TOWARDS GLOBAL ANALYSIS OF $b \to s + \ell^+\ell^-$

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Grenoble

RICH PHENOMENOLOGY . . .

$b \to s + \gamma$

$B \to K^* \gamma$

– Br

– time-dep. CP asy. $S_{K*\gamma}$

– iso-spin asymmetry Δ_{0-}

$B \to X_s \gamma$

– Br, dBr/dE_γ

– A_{CP} in $B \to X_s\gamma$ and $B \to X_{s+d}\gamma$

$b \to s + \bar{\ell}\ell$

$B_s \to \bar{\ell}\ell$

– Br

$B \to K + \bar{\ell}\ell$

– $d^2Br/dq^2\, d\cos\theta_l \to dBr/dq^2$, A_{FB}, F_H

$B \to K^*_{os}(\to K\pi) + \bar{\ell}\ell$

– $d^4Br/dq^2 d\cos\theta_l d\cos\theta_{K*}\, d\phi$

$\to$ angular observables $I^{(s,c)}_{1,\dots,9}(q^2)$

$\to dBr/dq^2$, A_{FB}, F_L, $A_T^{(2,3,4,5,\mathrm{re},\mathrm{im})}$, $H_T^{(1,2,3)}$, . . .

$B \to X_s + \bar{\ell}\ell$

– dBr/dq^2 and A_{FB}

. . . in $b \to s + \{\gamma, \bar{\ell}\ell\}$ FCNC's to test short-distance flavour physics:

C_i for $i = 7, 7'$

C_i for $i = 7, 7', 9, 9', 10, 10', \dots$

BUT need non-perturbative hadronic input:

B, K, K^*-decay constants and LCDA's

$(B \to K)$ form factors: $f_{+,T,P}$

$(B \to K^*)$ form factors: V, $A_{0,1,2}$, $T_{1,2,3}$

Exclusive $b \to s + \bar{\ell}\ell$: Data vs SM ...

$B \to K^* + \bar{\ell}\ell$: $\quad Br(q^2)$, $\quad A_{\rm FB}(q^2)$, $\quad F_L(q^2)$

$B \to K + \bar{\ell}\ell$: $\quad Br(q^2)$

1) Babar [arXiv:0804.4412]

2 q^2-bins: $\in [0.1 - 6.25]$ GeV^2 and $[> 10.24]$ GeV^2

$\Rightarrow (27 \pm 6) + (37 \pm 10) = 64$ events

2) Belle [arXiv:0904.0770]

6 q^2-bins $\Rightarrow$ 247 events (121 @ $q^2 > 14$ GeV^2)

3) CDF [arXiv:1101.1028]

Belle q^2-binning $\Rightarrow$ 101 events (42 @ $q^2 > 14$ GeV^2)

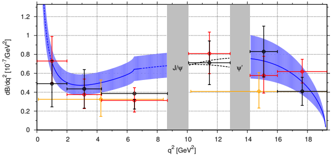
SM prediction + unc. @ low- and high-q^2

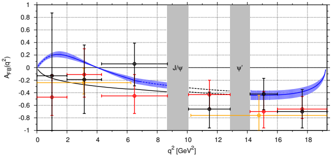
[CB/Hiller/van Dyk arXiv:1006.5013], [CB/Hiller/van Dyk/Wacker preliminary]

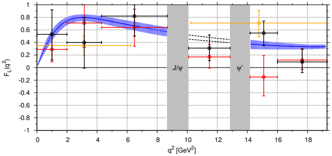
angular analysis $B \to K^* \bar{\ell}\ell$ in each q^2-bin in θ_ℓ and θ_{K*} $\Rightarrow$ fitted F_L and $A_{\rm FB}$

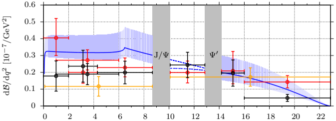
$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_{K*}} = \frac{3}{2} F_L \cos^2\theta_{K*} + (1 - F_L)(1 - \cos^2\theta_{K*}),$$

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_\ell} = \frac{3}{4} F_L (1 - \cos^2\theta_\ell) + \frac{3}{8}(1 - F_L)(1 + \cos^2\theta_\ell) + A_{\rm FB}\cos\theta_\ell$$









