$b \to s\mu^+\mu^-$ measurements: some theorists' suggestions and wishes

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in collaboration with J. Virto and M. Reboud

LHC Heavy Flavour WG topical meeting: $b \to s\ell\ell$

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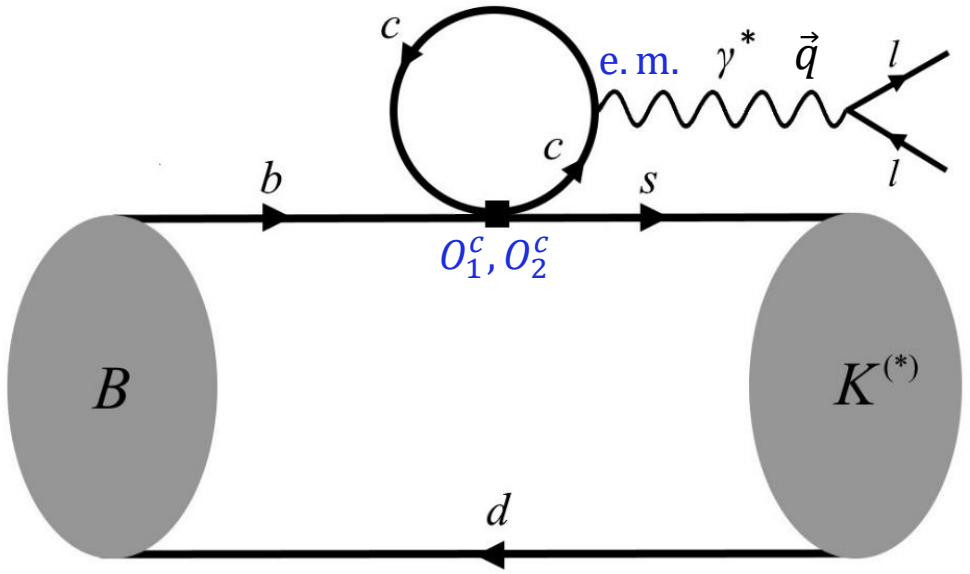
UNIVERSITY OF CAMBRIDGE

Disclaimer

most of the points in the following slides come from a meeting with J. Virto and M. Reboud

however, I have expanded on some points and concepts, so my colleagues may not agree 100%



Decay amplitude for $B \to K^{(*)}\ell^+\ell^-$

calculate decay amplitudes precisely to probe the SM

$b \to s\mu^+\mu^-$ anomalies: NP or underestimated QCD uncertainties?

$$\mathcal{A}\left(B \to K^{(*)}\ell^+\ell^-\right) = \mathcal{N}\left[\underbrace{\left(C_9 L_V^\mu + C_{10} L_A^\mu\right)}\ \mathcal{F}_\mu - \underbrace{\frac{L_V^\mu}{q^2}}\left(C_7\ \mathcal{F}_{T,\mu} + \mathcal{H}_\mu\right)\right]$$

Wilson coefficients, leptonic matrix elements (and constants α, V_{CKM}...)

