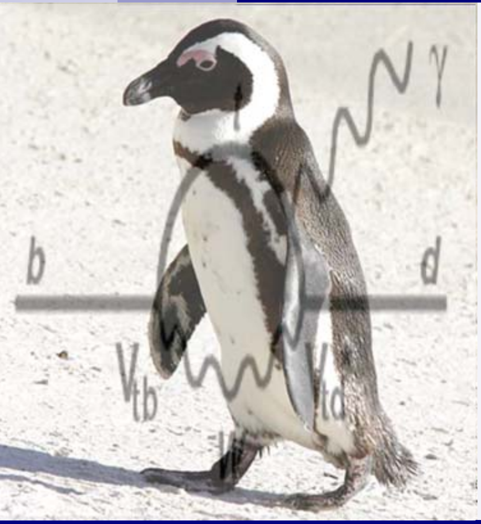
Experimental HEP Seminar
University of California at Davis
Davis, CA, February 17, 2009

BaBar

B Factory Measurements of the $b \rightarrow s(d)\,\gamma$ “Radiative Penguin” Transition Rates



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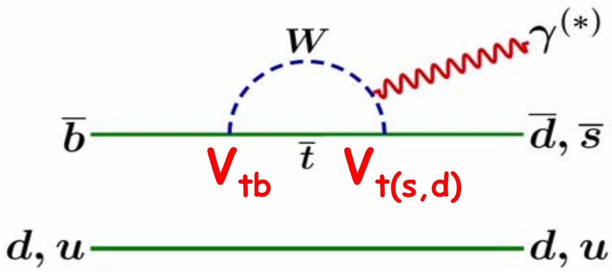
Outline

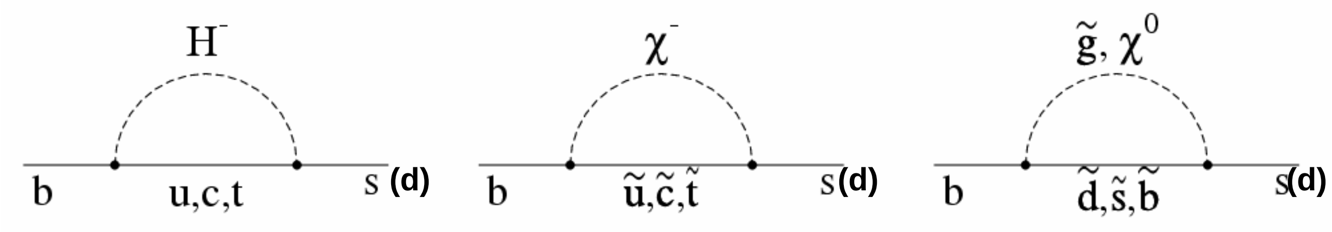
- Effective Neutral Currents: General Motivation
- $b \rightarrow s\gamma$ Penguins
  - SUSY parameter space implications
  - $b \rightarrow s\gamma$ "Inclusive" approach
  - $B \rightarrow X_S\gamma$ "Semi-Inclusive" approach
- $b \rightarrow d\gamma$ Penguins and $|V_{td}/V_{ts}|$
  - Motivation
  - $B \rightarrow (\rho,\omega)\gamma$ "Exclusive" approach
  - $B \rightarrow X_d$ "Semi-Inclusive" approach
  - Status of $|V_{td}/V_{ts}|$
- Conclusions

Effective Neutral Currents and Radiative Penguins

The SM $b \to s(d)\,\gamma$ transition is high order (two weak plus one EM vertex) …



so new physics can enter at leading order:



+ photon off any charged leg

Although rare (~ $5\text{x}10^{-4}$ for $s\gamma$ and ~10^{-5} for $d\gamma$), the isolated high-energy photon is a powerful signature.

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- $b \to s\gamma$
  - SUSY parameter space implications
  - Inclusive approach
  - Other approaches
- $b \to d\gamma$ and $|V_{td}/V_{ts}|$
  - Motivation
  - $B \to (\rho,\omega)\gamma$ ("Standard" Approach)
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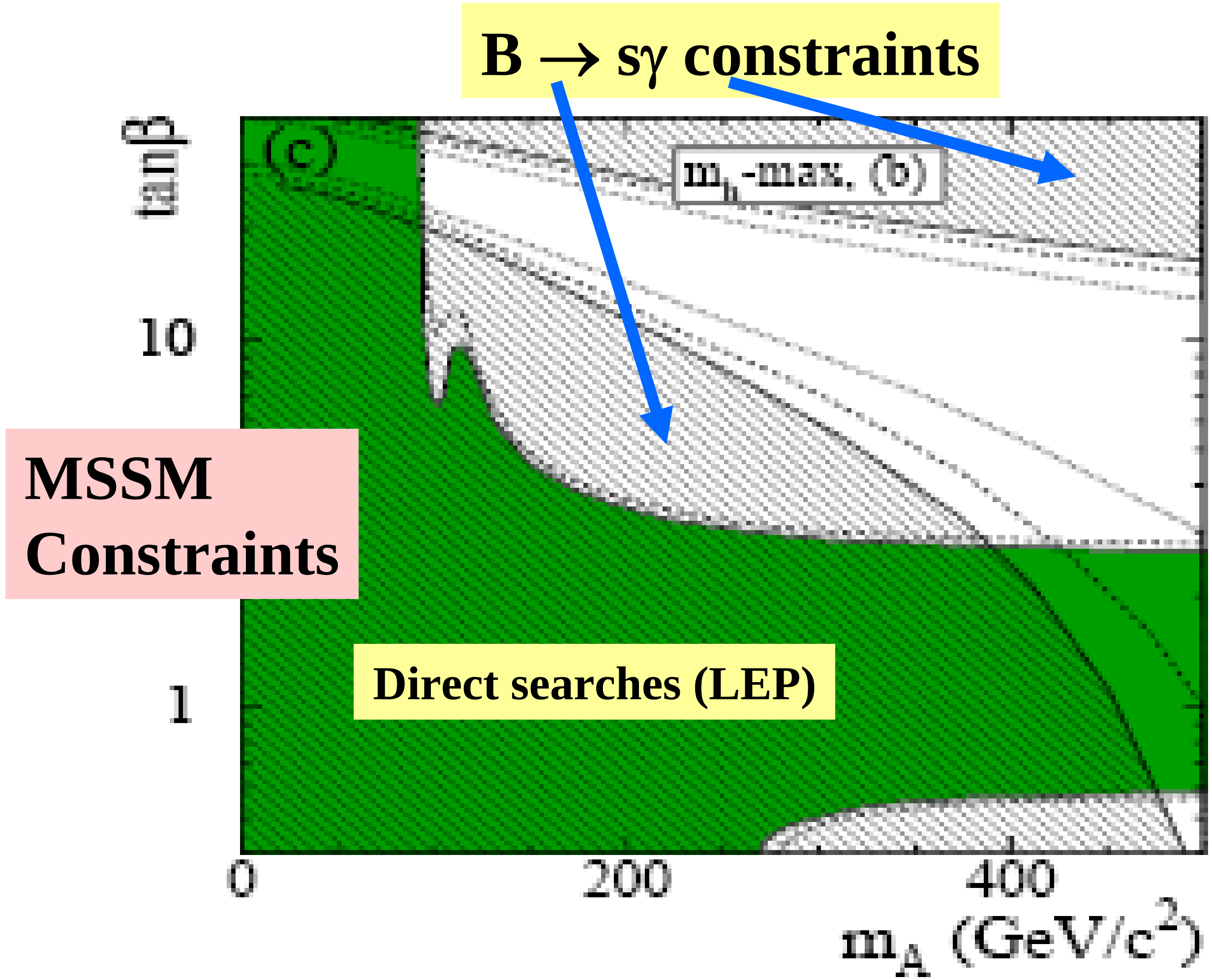
$B \to s\gamma$ and SUSY Parameter Space



$b \to s\gamma$ has a significant impact on the $\tan\beta$-m_A plane…

… on some of our favorite scenarios …

Fate of "Snowmass" MSSM study points

SPS1a	killed by b → sγ
SPS1a'	OK
SPS1b	killed by b → sγ
SPS2	killed by Ωh^2 (GUT) / OK(low)
SPS3	killed by Ωh^2 (low) / OK(GUT)
SPS4	killed by g-2
SPS5	killed by Ωh^2
SPS6	OK
SPS9	killed by Tevatron stable chargino

B → sγ and SUSY Parameter Space (cont'd)

… and just in general.

C.F. Berger, J.S. Gainer, J.L. Hewett, T.G. Rizzo, "Supersymmetry Without Prejudice", arXiv:0812.0980v1 [hep-ph]

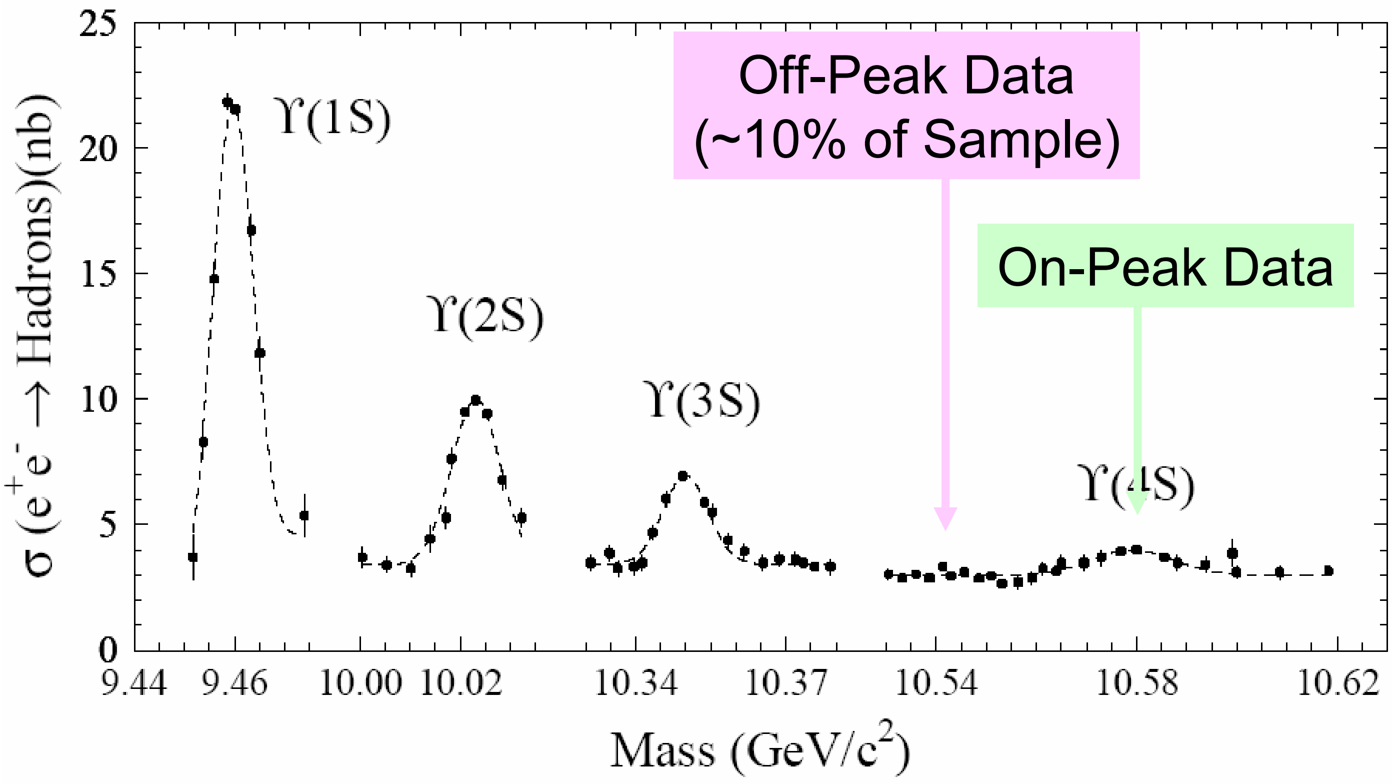
Explore 10^7 points over 19-dimensional parameter space of CP-conserving MSSM

b → sγ most effective constraint (72% of models surviving prior constraints are eliminated; better than direct searches for SUSY partners)

9999039	slha-okay.txt
7729165	error-okay.txt
3270330	lsp-okay.txt
3261059	deltaRho-okay.txt
2168599	gMinus2-okay.txt
617413	b2sGamma-okay.txt
594803	Bs2MuMu-okay.txt
592195	vacuum-okay.txt
582787	Bu2TauNu-okay.txt
471786	LEP-sparticle-okay.txt
471455	invisibleWidth-okay.txt
468539	susyhitProb-okay.txt
418503	stableParticle-okay.txt
418503	chargedHiggs-okay.txt
132877	directDetection-okay.txt
83662	neutralHiggs-okay.txt
73868	omega-okay.txt
73575	Bs2MuMu-2-okay.txt
72168	stableChargino-2-okay.txt
71976	triLepton-okay.txt
69518	jetMissing-okay.txt
68494	final-okay.txt

