# Global fits to radiative $b \to s$ transitions

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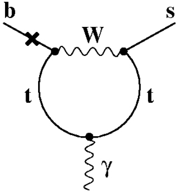
# Effective approach to radiative decays

- $b \to s\gamma$ and $b \to s\ell^+\ell^-$ Flavour-Changing Neutral Currents
- enhanced sensitivity to New Physics effects
- analysed in model-independent approach effective Hamiltonian
- integrating out all heavy degrees of freedom

$$b \to s\gamma(^*) : \mathcal{H}^{SM}_{\Delta F=1} \propto \sum_{i=1}^{10} V^*_{ts} V_{tb} C_i Q_i + \dots$$

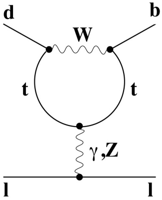



- $Q_7 = \frac{e}{g^2} m_b \bar{s}\sigma^{\mu\nu}(1+\gamma_5)F_{\mu\nu}\, b$ [real or soft photon]
- $Q_9 = \frac{e^2}{g^2} \bar{s}\gamma_\mu(1-\gamma_5)b\; \bar{\ell}\gamma_\mu\ell$ [$b \to s\mu\mu$ via $Z$/hard $\gamma$]
- $Q_{10} = \frac{e^2}{g^2} \bar{s}\gamma_\mu(1-\gamma_5)b\; \bar{\ell}\gamma_\mu\gamma_5\ell$ [$b \to s\mu\mu$ via $Z$]

NP changes short-distance $C_i$ and/or add new long-distance ops $Q'_i$

- Chirally flipped ($W \to W_R$) $Q_7 \to Q_{7'} \propto \bar{s}\sigma^{\mu\nu}(1-\gamma_5)F_{\mu\nu}\, b$
- (Pseudo)scalar ($W \to H^+$) $Q_9, Q_{10} \to Q_S \propto \bar{s}(1+\gamma_5)b\bar{\ell}\ell,\ Q_P$
- Tensor operators ($\gamma \to T$) $Q_9 \to Q_T \propto \bar{s}\sigma_{\mu\nu}(1-\gamma_5)b\; \bar{\ell}\sigma_{\mu\nu}\ell$

# Wilson Coefficients and processes




Matching SM at high-energy scale $\mu_0 = m_t$ and evolving down at $\mu_{\text{ref}} = 4.8$ GeV

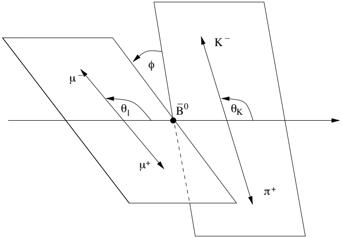
$$C_7^{SM} = -0.29, C_9^{SM} = 4.1, C_{10}^{SM} = -4.3,$$

(formulae known up to NNLO + e.m. corrections)

| $C_i$ | *Observables* | *SM values* |
|---|---|---|
| $C_7^{eff}$ | $\mathcal{B}(B \to X_s\gamma), A_I(B \to K^*\gamma), S_{K^*\gamma}, B \to K^*\ell\ell$ | $-0.29$ |
| $C_9$ | $\mathcal{B}(B \to X_s\ell\ell), B \to K(^*)\ell\ell$ | $4.1$ |
| $C_{10}$ | $\mathcal{B}(B_s \to \mu^+\mu^-), \mathcal{B}(B \to X_s\ell\ell), B \to K(^*)\ell\ell$ | $-4.3$ |
| $C_7'$ | $\mathcal{B}(B \to X_s\gamma), A_I(B \to K^*\gamma), S_{K^*\gamma}, B \to K(^*)\ell\ell$ | $0$ |
| $C_9'$ | $\mathcal{B}(B \to X_s\ell\ell), B \to K(^*)\ell\ell$ | $0$ |
| $C_{10}'$ | $\mathcal{B}(B_s \to \mu^+\mu^-), B \to K(^*)\ell\ell$ | $0$ |

- $B \to X_s\gamma$: strong constraints on $C_7, C_{7'}$ [Misiak, Gambino, Steinhauser. . . ]
- $B \to X_s\ell\ell$: not accurate enough expt [Misiak, Bobeth, Gorbahn, Haisch, Huber, Lunghi. . . ]
- $B_s \to \mu\mu$: recent th. and exp. progress [talks from C. Bobeth and M. Gorbahn]
- $B \to K(^*)\ell\ell$: recent th. and exp. progress

# $B \to K^* \ell\ell$: angular analysis




- $\theta_l$: angle of emission between $K^{\star 0}$ and $\mu^-$ in di-lepton rest frame
- $\theta_{K^*}$: angle of emission between $K^{\star 0}$ and $K^-$ in di-meson rest frame.
- $\phi$: angle between the two planes
- $q^2$: dilepton invariant mass square

$$\frac{d^4\Gamma}{dq^2\, d\cos\theta_l\, d\cos\theta_{K^*}\, d\phi} = \sum_i f_i(\theta_{K^*}, \phi, \theta_l) \times I_i$$

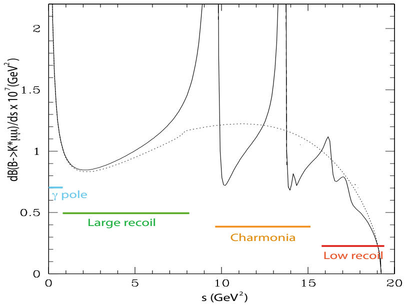
with 12 angular coeffs $I_i$, interferences between 8 transversity ampl.

