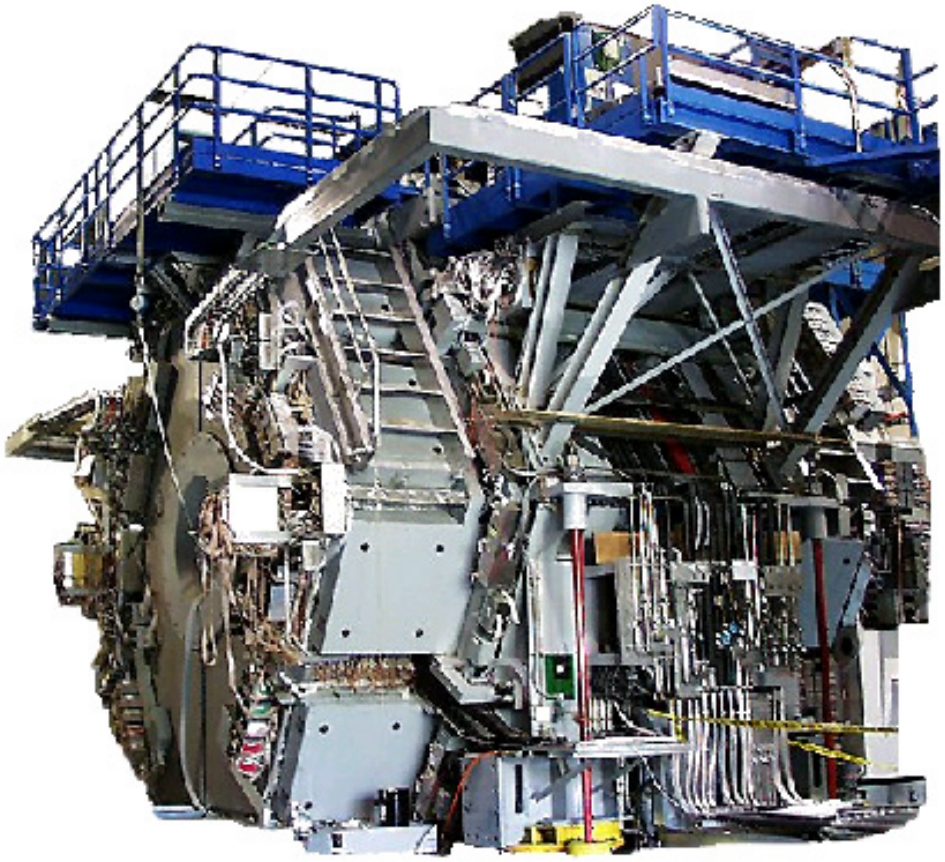
PEP-II
ASYMMETRIC B FACTORY
BABAR™

Physics Update



Stewart Smith
Princeton University
(for the collaboration)

HEPAP Meeting
Cornell, August 6, 2002

The *BABAR* Collaboration

9 Countries
74 Institutions
527 Physicists

50% Outside US

USA [37/261]

California Institute of Technology
UC, Irvine
UC, Los Angeles
UC, Riverside
UC, San Diego
UC, Santa Barbara
UC, Santa Cruz
U of Cincinnati
U of Colorado
Colorado State
Florida A&M
Harvard
U of Iowa
Iowa State U
LBNL
LLNL
U of Louisville
U of Maryland
U of Massachusetts, Amherst
MIT
U of Mississippi
Mount Holyoke College
Northern Kentucky U
U of Notre Dame
Ohio State
ORNL/Y-12
U of Oregon
U of Pennsylvania
Prairie View A&M
Princeton
SLAC
SUNY Albany
U of South Carolina
Stanford U
U of Tennessee
U of Texas at Austin
U of Texas at Dallas
Vanderbilt
U of Wisconsin
Yale

Canada [4/15]

U of British Columbia
McGill U
U de Montréal
U of Victoria

China [1/5]

Inst. of High Energy Physics, Beijing

France [5/52]

LAPP, Annecy
LAL Orsay
LPNHE des Universités Paris 6/7
Ecole Polytechnique
CEA, DAPNIA, CE-Saclay

Germany [3/24]

U Rostock
Ruhr U Bochum
Technische U Dresden

Italy [12/94]

INFN and U Bari
INFN and U Ferrara
Lab. Nazionali di Frascati dell' INFN
INFN and U Genova
INFN and U Milano
INFN and U Napoli
INFN and U Padova
INFN and U Pavia
INFN, SNS and U Pisa
INFN, Roma and U "La Sapienza"
INFN and U Torino
INFN and U Trieste

Norway [1/3]

U of Bergen

Russia [1/8]

Budker Institute, Novosibirsk

United Kingdom [10/65]

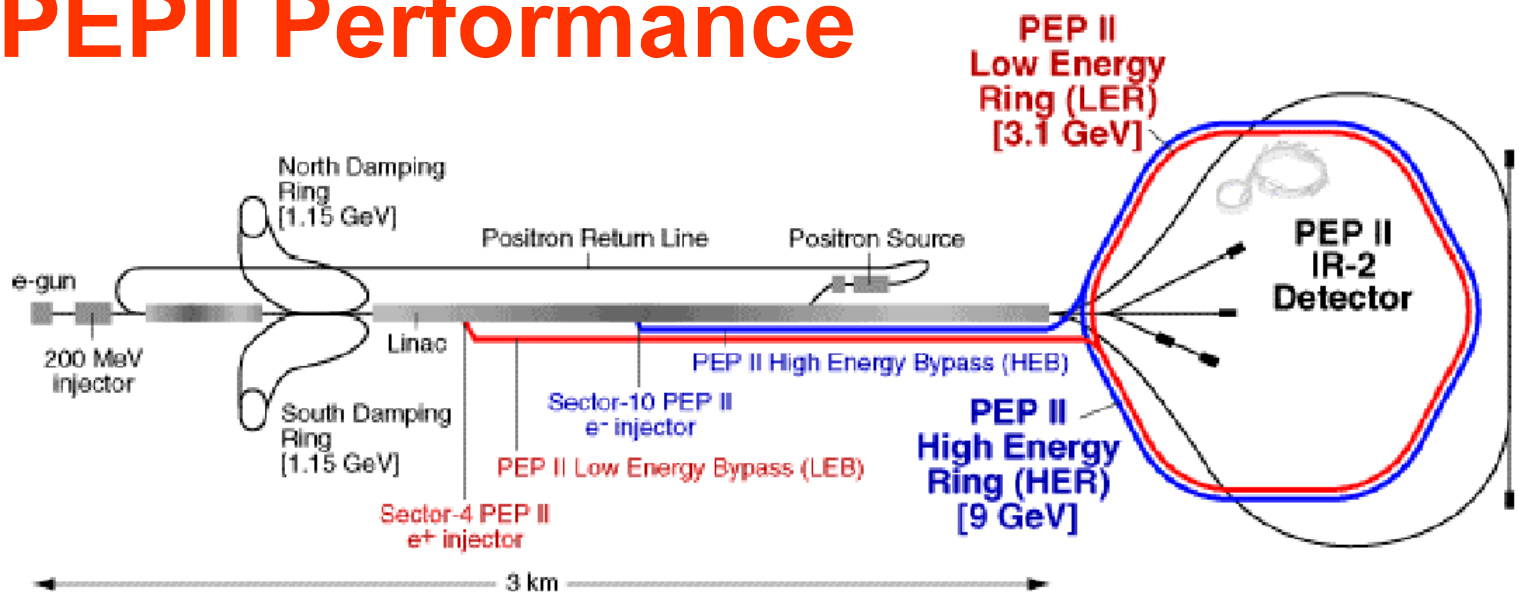
U of Birmingham
U of Bristol
Brunel University
U of Edinburgh
U of Liverpool
Imperial College
Queen Mary & Westfield College
Royal Holloway, University of London
U of Manchester
Rutherford Appleton Laboratory

- **New groups this year: U T Austin, SUNY Albany, Ohio State, U. C. Riverside**
- **EOI's expected this month from several institutions**

BaBar Overview

- Physics: - *CP* violation in *B* decay, CKM matrix
  - precise studies of b, c, τ.
- Method: Asymmetric Energies of PEPII beams and Si Vertex Detector
  $\rightarrow$ measurable decay distances for correlated B's (~260 μm)
- Huge, high purity data samples:
  90 million $B\bar{B}$ pairs recorded
  ~500 - 600 by ~2006
  ~800 -1000 ~ LHC turnon
- Plans to increase luminosity:
  - Baseline plan leads to 2 x 10^{34} by 2006
  - 4 x 10^{34} is feasible with "modest" extra improvements in IR optics and RF
    - funding and manpower limited – could be ready by 2005
- Task forces studying Improvement/Upgrade strategy:
  - Estimate physics reach for important modes
  - Identify limitations
  - Recommend detector, accelerator improvements
  - Report by end of summer

PEPII Performance

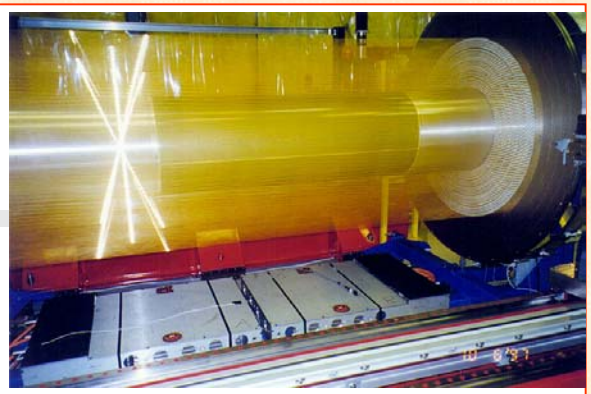


3.1 GeV e^+ on 9 GeV e^- cms boost $\langle\beta\gamma\rangle = 0.55$

Typical (best) performances during just-completed 18-month run.

- Peak Luminosity = 4.6×10^{33} cm^{-2} s^{-1} (3×10^{33} cm^{-2} s^{-1} design)
- Daily Luminosity = 310 pb^{-1}
- Positron current = 1775 mA
- Electron current = 1060 mA

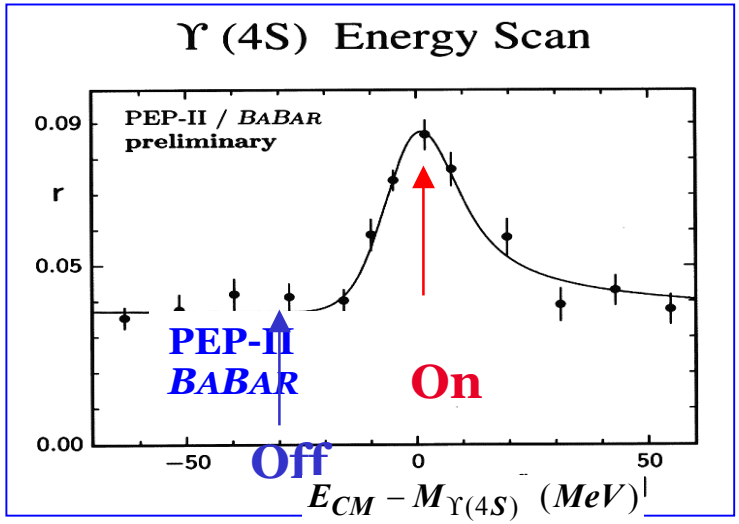
PEPII/BaBar improvements

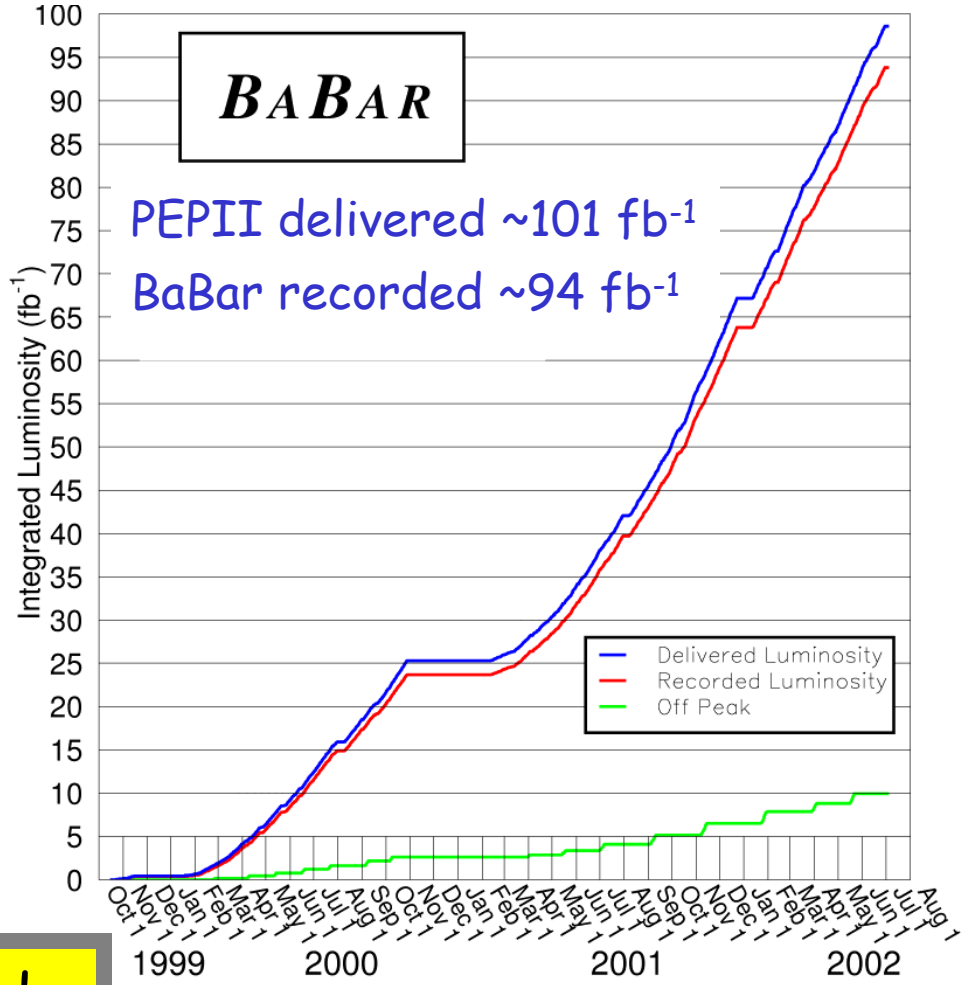


- Shutdown in progress (July 1 – Nov 15)
  - Install 2 RF stations to increase currents
  - Add cooling to PEPII beampipe near Interaction Point
  - Improve μ ID by upgrading IFR endcap
  - Reduce deadtime by replacing DIRC TDC's
- Winter 2002-3
  - Speed up DAQ and L3 Trigger
  - Add *z*-information to Level-1 Trigger to reject background tracks
- 2003-4 Remediation studies, R&D for IFR Barrel
- 2004-5 Replace SVT modules in beam plane
- 2003-2005 PEPII installs more RF, new kickers, …

BaBar Data Set

- Used in most analyses
  - 81.2 fb^{-1} on peak
  - 9.6 fb^{-1} off-peak





~88M $B\bar{B}$ pairs considered

$\not{CP}$ issues for BABAR

$$V_{ud}V^*_{ub} + V_{cd}V^*_{cb} + V_{td}V^*_{tb} = 0$$

B.R. ~ 4 x 10^{-6}
Theoretical Issues

Good look needs ~500 fb^{-1}

α

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

V_{ub}

V_{td}

$B^0 \to DK, D^*\pi$

γ

β

$B^0 \to (c\bar{c})K^0$

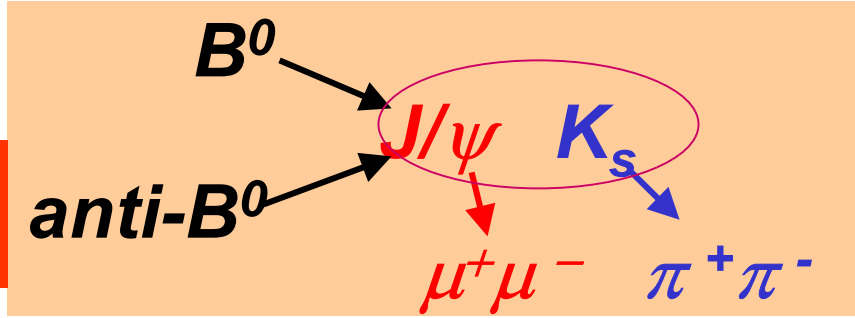
Eff B.R ~10^{-7}; tough!!

