Standard Model Predictions and Global Fits for $b \to s\mu^+\mu^-$

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Based on
arXiv:2011.09813
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in collaboration with
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Particle Physics Phenomenology after the Higgs Discovery
Collaborative Research Center TRR 257

UNIVERSITÄT SIEGEN
Center for Particle Physics Siegen

Talk outline

Introduction

Theoretical framework

- $b \to s\ell^+\ell^-$ effective Hamiltonian
- parametrization for local and non-local form factors
- dispersive bound

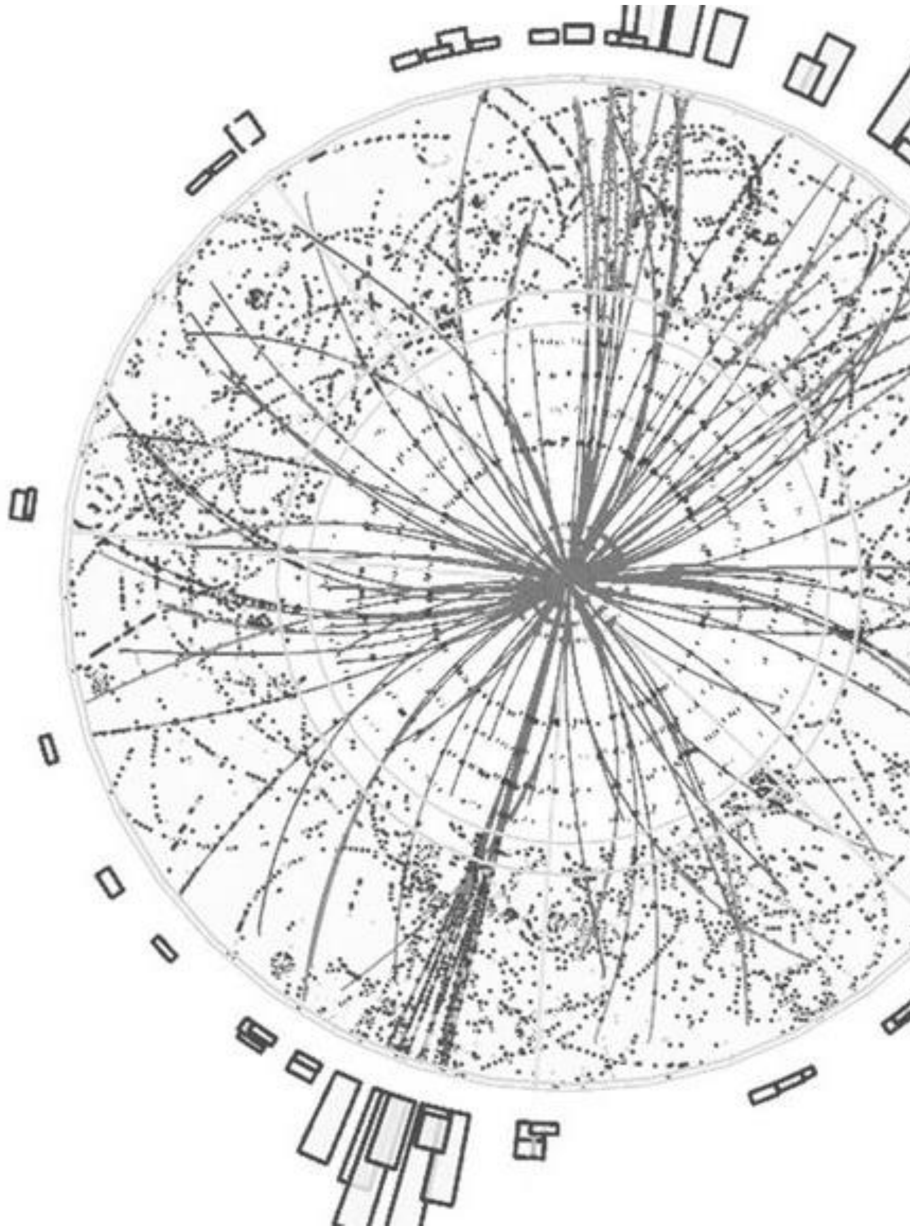
Theoretical predictions

- predictions for local and non-local form factors
- predictions of BRs and
  angular observables in $B_{(s)} \to \{K^{(*)}, \phi\}\ell^+\ell^-$

Confrontation with data

- comparison between SM predictions and data
- global fit to $b \to s\mu^+\mu^-$

Summary and outlook



Introduction

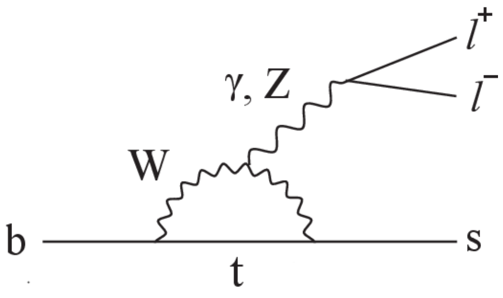
Flavour changing currents

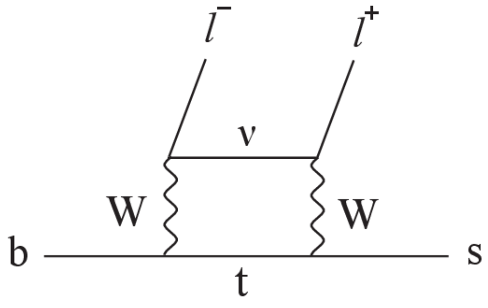
flavour changing neutral currents (FCNC) absent at tree level in the SM

FCNC are loop, GIM and CKM **suppressed in the SM**

FCNC **sensitive to new physics** contributions
probe the SM through **indirect searches**

focus on $b \to s\ell^+\ell^-$ transitions





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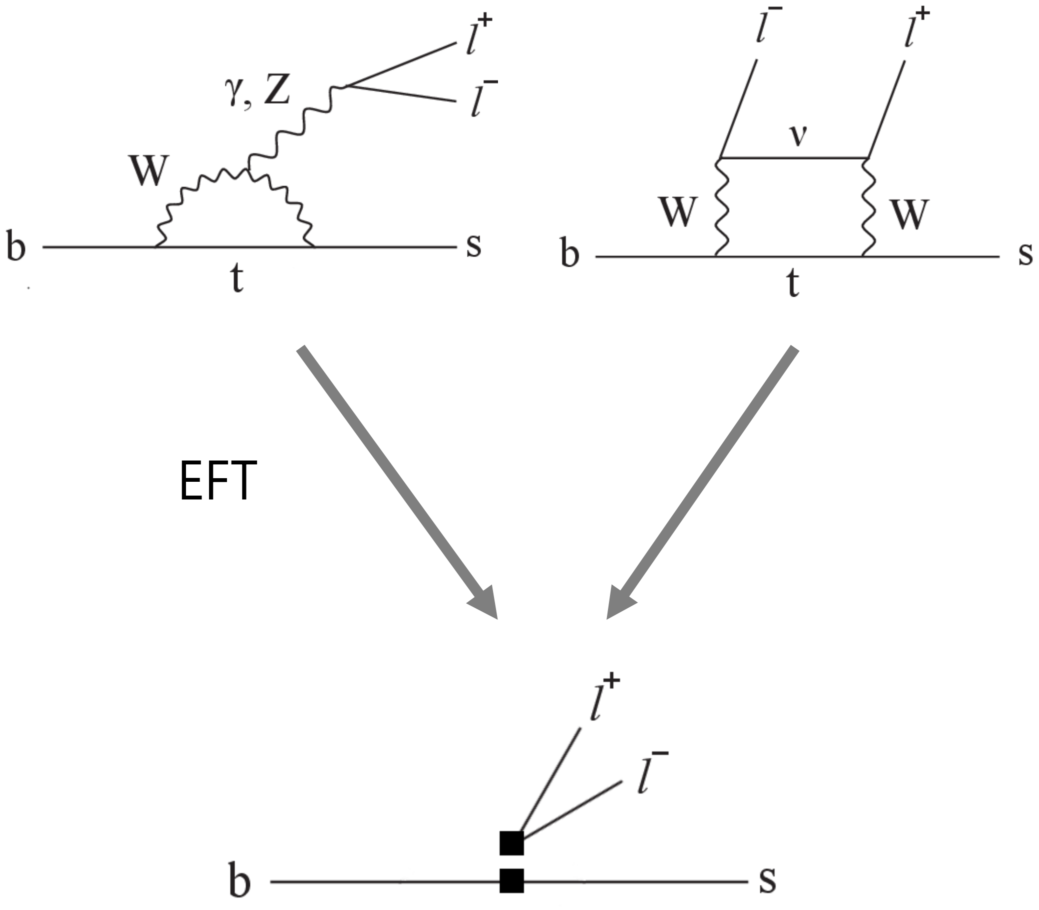
FCNC **sensitive to new physics** contributions
probe the SM through **indirect searches**

focus on $b \to s\ell^+\ell^-$ transitions

integrate out heavy degress of freedom
(W, Z, and Higgs boson, top quark)

$\Downarrow$

weak effective field theory



Hadronic matrix elements

study $\boldsymbol{B}$-meson decays to test the SM, focus on to $B \to K^{(*)}\ell^+\ell^-$ and $B_s \to \phi\ell^+\ell^-$
factorise decay amplitude as (neglecting QED corrections)

charged currents: $\langle \bar{D}^{(*)}\ell\nu_\ell|\mathcal{O}_{eff}|B\rangle = \langle \ell\nu_\ell|\mathcal{O}_{lep}|0\rangle\langle D^{(*)}|\mathcal{O}_{had}|B\rangle$

FCNC: $\langle K^{(*)}\ell^+\ell^-|\mathcal{O}_{eff}|B\rangle = \langle \ell\ell|\mathcal{O}_{lep}|0\rangle\langle K^{(*)}|\mathcal{O}_{had}|B\rangle$ + non−fact.

leptonic matrix elements: perturbative objects, high accuracy

hadronic matrix elements: non-perturbative QCD effects, usually large uncertainties

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leptonic matrix elements: perturbative objects, high accuracy

hadronic matrix elements: non-perturbative QCD effects, usually large uncertainties

decay amplitudes depend on:

- local hadronic matrix elements
  (local form factors)
  $\langle K^{(*)}|\mathcal{O}(0)|B\rangle$
  $\langle D^{(*)}|\mathcal{O}(0)|B\rangle$
- nonlocal hadronic matrix elements
  (soft gluon contributions
  to the charm-loop)
  $\langle K^{(*)}|\mathcal{O}(0,x)|B\rangle$

