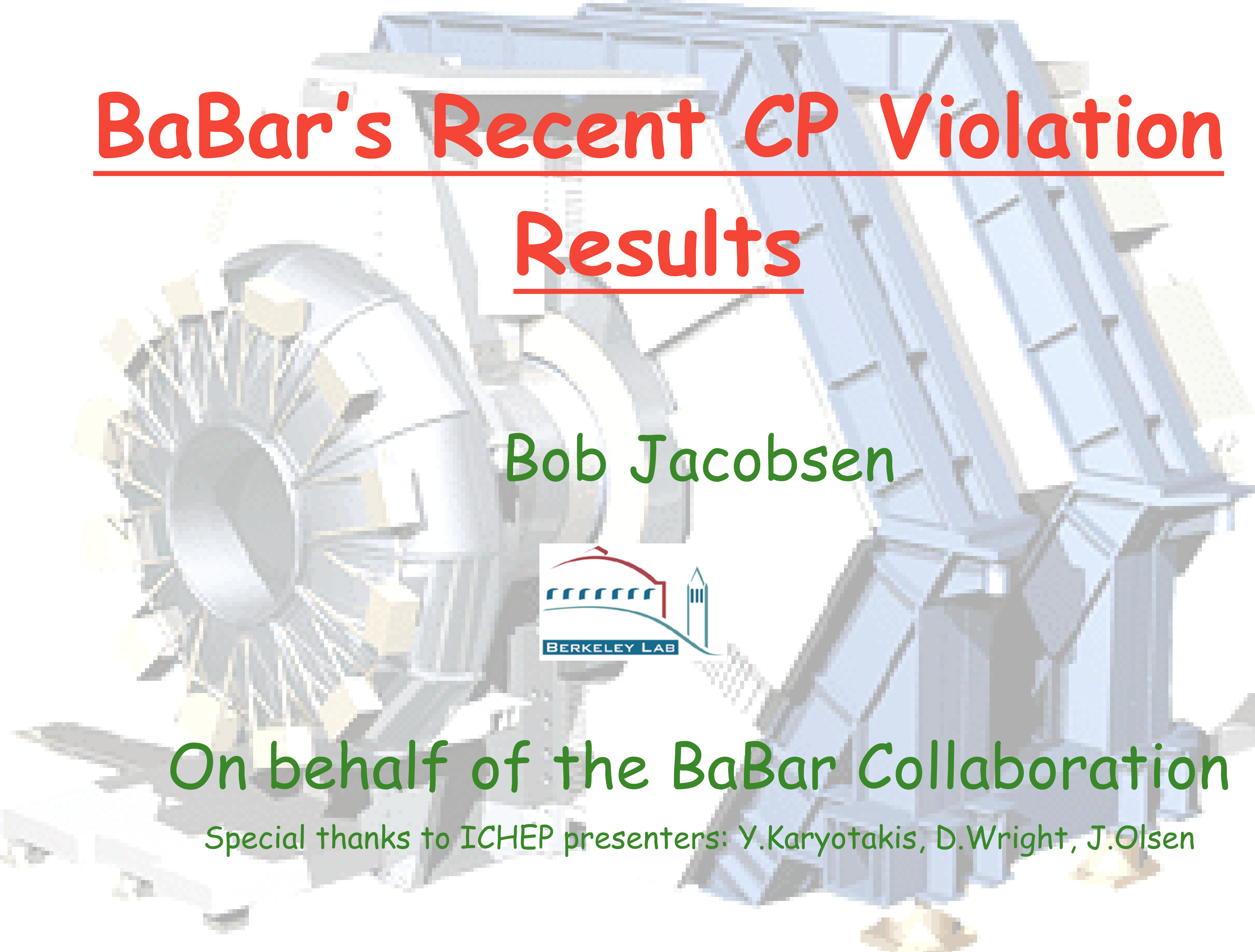


BaBar's Recent CP Violation Results

Bob Jacobsen

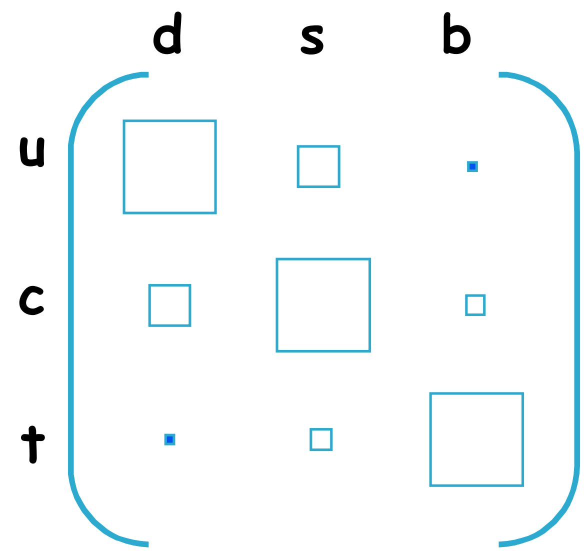
On behalf of the BaBar Collaboration

Special thanks to ICHEP presenters: Y.Karyotakis, D.Wright, J.Olsen

Outline

- Physics background
- Status of PEPII & The BaBar Experiment
- Measurement of sin2□
  - □ Golden Modes (b□ ccs)
  - □ Tree + Penguin modes (b□ dds)
  - □ Pure Penguin modes (b□ sss)
- Measurement of sin2□ $_{effective}$
  - □ CP violating asymmetries
    - □ □□ □□, □□
  - □ □ □ h□^{0}, □^{0}□^{0} branching ratios
- Direct CP asymmetries
- Conclusion

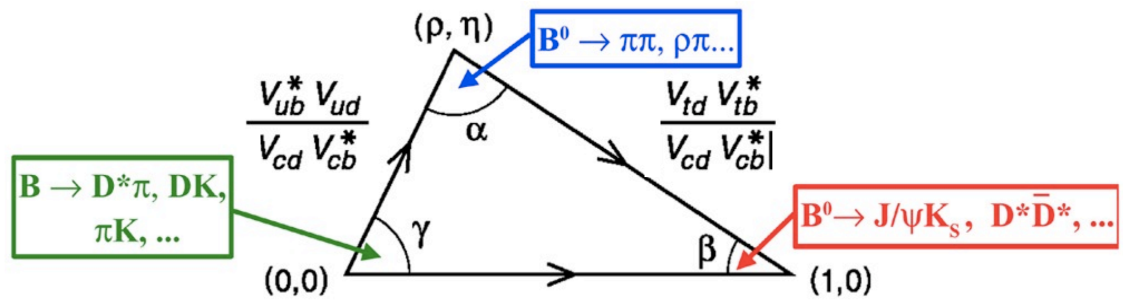
Standard Model mechanism for CP violation



From CKM unitarity

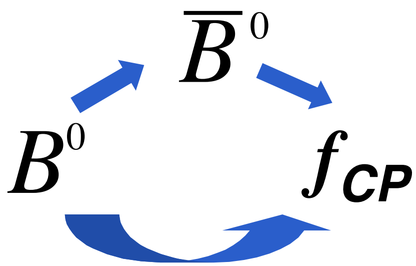
$$V_{ud}V_{ub}^{*} + V_{cd}V_{cb}^{*} + V_{td}V_{tb}^{*} = 0$$

UT



All angles related to □ and □

Mixing introduces time-dependant CP violation



$$|B_{L,H}\rangle = p|B^0\rangle \pm q|\overline{B}^0\rangle \qquad \frac{q}{p} \sim \frac{V_{td}}{V_{td}^*}$$

$$\Delta m_d = m_H - m_L$$

$$\lambda_f = \frac{q}{p}\frac{A(\overline{B}^0 \to f_{CP})}{A(B^0 \to f_{CP})}$$

$$f_- = \Gamma(B^0 \to f_{CP})$$
$$f_+ = \Gamma(\overline{B}^0 \to f_{CP})$$

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

$$A_{fCP}(t) = \frac{\Gamma(\overline{B}^0_{phys} \to f_{CP}) - \Gamma(B^0_{phys} \to f_{CP})}{\Gamma(\overline{B}^0_{phys} \to f_{CP}) + \Gamma(B^0_{phys} \to f_{CP})} = \frac{2\,\mathrm{Im}\,\lambda}{1+|\lambda|^2}\sin(\Delta m_d t) - \frac{1-|\lambda|^2}{1+|\lambda|^2}\cos(\Delta m_d t)$$

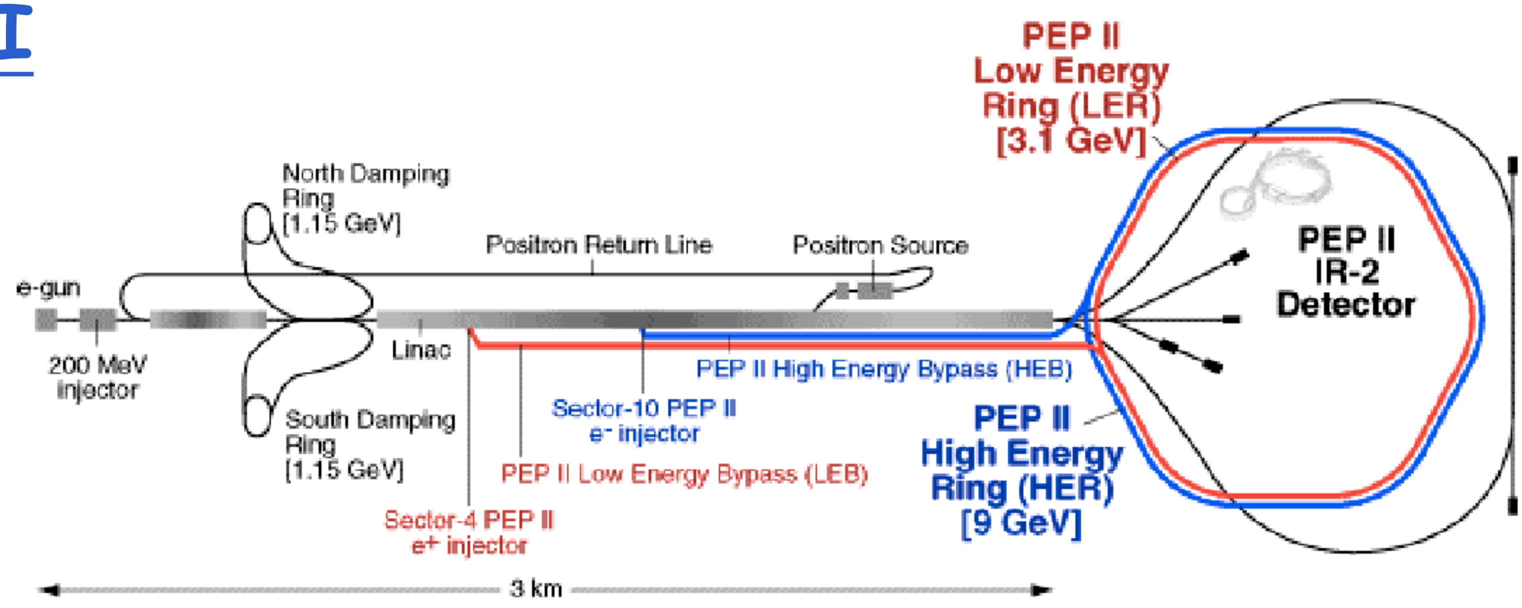
$$S_f = \frac{2\,\mathrm{Im}\,\lambda_f}{1+|\lambda_f|^2}$$

Sensitive to overall phase of λ_f even if no Direct CP Violation

$$C_f = \frac{1-|\lambda_f|^2}{1+|\lambda_f|^2}$$

Direct CP violation if multiple amplitudes with different phases

PEPII



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

- Peak Luminosity = 4.60×10^{33} cm^{-2} s^{-1} (3×10^{33} cm^{-2} s^{-1} design)
- Positron current = 1775 mA Electron current = 1060 mA
- Number of bunches = 800 IP beam sizes = 147 μm $\times$ 5 μm