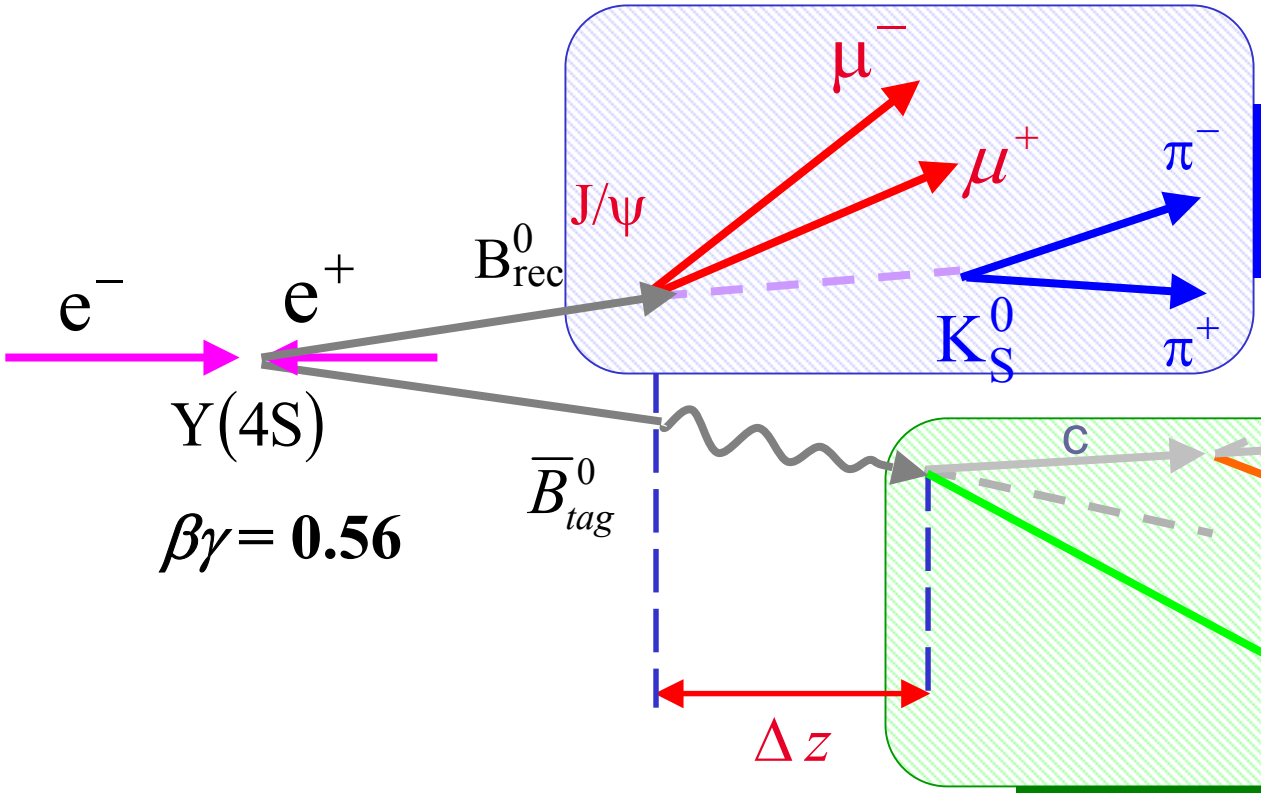
V_{cb}

Very clean, Eff B.R. ~ 10^{-4}

The Measurement:

Compare Time spectra of B and anti-B to common CP state





Complete B Meson Reconstruction

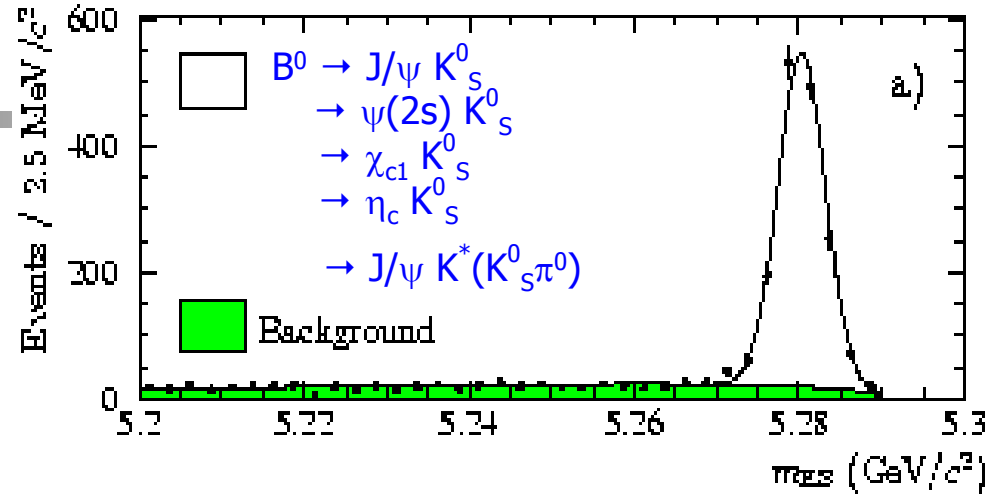
Partial Reconstruction for B-Flavour Tagging

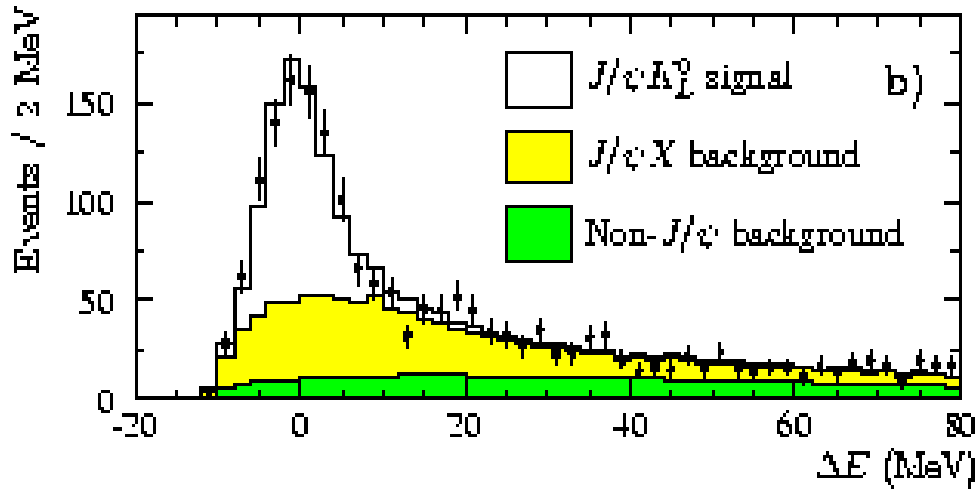
$\langle \Delta t \rangle \approx 1.5$ ps

$\langle \Delta z \rangle \approx \langle \Delta t \rangle \beta \gamma c \approx 260\ \mu m$

Charmonium CP Sample

Mode	Ntag	Purity (%)
$J/\psi K_s$ ($\pi^+\pi^-$)	974	96.5
$J/\psi K_s$ ($\pi^0\pi^0$)	170	88.5
$\psi(2s)K_s$	150	96.9
$\chi_c K_s$	80	94.5
$\eta_c K_s$	132	63.4
(cc)K_s	**1506**	**92.2**
$J/\psi K_L$	988	55.2
$J/\psi K^{*0}(K_s\,\pi^0)$	147	81.2
All CP	**2641**	**78.2**
Brec (had.)	23618	84.2
$J/\psi K^{*0}(K^+\pi^-)$	1757	95.8
Bflav	**25375**	**84.5**

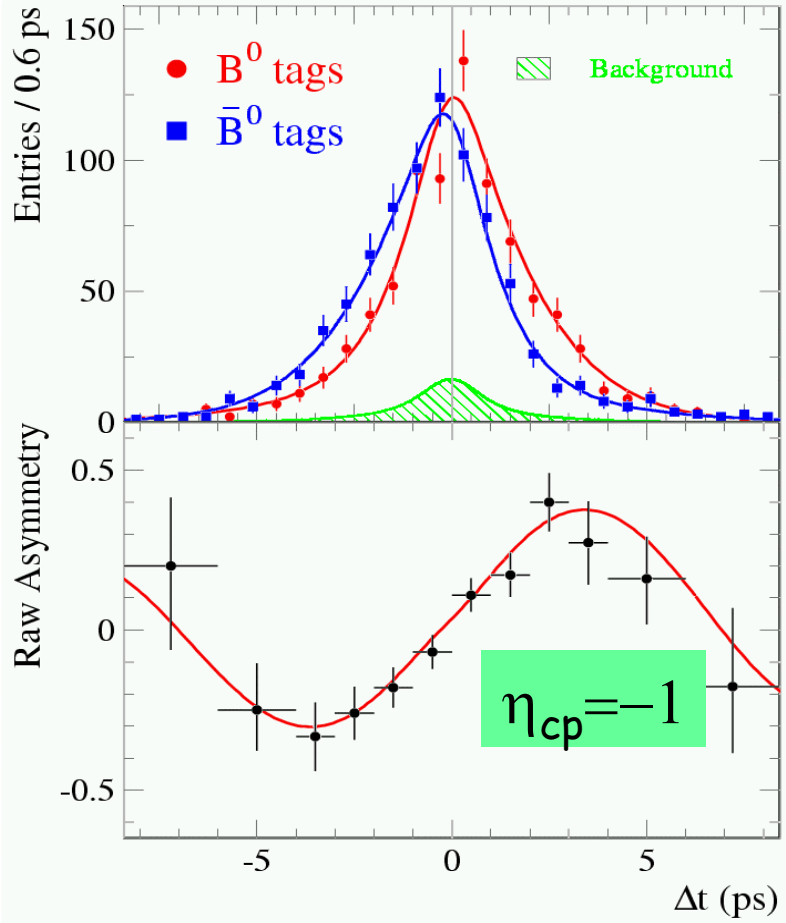


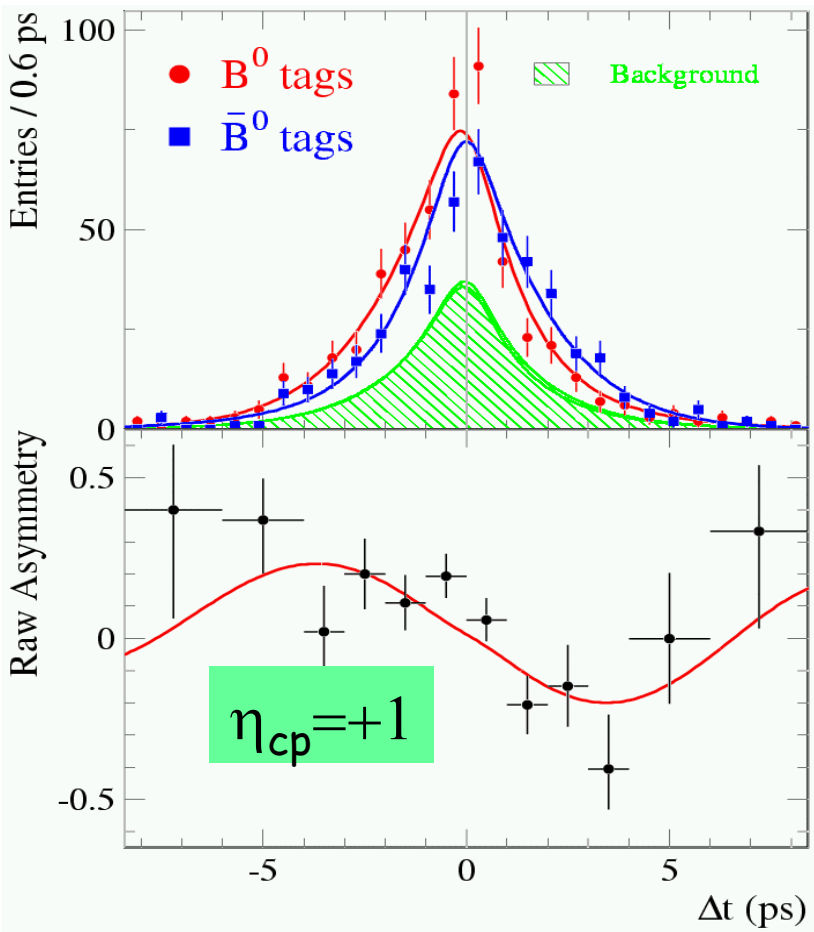


η_c has been added to the sample

$\eta_c \to K_s K^+\pi^-$ and $\eta_c \to K^+K^-\pi^0$

~~CP~~ in $B^0 \rightarrow$ Charmonium + $K^{0(*)}$



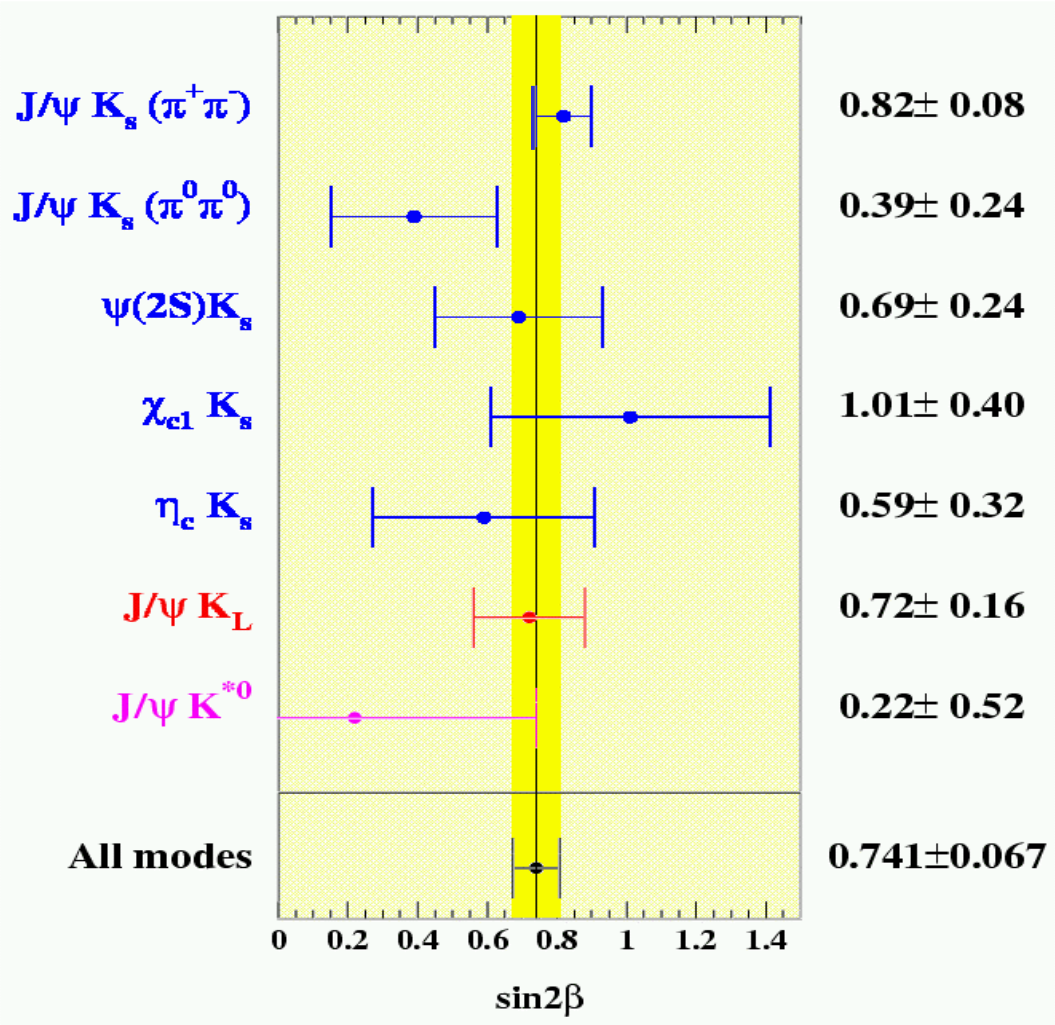


$\sin 2\beta = 0.755 \pm 0.074$ **$\sin 2\beta = 0.723 \pm 0.158$**

$$\sin 2\beta = 0.741 \pm 0.067\ (\text{stat}) \pm 0.033\ (\text{syst})$$

Submitted to PRL, hep-ex/0207042

sin2β (b→c$\bar{c}$s) results by decay mode



All consistent:

