Flavour $b \to s\ell\ell$ Anomalies : New Physics Fits

and

A Systematic Approach to Hadronic Contributions

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Moriond QCD 2017 – March 27, 2017

Based on :

Descotes-Genon, Hofer, Matias, Virto, 1510.04239 [hep-ph]

Bobeth, Chrzaszcz, van Dyk, Virto, 1704.xxxxx [hep-ph]

:: Effective Theory for $b \to s$ Transitions

For $\Lambda_{\rm EW}, \Lambda_{\rm NP} \gg M_B$: General model-independent parametrization of NP :

$$\mathcal{L}_W = \mathcal{L}_{\rm QCD} + \mathcal{L}_{\rm QED} + \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^\star \sum_i \mathcal{C}_i(\mu)\, \mathcal{O}_i(\mu)$$

$$\mathcal{O}_1 = (\bar{c}\gamma_\mu P_L b)(\bar{s}\gamma^\mu P_L c) \qquad \mathcal{O}_2 = (\bar{c}\gamma_\mu P_L T^a b)(\bar{s}\gamma^\mu P_L T^a c)$$

$$\mathcal{O}_7 = \frac{e}{16\pi^2} m_b (\bar{s}\sigma_{\mu\nu} P_R b) F^{\mu\nu} \qquad \mathcal{O}_{7'} = \frac{e}{16\pi^2} m_b (\bar{s}\sigma_{\mu\nu} P_L b) F^{\mu\nu}$$

$$\mathcal{O}_{9\ell} = \frac{\alpha}{4\pi} (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \ell) \qquad \mathcal{O}_{9'\ell} = \frac{\alpha}{4\pi} (\bar{s}\gamma_\mu P_R b)(\bar{\ell}\gamma^\mu \ell)$$

$$\mathcal{O}_{10\ell} = \frac{\alpha}{4\pi} (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \gamma_5 \ell) \qquad \mathcal{O}_{10'\ell} = \frac{\alpha}{4\pi} (\bar{s}\gamma_\mu P_R b)(\bar{\ell}\gamma^\mu \gamma_5 \ell),$$

SM contributions to $\mathcal{C}_i(\mu_b)$ known to NNLL Bobeth, Misiak, Urban '99; Misiak, Steinhauser '04, Gorbahn, Haisch '04; Gorbahn, Haisch, Misiak '05; Czakon, Haisch, Misiak '06

$$\mathcal{C}_{7\rm eff}^{\rm SM} = -0.3,\ \mathcal{C}_9^{\rm SM} = 4.1,\ \mathcal{C}_{10}^{\rm SM} = -4.3,\ \mathcal{C}_1^{\rm SM} = 1.1,\ \mathcal{C}_2^{\rm SM} = -0.4,\ \mathcal{C}_{\rm rest}^{\rm SM} \lesssim 10^{-2}$$

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* Important operators in this talk.

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:: Constraining Effective coefficients

- Inclusive
  - $B \to X_s\gamma$ (BR) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_{1,2}$
  - $B \to X_s\ell^+\ell^-$ (dBR/dq^2) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_9^{(\prime)}$, $\mathcal{C}_{10}^{(\prime)}$, $\mathcal{C}_{1,2}$
- Exclusive leptonic
  - $B_s \to \ell^+\ell^-$ (BR) .... $\mathcal{C}_{10}^{(\prime)}$
- Exclusive radiative/semileptonic
  - $B \to K^*\gamma$ (BR, S, A_I) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_{1,2}$
  - $B \to K\ell^+\ell^-$ (dBR/dq^2) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_9^{(\prime)}$, $\mathcal{C}_{10}^{(\prime)}$, $\mathcal{C}_{1,2}$
  - $B \to K^*\ell^+\ell^-$ (dBR/dq^2, Angular Observables) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_9^{(\prime)}$, $\mathcal{C}_{10}^{(\prime)}$, $\mathcal{C}_{1,2}$
  - $B_s \to \phi\ell^+\ell^-$ (dBR/dq^2, Angular Observables) .... $\mathcal{C}_7^{(\prime)}$, $\mathcal{C}_9^{(\prime)}$, $\mathcal{C}_{10}^{(\prime)}$, $\mathcal{C}_{1,2}$

Exclusive decay modes have huge weight in fits.

