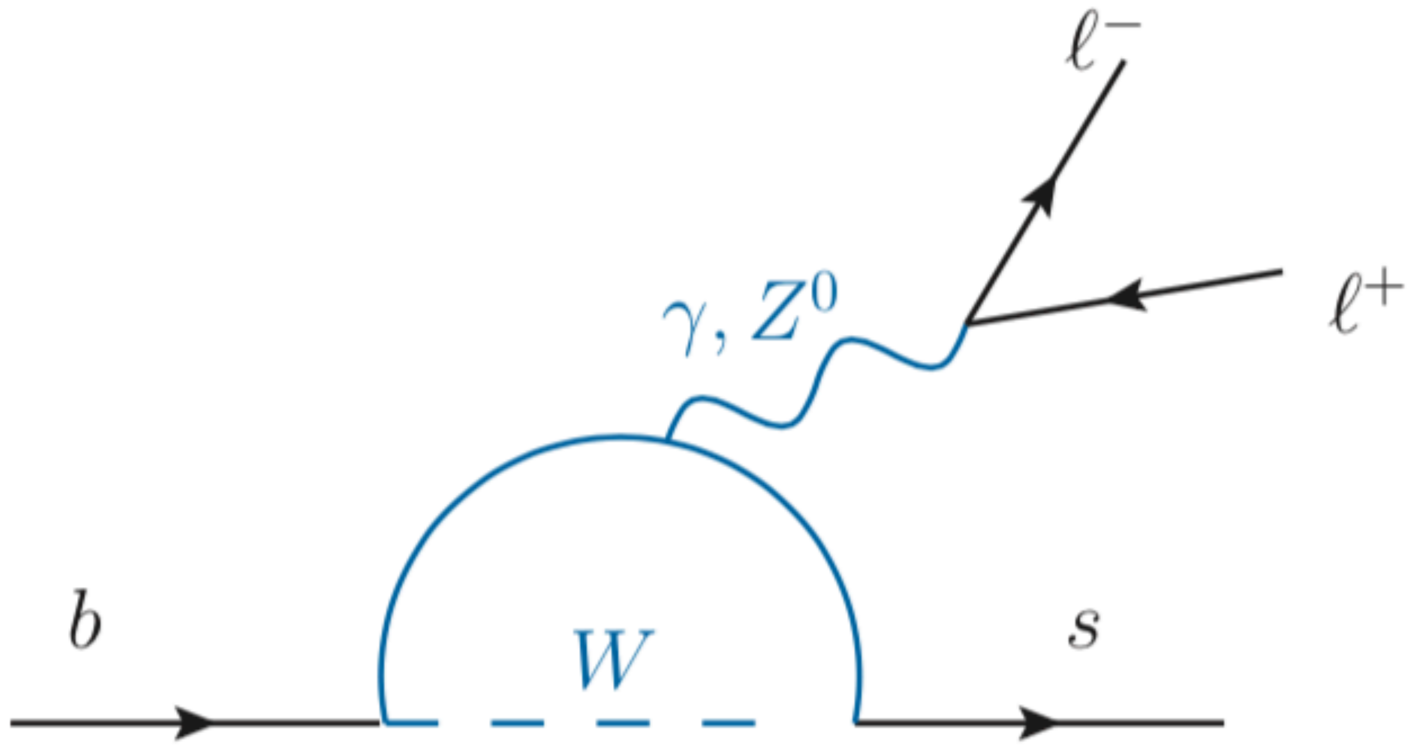
Suppressed in the SM

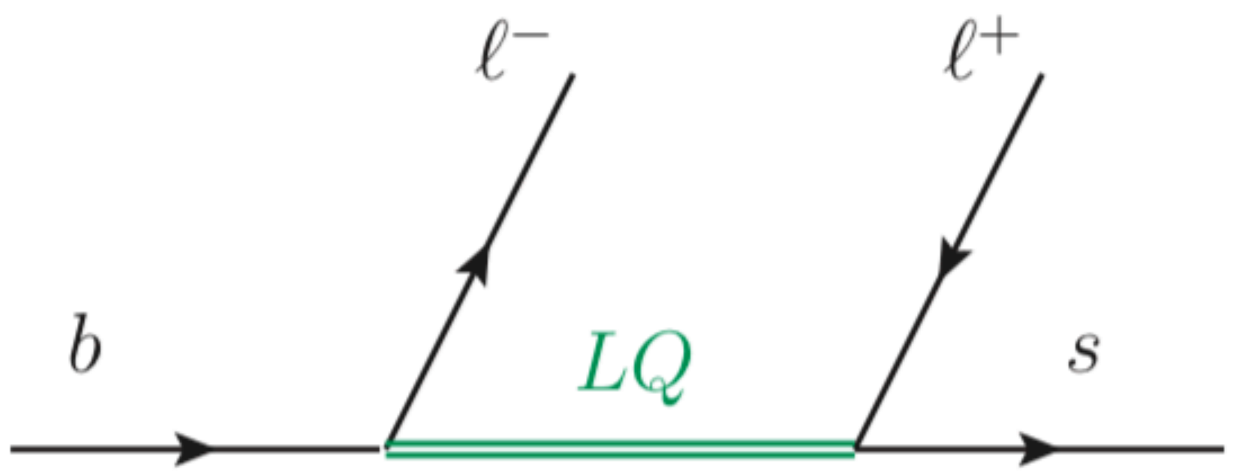
- Effects of new physics can be relatively large
- Access high mass scales, due to virtual contributions

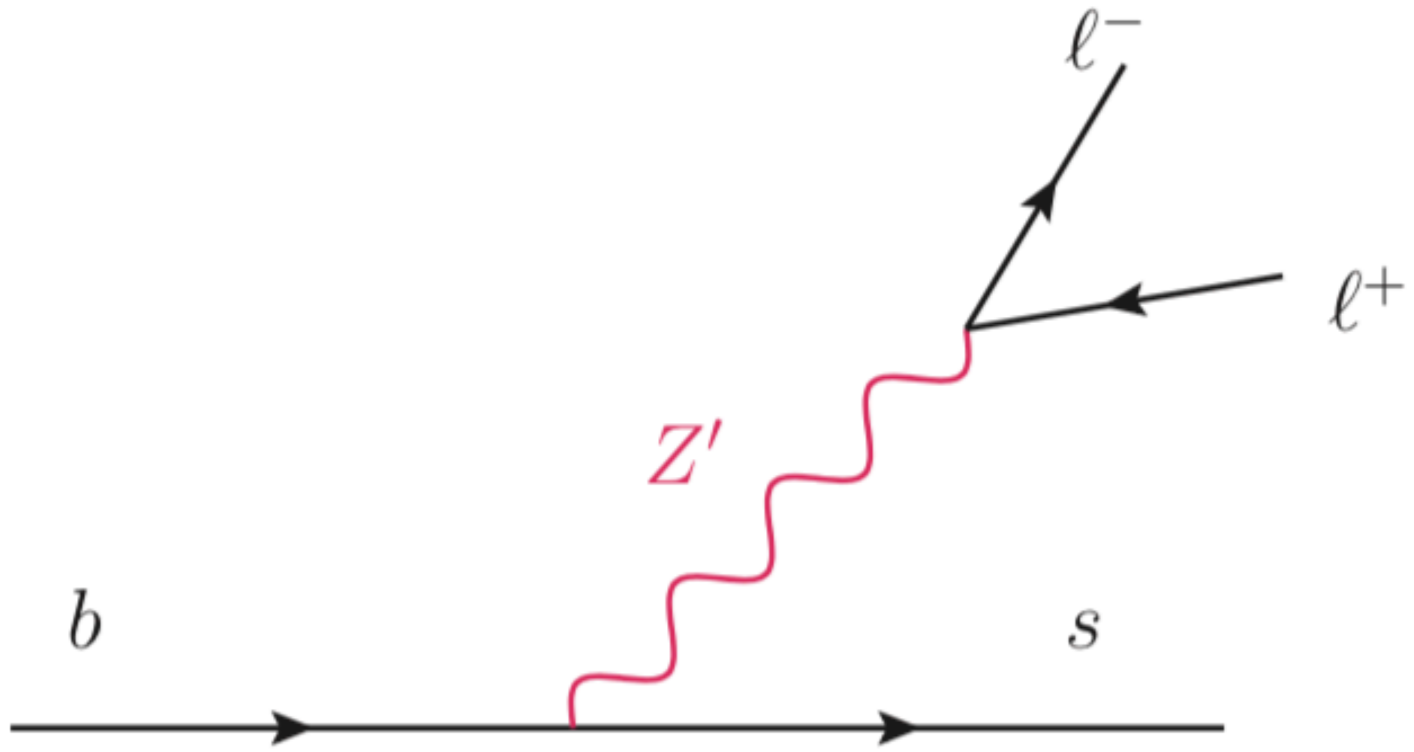
FCNC transitions, such as $b \to s(d)\ell\ell$ decays, are excellent candidates for indirect NP searches

Rare B decays offer rich phenomenology:

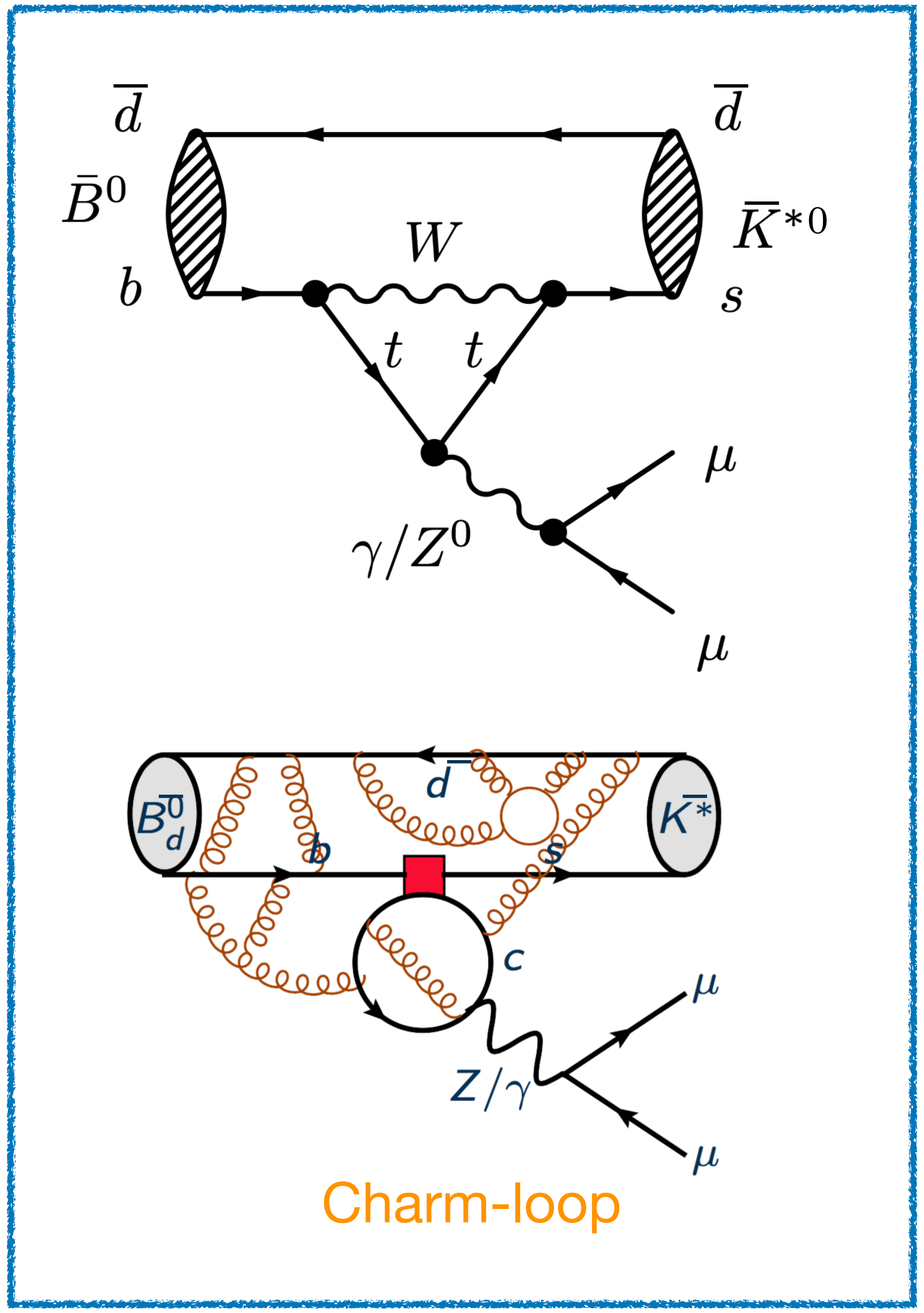
- Branching ratios, angular observables, LFU ratios…

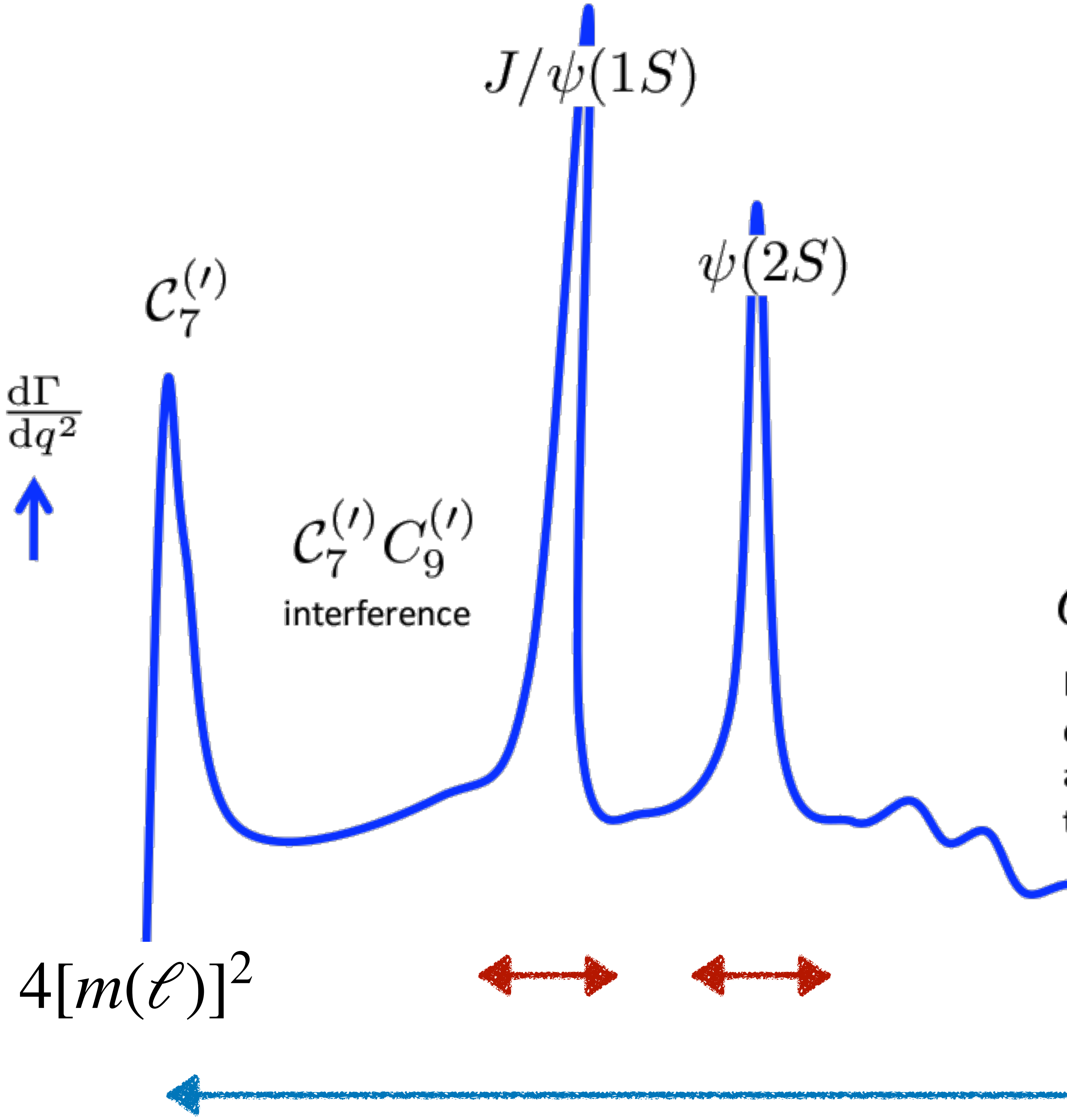


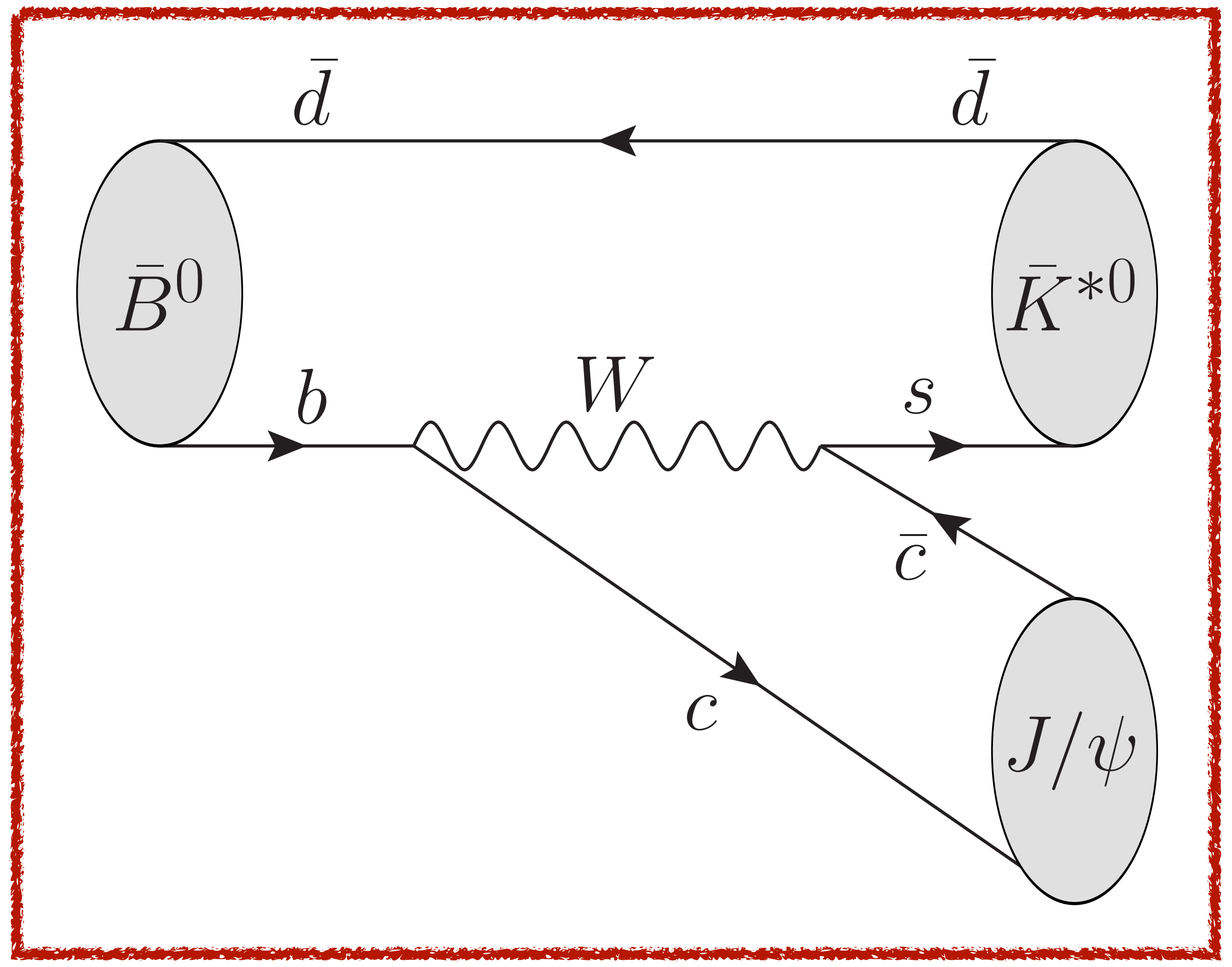




The di-lepton spectrum







$C_9^{(\prime)}$ and $C_{10}^{(\prime)}$

Long distance contributions from $c\bar{c}$ above open charm threshold

LFU tests in $b \to s \ell^+ \ell^-$

$B^{+,0}$, B_S, Λ_b

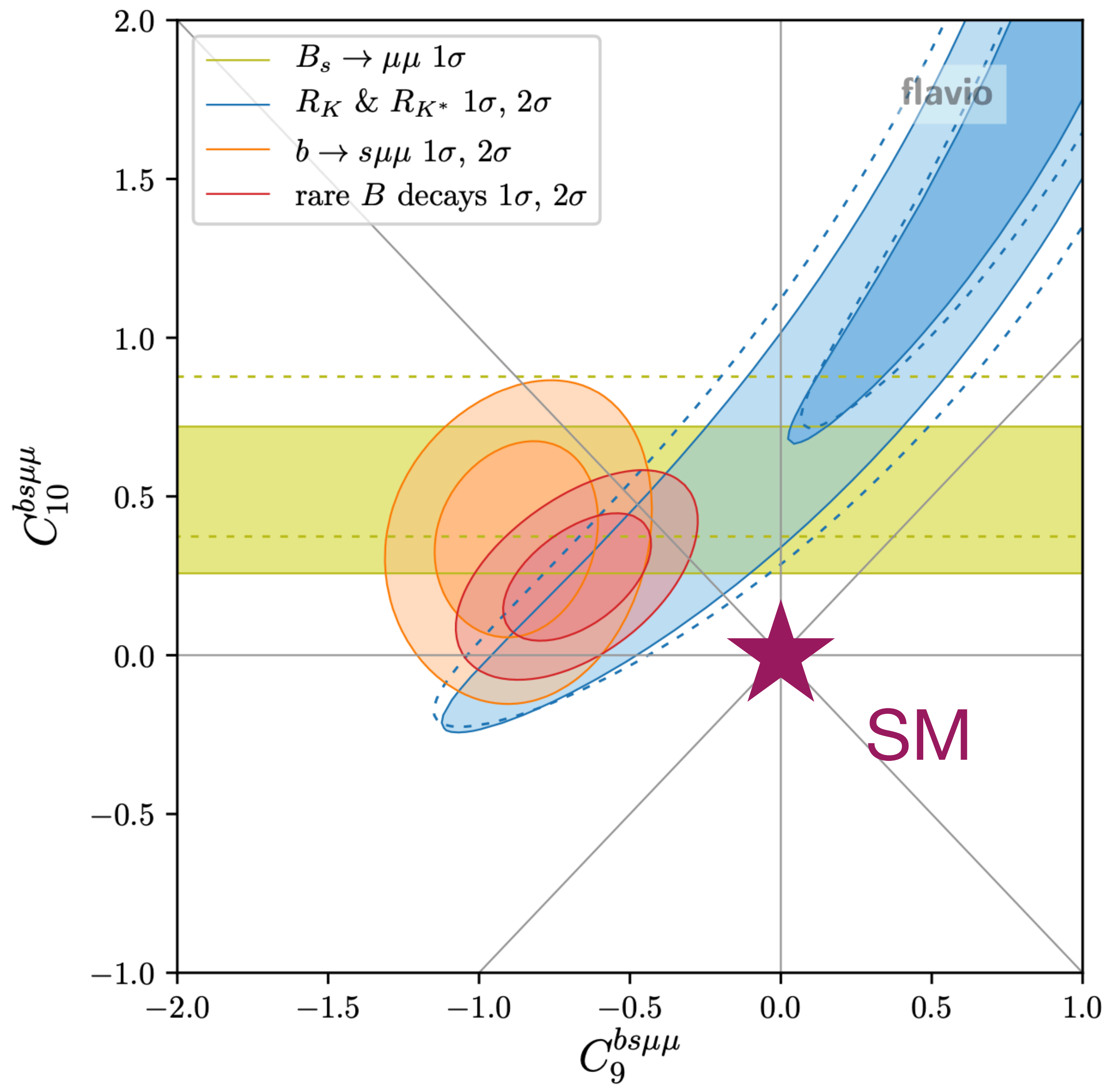
K, K^*, ϕ, pK …

$$R_{H_s} = \frac{\int \frac{d\Gamma(B \to H_s \mu^+ \mu^-)}{dq^2} dq^2}{\int \frac{d\Gamma(B \to H_s e^+ e^-)}{dq^2} dq^2} \overset{SM}{\cong} 1$$

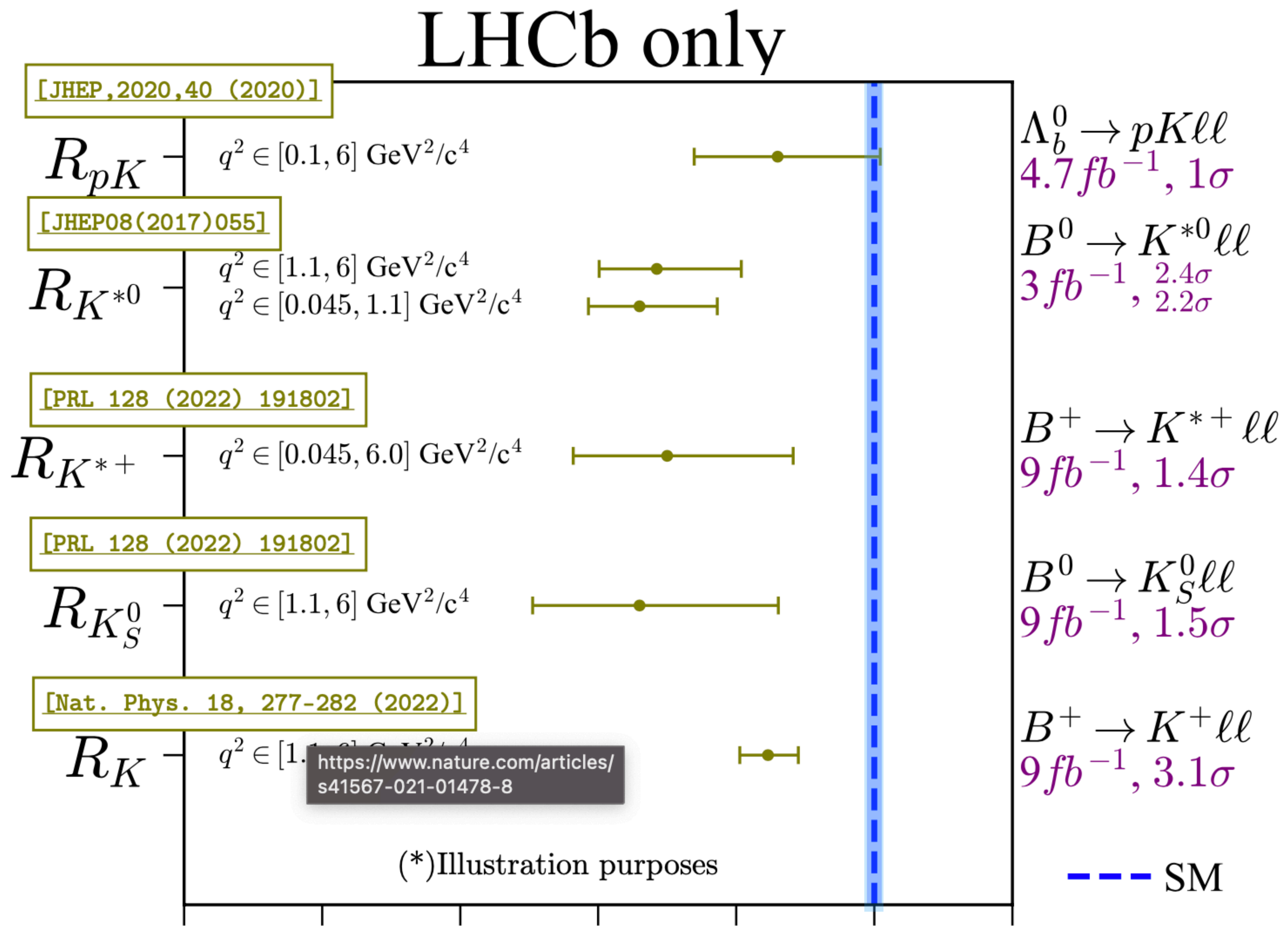
- Ratios of muons/electrons are extremely well predicted in the SM
    - Hadronic uncertainties of O(10-4)
    - QED uncertainties can be O(10-2)
- Any statistically significant deviation from 1 is a sign of New Physics

LFU tests in $b \to s\ell^+\ell^-$

- Before Dec 22, we had an pattern of measurements all below the SM prediction
- These aligned well with other deviations seen in $b \to s\mu\mu$ observables (BR, angular…)



[W. Altmannshofer et al., arXiv:2103.13370]



$$R_X = \frac{\mathcal{B}(b \to s\mu^+\mu^-)}{\mathcal{B}(b \to se^+e^-)}$$

(*) Measurements from Belle not shown (larger statistical uncertainties)

[R. Quagliani, CERN seminar 12/22]