Interesting observables

define observables smartly to reduce the hadronic uncertainties

e.g., observable P_5': angular observables in $B \to K^* \ell^+ \ell^-$

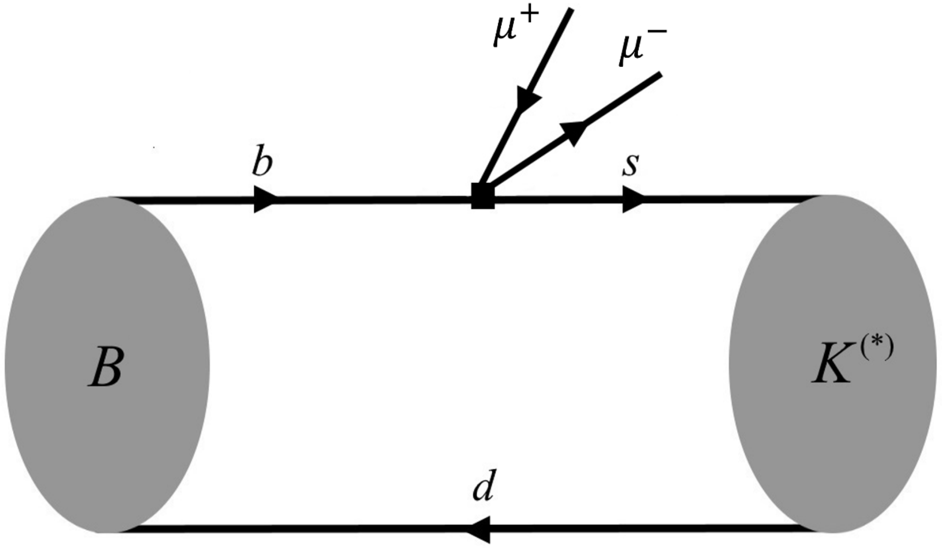
test the lepton flavour universality to test the SM

lepton flavour universality = the 3 lepton generations have the same couplings to the gauge bosons

violations of lepton flavour universality $\Longrightarrow$ new physics

observables to test LFU

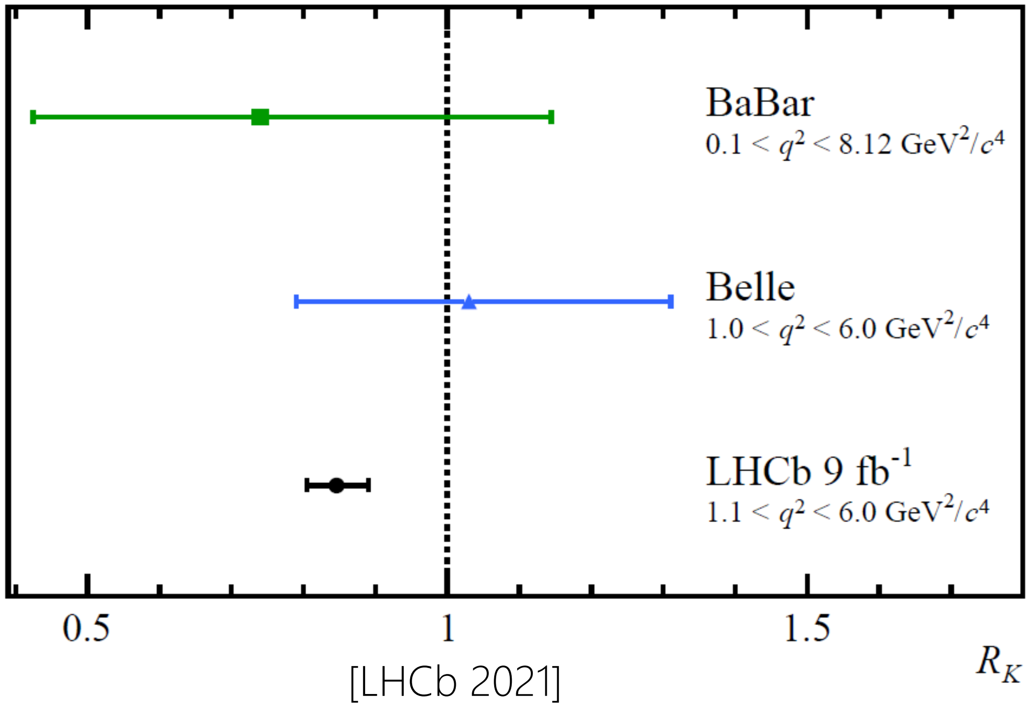
$$R_K = \frac{\Gamma(B \to K\, \mu^+\mu^-)}{\Gamma(B \to K\, e^+e^-)} \qquad R_{K^*} = \frac{\Gamma(B \to K^* \mu^+\mu^-)}{\Gamma(B \to K^* e^+e^-)}$$



$b(\to s\ell^+\ell^-)$ anomalies

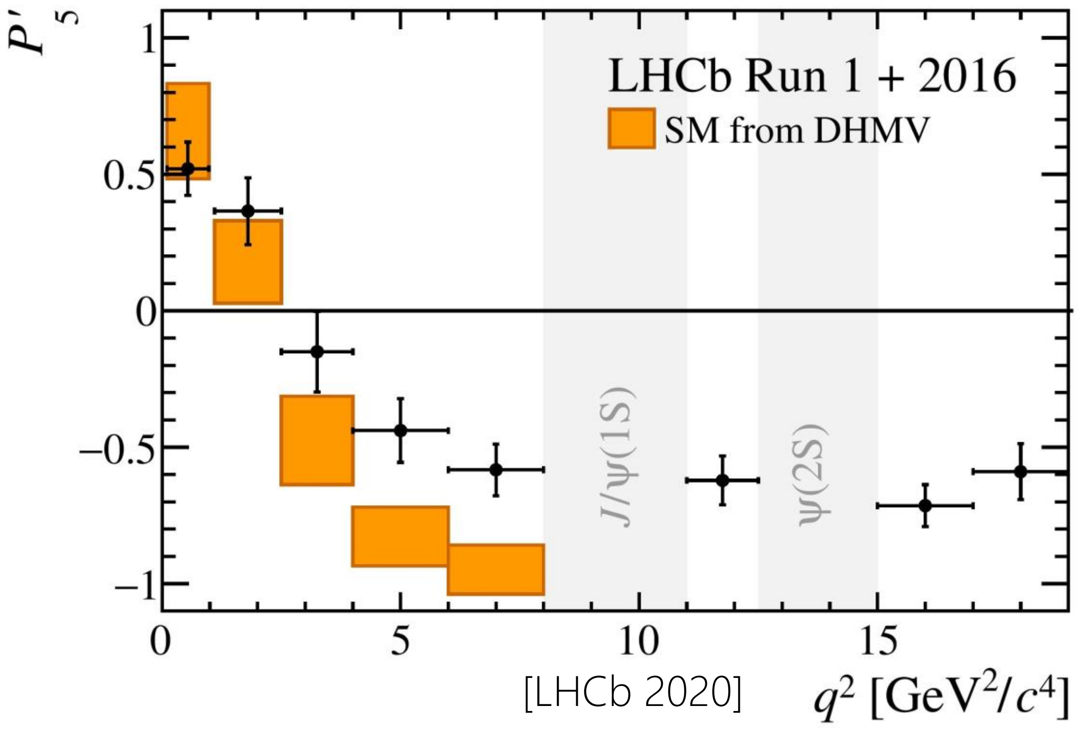
$b \to s\ell^+\ell^-$ anomalies = tension between experimental measurements and theoretical predictions in rare B-meson decays involving different observables ($R_K, R_{K^*}, P_5', B_s \to \phi\mu^+\mu^-$, branching ratio, ...)

3.1σ tension



[LHCb 2021]

~3σ tension



[LHCb 2020]

Theoretical framework

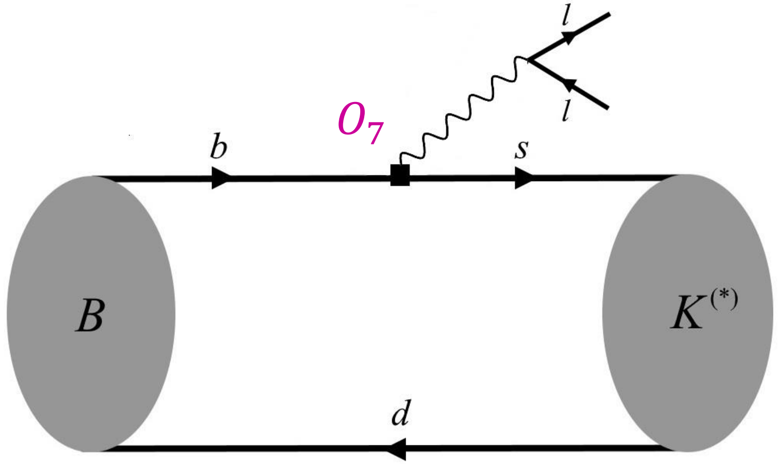
$b \to s\ell^+\ell^-$ effective Hamiltonian

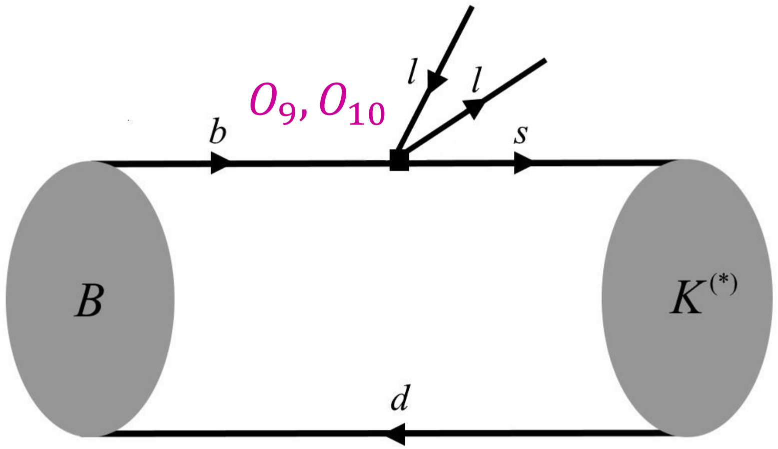
transitions described by the **effective Hamiltonian**

$$\mathcal{H}(b \to s\ell^+\ell^-) = -\frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^* \sum_{i=1}^{10} C_i(\mu) O_i(\mu) \qquad \mu = m_b$$

main contributions to $B_{(s)} \to \{K^{(*)}, \phi\}\ell^+\ell^-$ in the SM given by local operators O_7, O_9, O_{10}

