EW Penguins and New Physics

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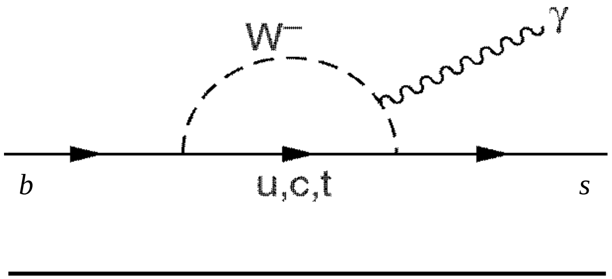
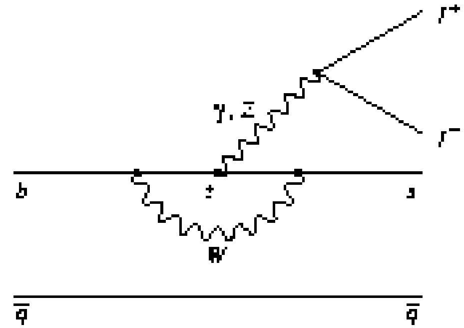
Outline

- Brief Theory introduction
- B->Kll, K*ll, wilson coefficients c7, c9, c10
  - Rate,
  - Forward-backward asymm.,
  - K* polarization
- Inclusive b->sgamma:
  - BF
- Photon polarization measurement
  - B->K* gamma
  - B->Ks eta/eta’ gamma [to do]
  - [B->Ks Phi Gamma ? Not ready]
- b->dgamma observation by belle
  - [Vtd/Vts]

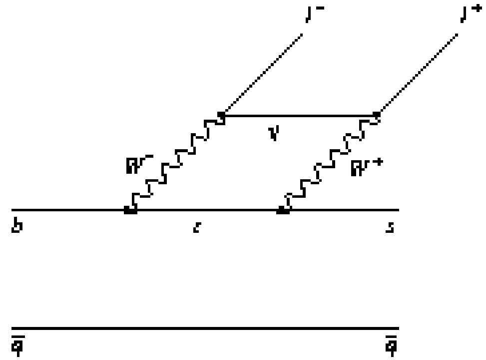
Introduction



Radiative penguin



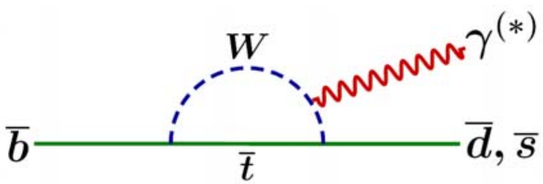
'Z/photon penguin C7/C9'



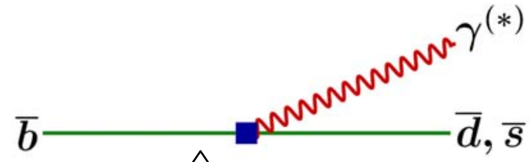
'W-box' C10

- Why are EW penguins a sensitive probe for new physics?
  - Are FCNC dominated in the SM by top loop diagrams
  - The contribution from new particles that can appear in the loop is not suppressed with respect to SM
  - Can actually calculate several observables in SM:
    - BF , A_{CP}, A_{FB}, polarizations
  - In SM radiative decays the photon is polarized because of the left handed nature of the interaction

Where does new physics appear?



$$= V_{tb}V_{td}^* \times C_7 \times$$



Short distance physics is encoded in wilson cefficients

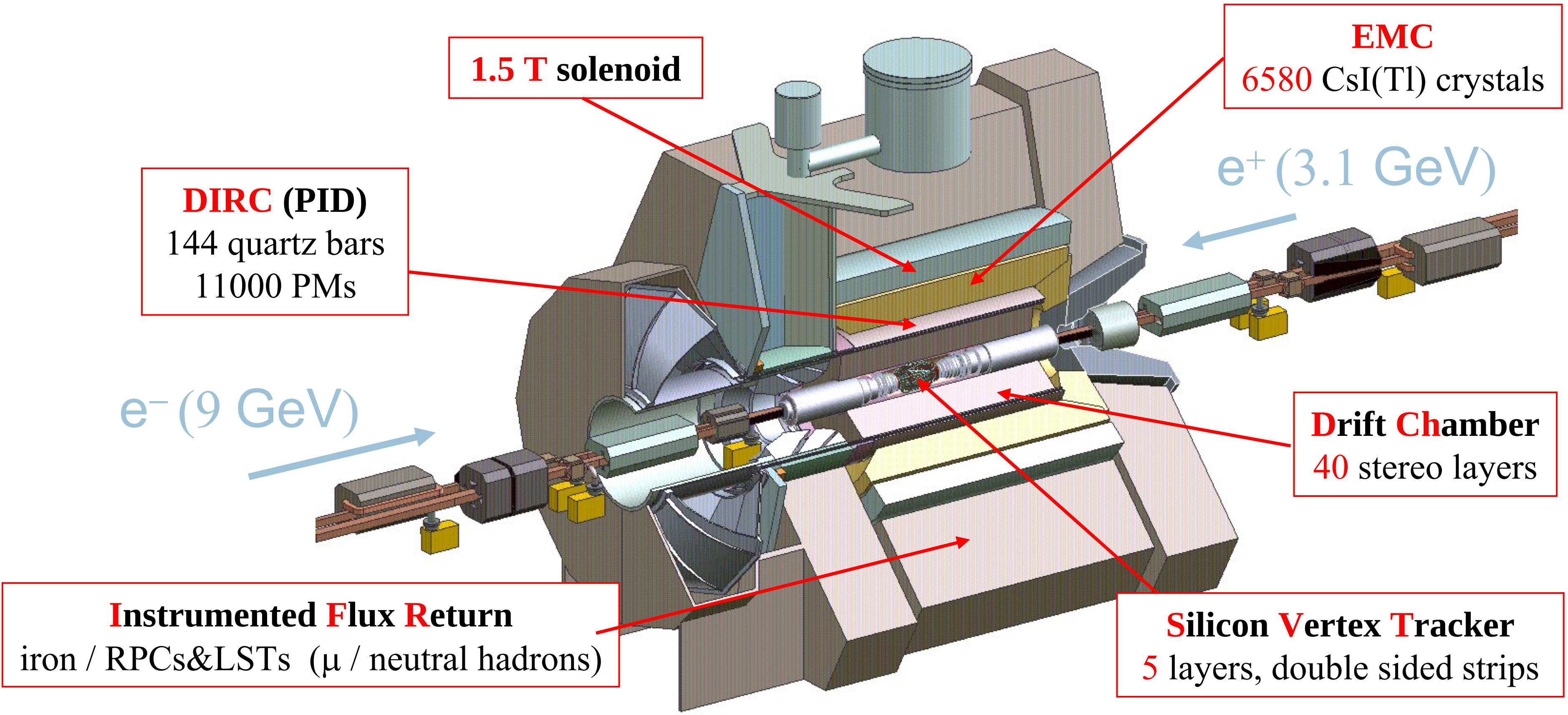
Calculation using perturbation theory

Effective lagrangian written in terms of local operators

HQE: expansion in powers of Λ/m_B

- New physics
  - Can affect the value of Wilson coefficients
  - Can introduce new operators
    - For example can change the polarization of the radiated photon (right handed currents)

The BABAR Detector



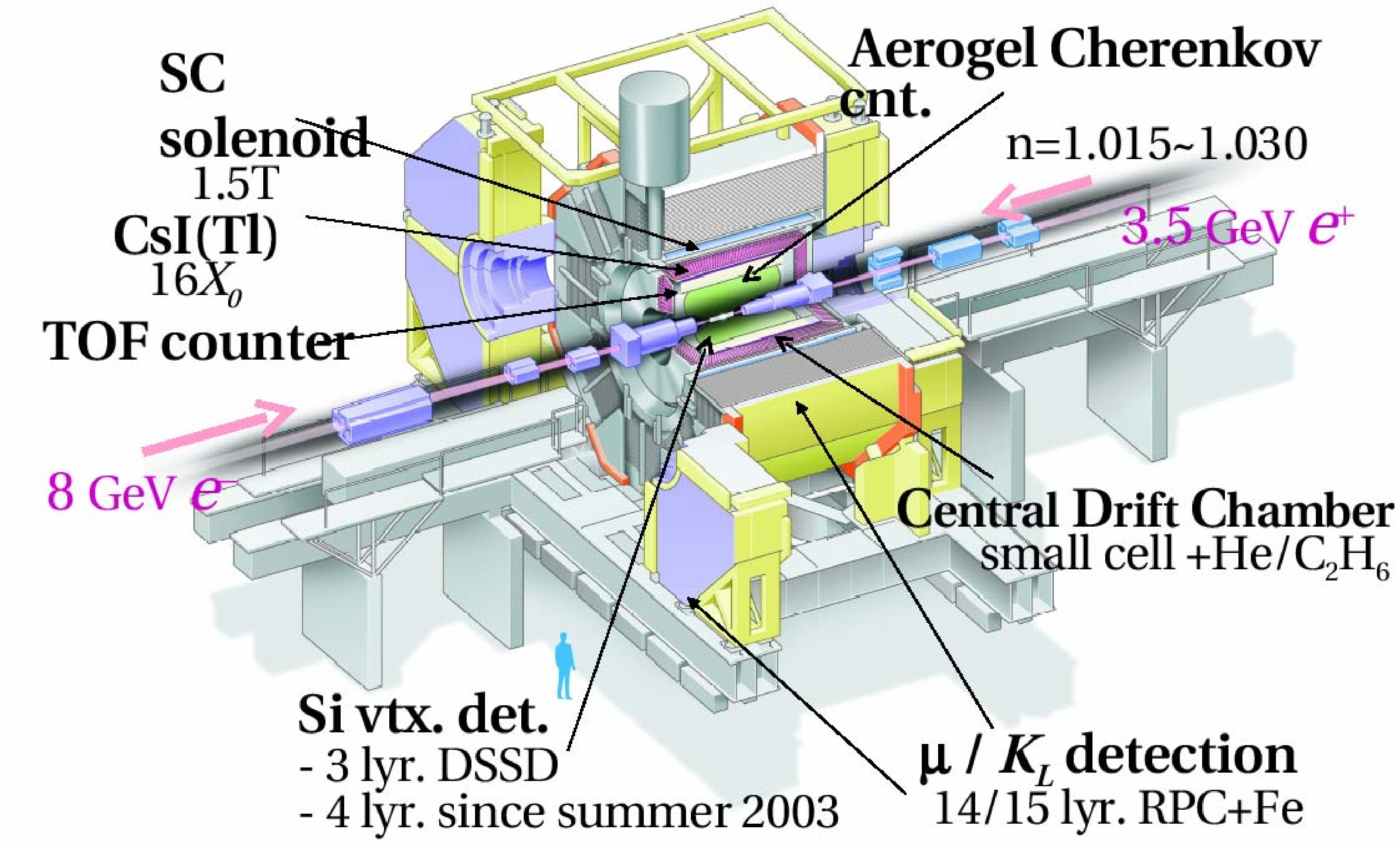
SVT: 97% efficiency, 15 μm z hit resolution (inner layers, perp. tracks)

SVT+DCH: $\sigma(p_T)/p_T = 0.13\,\% \oplus p_T + 0.45\,\%$, $\sigma(z_0) = 65\ \mu m$ @ 1 GeV/c

DIRC: K-π separation 4.2 σ @ 3.0 GeV/c → 3.0 σ @ 4.0 GeV/c

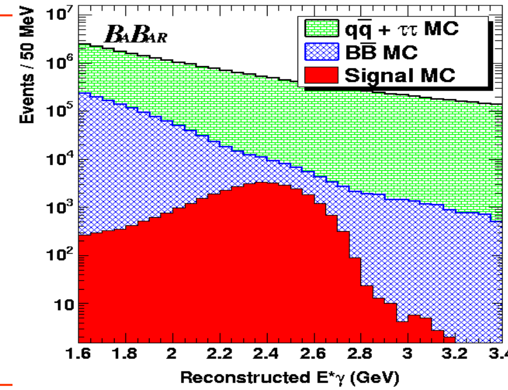
EMC: $\sigma_E/E = 2.3\,\%\sqrt{E^{-1/4}} \oplus 1.9\,\%$

Current Belle Detector



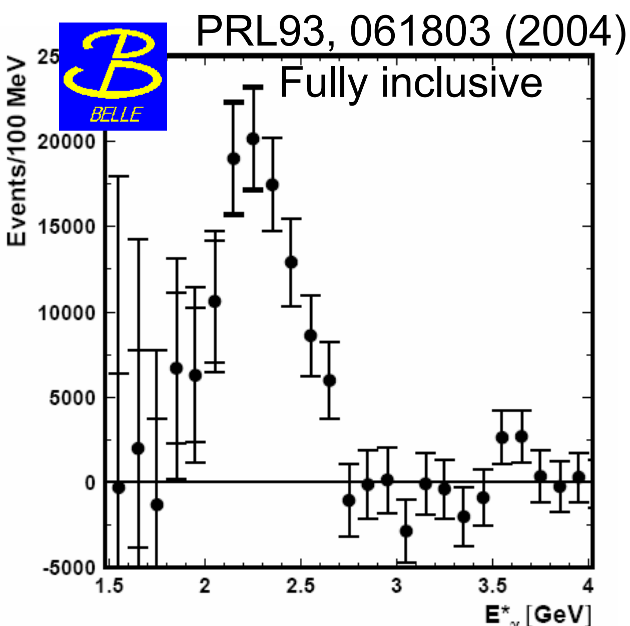
Inclusive B->$X_s\gamma$

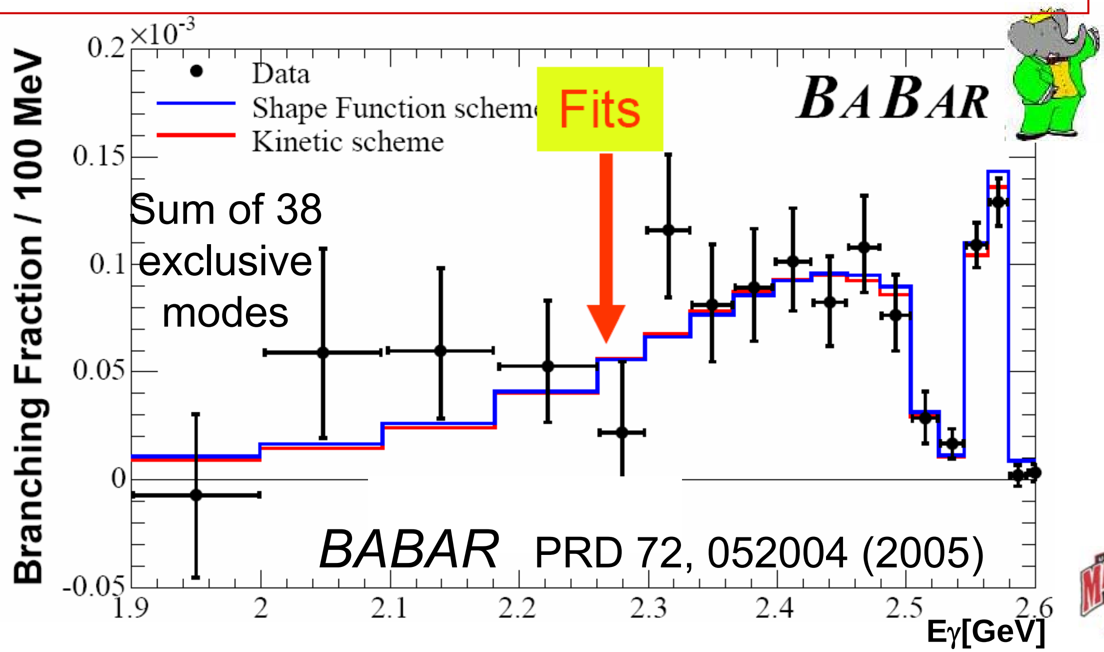
- Dominant contribution from radiative photon penguin
- Teoretically clean: inclusive BF computed in SM up to NLL
  - ->powerful contraint on the magnitude of C_7
- A lot of background: Experimentally challenging
- Two techniques: sum of exclusive modes ($Kn\pi\gamma$), fully inclusive



$B[B^- \to X_s\gamma] = (3.61+0.37-0.49)\times10^{-4}$ (Hurth et. al., Nucl. Phys. B, 704, 56 (2005) (see also Neubert, Eur.Phys. J C40, 165 (2005); Buras et al., Nucl.Phys. B631, 219 (2002)

Exp Average= $(3.55 \pm 0.26)\cdot 10^{-3}$





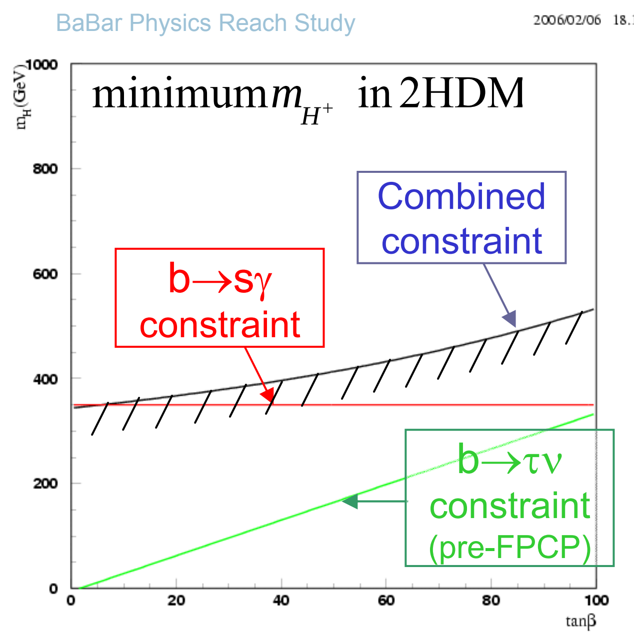
Inclusive B->$X_s\gamma$:constraints on NP

- Measured BF[B->$X_s\gamma$] agrees well with SM

$$\Gamma(b \to s\gamma) = \frac{G_F^2 \alpha_{em} m_b^5}{32\pi^4} |V_{ts}^* V_{tb}|^2 (|C_7|^2 + \text{corrections})$$

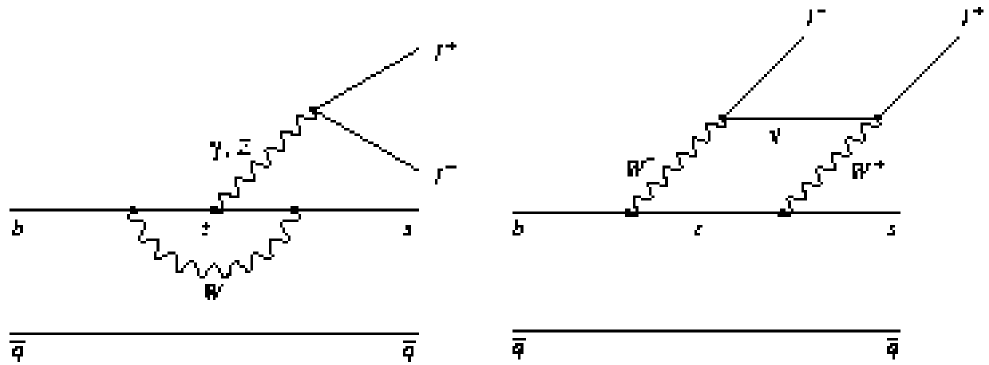
  - ->$|C_7|$ has no deviations from SM

- As an example take the 2 Doublet Higgs Model
  - ->Set a limit on the m_H-tanβ plane



Constraints to H^+ mass in 2hdm.
(following Hou, PRD 48 2342, 1993; and Gambino-Misiak hep-ph/0104034)

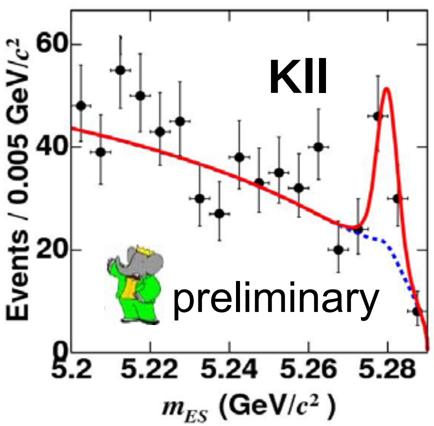
b->sll transitions

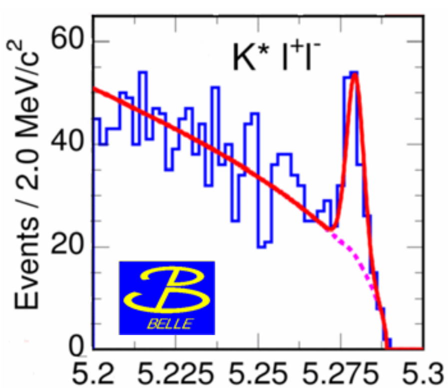


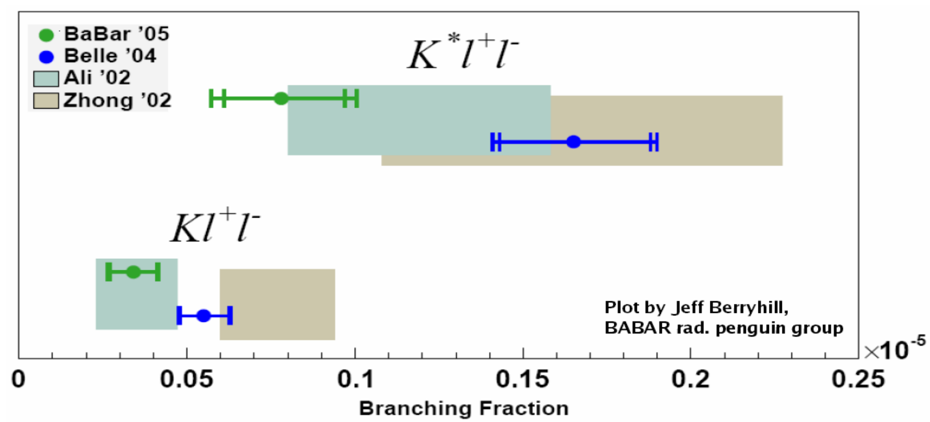
- Amplitude has contributions from all three penguin diagrams: C7(photon), C9(vector), C10(axial-vector)
- Exclusive decays are rare: BF ~ 10^{-6}
- Decay rates and three body kinematic distributions are the tool to measure all three complex penguin amplitudes

B->Kll and B->K*ll

- Reconstruct exclusive modes K+ll,Ksll,K*0ll,K*+ll, l=e or μ
- Require strict PID
- Veto peaking background
- Suppress combinatorial using multivariate discriminants
- Extract signal yield using ML fit to M_{ES}, ΔE, M_{K^*}

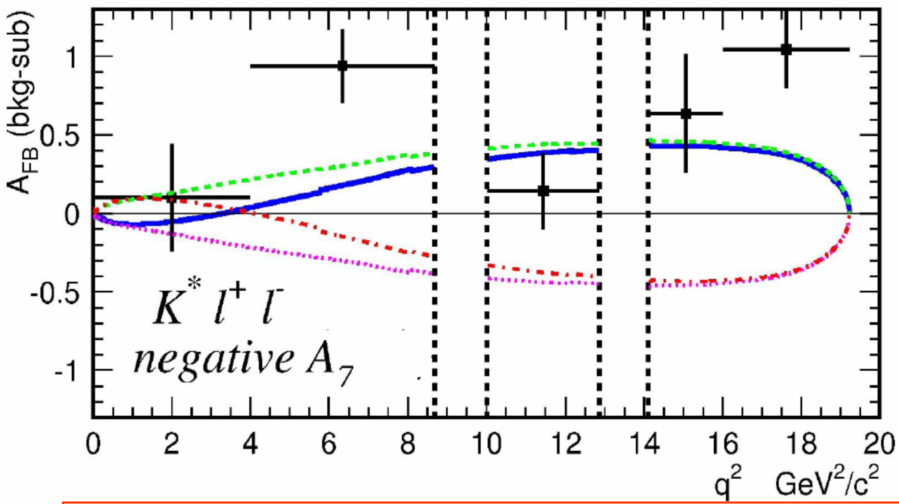






Aslo Acp consistent with zero at 25% level, e/μ ratio consistent with unity

B->K*ll: Angular distribution (Belle)



Fix A7 = -0.330

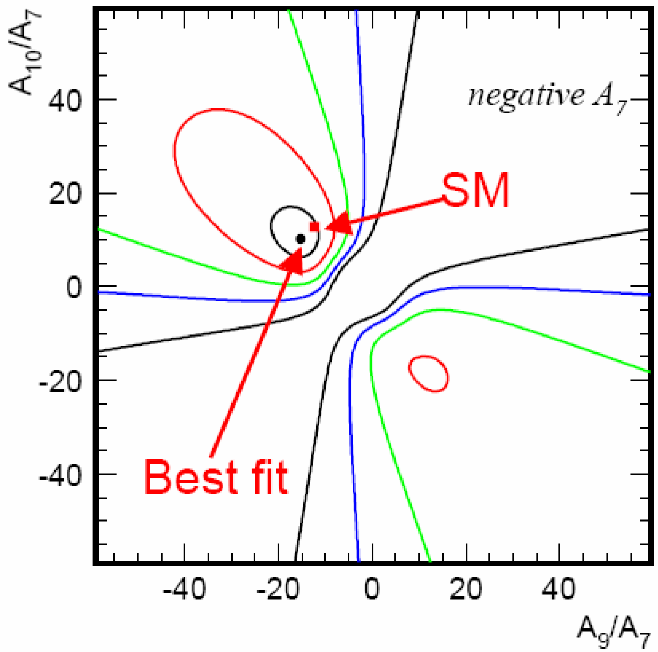
A7A10 sign flipped

Both A7A10 and A9A10 sign flipped

A9A10 sign flipped

Kll used for null test

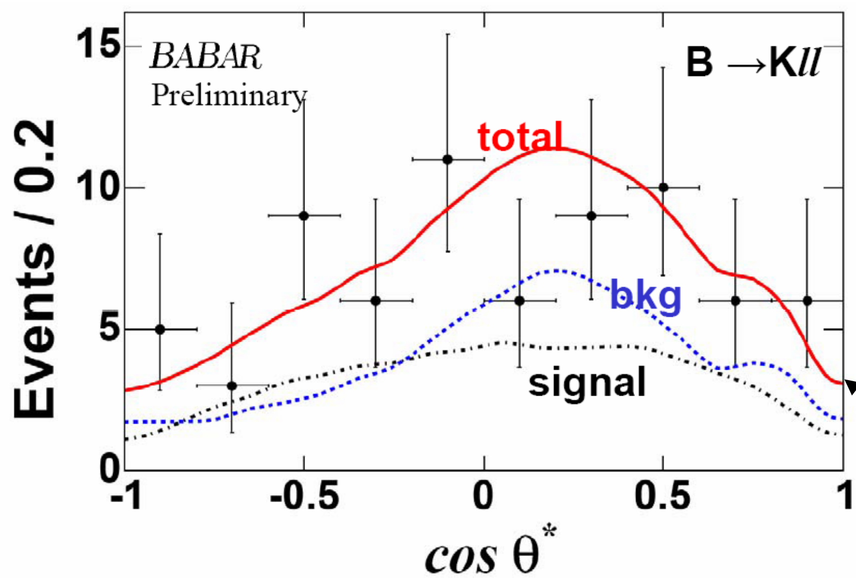
- $A_{FB}^{(B\to K^*ll)}$=0.50±0.15 (>0 3.4σ)
- A_9/A_7 = -15.3 $^{+3.4}_{-3.8}$ ± 1.1
- A_{10}/A_7 = 10.3$^{+5.2}_{-3.5}$ ±1.8
- -1400<A_9A_{10}/A_7^2<-26.4
- Positive A_9A_{10} excluded @98% CL



B->Kll: Angular distribution (Babar)

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta^*} = \frac{3}{4}(1-F_S)(1-\cos^2\theta^*) + \frac{1}{2}F_S + A_{FB}\cos\theta^*$$

- F_S,A_{FB} are allowed to be non zero even for Kll
- Scalar contribution from particles that replace γ/Z I the penguin can contribute to F_S, A_{FB}



F_S=0.81 $^{+0.58}_{-0.61}$ ± 0.56

A_{FB}=0.15 $^{+0.21}_{-0.23}$ ± 0.08

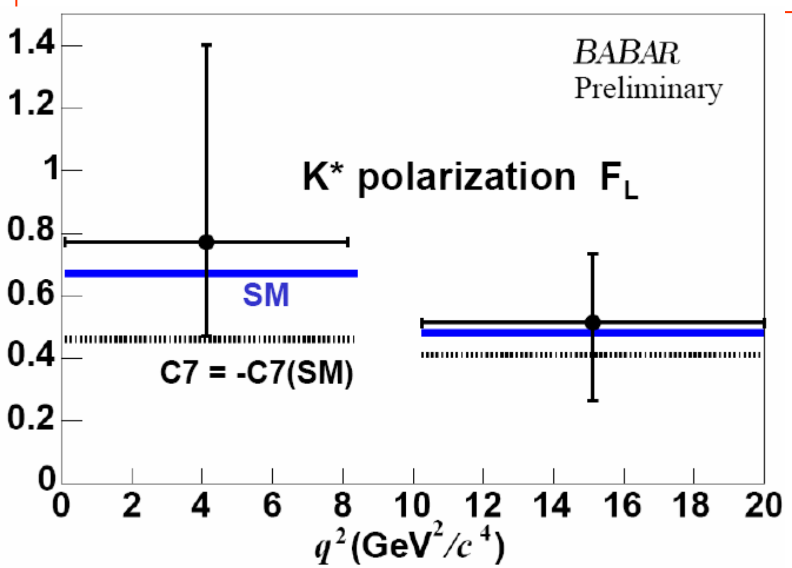
Consistent with SM (zero)

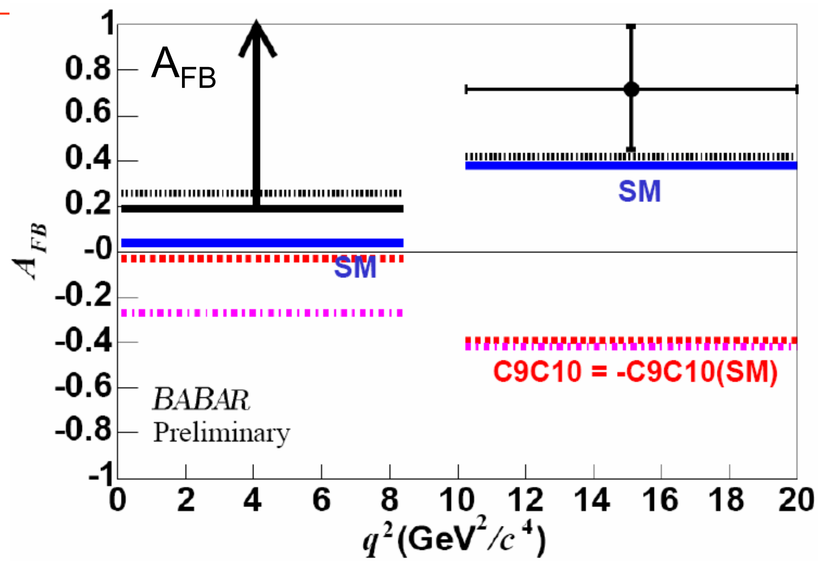
Efficiency corrected pdf projections obtained from signal simulations

B->K*ll: Angular distribution (Babar)

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_K} = \frac{3}{2}F_L\cos^2\theta_K + \frac{3}{4}(1-F_L)(1-\cos^2\theta_K)$$

- Measure also F_L,the longitudinal polarization of the K*
- $F_L = 0.63^{+0.18}_{-0.19} \pm 0.05$ consistent with SM prediction
- Low q^2 lower limit excludes SM at 98% CL
- At high q^2 wrong sign C_9C_{10} is excluded $>3\sigma$





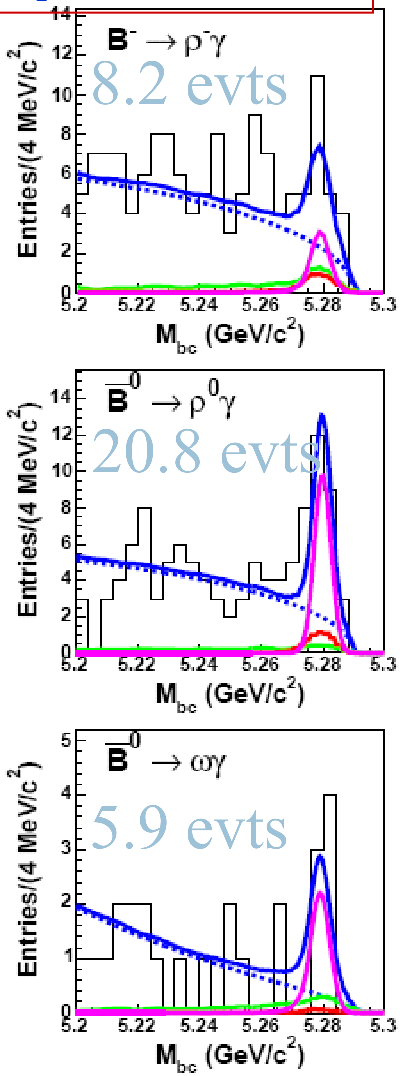
Inclusive b->sll: BF

- [to be completed]
- One way to allow large NP contributions still consistent with the current constraints is to reverse the sign of C7
- BF($C7=-C7_{SM}$)=3.3±0.3 is excluded at 3σ

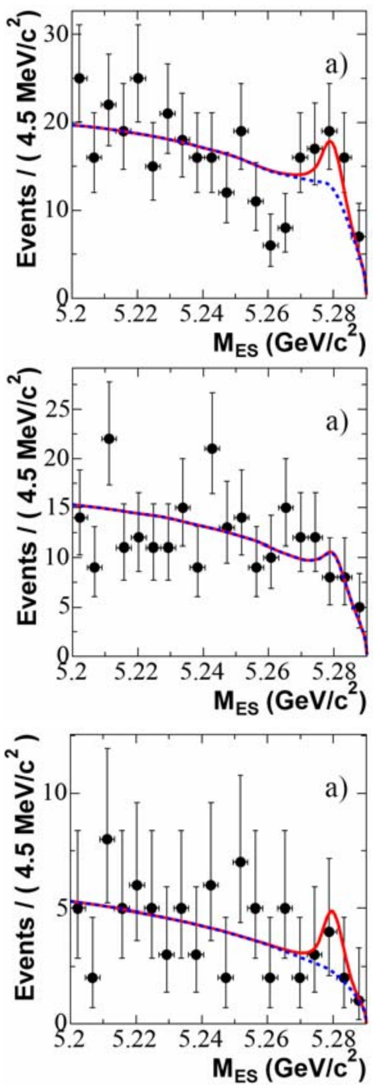
	BF $q^2 \in [1:6] GeV^2$
BaBar 2004	1.8±0.9
Belle 2005	1.5±0.6
exp. avg	1.6±0.5
SM	1.6±0.2

b->dγ

Belle, 386 M BB
hep-ex/0506079



BABAR, 211M BB
PRL 94, 011801 (2005)



Mode	*BABAR* (10^{-6}) (2.1σ signif.)	Belle (10^{-6}) (5.5σ signif.)
$B^+ \to \rho^+\gamma$	< 1.8	$0.55^{+0.43+0.12}_{-0.37-0.11}$
$B^0 \to \rho^0\gamma$	< 0.4	$1.17^{+0.35+0.09}_{-0.31-0.08}$
$B^0 \to \omega\gamma$	< 1.0	$0.58^{+0.34+0.14}_{-0.31-0.10}$

In B0->ργ big isospin violation [update from BaBar is coming soon]

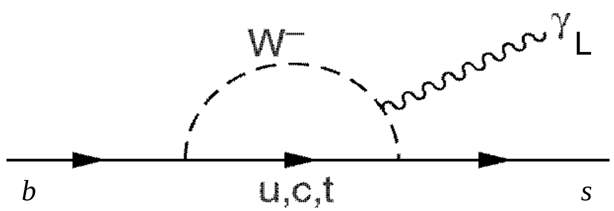
$$\frac{B(B \to (\rho,\omega)\gamma)}{B(B \to K^*\gamma)} = \left|\frac{V_{td}}{V_{ts}}\right|^2 \frac{\left(1 - m^2_{(\rho,\omega)}/m^2_B\right)^3}{\left(1 - m^2_{K^*}/m^2_B\right)^3} \zeta^2 (1 + \Delta R)$$

$$\left|\frac{V_{td}}{V_{ts}}\right| = 0.200^{+0.026+0.038}_{-0.025-0.029}$$

good agreement w/CMS Δm_s

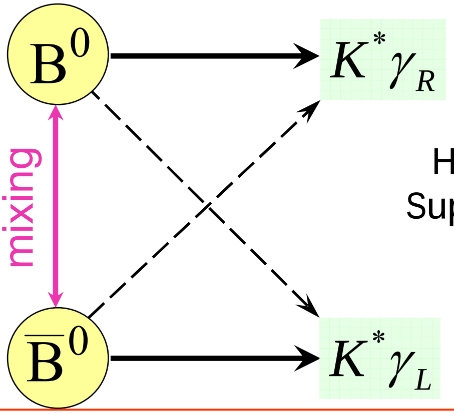
Photon polarization

(A. Atwood, M. Gronau & A. Soni (1997))



$\bar{b}$->$\bar{s}$ γ_R

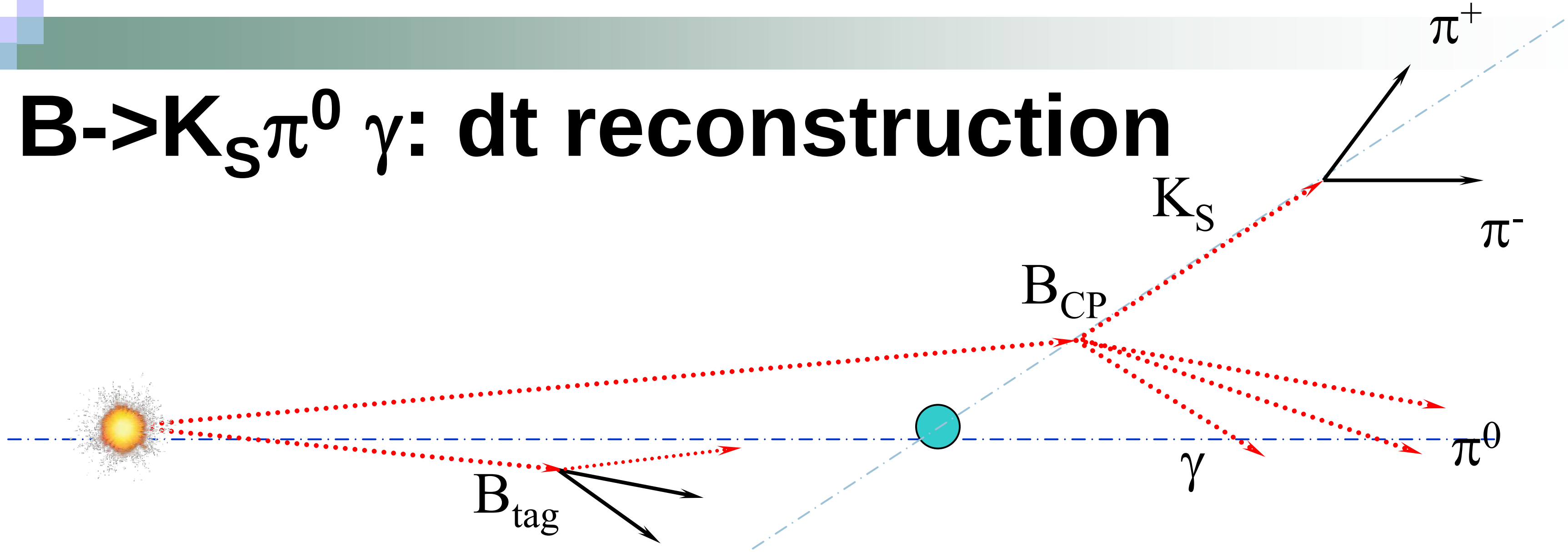
b->s γ_L



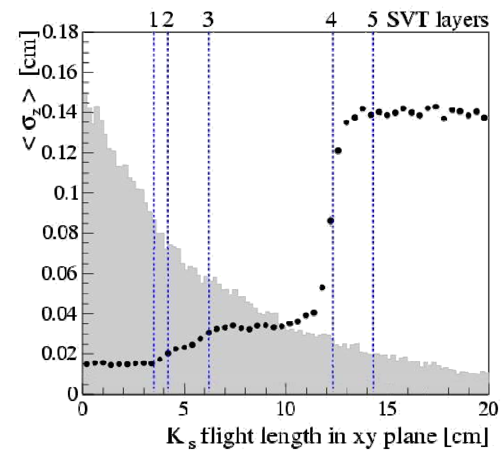
Helicity Flip Suppressed by ~ m_s/m_b

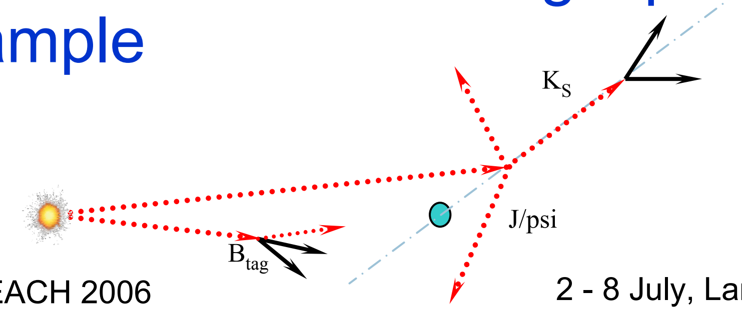
- γ is polarized in the SM -> final state is almost flavor specific
- The interference can happen only with helicity flip
- =>Tool to probe polarization: time dependent CP measurement
- SM 'naive' prediction S~–$2M_s/M_b$*sin(2β)~-0.04
  - Can be up to ~0.1 *(Grinstein, Grossman, Ligeti, Pirjol PRD 71, 011504(2005), Grinstein, Pirjol, hep-ph/0510104)*
- Right handed current with m=m_{heavy} -> m_{heavy}/m_b enhancement [find reference]
- LRSM: SU2_LxSU2_RxU1
  - $S(K_S\pi^0\gamma)$~0.5
- Doesn't need additional CPV phases

B->$K_S\pi^0\gamma$: dt reconstruction



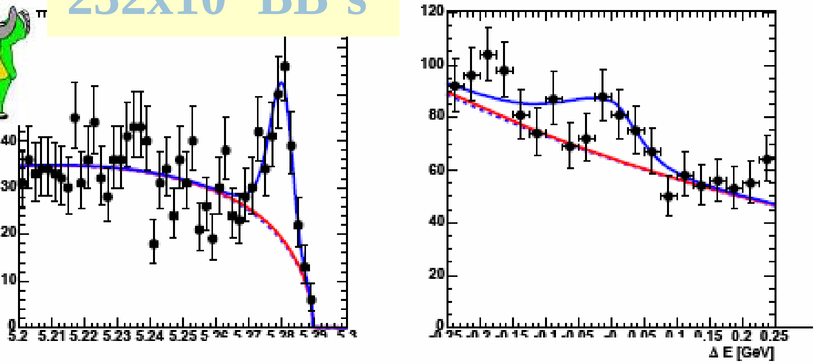
- Need to reconstruct decay vtx of the B but no tracks coming from the B decay point
- Exploit precise vertex detector and fit K_S track to the IP profile
- Validate the method using J/psi KS sample

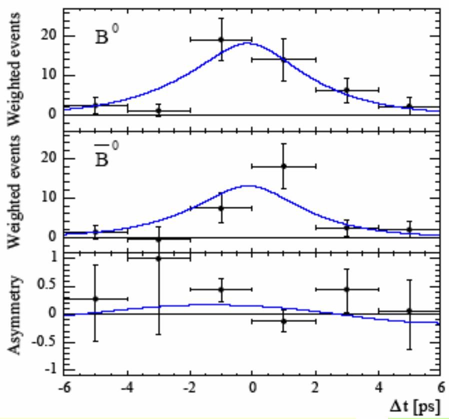




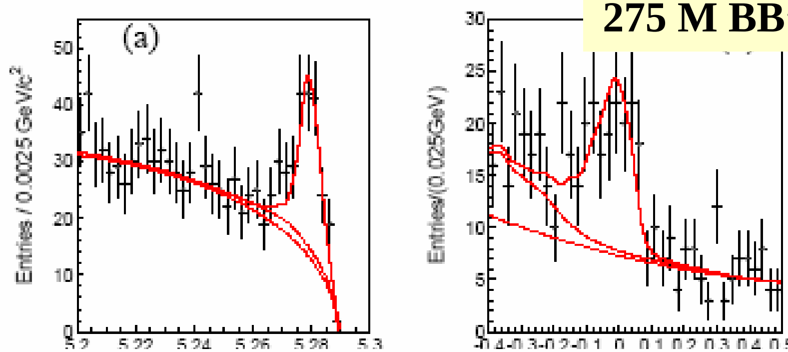
$B \to K_S \pi^0 \gamma$: Belle and BaBar

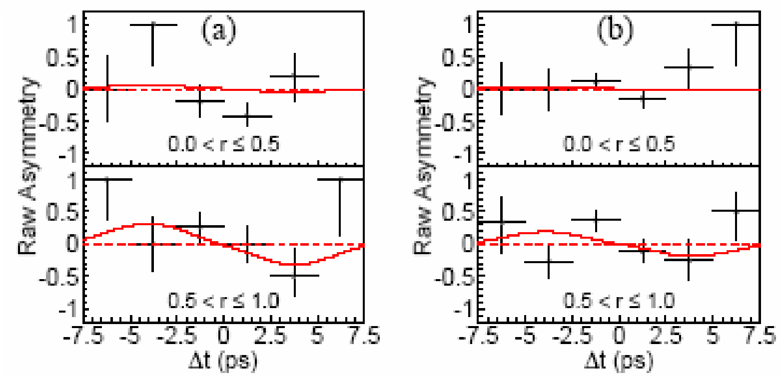
232×10^6 BB's





275 M BB's





$S_{K^*\gamma}$ =-0.21 +/- 0.40 +/- 0.05

$C_{K^*\gamma}$ = -0.40 +/- 0.23 +/- 0.04

$S_{K_S\pi^0\gamma}$ =-0.21 +/- 0.40 +/- 0.05

$C_{K\pi^0\gamma}$ = -0.40 +/- 0.23 +/- 0.03

HFAG Average:

S_{K^*g} =-0.13 +/- 0.32

C_{K^*g} = -0.31 +/0.19

$S_{K^*\gamma}$ =0.01 +/- 0.51 +/- 0.11

$C_{K^*\gamma}$ = -0.11 +/- 0.33 +/- 0.09

SM:S_{K^*g} ~ 0.1

Backup

Inclusive B->$X_s\gamma$: A_{CP}

- In SM A_{CP}(B->$X_s\gamma$) ~ <1%
  - Single phase dominant
  - GIM suppression
- BaBar: $A_{CP}^{BaBar}(\mathrm{b} \to s\gamma) \sim (25 \pm 50 \pm 15) \times 10^{-3}$ (sum of excl. modes)
- Belle: $A_{CP}^{Belle}(\mathrm{b} \to s\gamma) \sim (2 \pm 50 \pm 30) \times 10^{-3}$ (pseudo reconstruction)
- In SM A_{CP}(B->$X_{s+d}\gamma$) ~ 10^{-9}
  - Unitarity of CKM matrix
- BaBar: $A_{CP}^{BaBar}(b \to (s+d)\gamma) = -0.110 \pm 0.115 \pm 0.017$
  - [? I need find a reference for this ?]

Rate measurements