$P(\chi^2)$ = 57%

Beyond the Standard Model

$$A_{CP}(t) = S_f \sin(\Delta m_d t) - C_f \cos(\Delta m_d t)$$

$$\lambda_{f_{cp}} = \eta_{f_{cp}} \left|\frac{q}{p}\right| \left|\frac{\overline{A_{\bar{f}_{cp}}}}{A_{f_{cp}}}\right| e^{-2i\varphi_{cp}}$$

$$S = \frac{2\,\mathrm{Im}\,\lambda}{1+|\lambda|^2}$$

$$C = \frac{(1-|\lambda_{f_{cp}}|^2)}{1+|\lambda_{f_{cp}}|^2}$$

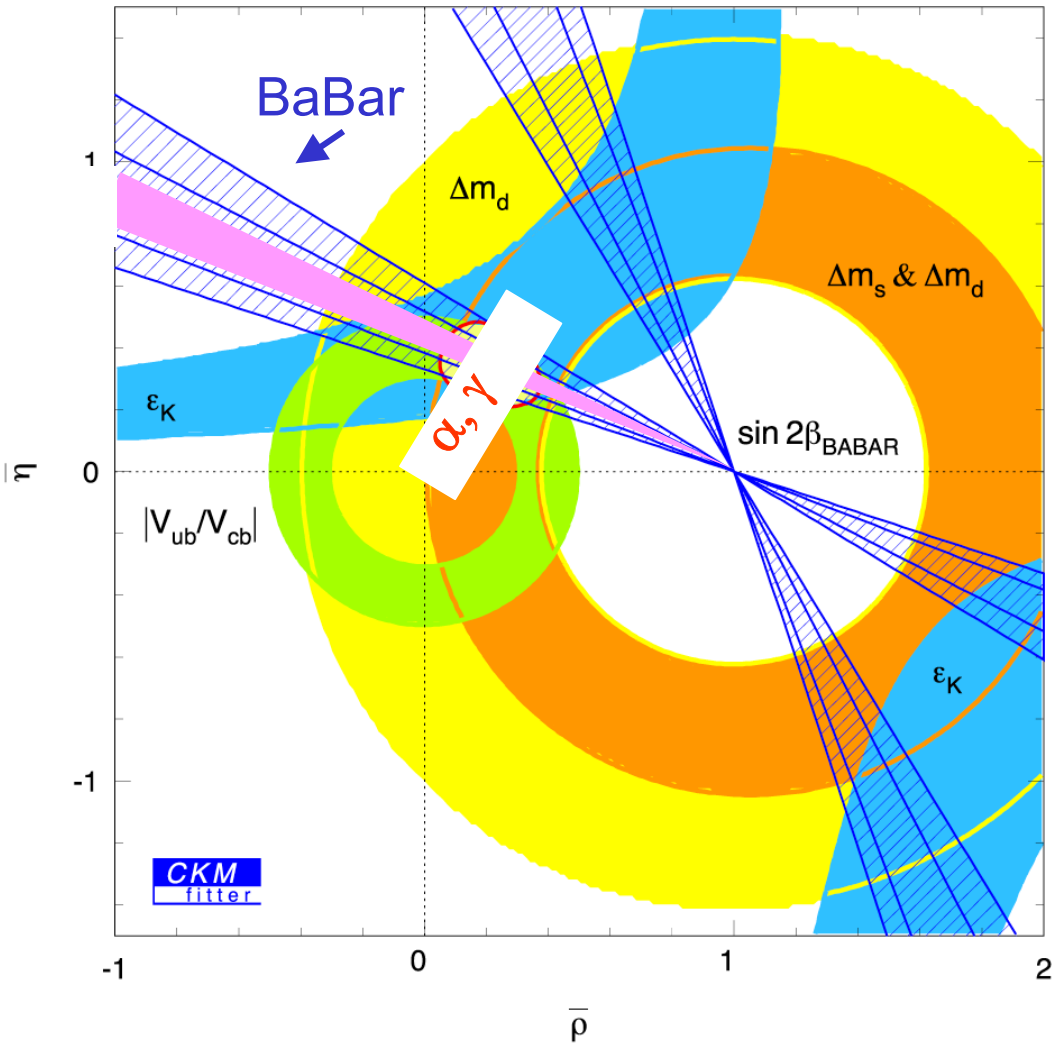
- No direct CP violation in *b→(cc)K* in the SM
  - $|\lambda|=1$ $C=0$ $S = \sin 2\beta$
- Direct CP would modify the time distributions:
- Leave λ free and fit for $|\lambda|$ and S_f

For b→(cc)K_s data sample

$$|\lambda| = 0.948 \pm 0.051(\text{stat}) \pm 0.017\ (\text{syst})$$

and $S_f = 0.759 \pm 0.074$ (stat)

Constraining the ρ ,η plane



New Belle result July 29:
sin 2β = 0.72 ± 0.074 ± 0.035

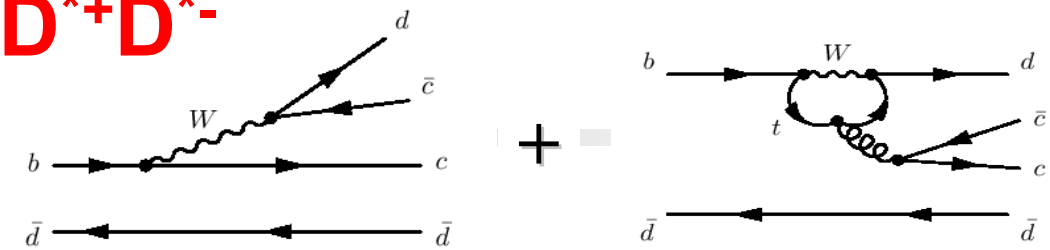
Unofficial World Average:
0.73 ± 0.055

Highly likely that CKM phase explains Observed CP Violation in K's and B's

(So far!)

Method as in Höcker et al, Eur.Phys.J.C21:225-259,2001

$\sin 2\beta$ from $B^0 \to D^{*+}D^{*-}$



We measure :

- $\mathrm{Im}(\lambda_+)$
- $|\lambda_+|$

$-\sin 2\beta$

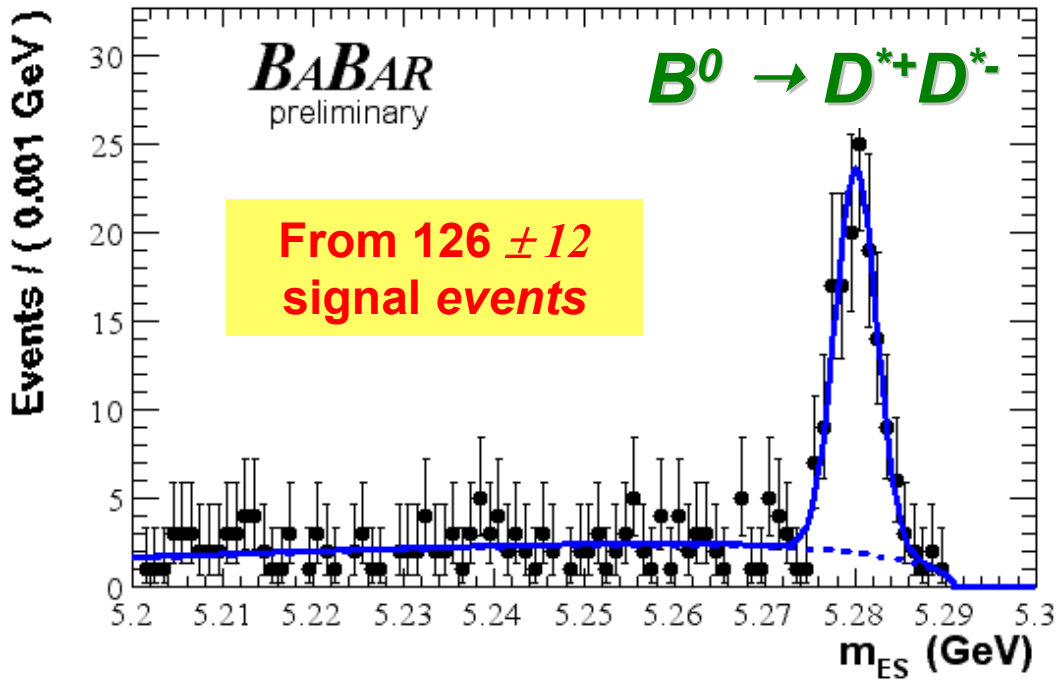
Small (< 0.1 T) penguin contribution expected

$\mathrm{Im}(\lambda_+) = 0.31 \pm 0.43\ (\mathrm{stat}) \pm 0.13\ (\mathrm{syst})$

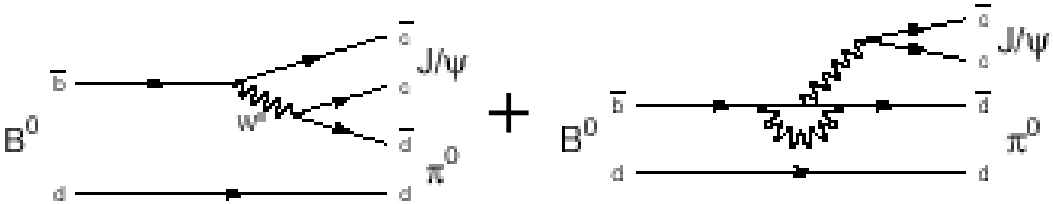
Cf: $-\sin 2\beta = -0.741 \pm 0.067$

$|\lambda_+| = 0.98 \pm 0.25\ (\mathrm{stat}) \pm 0.09\ (\mathrm{syst})$

~2.4 σ

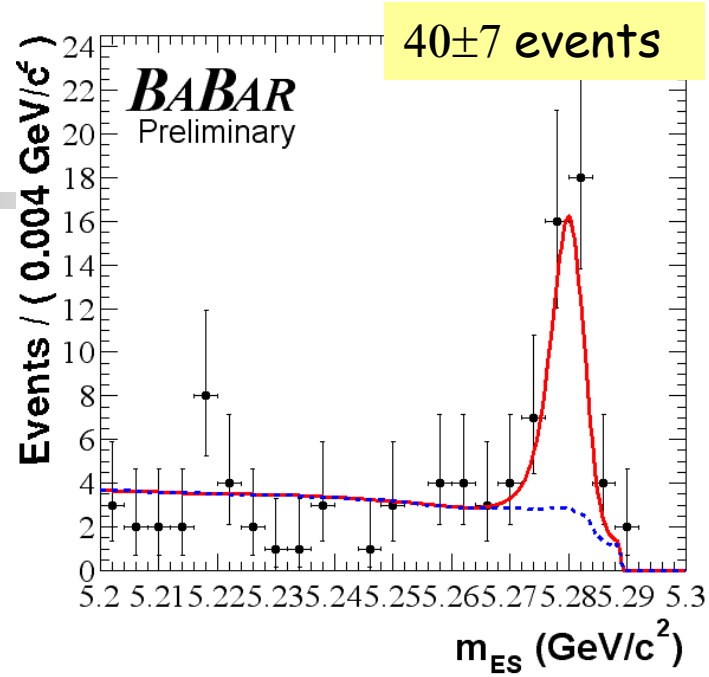


$B^0 \to J/\psi\ \pi^0$



$V_{cb}V_{cd}^* \sim \lambda^3$ $\sim \lambda^3$

Tree and penguins comparable

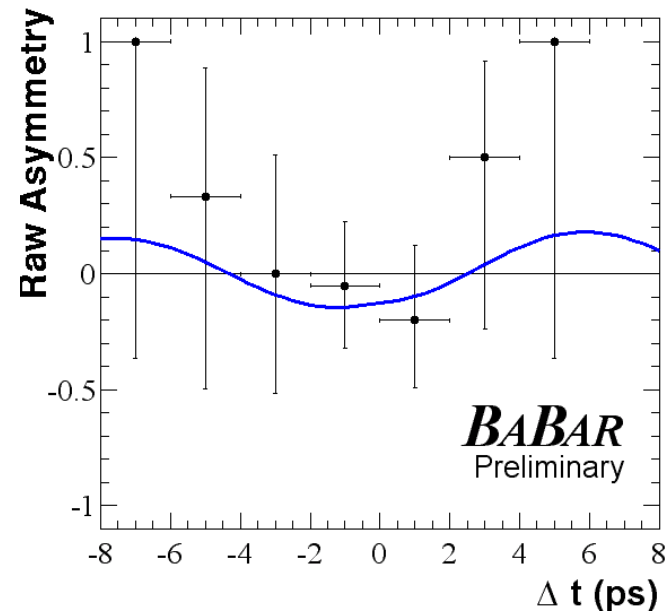


$$BR(B \to J/\psi\pi^0) = (2.0 \pm 0.6 \pm 0.2) \times 10^{-5}$$

If no penguins we measure -sin2β

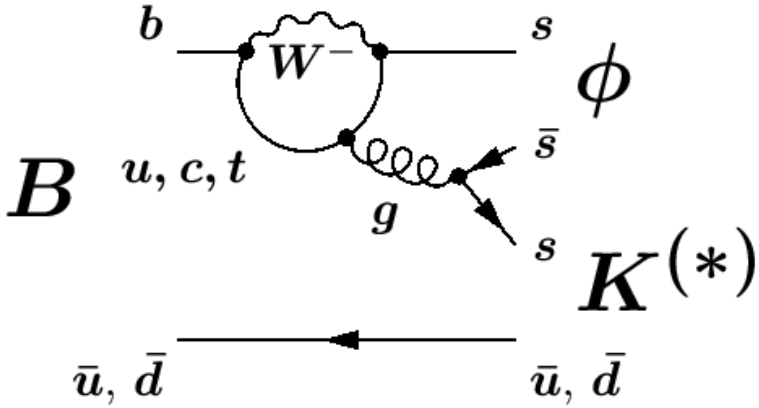
$$S_{J/\psi\pi^0} = 0.05 \pm 0.49(stat) \pm 0.16(syst)$$

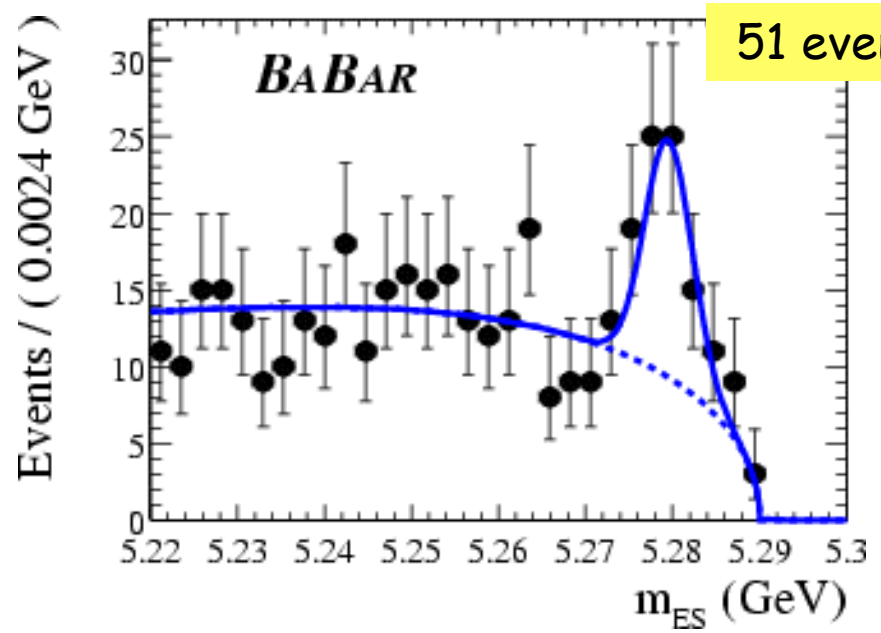
$$C_{J/\psi\pi^0} = 0.38 \pm 0.41(stat) \pm 0.09(syst)$$



$B^0 \to \phi K^0_s$: "pure penguin," tree highly suppressed

Within the SM we measure sin2β but new physics may show up through loop diagrams





$$BR(B \to \varphi K^0) = (8.1^{+3.1}_{-2.5} \pm 0.8) \times 10^{-6}$$

$$\sin 2\beta = -0.19^{+0.52}_{-050}(stat) \pm 0.09(syst)$$

Assuming $|\lambda|=1$

Future of *sin2β* Measurements

- **Increased Statistics in (c $\bar{c}$) s (Golden) modes: B → (J/ψ,ψ(2s),χ_C) K^0_S**

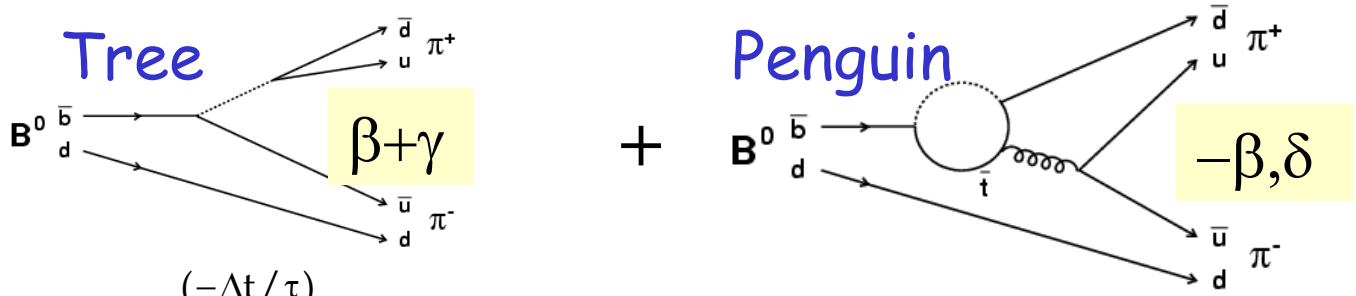
- **Other *CP* modes can provide independent measurements:**
  - different **quark processes**
  - various **penguin contributions**
  - **angular analyses** for VV modes