$O_7 = \frac{e}{16\pi^2} m_b(\bar{s}_L \sigma^{\mu\nu} b_R) F_{\mu\nu}$ $\quad O_9 = \frac{e^2}{16\pi^2}(\bar{s}_L \gamma^\mu b_L) \sum_\ell (\bar{\ell}\gamma_\mu \ell)$ $\quad O_{10} = \frac{e^2}{16\pi^2}(\bar{s}_L \gamma^\mu b_L) \sum_\ell (\bar{\ell}\gamma_\mu \gamma_5 \ell)$

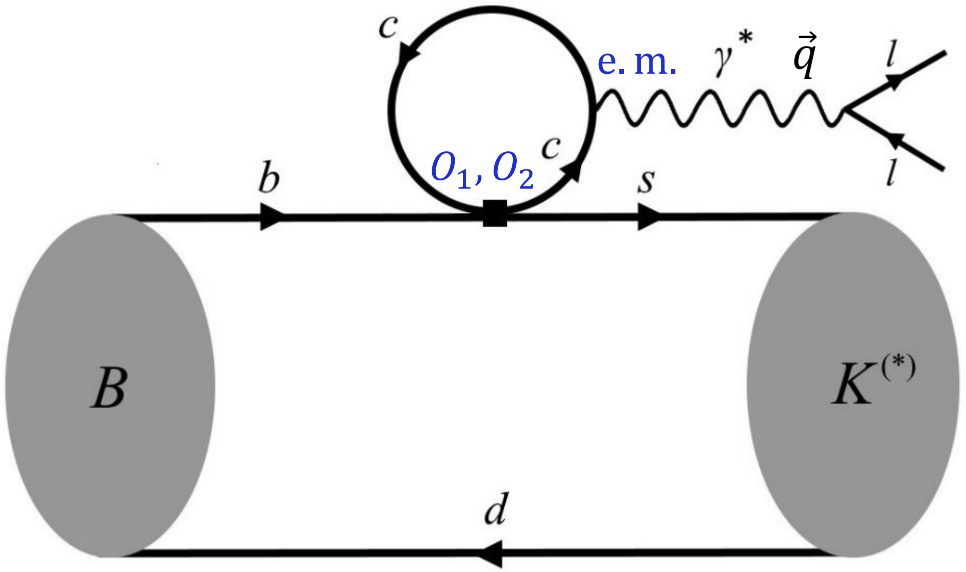




Charm loop in $B \to K^{(*)}\ell^+\ell^-$

additional non-local contributions come from O_1^c and O_2^c combined with the e.m. current (charm-loop contribution)

$$O_1^c = (\bar{s}_L \gamma^\mu c_L)(\bar{c}_L \gamma_\mu b_L) \qquad O_2^c = (\bar{s}_L^j \gamma^\mu c_L^i)(\bar{c}_L^i \gamma_\mu b_L^j)$$



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

calculate decay amplitudes precisely to probe the SM

B-anomalies: NP or underestimated systematic uncertainties?

(analogous formulas apply to $B_s \to \phi\ell^+\ell^-$ decays)

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

local hadronic matrix elements

$$\mathcal{F}_\mu = \langle K^{(*)}(k) | O_{7,9,10} | B(k+q) \rangle$$

non-local hadronic matrix elements

$$\mathcal{H}_\mu = i \int d^4x\, e^{iq\cdot x} \langle K^{(*)}(k) | T\{ j_\mu^{\text{em}}(x), (C_1 O_1^c + C_2 O_2^c)(0)\} | B(k+q) \rangle$$

Form factors definitions

form factors (FFs) **parametrize hadronic matrix elements**

FFs are functions of the momentum transfer squared $\boldsymbol{q^2}$

local FFs

$$\mathcal{F}_\mu(k,q) = \sum_\lambda \mathcal{S}_\mu^\lambda(k,q)\,\mathcal{F}_\lambda(q^2)$$

computed with lattice QCD and sum rules with good precision $\boldsymbol{\sim 10\%}$

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non-local FFs

$$\mathcal{H}_\mu(k,q) = \sum_\lambda \mathcal{S}_\mu^\lambda(k,q)\mathcal{H}_\lambda(q^2)$$

calculated using an **Operator Product Expansion (OPE)** or QCD factorization or …
(variety of approaches, most of them model-dependent)

large uncertainties → reduce uncertainties for a better understanding of rare B decays

Parametrization for $\mathcal{F}_\lambda$

obtain local FFs $\mathcal{F}_\lambda$ in the whole semileptonic region by combining

- lattice QCD (LQCD) calculations at high q^2
- light-cone sum rule (LCSR) calculation at low q^2

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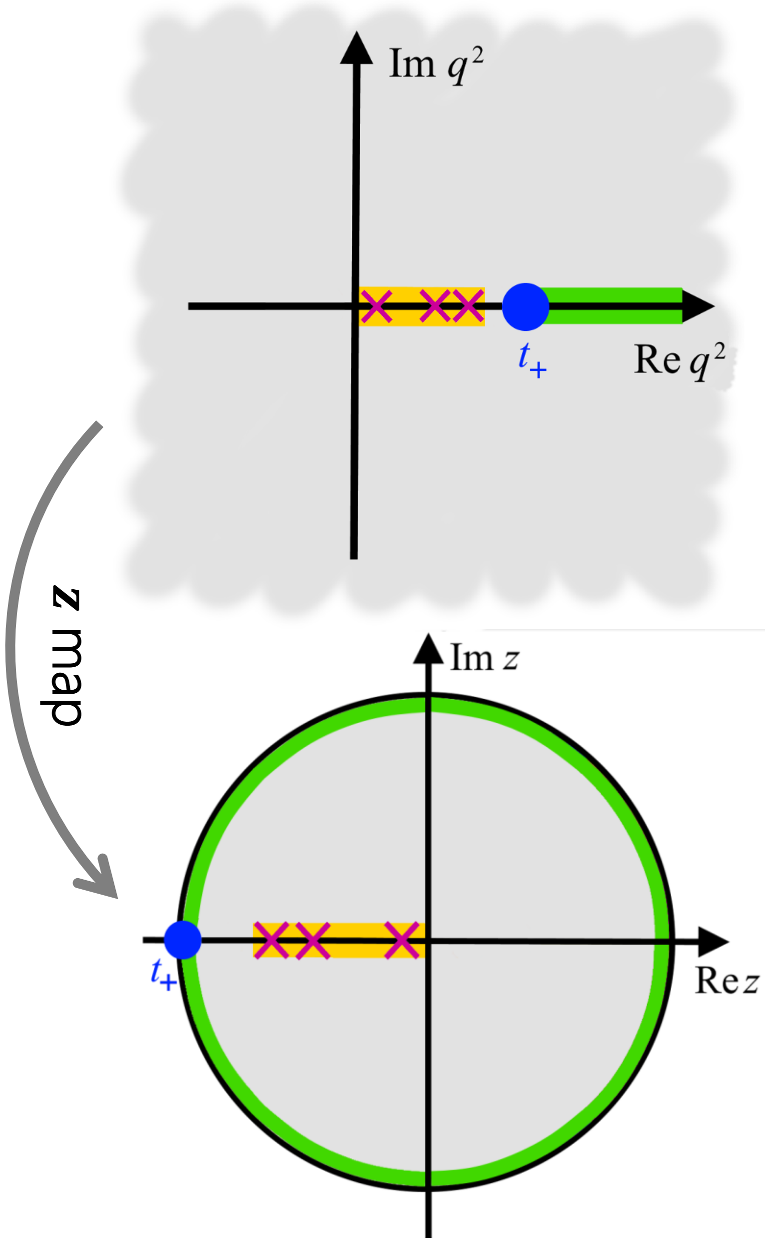
$\mathcal{F}_\lambda$ analytic functions of q^2 (branch cut for $q^2 > t_+ = \left(M_B + M_{K^{(*)}}\right)^2$)

fit results to a ***z* parametrization** (standard approach)

[Boyd/Grinstein/Lebed 1997]

$$\mathcal{F}_\lambda \propto \sum_{k=0}^{\infty} \alpha_k^{\mathcal{F}} z^k$$

$$z(q^2) = \frac{\sqrt{t_+ - q^2} - \sqrt{t_+}}{\sqrt{t_+ - q^2} + \sqrt{t_+}}$$



Calculation of $\mathcal{H}_\lambda$ at negative q^2

compute the non-local FFs $\mathcal{H}_\lambda$ using a light-cone OPE for $q^2 \ll 4m_c^2$ $(q^2 < 0)$

$$\mathcal{H}_\lambda(q^2) = \mathcal{C}_\lambda(q^2)\mathcal{F}_\lambda(q^2) + \tilde{\mathcal{C}}_\lambda(q^2)\mathcal{V}_\lambda(q^2) + \cdots$$

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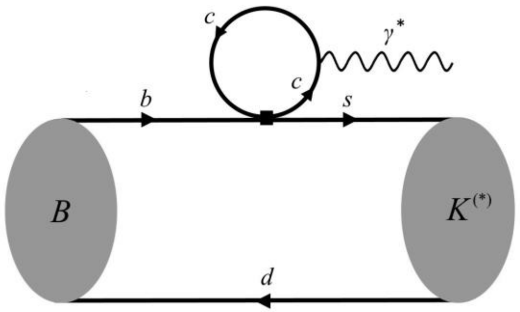
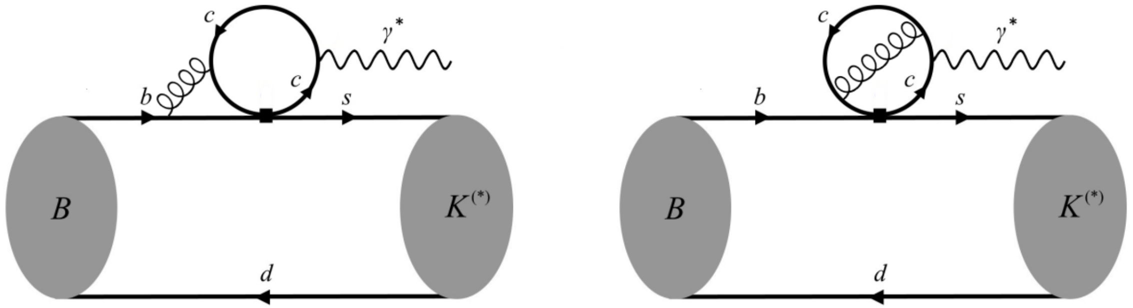
leading power (LO in α_s)



