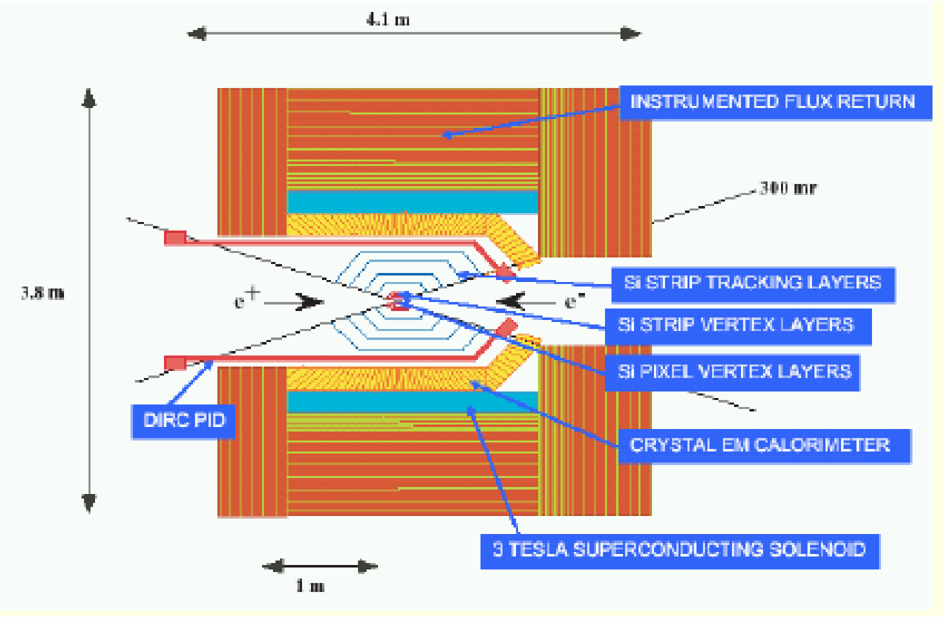


B physics at e+e-

Marcello A. Giorgi
Università di Pisa and INFN Pisa

presented at

XXXIII International Meeting On Fundamental Physics

Benasque (High Pyrenees), Aragon, Spain, March 6-11, 2005

B meson environment is a beautiful laboratory

- Sizable mixing and CP violation
- HQET works and has predictive power
- Many transitions probe different quantities

e^+e^- machines are fantastic probes

- Very clean environment: ½-track trigger
- Coherent initial state allows true interference measurements and high tagging efficiency with low dilution

Luminosity counts

- Large samples allow precision measurements
- Rare and very rare decays are becoming more and more
- crucial.

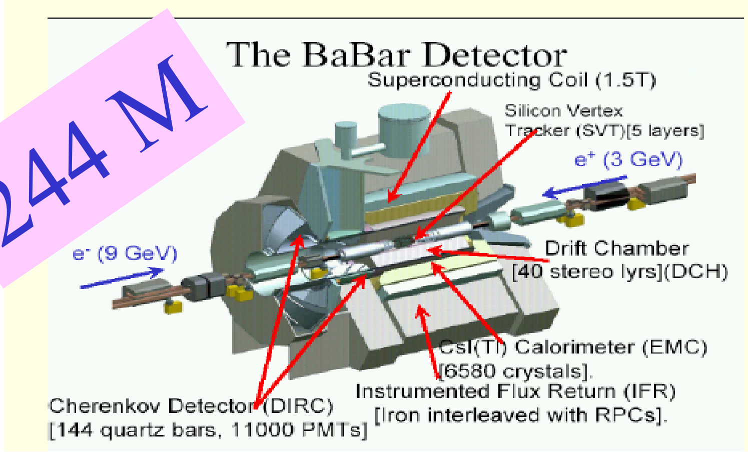
Yesterday

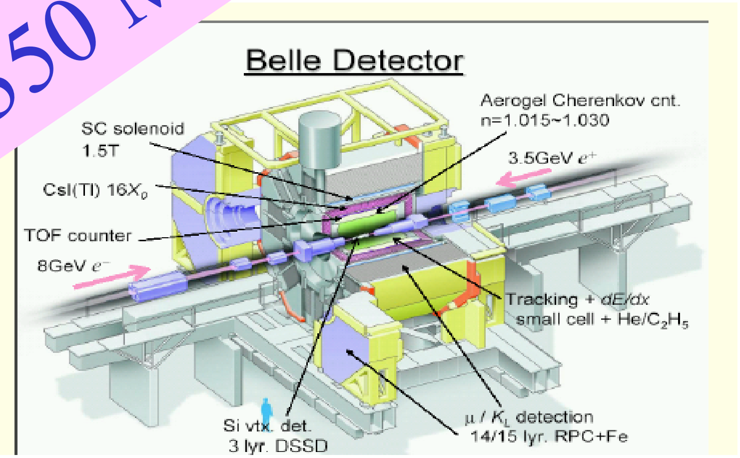
Experiments	Number of $b\bar{b}$ events ($\times\ 10^6$)	Environment	Characteristics
ALEPH, DELPHI OPAL, L3	$\sim$ 1 per expt.	Z^0 decays ($\sigma_{bb} \sim$ 6nb)	back-to-back 45 GeV b-jets all B hadrons produced
SLD	~ 0.1	Z^0 decays ($\sigma_{bb} \sim$ 6nb)	back-to-back 45 GeV b-jets all B hadrons produced beam polarized
ARGUS	~ 0.2	$\Upsilon(4S)$ decays ($\sigma_{bb} \sim$ 1.2nb)	mesons produced at rest B_d^0 and B^+
CLEO	~ 9	$\Upsilon(4S)$ decays ($\sigma_{bb} \sim$ 1.2nb)	mesons produced at rest B_d^0 and B^+
CDF	$\sim$ several	$p\bar{p}$ collisions $\sqrt{s} = 1.8$ TeV	events triggered with leptons all B hadrons produced

Today

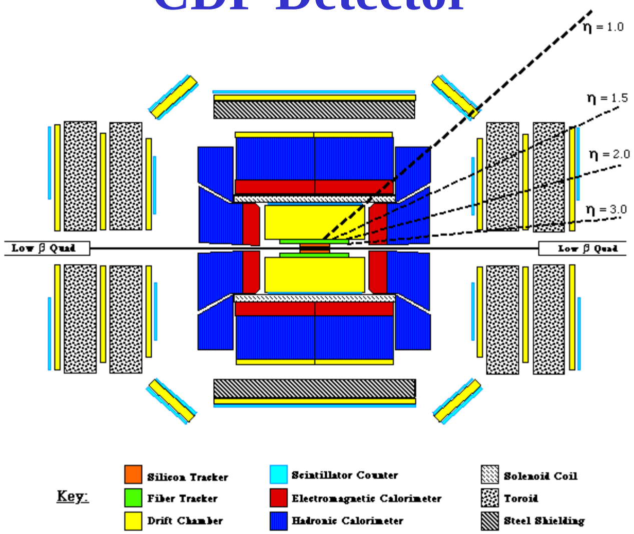
244 M

>350 M

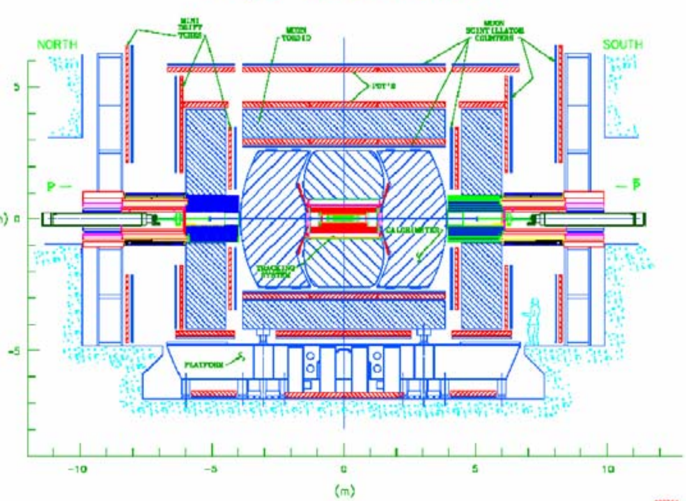




CDF Detector



DØ Detector

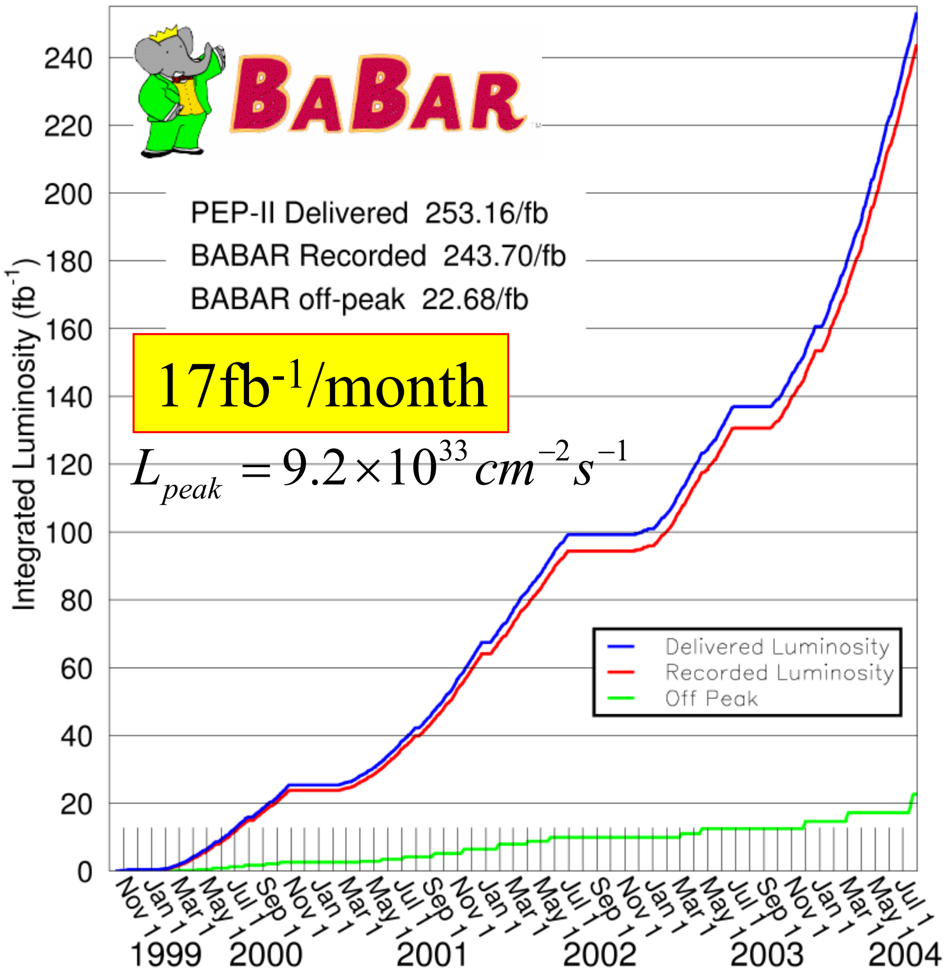


Tomorrow ????

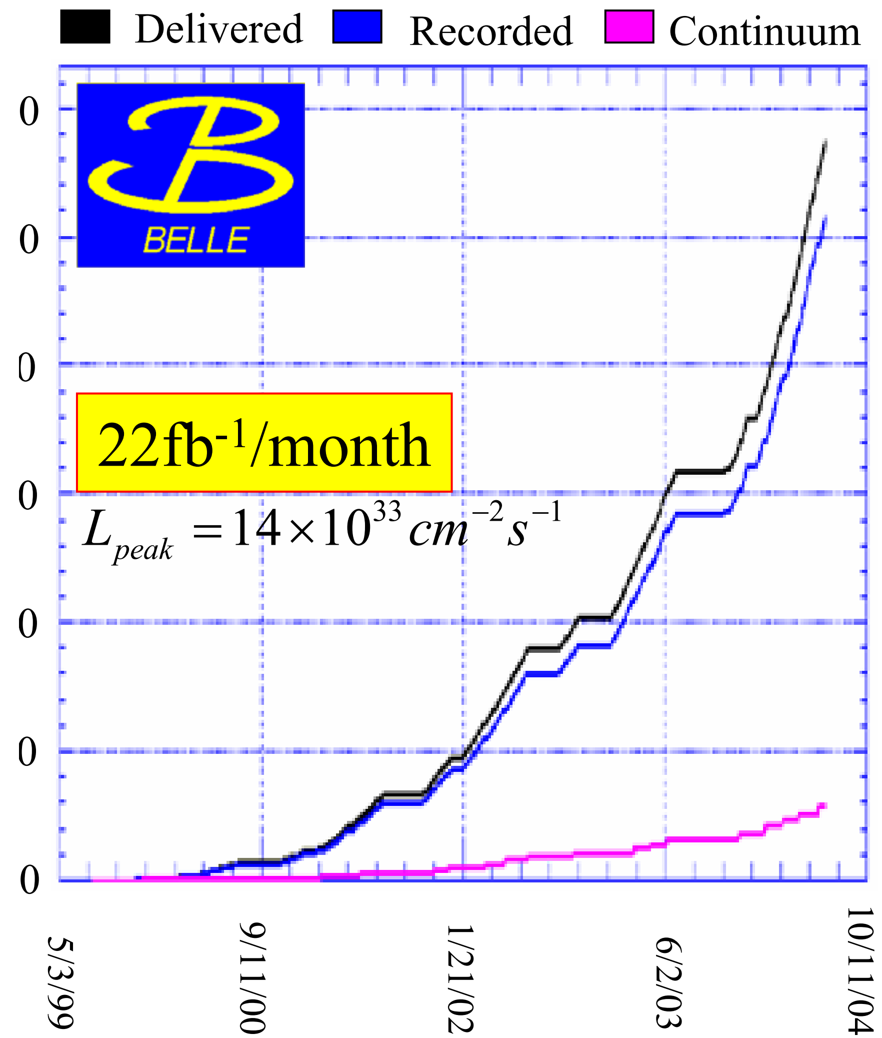
- What:
  - PEP-II/Babar & KEK-B/Belle currently at peak luminosity 10^{34} $cm^{-2}s^{-1}$ ± 10% and at the end of 2006 2.0 10^{34} $cm^{-2}s^{-1}$ ± 10%
  - Integrated sample of > $1ab^{-1}$ expected for each machine by 2009
  - Upgrade ideas/proposals to increase luminosity by a factor 10 to 100, for a sample size of 5-50 ab^{-1}.
- Why:
  - High precision Standard Model Unitarity Triangle (UT) measurements
  - New Physics (NP) contributions to rare decays B.R. & Asymmetries.
  - Distinctive patterns may discriminate between models
- How:
  - Different upgrade scenarios are being considered: from 1.5 x 10^{35} to 10^{36}
  - Detector and machine complexity/cost undergo a phase transition around 1÷2 x 10^{35} $cm^{-2}s^{-1}$.. Above that there are severe Detector issues.
- When:
  - in the era of LHCb, BTeV and LHC experiments.
  - Competitiveness and complementarity with hadron machines is a real issue.