1. Superluminal Review of New Physics Fits

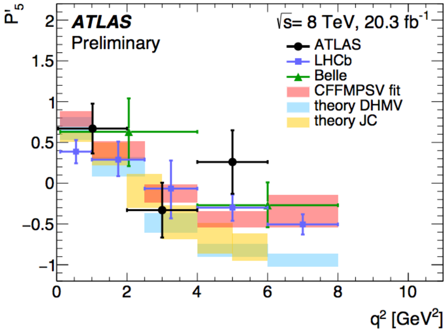
Descotes-Genon, Matias, Virto, 1307.5683 [hep-ph]

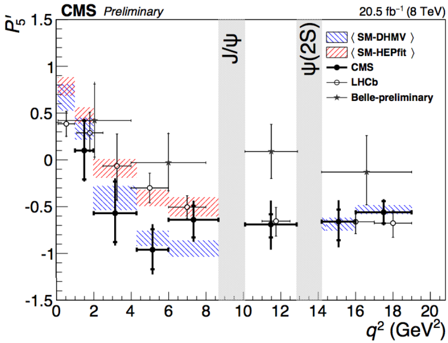
Descotes-Genon, Hofer, Matias, Virto, 1510.04239 [hep-ph]

:: The P_5' Anomaly

P_5' is an "optimized" angular observable in $B \to K^\star \mu^+ \mu^-$ defined originally in
Descotes-Genon, Matias, Ramon, Virto, 1207.2753 [hep-ph]

LHCb 2013 + 2015, Belle 2016 + Recent ATLAS + CMS Moriond 2017 !





Word of caution : CMS results take F_L and S-wave from separate analysis.

But P_5' is not the only observable ....

:: Global Fits to all $b \to s$ data

Descotes-Genon, Hofer, Matias, Virto

All include $B \to X_s\gamma$, $B \to K^*\gamma$, $B_s \to \mu^+\mu^-$, $B \to X_s\mu^+\mu^-$ by default.

- **Fit 1 (Canonical): $B_{(s)} \to (K^{(*)}, \phi)\mu^+\mu^-$, BR's and P_i's, All q^2** (91 obs)

- **Fit 2**: Branching Ratios only (27 obs)
- **Fit 3**: P_i Angular Observables only (64 obs)
- **Fit 4**: S_i Angular Observables only (64 obs)

- **Fit 5**: $B \to K\mu^+\mu^-$ only (14 obs)
- **Fit 6**: $B \to K^*\mu^+\mu^-$ only (57 obs)
- **Fit 7**: $B_s \to \phi\mu^+\mu^-$ only (20 obs)

- **Fit 8**: Large Recoil only (74 obs)
- **Fit 9**: Low Recoil only (17 obs)
- **Fit 10**: Only bins within [1,6] GeV^2 (39 obs)
- **Fits 11**: Bin-by-bin analysis.

- **Fit 12**: Full form factor approach [a la ABSZ] (91 obs)
- **Fit 13**: Enhanced Power Corrections (91 obs)
- **Fit 14**: Enhanced Charm loop effect (91 obs)

:: Canonical Fit: 6D hypotheses

Descotes-Genon, Hofer, Matias, Virto

▷ All 6 WCs free (but real).

Coefficient	1σ	2σ	3σ
$\mathcal{C}_7^{\rm NP}$	$[-0.02, 0.03]$	$[-0.04, 0.04]$	$[-0.05, 0.08]$
$\mathcal{C}_9^{\rm NP}$	$[-1.4, -1.0]$	$[-1.7, -0.7]$	$[-2.2, -0.4]$
$\mathcal{C}_{10}^{\rm NP}$	$[-0.0, 0.9]$	$[-0.3, 1.3]$	$[-0.5, 2.0]$
$\mathcal{C}_{7'}^{\rm NP}$	$[-0.02, 0.03]$	$[-0.04, 0.06]$	$[-0.06, 0.07]$
$\mathcal{C}_{9'}^{\rm NP}$	$[0.3, 1.8]$	$[-0.5, 2.7]$	$[-1.3, 3.7]$
$\mathcal{C}_{10'}^{\rm NP}$	$[-0.3, 0.9]$	$[-0.7, 1.3]$	$[-1.0, 1.6]$

▷ $\mathcal{C}_9$ consistent with SM only above $3\,\sigma$.

▷ All others consistent with the SM at $1\,\sigma$, except for $\mathcal{C}_9'$ at $2\,\sigma$.

▷ Pull_{SM} for the 6D fit is $3.6\,\sigma$.