+ hard gluons (α_s) corrections



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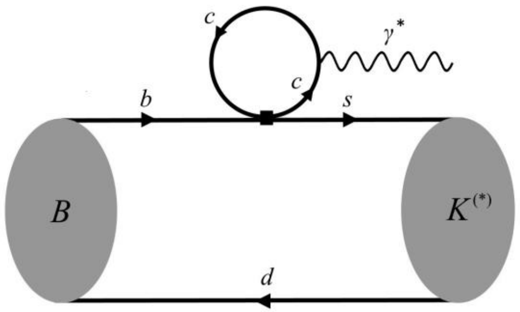

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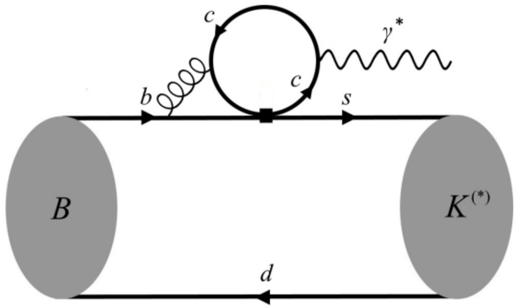
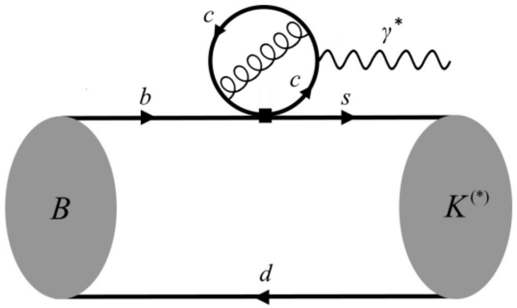
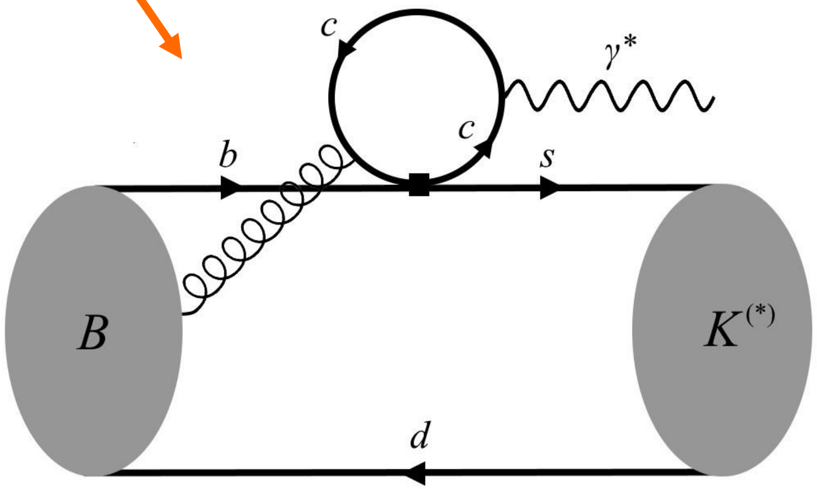




soft gluon correction
non-perturbative
$\Longrightarrow$ not α_s suppressed



[Khodjamirian et al. 2010]
[NG/van Dyk/Virto 2020]

NLP of the light-cone OPE

$\Delta C_9(q^2 = 1\ \mathrm{GeV}^2)$		**KMPW2010**	**GvDV2020**
leading power (LO α_s)		0.27	0.27
$B \to K\ell\ell$	$\mathcal{V}_{\mathcal{A}}$	$-0.09^{+0.06}_{-0.07}$	$(1.9^{+0.6}_{-0.6}) \cdot 10^{-4}$
	$\mathcal{V}_1$	$0.6^{+0.7}_{-0.5}$	$(1.2^{+0.4}_{-0.4}) \cdot 10^{-3}$
$B \to K^*\ell\ell$	$\mathcal{V}_2$	$0.6^{+0.7}_{-0.5}$	$(2.1^{+0.7}_{-0.7}) \cdot 10^{-3}$
	$\mathcal{V}_3$	$1.0^{+1.6}_{-0.8}$	$(3.0^{+1.0}_{-1.0}) \cdot 10^{-3}$
$B_s \to \phi\ell\ell$	$\mathcal{V}_i$	—	see paper

- results represented as a q^2 dependent correction to C_9
- we can reproduce the analytical results given in KMWP2010
- our results are **two orders of magnitude smaller** than in KMWP2010 ($\Longrightarrow$ **smaller unc.**)
- quick **convergence of the light-cone OPE**

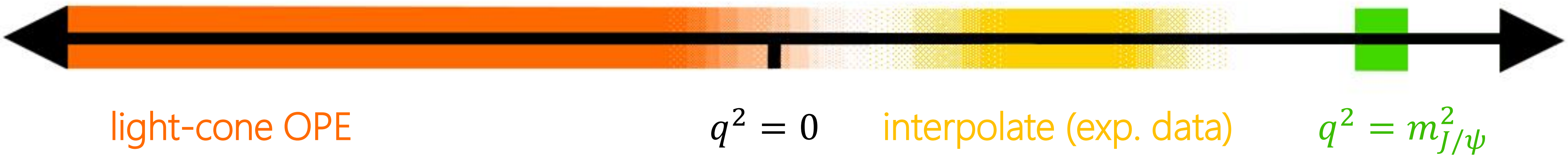
Obtaining theoretical predictions for $\mathcal{H}_\lambda$

1. extract $\mathcal{H}_\lambda$ at $q^2 = m^2_{J/\psi}$ from $B \to K^{(*)} J/\psi$ and $B_s \to \phi\, J/\psi$ measurements (no local contribution)

2. **interpolate** the OPE calculation at negative q^2 and the experimental results at $q^2 = m^2_{J/\psi}$ to obtain $\mathcal{H}_\lambda$ for $q^2 < m^2_{J/\psi}$

3. **new approach** to obtain theoretical predictions in the low q^2 $(0 < q^2 < 8\ \mathrm{GeV}^2)$ region
   $\Longrightarrow$ compare with experimental data

need a parametrization to interpolate $\mathcal{H}_\lambda$: which is the optimal parametrization?



Parametrizations for $\mathcal{H}_\lambda$

- q^2 parametrization [Jäger/Camalich 2012, Ciuchini et al. 2015]

$$\mathcal{H}_\lambda(q^2) = \mathcal{H}_\lambda^{\text{QCDF}}(q^2) + \mathcal{H}_\lambda^{\text{rest}}(0) + \frac{q^2}{M_B^2}\mathcal{H}_\lambda^{\text{rest},\prime}(0) + \frac{(q^2)^2}{M_B^4}\mathcal{H}_\lambda^{\text{rest},\prime\prime}(0) + \cdots$$

- dispersion relation [Khodjamirian et al. 2010]

$$\mathcal{H}_\lambda(q^2) = \mathcal{H}_\lambda(0) + \sum_{\psi=J/\psi,\psi(2S)} \frac{f_\psi \mathcal{A}_\psi}{M_\psi^2\left(M_\psi^2 - q^2\right)} + \int_{4M_D^2}^{\infty} dt \frac{\rho(t)}{t(t-q^2)}$$

- z expansion [Bobeth/Chrzaszcz/van Dyk/Virto 2017]

$$\mathcal{H}_\lambda(z) = \sum_{n=0}^{\infty} c_n z^n$$

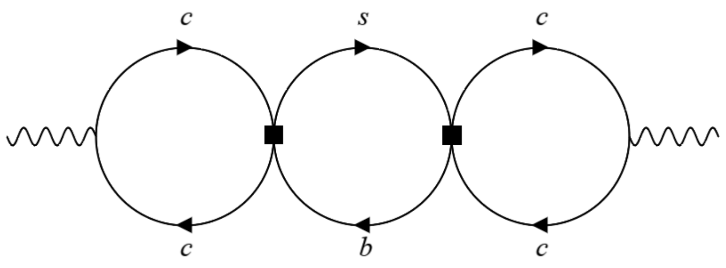
- we propose a new parametrization ($\hat{z}$ polynomials) [NG/van Dyk/Virto 2020]

$$\hat{\mathcal{H}}_\lambda(\hat{z}) = \sum_{n=0}^{\infty} \beta_n p_n(\hat{z})$$

Derivation of the dispersive bound

define the correlator

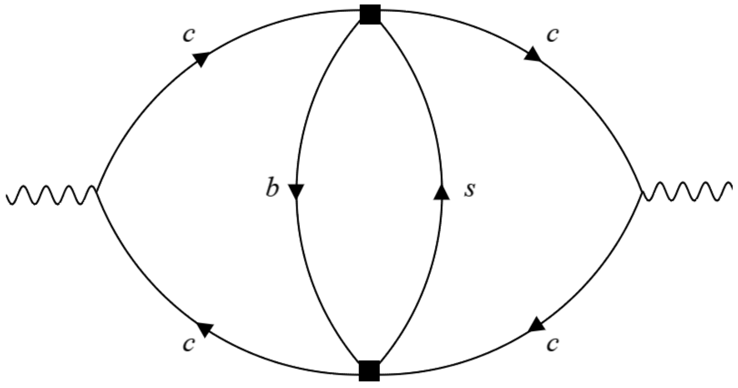
$$\Pi(k,q) = i\int \mathrm{d}^4x\, e^{ikx}\langle 0|T\{\mathcal{O}^\mu(x),\mathcal{O}_\mu(y)\}|0\rangle$$



where

$$\mathcal{O}_\mu \propto \int d^4x\, e^{iq\cdot x}\, T\{j_\mu^{em}(x),(C_1O_1^c + C_2O_2^c)(0)\}$$

use a subtracted dispersion relation



$$\chi(q^2) \propto \int_{(M_B+M_K)^2}^{\infty} ds \frac{\mathrm{Disc}_{bs}\Pi(s)}{(q^2-s)^3}$$

calculate $\chi(q^2)$ perturbatively and $\mathrm{Disc}_{bs}\Pi(q^2)$ using unitarity

Dispersive bound

using unitarity and dispersion relation, we obtain a constraint
on the non-local form factors $\mathcal{H}_\lambda$

dispersive bound

$$1 > \int_{(M_B+M_K)^2}^{\infty} ds\, |\phi^{B\to K}(z)|^2 |\mathcal{H}^{B\to K}(s)|^2 + B \to K^* \text{ and } B_s \to \phi \text{ contr.}$$