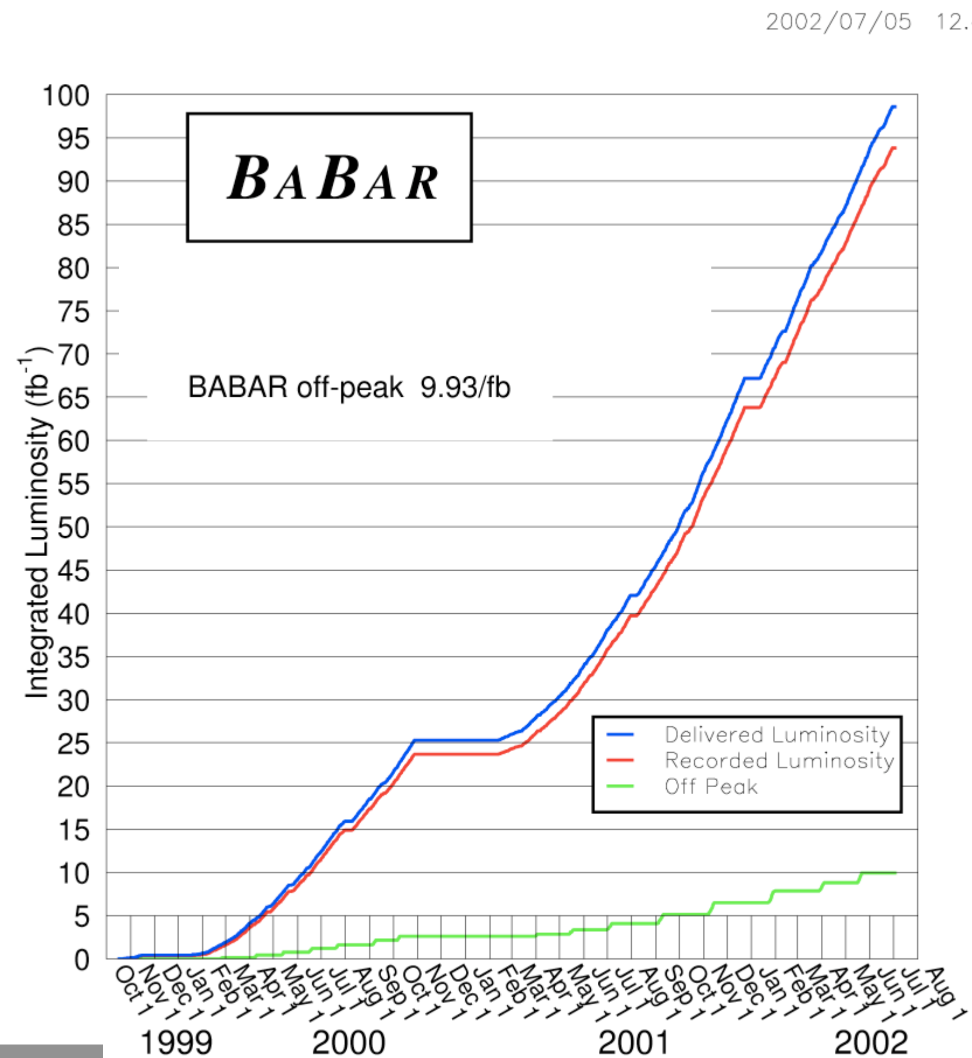
Data sample

PEPII delivered ~99 fb^{-1}

BaBar recorded ~94 fb^{-1}

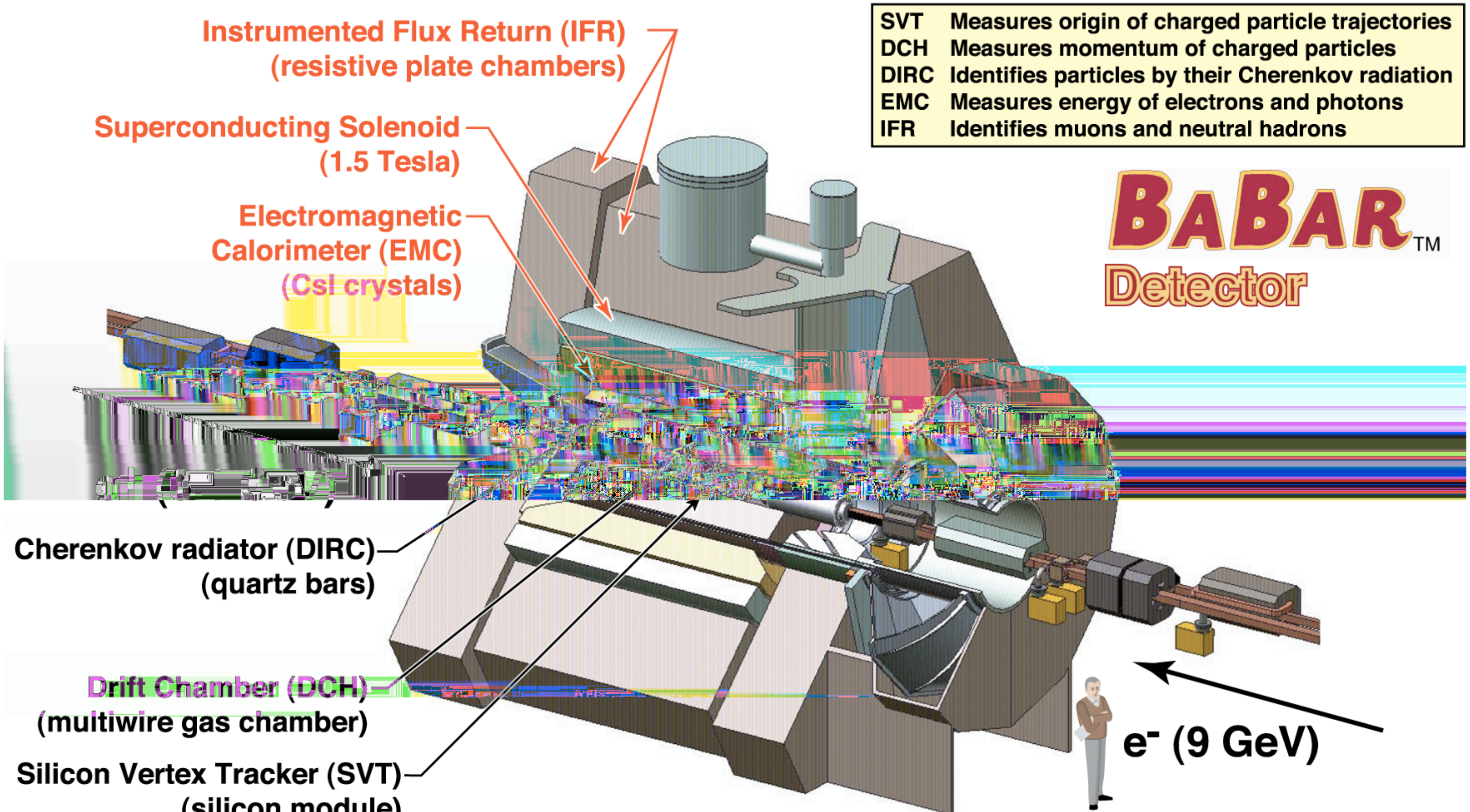
Used in the analysis

- 81.2 fb^{-1} on peak
- 9.6 fb^{-1} off-peak



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

BABAR Detector



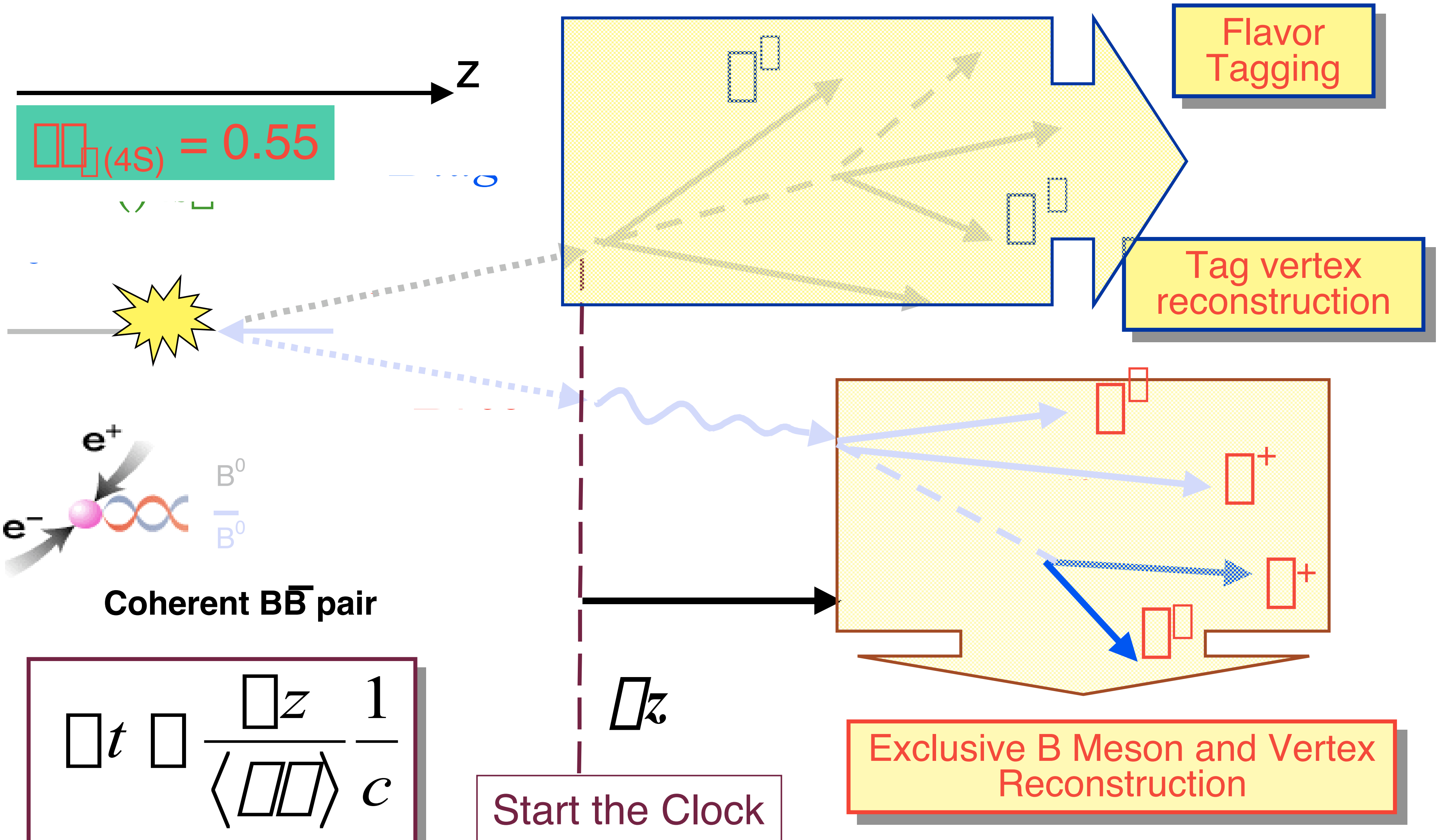
SVT: 97% efficiency, 15 μm z hit resolution (inner layers, perp. tracks)

SVT+DCH: $\sigma(p_T)/p_T = 0.13\,\% \times p_T + 0.45\,\%$

DIRC: K-π separation 4.2 σ @ 3.0 GeV/c → 2.5 σ @ 4.0 GeV/c

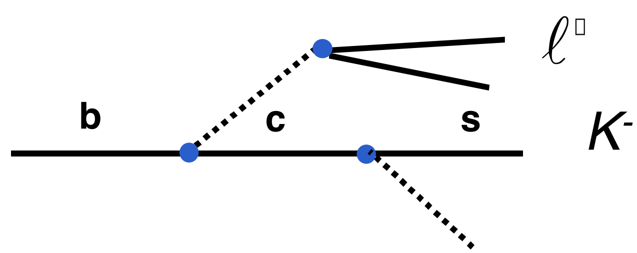
EMC: $\sigma_E/E = 2.3\,\% \cdot E^{-1/4} \oplus 1.9\,\%$

Experimental measurement



$$\Delta t \approx \frac{\Delta z}{\langle \beta\gamma \rangle} \frac{1}{c}$$

B Flavor tagging method



Using tracks with or without particle identification, and kinematic variables, a multilevel neural network assigns each event to one of five mutually-exclusive categories:

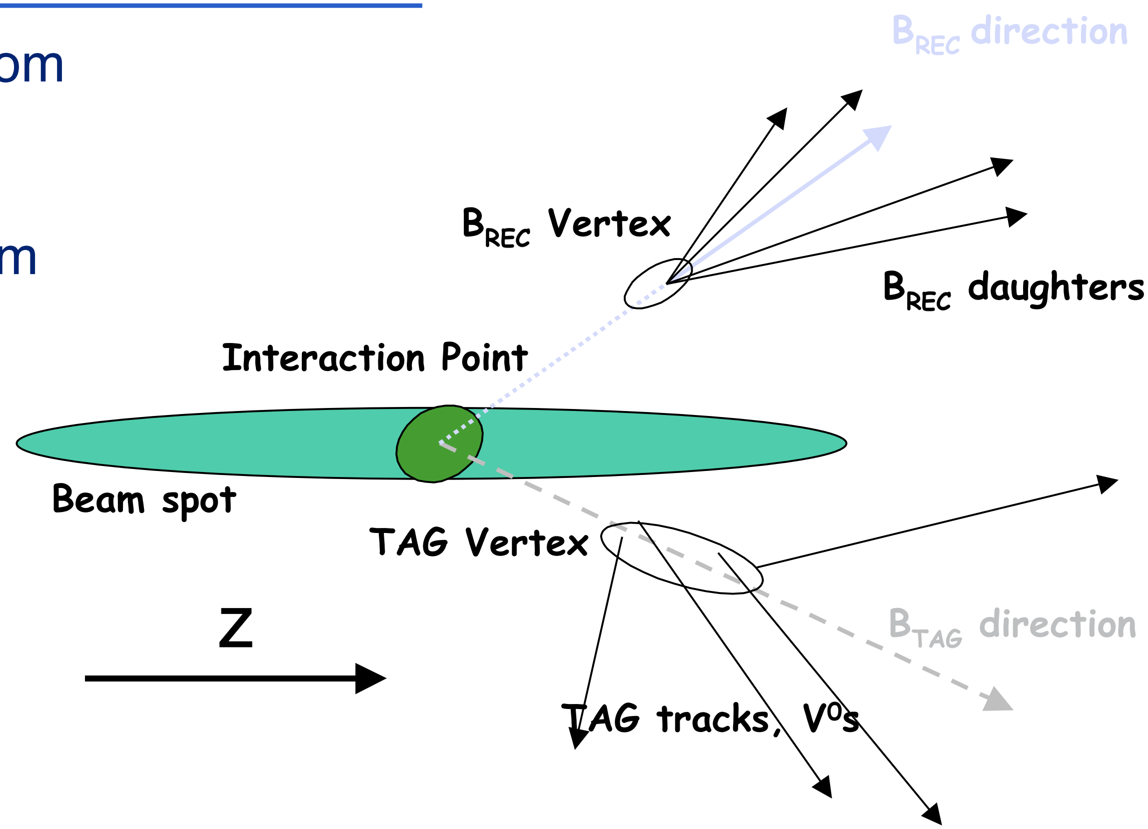
- Lepton tag: primary leptons from semileptonic decay
- Kaon1 tag: high quality kaons, correlated K^- *and* p^+_s (from D^*)
- Kaon2 tag: lower quality kaons, p_s from D^*
- Inclusive tag: unidentified leptons, low quality *K, p,* leptons
- No tag: event is not used for CP analysis

New and improved tagging method

Q=28.1 ± 0.7 % *Compared to Q=26.0 ± 0.8*

Vertex and Δt Reconstruction

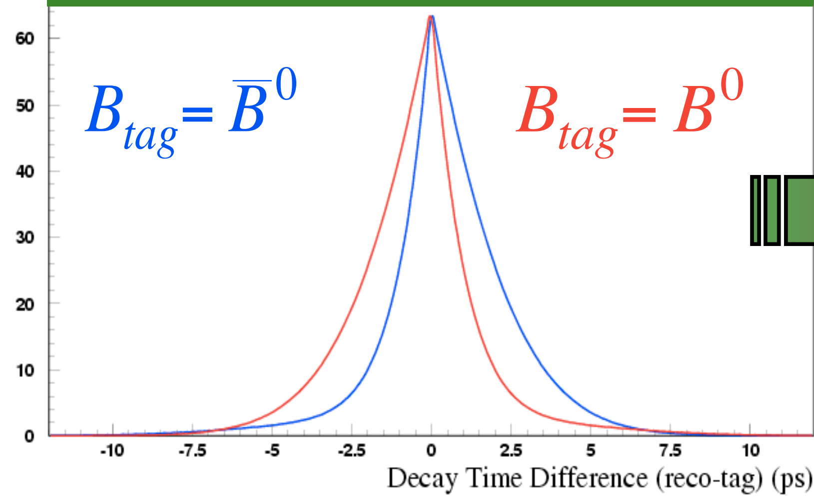
- Reconstruct B_{rec} vertex from charged B_{rec} daughters
- Determine B_{Tag} vertex from
  - All charged tracks not in B_{rec}
  - Constrain with B_{rec} vertex, beam spot, and ϒ(4S) momentum
  - Remove high χ^2 tracks (to reject charm decays)



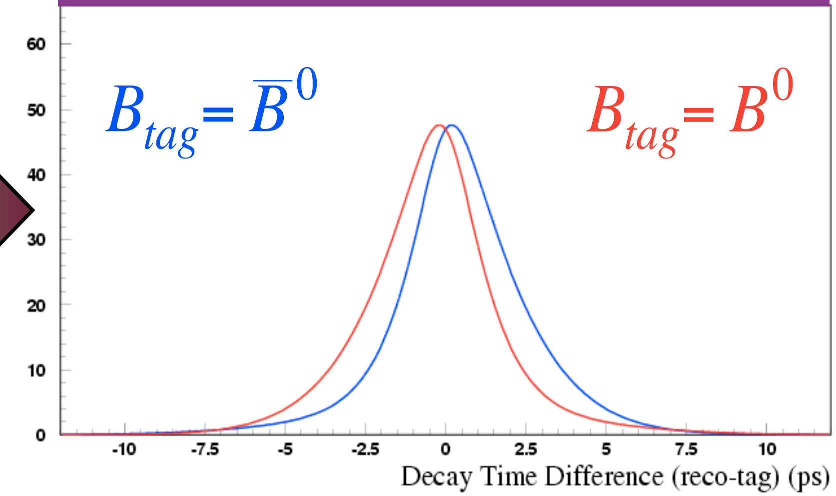
- High efficiency: 95%
- Average Δz resolution ~ 180 μm (dominated by B_{Tag}) (<|Δz|> ~ 260 μm)
- Δt resolution function measured from data