Experimental prospects

Babar/Belle/CDF 2011: analysis of final data

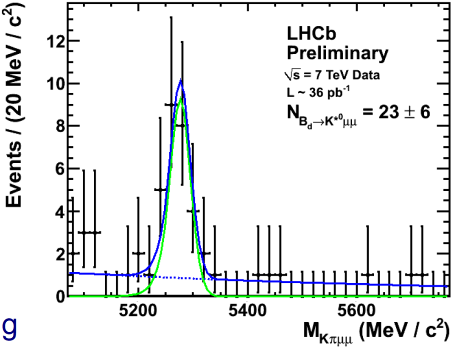
LHCb 2010: see figure

LHCb 2011: full year 1 fb^{-1} $\to$ $\mathcal{O}(600)$ events

$\to$ "dominate" statistically BaBar + Belle + CDF

LHCb upgrade: $(50-100)$ fb^{-1} (extrapolation of arXiv:0912.4179) can expect $\mathcal{O}(500k)$ events

[U.Egede, DESY, June 2011]



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2nd generation *B*-factories

- Belle $\to$ Belle II @ SuperKEKB (Japan)
- BaBar $\to$ Super-*B* planned @ Rome Torre Vergata (Italy) [Super-*B* Kickoff-Meeting, Elba, May 2011]

for example with 75 ab^{-1} @ Super-*B* $\mathcal{O}(20k)$ events [G.Eigen, Elba, May 2011]

$\Delta B = 1$ EFFECTIVE THEORY IN THE SM & BEYOND ...

$$\mathcal{L}_{\text{eff}}(\mu_b) = \mathcal{L}_{\text{QED}\times\text{QCD}}(u, d, s, c, b,\ e, \mu, \tau,\ ???)$$
$$+ \frac{4G_F}{\sqrt{2}} V_{\text{CKM}} \sum_{\text{SM}} (C_i + \Delta C_i)\mathcal{O}_i + \sum_{\text{NP}} C_j \mathcal{O}_j(???)$$

... beyond the SM:

- $\Rightarrow$ ΔC_i ... NP contributions to SM C_i
- $\Rightarrow$ $\sum_{\text{NP}} C_j \mathcal{O}_j$ ... NP operators (e.g. $C'_{7,9,10}$, $C^{(\prime)}_{S,P}$, ...)
- $\Rightarrow$??? ... additional light degrees of freedom ($\Leftarrow$ not pursued in the following)

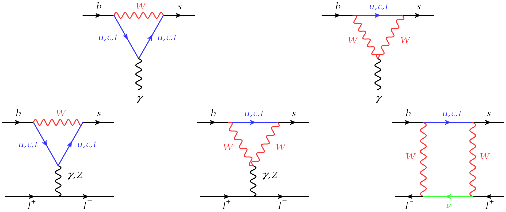
MODEL-DEP. 1) decoupling of new heavy particles @ NP scale: $\mu_{NP} \gtrsim M_W$

2) RG-running to lower scale $\mu_b \sim m_b$ (potentially tower of EFT's)

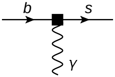
MODEL-INDEP. extending SM EFT-Lagrangian $\rightarrow$ ...

$b \to s + \{\gamma, \bar{\ell}\ell\}$ IN THE SM

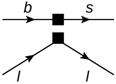
Main contributions within EFT:



$\longrightarrow \quad C_7^{\gamma} \quad \times$



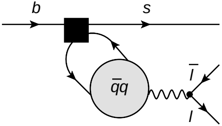
$\longrightarrow \quad C_{9,10}^{\ell\ell} \quad \times$



Background contribution $B \to K^{(*)}(\bar{c}c) \to K^{(*)}\bar{\ell}\ell$

from 4-quark operators $b \to s\bar{q}q$

q^2 = dilepton invariant mass:



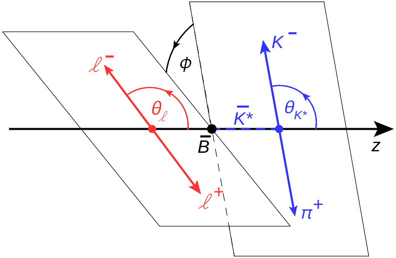
q^2 - REGIONS IN $b \to s + \bar{\ell}\ell$ $\quad$ $K^{(*)}$-ENERGY IN B-REST FRAME: $E_{K^{(*)}} = (M_B^2 + M_{K^{(*)}}^2 - q^2)/(2\, M_B)$

q^2-region	low-q^2: $q^2 \ll M_B^2$	high-q^2: $q^2 \sim M_B^2$
$K^{(*)}$-recoil	large recoil: $E_{K^{(*)}} \sim M_B/2$	low recoil: $E_{K^{(*)}} \sim M_{K^{(*)}} + \Lambda_{\rm QCD}$
theory method	QCDF, SCET: $q^2 \in [1, 6]$ GeV^2	OPE + HQET: $q^2 \gtrsim (14 \ldots 15)$ GeV^2