- $\perp, ||, 0, t$ polarisation of (real) $K^*$ and (virtual) $V^* = \gamma^*, Z^*$
- $L, R$ chirality of $\mu^+\mu^-$ pair

$A_{\perp,L/R}$, $A_{||,L/R}$, $A_{0,L/R}$, $A_t$ + scalar $A_s$ depend on

- $q^2$ (lepton pair invariant mass)
- Wilson coefficients $C_7, C_9, C_{10}, C_S, C_P$ (and flipped chiralities)
- $B \to K^*$ form factors $A_{0,1,2}$, $V$, $T_{1,2,3}$ from $\langle K^*|Q_i|B\rangle$

# Four different regions




- Very large $K^*$-recoil ($4m_\ell^2 < q^2 < 1$ GeV$^2$): $\gamma$ almost real
  ($C_7/q^2$ divergence and light resonances)
- Large $K^*$-recoil ($q^2 < 9$ GeV$^2$): energetic $K^*$
  ($E_{K^*} \gg \Lambda_{QCD}$: form factors from light-cone sum rules LCSR)
- Charmonium region ($q^2 = m^2_{\psi,\psi'\ldots}$ between 9 and 14 GeV$^2$)
- Low $K^*$-recoil ($q^2 > 14$ GeV$^2$): soft $K^*$
  ($E_{K^*} \simeq \Lambda_{QCD}$: form factors lattice QCD)

# Hadronic quantities: $B \to K^*$ form factors

7 independent form factors $A_{0,1,2}$, $V$ ($O_{9,10}$) and $T_{1,2,3}$ ($O_7$)

$$
\begin{aligned}
\langle K^*(k)|\bar{s}\gamma_\mu(1-\gamma_5)|B(\epsilon,p)\rangle &= -i\epsilon_\mu(m_B+m_V)A_1(q^2) + i(p+k)_\mu(\epsilon^*\cdot q)\frac{A_2(q^2)}{m_B+m_{K^*}} \\
&\quad + iq_\mu(\epsilon^*\cdot q)\frac{2m_{K^*}}{q^2}\tilde{A}_0(q^2) + \epsilon_{\mu\nu\rho\sigma}\epsilon^{*\nu}p^\rho k^\sigma \frac{2V(q^2)}{m_B+m_{K^*}} \\
\langle K^*(k)|\bar{s}\sigma_{\mu\nu}q^\nu(1+\gamma_5)|B(\epsilon,p)\rangle &= i\epsilon_{\mu\nu\rho\sigma}\epsilon^{*\nu}p^\rho k^\sigma 2T_1(q^2) + \epsilon^*_\mu(m_B^2-m_V^2)T_2(q^2) \\
&\quad -(p+k)_\mu(\epsilon^*\cdot q)\tilde{T}_3(q^2) + q_\mu(\epsilon^*\cdot q)T_3(q^2)
\end{aligned}
$$

In the limits of low and large $K^*$ recoil, separation of scales $\Lambda$ and $m_B$

- Large-recoil limit ($\sqrt{q^2} \sim \Lambda_{QCD} \ll m_B$) [LEET/SCET, QCDF]
    - two soft form factors $\xi_\perp(q^2)$ and $\xi_{||}(q^2)$
    - $O(\alpha_s)$ corr. from hard gluons [computable], $O(\Lambda/m_B)$ [nonpert]

[Charles et al., Beneke and Feldmann]

- Low-recoil limit ($E_{K^*} \sim \Lambda_{QCD} \ll m_B$) [HQET]
    - three soft form factors $f_\perp(q^2)$, $f_{||}(q^2)$, $f_0(q^2)$
    - $O(\alpha_s)$ corr. from hard gluons [computable] and $O(\Lambda/m_B)$ [nonpert]

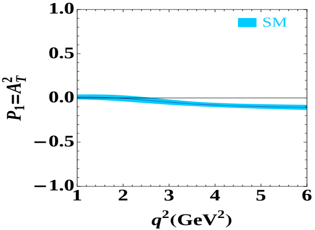
[Grinstein and Pirjol, Hiller, Bobeth, Van Dyk. . . ]

