Results from the B Factories and Future Prospects

David B. MacFarlane
for the BABAR and
Belle Collaborations

Physics at LHC
13-17 July 2004 . Vienna . Austria

Ongoing B Factory Physics Program

- *Comprehensively explore CP-violating asymmetries in B meson decays. Test the SM and search for CP-violating amplitudes from processes beyond the SM.*
- *Systematically map out rare B decay processes, including all those with sensitivity to new physics.*
- *Extract the magnitudes of CKM elements and other well-defined SM parameters.*
  - Detailed studies of dynamics of processes involving heavy quarks, QCD effects with existing and new theoretical tools
  - Implications for extraction of CKM matrix elements, e.g. from SL decays, spectroscopy, etc
- *Perform studies over a broad range of physics, such as spectroscopy, τ-lepton physics, QED studies, strong-interaction physics via ISR processes, etc.*

BABAR Collaboration

10 Countries
77 Institutions
593 Physicists
May 2004

Gathering at SLAC, July 2004

Belle Collaboration

12 Countries
54 Institutions
285 Physicists
July 2002

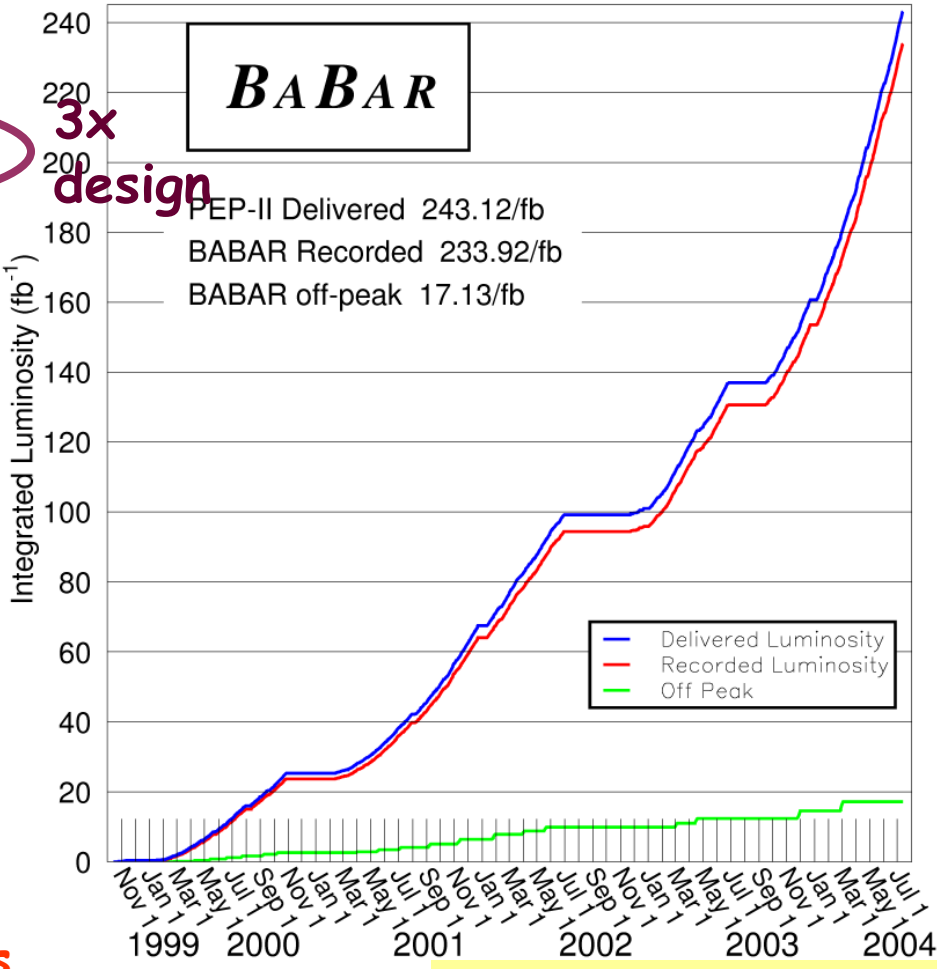
PEP-II Integrated Luminosity

2004/07/13 09.21

PEP-II Records	
Peak luminosity	0.921×10^{34} $cm^{-2}\ s^{-1}$
Best shift	246.3 pb^{-1}
Best day	710.5 pb^{-1}
Best 7 days	4.291 fb^{-1}
Best week	4.200 fb^{-1}
Best month	16.02 fb^{-1}
Best 30 days	16.05 fb^{-1}
BABAR logged	233.9 fb^{-1}

3x design

~235 million $B\bar{B}$ pairs

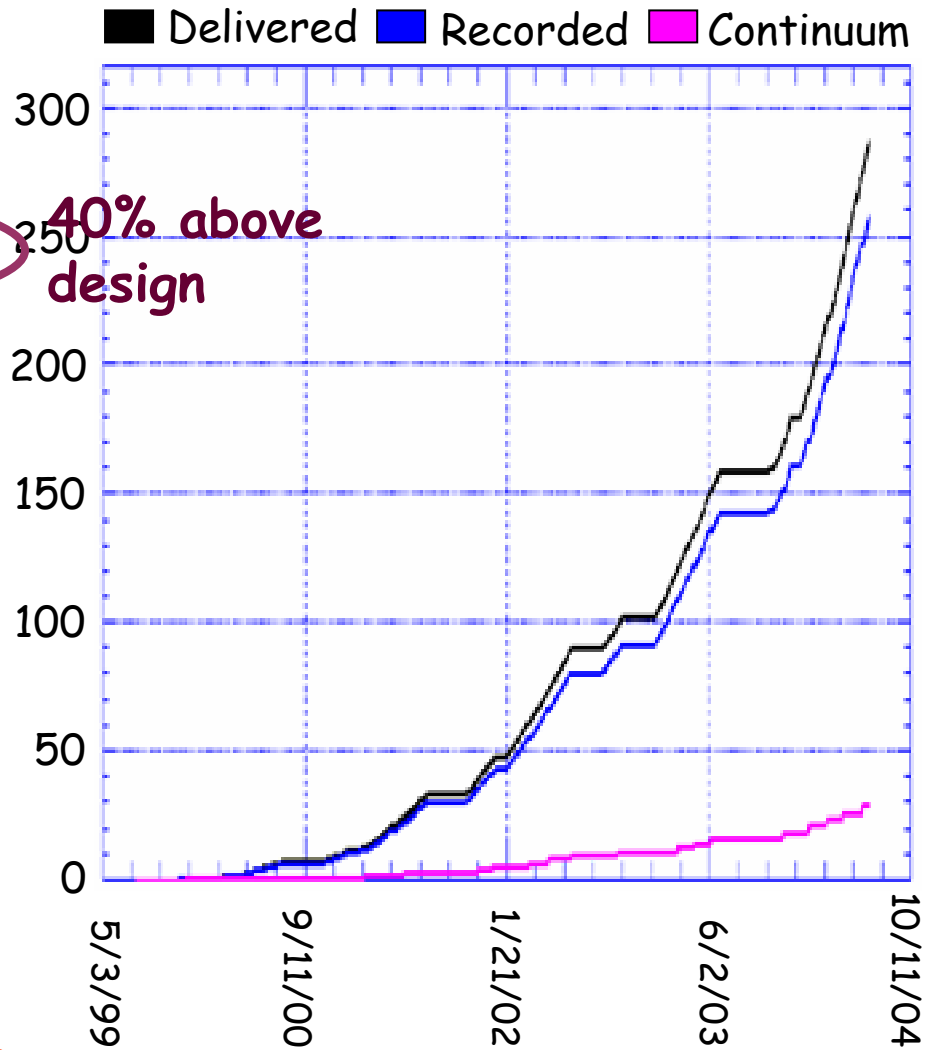


(as of July 14, 2004)

KEKB Integrated Luminosity

KEKB Records	
Peak luminosity	1.392×10^{34} $cm^{-2}\ s^{-1}$
Best shift	330.6 pb^{-1}
Best day	944.2 pb^{-1}
Best 7 days	6.009 fb^{-1}
Best week	5.939 fb^{-1}
Best month	22.11 fb^{-1}
Best 30 days	24.00 fb^{-1}
BELLE logged	286.8 fb^{-1}

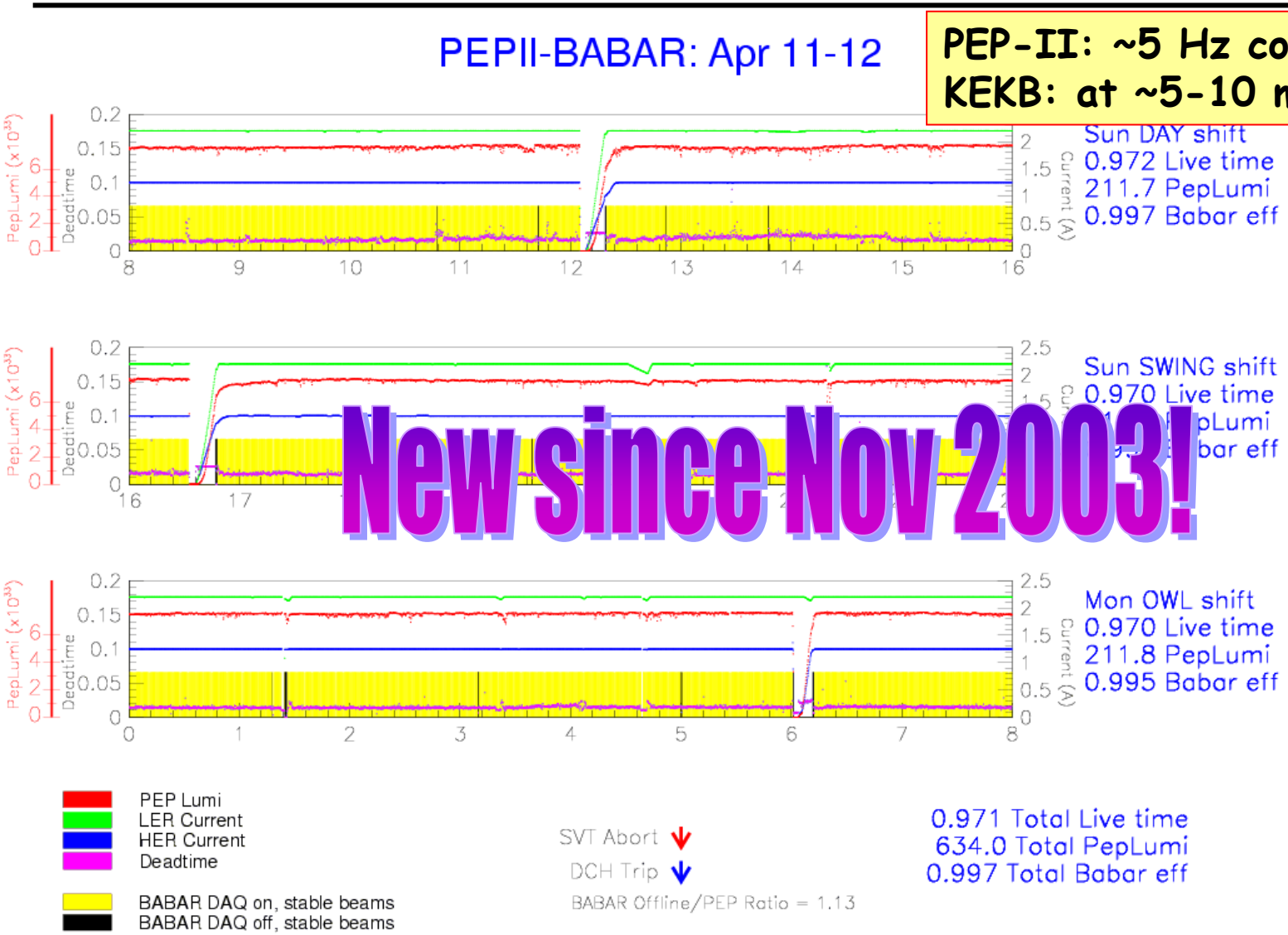
~280 million $B\bar{B}$ pairs



(as of June 30, 2004)

Trickle Injection at Both B Factories

PEP-II: ~5 Hz continuous
KEKB: at ~5-10 min intervals

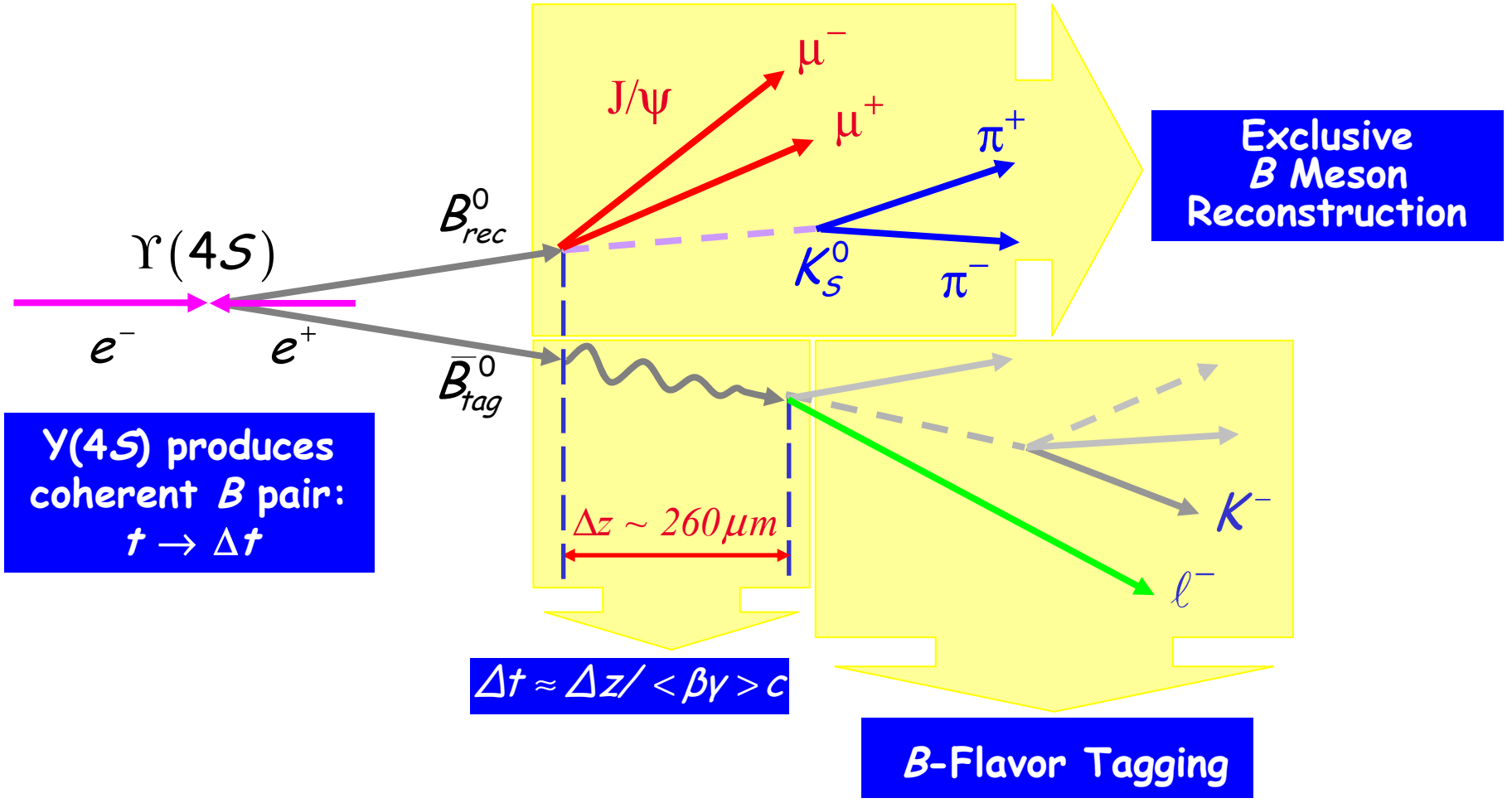


BABAR & Belle Publications

	BABAR	Belle
<2003	34	54
2003	47	28
2004 (July 1)	19	14
Total	100	96

Expect both Collaborations will have many significant updates and new results at ICHEP04

Time-Dependent CP Asymmetry Measurements



General CP Formalism

Decay distributions $f_+(f_-)$ when tag = $\bar{B}^0(B^0)$

$$f_{CP,\pm}(\Delta t) = \frac{\Gamma}{4} e^{-\Gamma \Delta t}\left[1 \pm S_{f_{CP}} \sin \Delta m_d \Delta t \mp C_{f_{CP}} \cos \Delta m_d \Delta t\right]$$

Asymmetry

$$A_{f_{CP}}(\Delta t) = C_{f_{CP}} \cos(\Delta m_d \Delta t) - S_{f_{CP}} \sin(\Delta m_d \Delta t)$$

CP parameter

CP eigenvalue

Amplitude ratio

$$\lambda_{f_{CP}} = \eta_{f_{CP}} \frac{q}{p} \frac{\bar{A}_{f_{CP}}}{A_{f_{CP}}}$$

$$\approx e^{-2i\beta}$$ from mixing

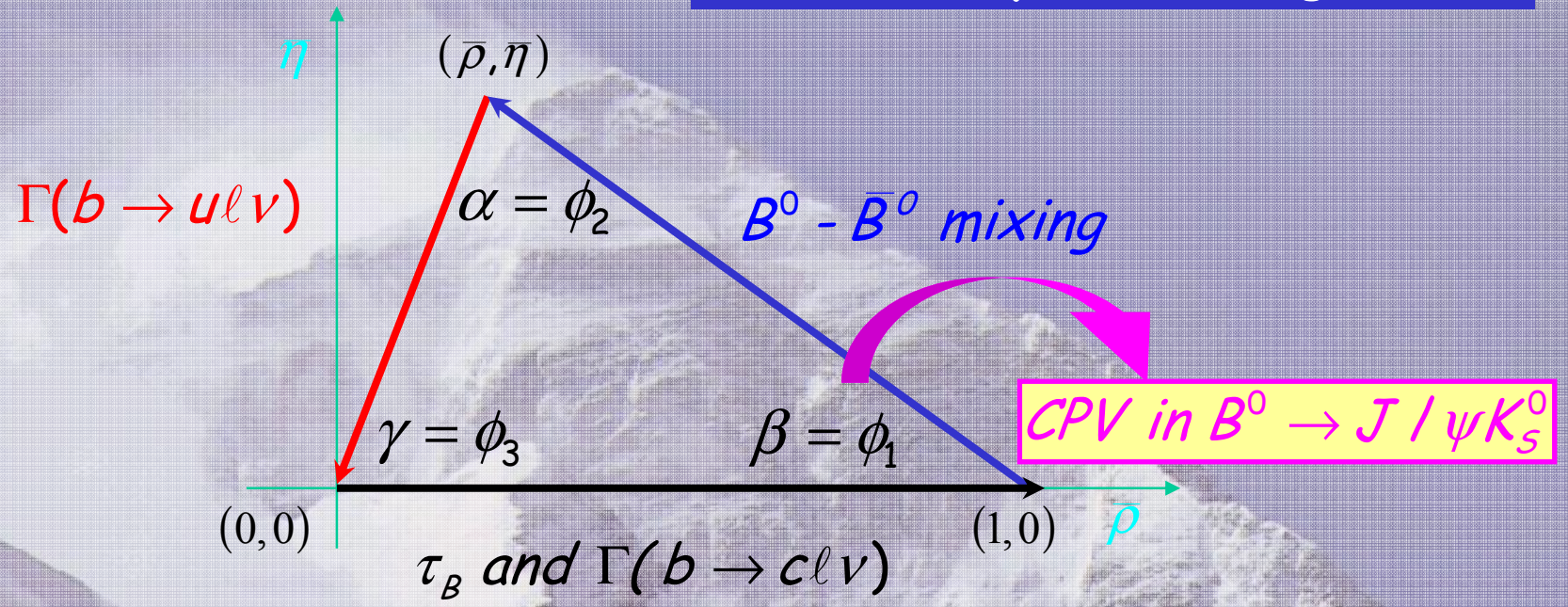
For single amplitude

$$C_{f_{CP}} = \frac{1 - |\lambda_{f_{CP}}|^2}{1 + |\lambda_{f_{CP}}|^2} = 0$$

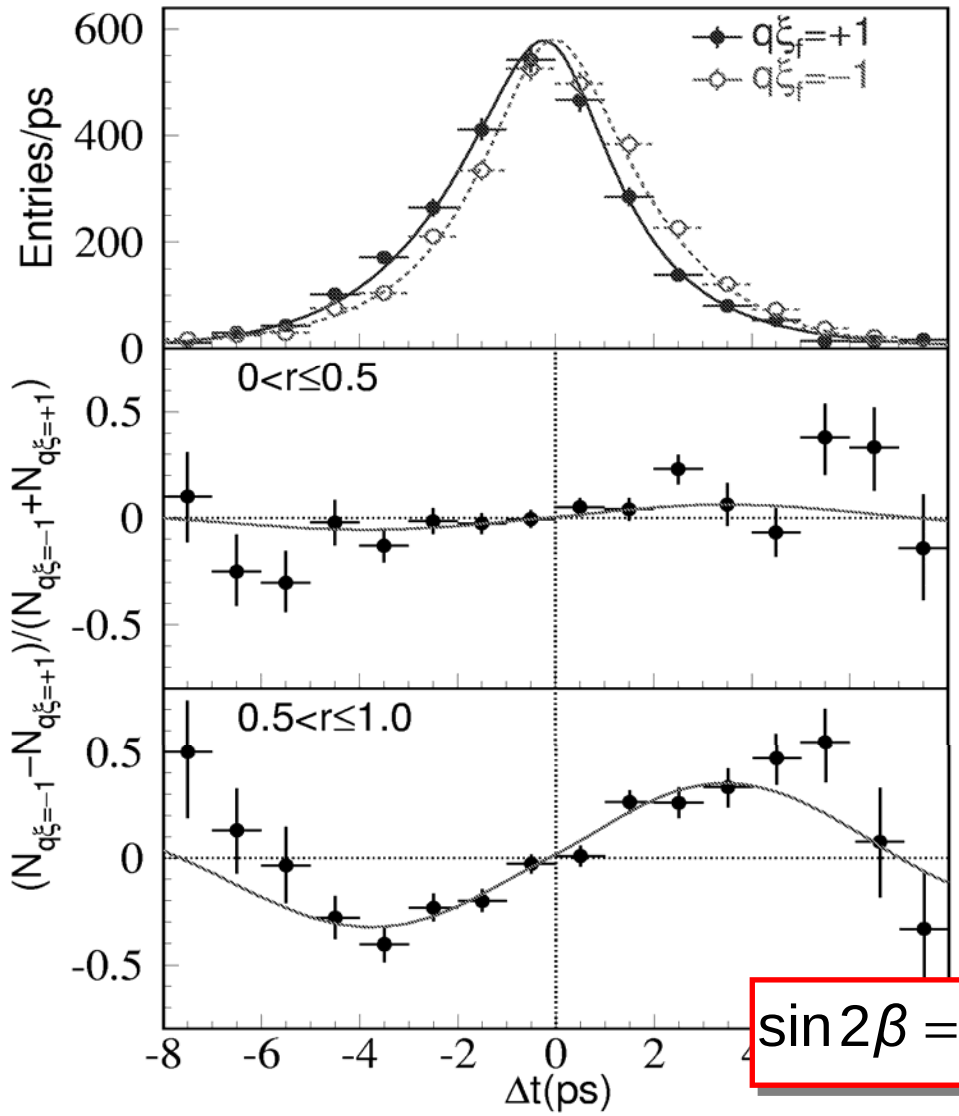
$$S_{f_{CP}} = \frac{-2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1 + |\lambda_{f_{CP}}|^2} = -\mathrm{Im}\,\lambda_{f_{CP}}$$