4-BODY DECAY: $\bar{B} \to \bar{K}^*_{on-shell}[\to \bar{K}\pi] + \bar{\ell}\ell$

1) $q^2 = m^2_{\bar{\ell}\ell} = (p_{\bar{\ell}} + p_\ell)^2 = (p_B - p_{K^*})^2$
2) $\cos\theta_\ell$ with $\theta_\ell \angle(\vec{p}_B, \vec{p}_{\bar{\ell}})$ in $(\bar{\ell}\ell)$-c.m. system
3) $\cos\theta_{K^*}$ with $\theta_{K^*} \angle(\vec{p}_B, \vec{p}_K)$ in $(K\pi)$-c.m. system
4) ϕ $\angle(\vec{p}_K \times \vec{p}_\pi, \vec{p}_{\bar{\ell}} \times \vec{p}_\ell)$ in B-RF

CP-conj: $B^0 \to K^{*0}(\to K^+\pi^-) + \bar{\ell}\ell$
similarly: $B_s \to \phi(\to K^+K^-) + \bar{\ell}\ell$



$$\frac{32\pi}{9}\frac{d^4\Gamma}{dq^2\, d\cos\theta_\ell\, d\cos\theta_{K^*}\, d\phi} = I_1^s \sin^2\theta_{K^*} + I_1^c \cos^2\theta_{K^*} + (I_2^s \sin^2\theta_{K^*} + I_2^c \cos^2\theta_{K^*})\cos 2\theta_\ell$$
$$+ I_3 \sin^2\theta_{K^*} \sin^2\theta_\ell \cos 2\phi + I_4 \sin 2\theta_{K^*} \sin 2\theta_\ell \cos\phi + I_5 \sin 2\theta_{K^*} \sin\theta_\ell \cos\phi$$
$$+ (I_6^s \sin^2\theta_{K^*} + I_6^c \cos^2\theta_{K^*})\cos\theta_\ell + I_7 \sin 2\theta_{K^*} \sin\theta_\ell \sin\phi$$
$$+ I_8 \sin 2\theta_{K^*} \sin 2\theta_\ell \sin\phi + I_9 \sin^2\theta_{K^*} \sin^2\theta_\ell \sin 2\phi$$

$I_i^{(s,c)}(q^2) = q^2$-dependent "ANGULAR OBSERVABLES"

$\Rightarrow$ "$2 \times (12 + 12) = 48$" if measured separately: A) decay + CP-conj & B) for $\ell = e, \mu$

$\Rightarrow$ for (SM + χ-flipped) operators and $m_\ell = 0$: $I_1^s = 3 I_2^s$, $I_1^c = -I_2^c$, $I_6^c = 0$, $+4$th

[Egede/Hurth/Matias/Ramon/Reece arXiv:1005.0571]

$I_i^{(s,c)} \longrightarrow$ OBSERVABLES

IDEA: USE FORM FACTOR (FF) SYMMETRY RELATIONS . . .

. . . @ low- & high-q^2 as guidance to form combinations of $I_i^{(s,c)}$ which are:

1) "FF"-free and/or 2) BSM-sensitive or 3) "short-distance"-free

examples @ low-q^2 using QCDF [Beneke/Feldmann/Seidel hep-ph/0106067 + 0412400]

- $A_T^{2,3,4,5}$ [Krüger/Matias hep-ph/0502060, Egede/Hurth/Matias/Ramon/Reece arXiv:0807.2589 + 1005.0571]
- $A_T^{\mathrm{re,im}}$ [Becirevic/Schneider, arXiv:1106.3283]

OPE + HQET @ HIGH-q^2 [GRINSTEIN/PIRJOL HEP-PH/0404250, BEYLICH/BUCHALLA/FELDMANN ARXIV:1101.5118]

$$(2\,I_2^s + I_3) = 2\,\rho_1\,f_\perp^2, \qquad -I_2^c = 2\,\rho_1\,f_0^2, \qquad I_5/\sqrt{2} = 4\,\rho_2\,f_0 f_\perp,$$

$$(2\,I_2^s - I_3) = 2\,\rho_1\,f_\parallel^2, \qquad \sqrt{2}\,I_4 = 2\,\rho_1\,f_0 f_\parallel, \qquad I_6^s/2 = 4\,\rho_2\,f_\parallel f_\perp,$$

$$I_7 = I_8 = I_9 = 0, \qquad (I_6^c = 0) \qquad (m_\ell = 0)$$

A) ρ_1 and ρ_2 are largely μ-scale independent and B) $f_{\perp,\parallel,0}$ FF-dependent

$$\rho_1(q^2) \equiv \left| C_9^{\mathrm{eff}} + \kappa \frac{2m_b^2}{q^2} C_7^{\mathrm{eff}} \right|^2 + |C_{10}|^2, \qquad \rho_2(q^2) \equiv \mathrm{Re}\left(C_9^{\mathrm{eff}} + \kappa \frac{2m_b^2}{q^2} C_7^{\mathrm{eff}} \right) C_{10}^*$$