Current luminosities and data samples

Total 244 + 286 fb^{-1} = 0.530 ab^{-1}!! As AUGUST 2004 (ICHEP04)



$L_{peak} = 9.2 \times 10^{33} cm^{-2} s^{-1}$



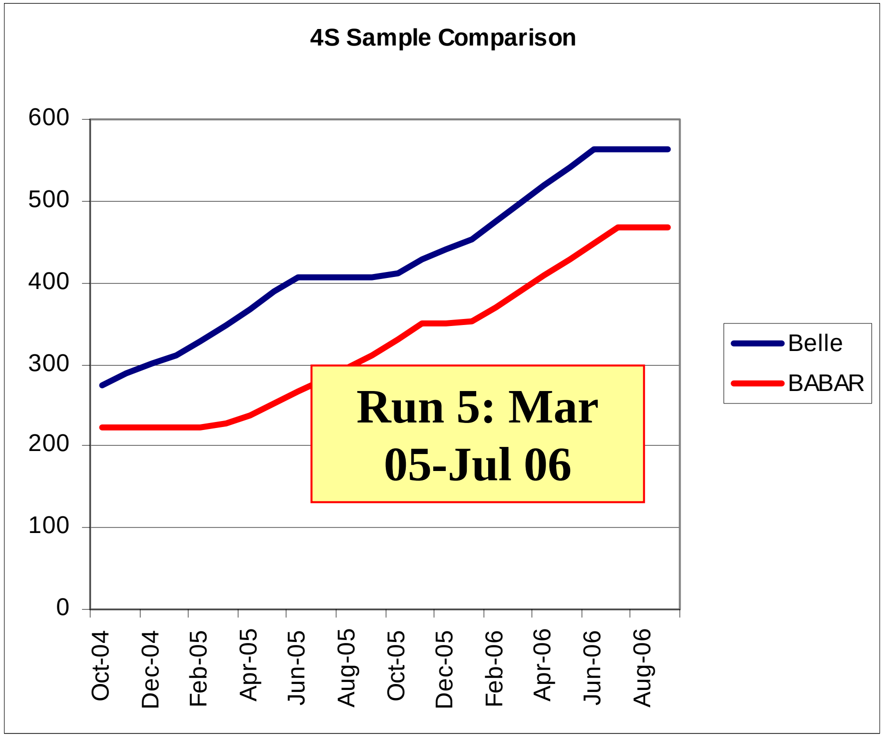
$L_{peak} = 14 \times 10^{33} cm^{-2} s^{-1}$

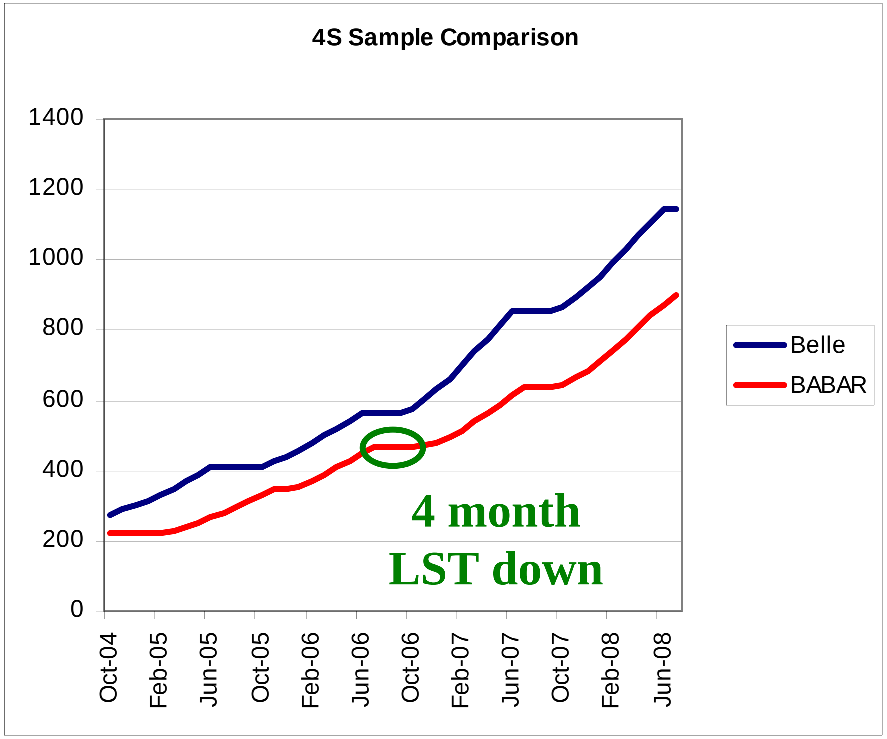
Since August 1st *BABAR* is not running.

BELLE has resumed the operations in September 04 and has already collected more than 350 M of B pairs.

Run 5 will start shortly. The plan is to run through July 31,2006 with one month down this fall. PEPII improvements already in place will allow the peak luminosity to grow to 1.3 10^{34} cm^{-2} s^{-1} *by the end of this run. Such an extended period is projected to allow the dubling of present sample by summer 2006 to about 530* fb^{-1} .

Running plan for 2005-2006 and beyond





Double data by summer 2006

Double again by summer 2008

PHYSICS MENU

- Unitarity Triangle sides measurements
  - From (semi)leptonic decays, inclusive or exclusive
  - $|V_{ub}|$, $|V_{cb}|$, $|V_{td}|$
- UT angles precision measurements
  - b→s penguin transitions very sensitive to new physics
  - CPV Asymmetries in $B \to \phi K_s$, $K_s \pi^0$ compared with $\sin 2\beta$.
  - α measurement with $B \to \pi\pi$ and $\rho\rho$; direct CPV
  - γ measurement with $B \to DK$ or similar channels.
- Rare decays
  - Exclusive and inclusive $b \to s\gamma$ BFs, direct asymmetries, photon helicities
  - Exclusive and inclusive $b \to sl^+l^-$ BFs, A_{FB}, CP asymmetries
  - B decays to states with large missing energy, such as $B_{(d,s)} \to \tau^+\tau^-$, $B \to K^{(*)}\nu\nu$, $b \to s\nu\nu$, $B \to D^{(*)}\tau\nu_\tau$, $B \to X_C\tau\nu_\tau$
  - LFV in $\tau \to \mu\gamma$ and similar channels

Impressive physics program achieved at B-Factories

- B mesons are a powerful laboratory
  - Sizable mixing and CP violation
  - HQET works and has predictive power
  - Many transitions probe different quantities
- e^+e^- machines are fantastic probes
  - Very clean environment: ½-track trigger
  - Coherent initial state allows true interference measurements and high tagging efficiency with low dilution The tagging quality factor $Q_T = \sum_i \varepsilon_i (1-2w)^2$ is 30.5% in BABAR it is 2% for CDF.
- Luminosity counts
  - Large samples allow precision measurements
  - Rare and very rare decays are becoming more and more crucial.

Exploring CKM picture or alternative origins for *CP* violation!

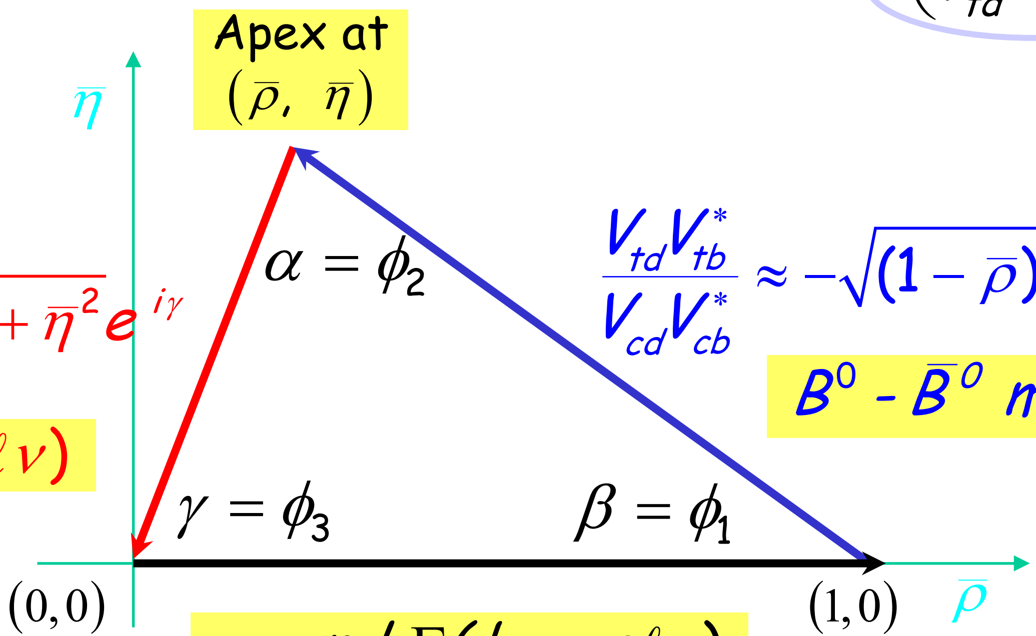
$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

+ phases

Unitarity Relations

$$\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*} \approx -\sqrt{\bar{\rho}^2 + \bar{\eta}^2}\, e^{i\gamma}$$

$\Gamma(b \to u \ell \nu)$



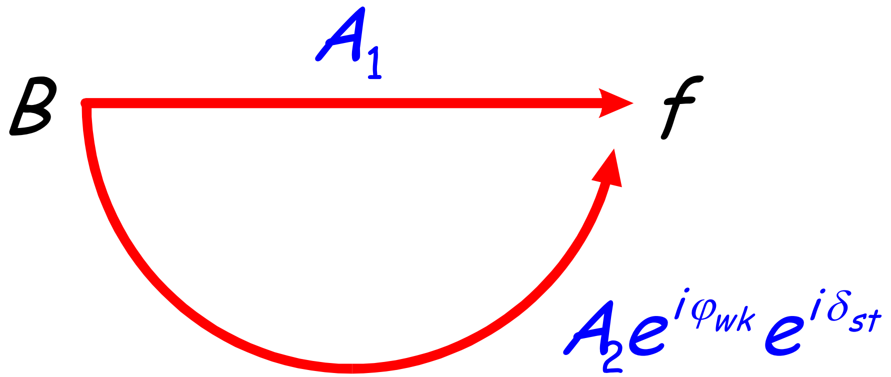
$$\frac{V_{td}V_{tb}^*}{V_{cd}V_{cb}^*} \approx -\sqrt{(1-\bar{\rho})^2 + \bar{\eta}^2}\, e^{-i\beta}$$

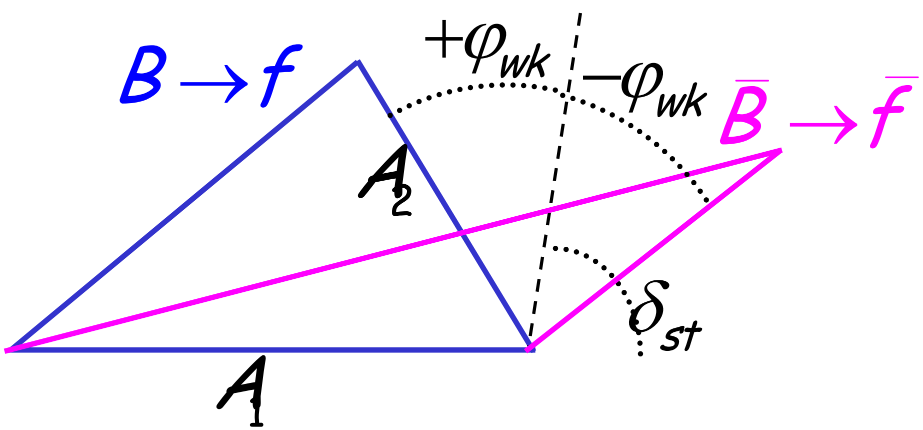
B^0 - $\bar{B}^0$ mixing

τ_B and $\Gamma(b \to c \ell \nu)$

$$\beta = -\arg V_{td};\ \gamma = \arg V_{ub}^*;\ \ \alpha = \pi - \gamma - \beta$$

CPV from interference of decay amplitudes





$$\Gamma(B \to f) = \left| A_1 + A_2 e^{i\varphi_{wk}} e^{i\delta_{st}} \right|^2$$

$$\Gamma(\bar{B} \to \bar{f}) = \left| A_1 + A_2 e^{-i\varphi_{wk}} e^{i\delta_{st}} \right|^2$$

$$\Gamma(B \to f) \neq \Gamma(\bar{B} \to \bar{f})$$
for $\varphi_{wk} \neq 0$ and $\delta_{st} \neq 0$

