

Exploring New Physics in the $C_7, C_{7'}$ plane

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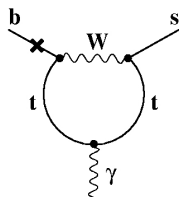
Portoroz 2011 - April 13th 2011



Radiative decays as probes of New Physics

$b \rightarrow D\gamma^{(*)}$ with $D = d, s$

- access to $|V_{t(d,s)}|$ within SM
- cross-check of neutral B mixing (box/penguin)
- loop processes very sensitive to NP
- studies at Belle and Babar, new results expected soon from LHCb



In terms of effective Hamiltonian (integrating d.o.f above b quark)

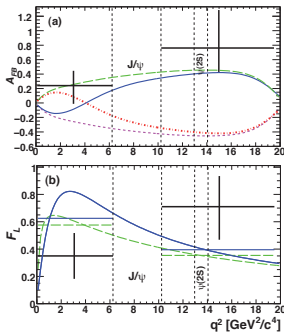
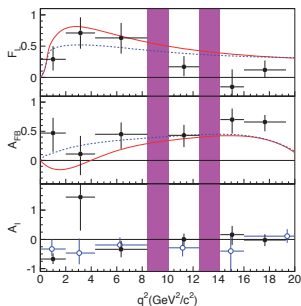
$\mathcal{H}_{\text{eff}} = \sum_i C_i O_i$, main contributions to radiative decays from:

- **Electromagnetic dipole:** $O_7 = \frac{e}{16\pi^2} m_b \bar{D} \sigma^{\mu\nu} (1 + \gamma_5) F_{\mu\nu} b$
- **Semileptonic (vector) operator:** $O_9 = \frac{e^2}{16\pi^2} \bar{D} \gamma_\mu (1 - \gamma_5) b \bar{\ell} \gamma_\mu \ell$
- **Semileptonic (axial) operator:** $O_{10} = \frac{e^2}{16\pi^2} \bar{D} \gamma_\mu (1 - \gamma_5) b \bar{\ell} \gamma_\mu \gamma_5 \ell$
- New physics changes Wilson coeffs and/or adds new operators

The example of the flipped-sign solution

$$C_7 \rightarrow -C_7^{SM}$$

- No change for $B(B \rightarrow X_s \gamma)$ (not sensitive to phase of C_7)



- Indication in Belle/Babar data on $B \rightarrow K^* \ell^+ \ell^-$
- Accomodate no zero in FB asymmetry

- In “contradiction” with $B \rightarrow X_s \ell^+ \ell^-$ [Gambino, Haisch, Misiak]
- Issue related to NP in operators that contribute to $B \rightarrow K^* \ell^+ \ell^-$
(dipole, semileptonic, chirally-flipped, scalar and tensor)

Effective Hamiltonian

$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} \left(V_{tb} V_{ts}^* \mathcal{H}_{\text{eff}}^{(t)} + V_{ub} V_{us}^* \mathcal{H}_{\text{eff}}^{(u)} \right) + h.c.,$$

[Chetyrkin, Misiak and Münz, Huber et al.]

$$\mathcal{H}_{\text{eff}}^{(t)} = \sum_{i=1}^6 C_i \mathcal{O}_i + \sum_{i=7}^{10} (C_i \mathcal{O}_i + C_{i'} \mathcal{O}_{i'}),$$

with dipole and semileptonic operators, SM and chirally-flipped

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

$$\mathcal{O}_9 = \frac{e^2}{16\pi^2} (\bar{s} \gamma_\mu P_L b) (\bar{\ell} \gamma^\mu \ell), \quad \mathcal{O}_{9'} = \frac{e^2}{16\pi^2} (\bar{s} \gamma_\mu P_R b) (\bar{\ell} \gamma^\mu \ell),$$

$$\mathcal{O}_{10} = \frac{e^2}{16\pi^2} (\bar{s} \gamma_\mu P_L b) (\bar{\ell} \gamma^\mu \gamma_5 \ell), \quad \mathcal{O}_{10'} = \frac{e^2}{16\pi^2} (\bar{s} \gamma_\mu P_R b) (\bar{\ell} \gamma^\mu \gamma_5 \ell),$$

where $P_{L,R} = (1 \mp \gamma_5)/2$ projection over the chiralities

Standard Model values

In the SM, NNLO in $\overline{\text{MS}}$ with fully anticommuting γ_5 including electromagnetic corrections [\[Chetyrkin, Misiak and Münz, Huber et al.\]](#)

$C_1(\mu_b)$	$C_2(\mu_b)$	$C_3(\mu_b)$	$C_4(\mu_b)$	$C_5(\mu_b)$
-0.263	1.011	-0.006	-0.081	0.000
$C_6(\mu_b)$	$C_7^{\text{eff}}(\mu_b)$	$C_8^{\text{eff}}(\mu_b)$	$C_9(\mu_b)$	$C_{10}(\mu_b)$
0.001	-0.292	-0.166	4.075	-4.308

- High-scale $\mu_0 = 2M_W$ [uncertainty: varied from M_W to $4M_W$]
- Low-scale $\mu_b = 4.8$ GeV [uncertainty: varied from 2.4 to 9.6 GeV]

For the chirally-flipped operators, we have the SM values

$$C_{7'}^{SM} = \frac{m_s}{m_b} C_7^{SM}, \quad C_{9',10'}^{SM} = 0$$

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How to discuss NP contributions to radiative decays, such as the possibility of flipped-sign solution for C_7 ?