CPV in Charmonium Modes

Interference of $b \to c$ tree decay with mixing



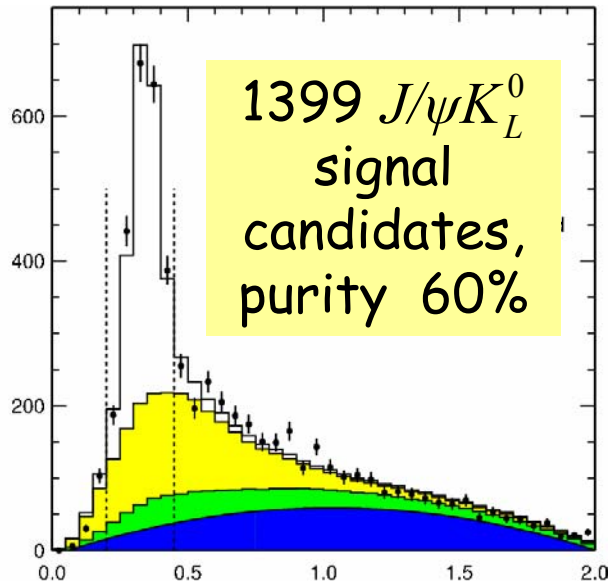
Latest Belle Result for sin2β



BELLE

Reported at LP03, hep-ex/0308040

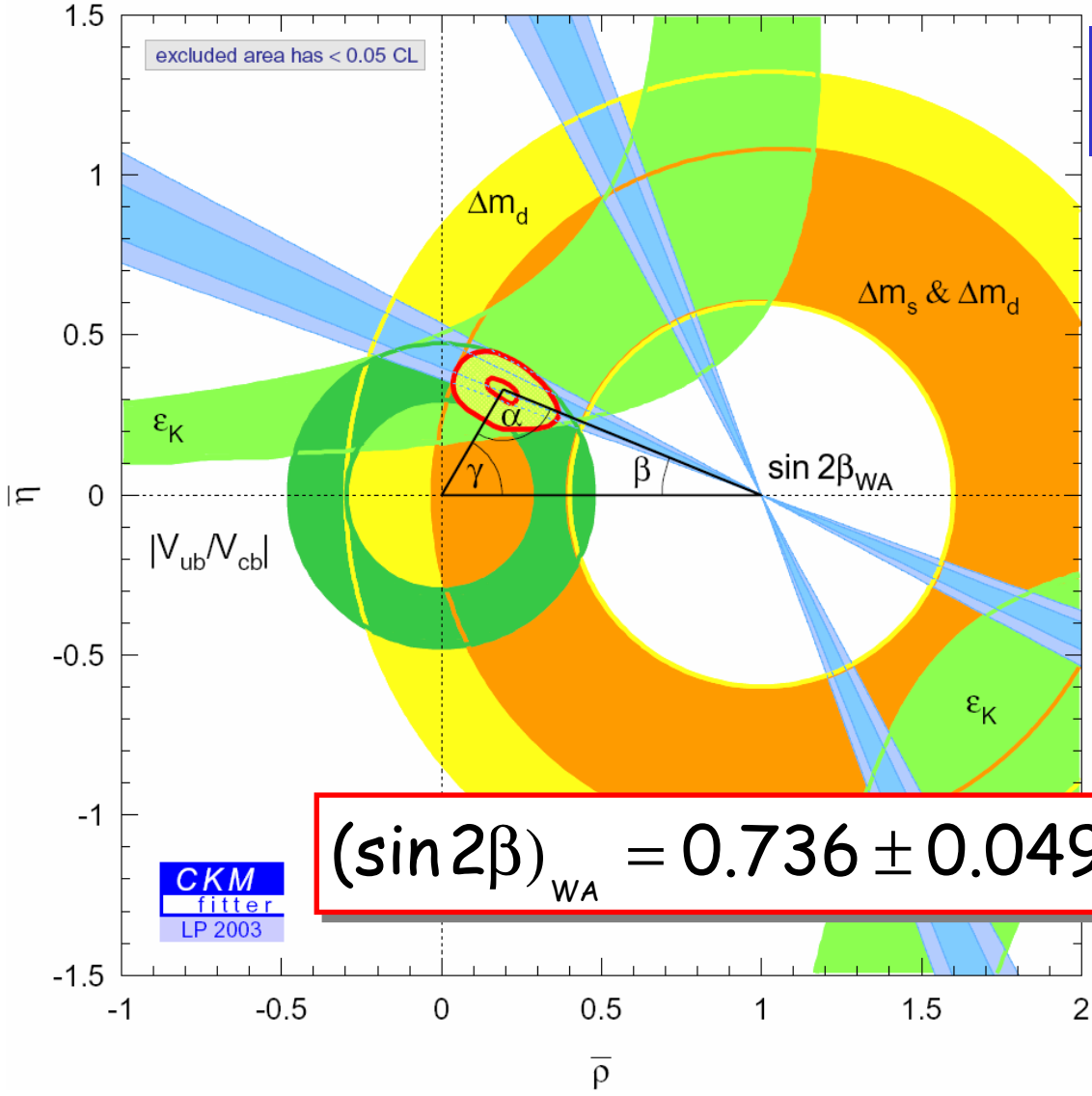
2716 charmonium signal events, 93% purity



1399 $J/\psi K_L^0$ signal candidates, purity 60%

$$\sin 2\beta = 0.733 \pm 0.057_{(stat)} \pm 0.028_{(syst)}$$

Standard Model Constraints



$$(\sin 2\beta)_{WA} = 0.736 \pm 0.049 \text{ (stat+syst)}$$

Indirect constraints vs direct measurement

At 95% CL:

$19.4 < \beta < 26.5^{o}$

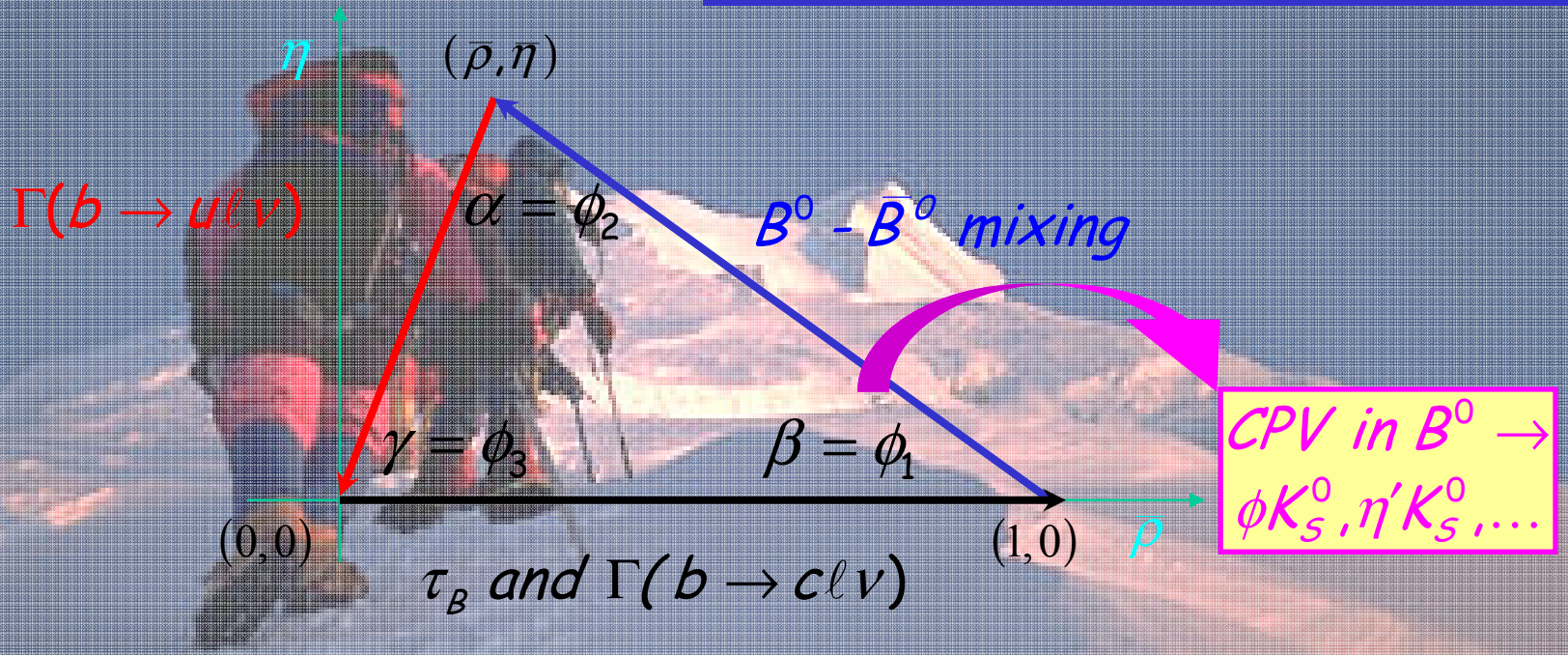
$77 < \alpha < 122^{o}$

$37 < \gamma < 80^{o}$

A.Hoecker et al.

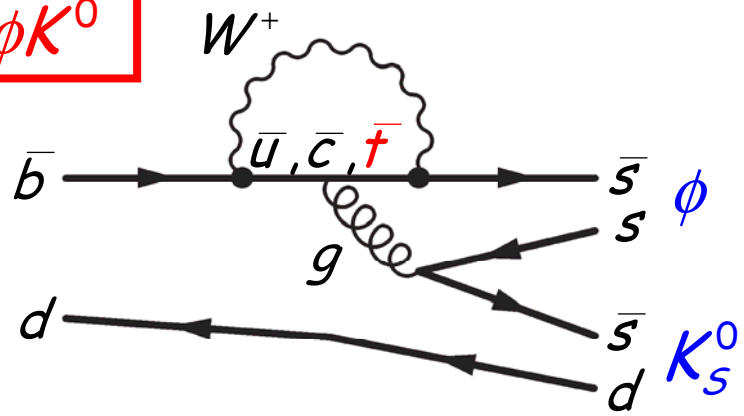
CPV in Penguin Modes

Interference of suppressed $b \to s$ Penguin decay with mixing



Asymmetries for $b \to s\bar{s}s$ Penguins

$B^0 \to \phi K^0$



"Internal Penguin"

u-penguin CKM suppressed by ~0.02

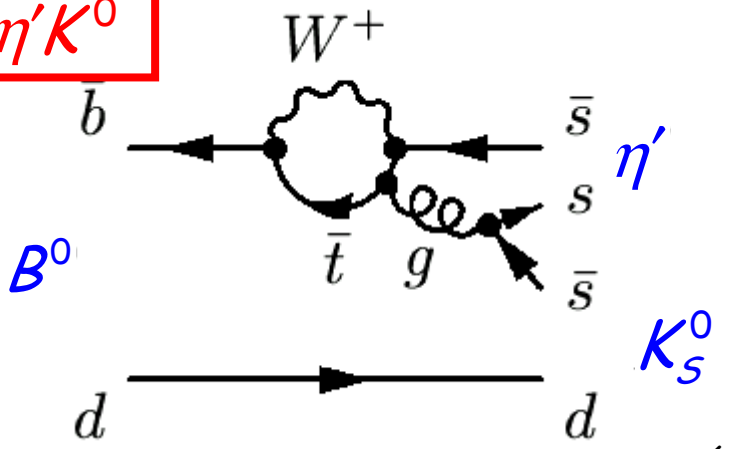
Expectation

$$S_{\phi K_S^0} = \sin 2\beta, C_{\phi K_S^0} = 0$$

Challenge

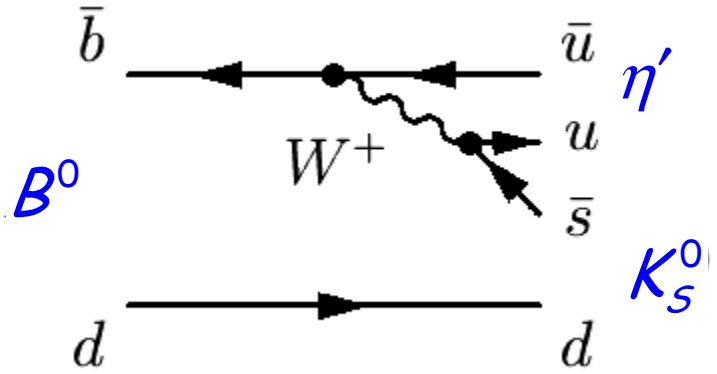
$$BF = \left(7.6^{+1.3}_{-1.2} \pm 0.5\right) \times 10^{-6}$$

$B^0 \to \eta' K^0$



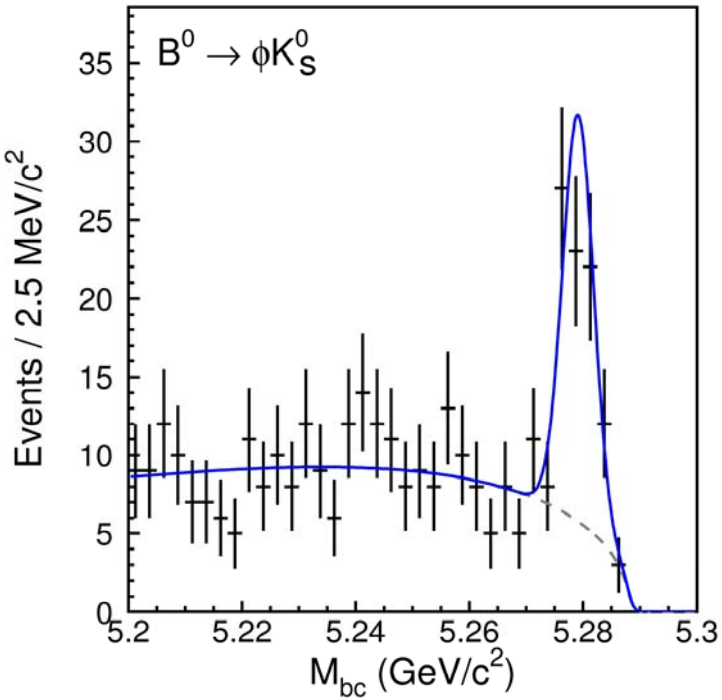
$$BF = (55.4 \pm 5.2 \pm 4.0) \times 10^{-6}$$

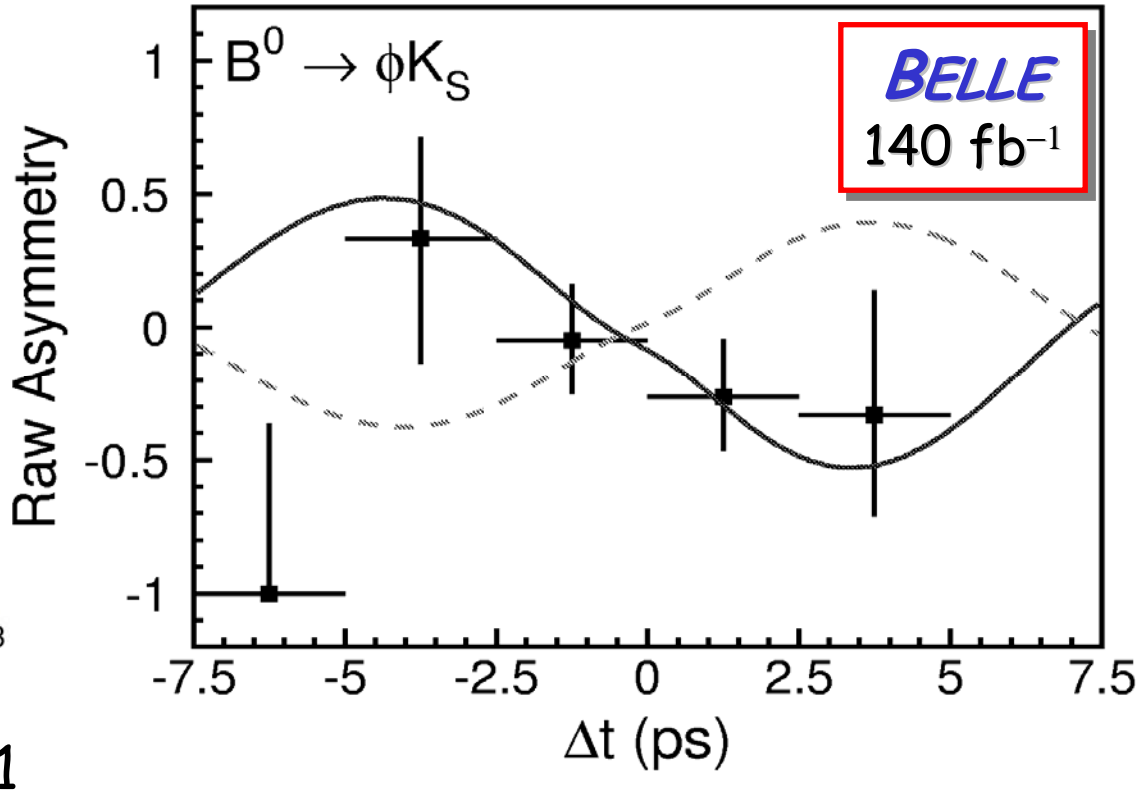
"Tree-level $b \to u$"



u-tree CKM suppressed T/P < 0.1

Belle Results for $B \to \phi K_S^0$





$$N\left(\phi K_S^0\left(\to \pi^+\pi^-\right)\right) = 68 \pm 11$$

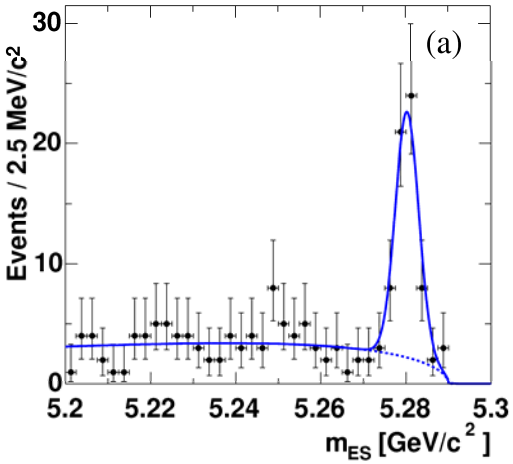
Summer 03

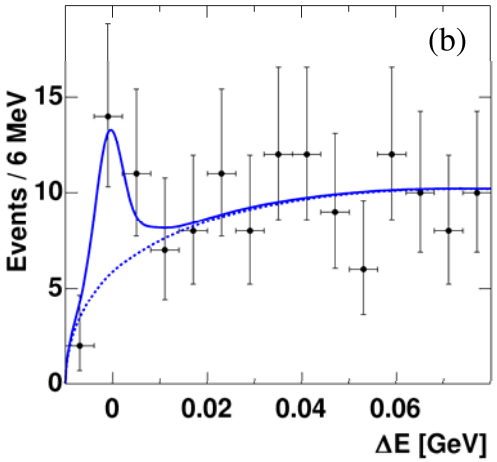
PRL **91** (2003) 261602

$$S_{\phi K_S^0} = -0.96 \pm 0.50_{(stat)}\ ^{+0.09}_{-0.11}\ _{(syst)}$$

$$C_{\phi K_S^0} = +0.15 \pm 0.29_{(stat)} \pm 0.07_{(syst)}$$

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





$N_{\phi K^0_S} = 70 \pm 9$ $\quad N_{\phi K^0_L} = 52 \pm 16$

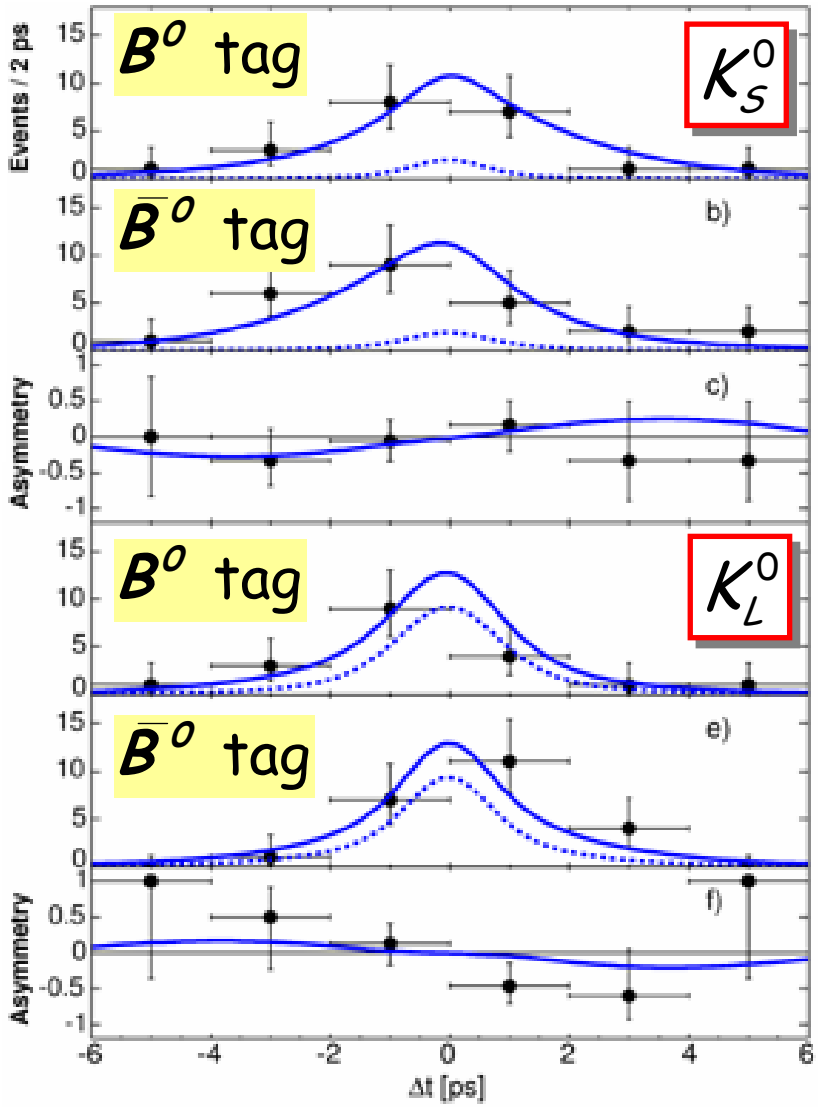
Summer 03

To appear in PRL

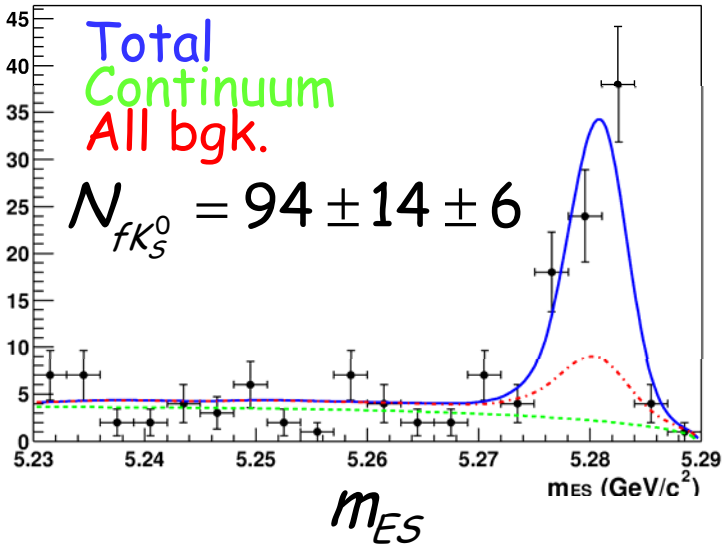
BABAR
110 fb^{-1}

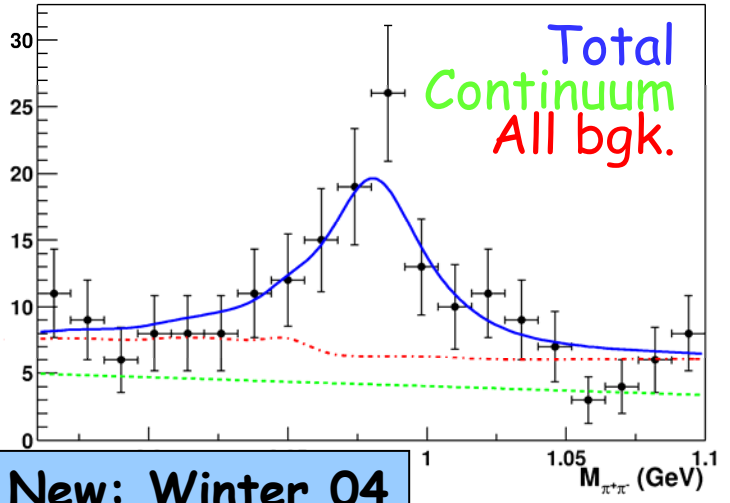
$$S_{\phi K^0_S} = +0.47 \pm 0.34_{(stat)} \, ^{+0.08}_{-0.06}{}_{(syst)}$$

$$C_{\phi K^0_S} = +0.10 \pm 0.33_{(stat)} \pm 0.10_{(syst)}$$

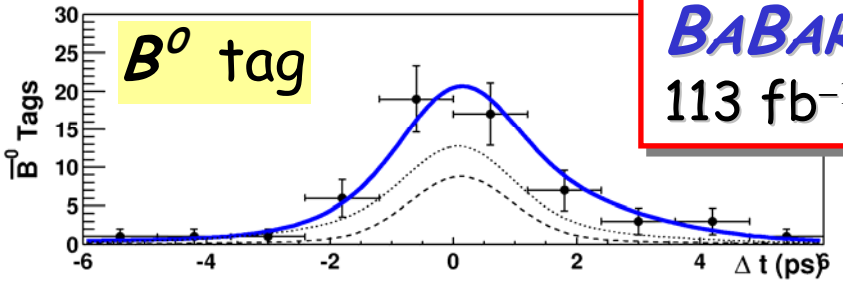


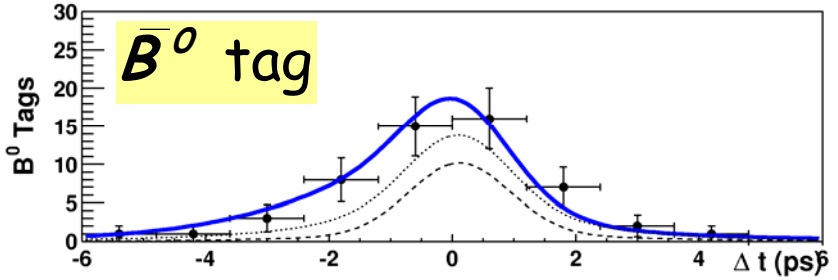
BABAR Results for $B \to f_0 K_S^0$

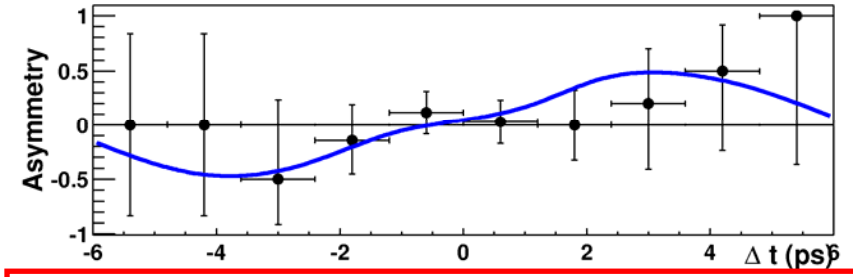




New: Winter 04







BABAR
113 fb^{-1}

$$S_{fK_S^0} = +1.62\,^{+0.51}_{-0.56}{}_{(stat)} \pm 0.10_{(syst)}$$

$$C_{fK_S^0} = +0.27 \pm 0.36_{(stat)} \pm 0.10_{(syst)}$$

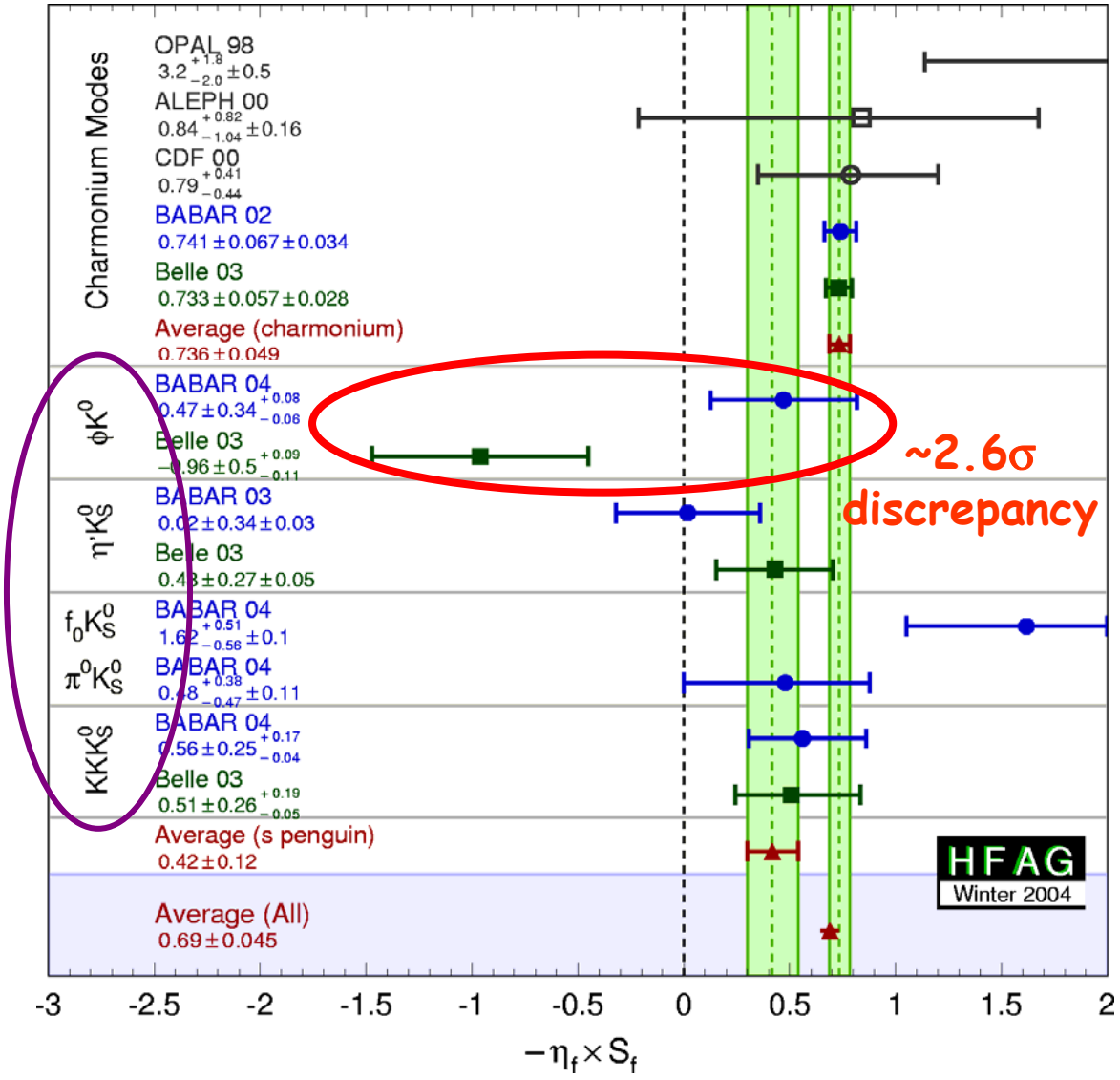
Intriguing Hint?