First observation of Direct CPV in B decays

$B^0 \to K^+\pi^-$

BABAR

PRL 93 (2004) 131801

$A_{CP} = -0.133 \pm 0.030 \pm 0.009$

4.2σ

Belle

Confirmation at ICHEP04

Signal (274M $B\bar{B}$ pairs): 2140 ± 53

$A_{CP} = -0.101 \pm 0.025 \pm 0.005$

3.9σ

Average

$A_{CP} = -0.114 \pm 0.020$

$B^+ \to K^+\pi^0$

$A_{CP} = +0.06 \pm 0.06 \pm 0.01$ BABAR

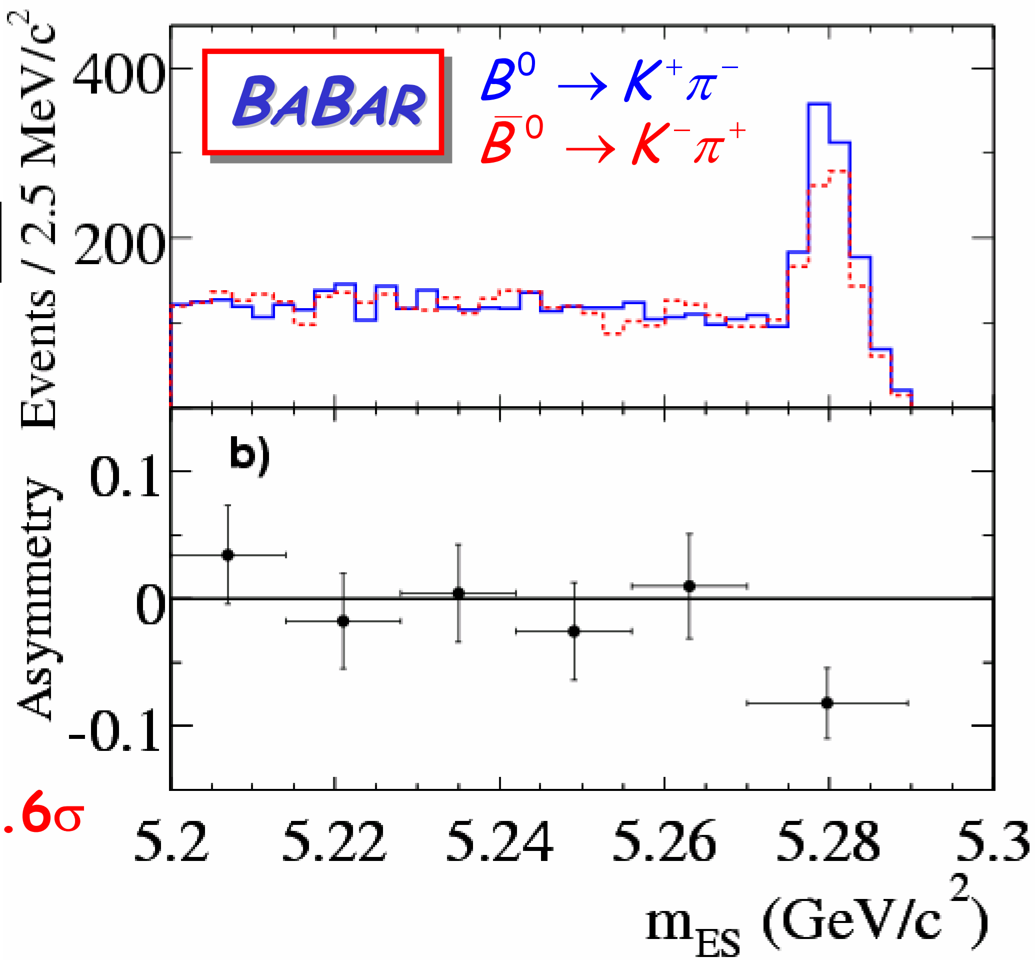
$A_{CP} = +0.04 \pm 0.05 \pm 0.02$ Belle

3.6σ

Average

$A_{CP} = +0.049 \pm 0.040$

Signal (227M $B\bar{B}$ pairs): 1606 ± 51

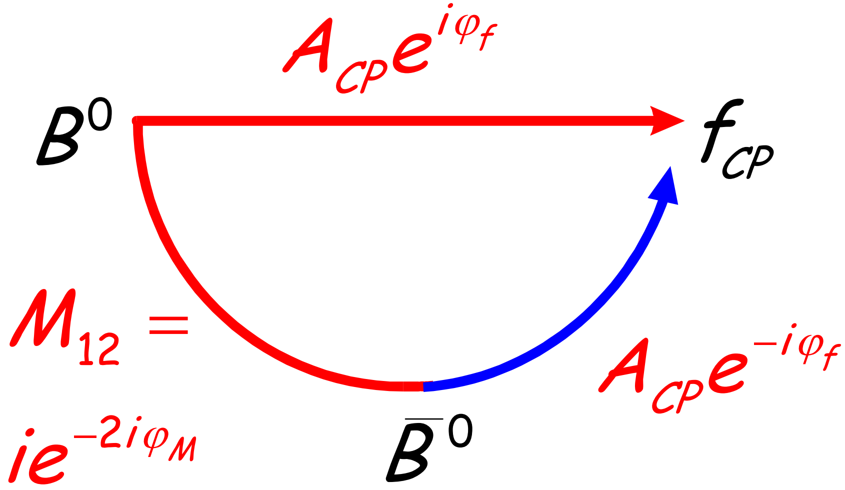


CP violation in the B system

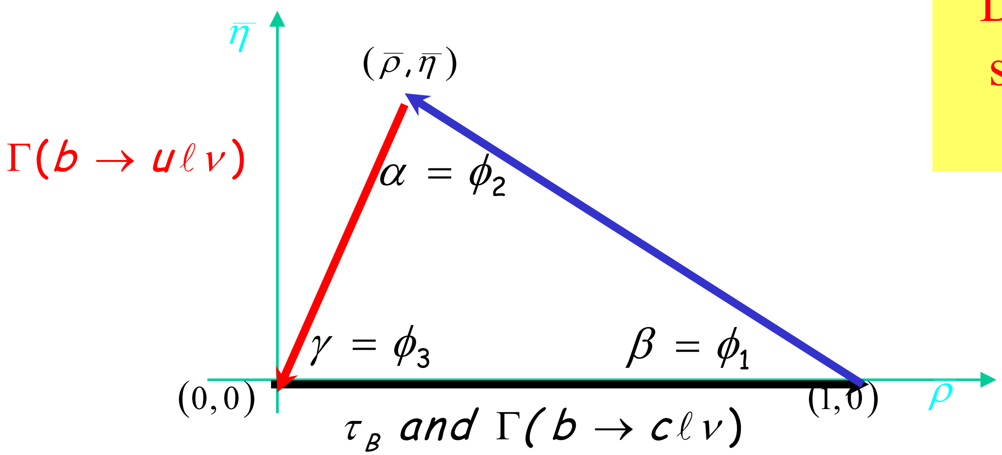
CPV through interference of decay amplitudes

CPV through interference of mixing diagram

CPV through interference between mixing and decay amplitudes



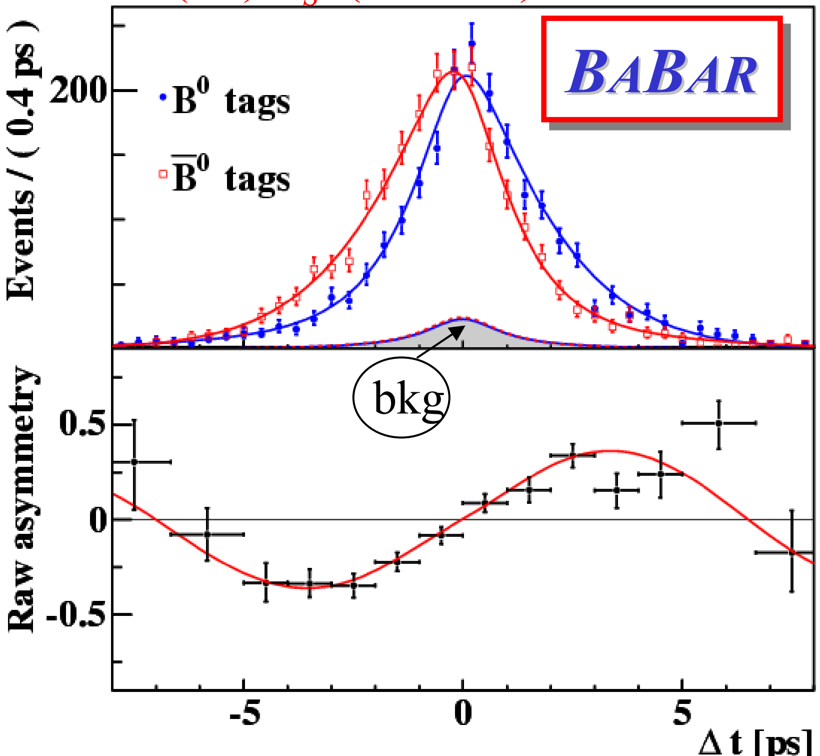
Directly related to CKM angles if a single amplitude contributes to the decay



Interference of $b \to c$ tree decay amplitude with mixing box diagram amplitude

$\sin 2\beta$ results from charmonium modes

$(c\bar{c})K_S^0$ (CP odd) modes



Update for ICHEP04

BABAR PUB-04/038

$$\sin 2\beta = +0.722 \pm 0.040 \pm 0.023$$
$$|\lambda| = |\bar{A}/A| = 0.950 \pm 0.031 \pm 0.013$$

Limit on direct CPV

$205\, fb^{-1}$ on peak or $227M\ B\bar{B}$ pairs

7730 CP events (tagged signal)

Belle CONF-0436

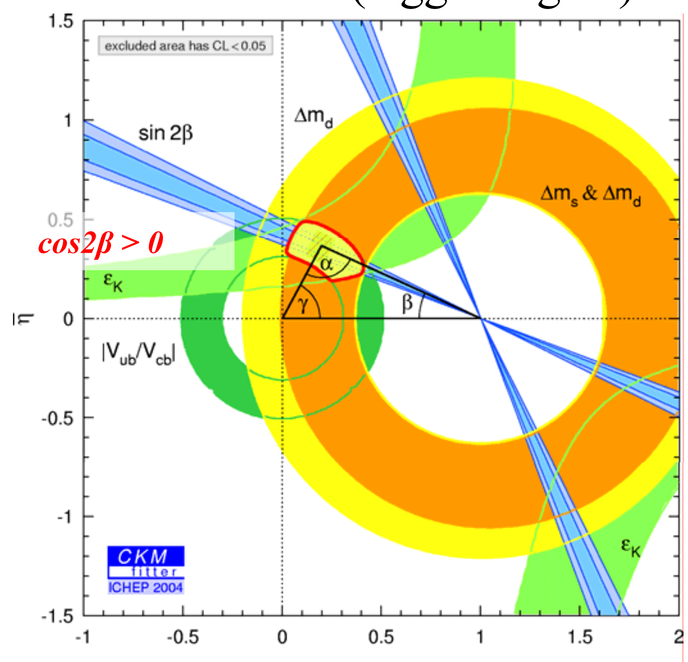
Belle 2003

$(c\bar{c})K_S^0 +$
$(c\bar{c})K_L^0$

$$\sin 2\beta = +0.728 \pm 0.056 \pm 0.023$$
$$|\lambda| = |\bar{A}/A| = 1.007 \pm 0.041 \pm 0.033$$

$140\, fb^{-1}$ on peak or $152M\ B\bar{B}$ pairs

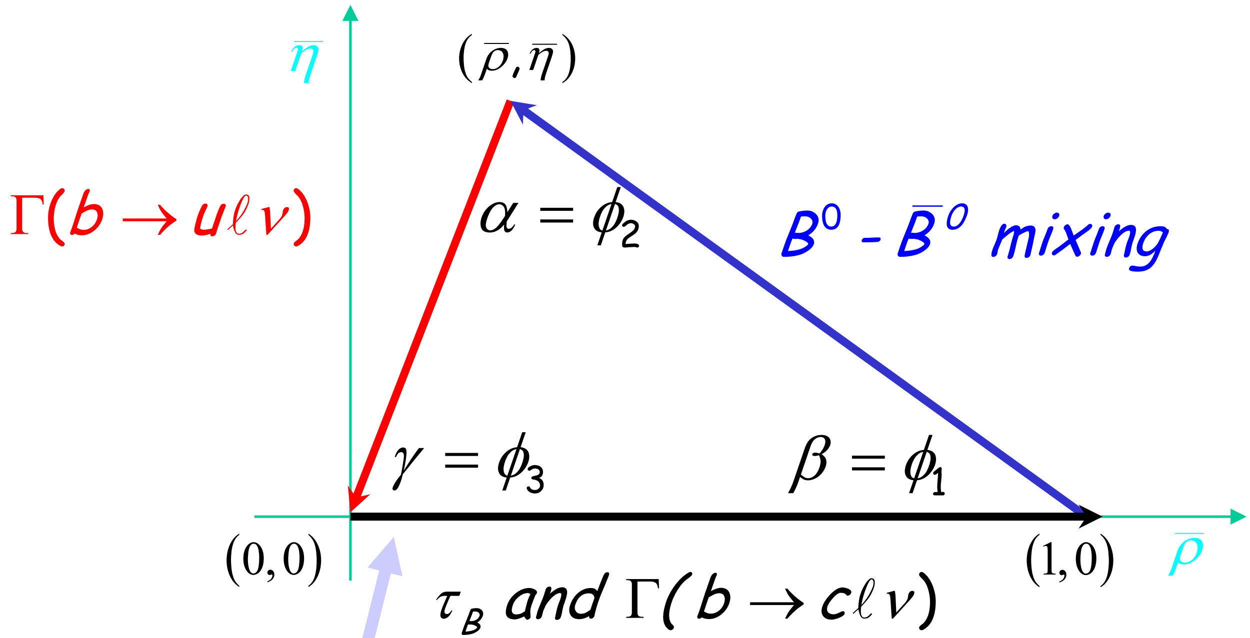
4347 CP events (tagged signal)



$$[\sin 2\beta]_{WA} = +0.726 \pm 0.037_{(stat+sys)}$$

γ

Interference of color-allowed and color-suppressed tree decays

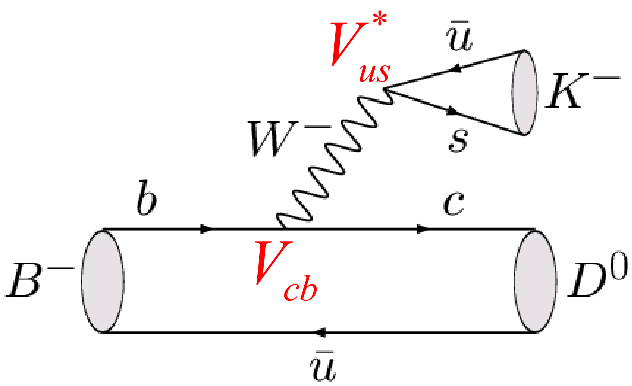


γ from CPV from $B^+ \to D_{CP}K, D_{DCS}K, \ldots.$

Methods for extraction of γ

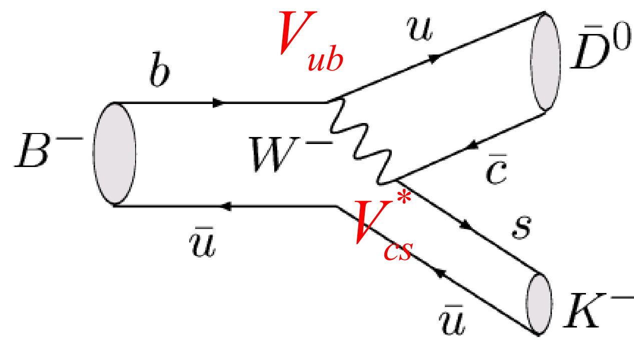
γ is phase between $b \to u$ ($\propto V_{ub}$) and $b \to c$ ($\propto V_{cb}$) amplitudes