SDG, D. Gosh, J. Matias, M. Ramon in preparation

Generally, discussion on radiative and leptonic b decays to be addressed in given framework, specific scenarios & observables

- **Framework:** NP in $C_7, C_9, C_{10}, C_{7'}, C_{9'}, C_{10'}$ as a real shift in the coefficients [scalar and tensors not addressed yet]
- **Scenarios** (from the more specific to the more general)
 - A : NP in 7,7' only
 - B : NP in 7,7', 9,10 only
 - C : NP in 7,7',9,10,9',10' only
- **Classes**
 - I: observables sensitive only to dipole operators
 - II: observables sensitive only to dipole and semileptonic operators
 - III: observables sensitive to dipole, semileptonic and other operators

⇒ Language that allows to discuss the impact of each observable for each scenario

Observables considered

- Observables with limited sensitivity to hadronic inputs
 - for inclusive decays: BRs $\mathcal{B}(B \rightarrow X_s \gamma)$ and $\mathcal{B}(B \rightarrow X_s l^+ l^-)$,
 - for $B \rightarrow K^* l^+ l^-$: polarization fraction F_L , forward-backward asymmetry A_{FB} and transverse asymmetry A_T^2
- Observables with less tight theoretical control, but strong impact
 - exclusive time-dependent CP asymmetry $S_{K^* \gamma}$
 - isospin asymmetry $A_I(B \rightarrow K^* \gamma)$

Express all quantities in terms of $\delta C_i = C_i(\mu_b) - C_i^{SM}(\mu_b)$
with simplistic treatment of constraints and uncertainties

- "naive" constraints $|X_{th}(\delta C_i) - X_{exp}| \leq \Delta X_{th} + \Delta X_{exp}$
- scan to find overlap of constraints
- uncertainties ΔX_{th} from SM analysis
(assumed not to be modified significantly by NP)

Form factors for $B \rightarrow K^* \gamma$

- full q^2 -range using light-cone sum rules
- large recoil for NLO QCD factorisation with soft form factors $\xi_{\perp, \parallel}$ + hard gluon corrections (+ 10% Λ/m_b corrections)

\implies we use the latter to treat exclusive observables for $q^2=1-6 \text{ GeV}^2$, extracting 2 soft form factors from LCSR determinations

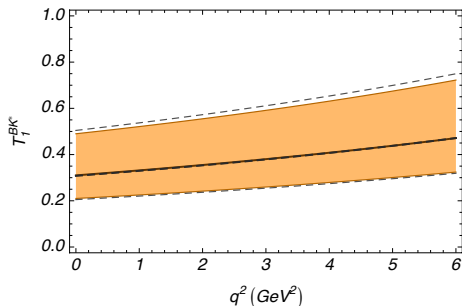
$$\xi_{\perp}(q^2) = \frac{m_B}{m_B + m_{K^*}} V(q^2), \quad \xi_{\parallel}(q^2) = \frac{m_B + m_{K^*}}{2E_{K^*}} A_1(q^2) - \frac{m_B - m_{K^*}}{m_B} A_2(q^2)$$

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5 other form factors then consistent, e.g. $T_1^{B \rightarrow K^*}$

- orange : full form factor from LCSR

[Khodjamirian et al]

- grey lines : NLO QCD factorisation [Beneke et al.] using our $\xi_{\perp}(q^2)$

Class-I observables: inclusive $\mathcal{B}(\bar{B} \rightarrow X_S \gamma)$

Class-I : only depending on $C_7, C_{7'}$, related to radiative decays

[Misiak, Gambino, Steinhauser...]

$$\mathcal{B}(\bar{B} \rightarrow X_S \gamma)_{E_\gamma > 1.6 \text{ GeV}}^{\text{exp}} = (3.55 \pm 0.24 \pm 0.09) \times 10^{-4}$$

$$\mathcal{B}(\bar{B} \rightarrow X_S \gamma)_{E_\gamma > 1.6 \text{ GeV}}^{\text{th}} = \left[a_{(0,0)} + a_{(7,7)} \left[(\delta C_7)^2 + (\delta C_{7'})^2 \right] + a_{(0,7)} \delta C_7 + a_{(0,7')} \delta C_{7'} \right] \times 10^{-4}$$

$$\mathcal{B}(\bar{B} \rightarrow X_S \gamma)_{E_\gamma > 1.6 \text{ GeV}}^{\text{SM}} = (3.15 \pm 0.23) \times 10^{-4}$$

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- SM value [$a_{(0,0)}$] expressed as

$$\mathcal{B}(B \rightarrow X_s \gamma)_{E_\gamma > E_0}^{\text{SM}} = \mathcal{B}(B \rightarrow X_c e \bar{\nu}) \left| \frac{V_{ts}^* V_{tb}}{V_{cb}} \right|^2 \frac{6\alpha_{\text{em}}}{\pi} [P(E_0) + N(E_0)]$$
$$P(E_0) = \sum_{i,j=1\dots 8} C_i^{\text{eff}}(\mu) C_j^{\text{eff}*}(\mu) K_{ij}(E_0, \mu)$$