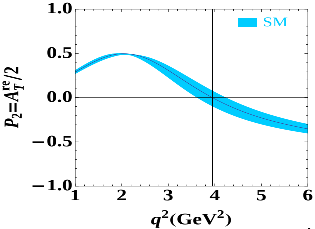
# Form-factor "independent" observables

= Obs. where soft form factors cancel at LO

- Zero of forward-back. asym. $A_{FB}(s_0) = 0$: $C_9^{\text{eff}}(s_0) + 2\frac{m_b M_B}{s_0} C_7^{\text{eff}} = 0$
- Transversity asymmetries [Krüger, Matias; Becirevic, Schneider]

$$P_1 = A_T^{(2)} = \frac{I_3}{2I_{2s}} = \frac{|A_\perp|^2 - |A_{||}|^2}{|A_\perp|^2 + |A_{||}|^2}, \quad P_2 = \frac{A_T^{re}}{2} = \frac{I_{6s}}{8I_{2s}} = \frac{Re[A_\perp^{L*} A_{||}^L - A_\perp^R A_{||}^{R*}]}{|A_\perp|^2 + |A_{||}|^2}$$

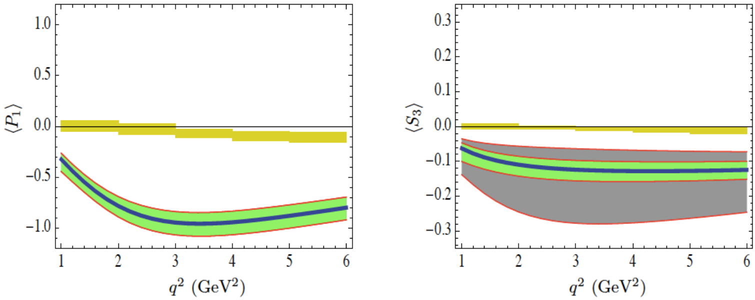



- 6 form-factor independ. obs. at large recoil ($P_1, P_2, P_3, P'_4, P'_5, P'_6$) + 2 form-factor dependent obs. ($\Gamma$, $A_{FB}$, $F_L \ldots$) [$A_{FB} = -3/2 P_2(1 - F_L)$] exhausting information in (partially redundant) angular coeffs $I_i$

[Matias, Krüger, Mescia, SDG, Virto, Hiller, Bobeth, Dyck, Buras, Altmanshoffer, Straub...]

# Sensitivity to form factors




- $P_i$ designed to have limited sensitivity to ffs
- $S_i$ CP-averaged version of $I_i$ ($A_i$ for CP-asym)

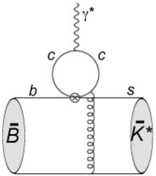
$$P_1 = \frac{2S_3}{1 - F_L} \qquad F_L = \frac{I_{1c} + \bar{I}_{1c}}{\Gamma + \bar{\Gamma}} \qquad S_3 = \frac{I_3 + \bar{I}_3}{\Gamma + \bar{\Gamma}}$$

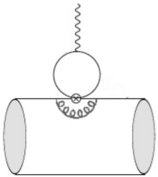
different sensivity to form factors inputs for given NP scenario (form factors from LCSR: green [Ball, Zwicky] vs gray [Khodjamirian et al.])

# Computation of amplitudes

Large recoil: NLO QCD factorisation

*in* $A_{\perp,||,0}$ *(non-factor.)* *in FFs (factor)*



- $V, A_i, T_i = \xi_{||,\perp}$ + factorisable $O(\alpha_s)$ + nonpert $O(\Lambda/m_b)$
- $A_{0,||,\perp} = C_i \times \xi_{||,\perp}$ + factorisable $O(\alpha_s)$ + nonfactorisable $O(\alpha_s)$ + nonpert $O(\Lambda/m_b)$

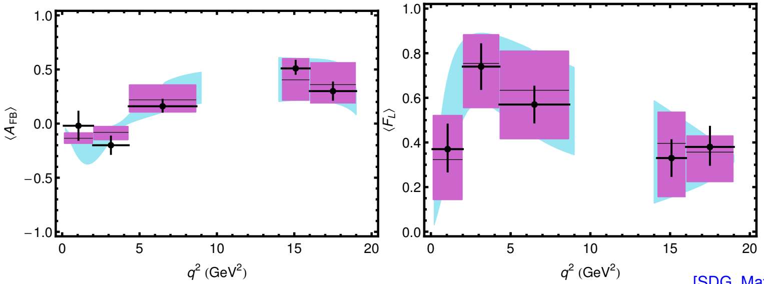
- either compute $A$ with $\xi_{||,\perp}$ extracted from $V, A_i$ (check $T_i$ OK)
- or compute $A$ from $V, A_i, T_i$ + nonfactorisable corrections
- nonperturbative corrections $O(\Lambda/m_b) \simeq 10\%$

