On $R_K$ and the global significance of new physics in $b \rightarrow s\ell\ell$ decays

SPS ÖPG joint annual meeting 2021
Universität Innsbruck
Rare decays as New Physics probes

- Rare $b \rightarrow s\ell\ell$ decays are sensitive New Physics (NP) probes since they are loop level and CKM suppressed.

- NP contributions could be of same size as the SM (e.g. enhancing/suppressing branching fractions).

- In the Standard Model (SM) couplings of vector bosons to leptons are flavour universal (LFU): any deviation from LFU is a clear NP indication.

$$\begin{align*}
B^+\left\{ \begin{array}{c}
u \\ \bar{b} & \end{array} \right\} W^+ & \rightarrow \left\{ \begin{array}{c}
u \\ \bar{s} \end{array} \right\} K^+ \\
\gamma/Z^0 & \rightarrow \ell^+ \ell^-
\end{align*}$$

$$\begin{align*}
B^+\left\{ \begin{array}{c}
u \\ \bar{b} & \end{array} \right\} LQ & \rightarrow \left\{ \begin{array}{c}
u \\ \bar{s} \end{array} \right\} K^+ \\
\ell^+ & \rightarrow \ell^-
\end{align*}$$

NP example
A coherent pattern?

Over the past decade a coherent set of tensions with SM predictions has emerged in $b \to s\ell\ell$ transitions (see Elena’s talk):

- Branching fractions (e.g. $B_s \to \mu^+\mu^-$, $B \to K^{(*)}\mu^+\mu^-$, $B_s^0 \to \phi\mu^+\mu^-$).
- Angular observables (e.g. $B^0 \to K^{*0}\mu^+\mu^-$).
- LFU probes involving $\mu/e$ ratios (e.g. $B^0 \to K^{*0}\ell\ell$, $B^+ \to K^+\ell\ell$).

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On $R_K$ and the global significance of NP in $b \to s\ell\ell$ decays 

31. August 2021

LHCb Run 1 + 2016

$R_K^{=}$

$P_{S}^{*}$

$dB/dq^2[10^8 \times c^2/GeV^2]$
The $R_K$ observable

- $B \to K^{(*)} \mu^+ \mu^-$ BF and angular observables known to suffer from potentially underestimated hadronic uncertainties.
The $R_K$ observable

- $B \to K^{(*)} \mu^+ \mu^-$ BF and angular observables known to suffer from potentially underestimated hadronic uncertainties.

- A theoretically clean observable is:

$$R_K = \frac{\int_{q^2 = 6 \text{ GeV}^2}^{q^2 = 1.1 \text{ GeV}^2} dB(B^+ \to K^+ \mu^+ \mu^-) dq^2}{\int_{q^2 = 6 \text{ GeV}^2}^{q^2 = 1.1 \text{ GeV}^2} dB(B^+ \to K^+ e^+ e^-) dq^2} \equiv 1 \pm O(10^{-2})$$

- Previous LHCb measurement [PRL 122 (2019) 1911801] exhibits tension with SM at $2.5\sigma$ level using $5 fb^{-1}$ collected up to 2016.
  - The 2021 update adds $4 fb^{-1}$ collected in 2017/18.
  - Effectively doubles the dataset with respect to previous analysis.
  - Follows identical analysis strategy as previous analysis.
**$R_K$ measurement at LHCb**

- Two main ingredients for this measurement: **yields and efficiencies**:

  \[
  R_K = \frac{N(B^+ \rightarrow K^+\mu\mu)}{N(B^+ \rightarrow K^+ee)} \frac{\varepsilon(B^+ \rightarrow K^+ee)}{\varepsilon(B^+ \rightarrow K^+\mu\mu)}
  \]

- Electrons and muons interact differently with the detector:
  - Different **trigger strategy** and **particle identification efficiencies**.
  - Electrons lose significant amount of energy to **bremsstrahlung radiation**:
    - Poorer **mass resolution** and **reconstruction efficiency** than muons.
    - Effect mitigated by **bremsstrahlung recovery algorithm**.
$R_K$ measurement at LHCb

Control electron-muon differences using double ratio between nonresonant $B^+ \rightarrow K^+ \ell^+ \ell^-$ and resonant $B^+ \rightarrow K^+ J/\psi(\ell^+ \ell^-)$.