Present average for $b \to s\bar{s}s$

0.42 ± 0.12

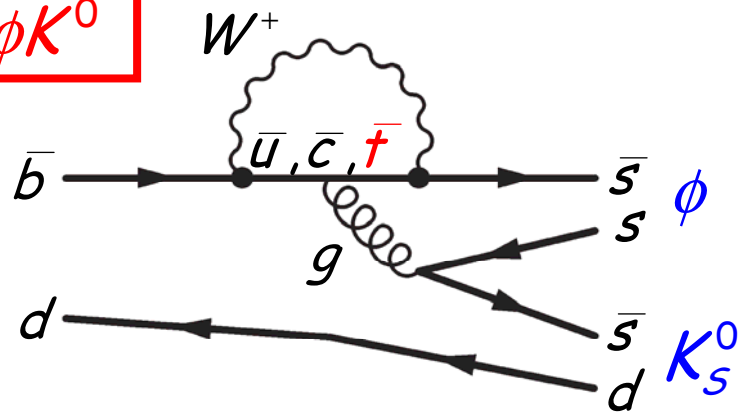
~2.4 sigma below charmonium modes

If central value remains as is, this would become ~5 sigma by 2005



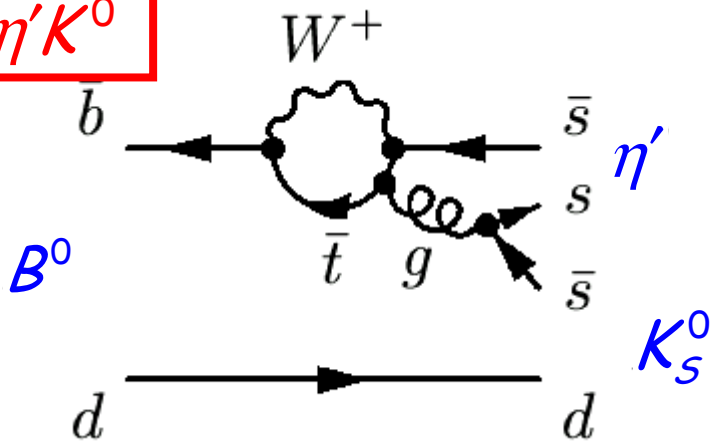
Asymmetries for $b \to s\bar{s}s$ Penguins

$B^0 \to \phi K^0$

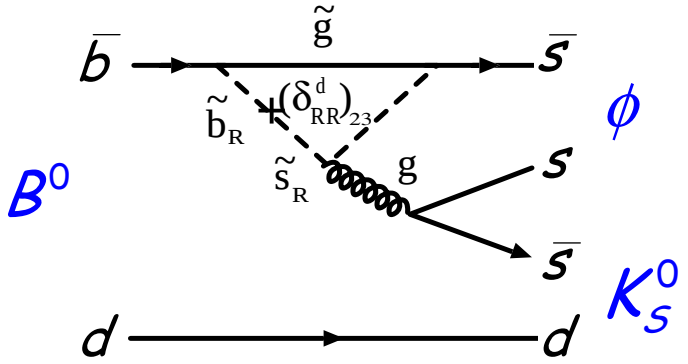


"Internal Penguin"

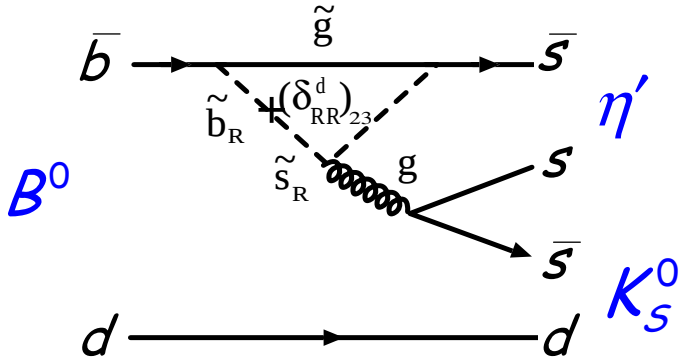
$B^0 \to \eta' K^0$



New physics in loops?

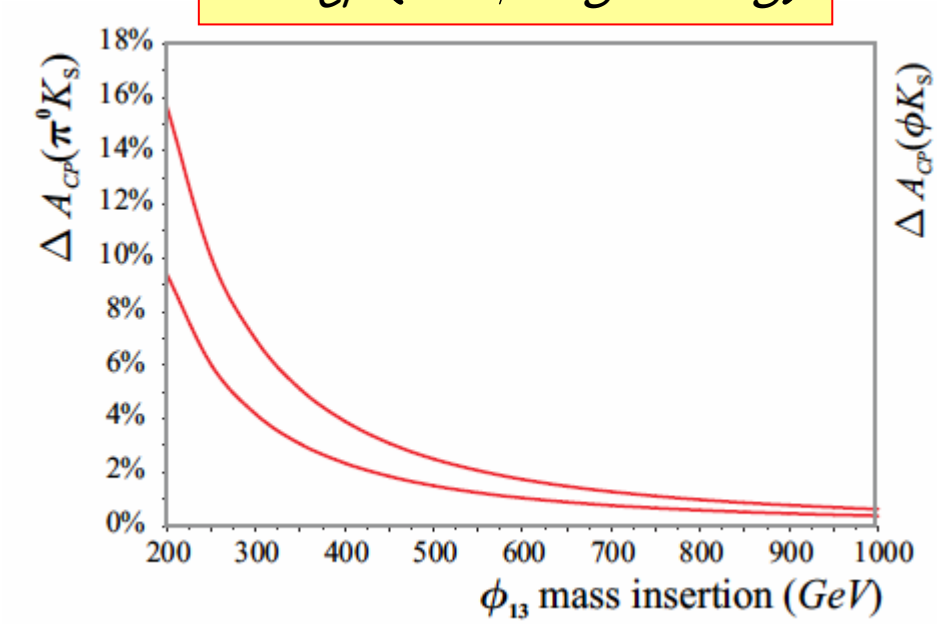


SUSY contribution with new phases

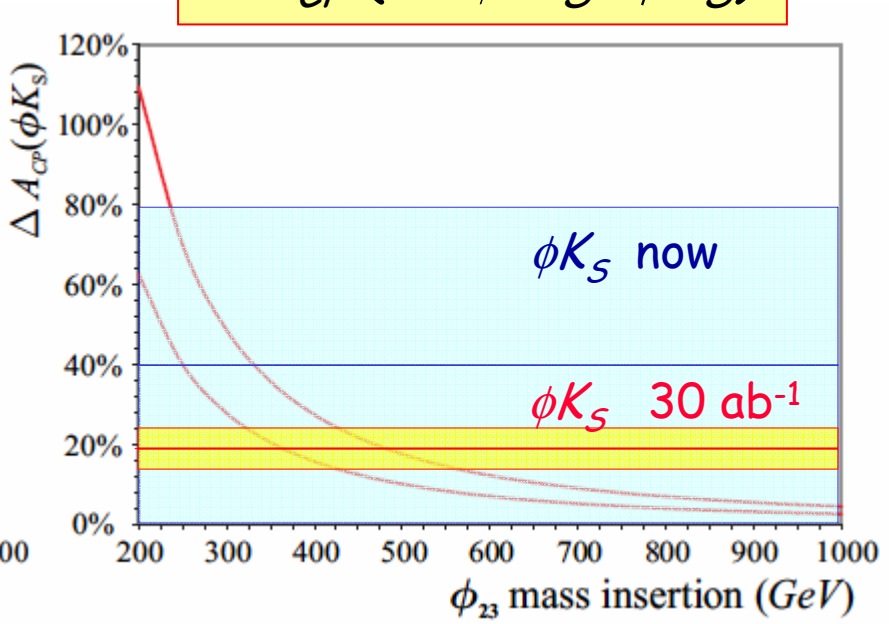


New Physics Sensitivity

$\Delta A_{CP}(J/\psi K_S - \pi^0 K_S)$



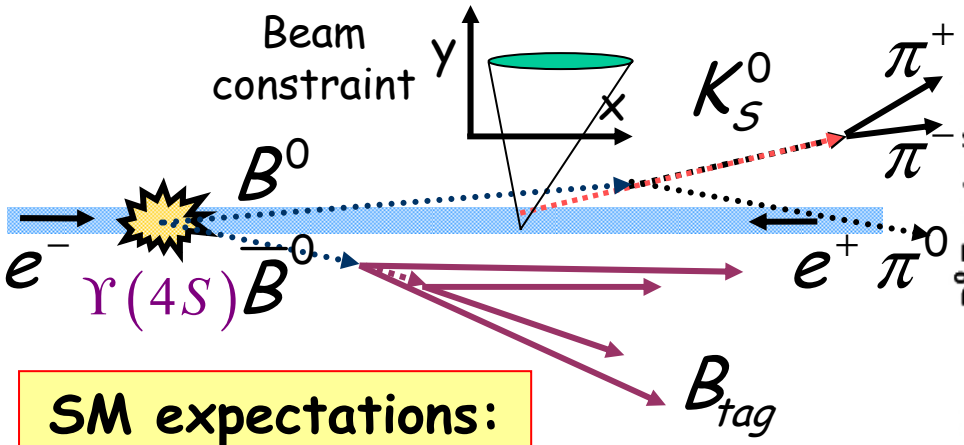
$\Delta A_{CP}(J/\psi K_S - \phi K_S)$



Ciuchini, Franco, Martinelli, Masiero, & Silvestrini

Intriguing Hint?

CP Asymmetry for $B^0 \to K^{*0}[\to K_S\pi^0]\gamma$



SM expectations:

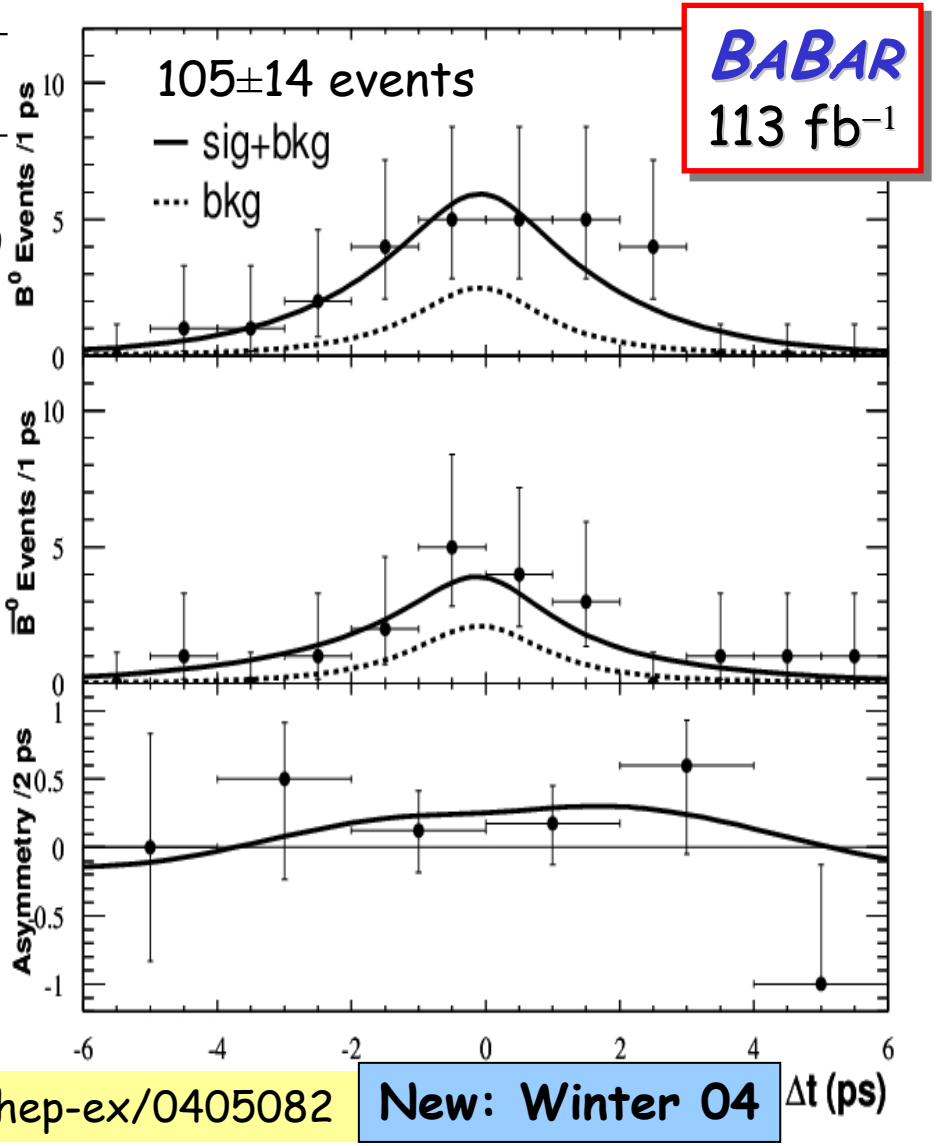
Helicity-suppressed asymmetry

$$S_{K^*\gamma} \approx 2\frac{m_s}{m_b}\sin(2\beta) \approx 0.05, \quad |C_{K^*\gamma}| < 1\%$$

New Physics models:

Photon polarization mixed

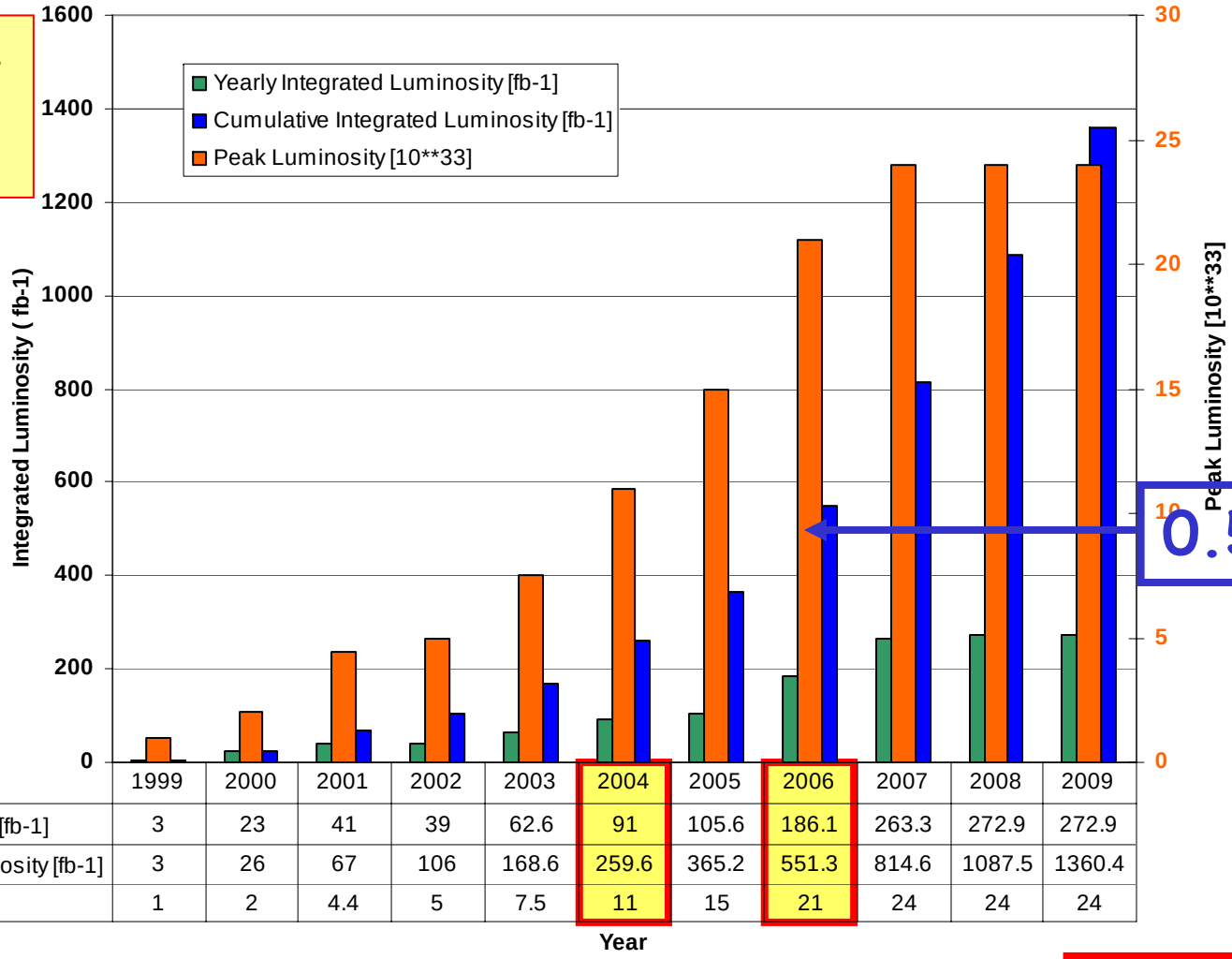
$$S_{K^*\gamma} = -0.25 \pm 0.63_{(stat)} \pm 0.14_{(syst)}$$
$$C_{K^*\gamma} = -0.56 \pm 0.32_{(stat)} \pm 0.09_{(syst)}$$



Preliminary! hep-ex/0405082 **New: Winter 04**

PEP II Luminosity Projections

KEKB plans are comparable or better!

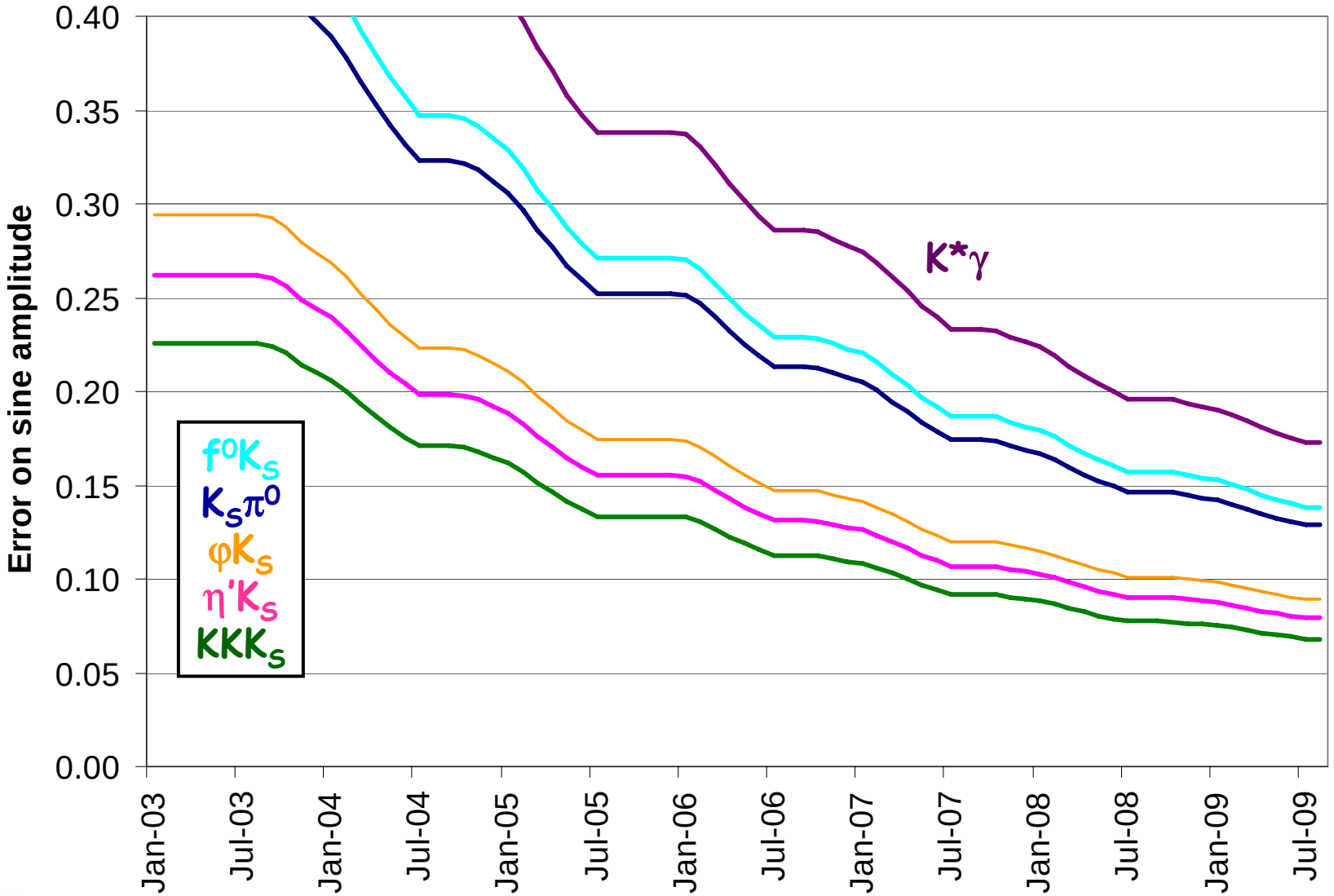


	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Yearly Integrated Luminosity [fb-1]	3	23	41	39	62.6	91	105.6	186.1	263.3	272.9	272.9
Cumulative Integrated Luminosity [fb-1]	3	26	67	106	168.6	259.6	365.2	551.3	814.6	1087.5	1360.4
Peak Luminosity [10**33]	1	2	4.4	5	7.5	11	15	21	24	24	24