Error in *sin2β*

Luminosity (fb^{-1})	30	60	100	500
(c $\bar{c}$) s (B → J/ψ K_S)	**0.14**	**0.09**	**0.07**	**0.03**
c $\bar{c}$ d (B → D^{*+} D^{*-})	**--**	**0.5**	**0.4**	**0.13**
(s $\bar{s}$) s (B → ϕ K_S)	**--**	**--**	**0.5**	**0.17**

Measuring sin2α ($B^0 \to \pi^+\pi^-$)

(We actually measure $\alpha_{eff} \neq \alpha$ due to non negligible penguin contributions)



$$f_{\pm}(\Delta t) = \frac{e^{(-\Delta t/\tau)}}{4\tau}[1 \pm S_f \sin(\Delta m_d \Delta t) \mp C_f \cos(\Delta m_d \Delta t)]$$

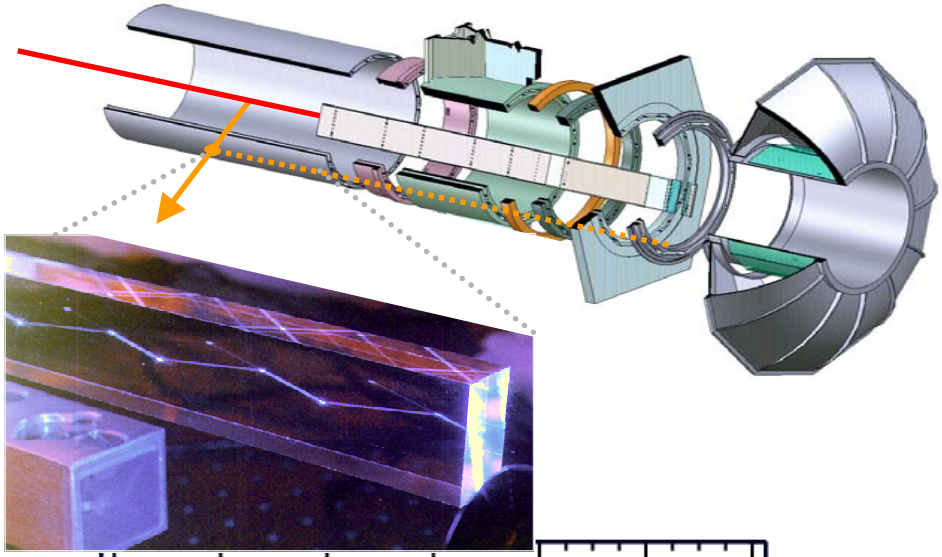
- Extra weak phase β, strong phase δ, and $|P/T|$, modify α by κ

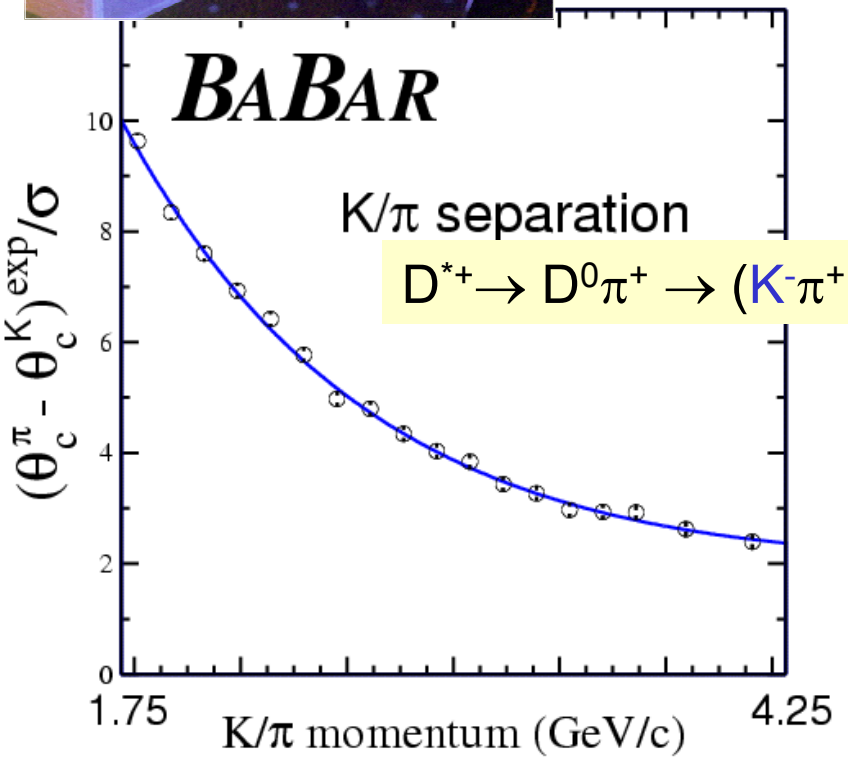
$$2\alpha_{eff} = 2\alpha + \kappa_{\pi\pi}$$

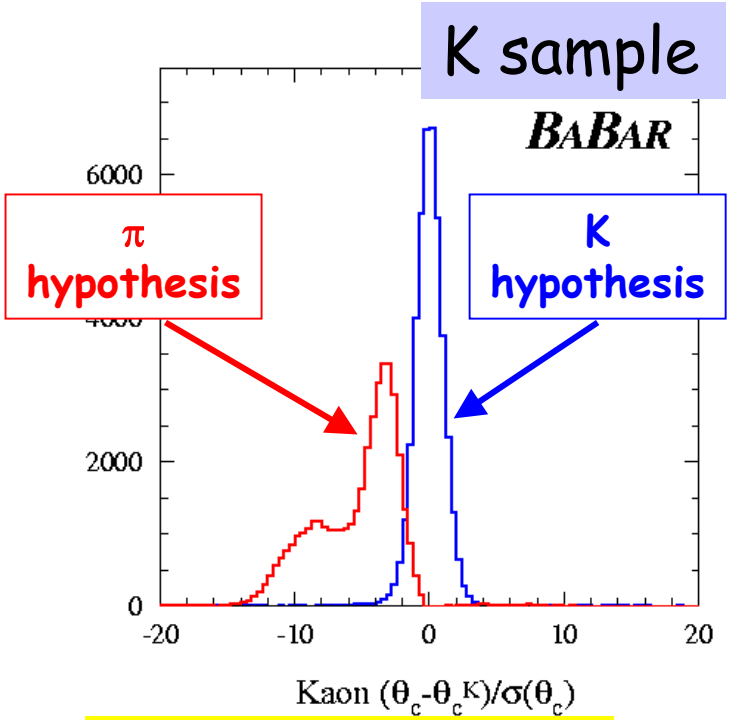
- Small Branching fractions
- Fierce backgrounds ($B \to \rho\pi$, $K\pi$)

→ Particle ID!!

π-K separation with the DIRC





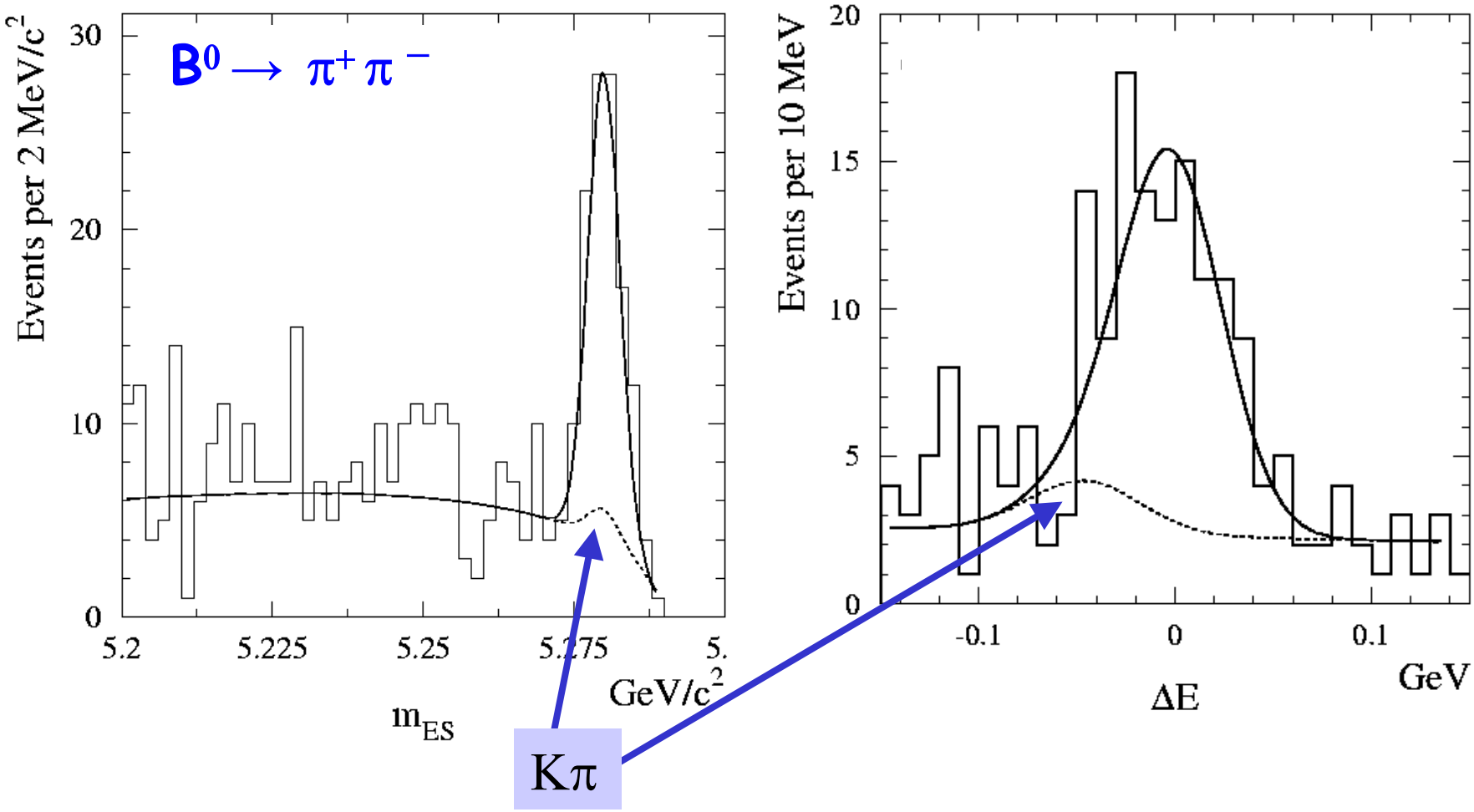


For $\varepsilon = 85\%$

$P(K \rightarrow \pi) = 1.7\%$

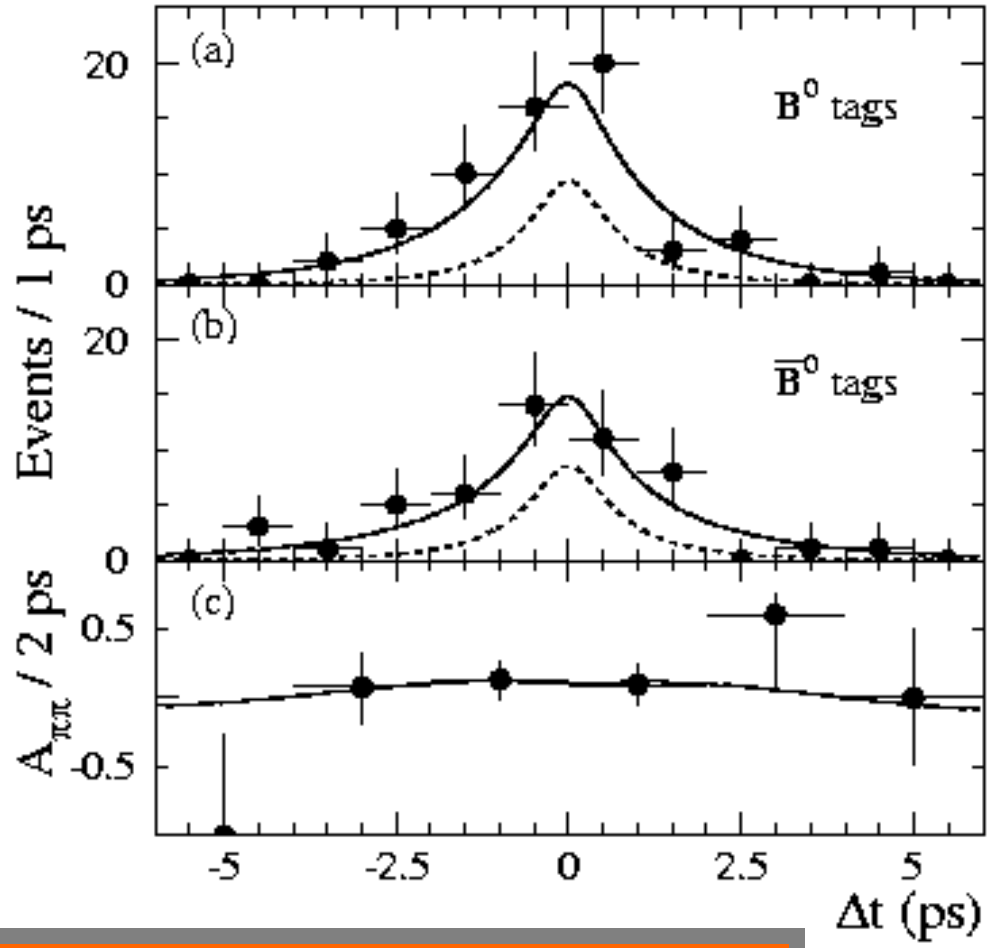
$P(\pi \rightarrow K) = 2.7\%$

Data sample for $B^0 \rightarrow \pi^+ \pi^-$



$S_{\pi\pi}$ and $C_{\pi\pi}$

From unbinned maximum likelihood fit



$$S_{\pi\pi} = 0.02 \pm 0.34(stat) \pm 0.05(syst)$$

$$C_{\pi\pi} = -0.30 \pm 0.25(stat) \pm 0.04(syst)$$

$B^0 \to \pi^0\pi^0$ branching ratio

- Tagging and energy flow to reduce background
- $B^{\pm} \to \rho^{\pm}\pi^0$ is reduced cutting on the $\pi^{\pm}\pi^0$ invariant mass and ΔE.
- $\varepsilon(B^0 \to \pi^0\pi^0)=16.5\%$

Fit results :

$$n_{\pi^0\pi^0} = 23^{+10}_{-9}$$

$$BR(B^0 \to \pi^0\pi^0) < 3.6\times10^{-6} \; at \; 90\% \; CL$$

Central Value :

$$BR(B^0 \to \pi^0\pi^0) = (1.6^{+0.7}_{-0.6}(stat)\;{}^{+0.6}_{-0.3}(syst))\times10^{-6}$$