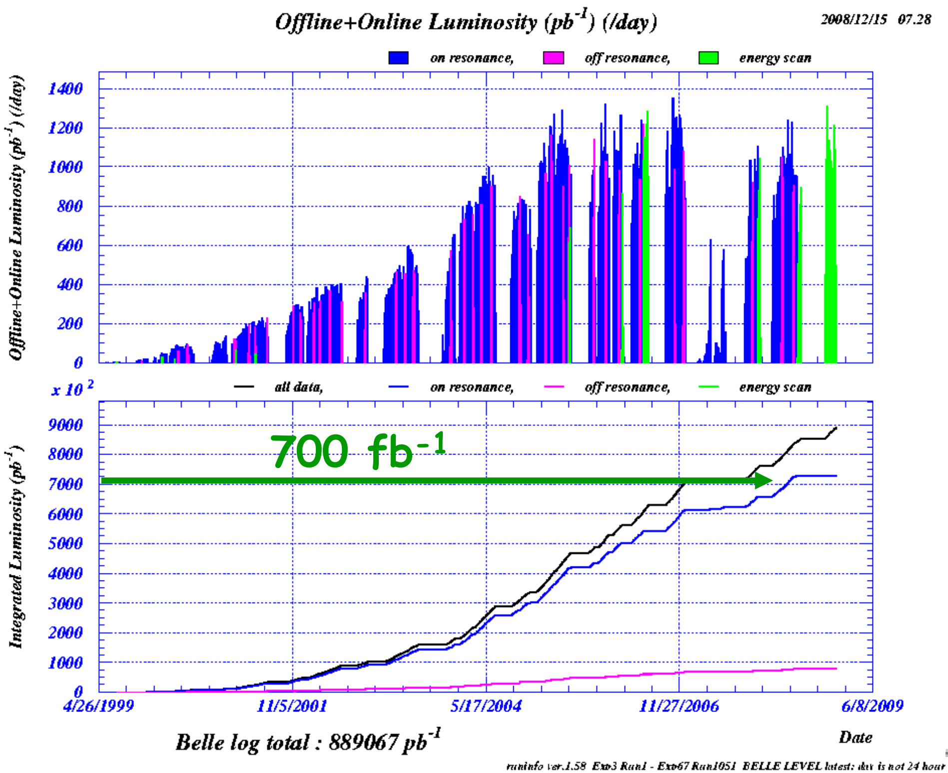
The e^+e^- Cross Section in the Upsilon Region

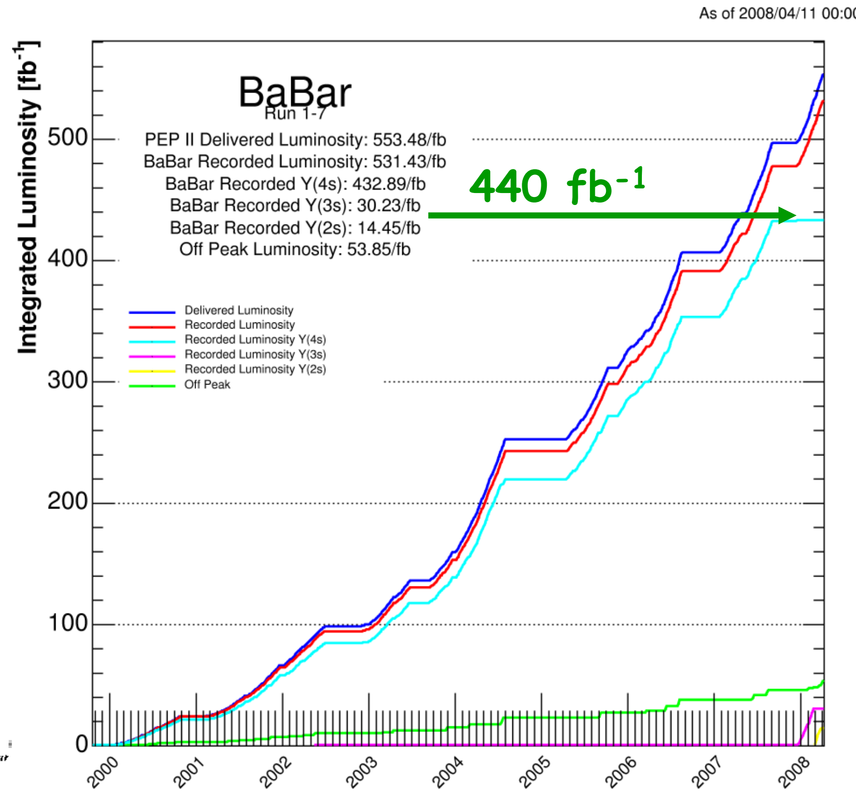
The $\Upsilon(4S)$ resonance is the lightest $b\bar{b}$ resonance that decays into "open Beauty" (B^+B^- or $B^0\overline{B}^0$)



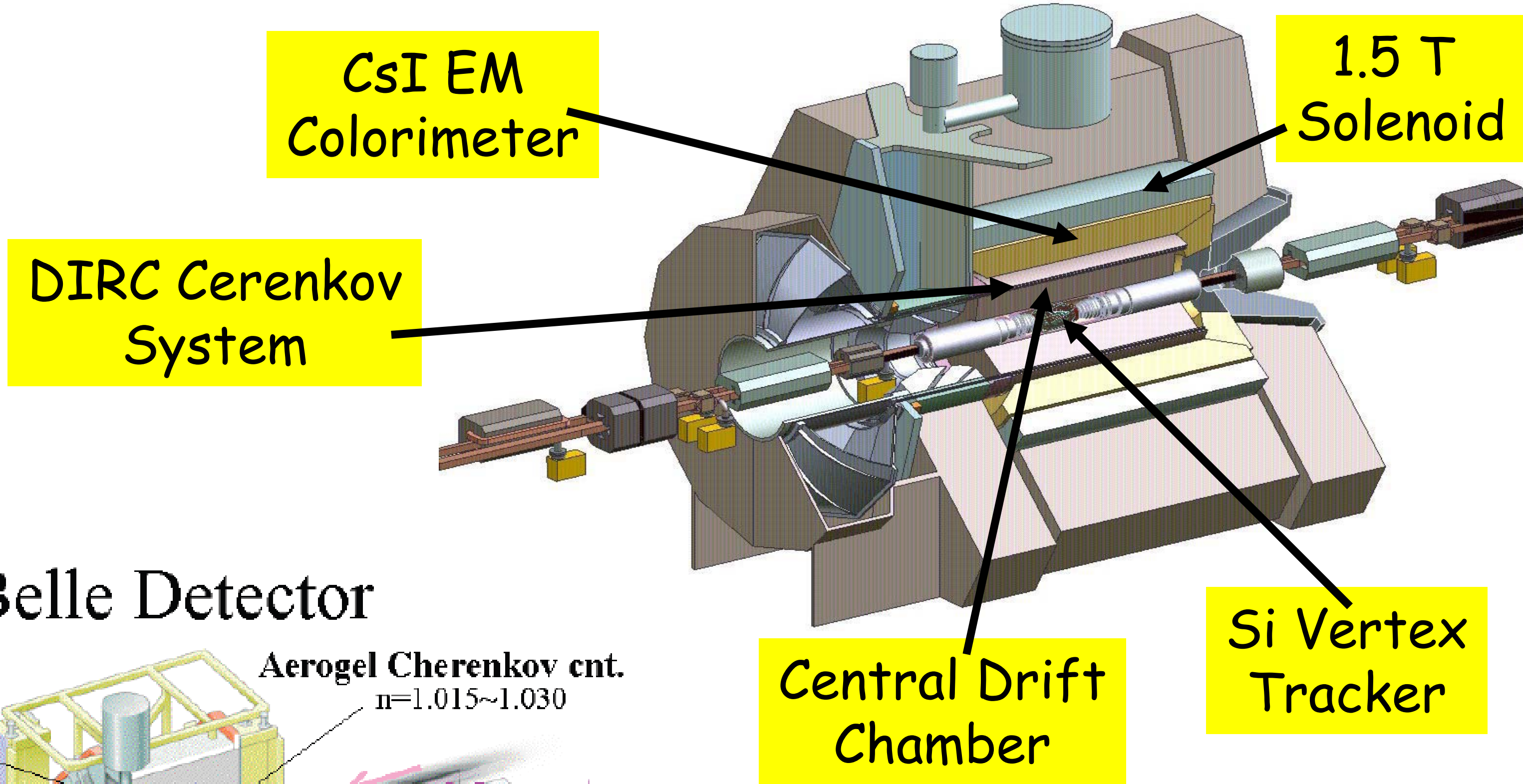
$\Upsilon(4S)$ resonance is ~1 nb at peak, competing with a "continuum" background of ~3 nb

B Factory Data Sets



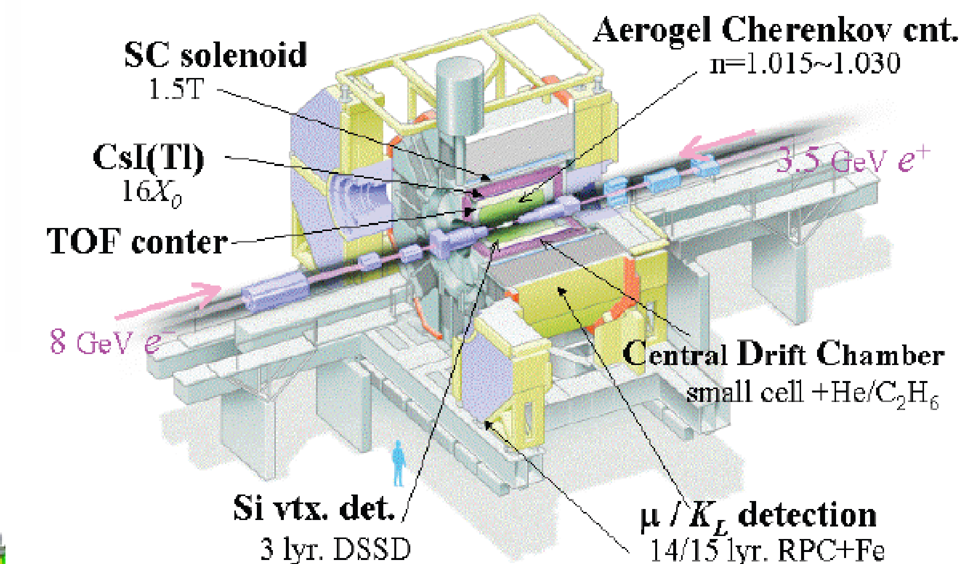


The Detectors

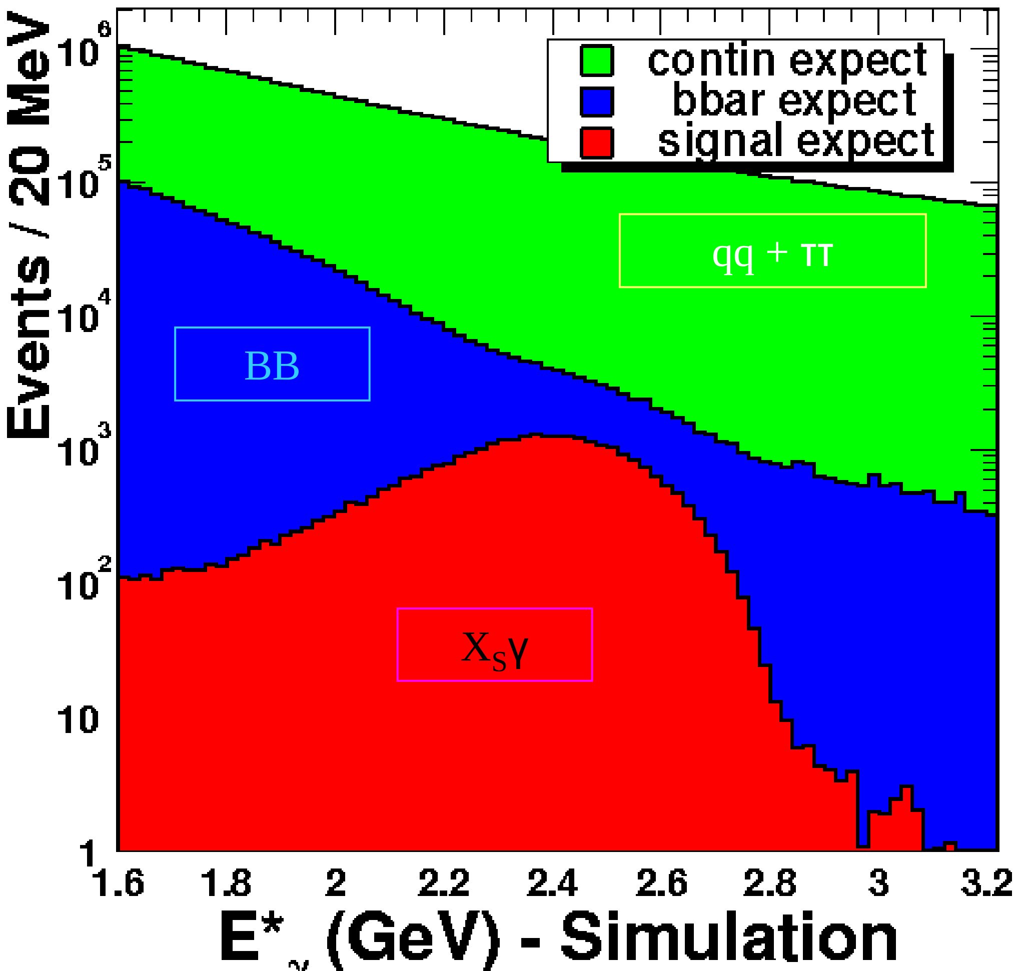


BaBar Detector

Belle Detector



Most exacting approach ("Inclusive") is aggressive:



Use only high-energy γ as signature

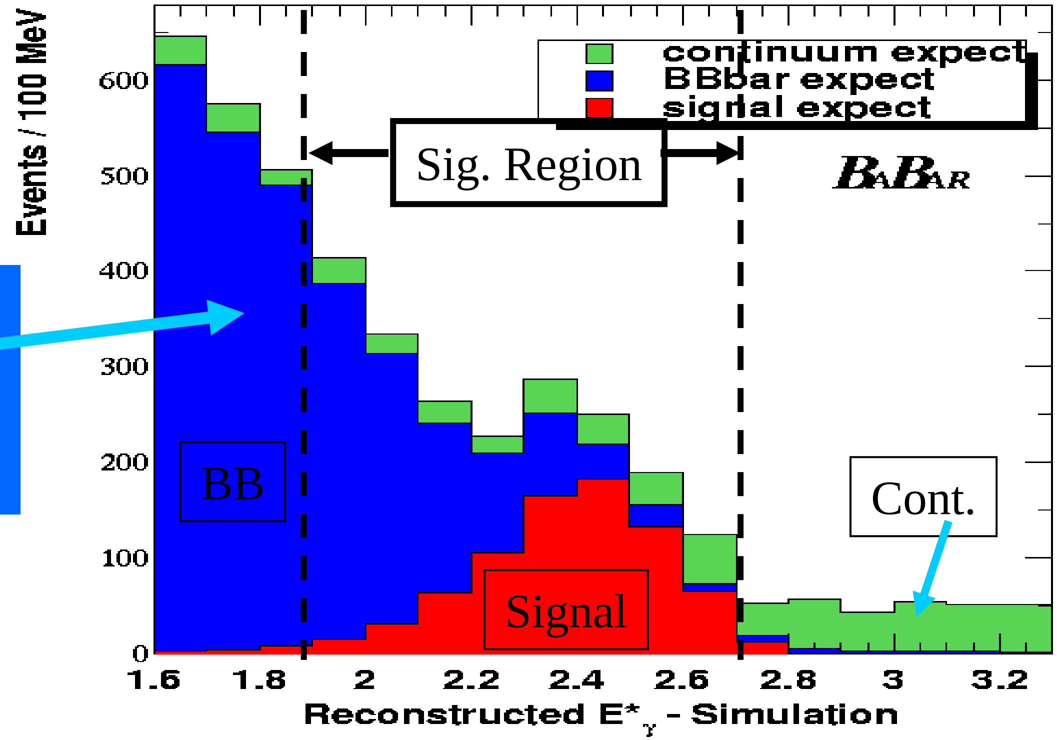
Suppress continuum with event shapes, requirement of a high-energy lepton.

Estimate remaining contribution by scaling off-peak data.

Challenge: background from $\pi^0(\eta) \rightarrow \gamma\gamma$ decays (plus some fakes) in B decays

Inclusive Measurement of b → sγ: Signal/Background

B/Bbar background control region



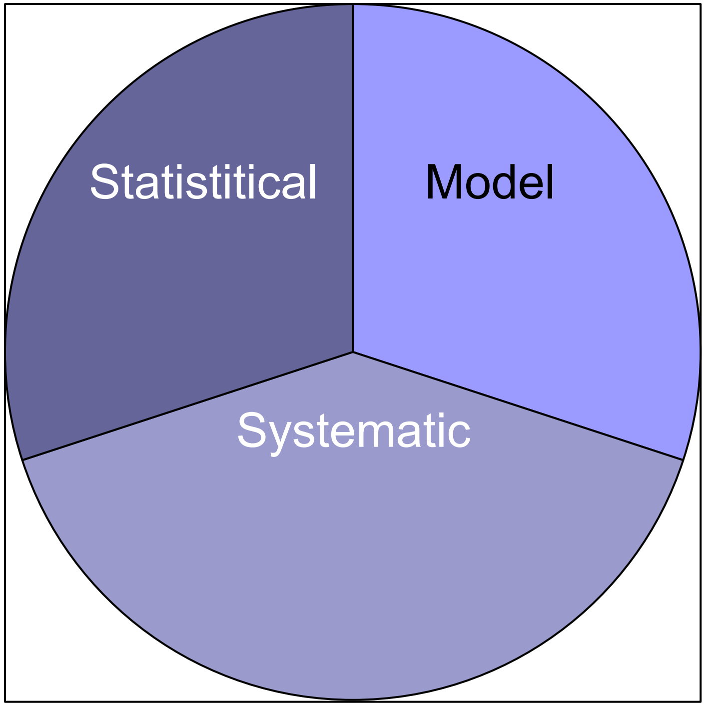
- After event selection, S/B is roughly 1:1
- Continuum measured from below-peak running
- B/Bbar backgrounds must be identified and constrained

Inclusive Measurement of $b \to s\gamma$: Challenges

BaBar result with 81.5 fb^{-1} (Phys. Rev. Lett. 97:171803,2006)

$$Br(B \to X_s \gamma) = (3.67 \pm 0.29 \pm 0.34 \pm 0.29)$$

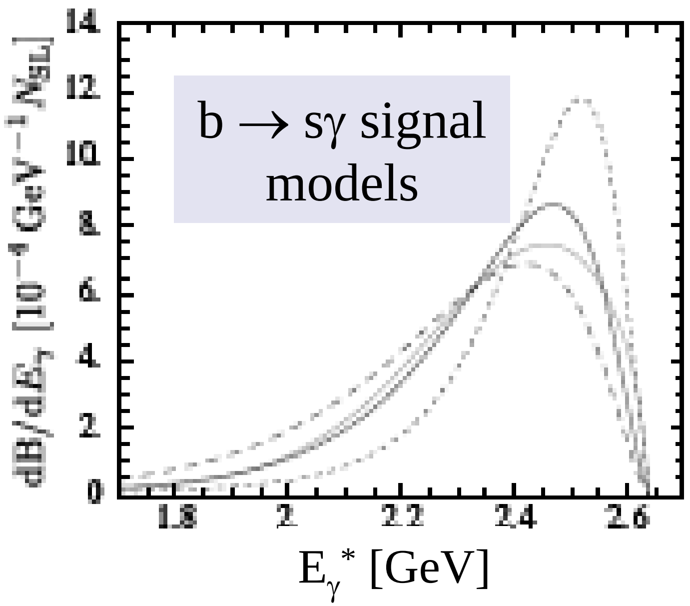
% of total Error

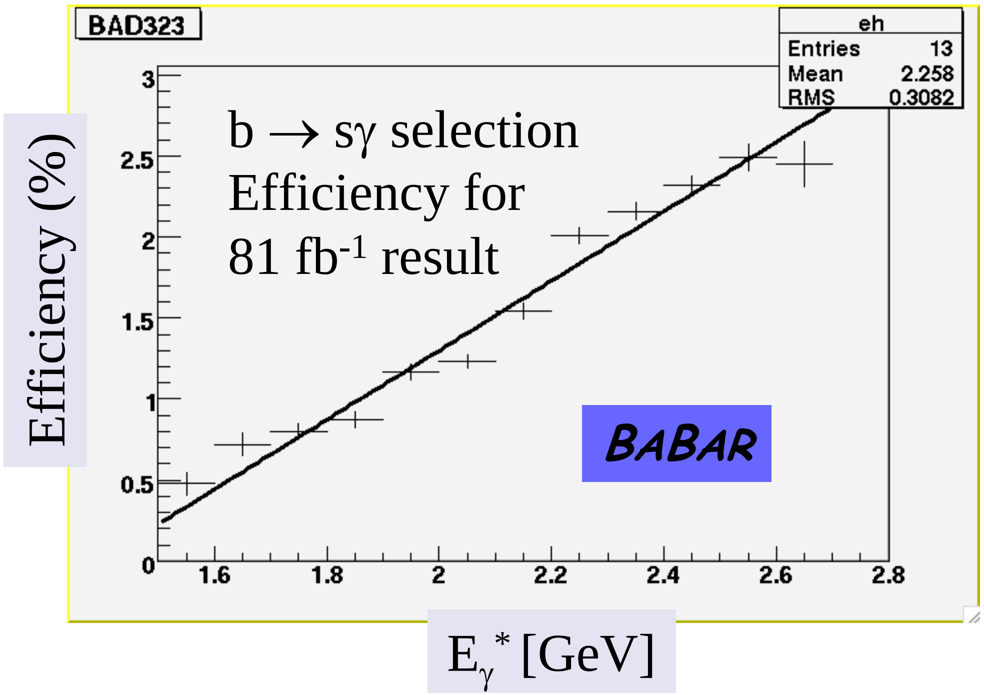


First round of B Factory results provide ~15% measurement of $b \to s\gamma$ transition rate

To exploit > 1 ab^{-1} sample, need to focus on reducing systematics

Model dependence arises through E_γ^* dependence of selection efficiency



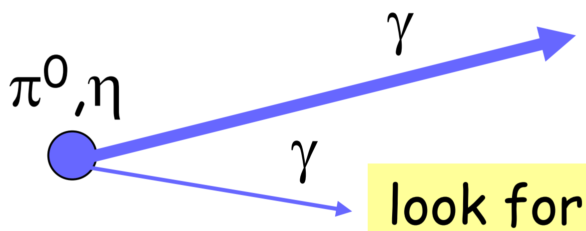


Engineer event selection to flatten efficiency (some loss of statistics) ➔reduce to < 3%

Sources of Remaining B/Bbar Background

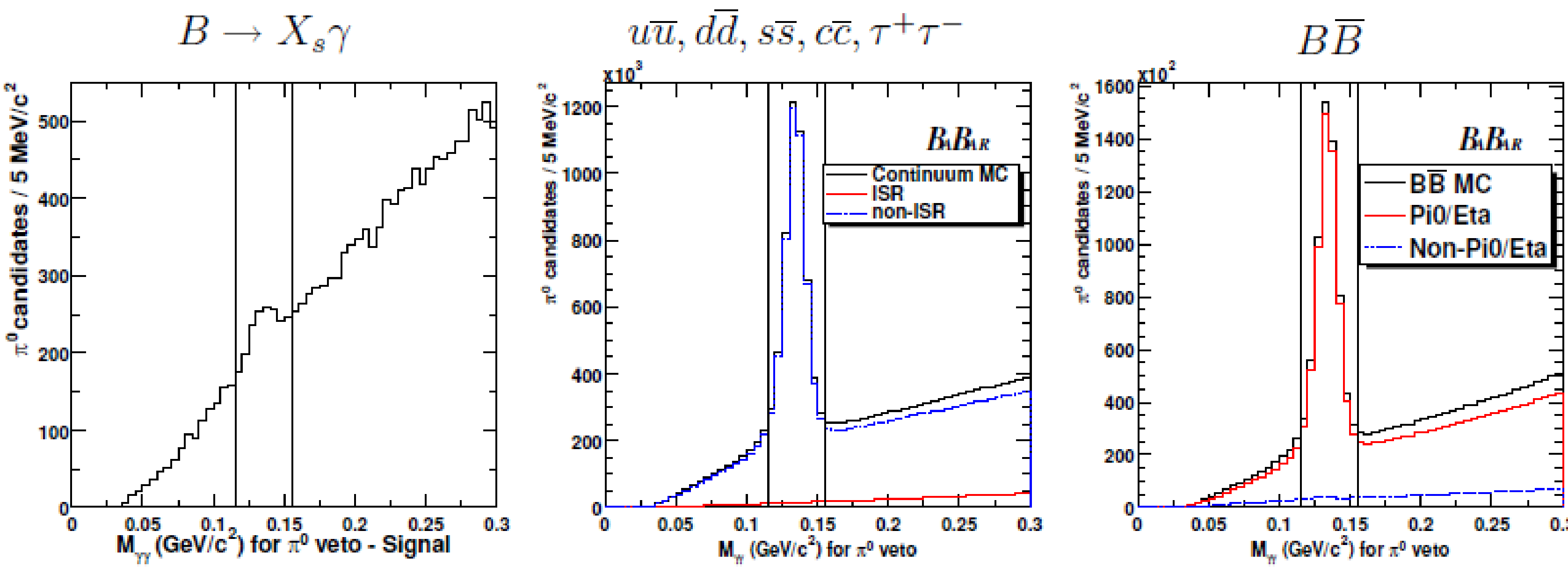
Object	Source	Control Region	Signal Region
γ	π^0	57.3%	66.6%
γ	η	17.1%	15.7%
γ	Other meson	8.7%	5.1%
γ	e	9.3%	4.7%
γ	Other	0.4%	0.4%
Total γ		**92.8%**	**92.4%**
e	Any	4.8%	3.7%
n/n_{bar}	Any	1.7%	2.9%
p^+/p^-	Any	0.0%	0.1%
π/K	Any	0.4%	0.8%
Total non- γ		**7.2%**	**7.6%**
Total		**100%**	**100%**

Inclusive Measurement of b → sγ: π^0,η Backgrounds



If high-energy γ passes selection, then

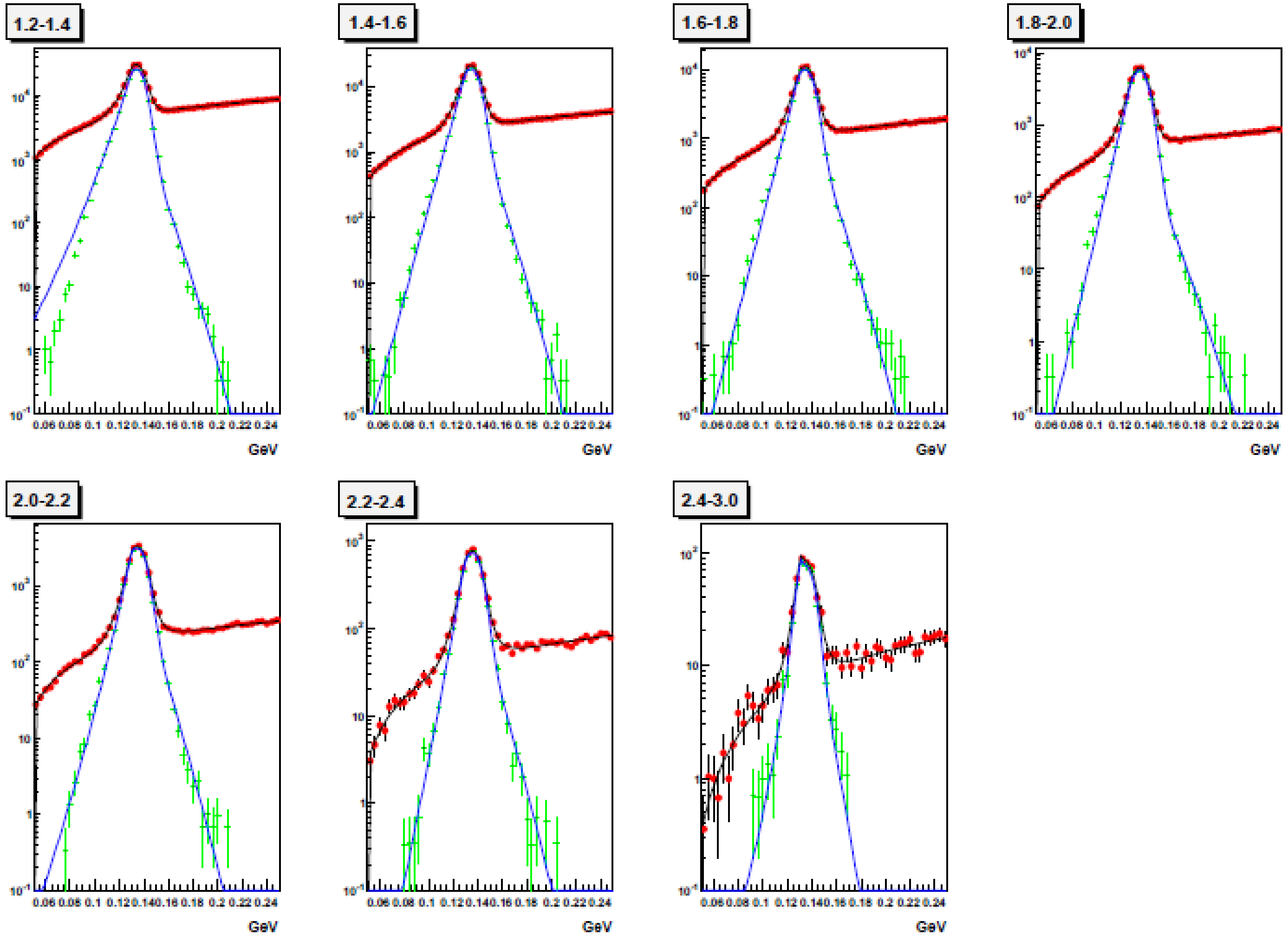
look for low-energy γ and veto event



But, ~50% of the time the low-energy photon is missing, or $M_{\gamma\gamma}$ falls outside the veto window

Inclusive Measurement of b → sγ: π^0,η Backgrounds

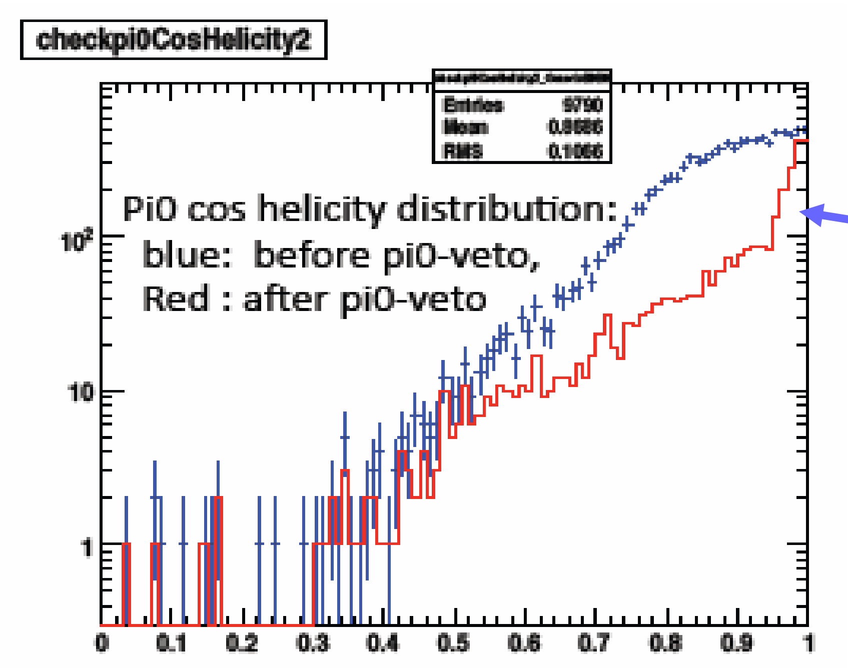
Basic Idea: Use measured $\pi^0(\eta)$ peak (as a function of $E_{\pi,\eta}$ to estimate production rate and $M_{\gamma\gamma}$ shape; lower high-energy E_γ cut to get more statistics.



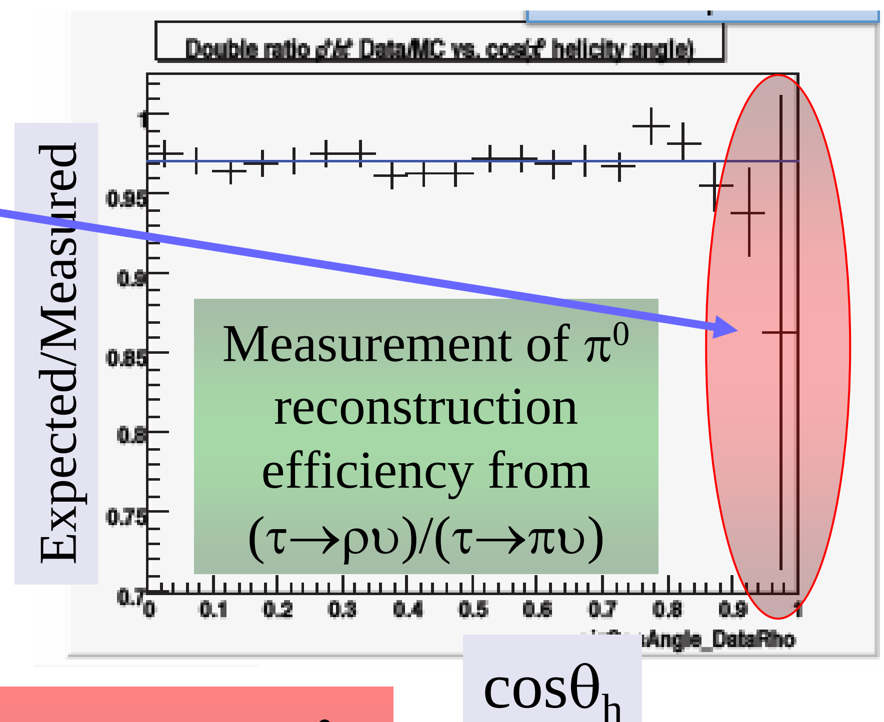
Define $\cos\theta_h \cong (E_{\gamma,high} - E_{\gamma,low})/ (E_{\gamma,high} + E_{\gamma,low})$ = energy asymmetry

Signal selection requirement of $E_\gamma^* > 1.8$ GeV pushes asymmetry up, and energy of 2nd photon down.

➔ Sensitive to reconstruction efficiency for 30-80 MeV photons.

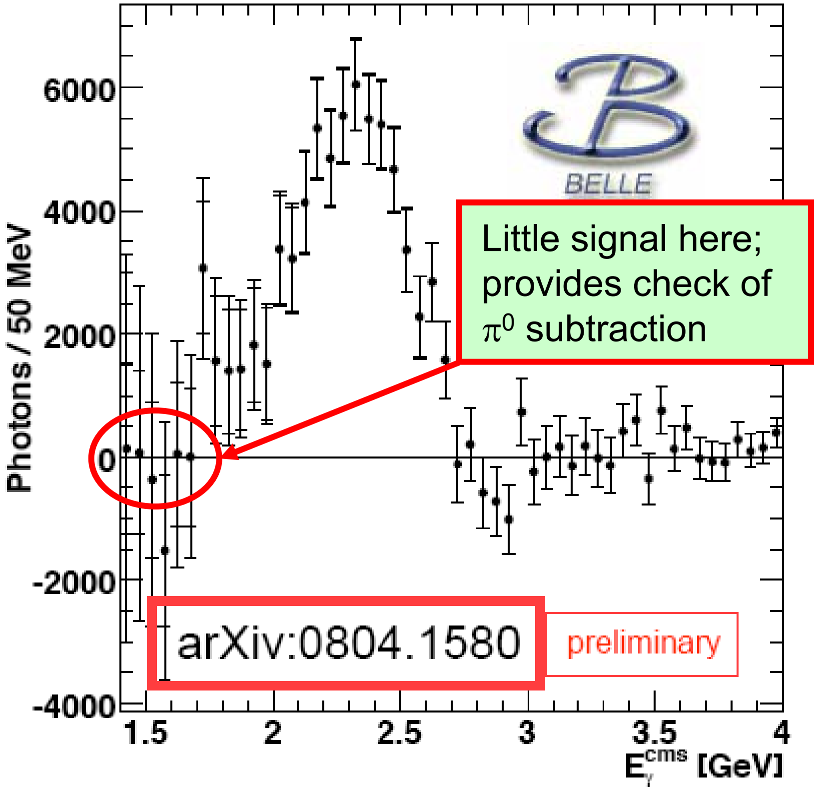


$\cos\theta_h$



Limiting Systematic

Inclusive Measurement of b → sγ: Practicalities



Most up-to-date result is from BELLE, with all 605 fb^{-1}

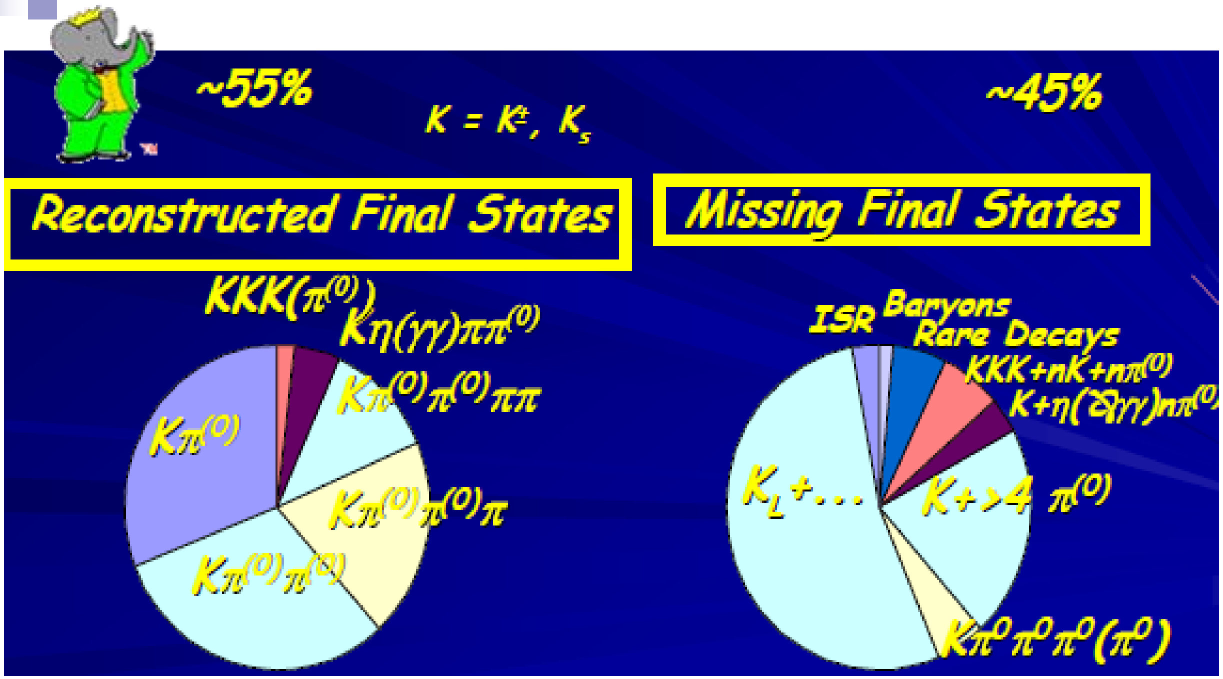
BaBar still working ideas to reduce B background errors, particularly from π^0,η contamination

BaBar goal is to get well below 10% in overall error

BELLE:	$(3.37\pm0.43)\times10^{-4}$	arXiv:0804.1580	605 fb^{-1}
BaBar:	$(3.92\pm0.56)\times10^{-4}$	PRL97,171803	82 fb^{-1}

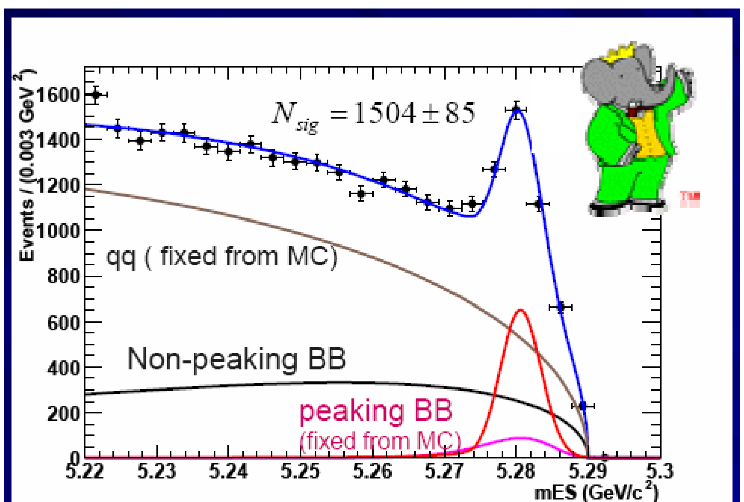
NOTE: Measurements scaled to E_γ^{cms} > 1.6 GeV

b → s γ Via a Sum of Exclusive Final States (BaBar)

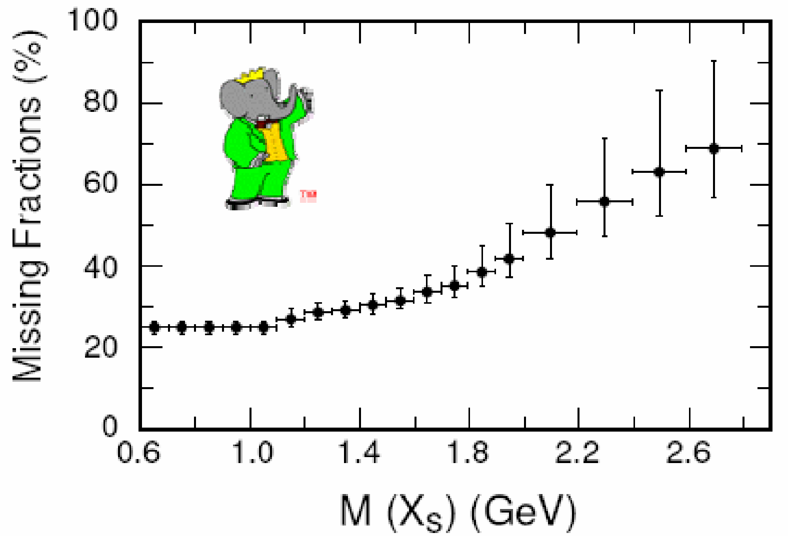


Reconstruct a total of 38 exclusive $b \rightarrow s\gamma$ final states that comprise about 55% of the total width

Fit to reconstructed mass of exclusive final state to determine signal yield

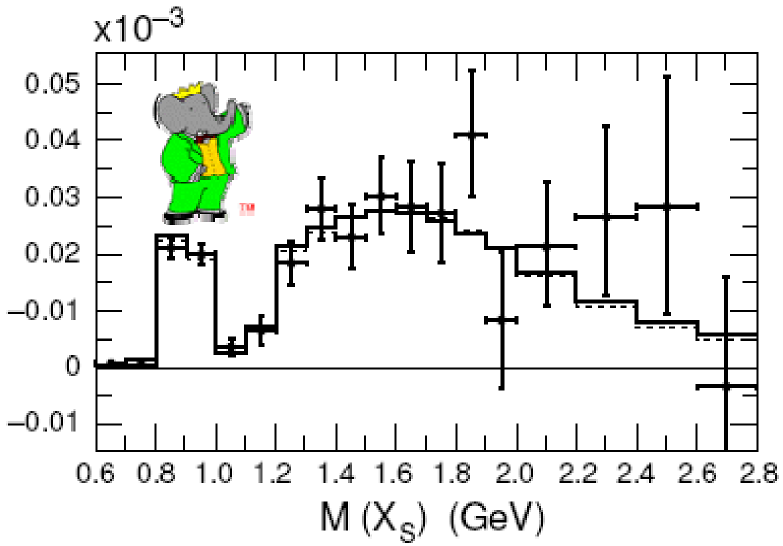


This "Semi-Inclusive" approaches employs a fit to the mass distribution, for which backgrounds tend to be self-calibrating…



But need to rely on models to correct for the 45% of states that are not measured (depends on mass M(X_s) that photon recoils against).

Mass Recoiling Against γ



RESULT

$BF(B \to s\gamma) = (3.49 \pm 0.57) \times 10^{-4}$

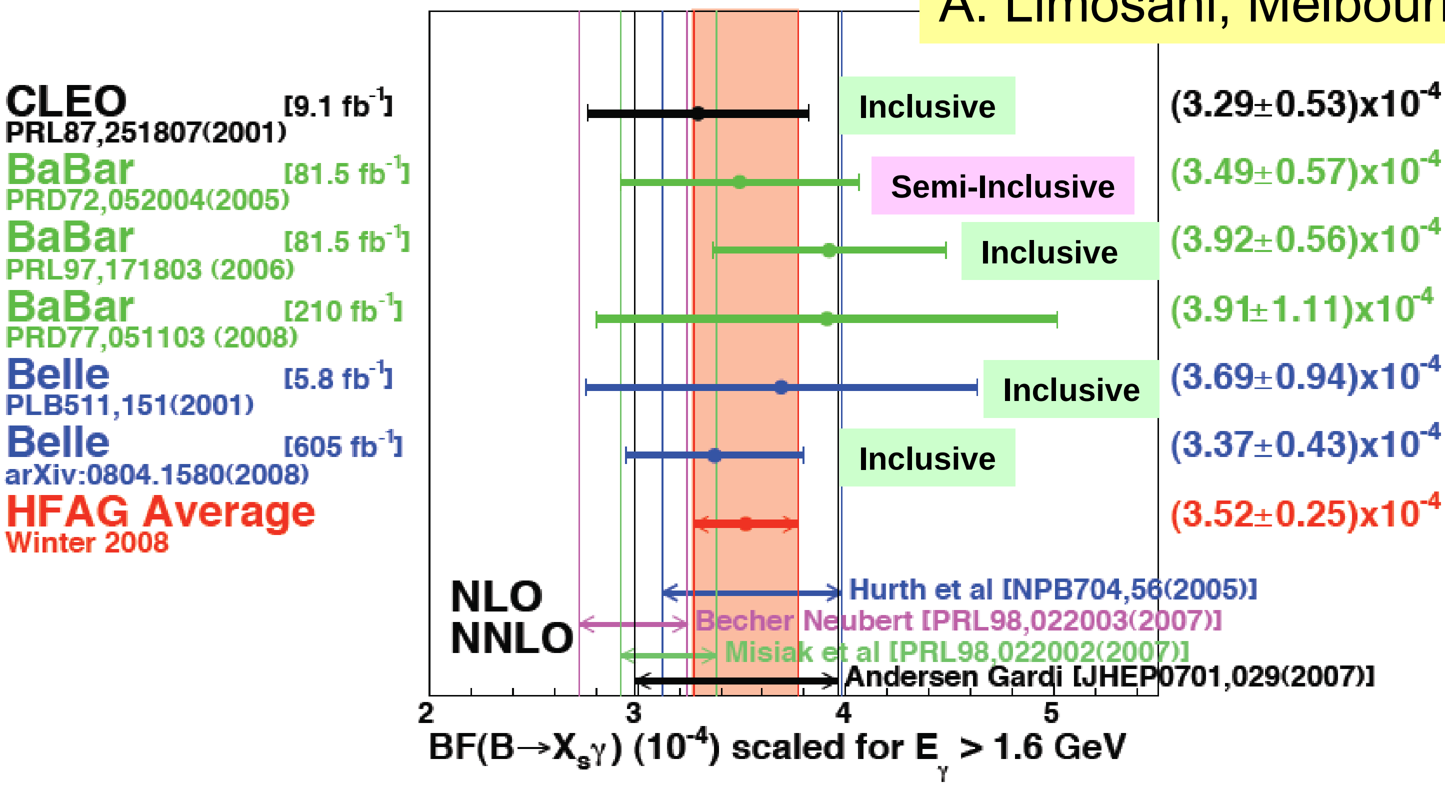
PRD72:052004

- 82 fb^{-1} analyzed is less than 10% of world sample
- Has systematics independent of those of inclusive approach

Summary of Measurements of the $b \to s\gamma$ Rate

Experimental accuracy commensurate with theoretical control, but work continue on both ends

A. Limosani, Melbourne



Most of BaBar data set still unanalyzed

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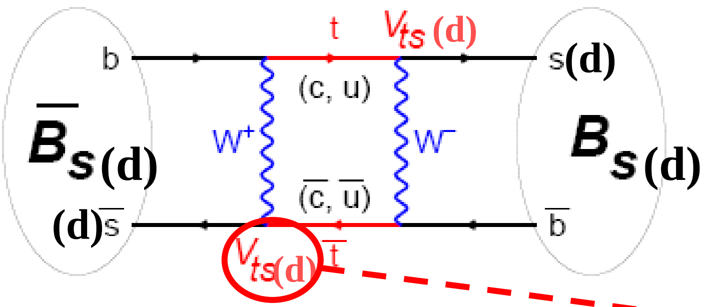
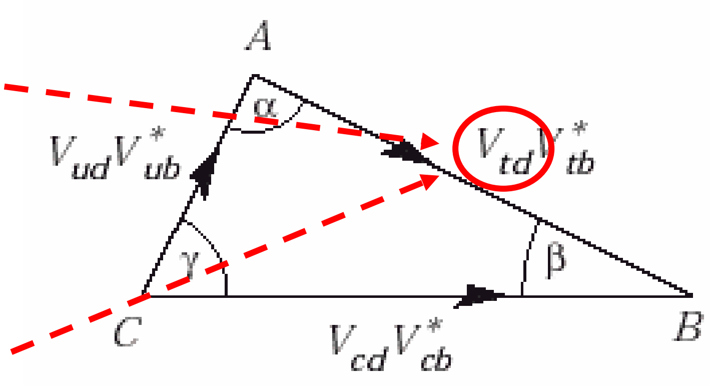
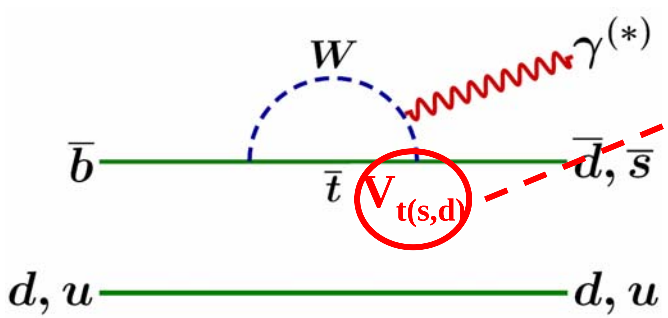
Measuring $|V_{td}/V_{ts}|$

Two independent diagrams provide sensitivity to CKM parameter V_{td}



B Mixing





Radiative Penguins

Note: In both cases, hadronic uncertainties minimized by comparing to corresponding V_{ts} process (B_s mixing, $b \to s\gamma$)

➔ Observable is $|V_{td} / V_{ts}|$

$|V_{td}/V_{ts}|$ from Penguins: Motivation

ICHEP '08 B Mixing Results [Farrington(CDF), Moulik(D0), averaged by DeLodovico(BaBar)]:

$$|V_{td}|/|V_{ts}| = 0.207 \pm 0.001_{exp} \pm 0.006_{theo}$$

How do penguins fit into the picture?

Mixing:	$x_d = \Delta m_B/\Gamma_B \sim 1$	➔	$\Delta m_B \sim \Gamma_B$
Penguins:	$Br(b \to d\gamma) \sim 10^{-5}$	➔	$\Gamma_{d\gamma} \sim \mathbf{10^{-5}}\,\Gamma_B$

SM effects suppressed by 10^{-5} relative to mixing

Furthermore (Ali, Asatrian, Greub, Phys. Lett B **429**, 87):

> *"These [b → dγ] vertices are CKM-suppressed in the standard model, but new physics contributions may not follow the CKM pattern in flavor-changing-neutral-current transitions and hence new physics effects may become more easily discernible in $B \to X_d + \gamma$ (and its charge conjugate) than in the corresponding CKM-allowed vertices $b \to s\gamma$ and $b \to sg$"*

With $|V_{td}/V_{ts}|$ precisely constrained by mixing, $b \to d\gamma$ is a compelling testbed for new physics.

Exclusive Approach: $B \to \rho(\omega)\,\gamma$

Standard ("Exclusive") Approach: measure exclusive rate $Br(B \to \rho(\omega)\,\gamma)$; normalize with $Br(B \to K^{*}\,\gamma)$

isopin factor: 1(.5) for $\rho^{\pm}(\rho^{0})$(and ω)

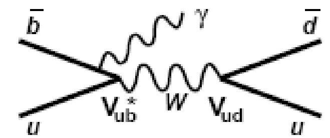
form factor ratio

$$\frac{\mathcal{B}(B \to \rho\gamma)}{\mathcal{B}(B \to K^{*}\gamma)} = S_{\rho}\left|\frac{V_{td}}{V_{ts}}\right|^{2}\left(\frac{1-m_{\rho}^{2}/M_{B}^{2}}{1-m_{K^{*}}^{2}/M_{B}^{2})}\right)^{3}\zeta^{2}[1+\Delta R]$$

well measured

annihilation amplitude corrections

Annihilation Diagram



Values of ς^{2} and ΔR are available from

Ali, Parkhomenko, arXiv:hep-ph/0610149

Ball, Zwicky, J. High. Energy Phys. 0604, 046 (2006); Ball, Jones, Zwicky, Phys. Rev. D 75 054004 (2007)

at approximately 8% overall accuracy.

Measurement of $B(B \to \rho(\omega)\gamma)$

Belle: New result this Spring

351 fb^{-1} (2006) ➔ 598 fb^{-1} (April 2008)

BaBar: New result this Summer

316 fb^{-1} (April 2007) ➔ 423 fb^{-1} (July 2008)

Challenge: BRs are small ($<10^{-6}$); backgrounds are high

- continuum — Multi-variate rejection with event shape, B tagging information, …
- $B \to K^*\gamma$; $K^* \to K\pi$ — Require excellent particle ID
- $B \to (\rho^{\pm,0},\omega)(\pi^0,\eta)$ — Veto if γ found such that $M_{\gamma\gamma} \sim M_{(\pi,\eta)}$

Measurement of $\mathcal{B}(B \to \rho(\omega)\,\gamma)$ (continued)

Remaining separation achieved by two-dimensional fit to the largely independent kinematic variables

$$M_{ES} = \sqrt{E^{*2}_{beam} - p^{*2}_{B}}$$

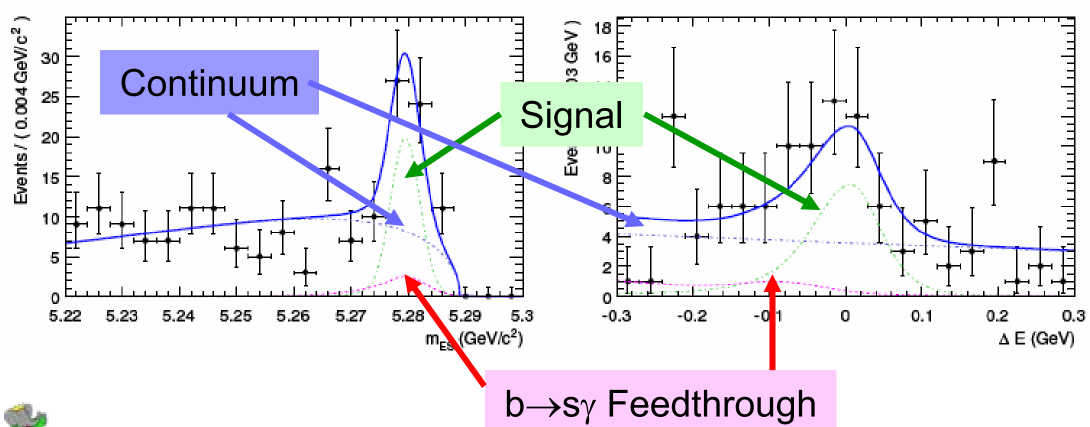
"Energy-substituted mass"; since $E_{beam} \sim M_B$, largely a measurement of momentum balance

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

$E_B = E_{beam}$ for properly reconstructed candidate; total energy measurement

*In e^+e^- CMS frame

Example: BaBar $B^0 \to \rho^0 \gamma$



- "self-calibrating" continuum background subtraction
- efficiencies (~5-15%) estimated with control samples

Recent Updates of $B \to \rho(\omega)\gamma$

BELLE: ➔ 598 fb^{-1}

Phys.Rev.Lett.101:111801,2008, Erratum-ibid.101:129904,2008

Mode	Belle '06 ($\times 10^{-7}$)	Belle '08 ($\times 10^{-7}$)
$\rho^+\gamma$	$5.5^{+4.2}_{-3.6}{}^{+0.9}_{-0.8}$	$8.7^{+2.9}_{-2.7}{}^{+0.9}_{-1.1}$
$\rho^0\gamma$	$12.5^{+3.7}_{-3.3}{}^{+0.7}_{-0.6}$	$7.8^{+1.7}_{-1.6}{}^{+0.9}_{-1.0}$
$\omega\gamma$	$5.6^{+3.4}_{-2.7}{}^{+0.5}_{-1.0}$	$4.0^{+1.9}_{-1.7} \pm 1.3$

BaBar: ➔ 423 fb^{-1}

Phys.Rev.D78:112001,2008

Mode	BaBar '07 ($\times 10^{-7}$)	BaBar '08 ($\times 10^{-7}$)
$\rho^+\gamma$	$11.0^{+3.7}_{-3.3} \pm 0.9$	$12.0^{+4.2}_{-3.7} \pm 2.0$
$\rho^0\gamma$	$7.9^{+2.2}_{-2.0} \pm 0.6$	$9.7^{+2.4}_{-2.2} \pm 0.6$
$\omega\gamma$	$4.0^{+2.4}_{-2.0} \pm 0.5$	$5.0^{+2.7}_{-2.3} \pm 0.9$

Isopsin-Averaged Branching Fractions

Assuming $SU_3(F)$ symmetry [$B(B\to\rho^0\gamma) \sim B(B\to\omega\gamma)$] and

$$|\rho^0\rangle = \frac{1}{\sqrt{2}}\left(|u\bar{u}\rangle - |d\bar{d}\rangle\right) \qquad |\omega\rangle = \frac{1}{\sqrt{2}}\left(|u\bar{u}\rangle + |d\bar{d}\rangle\right)$$

(approximately true by static quark model) we can write

$$\Gamma(B^+ \to \rho^+\gamma) = 2\Gamma(B^0 \to \rho^0\gamma) = 2\Gamma(B^0 \to \omega\gamma)$$

from which it follows

$$\mathrm{B}[B \to (\rho,\omega)\gamma] \equiv \frac{1}{2}\left\{\mathrm{B}(B^+ \to \rho^+\gamma) + \frac{\tau_{B^+}}{\tau_{B^0}}\left[\mathrm{B}(B^0 \to \rho^0\gamma) + B(B^0 \to \omega\gamma)\right]\right\}$$

➔ Can combine ρ^+, ρ^0, ω results to derive $|V_{td}/V_{ts}|$ from

$$\frac{\mathrm{B}(B \to (\rho,\omega)\gamma)}{\mathrm{B}(B \to K^*\gamma)} = \left|\frac{V_{td}}{V_{ts}}\right|^2 \left(\frac{1 - m_\rho^2 / M_B^2}{1 - m_{K^*}^2 / M_B^2}\right) \varsigma^2 \left[1 + \Delta R\right]$$

$|V_{td}/V_{ts}|$ from Exclusive (ρ,ω) Decays

Assuming static quark model, $SU(3)_F$ symmetry, can combine to get "isospin-averaged" BF, and then $|V_{td}/V_{ts}|$:

BELLE:

$$\mathrm{B}(B \to (\rho,\omega)\gamma) = (11.4 \pm 2.0^{+1.0}_{-1.2}) \times 10^{-7}$$ yielding

$$|V_{td}/V_{ts}| = 0.195^{+0.020}_{-0.019} \pm 0.015$$

BELLE

Phys.Rev.Lett.101:111801,2008, Erratum-ibid.101:129904,2008

BaBar:

$$\mathrm{B}(B \to (\rho,\omega)\gamma) = (16.3^{+3.0}_{-2.8} \pm 1.6) \times 10^{-7}$$ yielding

$$|V_{td}/V_{ts}| = 0.233^{+0.025}_{-0.024}{}^{+0.022}_{-0.021}$$

Phys.Rev.D78:112001,2008

assuming the world-average $\mathrm{B}(B \to K^*\gamma) = (4.16 \pm 0.17) \times 10^{-5}$

Combining, for exclusive radiative decay overall:

$$|V_{td}/V_{ts}| = 0.210 \pm 0.015 \pm 0.018$$

Semi-Inclusive Approach: $B \rightarrow X_d\, \gamma$ (Preliminary)

"New" Approach (BaBar): Reconstruct seven exclusive final states $X_d\gamma$ in range $0.6\ GeV/c^2 < M_{Xd} < 1.8\ GeV/c^2$

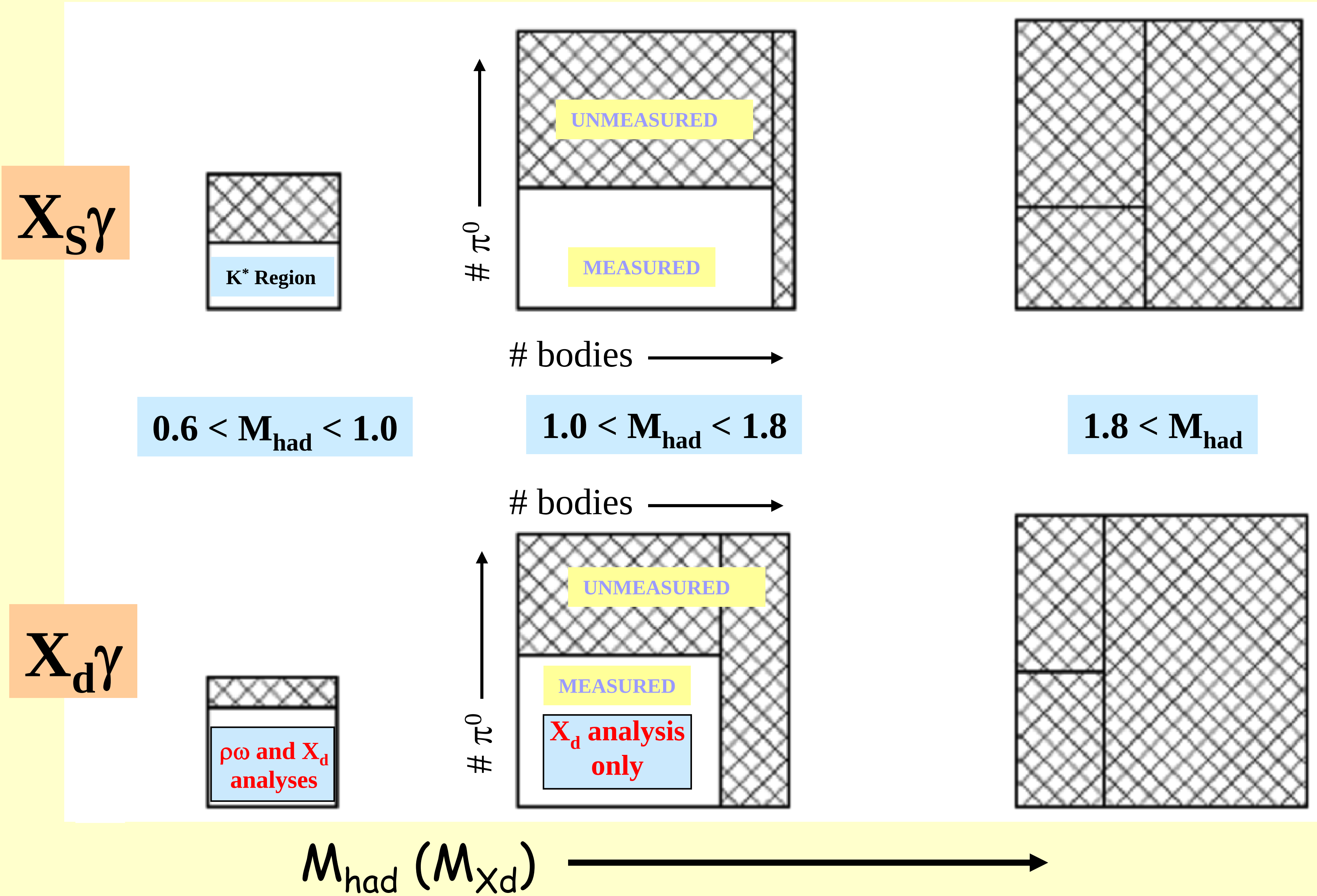
iType	X_s	X_d
1	$K^+\pi^-\gamma$	$\pi^+\pi^-\gamma$
2	$K^+\pi^0\gamma$	$\pi^+\pi^0\gamma$
3	$K^+\pi^-\pi^+\gamma$	$\pi^+\pi^-\pi^+\gamma$
4	$K^+\pi^-\pi^0\gamma$	$\pi^+\pi^-\pi^0\gamma$
6	$K^+\pi^-\pi^+\pi^-\gamma$	$\pi^+\pi^-\pi^+\pi^-\gamma$
7	$K^+\pi^-\pi^+\pi^0\gamma$	$\pi^+\pi^-\pi^+\pi^0\gamma$
9	$K^+\eta^0\gamma$	$\pi^+\eta^0\gamma$

$|V_{td}/V_{ts}|^2$ related to $\Gamma(b \rightarrow d\gamma)/\Gamma(b \rightarrow s\gamma)$ with ~1% theoretical uncertainty [**Ali, Asatrian, Greub, Phys. Lett. B 429, 87 (1998)**]

However, must correct for unmeasured regions:

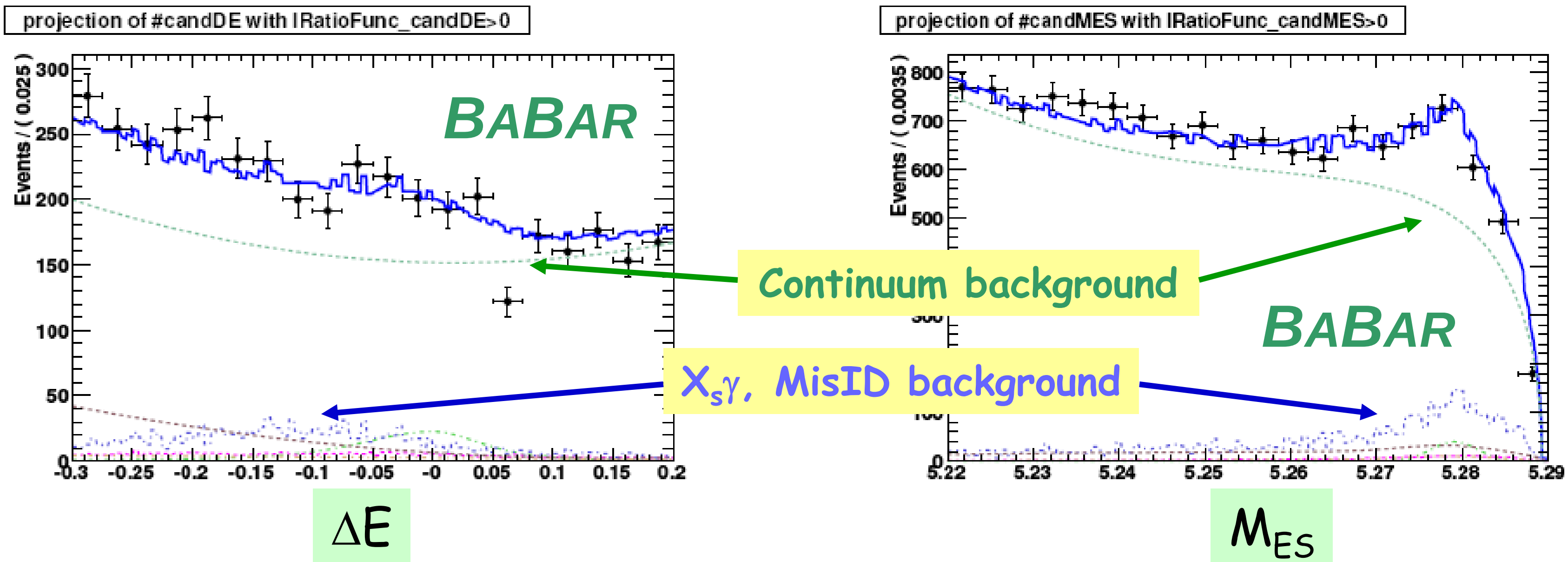
- Higher-multiplicity final states
- Higher-mass hadronic component (i.e. $M_{Xd} > 1.8\ GeV/c^2$)

Measured Regions for B → $X_{d(s)}\gamma$



$B \to X_{(s,d)}\,\gamma$ Partial Branching Fraction Results

Fit in high-mass $X_d\,\gamma$ region $1.0 < M_{had} < 1.6$ GeV/c^2



Yields and partial branching fractions:

Mode	Mass Range	Yield	Efficiency	Partial B. F. ($\times 10^{-6}$)
$b \to s\gamma$	$0.6 < M_{X_s} < 1.0$	1543 ± 46	8.5%	$23.7 \pm 0.7 \pm 1.7$
$b \to s\gamma$	$1.0 < M_{X_s} < 1.8$	2279 ± 75	6.1%	$48.7 \pm 1.6 \pm 4.1$
$b \to d\gamma$	$0.6 < M_{X_d} < 1.0$	66 ± 26	7.0%	$1.2 \pm 0.5 \pm 0.1$
$b \to d\gamma$	$1.0 < M_{X_d} < 1.8$	107 ± 47	5.2%	$2.7 \pm 1.2 \pm 0.4$

High-mass $b \to X_d\,\gamma$

PRELIMINARY

$B \to X_{(d,s)}\gamma$: Correction for Missing Modes

MC Simulation

- Two-body $X_{s(d)}\gamma$ decay; mass spectrum of $X_{s(d)}$ system given by Kagan-Neubert model

  A.L. Kagan, M. Neubert, Phys. Rev. D **58**, 094012 (1998)

- Fragment X_s system via prior experimental constraint
- Fragment X_d system via phase space

Missing modes with $0.6 < M_X < 1.0$

- MC suggests this region is dominated by resonaces (ρ and ω); confirmed by K^* dominance of $B \to X_s\gamma$
- Correction for missing modes well understood

$B \rightarrow X_{(d,s)}\gamma$: Correction for Missing Modes

Missing Modes with $1.0 < M_X < 1.8$

• Force 50% of decays to un-weighted mix of higher-mass resonances

$B \rightarrow X_S \gamma$ Resonances

- K_1 (1270)
- K_1 (1400)
- K^* (1410)
- K_2^*(1430)
- K^* (1680)

$B \rightarrow X_d \gamma$ Resonances

- h_1^0 (1170)
- b_1^0 (1235)
- b_1^+ (1235)
- a_1^0 (1260)
- a_1^+ (1260)
- f_2^0 (1270)
- f_1^0 (1285)
- a_2^0 (1320)
- a_2^+ (1320)

• Force X_d decay to be identical to X_s decay up to substitution $s \leftrightarrow d$

$B \to X(d,s)\gamma$: Experimental Results

Conclusion from missing modes studies:

•Systematic incorporated by varying extra bodies and extra neutrals, independently, by ±50%

•Can improve with statistics via internal constraints (e.g. $X_s\gamma$ fragmentation)

•Dominant systematic error for $1.0 < M_X < 1.8$ GeV/c^2

Errors: Stat. ± Experimental Syst.

arXiv:0807.4975 [hep-ex]; accepted by PRL

Mass Range (GeV/c^2)	$B(b \to d\gamma)$ $(\times 10^{-6})$	$B(b \to s\gamma)$ $(\times 10^{-6})$	$B(b \to d\gamma)/B(b \to s\gamma)$
$0.6 < M_{X_{(s,d)}} < 1.0$	$1.2 \pm 0.5 \pm 0.1$	$47 \pm 1 \pm 3$	$0.026 \pm 0.011 \pm 0.002$
$1.0 < M_{X_{(s,d)}} < 1.8$	$6.0 \pm 2.6 \pm 2.3$	$168 \pm 14 \pm 33$	$0.036 \pm 0.015 \pm 0.009$
$0.6 < M_{X_{(s,d)}} < 1.8$	$7.2 \pm 2.7 \pm 2.3$	$215 \pm 14 \pm 33$	$\mathbf{0.033 \pm 0.013 \pm 0.009}$

Primary experimental result

BABAR

PRELIMINARY

Extrapolation to $\Gamma(b \to d\gamma)/\Gamma(b \to s\gamma)$

Measured region $0.6 < M_X < 1.8$ is ~50% of width

Extrapolate to full mass region via "KN Model"; KN calculation suggests negligible difference and uncertainty in extrapolation of the ratio (because $m_s, m_d << 1.8$ GeV/c^2?)

BABAR

$$\frac{\Gamma(b \to d\gamma)}{\Gamma(b \to s\gamma)} = 0.033 \pm 0.013 \pm 0.009$$

PRELIMINARY

→ **Ali Asatrian Greub** →

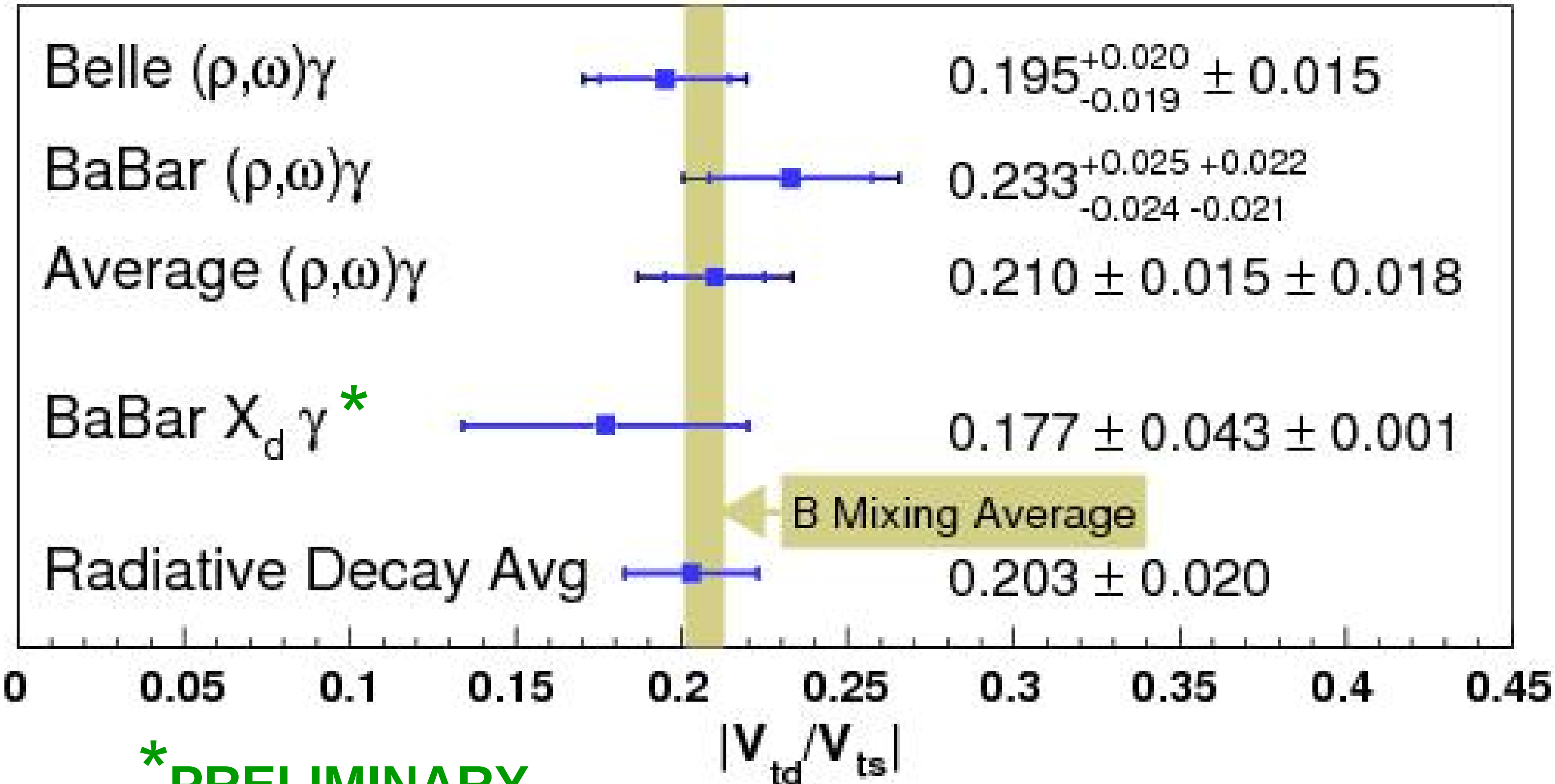
BABAR PRELIMINARY

$$|V_{td}/V_{ts}| = 0.177 \pm 0.043 \pm 0.001$$

Expt. Theory

arXiv:0807.4975 [hep-ex]; submitted to PRL

Global Status of $|V_{td}/V_{ts}|$



*PRELIMINARY

No evidence for non-Standard Model contribution to the decay width.

Concluding Remarks

- $B \to s\gamma$ continues to be leading constraint on MSSM parameter space
- More data exists (~80% of BaBar sample) to improve measurement, but "inclusive" approach starting to be limited by difficult systematics
- "Semi-inclusive" approach has systematics independent of inclusive approach; very little of existing sample has been analyzed in this way.

- Radiative measurements of $|V_{td}/V_{ts}|$ are becoming precise:

$$|V_{td}/V_{ts}|_{rad} = 0.203 \pm 0.020$$

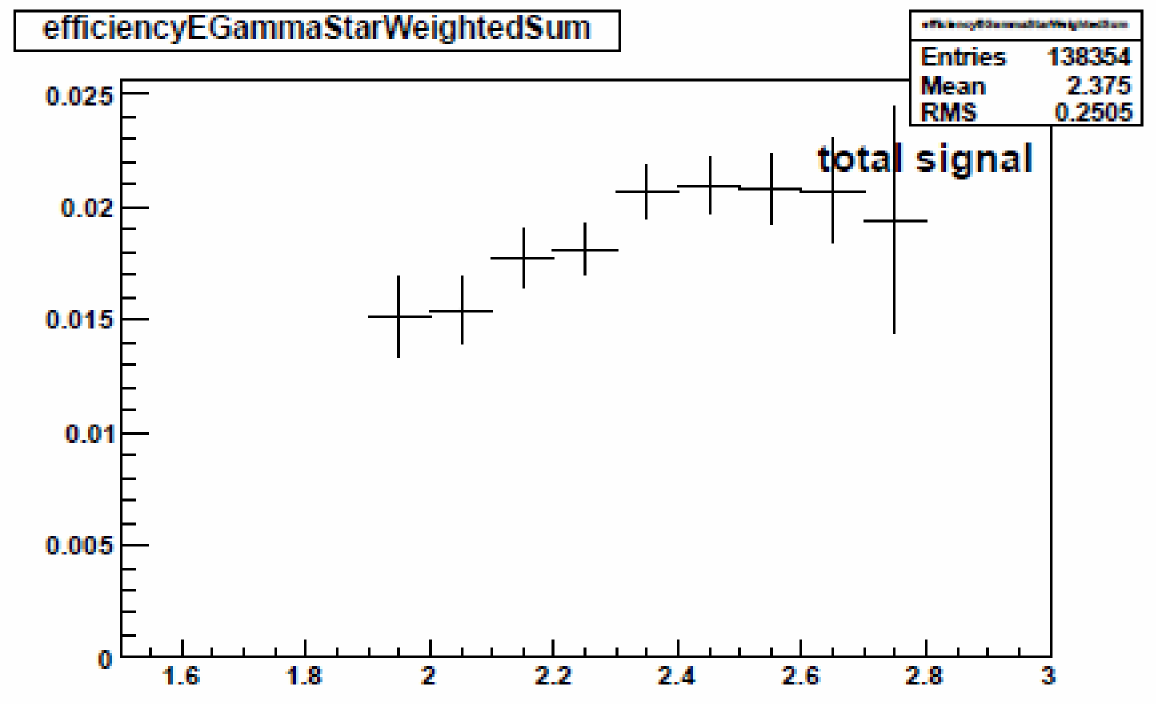
- Semi-inclusive approach works, and is independent of exclusive approach, with small theoretical uncertainty
- Agreement with SM (as constrained by B mixing) is good

In principle, the severe SM suppression of this radiative process (x10^{-6} of B mixing) should make it very sensitive to new physics contributions.

Have we fully thought through the meaning of this constraint?

Backup Slides

Inclusive Measurement of $b \rightarrow s\gamma$: Practicalities


efficiencyEGammaStarWeightedSum
Entries 138354
Mean 2.375
RMS 0.2505
total signal
0.025
0.02
0.015
0.01
0.005
0
1.6
1.8
2
2.2
2.4
2.6
2.8
3

Inclusive Measurement of b $\rightarrow$ sγ: Practicalities

Background + Signal function has 12 parameters.

$$\text{Signal} = \begin{cases} A_g[f_1 G(m,\mu_1,\sigma_1) + (1-f_1)G(m,\mu_2,\sigma_2)] & \text{for } m > m_0 \\ N\left[\dfrac{p\sigma_1/\lambda}{(m_0 - m) + p\sigma_1/\lambda}\right]^p & \text{for } m < m_0 \end{cases}$$

where $m_0 \equiv \mu_1 - \lambda\sigma_1$

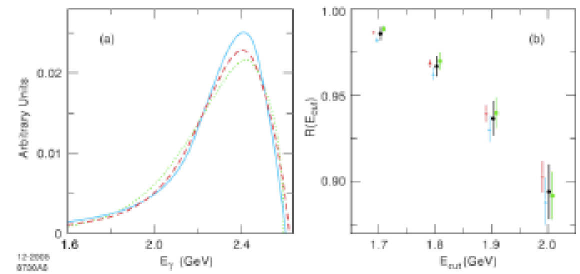
$$\text{Background} = \frac{am^b}{(m^2+c)^d}$$

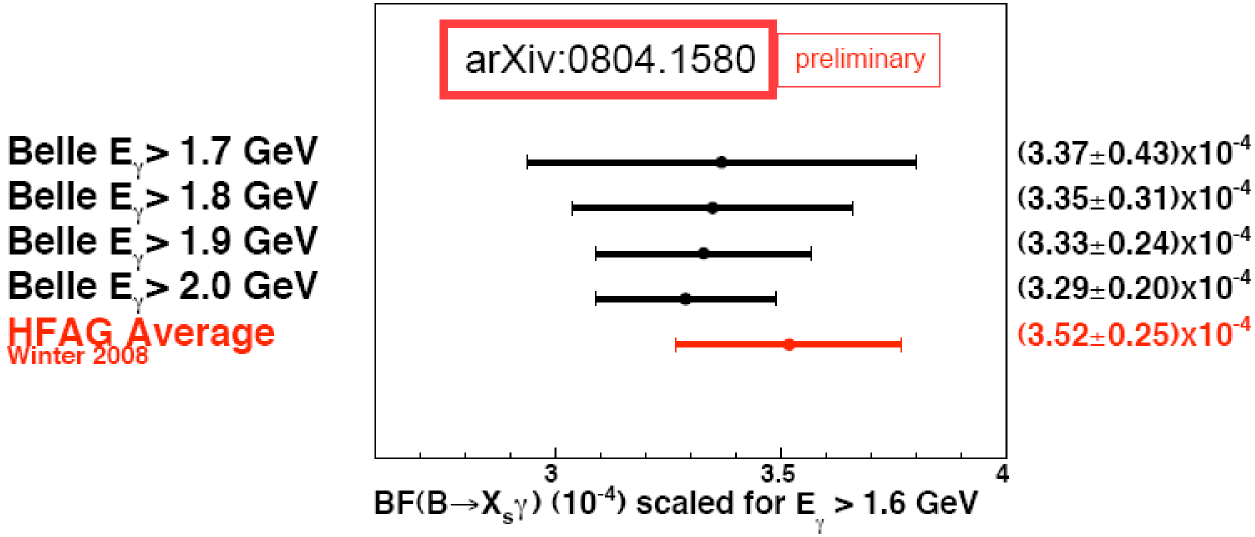
	Fixed Parameters	Floated Parameters
1. Fit π^0 signal	$\mu_2, \sigma_2/\sigma_1$	$\lambda, f_1, \mu_1, \sigma_1, p, A_g$
2. Fit π^0 signal+bkgd	$\mu_2, \sigma_2/\sigma_1, \lambda, f_1$	$\mu_1, \sigma_1, p, A_g, a, b, c, d$
3. Fit On-peak Data	$\mu_2, \sigma_2/\sigma_1, \lambda, f_1$	$\mu_1, \sigma_1, p, A_g, a, b, c, d$
4. Fit Off-peak Data	$\mu_2, \sigma_2/\sigma_1, \lambda, f_1, \mu_1, \sigma_1, p$	A_g, a, b, c, d

Which is the best cut to use?

Extrapolation factors used by HFAG
from Buchmuller & Flacher PRD73 073008 (2006)

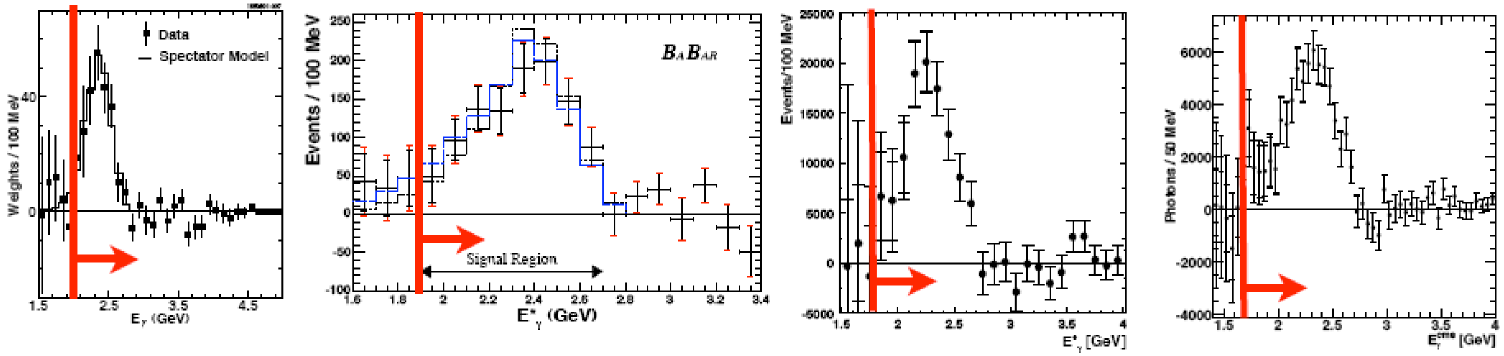
Scheme	$E_\gamma < 1.7$	$E_\gamma < 1.8$	$E_\gamma < 1.9$	$E_\gamma < 2.0$	$E_\gamma < 2.242$
Kinetic	0.986 ± 0.001	0.968 ± 0.002	0.939 ± 0.005	0.903 ± 0.009	0.656 ± 0.031
Neubert SF	0.982 ± 0.002	0.962 ± 0.004	0.930 ± 0.008	0.888 ± 0.014	0.665 ± 0.035
Kagan-Neubert	0.988 ± 0.002	0.970 ± 0.005	0.940 ± 0.009	0.892 ± 0.014	0.643 ± 0.033
Average	0.985 ± 0.004	0.967 ± 0.006	0.936 ± 0.010	0.894 ± 0.016	0.655 ± 0.037





Much lower uncertainty if E>2.0 GeV cut is used!

Summary of Fully Inclusive



CLEO	*BABAR*	*Belle*	*Belle*
9.1/fb ON	81.5/fb ON	140/fb ON	605/fb ON
4.4/fb OFF	9.6/fb OFF	15/fb OFF	68/fb OFF
$E_\gamma > 2.0$ GeV	$E_\gamma > 1.9$ GeV	$E_\gamma > 1.8$ GeV	$E_\gamma > 1.7$ GeV
PRL87, 251807 (2001)	PRL97, 171803 (2006)	PRL93, 061803 (2004)	arXiv:0804.1580 (2008)

More data, lower the photon energy cut

Roma, Italia, Sep 9-13, 2008 Antonio Limosani - University of Melbourne Slide 19