$B \rightarrow X_{s/d}\ \gamma$ & $B \rightarrow X_{s/d}\ l^+l^-$

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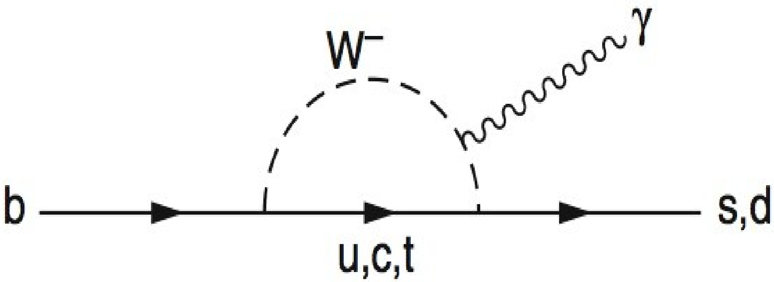
Outlook:

- **$B \rightarrow X_{s/d}\ \gamma$:**
  - **Motivations**
  - $X_s\gamma$ (Belle), Acp ($X_{s+d}\ \gamma$) (BaBar), $|V_{td}/V_{ts}|$ (BaBar)
  - **Spectral Moments**

- **$B \rightarrow X_{s/d}\ l^+l^-$:**
  - **Motivations**
  - $K^{(*)}l^+l^-$ (Belle), $K^{(*)}\mu^+\mu^-$ (CDF), $K^+\tau^+\tau^-$ (BaBar)
  - πl^+l^-

- **Conclusion**

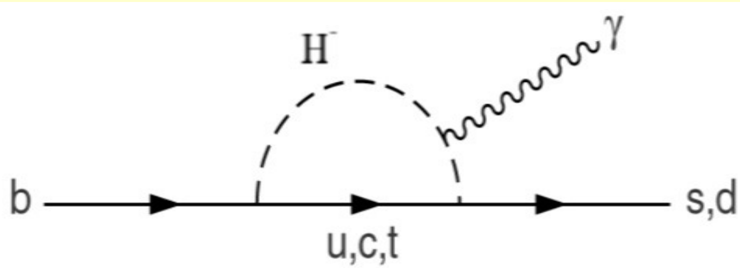
$B \to X_{s/d}\,\gamma$: Motivations

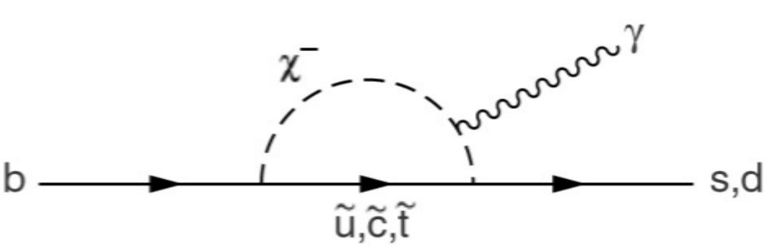


FCNC process forbidden at tree level:
Probe the SM!
NNLL order $BR(b \to s\gamma)_{(E^*\gamma>1.6\ GeV)} = (3.15 \pm 0.23)*10^{-4}$
(Misiak et al. PRL 98 022002)

Search for New Physics

New heavy particles in the loop could:
- Modify BR wrt SM prediction
- Modify Direct A_{CP}





Radiative Penguins are an Excellent Laboratory for

Study the dynamics of b-quark inside B mesons
- Provide inputs to Global Fits in the Kinetic Sheme to V_{cb}, V_{ub} & Heavy Quark Exansion parameters.

Measure |Vtd/Vts| from
- **$BR(b \to d\gamma)/BR(b \to s\gamma)$**
- **NP could affect in different way $X_s\gamma$ vs $X_d\gamma$ final states**

$B \to X_{s/d}\,\gamma$ Measurements

Exclusive Measurements

- Experimentally easier, reconstruct resonances ($K^*\gamma$, $\rho(\omega)\gamma$) with low Background
- Need Form Factors, modeling X_s fragmentation
- Affected by large theoretical uncertainties ($\delta|V_{td}/V_{ts}|$~7%)

VS

Inclusive Measurements

- Smaller theoretical error exploiting quark-hadron duality (small hadronization effects)
- Experimentally harder, large background

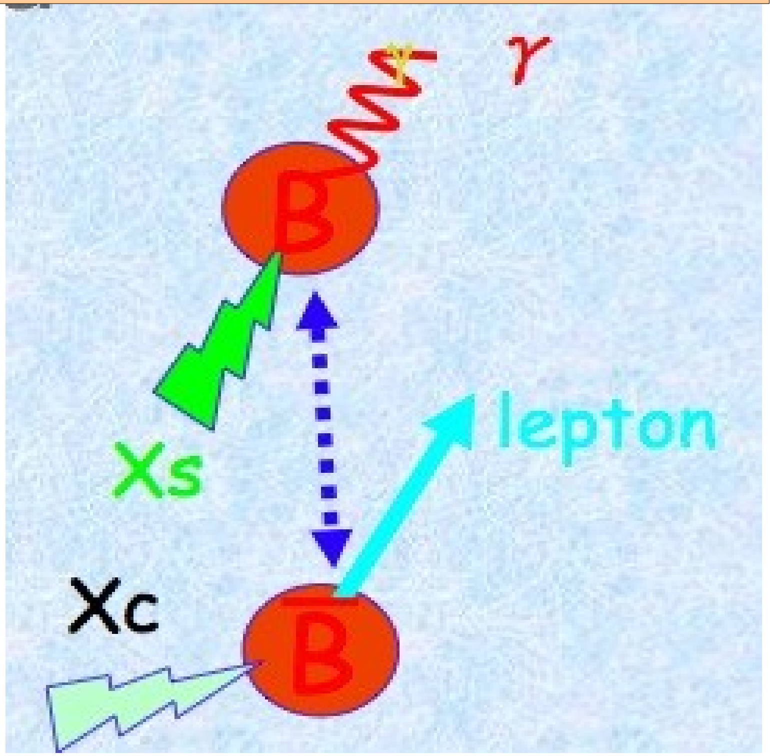
Recent Analyses Strategies:

Make the measurement **as inclusive as possible**, suppressing backgrounds via:

- Cut on $E\gamma$>[1.7-2.0] GeV
- Use recoil of reconstructed B or Lepton Tag

OR

- Cut on $E\gamma$, $M(X_{s/d})$<[1.8-2.0]GeV
- Sum over many exclusive modes



Belle Inclusive $B \to X_s \gamma$ (605 fb^{-1})

PRL 103, 241801

•**B-Meson Not Reconstructed: Not distinguish Xs & Xd !**

•Select High Energy Isolated γ
$E\gamma(B_{CM})>1.7$ GeV
Lowest threshold up to now, covered 97% of Xs spectrum, smallest model uncertainty

•π^0/η suppressed exploiting $m_{\gamma\gamma}$, shower profile, Eγ, θγ
•Bhabha events overlapped with B decays removed using timing informations in 60% of Data

•Dominant Background from Continuum suppressed by means of two different anayses streams (largely statistically uncorrelated) based on:

•Lepton Tag:
(1.26 GeV$<P^*_{lept}<$2.20 GeV)

•Two Fisher discriminants exploiting Energy Flow & Event Shape

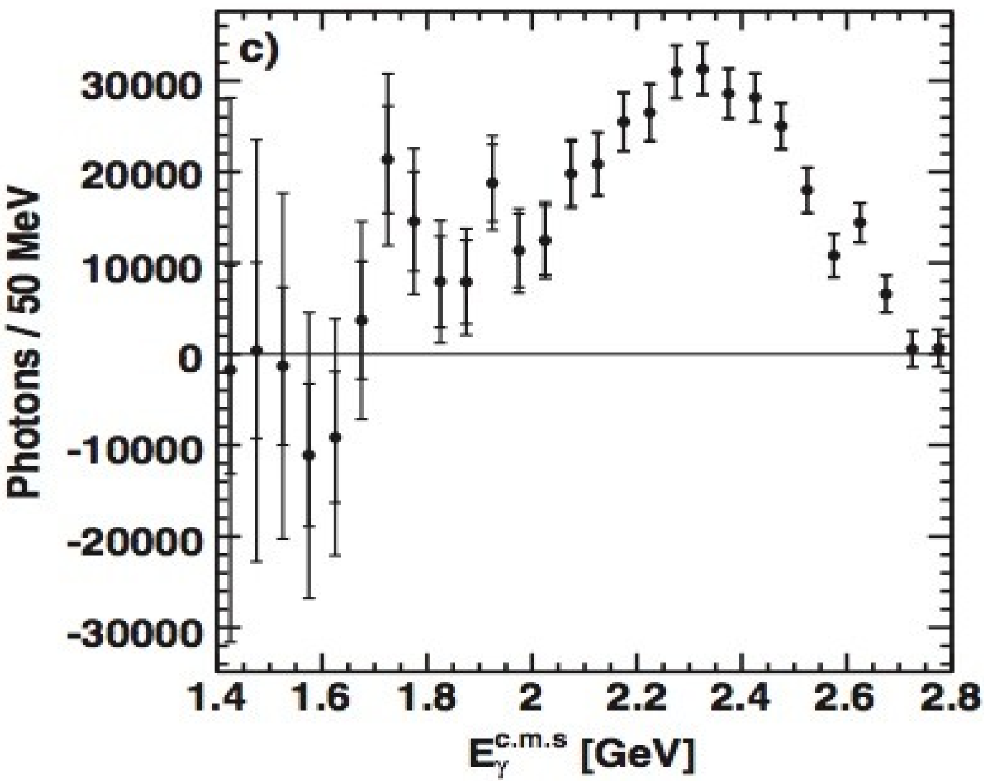
•Residual amount subtracted used off-resonance Data (corrected for Energy effects)

•$B\bar{B}$ Background from π^0/η decays estimated using Data-Corrected MC samples and subtracted

•BKG Subtraction checked in control regions $E\gamma(Y_{CM})<1.7$GeV(>2.8GeV) for $B\bar{B}$ (Continuum): No bias found

Belle Inclusive $B \to X_s\gamma$ ($605\ fb^{-1}$)

PRL 103, 241801



- True Spectrum obtained by means of efficiency correction & unfolding procedure
- X_d contribution subtracted assuming $B(X_d)/B(X_s)=4.5\%$ [Hurth et al., Nucl. Phys. B704 56, Charles et al., Eur. Phys. C41 1]

To date:

- **Most Inclusive Result, lowest theory error**
- **Most Precise Result lowest systematic error**

Eγ Cut (GeV)	$BR(B \to X_s\gamma)$ (10^{-4})
1.7	3.45±0.15±0.40
2.0	3.02±0.10±0.11

- Systematics dominated by Continuum & $B\bar{B}$ BKG subtraction

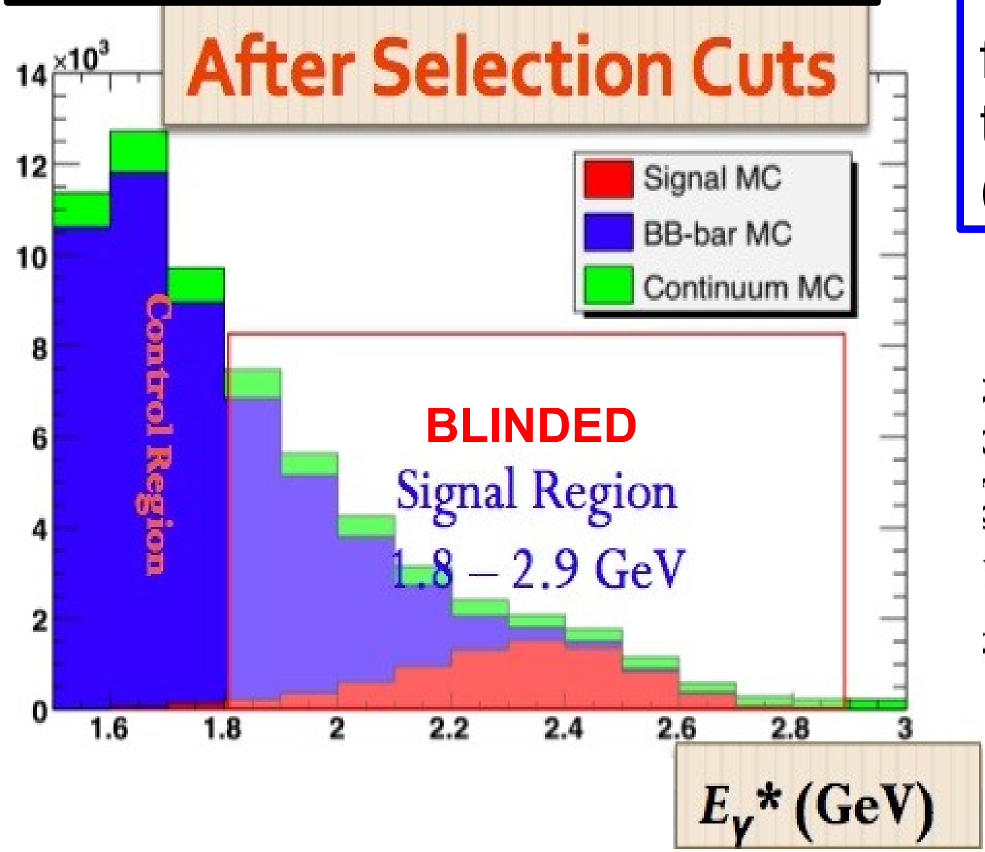
BaBar $B \to X_{s+d}\,\gamma$ Lepton Tag ($347\ fb^{-1}$)