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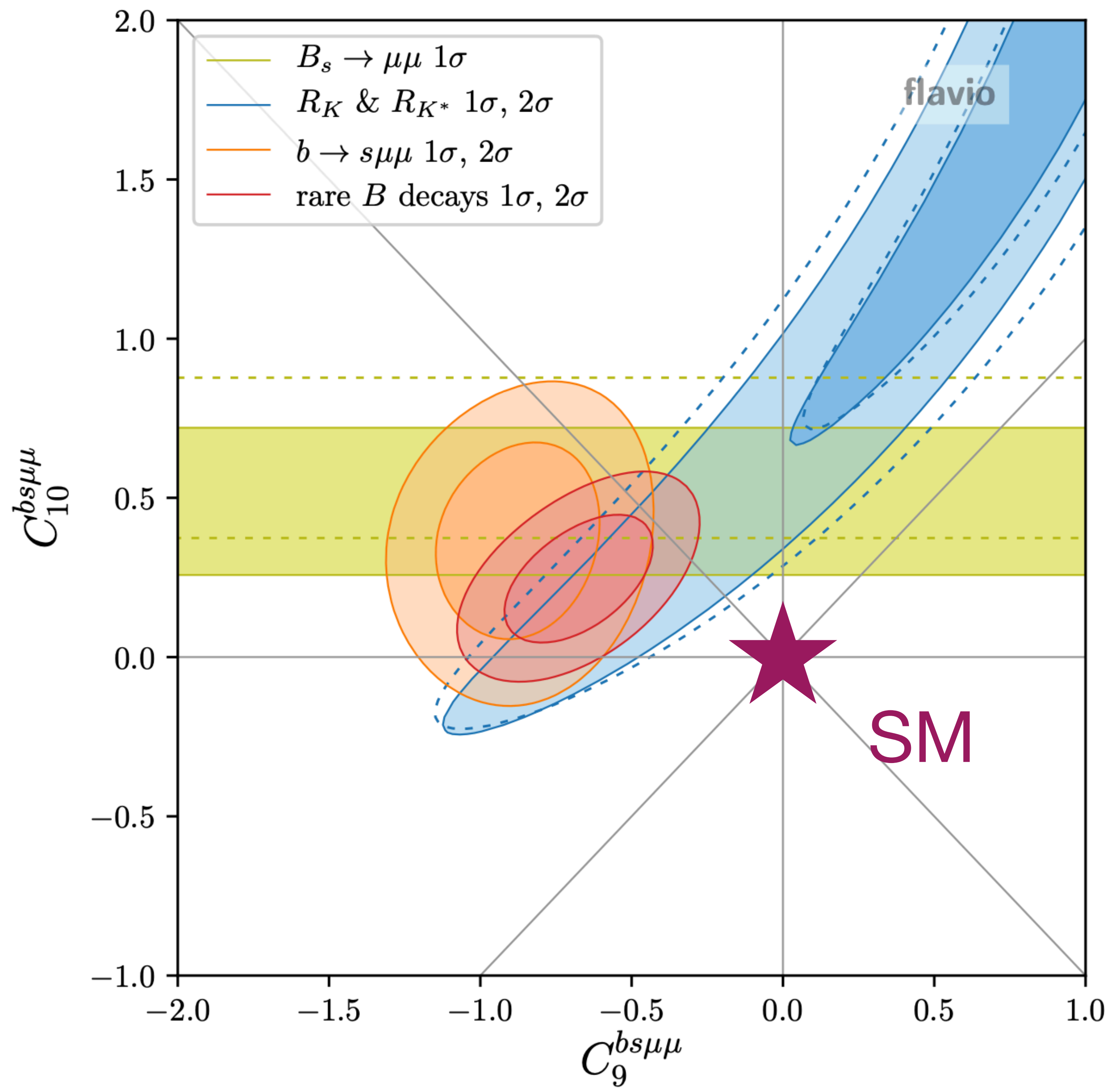

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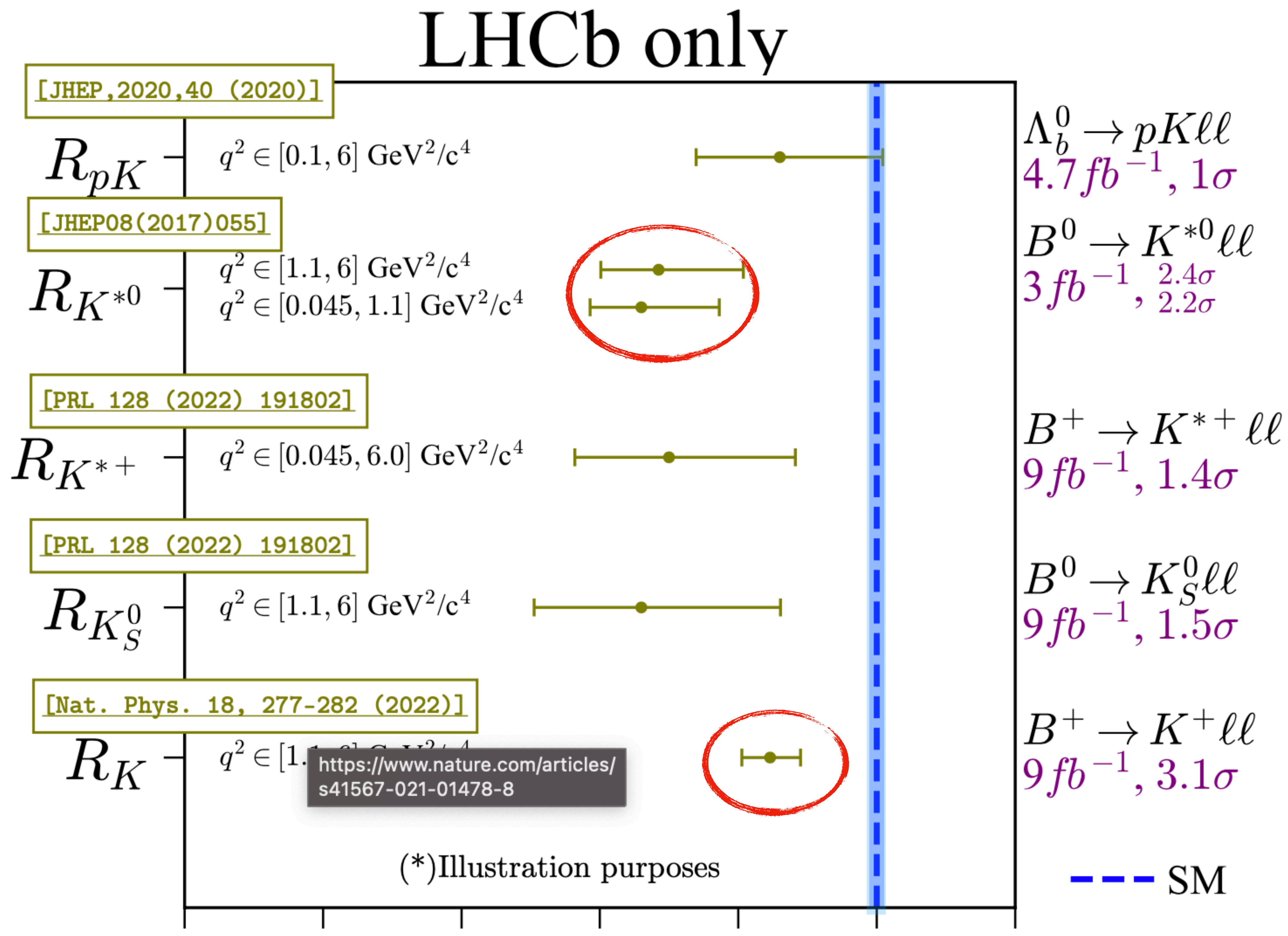

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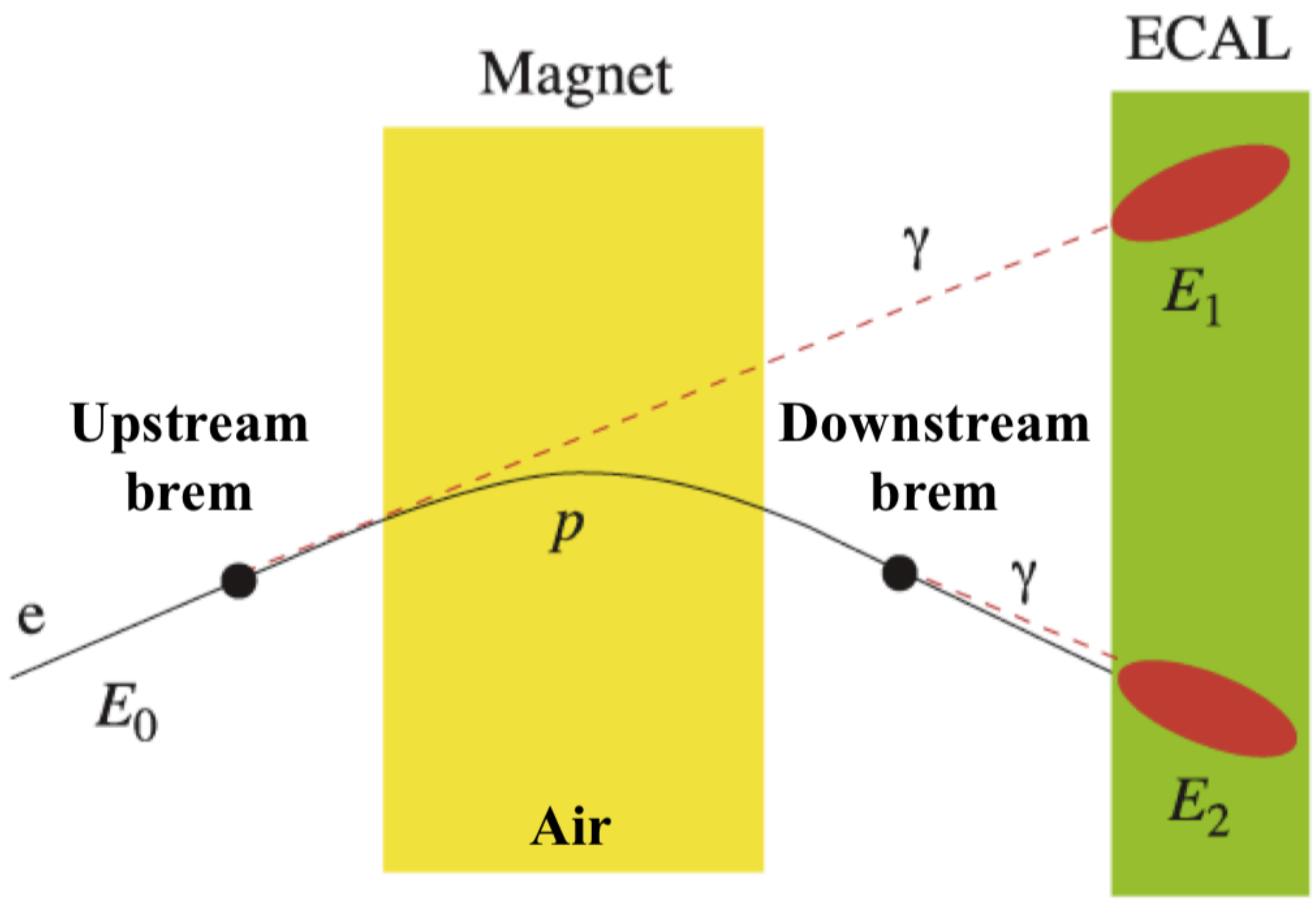
[R. Quagliani, CERN seminar 12/22]

Electrons vs Muons at LHCb

- Electrons lose a large fraction of their energy through Bremsstrahlung radiation
  - Bremsstrahlung recovery: Look for photon clusters in the calorimeter (E_T > 75 MeV) compatible with electron direction before magnet

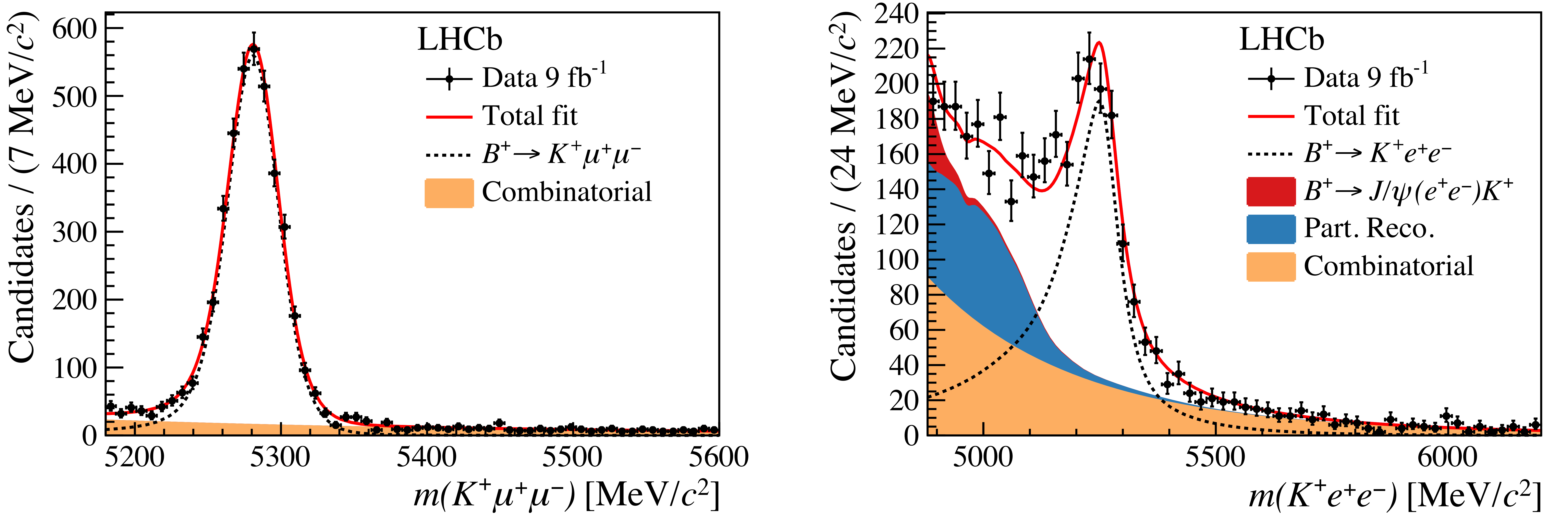
- After this correction electrons still have
  - Lower reconstruction/trigger/PID efficiency
  - Worse mass and q^2 resolution (more background)

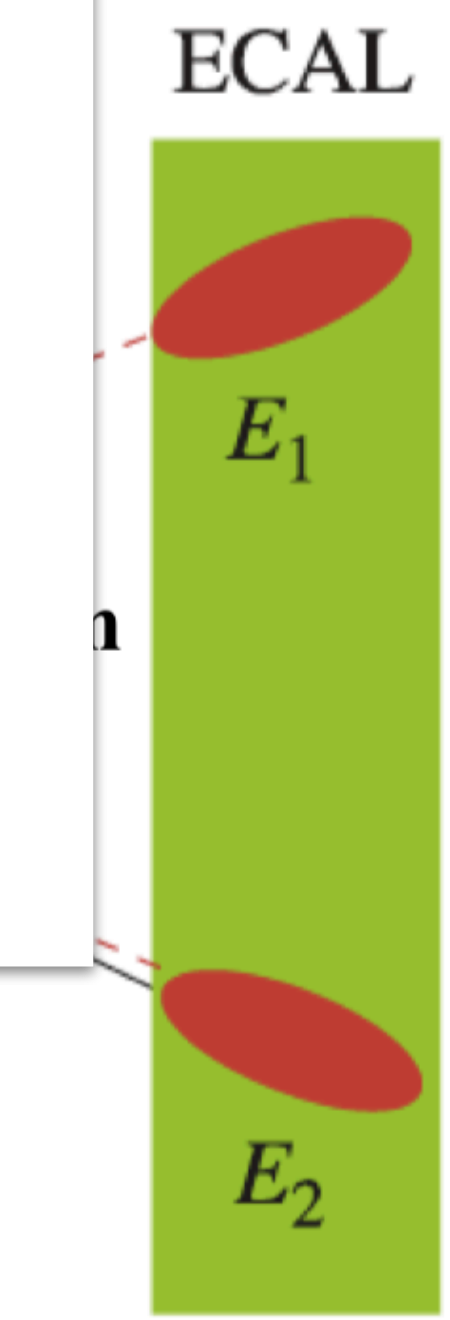


Electrons vs Muons at LHCb

- Electrons lose a large fraction of their energy through Bremsstrahlung radiation
- Af

[Nat. Phys. 18 (2022) 277]





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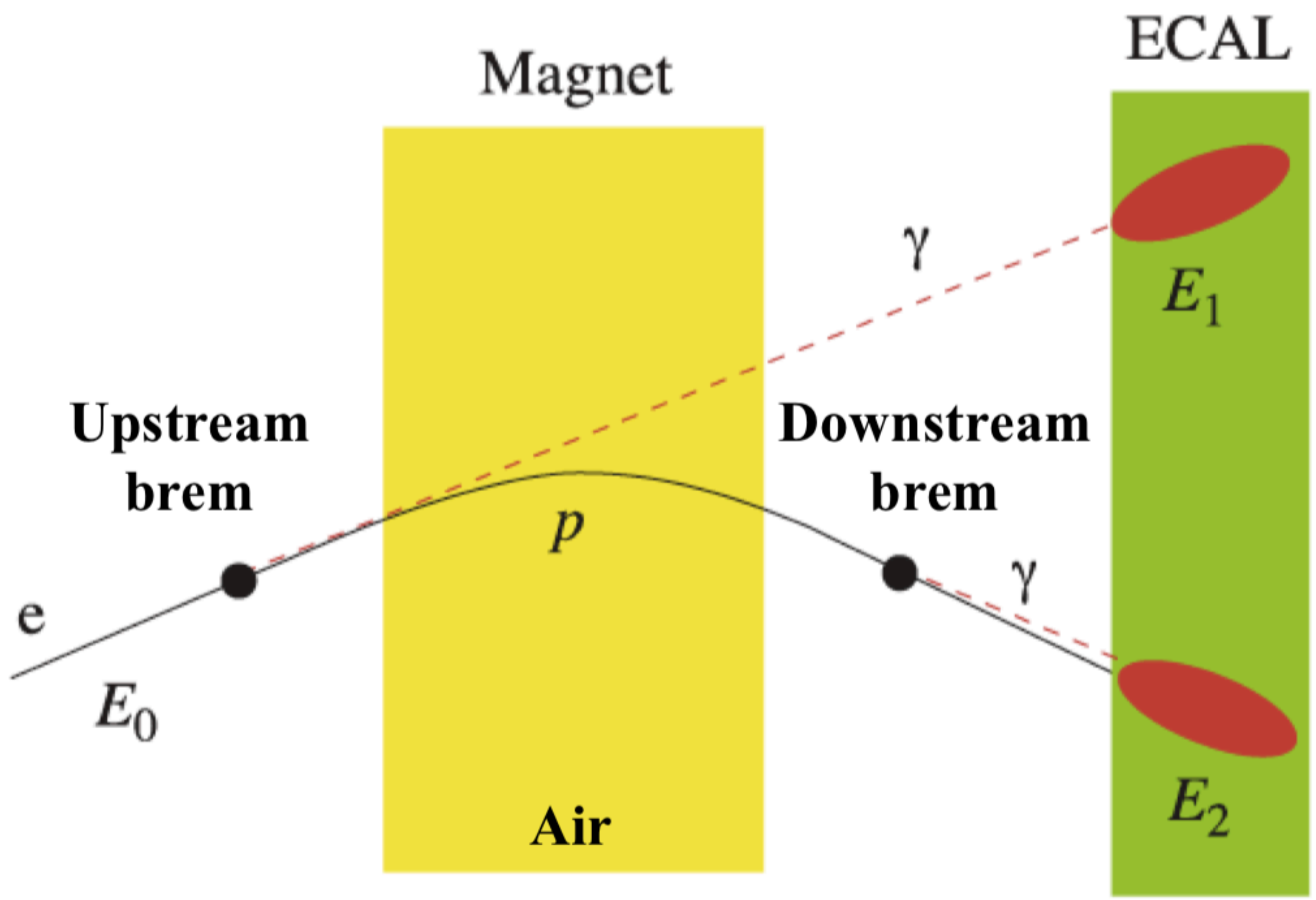

Electrons vs Muons at LHCb

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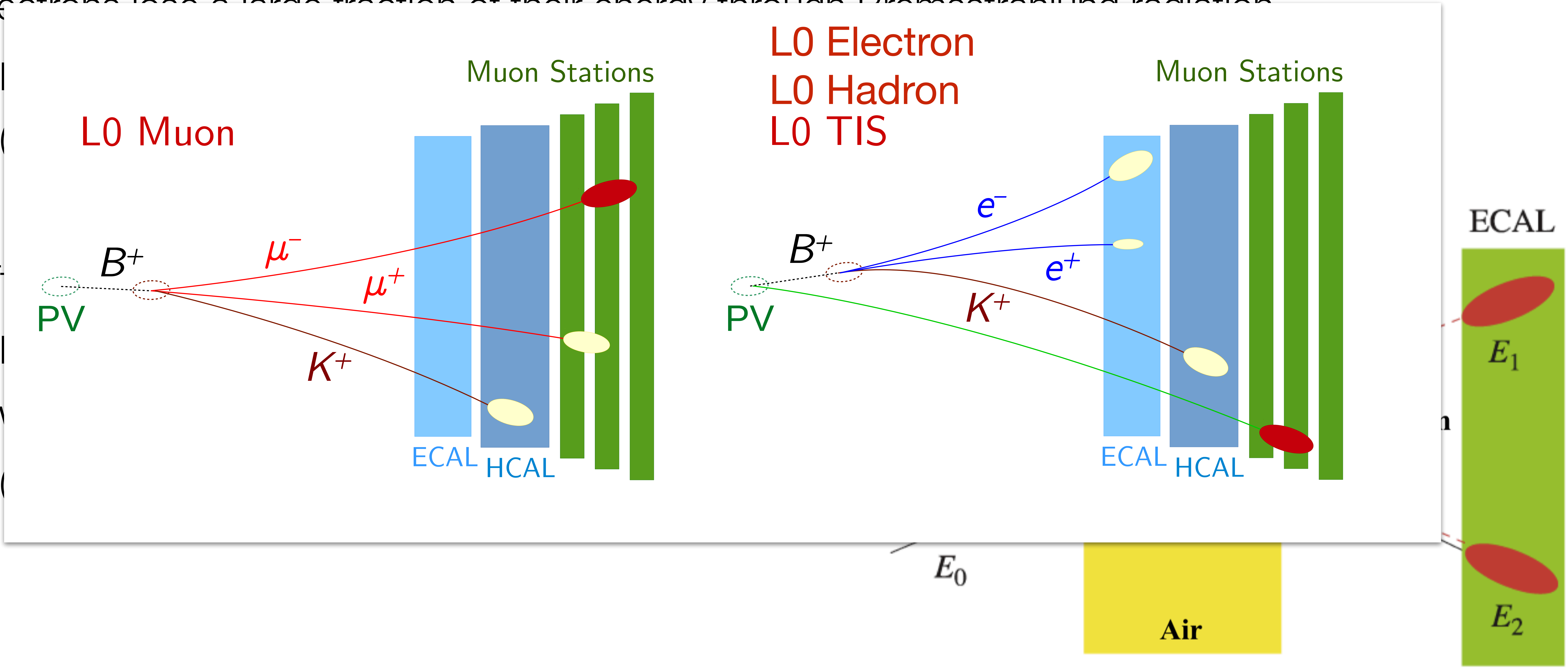
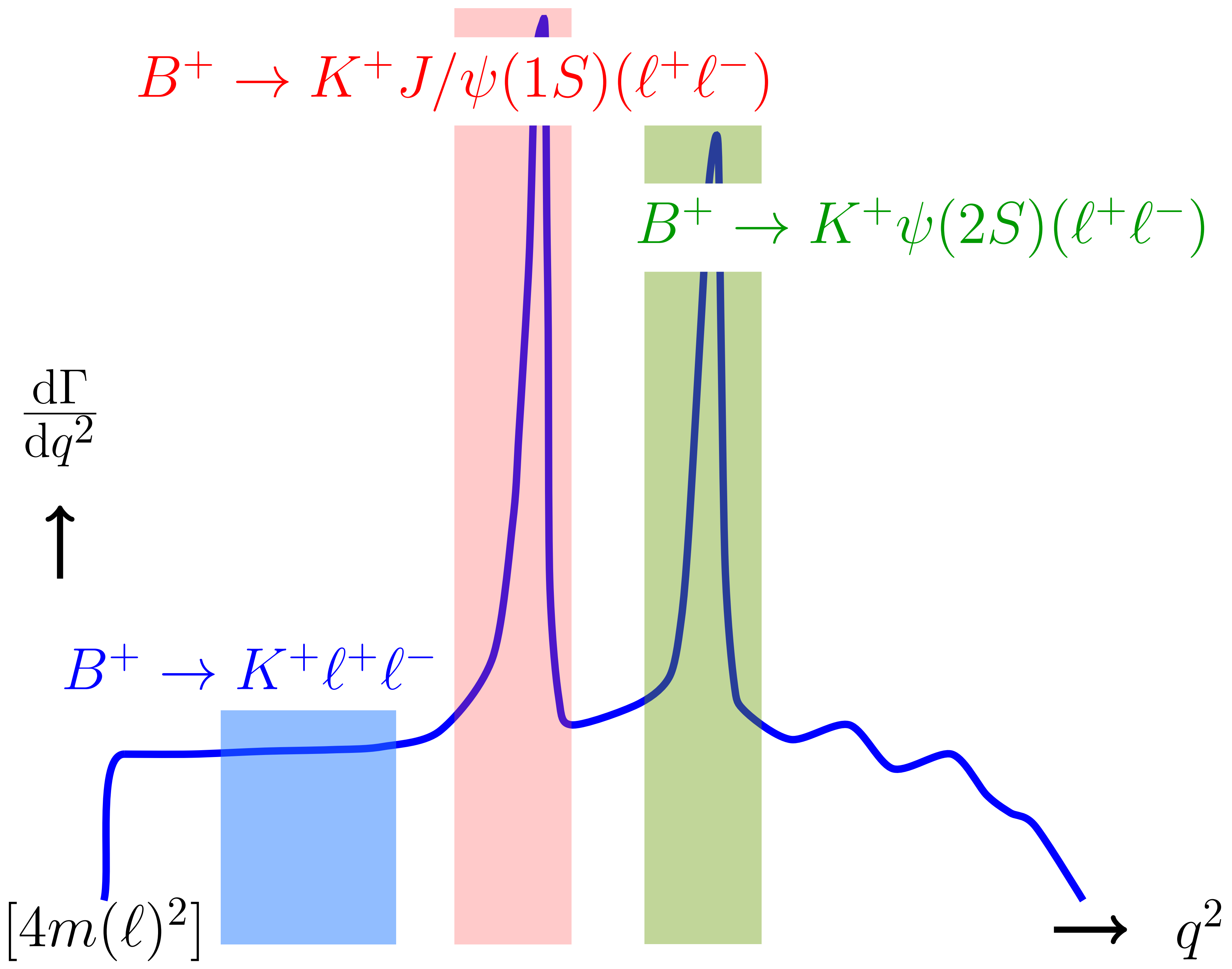


The double ratio

- Measure R_H as a double ratio, relative to equivalent ratio for $B \to H_s\, J/\psi(\ell\ell)$ decays
  - reduces impact of the differences in efficiency between electrons and muons



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

$$= \frac{N(K^+\mu^+\mu^-)}{N(K^+J/\psi(\mu^+\mu^-))} \cdot \frac{N(K^+J/\psi(e^+e^-))}{N(K^+e^+e^-)}$$

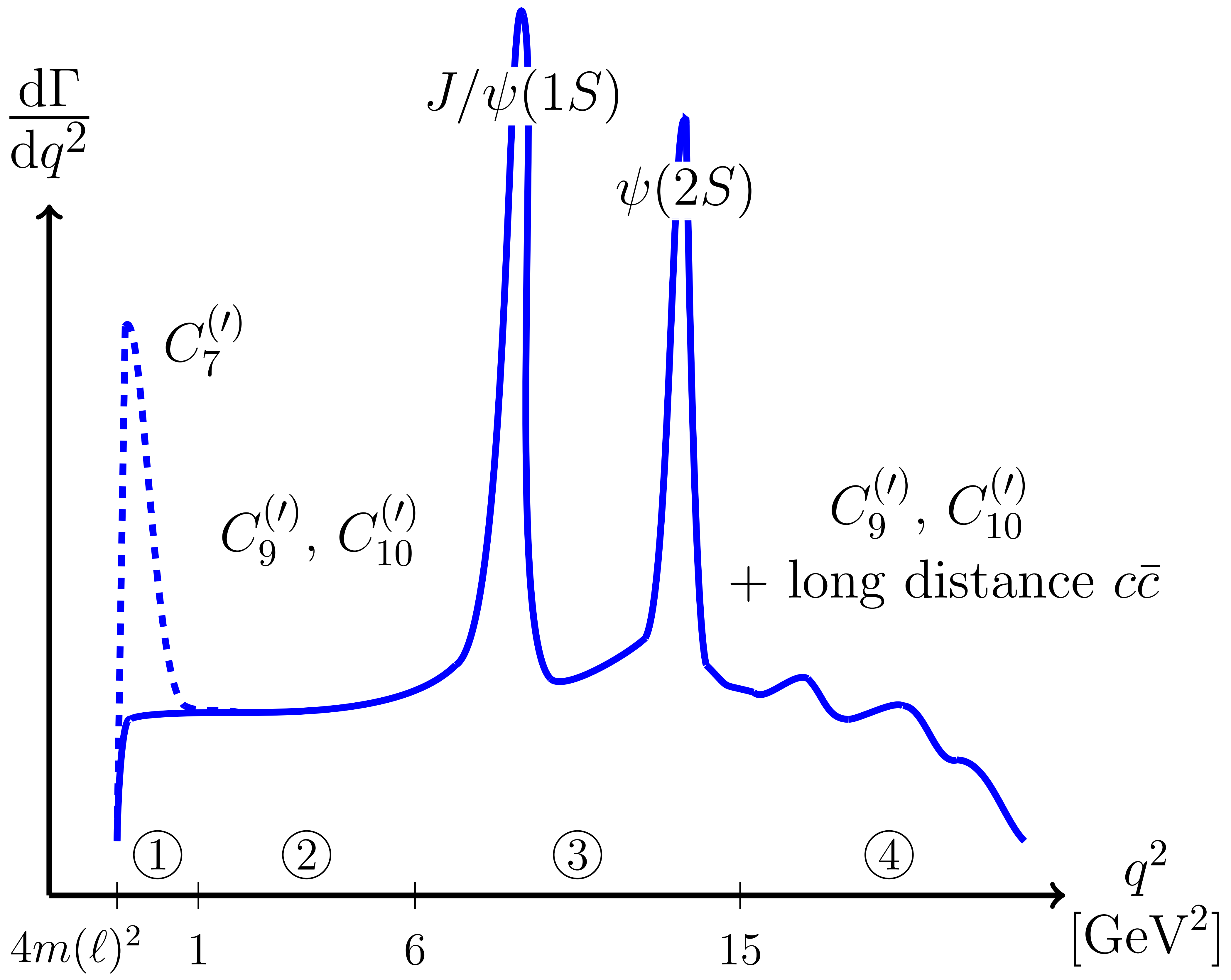
$$\cdot \frac{\varepsilon(K^+J/\psi(\mu^+\mu^-))}{\varepsilon(K^+\mu^+\mu^-)} \cdot \frac{\varepsilon(K^+e^+e^-)}{\varepsilon(K^+J/\psi(e^+e^-))}$$