- left- and right-handed polarisations add up incoherently
 - $a_{(7,7)} = a_{(7',7')}$ same structure for C_7 and $C_{7'}$, $\gamma_5 \rightarrow -\gamma_5$
 - $a_{(0,7)} \neq a_{(0,7')}$ since no 4-quark chirally flipped operators
- numerical a 's reproducing [Misiak, Steinhauser, Haisch]

Class-I observables: isospin asymmetry in $B \rightarrow K^* \gamma$

[Kagan and Neubert...]

$$A_I(B \rightarrow K^* \gamma) = \frac{\Gamma(\bar{B}^0 \rightarrow \bar{K}^{*0} \gamma) - \Gamma(B^- \rightarrow K^{*-} \gamma)}{\Gamma(\bar{B}^0 \rightarrow \bar{K}^{*0} \gamma) + \Gamma(B^- \rightarrow K^{*-} \gamma)}$$

- NLO QCD factorisation : isospin asymmetry from nonfactorisable contributions where spectator quark emits the photon
- from 4-quark and chromomagnetic operators
- thus no change once chirally-flipped operators included, apart from normalisation to isospin-averaged branching ratio

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$$A_I(B \rightarrow K^* \gamma)^{exp} = 0.052 \pm 0.026$$

$$A_I(B \rightarrow K^* \gamma)^{th} = c \times \frac{\sum_k d_k (\delta C_7)^k}{\sum_{k,l} e_{k,l} (\delta C_7)^k (\delta C_{7'})^l} \pm \delta c.$$

$$A_I(B \rightarrow K^* \gamma)^{SM} = 0.041 \pm 0.025$$

- c, d, e determined numerically,
reproducing [Kagan and Neubert, Feldmann and Matias]

Class-I observables: $B \rightarrow K^* \gamma$ CP-asymmetry

[Beneke Feldmann Seidel, Ball and Zwicky]

$$\frac{\Gamma(\bar{B}^0(t) \rightarrow \bar{K}^{*0} \gamma) - \Gamma(B^0(t) \rightarrow K^{*0} \gamma)}{\Gamma(\bar{B}^0(t) \rightarrow \bar{K}^{*0} \gamma) + \Gamma(B^0(t) \rightarrow K^{*0} \gamma)} = S_{K^* \gamma} \sin(\Delta m_B t) - C_{K^* \gamma} \cos(\Delta m_B t)$$

- Probe of photon helicity $S_{K^* \gamma} = \frac{2 \operatorname{Im} [e^{-2i\beta} (\mathcal{A}_L^* \bar{\mathcal{A}}_L + \mathcal{A}_R^* \bar{\mathcal{A}}_R)]}{|\mathcal{A}_L|^2 + |\mathcal{A}_R|^2 + |\bar{\mathcal{A}}_L|^2 + |\bar{\mathcal{A}}_R|^2}$
- Can be determined at NLO in QCD factorisation. At LO,

$$S_{K^* \gamma}^{(\text{LO})} = \frac{-2 |C_{7'}/C_7|}{1 + |C_{7'}/C_7|^2} \sin(2\beta - \arg(C_7 C_{7'}))$$

[Grinstein et al, Bobeth et al]

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[Grinstein et al, Bobeth et al]

$$S_{K^* \gamma}^{\text{exp}} = -0.16 \pm 0.22$$

$$S_{K^* \gamma} = f \begin{matrix} +\delta_f^u \\ -\delta_f^d \end{matrix} + \frac{\sum_{k,l} g_{k,l} (\delta C_7)^k (\delta C_{7'})^l}{\sum_{k,l} h_{k,l} (\delta C_7)^k (\delta C_{7'})^l}$$

$$S_{K^* \gamma}^{\text{SM}} = -0.30 \pm 0.01$$

- f, g, h fitting coefficients and uncertainties determined numerically

Class-II observables: A_T^2 asymmetry

Class-II : depending only on dipole and semileptonic operators

$$B \rightarrow K^* \ell^+ \ell^- \text{ asymmetry } A_T^2(q^2) = \frac{|A_\perp|^2 - |A_\parallel|^2}{|A_\perp|^2 + |A_\parallel|^2}, \quad [\text{Kruger and Matias}]$$

- $B \rightarrow K^* \ell^+ \ell^-$ expressed in terms of 7 spin amplitudes
- A_\perp and A_\parallel depend only on $C_{7,7',9,9',10,10'}$ (no tensors or scalars)
- can be determined from $d\Gamma/d\phi$
- weakly sensitive to soft form factors (only at NLO QCDF)
- not measured yet, but potential to discriminate among scenarios