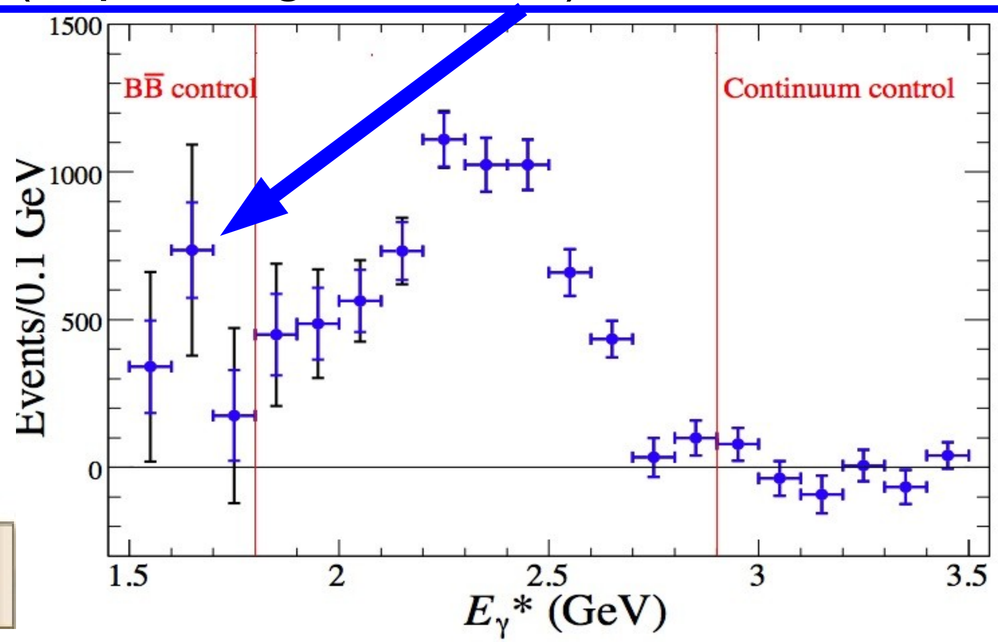
PRELIMINARY

Similar to Lepton-Tag Belle Analysis:

- Continuum suppressed using Lepton-Tag & Neural Network (Event Shape, P^*_{lept}, $\theta_{\gamma\text{-lept}}$)

- $B\bar{B}$ Background Estimated on MC & corrected on DATA control samples (97% of BKG yield)
- Background subtraction test: 1.4σ bias found in the BB control region, partly due to a tail of 100-400 signal events (depending on model)





BaBar $B \to X_{s+d}\gamma$ Lepton Tag (347 fb^{-1})

SM predicts $A_{CP}^{SM}(s+d) \sim 10^{-6}$
from almost perfect cancellation between X_s and X_d
[Hurth et al., hep-ph 0312260, hep-ph 0103331]

Experimentally:

$$A_{CP}(B \to X_{s+d}\gamma) = \frac{1}{1-2\omega}\frac{N^+ - N^-}{N^+ + N^-}$$

Lepton Charge gives B flavor

- Dilution due to mixing, cascade decays, fakes, $\omega \sim 13\%$

- **Most of the systematics common for +/- leptons cancel in A_{CP}**

Possible Bias from:

- $B\bar{B}$ Background asymmetry: checked in control region (-0.004±0.006 effect)
- Lepton tag asymmetry = 0.±0.011 measured in DATA control samples (e^+e^-, $\mu\mu\gamma$, $K^*J/\Psi(l^+l^-)$)
- Estimated error ±0.013 (Main Systematic Uncertainty)

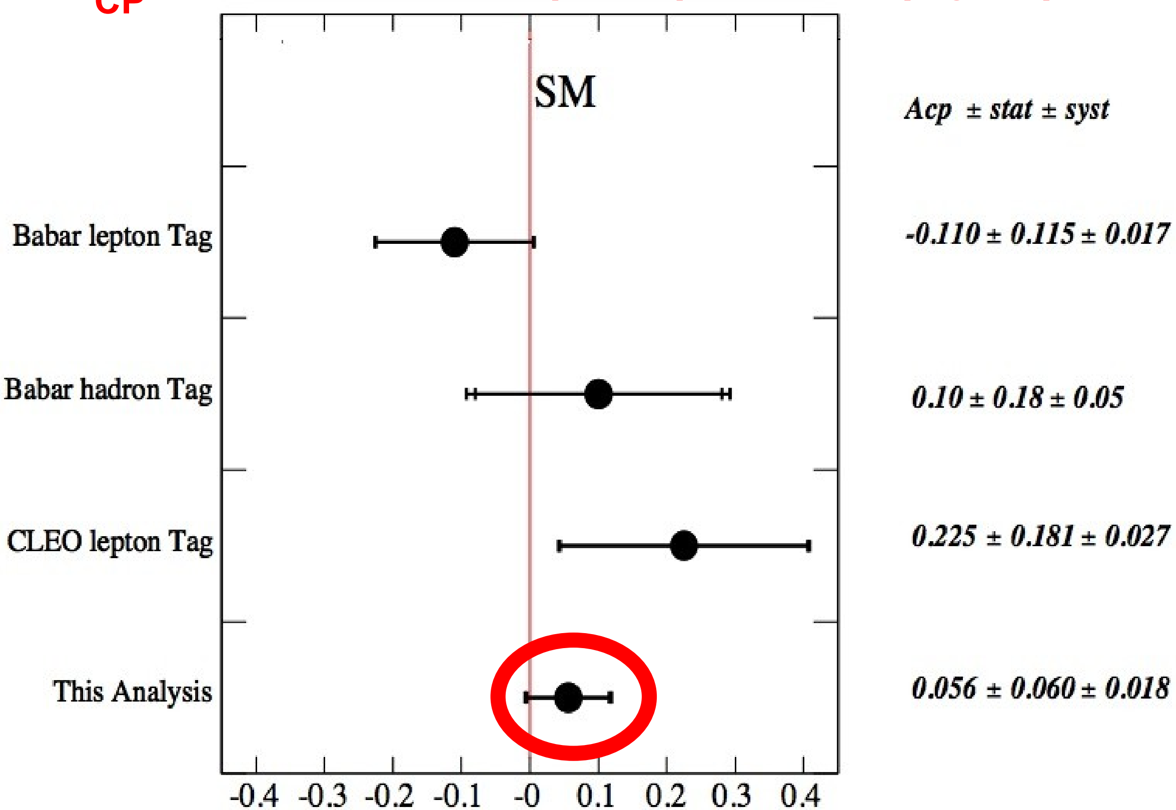
BaBar $B \to X_{s+d}\, \gamma$ Lepton Tag ($347\ fb^{-1}$)

Preliminary Result

$N(l^+)=2623\pm158$

$N(l^-)=2397\pm151$

$A_{CP}=0.056\pm0.060(stat)\pm0.018(syst)$



- A_{CP} total error minimized with $2.1\,GeV < E\gamma(Y_{CM}) < 2.8\,GeV$

- Statistical error dominated by continuum subtraction

- **Most precise measurement to date**
- **Consistent with SM expectation**

Same anaysis will provide soon also BR and spectral moments.

BaBar $|V_{td}/V_{ts}|$ (423 fb^{-1})

[PRD-RC 82, 051101]

- Ratio of Exclusive modes $B \to (\rho,\omega)\gamma$, $K^*\gamma$ provides a $|V_{td}/V_{ts}|$ measurement complementary to the more precise result from $\Delta m_d/\Delta m_s$

- New Physics could affect $b \to s\gamma/d\gamma$ in different way

Inclusive Measurements reduce theory error from 7% to ~1%

Experimentally:

- Inclusive rates extrapolated from a sum of 7 exclusive modes:

$B \to X_d\gamma$	$B \to X_s\gamma$
$B^0 \to \pi^+\pi^-\gamma$	$B^0 \to K^+\pi^-\gamma$
$B^+ \to \pi^+\pi^0\gamma$	$B^+ \to K^+\pi^0\gamma$
$B^+ \to \pi^+\pi^-\pi^+\gamma$	$B^+ \to K^+\pi^+\pi^-\gamma$
$B^0 \to \pi^+\pi^-\pi^0\gamma$	$B^0 \to K^+\pi^-\pi^0\gamma$
$B^0 \to \pi^+\pi^-\pi^+\pi^-\gamma$	$B^0 \to K^+\pi^-\pi^+\pi^-\gamma$
$B^+ \to \pi^+\pi^-\pi^+\pi^0\gamma$	$B^+ \to K^+\pi^-\pi^+\pi^0\gamma$
$B^+ \to \pi^+\eta\gamma$	$B^+ \to K^+\eta\gamma$

Add estimated missing states using Jetset $X_{s/d}$ fragmentation models corrected for measured exclusive X_s BRs [PRD 72, 052005]

Use two hadronic mass bins:

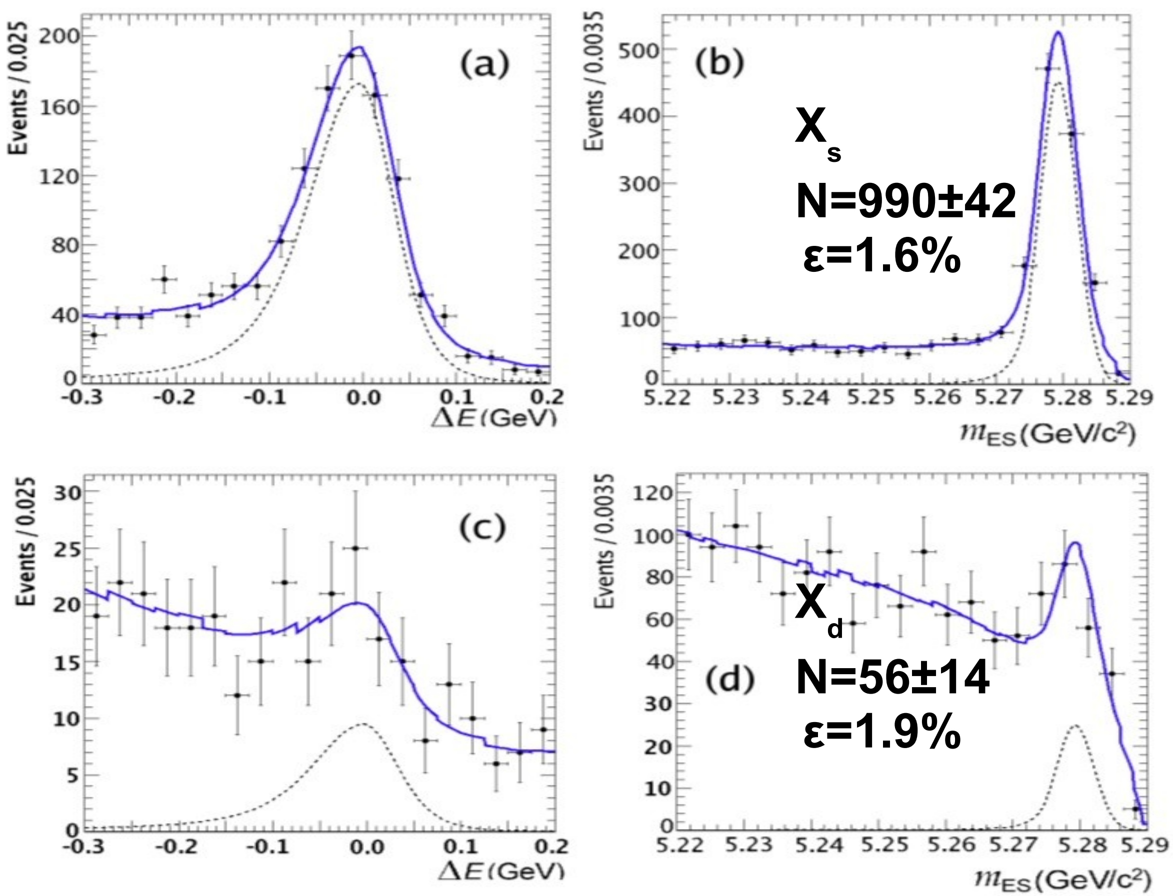
- 0.5<M(X)<1.0GeV (contain the previously measured K*, ρ,ω states)
- 1.0<M(X)<2.0GeV