Basic Idea: Use interference between $B^- \to D^0 K^-$ and $B^- \to \bar{D}^0 K^-$ decays where the $D^0(\bar{D}^0)$ decay to a common final state f



$A \propto V_{cb} V_{us}^*$ $\propto \lambda^3$

$A \propto V_{ub} V_{cs}^*$ $\propto \lambda^3 \sqrt{\rho^2 + \eta^2} e^{i\gamma}$



Color suppressed

GLW *Gronau-London-Wyler, 1991*
Use $B^- \to D^0_{CP\pm} K^-$ decays

ADS *Atwood-Dunietz-Soni, 2001*
Use $B^- \to D^{(*)0}\left[K^+\pi^-\right]K^-$ decays

D^0 Dalitz plot Use $B^- \to D^{(*)0}\left[K_S^0\pi^+\pi^-\right]K^-$ decays

Size of CP asymmetry depends on

$$r_B^{(*)} \equiv \frac{|A(B^- \to \bar{D}^{(*)0} K^-)|}{|A(B^- \to D^{(*)0} K^-)|} \sim 0.1 - 0.3$$

Constraints on r_b and γ

ADS

favored $B^- \to D^0 K^-$ suppressed $D^0 \to K^+\pi^-$

suppressed $B^- \to \overline{D}^0 K^-$ favored $\overline{D}^0 \to K^+\pi^-$

$\Rightarrow [K^+\pi^-]_D K^-$

$$R_{ADS} = \frac{BF([K^+\pi^-]K^-) + BF([K^-\pi^+]K^+)}{BF([K^-\pi^+]K^-) + BF([K^+\pi^-]K^+)} \sim r_B^2$$

Belle $r_b < 0.28$ (90% CL)

BABAR $r_B < 0.23$ (90% CL)

BABAR

D*K: $r_B = 0.155^{+0.070}_{-0.077} \pm 0.040 \pm 0.020$

$\delta_B = 303° \pm 34° \pm 14° \pm 10°$ (Dalitz)

DK: $r_B < 0.19$ (90% C.L.)

$\delta_B = 114° \pm 41° \pm 8° \pm 10°$ (Dalitz)

PRELIMINARY

$\gamma = 70° \pm 26° \pm 10° \pm 10°$ (Dalitz)

DALITZ Analysis

Belle 140 fb^{-1}

$\gamma = 77^{o}\,{}^{+17}_{-19} \pm 13 \pm 11_{(model)}$

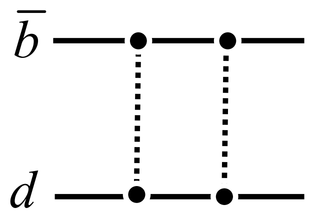
$26 < \gamma < 126^{o}$ [95% CL]

sin2α from $B \to \pi\pi, \rho\pi, \rho\rho$

Interference of suppressed
b $\to$ u "tree" decay with mixing

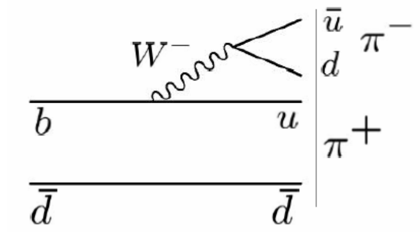
but: "penguin"
is sizeable!

B^0 mixing



$\oplus$

B^0 decay: tree

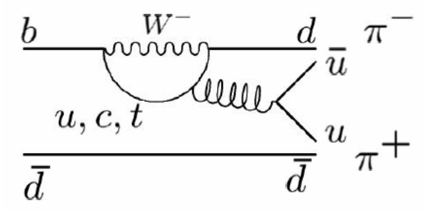


$$q/p \propto V_{tb}^* V_{td} / V_{tb} V_{td}^*$$

$$A \propto V_{ub}^* V_{ud} \quad \propto \lambda^3$$

$\oplus$

B^0 decay: penguin



$$A \propto V_{td}^* V_{tb} \quad \propto \lambda^3$$

$$\lambda_{\pi\pi} = \frac{q}{p}\frac{\bar{A}_{\pi\pi}}{A_{\pi\pi}} = e^{-i2\beta} e^{-i2\gamma} = e^{i2\alpha}$$

$$\lambda_{\pi\pi} = e^{i2\alpha} \frac{T + P e^{+i\gamma} e^{i\delta}}{T + P e^{-i\gamma} e^{i\delta}}$$

Coefficients of time-dependent CP Asymmetry

With no penguins

$$S_{\pi\pi} = \sin 2\alpha$$
$$C_{\pi\pi} = 0$$

With large penguins
and |P/T| ~ 0.3

$$S_{\pi\pi} = \sqrt{1 - C_{\pi\pi}^2} \sin 2\alpha_{eff}$$
$$C_{\pi\pi} \propto \sin \delta$$

Results from $B \to \pi\pi$ and ρρ decays

BABAR: Updated for ICHEP04

$B^0 \to \pi^+\pi^-$ (227M pairs)

$S_{\pi\pi} = -0.30 \pm 0.17 \pm 0.03$

$C_{\pi\pi} = -0.09 \pm 0.15 \pm 0.04$

Belle: PRL 93 (2004) 021601

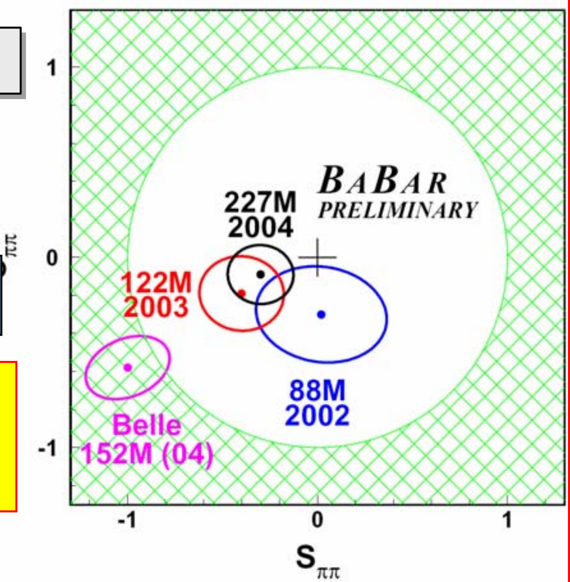
$S_{\pi\pi} = -1.00 \pm 0.21 \pm 0.07$

$C_{\pi\pi} = -0.58 \pm 0.15 \pm 0.07$

152M pairs

Comparison

Caution averaging!



(ππ)

$A_{\pi^\pm\pi^0} = -0.01 \pm 0.10 \pm 0.02$

$BF_{\pi^\pm\pi^0} = (5.8 \pm 0.6 \pm 0.4) \times 10^{-6}$

BABAR

$BF_{\pi^0\pi^0} = (1.17 \pm 0.32 \pm 0.10) \times 10^{-6}$

$C_{\pi^0\pi^0} = -0.12 \pm 0.56 \pm 0.06$

First measurements

$\alpha - \alpha_{eff} \le 35^o$ at 90% CL

(ρρ) Isospin Corrections for α

$B^0 \to \rho^+\rho^-$ (122M $B\bar{B}$ pairs)

$S_{long} = -0.19 \pm 0.33 \pm 0.11$

$C_{long} = -0.23 \pm 0.24 \pm 0.14$

Signal: 314 ± 34 events

$f_{long} = 1.00 \pm 0.02$

$B^0 \to \rho^+\rho^0$ 224M *pairs*

BABAR

$BF(B^+ \to \rho^+\rho^0) = (22.5^{+5.7}_{-5.4} \pm 5.8) \times 10^{-6}$

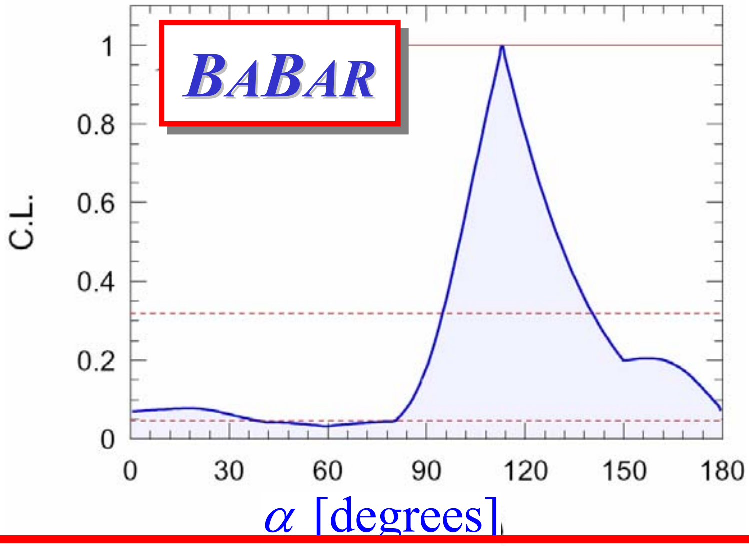
$B^0 \to \rho^0\rho^0$ 224M *pairs*

$BF(B^0 \to \rho^0\rho^0) < 1.1 \times 10^{-6}$ (90% CL)

:From Grossman-Quinn bound on $2\delta\alpha_{peng}$

$\alpha = \left[96 \pm 10_{(stat)} \pm 4_{(sys)} \pm 11_{(peng)}\right]^o$

More on α from ρπ



Results from Dalitz analysis of $B^0 \to (\rho\pi)^0$

BELLE

$\alpha = (102 \pm 11 \pm 15)^{\circ}$

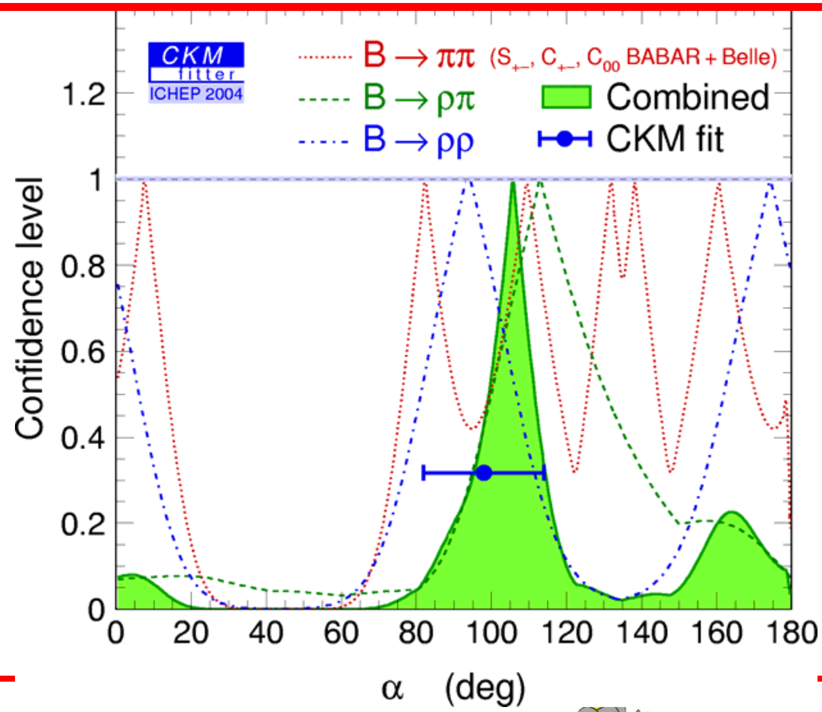
[Based on factorization & SU(3); Gronau & Zupan]

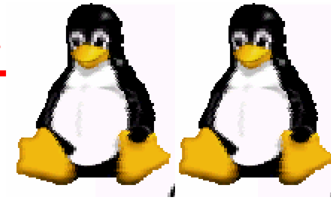
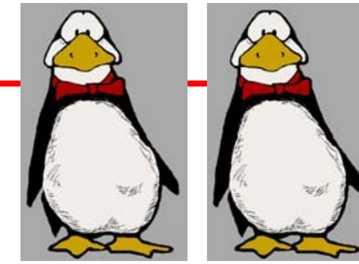
$\alpha = (113^{+27}_{-17} \pm 6)^{\circ}$

Full analysis

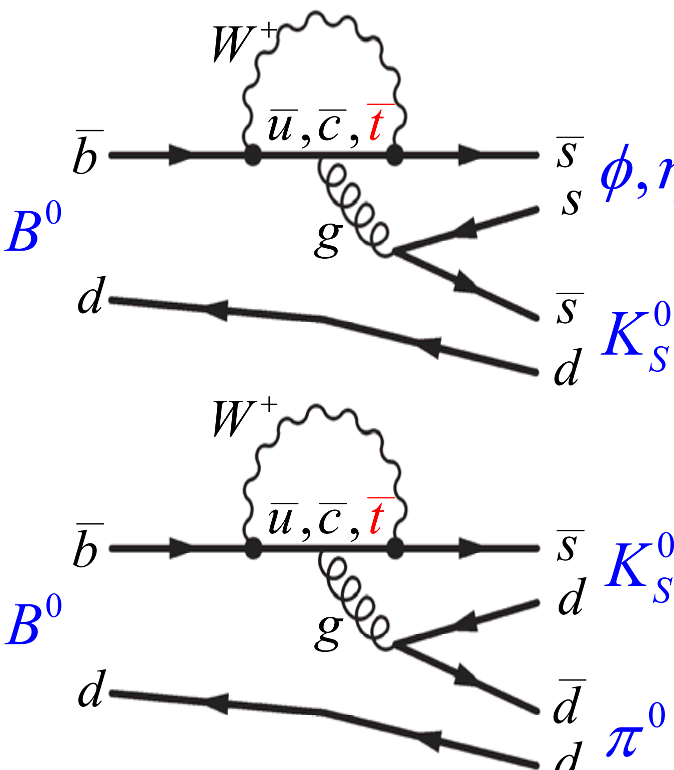
From combined $\pi\pi, \rho\pi, \rho\rho$ results:

$$\alpha = \left[106^{+8}_{-11}\right]^{\circ}$$



$\sin 2\beta$ and..  and.... 