Year

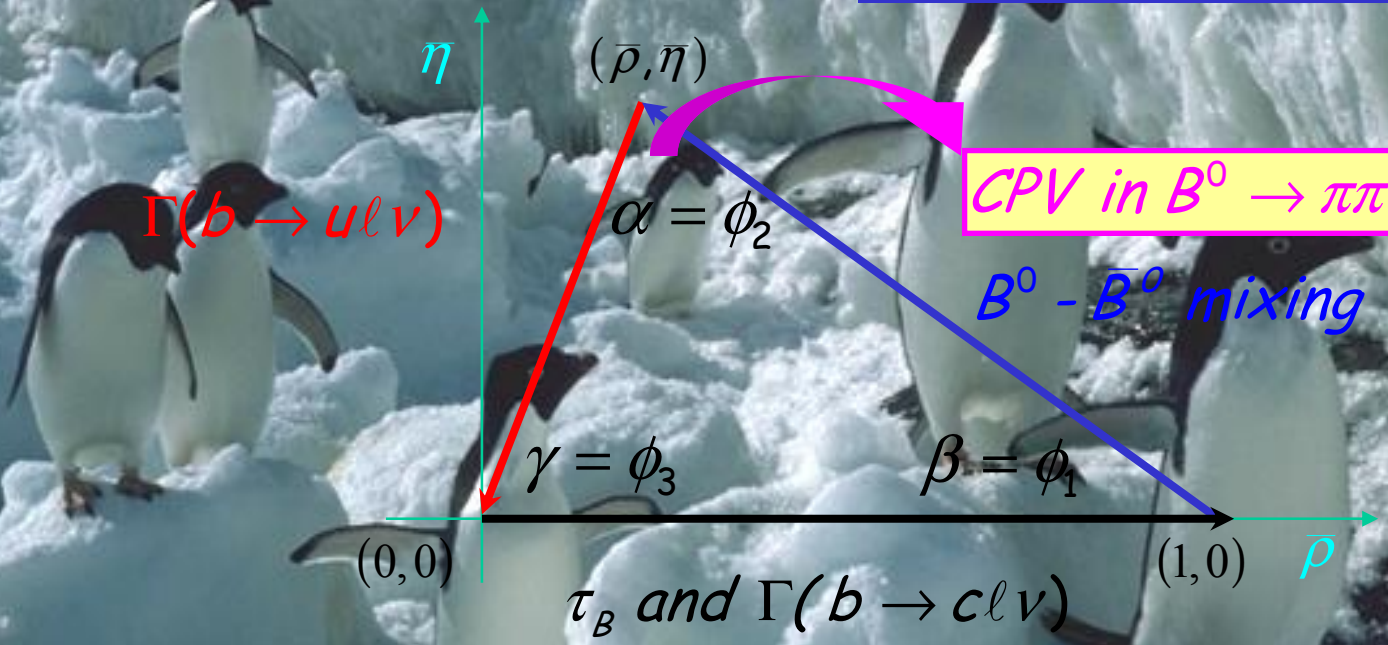
2004 2006 ← 2.1×10^{34}

Projections for Penguin Modes



CPV in Charmless Modes

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



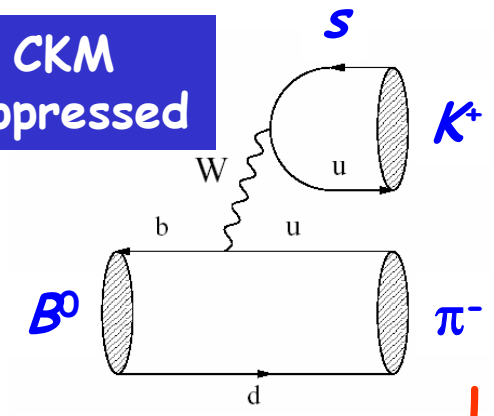
CPV in $B^0 \to \pi\pi, \rho\pi, \rho\rho, \ldots$

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

Competing Amplitudes for $B \to h^+h^-$

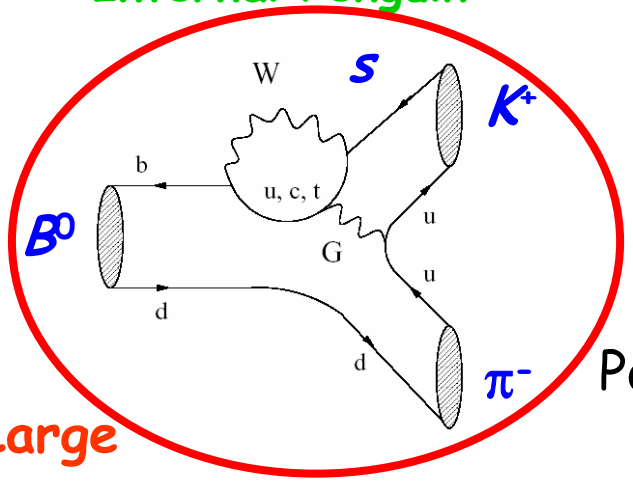
"Tree-level $b \to u$"

CKM suppressed



"Internal Penguin"

Large



Large

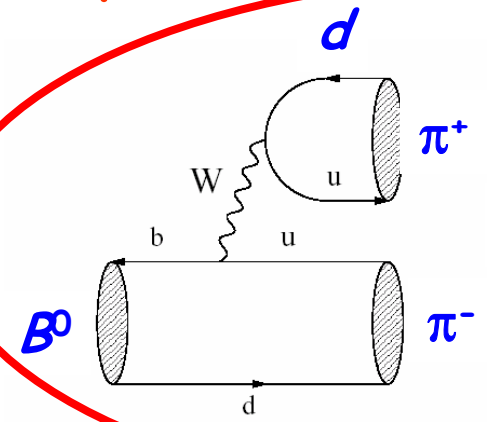
$$BF(B^0 \to K^+\pi^-) = (18.5 \pm 1.0) \times 10^{-6}$$

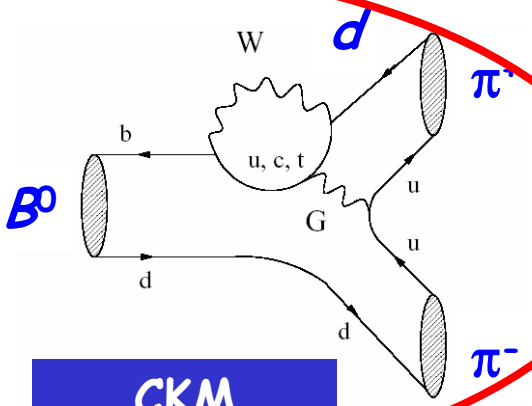
Penguin dominated:

$$A_{K\pi} = \lambda^2 e^{i\gamma} T + P$$

Potential direct *CPV* and constraints on γ

Comparable





CKM suppressed

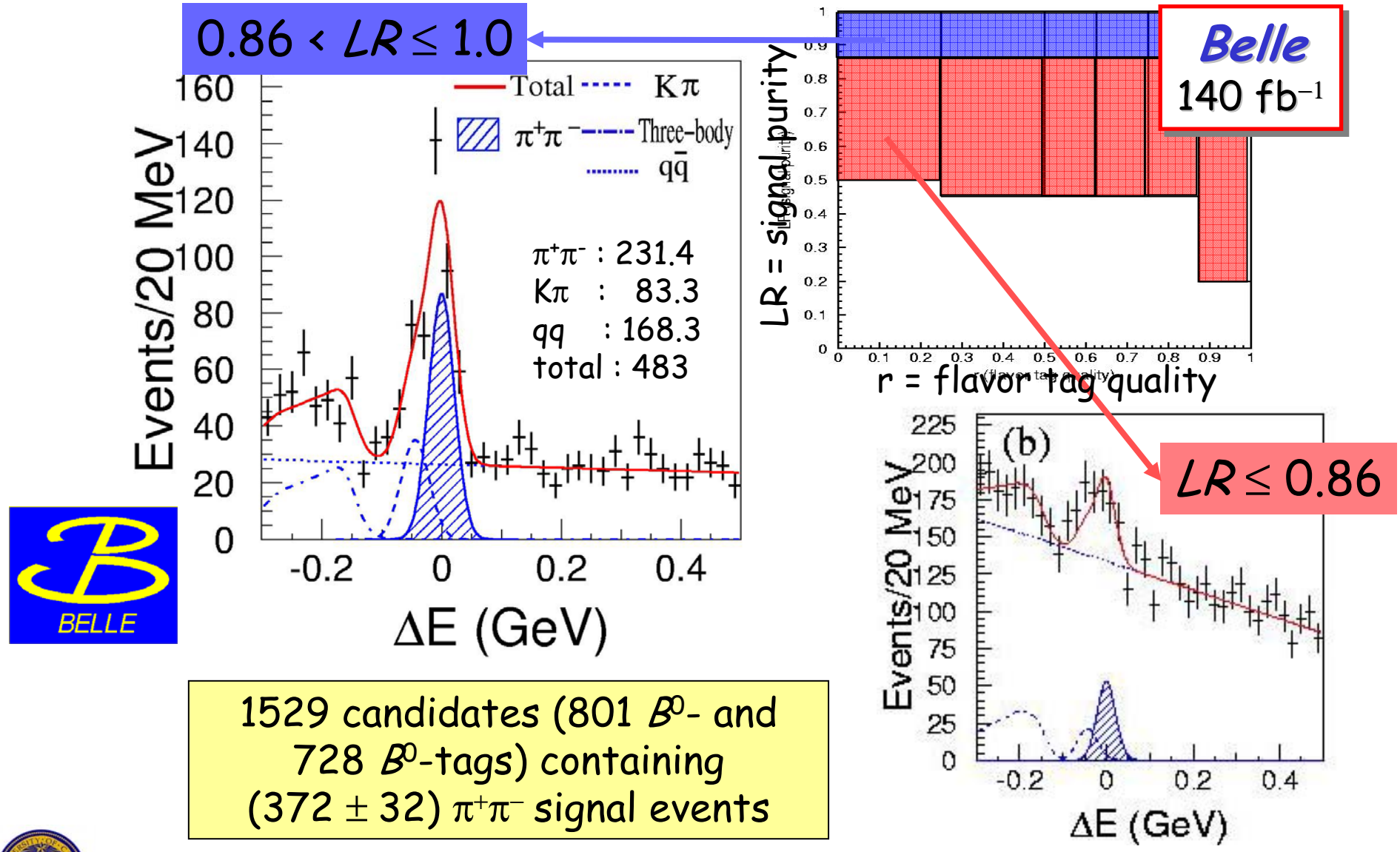
Small

$$BF(B^0 \to \pi^+\pi^-) = (4.8 \pm 0.5) \times 10^{-6}$$

|Penguin| ~ 0.3|Tree|

Complicates extraction of α from mixing induced *CPV*

$B^0 \to \pi^+\pi^-$ Candidates at Belle

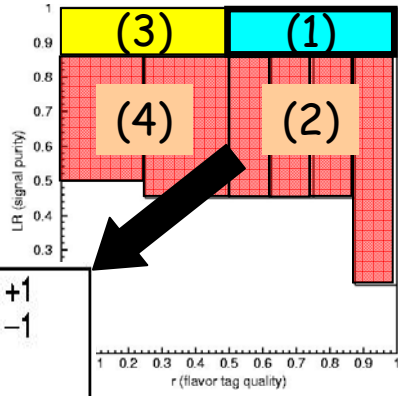


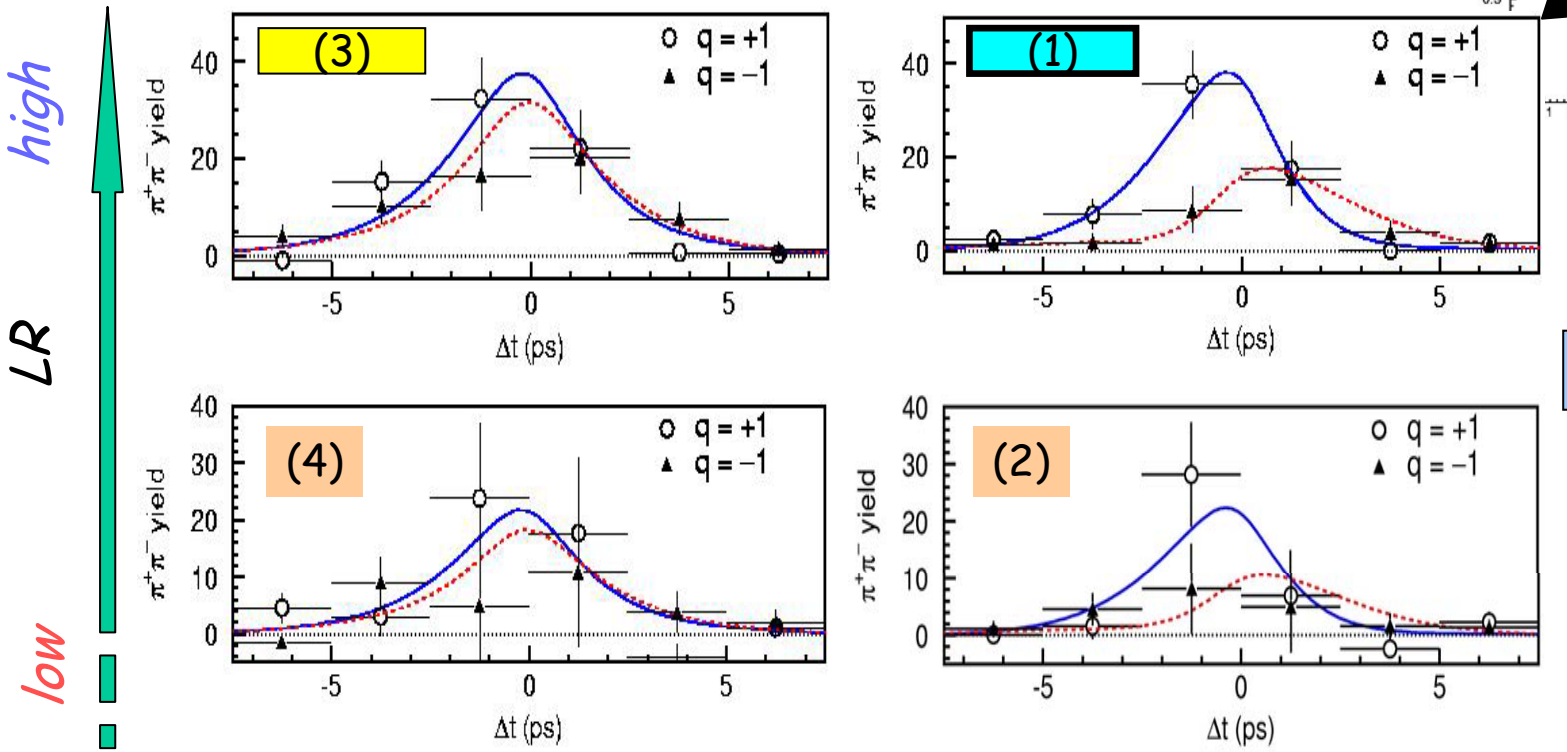
1529 candidates (801 B^0- and 728 B^0-tags) containing (372 ± 32) $\pi^+\pi^-$ signal events

Background Subtracted Δt Distributions

$$S_{\pi\pi} = -1.00 \pm 0.15_{(stat)} \pm 0.07_{(syst)}$$
$$A_{\pi\pi} = +0.58 \pm 0.15_{(stat)} \pm 0.07_{(syst)}$$

Belle
140 fb^{-1}



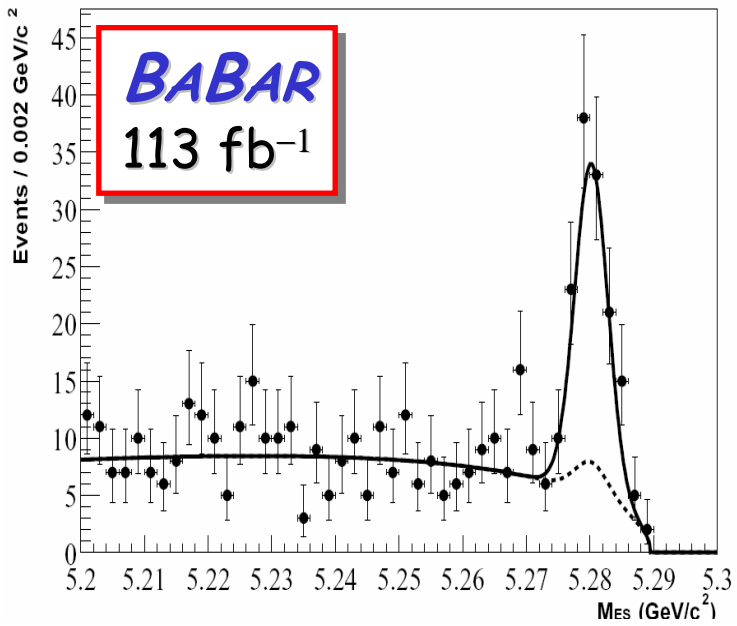


Summer 03

PRL **93** (2004) 021601

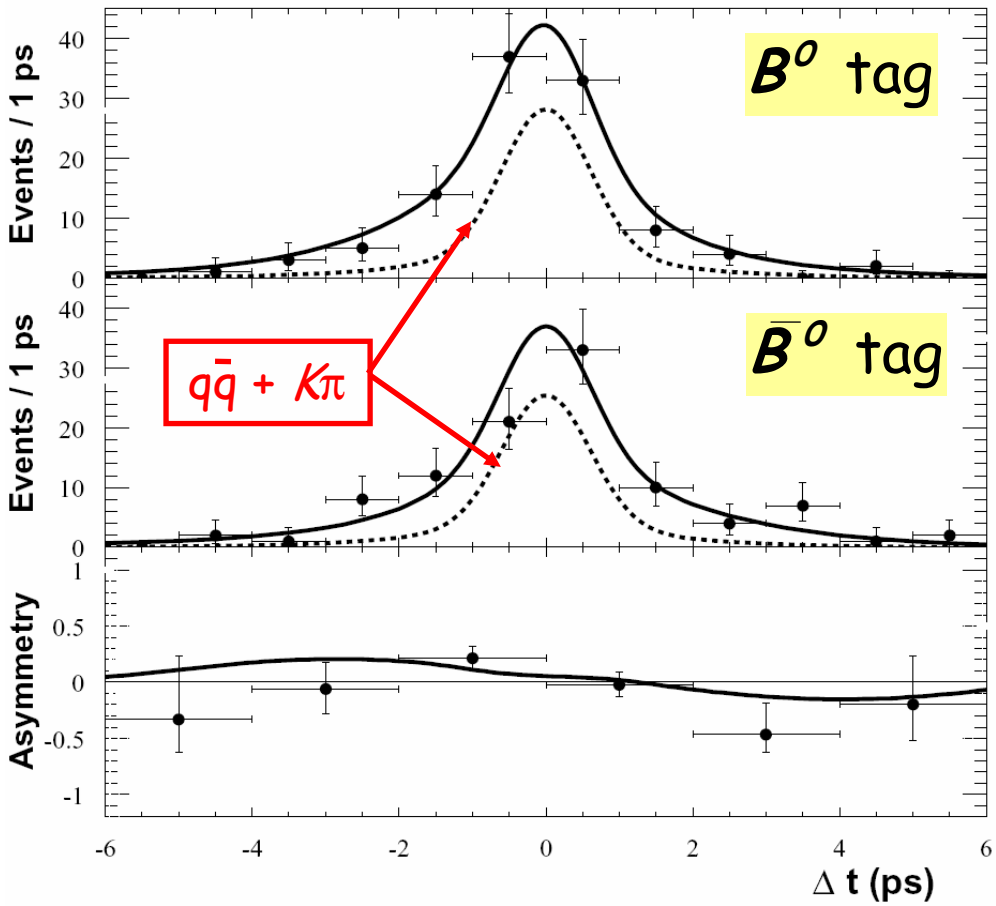
BELLE

Time-Dependent CP Asymmetry



266 ± 24 $\pi^+\pi^-$ candidates

Fit projections in sample of $\pi\pi$-enriched events



Summer 03

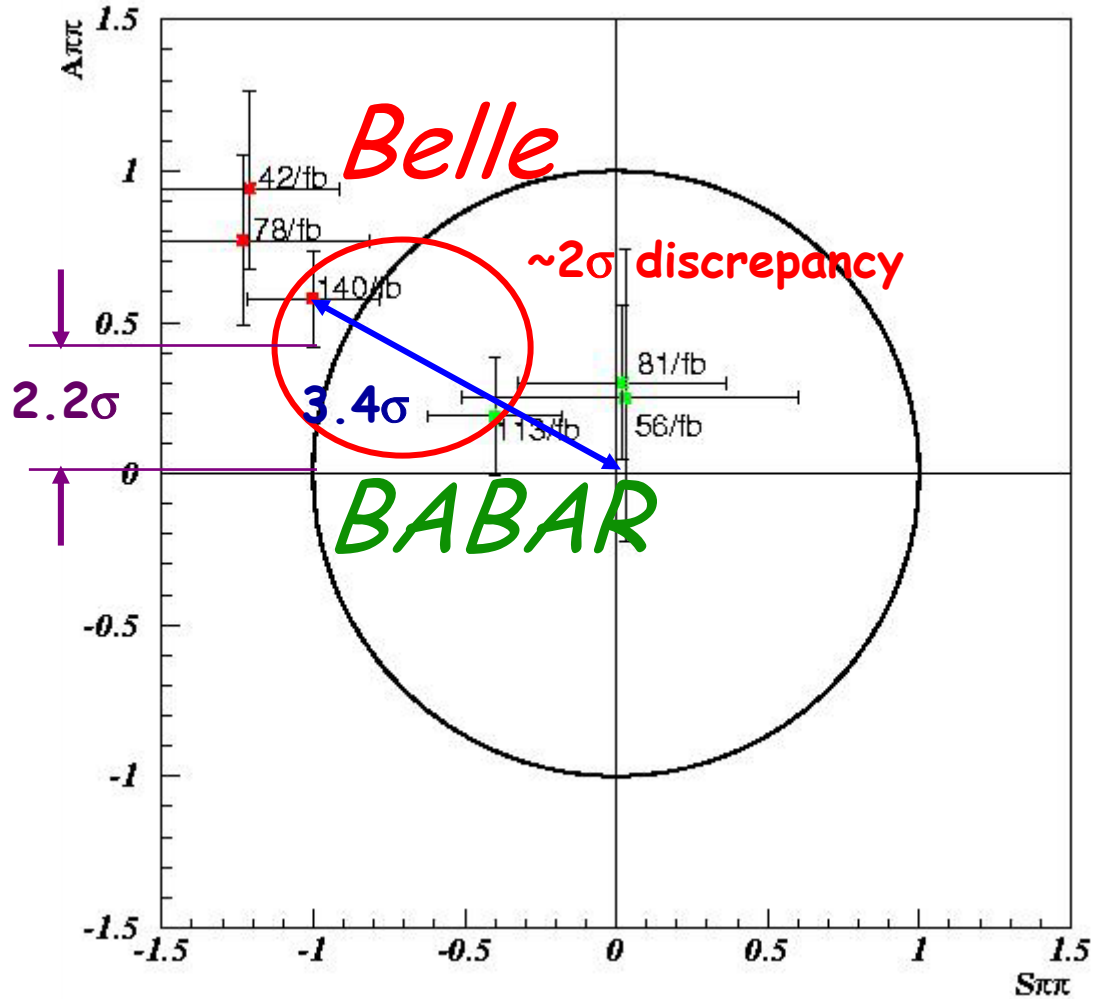
Reported at LP03

$$\sin 2\alpha_{eff} =$$

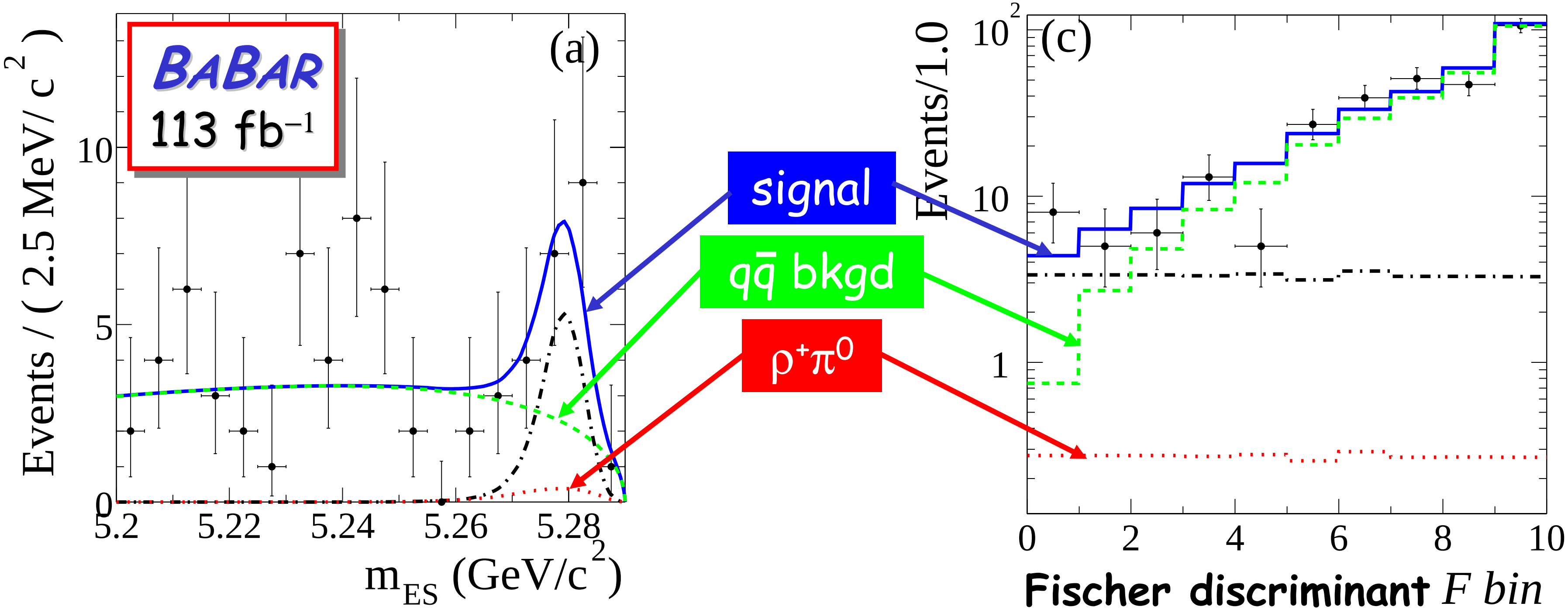
$$S_{\pi\pi} = -0.40 \pm 0.22_{(stat)} \pm 0.03_{(syst)}$$

$$C_{\pi\pi} = -0.19 \pm 0.19_{(stat)} \pm 0.05_{(syst)}$$

Comparison of $A_{\pi\pi} = -C_{\pi\pi}$ and $S_{\pi\pi}$



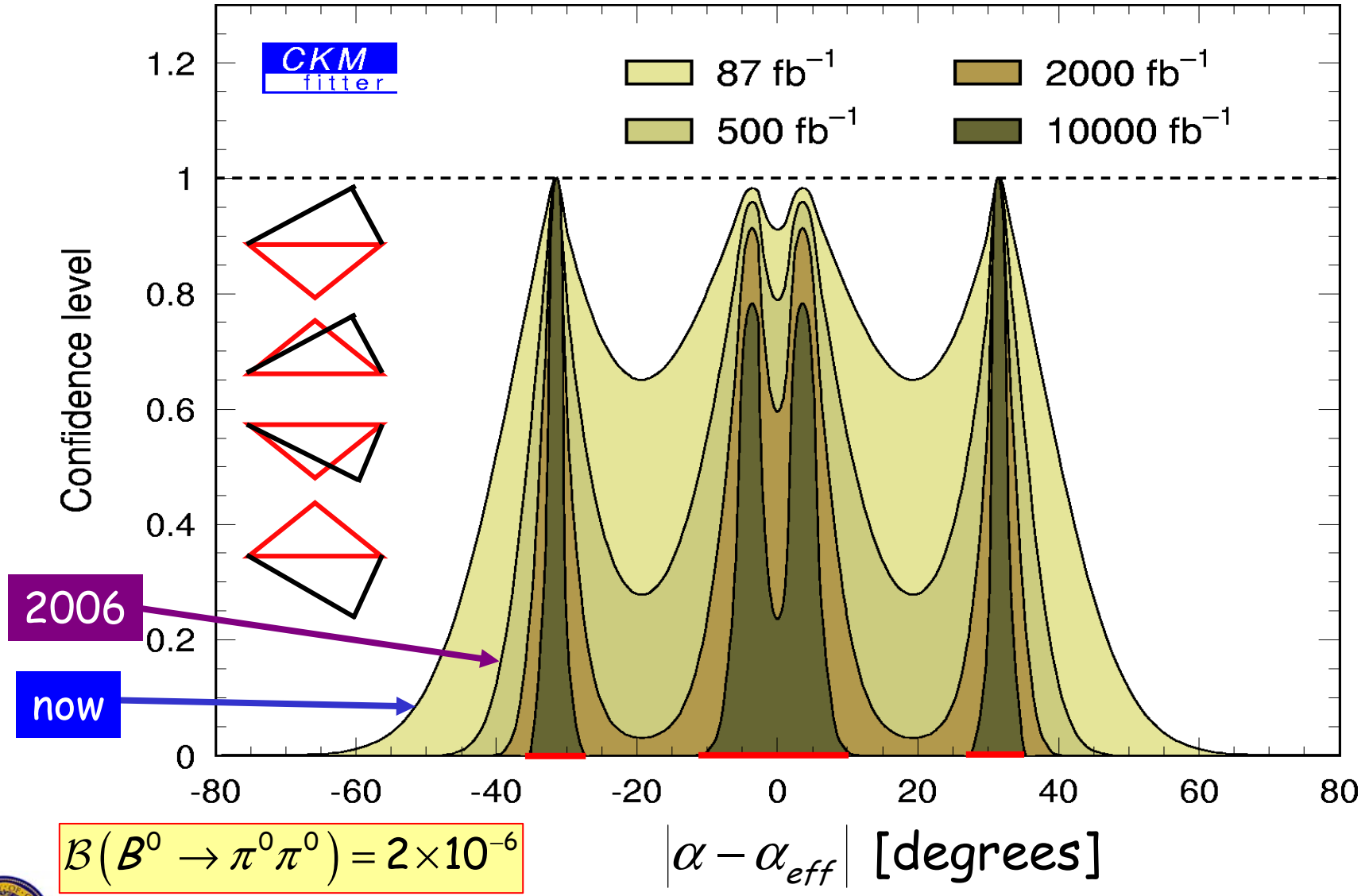
Observation of $B^0 \rightarrow \pi^0\pi^0$