Tagging errors and finite Δt resolution dilute the CP asymmetry

perfect
tagging & time resolution



typical
mistagging & finite time resolution

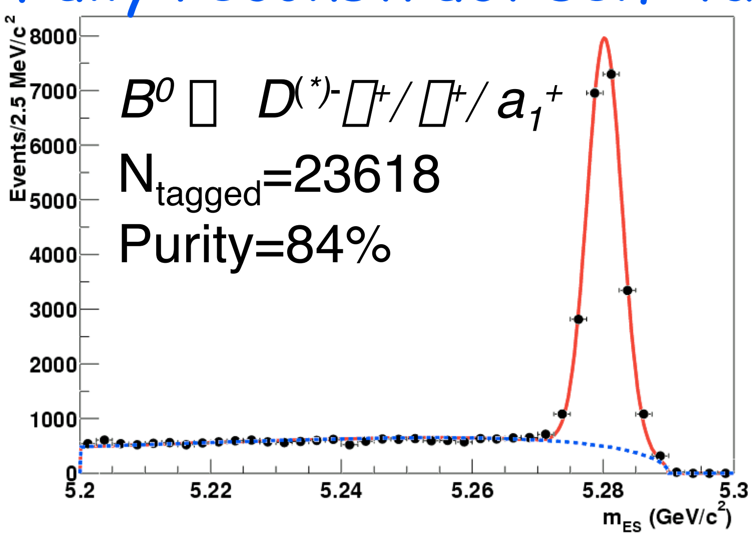


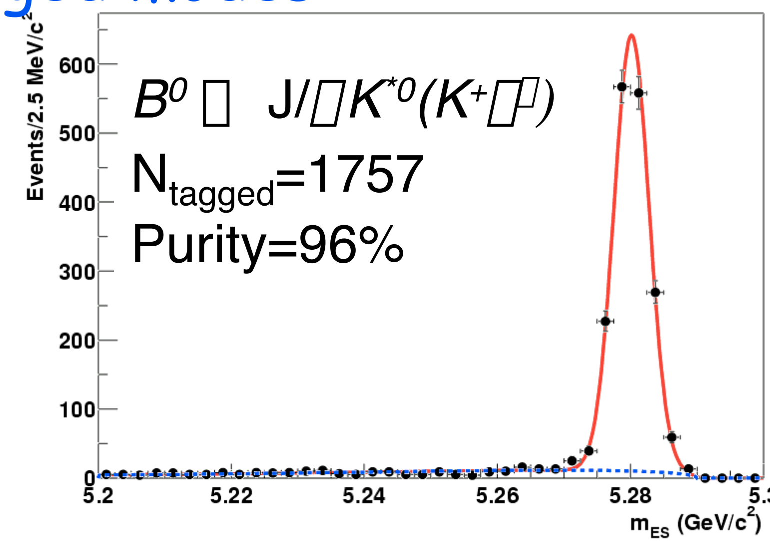
$$f(\Delta t) = \left(\frac{e^{-|\Delta t|/\tau_B}}{4\tau_B} \left[1 \mp \eta_f \sin 2\beta (1 - 2w) \sin(\Delta m_d \Delta t)\right] \right) \otimes R$$

- Need to know mistag fraction w and Δt resolution function R in order to measure CP asymmetry.
- Can extract these from data with B^0-$\bar{B}^0$ mixing events.

Use self-tagged B_{flav} sample to measure *w* and *R*

- Fully reconstruct self-tagged modes:





- Apply B_{tag} to other side, fit for B^0-$\bar{B}^0$ mixing

$$f_{\substack{Unmixed\\Mixed}}(\Delta t) = \left\{ \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B} \left[1 \pm (1-2w)\cos(\Delta m_d \Delta t)\right] \right\} \otimes R$$

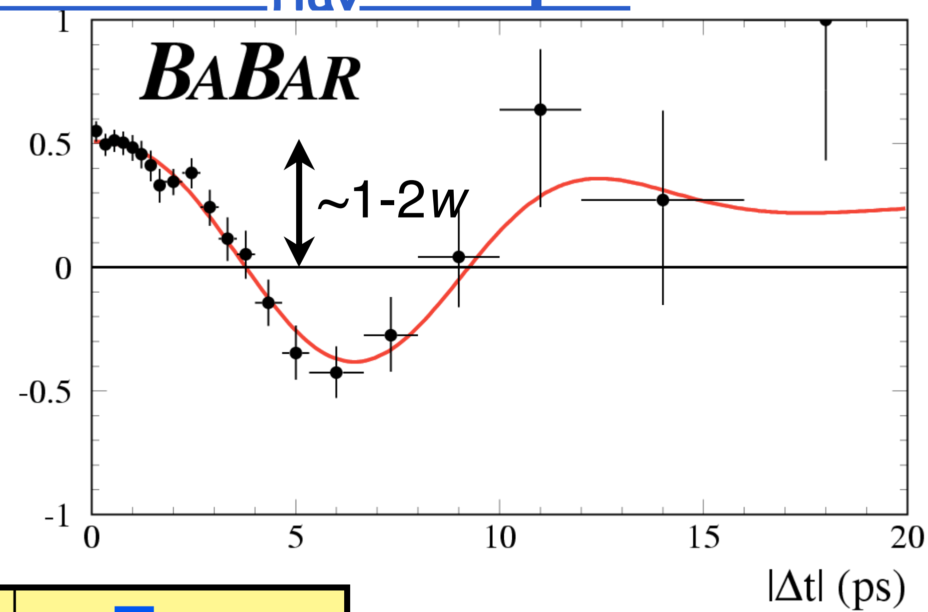
B_{flav} sample is x10 size of CP sample

Tagging performance from B_{flav} sample

$$A_{mixing} = \frac{N_{unmixed} - N_{mixed}}{N_{unmixed} + N_{mixed}}$$

$$\approx (1 - 2w)\cos(\Delta m_d \Delta t)$$

$$\sigma(\sin 2\beta) \propto \frac{1}{\sqrt{Q}}$$

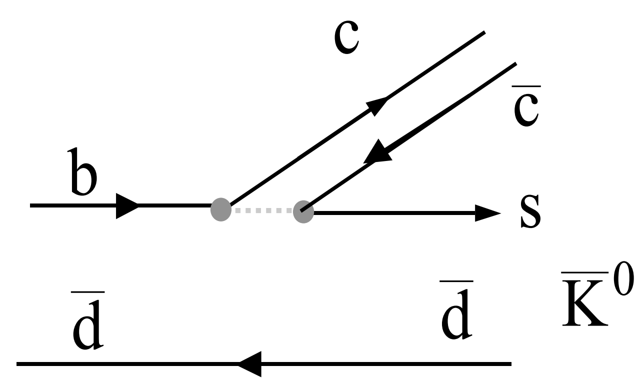


Category	Efficiency (ε)	Mistag Fr. (w)	$Q=\varepsilon(1-2w)^2$
Lepton	9.1 ± 0.2	3.3 ±0.6	7.9 ± 0.3
Kaon1	16.7±0.2	9.9 ±0.7	10.7 ± 0.4
Kaon2	19.8 ±0.3	20.9±0.8	6.7 ± 0.4
Inclusive	20.0±0.3	31.6 ±0.9	2.7 ± 0.3
Total	65.6±0.5		28.1 ± 0.7

This new tagging method increases Q by 7% compared to the method used in our previous result: PRL87 (Aug 01).

sin2β ($b \to c\bar{c}s$)

Charmonium states



$\eta_{CP} = -1$

- $B^0 \to J/\psi\ K^0_S$
- $B^0 \to \psi(2s)\ K^0_S$
- $B^0 \to \chi_{c1}\ K^0_S$
- $B^0 \to \eta_c\ K^0_S$

$\eta_{CP} = +1$

- $B^0 \to J/\psi\ K^0_L$

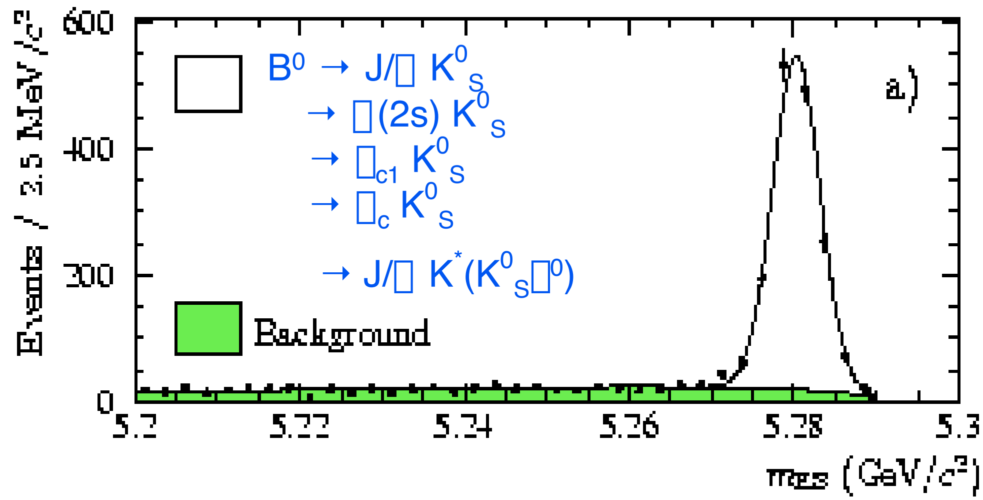
$\eta_{CP} = (1-2R_T)$

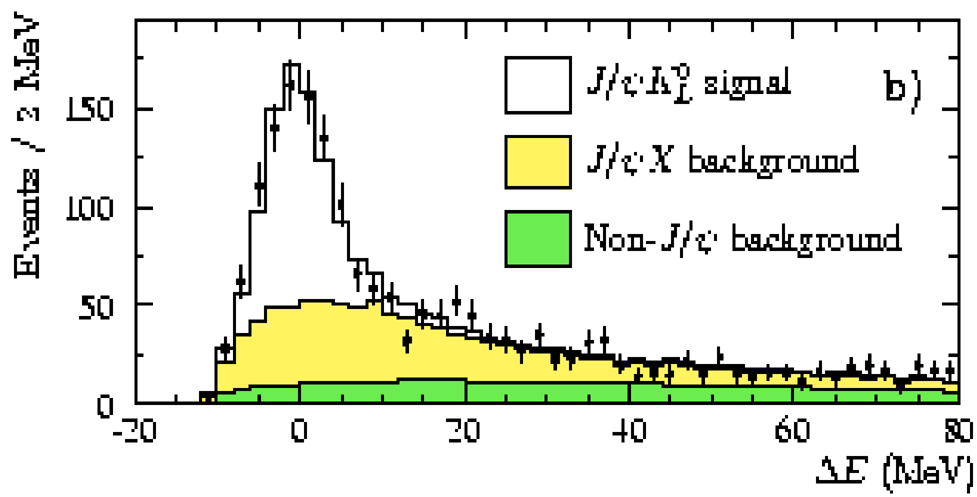
- $B^0 \to J/\psi\ K^*(K^0_S\pi^0)$

$$A_{fCP}(t) = \frac{\Gamma(\bar{B}^0_{phys} \to f_{CP}) - \Gamma(B^0_{phys} \to f_{CP})}{\Gamma(\bar{B}^0_{phys} \to f_{CP}) + \Gamma(B^0_{phys} \to f_{CP})} = -\eta_{CP} \sin(\Delta m_d t)$$

Yields

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
χ_cK_s	80	94.5
η_cK_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**