In SM interference between B mixing, K mixing and Penguin $b \to s\bar{s}s$ or $b \to s\bar{d}d$ gives the same $e^{-2i\beta}$ as in tree process $b \to c\bar{c}s$. However loops can also be sensitive to New Physics!



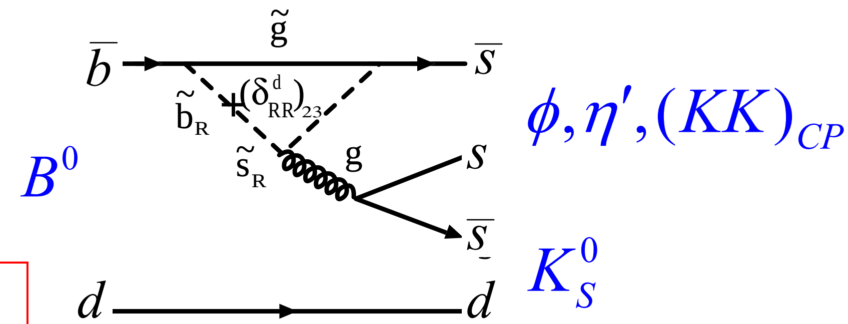
$O(\lambda^2)$

~ 5%

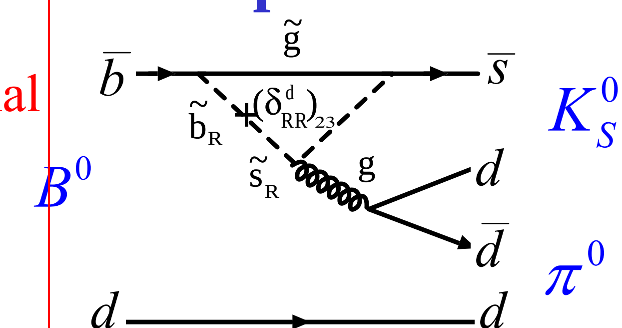
Purely dimensional estimate

$O(\lambda^2 / \bar{\lambda})$

~ 20%



New phases from SUSY?

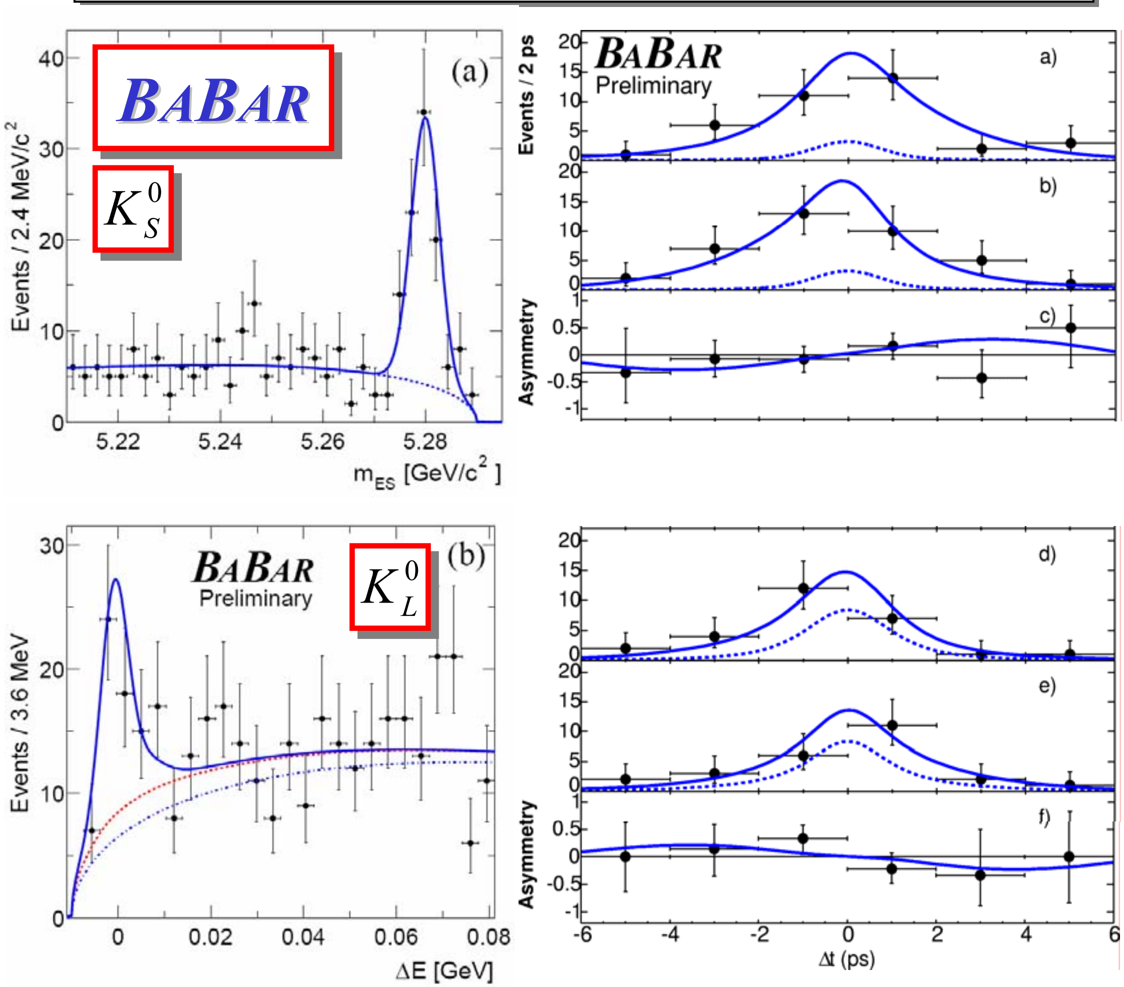


Note that within QCD these uncertainties turn out to be smaller !

A.Hoecker ICHEP04

BABAR results for $B^0 \to \phi K^0$

2004 = 227*M BB* pairs (2003 = 120M pairs)



2003 result

$$-\eta_{CP} \cdot S_{\phi K^0} = +0.47 \pm 0.34 {}^{+0.08}_{-0.06}$$
$$C_{\phi K^0} = +0.10 \pm 0.33 \pm 0.10$$

Update for ICHEP04

$B^0 \to \phi K_S^0$ 114 ± 12 events

$$S_{\phi K_S^0} = +0.29 \pm 0.31$$

$B^0 \to \phi K_L^0$ 98 ± 18 events

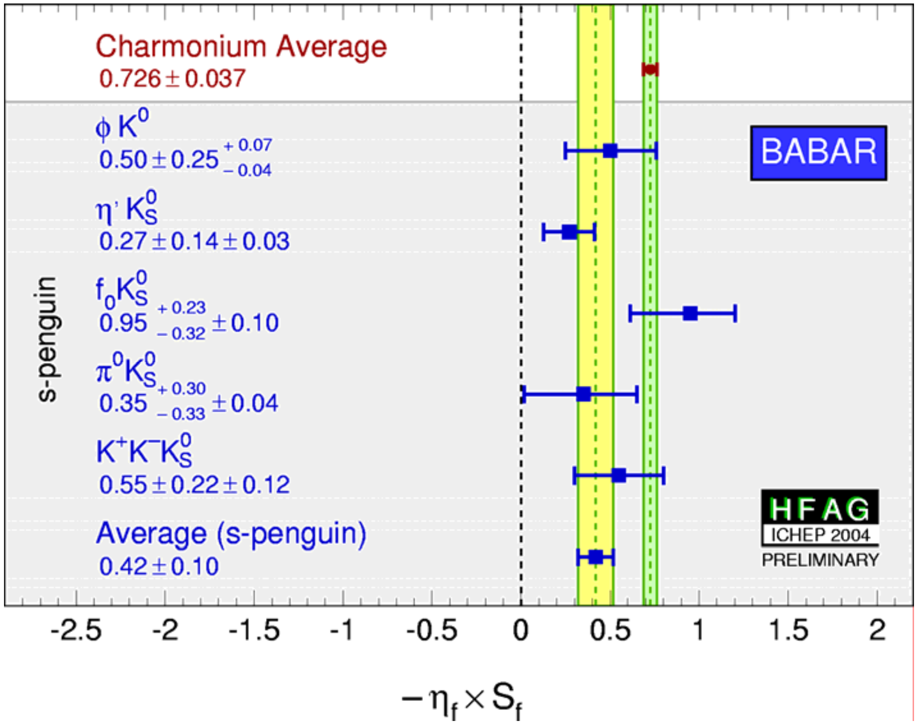
$$S_{\phi K_L^0} = -1.05 \pm 0.51$$

$$-\eta_{CP} \cdot S_{\phi K^0} = +0.50 \pm 0.25 {}^{+0.07}_{-0.04}$$
$$C_{\phi K^0} = +0.00 \pm 0.23 \pm 0.05$$

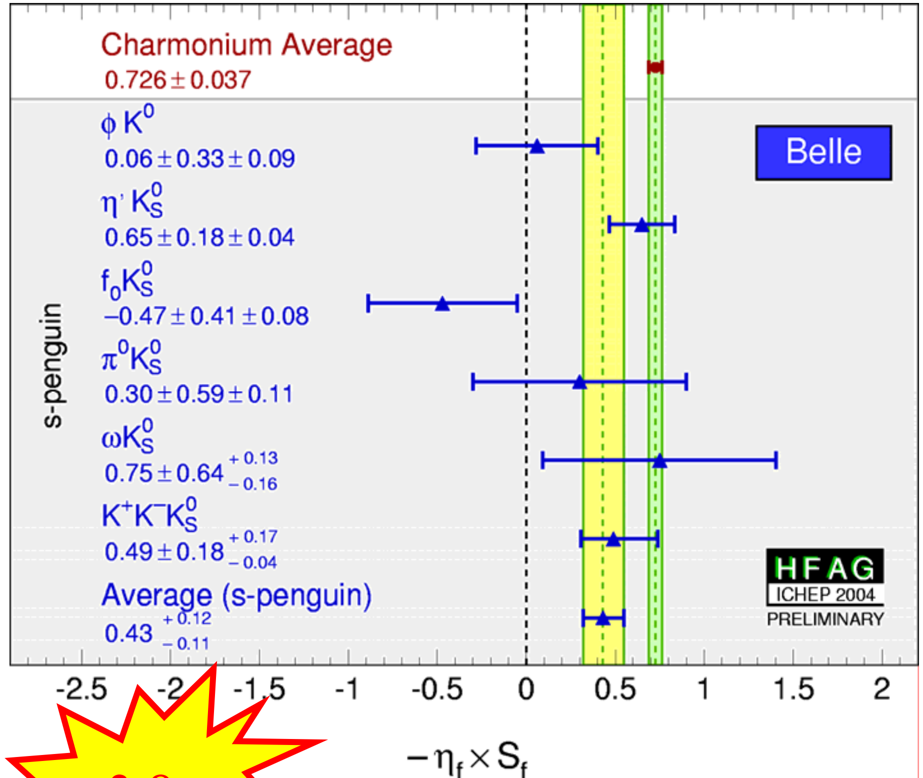
BABAR-CONF 04/033

Results on sin2β from s-penguin modes

ICHEP04



ICHEP04



$\approx 3.8\sigma$

2.7σ from s-penguin to sin2β ($c\bar{c}$)

2.4σ from s-penguin to sin2β ($c\bar{c}$)

A new mode: $B \to K_S K_S K_S$

Although 3-body decay, only L=even partial waves allowed:

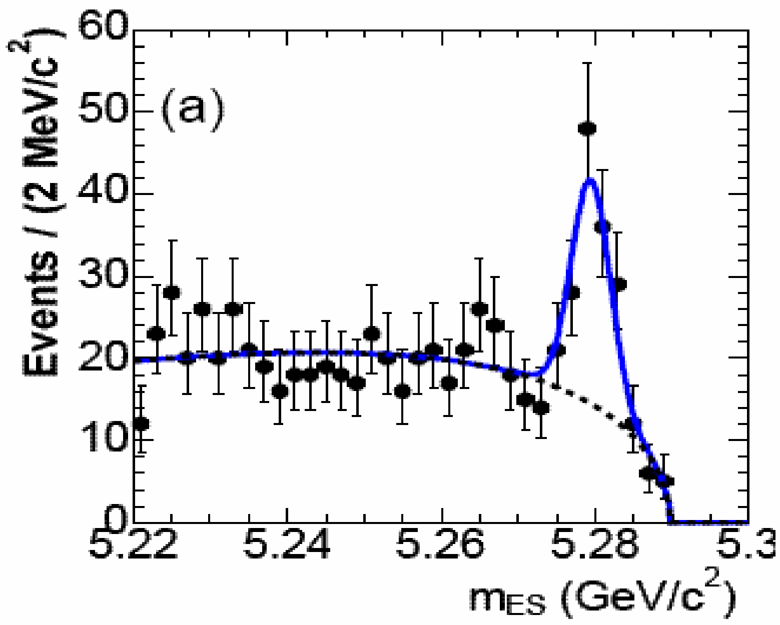
CP of final state known:

$$CP(K_S K_S K_S) = CP(K_S) = \text{even}$$

$K_S K_S K_S$ theoretically clean as ΦK

Gershon, Hazumi
hep-ph/0402097

88 ± 10 signal events



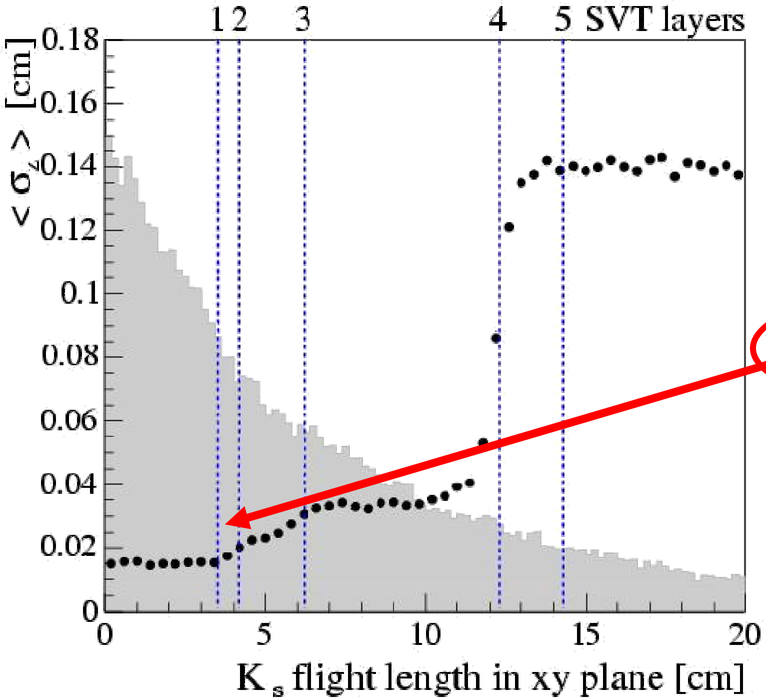
Since there are not mesurable tracks from B-vertex