New analysis of R_K and $R_{K^{*0}}$

LHCb-PAPER-2022-046
LHCb-PAPER-2022-045

- Data: full Run1+2 sample
  - Reanalysis of $B^+ \to K^+\ell\ell$
  - Update of $B^0 \to K^{*0}\ell\ell$ with Run2 (more than 5x more $b\bar{b}$ pairs)
- Two bins in the di-lepton mass
  - ① low-q^2: [0.1, 1.1] GeV²/c⁴
  - ② central-q^2: [1.1, 6.0] GeV²/c⁴
- Veto the q2 region close to the resonances ③
  - Use $B \to K^{(*)}J/\psi$ and $B \to K^{(*)}\psi(2S)$ for normalisation and cross-checks

$$\mathcal{H}_{eff} = \frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^* \frac{\alpha_e}{4\pi} \sum [C_i\mathcal{O}_i + C_i'\mathcal{O}_i']$$



Analysis strategy

- Reoptimised selection
  - Tighter PID and targeted partially reconstructed background selection
- Efficiency calculation using simulation
  - Extensive calibration using data-driven methods
  - Cross-checks using $r_{J/\psi}$ and $R_{\psi(2S)}$
- Signal yield determination through a simultaneous fit to $m(K\ell\ell)$ and $m(K\pi\ell\ell)$
  - Constrain partially reconstructed background on $B^+ \to K^+\ell\ell$ from $B^0 \to K^{*0}\ell\ell$ signal

$$r_{J/\psi} = \frac{\mathcal{B}(B \to K\ J/\psi(\mu\mu))}{\mathcal{B}(B \to K\ J/\psi(ee))}$$

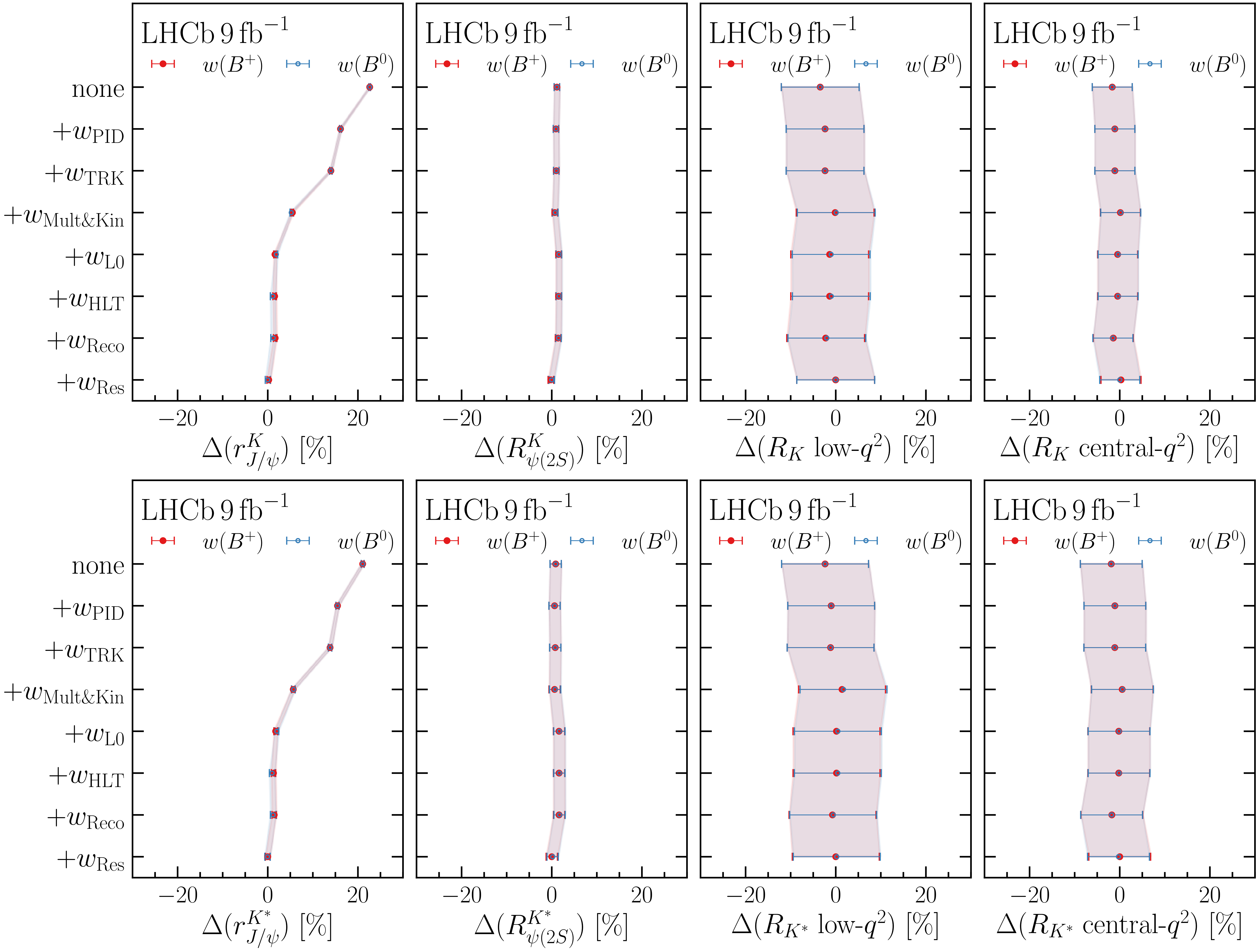
$$R_{\psi(2S)} = \frac{\mathcal{B}(B \to K\ \psi(2S)(\mu\mu))}{\mathcal{B}(B \to K\ \psi(2S)(ee))} \times r_{J/\psi}^{-1}$$

$$R_K = \frac{\frac{N}{\varepsilon}(B \to K\ \mu\mu)}{\frac{N}{\varepsilon}(B \to K\ ee)} \times r_{J/\psi}^{-1}$$

Efficiency calibration

[LHCb-PAPER-2022-046](#)
[LHCb-PAPER-2022-045](#)

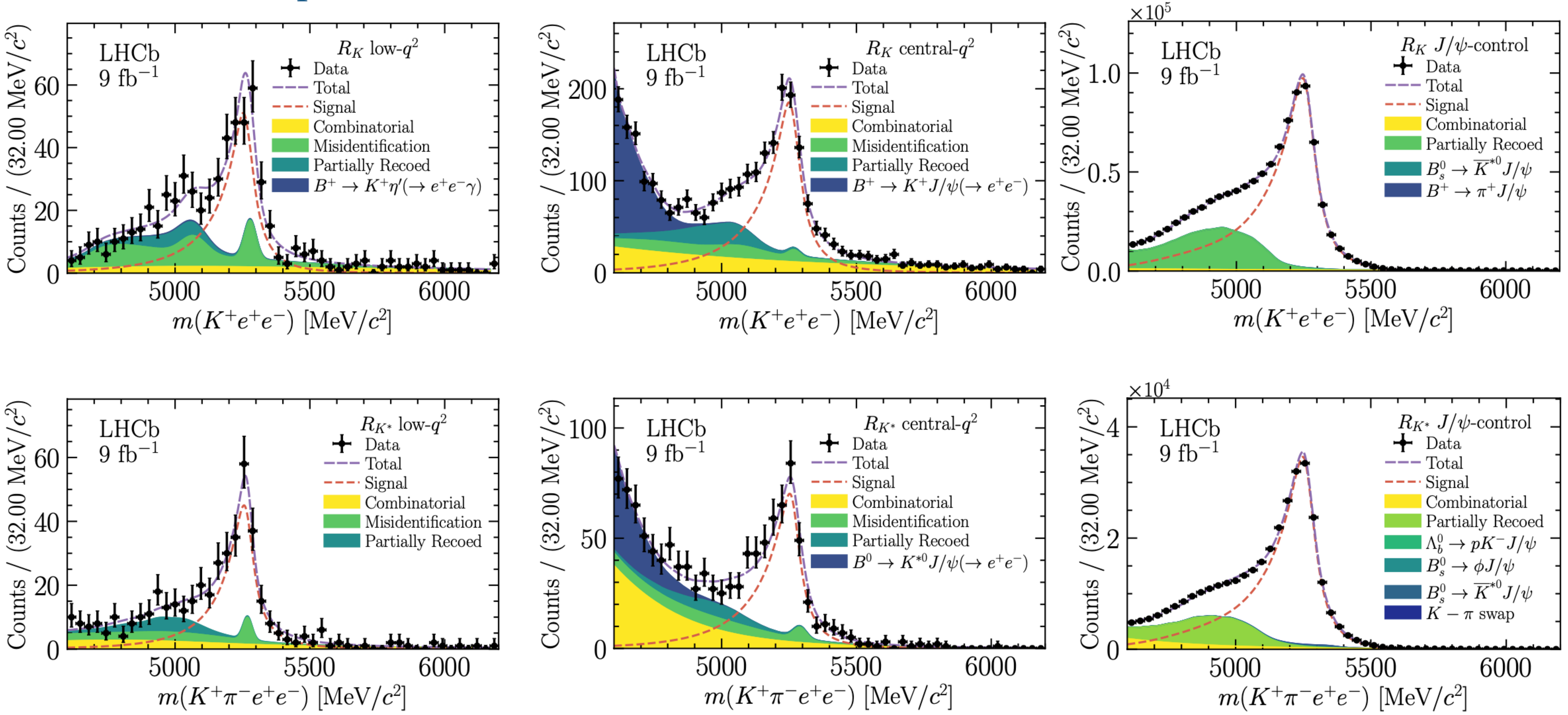
- Use control channels in data in order to correct the simulation modelling of
  - B production kinematics
  - Detector response (tracking, PID, trigger, etc)
- Cross-checks to ensure correct efficiency estimation
  - Single ratios (Δ~25%)
  - Double ratios (Δ~5%)
- Ratios determined also as a function of kinematics



Mass fits

LHCb-PAPER-2022-046
LHCb-PAPER-2022-045

low-q^2 central-q^2 resonant-J/ψ



MisID background

LHCb-PAPER-2022-046
LHCb-PAPER-2022-045

- PID criteria based on e/π separation log-likelihood (DLL) and neural-network based e ID (ProbNN)
- Tightening PID selection induced a systematic shift in the result
- Solved when including various (previously underestimated) backgrounds
  - Fully reconstructed $B \to K^{(*)}hh'$ such as $B \to K^{(*)}KK$, $B \to K^{(*)}\pi\pi$, $B \to D(hh')\pi$ (triple misID)
  - Partially reconstructed $B \to K^{(*)}\pi(\pi^0, \gamma)X$

R_K central-q^2

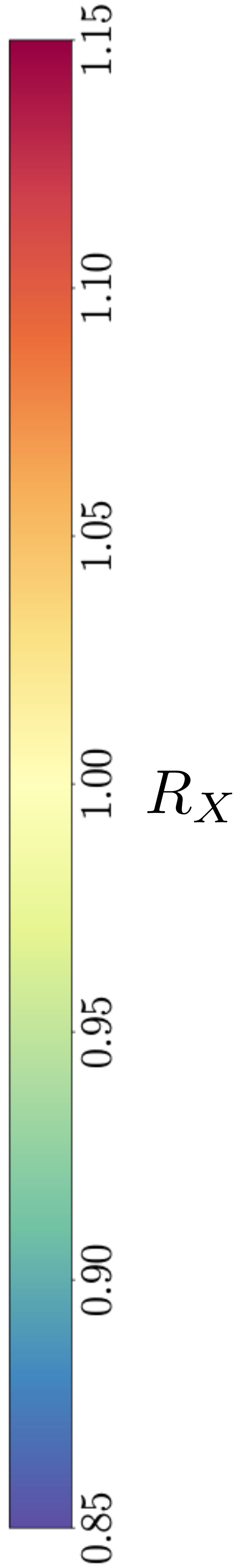
	> 0.20	> 0.25	> 0.30	> 0.35	> 0.40	> 0.45	> 0.50	> 0.55	> 0.60
DLL(e) > 7	0.948 ± 0.051	0.944 ± 0.051	0.944 ± 0.051	0.939 ± 0.051	0.939 ± 0.051	0.941 ± 0.051	0.934 ± 0.051	0.935 ± 0.051	0.937 ± 0.052
DLL(e) > 5	0.941 ± 0.044	0.938 ± 0.044	0.942 ± 0.044	0.933 ± 0.044	0.939 ± 0.045	0.951 ± 0.046	0.946 ± 0.046	0.953 ± 0.047	0.949 ± 0.048
DLL(e) > 2	0.906 ± 0.040	0.902 ± 0.040	0.907 ± 0.040	0.895 ± 0.040	0.904 ± 0.041	0.916 ± 0.042	0.920 ± 0.043	0.925 ± 0.044	0.919 ± 0.044

ProbNN(e)

R_{K^*} central-q^2

	> 0.20	> 0.25	> 0.30	> 0.35	> 0.40	> 0.45	> 0.50	> 0.55	> 0.60
DLL(e) > 7	1.127 ± 0.100	1.119 ± 0.099	1.116 ± 0.099	1.103 ± 0.098	1.097 ± 0.097	1.083 ± 0.095	1.097 ± 0.099	1.113 ± 0.101	1.119 ± 0.103
DLL(e) > 5	1.021 ± 0.074	1.016 ± 0.074	1.016 ± 0.075	0.997 ± 0.073	1.016 ± 0.076	1.001 ± 0.075	1.012 ± 0.077	1.035 ± 0.081	1.049 ± 0.084
DLL(e) > 2	0.965 ± 0.066	0.990 ± 0.069	0.986 ± 0.069	0.993 ± 0.071	1.024 ± 0.075	1.006 ± 0.073	1.014 ± 0.075	1.038 ± 0.079	1.039 ± 0.081

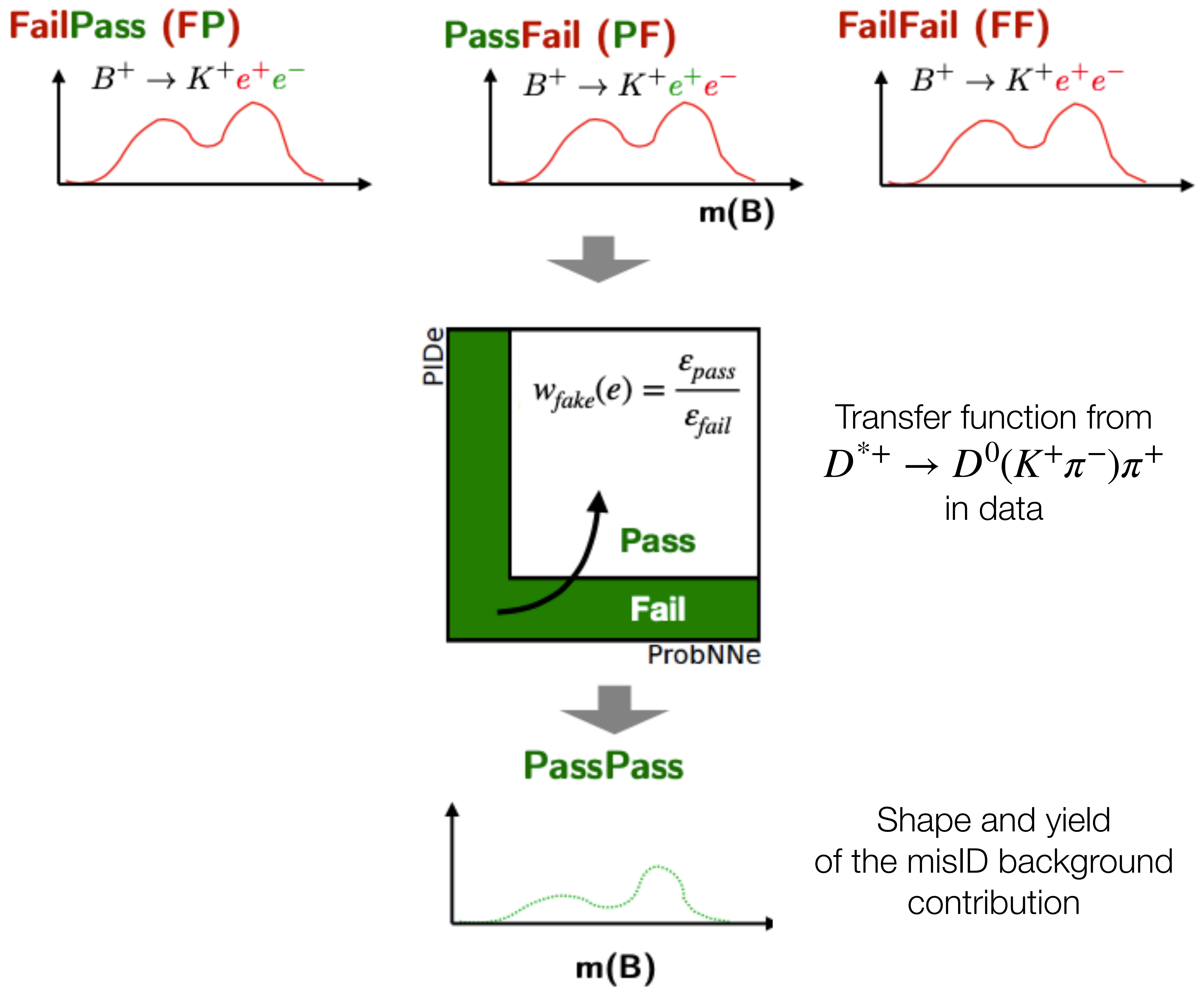
ProbNN(e)



LHCb-PAPER-2022-046
LHCb-PAPER-2022-045

Modelling the misID background

- Pass&Fail method
  - Invert PID selection in data to obtain the spectrum of misID enriched
  - Subtract residual signal using simulation
  - Use calibration samples to fold in the efficiency of the baseline PID criteria as a function of the electron kinematics



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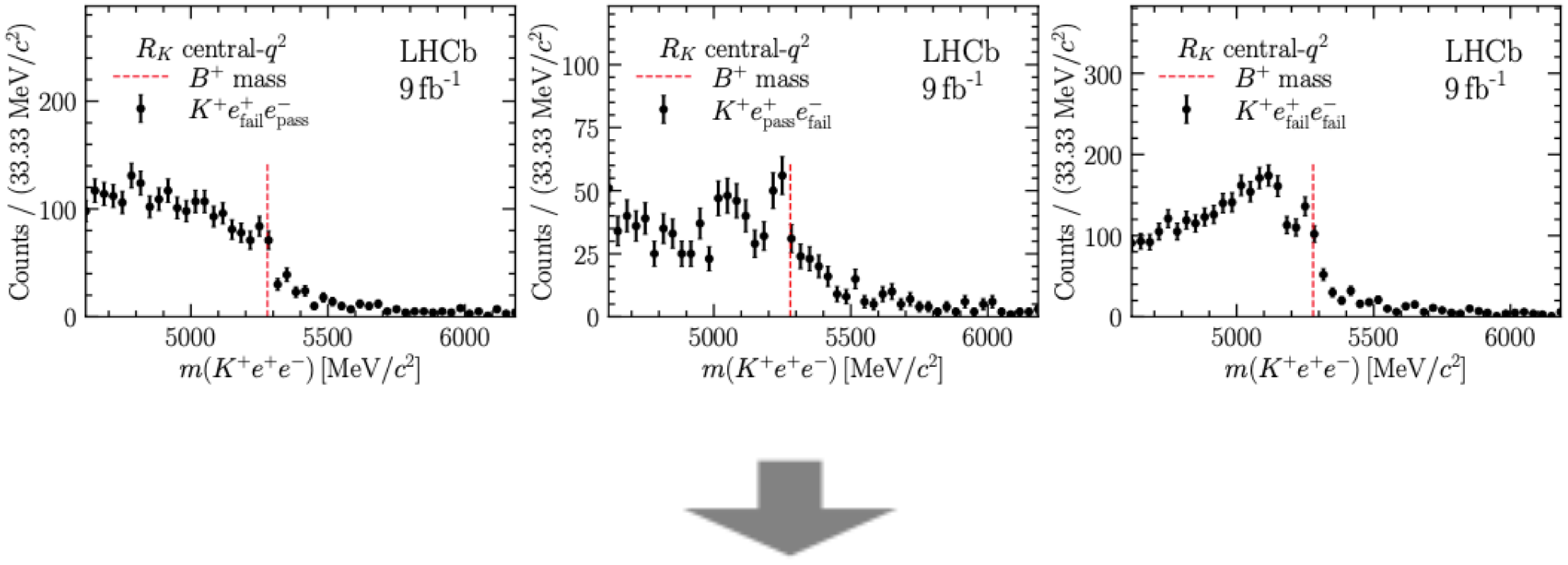
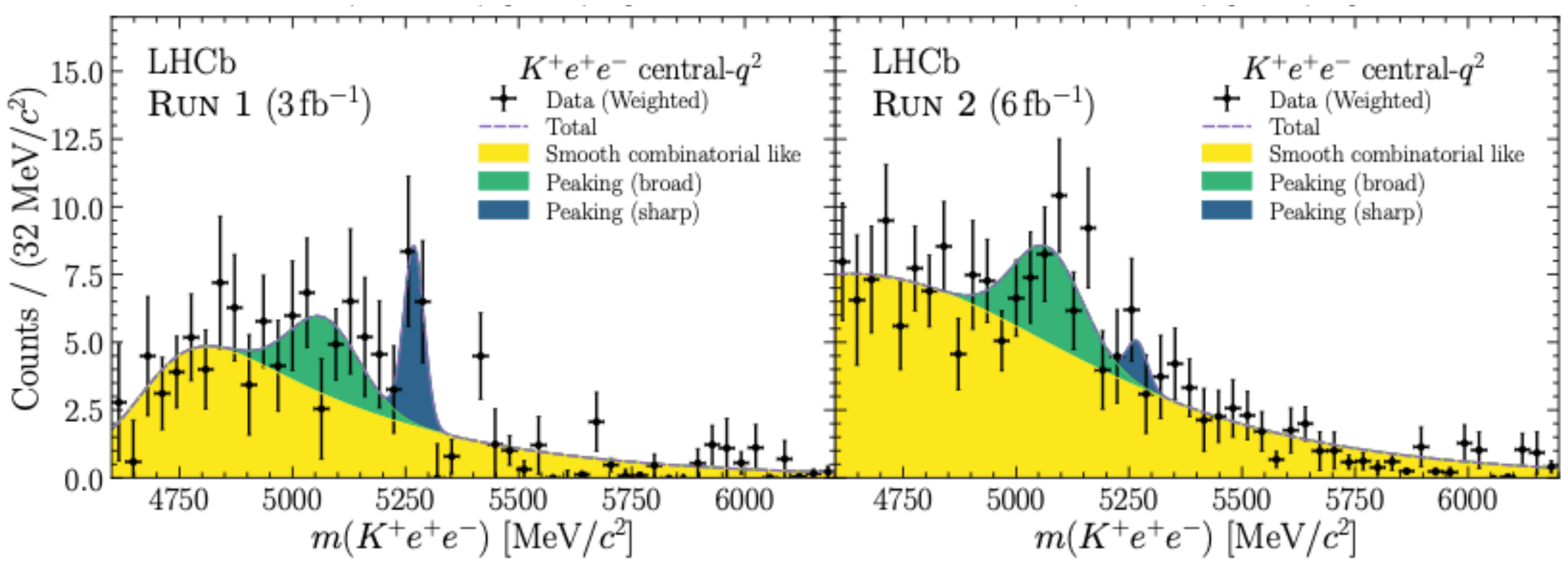




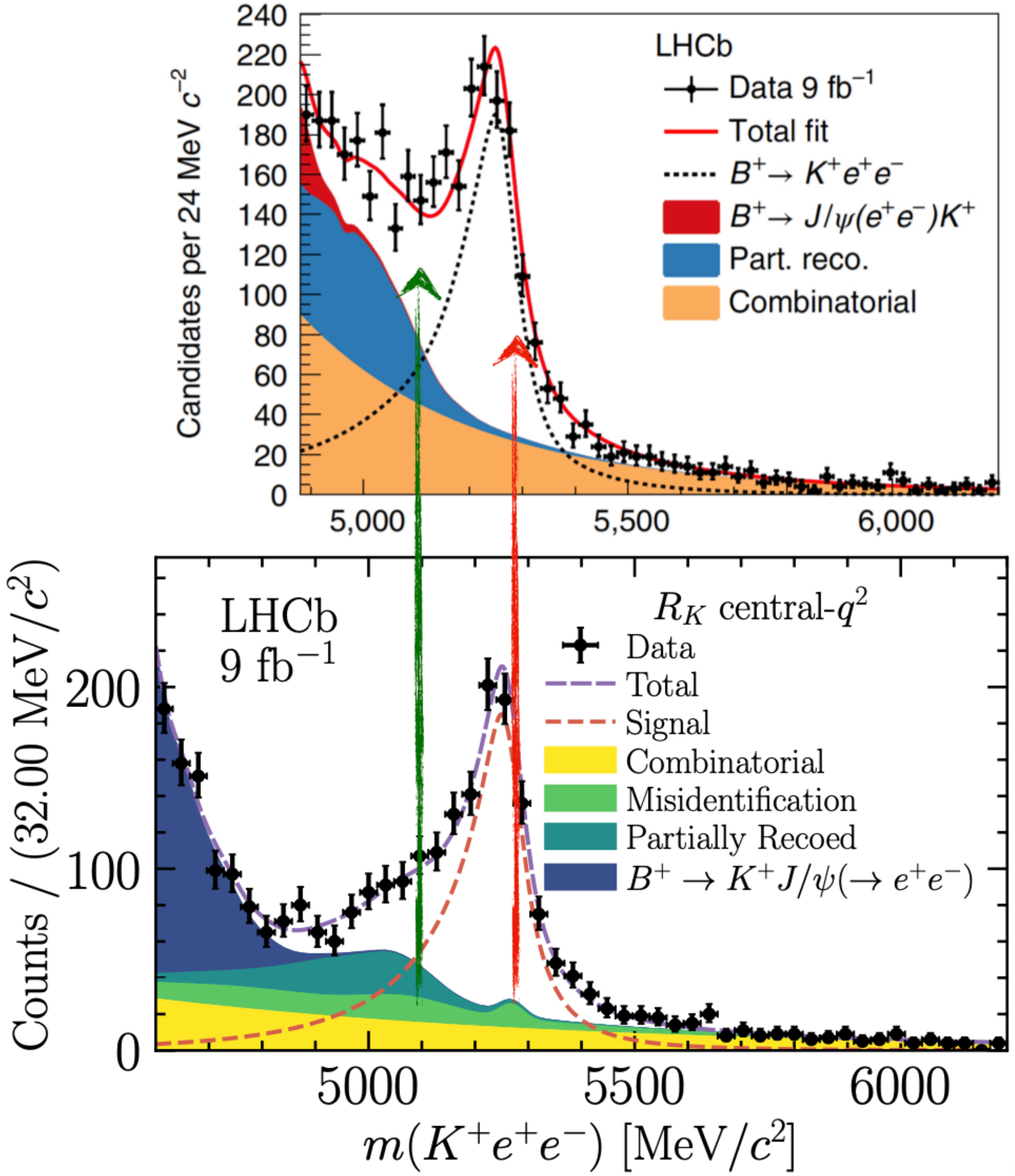
Modelled by empirical model including a narrow and broad peaking structures to describe fully and partially reconstructed misID backgrounds

LHCb-PAPER-2022-046, LHCb-PAPER-2022-045

Backup: comparison

Comparison to previous R_K measurement

[Nat. Phys. 18, 277-282 (2022)]



- Different PID cut used ➡ Allowed σ_{stat} : ±0.033
- Mis-ID rate from $D^{*-} \to D^0(K\pi)\pi$
- With new(previous) analysis requirements

	Sample	$\pi \to e$	$K \to e$
(11+12)	Run 1	1.78 (1.70) %	0.69 (1.24) %
(15+16)	Run 2p1	0.83 (1.51) %	0.18 (1.25) %
(17+18)	Run 2p2	0.80 (1.50) %	0.16 (1.23) %

single-misID	**× 1 (Run1)** **× 2 (Run2)**	**× 2 (Run1)** **× 7 (Run2)**
double-misID	**× 1² (Run1)** **× 2² (Run2)**	**× 2² (Run1)** **× 7² (Run2)**

- Shift due to contamination at looser working point : **+0.064**
- Shift due to not inclusion of background in mass fit: **+0.038**