Low recoil: OPE + HQET

- $A_{0,||,\perp} = C_i \times f_{0,||,\perp} + O(\alpha_s)$ corrections + $O(1/m_b)$ corrections
- $f_{0,||,\perp} \propto CL(A_1, A_2), A_1, V + O(1/m_b)$ corrections
- HQET relations between $V, A_i$ and $T_i$
- nonperturbative corrections smaller $O(C_7\Lambda/m_b, \alpha_s\Lambda/m_b)$

# SM predictions and LHCb results (1)

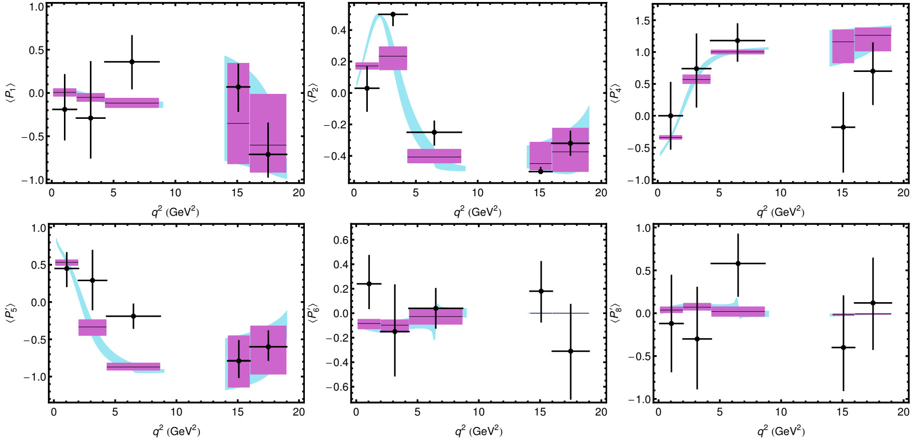
- Present bins
  - Large recoil: [0.1, 2], [2,4.3], [4.3,8.68] and [1,6] GeV$^2$
  - Low recoil: [14.18,16], [16,19] GeV$^2$
  - $c\bar{c}$ resonances : $[10.09, 12.89]$
- $[0.1, 1]$ with light resonances, washed out by binning [Camalich, Jäger]
- $q^2 > 6$ GeV$^2$ may be affected by charm-loop effects [Khodjamirian et al.]
- Beauty 12 and EPS 13 : results from LHCb




[SDG, Matias, Virto]

$\Longrightarrow$blue: SM unbinned, purple: SM binned, crosses: LHCb values

# SM predictions and LHCb results (2)

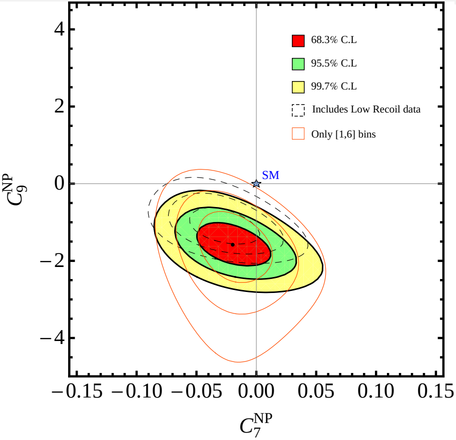



Meaning of the discrepancy in $P_2$ and $P'_5$ ? [SDG, Matias, Virto]

- $P_2$ same zero as $A_{FB}$, related to $C_9/C_7$
- $P_{5'} \to -1$ as $q^2$ grows due to $A^R_{\perp,||} \ll A^L_{\perp,||}$ for $C_9^{SM} \simeq -C_{10}^{SM}$
- A negative shift in $C_7$ and $C_9$ can move them in the right direction

# Global fit to radiative decays

(SDG, Matias, Virto)




$$C_i(\mu_{ref}) = C_i^{SM} + C_i^{NP}$$

Standard $\chi^2$ frequentist analysis

- $B \to K^* \mu\mu$: $P_1, P_2, P'_4, P'_5, P'_6, P'_8, A_{FB}$
- $B \to X_s\gamma$, $B \to X_s\mu\mu$: Br
- $B_s \to \mu\mu$: Br
- $B \to K^*\gamma$: $A_I$ and $S_{K^*\gamma}$

Several $B \to K^*\mu\mu$ sets [LHCb]