$B^0 \to \rho\pi$

Clear $B^0 \to \rho\pi$ signal observed

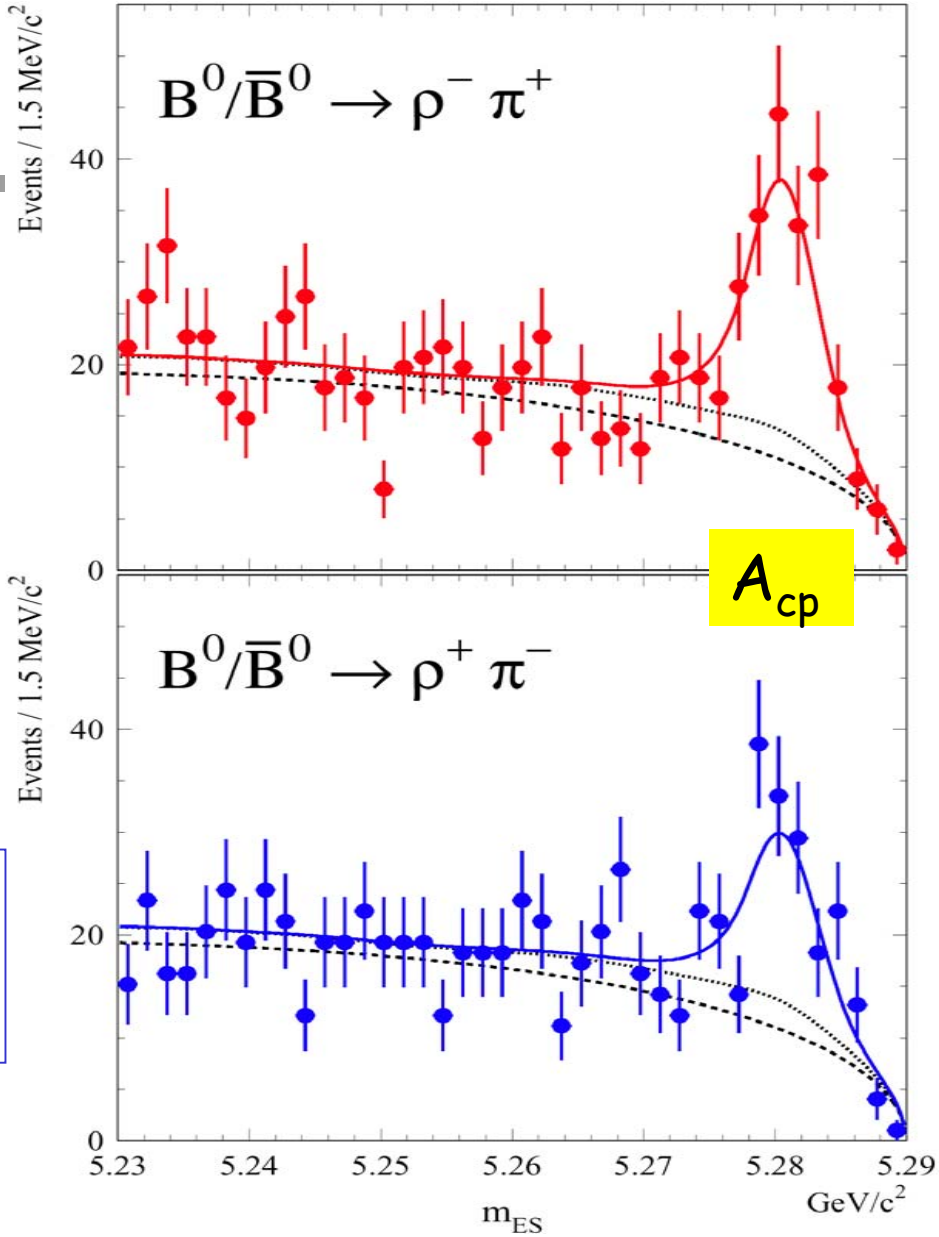
$$N_{\rho\pi} = 413^{+34}_{-33}$$

$$N_{\rho K} = 147^{+22}_{-21}$$

From $B^0 \to \rho\pi$

$\tau = 1.59 \pm 0.12$ ps

$\Delta m_d = 0.51 \pm 0.09$ ps^{-1}



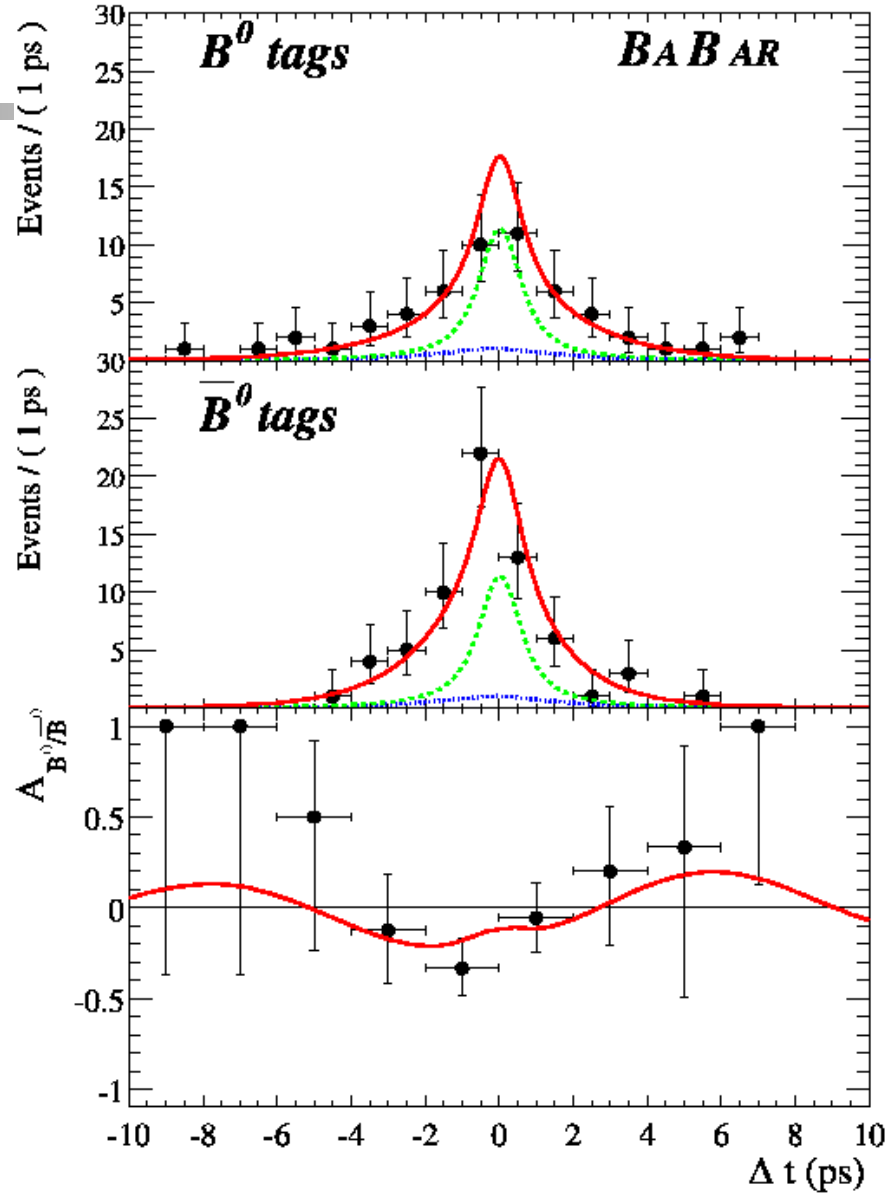
$B^0 \to \rho\pi$ asymmetry

$$A_{CP}^{\rho\pi} = -0.22^{+0.08}_{-0.08}(stat) \pm 0.07(syst)$$

$$A_{CP}^{\rho K} = 0.19^{+0.14}_{-0.14}(stat) \pm 0.11(syst)$$

$$C_{\rho\pi} = 0.45^{+0.18}_{-0.19}(stat) \pm 0.09(syst)$$

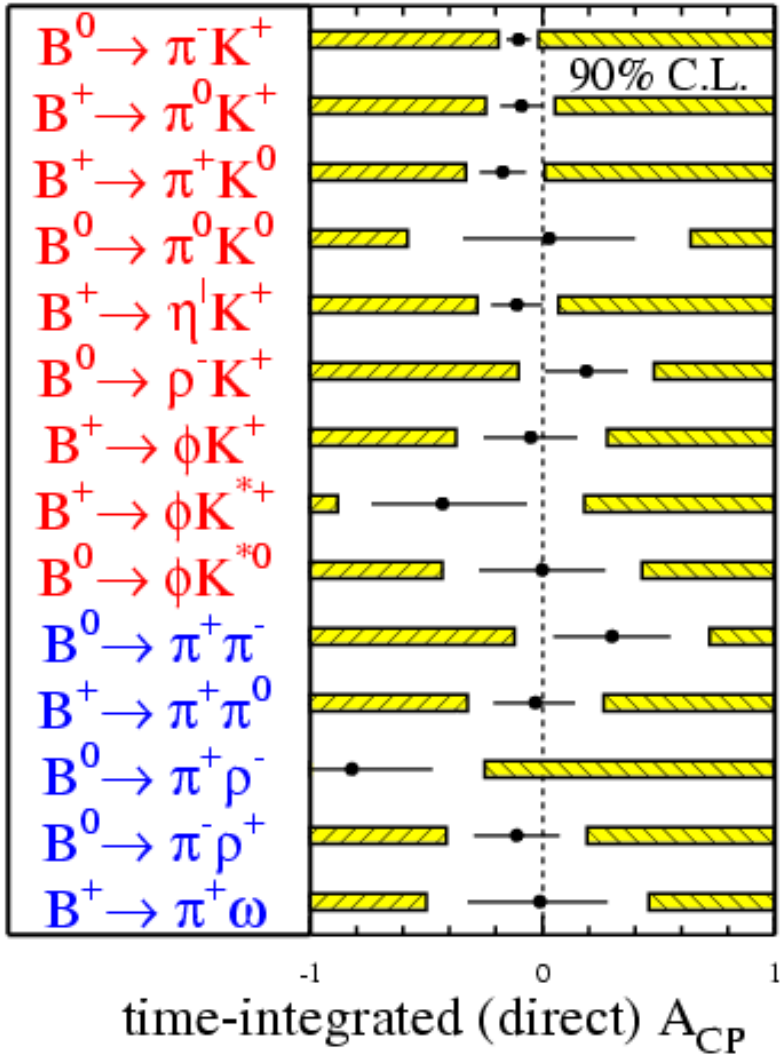
$$S_{\rho\pi} = 0.16^{+0.25}_{-0.25}(stat) \pm 0.07(syst)$$



A, C > 2σ

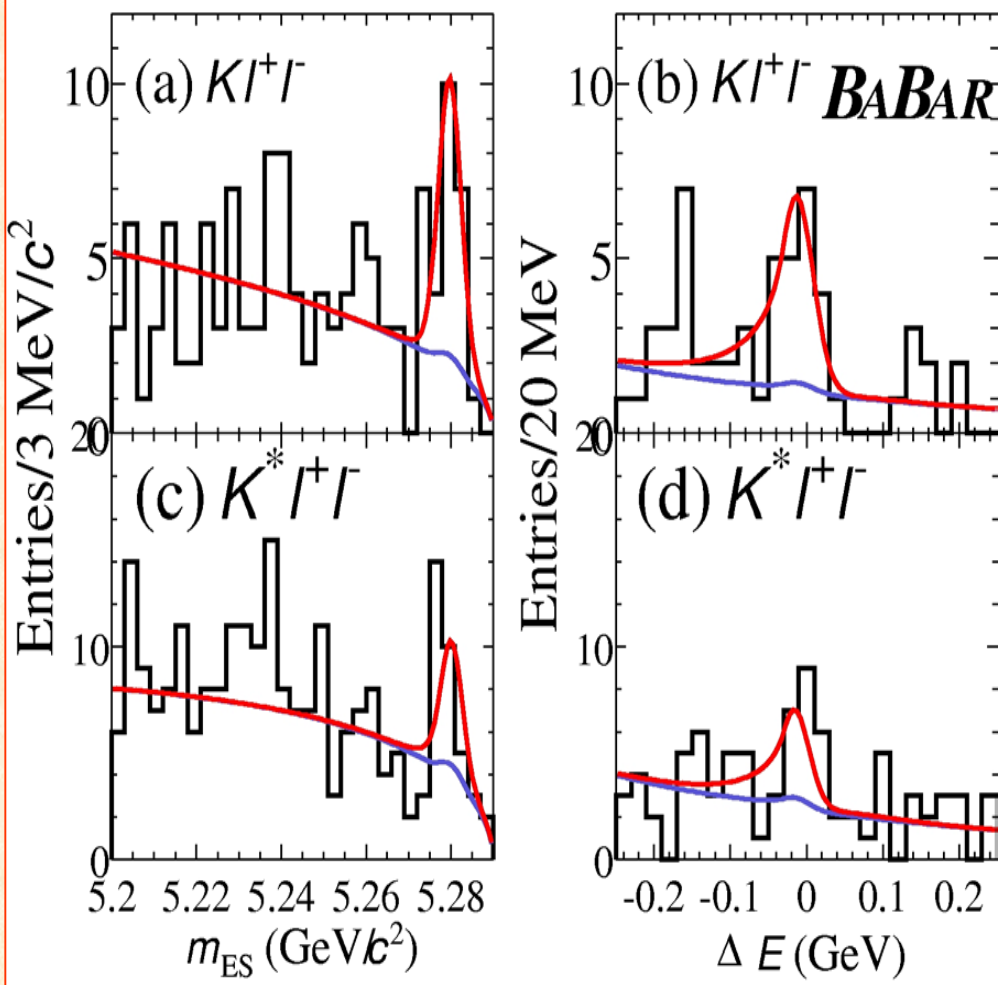
Direct CP measurements summary

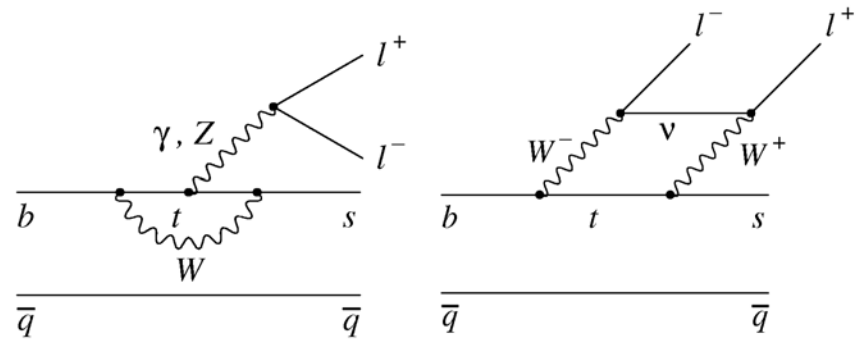
No evidence for direct CP violation yet



$B \to K^{(*)} l^+ l^-$ (Combined fits)

preliminary



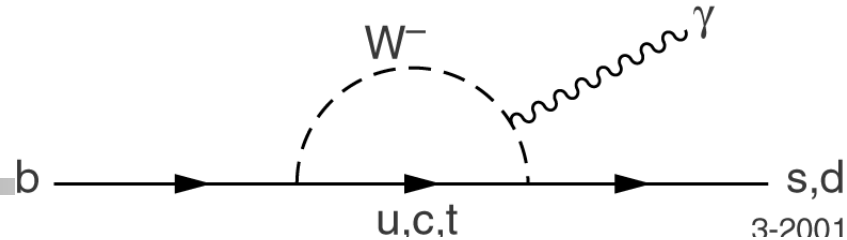


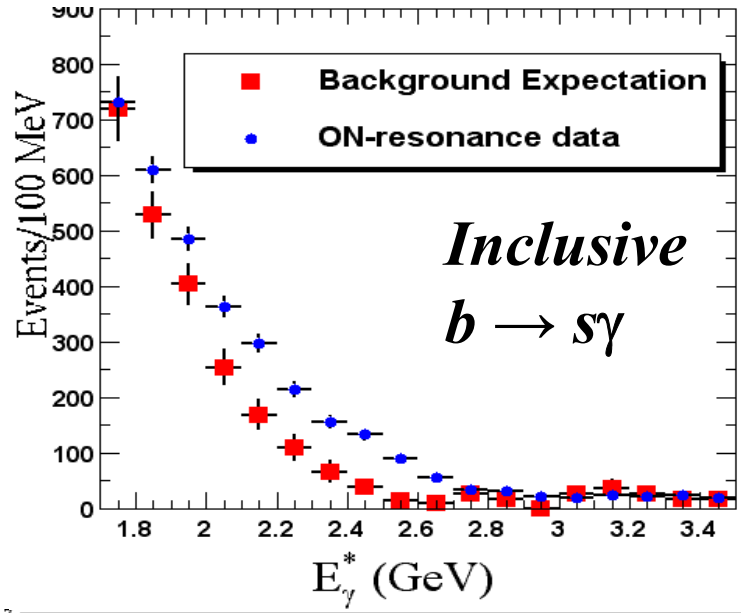
$$(0.78^{+0.24+0.11}_{-0.20-0.18}) \times 10^{-6}$$

$$(1.68^{+0.68}_{-0.58} \pm 0.28) \times 10^{-6}$$

$$< 3.0 \times 10^{-6} \quad 90\% \text{ C.L.}$$

Some new radiative penguin results



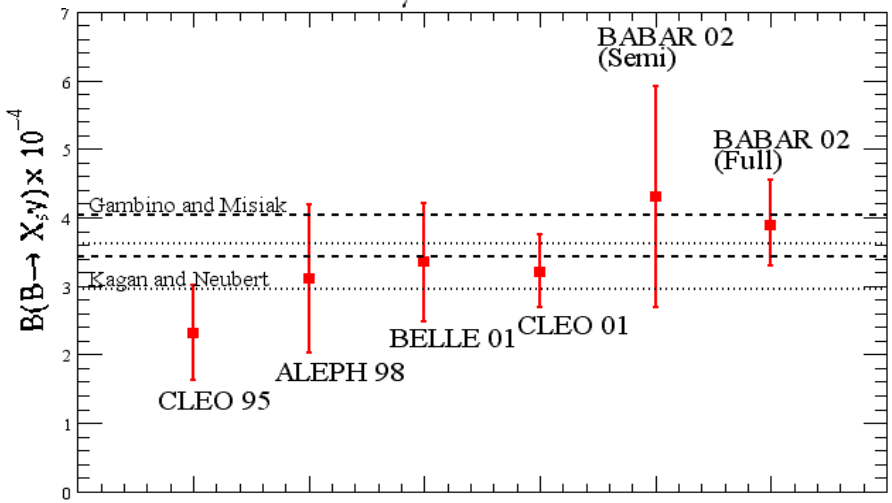


Most sensitive limits:

$B(B^0 \rightarrow \rho^0\gamma) < 1.4 \times 10^{-6}$ 90% C.L

$B(B^+ \rightarrow \rho^+\gamma) < 2.3 \times 10^{-6}$ 90% C.L

$B(B^0 \rightarrow \omega\gamma) < 1.2 \times 10^{-6}$ 90% C.L.