HIGH-q^2 PHENOMENOLOGY: SM OPERATOR BASIS

FF-FREE RATIOS !!! TEST SD FLAVOUR COUPLINGS VERSUS EXP. DATA + OPE

$$H_T^{(1)}(q^2) = \frac{\sqrt{2} I_4}{\sqrt{-I_2^c \left(2 I_2^s - I_3\right)}} = \mathrm{sgn}(f_0) \cdot 1$$

$$H_T^{(2)}(q^2) = \frac{I_5}{\sqrt{-2 I_2^c \left(2 I_2^s + I_3\right)}} = 2\,\frac{\rho_2}{\rho_1}, \qquad H_T^{(3)}(q^2) = \frac{I_6}{2\sqrt{(2 I_2^s)^2 - I_3^2}} = 2\,\frac{\rho_2}{\rho_1}$$

SM $q^2 \in [14.0, 19.2]$ GeV^2: $\langle H_T^{(2)} \rangle = -0.972 \pm 0.010$, $\langle H_T^{(3)} \rangle = -0.958 \pm 0.010$

SHORT-DISTANCE-FREE RATIOS !!! TEST LATTICE VERSUS EXP. DATA + OPE

$$\frac{f_0}{f_\perp} = \sqrt{\frac{-I_2^c}{2 I_2^s + I_3}}, \qquad \frac{f_0}{f_\|} = \frac{\sqrt{2} I_5}{I_6} = \frac{-I_2^c}{\sqrt{2} I_4} = \ldots, \qquad \frac{f_\perp}{f_\|} = \sqrt{\frac{2 I_2^s + I_3}{2 I_2^s - I_3}} = \frac{\sqrt{-I_2^c \left(2 I_2^s + I_3\right)}}{\sqrt{2} I_4}$$

FF-free CP-asymmetries

$a_{\rm CP}^{(3)}$ without B-tagging!

$$a_{\rm CP}^{(1)} = \frac{\rho_1 - \bar\rho_1}{\rho_1 + \bar\rho_1}, \qquad a_{\rm CP}^{(3)} = 2\,\frac{\rho_2 - \bar\rho_2}{\rho_1 + \bar\rho_1},$$

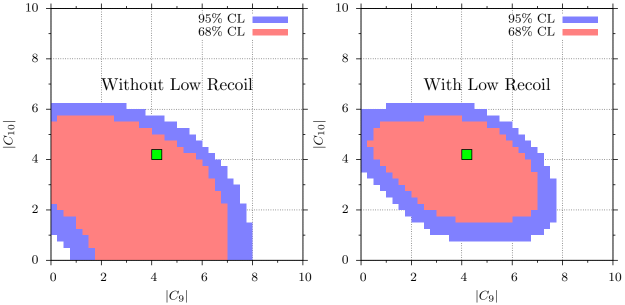
Correlations among $B \to K^* \bar\ell\ell$ and $B \to K \bar\ell\ell$

$$\rho_1[\bar B \to \bar K^* \bar\ell\ell] = \rho_1[\bar B \to \bar K \bar\ell\ell],$$

$$a_{\rm CP}^{(1)}[B \to K^* \bar\ell\ell] = A_{\rm CP}[B \to K \bar\ell\ell]$$

[CB/Hiller/van Dyk arXiv:1006.5013 + 1105.0376, CB/Hiller/van Dyk/Wacker preliminary]

"Global" Fit of C_9 and C_{10} – complex



[CB/Hiller/van Dyk arXiv:1105.0376]

Scan resolution

$|C_7| \in [.30, .35]$, $\Delta|C_7| = .01$

$|C_{9,10}| \in [0, 15]$, $\Delta|C_{9,10}| = 0.25$

$\phi_7 \in [0, 2\pi)$, $\Delta\phi_7 = \pi/16$

$\phi_{9,10} \in [0, 2\pi)$, $\Delta\phi_{9,10} = \pi/16$

SM = green square

- $B \to X_s \bar{\ell}\ell$: Br in $q^2 \in [1, 6]$ GeV^2 [Babar/Belle]
- $B \to K^* \bar{\ell}\ell$: Br, $A_{\rm FB}$, F_L in $q^2 \in [1, 6]$ GeV^2