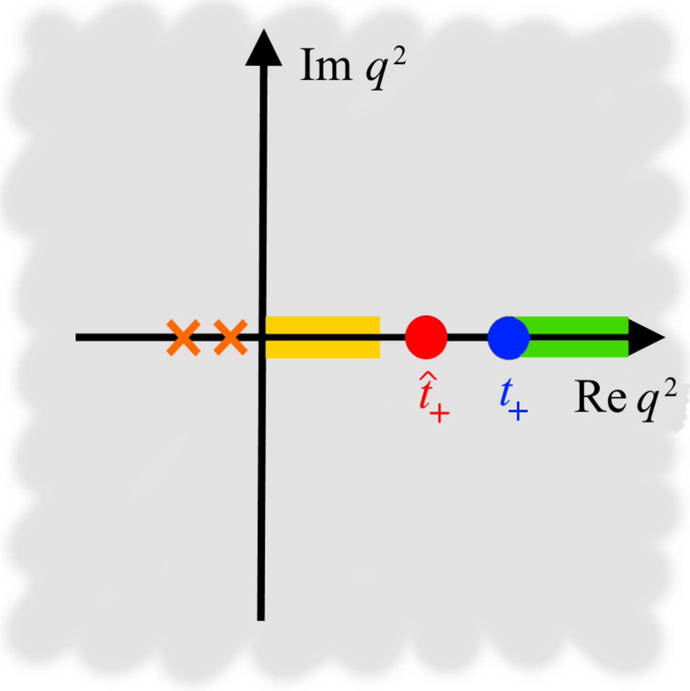
- **first dispersive bound** for $\mathcal{H}^{B\to K}$, $\mathcal{H}_\lambda^{B\to K^*}$, $\mathcal{H}_\lambda^{B_s\to\phi}$
- **model independent** constraint
- strengthen the bound by adding additional contributions (baryons)

Exploit the dispersive bound

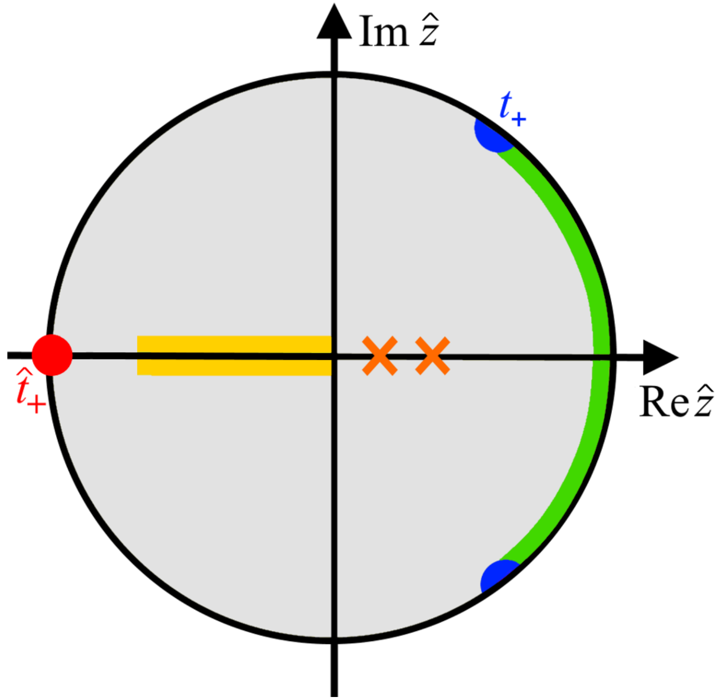
$\mathcal{H}_\lambda$ has a branch cut for $q^2 > \hat{t}_+ = 4M_D^2$ — note that $\hat{t}_+ \neq t_+ \equiv \left(M_B + M_{K^{(*)}}\right)^2$

define the $\hat{z}$ mapping

$$\hat{z}(q^2) = \frac{\sqrt{\hat{t}_+ - q^2} - \sqrt{\hat{t}_+}}{\sqrt{\hat{t}_+ - q^2} + \sqrt{\hat{t}_+}}$$



q^2 plane
real axis $q^2 > \hat{t}_+$ $\Longrightarrow$ $\hat{z}$ plane
arc of unit circle



Exploit the dispersive bound

$$1 > \int_{(M_B+M_K)^2}^{\infty} ds\, |\phi^{B\to K}(s)|^2 |\mathcal{H}^{B\to K}(s)|^2 + B \to K^* \text{ and } B_s \to \phi \text{ contr.}$$

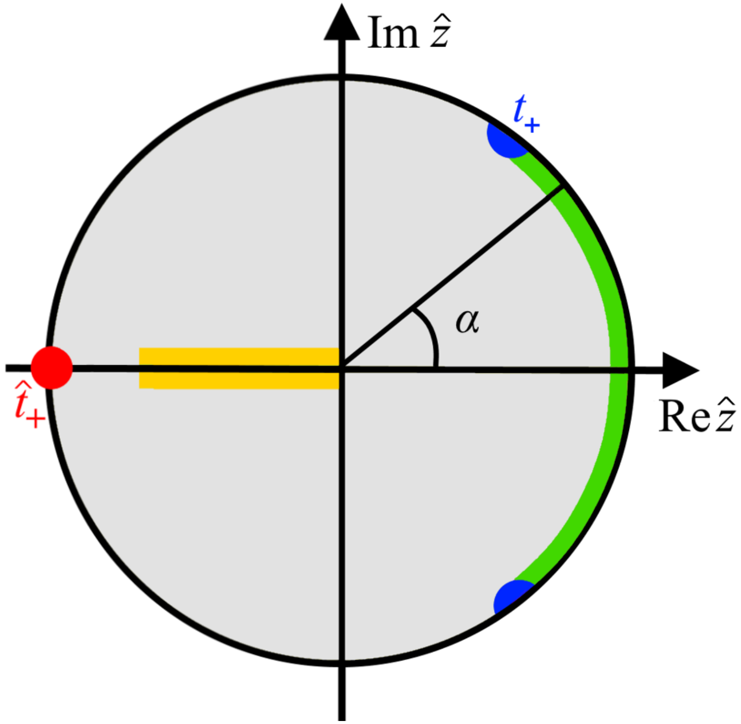
apply the $\hat{z}$ mapping

$$1 > \int_{-\alpha_{BK}}^{+\alpha_{BK}} d\alpha \sum_{\lambda} \left|\widehat{\mathcal{H}}^{B\to K}(\hat{z})\right|^2 + B \to K^* \text{ and } B_s \to \phi \text{ contr.}$$

where $\hat{z} = e^{i\alpha}$ and

$$\widehat{\mathcal{H}}^{B\to K}(\hat{z}) = \mathcal{P}(\hat{z})\, \phi^{B\to K}(\hat{z})\, \mathcal{H}_{\lambda}^{B\to K}(\hat{z})$$

Blaschke factor $\mathcal{P}$, outer function $\phi^{B\to K}$



$\hat{\mathcal{H}}_\lambda$ parametrization

$$1 > \int_{-\alpha_{BK}}^{+\alpha_{BK}} d\alpha \left|\hat{\mathcal{H}}^{B\to K}(\hat{z})\right|^2 + B \to K^* \text{and } B_s \to \phi \text{ contr.}$$

expand $\hat{\mathcal{H}}_\lambda$ in orthogonal polynomials $p_n(\hat{z})$

$$\hat{\mathcal{H}}(\hat{z}) = \sum_{n=0}^{\infty} \beta_n \, p_n(\hat{z})$$

now the dispersive bound reads

$$1 > \sum_{n=0}^{\infty} |\beta_n^{B\to K}|^2 + \sum_\lambda \left(2 \sum_{n=0}^{\infty} \left|\beta_{\lambda,n}^{B\to K^*}\right|^2 + \sum_{n=0}^{\infty} \left|\beta_{\lambda,n}^{B_s\to\phi}\right|^2 \right)$$

no bound for the $\hat{z}$ monomials
(coefficient of the Taylor expansion)

$$p_0^{B\to K}(\hat{z}) = \frac{1}{\sqrt{2\alpha_{BK}}}$$

$$p_1^{B\to K}(\hat{z}) = \left(\hat{z} - \frac{\sin(\alpha_{BK})}{\alpha_{BK}}\right) \sqrt{\frac{\alpha_{BK}}{2\alpha_{BK}^2 + \cos(2\alpha_{BK}) - 1}}$$

$$p_2^{B\to K}(\hat{z}) = \left(\hat{z}^2 + \frac{\sin(\alpha_{BK})(\sin(2\alpha_{BK}) - 2\alpha_{BK})}{2\alpha_{BK}^2 + \cos(2\alpha_{BK}) - 1}\hat{z} + \frac{2 \sin}{}\right.$$

$$p_3^{B\to K}(\hat{z}) = \cdots$$

Theoretical predictions

Local form factors predictions

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

obtain numerical results for the local FFs

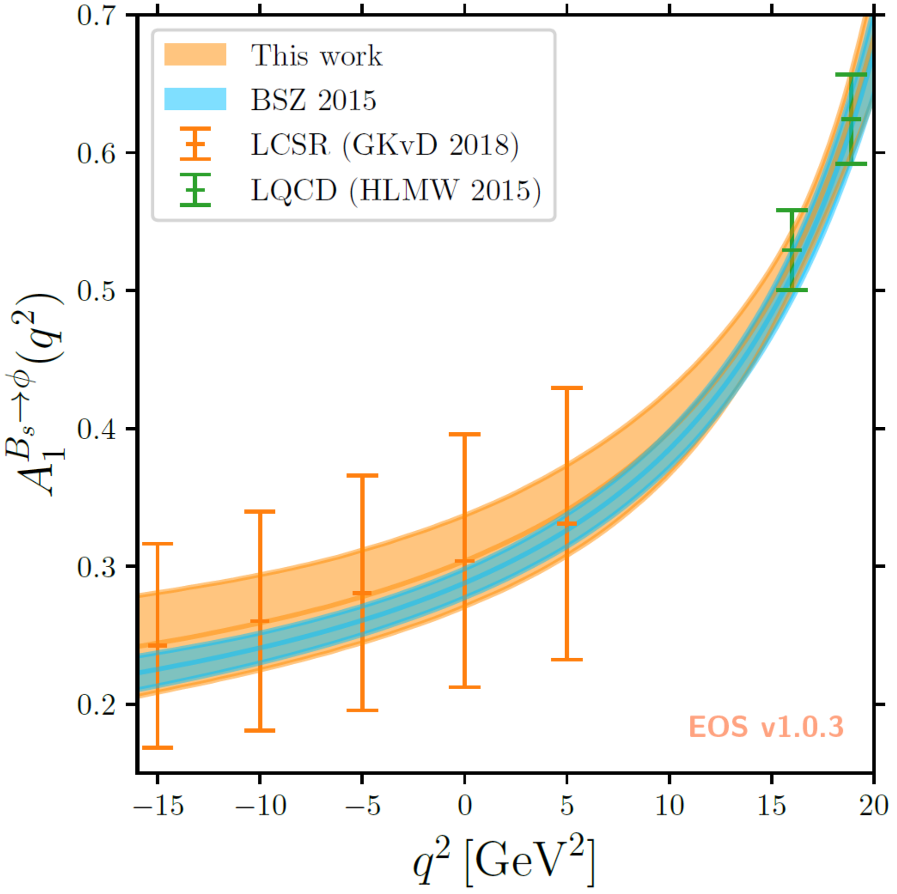
$$\mathcal{F}_\lambda \cong \mathcal{P} \sum_{k=0}^{3} \alpha_k^{\mathcal{F}}\, z^k$$

for $B \to K^{(*)}\ell^+\ell^-$ and $B_s \to \phi\ell^+\ell^-$ fit the $\boldsymbol{z}$ parametrization to