Electroweak Penguins will provide sensitive searches for new physics over the next 5-10 years

Summary

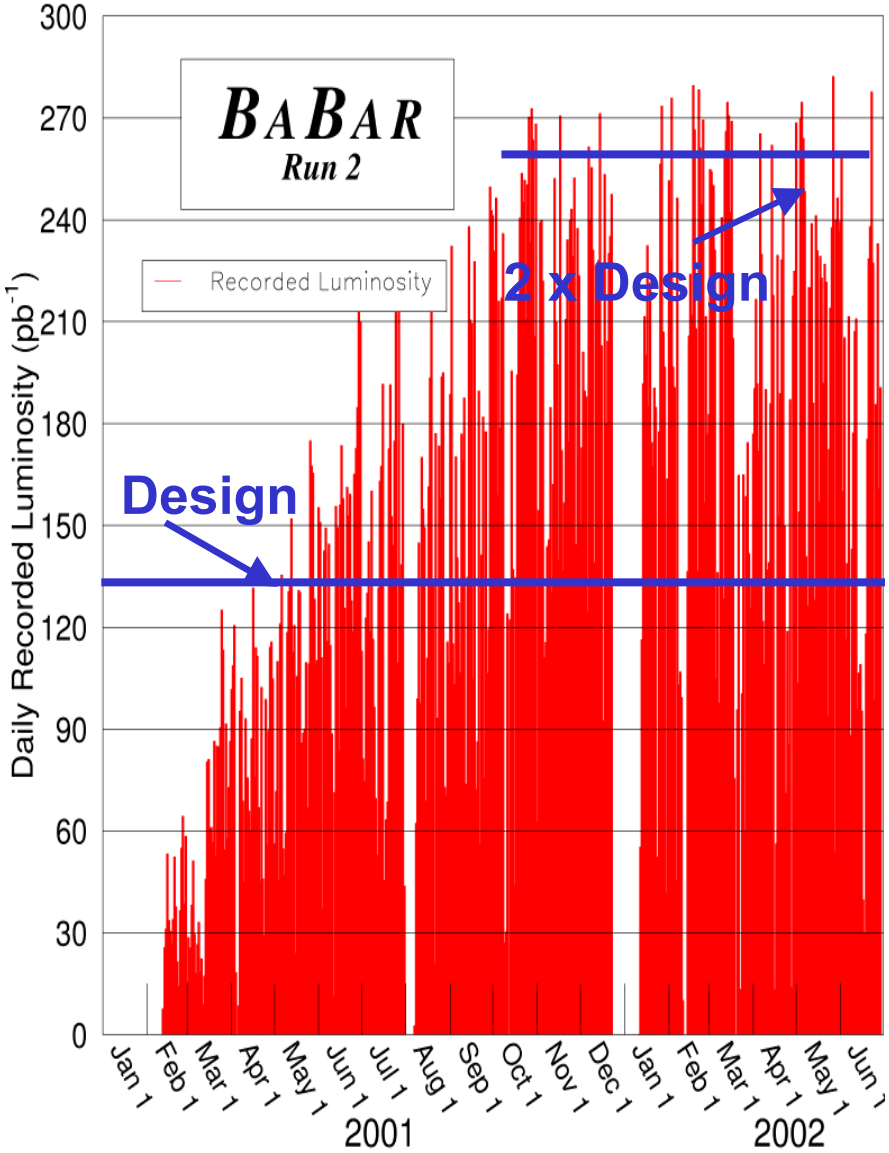
- sin 2β has become a precise fundamental constant, thanks to the asymmetric B factory.
- PEP-II is performing well above design, but we need more.
- >2 σ effects appearing -- signal of direct CPV if they persist!
- sin 2α is now a central focus – thank God for the DIRC!
- 28 journal papers, ~ 20 more to come this year.
- 32 new results, 25 conference papers presented at ICHEP.
- Detector systems will survive to ~2 x10^{34} with only moderate modifications.

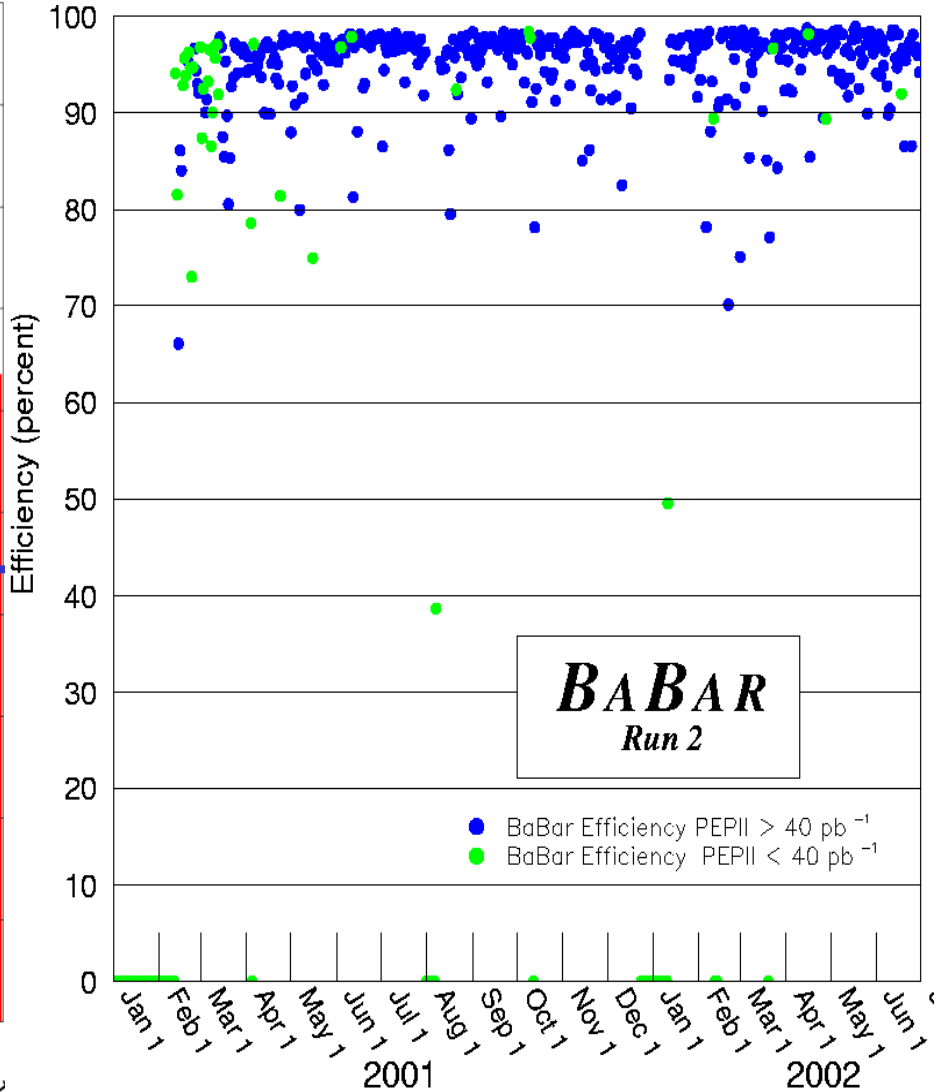
Backup Slides

The SLAC B Factory -- A major success for DoE Science

- On-time, on-budget; example of DOE and Office of Science's ability to manage a major multi-lab, multi-nation project
- All design parameters exceeded – PEP-II delivers and BABAR records twice the design daily integrated luminosity
- Physics "fountain" – 28 papers in publication chain, . >20 more in the next few months.
- At the recent ICHEP in Amsterdam, BaBar presented 32 brand new results in 13 talks.

PEPII/BaBar Performance





Issues for 2 x 10^{34}

- Install more RF stations (+4)
- Reduce β_y^* (1.25 $\rightarrow$ 0.7 cm)
- Reduce β_x^* (50 $\rightarrow$ 35 cm)
- Inject at higher repetition rate (~60 Hz)
- Some improved IP vacuum chambers
- Better feedback kickers
- Shorter abort kicker pulses

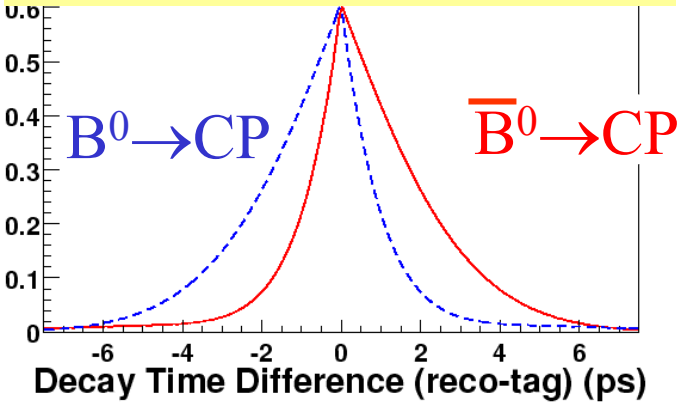
CP Analysis Overview

- Fully reconstruct exclusive *B* decays to eigenstates of *CP* or flavour, and tag flavour of the other *B* in the event.
  - Select B_{CP} candidates ($B^0 \rightarrow J/\psi\, K_s$, *etc.*) and B_{flav} candidates ($B^0 \rightarrow D^*\pi$, *etc.*)
  - Select B_{tag} events using, primarily, leptons and *K*'s from *B* hadronic decays, and determine the *B* flavour.
- Measure ΔZ between B_{reco} and B_{tag} to determine the signed time difference Δt between the decays.
- Use large statistics of B_{flav} sample and mixing channels to measure the mistag fractions w_i and determine the dilutions $D_i = 1 - 2w_i$
- Determine the resolution function for Δt
- Fit events in CP sample for time-dependent asymmetry and extract sin2β

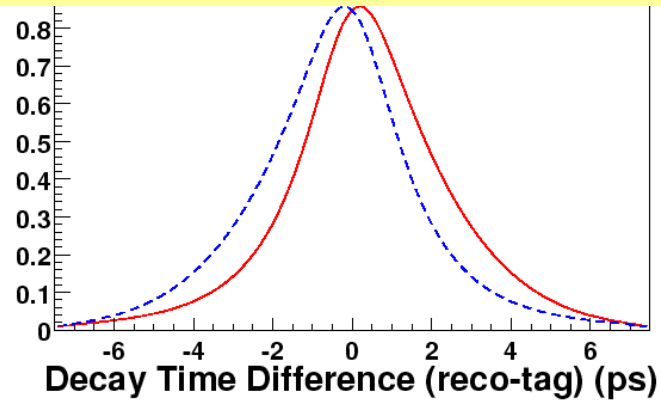
CP Analysis: Time Distributions

$$f_{CP,\pm}(\Delta t) = \left\{ \frac{e^{-|\Delta t|/\tau_{B_d}}}{2\tau_{B_d}} \times \left(1 \mp \eta_f.(1-2\omega).\sin 2\beta.\sin(\Delta m_{B_d}\Delta t)\right) \right\} \otimes R$$

perfect flavor tagging & time resolution



realistic mis-tagging probability, time resolution



Mixing via ~30k flavor events

$$A_{mixing}(\Delta t) = \frac{N(unmixed) - N(mixed)}{N(unmixed) + N(mixed)} \approx (1-2w).\cos(\Delta m_{B_d}\Delta t)$$

$\not{C}P$ via B_{CP} sample eg $B \to J/\psi K_S$

$$A_{CP}(\Delta t) = \frac{N(B_{tag}=B^0) - N(B_{tag}=\overline{B}^0)}{N(B_{tag}=B^0) + N(B_{tag}=\overline{B}^0)} \approx (1-2\omega).\sin 2\beta.\sin(\Delta m_{B_d}\Delta t)$$

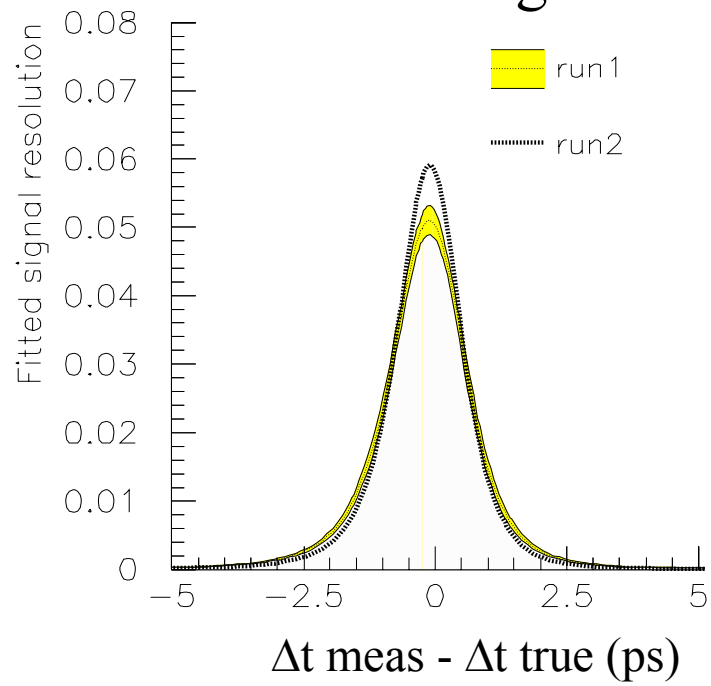
Use the (10x larger) B_{flav} data sample to measure mis-tagging probabilities and parameters of time-resolution function

Likelihood Fit Method

- Global unbinned maximum likelihood fit to data:
  - Mistag rates, Δt resolutions = tagged flavor sample
    - Separate Δt resolutions for run1 and run2
  - $\sin 2\beta$ = tagged *CP* samples
- 44 parameters for mistag rates, Δt resolution & backgrounds: floated to obtain an empirical description from data. Largest correlation with $\sin 2\beta$: 13%

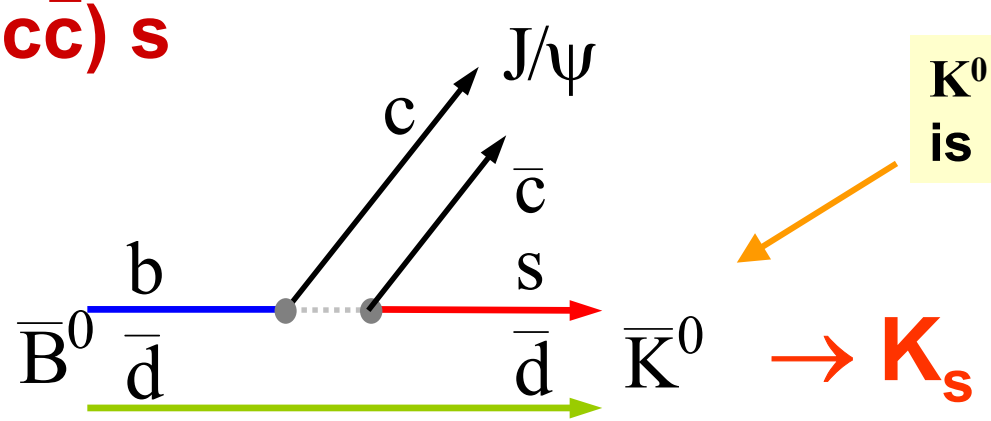
parameter	#	Subsample
$\sin 2\beta$	1	*CP*
w & Δw	8	flavor
Δt resolution	16	flavor and *CP*
Background w	8	sidebands
Background Δt	12	sidebands