:: Canonical Fit: 1D hypotheses

Descotes-Genon, Hofer, Matias, Virto

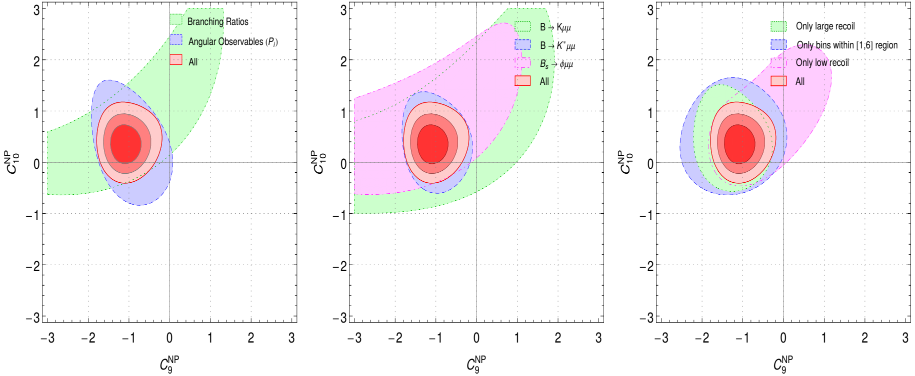
- ▷ Pull$_{\rm SM}$: $\sim \chi^2_{\rm SM} - \chi^2_{\rm min}$ (metrology: how less likely is SM vs. best fit?)
- ▷ p-value: $p(\chi^2_{\rm min}, N_{\rm dof})$ (goodness of fit: is the best fit a good fit?)
- ▷ Contribution $\mathcal{C}_9^{\rm NP} < 0$ always favoured.

Coefficient	Best fit	3σ	Pull$_{\rm SM}$	p-value (%)
SM	–	–	–	16.0
$\mathcal{C}_7^{\rm NP}$	-0.02	$[-0.07, 0.03]$	1.2	17.0
$\boldsymbol{\mathcal{C}_9^{\rm NP}}$	-1.09	$[-1.67, -0.39]$	**4.5**	63.0
$\mathcal{C}_{10}^{\rm NP}$	0.56	$[-0.12, 1.36]$	2.5	25.0
$\mathcal{C}_{7'}^{\rm NP}$	0.02	$[-0.06, 0.09]$	0.6	15.0
$\mathcal{C}_{9'}^{\rm NP}$	0.46	$[-0.36, 1.31]$	1.7	19.0
$\mathcal{C}_{10'}^{\rm NP}$	-0.25	$[-0.82, 0.31]$	1.3	17.0
$\mathcal{C}_9^{\rm NP} = \mathcal{C}_{10}^{\rm NP}$	-0.22	$[-0.74, 0.50]$	1.1	16.0
$\boldsymbol{\mathcal{C}_9^{\rm NP} = -\mathcal{C}_{10}^{\rm NP}}$	-0.68	$[-1.22, -0.18]$	**4.2**	56.0
$\mathcal{C}_{9'}^{\rm NP} = \mathcal{C}_{10'}^{\rm NP}$	-0.07	$[-0.86, 0.68]$	0.3	14.0
$\mathcal{C}_{9'}^{\rm NP} = -\mathcal{C}_{10'}^{\rm NP}$	0.19	$[-0.17, 0.55]$	1.6	18.0
$\boldsymbol{\mathcal{C}_9^{\rm NP} = -\mathcal{C}_{9'}^{\rm NP}}$	-1.06	$[-1.60, -0.40]$	**4.8**	72.0

:: Consistency of different fits

Descotes-Genon, Hofer, Matias, Virto

▷ $3\,\sigma$ constraints, always including $b \to s\gamma$ and inclusive.



▷ Good consistency between BRs and Angular observables (P_i's dominate).

▷ Good consistency between different modes ($B \to K^\star$ dominates).

▷ Good consistency between different q^2 regions (Large-R dominates, [1,6] bulk).

▷ Remember: Quite different theory issues in each case!

:: Summary I

A NP contribution $\mathcal{C}_{9\mu}^{\rm NP} \sim -1$ gives a **substantially improved fit** for

- ▷ $B \to K\mu\mu$, $B \to K^*\mu\mu$ and $B_s \to \Phi\mu\mu$
- ▷ BRs and angular observables (including P_5')
- ▷ Low q^2 and large q^2
- ▷ R_K

All these receive, in general, quite different contributions from hadronic operators.

Different fits with similar results:

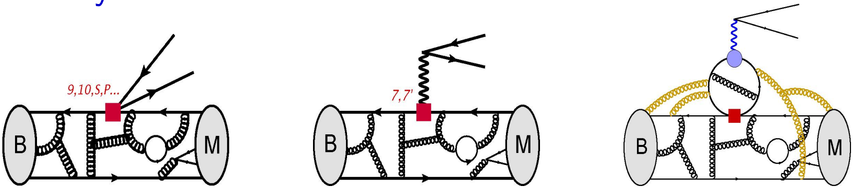
- Descotes-Genon, Matias, Virto, 1307.5683 [hep-ph]
- Altmannshofer, Straub, 1308.1501 [hep-ph], 1411.3161 [hep-ph]
- Beaujean, Bobeth, van Dyk, 1310.2478 [hep-ph]
- Horgan, Liu, Meinel, Wingate, 1310.3887 [hep-ph]
- Hurth, Mahmoudi, Neshatpour, 1410.4545[hep-ph], 1603.00865 [hep-ph]

But the Devil's in the details...