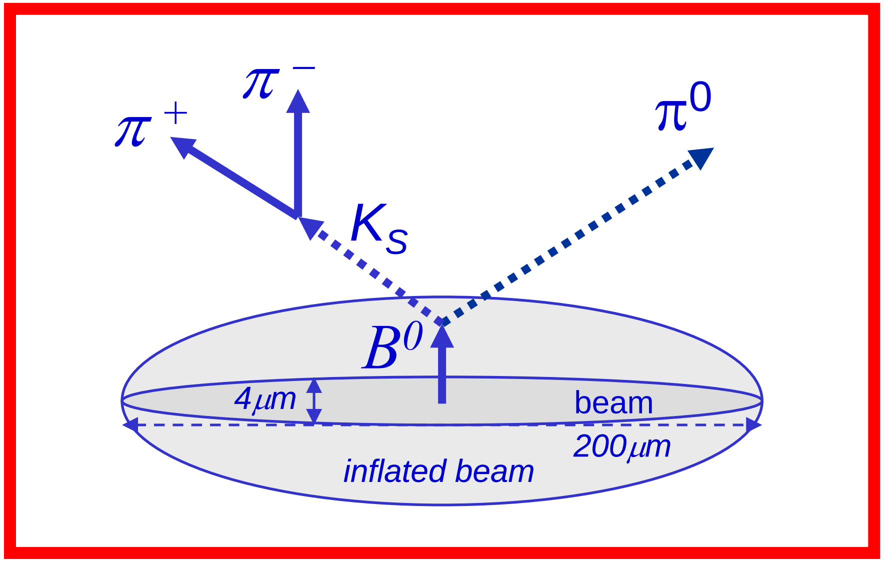
IP constrained vertexing is used

Constrained Vertex technique

Same technique as $K_s\pi^0$
hep-ex/0408062

Decay products constrained to x-y beam spot:

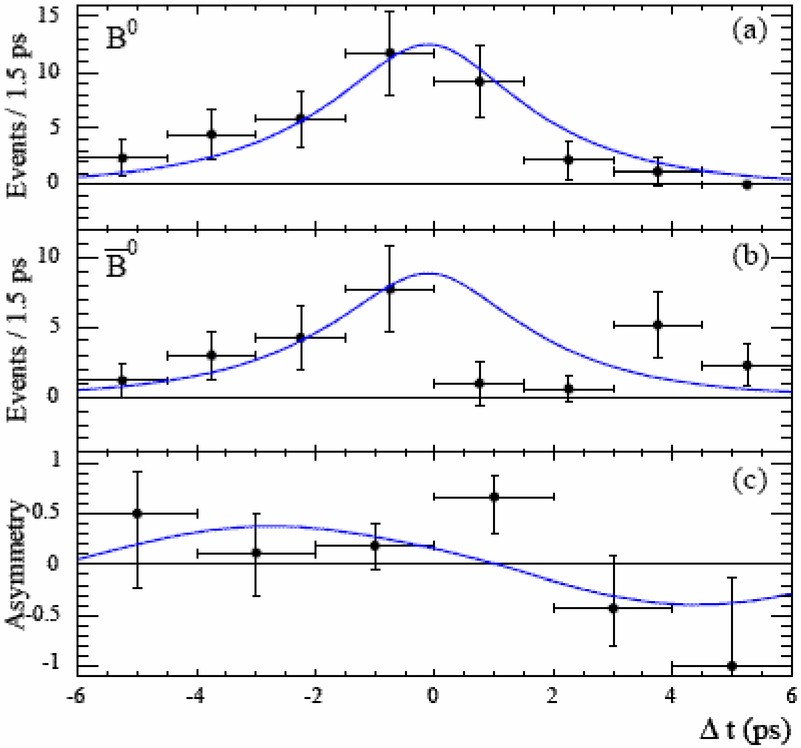




For ≥4 hits, Δt resolution as good as with charged tracks (60% events)

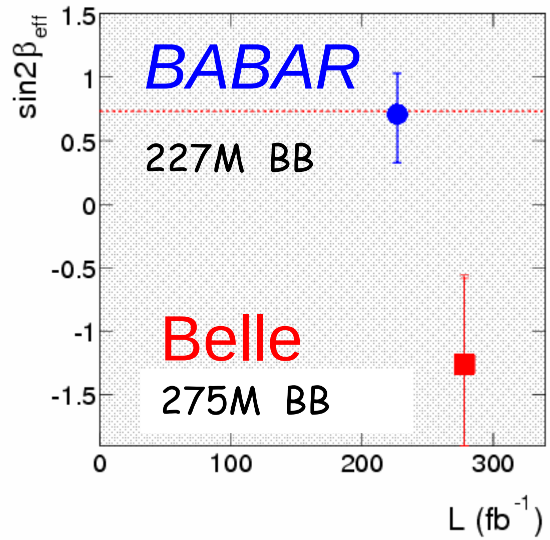
$J/\psi K_S$ used for control compare constrained vertex (using K_s) and the true J/ψ vertex

hep-ex/0502013

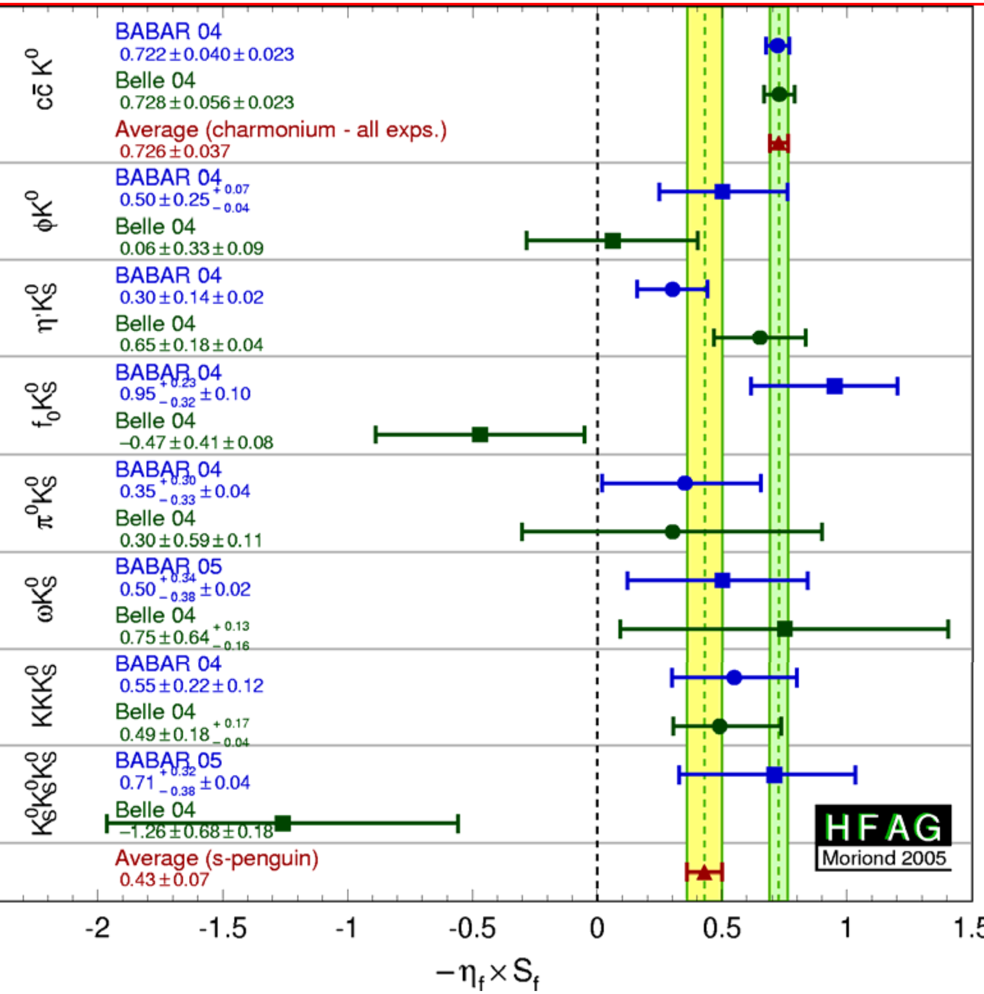


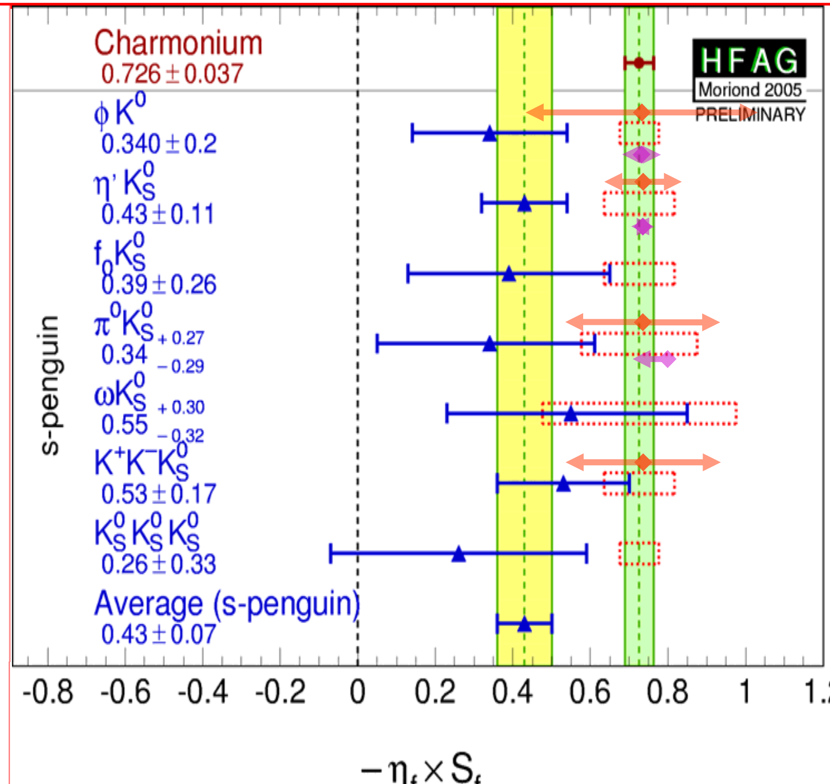
$$S_{3K_S} = -0.71^{+0.38}_{-0.32} \pm 0.04$$

$$C_{3K_S} = -0.34^{+0.28}_{-0.25} \pm 0.05$$



Update of the status





Deviation from SM:
No theory error: **3.7 s**
Naïve theory errors: **2.9 s**

SM model predictions for some modes: model independent upper limits based on SU(3) flavor and measured ***b → dqq*** B.R.
[Grossman et al, Phys Rev D58; Grossman et al., Phys Rev D68; Gronau, Rosner, Phys.Lett. B564; Gronau et al., Phys.Lett.B579; Gronau, at al. Phys.Lett.B596; Chiang atal., Phys.Rev.D70
estimate of deviations based on specific models *[Beneke at al., NPB591; Buras et al. NPB697; Ciuchini at al., hep-ph/0407073]*

Comment on averaging

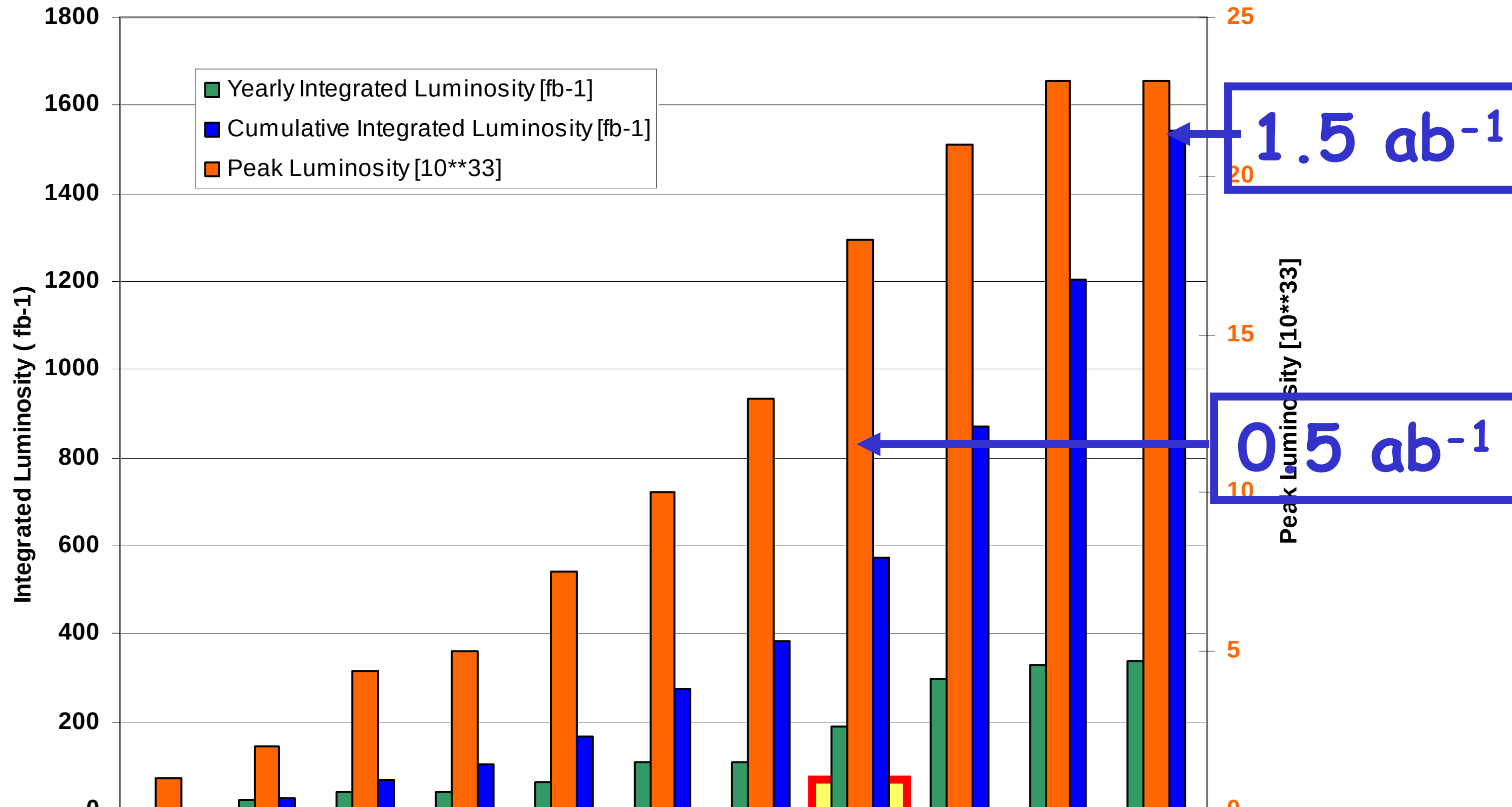
- On purely dimensional considerations the corrections to the $b \to s$ penguins are ranging between 5% and 20% , on the other hand the sign of the corrections is far from been the same for different channels.
- As I mentioned at ICHEP averaging the results on penguins is something adventurous and not simply legitimate.
- The averaged value can be diluted and non reflecting the real amount of the difference from $\sin 2\beta$ value of charmonium.
- However the distance of the (*BABAR-BELLE*) average value of penguins of 3.9 σ from the w.a. $\sin 2\beta=0.726$ is already something and intriguing.
- CP asymmetries in $b \to s$ penguins will show perhaps the first indications of new physics.