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At low q^2 , at NLO QCD factorisation $A_T^2(q^2) = A_T^{(2), CV}(q^2) \begin{matrix} +\delta_u(q^2) \\ -\delta_d(q^2) \end{matrix}$
with fitting q^2 -polynomials for errors δ_u, δ_d and central value

$$A_T^{(2), CV}(q^2) = \frac{\sum_{i=0,7,7',9,9',10,10'} \sum_{j=i,..10'} F_{(i,j)}(q^2) \delta C_i \delta C_j}{\sum_{i=0,7,7',9,9',10,10'} \sum_{j=i,..10'} G_{(i,j)}(q^2) \delta C_i \delta C_j}$$

$[\delta C_0 = 1 \text{ to deal with constant, linear and quadratic terms}]$

Class-III observables: $\bar{B} \rightarrow X_s \mu^+ \mu^-$

Class-III: depending on dipole and semileptonic operators, but also others (scalar, tensors) \implies most of semileptonic observables

- $\bar{B} \rightarrow X_s \mu^+ \mu^-$ at low q^2 [1-6 GeV²]

$$\mathcal{B}(\bar{B} \rightarrow X_s \mu^+ \mu^-)^{exp} = (1.60 \pm 0.50) \times 10^{-6}$$

$$\mathcal{B}(B \rightarrow X_s \mu^+ \mu^-) = 10^{-7} \times \sum_{i,j=0,7,7',9,9',10,10'} b_{(i,j)} \delta C_i \delta C_j$$

$$\mathcal{B}(\bar{B} \rightarrow X_s \mu^+ \mu^-)^{SM} = (1.59 \pm 0.15) \times 10^{-6}$$

- $\delta C_7, \delta C_9, \delta C_{10}$ -only contributions known up to NNLO including e.m. corrections [Huber et al]
- $\delta C_{7'}, \delta C_{9'}, \delta C_{10'}$ -only contributions with similar structure ($\gamma_5 \rightarrow -\gamma_5$)
- crossed terms (primed-unprimed) only at LO in α_s , and are suppressed by m_s/m_b [Guetta Nardi]
- b coefficients determined numerically agreeing with [Huber et al]

Class-III observables: \tilde{A}_{FB} and \tilde{F}_L

Average forward-backward asymmetry \tilde{A}_{FB}
and longitudinal polarisation \tilde{F}_L over low $q^2 = 1-6 \text{ GeV}^2$

$$\frac{dA_{FB}}{dq^2} = \left(\int_0^1 d(\cos\theta_l) \frac{d^2\Gamma}{dq^2 d\cos\theta_l} - \int_{-1}^0 \dots \right) / \frac{d\Gamma}{dq^2} \quad F_L = |A_0|^2 / \frac{d\Gamma}{dq^2}$$

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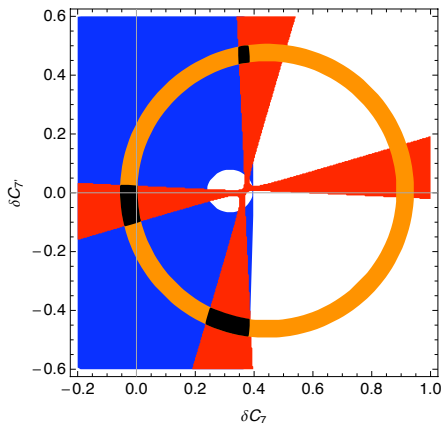
$$\tilde{A}_{FB}^{\text{exp}} = 0.33_{-0.24}^{+0.22} \quad \tilde{F}_L^{\text{exp}} = 0.60_{-0.19}^{+0.18}$$

$$\tilde{A}_{FB} = \frac{\int_{1\text{GeV}^2}^{6\text{GeV}^2} \sum_{i=0,7,7',9,9',10,10'} \sum_{j=i,..10'} H_{(i,j)}(q^2) \delta C_i \delta C_j dq^2}{\int_{1\text{GeV}^2}^{6\text{GeV}^2} \sum_{i=0,7,7',9,9',10,10'} \sum_{j=i,..10'} I_{(i,j)}(q^2) \delta C_i \delta C_j dq^2} \begin{matrix} +\tilde{\delta}_u \\ -\tilde{\delta}_d \end{matrix}$$

computed at NLO in QCD factorisation [Beneke and Feldmann]
with fitting q^2 -polynomials for central value and errors (same for \tilde{F}_L)

$$\tilde{A}_{FB}^{SM} = 0.022_{-0.028}^{+0.028} \quad \tilde{F}_L^{SM} = 0.732_{-0.031}^{+0.021}$$

$C_7, C_{7'}$ plane : constraints at 1σ



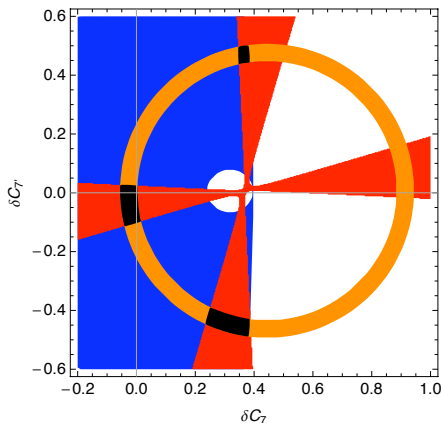
Class I observables

- A_I (blue)
- $B(B \rightarrow X_S \gamma)$ (brown)
- $S_{K^* \gamma}$ (red)

Combined regions (black)