2. A Systematic Approach to Hadronic Contributions

Bobeth, Chrzaszcz, van Dyk, Virto (w.i.p.)

:: Theory calculation for $B \to M\ell^+\ell^-$



$$\mathcal{M}_\lambda = \frac{G_F\alpha}{\sqrt{2}\pi} V_{tb}V_{ts}^* \Big[(\mathcal{A}_\lambda^\mu + \mathcal{H}_\lambda^\mu)\ \bar{u}_\ell\gamma_\mu v_\ell + \mathcal{B}_\lambda^\mu\ \bar{u}_\ell\gamma_\mu\gamma_5 v_\ell\Big] + \mathcal{O}(\alpha^2)$$

Local:

$$\mathcal{A}_\lambda^\mu = -\frac{2m_b q_\nu}{q^2}\mathcal{C}_7 \langle M_\lambda|\bar{s}\sigma^{\mu\nu}P_R b|B\rangle + \mathcal{C}_9 \langle M_\lambda|\bar{s}\gamma^\mu P_L b|B\rangle$$

$$\mathcal{B}_\lambda^\mu = \mathcal{C}_{10} \langle M_\lambda|\bar{s}\gamma^\mu P_L b|B\rangle$$

Non-Local:

$$\mathcal{H}_\lambda^\mu = -\frac{16i\pi^2}{q^2}\sum_{i=1..6,8}\mathcal{C}_i \int dx^4 e^{iq\cdot x}\langle M_\lambda|T\{\mathcal{J}_{\rm em}^\mu(x),\mathcal{O}_i(0)\}|B\rangle$$

Two theory issues:

1. **Form Factors** (LCSRs, LQCD, symmetry relations . . .)
2. **Hadronic contribution** (SCET/QCDF, OPE, LCOPE . . . **THIS TALK**)

:: Hadronic correlator : Decomposition

Bobeth, Chrzaszcz, van Dyk, Virto

$$\mathcal{H}^\mu(q^2) \equiv i \int \mathrm{d}^4x\; e^{iq\cdot x}\; \langle \bar{K}^*(k,\eta)|\, T\{\bar{c}\gamma^\mu c(x), \mathcal{C}_1\mathcal{O}_1 + \mathcal{C}_2\mathcal{O}_2(0)\}|\bar{B}(p)\rangle$$

$$\equiv M_B^2\, \eta_\alpha^* \left[S_\perp^{\alpha\mu}\, \mathcal{H}_\perp - S_\parallel^{\alpha\mu}\, \mathcal{H}_\parallel - S_0^{\alpha\mu}\, \mathcal{H}_0 \right]$$

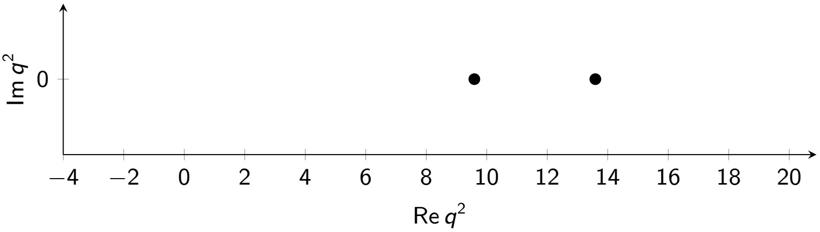
- $S_\lambda^{\alpha\mu}$ – basis of Lorentz structures (carefully chosen)
- $\mathcal{H}_\lambda$ – Lorentz invariant correlation functions
- λ – polarization states ($\perp$, $\parallel$, 0)

The idea :

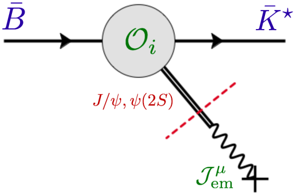
- Understand analytic structure of $\mathcal{H}_\lambda(q^2)$ to write a general parametrisation consistent with QCD.
- Use **suitable** experimental information to constrain the correlator.
- Use theory to constrain the correlator in **suitable** kinematic points.