Theoretical uncertainties

Measurement (in SM)	Theoretical limit	Present error
$B \to \psi K_S \ (\beta)$	$\sim 0.2^\circ$	1.6°
$B \to \phi K_S,\ \eta^{(\prime)} K_S,\ \ldots\ (\beta)$	$\sim 2^\circ$	$\sim 10^\circ$
$B \to \pi\pi,\ \rho\rho,\ \rho\pi \ (\alpha)$	$\sim 1^\circ$	$\sim 15^\circ$
$B \to DK \ (\gamma)$	$\ll 1^\circ$	$\sim 25^\circ$
$B_s \to \psi\phi \ (\beta_s)$	$\sim 0.2^\circ$	—
$B_s \to D_s K \ (\gamma - 2\beta_s)$	$\ll 1^\circ$	—
$\lvert V_{cb}\rvert$	$\sim 1\%$	$\sim 3\%$
$\lvert V_{ub}\rvert$	$\sim 5\%$	$\sim 15\%$
$B \to X \ell^+ \ell^-$	$\sim 5\%$	$\sim 25\%$
$B \to K^{(*)} \nu\bar{\nu}$	$\sim 5\%$	—

Ligeti, ICHEP 2004

PEP II Luminosity Projections

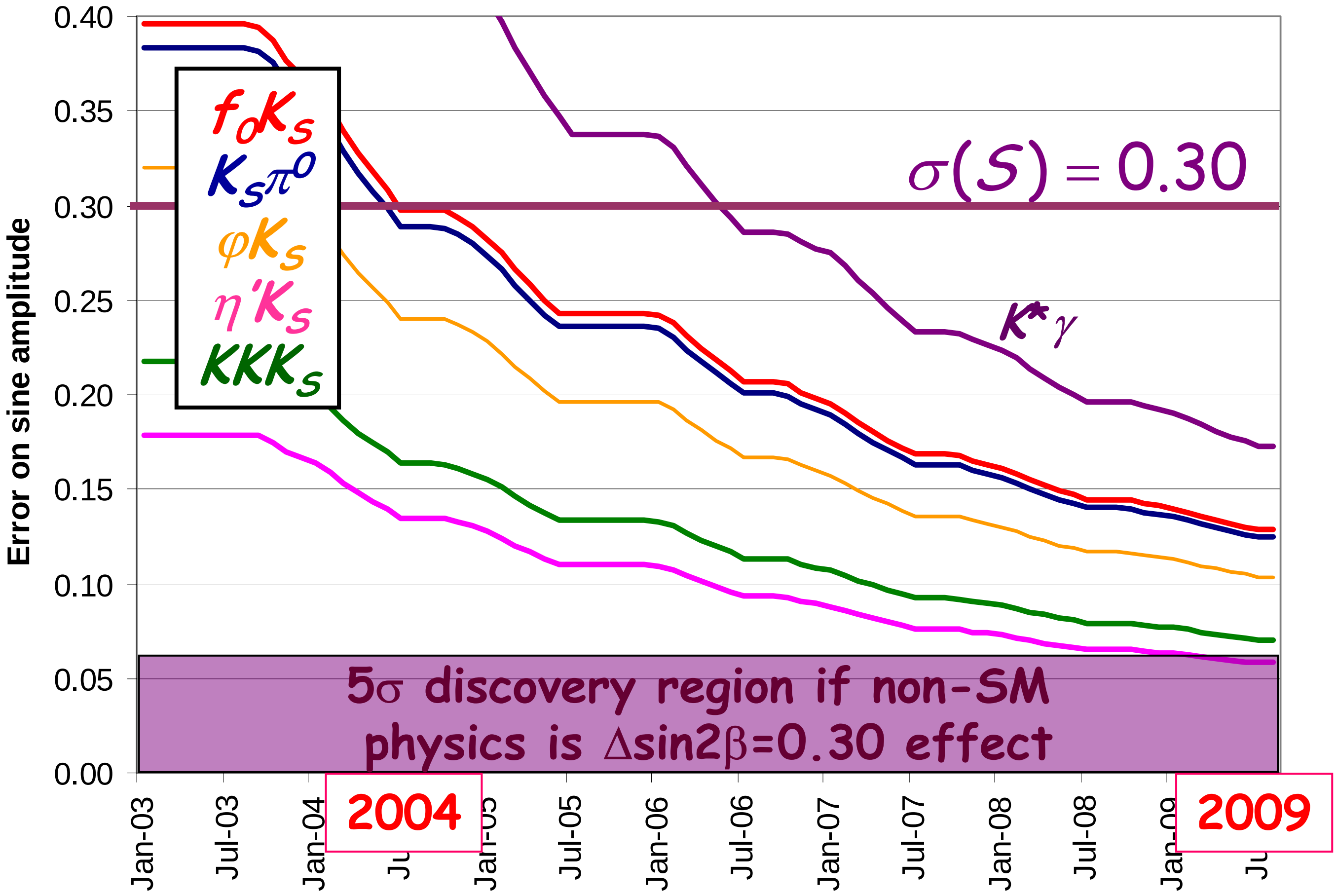


	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Yearly Integrated Luminosity [fb-1]	3	23	41	39	62.6	107.3	109.6	187.8	298.6	331.3	339.5
Cumulative Integrated Luminosity [fb-1]	3	26	67	106	168.6	275.9	385.5	573.3	871.9	1203.2	1542.7
Peak Luminosity [10**33]	1	2	4.4	[illegible]	[illegible]	[illegible]	[illegible]	18	21	23	23

Calendar Year

2006 ← 1.8×10^{34}

Projections for Penguin Modes



Luminosity expectations:

2004=240 fb^{-1}
2009=1.5 ab^{-1}

Similar projections for Belle as well

Projections are statistical errors only;
but systematic errors at few percent level

SUPER BFACTORY ?

BABAR has shown that in the continuous injection operation mode and thanks to the data taking efficiency >98% is able to integrate in one year 10^7x L_{peak} . 7.0 10^{35} cm^{-2} s^{-1} corresponds to 10000 fb^{-1}/year.

After 7 months study in BABAR the preferred option is a machine of *7.0 1035 cm-2 s-1* to integrate *10000 fb-1/year and upgradable to investigate NP at a mass scale* ~ 1 TeV

Possible Super B parameters

Luminosity	2-3x10^{34}	1.5x10^{35}	2.5x10^{35}	7x10^{35}	Units
e^+	3.1	3.1	3.5	8.0	GeV
e^-	9.0	9.0	8.0	3.5	GeV
I^+	4.5	8.7	11.0	6.8	A
I^-	2.0	3.0	4.8	15.5	A
β(y*)	7	3.6	3.0	1.5	mm
β(x*)	30	30	25	15	cm
Bunch length	7.5	4	3.4	1.7	mm
# bunches	1700	1700	3450	6900	
Crossing angle	0	0	±11	±15	mrad
Tune shifts (x/y)	8/8	11/11	11/11	11/11	x100
rf frequency	476	476	476	952	MHz
Site power	40	75	85	100	MW

PEPII before 09

Unitarity Triangle – Sides& Angles

Unitarity Triangle - Sides		e^+e^- **Precision**		
Measurement	**Goal**	**3/ab**	**10/ab**	**50/ab**
V_{ub} (inclusive)	syst =5-6%	2%	1.3%	
V_{ub} (exclusive) (π,ρ)	syst=3%	5.5%	3.2%	
f_b B($B\rightarrow\mu\nu$)	SM: B~5x10^{-7}			
F_b B($B\rightarrow\tau\nu$)	SM: B~5x10^{-5}	3.3 σ	6 σ	13σ f_b to ~10%
V_{td}/V_{ts} ($\rho\gamma/K^*\gamma$)	Theory 12%	~3%	~1%	

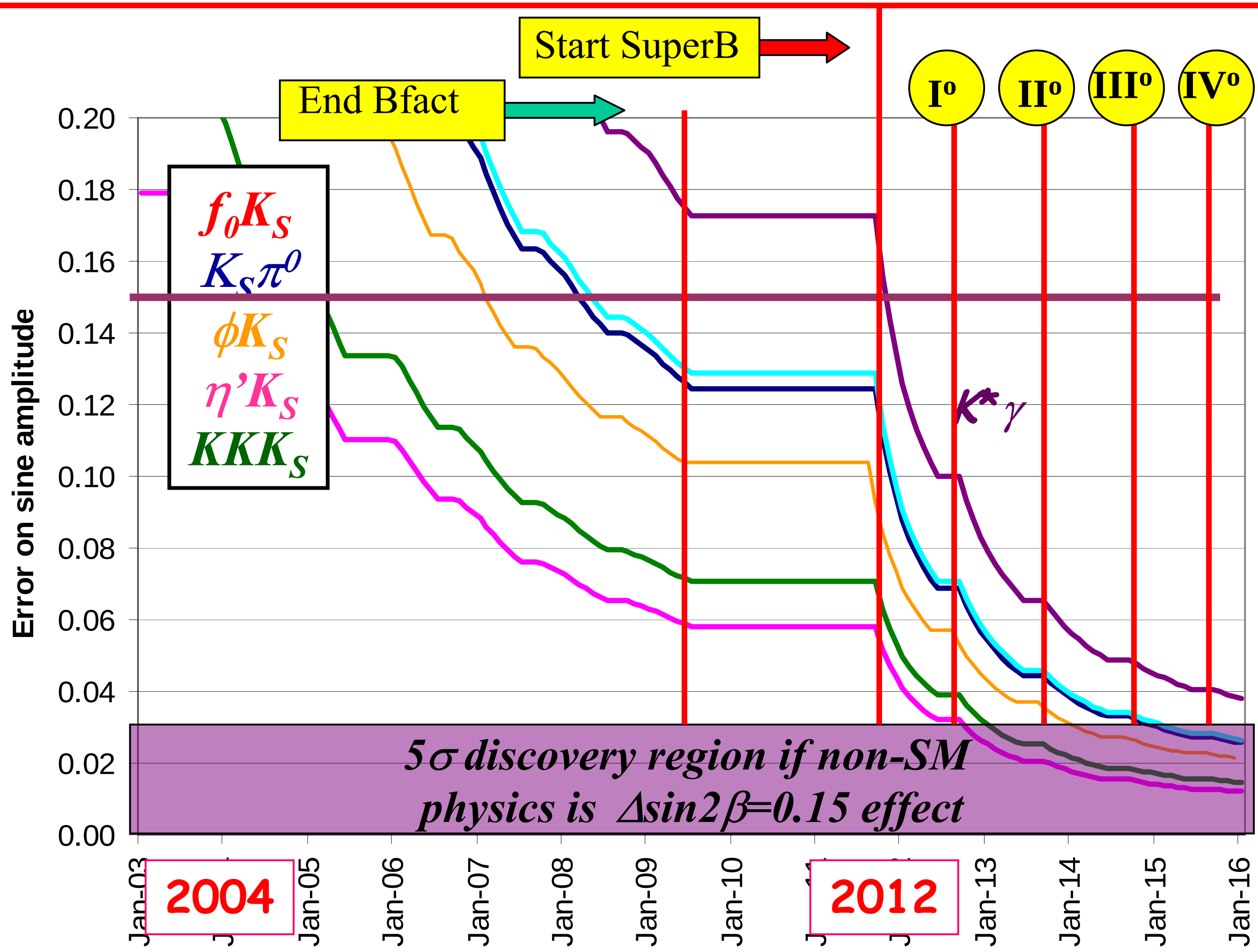
Unitarity Triangle - Angles	e^+e^- **Precision**			**1 Year Precision**	
Measurement	**3/ab**	**10/ab**	**50/ab**	**LHC*b***	***B*TeV**
α ($\pi\pi$) ($S_{\pi\pi}$, $B\rightarrow\pi\pi$ BR's+ isospin)	6.7°	3.9°	2.1°	-	-
α ($\rho\pi$) (Isospin, Dalitz) (syst ≥3°)	3, 2.3°	1.6, 1.3°	1, 0.6°	2.5° -5°	4°
α ($\rho\rho$) (penguin, isospin, stat+syst)	2.9°	1.5°	0.72°		
β ($J/\psi K_S$) (all modes)	0.3°	0.17°	0.09°	0.57°	0.49°
γ ($B\rightarrow D^{(*)}K$) (ADS)		2-3°		~10°	<13°
γ (*all*)		1.2-2°		7°	8°