- SM solution
 $(C_7, C_{7'}) = (C_7^{SM}, 0)$
- two non-SM solutions
 $(C_7, C_{7'}) = (0, \pm 0.4)$

$C_7, C_{7'}$ plane : constraints at 1σ



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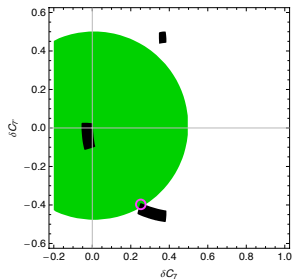
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($C_7, C_{7'}$) = ($C_7^{SM}, 0$)
- two non-SM solutions
($C_7, C_{7'}$) = ($0, \pm 0.4$)

- In qualitative agreement with [Bobeth et al, Huth et al]
- A_I disfavours flipped-sign solution ($C_7, C_{7'}$) = ($-C_7^{SM}, 0$) [allowed if loosen constraints to 1.6σ]
 \implies Same conclusion as [Gambino, Haisch, Misiak], but without using Class-III $B \rightarrow X_S \ell^+ \ell^-$ (less dependent on NP scenario)

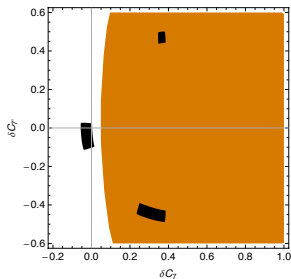
Scenario A : class-III observables

In Scenario A, no NP apart from C_7, C_7'

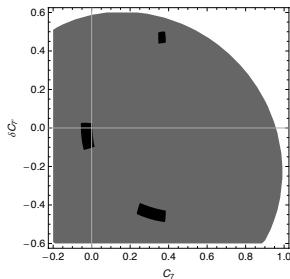
\implies class-III observables constrain also the shifts $\delta C_7, \delta C_7'$



$B(B \rightarrow X_S \mu^+ \mu^-)$
($\delta C_7, \delta C_7'$)



\tilde{A}_{FB}
($\delta C_7, \delta C_7'$)

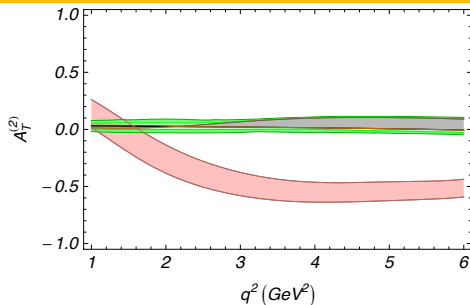


\tilde{F}_L
($\delta C_7, \delta C_7'$)

- $B(B \rightarrow X_S \mu^+ \mu^-)$ more for SM-like region [Gambino, Haisch, Misiak]
- \tilde{A}_{FB} in favour of non-SM regions

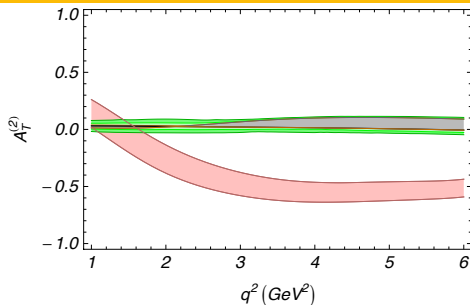
\implies At 1σ , only a small region around $(C_7, C_7') = (0, -0.4)$ allowed

Scenario A : prediction for class-II observable $A_T^{(2)}$



- In the SM (green, including uncertainties from form factors and estimate of $1/m_b$ -suppressed corrections)
- Under scenario A (pink), including errors from varying $C_7, C_{7'}$

Scenario A : prediction for class-II observable $A_T^{(2)}$



- In the SM (green, including uncertainties from form factors and estimate of $1/m_b$ -suppressed corrections)
- Under scenario A (pink), including errors from varying $C_7, C_{7'}$
- Enhancement understood from LO expression in large-recoil limit

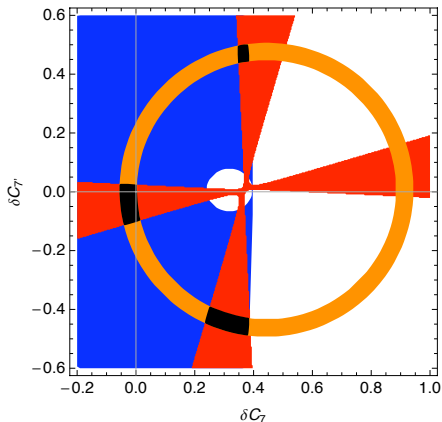
$$A_T^{(2)} \Big|_{LR} = \frac{2 \left[(C_9 + C_7 \cdot 2m_B m_b/s) C_{7'} \cdot 2m_B m_b/s \right]}{\left[C_{10}^2 + (C_9 + C_7 \cdot 2m_B m_b/s)^2 + (C_{7'} \cdot 2m_B m_b/s)^2 \right]}$$

$$\text{SM} \simeq (C_9^{SM} + C_7^{SM} \cdot 2m_B m_b/s) m_s/m_b C_7^{SM} \rightarrow \text{non-SM} \simeq C_9^{SM} \cdot C_7^{SM}$$