- LQCD calculations at high q^2
  [FLAG review 2021] [Horgan et al. 2013][Horgan et al. 2015]
- LCSR calculation at low q^2
  [Khodjamirian/Rusov 2017] [NG/Kokulu/van Dyk 2018]
  [NG/van Dyk/Virto 2020]

large p values

results given in machine readable files



Non-local form factors predictions

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

obtain numerical results for the non-local FFs $\mathcal{H}_\lambda$

$$\hat{\mathcal{H}}_\lambda \cong \sum_{n=0}^{5} \beta_n p_n(\hat{z})$$

fit the $\hat{z}$ parametrization

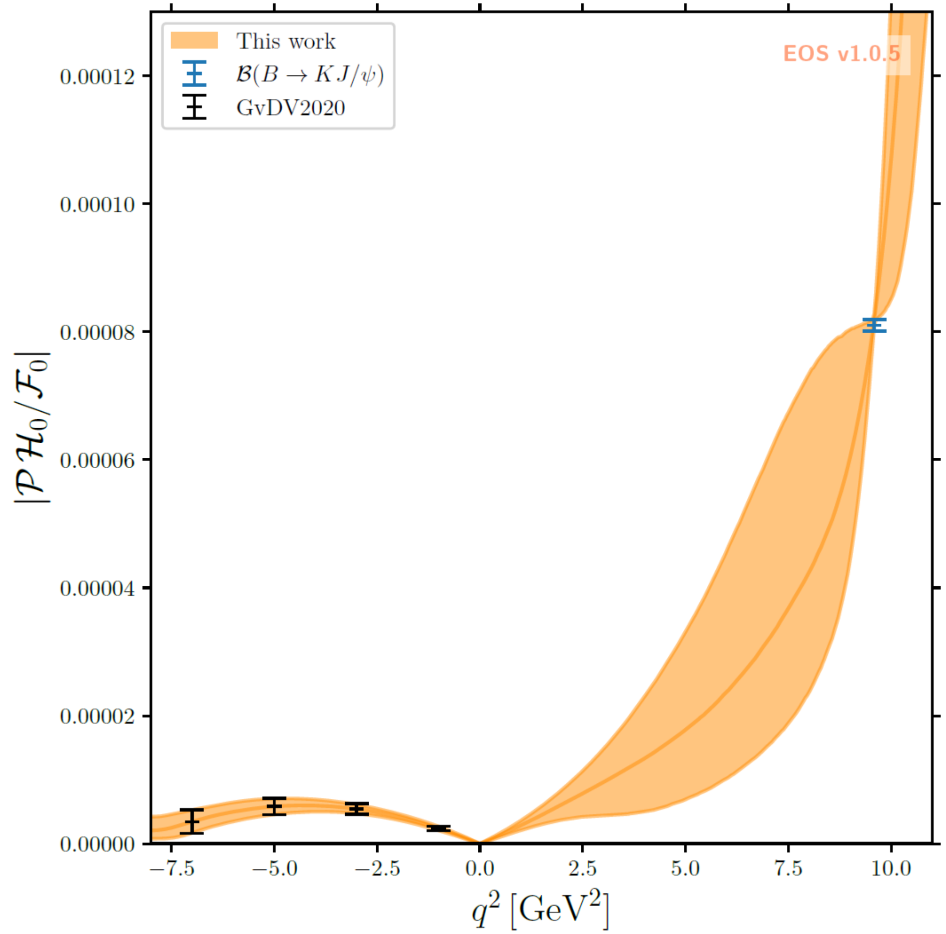
- light-cone OPE calculation at negative q^2

$$\mathcal{H}_\lambda(q^2) = C_\lambda(q^2)\mathcal{F}_\lambda(q^2) + \tilde{C}_\lambda(q^2)\mathcal{V}_\lambda(q^2) + \cdots$$

- $B \to K^{(*)} J/\psi$ and $B_s \to \phi\, J/\psi$ measurements at $q^2 = m_{J/\psi}^2$
- dispersive bound

all p values $> 11\%$

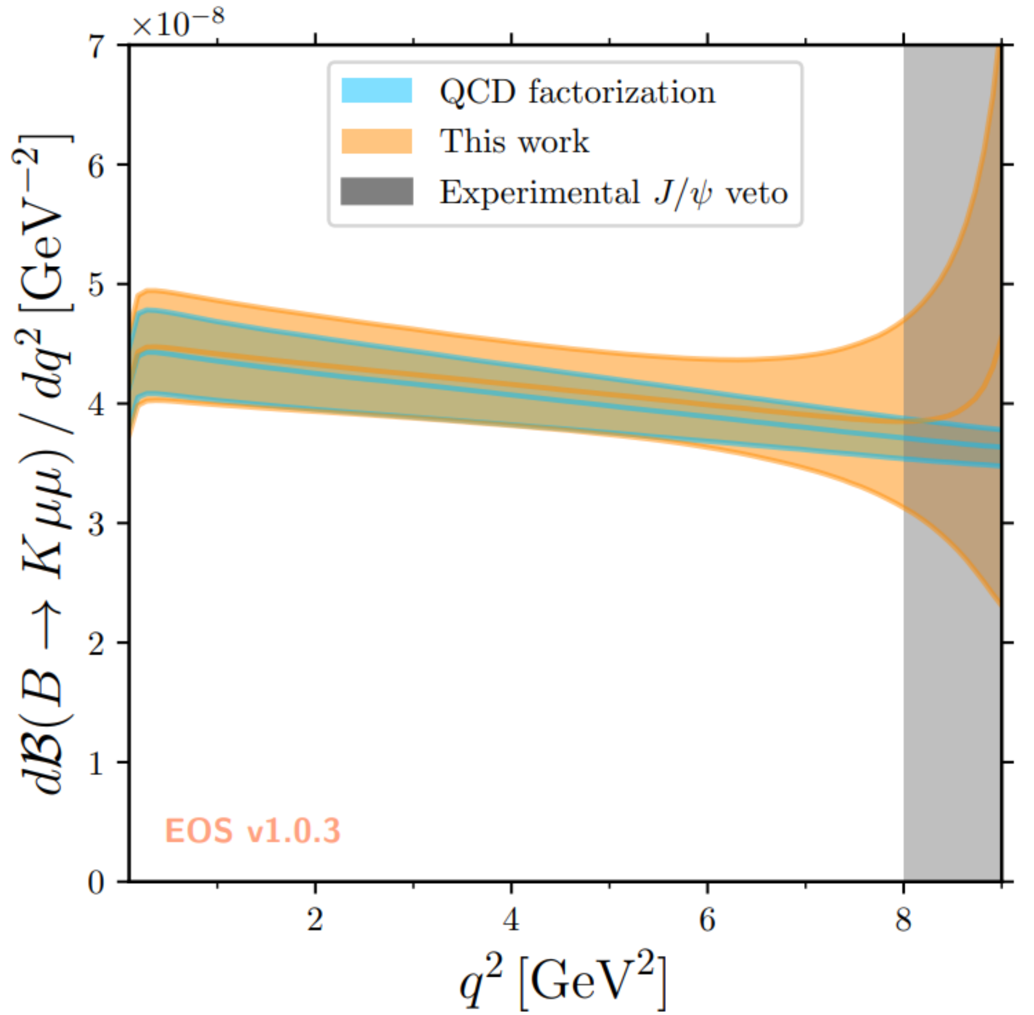
results given in machine readable files



Standard Model predictions

using our local and non-local FFs values
we predict branching ratios and angular observables in $B \to K\mu^+\mu^-$, $B \to K^*\mu^+\mu^-$, and $B_s \to \phi\mu^+\mu^-$ in the SM

- we **do not use QCD factorization** (QCDF) like all previous SM predictions (non-quantifiable systematic uncertainty)
- first predictions using dispersive bounds (control the truncation errors)
- **systematically improvable approach** (more precise form factor results, saturate the bound,…)