$$R_K = \frac{N(K^+\mu\mu) \varepsilon(K^+ee)}{N(K^+ee) \varepsilon(K^+\mu\mu)} \bigg/ \frac{N(K^+ J/\psi(\mu\mu)) \varepsilon(K^+ J/\psi(ee))}{N(K^+ J/\psi(ee)) \varepsilon(K^+ J/\psi(\mu\mu))}$$

$J/\psi$ known to be LFU within 0.4% [PDG]
Control electron-muon differences using double ratio between nonresonant \( B^+ \to K^+ \ell^+ \ell^- \) and resonant \( B^+ \to K^+ J/\psi(\ell^+ \ell^-) \).

\[
R_K = \frac{N(K^+ \mu\mu)}{N(K^+ J/\psi(\mu\mu))} \frac{\varepsilon(K^+ J/\psi(\mu\mu))}{\varepsilon(K^+\mu\mu)} \frac{N(K^+ ee)}{N(K^+ J/\psi(ee))} \frac{\varepsilon(K^+ J/\psi(ee))}{\varepsilon(K^+ee)}
\]

known to be LFU within 0.4% [PDG]

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On \( R_K \) and the global significance of NP in \( b \to s\ell\ell' \) decays

31. August 2021
Efficiency calibration

Efficiencies are estimated from simulated samples and calibrated using data, following identical procedure as in the previous analysis:

- Calibration of $B^+$ kinematics;
- Particle identification efficiency calibration (method described in [EPJ T&I (2019) 6:1]);
- Trigger efficiency (plot on the right);
- Resolution of $q^2$ and of reconstructed $B^+$ mass;

Leads to excellent agreement between data and simulation
- Extensive cross checks to verify procedure

Measurement of the electron trigger efficiency using $B^+ \rightarrow K^+ J/\psi (ee)$ data
Cross check: $r_{J/\psi}$ single ratio

\[ r_{J/\psi} = \frac{N(K^+ J/\psi(\mu\mu))}{N(K^+ J/\psi(ee))} \frac{\varepsilon(K^+ J/\psi(ee))}{\varepsilon(K^+ J/\psi(\mu\mu))} \]

- Single ratio requires direct control of electrons with respect to muons:
  - Stringent cross-check of efficiencies.

Measured value: $r_{J/\psi} = 0.981 \pm 0.020$ (stat & syst)
Cross check: $r_{J/\psi}$ single ratio

$$r_{J/\psi} = \frac{N(K^+ J/\psi(\mu\mu))}{N(K^+ J/\psi(ee))} \frac{\varepsilon(K^+ J/\psi(\mu\mu))}{\varepsilon(K^+ J/\psi(ee))}$$

- Single ratio requires direct control of electrons with respect to muons
  - Stringent cross-check of efficiencies

Measured value: $r_{J/\psi} = 0.981 \pm 0.020$ (stat & syst)

- Cross check that efficiencies are understood in all kinematic regions by checking $r_{J/\psi}$ is flat in all variables relevant to the detector response.
  - If deviations from flatness is actually due to efficiency mismodelling, impact on $R_K$ is of 0.1%.
$R_K$ is extracted as a parameter from a simultaneous unbinned maximum likelihood fit to all $B^+ \to K^+ \ell^+ \ell^-$ data:

\[ R_K \]

\[
N(K^+\mu^+\mu^-) \sim 3850
\]

\[
N(K^+e^+e^-) \sim 1640
\]
$R_K$ with full Run1 and Run2 LHCb data

Result obtained for $R_K$:

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

- Dominant systematic effect: fit model.
  - Trigger and kinematic calibration are at permille-level.
- P-value under the SM hypothesis: 0.0010
  - Evidence of LFU violation at $3.1\sigma$.
- Compatibility with SM obtained integrating the profiled likelihood as a function of $R_K$ above 1
The bigger picture

- EFT is a model independent approach, assuming no light NP in $b \to s\ell\ell$ transitions.