:: Hadronic correlator : Analytic structure

Bobeth, Chrzaszcz, van Dyk, Virto

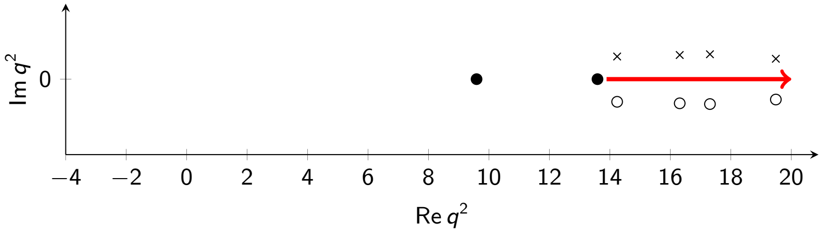


- narrow charmonia, assumed to be stable

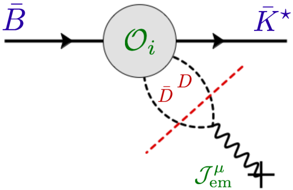


:: Hadronic correlator : Analytic structure

Bobeth, Chrzaszcz, van Dyk, Virto

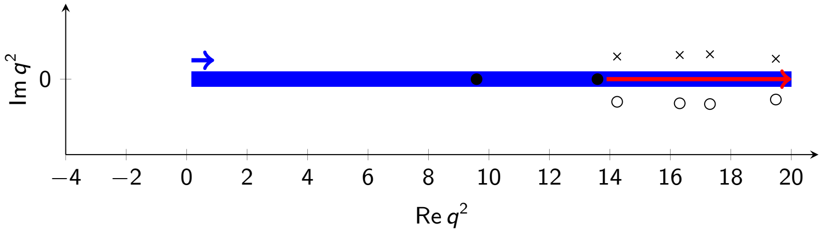


- ● narrow charmonia, assumed to be stable
- red branch cut from $D\bar{D}$ production
- ○ broad charmonia, decaying to $D\bar{D}$
- × potential mirror poles

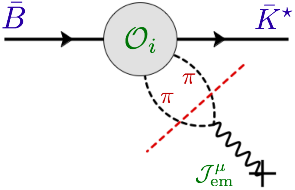


:: Hadronic correlator : Analytic structure

Bobeth, Chrzaszcz, van Dyk, Virto

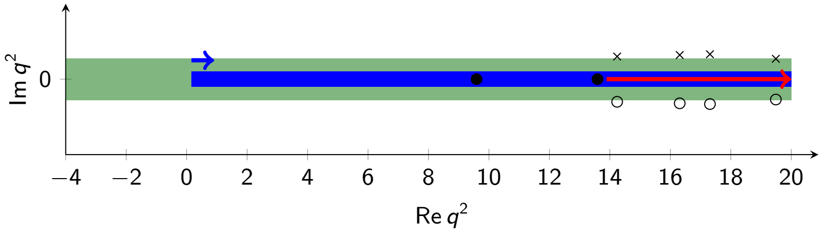


- ● narrow charmonia, assumed to be stable
- red branch cut from $D\bar{D}$ production
- ○ broad charmonia, decaying to $D\bar{D}$
- × potential mirror poles
- blue branch cut from light hadrons

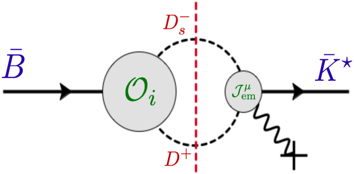


:: Hadronic correlator : Analytic structure

Bobeth, Chrzaszcz, van Dyk, Virto



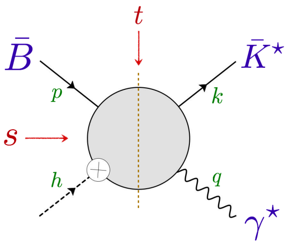
- ● narrow charmonia, assumed to be stable
- red branch cut from $D\bar{D}$ production
- ○ broad charmonia, decaying to $D\bar{D}$
- × potential mirror poles
- blue branch cut from light hadrons
- green q^2-dep. imaginary due to branch cut in p^2

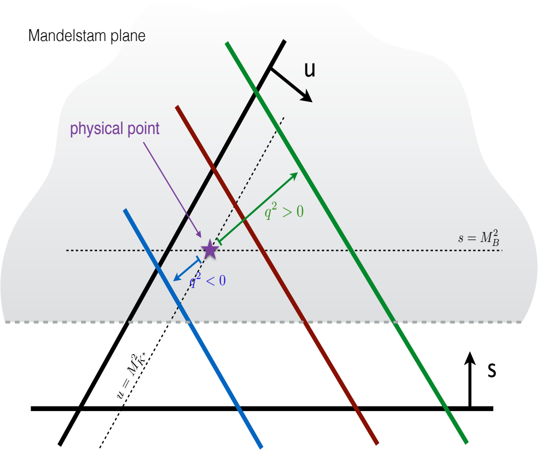


:: Understanding the p^2 cut

Bobeth, Chrzaszcz, van Dyk, Virto

Trick : Add spurious momentum h to $\mathcal{O}_i$
Recover physical kinematics as $h \to 0$