perturbative objects, **small uncertainties**

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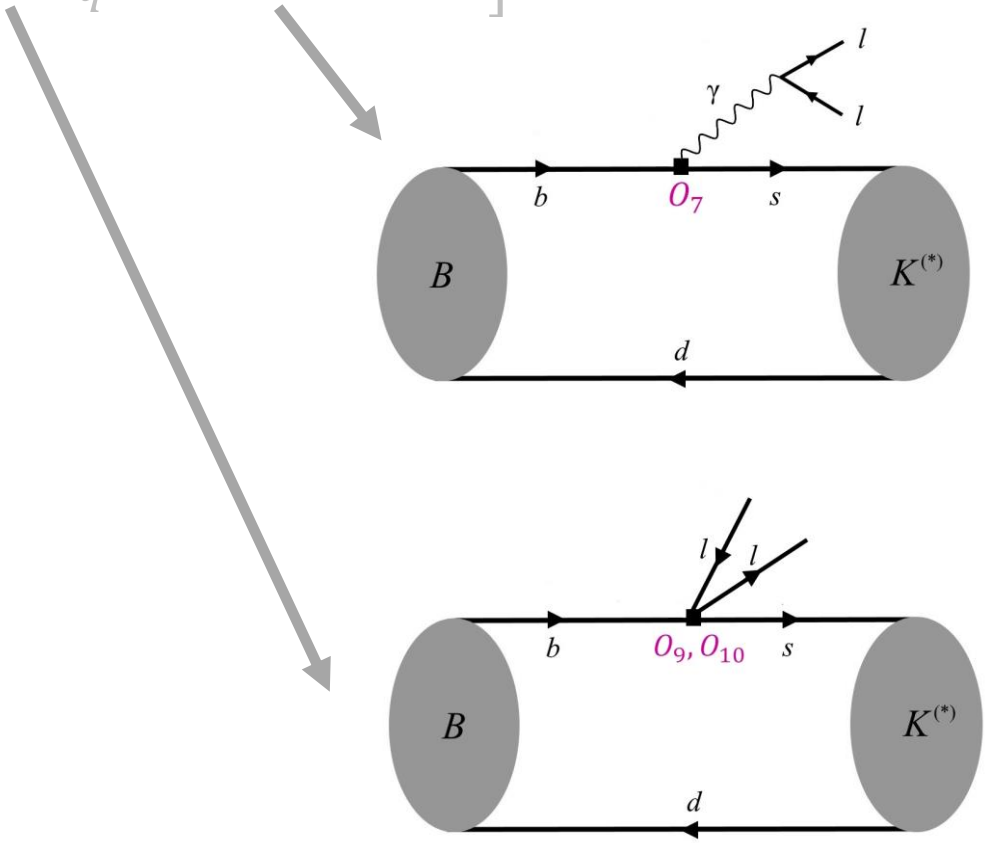
local hadronic matrix elements (MEs)

$$\mathcal{F}_\mu = \left\langle K^{(*)}\middle|O_{7,9,10}^{\text{had}}\middle|B\right\rangle \qquad O_{7,9,10}^{\text{had}} = (\bar{s}\,\Gamma\,b)$$

leading hadronic contributions

non-perturbative QCD objects
$\Longrightarrow$ calculate with lattice QCD (or LCSR)

moderate uncertainties $(3\% - 15\%)$



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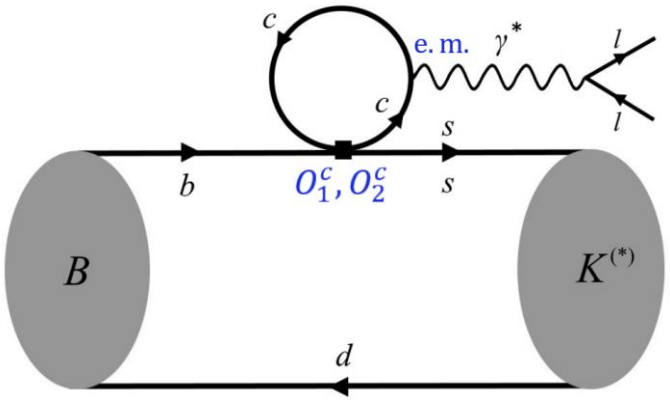
non-local hadronic MEs

$$\mathcal{H}_\mu = i\int d^4x\, e^{iq\cdot x}\left\langle K^{(*)}\middle|T\left\{j_\mu^{\mathrm{em}}(x), O_{1,2}^c(0)\right\}\middle|B\right\rangle$$