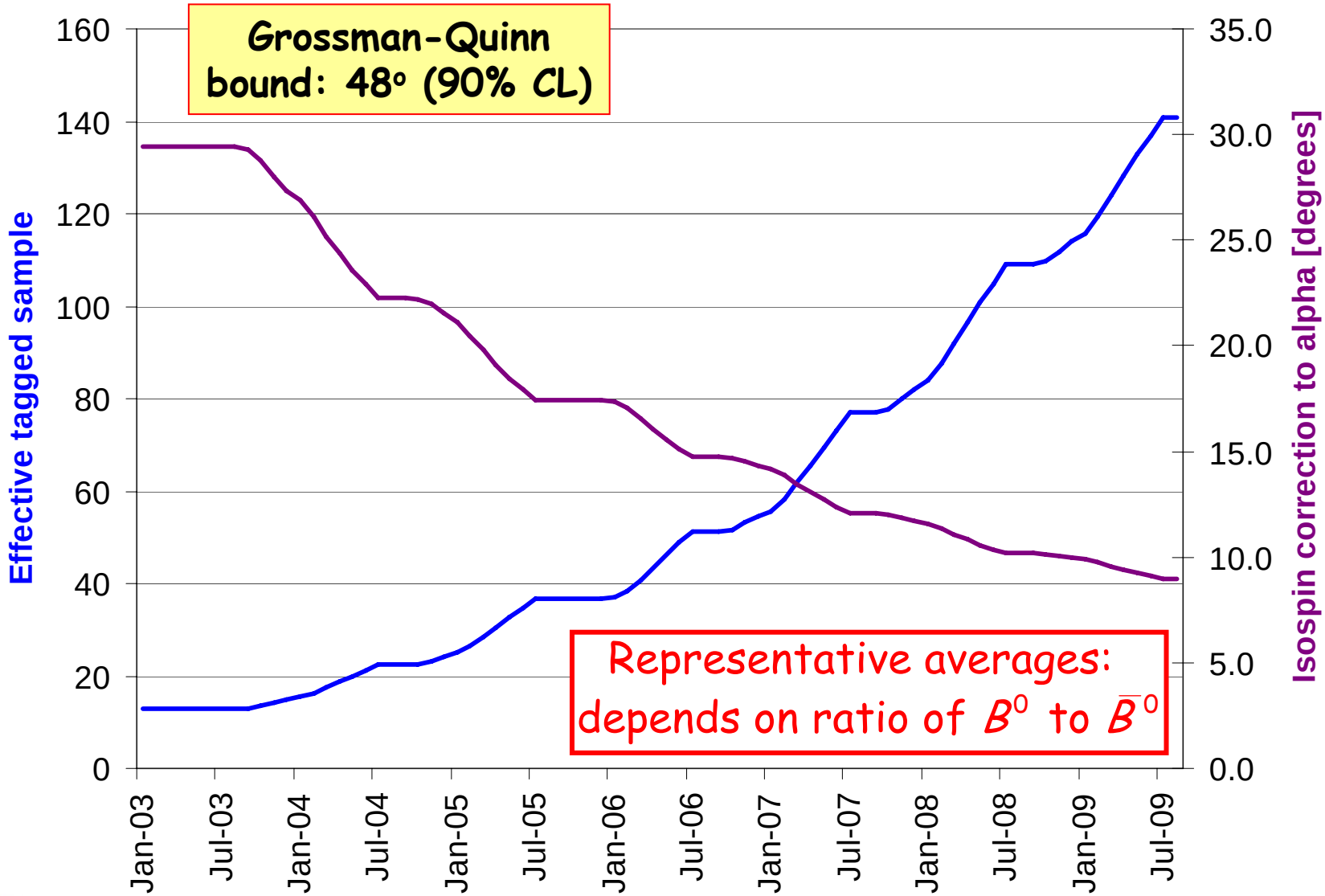
Summer 03	Signal	BF x 10^{-6}	σ	
BABAR	$46^{+14}_{-13}{}^{+2}_{-3}$	$2.1 \pm 0.6 \pm 0.3$	4.2	PRL **91** (20[illegible]3) 2[illegible]
BELLE	$25.6^{+9.3}_{-8.4}$	$1.7 \pm 0.6 \pm 0.3$	3.4	[illegible]003) 262001

Large!

Projections of $\pi\pi$ Isospin Analysis



Projections for 2-Body Isospin Analysis

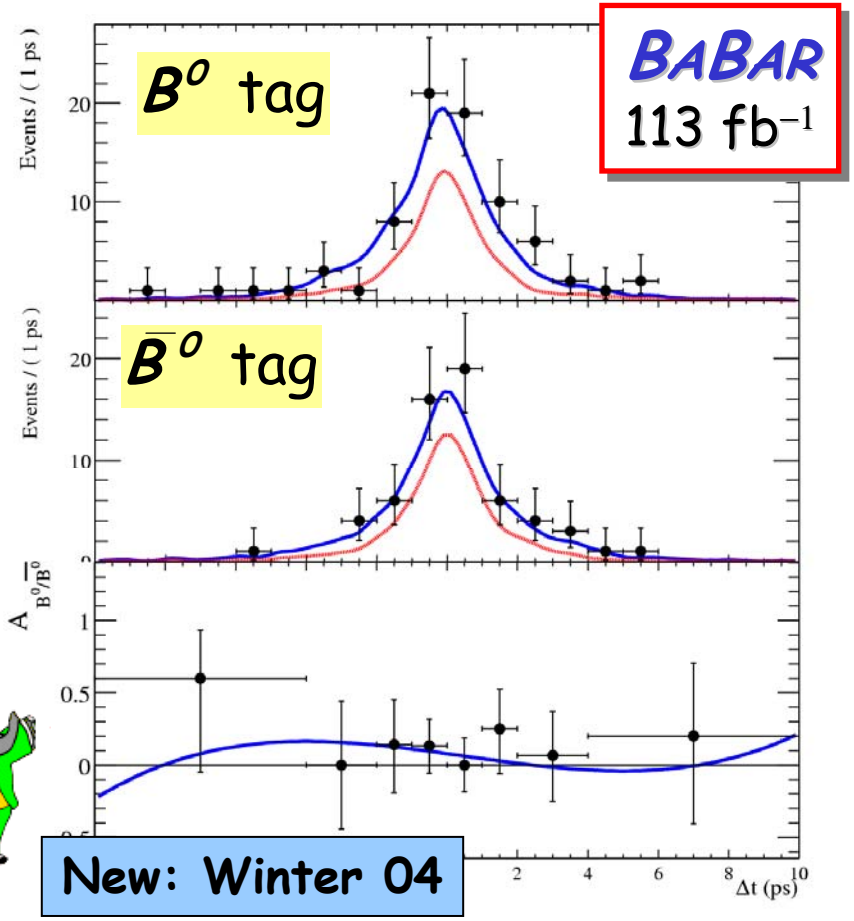


New Result on $B^0 \to \rho^+\rho^-$

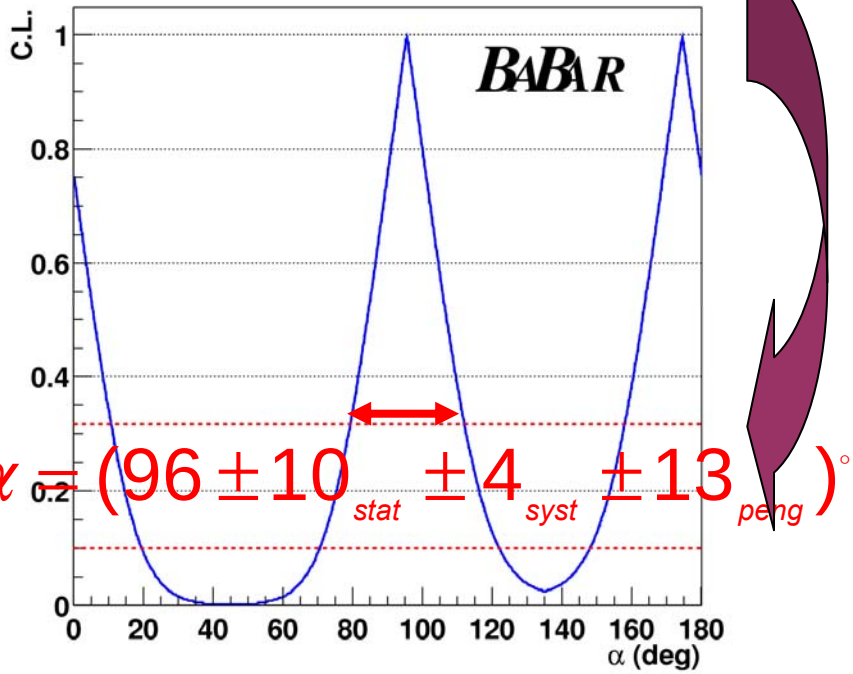
$$S_{long} = -0.19 \pm 0.33_{(stat)} \pm 0.11_{(syst)}$$
$$C_{long} = -0.23 \pm 0.24_{(stat)} \pm 0.14_{(syst)}$$

$BF(B^0 \to \rho^0\rho^0) < 2.1\times10^{-6}$ (90% CL)

Small!

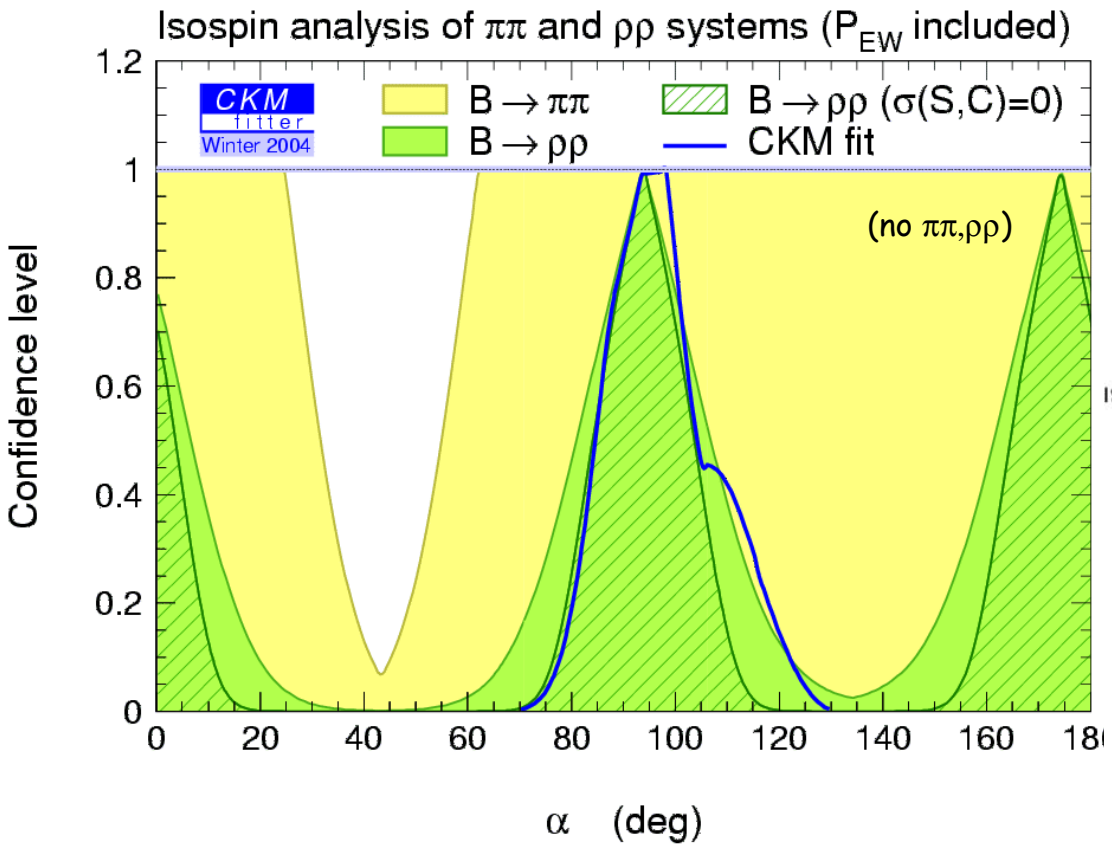


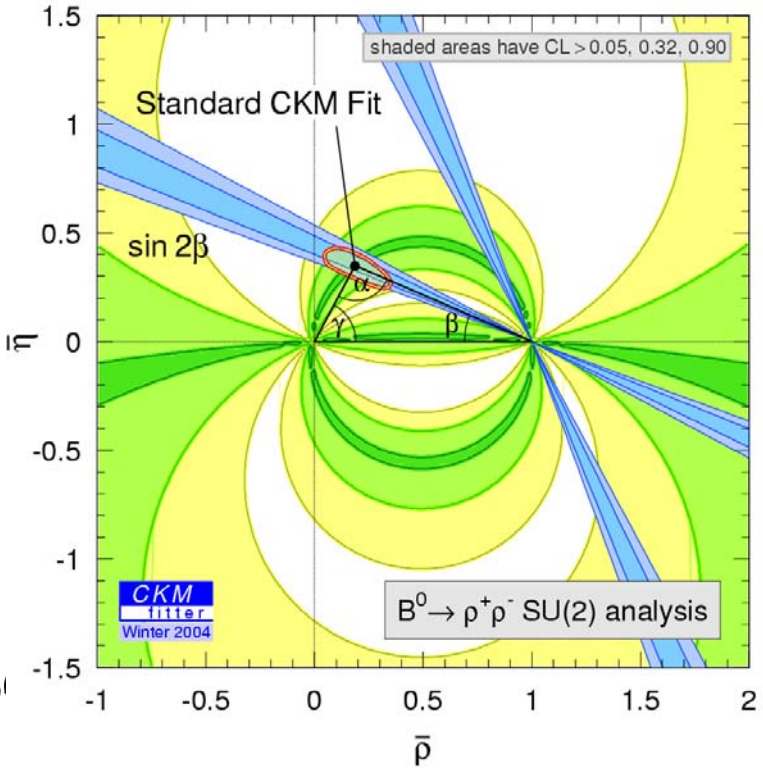
New: Winter 04



- Isospin analysis: interference, NR contributions, I=1 amplitudes neglected

Analysis from CKMFitter Group



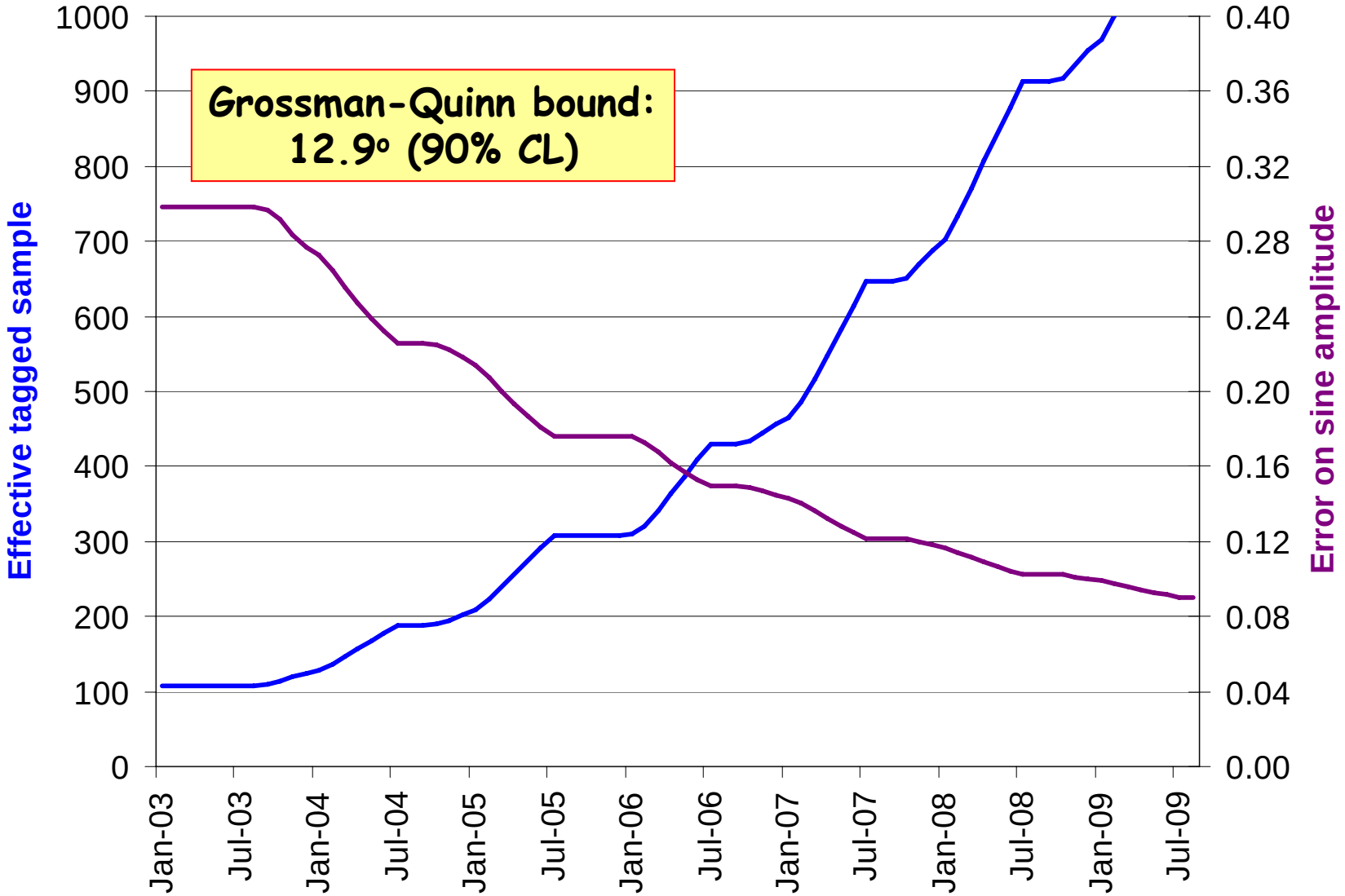


Other ingredients in $\rho\rho$ isospin analysis:

$BR(\rho^+\rho^0) = (26.4 \pm 6.4)10^{-6}$ [*BABAR*,Belle] $BR(\rho^0\rho^0) = (0.62^{+0.72}_{-0.60} \pm 0.12)10^{-6}$ [*BABAR*]

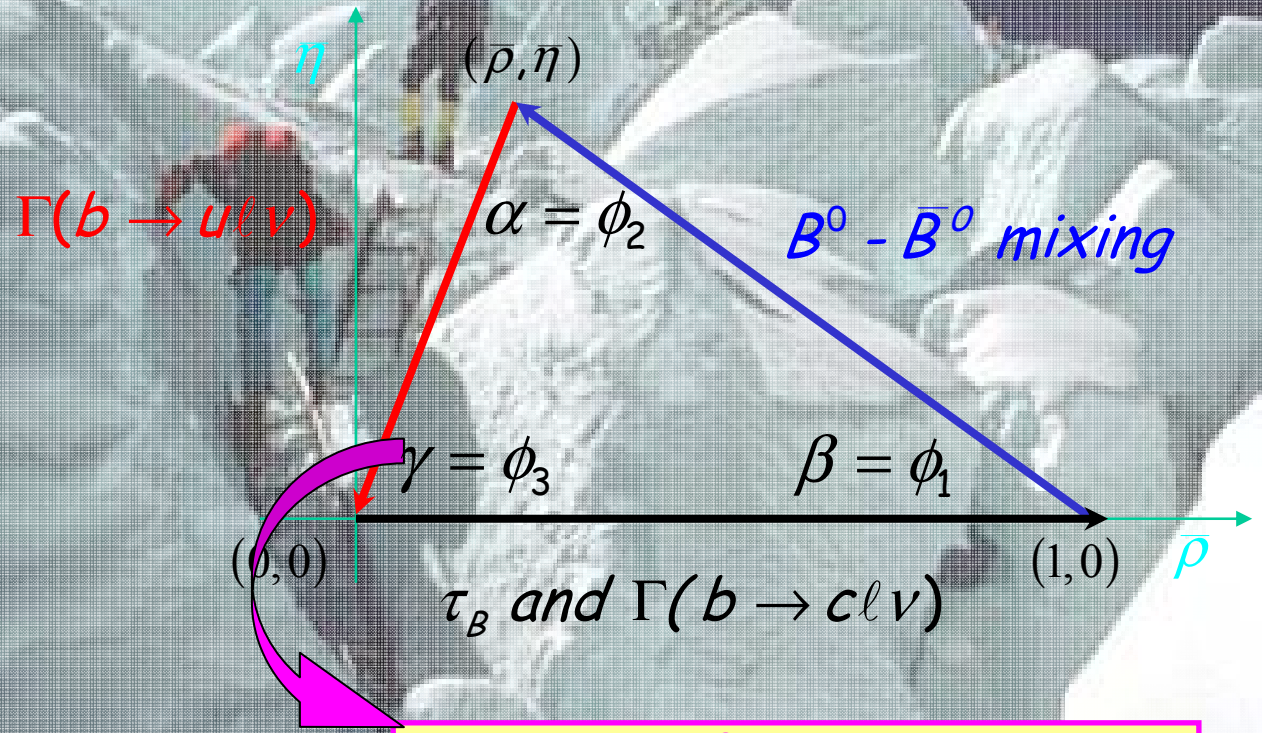
$f_{long}(\rho^+\rho^0) = 0.962^{+0.049}_{-0.065}$ [*BABAR*,Belle] $f_{long}(\rho^0\rho^0) = 1.0$ [assumed]

Projections for α from $B^0 \to \rho^+ \rho^-$



First Look at Gamma

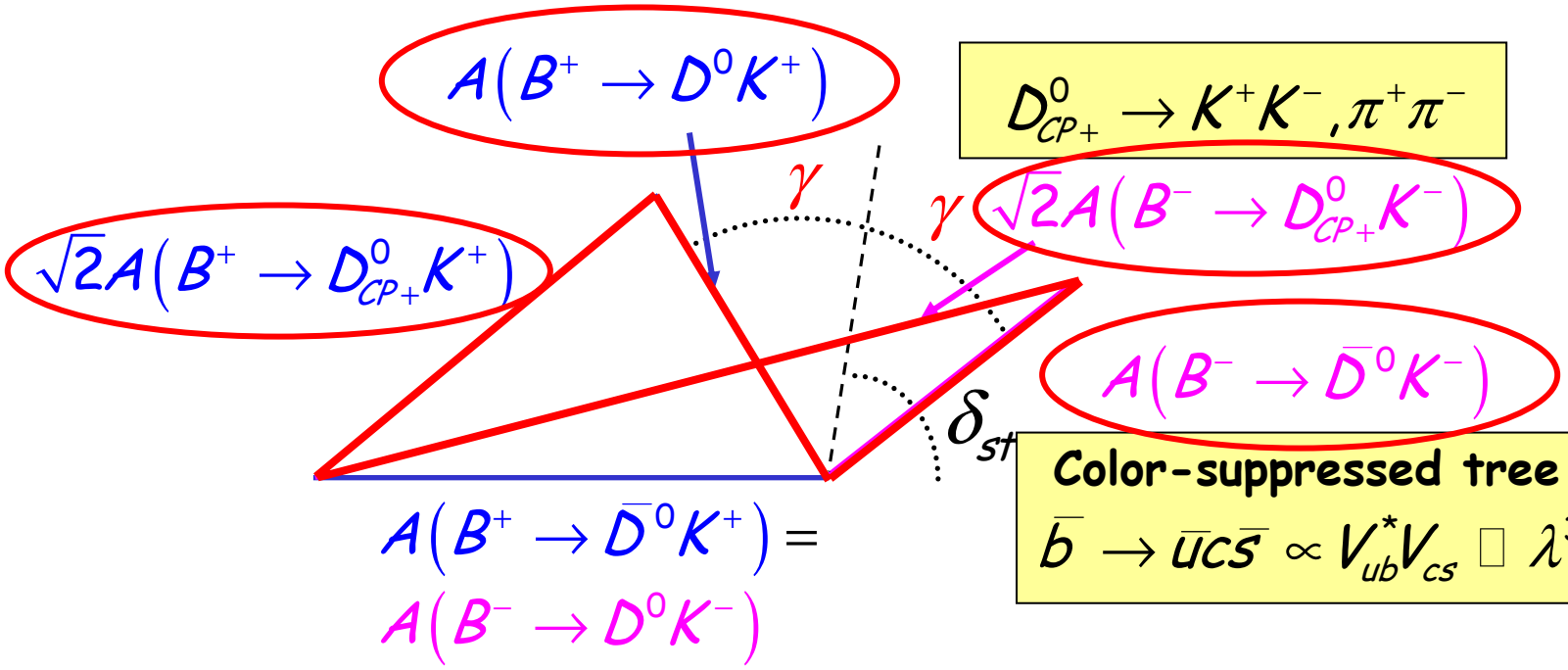
Interference of color-allowed and color-suppressed tree decays