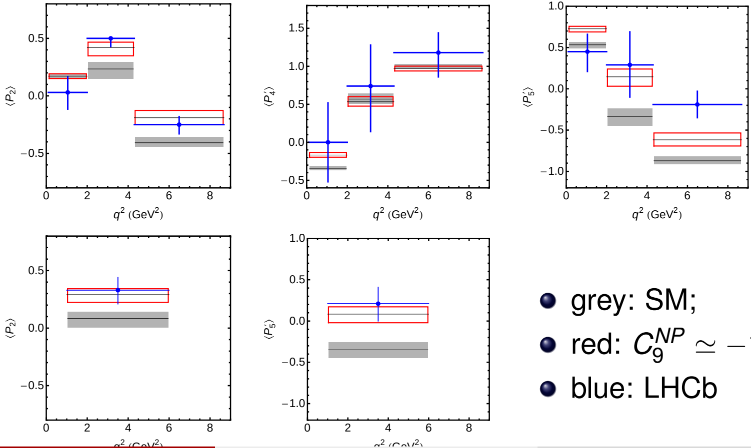
- full: 3 fine large-recoil bins
- dashed: 3 fine large-recoil bins + low-recoil bins
- orange: 1 large recoil-bin only

- Form factors from LCSR [Khodjamirian et al.], extrapolated if needed
- Large recoil: Soft form factors $\xi_{||,\perp}$ + QCDF
- Low recoil: Full form factors $V, A_i$ + HQET for $T_i$

# Only $C_7, C_9$

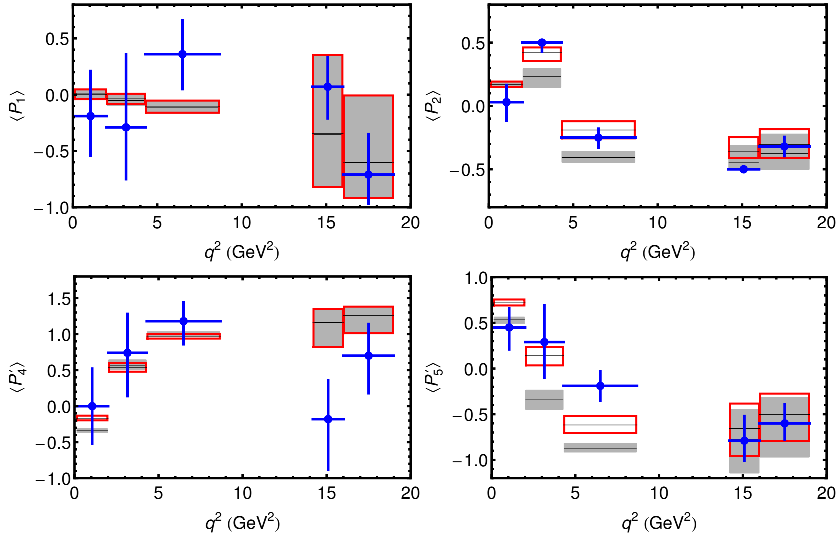
Pull of SM value for each $C_i$ $[\Delta\chi^2_i = \chi^2(C_i = 0) - \min_{C_i} \chi^2(C_i)]$

- pull for $C_9 \simeq 4\sigma$, pull for $C_7 \simeq 3\sigma$
- once both $C_9^{NP}$ and $C_7^{NP}$ included, low pulls for the other $C_i$'s
- consistent pattern favouring $C_9^{NP} \simeq -1.5$ [added to $C_9^{SM} \simeq 4.1$]




- grey: SM;
- red: $C_9^{NP} \simeq -1.5$;
- blue: LHCb

# $C_9 = -1.5$



$\langle P_1 \rangle$
$\langle P_2 \rangle$
$\langle P'_4 \rangle$
$\langle P'_5 \rangle$
$q^2$ (GeV$^2$)

# Other scenarios

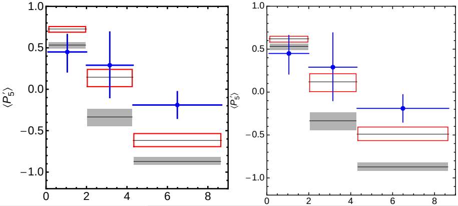
## SM operators + chirally flipped

| Coefficient | $1\,\sigma$ | $2\,\sigma$ | $3\,\sigma$ |
|---|---|---|---|
| $C_7^{NP}$ | $[-0.05, -0.01]$ | $[-0.06, 0.01]$ | $[-0.08, 0.03]$ |
| $C_9^{NP}$ | $[-1.6, -0.9]$ | $[-1.8, -0.6]$ | $[-2.1, -0.2]$ |
| $C_{10}^{NP}$ | $[-0.4, 1.0]$ | $[-1.2, 2.0]$ | $[-2.0, 3.0]$ |
| $C_{7'}^{NP}$ | $[-0.04, 0.02]$ | $[-0.09, 0.06]$ | $[-0.14, 0.10]$ |
| $C_{9'}^{NP}$ | $[-0.2, 0.8]$ | $[-0.8, 1.4]$ | $[-1.2, 1.8]$ |
| $C_{10'}^{NP}$ | $[-0.4, 0.4]$ | $[-1.0, 0.8]$ | $[-1.4, 1.2]$ |