- $s \sim p^2$ independent of $t \sim q^2$.
- Cut in p^2 does not translate into cut in q^2
- Two correlators:

$$\mathcal{H}_\lambda(q^2) \to \mathcal{H}_\lambda^{\text{real}}(q^2) + i\,\mathcal{H}_\lambda^{\text{imag}}(q^2)$$

- Both $\mathcal{H}_\lambda^{\text{real}}(q^2)$ and $\mathcal{H}_\lambda^{\text{imag}}(q^2)$ are analytic at $q^2 \leq 0$
- Both $\mathcal{H}_\lambda^{\text{real}}(q^2)$ and $\mathcal{H}_\lambda^{\text{imag}}(q^2)$ have branch cuts at $q^2 > 0$

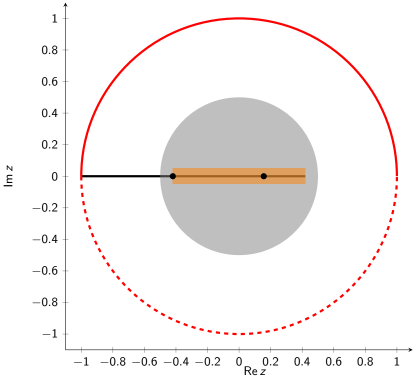
:: Parametrization A : $J/\psi, \psi(2s)$ poles + $D\bar{D}$ cut

Bobeth, Chrzaszcz, van Dyk, Virto

Motivated by famous "z-parametrization" of form factors. Boyd et al '94, Bourelly et al '08

1. extract the poles

$$\mathcal{H}_\lambda(q^2) = \frac{1}{q^2 - M^2_{J/\psi}} \frac{1}{q^2 - M^2_{\psi(2S)}} \hat{\mathcal{H}}_\lambda(q^2)$$



2. $\hat{\mathcal{H}}_\lambda(q^2)$ is analytic except for $D\bar{D}$ cut.
3. Perform conformal mapping $q^2 \mapsto z(q^2)$.
4. $\hat{\mathcal{H}}_\lambda(z)$ analytic within unit circle.
5. Taylor expand $\hat{\mathcal{H}}_\lambda(z)$ around $z = 0$.
6. Good convergence expected since $|z| < 0.42$ for $-5\,\text{GeV}^2 \leq q^2 \leq 14\text{GeV}^2$

:: Experimental constraints on the correlator

Bobeth, Chrzaszcz, van Dyk, Virto

The correlators $\mathcal{H}_\lambda$ can be related to observables in the decays $B \to K^* J/\psi, K^* \psi(2S)$

- Independent of short-distance contributions ($\mathcal{C}_7$, $\mathcal{C}_9$, etc) in $B \to K^*\{\gamma, \mu^+\mu^-\}$
- Important constraints at $\boldsymbol{q^2 \simeq 9}\,\mathrm{GeV}^2$ and $\boldsymbol{q^2 \simeq 14}\,\mathrm{GeV}^2$.

Details:

- residues of the correlator can be expressed in terms of $B \to K^*\psi$ amplitudes.
  Khodjamirian et. al. 2010
- $\mathcal{B}$ and 4 angular observables measured in $B \to K^* J/\psi$ and $B \to K^*\psi(2S)$
  LHCb 2013, BaBar 2007
- Allows to constrain all moduli and two relative phases of the amplitudes, and therefore of the residues of the correlator.

:: Theory constraints on the correlator

Bobeth, Chrzaszcz, van Dyk, Virto

The correlator **can be calculated at $q^2 < 0$ reliably** by means of a light-cone OPE

Khodjamirian et al. 2010

Using $\mathcal{H}_\perp(q^2)$ as an example:

$$\mathcal{H}_\perp(q^2) = \# \times g(q^2, m_c^2)\, \mathcal{F}_\perp(q^2) \; + \; \# \times \widetilde{V}_1(q^2) \; + \; \mathrm{NLO}_{\alpha_s}$$

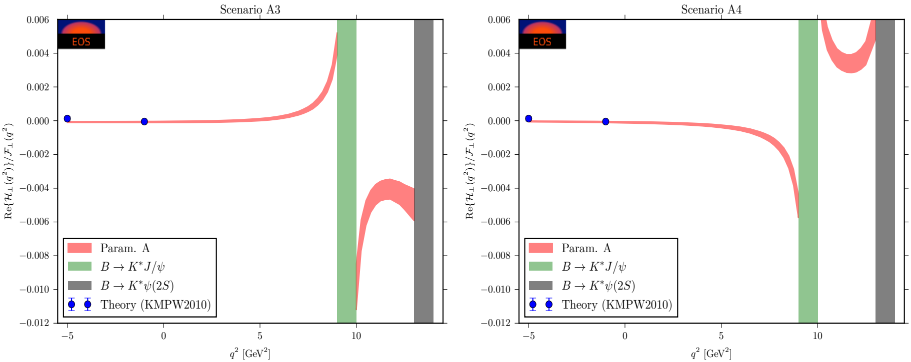
- first term is usual form-factor-like contribution
- second term arises from soft-gluon effects only
- third term arises from NLO corrections (produces p^2 cut !!)