γ : CPV in $B^0 \to D_{CP}K, D_{DCS}K, \ldots$

GLW Method for γ from $B^+ \to D^0_{CP+} K^+$

GLW = Gronau-London-Wyler, 1991



Color-suppressed tree

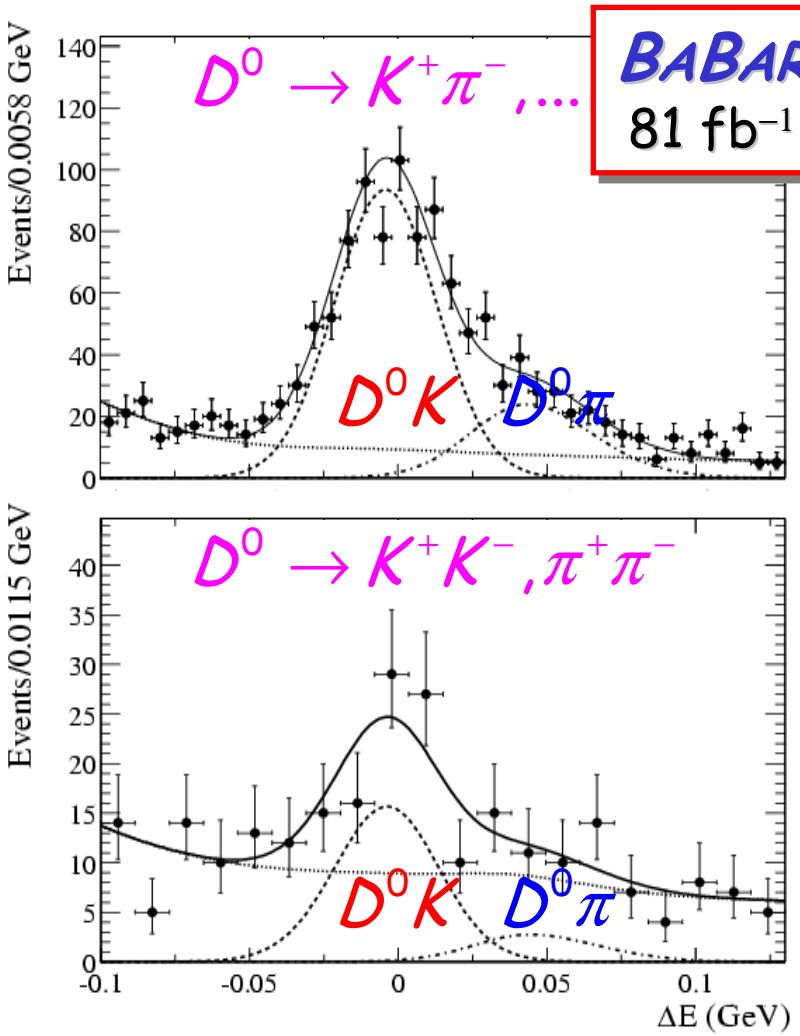
$\bar{b} \to \bar{u}c\bar{s} \propto V^*_{ub}V_{cs} \sim \lambda^3$

Color-allowed tree

$\bar{b} \to u\bar{c}\bar{s} \propto V^*_{cb}V_{us} \sim \lambda^3$

$$r_{DK} = \frac{\left|A(B^- \to \bar{D}^0 K^-)\right|}{\left|A(B^- \to D^0 K^-)\right|} \sim 0.1 - 0.3$$

Signals for $B^+ \to D^0_{CP+} K^+$



$$R_{\pm} = \frac{\mathcal{B}(D^0_{\pm}K^-) + \mathcal{B}(D^0_{\pm}K^+)}{\mathcal{B}(\bar{D}^0K^-) + \mathcal{B}(D^0K^+)} = 1 + r_{DK}^2 \pm 2r_{DK}\cos\gamma\cos\delta$$

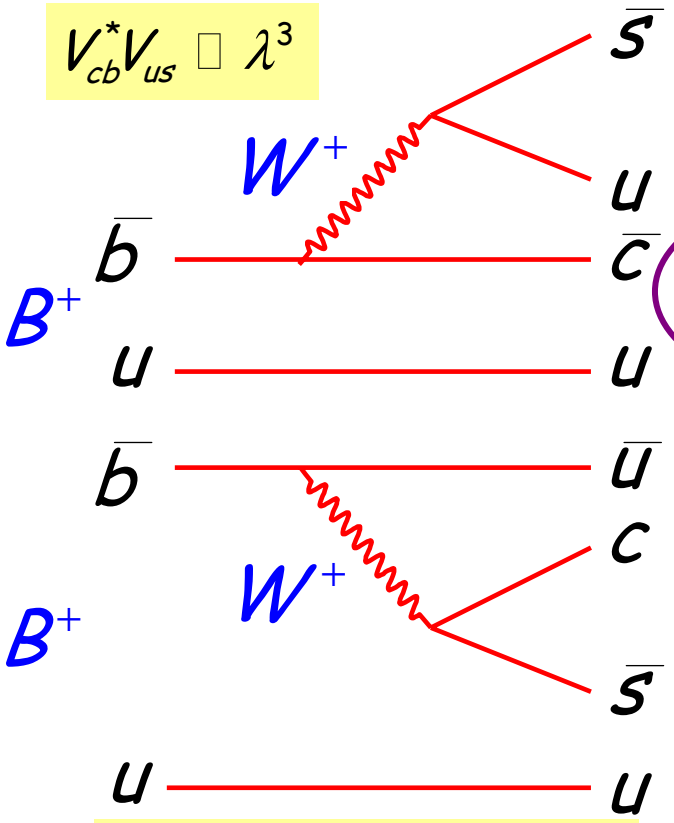
$$A_{CP\pm} = \frac{\mathcal{B}(D^0_{\pm}K^-) - \mathcal{B}(D^0_{\pm}K^+)}{\mathcal{B}(D^0_{\pm}K^-) + \mathcal{B}(D^0_{\pm}K^+)} = \frac{\pm r_{DK}\sin\gamma\sin\delta}{R_{\pm}}$$

	BABAR [81 fb^{-1}]	Belle [78 fb^{-1}]
R_+	1.06±0.19±0.06	1.21±0.25±0.14
A_{CP+}	0.07±0.17±0.06	0.06±0.19±0.04
R_-	*	1.41±0.27±0.15
A_{CP-}	*	0.19±0.17±0.05

*Coming soon

ADS* Method for γ from $B^+ \to \bar{D}^0_{DCS} K^+$

$V^*_{cb}V_{us} \sim \lambda^3$



N_{DCS} = 1.1 ± 3.0

DCS decay

$\bar{D}^0 \to K^-\pi^+$

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

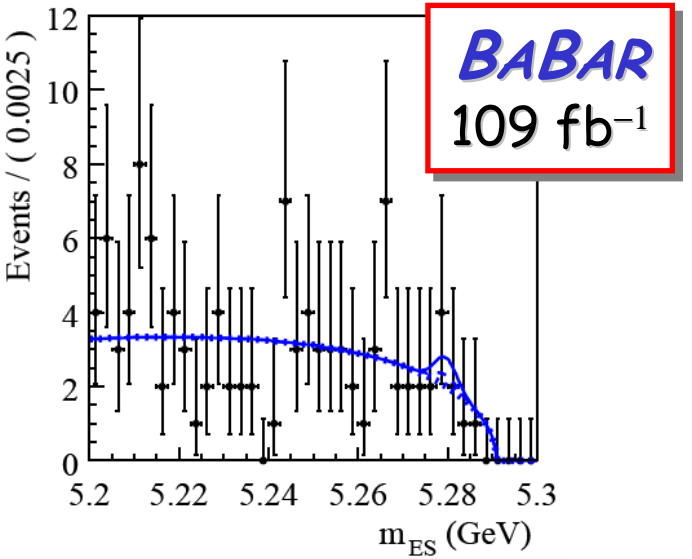
$N_{favored}$ = 261 ± 22

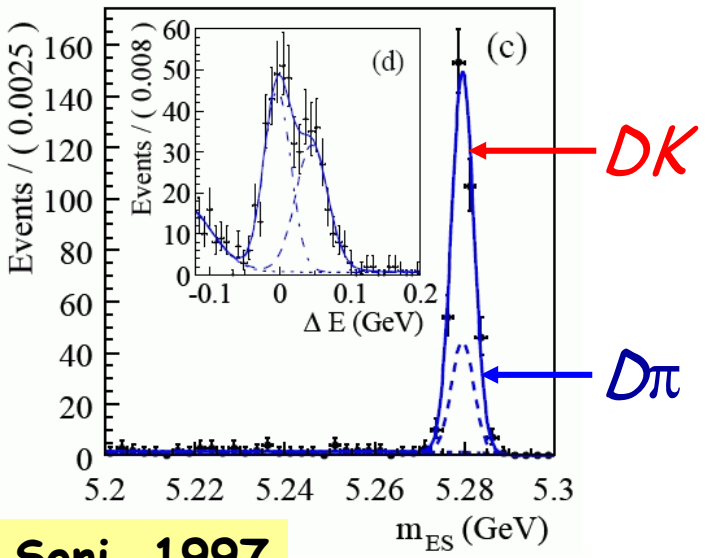
$V^*_{ub}V_{cs} \sim \lambda^3\sqrt{\bar{\rho}^2+\bar{\eta}^2}e^{i\gamma}$

r_{DCS} = 0.004 ± 0.012

r_{DCS} < 0.026, 90% CL

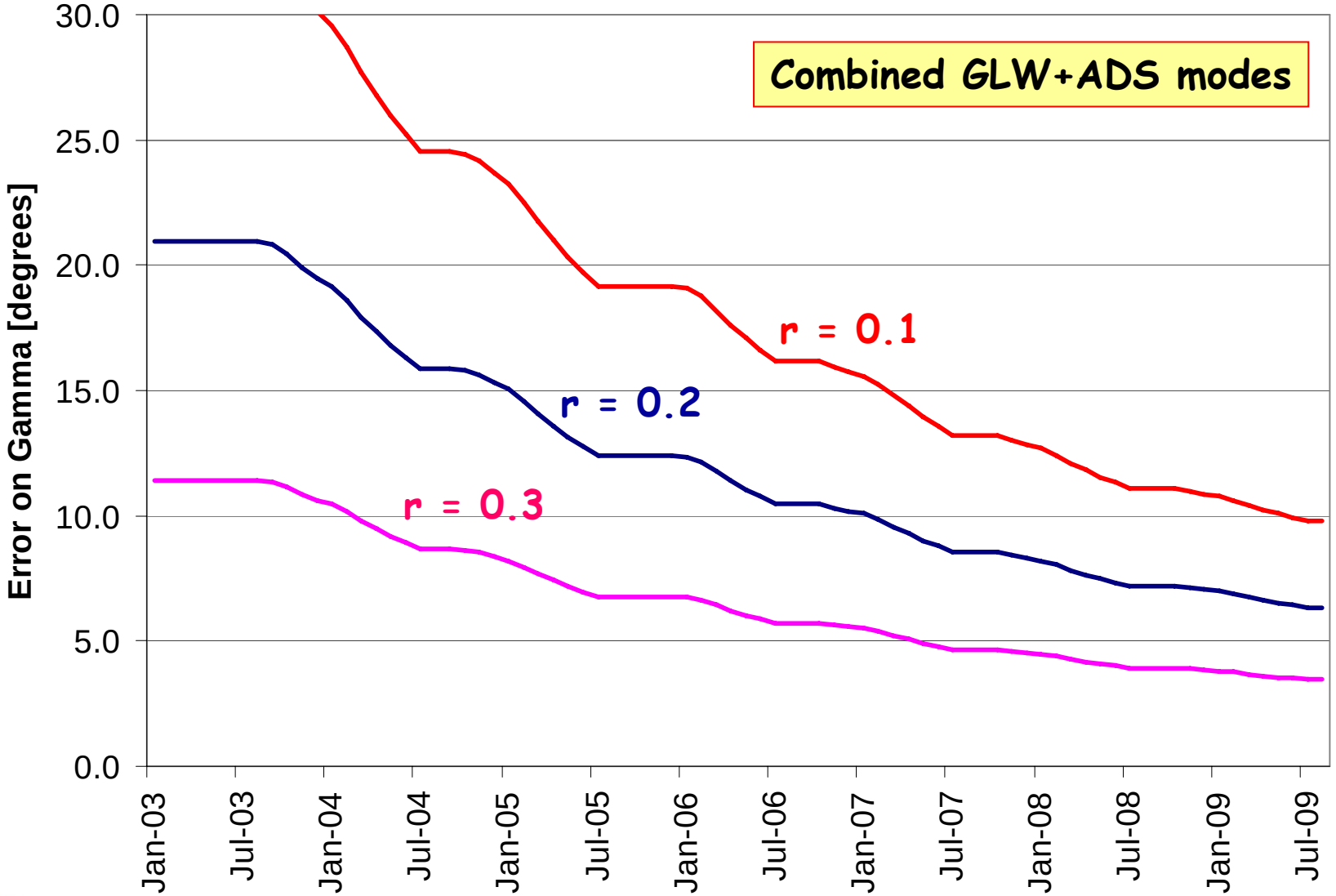
New: Winter 04



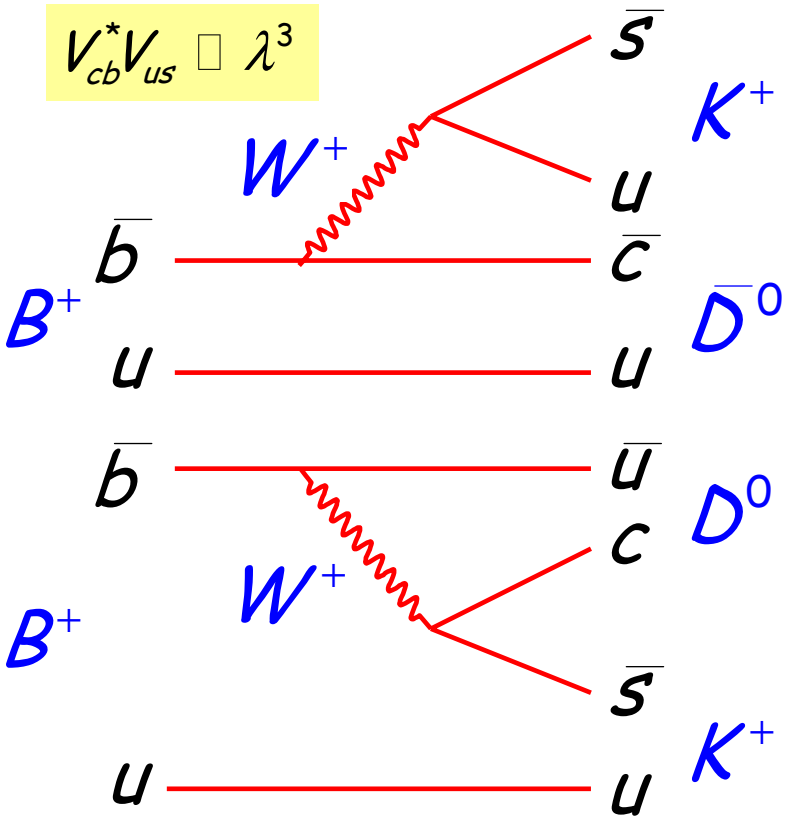


*Atwood-Dunietz-Soni, 1997

Projections of gamma modes



Another Promising Variant



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

+ color suppressed

Ingredients

Both $B^{\pm}$ decay to $D^{(*)0}K^{\pm}$ and $\bar{D}^{(*)0}K^{\pm}$ with $D^0\left(\bar{D}^0\right) \to K_S^0\pi^+\pi^-$

Sensitivity to γ enters via amplitude $\propto V_{ub}$

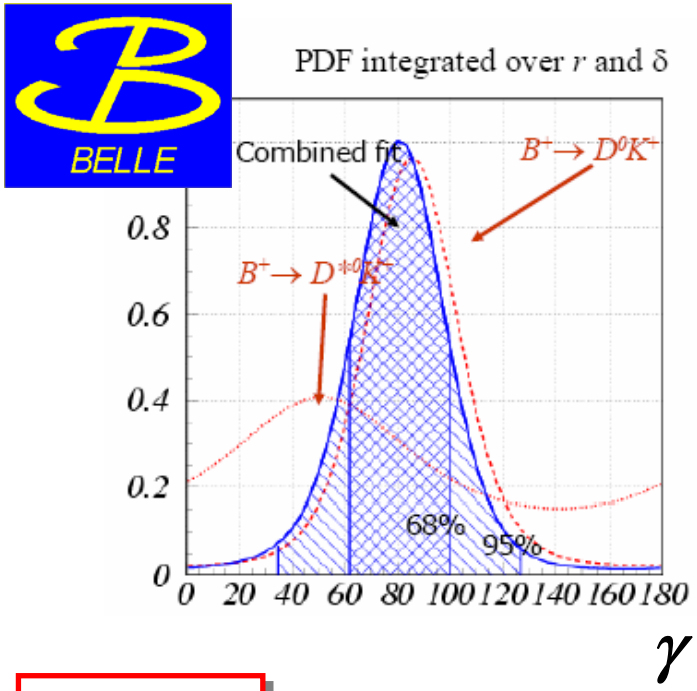
Interference occurs in Dalitz plot for $D^0\left(\bar{D}^0\right) \to K_S^0\pi^+\pi^-$

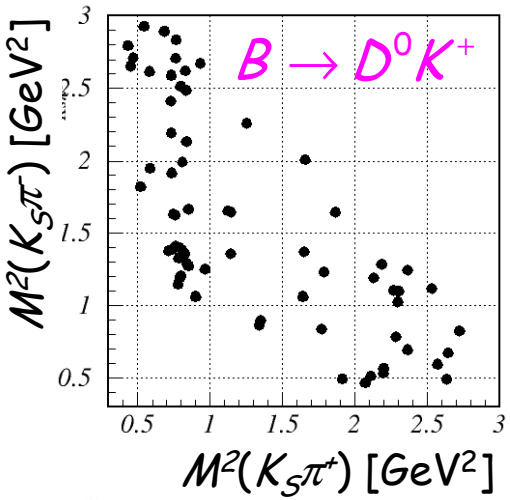
$$M_+ = f(m_+^2, m_-^2) + re^{i(\gamma+\delta)}f(m_-^2, m_+^2)$$
$$M_- = f(m_-^2, m_+^2) + re^{i(-\gamma+\delta)}f(m_+^2, m_-^2)$$

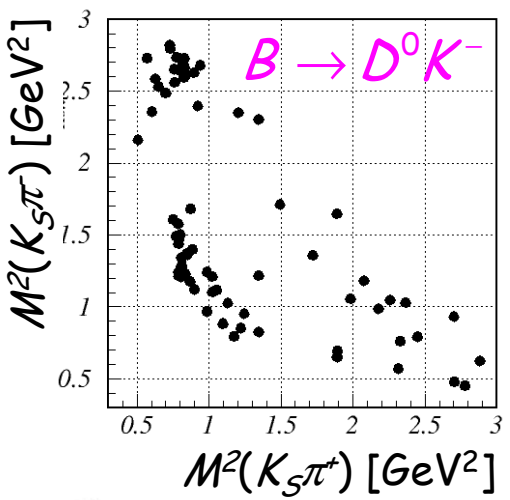
Dalitz plot for characterized with large sample of $D^0\left(\bar{D}^0\right) \to K_S^0\pi^+\pi^-$

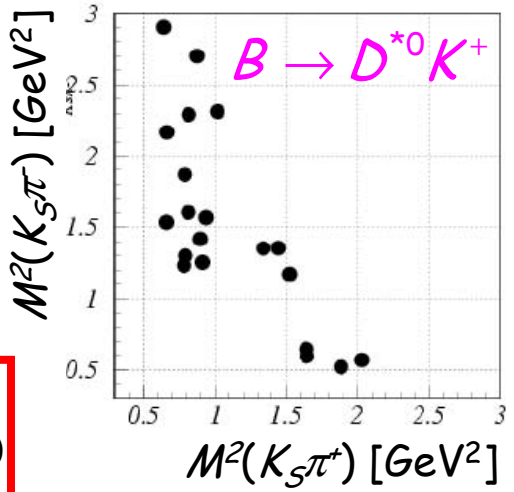
Giri, Grossman, Soffer, Zupan

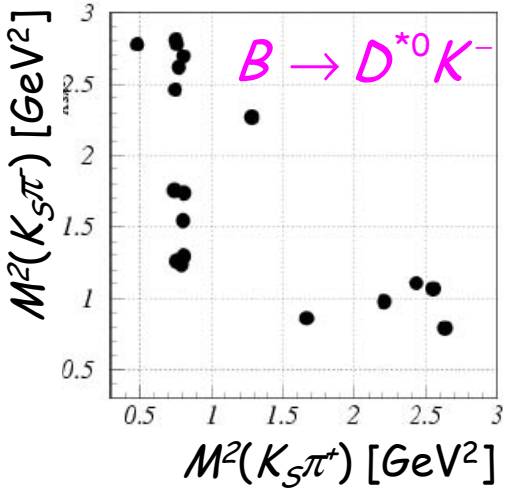
Fit to $B^- \to D^0 [\to K^0_S \pi^+ \pi^-] K^-$ Sample











Belle
140 fb^{-1}

Parameters:
$\gamma, r_D, r_{D^*}, \delta_D, \delta_{D^*}$

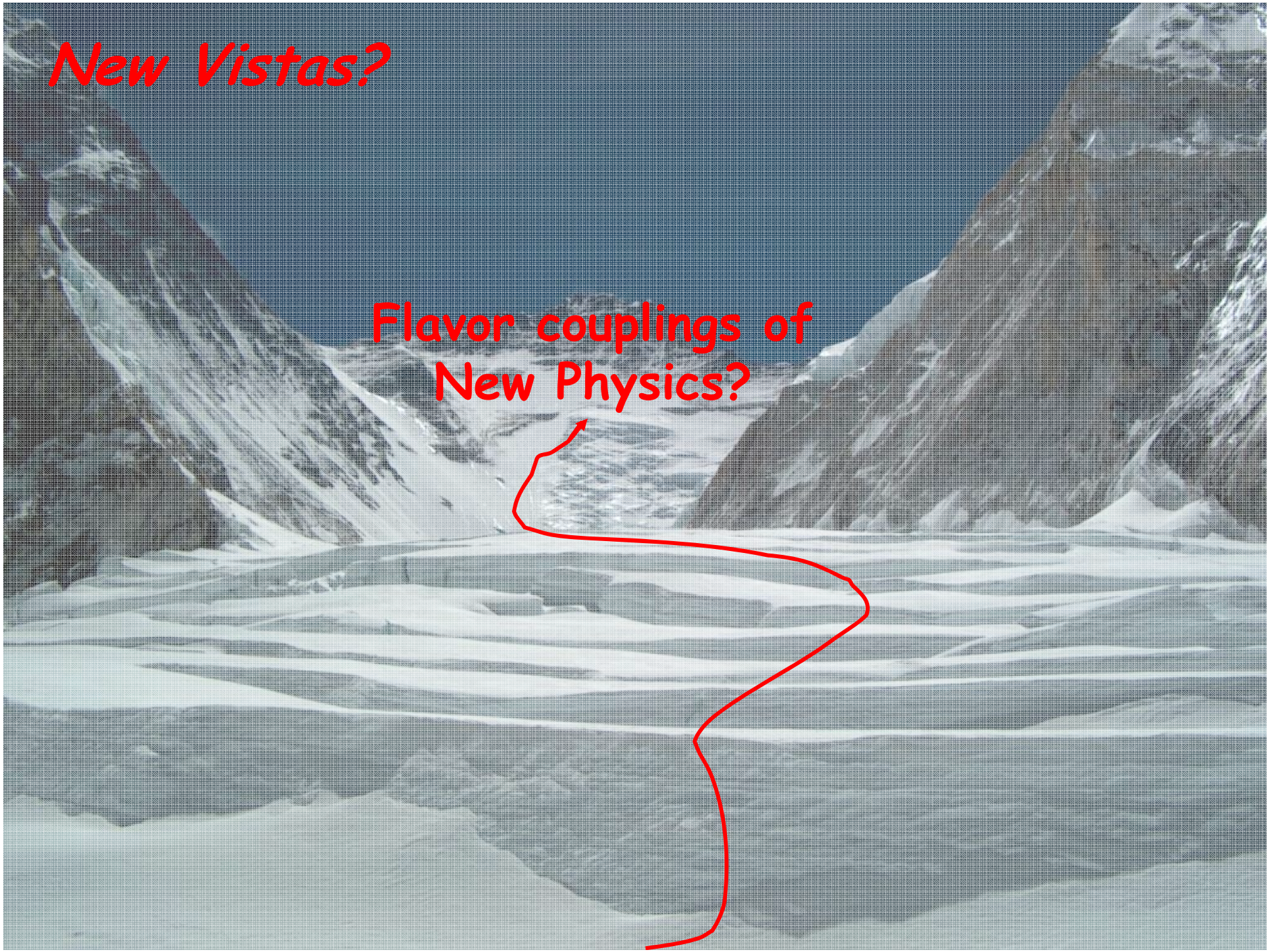
$$\gamma = 77^\circ \,{}^{+17}_{-19}{}_{(stat)} \pm 13_{(sys)} \pm 11_{(model)}$$
$$26 < \gamma < 126^\circ \ [95\%\ CL]$$

New: Winter 04

hep-ex/0406067

Opportunities for Super B Factory

- *Current program of PEP-II/BABAR and KEKB/Belle could attain ~1-2 ab^{-1} by end of the decade*
  - Data samples will be almost 10x larger than now
    - **With such a large increase in sensitivity to rare decays, there is a significant potential for new discoveries**
    - **Rich program of flavor physics/CP violation to be pursued**
- *Even larger samples may offer opportunity to search for new physics in CP violation and rare decays*
  - High-luminosity asymmetric e^+e^- colliders with luminosities 10^{35}-10^{36} $cm^{-2}s^{-1}$ and up to 10 ab^{-1}/year – "Super *B* Factory"
    - **Emphasis on discovery potential and complementarity in an era when LHC is operating, along with LHCb and BTeV (?)**
    - **Complementary to LHC discoveries of New Physics, e.g. SUSY, etc; elucidating flavor couplings as part of unraveling symmetry breaking mechanism**


New Vistas?
Flavor couplings of
New Physics?