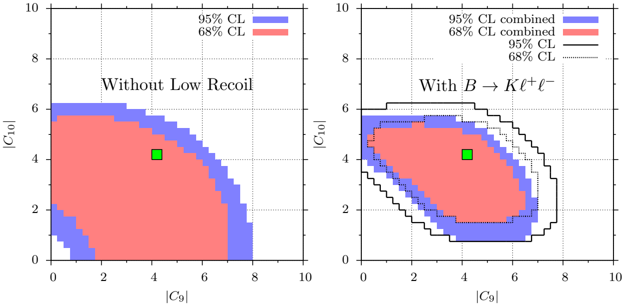
  [Belle/CDF] Br, $A_{\rm FB}$ in $q^2 \in [14.2, 16] + [> 16]$ GeV^2

Determining 68 (95) % CL in 6D pmr-space $|C_{7,9,10}|$ and $\phi_{7,9,10}$ $\to$ projection on $|C_9| - |C_{10}|$

$\Rightarrow$ without high-q^2 data [left] and with [right] $\to$ important impact,

BUT form factors from lattice very desirable !!!

"GLOBAL" FIT OF C_9 AND C_{10} – COMPLEX



[CB/Hiller/van Dyk/Wacker preliminary]

Scan resolution

$$|C_7| \in [.30, .35], \qquad \Delta|C_7| = .01$$
$$|C_{9,10}| \in [0, 15], \qquad \Delta|C_{9,10}| = 0.25$$
$$\phi_7 \in [0, 2\pi), \qquad \Delta\phi_7 = \pi/16$$
$$\phi_{9,10} \in [0, 2\pi), \qquad \Delta\phi_{9,10} = \pi/16$$

SM = green square

- $B \to X_s\bar{\ell}\ell$: Br in $q^2 \in [1, 6]$ GeV^2 [Babar/Belle]
- $B \to K^*\bar{\ell}\ell$: Br, $A_{\rm FB}$, F_L in $q^2 \in [1, 6]$ GeV^2
  [Belle/CDF] Br, $A_{\rm FB}$ in $q^2 \in [14.2, 16] + [> 16]$ GeV^2

Adding also ...

- $B \to K\bar{\ell}\ell$: Br in $q^2 \in [1, 6]$ GeV^2
  [Belle/CDF] Br in $q^2 \in [14.2, 16] + [> 16]$ GeV^2

@ 95 % CL

$$0.0 \le |C_9| \le 7$$
$$0.8 \le |C_{10}| \le 5.8$$
$$Br(B_s \to \bar{\mu}\mu) < 1 \cdot 10^{-8}$$
$$q^2_{0,\rm FB}[B \to K^*\bar{\ell}\ell] > 2.3\,\mathrm{GeV}^2$$

CONCLUSION

- rare decays ($\Delta F = 1, 2$) are suppressed in the SM $\rightarrow$ indirect search of New Physics
  - provide strong constraints on generic extensions of flavour sector
- 2nd generation exp's: LHCb, Belle II and SuperB will provide new $b \rightarrow s\{\gamma, \bar{\ell}\ell\}$ data: this year, this conference!? + high statistics through next decade
- FCNC can be treated within EFT-framework
  - A) test SM prediction $\rightarrow$ search for deviations: need certain precision
  - B) model-independent $\rightarrow$ constrain effective couplings C_i:
    limits set of experimental data to $\Delta B = 1$ decays
  - C) model-dependent $\rightarrow$ constrain parameter spaces of NP models:
    complementarity of rare decays with collider and astro-particle sectors
- angular observables $I_i^{(s,c)}$ in exclusive $B \rightarrow K^*(\rightarrow K\pi)\bar{\ell}\ell$ provide @ low- and high-q^2 combinations with small hadronic uncertainties
- SM test and BSM search require extension of CKM-fit strategy:

"combine all data and overconstrain scenarios"

EOS = new Flavour tool @ TU Dortmund by Danny van Dyk et al.
Download @ http://project.het.physik.tu-dortmund.de/eos/
first stable release expected 2011

Model-independent: BSM operator list

frequently considered in model-(in)dependent studies

$b \to s + \{\gamma, g\}$

$$\mathcal{O}_{7',8'}^{\gamma,g} = \frac{(e, g_s)}{16\pi^2} m_b [\bar{s}\, \sigma_{\mu\nu} P_L (T^a)\, b] (F, G^a)^{\mu\nu}$$