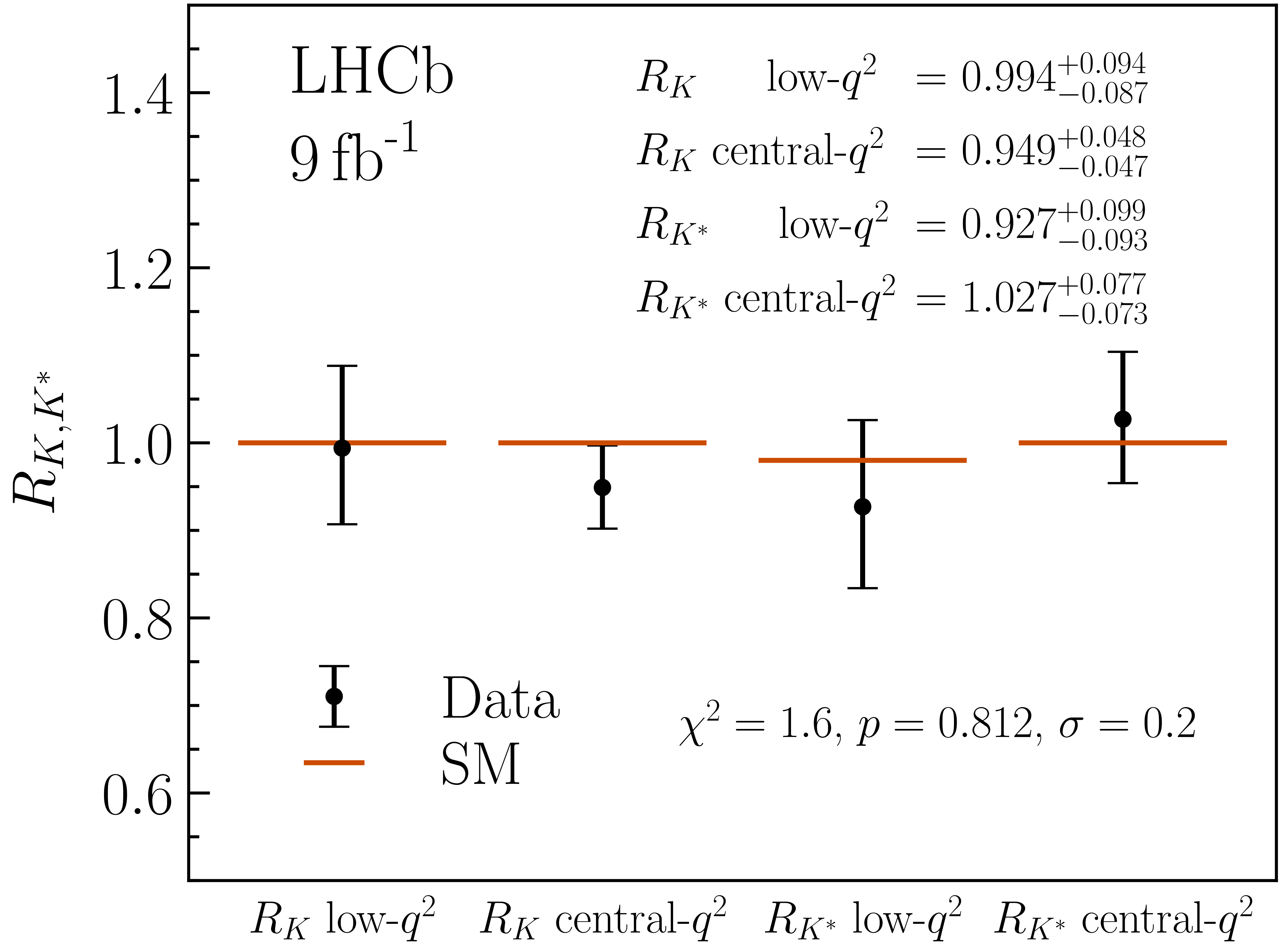
Adds linearly

R. Quagliani, CERN seminar

Renato Quagliani LHC Seminar, CERN 54

Results for R_K & $R_{K^{*0}}$

LHCb-PAPER-2022-046
LHCb-PAPER-2022-045



$$\text{low-}q^2 \begin{cases} R_K = 0.994\ ^{+0.090}_{-0.082}\,(\text{stat})\ ^{+0.029}_{-0.027}\,(\text{syst}), \\ R_{K^*} = 0.927\ ^{+0.093}_{-0.087}\,(\text{stat})\ ^{+0.036}_{-0.035}\,(\text{syst}), \end{cases}$$

$$\text{central-}q^2 \begin{cases} R_K = 0.949\ ^{+0.042}_{-0.041}\,(\text{stat})\ ^{+0.022}_{-0.022}\,(\text{syst}), \\ R_{K^*} = 1.027\ ^{+0.072}_{-0.068}\,(\text{stat})\ ^{+0.027}_{-0.026}\,(\text{syst}), \end{cases}$$

- Most precise and accurate determination of LFU ratios in $b \to s\ell\ell$ decays
- Compatible with the SM prediction

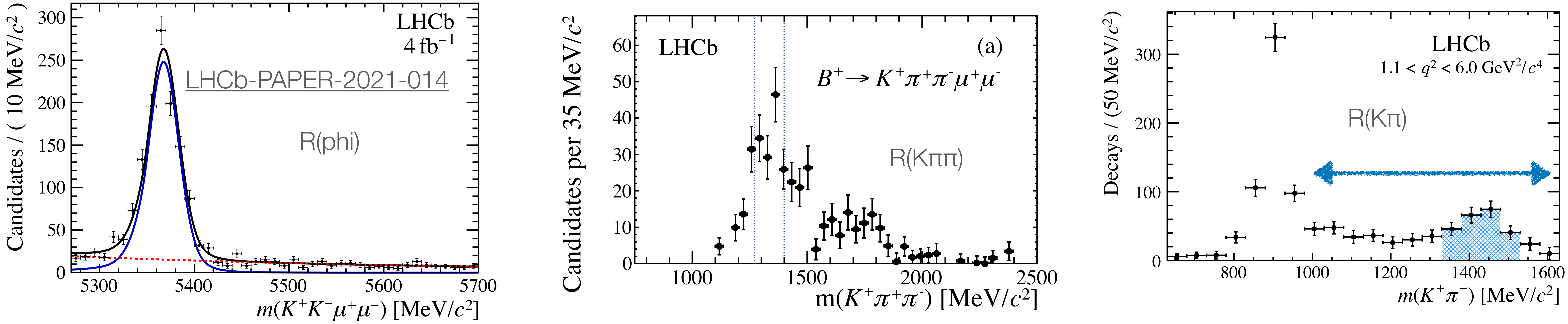
What else from Run1&2?

Many results still to come from Run1+2 data

- LFU test in different channels [$R_{K\pi}$, $R_{K\pi\pi}$, R_{ϕ}, R_{Λ}, R_{π},…]
- Additional bins in q^2, $m(K\pi)$, …
- Comparison of angular distributions between e and μ

[LHCb, arXiv:1808.08865]

R_X precision	$9\,\mathrm{fb}^{-1}$
R_K	0.043
$R_{K^{*0}}$	0.052
R_ϕ	0.130
R_{pK}	0.105
R_π	0.302

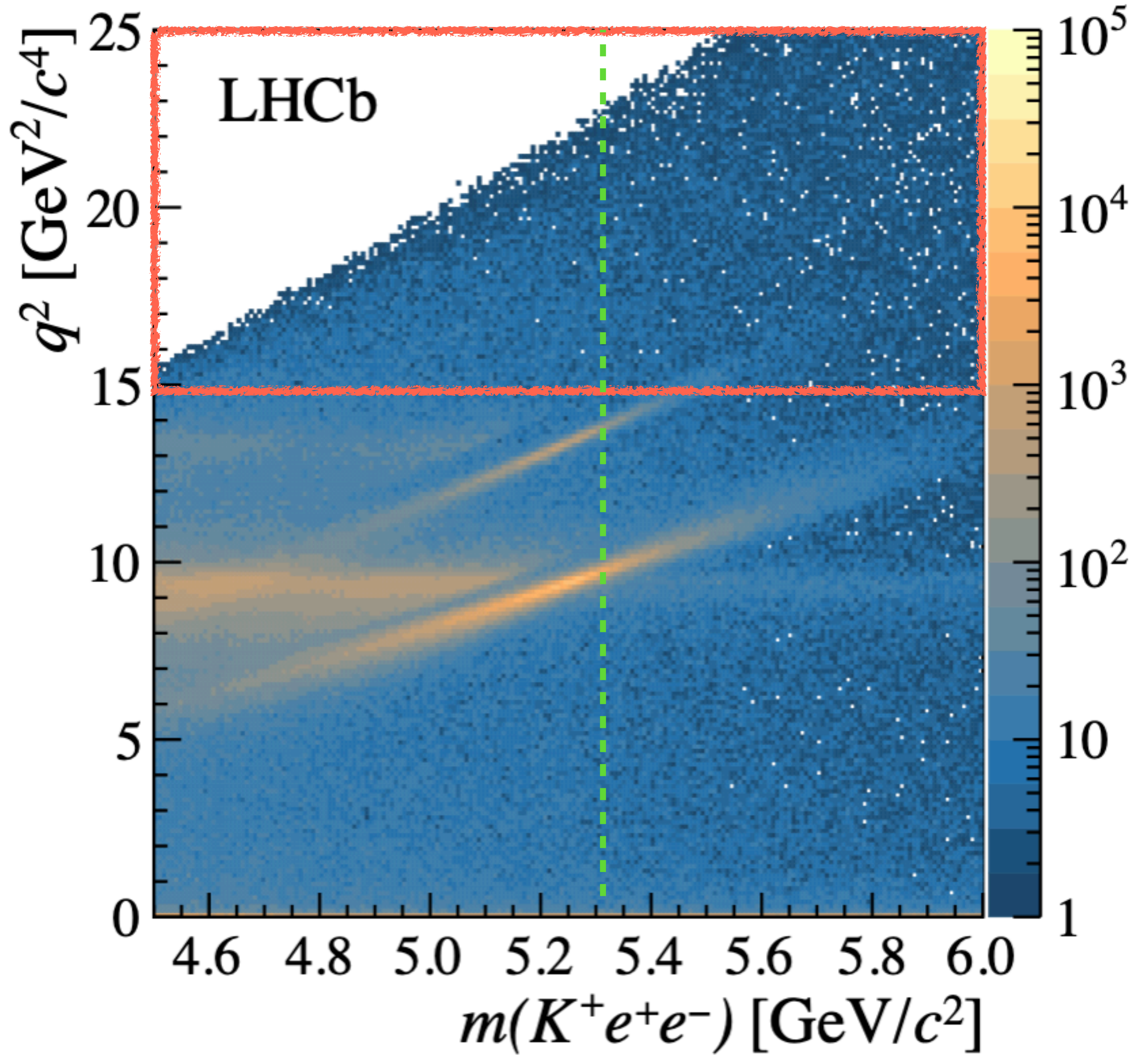


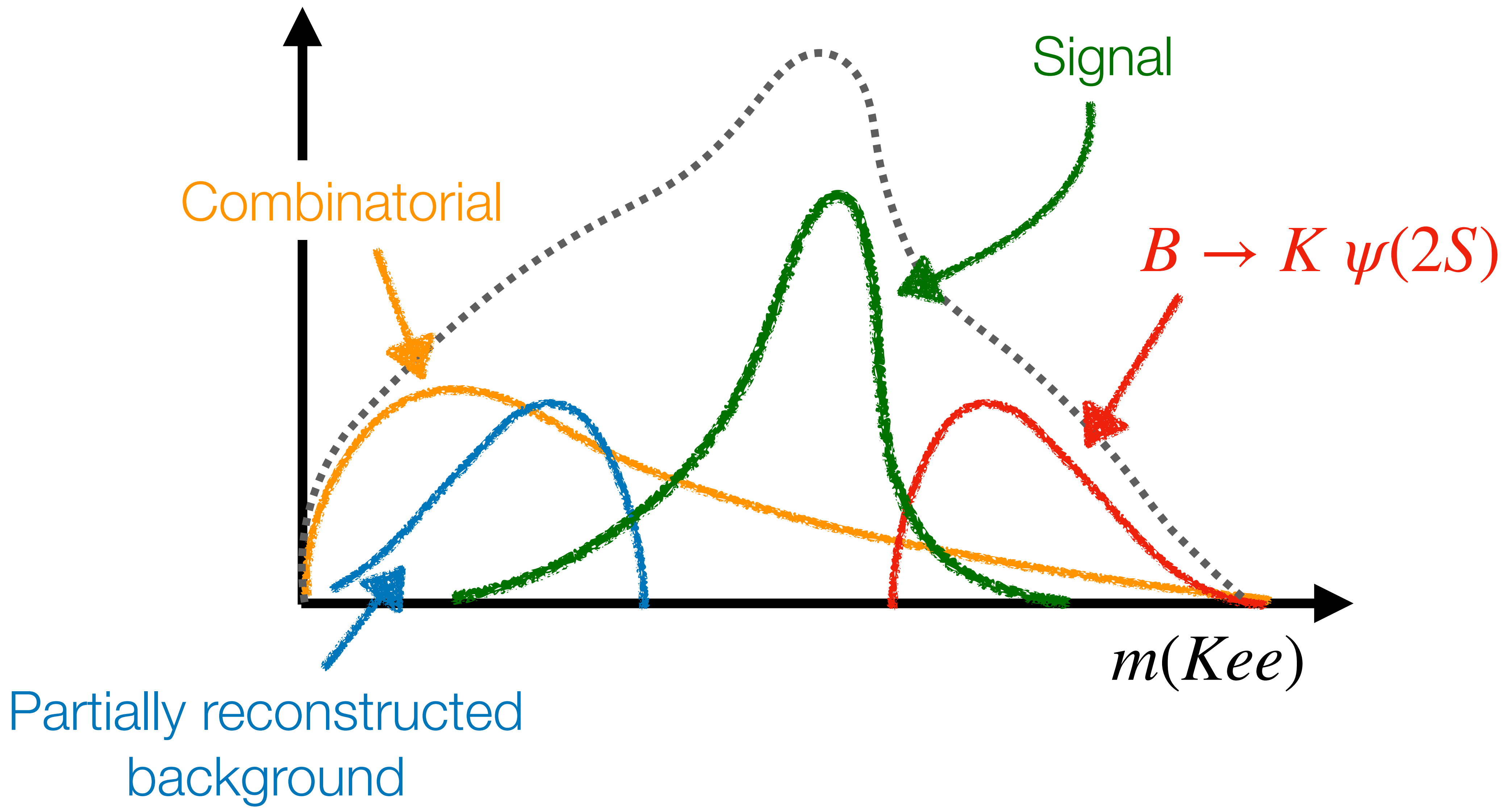
Run1&2: High q^2

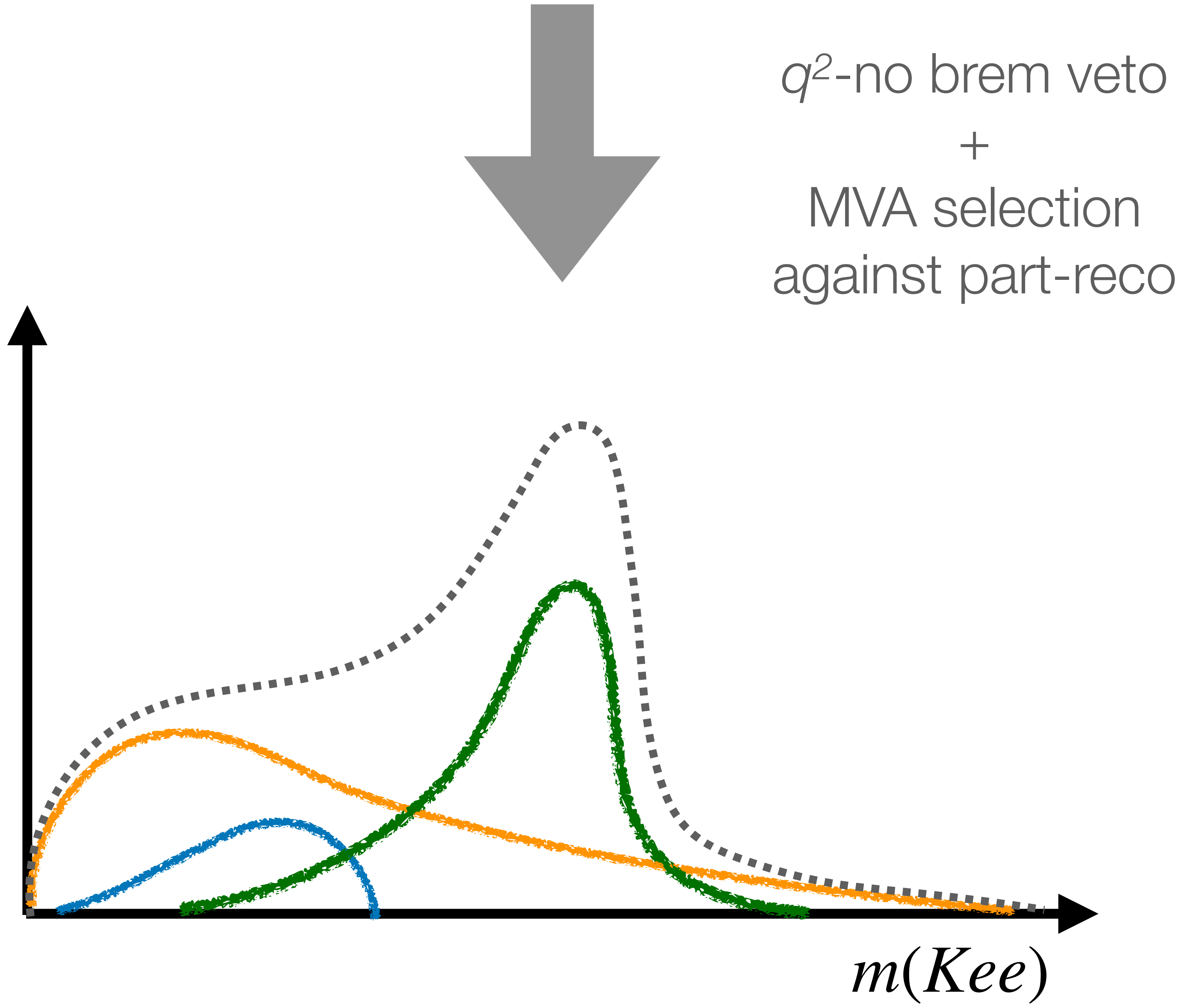
The high q2 region is experimentally more challenging due to interplay between different backgrounds

- use q2 calculated without bremsstrahlung correction (q2-nobrem), multivariate q2 selection, …

[PRL 123 (2019) 241802]

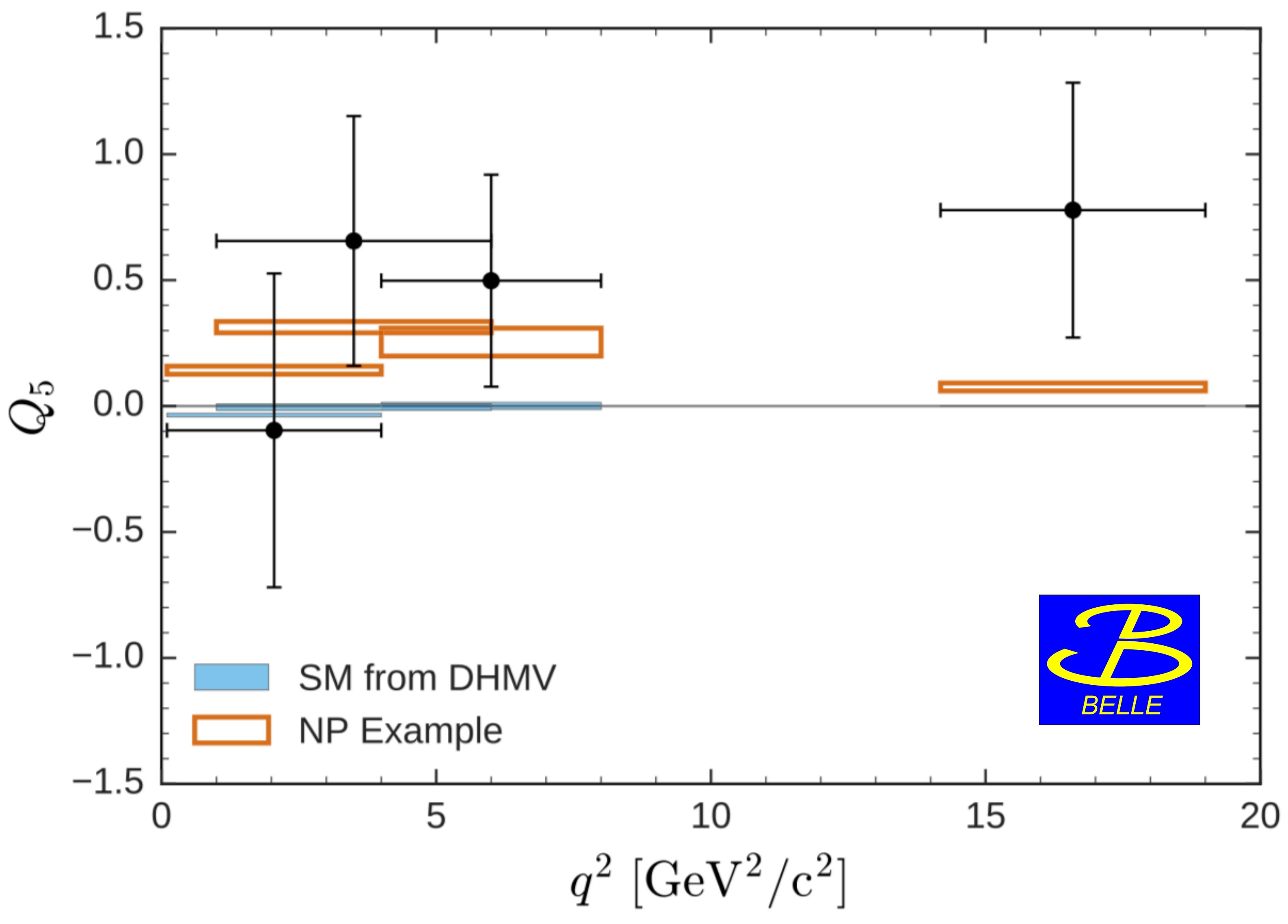




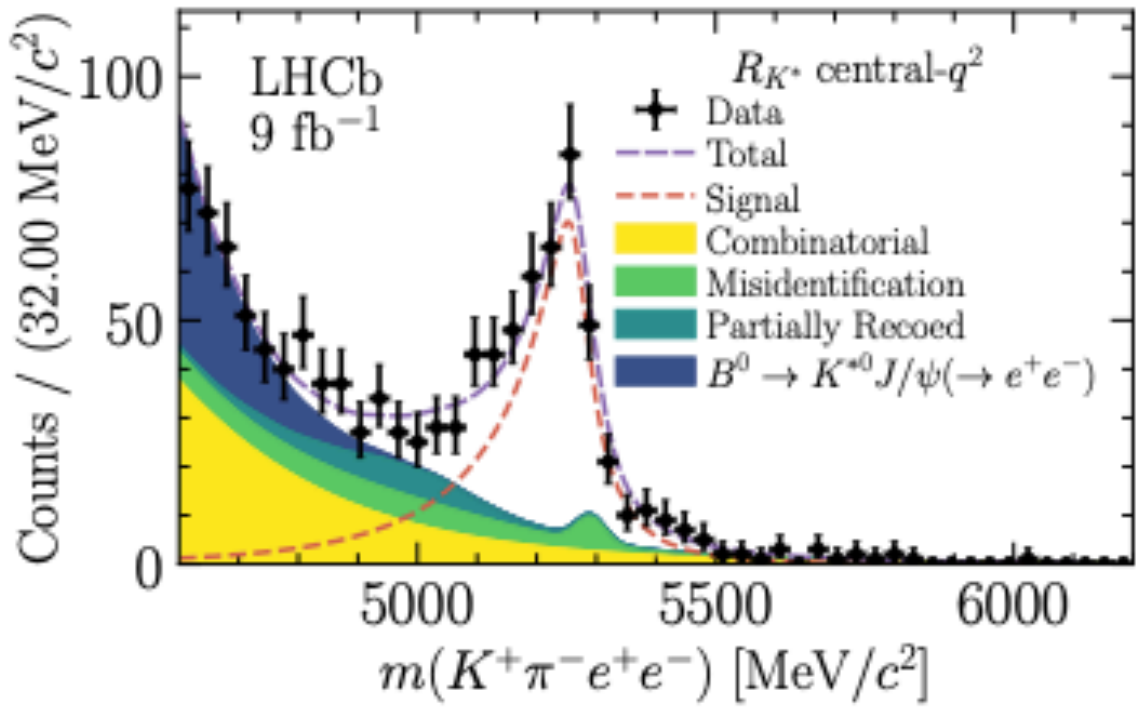


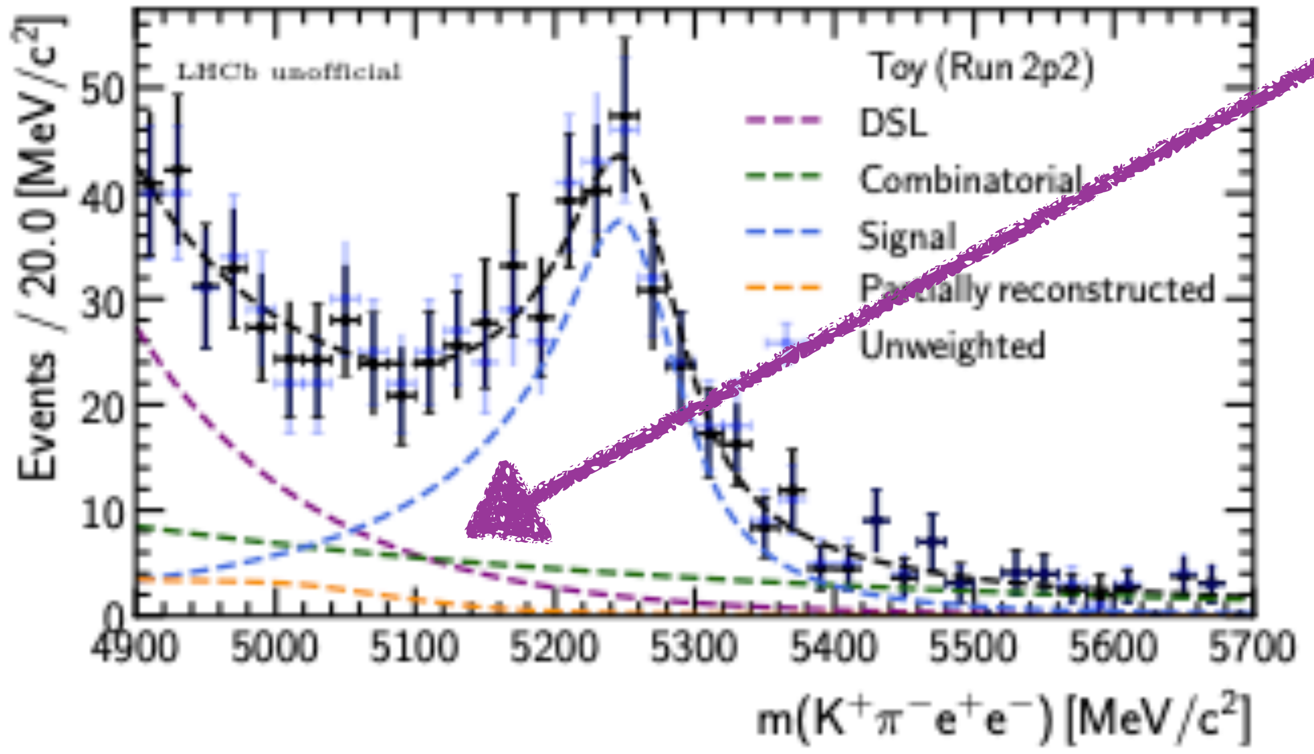
Run1&2: Angular LFU

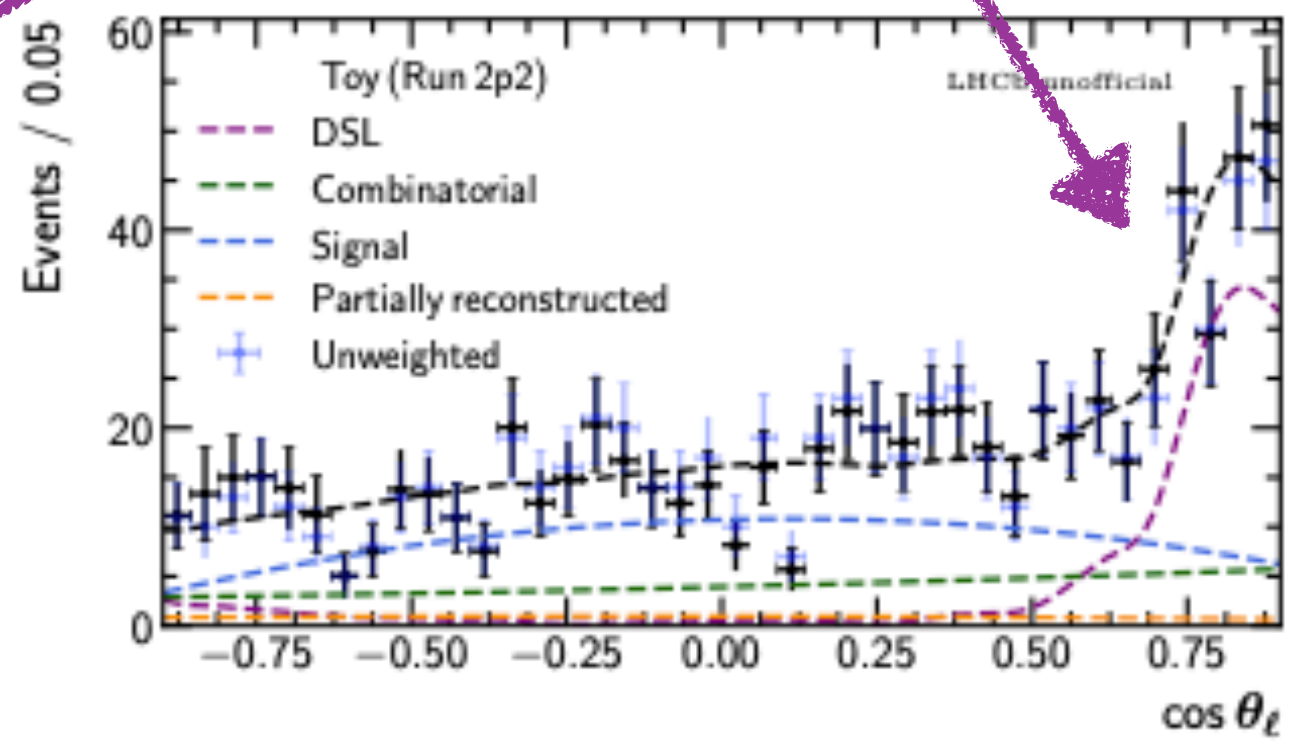
- Difference in angular observables between muons and electrons (e.g. $Q_5 = P'_5(\mu) - P'_5(e)$)
  - Complementary sensitivity to NP effects
  - Very different experimental systematics
- At LHCb, challenges introduced by the worse electron resolution (backgrounds, q^2 migration, …)