t_B = 1.548 ps and Δm_d = 0.472 ps^{-1} fixed



Golden Channels: $B^0 \to$ Charmonium + $K^{0(*)}$

$b \to (c\bar{c})\, s$

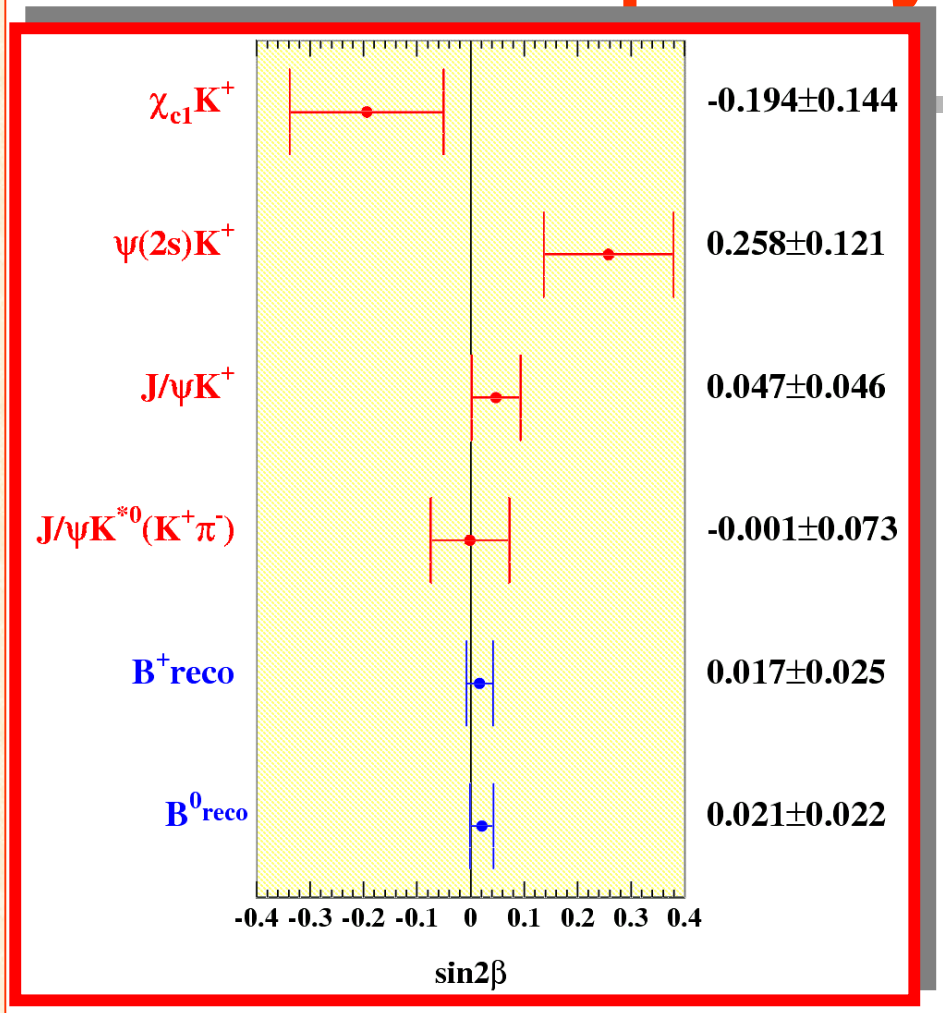


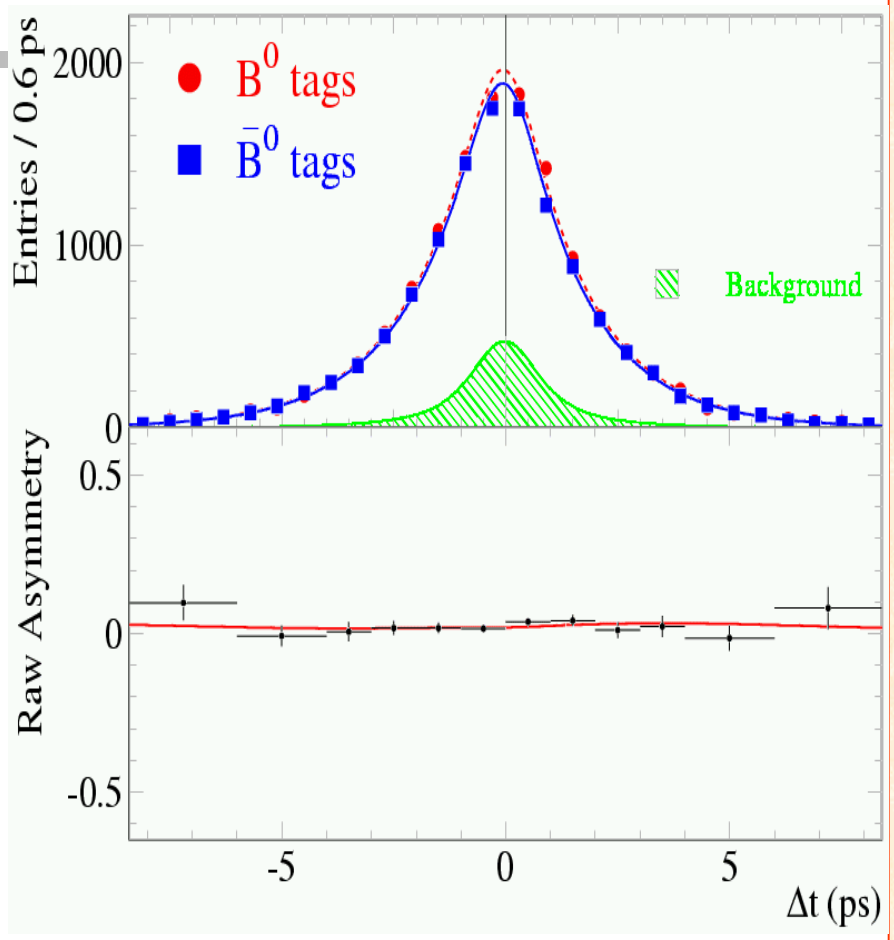
K^0 mixing is required

$\to K_s$

- Clear Experimental Signatures
- Relatively high branching fractions
- Theoretically clean process for measuring sin 2β
  - **single weak phase $\to$ no direct CPV**

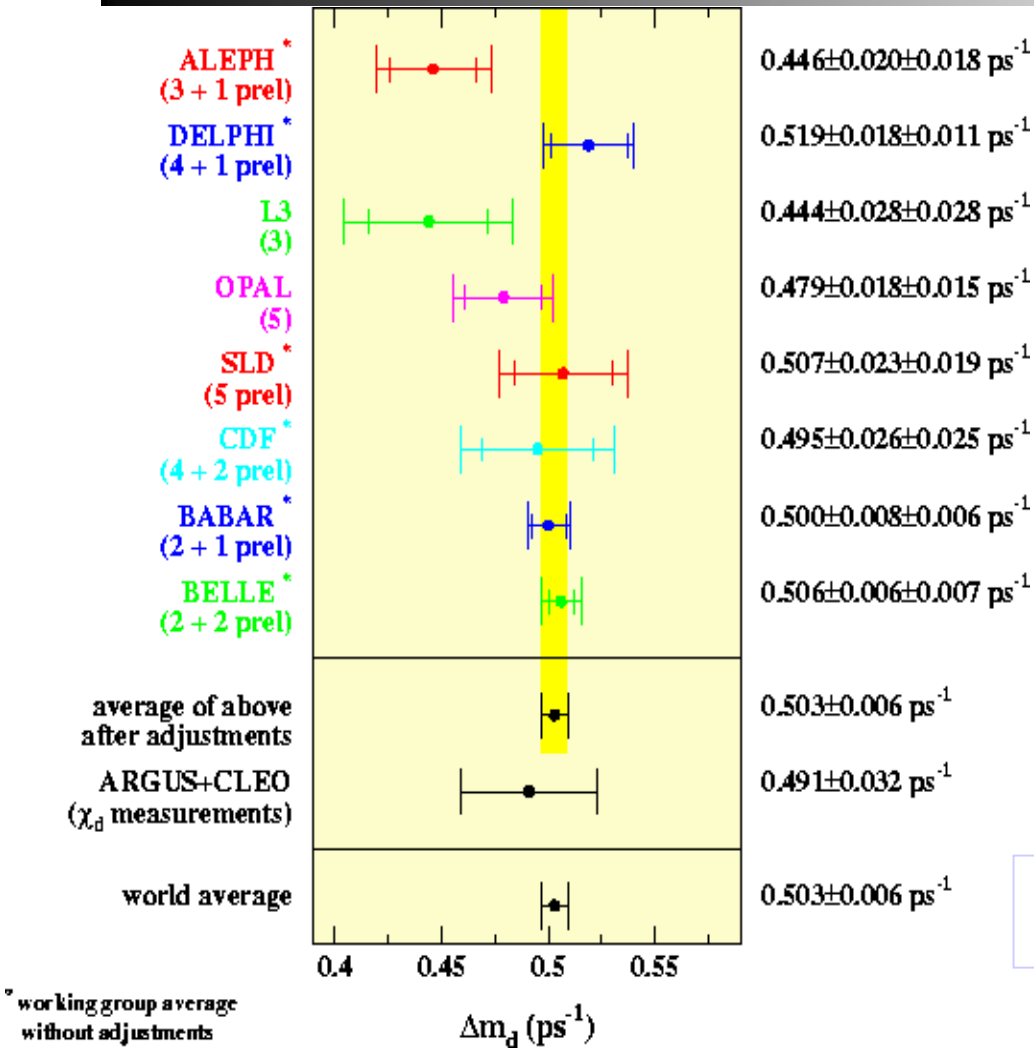
Control sample asymmetry





No asymmetry observed as expected

Summary of mixing results



- New simultaneous measurement of Δm_d and τ_{B0} with the exclusive $B^0 \to D^{*-} l^+ \nu_l$ sample

Preliminary

$\Delta m_d = 0.492 \pm 0.018 \pm 0.013$ ps^{-1}

$\tau_{B0} = 1.523^{+0.024}_{-0.023} \pm 0.022$ ps

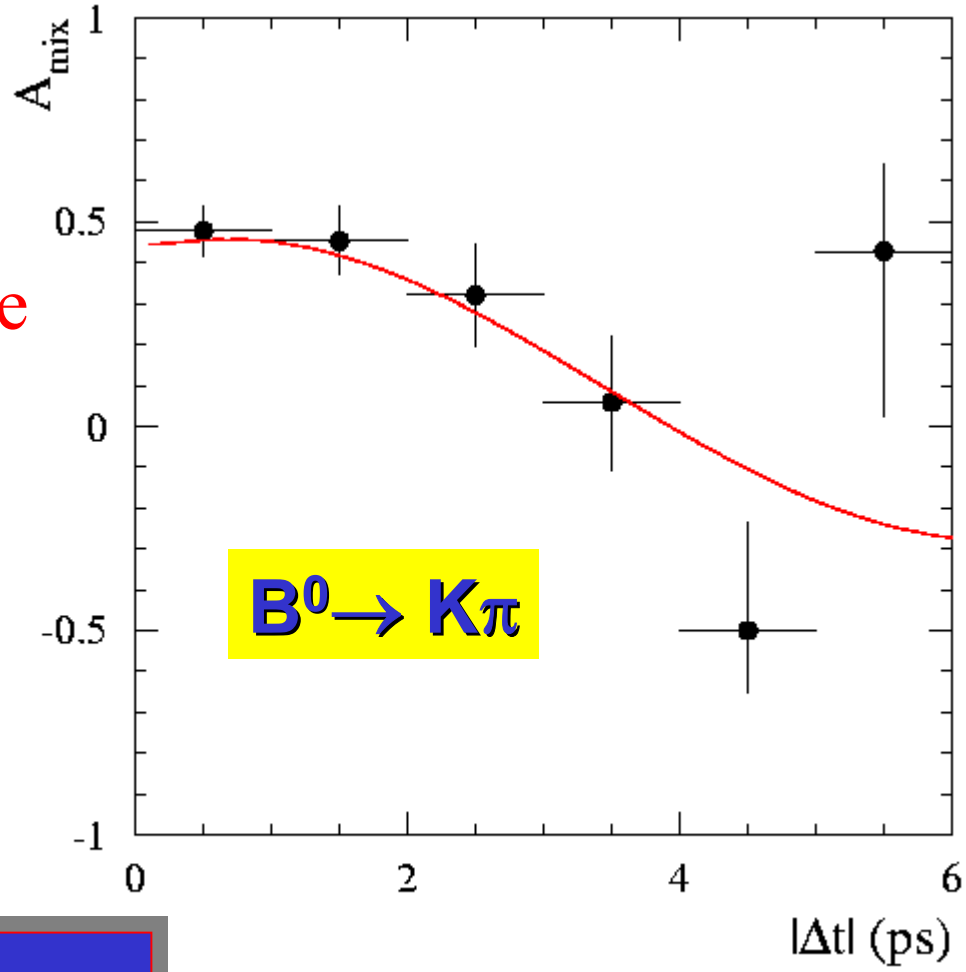
- Combined BaBar result for B_d mixing frequency:

$\Delta m_d = 0.500 \pm 0.008 \pm 0.006$ ps^{-1}

Validation test

From $B^0 \rightarrow K\pi$ we measure

- Life time τ
- Δm_d



$$\tau = (1.56 \pm 0.07)\, ps$$

$$\Delta m_d = (0.517 \pm 0.048)\, ps^{-1}$$

WA

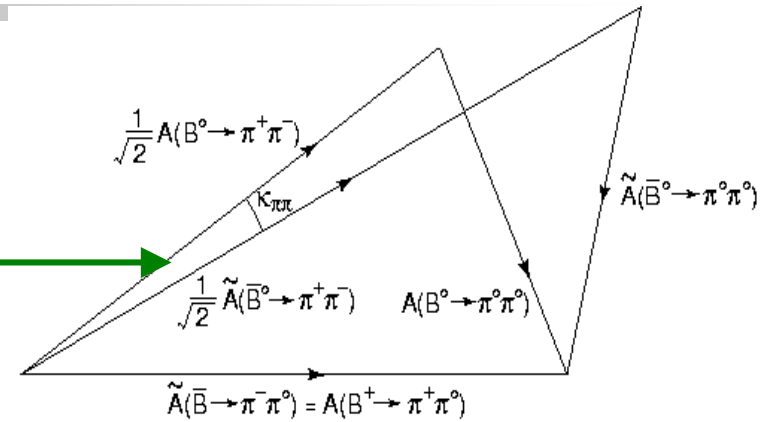
τ=1.540±0.014 ps

Δm_d=0.503 ± 0.006 ps^{-1}

From α_{eff} to α

- Isospin analysis is required to extract α

$$2\alpha_{\text{eff}} = 2\alpha + \kappa_{\pi\pi}$$



- Need to measure

$B^{\pm} \to \pi^{\pm}\pi^0 \quad B^0 \to \pi^0\pi^0 \quad$ *and* $\quad \overline{B^0} \to \pi^0\pi^0$

➢ Or put a limit on $BR(B^0 \to \pi^0\pi^0)$

$$\left|2\alpha - 2\alpha_{eff}\right| \le \arccos\left[\frac{1}{\sqrt{1 - C_{\pi\pi}^2}}\left(1 - 2\frac{BR(\pi^0\pi^0)}{BR(\pi^{\pm}\pi^0)}\right)\right]$$

Grossman-Quinn
Charles

Branching fractions / direct CP violation

- Maximum Likelihood to extract branching ratios and Kπ asymmetries
- No tagging or vertexing needed

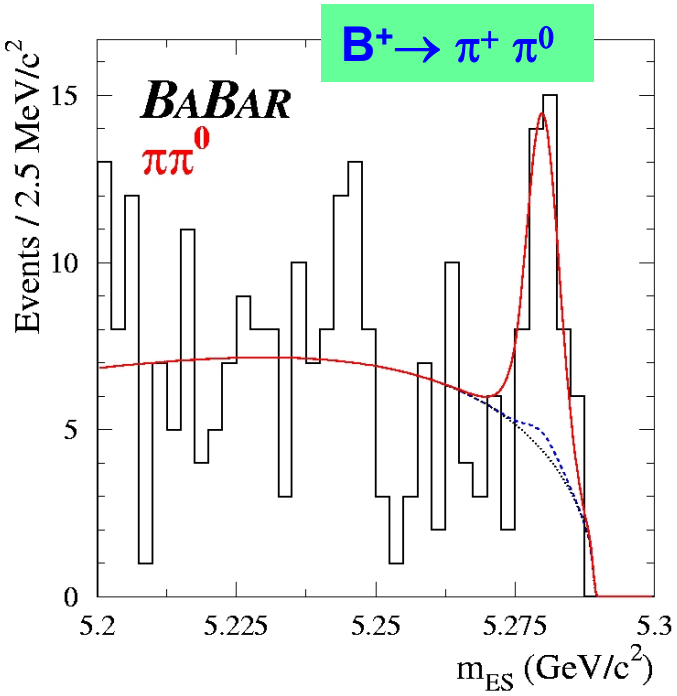
Direct CP violation

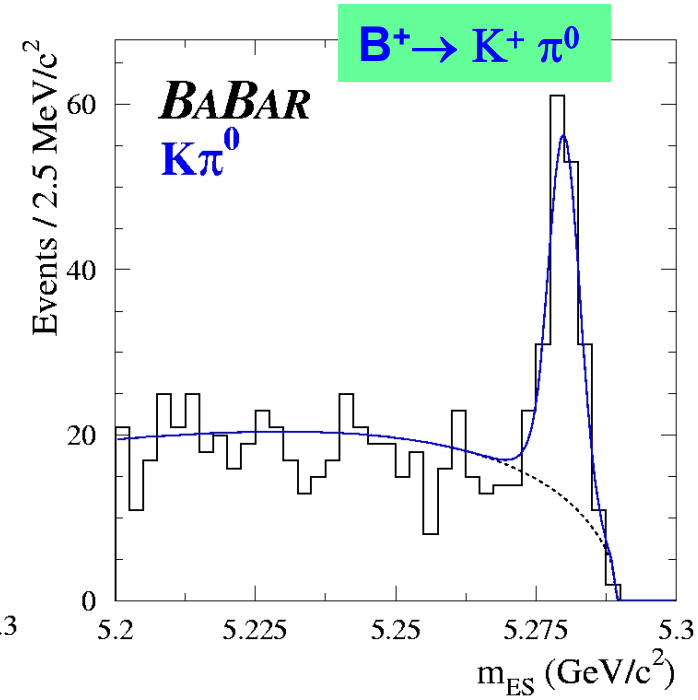
$$A_{K\pi} \equiv \frac{Br(\overline{B^0} \to K^-\pi^+) - Br(B^0 \to K^+\pi^-)}{Br(\overline{B^0} \to K^-\pi^+) + Br(B^0 \to K^+\pi^-)} \sim \left|\frac{P}{T}\right| \sin(\gamma)\sin(\delta)$$