$b \to s + \bar{\ell}\ell$

$$\mathcal{O}_{9',10'}^{\ell\ell} = \frac{\alpha_e}{4\pi} [\bar{s}\, \gamma^\mu P_R\, b][\bar{\ell}\, (\gamma^\mu, \gamma^\mu \gamma_5)\, \ell],$$

$$\mathcal{O}_{S,S'}^{\ell\ell} = \frac{\alpha_e}{4\pi} [\bar{s}\, P_{R,L}\, b][\bar{\ell}\, \ell], \qquad \mathcal{O}_{P,P'}^{\ell\ell} = \frac{\alpha_e}{4\pi} [\bar{s}\, P_{R,L}\, b][\bar{\ell}\, \gamma_5\, \ell],$$

$$\mathcal{O}_{T}^{\ell\ell} = \frac{\alpha_e}{4\pi} [\bar{s}\, \sigma_{\mu\nu}\, b][\bar{\ell}\, \sigma^{\mu\nu}\, \ell], \qquad \mathcal{O}_{TE}^{\ell\ell} = \frac{\alpha_e}{4\pi}\, i\, \varepsilon^{\mu\nu\alpha\beta} [\bar{s}\, \sigma_{\mu\nu}\, b][\bar{\ell}\, \sigma_{\alpha\beta}\, \ell]$$

- new Dirac-structures beyond SM:
  - right-handed currents
  - scalar and pseudo-scalar interactions (higgs-exchange & box-type diagrams)
  - tensor interactions (box-type diagrams)
- usually added to $\mathcal{L}_{\mathrm{SM}}^{(t)}$

HIGH-q^2 – AMPLITUDE STRUCTURE

TRANSVERSITY AMPLITUDES $A_i^{L,R}(\bar{B} \to \bar{K}^* \bar{\ell}\ell)$

$$A_\perp^{L,R} = + \left[C^{L,R} + \tilde{r}_a\right] f_\perp \,, \qquad\qquad A_\parallel^{L,R} = - \left[C^{L,R} + \tilde{r}_b\right] f_\parallel \,,$$

$$A_0^{L,R} = -C^{L,R} f_0 - N M_B \frac{(1 - \hat{s} - \hat{M}_{K^*}^2)(1 + \hat{M}_{K^*})^2 \tilde{r}_b A_1 - \hat{\lambda}\, \tilde{r}_c A_2}{2\, \hat{M}_{K^*} (1 + \hat{M}_{K^*}) \sqrt{\hat{s}}}$$

$\Rightarrow$ Universal short-distance coefficients: $C^{L,R} = C_9^{\rm eff} + \kappa \frac{2 m_b M_B}{q^2} C_7^{\rm eff} \mp C_{10}$

(SM: $C_9 \sim +4$, $C_{10} \sim -4$, $C_7 \sim -0.3$)

known structure of sub-leading corrections (Grinstein/Pirjol hep-ph/0404250)

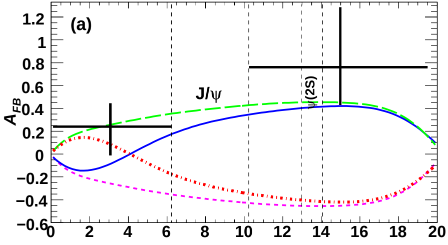
$$\tilde{r}_i \sim \pm \frac{\Lambda_{\rm QCD}}{m_b} \left(C_7^{\rm eff} + \alpha_s(\mu) e^{i\delta_i}\right) \,, \qquad\qquad i = a, b, c$$

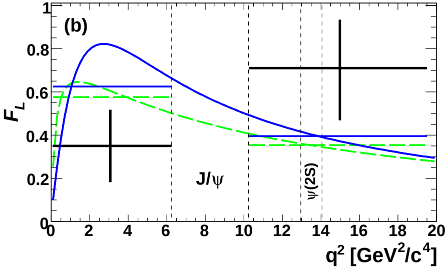
Non-PT FF's ("helicity FF's" Bharucha/Feldmann/Wick arXiv:1004.3249)

$$f_\perp = \frac{\sqrt{2\hat{\lambda}}}{1 + \hat{M}_{K^*}} V, \qquad f_\parallel = \sqrt{2}\,(1 + \hat{M}_{K^*})\, A_1, \qquad f_0 = \frac{(1 - \hat{s} - \hat{M}_{K^*}^2)(1 + \hat{M}_{K^*})^2 A_1 - \hat{\lambda}\, A_2}{2\, \hat{M}_{K^*} (1 + \hat{M}_{K^*}) \sqrt{\hat{s}}}$$