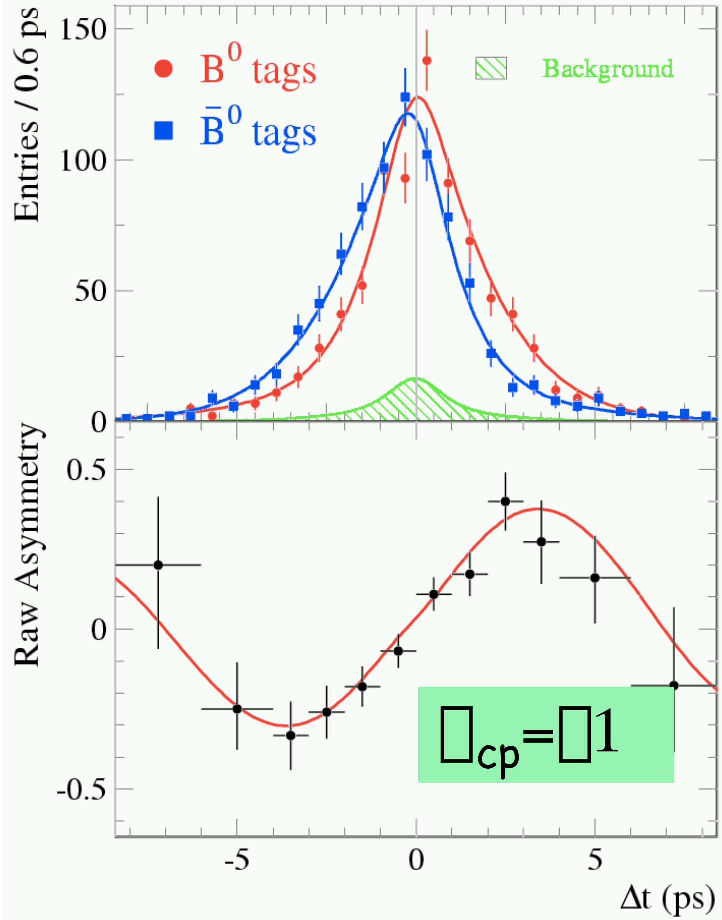


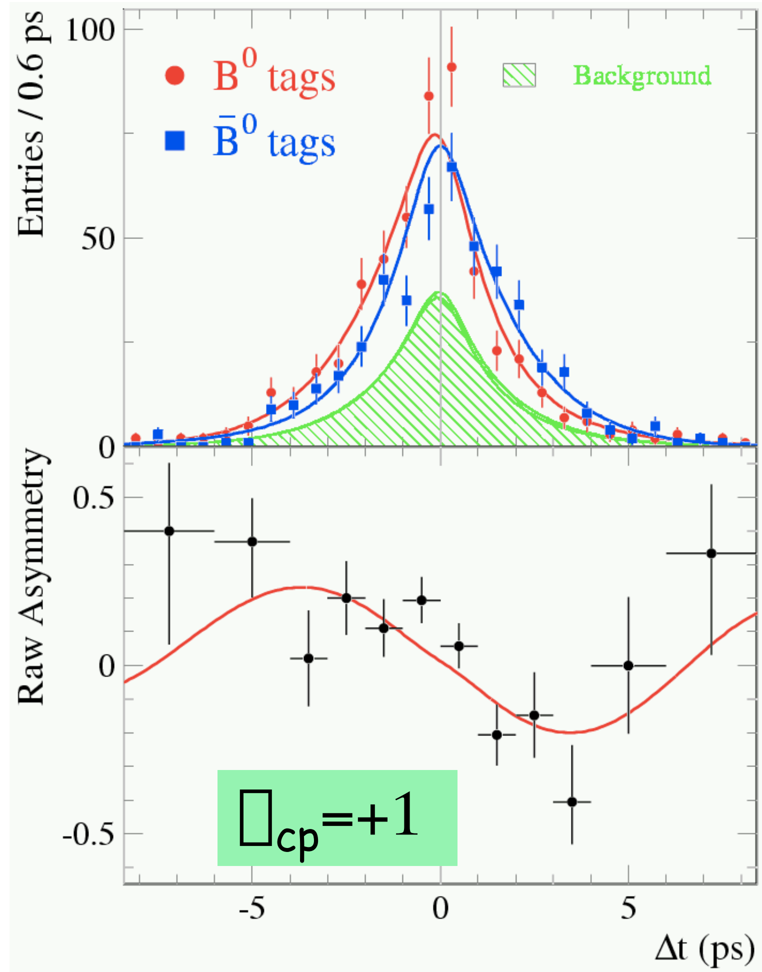


η_c has been added to the sample

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

CP asymmetries



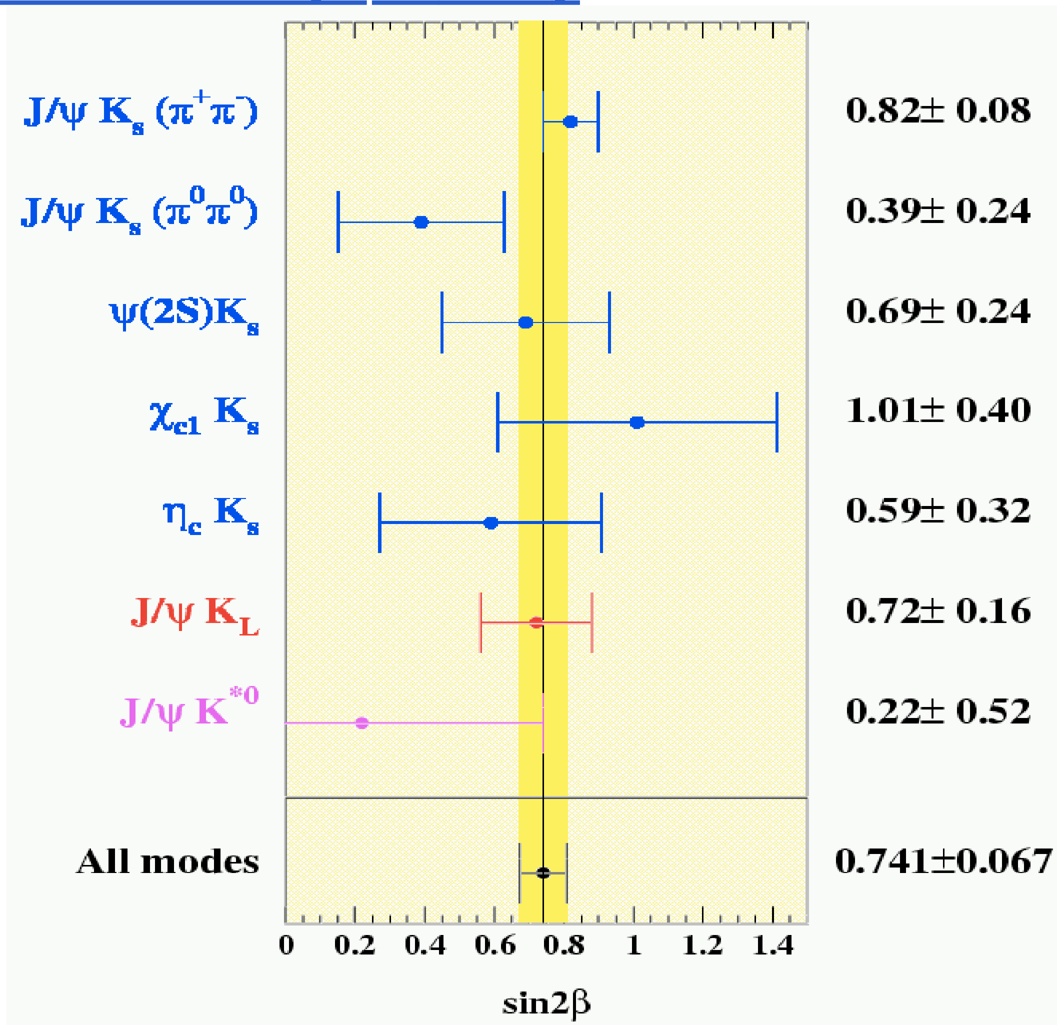


$\sin 2\beta = 0.755 \pm 0.074$ **$\sin 2\beta = 0.723 \pm 0.158$**

$\sin 2\beta = 0.741 \pm 0.067$ (stat) ± 0.033 (syst)

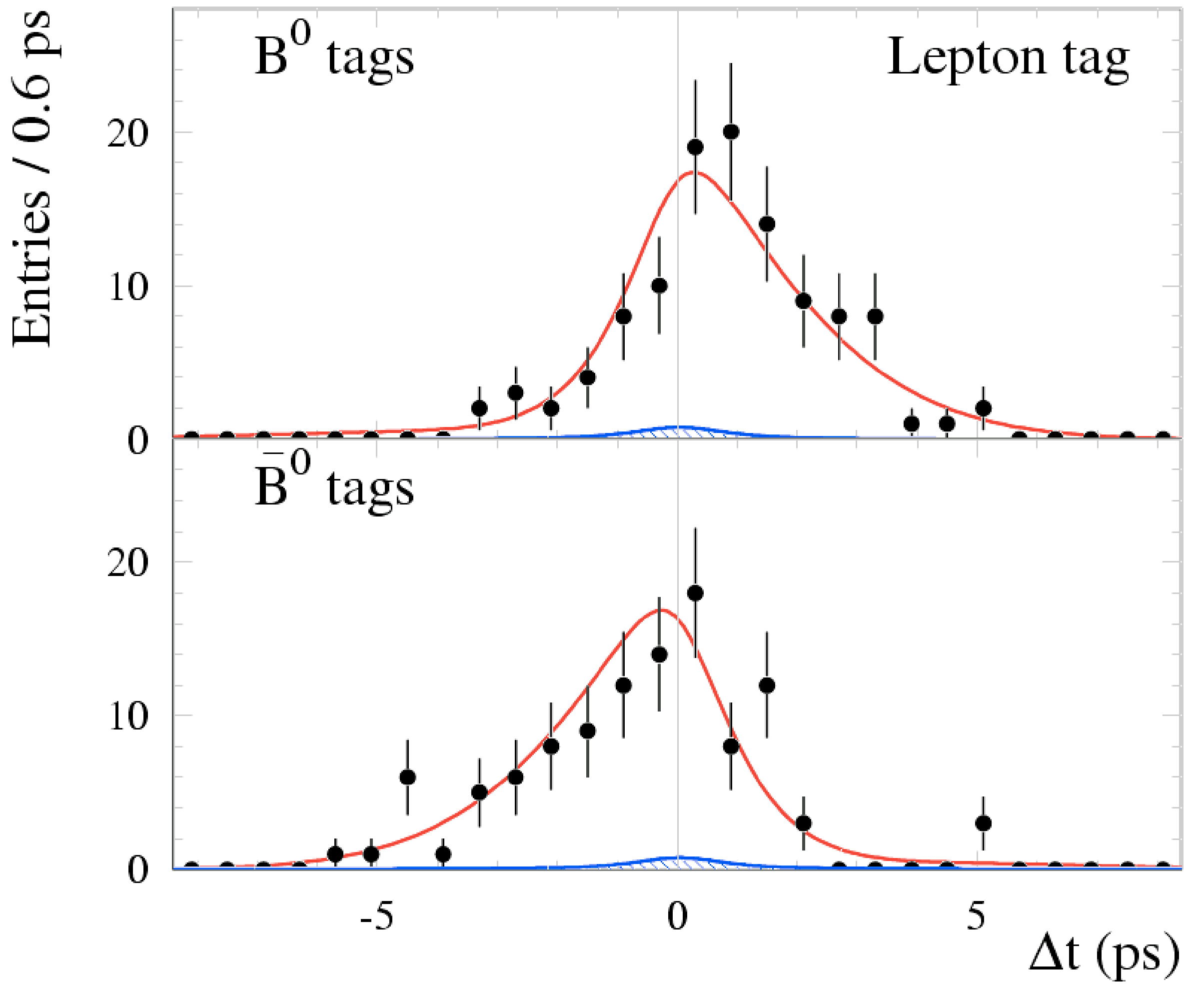
Submitted to PRL, hep-ex/0207042

sin2β results ($b \rightarrow c\bar{c}s$)



All consistent P(χ^2) = 57%

Dramatic effect in golden modes with lepton tag



$(c\bar{c})K_S$ with lepton tag

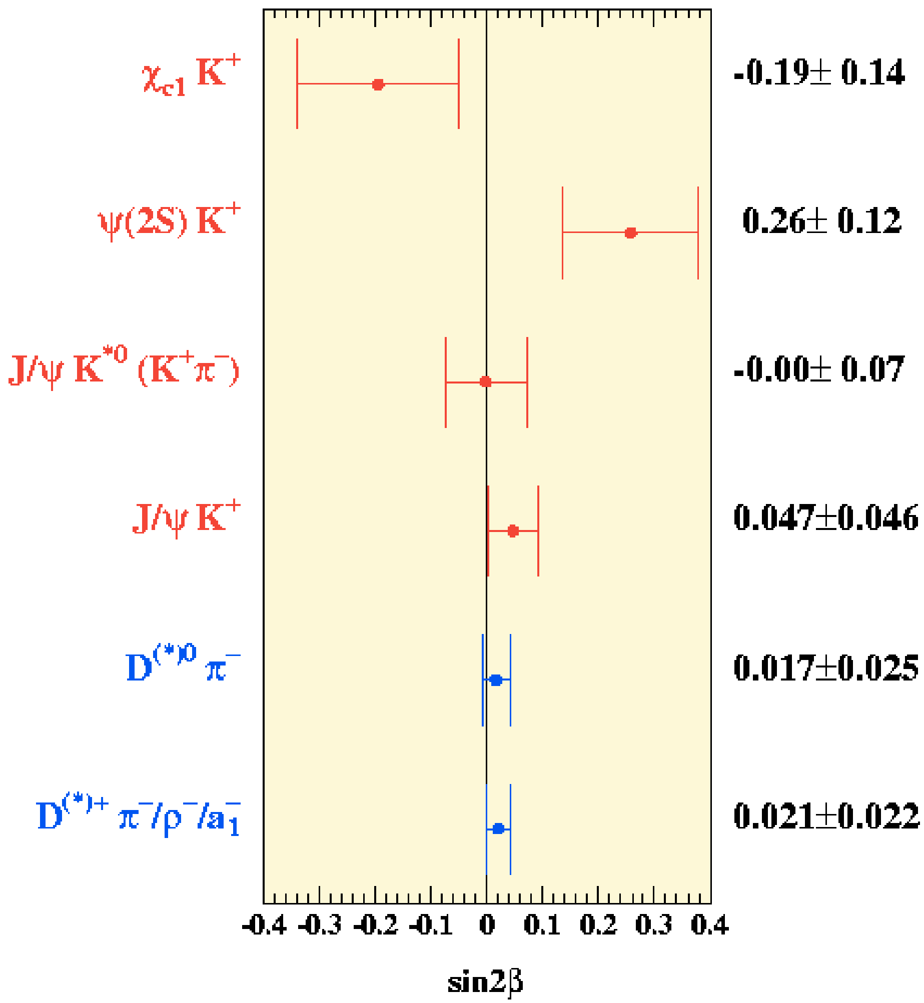
N_{tagged} = 220
Purity = 98%

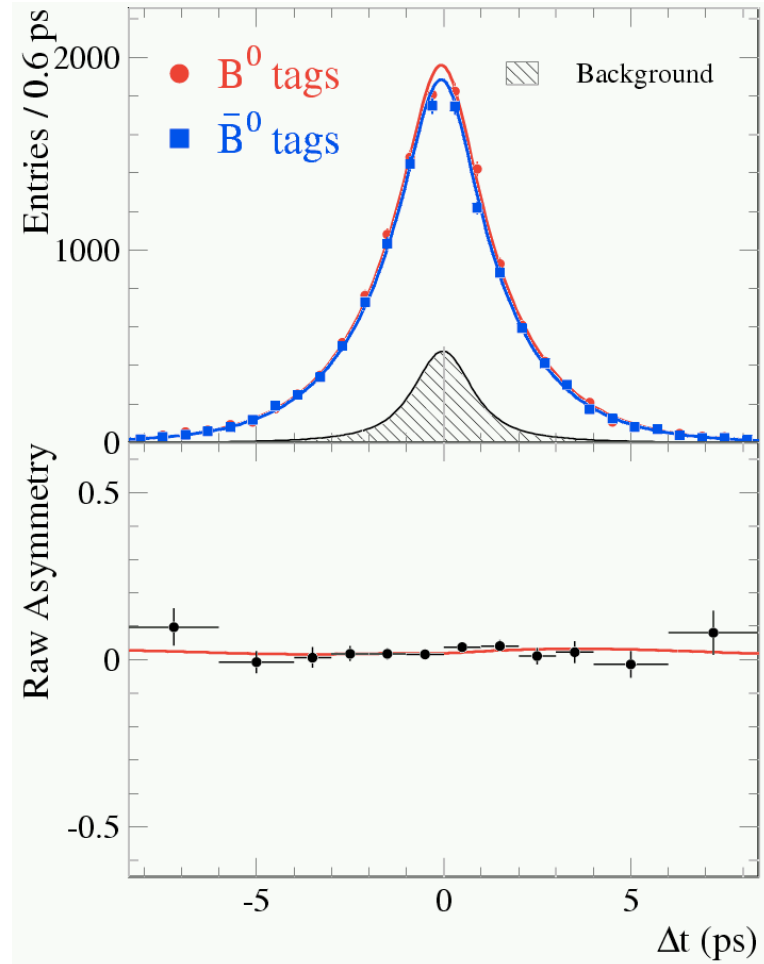
Mistag fraction 3.3%

$\sigma_{\Delta t}$ 20% better than other tag categories

$\sin 2\beta = 0.79 \pm 0.11$

Cross-check on data control samples





Observed no asymmetry, as expected

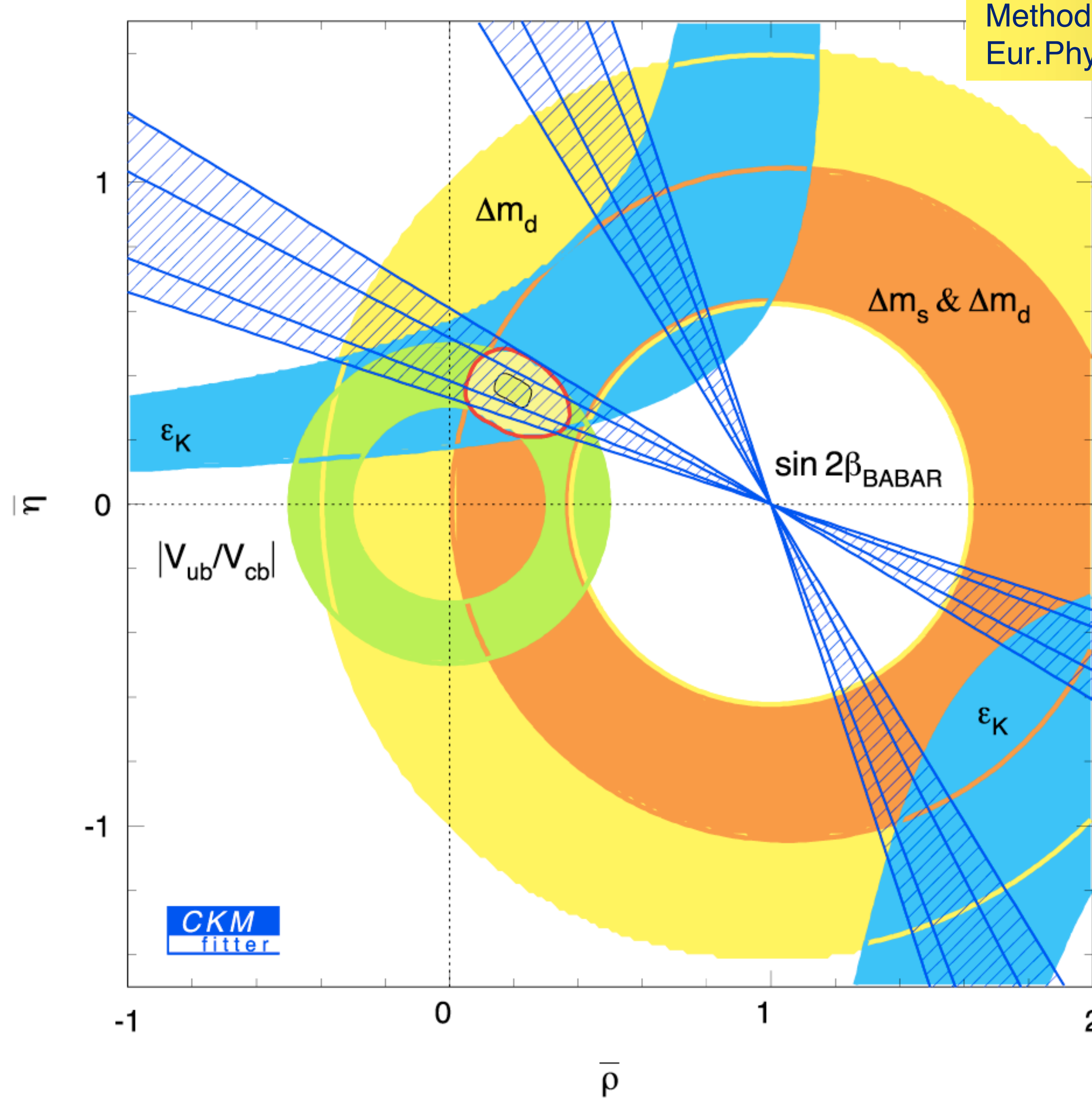
Sources of Systematic Error

	s(sin2*b*)
Description of background events	0.017
CP content of background components	
Background shape uncertainties	
Composition and content of $J/y\ K_L$ background	0.015
Dt resolution and detector effects	0.017
Silicon detector alignment uncertainty	
Dt resolution model	
Mistag differences between B_{CP} and B_{flav} samples	0.012
Fit bias correction	0.010
Fixed lifetime and oscillation frequency	0.005
TOTAL	0.033