Scenario B : class-I constraints in $(\delta C_7, \delta C_{7'})$

In Scenario B, NP in

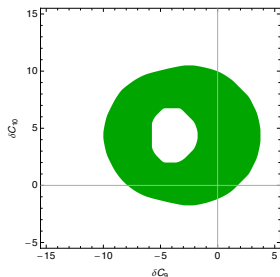
- $C_7, C_{7'}$: same constraints as before from class-I observables



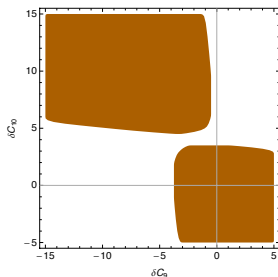
Scenario B : class-III constraints in $(\delta C_9, \delta C_{10})$

In Scenario B, NP in

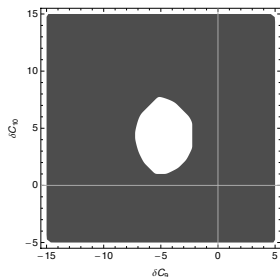
- $C_7, C_{7'}$: same constraints as before from class-I observables
- C_9, C_{10} : to be fixed from class-III observables
(in principle, class-III could also constrain $C_7, C_{7'}$ but not here)



$$B(B \rightarrow X_S \mu^+ \mu^-)$$
$$(\delta C_9, \delta C_{10})$$



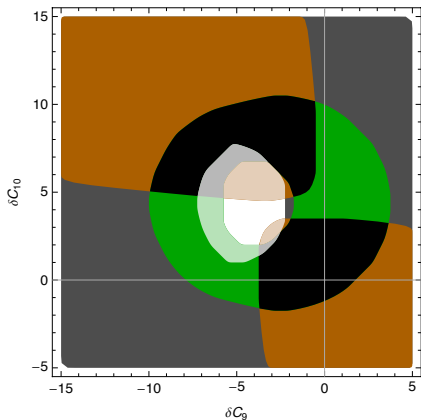
$$\tilde{A}_{FB}$$
$$(\delta C_9, \delta C_{10})$$



$$\tilde{F}_L$$
$$(\delta C_9, \delta C_{10})$$

- Small absolute values of (C_9, C_{10}) disfavoured
- Qualitative agreement with [\[Hurth et al.\]](#)

Scenario B : Overlap and non-SM regions



- $B(B \rightarrow X_s \mu^+ \mu^-)$ (green)

- A_{FB} (brown)

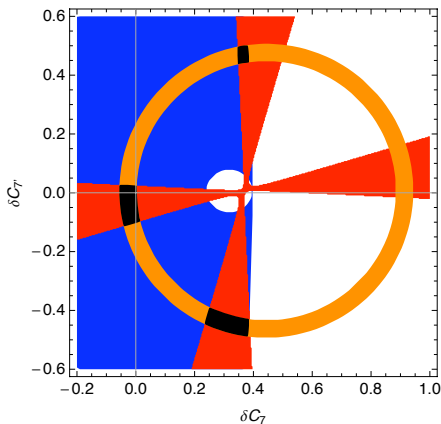
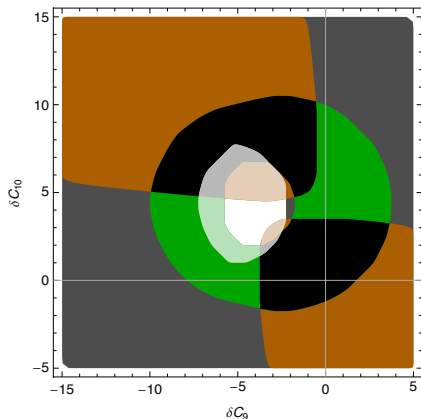
- F_L (grey)

Two combined regions (black)

- SM region around
 $(C_9, C_{10}) = (C_9^{SM}, C_{10}^{SM})$

- non-SM region around
 $(C_9, C_{10}) = (-C_9^{SM}, -C_{10}^{SM})$

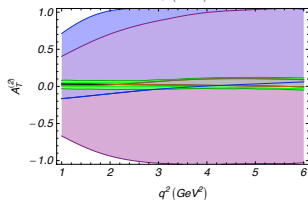
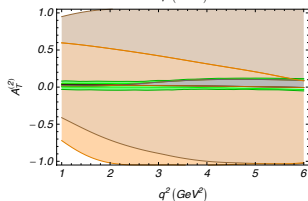
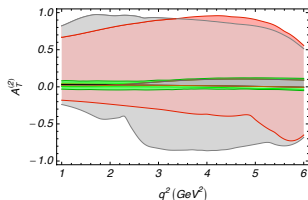
Scenario B : Overlap and non-SM regions



Both combined regions in (C_9, C_{10}) can accommodate values of $(C_7, C_{7'})$ either in the SM region or the two non-SM ones.