BaBar [arXiv:0804.4412]

Analysis of 384 M $B\bar{B}$ pairs → search all channels $B^{+,0}$, $K^{(*),+,-}$ and $\ell = e,\ \mu$





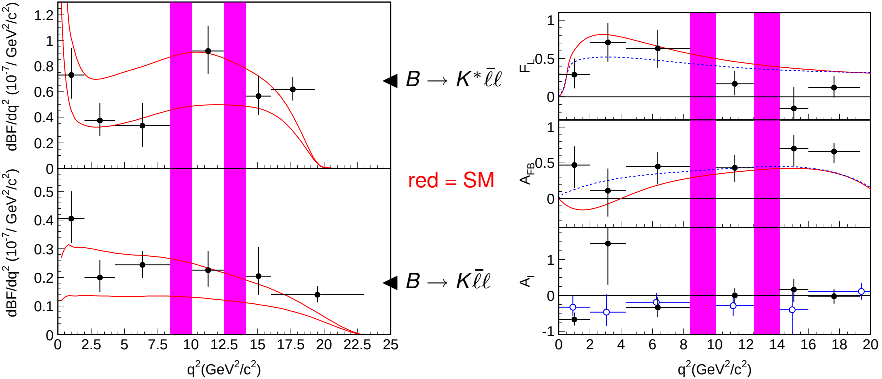
- 2 bins: low-$q^2 \in [0.1 - 6.25]$ GeV^2 and high-$q^2 > 10.24$ GeV^2
  $\Rightarrow (27 \pm 6) + (37 \pm 10) = 64$ events
- veto of J/ψ and ψ' regions: background $B \to K^*(\bar{c}c) \to K^*\bar{\ell}\ell$
- angular analysis in each q^2-bin in θ_ℓ and θ_{K^*} ⇒ fit F_L and $A_{\rm FB}$

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_{K^*}} = \frac{3}{2} F_L \cos^2\theta_{K^*} + (1 - F_L)(1 - \cos^2\theta_{K^*}),$$

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_\ell} = \frac{3}{4} F_L (1 - \cos^2\theta_\ell) + \frac{3}{8}(1 - F_L)(1 + \cos^2\theta_\ell) + A_{\rm FB}\cos\theta_\ell$$

BELLE [ARXIV:0904.0770]

Analysis of 657 M $B\bar{B}$ pairs = 605 fb^{-1} $\rightarrow$ search all channels $B^{+,0}$, $K^{(*),+,-}$ and $\ell = e,\ \mu$



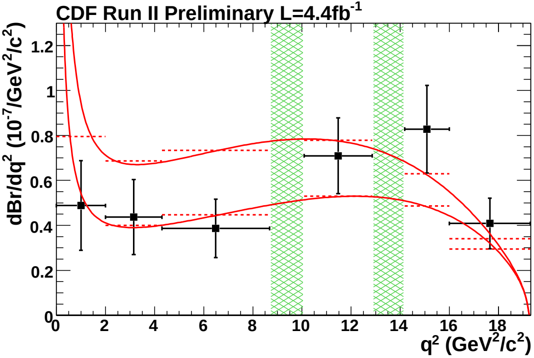
- 6 bins $\Rightarrow$ 247 events (121 @ $q^2 > 14$ GeV^2)
- angular analysis in each q^2-bin in θ_ℓ and θ_{K^*} $\Rightarrow$ fit F_L and $A_{\rm FB}$
- all-q^2 extrapolated results:

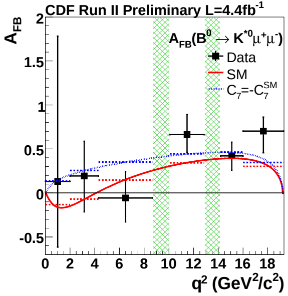
$$Br = (10.7^{+1.1}_{-1.0} \pm 0.09) \times 10^{-7}, \qquad A_{\rm CP} = -0.10 \pm 0.10 \pm 0.01,$$

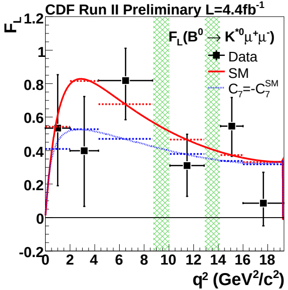
$$R_{K^*} = 0.83 \pm 0.17 \pm 0.08 \text{ (SM} = 0.75), \qquad A_I = -0.29^{+0.16}_{-0.16} \pm 0.09 \ (q^2 < 8.68 \text{ GeV}^2)$$