Steadily reducing systematic error: July 2002 = 0.033
July 2001 = 0.05

Constraining the □,□ plane

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



Golden Modes beyond the Standard Model

- If another amplitude (new physics) contributes a different phase, then

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

$$S_f = \frac{2\,\mathrm{Im}\,\lambda_f}{1+|\lambda_f|^2} \qquad C_f = \frac{1-|\lambda_f|^2}{1+|\lambda_f|^2}$$

- In the Standard Model $|\lambda_f| = 1$ (which we assume in the nominal sin2β fit)

$$S_f \approx -\eta_f \sin 2\beta \qquad C_f \approx 0$$

- Fit $|\lambda_f|$ and S_f using the clean $(c\bar{c})K_s$ modes (η_f =-1, N_{tagged} = 1506, Purity = 92%):

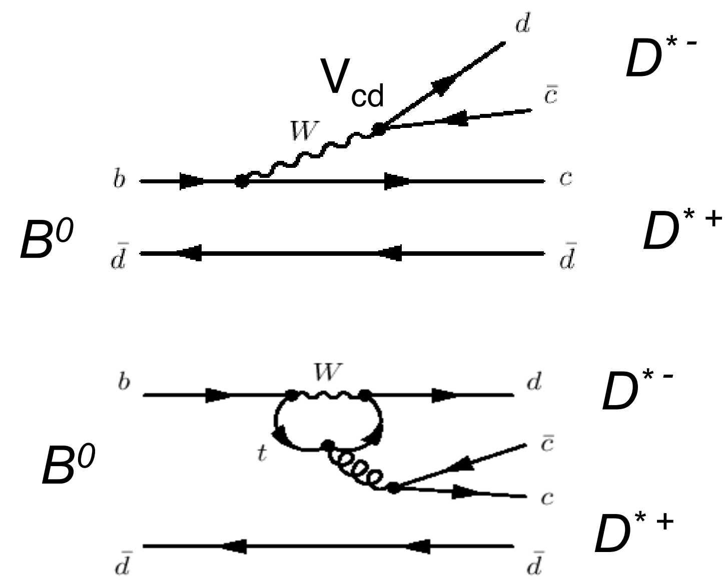
$$|\lambda_f| = 0.948 \pm 0.051\ (\text{stat}) \pm 0.017\ (\text{syst})$$

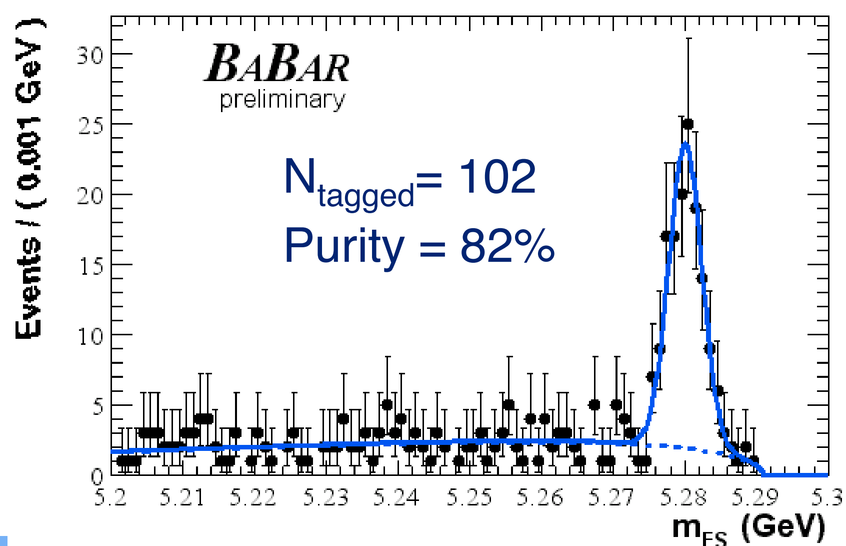
$$S_f = 0.759 \pm 0.074\ (\text{stat}) \pm 0.032\ (\text{syst})$$

Consistent with the Standard Model expectation of $|\lambda_f|$=1 and nominal fit sin2β = 0.755 ± 0.074 for $(c\bar{c})K_s$ modes alone.

(b → c$\bar{c}$d) mode B^0 → $D^{*+}D^{*-}$

- Cabbibo-suppressed mode with tree level weak phase same as b → ccs
- Penguin contribution uncertain, expected to be small < 0.1 Tree
- Not a CP eigenstate, mixture of CP even (L=0,2) and CP odd (L=1)



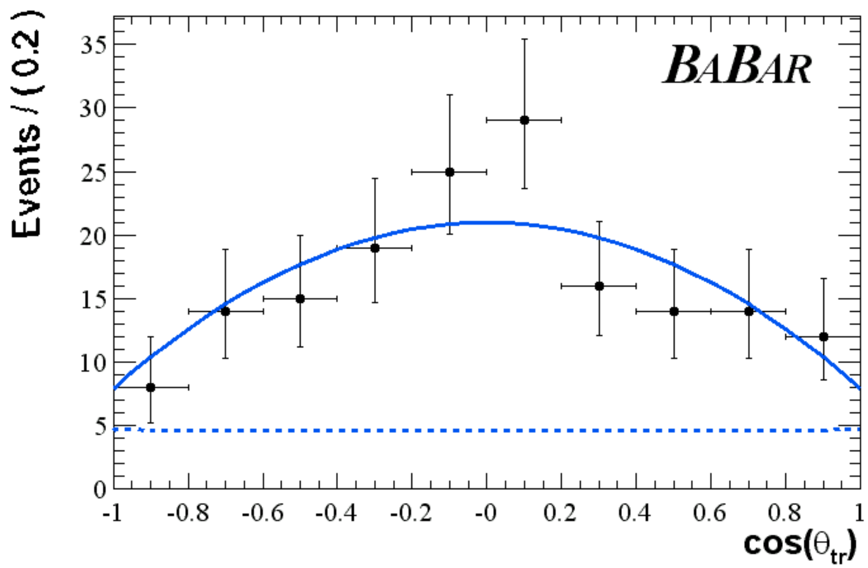


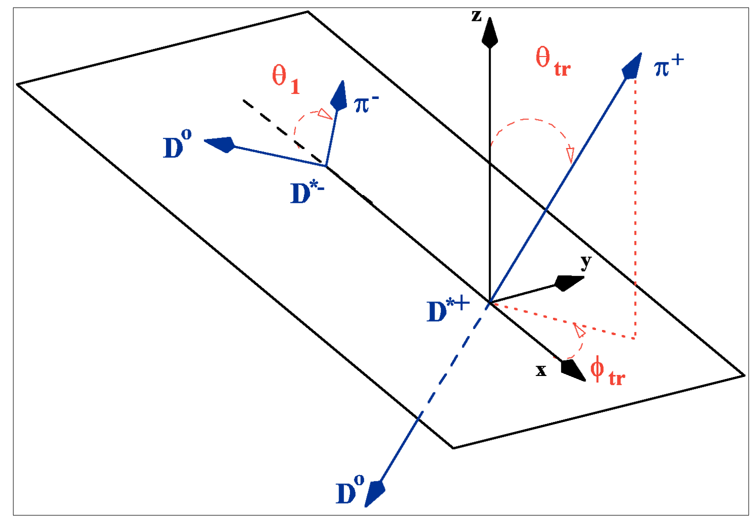
Reconstruct D^{*+} → $D^0\pi^+$ or $D^+\pi^0$, but not both to π^0 mode

CP composition of $B^0 \to D^{*+}D^{*-}$

- We measure CP odd fraction (corrected for acceptance) to be small:

  $R_\perp = 0.07 \pm 0.06\ (\text{stat}) \pm 0.03\ (\text{syst})$





$$\frac{d\Gamma}{\Gamma d\cos\theta_{tr}} = \frac{3}{4}(1 - R_\perp)\sin^2\theta_{tr} + \frac{3}{2}R_\perp\cos^2\theta_{tr}$$

CP asymmetry fit $B^0 \to D^{*+}D^{*-}$

- Improved fitting strategy:
  - Parameterize in terms of CP even (l_+) and odd ($l_\perp$) components, include angular information from partial-wave analysis
  - Fix CP odd component to $l_\perp$=1, Im($l_\perp$) = -0.741

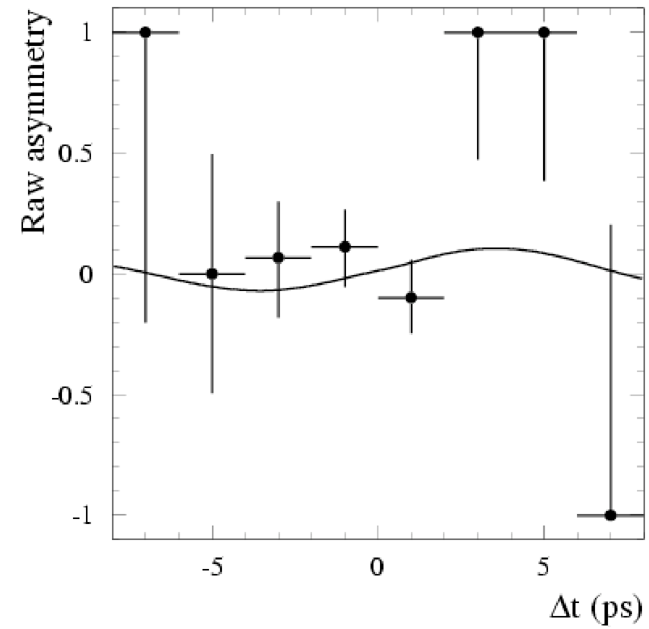
$|\lambda_+|$ = 0.98 ± 0.25 (stat) ± 0.09 (syst)

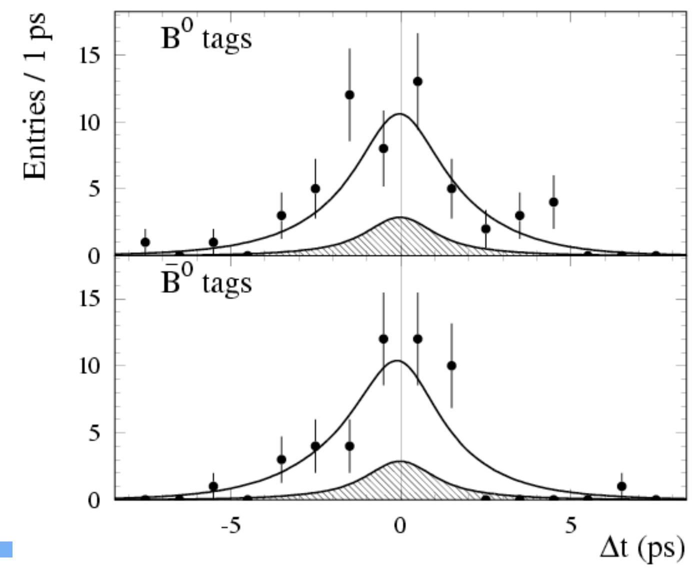
Im(λ_+) = 0.31 ± 0.43 (stat) ± 0.10 (syst)

If penguins are negligible, then

Im(λ_+) = - sin2β

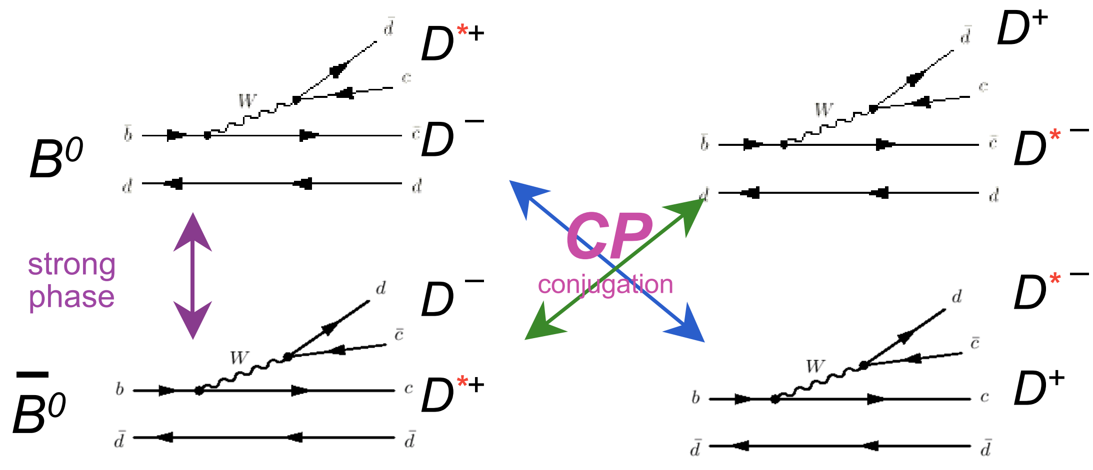
Im(λ_+) measurement ~2.7σ from BaBar sin2β in charmonium, assuming no penguins.