\implies Scenario B NP may alter $(C_7, C_{7'})$ and/or (C_9, C_{10}) and reproduce the experimental value $B \rightarrow X_s \mu^+ \mu^-$ at the same time

Scenario B : prediction for class-II obs. $A_T^2(q^2)$



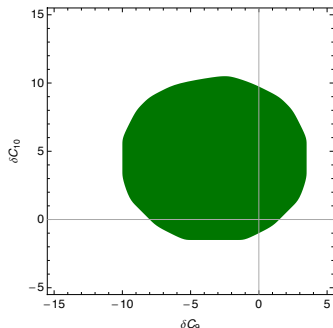
- $A_T^2(q^2)$ for $q^2 = 1 \dots 6 \text{ GeV}^2$
- Different shapes for the three regions in $(C_7, C_{7'})$
 - $(\delta C_7, \delta C_{7'}) \simeq (0, 0)$
 - $(\delta C_7, \delta C_{7'}) \simeq (0.3, -0.4)$
 - $(\delta C_7, \delta C_{7'}) \simeq (0.3, 0.4)$
 - two possibilities for SM and non-SM regions for (C_9, C_{10})
- Very large uncertainties due to the size of the two regions for (C_9, C_{10}) (in particular from non-SM region)
- Discriminating power from variation with q^2 (value at upper end)

Scenario C : class-III observables

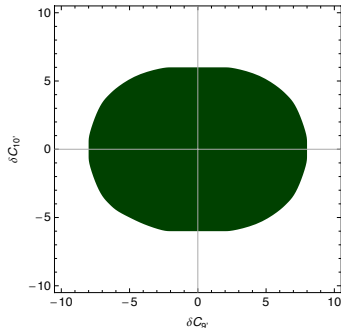
In Scenario B, NP in

- $C_7, C_{7'}$: same constraints as before from class-I observables
- $C_9, C_{10}, C_{9'}, C_{10'}$: to be fixed from class-III observables

Actually, only $B(B \rightarrow X_S \mu^+ \mu^-)$ elliptic constraint still yields constraints



$(\delta C_9, \delta C_{10})$



$(\delta C'_9, \delta C'_{10})$

\implies Too many possibilities to get a prediction for A_7^Z

Conclusion

- Effective Hamiltonian to probe NP in radiative/leptonic decays
- Need to define framework/scenario, with classification of observables (A_7^2 interesting with that respect)
- Starting point: $C_7, C_{7'}$ plane from class-I observables
 - Flipped-sign solution disfavoured by $A_I(B \rightarrow K^* \gamma)$
irrespective of NP in semileptonic operators
 - Funny non-SM regions ($C_7 = 0, C_{7'} = \pm 0.4$)
- Various scenarios of NP considered
 - A (NP in $C_{7,7'}$ only): small region in $(C_7, C_{7'})$, with prediction for A_7^2
 - B (NP in $C_{7,7',9,10}$): two regions in (C_9, C_{10})
 - C (NP in $C_{7,7',9,10,9',10'}$): nothing from exclusive decays (yet), only bounds on semileptonic ops. from $B \rightarrow X_s \ell^+ \ell^-$

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Outlook

- Scalar, tensors ? Other (well-controlled) observables ?
- Bin-by-bin information at low q^2 rather than averages
- Proper statistical treatment

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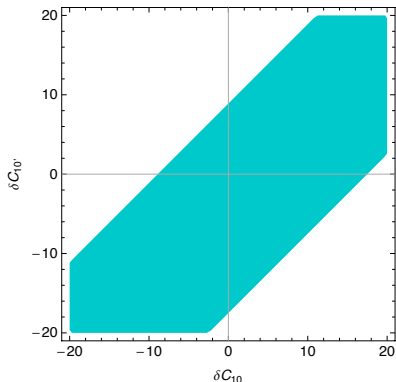
Outlook

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 - Bin-by-bin information at low q^2 rather than averages
 - Proper statistical treatment
- ... for Portoroz 2012 ?

Back-up

Constraint on $C_{10}, C_{10'}$ from $B_s \rightarrow \mu^+ \mu^-$

$$\mathcal{B}(\bar{B}_s \rightarrow \mu^+ \mu^-)|_{\text{axial}} = \frac{G_F^2 \alpha^2}{16\pi^3} f_{B_s}^2 m_{B_s} \tau_{B_s} |V_{tb} V_{ts}^*|^2 m_\mu^2 \sqrt{1 - \frac{4m_\mu^2}{m_{B_s}^2}} |C_{10} - C_{10'}|^2$$



Using our inputs, we get

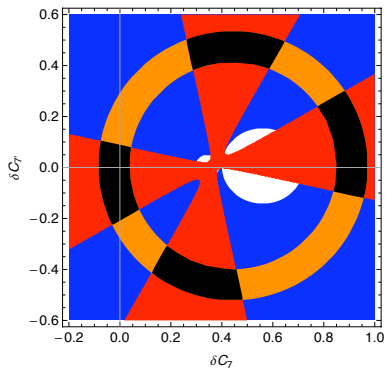
$$\mathcal{B}(\bar{B}_s \rightarrow \mu^+ \mu^-)^{\text{SM}} = (3.44 \pm 0.32) \cdot 10^{-9}$$