We use this to constrain the correlators at $\boldsymbol{q^2 = -1}\,\mathrm{GeV}^2$ and $\boldsymbol{q^2 = -5}\,\mathrm{GeV}^2$.

:: Results Parametrization A Preliminary

Bobeth, Chrzaszcz, van Dyk, Virto

Results for $\mathrm{Re}(\mathcal{H}_\perp/\mathcal{F}_\perp)$:



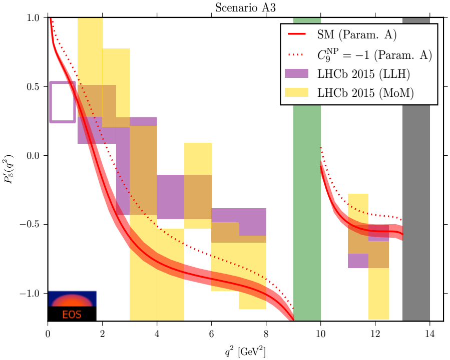
Discrete ambiguity in phases of the residues : (only two shown)

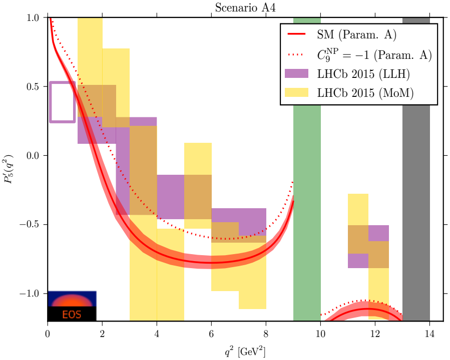
Left : $\phi_{J/\psi} = \pi$, $\phi_{\psi(2S)} = 0$ **Right :** $\phi_{J/\psi} = \phi_{\psi(2S)} = \pi$

:: Results Parametrization A Preliminary

Bobeth, Chrzaszcz, van Dyk, Virto

SM predictions for P_5'





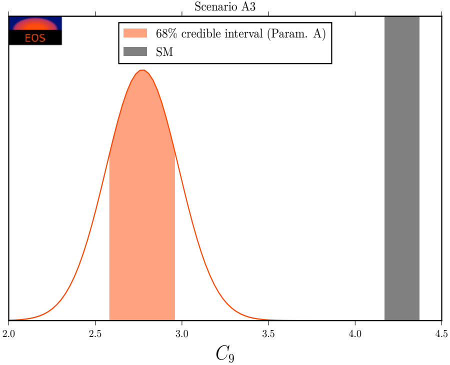
Left : $\phi_{J/\psi} = \pi \ , \ \phi_{\psi(2S)} = 0$ **Right :** $\phi_{J/\psi} = \phi_{\psi(2S)} = \pi$

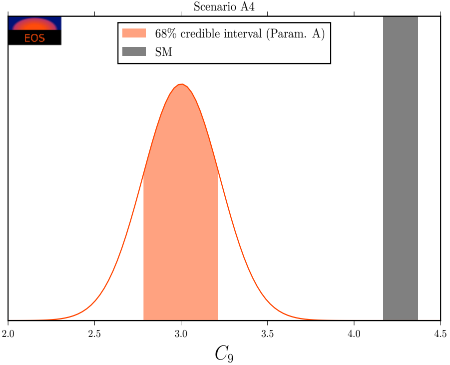
▷ first-time use of inter-resonance bin : **great potential!!**

:: Confronting $B \to K^\star \mu\mu$ data Preliminary

Bobeth, Chrzaszcz, van Dyk, Virto

Global fit to all $B \to K^\star\{\gamma, \mu^+\mu^-, J/\psi, \psi(2S)\}$ data using Parametrization A





Left : $\phi_{J/\psi} = \pi \ , \ \phi_{\psi(2S)} = 0$ **Right :** $\phi_{J/\psi} = \phi_{\psi(2S)} = \pi$