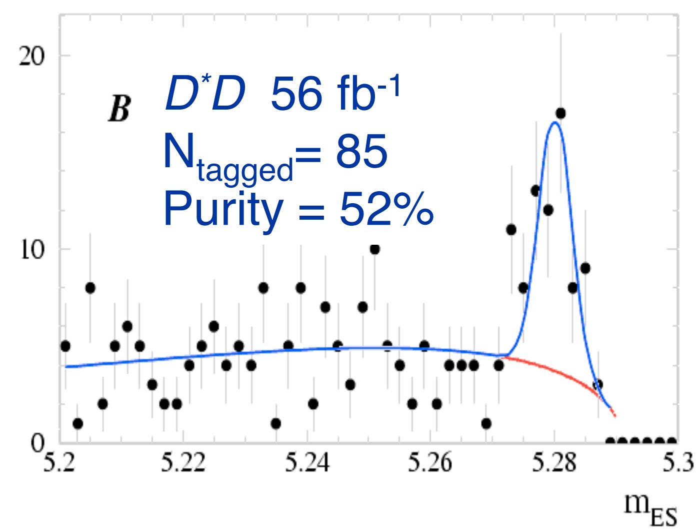
(b $c\bar{c}d$) mode B^0 $D^{*+}D^-$

- D^*D not CP eigenstate
- Possible strong phase contribution (and still have penguins)
- Different (but related) decay time distributions for
  B^0 $D^{*+}D^-$
  B^0 $D^{*-}D^+$



S_{+-} = - 0.43 ± 1.41 ± 0.20
C_{+-} = 0.53 ± 0.74 ± 0.13

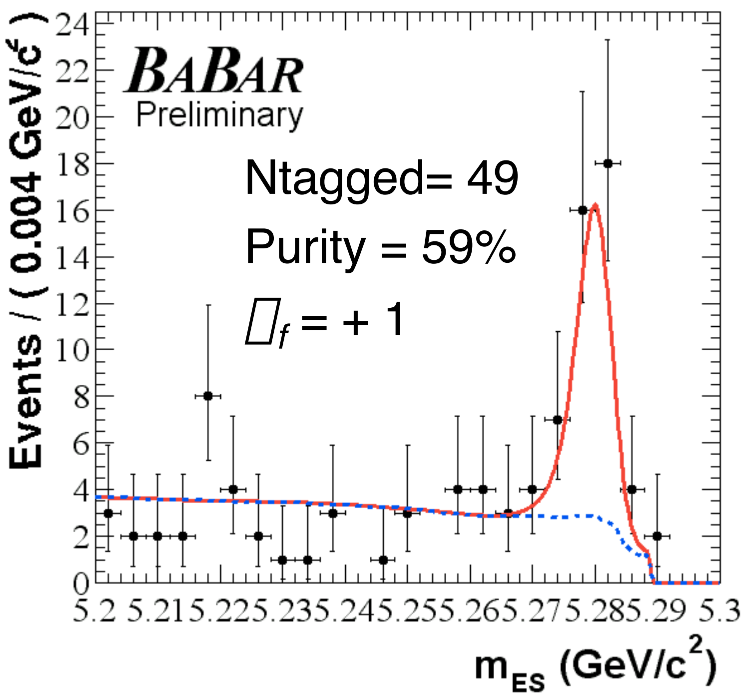
S_{-+} = 0.38 ± 0.88 ± 0.05
C_{-+} = 0.30 ± 0.50 ± 0.08

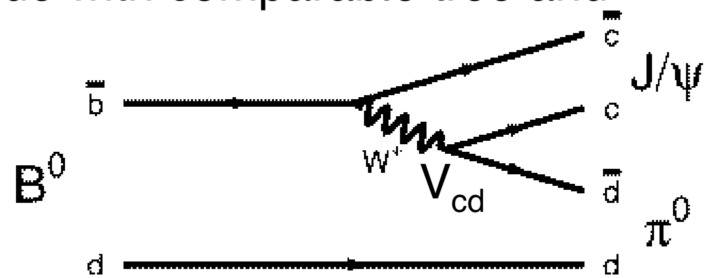


Update to full data set in progress

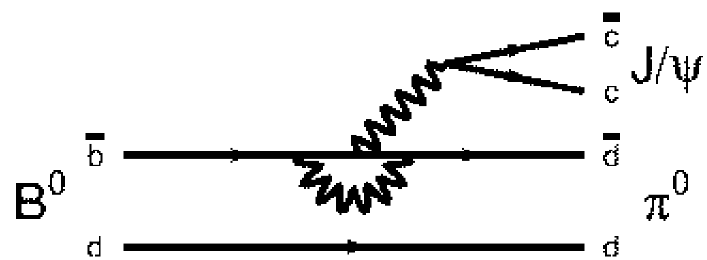
(b→ c$\bar{c}$d) mode B^0 → $J/\psi\ \pi^0$

Cabibbo and color-suppressed mode with comparable tree and penguin contributions



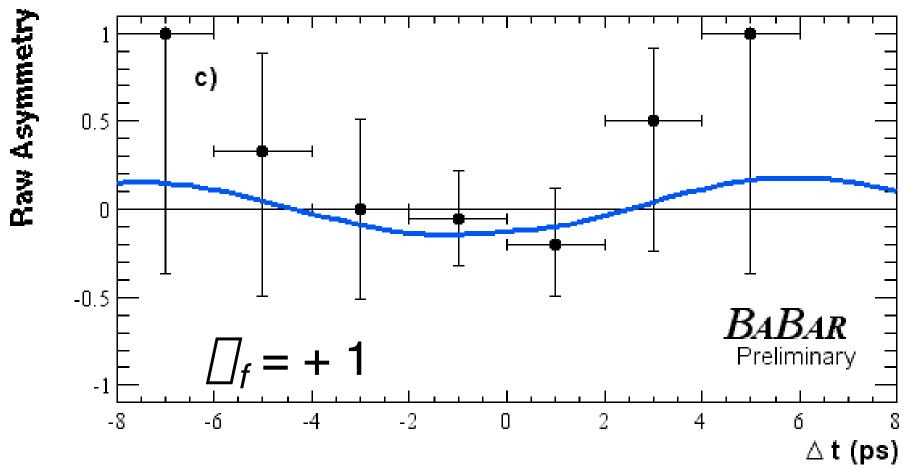


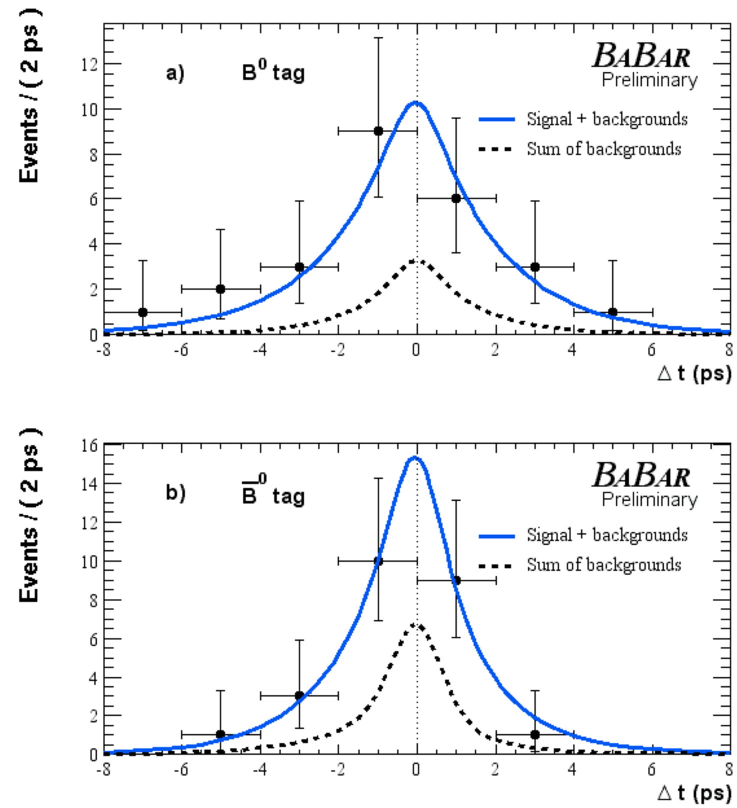
Tree: ~$V_{cb}V_{cd}^* \sim O(\lambda^3)$
same weak phase as b→ c$\bar{c}$s



Penguin:~$V_{cb}V_{cd}^* + V_{ub}V_{ud}^* \sim O(\lambda^3)$
adds additional weak phase

CP asymmetry fit for $B^0 \to J/\psi\ \pi^0$





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

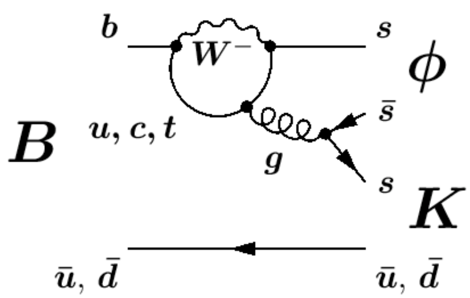
$S_{J/\psi\ \pi^0} = 0.05 \pm 0.49\ (\text{stat}) \pm 0.16\ (\text{syst})$

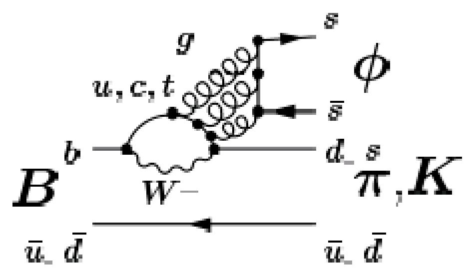
In absence of penguins $C_{\psi\pi}=0$, $S_{\psi\pi} = -\sin 2\beta$

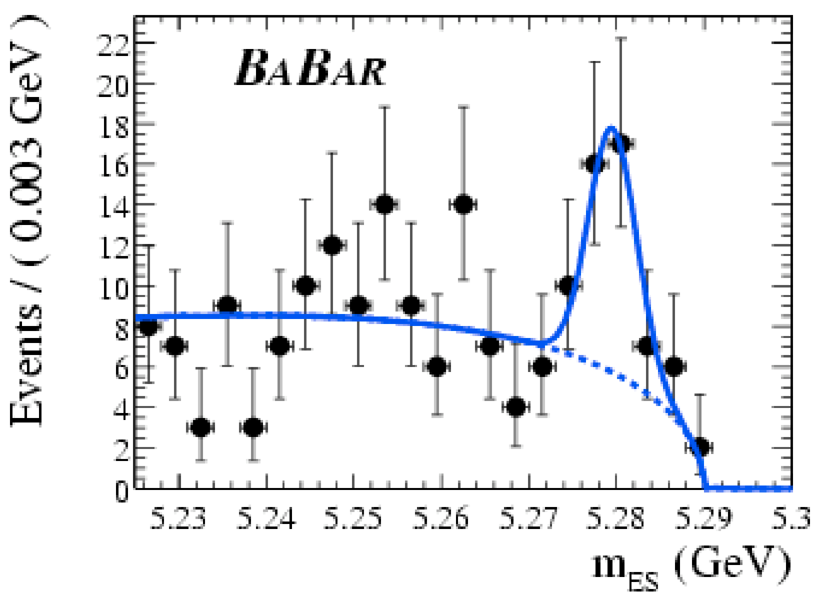
sin2β from penguin mode $B^0 \to \phi K_S$

Charmless decay dominated by ($b \to s\bar{s}s$) gluonic penguins

Weak phase as $b \to c\bar{c}s$, but sensitive to new physics in loops





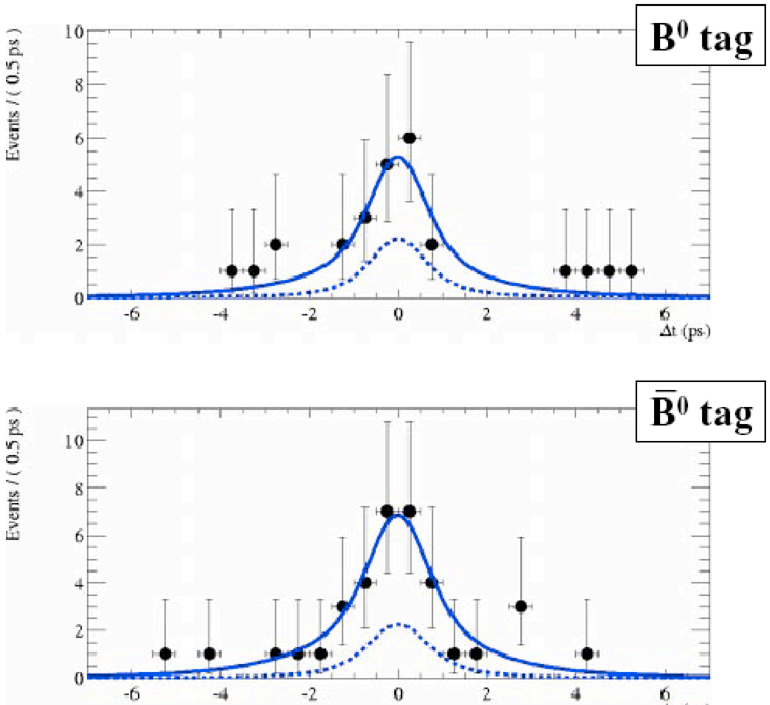


- Small branching fraction $O(10^{-5})$
- Significant background from $q\bar{q}$ continuum
- Using only $\phi \to K^+K^-$

$N_{tagged} = 66$
Purity = 50%
$\eta_f = -1$

CP asymmetry fit for B^0 □ □ K_S

Fix $|□_{□K}| = 1$, fit: $S_{□K} = -0.19 \, {}^{+0.52}_{-0.50}$ (stat) ± 0.09 (syst)



□t (ps)

Cross check on B^+ □ □K^+

$S_{□K} = 0.26 \pm 0.27$

Analysis of B^0 □ $h' K_S$ in progress

If no new physics, $S_{□K} = \sin 2□$

sin2β Conclusion

- New measurement of sin2β from charmonium modes (88 x10^6 $B\bar{B}$)

sin2β = 0.741 ± 0.067 (stat) ± 0.033 (syst)

Submitted to PRL July 17, 2002
(hep-ex/0207042)

- Begun to probe the same *CP*-violating phase and look for new physics via penguin modes:

  $B^0 \to \phi K^0_S$ (First BaBar results)

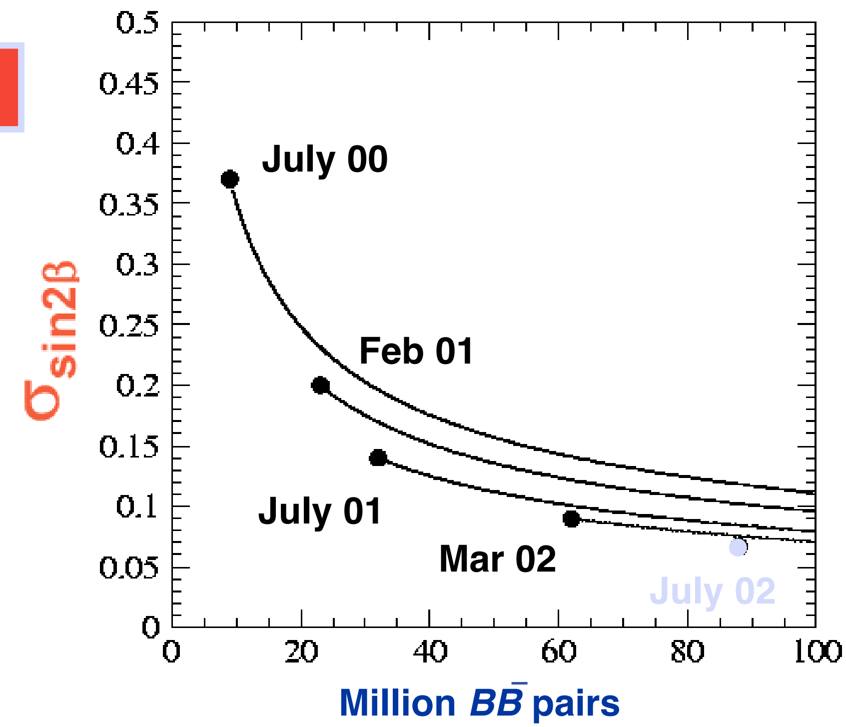
  $B^0 \to J/\psi \pi^0$

  and open charm modes:

  $B^0 \to D^{*+}D^{*-}$

  $B^0 \to D^{*+}D^-$

Results have been improving by more than just luminosity gain



The Standard Model remains unscathed, but the high statistics future of BaBar will provide further opportunities to challenge the theory.