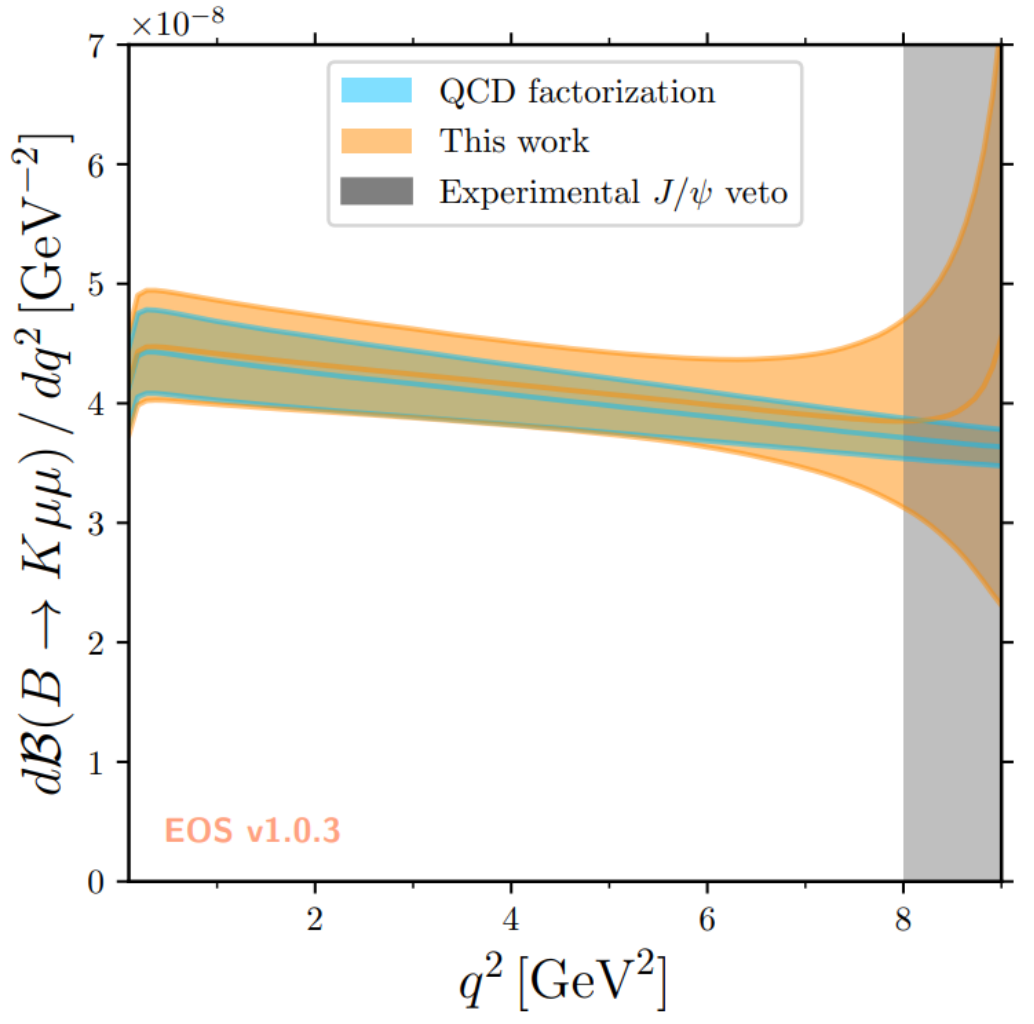
Comparison with QCD factorization

- plot produced with same FFs inputs

- **central values in** excellent **agreement** but **smaller uncertainties** in QCDF (systematic unc. not considered)

- **same shape** (also in $B \to K^{*}\mu^{+}\mu^{-}$, deviation found in $B_s \to \phi\mu^{+}\mu^{-}$)

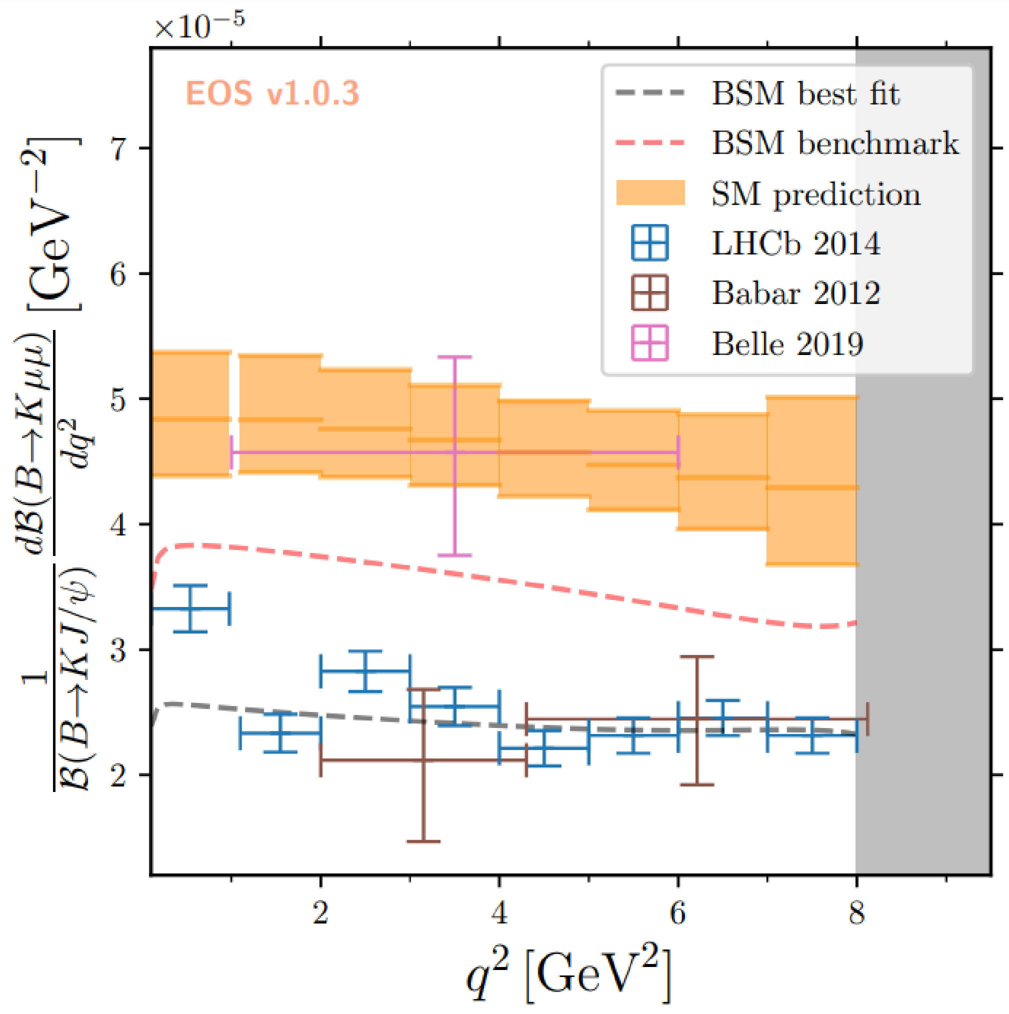
- **no increasing uncertainty at the J/ψ** pole in QCDF (charm-loop treated perturbatively)



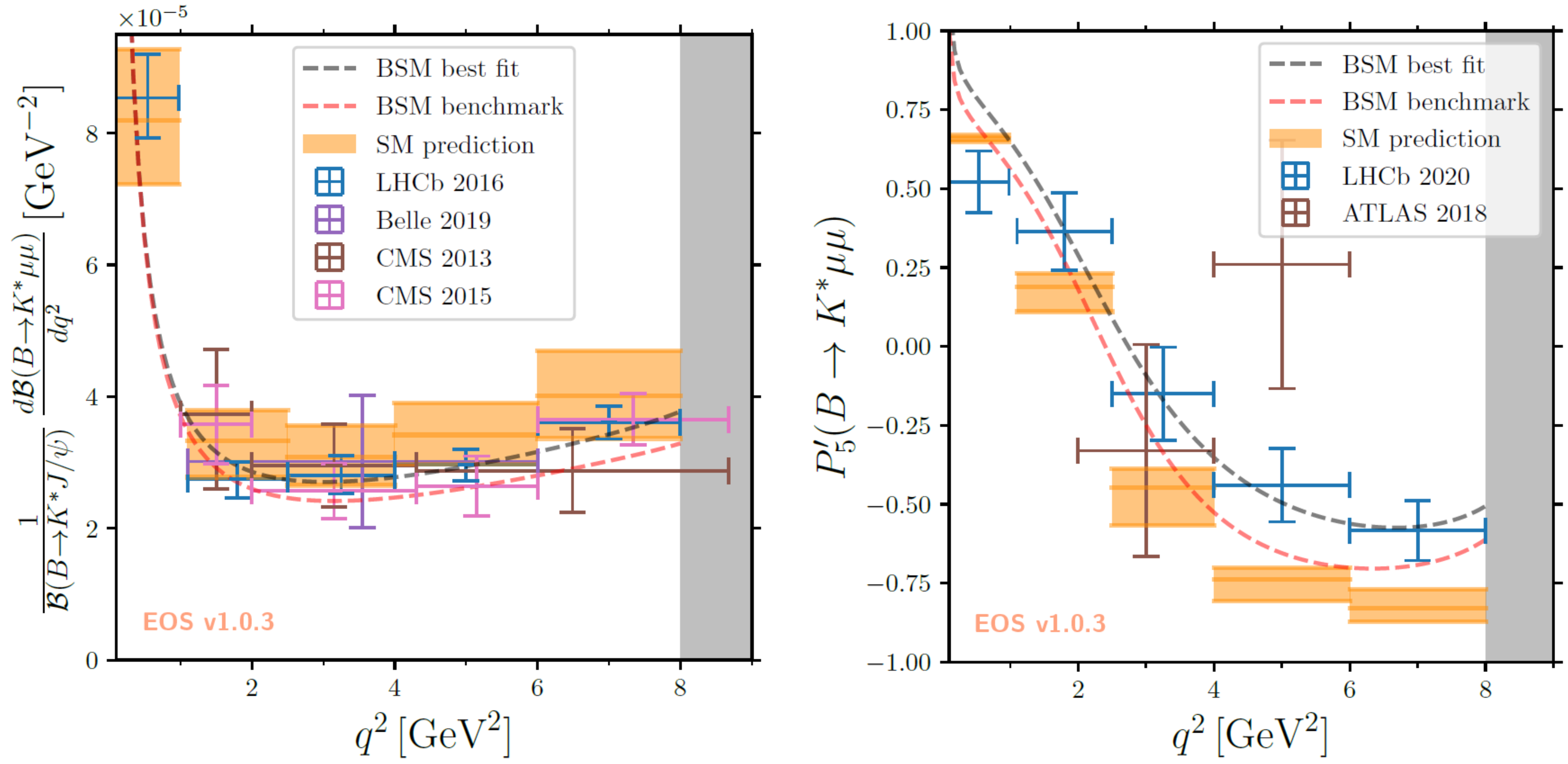
Confrontation with data

Comparison with measurements for $B \to K\mu^+\mu^-$

- "BSM best fit" ⟶ best fit point of our BSM fit (see next slides)
- "BSM benchmark" ⟶ set $C_9^{\mathrm{NP}\mu} = -C_{10}^{\mathrm{NP}\mu} = -0.5$
- **sizable tension** between SM predictions and experimental results
- tension larger than in other works in the literature ⟶ inputs for the local FFs $\boldsymbol{\mathcal{F}_\lambda}$
- results consistent with the deviations found in R_K