BaBar $|V_{td}/V_{ts}|$ (423 fb^{-1})

- Select High Energy Isolated γ
- π^0/η suppression by $m_{\gamma\gamma}$ cut
- Same cuts to sγ/dγ final states reduce systematics in the BR ratio

- Continuum suppressed using Neural Network (event shape)

High Mass Region 1.0 GeV<M(X)<2.0 GeV



- Yelds from Simultaneous Fit to

$$\Delta E = E^*_B - E^*_{\rm beam}$$

$$m_{\rm ES} = \sqrt{E^{*2}_{\rm beam} - \vec{p}^{*2}_B}$$

0.5 GeV<M_{HAD}<2.0 GeV

BR(b→sγ)= 230±8±30 x 10^{-6}

BR(b→dγ)= 9.2±2.0±2.3 x 10^{-6}

first measurement in high mass region

BaBar $|V_{td}/V_{ts}|$ (423 fb^{-1})

- **Extract |Vtd/Vts| from:**

$$\frac{\Gamma(b \to d\gamma)}{\Gamma(b \to s\gamma)} = \xi^2 \left|\frac{V_{td}}{V_{ts}}\right|^2 (1+\Delta R)$$

[Ali et al. Phys. Lett. B 429, 87]

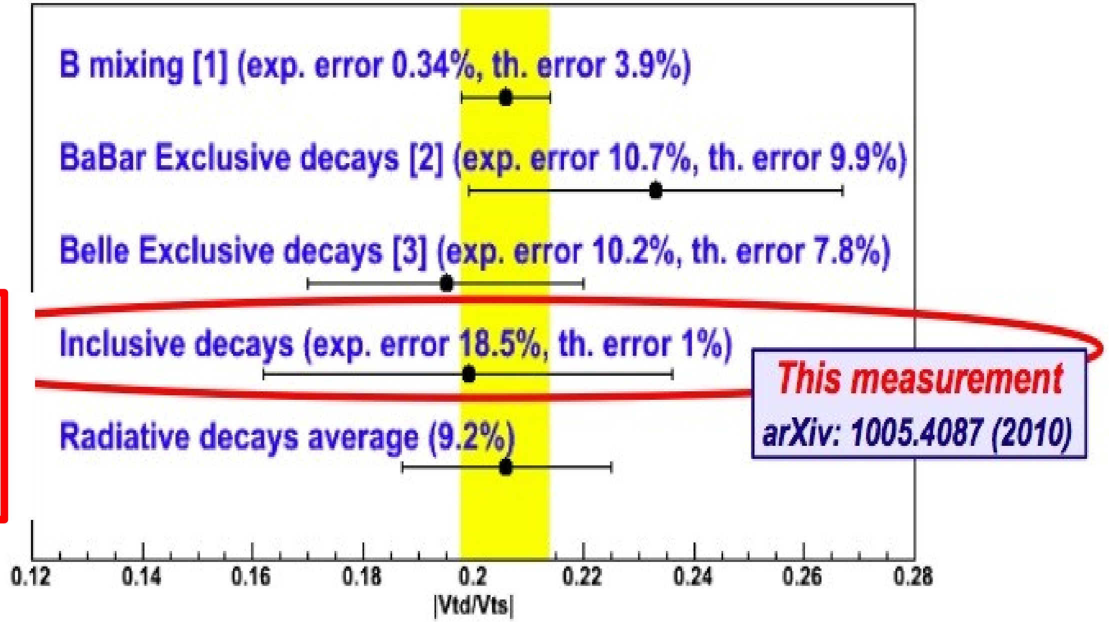
- Unmeasured M(X)>2.0 GeV extrapolated using Kagan-Neubert spectral shape [PRD 58, 094012]

- ξ(SU(3) Breaking), ΔR(annihilation correction) computed in terms of Wolfenstein parameters (ρ, η)
  - (ρ, η) re-expressed in terms of angle β to avoid circularity from previous |Vtd/Vts| measurements

$|V_{td}/V_{ts}|=0.199\pm0.022(stat)\pm0.024(syst)\pm0.002(th)$

- Systematics dominated by Extrapolation to Inclusive Rates (alternative fragmentation models)

- **Compatible & Competitive with Previous Eclusive Decays Results (with lower theory error) !**



BR($B \rightarrow X_s \gamma$): Summary

- Experiments cut on minimum $E\gamma$
- BR extrapolated to E_{min}=1.6 GeV using Shape Functions (correlated error)
- Error dominated by Systematics

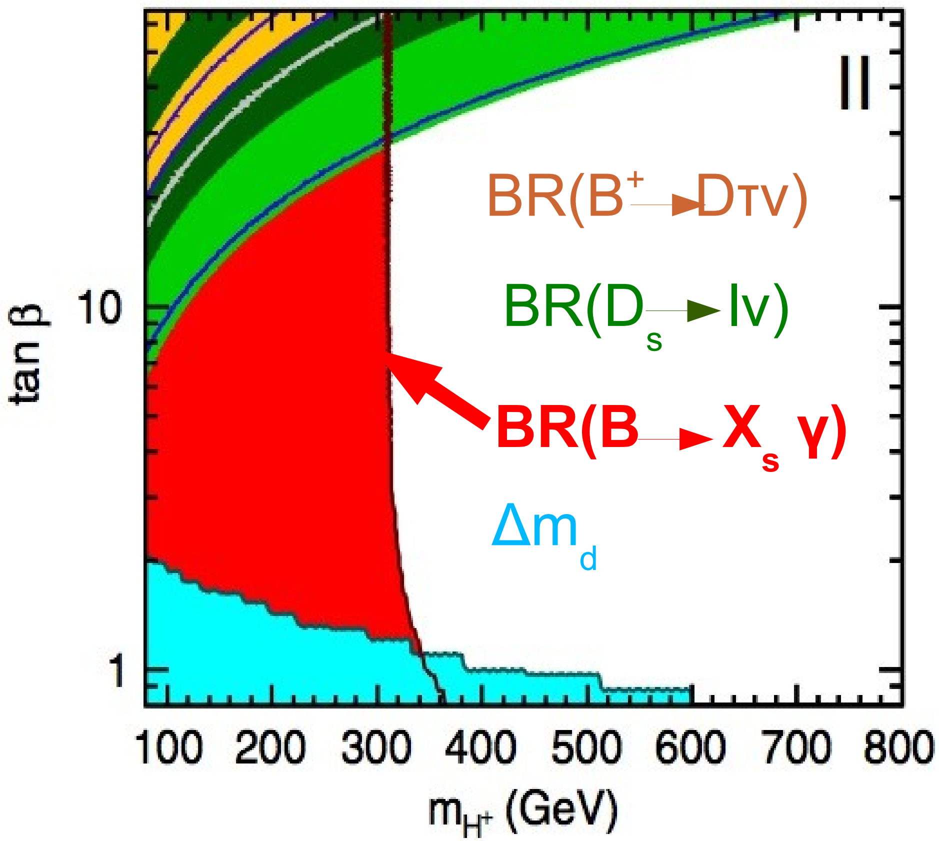
HFAG 2010 Inclusive BR($b \rightarrow s\gamma$)x10^{-6} :

Mode	$\mathcal{B}$	$E_{\min}$	$\mathcal{B}(E_\gamma > E_{\min})$	$\mathcal{B}^{\mathrm{cnv}}(E_\gamma > 1.6)$
CLEO Inc. [3]	$321 \pm 43 \pm 27^{+18}_{-10}$	2.0	$306 \pm 41 \pm 26$	$327 \pm 44 \pm 28 \pm 6$
Belle Semi.[4]	$336 \pm 53 \pm 42^{+50}_{-54}$	2.24	–	$369 \pm 58 \pm 46^{+56}_{-60}$
BABAR Semi.[6]	$335 \pm 19^{+56+4}_{-41-9}$	1.9	$327 \pm 18^{+55+4}_{-40-9}$	$349 \pm 20^{+59+4}_{-46-3}$
BABAR Inc. [7]	–	1.9	$367 \pm 29 \pm 34 \pm 29$	$390 \pm 31 \pm 47 \pm 4$
BABAR Full [8]	$391 \pm 91 \pm 64$	1.9	$366 \pm 85 \pm 60$	$389 \pm 91 \pm 64 \pm 4$
Belle Inc.[5]	–	1.7	$345 \pm 15 \pm 40$	$347 \pm 15 \pm 40 \pm 1$
Average				$355 \pm 24 \pm 9$

SM: BR($b \rightarrow s\gamma$)$_{(E^*\gamma>1.6\ \mathrm{GeV})}$=(315±23)*10^{-6}
Misiak et al. PRL 98 022002 (2007)
5% non-perturbative error

Good Agreement (1.2 σ) with NNLL prediction

BR($B \to X_s \gamma$): Summary



- Recent Calculations in the 2Higgs-Doublet-Model framework provide Constraints on the coupling of the 2nd & 3rd generation fermions to H^+ obtained from flavor physics experimental results:
- **BR($B \to X_s \gamma$)**, Δm_d, BR($B^+ \to (D)\tau\nu$), BR($D_s \to l\nu$)

- **Best Limit on $MH^+ > 300$ GeV @ 95% CL**

[Mahmoudi, Stal, PRD81 035016]

$B \to s\gamma$ Spectral Moments

Vcb & Vub from Inclusive Semileptonic Decays

•|Vcb| from inclusive $B \to X_c l\nu$ using HQET & OPE requires non perturbative parameters (mb)

•|Vub| from inclusive $B \to X_u l\nu$ requires Shape Function to extrapolate the Inclusive BR from Partial Rates & compute kinematic acceptances

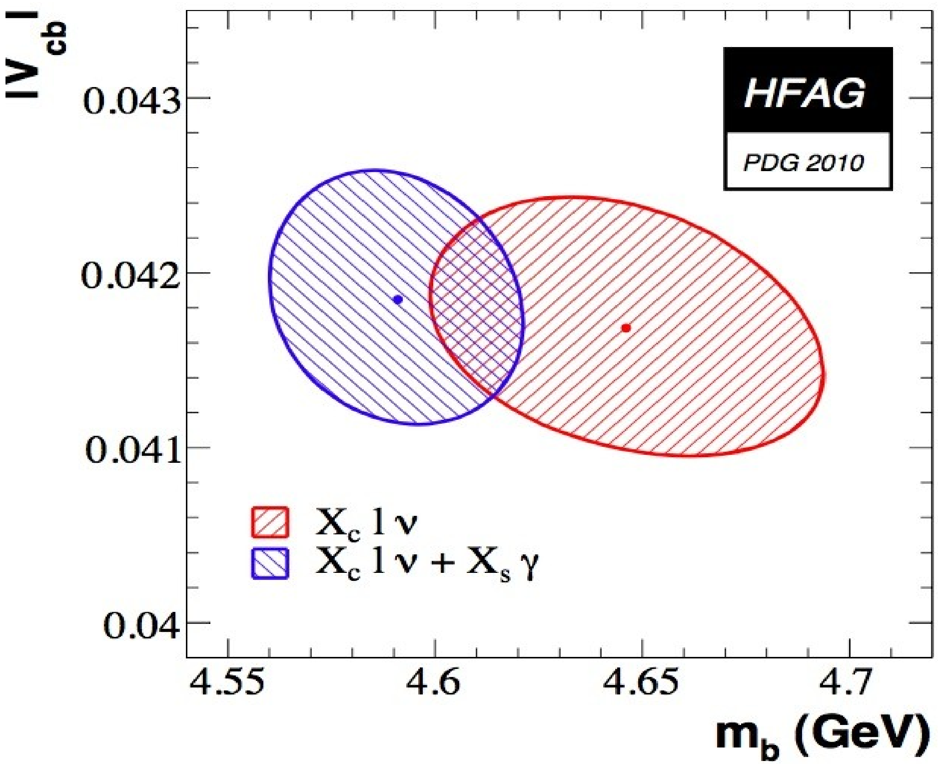
Universal motion of b-quark inside B meson:

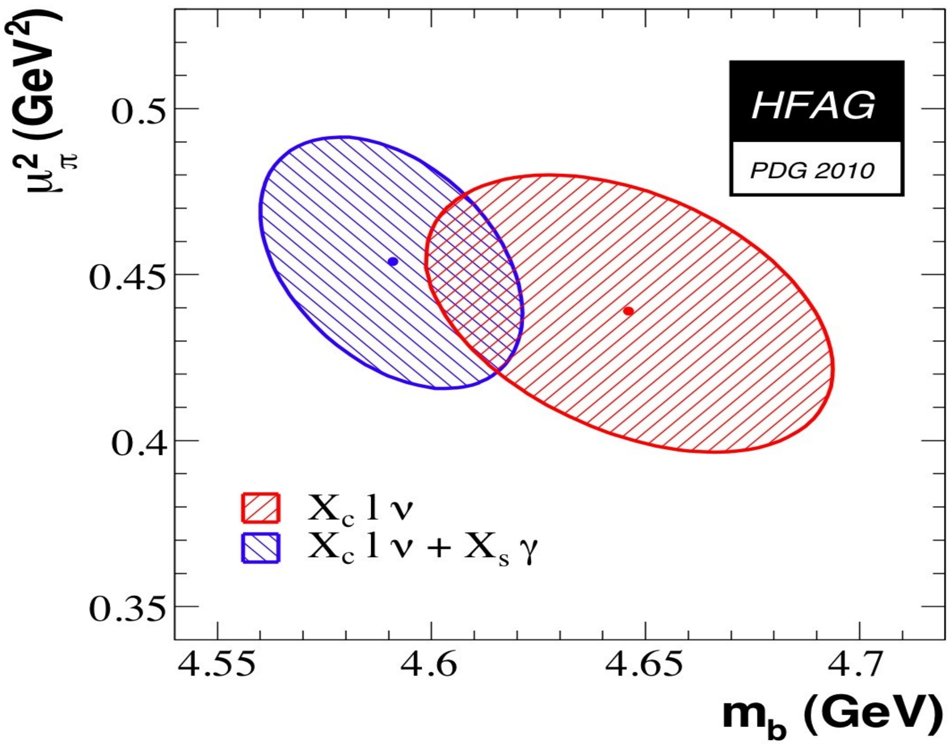
•Global Fits to the moments of inclusive distributions in $B \to X_c l\nu$ & $B \to X_s \gamma$ in the kinetic mass scheme provides |Vcb| together with non-perturbative parameters
[Gambino et al., Eur. Phys. C34 181-189; Benson et al., Nucl Phys. B710, 371-401]

•Uncertainties on shape function limited by comparing the inclusive $B \to X_u l\nu$ rate & inclusive $B \to X_s \gamma$ photon spectrum
[Neubert et al., PRD 49 4623-4633 ; Leibovich et al., PRD 61 053006; Lange et al., JHEP 10 084]

B→sγ Spectral Moments

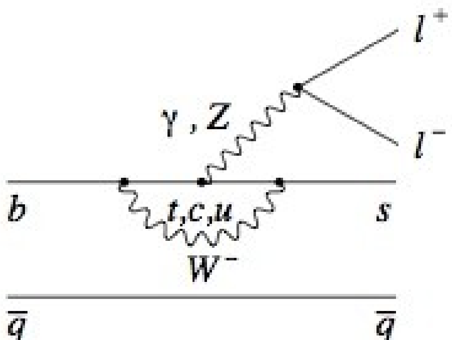
HFAG Fit in Kinetic Mass Scheme (2010)



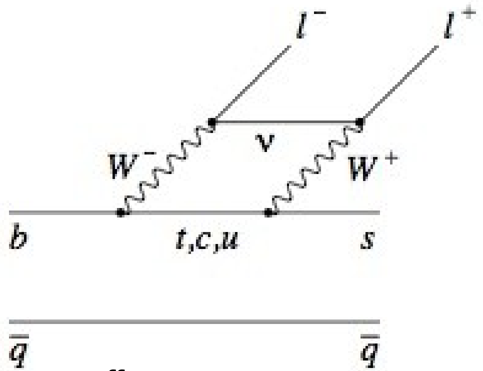


Data	χ^2/dof	$\lvert V_{cb}\rvert$ (10^{-3})	m_b^{kin} (GeV)	μ_π^2 (GeV^2)
All moments ($X_c \ell \nu_\ell$ and $X_s \gamma$)	$29.7/(66-7)$	41.85 ± 0.73	4.591 ± 0.031	0.454 ± 0.038
$X_c \ell \nu_\ell$ only	$24.2/(55-7)$	41.68 ± 0.74	4.646 ± 0.047	0.439 ± 0.042

$B \rightarrow X_{s/d}\, l^+l^-$: Motivations



C^{eff}_7



C^{eff}_9 (vector)

C^{eff}_{10} (axial-vector)

FCNC process forbidden at tree level, BF~10^{-6}: Probe the SM!

Amplitudes expressed using OPE in terms of:

- Hadronic FF (accuracy ~20%) [Bharucha et al. Hep-ph 1004.3249]
- Wilson coefficients C^{eff}_7, C^{eff}_9, C^{eff}_{10} [Ali et al. PRD 61 074024, Z. Phys. C 67 417]

New Particles in the loop could:

- Modify SM Wilson Coefficients
- Introduce additional ones

Observables Include:

- **Inclusive BR, dBR/dq^2**
- **A_{CP}, $A_{ISOSPIN}$, $RK^{(*)}$ (theory error suppressed in the ratios!)**
- **A_{FB} & K polarization from angular analyses (defined below)**

SM predicts ($q^2=m_{l+l-}{}^2$):

$$A_{CP}^{K^{(*)}} \equiv \frac{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) - \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) + \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}$$

~10^{-3}

$$A_I \equiv \frac{(\tau_{B^+}/\tau_{B^0})\mathcal{B}(K^{(*)0}\ell^+\ell^-) - \mathcal{B}(K^{(*)\pm}\ell^+\ell^-)}{(\tau_{B^+}/\tau_{B^0})\mathcal{B}(K^{(*)0}\ell^+\ell^-) + \mathcal{B}(K^{(*)\pm}\ell^+\ell^-)}$$

<10% All q^2

$$R_{K^{(*)}} \equiv \frac{\mathcal{B}(B \to K^{(*)}\mu^+\mu^-)}{\mathcal{B}(B \to K^{(*)}e^+e^-)}$$

RK=1
RK*=0.75
($q^2 \rightarrow 0$ γ-pole)

Belle $B \to K^{(*)} l^+l^-$ (605 fb^{-1}) PRL 103, 171801

$B \to K^{(*)}l^+l^-$ fully reconstructed in 10 final states: ($K^+\pi^-$, $K^0_s\pi^+$, $K^+\pi^0$, K^+, K^0_s) + l^+l^-

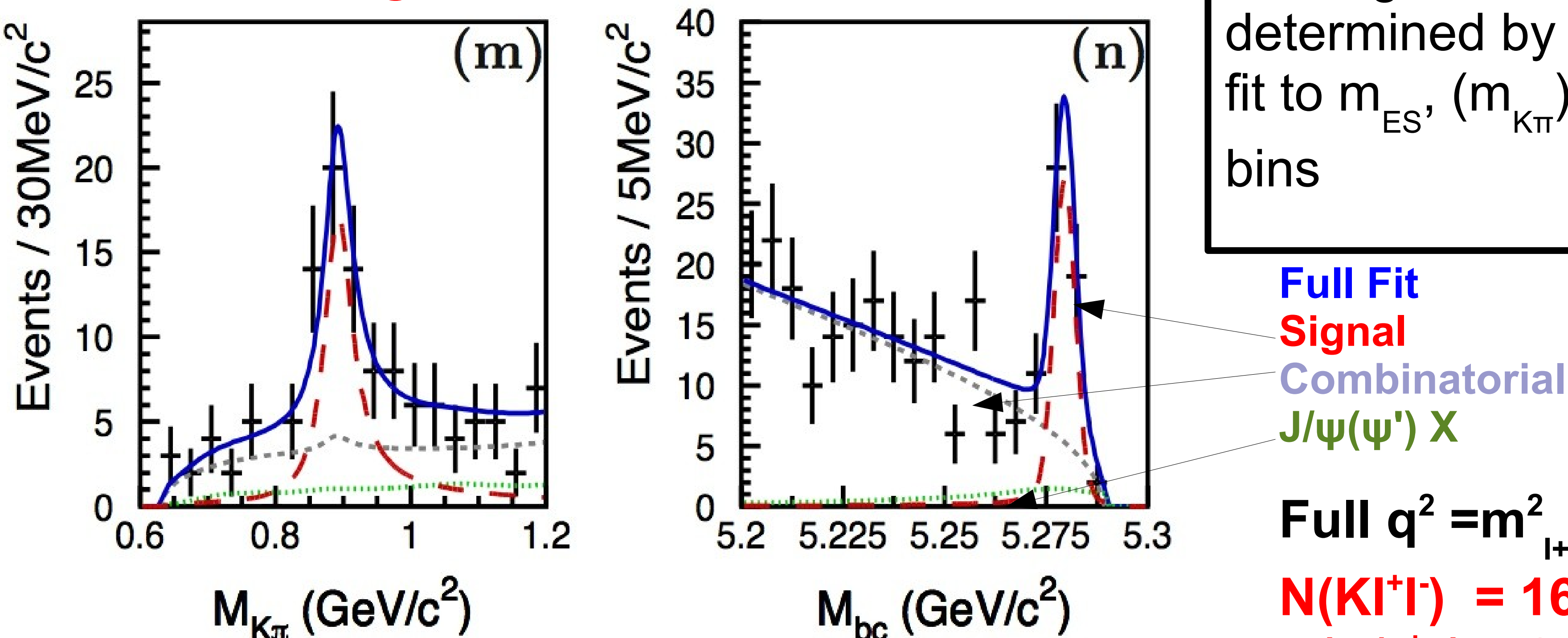
- Peaking $B \to J/\Psi(\Psi')$ X rejected by $m(l^+l^-)$ cut

- Continuum Suppressed exploiting Event Shape Variables

- B Semileptonic Decays Suppressed using Event Shape, Missing Mass, Lepton separation

- $K^{(*)}$ Signal Yields determined by unbinned fit to m_{ES}, $(m_{K\pi})$ in 6 q^2 bins

K* Fit single bin: $10.09<q^2<12.86$ GeV^2



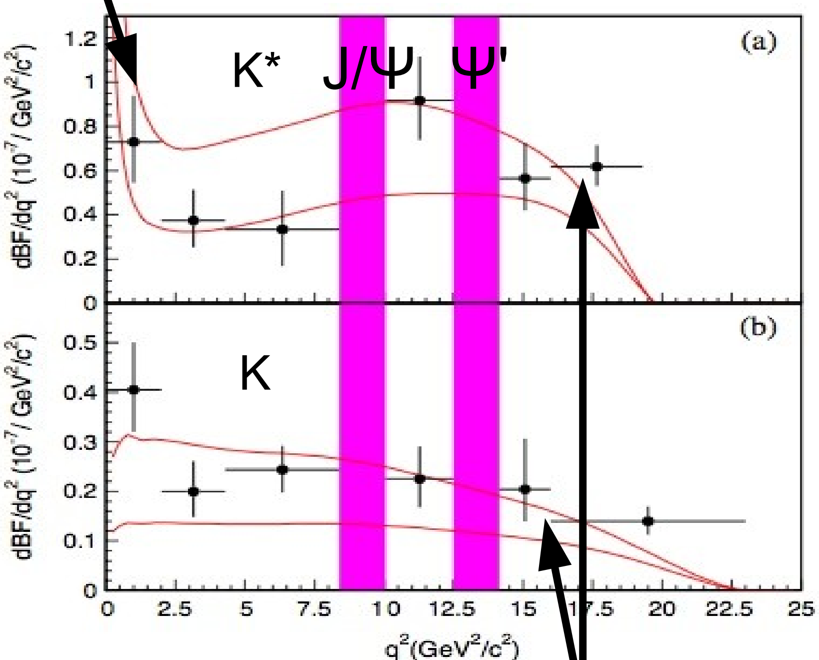
Full $q^2 = m^2_{l+l-}$ range:

$N(Kl^+l^-) = 162\pm22$
$N(K^*l^+l^-) = 246\pm15$

Belle $B \to K^{(*)} l^+l^-$ (605 fb^{-1})

q^2 → 0 γ-pole

dBR/dq^2 from Signal Yields corrected for ε(q^2) **PRL 103, 171801**



SM prediction with different FF assumptions [Ali et al. PRD61 074024, PRD66 034002]

Inclusive BR, A_{CP}, A_I & e/μ ratio agree with SM:

$$\mathcal{B}(B \to K^*\ell^+\ell^-) = (10.7^{+1.1}_{-1.0} \pm 0.9) \times 10^{-7},$$
$$\mathcal{B}(B \to K\ell^+\ell^-) = (4.8^{+0.5}_{-0.4} \pm 0.3) \times 10^{-7},$$

$$A_{CP}(K^*\ell^+\ell^-) = -0.10 \pm 0.10 \pm 0.01;$$
$$A_{CP}(K^+\ell^+\ell^-) = 0.04 \pm 0.10 \pm 0.02.$$

$$A_I(B \to K^*\ell^+\ell^-) = -0.29^{+0.16}_{-0.16} \pm 0.09$$
$$A_I(B \to K\ell^+\ell^-) = -0.31^{+0.17}_{-0.14} \pm 0.08$$

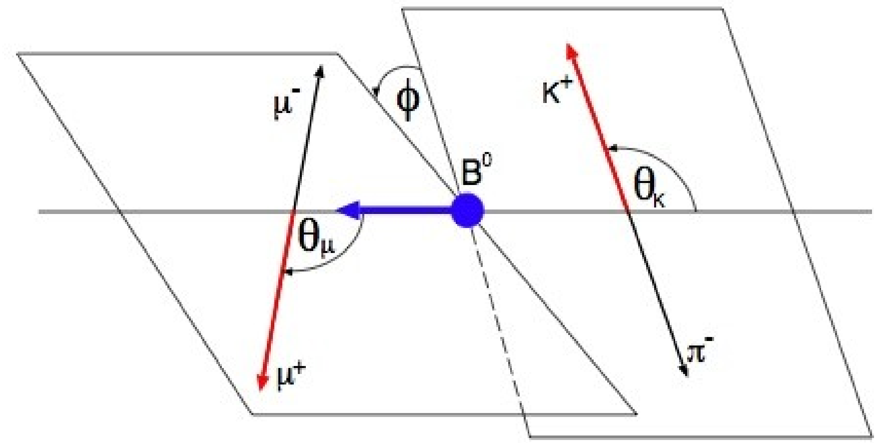
$$R_{K^*} = 0.83 \pm 0.17 \pm 0.08,$$
$$R_K = 1.03 \pm 0.19 \pm 0.06.$$

- Systematics dominated by tracking, PID, lepton selection & MC Decay Models

Belle $B \to K^{(*)} l^+l^-$ (605 fb^{-1})

PRL 103, 171801

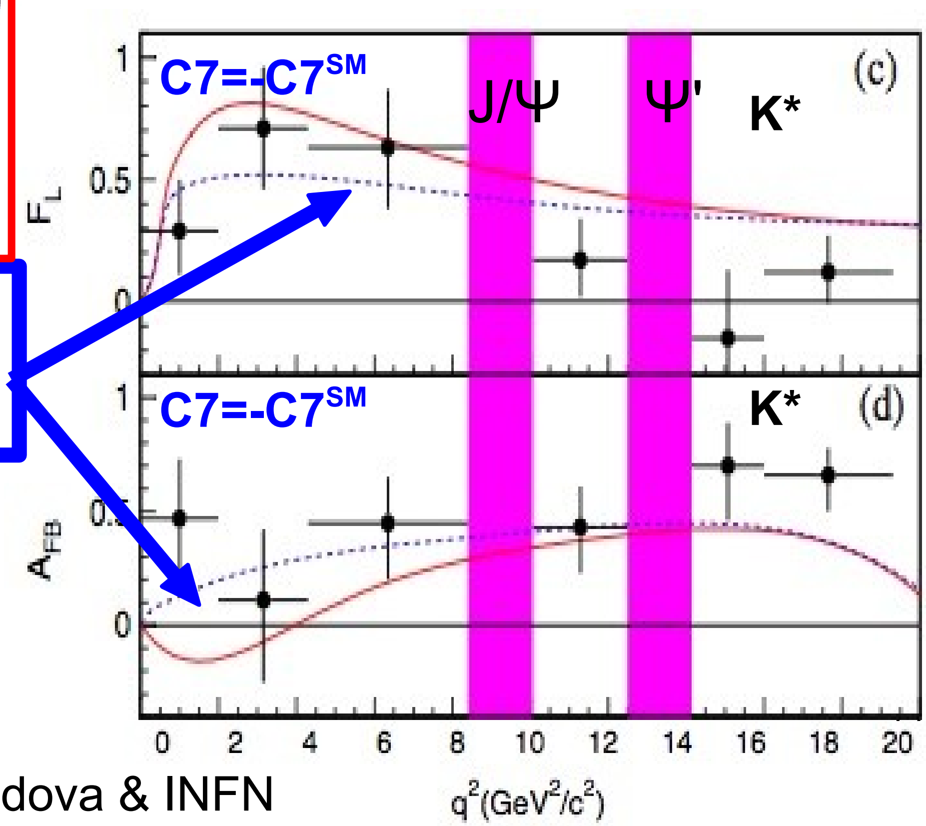
- Event Angular Distribution depends on three angles
- K^* longitudinal polarization fraction F_L & lepton A_{FB} obtained from fits to θ_{K^*} & θ_l in q^2 bins



$$W(\theta_{K^*}) \sim [\tfrac{3}{2}F_L\cos^2\theta_{K^*} + \tfrac{3}{4}(1-F_L)(1-\cos^2\theta_{K^*})]\epsilon(\cos\theta_{K^*})$$

$$W(\theta_l) \sim [\tfrac{3}{4}F_L(1-\cos^2\theta_{B\ell}) + \tfrac{3}{8}(1-F_L)(1+\cos^2\theta_{B\ell}) + A_{FB}\cos\theta_{B\ell}]\epsilon(\cos\theta_{B\ell}),$$

$AFB(q^2=m^2_{l+l-} < m^2(J/\Psi))$ sensitive to C7 sign-flip



- Dominant Systematics from fixed normalization & fixed F_L in A_{FB} fit

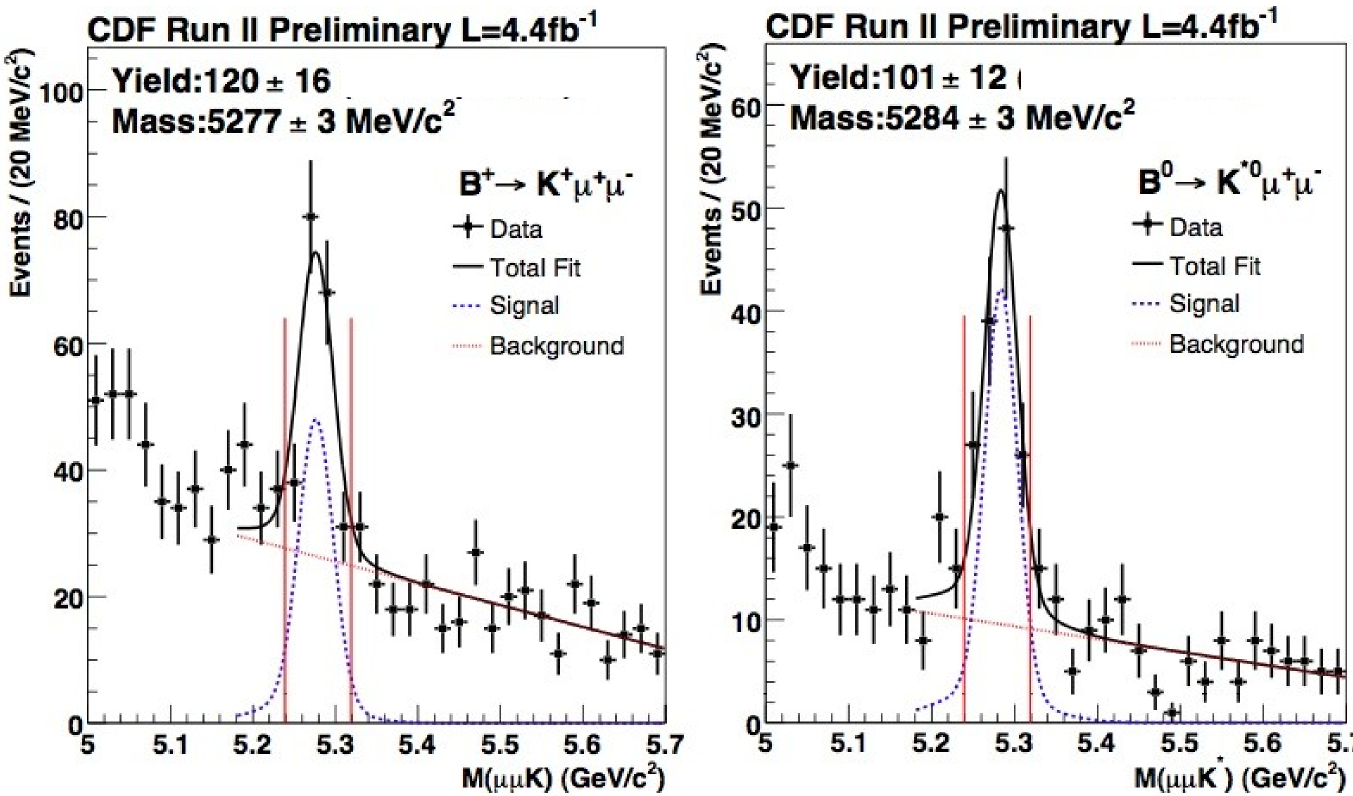
CDF B→Kμμ (4.4 fb^{-1})

$B \to K^{(*)}\mu^+\mu^-$ fully reconstructed ($K^* \to K^+\pi^-$)

PRELIMINARY
CDF Note 10047

- Dimuon level-3 trigger applied (P_T, VTX($\mu^+\mu^-$) informations)
- Vetoes applied to reject peaking $B \to J/\Psi$ (Ψ'), $D\pi$

- Signal selected using a Neural Network (vertexes, event shape, lepton separation)

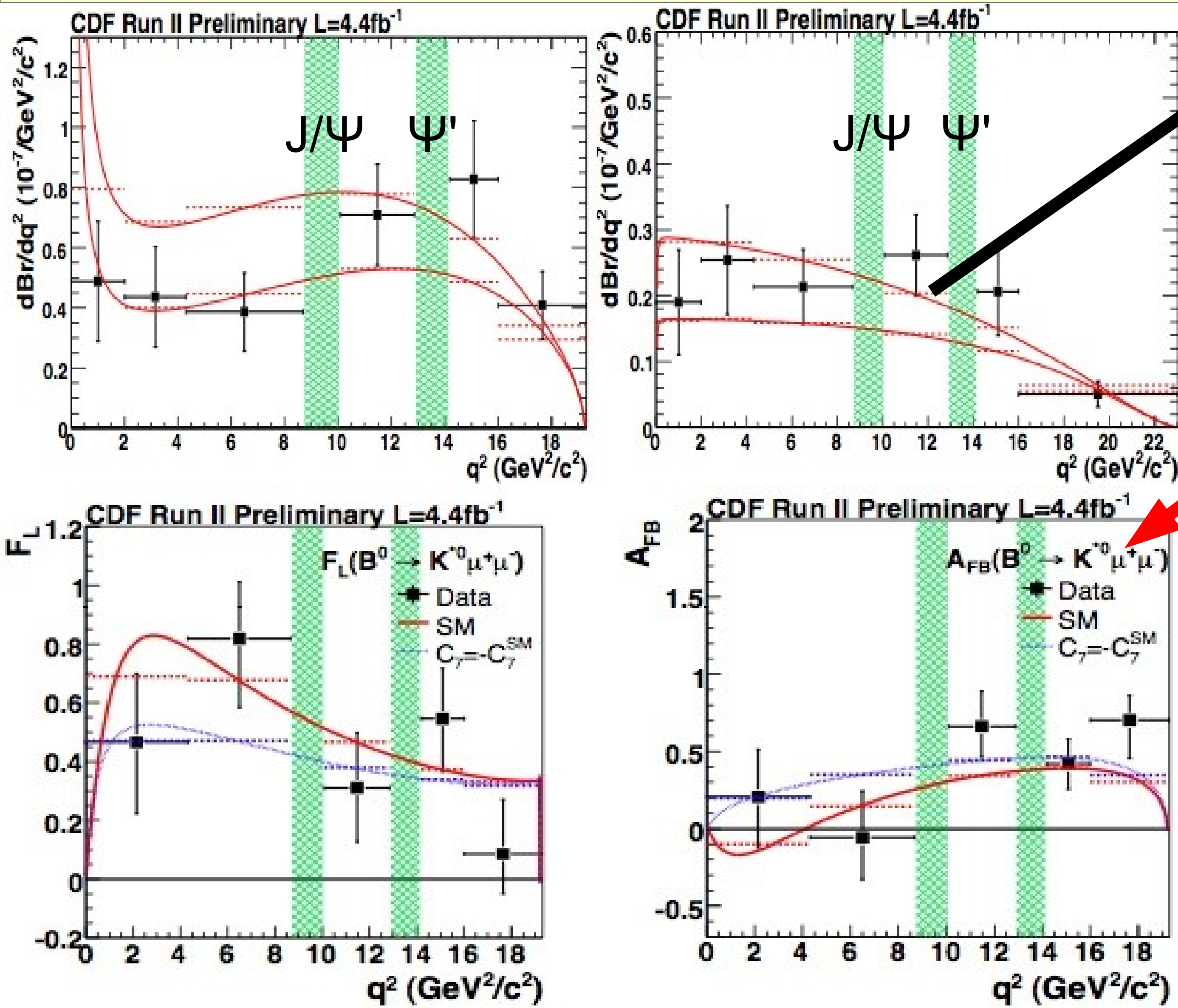


- Signal yield from unbinned likelihood fit to m(B)

$N(Kl^+l^-) = 120\pm16$
$N(K^*l^+l^-) = 101\pm12$

CDF B→Kμμ (4.4 fb^{-1})

•BR computed relative to BR(B→J/Ψ $K^{(*)}$) (identical final states) to reduce efficiency systematics in the ratio



Results consistent with SM

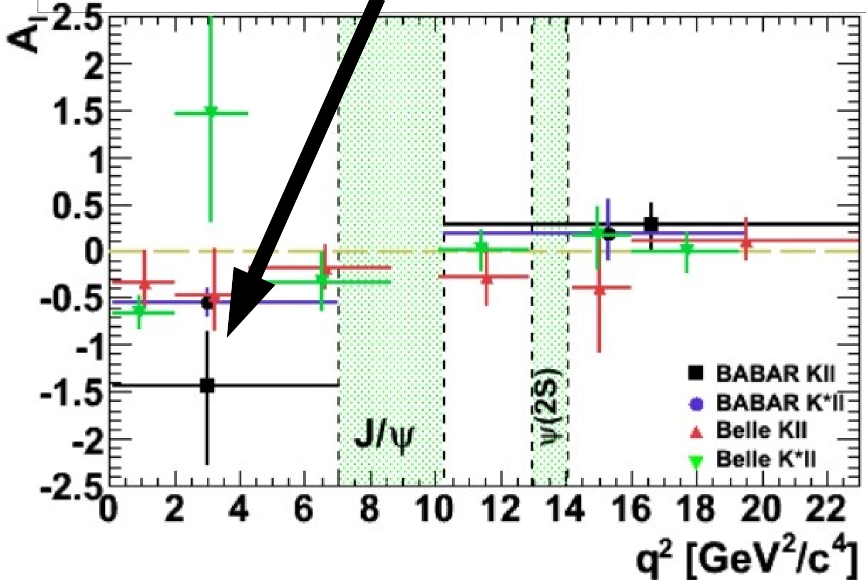
BR Systematics from:
- Background PDF
- BR(B→J/Ψ $K^{(*)}$)

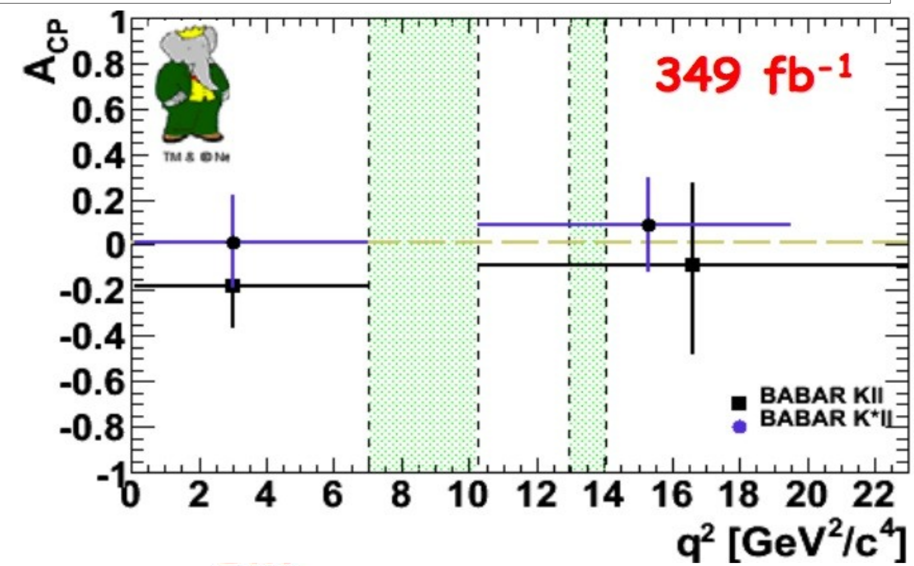
A_{FB} : first measurement in hadron collision !

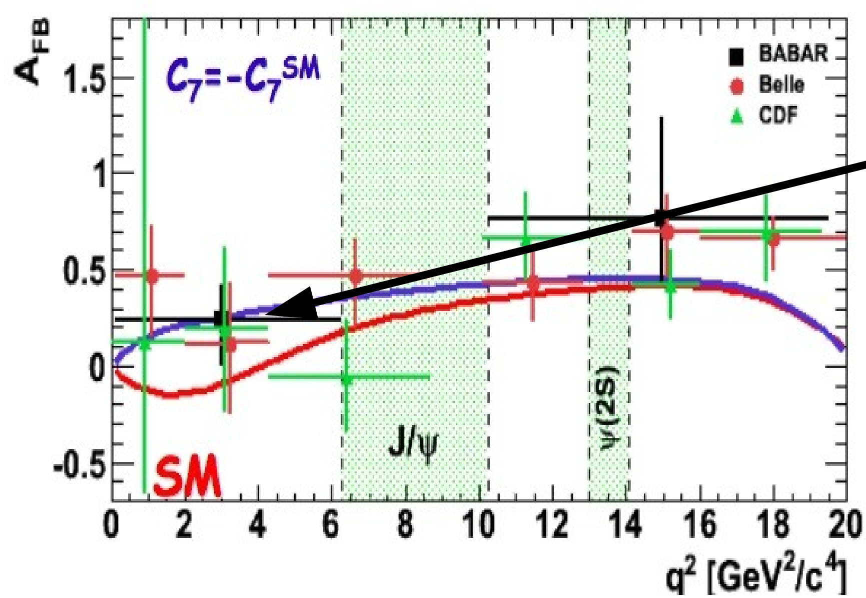
Angular Analysys Systematics from:
- Fraction of K-π swapped K* (~7%)
- Combinatorial PDF from B-mass Side Band

B → X_s l^+l^- : Summary

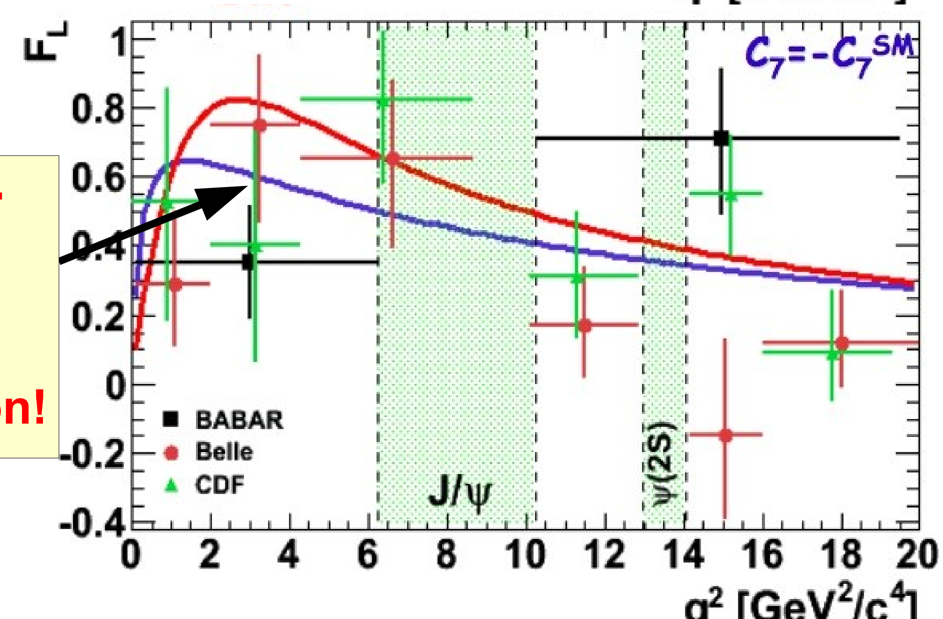
- BaBar finds a hint of $A_{ISOSPIN}$ deviation in the low q^2 region [PRL 102 091803]
- Belle results in agreement both with SM & BaBar [PRL 103 171801]







C7 sign-flip? Wait for error reduction!



BaBar $B^{\pm} \to K^+\tau^+\tau^-$ (423 fb^{-1})

- $BR(B \to X_s l^+ l^-)$ expected to show weak dependence on lepton flavor in the high q^2 region
- $B^+ \to K^+\tau^+\tau^-$ ~50% of total $X_s\tau^+\tau^-$ inclusive rate

[Hewett, PRD53 4964-4969]

$BR(B \to X_s l^+ l^-)$ $0.6<(q/m_b)^2<1$

Electron	8.5×10^{-7}
Muon	8.5×10^{-7}
Tau	4.3×10^{-7}

- **In NMSSM New Physics could couple with strength ~m^2_{LEPTON}**

[Hiller, PRD70 034018]

→ **Important Channel!**

Experimentally:

Exclusive reconstruction not possible due 2-4 neutrinos in the final state

BaBar performed the first search for $B^+ \to K^+\tau^+\tau^-$

BaBar $B^{\pm} \to K^+\tau^+\tau^-$ (423 fb^{-1})

PRELIMINARY

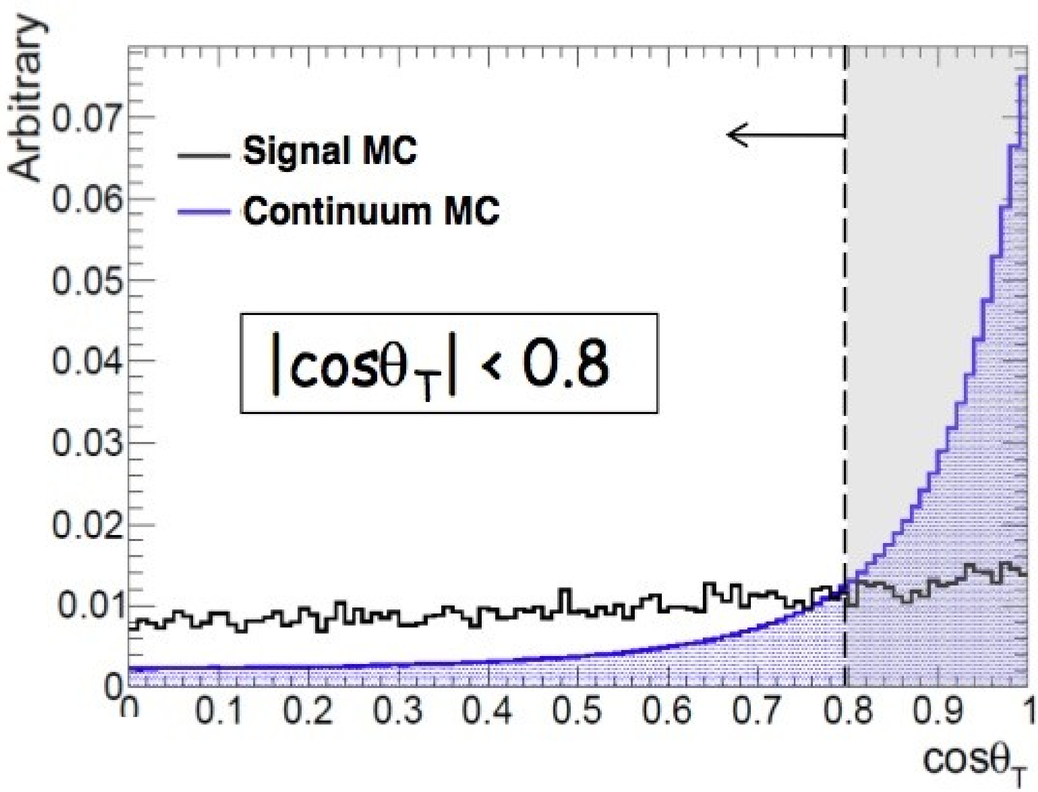
- $K^+\tau^+\tau^-$ Decays searched on the recoil of fully reconstructed $B \to D^{(*)}X$
- ε_{tag}=0.13%

- One-prong τ decays reconstructed: $\tau \to e(\mu)\nu\nu$, $\pi\nu$
- Signal events with 3 charged tracks only selected exploiting Missing Energy, m(τ-daughters)
- Veto applied to remove J/Ψ

Main Backgrounds:

Continuum
- Suppressed exploiting the opening angle between the tag B thrust and the rest-of-event thrust

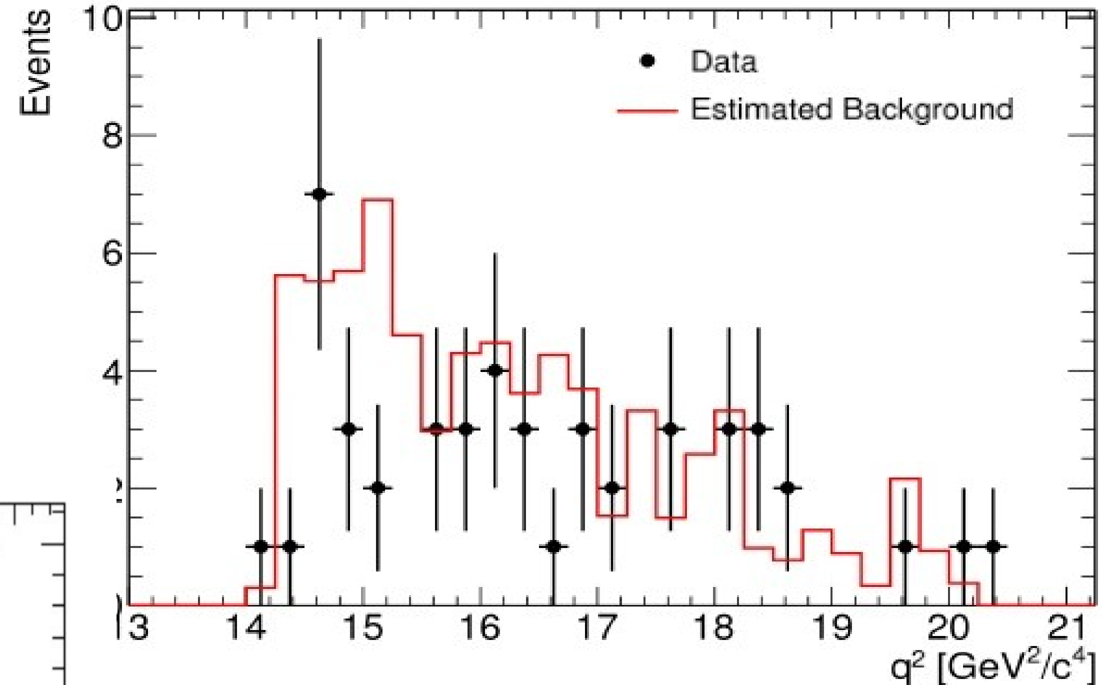
Peaking
- B semileptonic Decays Suppressed by P_{Lepton} cut
- $B \to DX$ Reduced by m(Kπ) cut



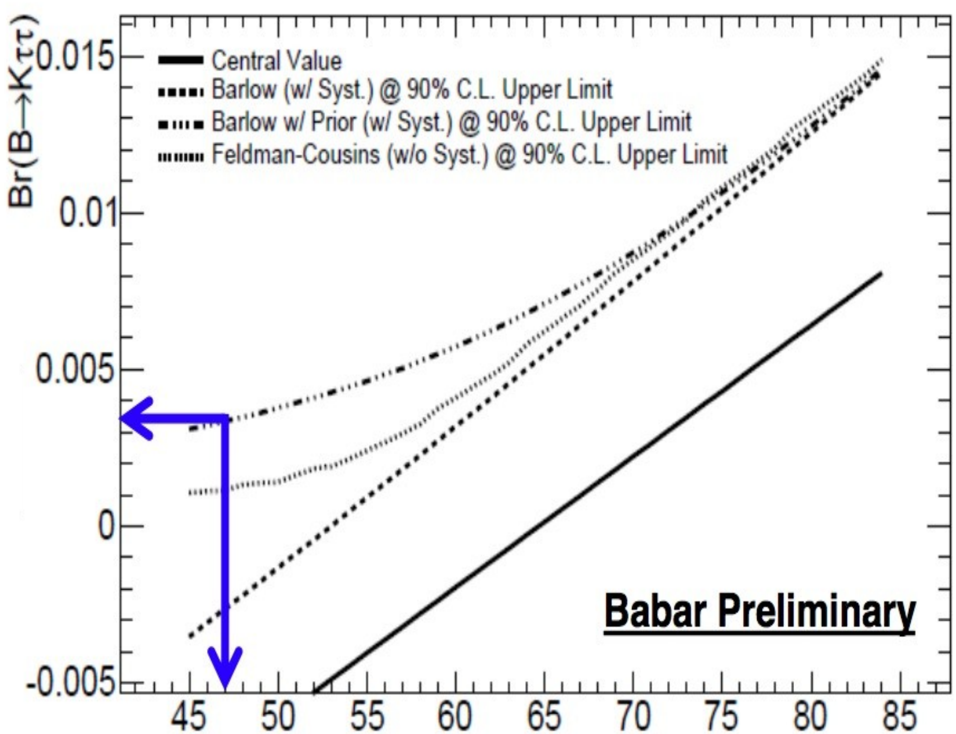
M. Margoni Universita` di Padova & INFN

BaBar $B^{\pm} \rightarrow K^{+}\tau^{+}\tau^{-}$ (423 fb^{-1})

- Systematics from ε_{SIGNAL}, Background shape & yield, ε_{TAG}



47 events observed
(65 expected from BKG)



- Upper Limit obtained using Barlow method [Comput. Phys. Commun. 149, 97] with prior assuming the model of Ali et al. [PRD66 034002]
- Conservative Approach!

$BR(B^{+} \rightarrow K^{+}\tau^{+}\tau^{-}) < 3.3 \times 10^{-3}$ @ 90%CL

$B \to X_d\, l^+l^-$

No Inclusive Analyses performed. Experiments Fully reconstruct $B \to \pi l^+l^-$

•J/Ψ(Ψ'), γ conversion vetoes applied

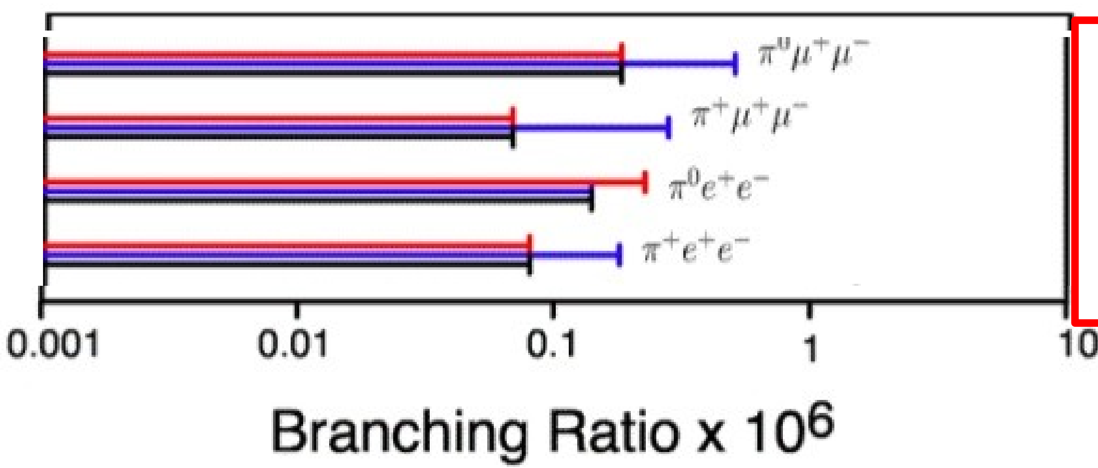
Main Backgrounds:

•Continuum reduced exploiting event shape variables & B-flavor tagging

•B & D Semileptonic Decays suppressed by means of missing energy, vertex fit informations

Belle (605 fb^{-1}) [PRD 78 011101R] **$BR(B \to \pi l^+l^-) < 6.2 \times 10^{-8}$**

BaBar (209 fb^{-1}) [PRL 99 051801] **$BR(B \to \pi l^+l^-) < 9.1 \times 10^{-8}$**



Hfag 2010:

$BR(B \to \pi l^+l^-) < 6.2 \times 10^{-8}$

Conclusion

Radiative penguin decays are an excellent laboratory for the search for physics beyond the SM & the study of b-quark dinamics

Almost all results in agreement with expectations

In the Future they will offer Opportunity to:

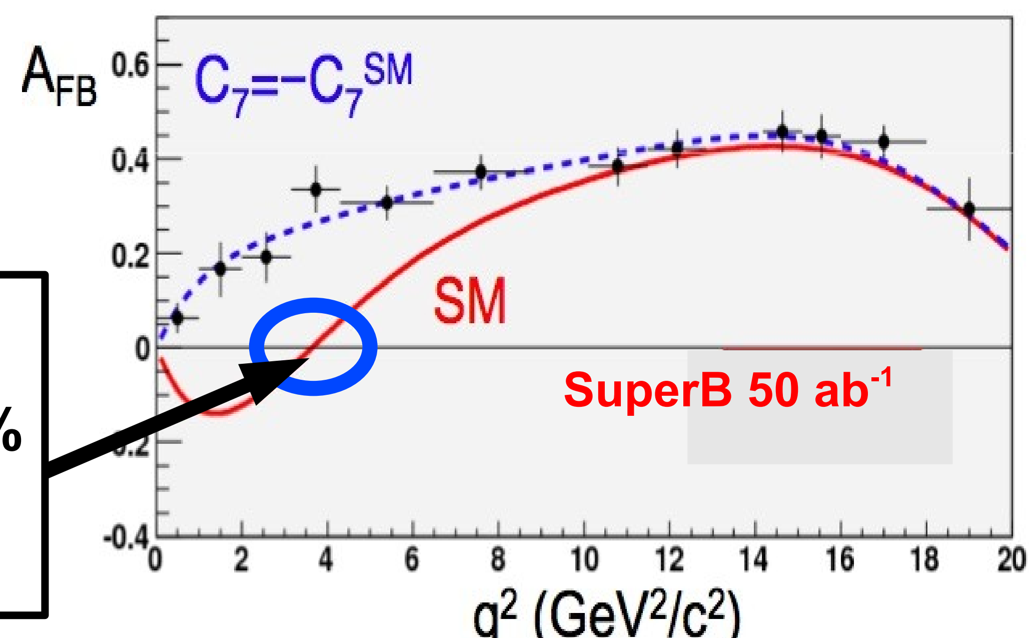
- Improve Experimental Technics by using New Observables with reduced dependence on Form Factors (e.g. Transversity Amplitudes) [Bobeth et al., arXiv:1006.5013]

$AFB(q^2_0)=0$

SuperBelle(50ab^{-1}) δq^2_0~5%

LHCb(2fb^{-1}): δq^2_0~13%

- Provide very stringent SM tests:



- Discover/Understand New Physics

Backup

Extract X=$|V_{td}/V_{ts}|$ from Ratio of Inclusive BFs

•Use NLO calculation [Ali et a., Phys. Lett. B429 87]

$$R = \lambda^2[1+\lambda^2(1-2\bar{\rho})]\left[(1-\bar{\rho})^2+\bar{\eta}^2+\frac{D_u}{D_t}(\bar{\rho}^2+\bar{\eta}^2)+\frac{D_r}{D_t}(\bar{\rho}(1-\bar{\rho})-\bar{\eta}^2)\right]$$

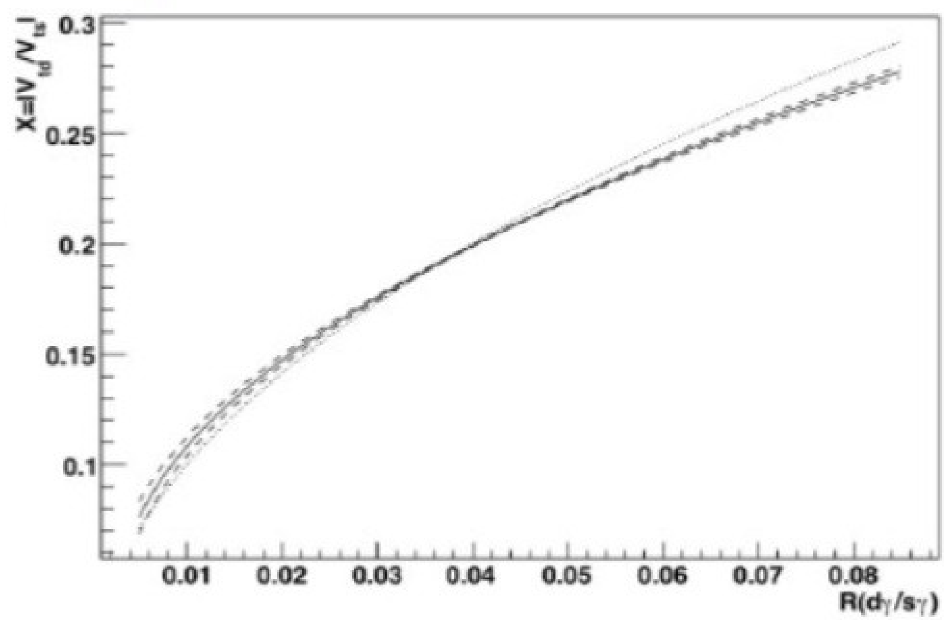
•Rewrite in terms of X and UT angle β

$$R = \kappa_1 X^2 + \kappa_2 X + \kappa_3,$$

$$\kappa_1 = 1+\frac{D_u}{D_t}(1-2\lambda^2\cos^2\beta)-\frac{D_r}{D_t}(\lambda^2\cos^2\beta+1),$$

$$\kappa_2 = \lambda\cos\beta\left[\frac{D_u}{D_t}(3\lambda^2-2)+\frac{D_r}{D_t}\left(1+\frac{\lambda^2}{2}\right)\right],$$

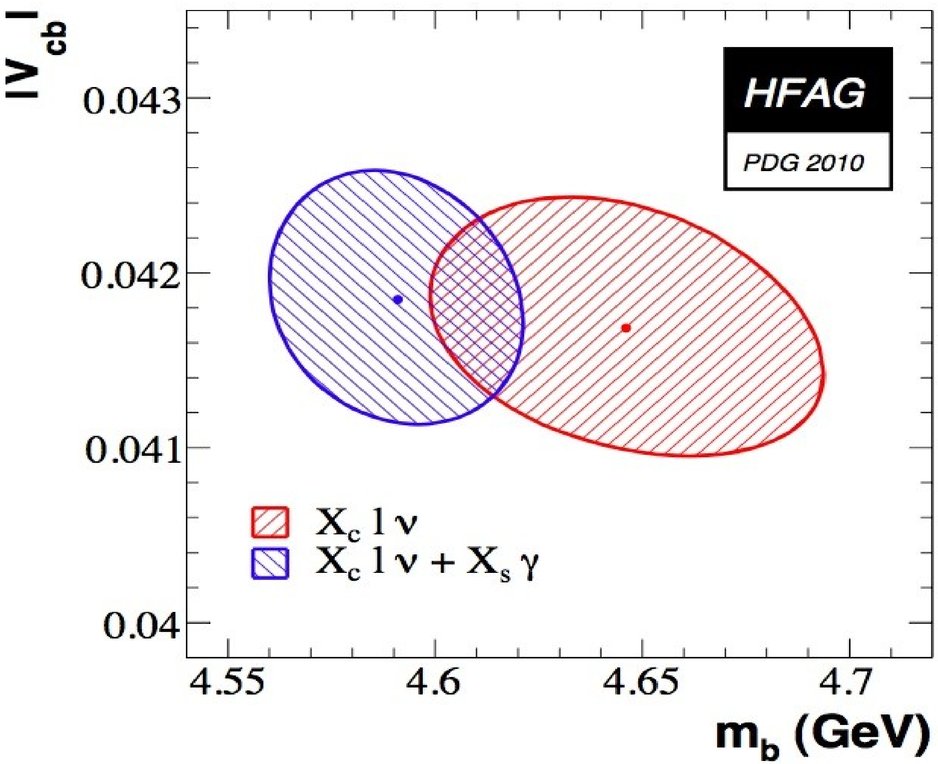
$$\kappa_3 = \lambda^2\frac{D_u}{D_t}(1-\lambda^2).$$



•Uncertaintes from PDG & numerical calculation of D factors

B→sγ Spectral Moments

HFAG Fit in Kinetic Mass Scheme (2010)



|Vub| From Inclusive BR in different Theorical Frameworks using $X_s\gamma$ Moments [HFAG2010]

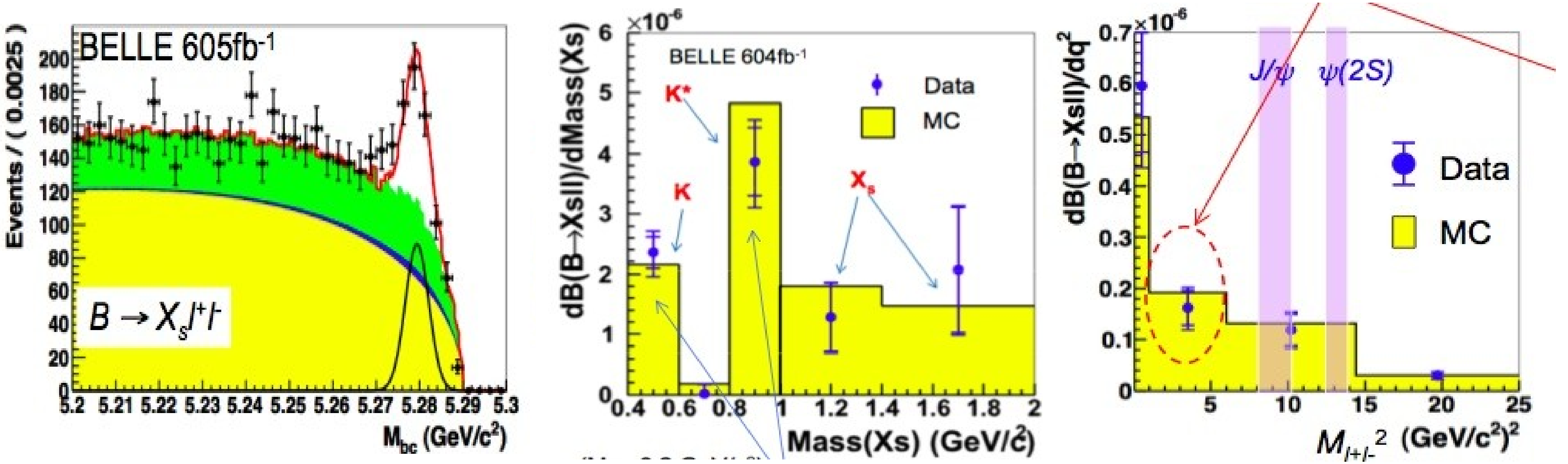
Framework	$\lvert V_{ub}\rvert [10^{-3}]$
BLNP	$4.32 \pm 0.16^{+0.22}_{-0.23}$
DGE	$4.46 \pm 0.16^{+0.18}_{-0.17}$
GGOU	$4.34 \pm 0.16^{+0.15}_{-0.22}$
ADFR	$4.16 \pm 0.14^{+0.25}_{-0.22}$
BLL (m_X/q^2 only)	$4.87 \pm 0.24 \pm 0.38$
LLR (*BABAR*) [394]	$4.43 \pm 0.45 \pm 0.29$
LLR (*BABAR*) [395]	$4.28 \pm 0.29 \pm 0.29 \pm 0.26 \pm 0.28$
LNP (*BABAR*) [395]	$4.40 \pm 0.30 \pm 0.41 \pm 0.23$

Data	χ^2/dof	$\lvert V_{cb}\rvert$ (10^{-3})	m_b^{kin} (GeV)	μ_π^2 (GeV^2)
All moments ($X_c\ell\nu_\ell$ and $X_s\gamma$)	29.7/(66 − 7)	41.85 ± 0.73	4.591 ± 0.031	0.454 ± 0.038
$X_c\ell\nu_\ell$ only	24.2/(55 − 7)	41.68 ± 0.74	4.646 ± 0.047	0.439 ± 0.042

Belle $B \to X_s l^+l^-$ (605 fb^{-1}) PRELIMINARY

Improved Analysis, sum up 36 exclusive modes (~80% coverage)

- Continuum Suppressed by event shape variables
- Cascades $b \to c \to s/d$ rejected exploiting missing mass & energy



Mode	Yield	BF (x 10^{-6})	Σ
$B \to X_s e^+e^-$	121.6 ± 19.3(stat.) ± 2.0(syst.)	$4.56 \pm 1.15(stat.) ^{+0.33}_{-0.40}(syst.)$	7.0
$B \to X_s \mu^+\mu^-$	118.5 ± 17.3(stat.) ± 1.5(syst.)	$1.91 \pm 1.02(stat.) ^{+0.16}_{-0.18}(syst.)$	7.9
$B \to X_s l^+l^-$	238.3 ± 26.4(stat.) ± 2.3(syst.)	$3.33 \pm 0.80(stat.) ^{+0.19}_{-0.24}(syst.)$	10.1

ps: $BF(X_s e^+e^-) / BF(X_s \mu^+\mu^-) = 2.39 \pm 1.41$

In agreement with SM

Transversity Amplitudes

[Bobeth et al., arXiv:1006.5013]

- HQET Calculations Give possibility to disentangle QCD Effects from possible New Physics Effects at high $q^2=m_{l+l-}^2$ in $B \to K^* l^+ l^-$ angular analyses
- New Observables defined with **do not depend on FF** at low recoil and cleanily test SM:

$$H_T^{(1)} = \frac{\mathrm{Re}(A_0^L A_\parallel^{L*} + A_0^{R*} A_\parallel^R)}{\sqrt{\left(|A_0^L|^2 + |A_0^R|^2\right)\left(|A_\parallel^L|^2 + |A_\parallel^R|^2\right)}}$$

$$H_T^{(2)} = \frac{\mathrm{Re}(A_0^L A_\perp^{L*} - A_0^{R*} A_\perp^R)}{\sqrt{\left(|A_0^L|^2 + |A_0^R|^2\right)\left(|A_\perp^L|^2 + |A_\perp^R|^2\right)}}$$

$$H_T^{(3)} = \frac{\mathrm{Re}(A_\parallel^L A_\perp^{L*} - A_\parallel^{R*} A_\perp^R)}{\sqrt{\left(|A_\parallel^L|^2 + |A_\parallel^R|^2\right)\left(|A_\perp^L|^2 + |A_\perp^R|^2\right)}}$$

Computed in terms of left & right Transversity Amplitudes:

$$A_\perp^{L,R} = +i\left\{(\mathcal{C}_9^{\mathrm{eff}} \mp \mathcal{C}_{10}) + \kappa\frac{2\hat{m}_b}{\hat{s}}\mathcal{C}_7^{\mathrm{eff}}\right\} f_\perp,$$

$$A_\parallel^{L,R} = -i\left\{(\mathcal{C}_9^{\mathrm{eff}} \mp \mathcal{C}_{10}) + \kappa\frac{2\hat{m}_b}{\hat{s}}\mathcal{C}_7^{\mathrm{eff}}\right\} f_\parallel,$$

$$A_0^{L,R} = -i\left\{\left(\mathcal{C}_9^{\mathrm{eff}} \mp \mathcal{C}_{10}\right) + \kappa\frac{2\hat{m}_b}{\hat{s}}\mathcal{C}_7^{\mathrm{eff}}\right\} f_0,$$

Form Factors

- Other Observables which do not depend on Wilson Coefficients at low recoil probe some $B \to K^*$ FF combinations