[Belle, arXiv:1612.05014]







Double semi-leptonic decays
$B \to D(K\pi e\nu)\, e\nu$

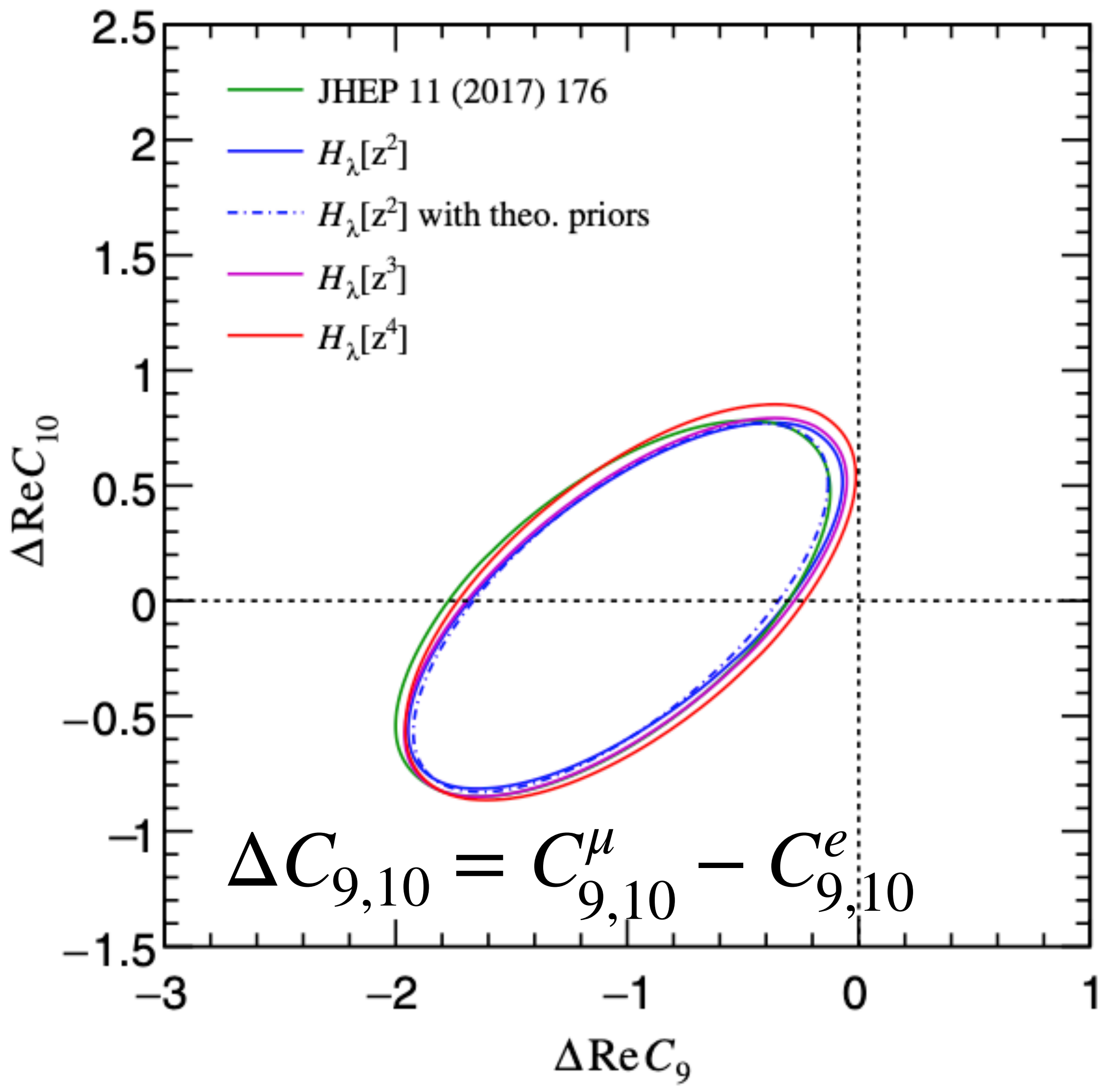
Z. Wang PhD Thesis

Run1&2: Angular LFU

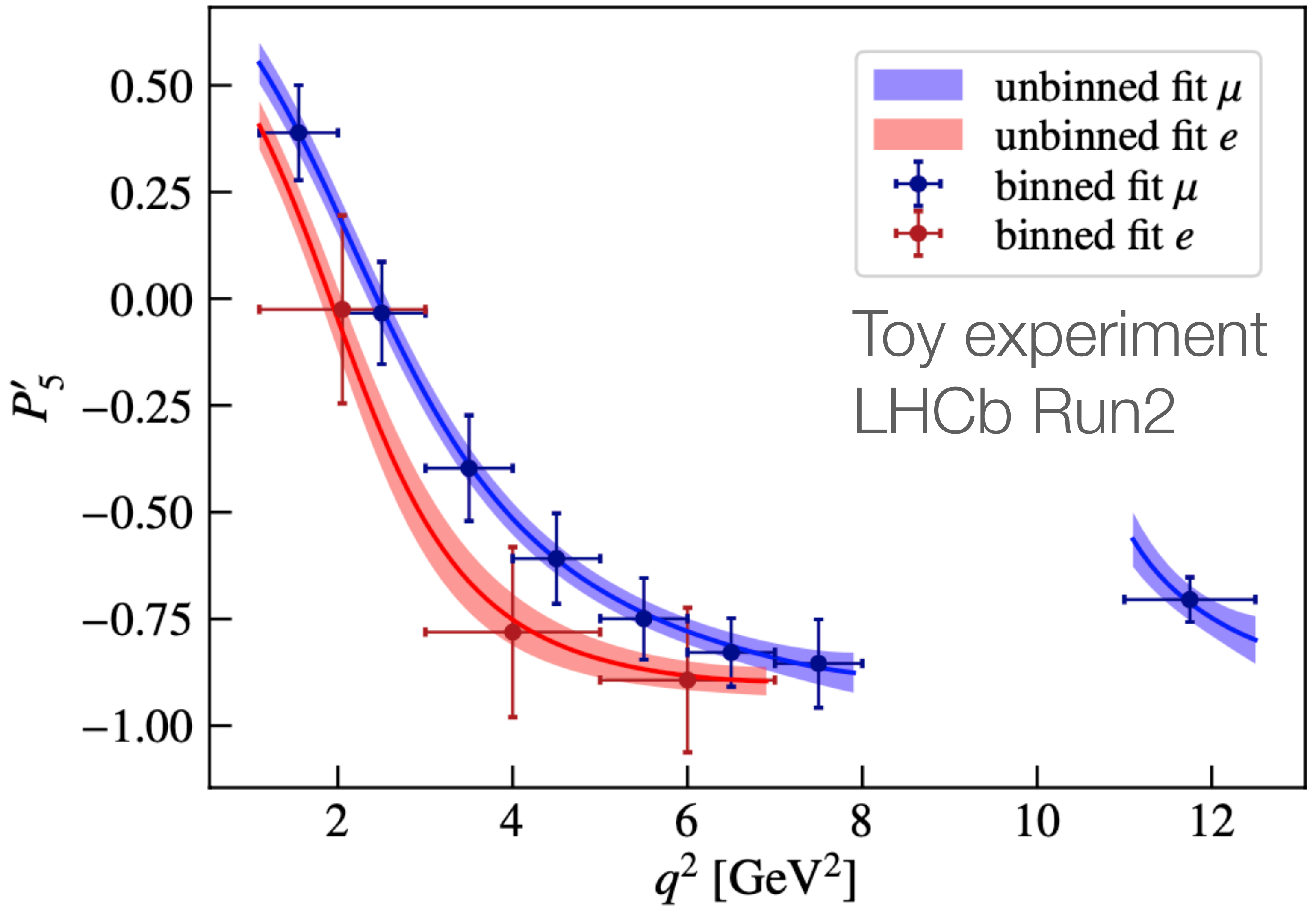
- Unbinned angular analysis to measure the difference in WC's directly:

$$\mathcal{A}_\lambda^{(\ell)\,L,R} = \mathcal{N}_\lambda^{(\ell)} \left\{ \left(C_9^{(\ell)} \mp C_{10}^{(\ell)}\right)\mathcal{F}_\lambda(q^2) + \frac{2m_b M_B}{q^2}\left[C_7^{(\ell)}\mathcal{F}_\lambda^T(q^2) - 16\pi^2\frac{M_B}{m_b}\mathcal{H}_\lambda(q^2)\right]\right\}$$

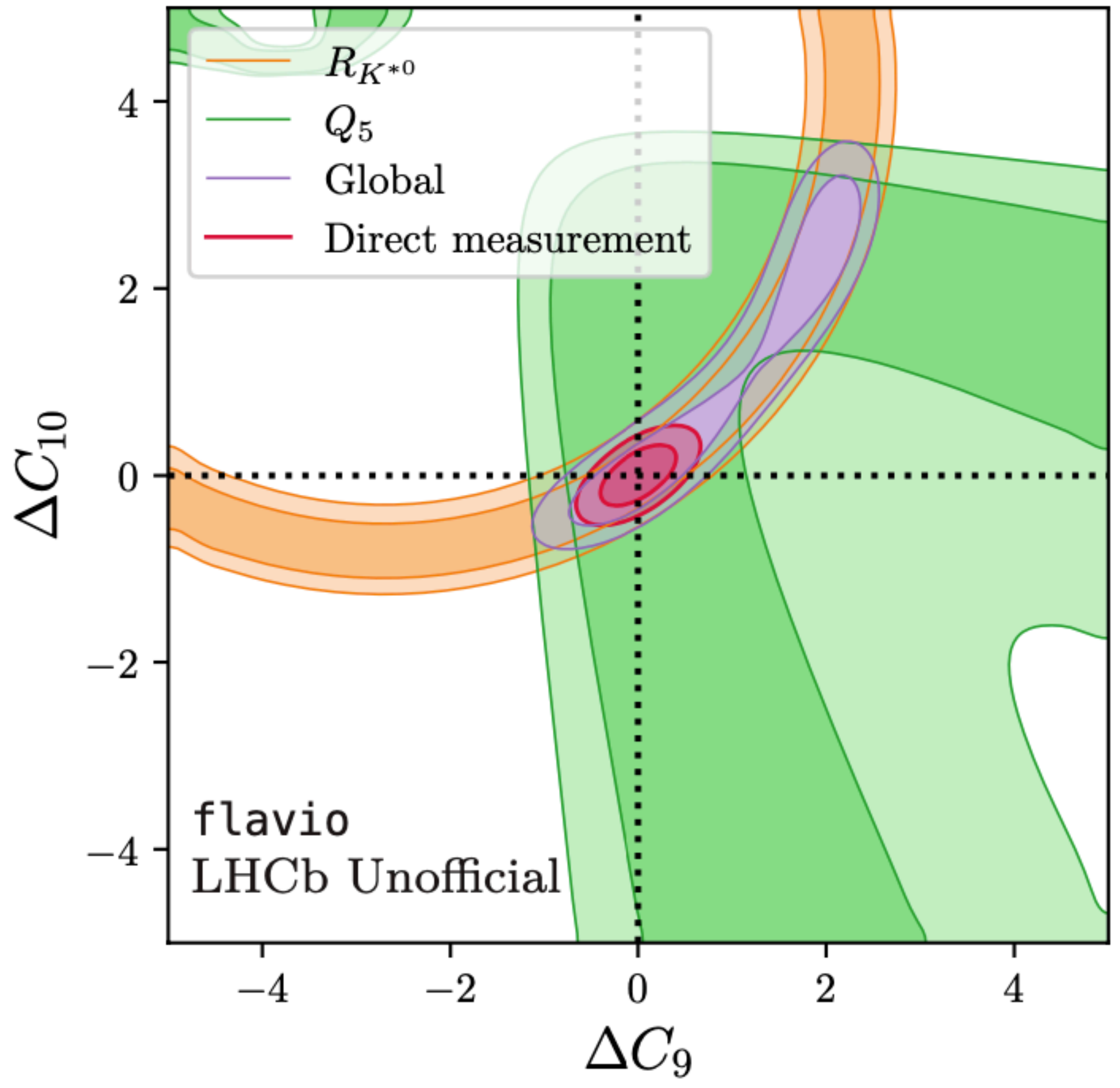
  - $\Delta C_{9,10}$ insensitive to truncation order of non-local contributions
  - Analysis ongoing in central-q2 (in parallel with individual μ/e unbinned analyses)



[PRD 99 (2019) 013007]

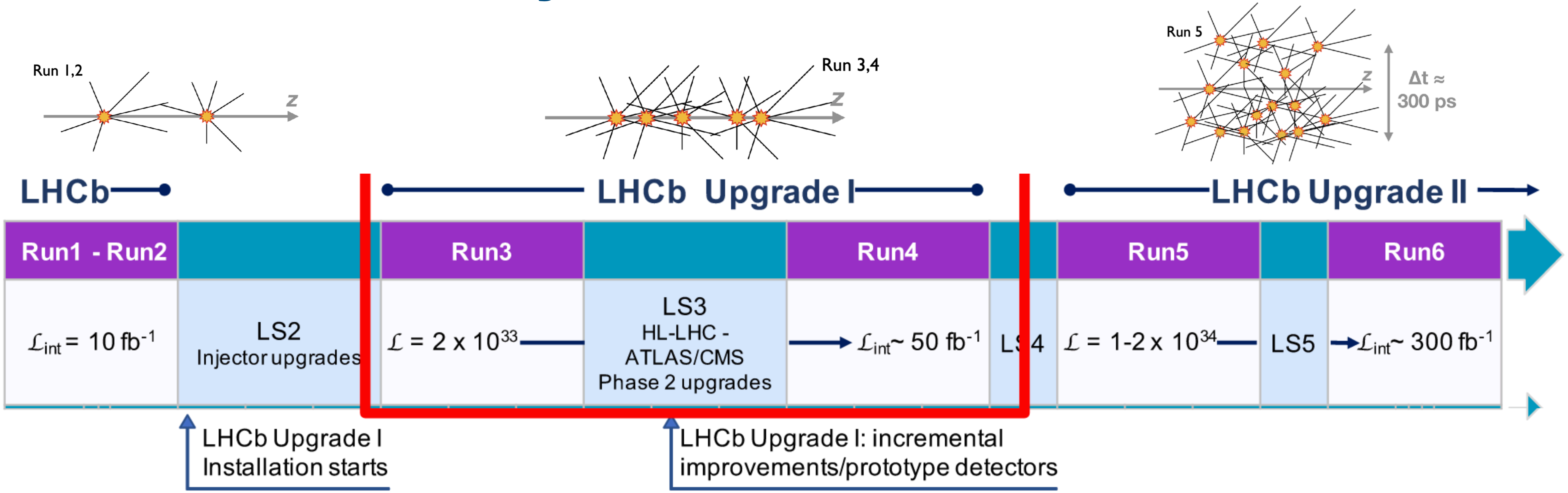


[A. Mauri, PhD Thesis]



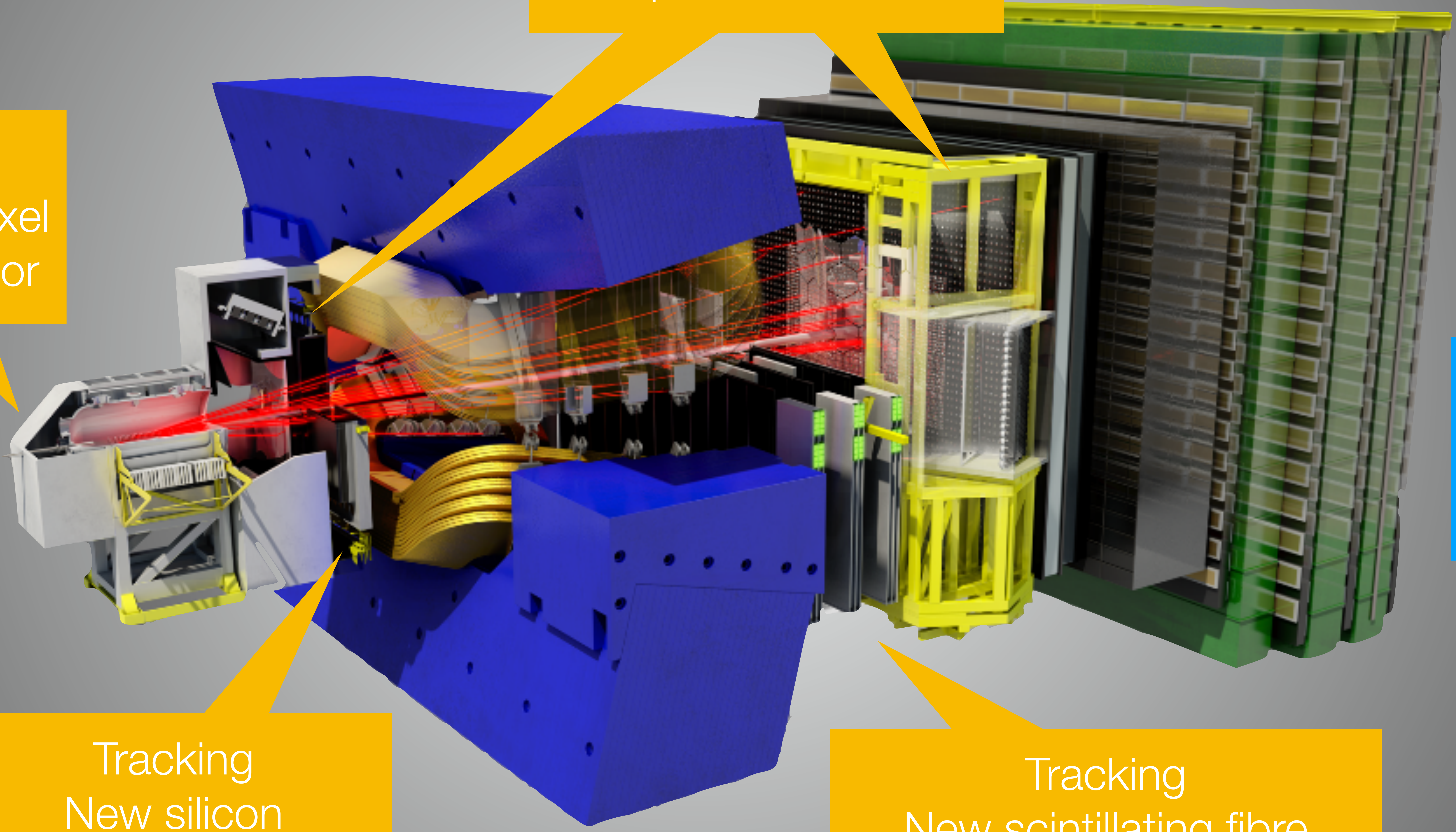
M. Atzeni, PhD Thesis

Run 3 and beyond



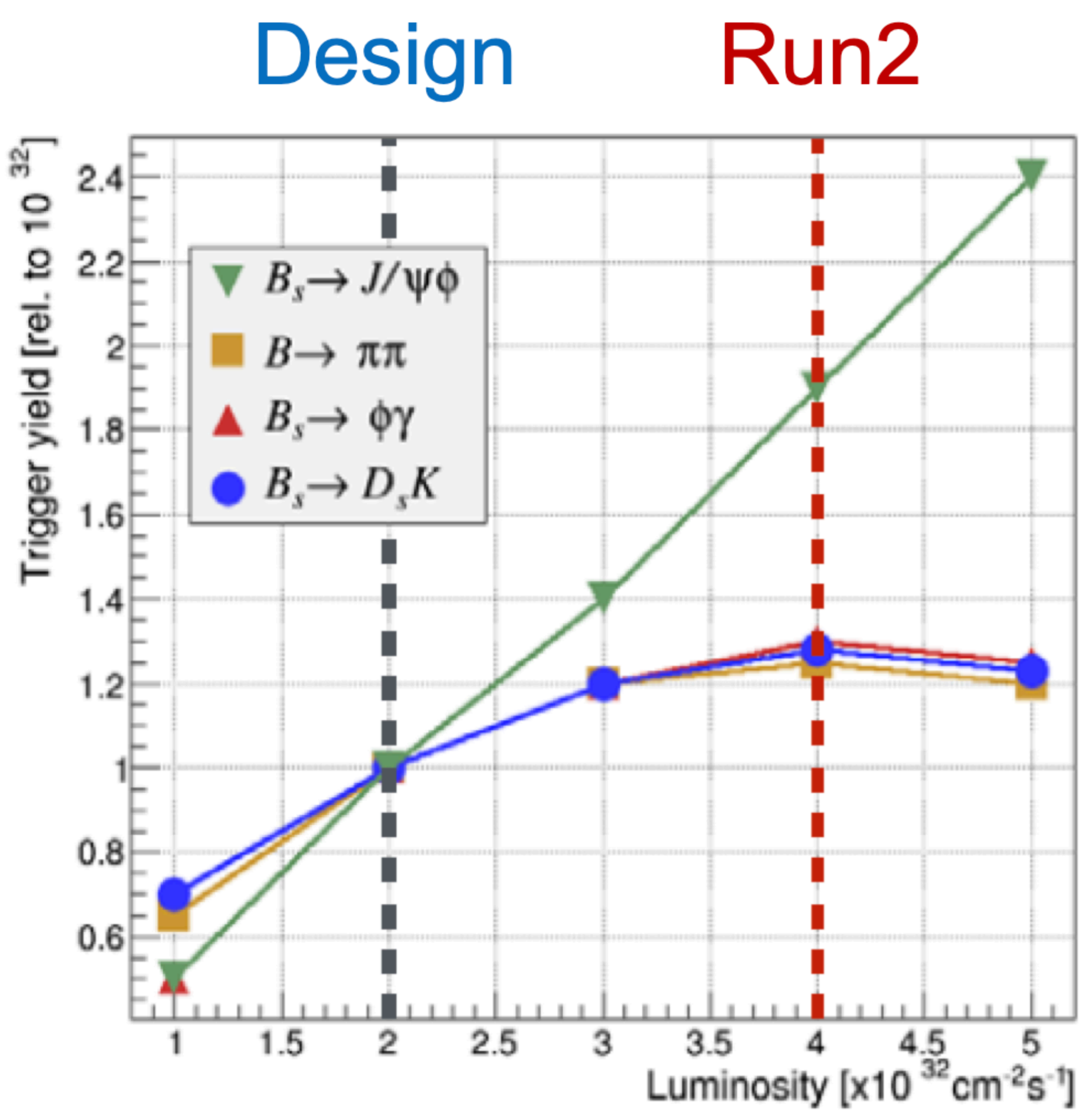
- **LHCb Upgrade I for Run3 and Run4** ($\mathscr{L} \sim 2 \times 10^{33}\ s^{-1}cm^{-2}$)
  - Large detector upgrade, trigger-less readout and full software trigger
  - Goal is to keep the excellent performance of Run1&2 in a more challenging environment
- LHCb Upgrade II to fully profit from HL-LHC ($\mathscr{L} \sim 2 \times 10^{34}\ s^{-1}cm^{-2}$)
  - Novel technologies and timing information to deal with the pile up in the HL-LHC

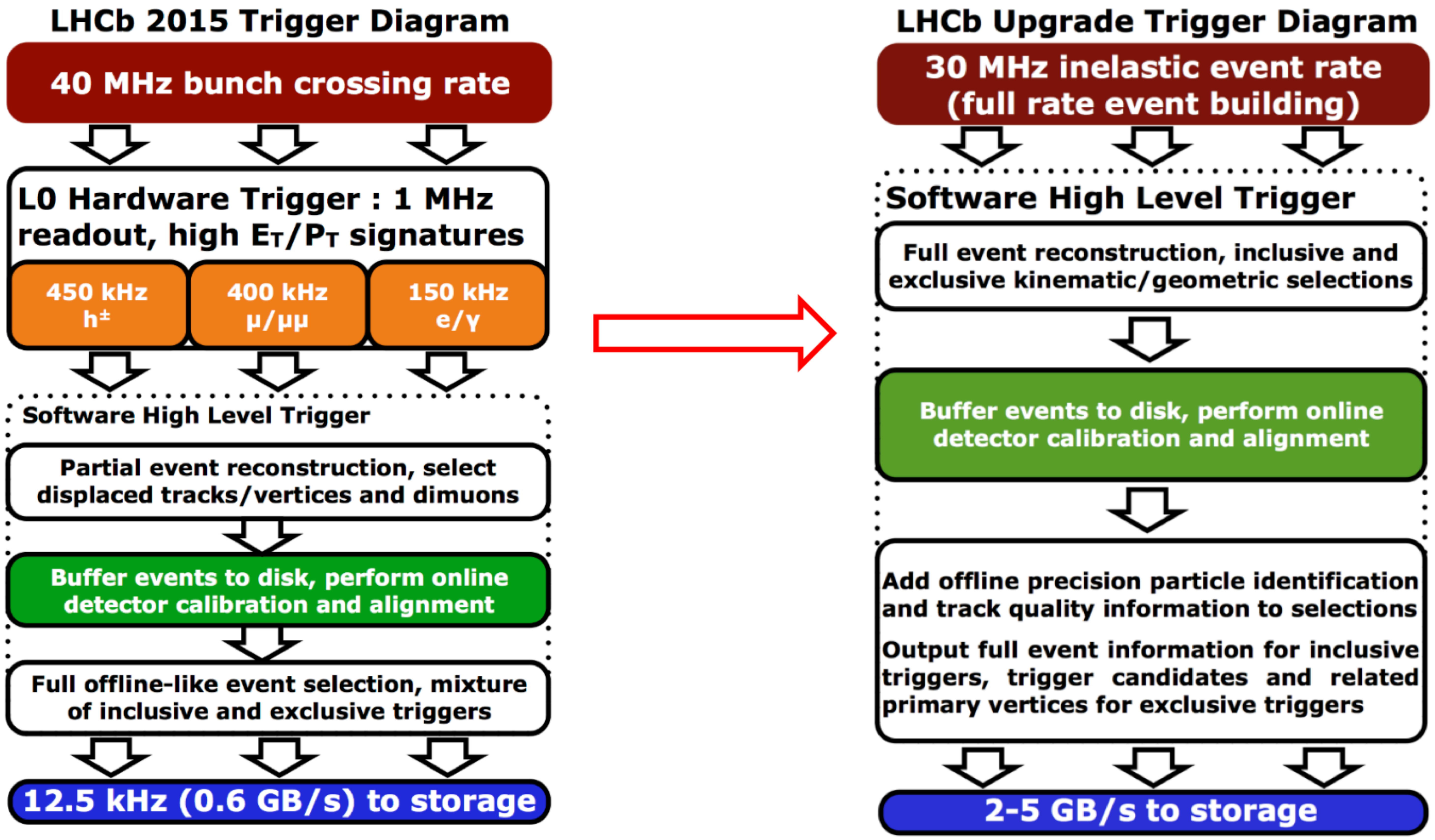
LHCb Upgrade I



Going Trigger-less & fully software

Remove limitations from the hardware trigger, to fully profit from the higher luminosity





Collect data at 5x the rate for di-muon channels and 10x the rate for hadronic channels