- Separate NP effects (Wilson coefficients $C_i$'s) from long distance QCD effects (matrix elements $O_i$'s) in a systematic OPE.

\[
\mathcal{H}_{b \to s}^{\text{EFT}} = -\frac{4G_F}{\sqrt{2}} V_{ts}^* V_{tb} \sum_i (C_i O_i + C'_i O'_i)
\]

<table>
<thead>
<tr>
<th>Operator $O_i$</th>
<th>$B \to K^{*0}\gamma$</th>
<th>$B \to K^{*0}\mu^+\mu^-$</th>
<th>$B \to \mu^+\mu^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_7 \sim m_b (\bar{s}<em>L\sigma</em>{\mu\nu}b_R) F_{\mu\nu}$</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>$O_9 \sim (\bar{s}b) V_A (\bar{\ell}\ell)_V$</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$O_{10} \sim (\bar{s}b) V_A (\bar{\ell}\ell)_A$</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>$O_{5,P} \sim (\bar{s}b) S_{+P} (\bar{\ell}\ell)_{S,P}$</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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On $R_K$ and the global significance of NP in $b \to s\ell\ell$ decays

31. August 2021
The bigger picture

- NP models can coherently explain these “flavour anomalies”.

- However when performing global fits, choosing which WC to fit is based on the deviations seen in data.

- Might lead to overestimate the significance due to Look Elsewhere Effect (LEE).

Need to formulate an a-priori hypothesis for which the data has no influence.
Generic NP hypothesis

- Write down all independent combinations of dimension 6 operators contributing to $b \rightarrow s \ell \ell$ transitions

\[
O_9^{\ell} = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell} \gamma_\mu \ell), \quad O_{10}^{\ell} = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell} \gamma_\mu \gamma_5 \ell), \\
O_9^{\ell'} = (\bar{s}_R \gamma_\mu b_R)(\bar{\ell} \gamma_\mu \ell), \quad O_{10}^{\ell'} = (\bar{s}_R \gamma_\mu b_R)(\bar{\ell} \gamma_\mu \gamma_5 \ell), \\
O_8^{\ell} = (\bar{s}_L b_R)(\bar{\ell}_R \ell_L), \quad O_{8}^{\ell'} = (\bar{s}_R b_L)(\bar{\ell}_L \ell_R).
\]

- Include $R_K, R_{K^*}, B_s \rightarrow \mu \mu$ and $B \rightarrow K^* \mu \mu$ angular observables

- Generate toys based on SM predictions and experimental uncertainties. Fit all possible 1 or 2 WC combinations take the largest $\Delta \chi^2$ as test statistic
Generic NP hypothesis

- Write down all independent combinations of dimension 6 operators contributing to $b \to s\ell\ell$ transitions

\[
\mathcal{O}_9^\ell = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell}\gamma_\mu \ell), \quad \mathcal{O}_{10}^\ell = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell}\gamma_\mu \gamma_5 \ell), \\
\mathcal{O}_9^{\ell'} = (\bar{s}_R \gamma_\mu b_R)(\bar{\ell}\gamma_\mu \ell), \quad \mathcal{O}_{10}^{\ell'} = (\bar{s}_R \gamma_\mu b_R)(\bar{\ell}\gamma_\mu \gamma_5 \ell), \\
\mathcal{O}_S^\ell = (\bar{s}_L b_R)(\bar{\ell}_R \ell_L), \quad \mathcal{O}_{S'}^\ell = (\bar{s}_R b_L)(\bar{\ell}_L \ell_R).
\]

- Include $R_K$, $R_{K^*}$, $B_s \to \mu\mu$ and $B \to K^*\mu\mu$ angular observables

- Generate toys based on SM predictions and experimental uncertainties. Fit all possible 1 or 2 WC combinations take the larges $\Delta \chi^2$ as test statistic

Trial factor can be as large as 4/7 when varying 1/2 WCs
Generic NP hypothesis

- BF and $B \rightarrow K^{*}\mu\mu$ angular are affected by potentially large QCD uncertainties:
  - This is true for some angular observables but not all of them (charmloop cannot interfere with primed coefficients) → cannot ignore information from clean $B \rightarrow K^{*}\mu\mu$ angular observables
  - Any NP effect in $C_9$ is included as part of the SM definition, allow for a universal shift in $C_9$

- Generate toys based on SM predictions, central values fluctuated with the experimental sensitivity and evaluate:

$$\Delta \chi^2 = -2 \log \frac{\mathcal{L}(X | \Delta \hat{C}_9 \ , \ C_i^{SM})}{\mathcal{L}(X | \hat{C}_i)}$$

- This method allows to assess the probability to observe the numerical coherence that is seen in data by chance.