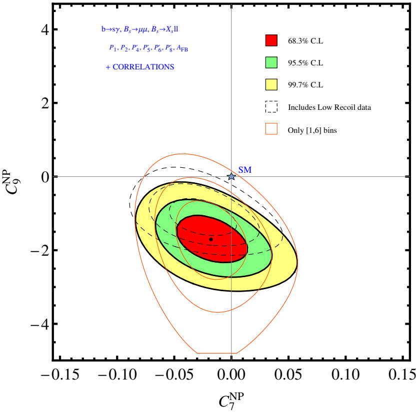
- Large-recoil shape of $P_2$ and $P_5'$ favours $C_7^{NP} < 0$ and $C_9^{NP} < 0$
- No other NP contrib favoured (small pulls once $C_7^{NP}$ and $C_9^{NP} \neq 0$)

## $C_9, C_{9'}$ scenario

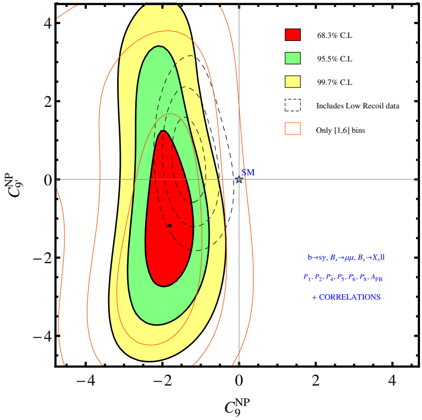
- $C_9^{NP} \sim -1.6$, $C_{9'}^{NP} \sim -1.5$ improves large-recoil $P_5'$
- low-recoil dilute effect, allow $C_{9'} < 0$ or $> 0$



# With exp. correlations: two scenarios




NP in $C_7, C_9$



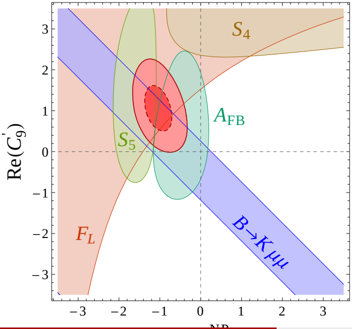

NP in $C_9, C_{9'}$

For $C_7, C_9$ scenario

- $4.2\sigma$ (large-recoil), $3.5\sigma$ (large + low recoil), $2.7\sigma$ ([1-6] bin)
- same conclusions hold if $P_i, P'_i, F_L$ rather than $P_i, P'_i, A_{FB}$

# Global fit with $S_i$, $A_i$ (Altmannshofer, Straub)

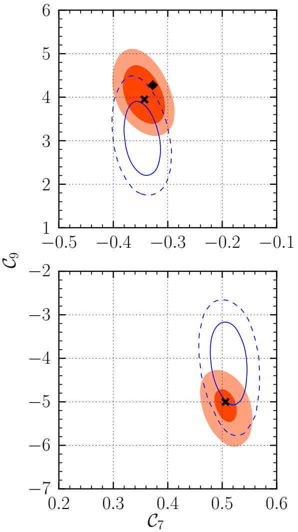
- Frequentist frame: $S_i, A_i, A_{FB}, Br(B \to K^* \mu\mu), Br(B^- \to K^- \mu\mu)$, with wide [1-6] at large recoil + low recoil
  $S_{K^*\gamma}, Br(B \to X_s\gamma), A_{CP}(b \to s\gamma), Br(B \to X_s \ell\ell), Br(B_s \to \mu\mu)$
- Amplitudes from full form factors LCSR [Ball, Zwicky]
  + non-factorisable corrections + $O(\Lambda/m_b)$ non fact.
- $C_9^{NP} \sim -0.9$ with less significance due to use of $S_i$, [1,6] bins, $F_L$
- Need for $C_{9'}^{NP} > 0$ due to low-recoil $B(B^- \to K^- \mu^+ \mu^-)$




"Equivalent analysis" for with LHCb $F_L, A_{FB}, S_{3,4,5,7,8}$ with three low-recoil bins (but no $B \to K\mu\mu$)

- 2.7 $\sigma$ for $C_7^{NP}, C_9^{NP}$
- Best fit point
  $C_7^{NP} = -0.02, C_9^{NP} = -1.76$
- No need for $C_{9'}^{NP} \neq 0$

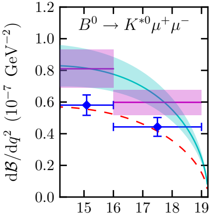
# Global fit with Bayesian approach (Beaujean, Bobeth, Van Dyk)