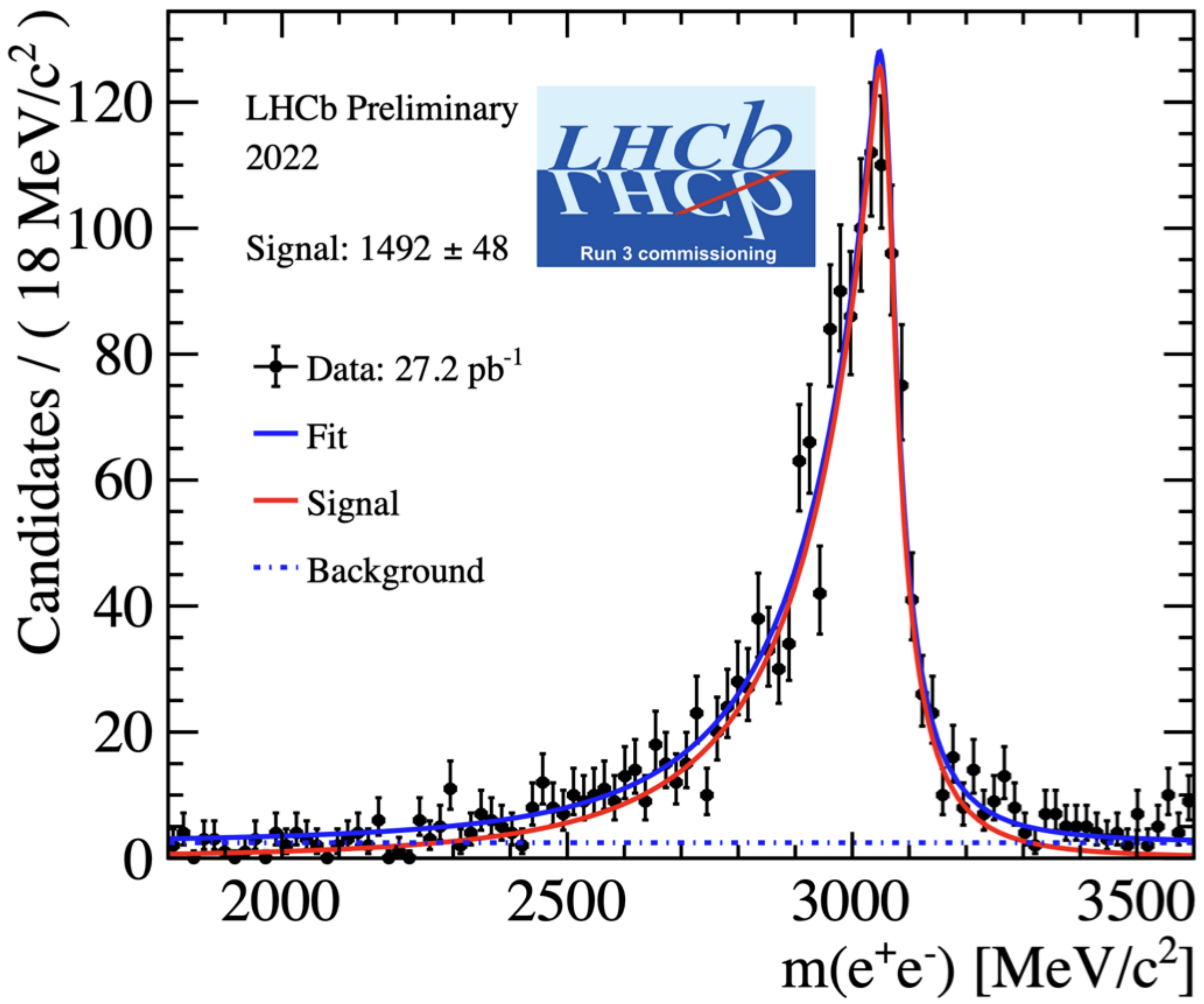
Electrons in Run3

- LHCb will be running at higher lumi ⇒ more pile-up (~5x more tracks)
  - New tracking & vertexing
  - ECAL remains unchanged (new electronics) and removal of PS and SPD detectors
  - Removal of the hardware trigger

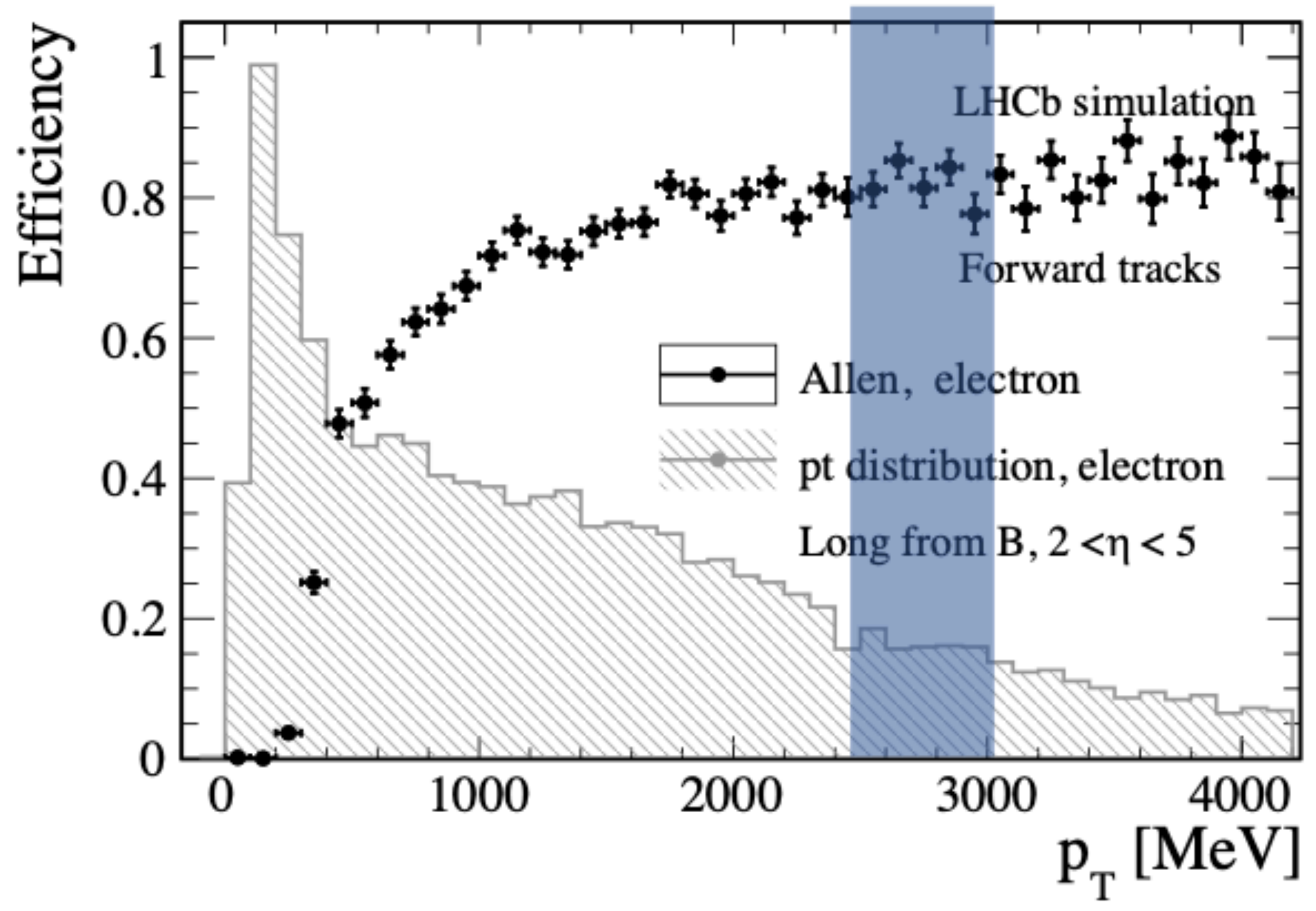
- Larger occupancy & more material: more background in the calorimeter & larger energy loss
  - Momentum and mass resolution (Brem. recovery)
  - Electron ID is more challenging in this environment

    Significant work to improve electron & calorimeter reconstructions

- Software trigger: use higher level information to select electrons more efficiently
  - recover efficiency lost in the L0 and the L0 related systematic errors disappear (better kinematic overlap between μ and e)



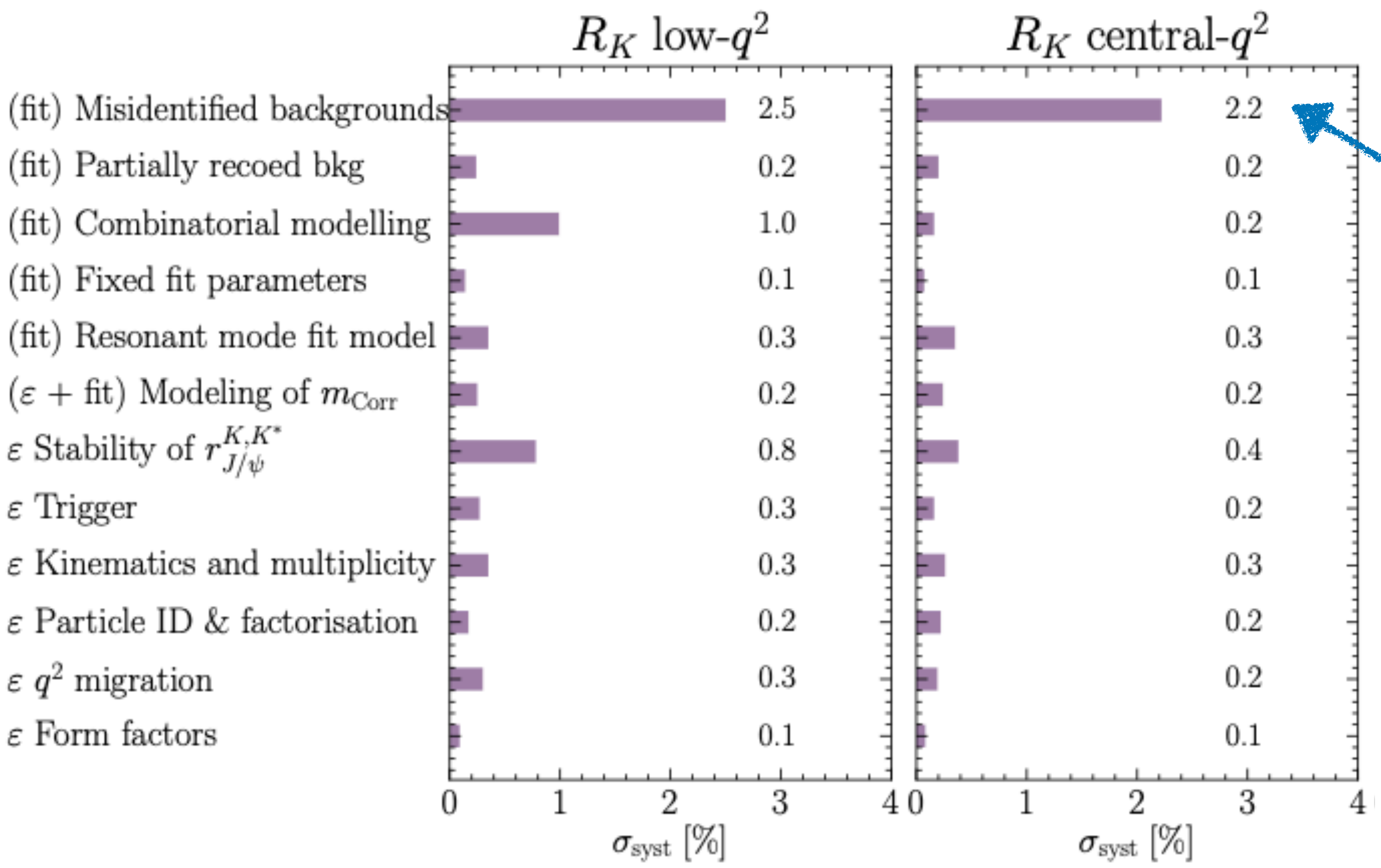
L0Electron thresholds in Run1/2



LFU in Run 3 and beyond

- R_K and start to get systematically limited towards the end

LHCb-PAPER-2022-045



Systematic associated with the determination of misID backgrounds:
- Uncertainty on the transfer function (calibration samples)
- Definition of control regions

Statistical component will be reduced with more data
Detailed studies of misID backgrounds & $B \to Khh'$ Dalitz structures will help keeping these under control

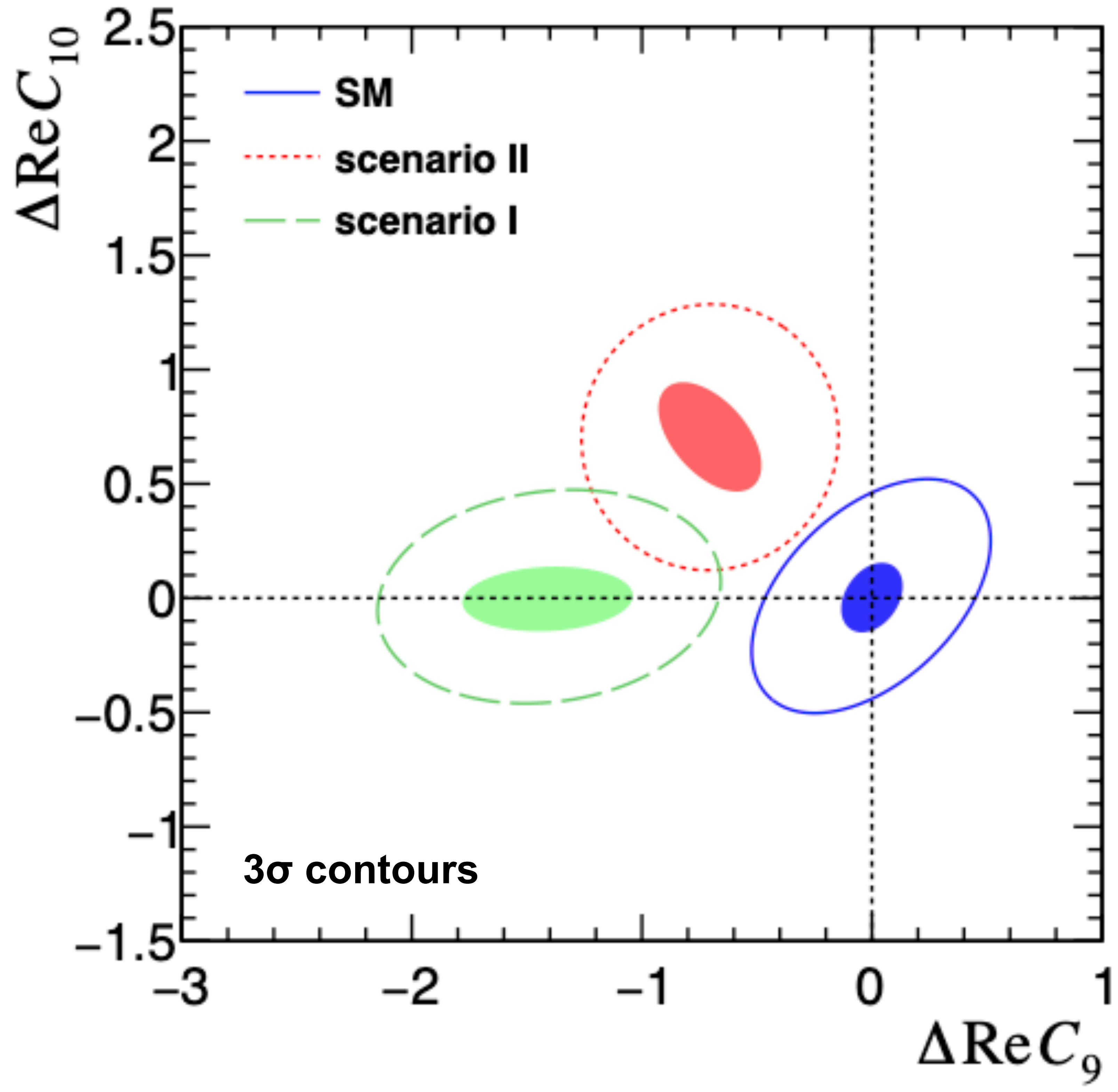
- Other ratios achieving sensitive precision
- Ability to define smaller q^2 bins

[LHCb, arXiv:1808.08865]

R_X precision	$9\,\text{fb}^{-1}$	$23\,\text{fb}^{-1}$	$50\,\text{fb}^{-1}$
R_K	0.043	0.025	0.017
$R_{K^{*0}}$	0.052	0.031	0.020
R_ϕ	0.130	0.076	0.050
R_{pK}	0.105	0.061	0.041
R_π	0.302	0.176	0.117

LFU in Run 3 and beyond

- Comparison of the angular distributions between electrons and muons will give the ultimate precision in LFU observables, allowing to distinguish between NP scenarios



[LHCb, arXiv:1808.08865]

Lines: Run3
Shaded areas: Upgrade II

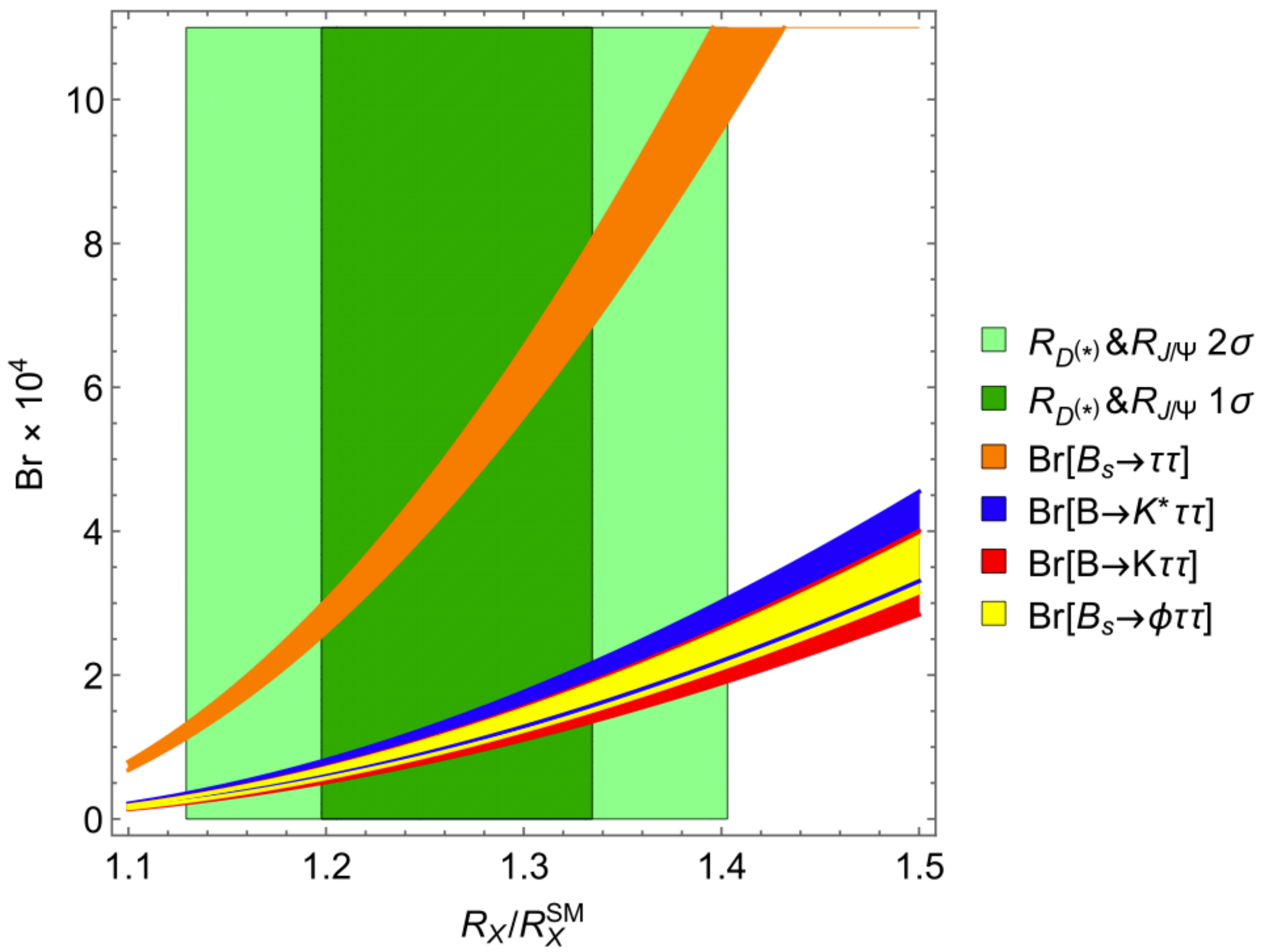
μ vs τ?

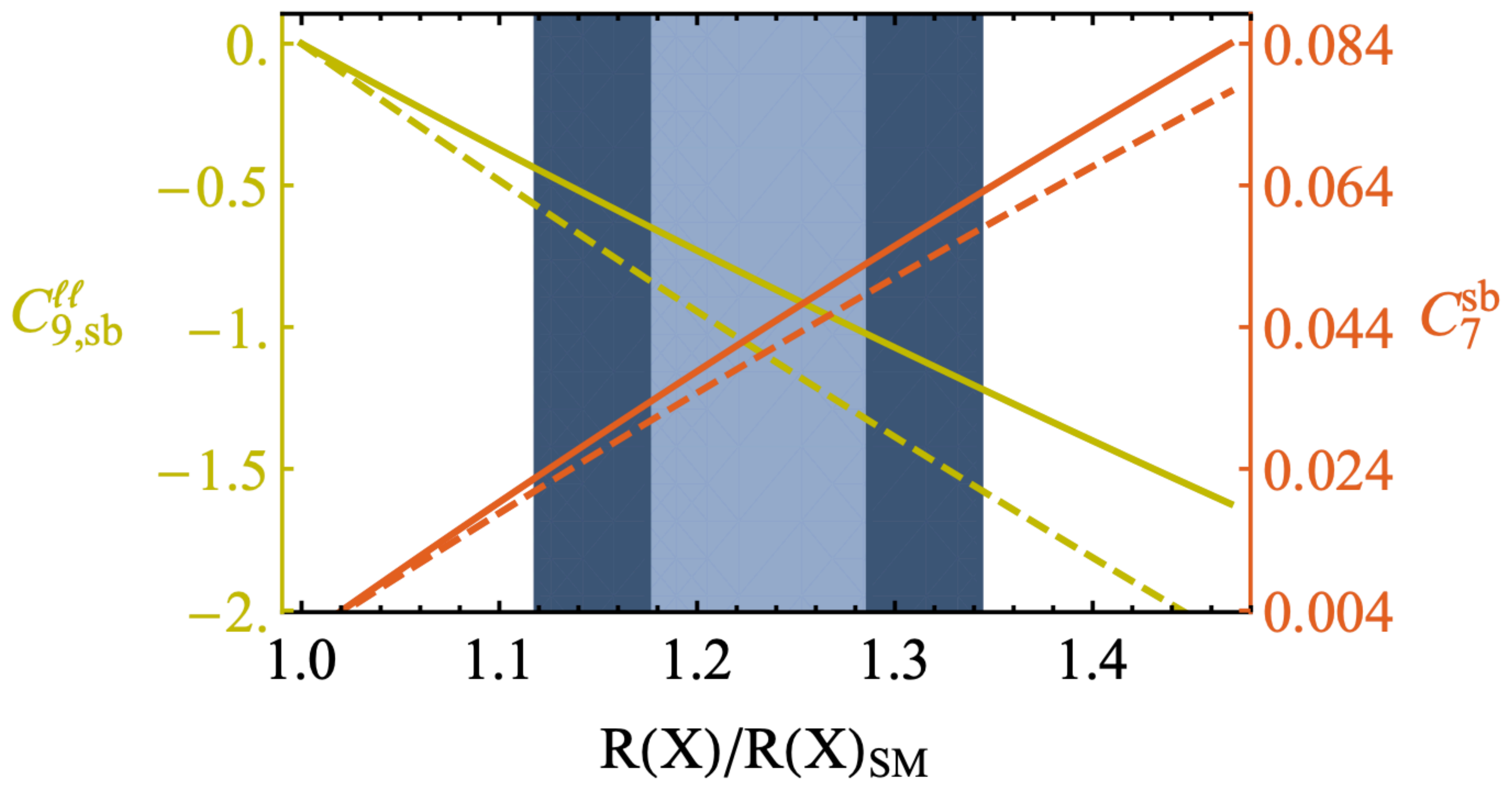
- Attempts to explain LFU violating effects in R(D)-R(D*) tend to enhance $b \to s\tau\tau$ couplings
- As a bonus, one obtains higher order corrections to $b \to s\ell\ell$, causing a LFU shift in C_9
  - In many models additional couplings to lighter leptons can be included to take care of e/μ LFnU

		SM prediction
$B_s \to \tau\tau$		$(7.73 \pm 0.49) \times 10^{-7}$
$B \to K\tau\tau$	$[15, 22]\mathrm{GeV}^2/c^2$	$(1.20 \pm 0.12) \times 10^{-7}$
$B \to K^*\tau\tau$	$[15, 19]\mathrm{GeV}^2/c^2$	$(0.98 \pm 0.10) \times 10^{-7}$
$B_s \to \phi\tau\tau$	$[15, 18.8]\mathrm{GeV}^2/c^2$	$(0.86 \pm 0.06) \times 10^{-7}$