Mode	Yield	BR (10^{-6})	($A_{K\pi}$)
$B^0 \to \pi^+\pi^-$	157 ± 19	4.7 ±0.6 ±0.2	
$B^0 \to K^+\pi^-$	589 ± 30	17.9 ±0.9 ±0.7	-0.102 **±0.050 ±0.016**
$B^0 \to K^+K^-$	1 ± 8	<0.6 (90%CL)	

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

- $B^+ \to \pi^+ \pi^0$ pure tree, no direct CP expected





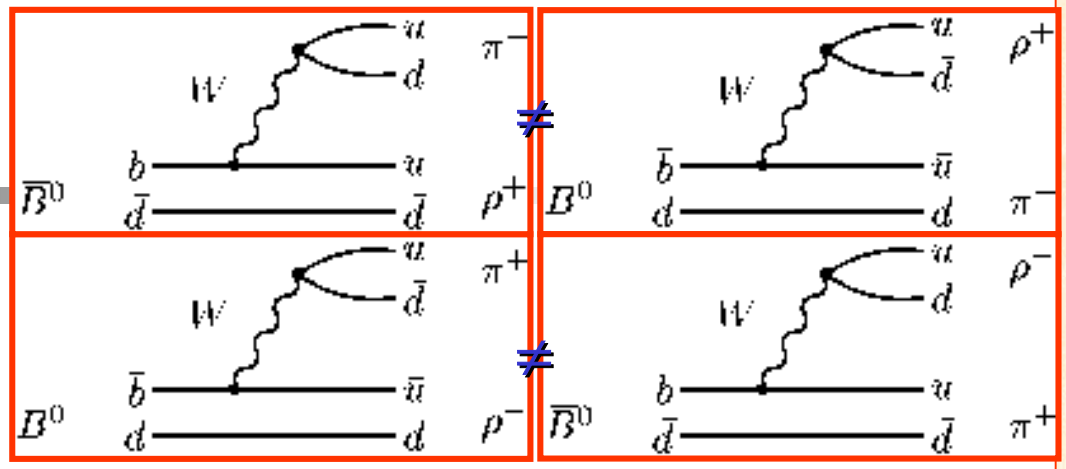
Mode	Yield	BR (10^{-6})	A
$B^0 \to \pi^+\pi^0$	$125^{+23}_{-21} \pm 10$	$5.5^{+1.0}_{-0.9} \pm 0.6$	$-0.03^{+0.18}_{-0.17} \pm 0.02$
$B^0 \to K^+\pi^0$	$239^{+21}_{-22} \pm 6$	$12.8^{+1.2}_{-1.1} \pm 1.0$	$-0.09 \pm 0.09 \pm 0.01$
$B^0 \to K^0\pi^0$	$86 \pm 13^{+3}_{-2}$	$10.4 \pm 1.5 \pm 0.8$	$0.03 \pm 0.36 \pm 0.09$

$B^0 \to \rho\pi$

$Br(B \to \rho\pi) = (28.9 \pm 5.4 \pm 4.3) \times 10^{-6}$

Not a CP eigenstate

Four amplitudes



$$f^{\rho^\pm h^\mp}_{B^0 tag} = (1 \pm A_{CP}{}^{\rho h})\left[1 + \frac{\Delta D}{2} + \langle D \rangle \left((S_{\rho h} \pm \Delta S_{\rho h}) \sin(\Delta m \Delta t) - (C_{\rho h} \pm \Delta C_{\rho h}) \cos(\Delta m \Delta t) \right)\right]$$

Tagging dilution

No CP

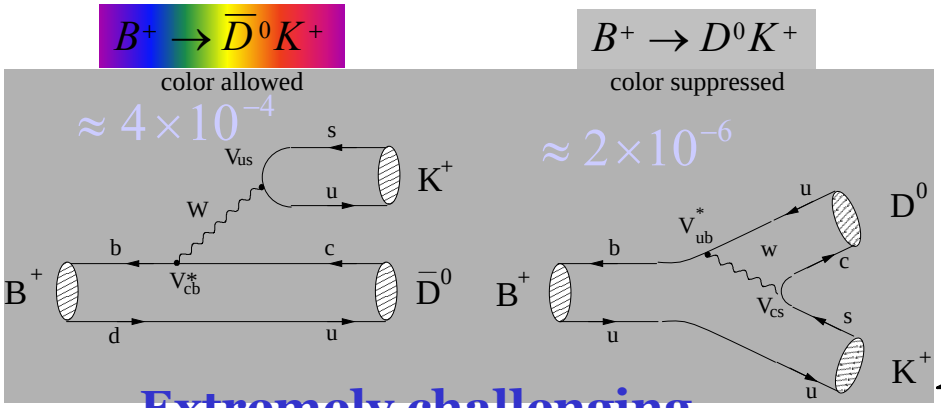
$$A_{B^0/\overline{B}^0} \square S_{\rho\pi} \sin(\Delta m_d \Delta t) - C_{\rho\pi} \cos(\Delta m_d \Delta t)$$

$\Delta C_{\rho\pi} \square 0.4$ ← From naïve factorization

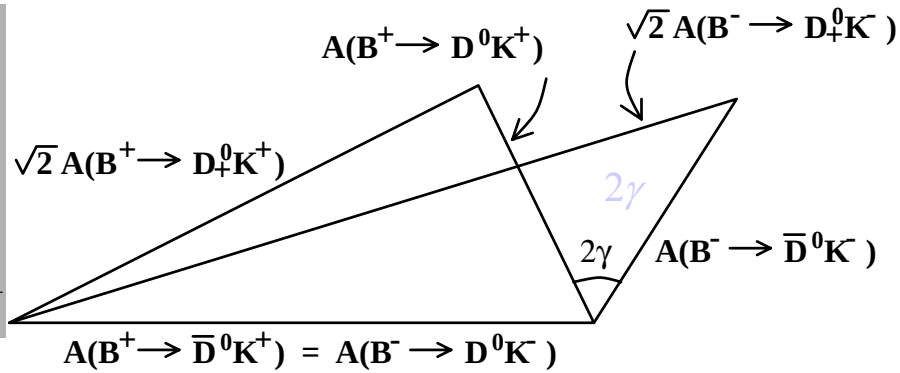
$\Delta S_{\rho\pi}$ ← Sensitive to phase differences

Measuring γ with B to DK Decays

Original theoretical construction due to **Gronau&Wiler**:



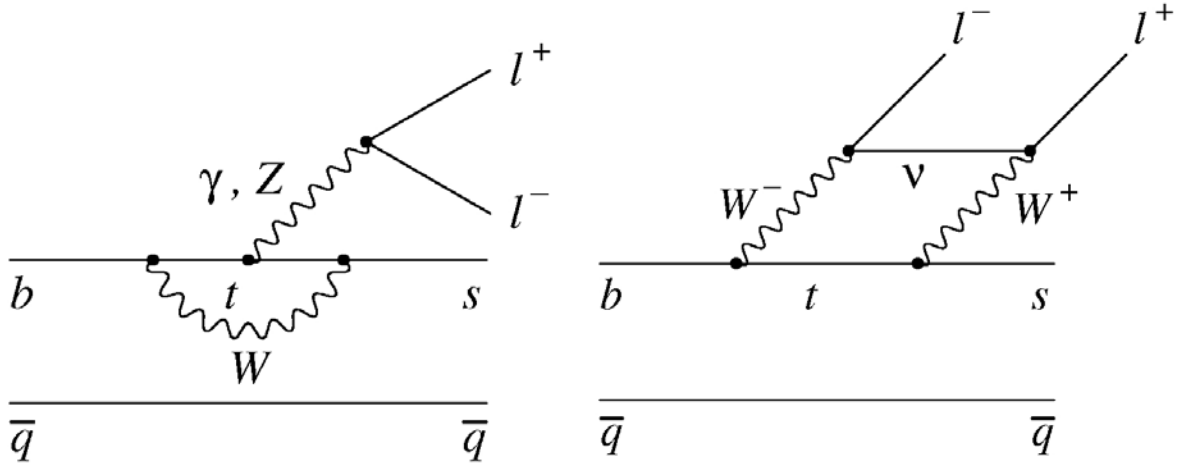
Extremely challenging experimentally!



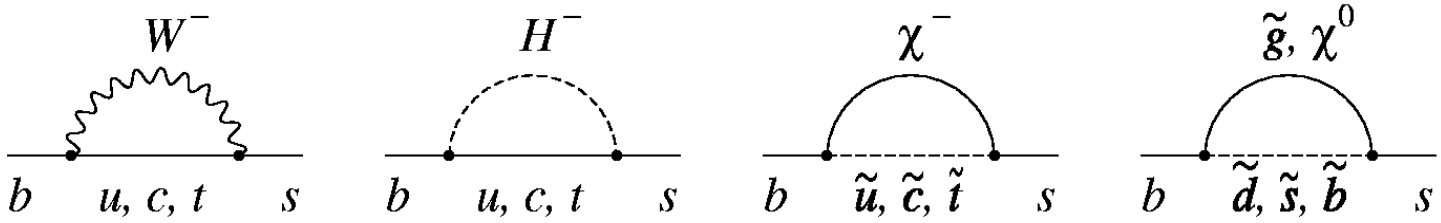
if $\gamma \neq 0$, $\left|A(B^+ \to D_+^0 K^+)\right| \neq \left|A(B^- \to D_+^0 K^-)\right|$

- Very low branching fractions : $B^+ \to K^+\left[D^0 \to K^-\pi^+\right]$ of order 10^{-7}
- The doubly Cabbibo-suppressed channel $B^+ \to K^+\left[\bar{D}^0 \to K^-\pi^+\right]$ is also of order $10^{-7} \Rightarrow$ use semileptonic decays?
- CP - eigenstate decays $D_+^0 \to \pi^+\pi^-, K^+K^-$ have low BF and/or S/B ratios
- In any case, this kind of analysis would require **at least 300 fb^{-1} of data**!

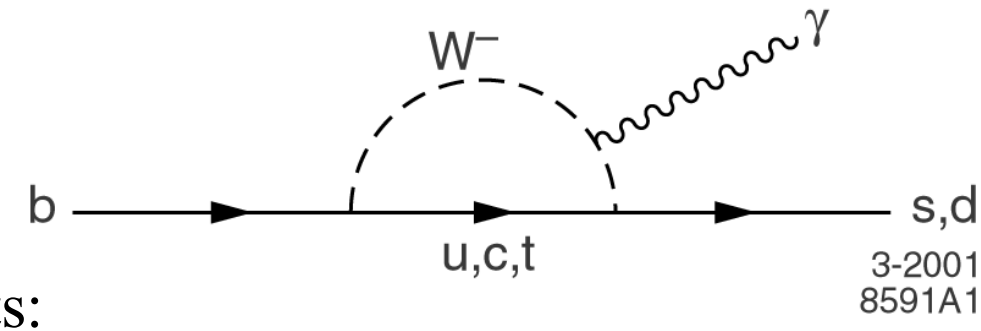
$B \to K^{(*)} l^+ l^-$: standard model and beyond



- $B \to K^{(*)} l^+ l^-$: sensitive to Wilson coefficients C_7, C_9, C_{10} in OPE
- $B \to K^* \gamma$: depends on $|C_7|$
- New, heavy particles can enter the loop and enhance rate by 2x.



Radiative Penguins: b –> $s\gamma$, d γ



<u>Exclusive Measurements</u>:

$B(\mathrm{B} \longrightarrow \mathrm{K}^*\gamma)$ QCD test

$A_{cp}(\mathrm{B} \longrightarrow \mathrm{K}^*\gamma)$ Non SM CP violation

$B(\mathrm{B} \longrightarrow \rho\gamma)/B(\mathrm{B} \longrightarrow \mathrm{K}^*\gamma)$ Constrain V_{td}/V_{ts}

<u>Inclusive Measurements</u>:

$B(b \longrightarrow s\gamma)$ Constrain new physics

E_γ spectrum from $b \longrightarrow s\gamma$ Mass and Fermi motion of b

Fully Inclusive $B \rightarrow X_s\gamma$

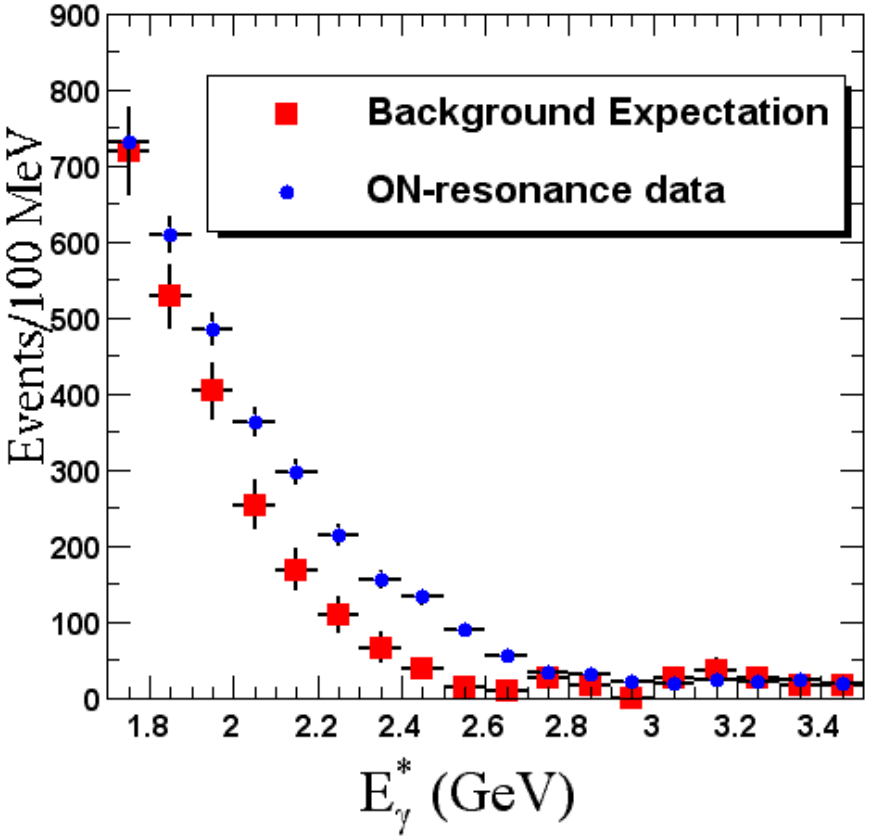
61 x 106 BB (54.6 fb^{-1})

Continuum Subtraction with
6.4 fb^{-1} of "off-resonance" data

BB subtraction with Monte Carlo

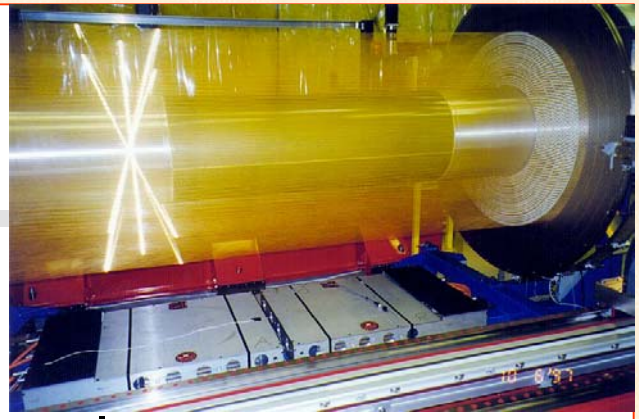
Subtraction assumed 4±1.6% $b \rightarrow d\gamma$

Signal Region was "blinded"



$B(B \rightarrow X_s\gamma) = 3.88 \pm 0.36(\text{stat.}) \pm 0.37(\text{sys.}) +0.43/-0.28\ (\text{theory}) \times 10^{-4}$

Detector Prognosis



- With due care and feeding, most detector systems will work up to ~2 x 10^{34} and should last for several years.
- Drift CHamber; DIRC; and E M Calorimeter
  - radiation aging tests show they should last
  - Significant modifications in electronics likely to be needed
- Silicon Vertex Tracker (SVT)
  - Spare modules under construction for installation in 2004
  - Radiation damage tests indicate lifetime > 5 Mrad (2.5 x design)
- Instrumented Flux Return (IFR)
  - Muon ID will be improved by adding material
    - ⇒ **Upgrade forward endcap in 2002 (now!)**
  - Concerns because of decreasing RPC efficiency Barrel
    - ⇒ **Will address it in 2004**