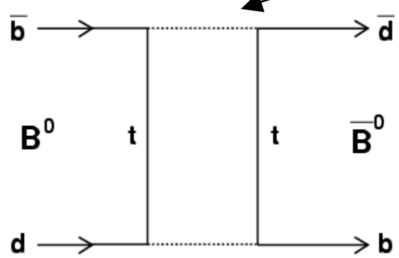
Sin2α: *CP* Violation in $B^0 \to \pi^+\pi^-$

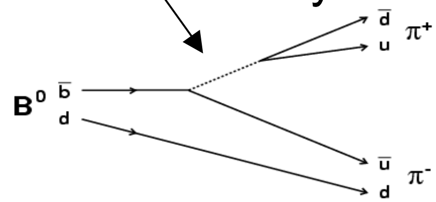
Tree (T) Level:

$$\lambda_{\pi\pi} = \frac{V_{tb}^* V_{td}}{V_{tb} V_{td}^*} \frac{V_{ud}^* V_{ub}}{V_{ud} V_{ub}^*}$$

mixing

decay



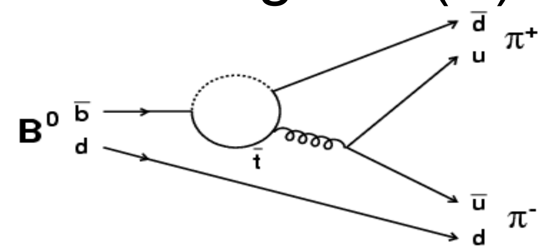


$$\lambda_{\pi\pi} = e^{2i\alpha}$$

$$C_{\pi\pi} = 0$$

$$S_{\pi\pi} = \sin(2\alpha)$$

With Penguins (P):



$$\lambda_{\pi\pi} = e^{2i\alpha} \frac{1+|P/T|e^{i\delta}e^{i\gamma}}{1+|P/T|e^{i\delta}e^{-i\gamma}}$$

$$C_{\pi\pi} \quad \sin(\delta)$$

$$S_{\pi\pi} = \sqrt{1-C_{\pi\pi}^2}\,\sin(2\alpha_{\rm eff})$$

Need branching fractions for $\pi^+\pi^-$, $\pi^\pm\pi^0$, and $\pi^0\pi^0$ to get α from $\alpha_{\rm eff}$ -> isospin analysis

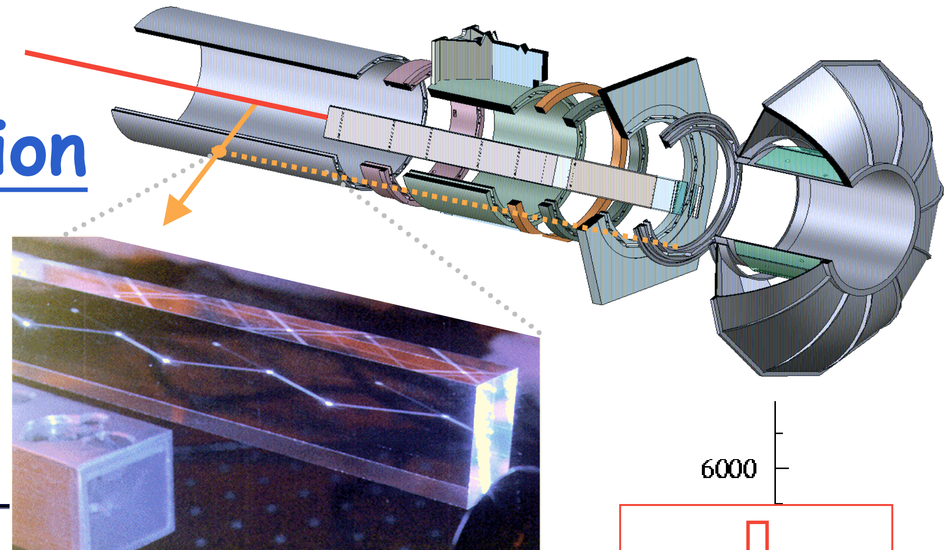
$B^0 \to \pi\pi, K\pi, KK$

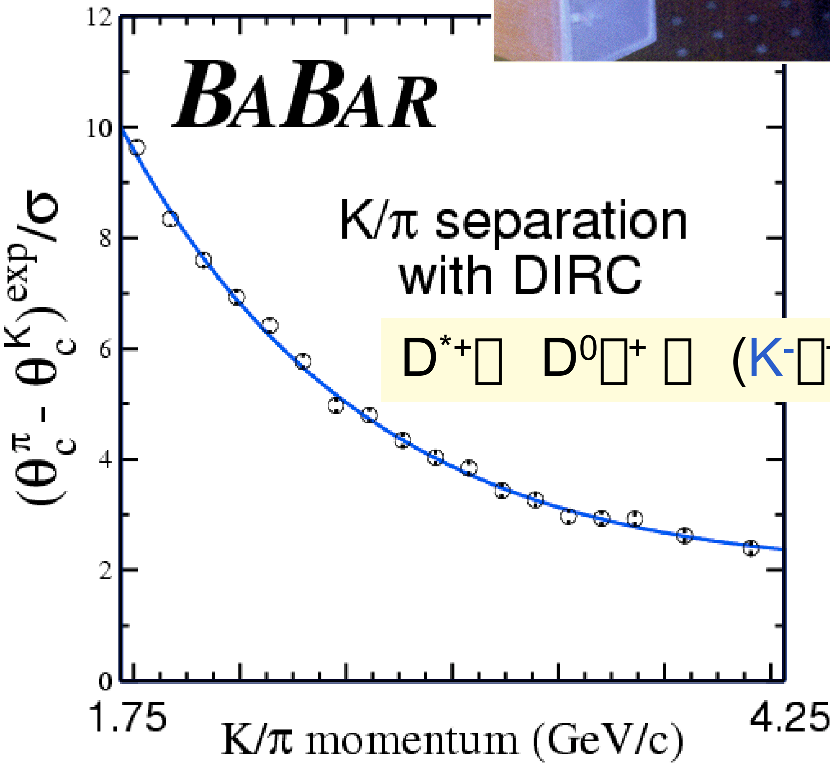
- Small branching ratios (few $\times 10^{-6}$)
- Important continuum background
  - Topological variables
  - Kinematics

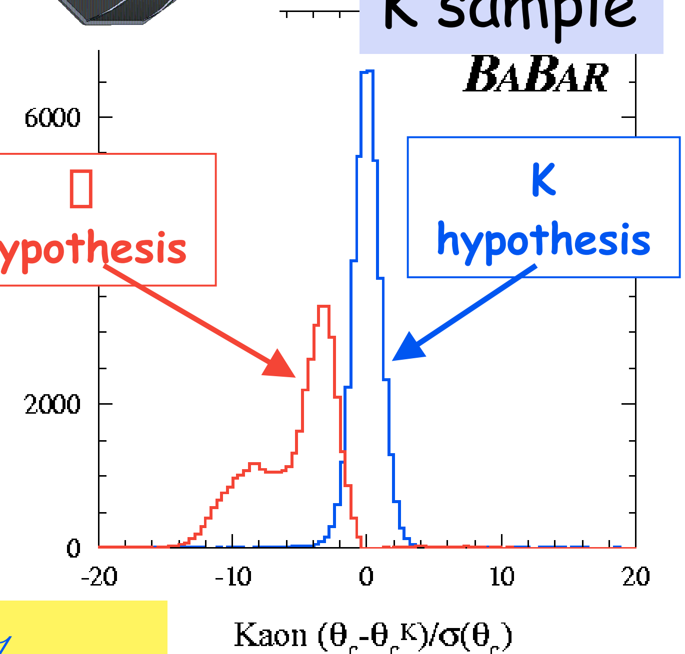
BUT → **The key issue is Particle Identification**

First results presented last year

π-K separation







For ε=85%

P(K→ π)=1.7%

P(π→ K)=2.7%

Branching fractions and direct CP violation

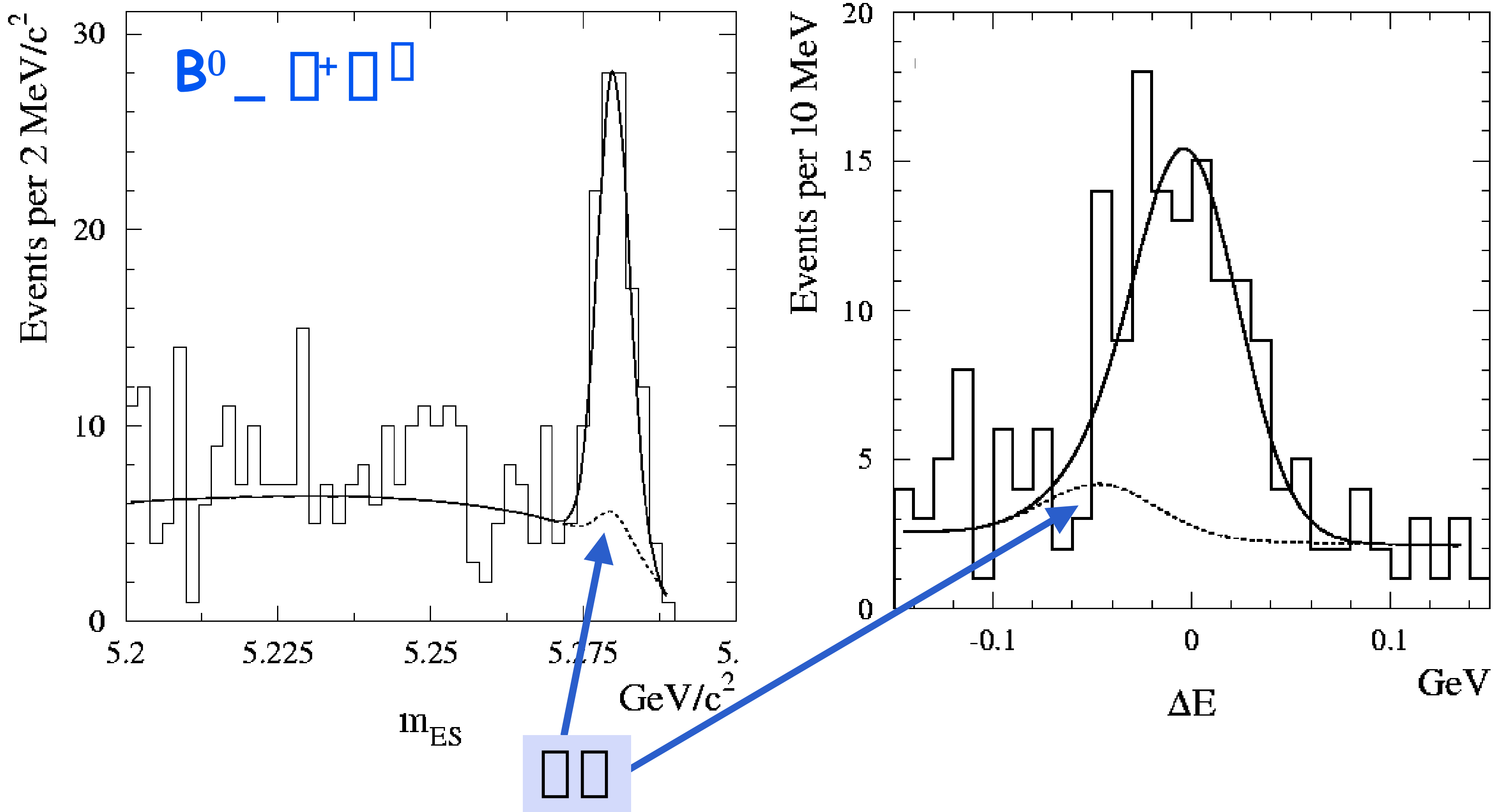
- Maximum Likelihood to extract branching ratios and Kπ asymmetries
- No tagging or vertexing needed

Direct CP violation

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

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)	

m_{es} and □E for B^0□ □$^+$□$^□$



Validation of Tagging, Vertexing, and ML Fit

- Kp decays are self-tagging
  - T = tag charge
  - Q = kaon charge

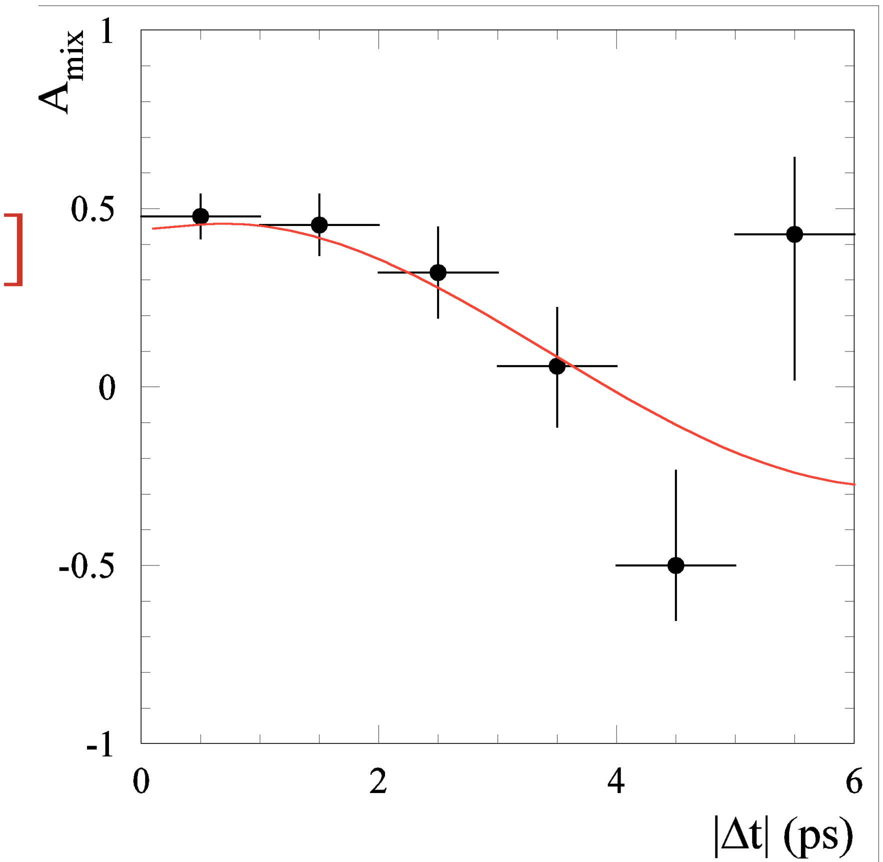
$$f_{T,Q}^{K\pi}(\Delta t) = \frac{e^{-|\Delta t|/\tau}}{4\tau}\left[1 - TQ(1-2w)\cos(\Delta m_d \Delta t)\right]$$

- Float t and Dm$_d$ in same sample used to extract CP asymmetries:

$$\tau = (1.56 \pm 0.07)\text{ps}$$

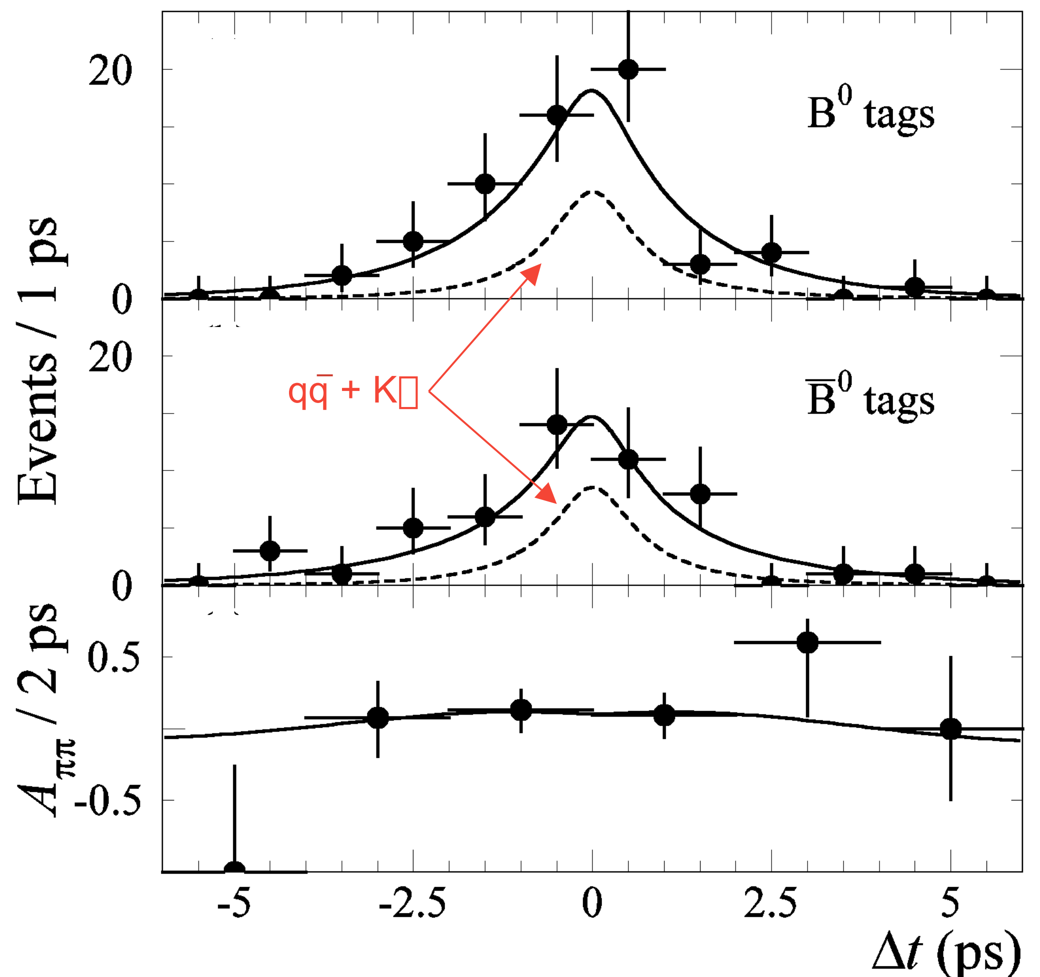
$$\Delta m_d = (0.52 \pm 0.05)\text{ps}^{-1}$$