Bobeth et al, PRL 112 (2014) 101801, Capdevila et al, PRL120 (2018) 181802

Capdevila et al, PRL120 (2018) 181802

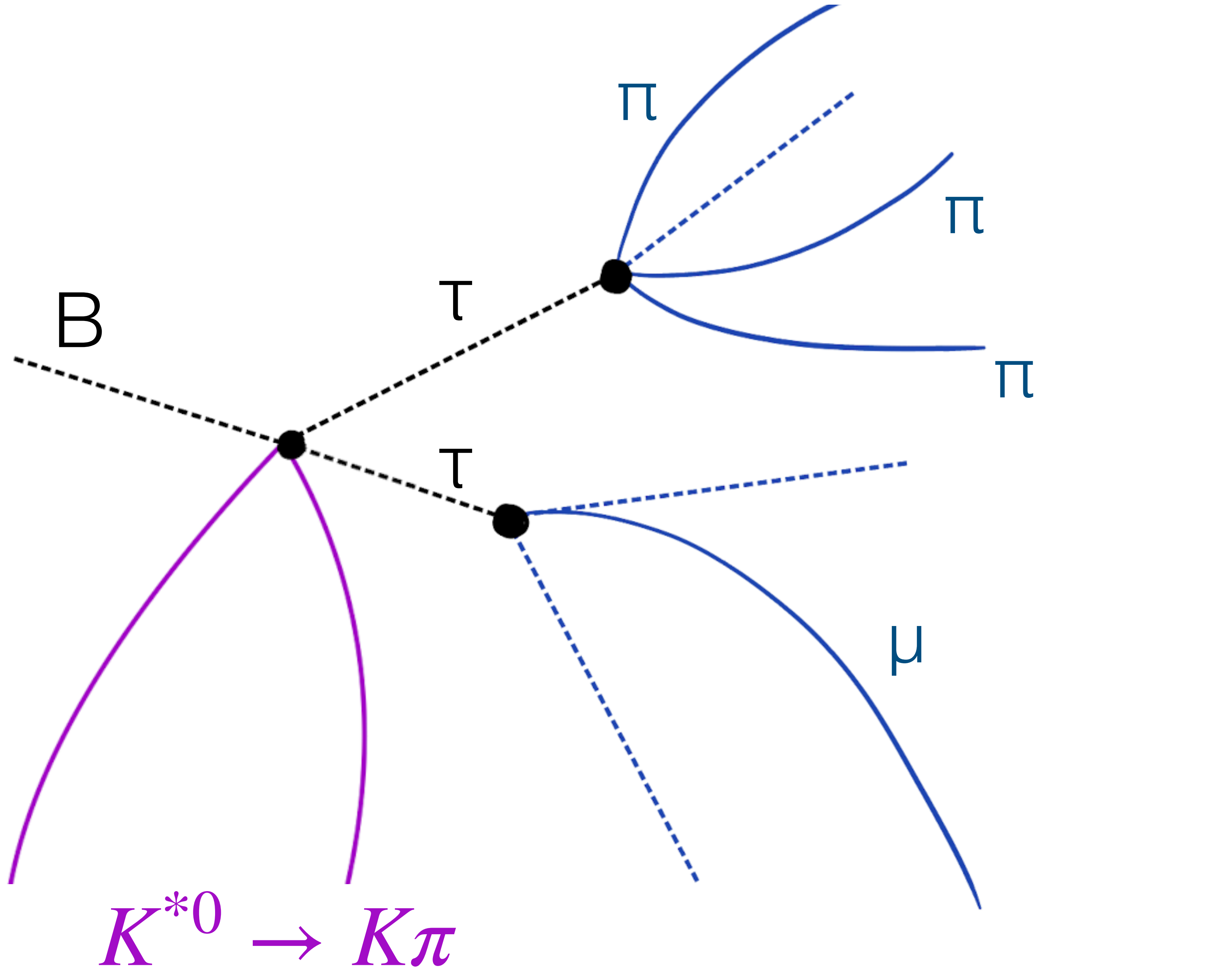


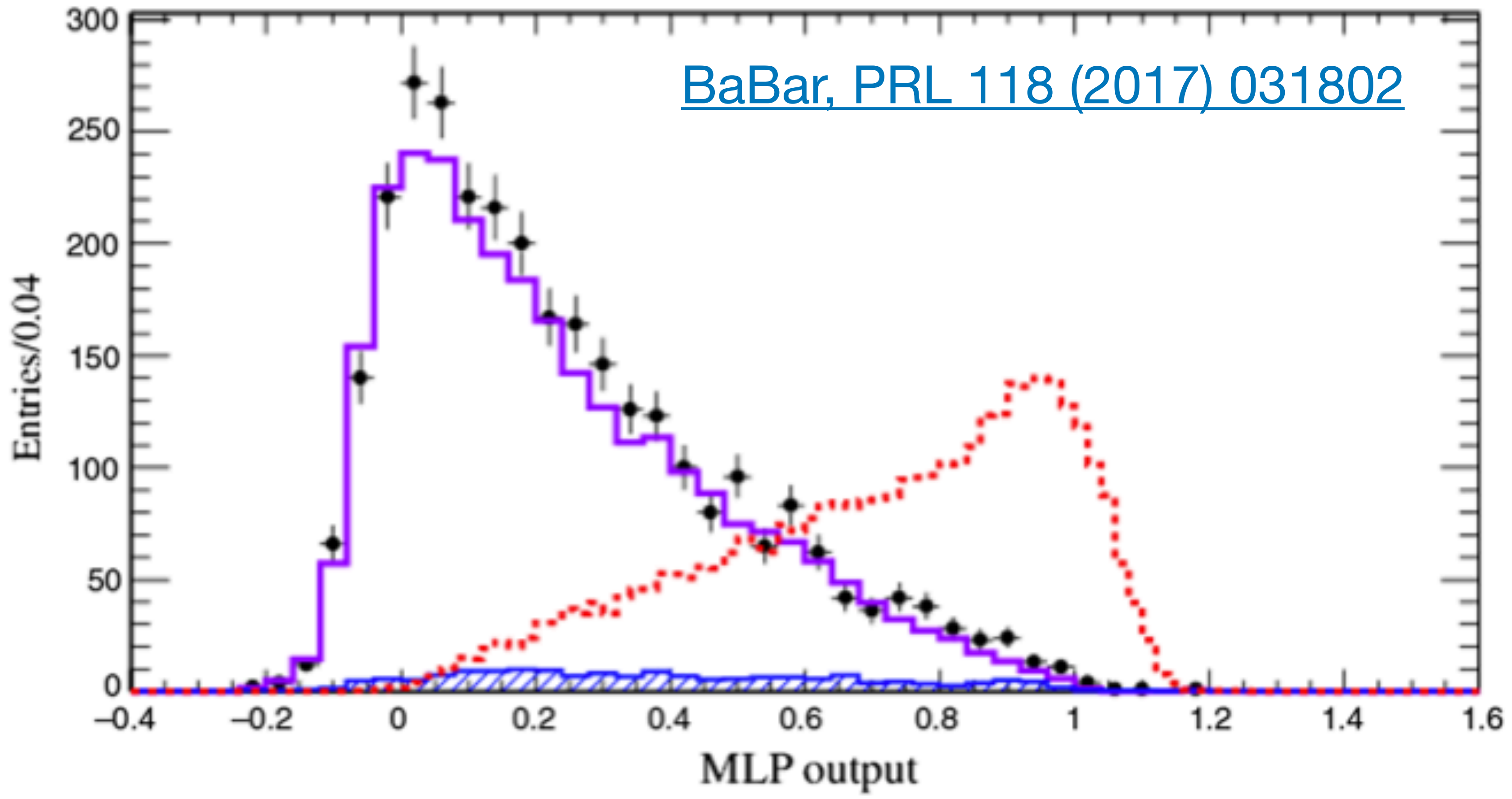


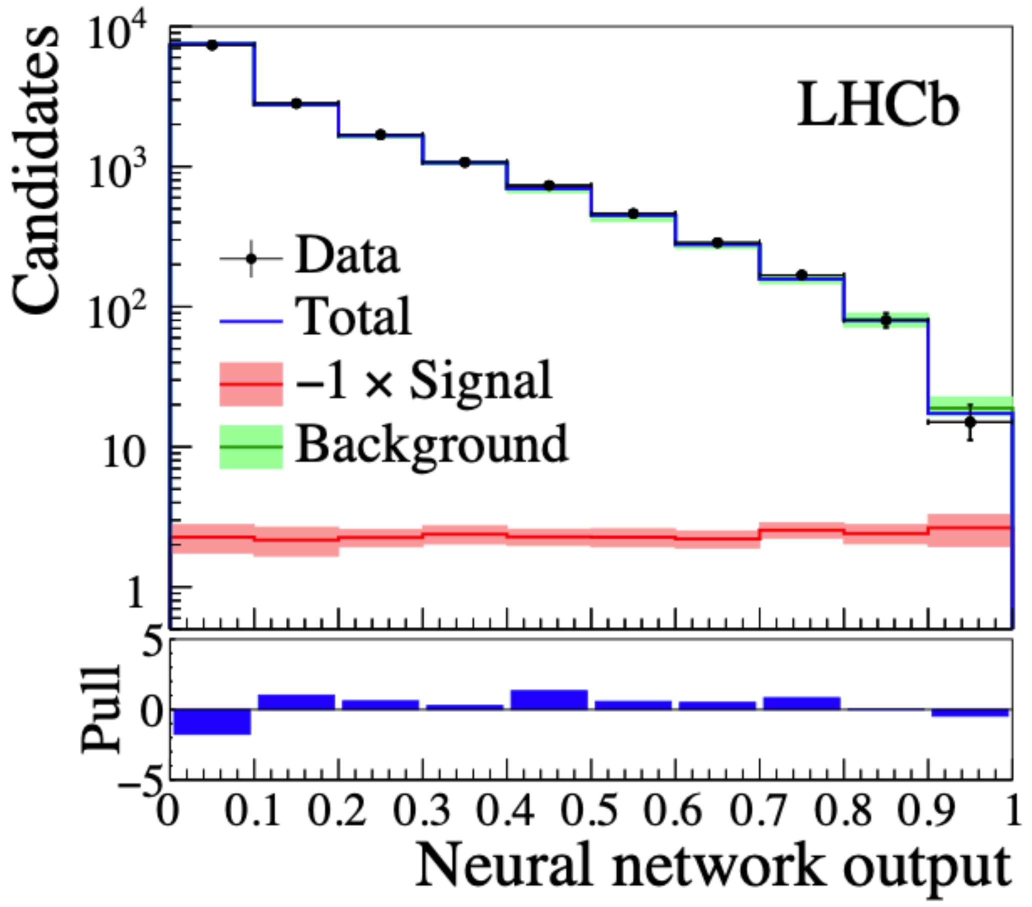
Crivellin et al, PRL 122 (2019) 011805

$b \to s\tau\tau$

- At least two undetected neutrinos in the final state
  - Mass resolution, backgrounds ($B \to DDX$)
  - challenging for both Belle II and LHCb







LHCb, PRL 118 (2017) 251802

A lot of work ongoing on the experiments to improve these limits

- Additional modes (e.g. $B_s \to \phi\tau\tau$, $\Lambda_b \to pK\tau\tau$)
- Favourable kinematic regions
- Both hadronic and leptonic τ decays
- ττ→μμ re-scattering in $B \to K\mu\mu$

Limit [95% CL]	Current	LHCb $[9/fb]$	LHCb $[50/fb]$	LHCb $[300/fb]$	Belle II $[50/ab]$
$B_s \to \tau\tau$	6.8×10^{-3} (LHCb)	3×10^{-3}	1×10^{-3}	5×10^{-5}	8×10^{-3} (*)
$B^+ \to K^+\tau\tau$	2.25×10^{-3} (BaBar)				1×10^{-5}
$B^0 \to K^{*0}\tau\tau$	2.25×10^{-3} (BaBar)	3×10^{-4}	1×10^{-4}	5×10^{-7}	1×10^{-5}

[J. Cerasoli, PhD Thesis]

[LHCb, arXiv:1808.08865]

[Belle II, PTEP(2019)123C01]

(*) Assumes 5/ab at the Υ(5S)

Summary

- Latest measurement of R_K and $R_{K^{*0}}$ in agreement with the SM prediction
  - Most accurate description of the misID background in the electron modes
- Many LFU measurements still to come from LHCb Run1&2 samples
  - Additional modes, high q2 and first angular μ/e comparisons
- Ongoing Run3 comes with new challenges but we are working hard to maintain performance unchanged
- Increase in data rate opens new possibilities for precision LFU measurements
  - $b \to d\ell\ell$
  - Differential measurements with finer binning
- Belle II will be complementary in the study of $b \to s\ell\ell$ transitions
  - Crucial for measurements of $b \to s\tau\tau$ and invisible final states

Backup

$B_s \to \tau\tau$

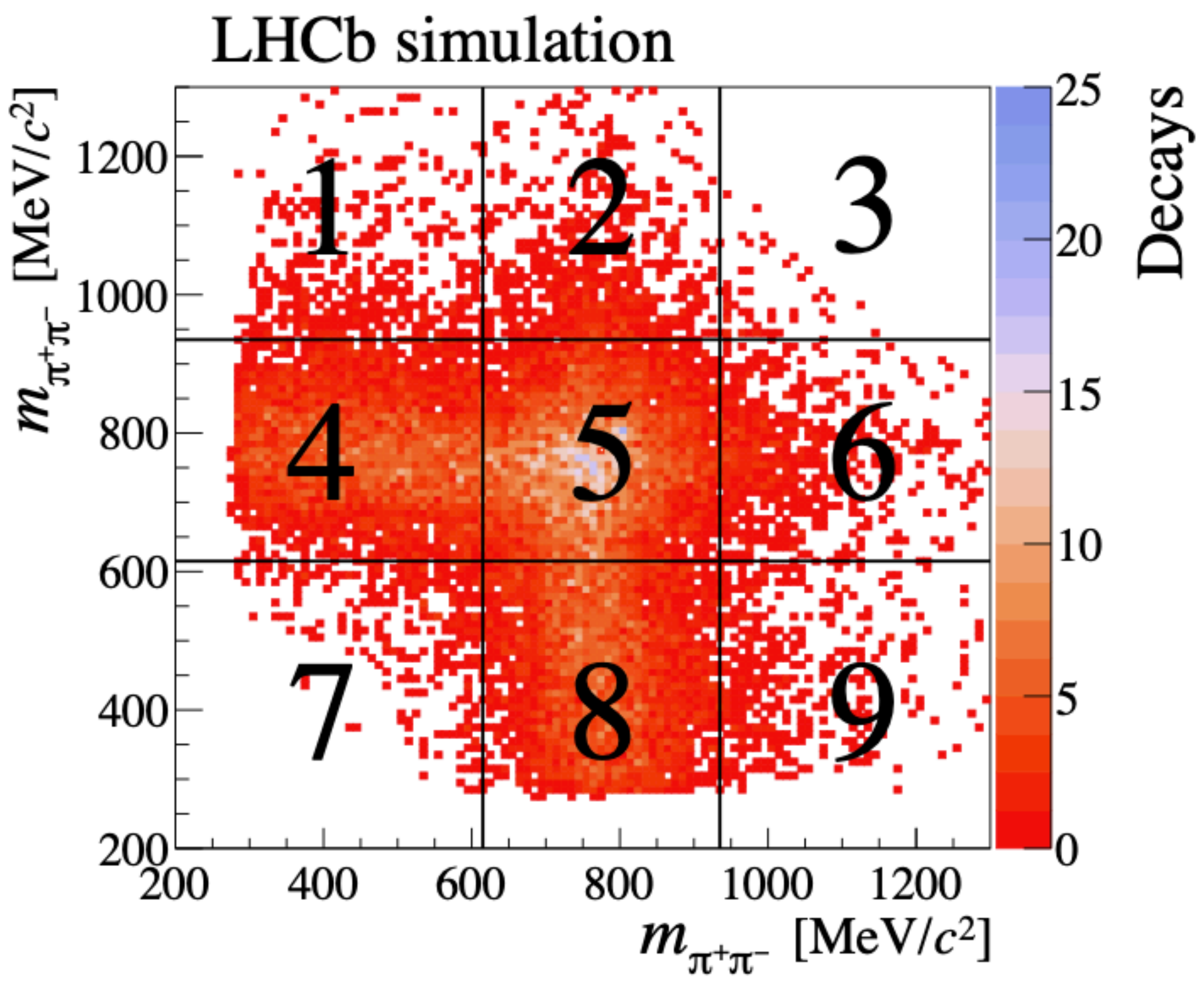
- Only limit coming from LHCb Run1, using hadronic τ decays

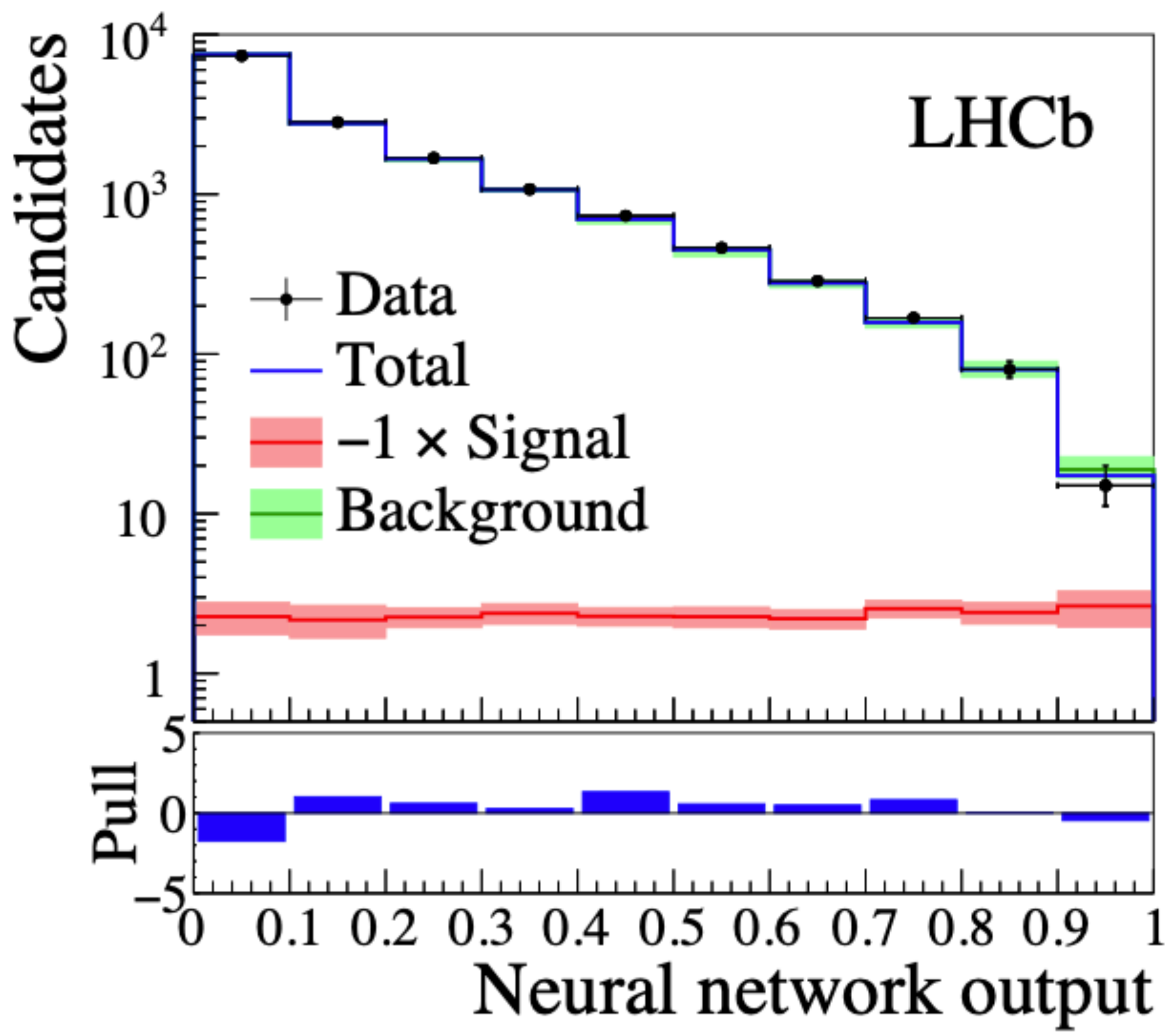
$$Br(B_s \to \tau\tau) < 6.8 \times 10^{-3} \quad @95\% \ \ \mathrm{CL}$$
$$Br(B_d \to \tau\tau) < 2.1 \times 10^{-3} \quad @95\% \ \ \mathrm{CL}$$

  - Analysis of the full Run2 data ongoing (at least x2)
  - Expected to reach 10^{-3} at the end of Run4 [50/fb]
  - And 5×10^{-5} by the end of Upgrade II [300/fb]
  - Tau decay model will become limiting

- Belle II, assuming will collect 5/ab at the ϒ(5S), would reach 8×10^{-3}

Belle II, PTEP(2019)123C01





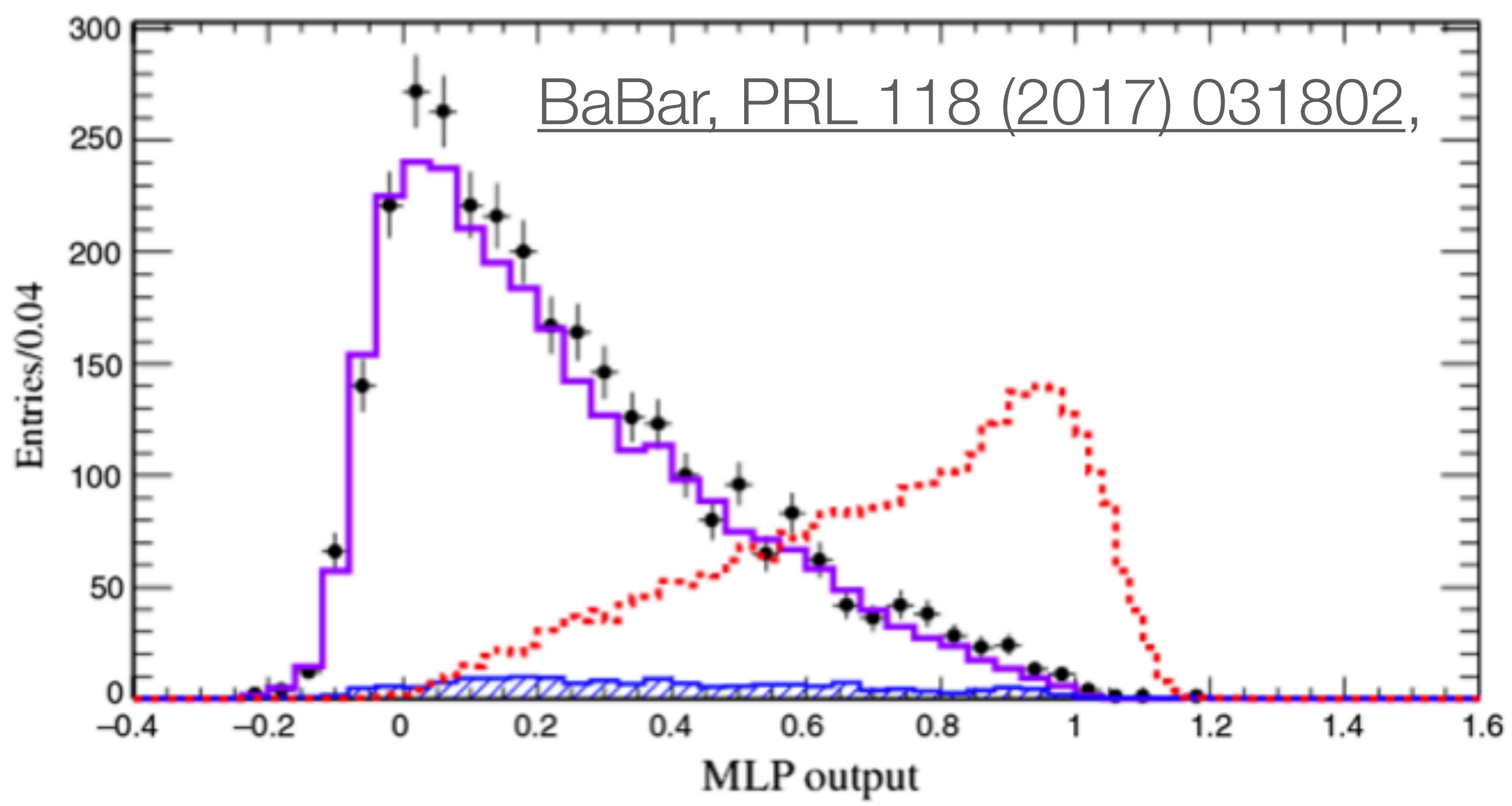
LHCb, PRL 118 (2017) 251802

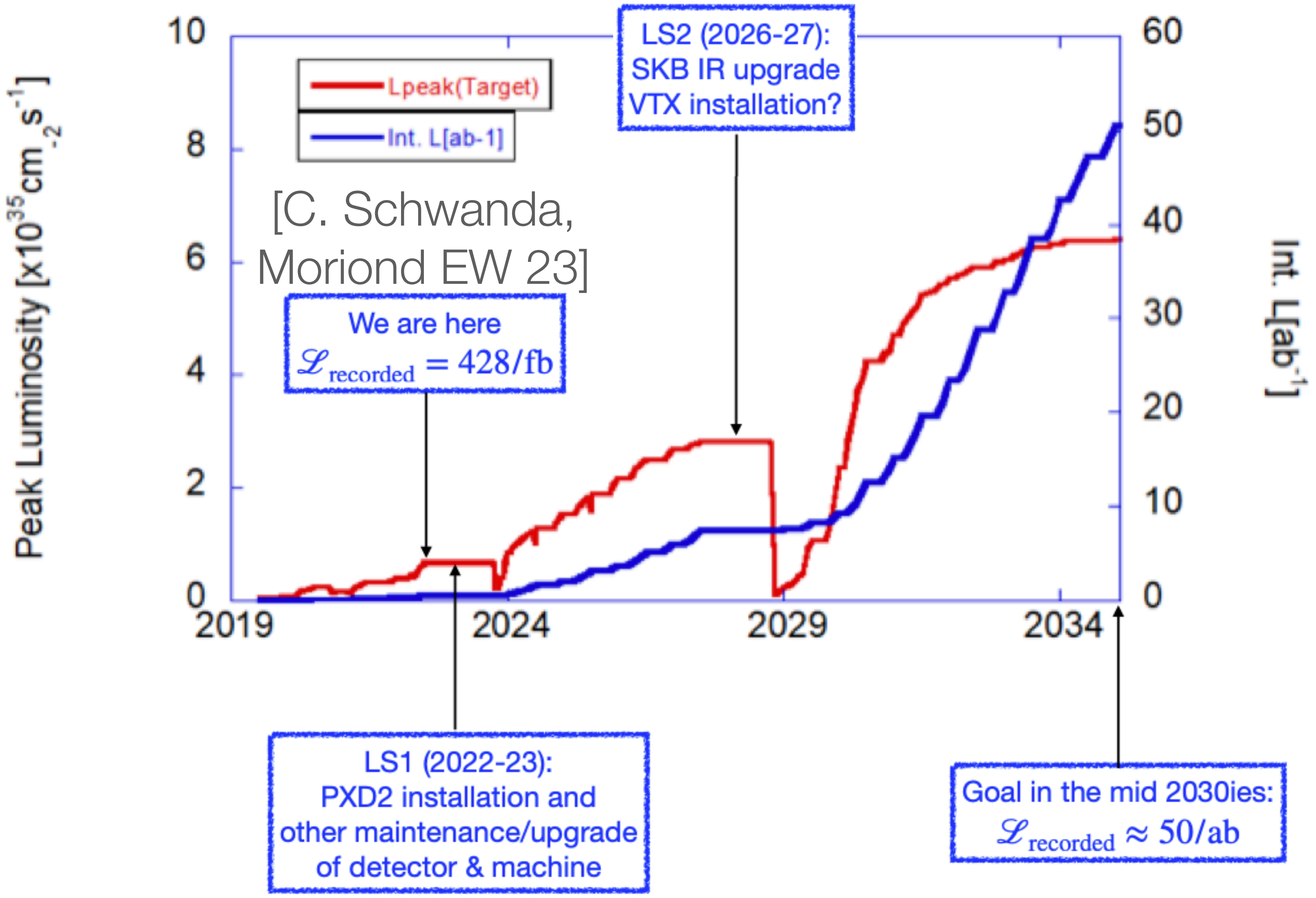
$B \to K^{(*)}\tau\tau$

- Only limit coming from BaBar, using leptonic τ decays (μμ, ee, eμ)

$$Br(B^+ \to K^+\tau\tau) < 2.25 \times 10^{-3} \;\; @90\% \;\; \text{CL}$$

  - Fully reconstructed Btag, gives access to missing momentum from Bsig
- At Belle II, soon reach 10^{-4} [1/ab] and 10^{-5} by the end of data taking [50/ab]
  Belle II, PTEP(2019)123C01
- At LHCb, $B \to h^+h^-\tau\tau$ has better prospects, e.g. $B \to K^{*0}\tau\tau$ expected to reach 10^{-4} [Run1+2]
  - Also $B_s \to \phi\tau\tau$ or $\Lambda_b \to pK\tau\tau$ being pursued both in the hadronic and leptonic modes





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  Belle II, PTEP(2019)123C01
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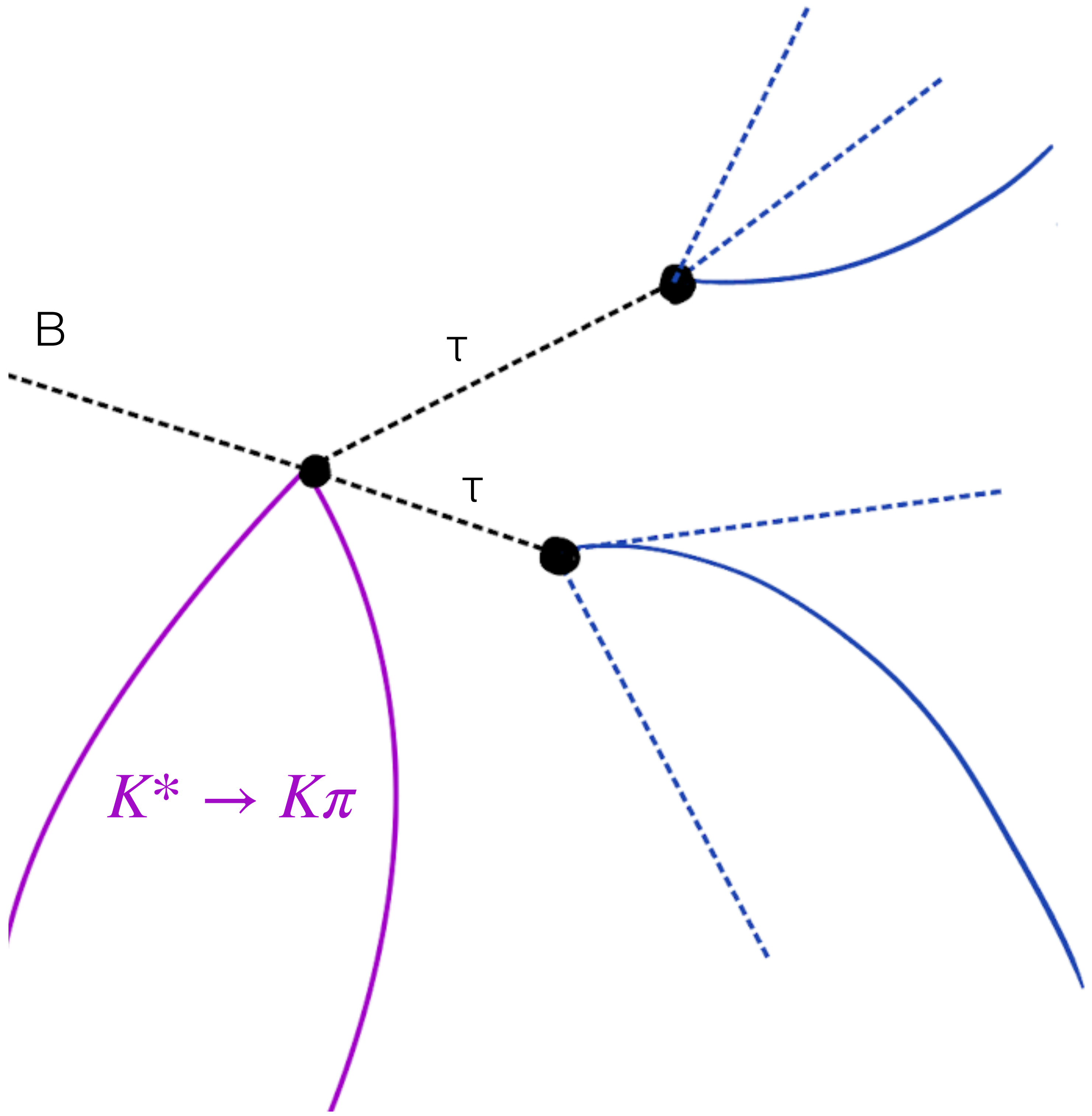
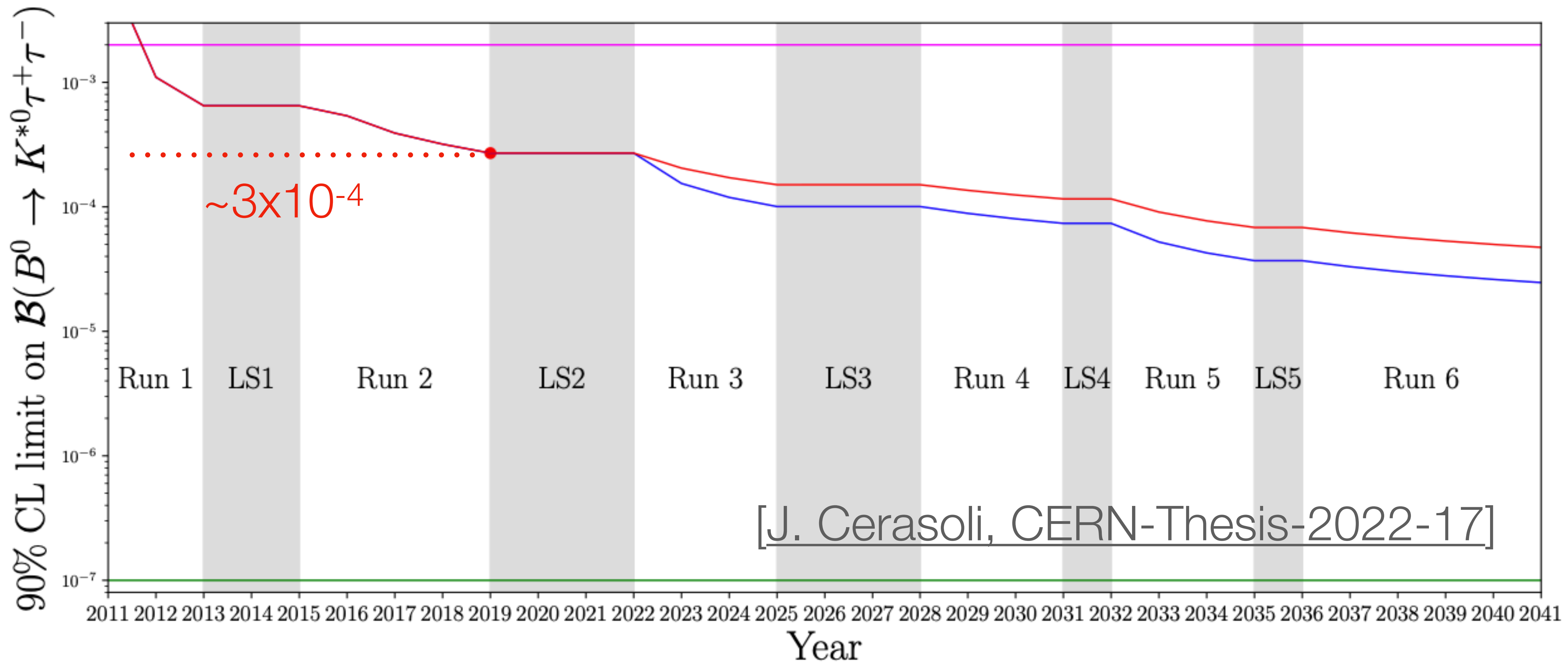
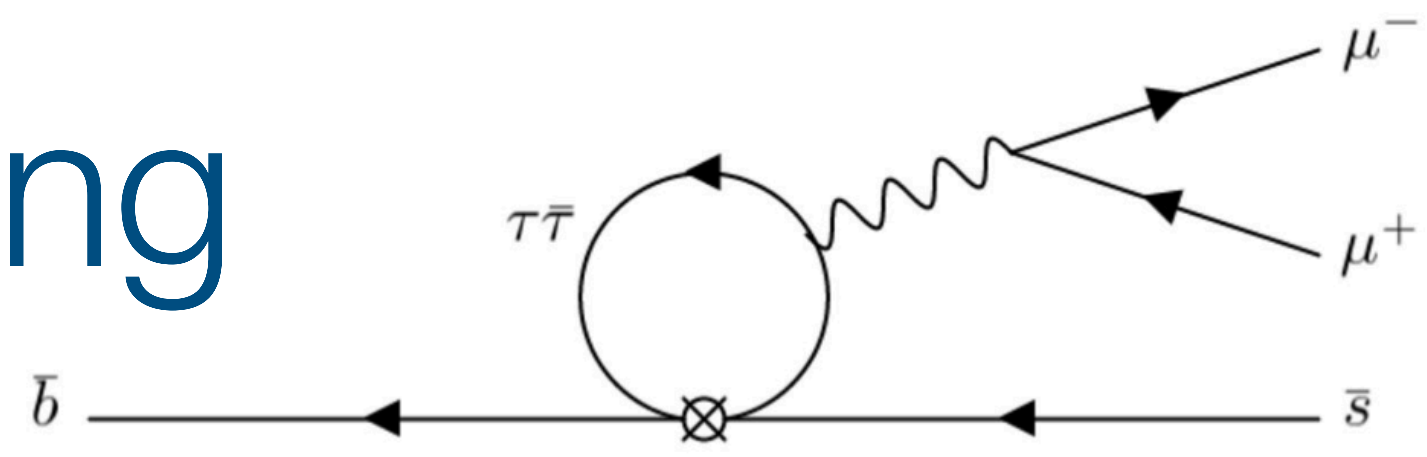