Theory: α ~1° β ~ 0.2° γ <<1°

CP Violation in b→s penguins

Rare Decays – New Physics – *CPV (?)*		e^+e^- **Precision**			**1 Year Precision**	
Measurement	**Goal**	**3/ab**	**10/ab**	**50/ab**	**LHC*b***	***B*TeV**
$S(B^0 \to \phi K_S)$	SM: <0.25 (0.05)	*0.08*	*0.05*	*0.02 (?)*	*0.08?*	*0.04?*
$S(B^0 \to \phi K_S + \phi K_L)$	SM:<0.25 (0.05)					
$S(B \to \eta' K_s)$	SM:<0.3 (0.1)	*0.06*	*0.03*	*0.01*		
$S(B \to K_s \pi^0)$	SM:<0.2 (0.15)	*0.08*	*0.05*	*0.04 (?)*		
$S(B \to K_S \pi^0 \gamma)$	SM:<0.1	*0.11*	*0.06*	*0.04 (?)*		
$A_{CP}(b \to s\gamma)$	SM: <0.6%	2.4%	1%	0.5% (?)		
$A_{CP}(B \to K^*\gamma)$	SM: <0.5%	0.59%	0.32%	0.14%	-	-
CPV in mixing ($\lvert q/p \rvert$)		<0.6%			X	X

Projections for b→s penguins



Luminosity expectations:

Super *B* Factory
5-7x10^{35} cm^{-2}s^{-1}

Projections are statistical errors only;
but systematic errors at few percent level

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

New Physics – $K l^+ l^-$, $s l^+ l^-$		***e⁺e⁻* Precision**			**1 Year Precision**	
Measurement	**Goal**	**3/ab**	**10/ab**	**50/ab**	**LHC*b***	***B*TeV**
$B(B \rightarrow K\mu^+\mu^-)$ / $B(B \rightarrow K e^+ e^-)$	SM: 1	~8%	~4%	~2%	X	X
$A_{CP}(B \rightarrow K^* l^+ l^-)$ (all) (high mass)	SM: < 0.05%	~6% ~12%	~3% ~6%	~1.5% ~3%	~1.5% ~3% (?)	~2% ~4% (?)
$A^{FB}(B \rightarrow K^* l^+ l^-) : s_0$ $A^{FB}(B \rightarrow K^* l^+ l^-) : A_{CP}$	SM: ±5%	~20%	~9%	9%	~12%	
$A^{FB}(B \rightarrow s l^+ l^-) : \hat{s}_0$		27%	15%	6.7%		
$A_{FB}(B \rightarrow s l^+ l^-) : C_9, C_{10}$		36-55%	20-30%	9-13%		

NP observables in s/d l+l- decay

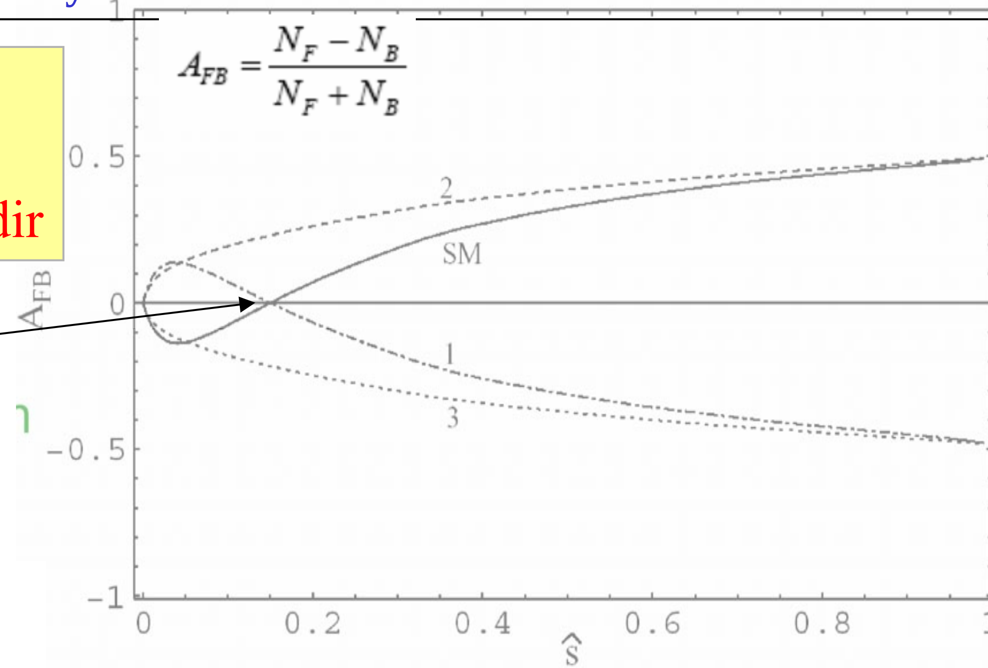
$A_{cp}(B\rightarrow s\ l^+\ l^-)$	**SM:** <0.5% (0.05% for $K^*\ l^+\ l$)
$A_{cp}(B\rightarrow d\ l^+\ l^-)$	**SM:** $^-$~(4.4+/-4)%
$B(B\rightarrow s\mu^+\mu^-)/B(B\rightarrow se^+e^-)$	**SM:** ~1
$A^{FB}(K^*l^+\ l^-)$:s_0(zero crossing)	**SM predicts with ~5% accuracy**
$A^{FB}(K^*l^+\ l^-)$:CP asymmetry	**Very small in SM**

In dilepton rest frame
N_F = when l^+ along b dir
N_B = when l^+ opposite b dir

SM:
S_0 NNLO error = 5%

S_0 = 0.162+/-0.008 ~ C7/C9

$$\hat{s} = (m_{l^+l^-}/m_b)^2$$



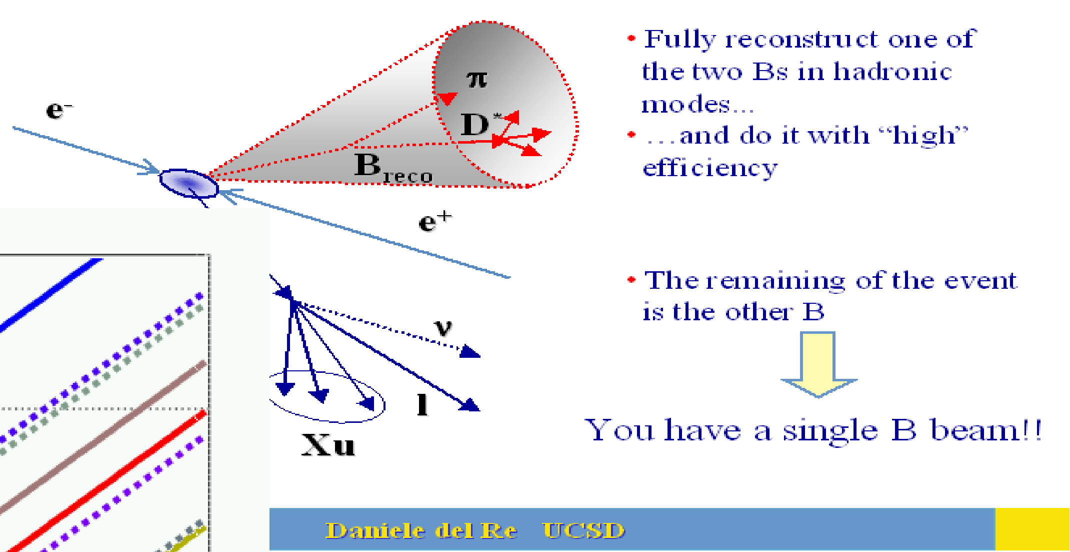
$$\hat{s} = (m_{l^+l^-}/m_b)^2$$

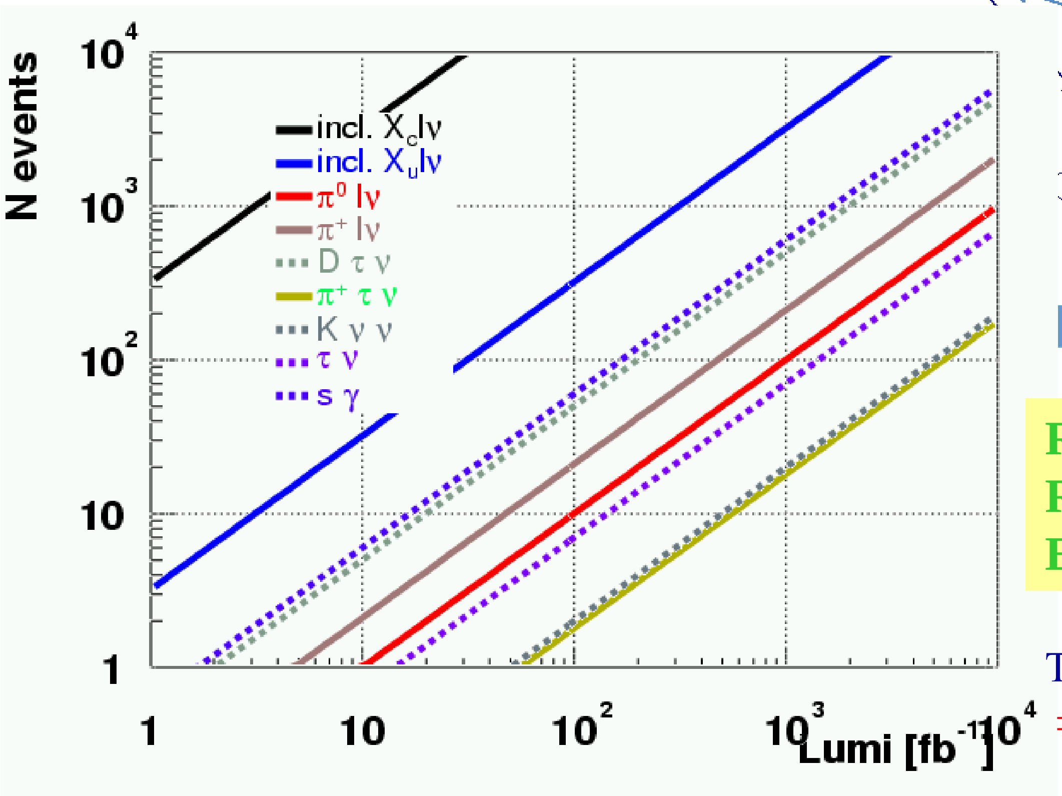
In SM: A^{CP}_{FB}~ 0
Determination of sign of AFB very important.

SUPER B Rare Decays

MEASUREMENT	Goal	3/ab	10/ab	50/ab
B($B \to D^* \tau \nu$)	SM: B: 8x10^{-3}	10.2%	5.6%	2.5%
B($B \to s\, \nu\nu$)K,K^*	SM:Theory ~5% 1 excl: 4x10^{-6}			~3σ
B($B \to invisible$)		<2x10^{-6}	<1x10^{-6}	<4x10^{-7}
B($B_d \to \mu\mu$)		-	-	?
B($B_d \to \tau\tau$)		-	-	?
B($\tau \to \mu\gamma$)			<10^{-8}	

Recoil Method as pure B beam





Recoil cinematics well known
Recoil flavor and charge is determined
Event closure needed with neutrinos

The final efficiency is ~0.4% (per bb_{bar} pair)

$\Rightarrow$ ~4000 B/fb^{-1} (at 30% purity)

$\Rightarrow$ 1500 B^0/fb^{-1}

$\Rightarrow$ 2500 B^+/fb^{-1}

> 10^7 recoil Bs in 10ab^{-1}

Conclusions

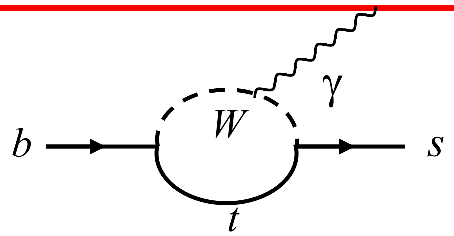
- Babar has a promising future for the next 5 years

The experiment has become a "laboratory" with high capability of inventing new analyses

- A Super B-Factory at 10ab^{-1}/year or more has discovery potential:
  - *NP effects in loops are becoming accessible*
  - In LHC era
    - masses of NP from LHC experiments
    - *flavour experiments can give phases and also couplings.*
    - *further informations UT precision measurements*
- Complementary and competitive with LHCB/ BTeV **??**
  - *No B_s, but on remaining same or higher precision*
  - *Sample very clean (see. Recoil technique allowing pure B beam)*
  - *Access to channels with neutrals and neutrinos : γ, ν, π^0*
  - *no bias from selective triggers*

- BACKUP

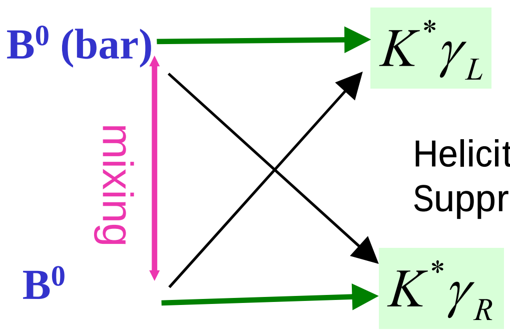
$B \to K_s \pi^0 \gamma$



The dominant SM amplitude gives: $b \to s\gamma_L$, $\bar{b} \to s\gamma_R$

NP can modify helicity structure: e.g. LR symmetry, higgs in loops

Use TDCP to probe the helicity structure: (**but limited to $K^{*0} \to K_s \pi^0$ ~ 11%**)



Helicity Flip
Suppressed by m_s/m_b

→ Expect:

$$S_{K^*\gamma} = 2\frac{m_s}{m_b}\sin 2\beta \approx 0$$

~0.042

David Atwood, Michael Gronau, Amarjit Soni (1997)

PRL **79**, 185(1997)

	$0.1\ ab^{-1}$	$2\ ab^{-1}$	$5\ ab^{-1}$	$10\ ab^{-1}$	$50\ ab^{-1}$		
$S(K_s \pi^0 \gamma)$	0.6	0.14	0.09 (0.12)	0.06	0.04(?)		

Soni: m_s is the "current" mass: (m_s ~150 +/- 50 MeV), m_b ~5 GeV

→ Theory error ~0.01 to 0.02 (??) (~30% of SM value of S)