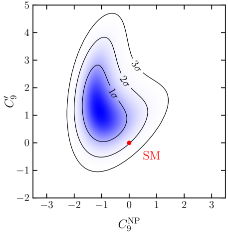



- Bayesian analysis: $P_i, F_L, A_{FB}$, $Br(B \to K^*\mu\mu)$, $Br(B \to K\mu\mu)$, $Br(B \to K^*\gamma)$, $C_{K^*\gamma}$, $S_{K^*\gamma}$, $Br(B \to X_s\gamma)$, $A_{CP}(b \to s\gamma)$, $Br(B \to X_s\ell\ell)$, $Br(B_s \to \mu\mu)$
  wide [1-6] at large recoil + low recoil
- Priors on nuisance parameters (form factors, $\Lambda/m_b$ corrections)
- SM with decent $p$-values from $\chi^2_{\rm min}$ if shift of $10-20\%$ $\Lambda/m_b$ corrections to amplitudes (but $N_{dof}$ ? asymptotic ?)
- 2 $\sigma$ dev. from SM for NP in 7,9,10 only
  $C_7^{NP} = 0\pm0.02$, $C_9^{NP} = -0.3\pm0.4$, $C_{10}^{NP} = -0.4\pm0.3$
- Bayes factors favour NP in SM operators + chirally flipped operators, either generic or restricted to $(C_9, C_{9'})$

# Analysis based on lattice QCD form factors

## $B \to K^*\ell\ell$ and $B_s \to \phi\ell\ell$ form factors [Horgan et al.]



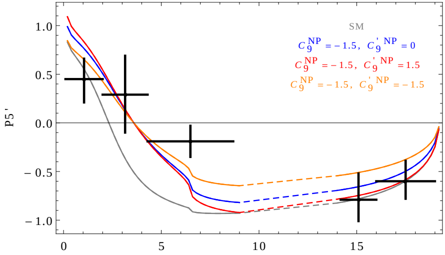




- Lattice simulations (staggered + NRQCD)
- Main problem in BRs [≠ previous studies]
  SM predictions 30% higher than experiment
  (similar to results using [Ball, Zwicky])
  (blue and pink : SM, dashed: $C_9^{NP} = -C_{9'}^{NP} = 1.1$)
- Frequentist with only large-recoil $B_q \to V\ell\ell$:
  $d\Gamma/dq^2, F_L, S_3, S_4, S_5, A_{FB}$ for $B \to K^*\ell\ell$;
  $d\Gamma/dq^2, F_L, S_3$ for $B_s \to \phi\ell\ell$
- 2 low-recoil bins: $C_9^{NP} = -1.1 \pm 0.5$, $C_{9'}^{NP} = 1.1 \pm 1.0$
- Last low-recoil bin: $C_9^{NP} = -1.1 \pm 0.7$, $C_{9'}^{NP} = 0.4 \pm 0.7$

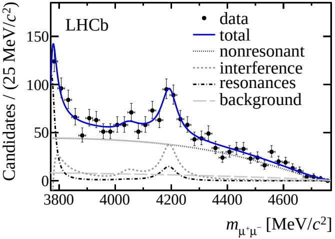
# $C_{9'}^{NP} \sim 0$ or $C_{9'}^{NP} > 0$ ?

## [1-6] bins for $B \to K^* \mu\mu$

- $q^2$ dependence of $P_{5'}$
- $C_{9'}^{NP} < 0$ better agreement for 1st and 3rd bins of $P_{5'}$
- $C_{9'}^{NP} > 0$ worse agreement for 1st and 3rd bins of $P_{5'}$




- integrated value over $[1, 6]$ almost same: no sensitivity




## Low-recoil $B(B^- \to K^- \mu^+ \mu^-)$

- [14.18,22] good agreement with SM
- favours $C_9^{NP} + C_{9'}^{NP} \simeq 0$, $C_{9'}^{NP} > 0$
- in [Altmannshofer, Straub], low-recoil 3 bins with 20% uncertainty to account for $\psi(4160)$ in first large-recoil bin

# Fluctuation of the data ?

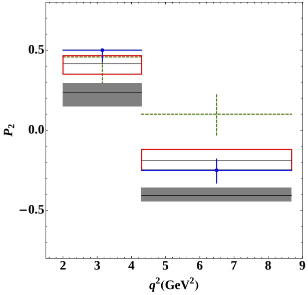
(Matias, Serra)

- Redundancy in angular coefficients

$$P_2 = \frac{1}{2}\left[P'_4 P'_5 + \frac{1}{\beta_\ell}\sqrt{(-1 + P_1 + P'^2_4)(-1 - P_1 + \beta_\ell^2 P'^2_5)}\right]$$

if no new CPV phase in $C_i$'s and negligible $P_{3,5',8'}$ $(Im[A_i A_j^*])$

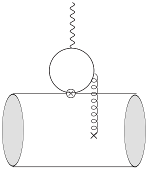
- Corrections from binning can be computed and are small, apart from [0.1-2] and [1-6] bins