Parameters for High-Luminosity B Factory

Luminosity	$2\text{-}3\times10^{34}$	1.5×10^{35}	2.5×10^{35}	7×10^{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
$\beta(y^*)$	7	3.6	3.0	1.5	mm
$\beta(x^*)$	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

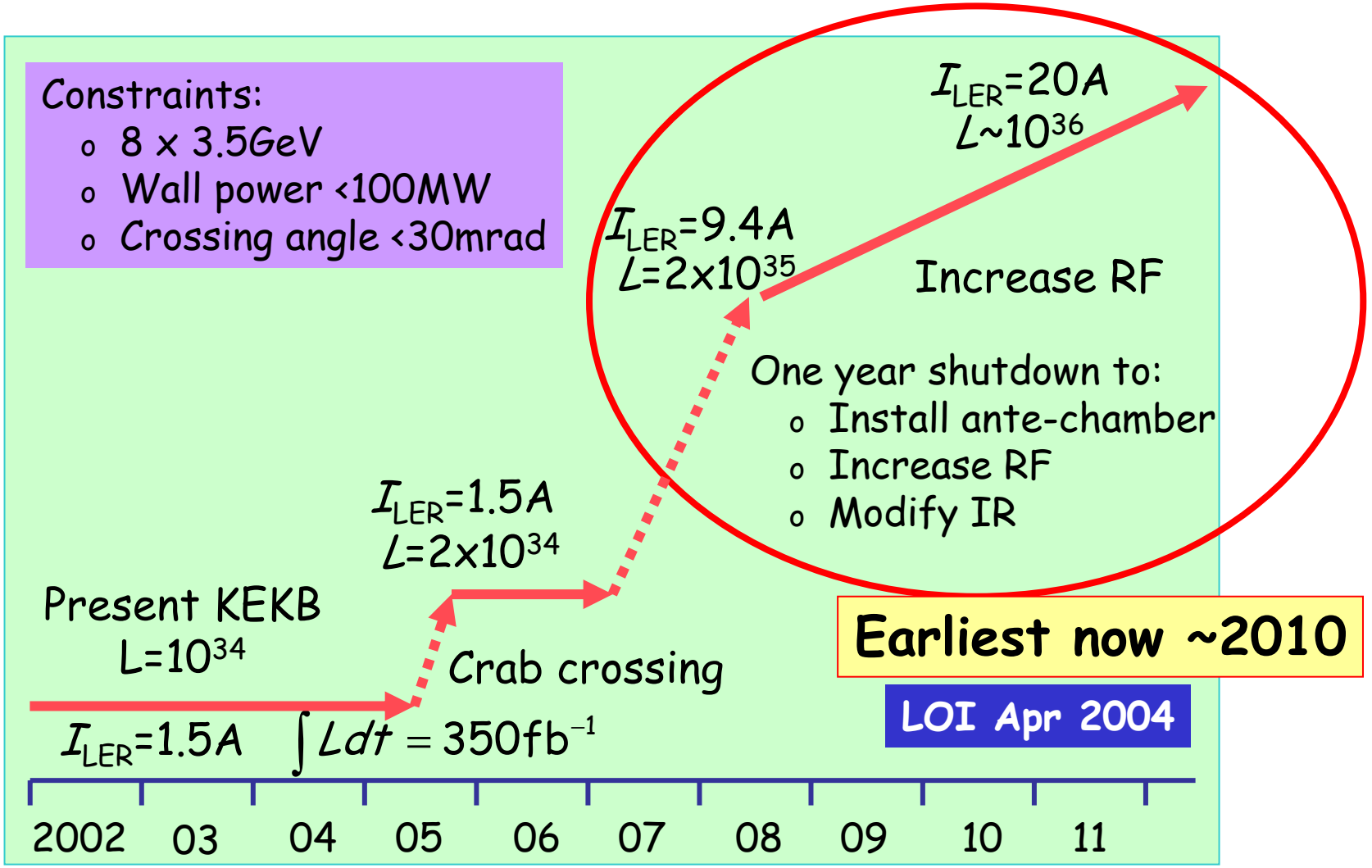
J.Seeman

LER vacuum

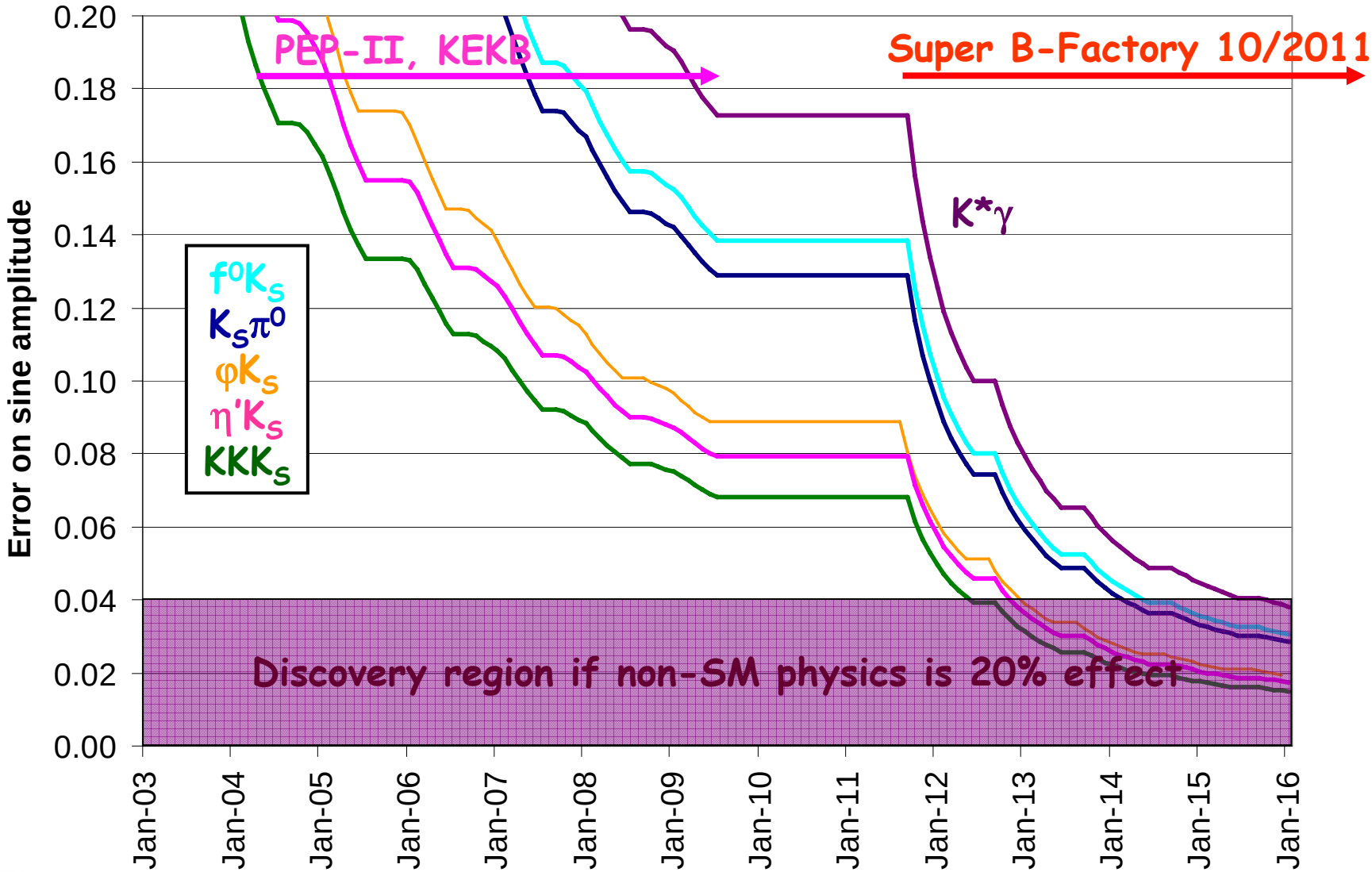
+IR

+HER vacuum, 952 MHz rf

SuperKEKB Upgrade Proposal



Searching for New Physics



Conclusions

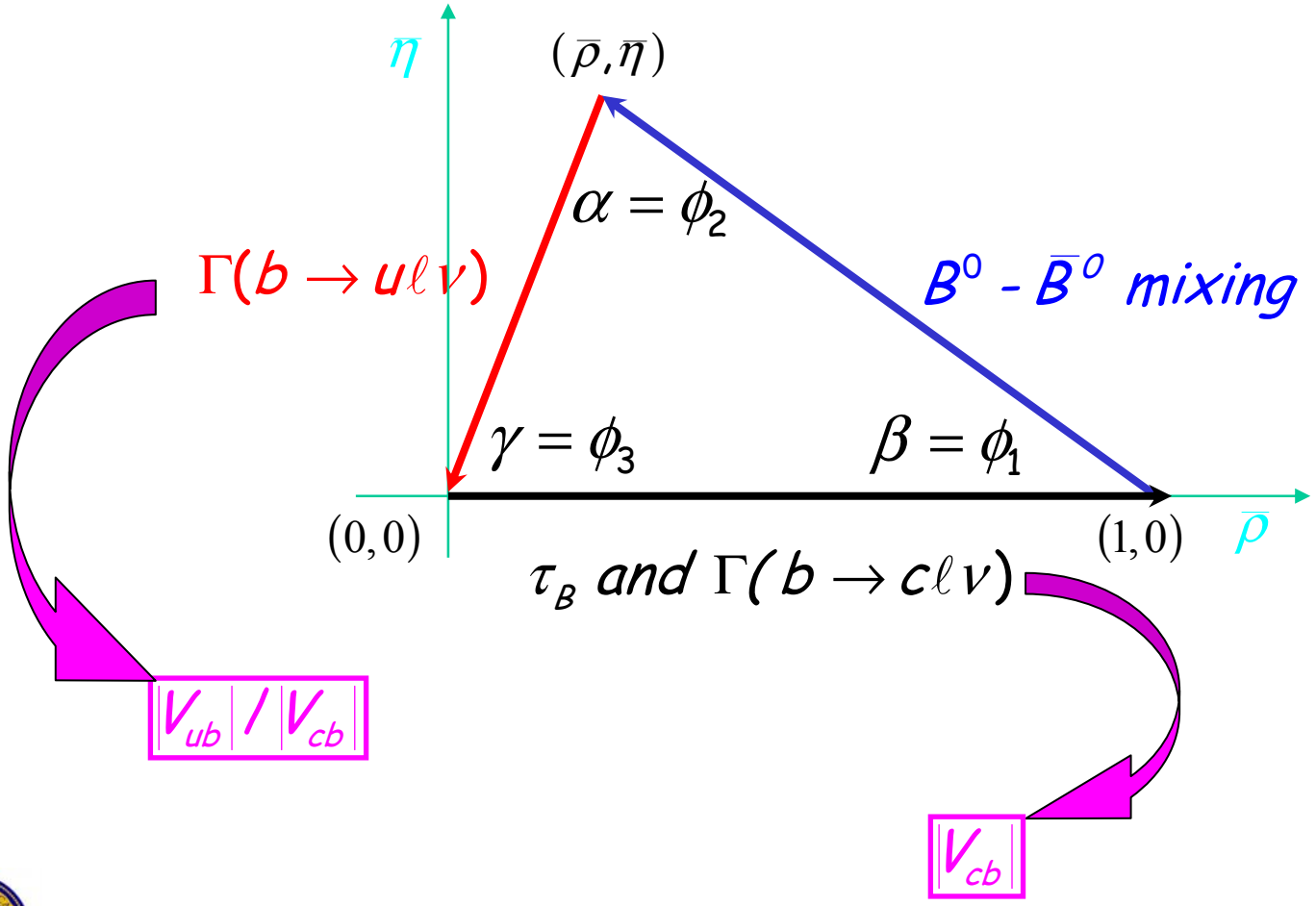
- ***B Factories continuing along planned path towards ever higher luminosity***
  - Accumulating data with high efficiency, exploiting great strides with colliders; addressing known detector & computing issues
  - Both experiments expect to accumulate 0.5 ab^{-1} by calendar 2006, representing a doubling of current data samples
  - Strong physics case for doubling the data sample again by end of decade, achieving 1-2 ab^{-1}
- ***BABAR & Belle have accumulated one of the great data samples in particle physics***
  - Expect many new and updated results at ICHEP04, including results that use full data samples
  - Many analyses are doubling their available data samples: should be real progress in understanding SM *CP* & hints for new physics

Conclusions

- ***Plans in place for continuation of these programs through end of decade and possibly beyond***
  - Builds on ideas of Super *B* Factories from Snowmass 2001 and subsequent workshops; builds on proven track record of high-luminosity storage rings and general purpose e^+e^- detectors
  - Builds on our present knowledge of *CP* violation and rare *B* decays; expect that case will only strengthen as we achieve planned luminosity improvements over the next few years
  - SuperKEKB and Belle submitted LOI to KEK Directorate this spring; considerable progress at *BABAR* as well in defining parameters and scope of SuperPEP-II
  - Physics case rests on precision SM *CP* and rare decay physics, but the primary motivation is the capability to explore flavor properties of new physics

Backup Slides

Measurements of UT Sides



Fully Reconstructed B Sample

Old idea with new level of sensitivity

Reconstruct *B* mesons in ~1000 modes

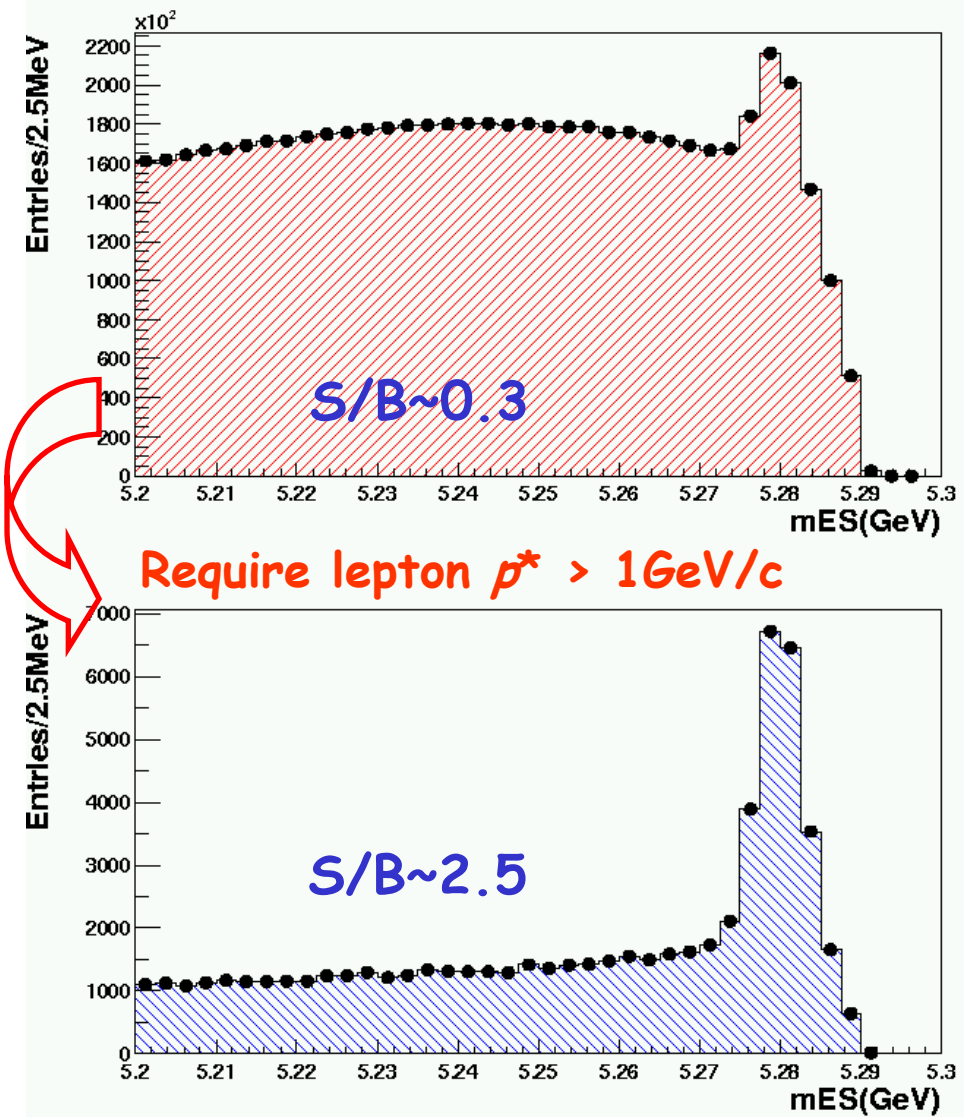
$$B \to D^{(*)}\pi, D^{(*)}\pi\pi^0, D^{(*)}3\pi, \text{etc}$$

Efficiency ~0.4% or ~4000 *B* mesons/fb^{-1} (charged and neutral)

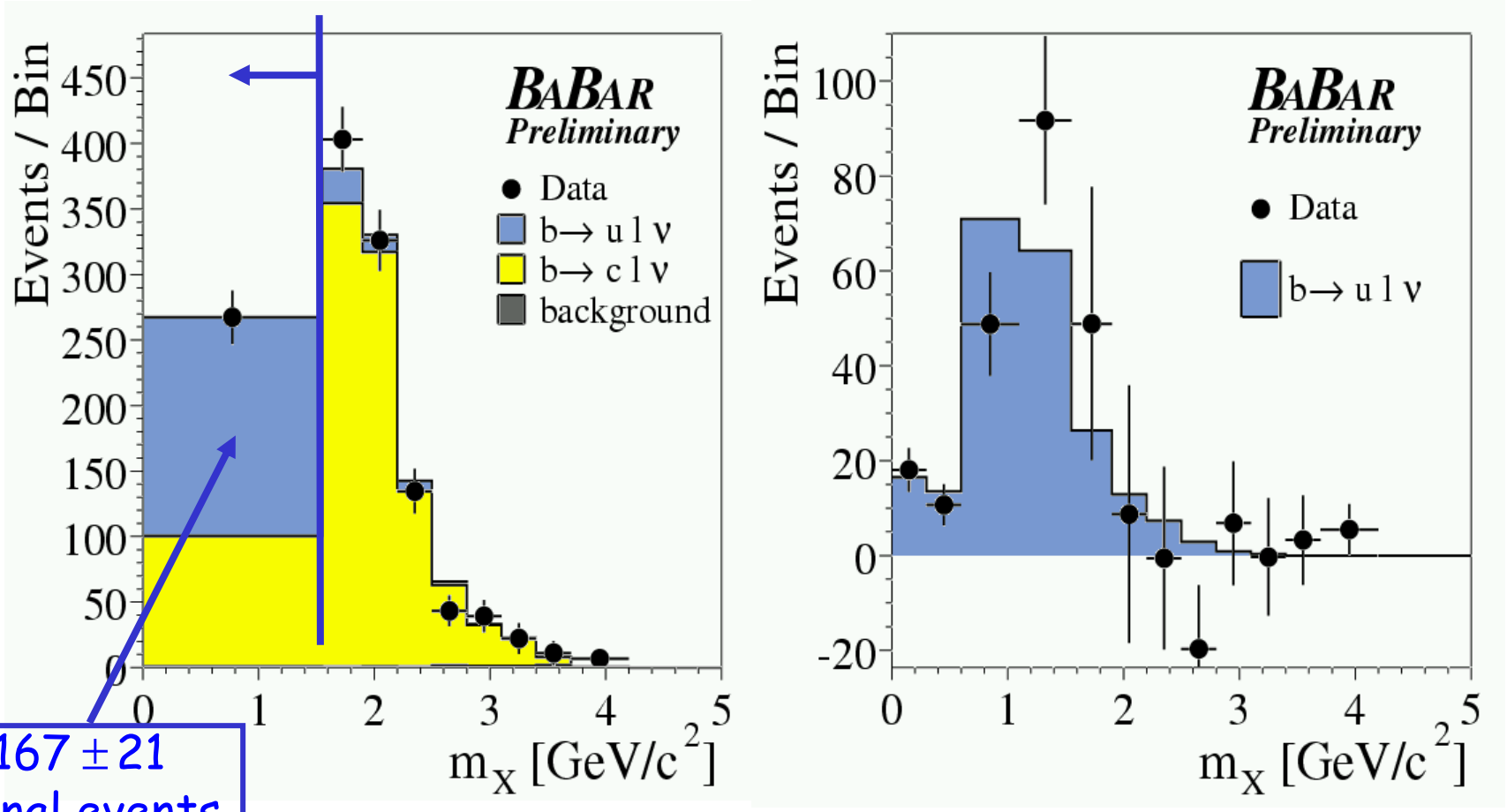
Now

~330000 events tagged with fully reconstructed *B* meson

By 2006 **2,000,000 events**



Study of $b \to u$ Enriched Sample

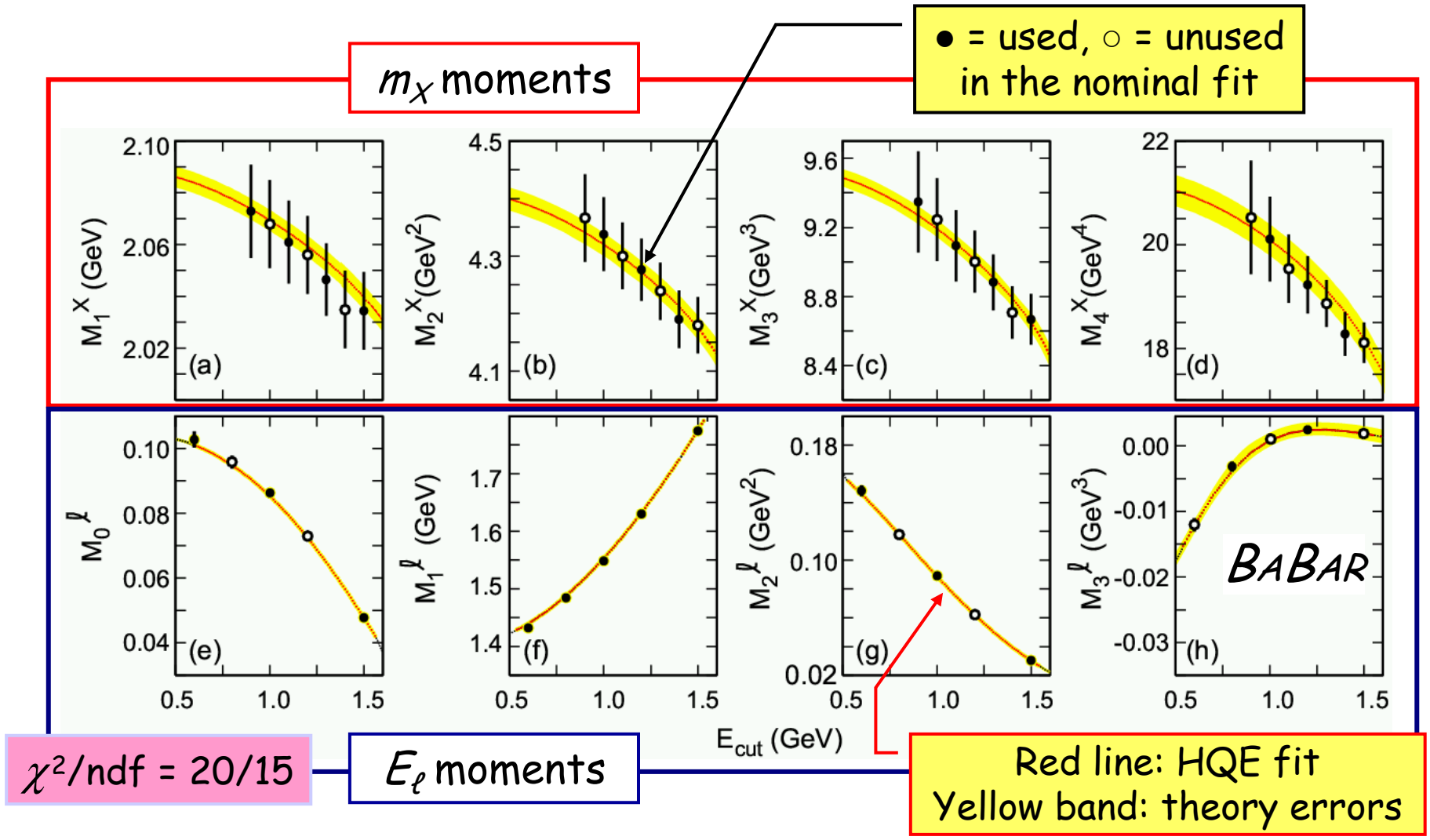


167 ± 21 signal events

$$|V_{ub}| = (4.52 \pm 0.31(stat) \pm 0.27(syst) \pm 0.40(theo)) \times 10^{-3}$$