- Generic NP hypothesis gives $\sim 4\sigma$ global significance

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Summary

- LHCb has performed the most precise measurement of the LFU ratio $R_K$ using the full available dataset:
  - $3.1\, \sigma$ tension with SM prediction: first evidence of LFU violation in $B^+ \to K^+\ell^+\ell^-$ decays with a single measurement.

- It is of crucial importance to continue studying flavour anomalies, highly anticipated measurements are underway:
  - Updates of LFU observables with different decay modes and kinematic regions, as well as angular analyses of $B \to K^{(*)}\ell^+\ell^-$ and $B \to K^{(*)}\mu^+\mu^-$ decays.
  - Further validation of our understanding of low $q^2$ efficiencies with $D_s^+ \to \phi(\ell^+\ell^-)\pi^+$ decays.

- The LEE in $b \to s\ell\ell$ is sizeable and needs to be taken into account when performing global fits:
  - Nonetheless the global significance of the NP hypothesis in the $b \to s\ell\ell$ system is high.
  - Method allows for (relatively) easy addition of new $b \to s\ell\ell$ measurements.
Thanks for your attention!
Backup
The LHCb detector
The LHCb detector

- VErtex LOcator
  \[ \sigma_{PV}^{xy} \sim 15\mu m \]
  \[ \sigma_{PV}^z \sim 80\mu m \]
- Trackers
  \[ \sigma_p / p \sim (0.1 - 0.6)\% \text{ GeV/c} \]
  at 5 - 100 GeV/c
The LHCb detector

\[ \mu ID \in 97\%, (1 - 3)\% \pi \rightarrow \mu \]
\[ e ID \in 95\%, 5\% e \rightarrow h \]
\[ K ID \in 95\%, 5\% \pi \rightarrow K \]
The LHCb detector

Calorimeters

Muon stations
\(B^+ \rightarrow K^+ \ell^+ \ell^-\)

- Peaking structures: \(B^+ \rightarrow K^+ J/\psi(\ell^+ \ell^-)\) and \(B^+ \rightarrow K^+ \psi(2S)(\ell^+ \ell^-)\) (resonant decay modes)
- Diagonal elongations: radiative tails + incorrectly-added bremsstrahlung
- Vertical band: \(B^+ \rightarrow K^+ \ell^+ \ell^-\) (rare decay mode)

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Selection

Requirements on reconstructed data, unchanged w.r.t. previous $R_K$ analysis

- **High quality tracks** and reconstructed $B^+$ decay vertex

- **Particle identification** (PID) on kaon and lepton candidates, to suppress background from mis-ID

- **Trigger** requirements (more on next slide)

- **Mass vetoes** in order to suppress semileptonic cascades

- **Multivariate selection** to suppress combinatorial background
Trigger strategy

- For muon channels, trigger on L0 Muon
- For electron channels, three exclusive trigger categories:
  - L0 Electron, L0 Hadron and L0 TIS.
- Systematics evaluated and cross-checks performed individually on each trigger category
Efficiency calibration

Efficiencies are estimated from simulated samples and calibrated using data, following identical procedure as in the previous analysis:

- Particle identification efficiency calibration;
- Trigger efficiency;
- Calibration of $B^+$ kinematics;
- Resolution of $q^2$ and of reconstructed $B^+$ mass;

Fit to the data sample used as a source of $\pi^\pm$ and $K^\pm$ calibration.
Efficiency calibration

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Measurement of the electron trigger efficiency using $B^+ \rightarrow K^+ J/\psi(ee)$ data
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Transverse momentum spectrum of $B^+ \to K^+ J/\psi(\mu\mu)$ calibration data vs simulation

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- Resolution of $q^2$ and of reconstructed $B^+$ mass;

![Resolution of dilepton invariant mass](image)
Efficiency calibration

Efficiencies are estimated from simulated samples and calibrated using data, following identical procedure as in the previous analysis:

- Particle identification efficiency calibration;
- Trigger efficiency;
- Calibration of $B^+$ kinematics;
- Resolution of $q^2$ and of reconstructed $B^+$ mass;

Leads to excellent agreement between data and simulation

- Extensive cross checks to verify procedure
Systematic uncertainties

Main contributions to systematic uncertainty on $R_K$:

- **Dominant sources $\sim 1\%$**:
  - Choice of fit model.
    - Signal and partially reconstructed background shape.
  - Statistics of calibration samples.
    - Evaluated through bootstrapping method.
- **Sub-dominant sources $\sim 1\%$**:
  - Efficiency calibration.
    - Dependence on trigger calibration method.
    - Precision of the $q^2$ and $m(K^+e^+e^-)$ resolution correction.
  - Inaccuracies in detector material description in simulation.
Systematic uncertainties

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  - Efficiency calibration.
    - Dependence on trigger calibration method.
    - Precision of the $q^2$ and $m(K^+e^+e^-)$ resolution correction.
    - Inaccuracies in detector material description in simulation.

Total relative systematic of $\sim 1.5\%$ in the final $R_K$ measurement:

→ Expect the result to be dominated by statistical uncertainty
• High statistics of the control modes, not all of the backgrounds are visible in the plots

• Resolution on reconstructed $B^+$ mass improved by constraining dilepton invariant mass to that of $J/\psi$
Fits to the control modes

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Cross check: $R_{\psi(2S)}$ double ratio

$$R_{\psi(2S)} = \frac{\mathcal{B}(B^+ \to K^+\psi(2S)(\mu\mu))}{\mathcal{B}(B^+ \to K^+\psi(2S)(ee))} \Bigg/ \frac{\mathcal{B}(B^+ \to K^+J/\psi(\mu\mu))}{\mathcal{B}(B^+ \to K^+J/\psi(ee))}$$

- Data are selected at the $\psi(2S)$ resonance with a suitable $q^2$ cut.
- Independent validation of double-ratio procedure.
- Test of the efficiencies at $q^2$ away from $J/\psi$. 

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Cross check: $R_{\psi(2S)}$ double ratio

\[ R_{\psi(2S)} = \frac{\mathcal{B}(B^+ \to K^+ \psi(2S)(\mu\mu))}{\mathcal{B}(B^+ \to K^+ \psi(2S)(ee))} \div \frac{\mathcal{B}(B^+ \to K^+ J/\psi(\mu\mu))}{\mathcal{B}(B^+ \to K^+ J/\psi(ee))} \]

- Data are selected at the $\psi(2S)$ resonance with a suitable $q^2$ cut.
- Independent validation of double-ratio procedure.
- Test of the efficiencies at $q^2$ away from $J/\psi$.
- Result is well compatible with unity:

Measured value $R_{\psi(2S)} = 0.997 \pm 0.011 \text{ (stat & syst)}$
Variables overlap (I)

\[ B^+ \rightarrow K^+e^+e^- \]
\[ B^+ \rightarrow K^+\mu^+\mu^- \]
\[ B^+ \rightarrow J/\psi(e^+e^-)K^+ \]
\[ B^+ \rightarrow J/\psi(\mu^+\mu^-)K^+ \]
Variables overlap (II)

\[ \text{Candidates} / (\text{a. u.}) \]

\[ \begin{align*}
\eta(K^+) & \quad \text{LHCb simulation} \\
\min(\eta(l^+), \eta(l^-)) & \quad \text{LHCb simulation} \\
\max(\eta(l^+), \eta(l^-)) & \quad \text{LHCb simulation} \\
\log_{10}(\chi^2_{\text{Vtx}}(B^+)) & \quad \text{LHCb simulation} \\
\log_{10}(\chi^2_{\text{IP}}(B^+)) & \quad \text{LHCb simulation}
\end{align*} \]

\[ \begin{align*}
&B^+ \to K^+e^+e^- \\
&B^+ \to K^+\mu^+\mu^- \\
&B^+ \to J/\psi(e^+e^-)K^+ \\
&B^+ \to J/\psi(\mu^+\mu^-)K^+
\end{align*} \]
Additional $r_{J/\psi}$ checks

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[arXiv:2103.11769]
Cross-check: 2D $r_{J/\psi}$

The 1D $r_{J/\psi}$ cross-check is extended to two variables.

