Measuring LFNU in $\overline{B} \to \overline{K}^{*} \ell^{+} \ell^{-}$

Ideas for new observables

Nicola Serra, Rafael Silva Coutinho, Danny van Dyk

Universität Zürich

preparing ZH-TH-12/16

Rare B Decays: Theory and Experiment 2016
Barcelona, 19.04.2016

Status Quo

- in the SM R_K and R_{K^*} are theoretically clean observables
  - hadronic uncertainties cancel to large extent if $\beta_e \sim \beta_\mu$
  - $R_K \simeq R_{K^*} \simeq 1$
- consider benchmark point (BMP): $C_9^e = C_9^{\text{SM}}$, $C_9^\mu = C_9^{\text{SM}} - 1$
  - theory: $\langle R_{K^*} \rangle_{1,6} \simeq 0.86$
  - theory: depends quadratically on non-local charm effects (as any BR)
  - central value only 14% away from 1
  - assuming normal distribution, 5σ discovery needs an exp. error of $< 3\%$
- question: are there observables, which are free of charm effects in a NP scenario?

Proposal: Differences of J_i Preliminary!

definition:

$$D_i(q^2) \equiv \frac{J_i^e(q^2) - J_i^\mu(q^2)}{\tau_B} = \frac{\mathrm{d}\mathcal{B}^e}{\mathrm{d}q^2} S_i^e - \frac{\mathrm{d}\mathcal{B}^\mu}{\mathrm{d}q^2} S_i^\mu \qquad i = 4, 5, 6s$$

analytically:

$$\frac{D_{6s}(q^2)}{N^2 \tau_B} = 6\,\mathrm{Re}\left\{\left(\beta_e^3 C_9^e - \beta_\mu^3 C_9^\mu\right) \mathcal{C}_{10}\right\} F_{V,\parallel} F_{V,\perp}$$
$$+ \mathcal{O}\left(\beta_e^3 - \beta_\mu^3\right) \times [\text{terms incl. hadronic contr.}]$$

– non-local hadronic contributions cancel identically in the leading term!
– trade in for larger sensitivity to form factors no free lunch

Proposal: Differences of J_i **Preliminary!**

definition:

$$D_i(q^2) \equiv \frac{J_i^e(q^2) - J_i^\mu(q^2)}{\tau_B} = \frac{\mathrm{d}\mathcal{B}^e}{\mathrm{d}q^2} S_i^e - \frac{\mathrm{d}\mathcal{B}^\mu}{\mathrm{d}q^2} S_i^\mu \qquad i = 4, 5, 6s$$

theory:

– SM: unclean observables (unc: CKM + FF + SL estimates)

$$\langle D_5^{\text{SM}} \rangle_{1,6} = (-5.7 \pm 5.2) \cdot 10^{-11} \qquad \langle D_{6s}^{\text{SM}} \rangle_{1,6} = (+1.5 \pm 0.6) \cdot 10^{-11} \tag{1}$$

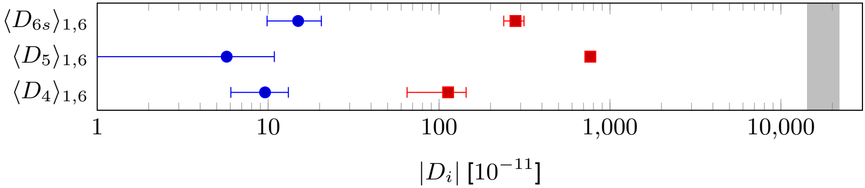
– BMP: cleanish observables (unc stem dominantly from FFs)

$$\langle D_5^{\text{BMP}} \rangle_{1,6} = (-7.7 \pm 0.4) \cdot 10^{-9} \qquad \langle D_{6s}^{\text{BMP}} \rangle_{1,6} = (-2.8 \pm 0.4) \cdot 10^{-9} \tag{2}$$

– enlargement by factors ~ 130 and ~ 20, respectively.

Numerics

Preliminary!



SM estimate Benchmark $\mathcal{B}(B \to K^* \mu\mu)$

experiment:

- discovery potential is higher due to large difference between SM and BMP
- basically a nulltest!
- feasible? (toys are being worked on)