one order of magnitude smaller
than 90% CL exp bound

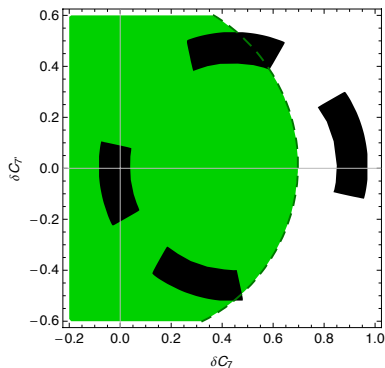
$$\mathcal{B}(\bar{B}_s \rightarrow \mu^+ \mu^-)^{\text{exp}} < 3.2 \cdot 10^{-8}$$

and only weak constraints on
 $C_{10}, C_{10'}$

At two sigmas : $(C_7, C_{7'})$ and scenario A

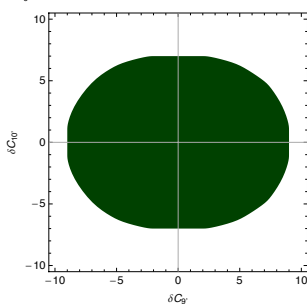
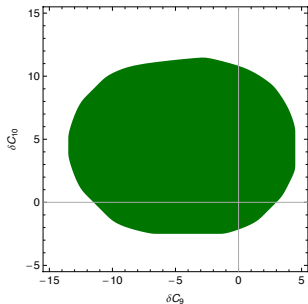
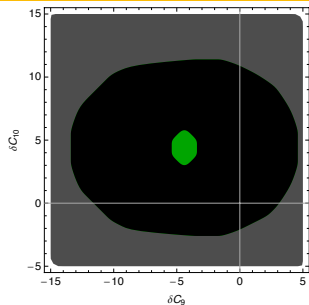


$(C_7, C_{7'})$ from class-I



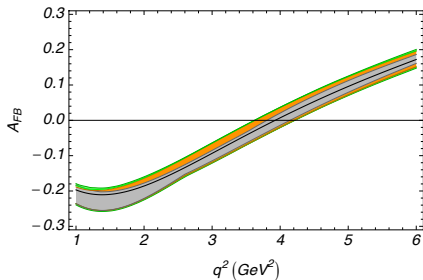
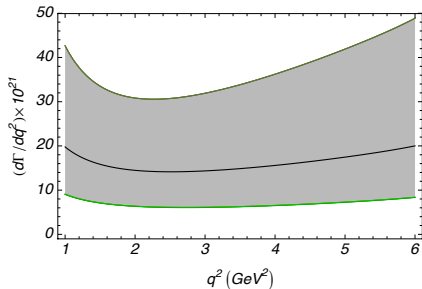
$B \rightarrow X_S \mu^+ \mu^-$ in scenario A

At two sigmas : scenario B and C



- Scenario *B*
(up):
 $B \rightarrow X_S \mu^+ \mu^-$
and \tilde{F}_L
- Scenario *C*
(down):
 $B \rightarrow X_S \mu^+ \mu^-$

SM prediction for $B \rightarrow K^* l^+ l^-$: $d\Gamma/dq^2$ and A_{FB}



$\mu_b = 4.8 \text{ GeV} [/2 \rightarrow \times 2]$	$\mu_0 = 2M_W [/2 \rightarrow \times 2]$
$\sin^2 \theta_W = 0.2313$ $\alpha_{em}(M_Z) = 1/128.940$	$\alpha_s(M_Z) = 0.1184 \pm 0.0007$
$m_t^{\text{pole}} = 173.3 \pm 1.1 \text{ GeV}$ $m_c^{\overline{MS}}(m_c) = 1.27 \pm 0.09 \text{ GeV}$	$m_b^{1S} = 4.68 \pm 0.03 \text{ GeV}$ $m_s^{\overline{MS}}(2 \text{ GeV}) = 0.101 \pm 0.029 \text{ GeV}$
$\lambda_{CKM} = 0.22543 \pm 0.0008$ $\bar{\rho} = 0.144 \pm 0.025$	$A_{CKM} = 0.805 \pm 0.020$ $\bar{\eta} = 0.342 \pm 0.016$
$\mathcal{B}(B \rightarrow X_c e \bar{\nu}) = 0.1061 \pm 0.00017$ $\lambda_2 = 0.12 \text{ GeV}^2$	$C = 0.58 \pm 0.016$
$\Lambda_h = 0.5 \text{ GeV}$ $f_{K^*, } = 0.220 \pm 0.005 \text{ GeV}$ $\xi_{\perp}(0) = 0.31^{+0.20}_{-0.10}$ $a_{1, ,\perp}(2 \text{ GeV}) = 0.03 \pm 0.03$ $\lambda_B(\mu_h) = 0.51 \pm 0.12 \text{ GeV}$	$f_B = 0.200 \pm 0.025 \text{ GeV}$ $f_{K^*,\perp}(2 \text{ GeV}) = 0.163 \pm 0.008 \text{ GeV}$ $\xi_{ }(0) = 0.10 \pm 0.03$ $a_{2, ,\perp}(2 \text{ GeV}) = 0.08 \pm 0.06$
$f_{B_s} = 0.2358 \pm 0.0089 \text{ GeV}$	$\tau_{B_s} = 1.472 \pm 0.026 \text{ ps}$