CDF [arXiv:1101.1028]

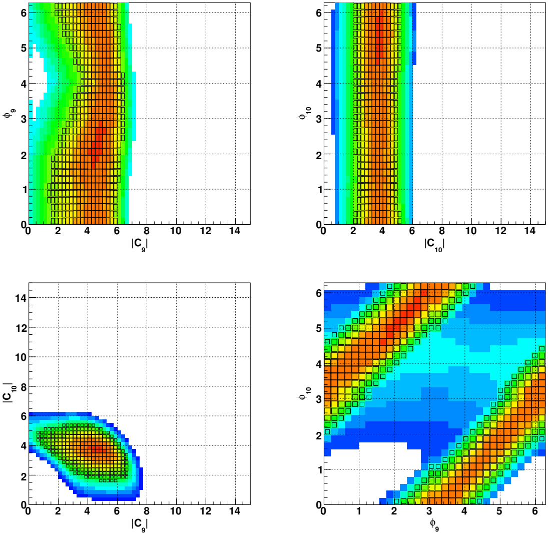
- analysis of 4.4 fb^{-1} (CDF Run II) $\Rightarrow$ only $B^0 \to K^{*0}\bar{\mu}\mu$
- discovery of $B_s \to \phi\bar{\mu}\mu$ 6.3 σ (27 $\pm$ 6) events
- 101 events (42 @ $q^2 > 14$ GeV^2) - Belle q^2-binning







Model-indep. fit of complex $C_{9,10}$ ($C_9^{\rm SM} = 4.2,\ C_{10}^{\rm SM} = -4.2$)



$B \to K^* \bar{\ell}\ell$

- Br and $A_{\rm FB}$ in q^2-bins

  $[1, 6]$ GeV^2
  $[14.2, 16]$ GeV^2
  $[> 16]$ GeV^2

- F_L in $q^2 \in [1, 6]$ GeV^2

$B \to X_s \bar{\ell}\ell$

- Br in $[1, 6]$ GeV^2

$B \to K \bar{\ell}\ell$

- Br in $[1, 6]$, $[14.2, 16]$, $[> 16]$ GeV^2

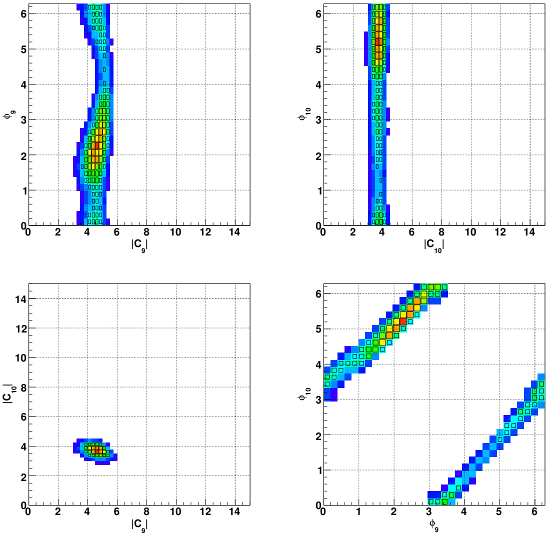
margnialised profile likelihood
95 % (68 % box) CL regions

- ▶ $|C_7| = |C_7^{\rm SM}|$
- ▶ $|C_{9,10}| \in [0, 15]$
- ▶ $\phi_{7,9,10} \in [0, 2\pi)$

preliminary
Beaujean/CB/van Dyk/Wacker

FIT $C_{9,10}$ – COMPLEX – FUTURE?

For fun: keep exp. central values, divide all exp. errors by 5



$B \to K^* \bar{\ell}\ell$

- *Br* and A_{FB} in q^2-bins

  $[1, 6]$ GeV^2
  $[14.2, 16]$ GeV^2
  $[> 16]$ GeV^2
- F_L in $q^2 \in [1, 6]$ GeV^2

$B \to X_s \bar{\ell}\ell$

- *Br* in $[1, 6]$ GeV^2

$B \to K \bar{\ell}\ell$

- *Br* in $[1, 6]$, $[14.2, 16]$, $[> 16]$ GeV^2

margnialised profile likelihood 95 % (68 % box) CL regions

- $|C_7| = |C_7^{\mathrm{SM}}|$
- $|C_{9,10}| \in [0, 15]$
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preliminary
Beaujean/CB/van Dyk/Wacker