:: Summary II

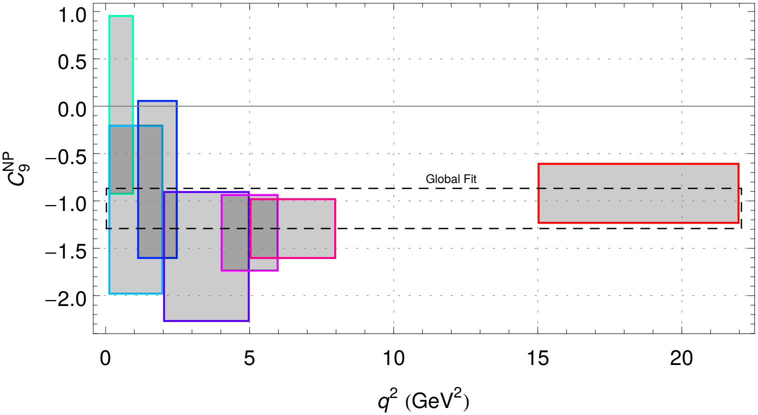
- Systematic framework to access nonlocal correlator
  - First approach to use both theory inputs and experimental constraints in fit
  - Can accommodate existing and future theory results (systematically improvable)
  - Provides model-independent prior predictions for $B \to K^{(*)}\mu^+\mu^-$
  - Can be easily embedded in global fits
- Present data in tension with parametrization A
  - favours NP interpretation with $> 4\sigma$
- Other results not disclosed here: see Bobeth, Chrzaszcz, van Dyk, Virto
  - Complex parametrization A : needs analytic NLO Greub, Virto w.i.p.
  - Parametrization B : includes light-hadron cut from ψ decay

Keep an eye on this !!

Back-up

Descotes-Genon, Hofer, Matias, Virto

$\rightarrow \; \mathcal{T}_\mu \;=\; -\frac{16 i \pi^2}{q^2} \sum_{i=1..6,8} \mathcal{C}_i \int dx^4 e^{iq\cdot x} \langle M_\lambda | T\{\mathcal{J}^{\rm em}_\mu(x) \mathcal{O}_i(0)\} | B \rangle$ is q^2-dependent



$\Rightarrow$ No evidence for q^2-dependence $\rightarrow$ Good crosscheck of hadronic contribution!

:: Overview of exp. constraints on Correlator

Bobeth, Chrzaszcz, van Dyk, Virto

name	observables	degrees of freedom	source
$\bar{B} \to \bar{K}^* J/\psi$	$\mathcal{B},\ F_\perp,\ F_\parallel,\ \delta_\perp,\ \delta_\parallel$	5	BaBar
	$\mathcal{B},\ F_\perp,\ F_\parallel,\ \delta_\perp,\ \delta_\parallel$	5	Belle
	$\mathcal{B},\ F_\perp,\ F_0,\ \delta_\perp,\ \delta_\parallel$	5	CDF
	$\mathcal{B}$	1	CLEO
	$F_\perp,\ F_0,\ \delta_\perp,\ \delta_\parallel$	4	LHCb
$\bar{B} \to \bar{K}^* \psi(2S)$	$\mathcal{B},\ F_\perp,\ F_\parallel,\ \delta_\perp,\ \delta_\parallel$	5	BaBar
	$\mathcal{B}$	1	Belle
	$\mathcal{B}$	1	CDF
	$\mathcal{B}$	1	CLEO
$\bar{B} \to \bar{K}^* \gamma$	$\mathcal{B}$	1	CLEO
	$\mathcal{B},\ S_{K^*\gamma}$	1	Belle
	$\mathcal{B},\ S_{K^*\gamma}$	1	BaBar
$\bar{B} \to \bar{K}^* \mu^+\mu^-$	$\mathcal{B},\ F_L,\ S_3,\ S_4,\ S_5,\ A_{\rm FB},\ S_7,\ S_8,\ S_9$	4×9	LHCb
$\bar{B} \to \bar{K}^* \mu^+\mu^-$ "inter-resonance"	$\mathcal{B},\ F_L,\ S_3,\ S_4,\ S_5,\ A_{\rm FB},\ S_7,\ S_8,\ S_9$	9	LHCb

:: Anomaly patterns

		R_K	$\langle P_5' \rangle_{[4,6],[6,8]}$	$BR(B_s \to \phi\mu\mu)$	low recoil BR	Best fit now
$\mathcal{C}_9^{\rm NP}$	$+$					
	$-$	✓	✓	✓	✓	X
$\mathcal{C}_{10}^{\rm NP}$	$+$	✓		✓	✓	X
	$-$		✓			
$\mathcal{C}_{9'}^{\rm NP}$	$+$			✓	✓	X
	$-$	✓	✓			
$\mathcal{C}_{10'}^{\rm NP}$	$+$	✓	✓			
	$-$			✓	✓	X

- ▷ $\mathcal{C}_9 < 0$ consistent with all the anomalies
- ▷ No consistent and global alternative from long-distance dynamics.

:: Outlook: Potential of inclusive measurements at Belle-2

If the (current) exclusive fit is accurate, inclusive $b \to s\ell\ell$ Belle-2 measurements alone have the potential for a NP discovery: