



New Physics Search at B Factory

Paoti Chang
National Taiwan University

Beyond the 3 SM Generation Workshop

CERN, Geneva

September 5, 2008



05/09/2008

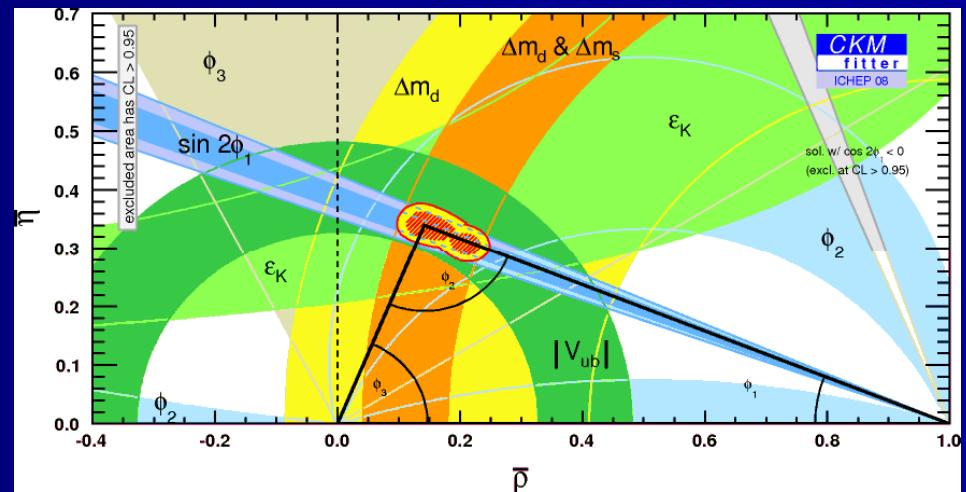
Beyond the 3SM workshop



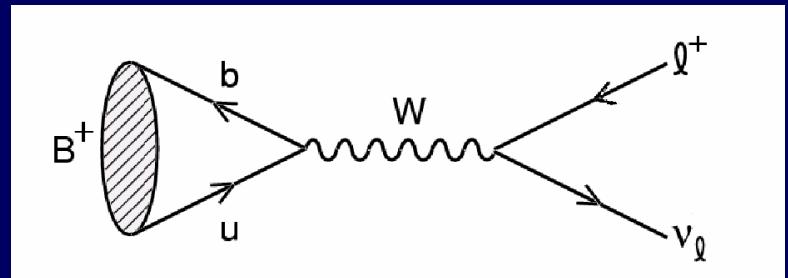
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Introduction

- CKM successful but NP may be present.
- Goal: Present results from B factories that are a clean probe or hints at new physics.
- Topics:
 1. $B \rightarrow \tau v$, ΔS and ΔA
 2. $b \rightarrow X s \gamma$
 3. A_{FB} in $B \rightarrow K^* l l$
 4. D^0 mixing, τ decays
- Summary



$B^+ \rightarrow \tau^+ \nu$



- In SM, decay rate related to decay constant and V_{ub}

$$\mathcal{B}(B \rightarrow \ell \nu) = \frac{G_F^2 m_B}{8\pi} m_\ell^2 \left(1 - \frac{m_\ell^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

$$\Rightarrow \mathcal{B}(B \rightarrow \tau \nu) = (0.78^{+0.09}_{-0.13}) \times 10^{-4}$$

(CKM fitter 2008 prediction)

- Charged Higgs may contribute to BF. destructive

$$\mathcal{B}(B \rightarrow \tau \nu) = \mathcal{B}(B \rightarrow \tau \nu)_{\text{SM}} \times r_H$$

W.S. Hou, PRD 48, 2342 (1993)

$$r_H = \left(1 - \frac{m_B^2}{m_H^2} \tan^2 \beta\right)^2$$

- Previous results:

Belle hadronic tag

$$\mathcal{B}(B \rightarrow \tau \nu) = (1.79^{+0.56+0.46}_{-0.49-0.51}) \times 10^{-4}$$

447 M $\bar{B}B$ with 3.5σ

BaBar hadronic & semileptonic tags

$$\mathcal{B}(B \rightarrow \tau \nu) = (1.2 \pm 0.4 \pm 0.3 \pm 0.2) \times 10^{-4}$$

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383 M $\bar{B}B$ with 2.6σ

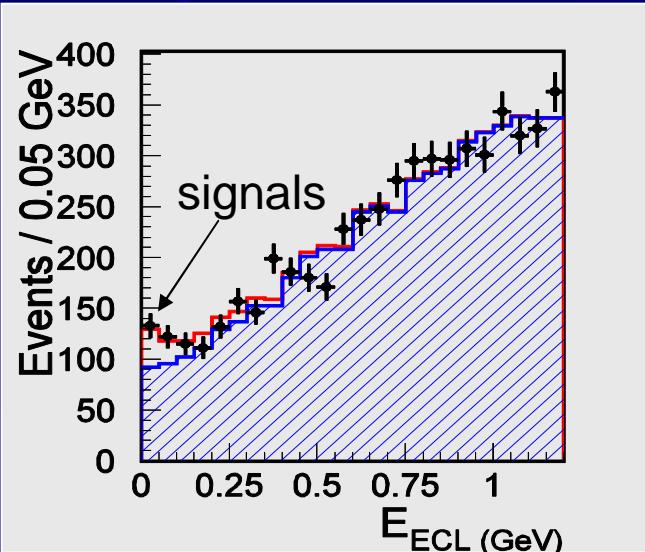
New Belle Result on $B^+ \rightarrow \tau^+ \nu$

Method: Tag B on one side (hadronic tag or $D^{(*)} \bar{l} \nu$ tag)

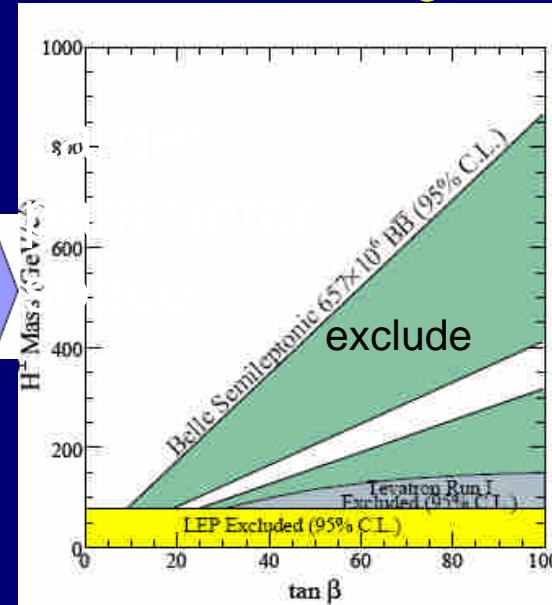
Look for τ signature with “extra” energy in the ECAL



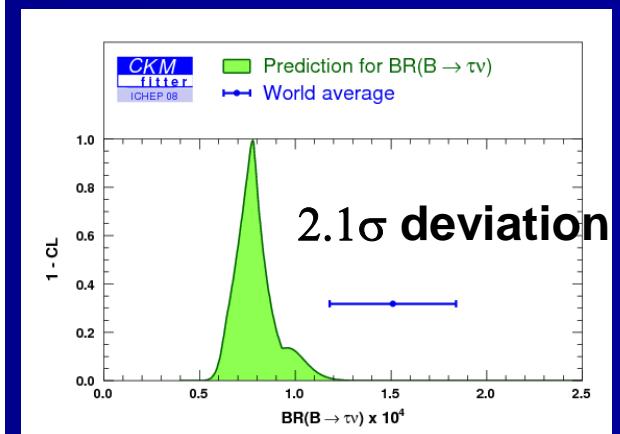
NEW with 3.8σ



657 M BB with $D^{(*)} \bar{l} \nu$ tag



Naïve Average
 $\mathcal{B}(B \rightarrow \tau \nu) = (1.51 \pm 0.33) \times 10^{-4}$



$$N_{\text{sig}} = 154^{+36}_{-35} \text{ (stat)} \quad {}^{+20}_{-22} \text{ (syst)} \\ \Rightarrow \mathcal{B}(B \rightarrow \tau \nu) = (1.65^{+0.38+0.35}_{-0.37-0.37}) \times 10^{-4}$$

Note that interference is destructive in 2HDM (type II). $\mathcal{B} > \mathcal{B}_{\text{SM}}$ implies that H^+ contribution dominates

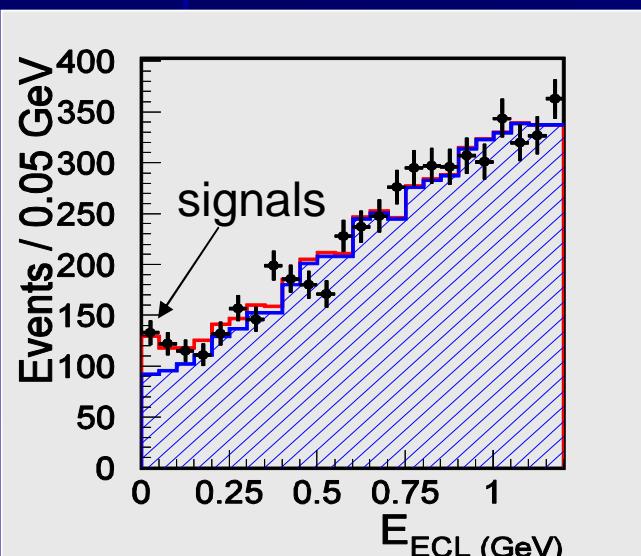
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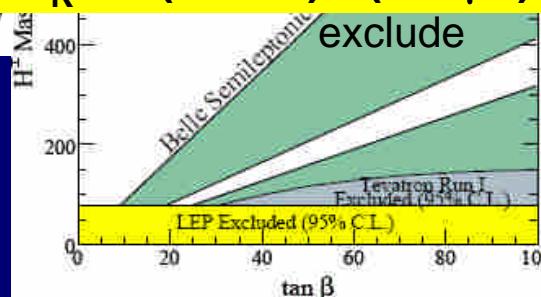
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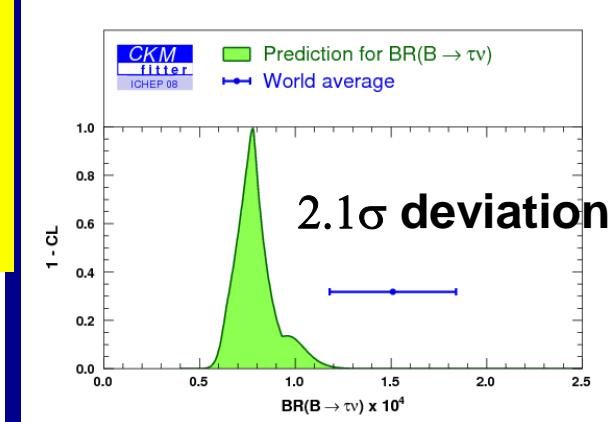
657 M $B\bar{B}$ with $D^{(*)} \ell \nu$ tag

Larger parameter space has been excluded using kaon results:

$$R_K = \Gamma(K \rightarrow e\nu)/\Gamma(K \rightarrow \mu\nu)$$



Naïve Average
 $\mathcal{B}(B \rightarrow \tau \nu) = (1.51 \pm 0.33) \times 10^{-4}$



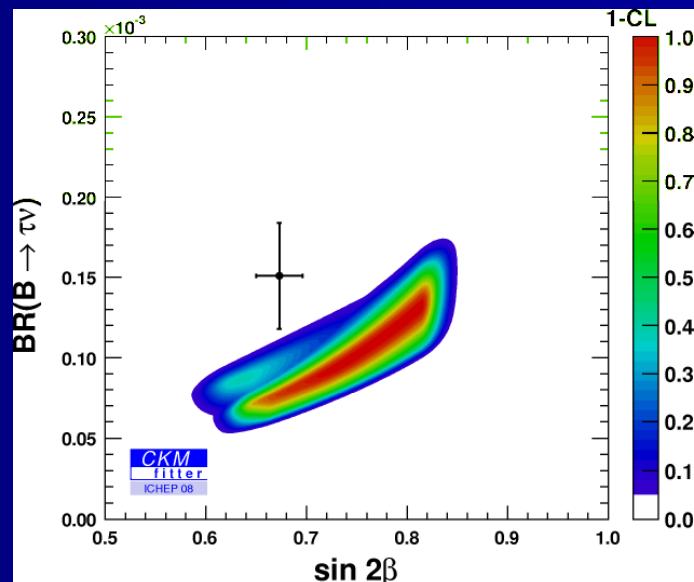
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Note that interference is destructive in 2HDM (type II). $\mathcal{B} > \mathcal{B}_{\text{SM}}$ implies that H^+ contribution dominates

$\mathcal{B}(B \rightarrow \tau\nu) \text{ vs } \sin 2\phi_1 / 2\beta$

$$\frac{\text{BR} (B \rightarrow \tau\nu)}{\Delta m^2} = \frac{3}{4} \frac{\pi}{m_W^2 S(xt)} \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 \bar{\tau} B^+ \frac{1}{B_{Bd}} \frac{1}{|V_{ud}|^2} \left(\frac{\sin\theta}{\sin\gamma}\right)^2$$

- Using ratio, the relation is independent of f_B and V_{ub}
- Belle and BaBar will have new updates soon.
- Good topics for the future Super B factory

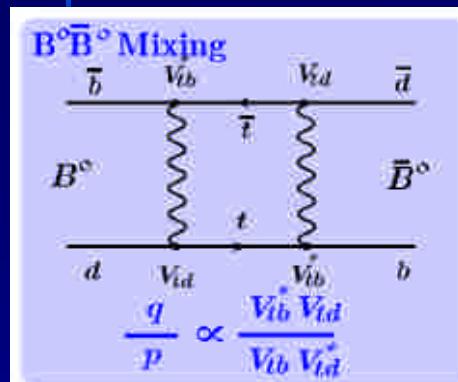


1σ deviation

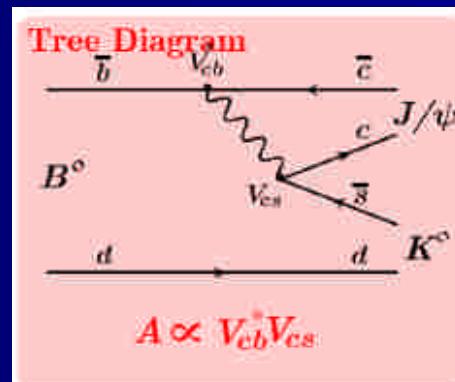
Time dependent CPV in $b \rightarrow s$ Penguin

$$A_f(t) = \frac{\Gamma(B^0(t) \rightarrow f) - \Gamma(\bar{B}^0(t) \rightarrow f)}{\Gamma(\bar{B}^0(t) \rightarrow f) + \Gamma(B^0(t) \rightarrow f)} = -S_f \sin(\Delta m_B t) + C_f \cos(\Delta m_B t)$$

$S_f = \sin 2\phi_1; C_f = -A$



+

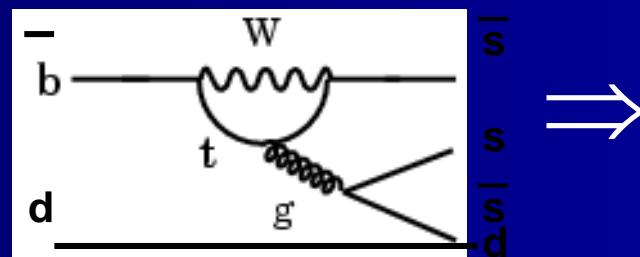


golden mode

$\sin 2\phi_1 / \sin 2\beta$

$$\Delta S = \sin 2\phi_1 (s\bar{q}\bar{q}) - \sin 2\phi_1 (c\bar{c}s\bar{s})$$

- May have tree pollution.
- Theoretical expectation: for penguin dominant modes $\Delta S > 0$ within 0.05
- Clean signals for new physics

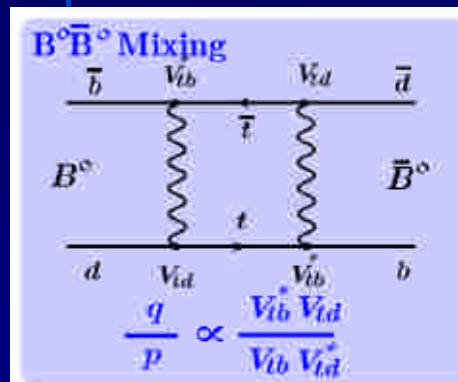


New physics phase in the loop causes deviation

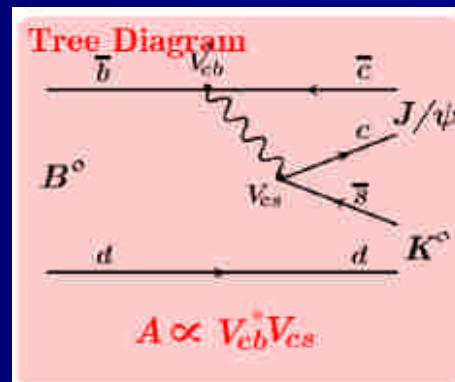
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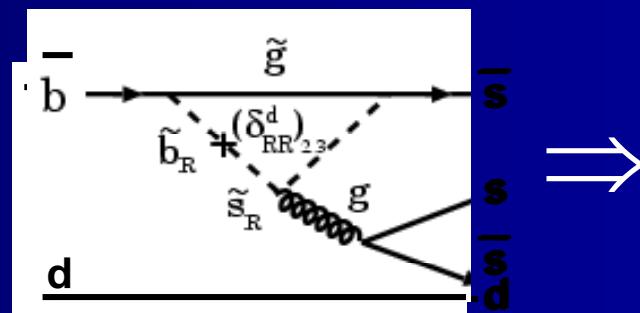
+



golden mode
 $\Rightarrow \sin 2\phi_1 / \sin 2\beta$

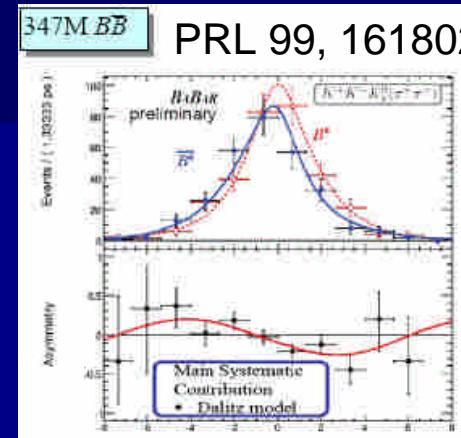
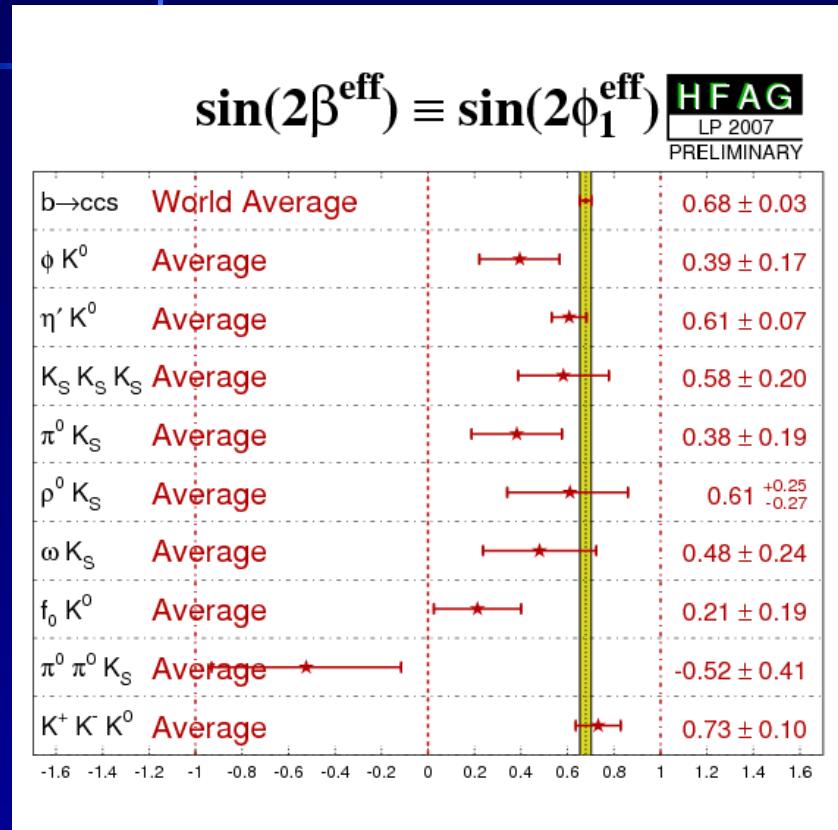
$$\Delta S = \sin 2\phi_1 (s_{\bar{q}\bar{q}}) - \sin 2\phi_1 (c\bar{c}s)$$

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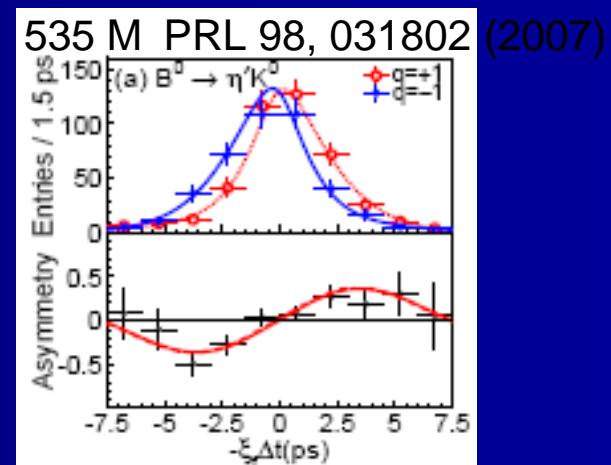
New physics phase in the loop causes deviation

ΔS results before ICHEP 2008



Based on
KKK Dalitz
analysis

$$\phi K^0: \sin 2\beta_{\text{eff}} = +0.12 \pm 0.31(\text{stat}) \pm 0.10 (\text{syst})$$



For most modes, $\Delta S(\text{SM})$ is positive.

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Beyond

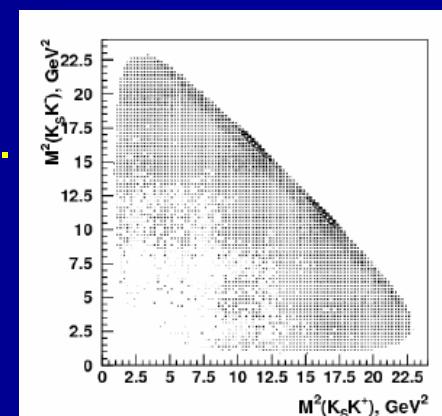
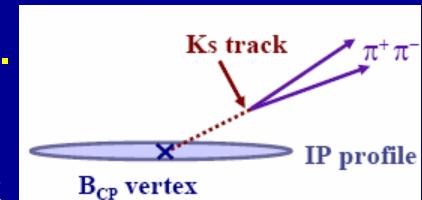
$$\eta' K^0: \sin 2\phi_{1\text{eff}}: +0.64 \pm 0.10 \pm 0.04$$

Decay Modes with Updated Results

- Class A: $\eta' K^0, \omega K_S \Rightarrow$ Same method as $J/\Psi K^0$
- Class B: $K^0\pi^0$
 - No tracks on B decay vertex.
 - Require tracks with SVD hits.
 - Perform fit by constraining C.
- Class C: $\pi^+\pi^-K_S, K^+K^-K_S$
 - Model the Dalitz distributions.
 - Many parameters: phase, S and C for each mode
- Class D: $\phi K_S \pi^0$:

Low statistics. Need to know the CP content. Use results from $\phi K^+\pi^-$.

Class is characterized by the analysis complexity.



TCPV Results on $b \rightarrow s \bar{q}\bar{q}$

Official HFAG average is still not ready yet!

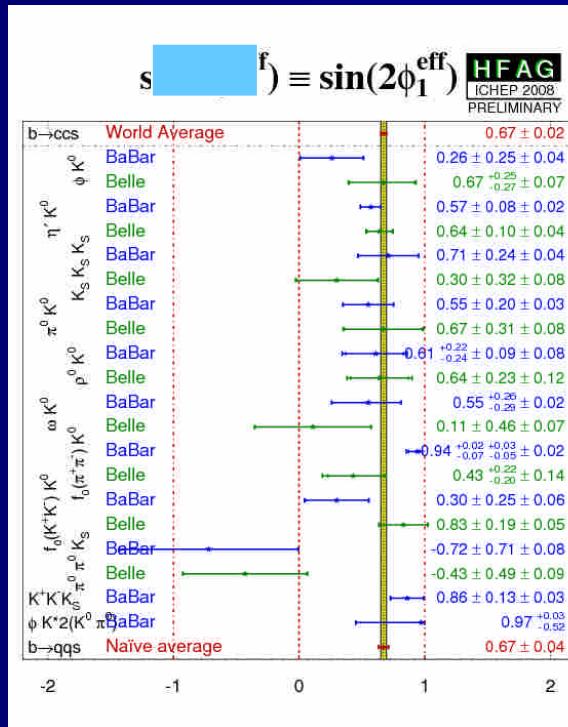
$$S(c\bar{c}s) = 0.67 \pm 0.02$$

- $B \rightarrow \phi K^0$
 Belle $0.67^{+0.21}_{-0.30} \pm 0.07$
 BaBar $0.21 \pm 0.26 \pm 0.11$
- $B \rightarrow \eta' K^0$
 Belle $0.64 \pm 0.10 \pm 0.02$
 BaBar $0.58 \pm 0.08 \pm 0.04$
- $B \rightarrow f_0 K_S$
 Belle $0.60^{+0.16}_{-0.19}$
 BaBar 0.90 ± 0.07

Naïve

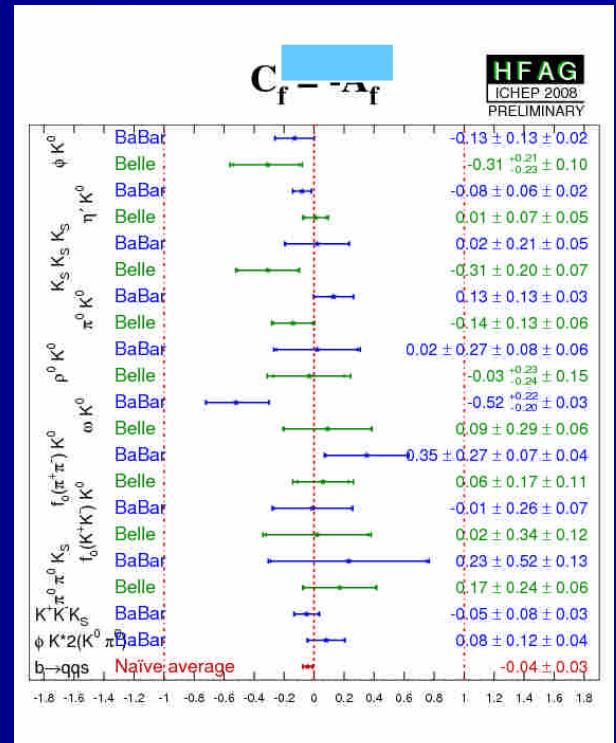
Average

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$$S(q\bar{q}s) = 0.67 \pm 0.04$$

$S(q\bar{q}s) = 0.60 \pm 0.05$ after removing BaBar's $f_0(\pi\pi)K^0$ and $\phi K^0\pi^0$



$$C = -0.04 \pm 0.03$$

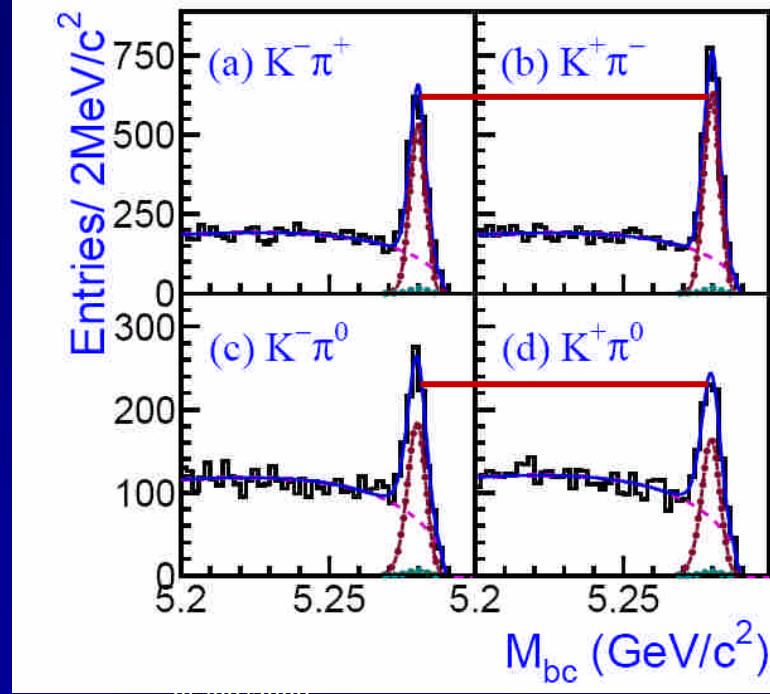
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Direct CP Violation in $B \rightarrow K\pi$ Decays

$$\mathcal{A}_{CP}(B \rightarrow f) = \frac{|\bar{A}|^2 - |A|^2}{|\bar{A}|^2 + |A|^2} \propto \sum_{i,j} A_i A_j \sin(\delta_i - \delta_j) \sin(\phi_i - \phi_j)$$

Belle Results: Nature 452, 332 (2008)



New Update

$$A_{cp}(K^+\pi^-) = \left\{ \begin{array}{l} -0.107 \pm 0.016 \quad {}^{+0.006}_{-0.004} \\ -0.094 \pm 0.018 \pm 0.008 \\ -0.086 \pm 0.023 \pm 0.009 \\ -0.04 \pm 0.16 \pm 0.02 \end{array} \right. \begin{array}{l} \text{BaBar} \\ \text{Belle} \\ \text{CDF} \\ \text{CLEO} \end{array}$$

$\Rightarrow -0.098 \pm 0.012 @ 8.1\sigma$ **AVG**

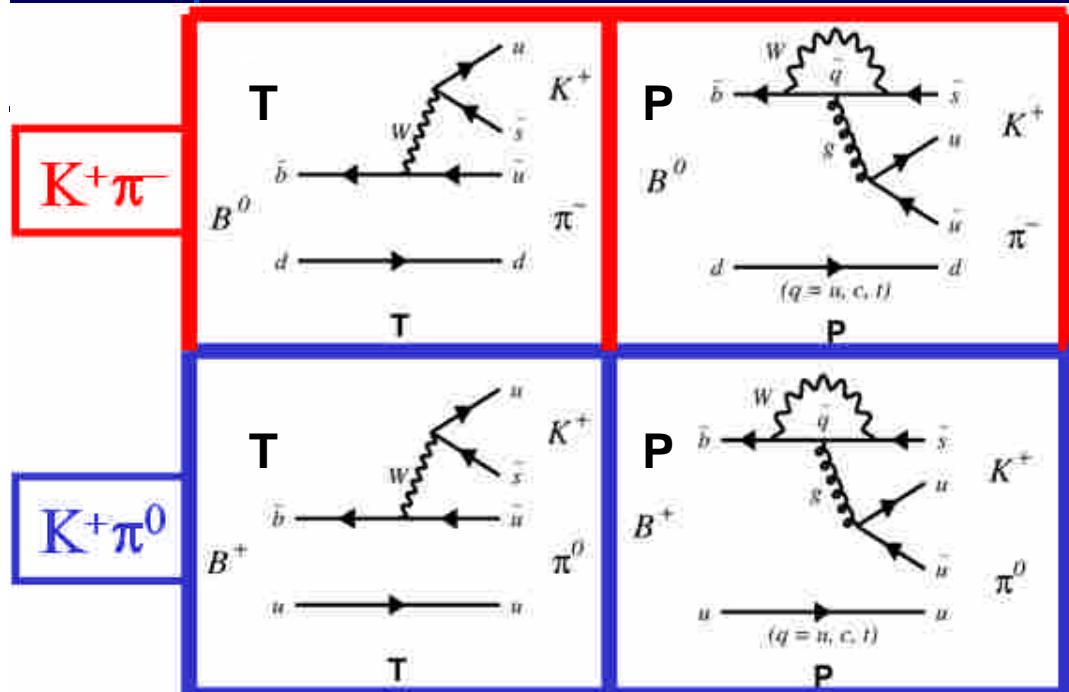
$$A_{cp}(K^+\pi^0) = \left\{ \begin{array}{l} +0.030 \pm 0.039 \pm 0.010 \\ +0.07 \pm 0.03 \pm 0.01 \\ -0.29 \pm 0.23 \pm 0.02 \end{array} \right. \begin{array}{l} \text{BaBar} \\ \text{Belle} \\ \text{CLEO} \end{array}$$

$\Rightarrow +0.050 \pm 0.025 @ 2.0\sigma$ **AVG**

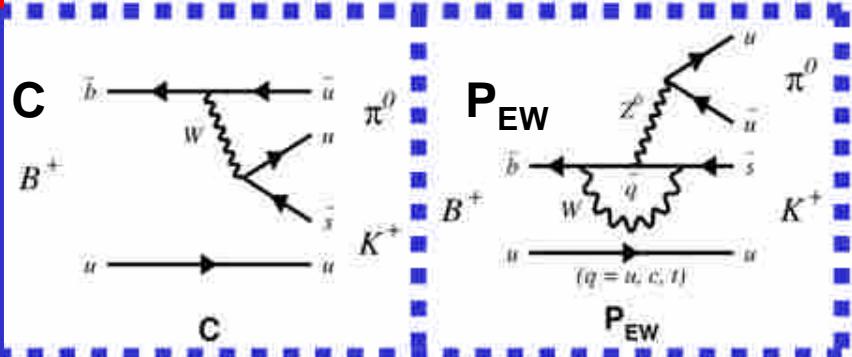
$$\Delta A_{K\pi} = A_{cp}(K^+\pi^-) - A_{cp}(K^+\pi^0) \\ = -0.147 \pm 0.028 @ 5.3\sigma$$

Beyond

$\Delta A_{K\pi}$ Puzzle



Expectation from current theory
 T & P are dominant $\Rightarrow \Delta A_{K\pi} \sim 0$



- Enhancement of large C with large strong phase to $T \Rightarrow$ strong inter. !?

Chiang et. al. 2004
 Li, Mishima & Sanda 2005

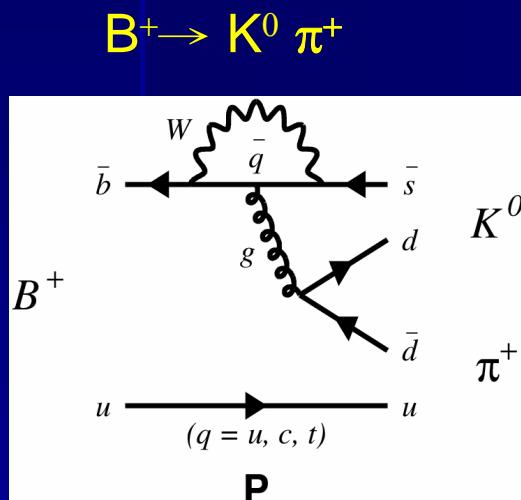
- Enhancement of large P_{EW}
 \Rightarrow New physics

Yoshikawa 2003; Mishima & Yoshikawa 2004;
 Buras et. al. 2004, 2006; Baek & London 2007;
 Hou et. al. 2007; Feldmann, Jung & Mannel 2008

Model independent checks for NP

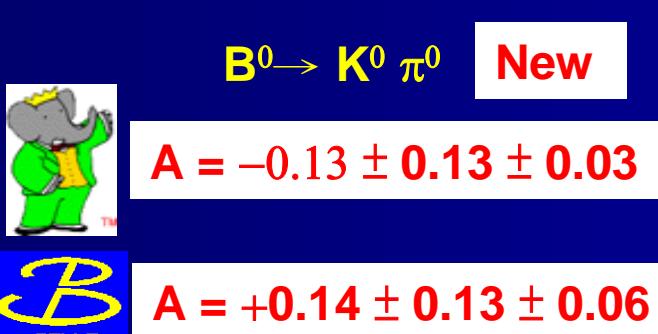
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$$\mathcal{A}_{CP}(K^+\pi^-) + \mathcal{A}_{CP}(K^0\pi^+) \frac{\mathcal{B}(K^0\pi^+)}{\mathcal{B}(K^+\pi^-)} \frac{\tau_0}{\tau_+} = \mathcal{A}_{CP}(K^+\pi^0) \frac{2\mathcal{B}(K^+\pi^0)}{\mathcal{B}(K^+\pi^-)} \frac{\tau_0}{\tau_+} + \mathcal{A}_{CP}(K^0\pi^0) \frac{2\mathcal{B}(K^0\pi^0)}{\mathcal{B}(K^+\pi^-)}$$



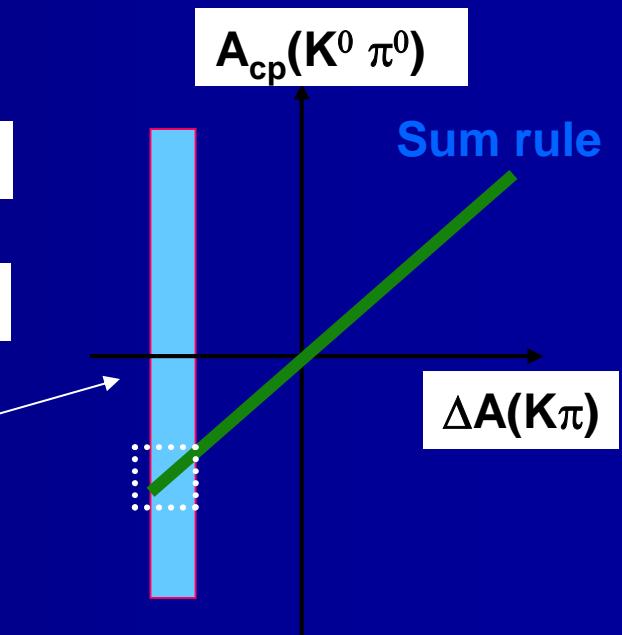
P dominants. $\Rightarrow \mathcal{A}_{cp}(K^0\pi^+) \sim 0$

World Average
 $\mathcal{A}_{cp}(K^0\pi^+) = 0.009 \pm 0.025$



Important topic for
Super B factory

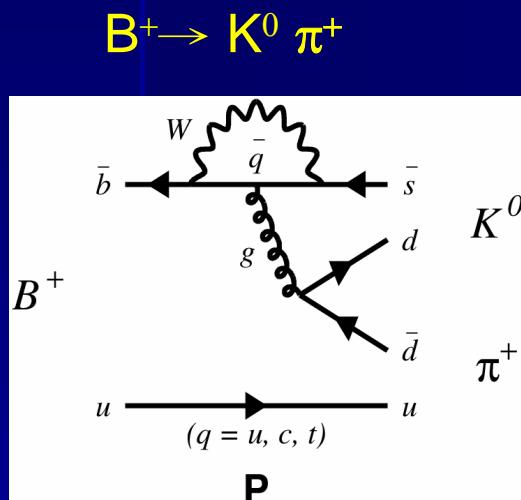
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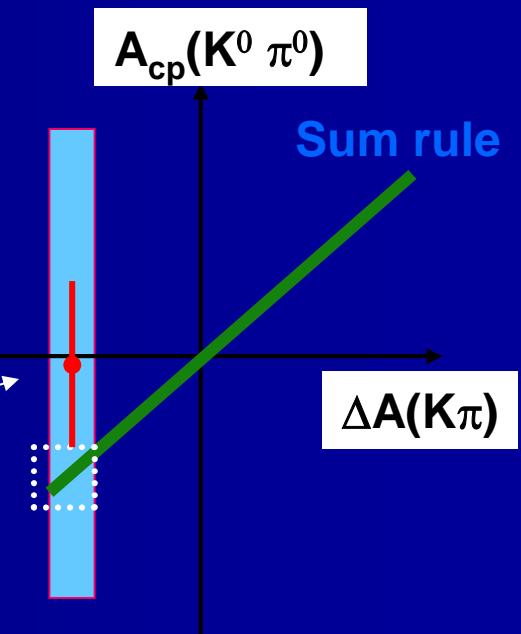
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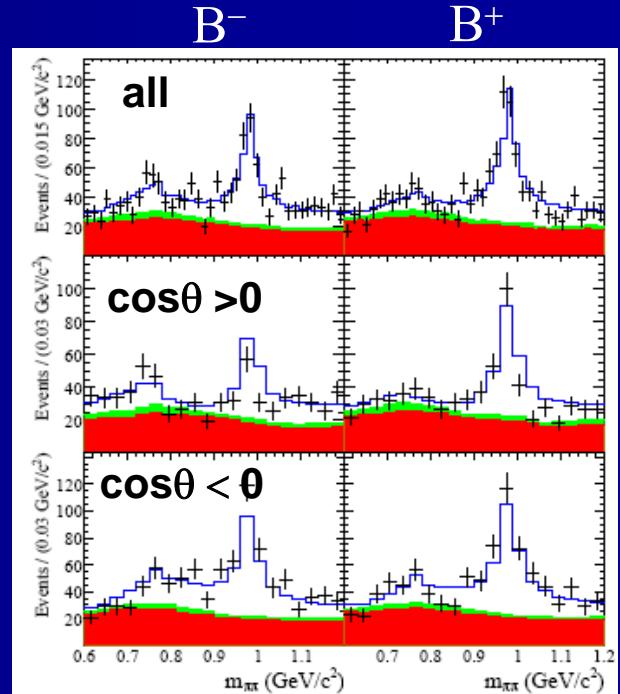
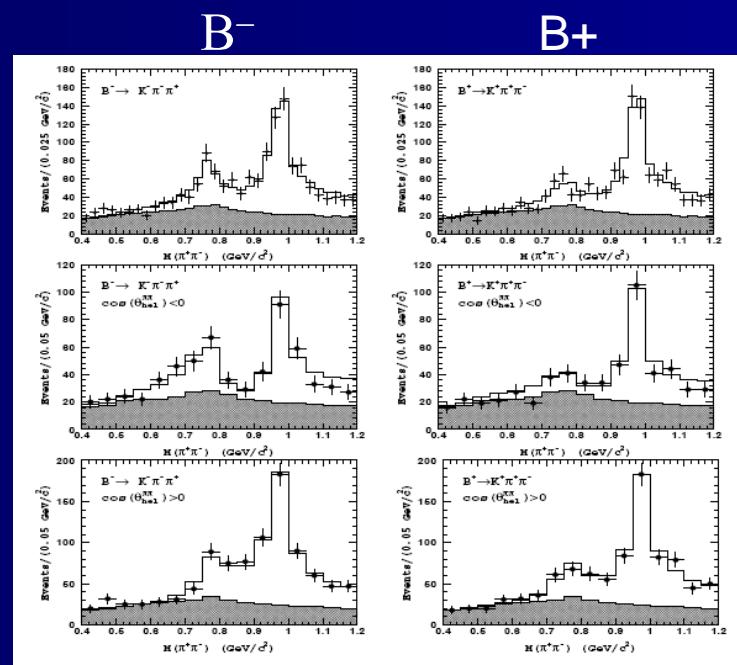
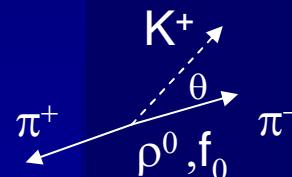
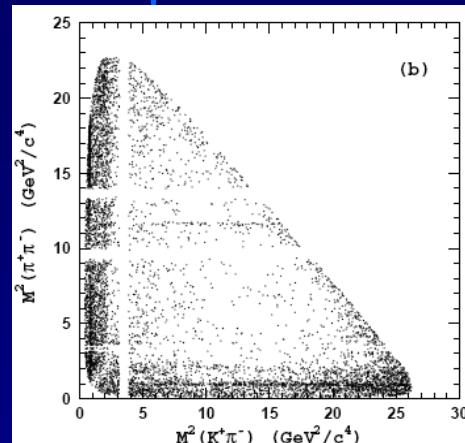


First observation of direct CP violation in charged B decays

- Dalitz analysis on $B^+ \rightarrow K^+ \pi^+ \pi^-$

657M BB, BELLE-CONF-0827

383M BB, PRD78, 012004, 08



05/09/2006

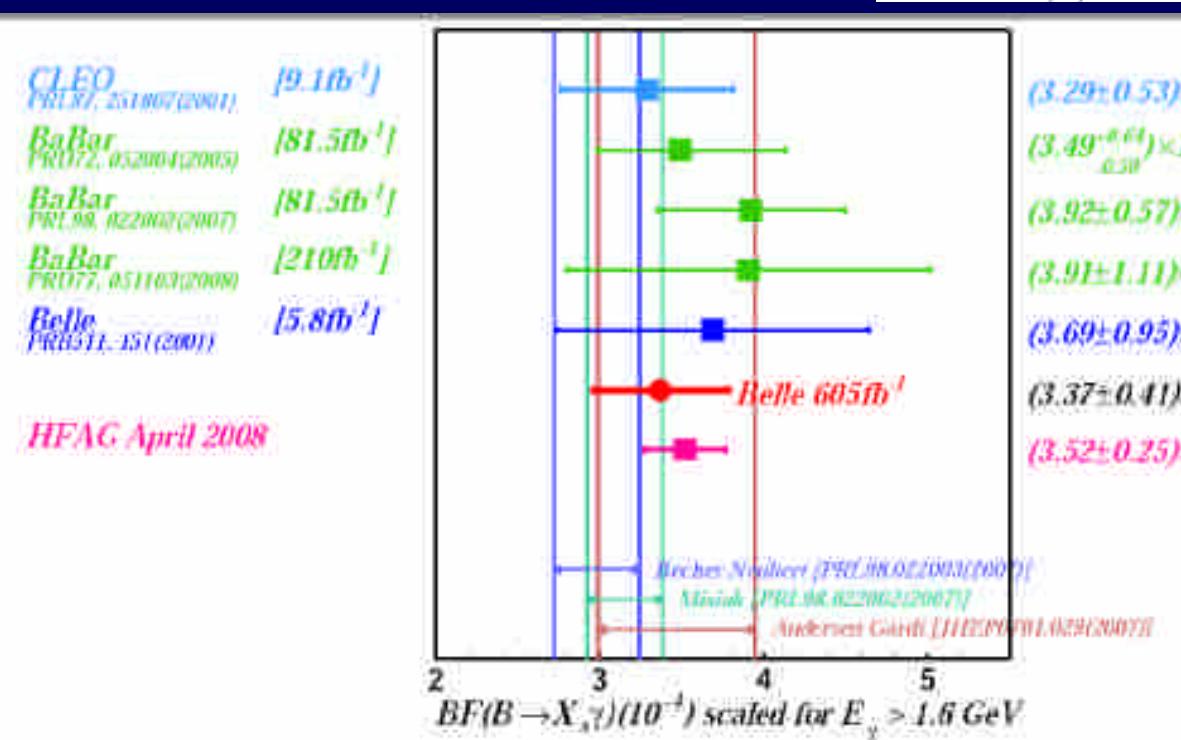
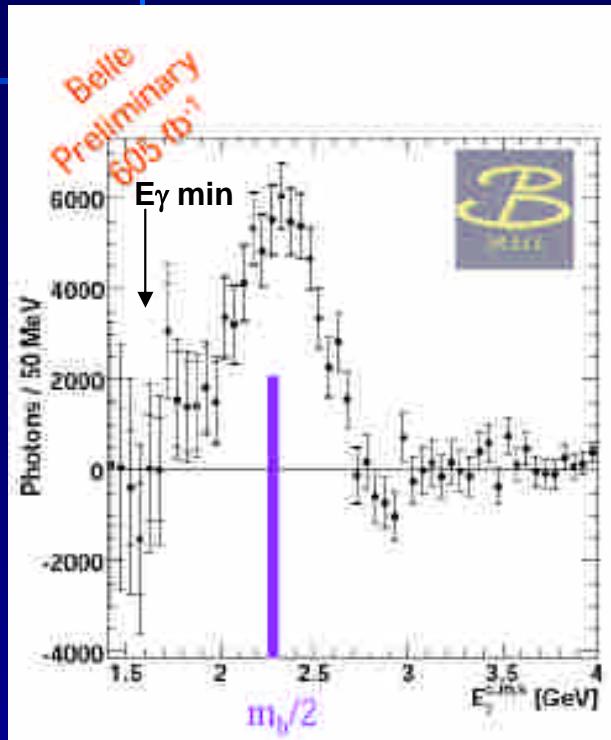
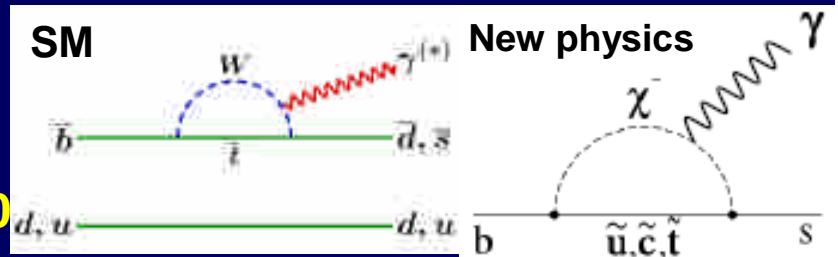
$$A_{\text{CP}}(B^+ \rightarrow \rho^0 K^\pm) = (+41 \pm 10 \pm 3 {}^{+3}_{-7}) \% @ 4.0\sigma$$

$$A_{\text{CP}}(B^+ \rightarrow \rho^0 K^\pm) = (+44 \pm 10 \pm 4 {}^{+5}_{-13}) \% @ 3.7\sigma$$

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$B \rightarrow X_s \gamma$

Belle update with $E_\gamma > 1.7$ GeV: arXiv:0804.1580



SM NNLO calculation:

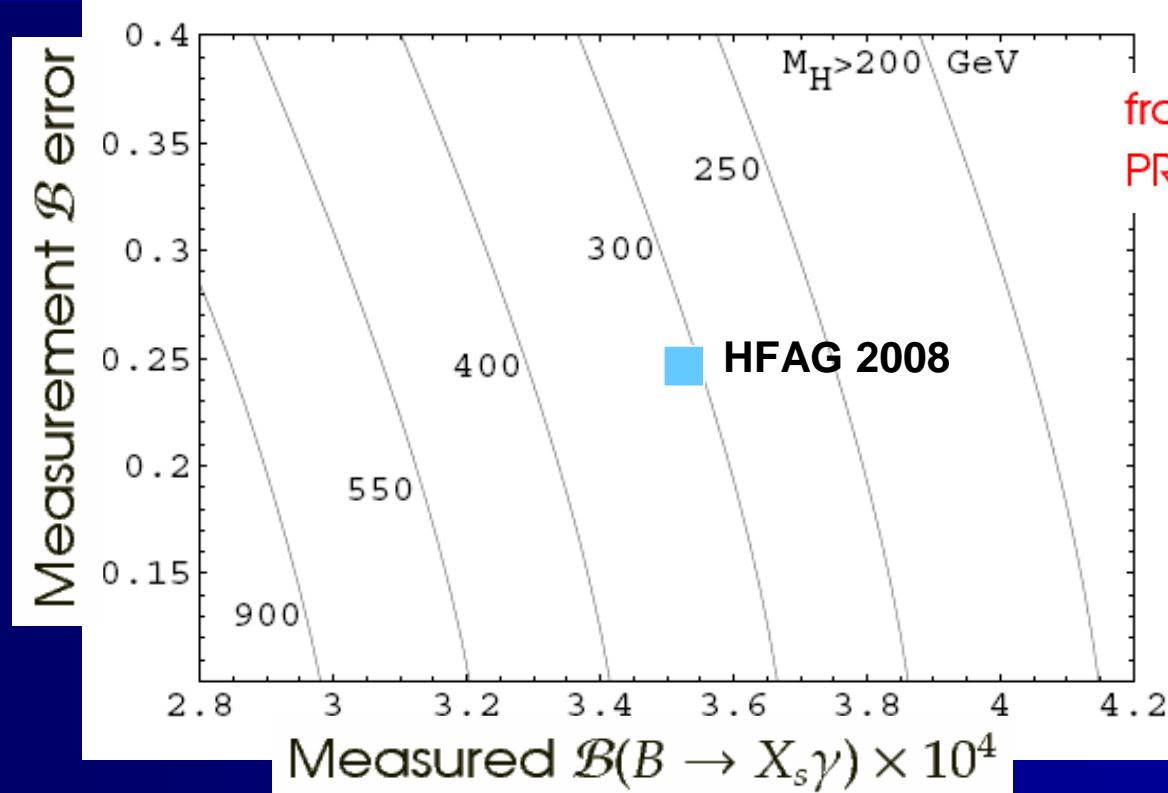
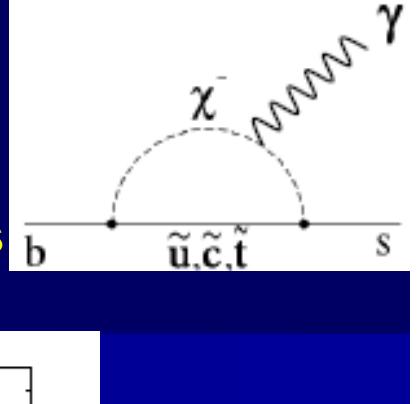
$$\mathcal{B}(B \rightarrow X_s \gamma) |_{E_\gamma > 1.6 \text{ GeV}} = \left\{ \begin{array}{ll} (3.15 \pm 0.23) \times 10^{-4} & \text{Misiak et al.} \\ (2.98 \pm 0.26) \times 10^{-4} & \text{Becher Neubert} \\ (3.47 \pm 0.49) \times 10^{-4} & \text{Anderson Gardi} \end{array} \right.$$

HFAG 2008:

$$\mathcal{B}(B \rightarrow X_s \gamma) |_{E_\gamma > 1.6 \text{ GeV}} = (3.52 \pm 0.25) \times 10^{-4}$$

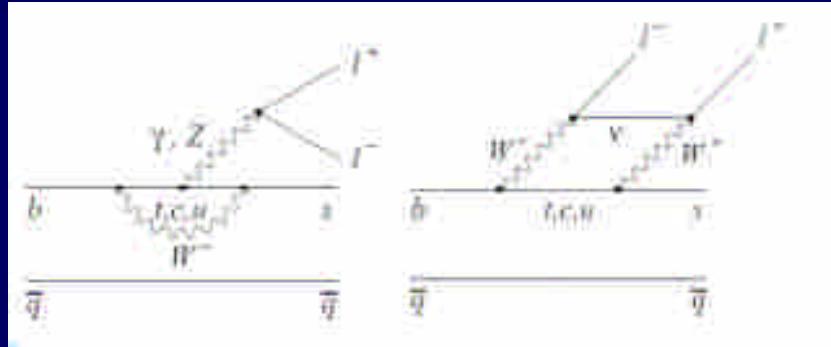
Charged Higgs Bound

The 95% lower bound of charged Higgs mass
as a function of $\mathcal{B}(B \rightarrow X_s \gamma)$ and its error.



$M_H + > 300$ GeV/c² @ 95% C.L. for all tan β

$b \rightarrow s l^+ l^-$



- Loop dominant \Rightarrow Small BF ; good place for new physics!
- Contributions from three coefficients:
 $\mathcal{L}_{\text{eff}} = \sum C_i O_i$, C_i (short distance effect). SM expects real C_i
 C_7^{eff} : EM penguin; C_9^{eff} (C_{10}^{eff}): vector (axial vector) part of weak diagrams
- More observables sensitive to NP:

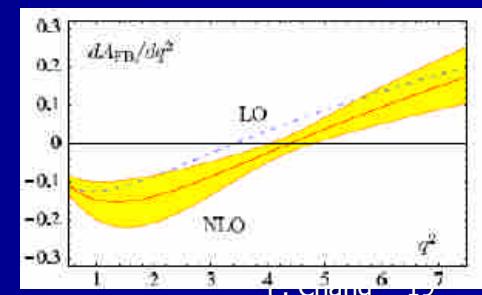
- **FB lepton asymmetry, A_{FB}**
- **K* polarization, FL**
- **CP asymmetry, A_{CP}**
- **Isospin asymmetry**
- **e/ μ ratio**

• $A_{\text{FB}}(q^2)$:

$e^+e^- \rightarrow \mu^+\mu^-$ indication of Z^0

$b \rightarrow s l^+ l^-$:

SM \Rightarrow



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Good agreement with SM BF



657M, NEW



384M FPCP 08

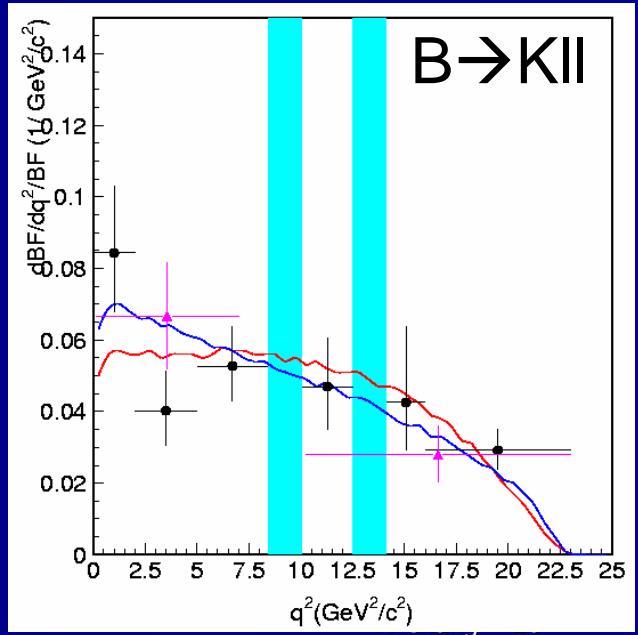
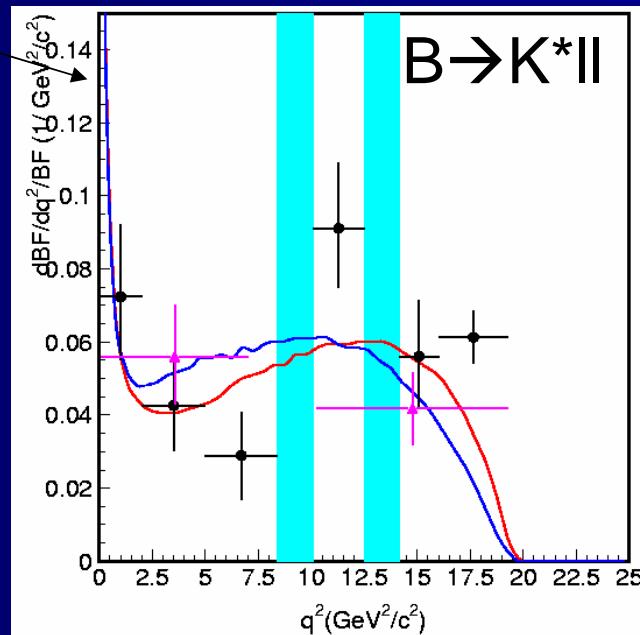
- Obtain partial BF in 6 bins in q^2 ; extrapolate the total BF.
- $\text{BF}(B \rightarrow K^* ll) = (10.8 \pm 1.0 \pm 0.9) \times 10^{-7}$
- $\text{BF}(B \rightarrow K ll) = (4.8^{+0.5}_{-0.4} \pm 0.3) \times 10^{-7}$

- $\text{BF}(B \rightarrow K^* ll) = (11.1 \pm 1.9 \pm 0.7) \times 10^{-7}$
- $\text{BF}(B \rightarrow K ll) = (3.9 \pm 0.7 \pm 0.2) \times 10^{-7}$

photon pole
Veto events in the J/ψ and ψ' regions

- **Belle, ICHEP 08**
- **BABAR, FPCP 08**
- **Melikhov et. al (quark model, PLB 410, 1997)**
- **Ali (PRD 66, 034002, 290, 2002)**

05/09/2008



Good agreement with SM BF



657M, NEW



384M FPCP 08

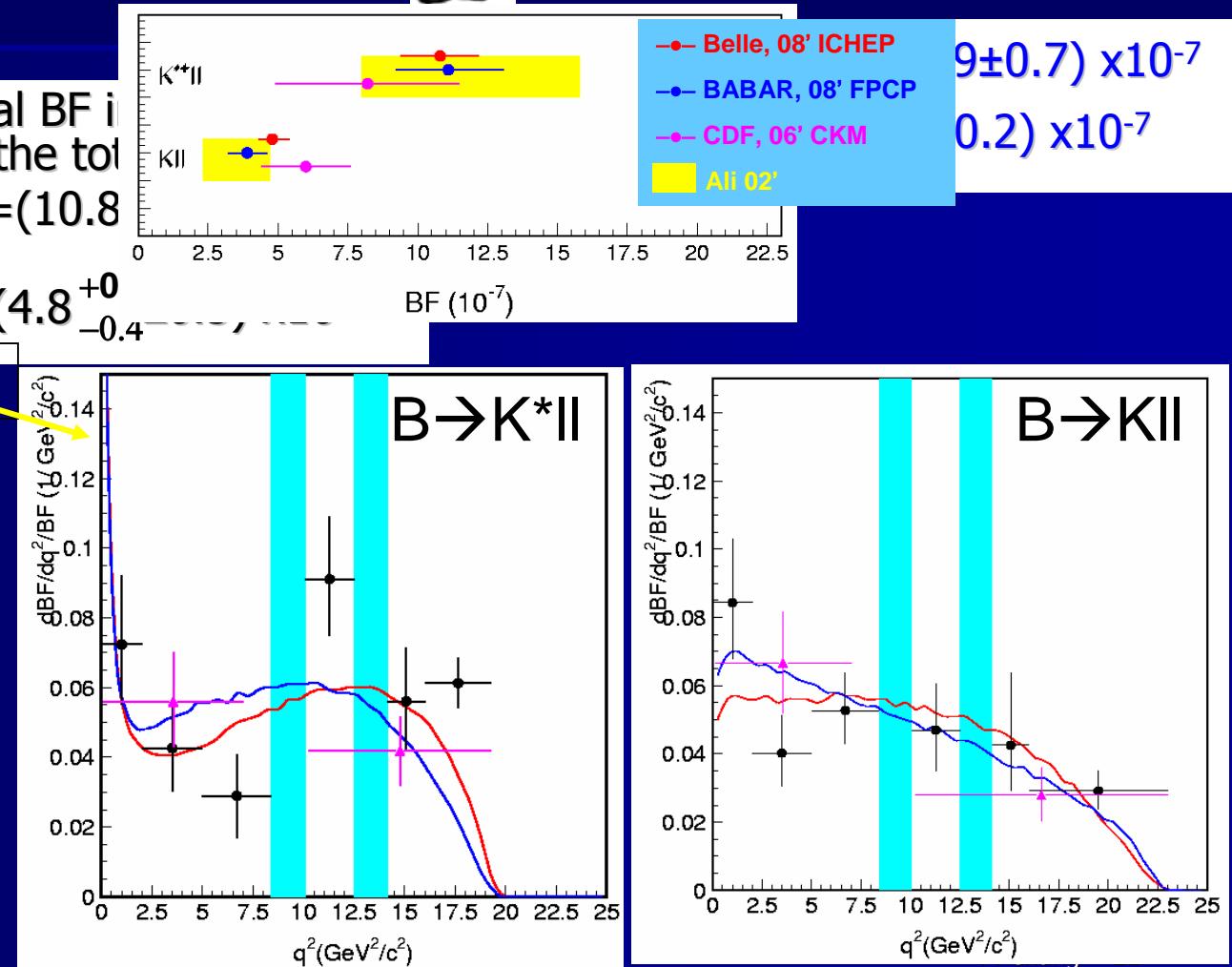
- Obtain partial BF in extrapolate the total
- $BF(B \rightarrow K^* ll) = (10.8 \pm 0.7) \times 10^{-7}$
- $BF(B \rightarrow K ll) = (4.8^{+0.4}_{-0.4}) \times 10^{-7}$

photon pole

Veto events in the J/ψ and ψ' regions

- Belle, ICHEP 08
- BABAR, FPCP 08
- Melikhov et. al (quark model, PLB 410, 1997)
- Ali (PRD 66, 034002, 290, 2002)

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Lepton Flavor & CP Asymmetries

- In *SM, $R_K \sim 1.33$ and $R_K \sim 1.0$.
- R_K is sensitive to the size of photon pole.
- $R_K > 1.0$ in the two Higgs doublet model with large $\tan \beta$.
(Y. Wang and D. Atwood, PRD 68, 094016, 2003)

$$R_{K^{(*)}} = \frac{\mathcal{B}(B \rightarrow K^{(*)} ee)}{\mathcal{B}(B \rightarrow K^{(*)} \mu\mu)}$$

A_{CP}

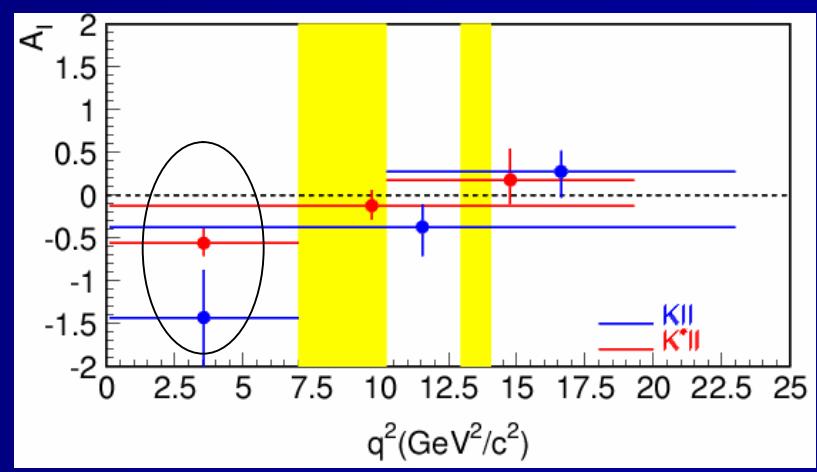
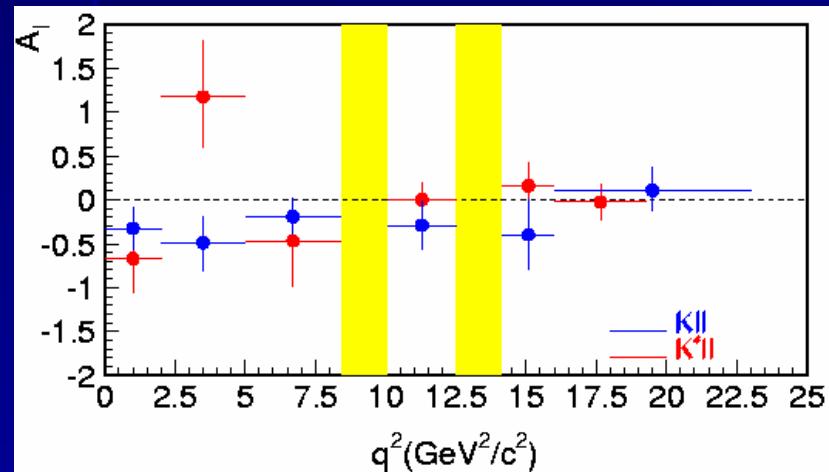
Lepton Asy.	Belle (657M)	BABAR (384M)
$K^* \ell \ell$	$1.21 \pm 0.25 \pm 0.07$	$1.37^{+0.53}_{-0.40}$
$K \ell \ell$	$0.97 \pm 0.18 \pm 0.05$	$0.96^{+0.44}_{-0.34}$

CP Asy.	Belle (657M)	BABAR (384M)
$K^* \ell \ell$	$-0.10 \pm 0.10 \pm 0.03$	-0.02 ± 0.16
$K \ell \ell$	$0.04 \pm 0.10 \pm 0.02$	-0.18 ± 0.18

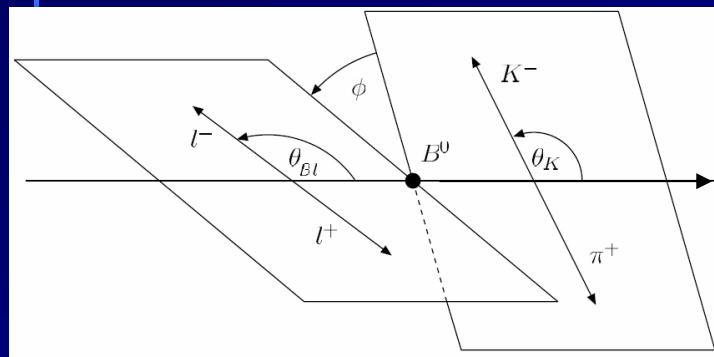
Unexpectedly Large Isospin Asymmetry?



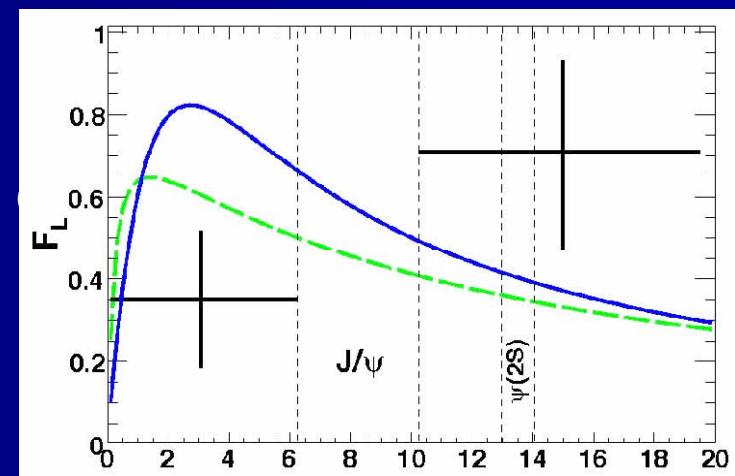
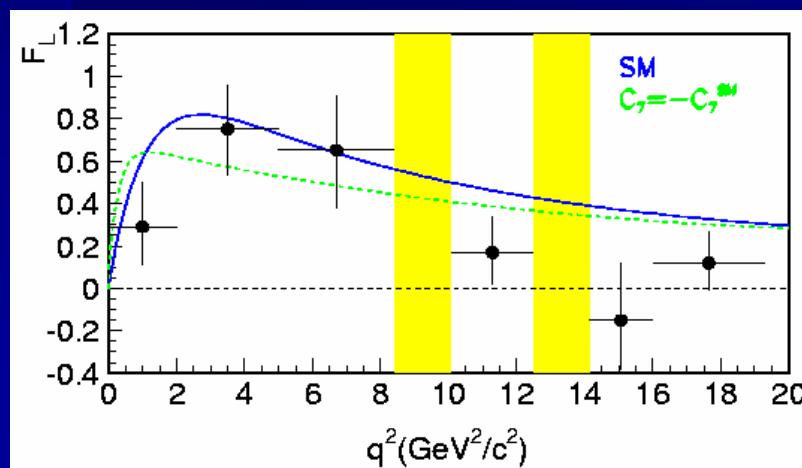
$$A = \frac{1.071 \times BF(B^0 \rightarrow K^{(*)0} ll) - BF(B^\pm \rightarrow K^{(*)\pm} ll)}{1.071 \times BF(B^0 \rightarrow K^{(*)0} ll) + BF(B^\pm \rightarrow K^{(*)\pm} ll)}$$



K* Helicity Distribution



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



Anomalous $A_{FB}(q^2)$ in $B \rightarrow K^{(*)} \bar{K}$?

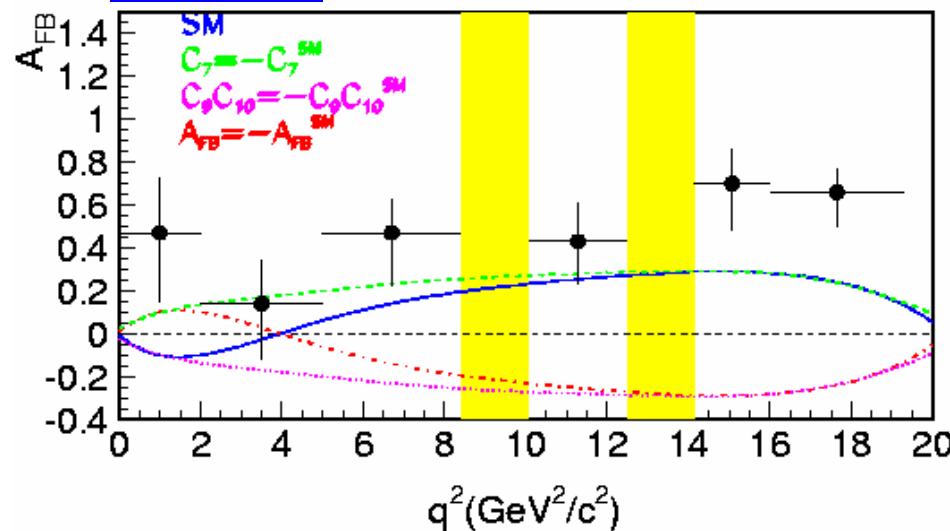
Obtain A_{FB} by a fit:

$$\frac{3}{4}F_L(1 - \cos^2 \theta_{Bl}) + \frac{3}{8}(1 - F_L)(1 + \cos^2 \theta_{Bl}) + A_{FB} \cos \theta_{Bl}$$

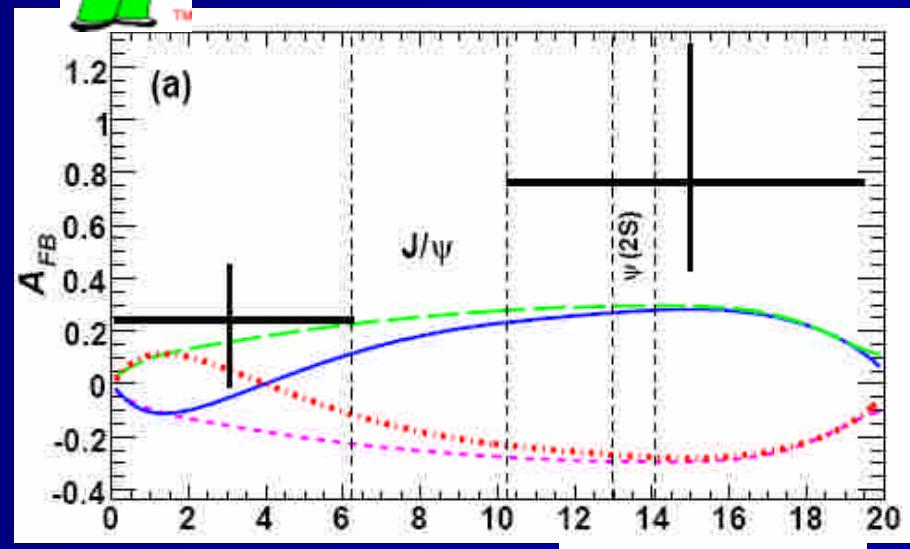
Efficiency corrected



657 M $B\bar{B}$



384 M $B\bar{B}$



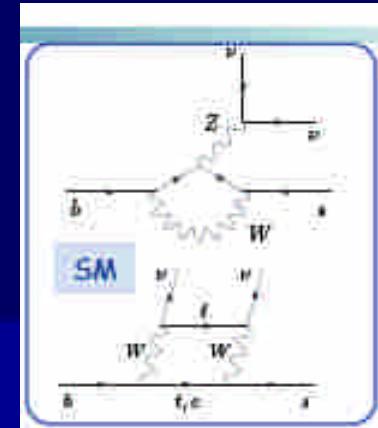
Data show positive A_{FB} at low q^2 , while the SM predicts negative A_{FB} .

At high q^2 , data above the SM expectation.

$B \rightarrow K^*(*) \nu\bar{\nu}$

One-loop FCNC

Similar to $K \rightarrow \pi \nu\bar{\nu}$



New physics:

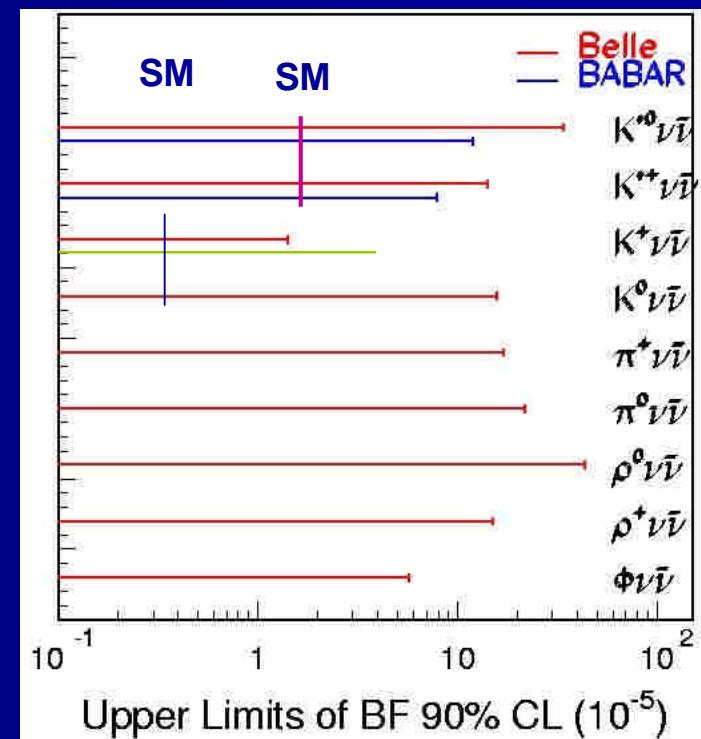
- * Non-Standard Z Couplings
- * Unparticle Physics
- * Light Dark Matter

G. Buchalla et al,
PRD 63, 014015
T.M.Aliev et al
arXiv:0705.4542
C. Bird et al
PRL 93, 201803

BaBar update with 467 M $B\bar{B}$

UL @ 90% CL in Bayesian approach

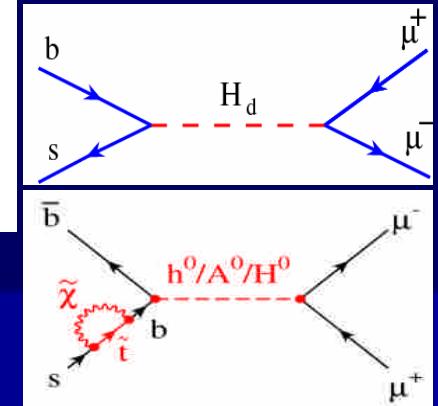
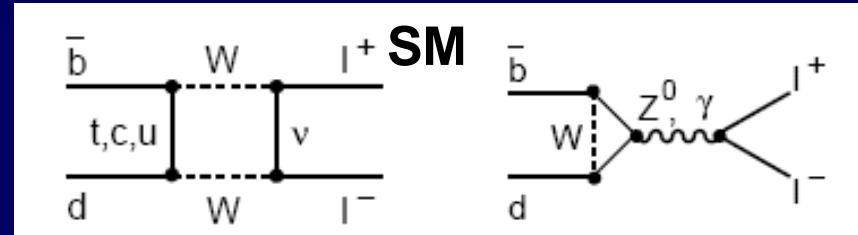
$$\begin{aligned} \mathcal{B}(B^+ \rightarrow K^{*+} \nu\bar{\nu}) &< 8 \times 10^{-5} \\ \mathcal{B}(B^0 \rightarrow K^{*0} \nu\bar{\nu}) &< 12 \times 10^{-5} \\ \mathcal{B}(B \rightarrow K^* \nu\bar{\nu}) &< 8 \times 10^{-5}. \end{aligned}$$



Still few times higher than SM \Rightarrow More data in clean environment \Rightarrow SuperB
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New physics

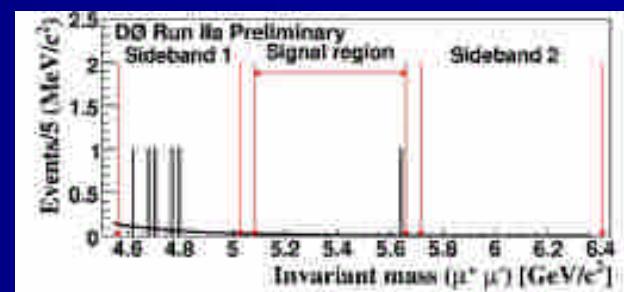
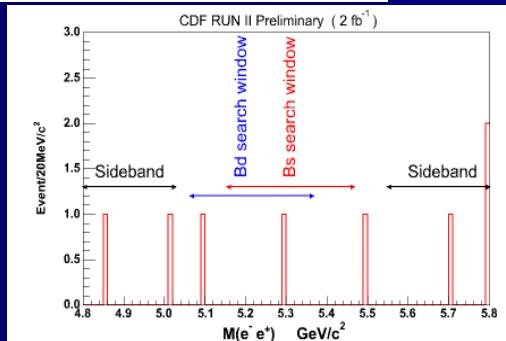
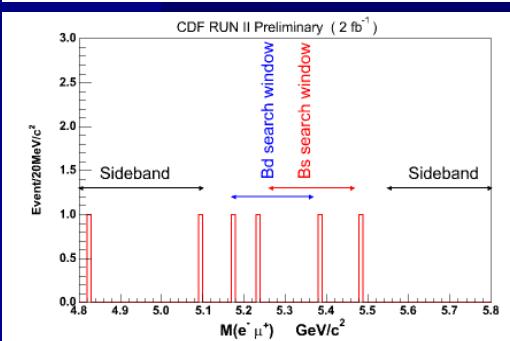
$B_s, d \rightarrow l^+ l^-$



Modes	$B^0 \rightarrow e^+ e^-$	$B^0 \rightarrow \mu^+ \mu^-$	$B^0 \rightarrow e^\pm \mu^\mp$
SM	1.9×10^{-15}	1.0×10^{-10}	0
BaBar	$< 1.1 \times 10^{-7}$	$< 5.2 \times 10^{-8}$	$< 9.2 \times 10^{-8}$
Belle	$< 1.9 \times 10^{-7}$	$< 1.6 \times 10^{-7}$	$< 1.7 \times 10^{-7}$
CLEO	$< 8.3 \times 10^{-7}$	$< 6.1 \times 10^{-7}$	$< 1.5 \times 10^{-6}$
CDF	$< 8.3 \times 10^{-8}$	$< 1.5 \times 10^{-8}$	$< 6.4 \times 10^{-8}$

NEW —

Modes	$B_S^0 \rightarrow e^+ e^-$	$B_S^0 \rightarrow \mu^+ \mu^-$	$B_S^0 \rightarrow e^\pm \mu^\mp$
SM	—	3.42×10^{-9}	0
CDF	$< 2.8 \times 10^{-7}$	$< 4.8 \times 10^{-8}$	$< 2.0 \times 10^{-7}$
D0	—	$< 7.3 \times 10^{-8}$	—



eu
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CDF

ee

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D0

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D⁰ mixing

Average of results

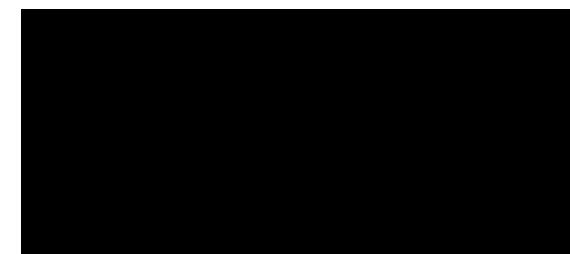
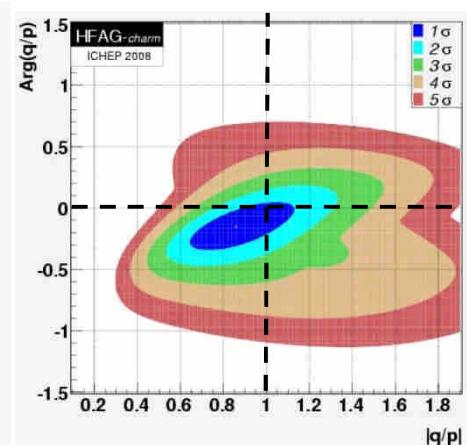
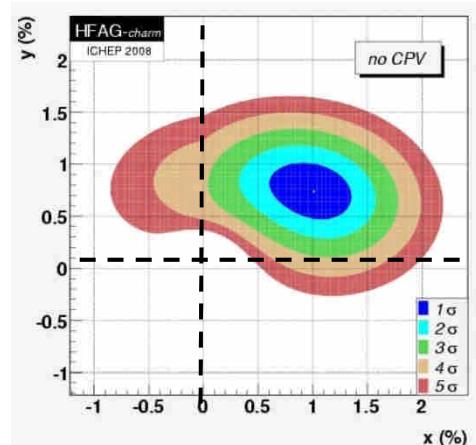
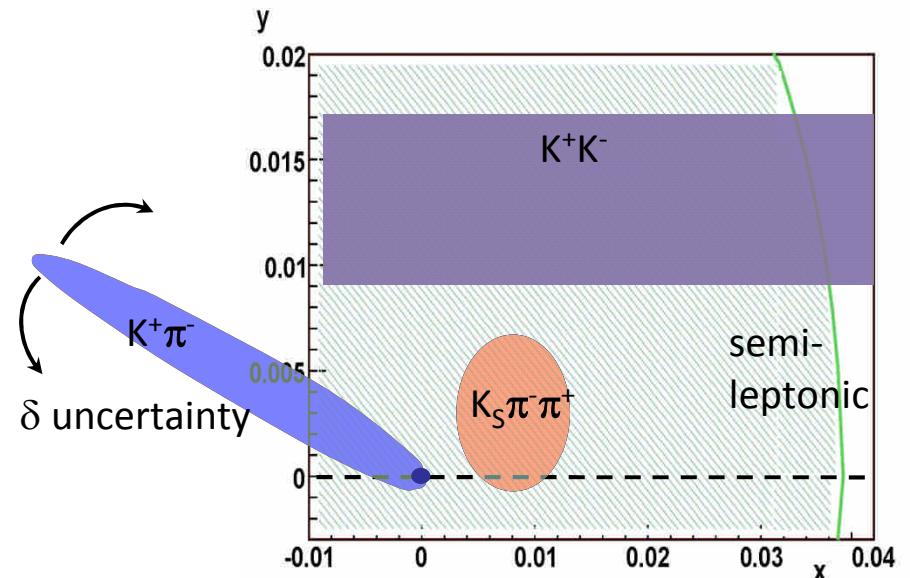
χ^2 fit including correlations among measured quantities

CPV

x	$(1.00^{+0.24}_{-0.26})\%$	[0.48, 1.46]%
y	$(0.76^{+0.17}_{-0.18})\%$	[0.40, 1.10]%
δ	$(22.5^{+10.4}_{-11.0})^\circ$	[-0.6, 43.2]°
$\delta_{K\pi\pi}$	$(11.2^{+20.6}_{-22.5})^\circ$	[-34.5, 51.1]°
R _D	$(0.336 \pm 0.009)\%$	[0.320, 0.353]%
A _D	$(-2.1 \pm 2.4)\%$	[-6.8, 2.7]%
q/p	$0.86^{+0.17}_{-0.15}$	[0.59, 1.22]
Φ	$(-8.8^{+7.6}_{-7.2})^\circ$	[-23.0, 6.3]°

$\chi^2/n.d.f.=25.3/20$ from HFAG

$$x \equiv \frac{m_1 - m_2}{\bar{\Gamma}}; y \equiv \frac{\Gamma_1 - \Gamma_2}{2\bar{\Gamma}};$$

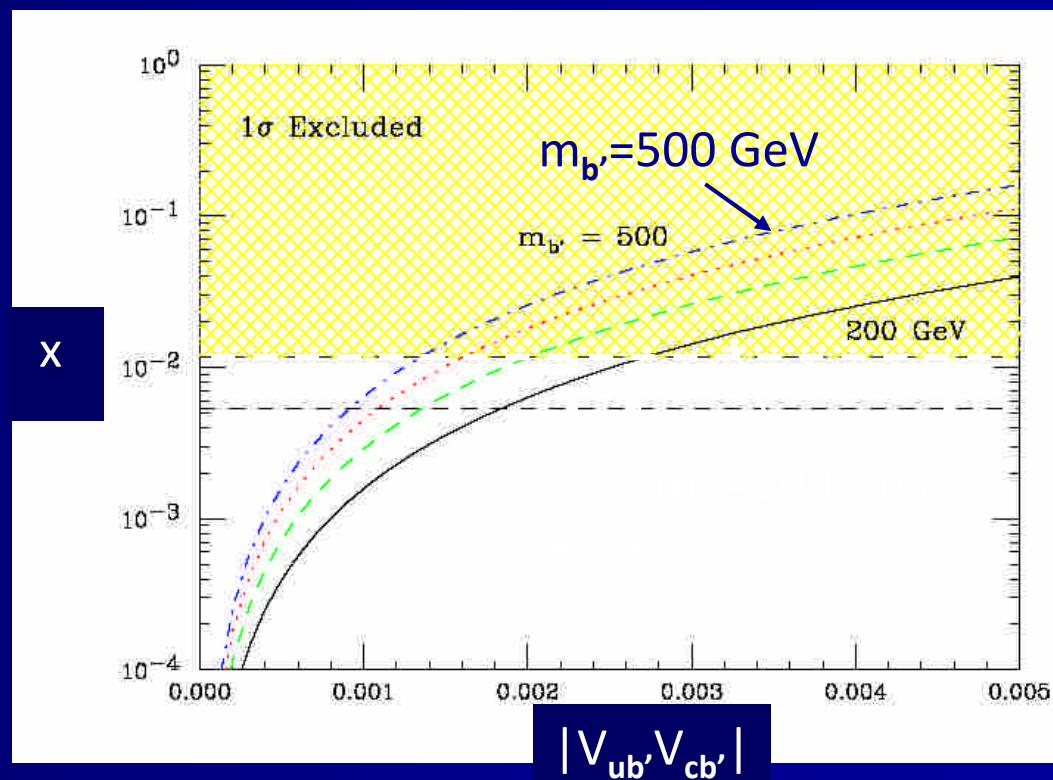


Constraint on 4th fermion family

E. Golowich et al., PRD76, 095009 (2007)

21 different NP models:
only 4 no constraints in
parameter space
from established D⁰
mixing rate $x^2+y^2 \leq \sim 10^{-4}$

example:
4th fermion family
(much more severe constraints
on $|V_{ub}' V_{cb}'|$ than from
CKM unitarity)



Constraint on NP

E. Golowich et al., PRD76, 095009 (2007)

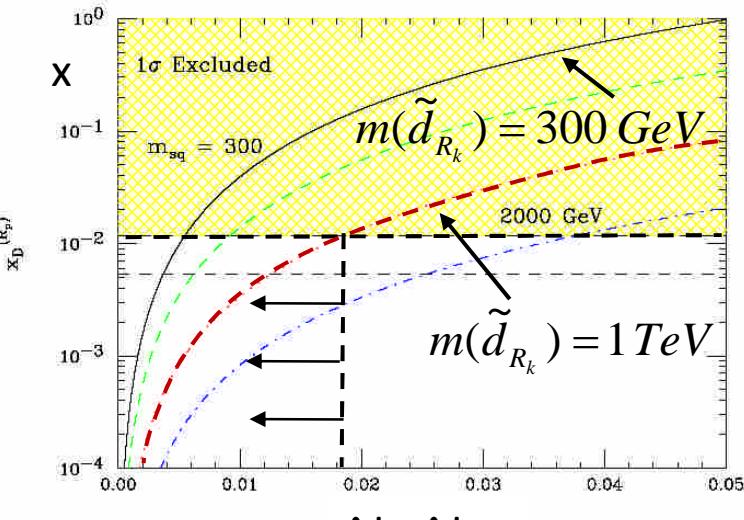
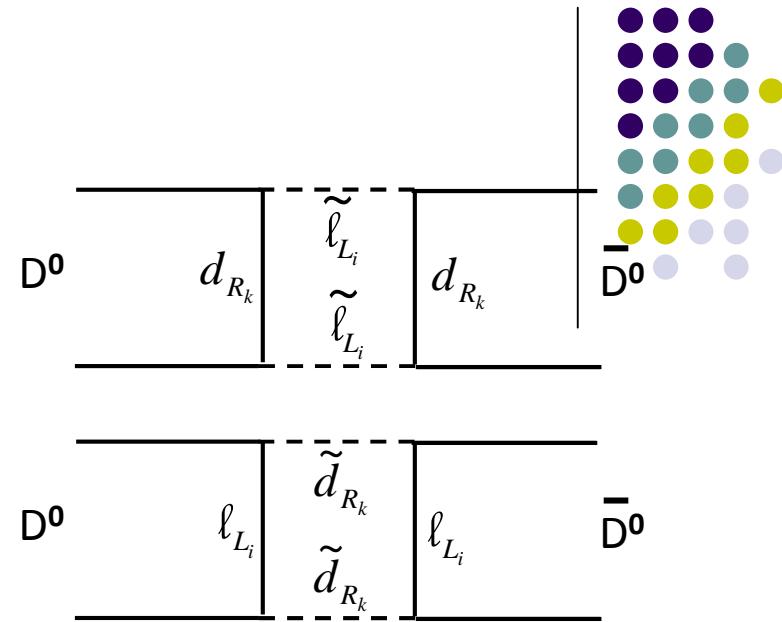
example:

R parity violating SUSY
(severe constraints on
R violating couplings)

	Super-B				
	$\sigma(x)$	$\sigma(y)$	$\sigma(q/p)$	$\sigma(\phi)$	
initial \rightarrow	5 ab $^{-1}$	0.15%	0.08%	0.09	0.10
	50 ab $^{-1}$	0.10%	0.06%	0.06	0.05

LHCb	$\sigma(x^2)$	$\sigma(y')$
10 fb $^{-1}$	6×10^{-5}	0.1%

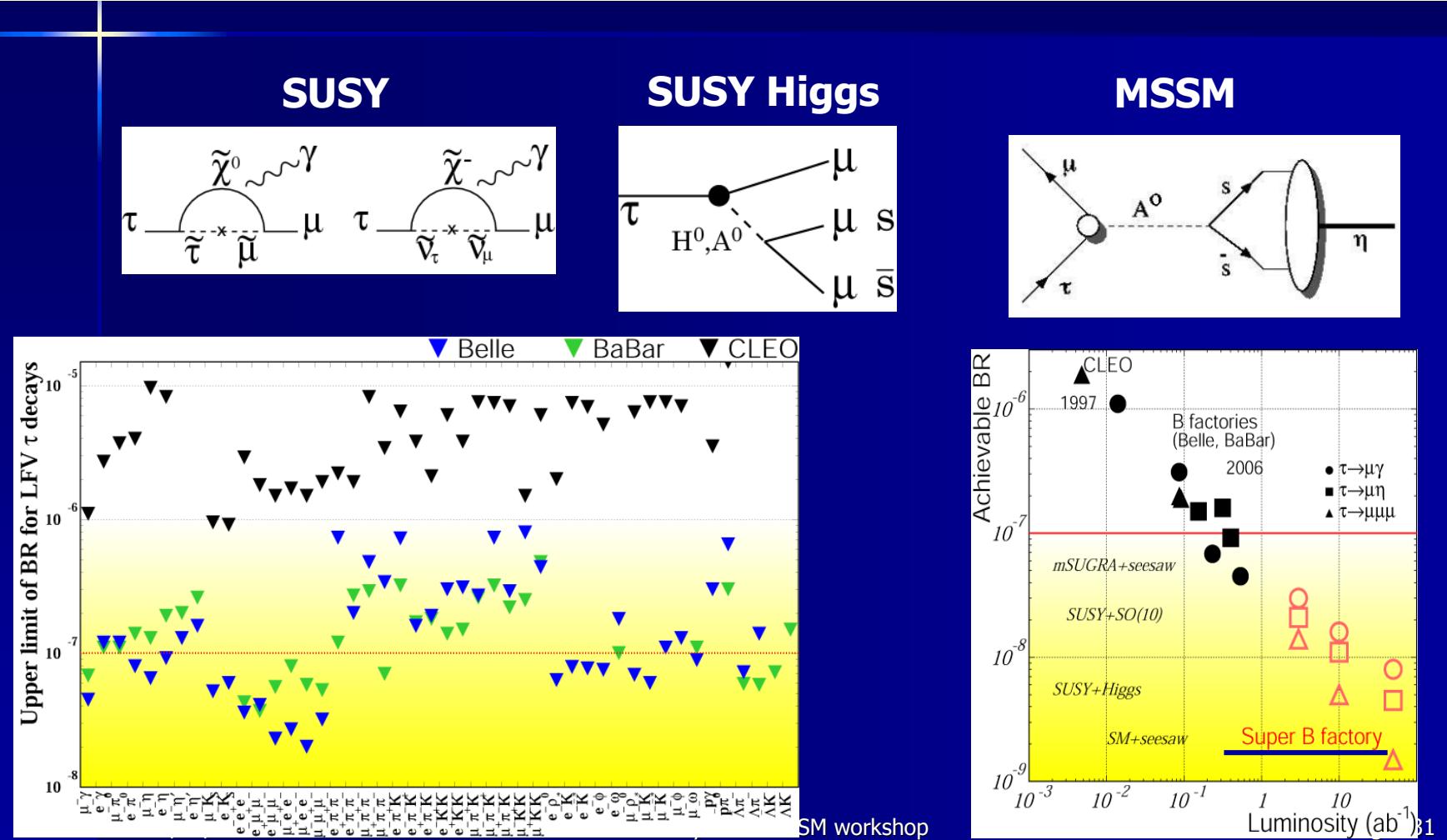
Initial stage of Super-B, LHCb;
 $x, y \sim 3x$ better than WA;
 sensitivity to CPV \gg range of SM predict



R-parity violating
coupling const.

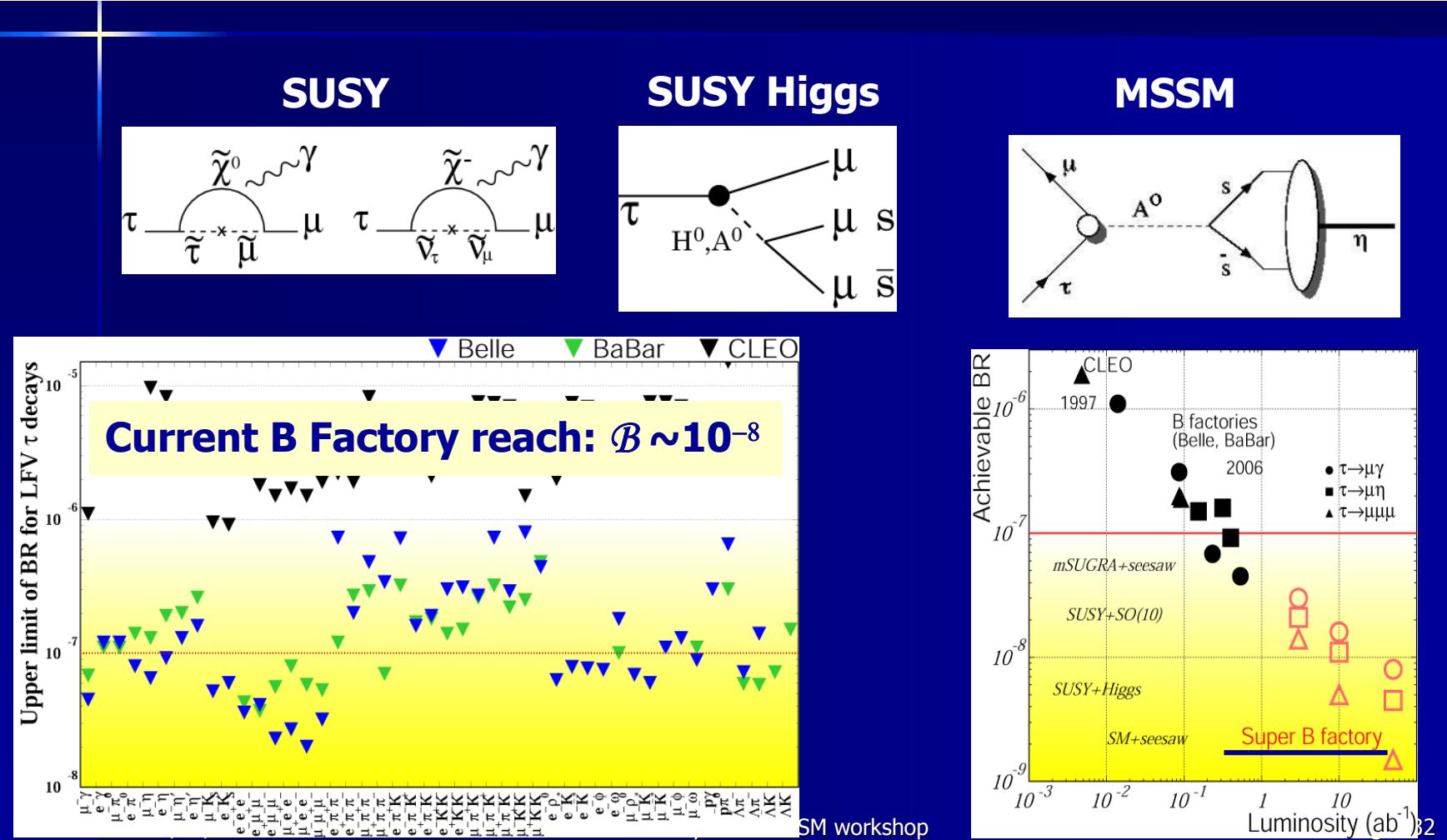
Lepton Flavor Violation in τ Decay

- Forbidden in SM but various new physics models predict \mathcal{B} as high as 10^{-8}



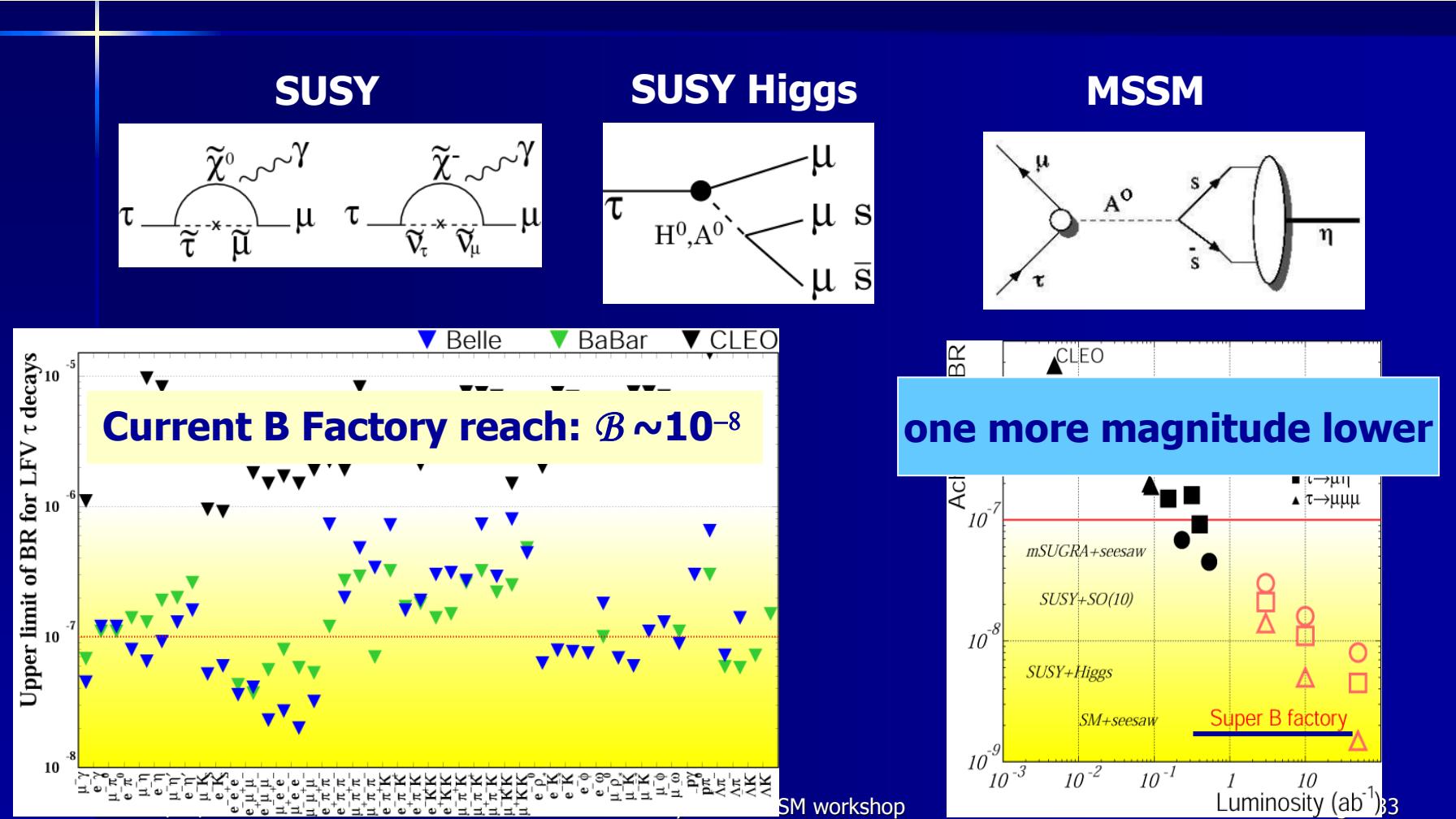
Lepton Flavor Violation in τ Decay

- Forbidden in SM but various new physics models predict \mathcal{B} as high as 10^{-8}



Lepton Flavor Violation in τ Decay

- Forbidden in SM but various new physics models predict \mathcal{B} as high as 10^{-8}



Conclusion

- Results start to probe NP but limited by statistics:
 $B \rightarrow \tau\nu, A_{FB}$, isospin asymmetry
- $\mathcal{B}(B \rightarrow X s\gamma)$ strong constraint to NP
- ΔS puzzle and D^0 mixing \Rightarrow still needs more data
 ΔA explanation \Rightarrow if from new physics, what is it?
- LHCb: ϕ_{Bs}, A_{FB} on $K^* ll, Bs,d \rightarrow ll, \dots$
SuperB: $B \rightarrow \tau\nu, K^* vv, A_{cp}(K^0\pi^0), \dots$

Thanks to Bostjan Golob for preparing the D^0 mixing slides.

Backup Slides

More on A_{FB}

$$\frac{dA_{FB}}{d\hat{s}} \propto - \left\{ \text{Re}(C_9^{\text{eff}} C_{10}) V A_l + \frac{\hat{m}_b}{\hat{s}} \text{Re}(C_7^{\text{eff}} C_{10}) [V T_2 (1 - \hat{m}_{K^*}) + A_l T_1 (1 + \hat{m}_{K^*})] \right\}$$

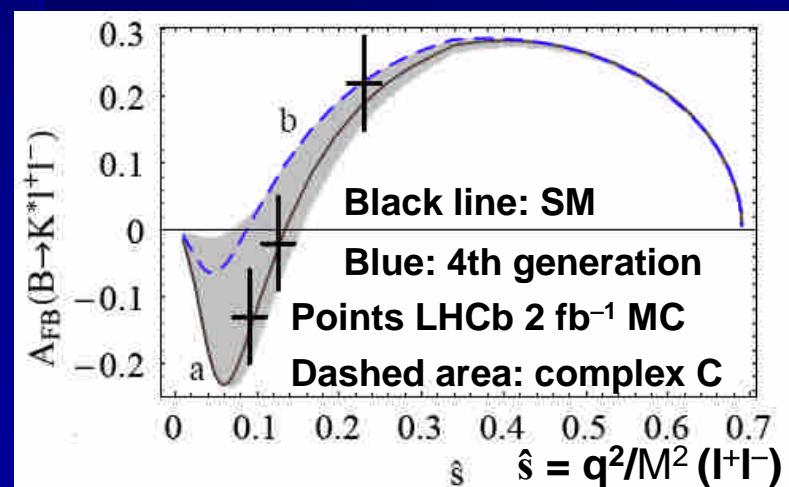
- $C_7 = -C_7^{\text{SM}}$? If yes, \mathcal{B} will change!

The sign of C_7 is constrained by \mathcal{B} (XsII).

Gambino et. al, PRL94, 061803, 05

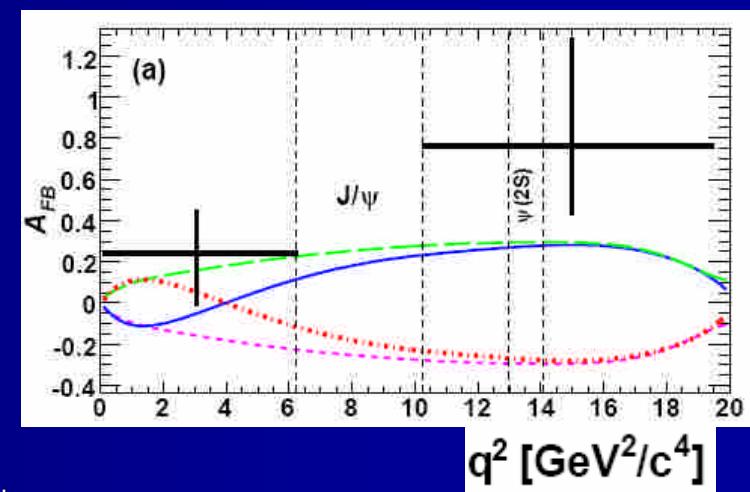
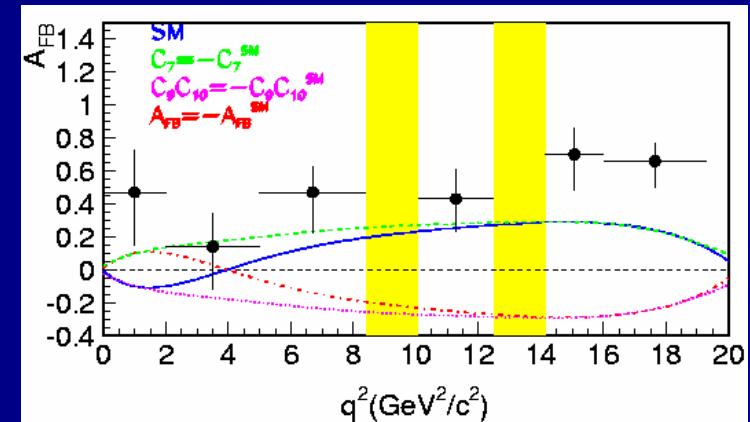
- C may be complex due to new physics.

Hou et. Al, PRD77, 014016, 08



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Direct CP Violation on $B \rightarrow X_s \gamma$

BaBar measurement using sum of 16 exclusive modes

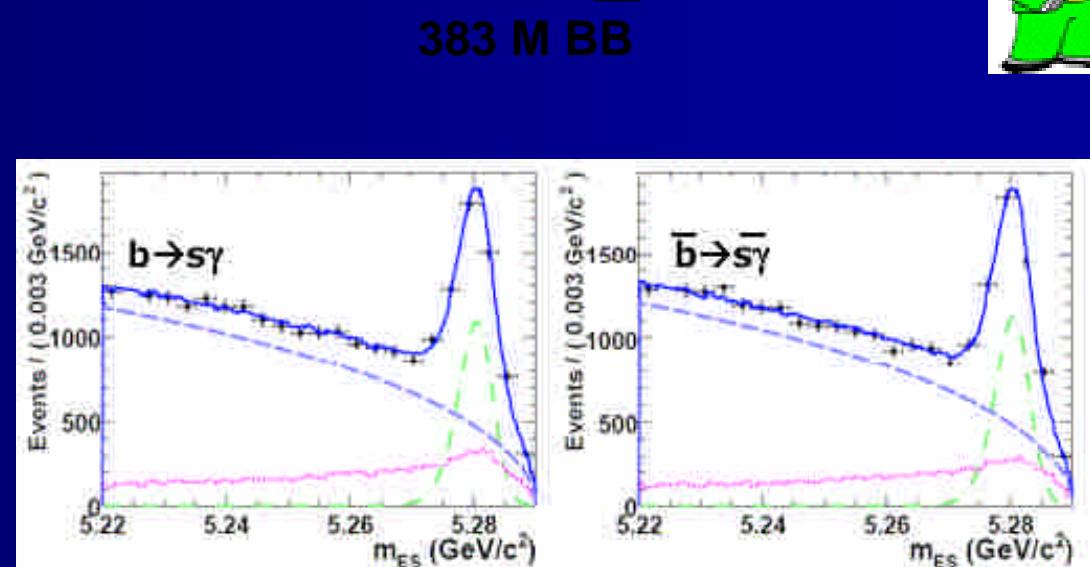
arXiv: 0805.4796



$$A_{CP} = \frac{B(b \rightarrow s\gamma) - B(\bar{b} \rightarrow \bar{s}\gamma)}{B(b \rightarrow s\gamma) + B(\bar{b} \rightarrow \bar{s}\gamma)}$$

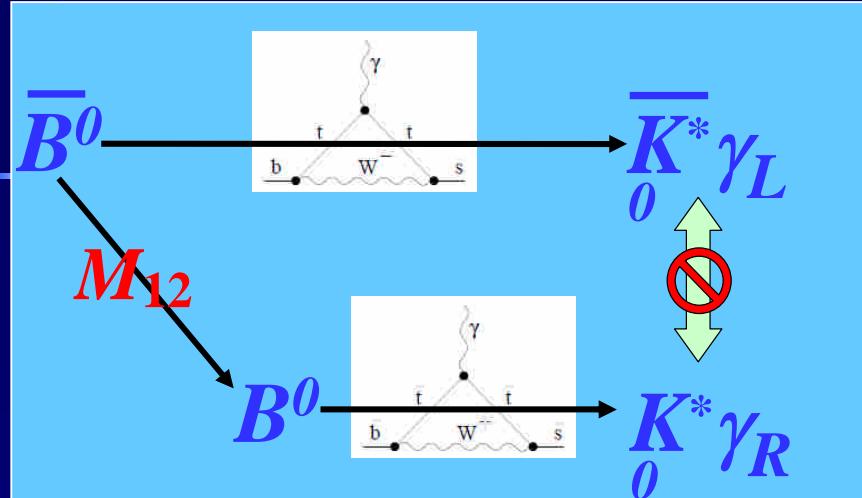
SM expectation by
Kagan & Neubert,
PRD58, 094012 (1998)

$A_{CP} \sim (0.5 \pm 0.2)\%$
 \Rightarrow small CP asymmetry



$$A_{CP} = -0.011 \pm 0.030 \text{ (stat.)} \pm 0.014 \text{ (syst.)}$$

tCPV on Radiative Penguin



γ_R m_s/m_b suppressed

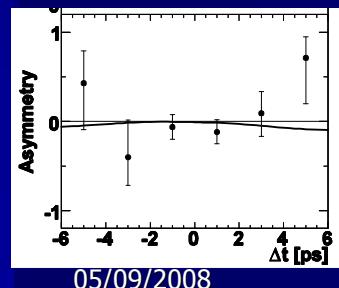
Interference suppressed in SM

γ_L m_s/m_b suppressed

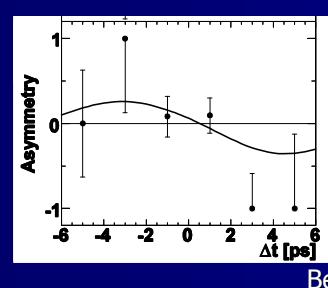
- No CPV seen before; this conference:

$K^0\pi^0\gamma$

K^* region



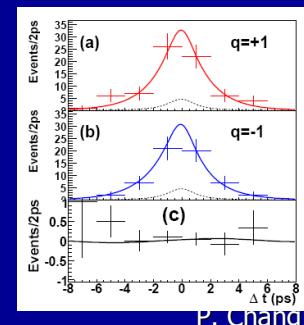
$1.2 < M(K\pi) < 1.6$



$K^0\eta\gamma$

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$K^0\pi^+\pi^-\gamma$

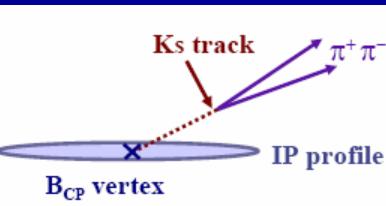
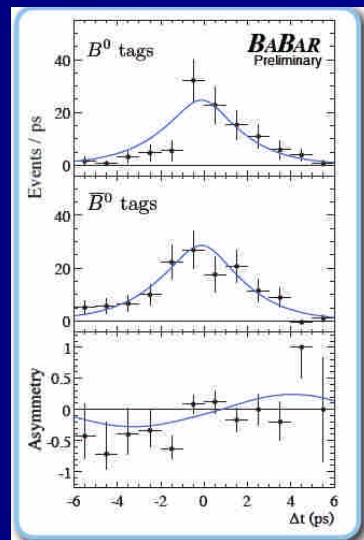
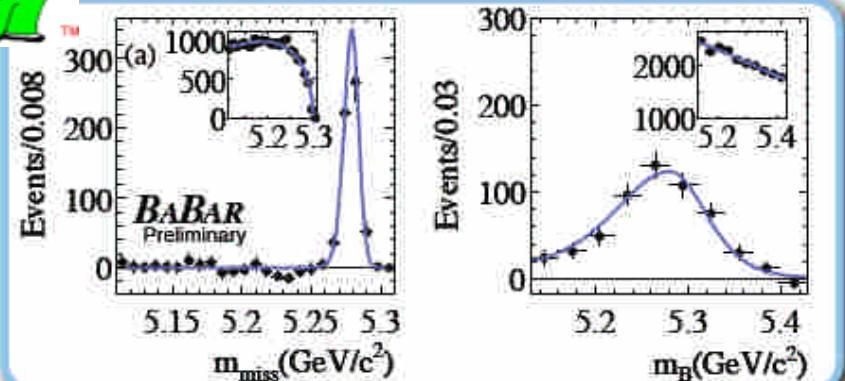


TCPV on $B^0 \rightarrow K^0 \pi^0$

NEW



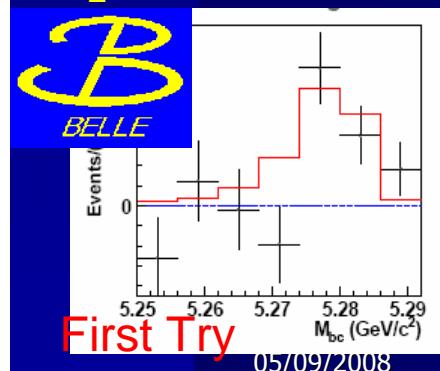
556 ± 32 evts



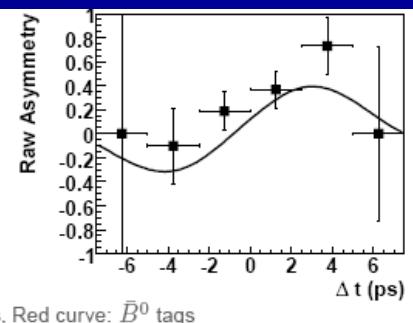
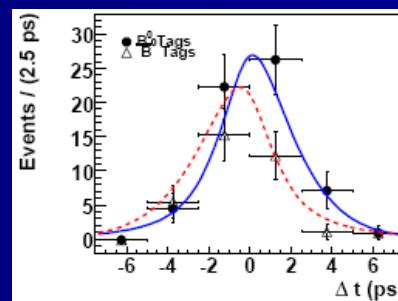
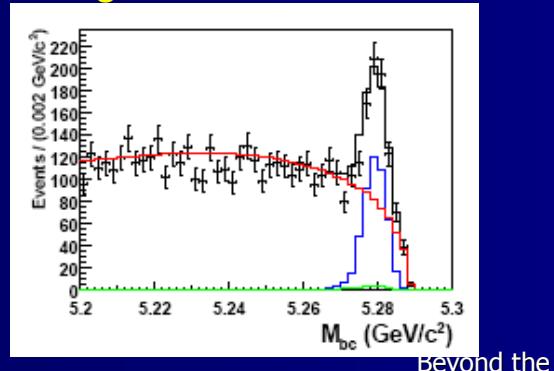
For S, use candidates with SVD hits

For C, all signals

$K_L \pi^0$ 239 ± 47 evts



$K_S \pi^0$ 657 ± 37 evts

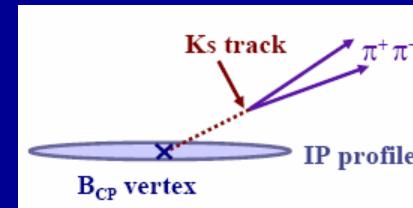
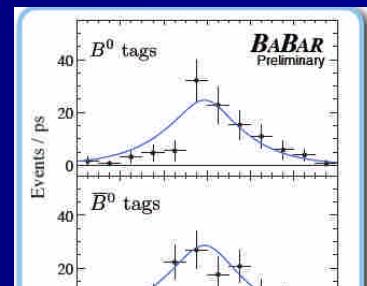
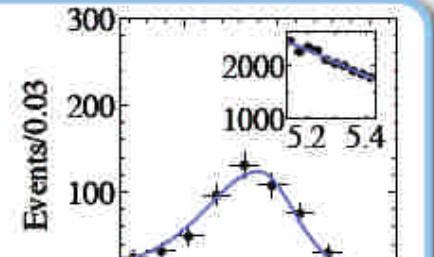
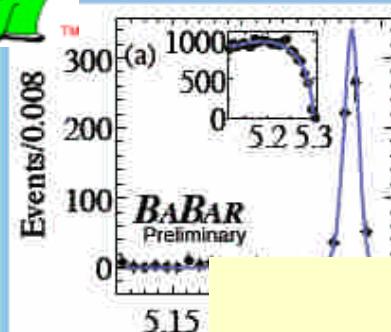


TCPV on $B^0 \rightarrow K^0 \pi^0$

NEW



556 ± 32 evts



for S, use candidates with D/D hits
for C, all signals

$K_L \pi^0$ 239 ± 4

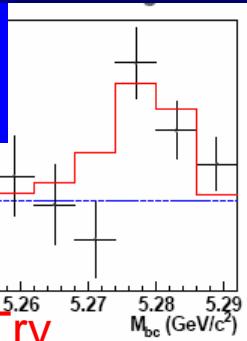
S

$$+0.55 \pm 0.20 \pm 0.03$$

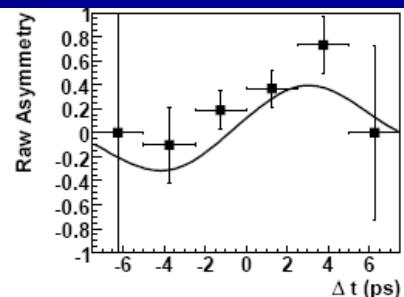
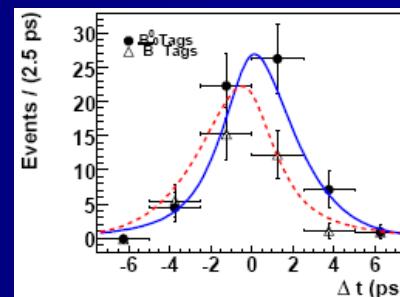
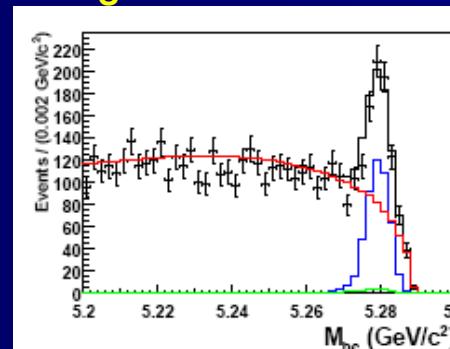
$$+0.13 \pm 0.13 \pm 0.03$$

$$+0.67 \pm 0.31 \pm 0.08$$

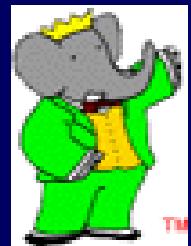
$$-0.14 \pm 0.13 \pm 0.06$$



First Try

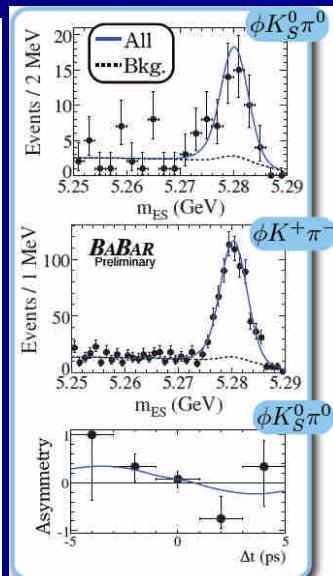
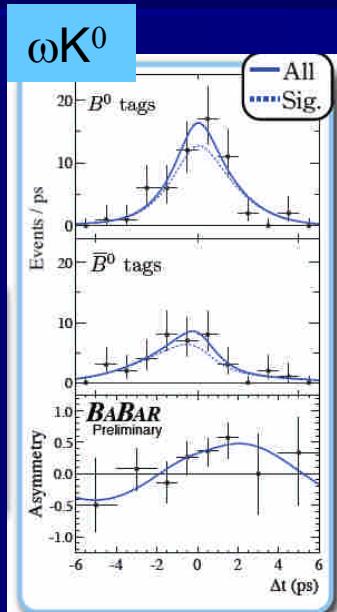
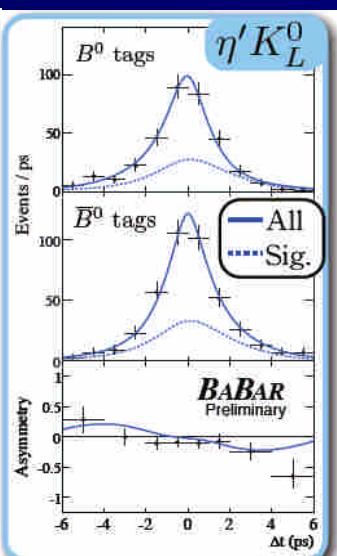
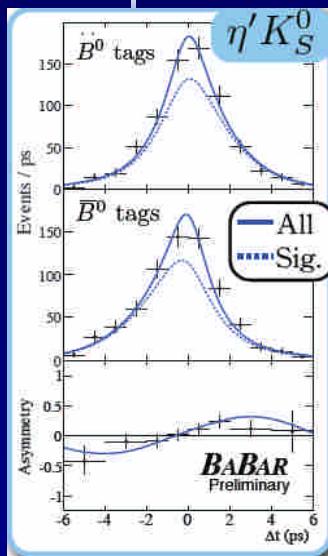


TCPV on $\eta' K^0$, ωK_S and $\phi K_S \pi^0$



NEW

467 M $B\bar{B}$ final dataset



- See Hirschauer's talk for details.
- For $\phi K^0 \pi^0$, polarizations, yields, A_{cp} ... are constrained with $\phi K^+ \pi^-$

S

$\eta' K^0$ $+0.57 \pm 0.08 \pm 0.02$

ωK_S $+0.55^{+0.26}_{-0.29} \pm 0.02$

$\phi(K_S \pi^0)_0$ $+0.97^{+0.03}_{-0.52}$

C = -A

$-0.08 \pm 0.06 \pm 0.02$

$-0.52^{+0.22}_{-0.20} \pm 0.03$

$+0.20 \pm 0.14 \pm 0.06$

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T-dependent Dalitz on $\pi^+\pi^-K_S^0$

Decay modes considered:

$K^{*+}(892)\pi^-$, $K^{*+}(1430)\pi^-$, $\rho^0 K^0$,
 $f_0(980)K_S$, $f_0(1270)K_S$, $f_X(1300)K^0$,
 $(K_S\pi^+)\text{NR}\pi^-$, $(K_S\pi^-)\text{NR}\pi^+$, $(\pi^+\pi^-)\text{NR}K_S$

Solution 1: $f(K_0^{*+}(1430)\pi^-) = (61.7 \pm 10.4)\%$

$$\mathcal{A}_{CP}(\rho^0(770)K_S^0) = +0.03^{+0.23}_{-0.24} \pm 0.11 \pm 0.10$$

$$\phi_1^{\text{eff}}(\rho^0(770)K_S^0) = (20.0^{+8.6}_{-8.5} \pm 3.2 \pm 3.5)^\circ$$

$$\mathcal{A}_{CP}(f_0(980)K_S^0) = -0.06^{+0.17}_{-0.17} \pm 0.07 \pm 0.09$$

$$\phi_1^{\text{eff}}(f_0(980)K_S^0) = (12.7^{+6.9}_{-6.5} \pm 2.8 \pm 3.3)^\circ$$

Solution 2: $f(K_0^{*+}(1430)\pi^-) = (17.4 \pm 5.0)\%$

$$\mathcal{A}_{CP}(\rho^0(770)K_S^0) = -0.16^{+0.24}_{-0.24} \pm 0.12 \pm 0.10$$

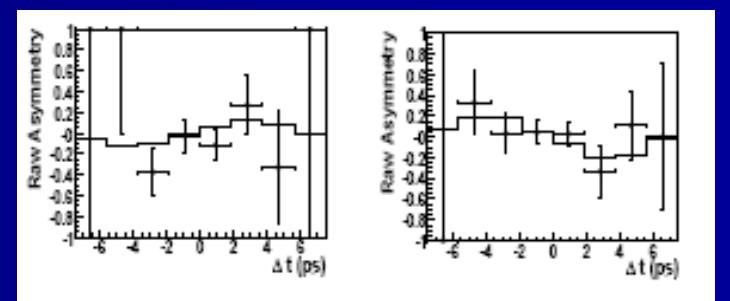
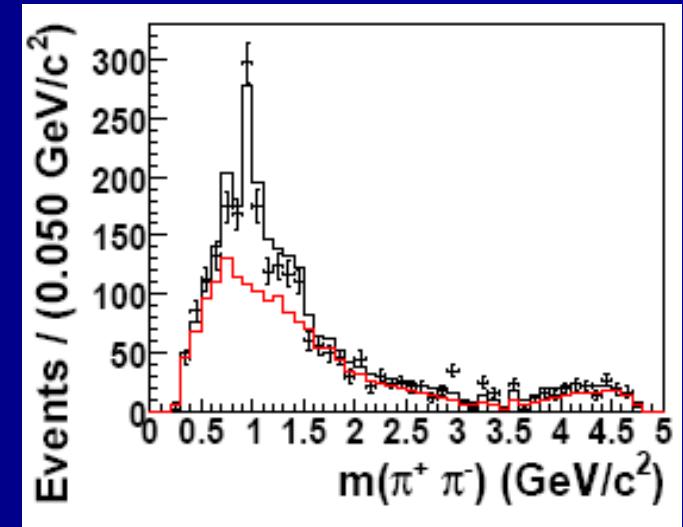
$$\phi_1^{\text{eff}}(\rho^0(770)K_S^0) = (22.8^{+7.5}_{-7.5} \pm 3.3 \pm 3.5)^\circ$$

$$\mathcal{A}_{CP}(f_0(980)K_S^0) = +0.00^{+0.17}_{-0.17} \pm 0.06 \pm 0.09$$

$$\phi_1^{\text{eff}}(f_0(980)K_S^0) = (14.8^{+7.3}_{-6.7} \pm 2.7 \pm 3.3)^\circ$$

difference as systematic errors

NEW 657 M $B\bar{B}$

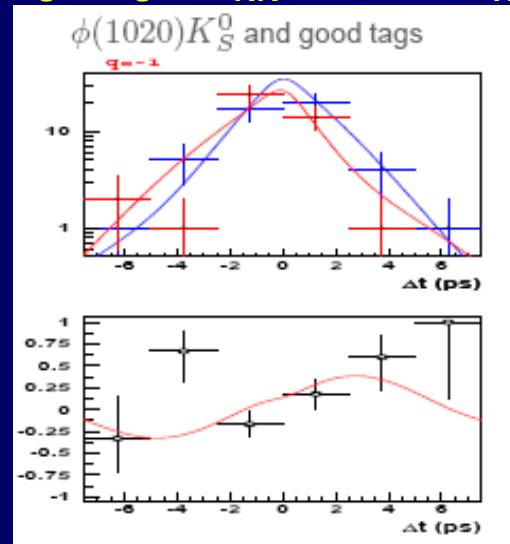


T-dependent Dalitz on $K^+K^-K_S^0$ NEW



Model uses:

$f_0(980)K_S$, $\phi(1020)K_S$, $f_X(1500)K_S$,
 $\chi_{c0} K_S$, $(K_S K^+)_{NR} K^+$, $(K^+ K^-)_{NR} K_S$

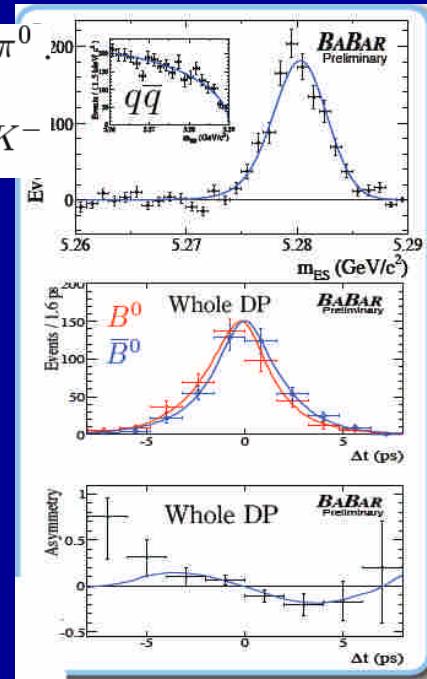


$$\begin{aligned} \mathcal{A}_{CP}(f_0(980)K_S^0) &= -0.02 \pm 0.34 \pm 0.08 \pm 0.09 \\ \phi_1^{\text{eff}}(f_0(980)K_S^0) &= (28.2^{+9.8}_{-9.9} \pm 2.0 \pm 2.0)^\circ \\ \mathcal{A}_{CP}(\phi(1020)K_S^0) &= +0.31^{+0.21}_{-0.23} \pm 0.04 \pm 0.09 \\ \phi_1^{\text{eff}}(\phi(1020)K_S^0) &= (21.2^{+9.8}_{-10.4} \pm 2.0 \pm 2.0)^\circ \end{aligned}$$

05/05/2008

- Reconstruct $K_S^0 \rightarrow \pi^+\pi^-$ and $\pi^0\pi^0$
- Model uses: ϕK_S^0 , $f_0 K_S^0$, $X_0 K_S^0$, NR , $\chi_{c0} K_S^0$, $D^+ K^-$, $D_s^+ K^-$

657 M $B\bar{B}$

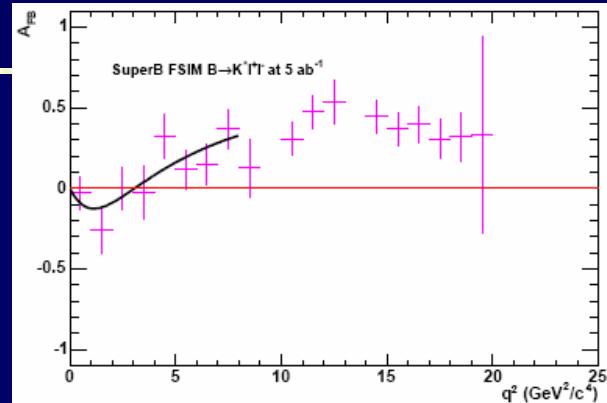


Fit	$A_{CP}(-C_f)$	$\beta_{\text{eff}} (\beta_{\text{SM}} \simeq 0.37)$
Whole DP	$0.03 \pm 0.07 \pm 0.02$	$0.44 \pm 0.07 \pm 0.02$
High-Mass	$0.05 \pm 0.09 \pm 0.04$	$0.52 \pm 0.08 \pm 0.03$
ϕK_S^0	$0.14 \pm 0.19 \pm 0.02$	$0.13 \pm 0.13 \pm 0.02$
$f_0 K_S^0$	$0.01 \pm 0.26 \pm 0.07$	$0.15 \pm 0.13 \pm 0.03$

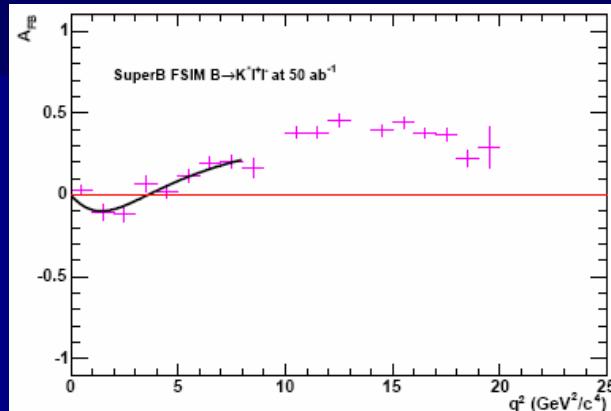
Beyond the 3SM workshop

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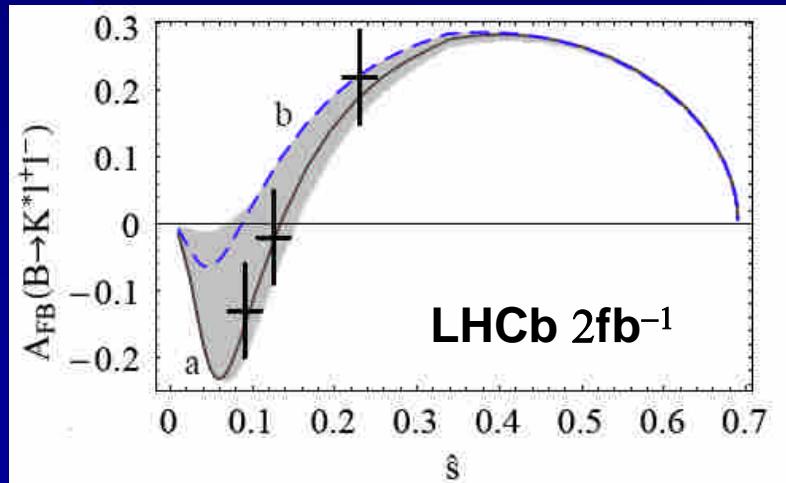
Future Prospects for $A_{FB}(q^2)$



5ab^{-1} MC study of SuperB

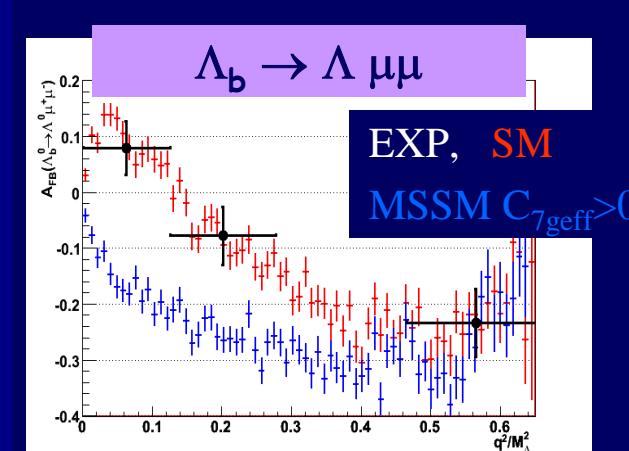


50ab^{-1} MC study of SuperB



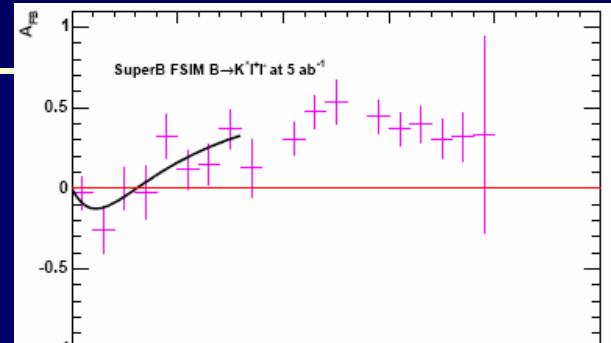
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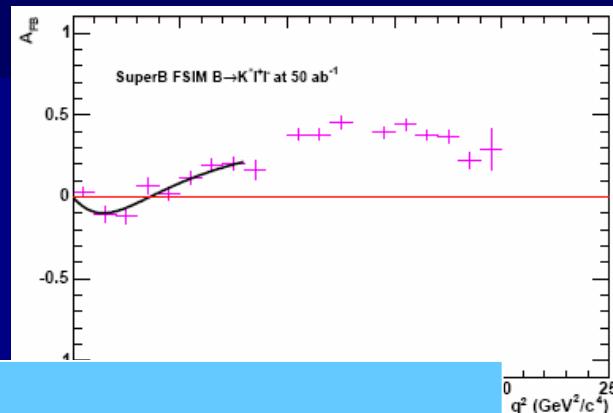
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Future Prospects for $A_{FB}(q^2)$

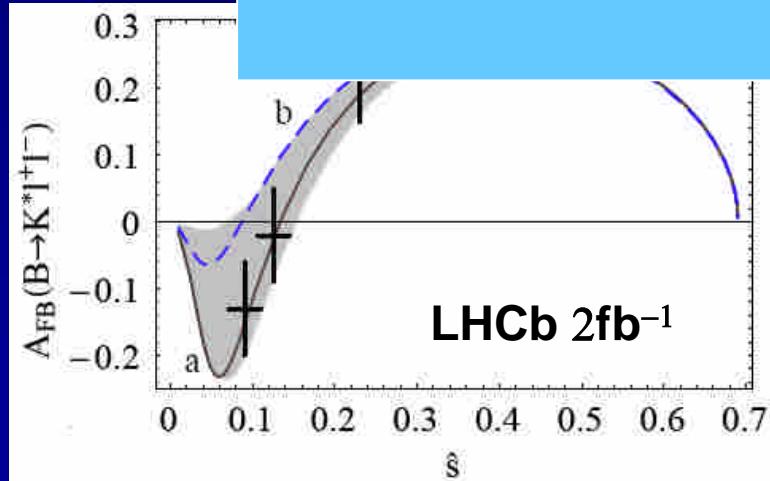


5 ab^{-1}

CDF and D0, please contribute!

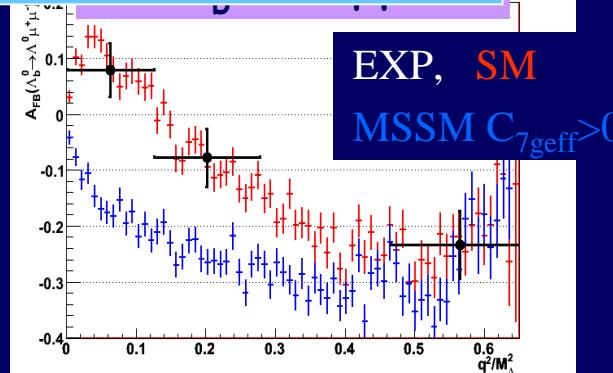


SuperB



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