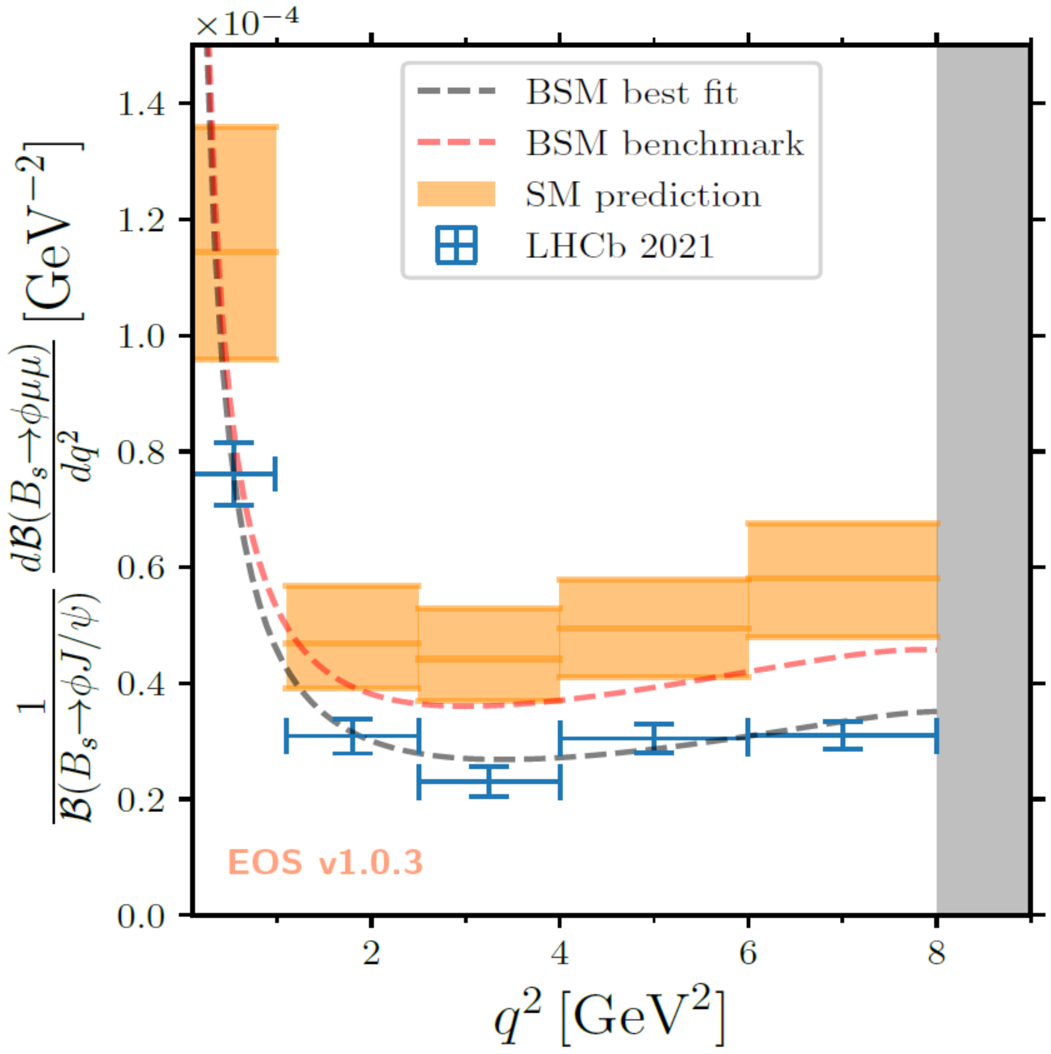
Comparison with measurements for $B \to K^*\mu^+\mu^-$



tension **smaller** than in other works in the literature ⟶ inputs for the local FFs $\mathcal{F}_\lambda$

Comparison with measurements for $B_s \to \phi\mu^+\mu^-$

- **consistent picture** with the deviations in $B \to K\mu^+\mu^-$, $B \to K^*\mu^+\mu^-$
- choice of theory inputs (local FFs $\mathcal{F}_\lambda$) is decisive
  $\longrightarrow$ usage of light-meson LCSRs rather than B-meson LCSRs yields much larger tension w.r.t. data
- **precise LQCD** calculations at low q^2 **essential** to have more reliable theoretical predictions (already available for $B \to K\ell^+\ell^-$ [HPQCD 2022])
- expect deviation in R_ϕ measurement (not measured yet)



Global fit to $b \to s\mu^+\mu^-$ (setup)

use our predictions for the local and non-local FFs as priors

fit the Wilson coefficients $C_9^{\mathrm{NP}\mu}$ and $C_{10}^{\mathrm{NP}\mu}$ to the available experimental measurements in $b \to s\mu^+\mu^-$ transitions
$(C_{9,10} = C_{9,10}^{\mathrm{SM}} + C_{9,10}^{\mathrm{NP}\mu})$

we perform three fits, one for each set of the following set of experimental measurements: (BRs, angular observables, binned and not binned)

- $B \to K\mu^+\mu^- + B_s \to \mu^+\mu^-$
- $B \to K^*\mu^+\mu^-$
- $B_s \to \phi\mu^+\mu^-$

combined fit would be very challenging ⟶ 130 nuisance parameter

Global fit to $b \to s\mu^+\mu^-$ (results)

we **obtain good fits**, agreement between the three fits

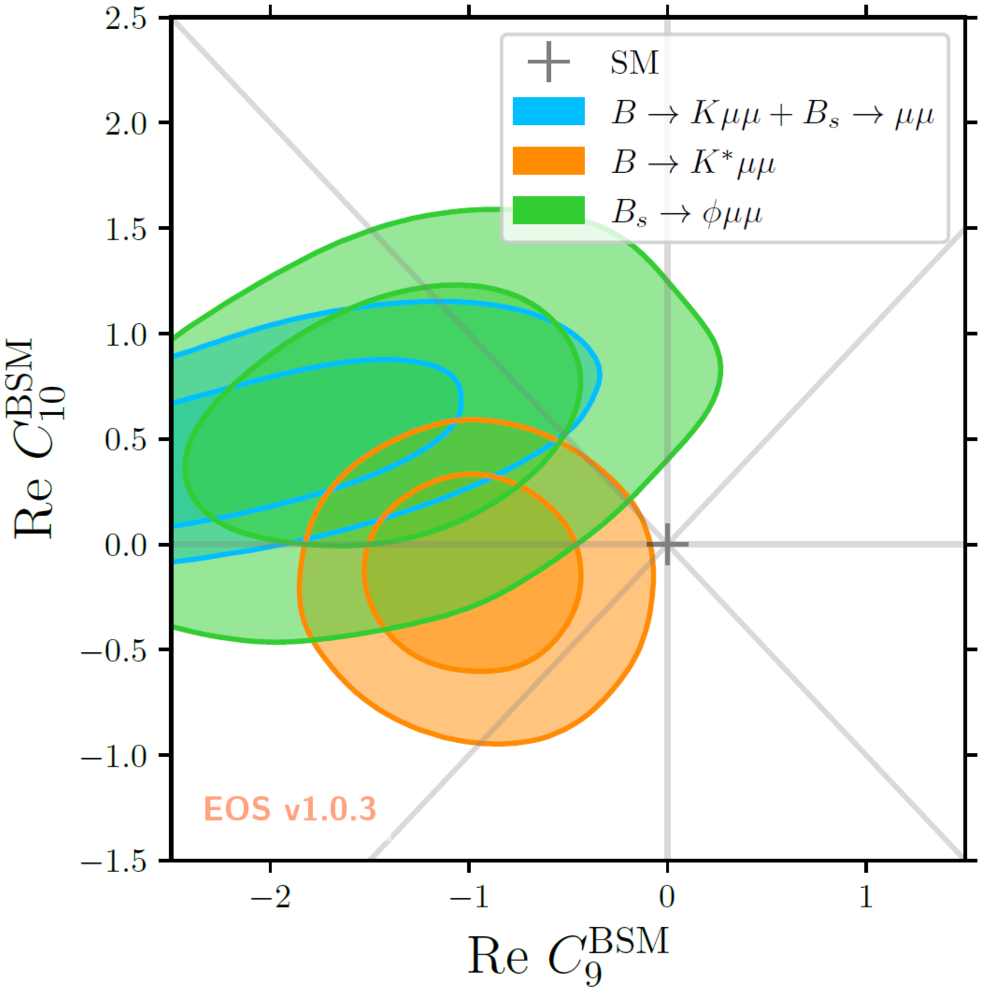
substantial tension w.r.t. SM (in agreement with the literature)

pulls (p value of the SM hypothesis):

- 5.7σ for $B \to K\mu^+\mu^- + B_s \to \mu^+\mu^-$
- 2.7σ for $B \to K^*\mu^+\mu^-$
- 2.6σ for $B_s \to \phi\mu^+\mu^-$

local FFs $\mathcal{F}_\lambda$ main uncertainties

non-local FFs $\mathcal{H}_\lambda$ cannot explain this tension



Summary and outlook

Summary

1. new theoretical predictions using our calculation for the non-local form factors $\mathcal{H}_\lambda$ at $q^2 < 0$, experimental data for $B \to K^{(*)} J/\psi$, and a dispersive bound

   dispersive bound allows to control truncation error

   new approach — $\mathcal{H}_\lambda$ uncertainties can be systematically reduced

   predictions improvable with more precise local form factors $\boldsymbol{\mathcal{F}_\lambda}$ results (new lattice QCD results), saturating the dispersive bound, …

2. fit the Wilson coefficients $C_9^{\mathrm{NP}\mu}$ and $C_{10}^{\mathrm{NP}\mu}$ using the available experimental data

   good fit to the data, corroborate substantial tension w.r.t. SM (in agreement with the literature)
   $\Longrightarrow$ coherent BSM explanation

Outlook

FFs predictions

- dispersive analysis of the local FFs
- include $\Lambda_b \to \Lambda\ell^+\ell^-$ decays to further constrain the non –local FFs
- use $B \to K^{(*)}\psi(2S)$ and $B_s \to \phi\,\psi(2S)$ measurements

Global analysis

- perform a simultaneous analysis of the three decay modes
- include the LFU ratios $R_K^{(*)}$ (and R_ϕ) in the global fit
- include $\Lambda_b \to \Lambda\ell^+\ell^-$ decays to further constrain the Wilson coefficients

Thank you!