$$O_{1,2}^c = (\bar{s}\,\Gamma\, b)(\bar{c}\,\Gamma\, c)$$



subleading (?) hadronic contributions

non-perturbative QCD objects
$\Longrightarrow$ calculate with OPE

large uncertainties

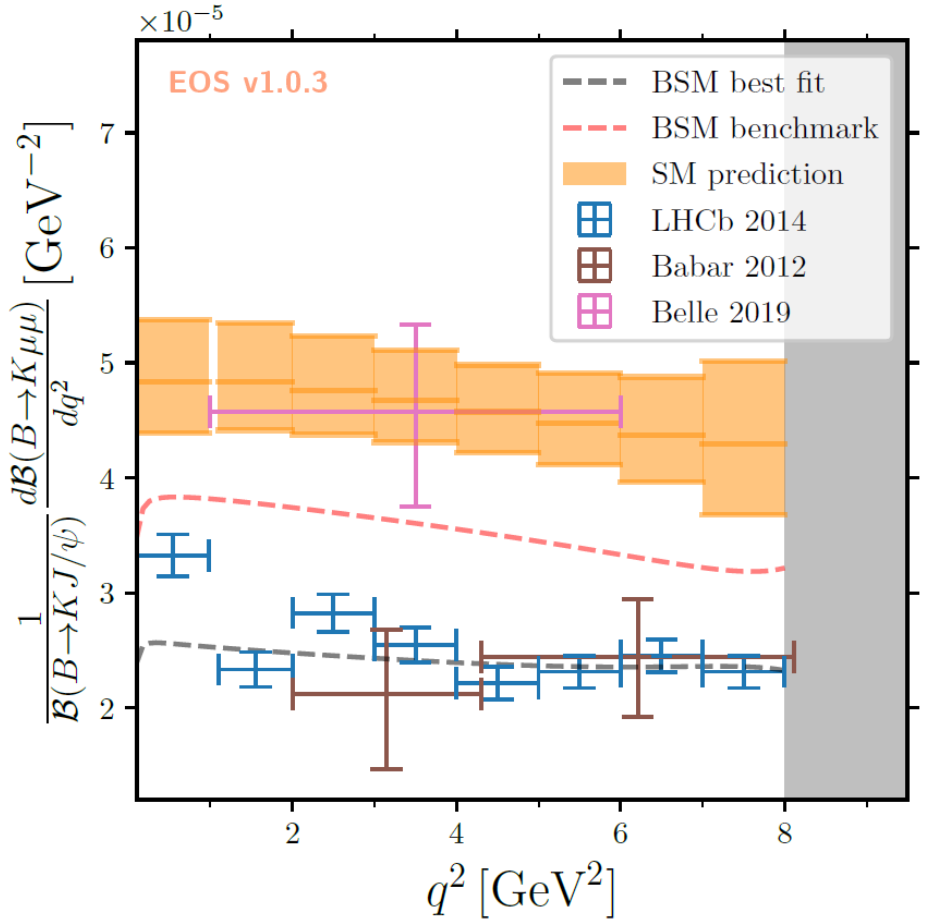
Binned vs. unbinned measurements

binned vs. unbinned

- we need binned measurements:
  last $B^+ \to K^+ \mu^+\mu^-$ BR measurement
  from LHCb 10 years ago!!!