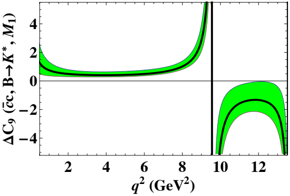



- $\langle P_2 \rangle$ : Gray: SM prediction, blue: data, red: $C_9^{NP} = -1.5$, green: relation
- [2.4,3]: $0.2\sigma$ measured vs relation
- [4.3,8.68]: $2.4\sigma$ measured vs relation, $1.9\sigma$ rel. vs NP best fit, $3.6\sigma$ rel. vs SM
- More consistent for $(P_2, P'_5)$ in the future if third-bin $P_{5'}$ goes down (closer to SM) and third-bin $P_2$ goes up (away from SM)

# Charm-loop effects

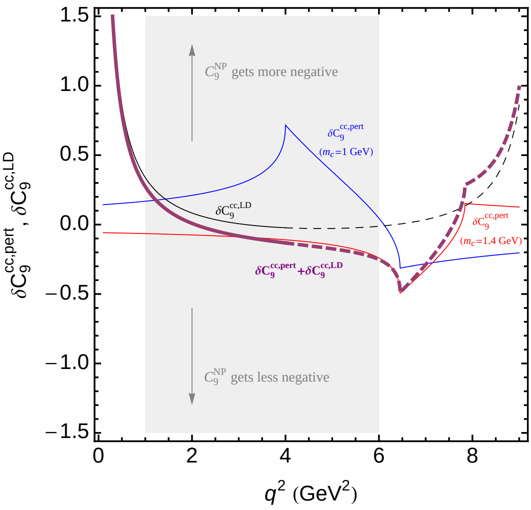
- Charmonium resonances
  - Large recoil: $q^2 \leq$ 6-7 GeV$^2$ to avoid $J/\psi$ tail
  - Low recoil: quark-hadron duality
    - sum of res. integrated over wide bin $\simeq$ perturbative computation
    - toy models suggest small corrs, but large bin = less $q^2$ sensitivity
- Short-distance non-resonant (hard gluons)
  - LO included $C_9 \to C_9 + Y(q^2)$, dependence on $m_c$ (which scheme)
  - higher-order short -dist QCD via QCDF/HQET
- Long-distance non-resonant (soft gluons)
  - $\Delta C_9^{BK^{(*)}}$ using LCSR [Khodjamirian, Mannel, Wang]
  - For $B \to K^*$, $\Delta C_9^{BK^{(*)}} < 0$ tend to increase the need for $C_9^{NP} \neq 0$





# Impact of $\Delta C_9^{BK^{(*)}}$ and $m_c$

(SDG, Matias, Virto)

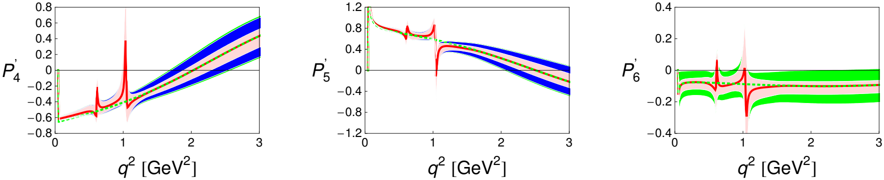



Shifts induced by change in $m_c$ and long-distance gluons in $c\bar{c}$ loops

# $1/m_b$ corrections

[Camalich, Jäger] SM preds with same central values but larger errors

- FF=soft form factor + $O(\alpha_s)$ corrections + $O(\Lambda/m_b)$
- Fix soft form factors $\xi_\perp, \xi_{||}$ from 2 form factors [LCSR]
- Then compare predictions for the other form factors




- [Camalich, Jäger] assume $C_7 = C_7^{SM}$ and extract from $B(B \to K^*\gamma)$ the very accurate value $\xi_\perp(0) = T_1(0) = 0.277 \pm 0.013$
  $\Longrightarrow$Need large $O(\Lambda/m_b)$ to predict other form factors in agreement with other approaches (LCSR, Dyson-Schwinger eqs. . . )

- [SDG, Matias, Virto] $\xi_\perp(0) = 0.31^{+0.20}_{-0.10}$ from LCSR
  10% $O(\Lambda/m_b)$ enough for QCDF and LCSR to agree for all FFs

# Outlook

$b \to s\gamma(^*)$ transition

- Very interesting playing ground for FCNC studies
- Many observables, more or less sensitive to hadronic unc.
- Intriguing LHCb results for $B \to K^*\mu\mu$, supporting $C_9^{NP} \neq 0$
- And a lot theoretical discussions on accuracy of computations and/or interpretation in terms of NP

How to improve ?

- Exp: finer binning in $[1, 6]$ region, other expts (ATLAS and CMS ?)
- Exp: refine $B \to K\mu\mu$ and impact of $\psi(4160)$
- Th: form factors from lattice on a larger $q^2$ range ?
- Th: $c\bar{c}$ loops, soft-gluon exchanges, quark/hadron duality
- Both: cross check with other modes/observables

Only the beginning of the story… more very soon !