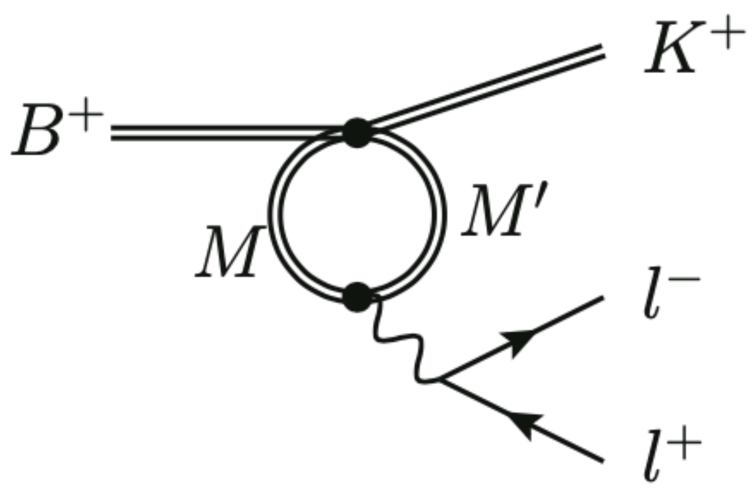


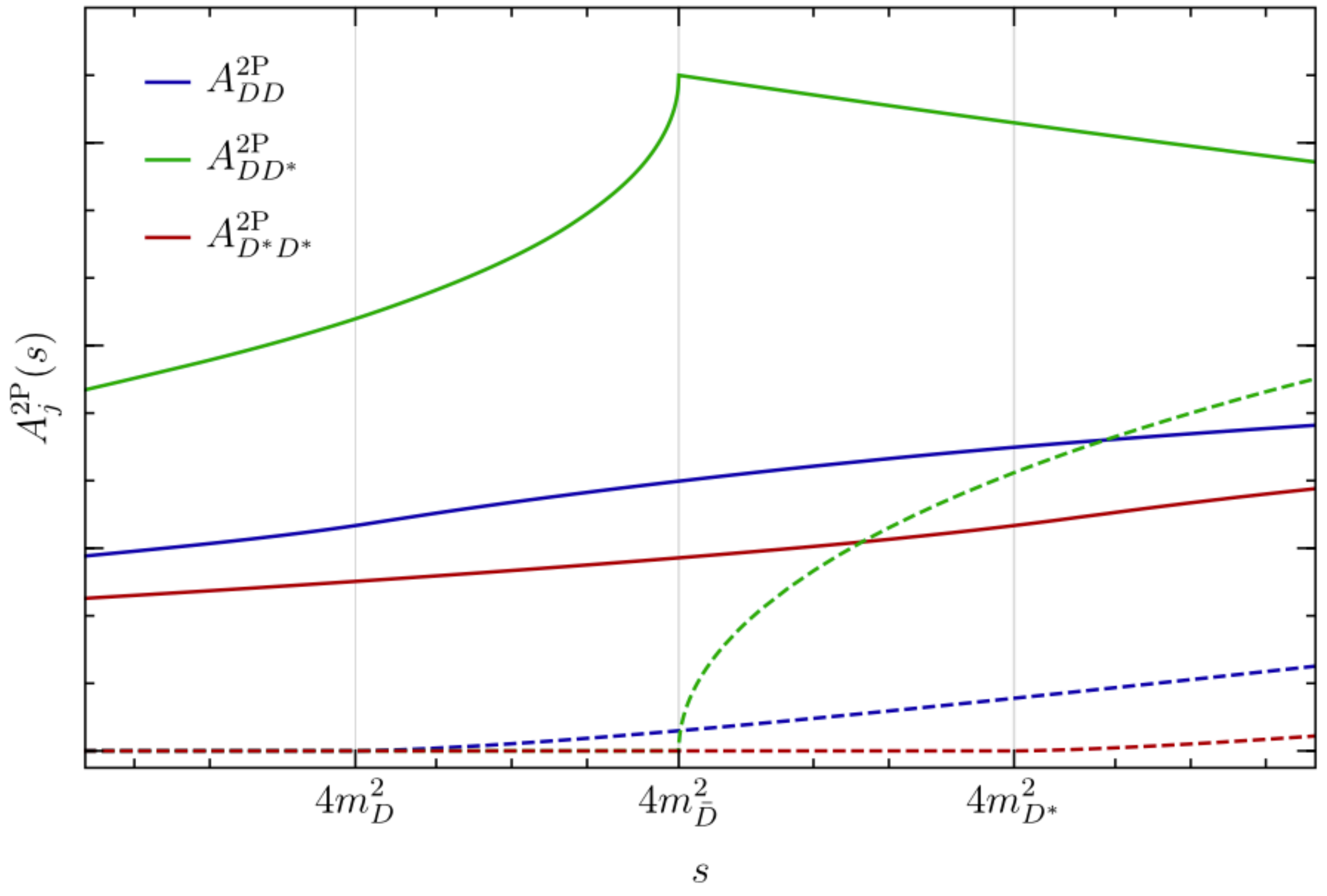
$B \to K^{(*)}\tau\tau \to K^{(*)}\mu\mu$ re-scattering



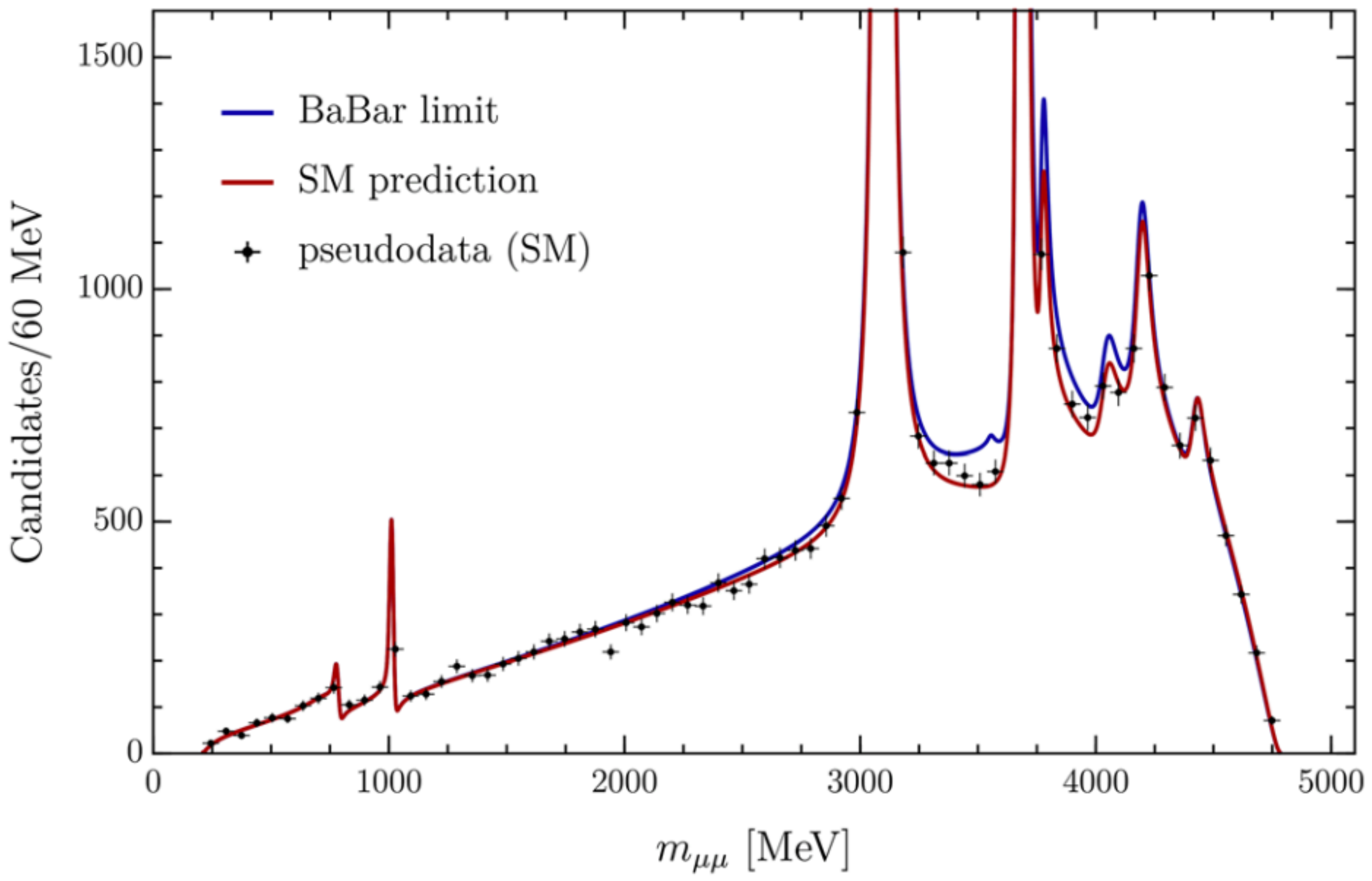
- Indirect limit to $B \to K\tau\tau$ from the precise study of the $B \to K\mu\mu$ di-μ mass spectrum
  - cusp in-between the J/ψ and ψ(2S) resonances (2xm$_\tau$)
  - distortion in the shape of the spectrum before the resonances

- Requires to experimentally distinguish the $b \to s\tau\tau$ amplitude from long distance hadronic contributions also with q2-dependence





Cornella et al, EPJC 80 (2020) 1095

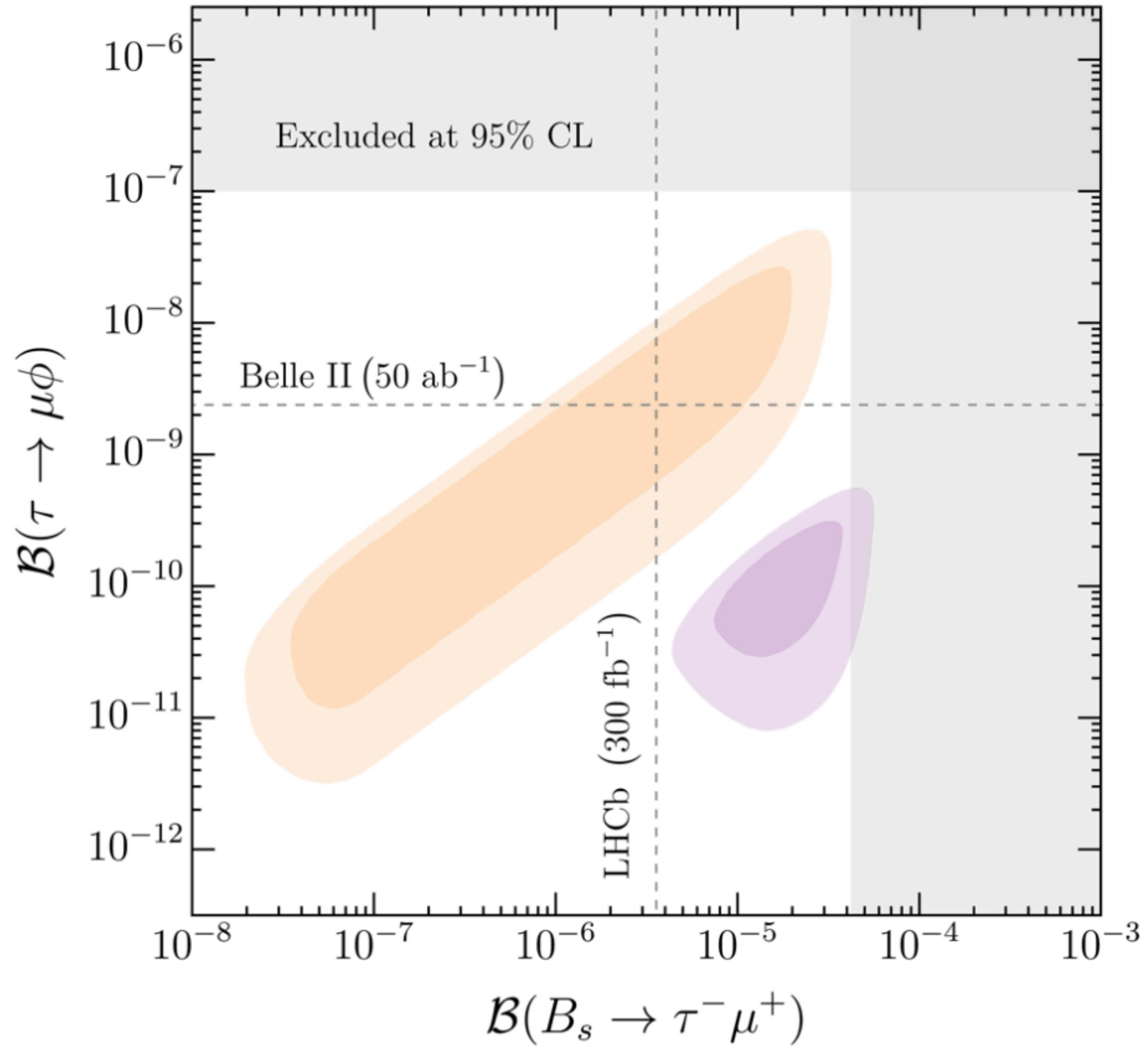


Scenario	C_9^τ (90% CL)	$\mathcal{B}\,(C_{10}^\tau = -C_9^\tau)$	$\mathcal{B}\,(C_{10}^\tau = 0)$
Run I–II dataset	533	2.7×10^{-3}	0.8×10^{-3}
Run I–V dataset	139	1.8×10^{-4}	0.5×10^{-4}

Competitive with current direct searches

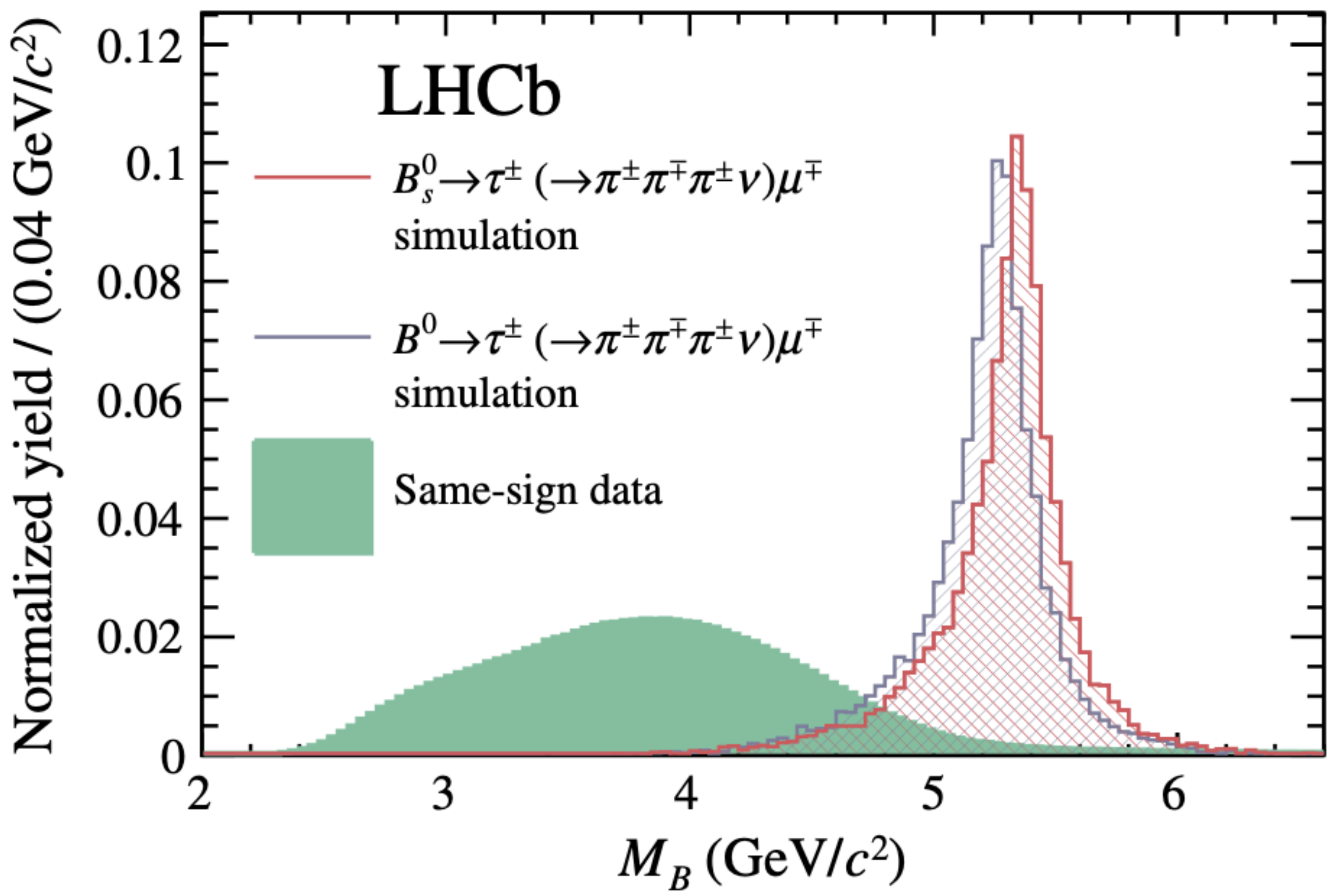
LFV decays: $b \to s\tau\mu$

- Without NC LFU anomalies, enhancement in $b \to s\tau\mu$ not as favoured?
  - Tiny in the SM (neutrino oscillation), null test of SM
- Experimentally look for $B_s \to \tau\mu$, $B \to K\tau\mu$, etc
  - With only one τ things get a bit easier:
    - Reconstruct full kinematics for the hadronic decay (up to ambiguities)
    - Use additional constraints from beam energy (B-factories) or $B^*_{2s} \to BK$ (LHCb)



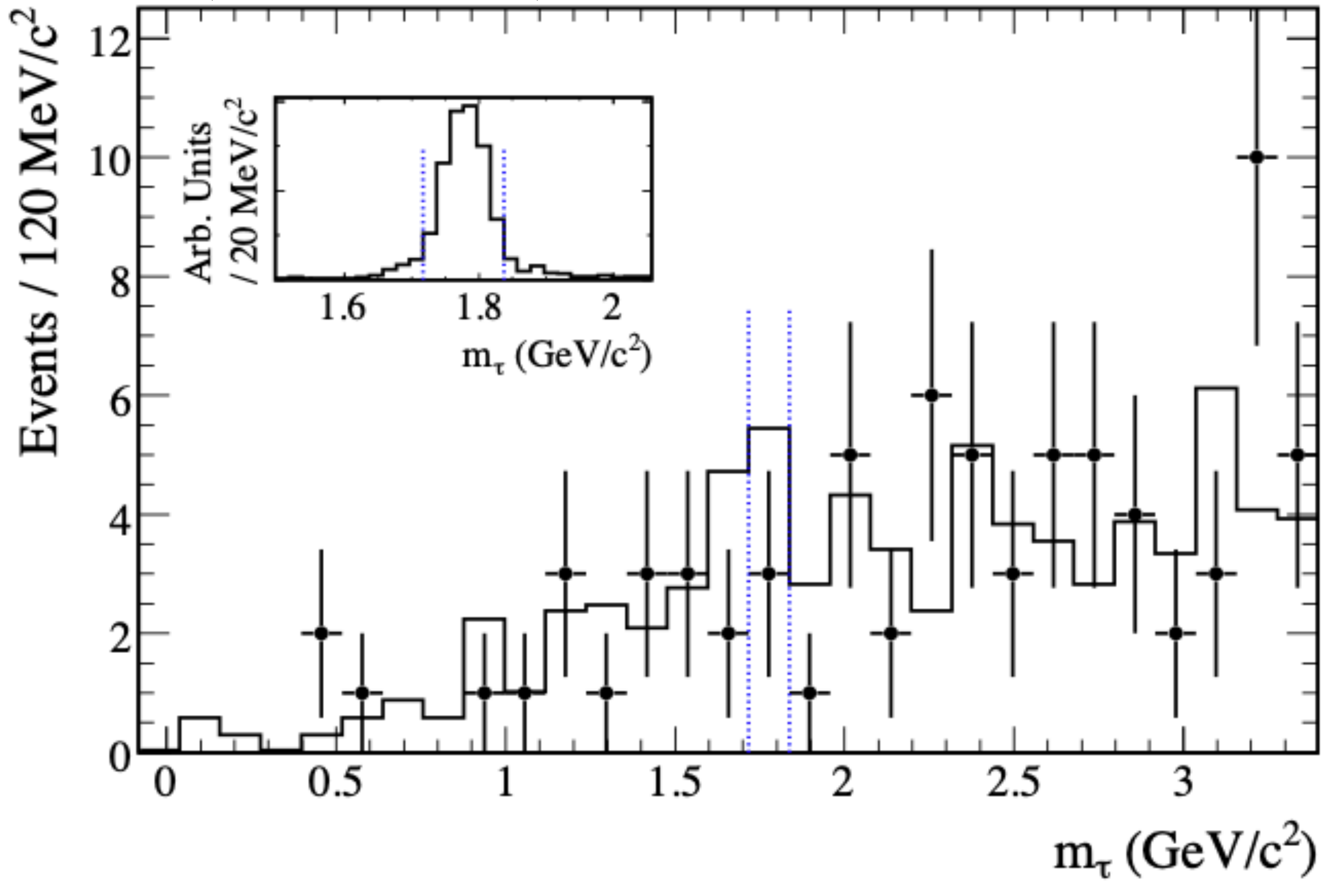
Cornella et al, JHEP 08 (2021) 050

$Br(B_s \to \tau\mu) < 3.4 \times 10^{-5}$ @90% CL



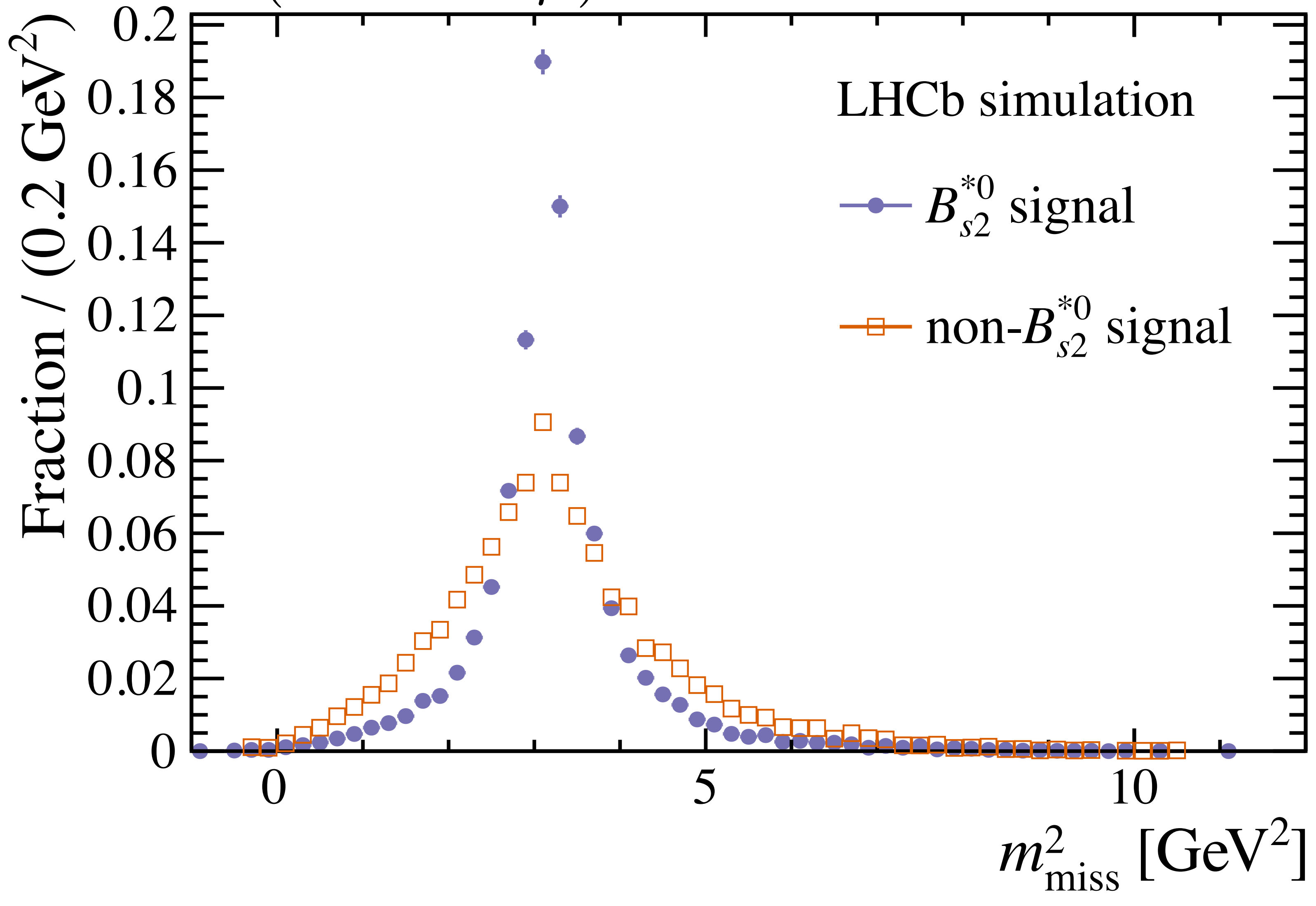
LHCb, PRL 123 (2019) 211801

$Br(B \to K\tau\mu) < 2.8 \times 10^{-5}$ @90% CL



BaBar, PRD 86 (2012) 012004

$Br(B \to K\tau\mu) < 3.9 \times 10^{-5}$ @90% CL



LHCb, JHEP 06 (2020) 129

New limit on $B \to K^* \tau\mu$

- Using full Run1+Run2 dataset & hadronic τ's
  - Separate $\tau^+\mu^-$ from $\tau^-\mu^+$, due to different mix of backgrounds
  - Fit the corrected mass: $m_{\rm corr} = \sqrt{p_\perp^2 + m^2_{K^*\tau\mu}} + p_\perp$
- Best experimental limit in $b \to s\tau\mu$

$$Br(B^0 \to K^{*0}\tau^+\mu^-) < 1.0 \times 10^{-5} \ \ @90\% \ \ \mathrm{CL}$$
$$Br(B^0 \to K^{*0}\tau^-\mu^+) < 8.2 \times 10^{-6} \ \ @90\% \ \ \mathrm{CL}$$

- For similar performances, can expect limits around 10^{-7} for the end of LHCb Upgrade II
- At Belle II, expect limits around 10^{-6} with 50/ab [naive extrapolation of BaBar result]

LHCb-PAPER-2022-021