  binned measurements can
  1. be combined,
  2. re-analysed
  3. interpreted

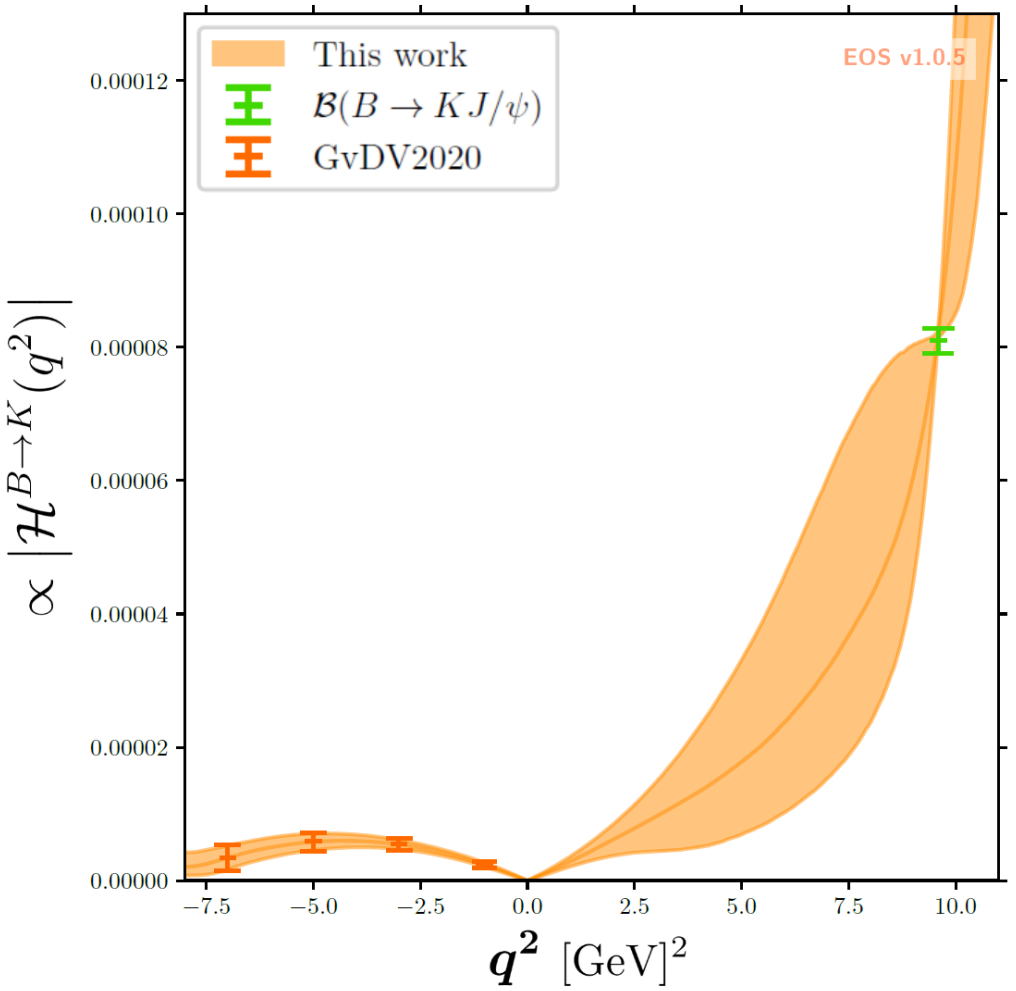
- unbinned measurements are interesting but…
  1. are model dependent
  2. cannot be used in pheno analyses
  3. cannot be combined with different measurements



For binned measurements

for binned measurements

- same binning in different collaborations
  makes things easier but is not crucial
- for a given phase space region,
  provide results using as many bins as possible
  (optimal number of bins)
- provide results also close to
  the J/ψ and between the J/ψ and $\psi(2S)$



Other points

- please give the results (if you don't do it already) as ratios

$$\frac{\Gamma(B \to K^{(*)}\mu\mu)}{\Gamma(B \to K^{(*)}J/\psi)}$$

  other experiments will provide very precise measurements for $\Gamma(B \to K^{(*)}J/\psi)$

- important to consider alternative processes (Belle II cannot do it!)

$$B_s \to \phi\mu\mu, \qquad \Lambda_b \to \Lambda\mu\mu, \qquad B \to \pi\mu\mu \ldots.$$

- As long as we have proper exp correlations, S_i vs P_i not so relevant
  P_i still better if we want to look at single observables

- $K\pi$ moments in bins of $m_{K\pi}$ from below the K^* up to beyond 1430 MeV are very useful

- we are always happy to discuss with you!
  please contact us: nicogubernari@gmail.com, jvirto@gmail.com, merilreboud@gmail.com

Thank you!