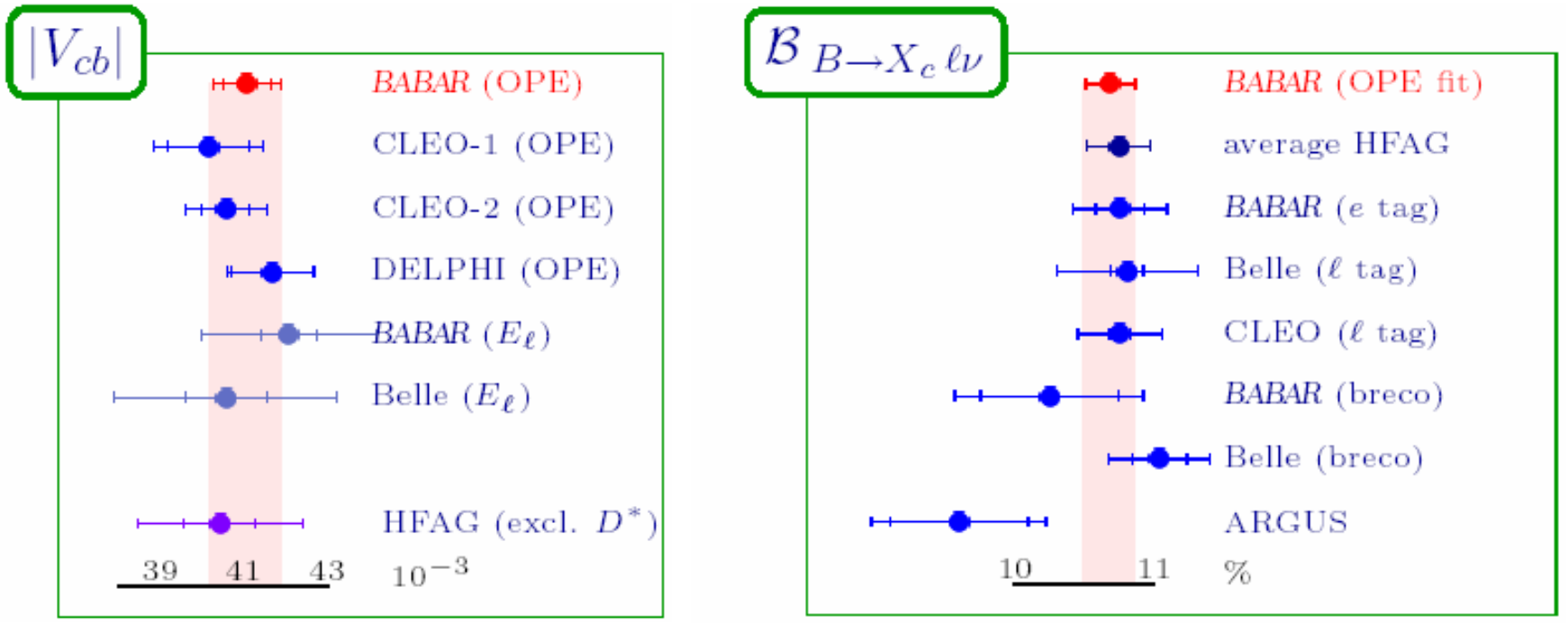
6.9% 6.0% 8.8%

HQE Fit Results for Combined Moments



Measurement Improvements

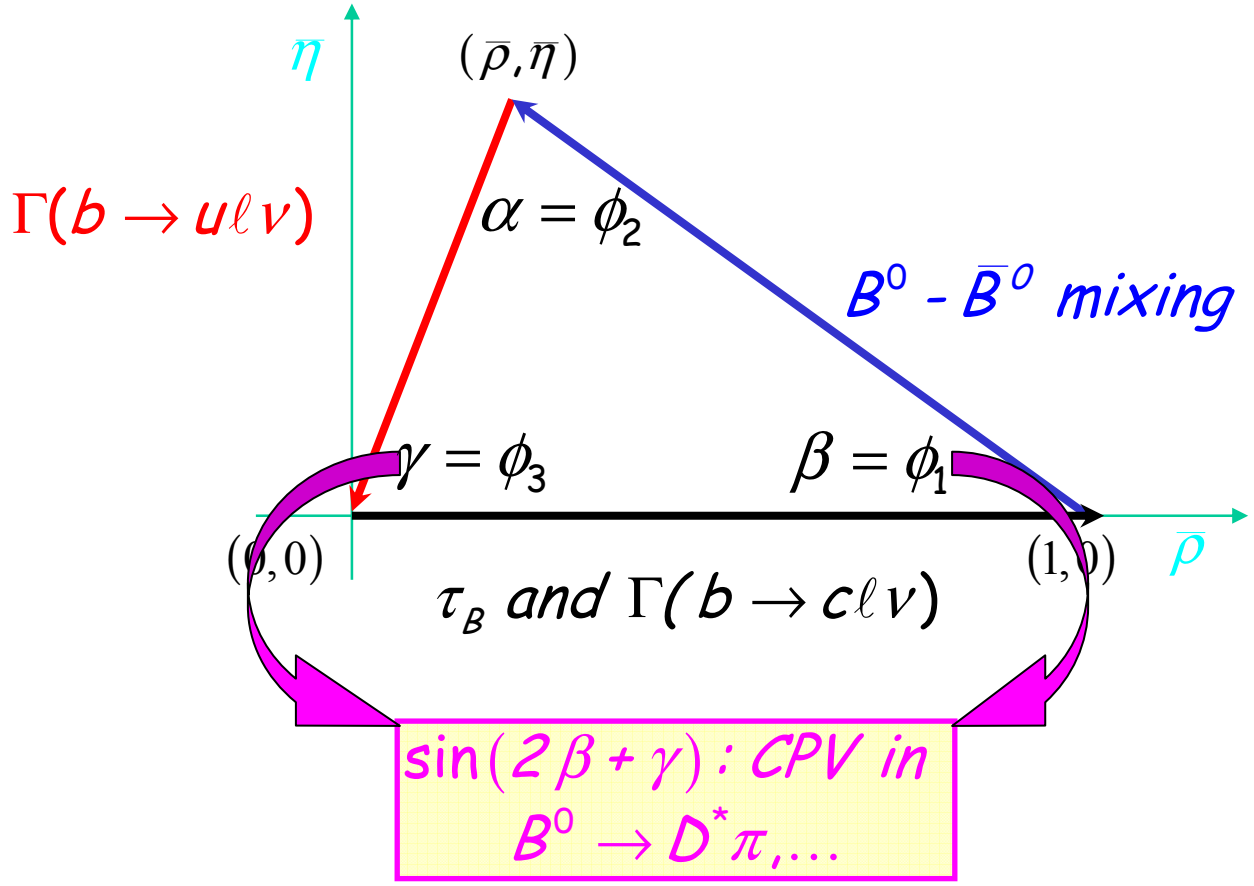
- *New BABAR result compares well with previous measurements*



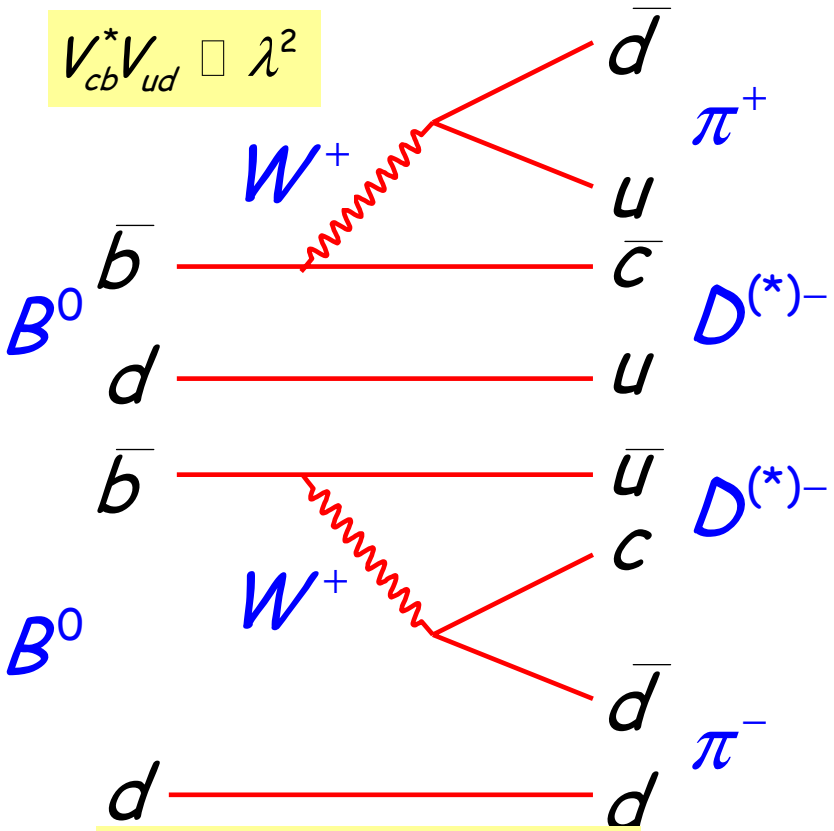
- $|V_{cb}|$ is now measured to ±2%

Other Methods for Gamma

Interference of $b \to c$ allowed and doubly-suppressed tree decays



Decays to Common Final States



Ingredients

Both B^0 and $\bar{B}^0$ decay to $D^{(*)+}\pi^-$ and $D^{(*)-}\pi^+$

Sensitivity to γ enters via amplitude $\propto V_{ub}$

Mixing induced time-dependent asymmetries

Current status

$$\left|\lambda_{D^{(*)}\pi}\right| = \frac{\left|A\left(\bar{B}^0 \to D^{(*)-}\pi^+\right)\right|}{\left|A\left(B^0 \to D^{(*)-}\pi^+\right)\right|} \sim 0.02$$

from $BF\left(B^0 \to D_S^+\pi^-\right)$ and SU(3) symmetry

Estimated error

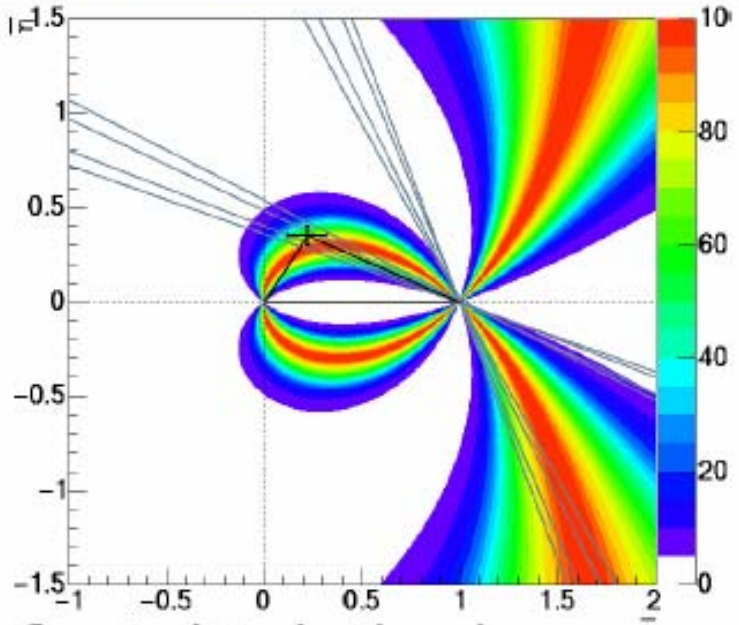
$\sigma[\sin(2\beta+\gamma)] \sim 0.6$ for 80fb^{-1}

Limits on $|\sin(2\beta+\gamma)|$

Method assuming SU(3) :

minimise a χ^2 : fit $|(\sin(2\beta+\gamma)|$, δ, δ^*, r & r*
assume a 30% flat theoretical error for r and r*

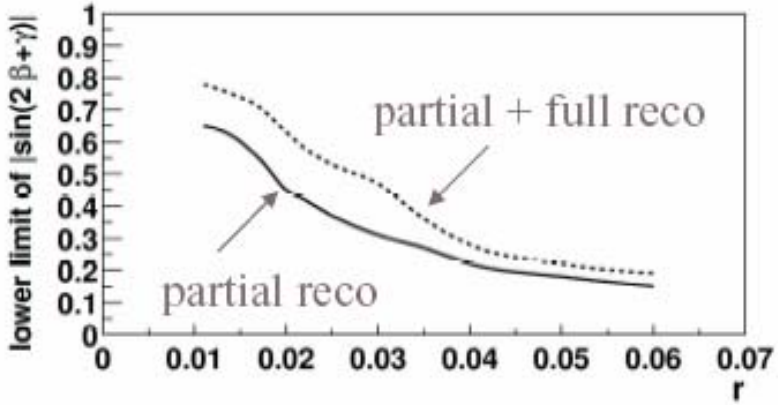
$|\sin(2\beta+\gamma)|$ > 0.74 at 90 % CL
$|\sin(2\beta+\gamma)|$ > 0.58 at 95 % CL



Constraints in the plane $\rho,\bar{\eta}$

Method « r* scan »
(only with $B^0 \to D^*\pi$)

To avoid any assumption on r* :
Fit only $|(\sin(2\beta+\gamma)|$ & δ^* in the χ^2



95% CL lower limit on $|\sin(2\beta+\gamma)|$ as a function of r*

PEP-II Upgrades Schemes

Luminosity ($\times 10^{35}$)	1.5	2.5	7	5→7
RF frequency (MHz)	476	476	952	476→952
Site power (MW)	75	85	100	70→100
Crossing angle	No	Yes	Yes	Yes
Crab cavities	No	Yes	Yes	Yes
Replace LER	Yes	Yes	Yes	Yes
Replace HER	No	Yes	Yes	Yes
Upgradeable	No	Yes (to 952MHz)	**Yes**	**Yes**

Detector requirements depend on projecting backgrounds for luminosities that are >20 times larger than at present

Physics Capabilities: Angle Projections

Unitarity Triangle Angles [degrees]	e^+e^- [ab^{-1}]			Hadronic b [1yr]	
Measurement	3	10	50	LHCb	BTeV
$\alpha(\pi\pi)$ ($S_{\pi\pi}$, $B\to\pi\pi$ BR's+ isospin)	6.7	3.9	2.1	-	-
$\alpha(\rho\pi)$ (Isospin, Dalitz) (syst $\geq 3°$)	3, 2.3	1.6, 1.3	1, 0.6	2.5 -5	4
$\alpha(\rho\rho)$ (penguin, isospin, stat+syst)	2.9	1.5	0.72		
$\beta(J/\psi K_S)$ (all modes)	0.3	0.17	0.09	0.57	0.49
$\gamma(B\to D^{(*)}K)$ (ADS)		2-3		~10	<13
γ(all methods)		1.2-2			

Theory: α ~ 5%, β ~ 1%, γ ~ 0.1%

CP Violation in b→s penguins

Rare Decays, New Physics, CPV [%]		e^+e^- [ab^{-1}]			Hadronic b [1yr]	
Measurement	Goal	3	10	50	LHCb	BTeV
$S(B^0 \to \phi K_S)$	SM: <5	16	8.7	3.9	16 (?)	7 (?)
$S(B^0 \to \phi K_S + \phi K_L)$	SM: <5					
$S(B \to \eta' K_S)$	SM: <5	5.7	3	1		
$S(B \to K_S \pi^0)$	SM: <5	8.2	5	4		
$S(B \to K_S \pi^0 \gamma)$	SM: <2	11.4	6	4		
A_{CP} $(b \to s\gamma)$	SM: <0.5	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			-	-

$b \to s l^+ l^-$ precision

New Physics – Kl^+l^-, sl^+l^- [%]		e^+e^- [ab^{-1}]			Hadronic b [1 yr]	
Measurement	Goal	3	10	50	LHCb	BTeV
$\mathcal{B}(B \to K\mu^+\mu^-)$ / $\mathcal{B}(B \to Ke^+e^-)$	SM: 1	~8	~4	~2	-	-
$A_{CP}(B \to K^* \ell^+ \ell^-)$: all	SM: <5	~6	~3	~1.5	~1.5	~2
$A_{CP}(B \to K^* \ell^+ \ell^-)$: high mass	SM: <5	~12	~6	~3	~3	~4
$A^{FB}(B \to K^* \ell^+ \ell^-)$: s_0 $A^{FB}(B \to K^* \ell^+ \ell^-)$: A_{CP}	SM: ±5	~20	~9	9	~12	
$A^{FB}(B \to s\ell^+ \ell^-)$: $\hat{s}_0$		27	15	6.7		
$A_{FB}(B \to s\ell^+ \ell^-)$: C_9, C_{10}		36-55	20-30	9-13		

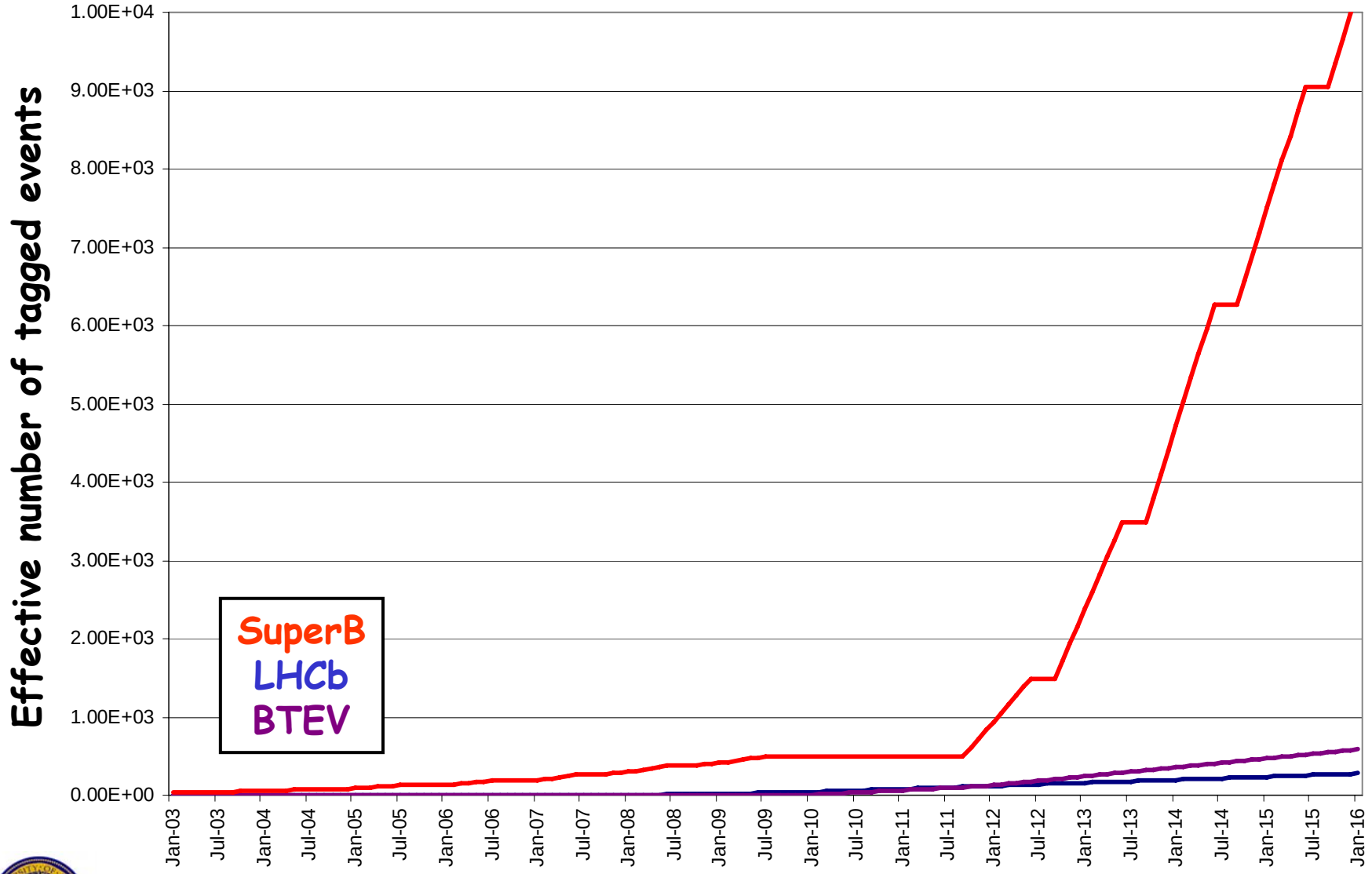
More Rare decays precision

Rare Decays – New Physics		e^+e^- [ab^{-1}]			Hadronic b [1 yr]	
Measurement	Goal	3	10	50	LHCb	BTeV
$\Gamma(b\to d\gamma)$ / $\Gamma(b\to s\gamma)$					-	-
$\mathcal{B}(B\to D^{(*)}\tau\nu)$	SM:8×10^{-3}	10.2%	5.6%	2.5%	-	-
$\mathcal{B}(B\to s\nu\nu)$ ($K^{-,0}$,$K^{*-,0}$)	SM: ~5% 1 excl: 4×10^{-6}			~3σ	-	-
$\mathcal{B}(B\to$invisible$)$		$<2\times10^{-6}$	$<1\times10^{-6}$	$<4\times10^{-7}$	-	-
$\mathcal{B}(B_d\to\mu\mu)$		-	-		1-2 evts	1-2 evts
$\mathcal{B}(B_d\to\tau\tau)$		-	-		-	-
$\mathcal{B}(\tau\to\mu\gamma)$			$<10^{-8}$		-	-

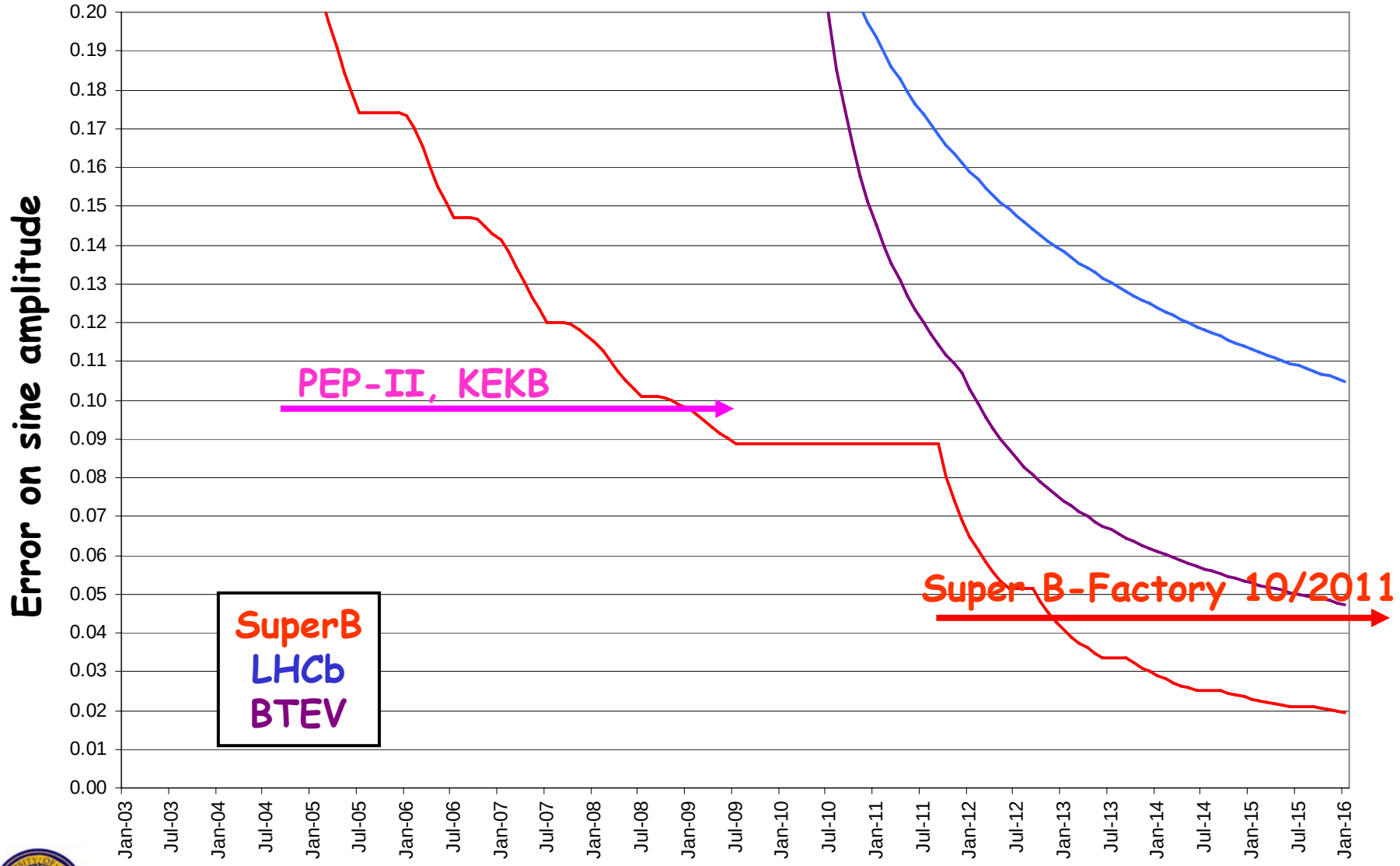
Projecting Physics Reach

- ***Working assumptions for projections***
  - LHCb:
    - Start in Jan 2008 with 50% of design for 2 years
  - BTEV:
    - Start in Jan 2010 with 50% of design for 2 years
  - Rolling start for Super *B* Factory:
    - Oct 2011 = 2.5×10^{35}
    - Oct 2012 = 5×10^{35}
    - Oct 2013 = 7×10^{35} with replacement of inner SVT by thin pixel device

Tagged Sample Projections for φK^0



Error Projections for φK^0



Projections for $\pi^+\pi^-$