- Flatness of 2D $r_{J/\psi}$ gives confidence that efficiencies are understood across entire phase-space

2D $r_{J/\psi}$, binned in max lepton momentum and angle between leptons

LHCb simulation

$B^+ \to K^+ J/\psi(e^+e^-)$ and $B^+ \to K^+(e^+e^-)$ distributions
Correlated systematic uncertainties

- Most of the calibration histograms are computed from the normalisation modes $B^+ \to K^+ J/\psi(e^+ e^-)$ and $B^+ \to K^+ J/\psi(\mu^+ \mu^-)$, correlations among the systematic have to be properly taken into account.

- Given two efficiency estimations $\epsilon_1$ and $\epsilon_2$, systematics are estimated from recomputing their values in $n$ different ways, to give

$$\sigma_1 = \left( \frac{1}{n} \sum_{i=1}^{n} (\epsilon_1^i - \bar{\epsilon}_1)^2 \right)^{\frac{1}{2}}, \quad \sigma_2 = \left( \frac{1}{n} \sum_{i=1}^{n} (\epsilon_2^i - \bar{\epsilon}_2)^2 \right)^{\frac{1}{2}}, \quad \text{cov}_{1,2} = \frac{1}{n} \sum_{i=1}^{n} (\epsilon_1^i - \bar{\epsilon}_1) \cdot (\epsilon_2^i - \bar{\epsilon}_2)$$

- The fractional error matrix is defined as:

$$\sigma = \begin{pmatrix} \sigma_1/\bar{\epsilon}_1 & \text{cov}_{1,2} \\ \text{cov}_{1,2}/\sigma_1 & \sigma_2/\bar{\epsilon}_2 \end{pmatrix}$$

- Use this procedure to calculate systematic uncertainties on $r_{J/\psi}$, $R_{\phi\pi}$ and $R_{\phi\pi}^8$
Extracting $R_K$ from data

Perform an unbinned maximum likelihood fit to $m(K^+\ell^+\ell^-)$ distribution in fully selected $B \to K^+\mu^+\mu^-$ and $B \to K^+e^+e^-$ data, simultaneously

- $R_K$ is one of the floating fit parameters

- Already-known efficiencies and control yields are embedded in the fit as $c_{K}^{rt}$

$$R_K^{rt} = \frac{N_{K\mu}\mu}{N_{Kee}} \cdot \frac{N_{KJ/\psi,ee}}{N_{KJ/\psi,\mu\mu}} \cdot \frac{\varepsilon_{Kee}^{r} \cdot \varepsilon_{KJ/\psi,\mu\mu}^{r}}{\varepsilon_{KJ/\psi,ee}^{r}} \cdot c^{rt}_{K}$$

$$-\log \mathcal{L} = \sum_{r} \sum_{i} \log P^r_{\mu}(m^{rt}_{i} \mid N_{K\mu\mu}^{r}) + \sum_{rt} \sum_{i} \log P^r_{e}(m^{rt}_{i} \mid \frac{N_{K\mu\mu}^{r} \cdot c^{rt}_{K}}{R_K}) + \sum_{j} \mathcal{G}_{j}(\boldsymbol{x}_{j} \mid \mu_{j}, \Sigma_{j})$$

- Constraints are on e.g. $c^{rt}_{K}$, background normalisation, relative signal yields
Result on electrons branching fraction

• Combining the measured $R_K$ value with $\mathcal{B}(B^+ \rightarrow K^+ \mu^+ \mu^-)$ result from [JHEP 06 (2014) 133] gives:

\[
\int_{q^2=1.1 \text{ GeV}^2}^{q^2=6 \text{ GeV}^2} \frac{d\mathcal{B}(B^+ \rightarrow K^+ e^+ e^-)}{dq^2} dq^2 = (28.6^{+1.5}_{-1.4} \text{ (stat.)} \pm 1.3 \text{ (syst.)}) \times 10^{-9}
\]

• Suggesting that electrons are more SM-like than muons.

[arXiv:2103.11769]
Inclusion of $C_7, C'_7$


- Generated toys based on SM $B^0 \rightarrow K^{*}e e$ with experimental uncertainty.

- In the toy fit, added as a constraint to $C_7, C'_7$ the results previous to flavour anomalies from $b \rightarrow s\gamma$ [link].

- Adding the difference in the likelihood to the LEE paper results and updating the fit to data to include $B^0 \rightarrow K^{*}e e$ and $b \rightarrow s\gamma$ yields a shift in significance of $\sim -2\%$