Fit projection in sample of Kπ-selected events



CP Asymmetry Results

Fit projection in sample of ππ-selected events



Preliminary

$$S_{\pi\pi} = 0.02 \pm 0.34 \pm 0.05$$
$$C_{\pi\pi} = -0.30 \pm 0.25 \pm 0.04$$

Submitted to Phys Rev (hep-ex/0207055)

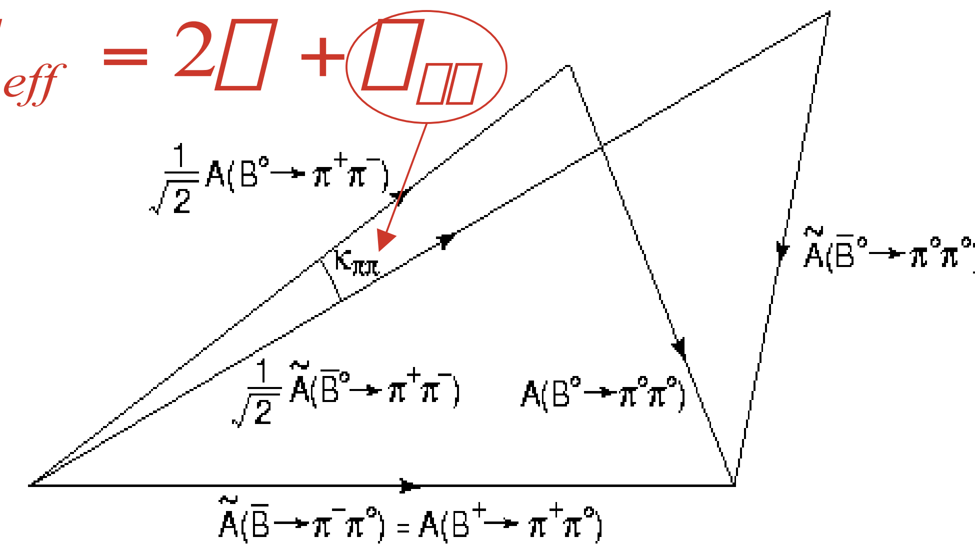
$$A_{\pi\pi}(\Delta t) \equiv \frac{N\left(B^0_{tag}\right) - N\left(\overline{B}^0_{tag}\right)}{N\left(B^0_{tag}\right) + N\left(\overline{B}^0_{tag}\right)}$$
$$= S_{\pi\pi}\sin(\Delta m_d \Delta t) - C_{\pi\pi}\cos(\Delta m_d \Delta t)$$

Isospin Analysis to get α from α_{eff}?

Gronau and London, Phys. Rev. Lett. 65, 3381 (1991)

- The decays $B \to \pi^+\pi^-$, $\pi^+\pi^0$, $\pi^0\pi^0$ are related by isospin
- Central observation is that ππ states can have I = 2 or 0
  - (gluonic) penguins only contribute to I = 0 (ΔI = 1/2)
  - $\pi^+\pi^0$ is pure I = 2 (ΔI = 1/2) so has only tree amplitude
  - → $(|A^{+0}| = |\bar{A}^{+0}|)$
- Triangle relations allow determination of penguin-induced shift in α

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

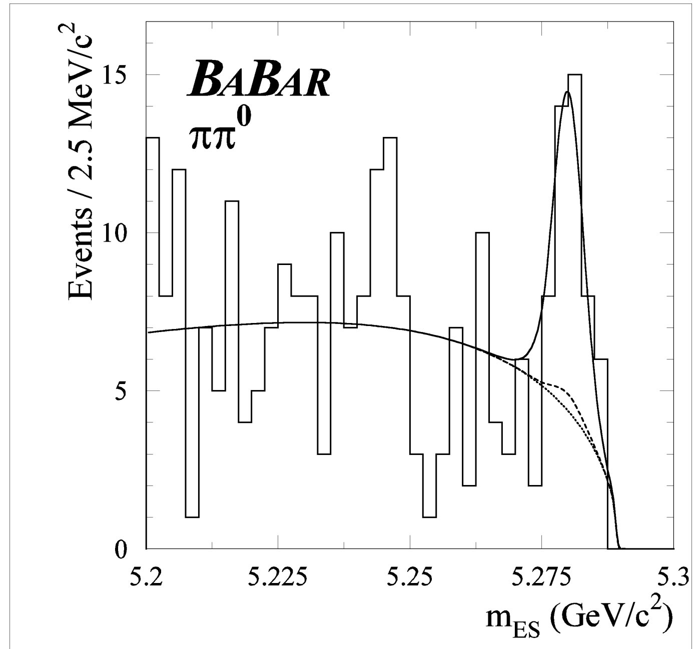


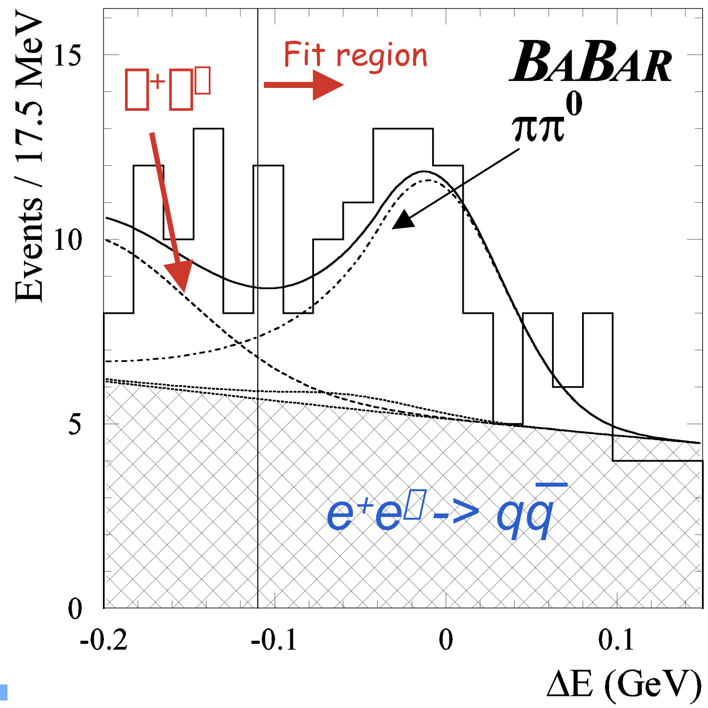
But, need branching fractions for all three decay modes, and for B^0 and $\overline{B^0}$ separately

The Base of the Isospin Triangle: $B^+ \to \pi^+\pi^0$

Simultaneous fit to $\pi\pi^0/K\pi^0$

Preliminary



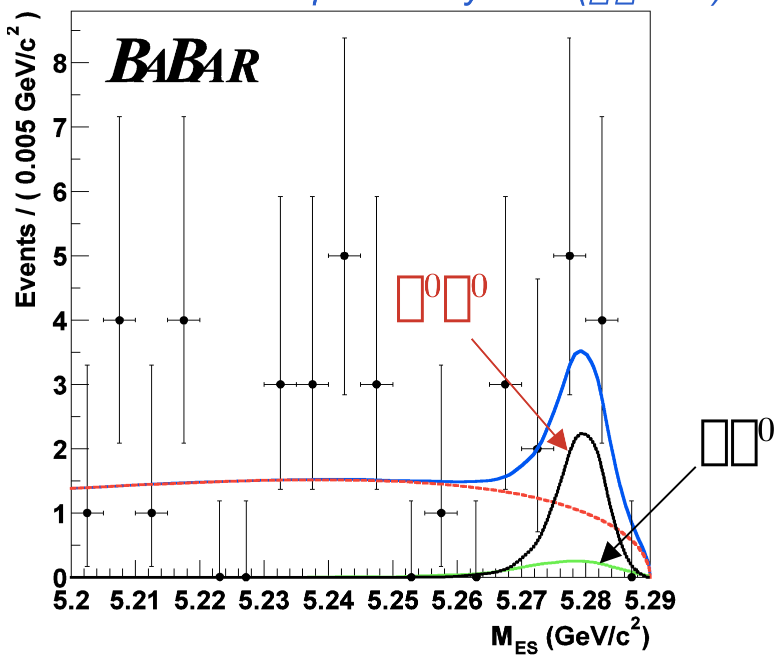


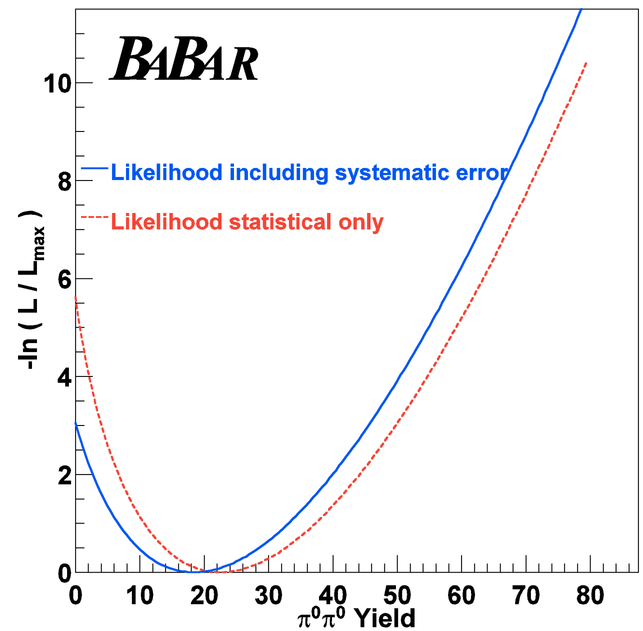
Mode	Yield	BR (10^{-6})	A_{CP}
$B^+ \to \pi^+\pi^0$	125^{+23}_{-21}	$5.5^{+1.0}_{-0.9} \pm 0.6$	$-0.03^{+0.18}_{-0.17} \pm 0.02$
$B^+ \to K^+\pi^0$	239^{+21}_{-22}	$12.8^{+1.2}_{-1.1} \pm 1.0$	$-0.09 \pm 0.09 \pm 0.01$

hep-ex/0207065

Remaining side: $B^0 \to \pi^0\pi^0$

Data after cut on probability ratio (> 20%)





hep-ex/0207063

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

Preliminary

$B(B^0 \to \pi^0\pi^0) < 3.6 \times 10^{-6}$ @ 90% C.L.

Significance including systematic errors = 2.5σ

Setting a Bound on Penguin Pollution

- Can still get information on α with only an upper bound on $\pi^0\pi^0$:
  - For example: Grossman-Quinn bound (assume only isospin)

$$\sin^2(\alpha_{\text{eff}} - \alpha) < \frac{\frac{1}{2}\left[BR(B^0 \to \pi^0\pi^0) + BR(\overline{B}^0 \to \pi^0\pi^0)\right]}{BR(B^\pm \to \pi^\pm\pi^0)}$$

$$< 0.61 @ 90\% \text{ C.L.}$$

$$\left|\alpha_{\text{eff}} - \alpha\right| < 51^\circ @ 90\% \text{ C.L.}$$

Correlations and systematic errors included

- Many other bounds on the market
  - Charles, Gronau/London/Sinha/Sinha, etc…

B^0□ □□

Clear B^0□ □□ signal observed

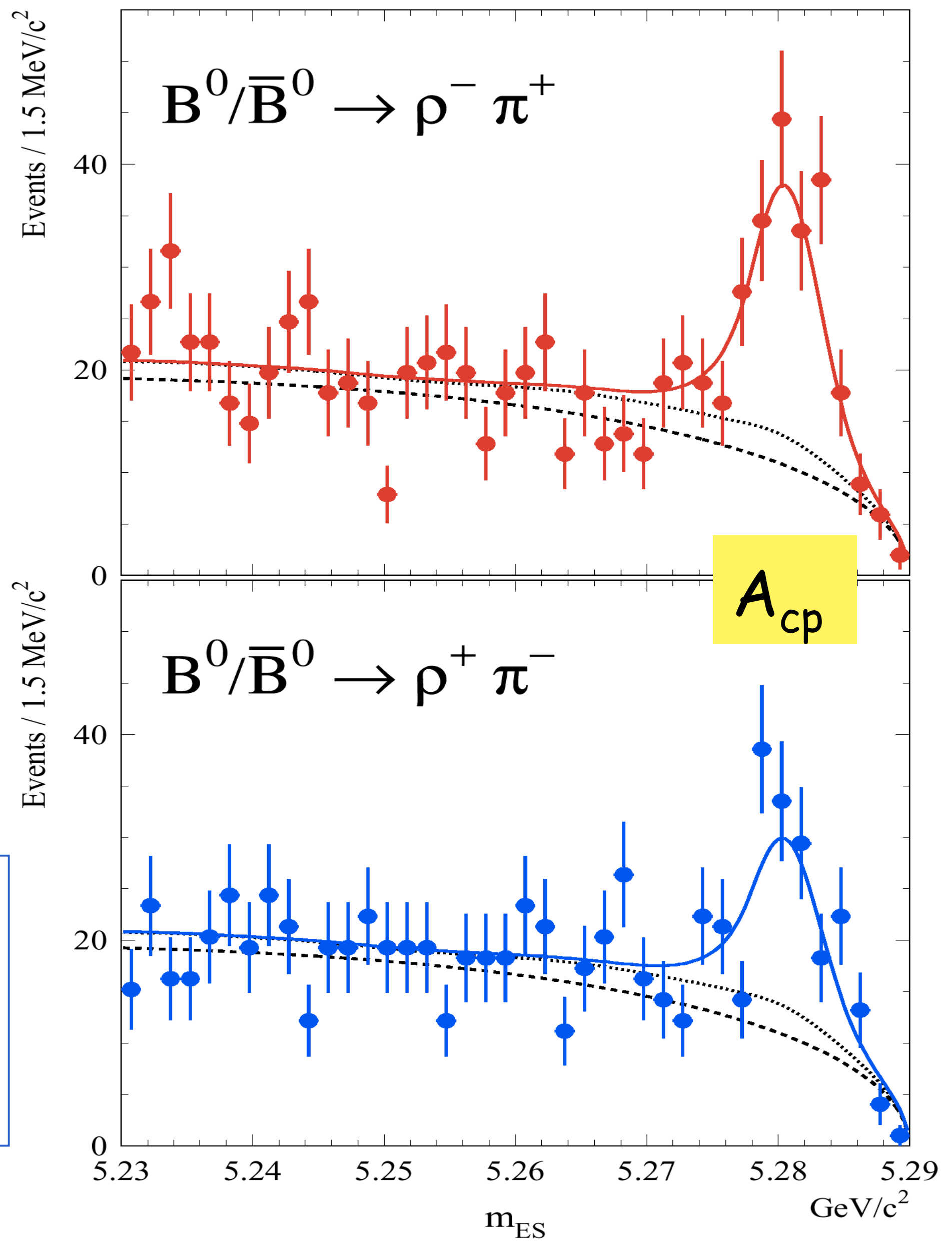
$N_{□□} = 413^{+34}_{□33}$

$N_{□K} = 147^{+22}_{□21}$

From B⁰□ □□

□=1.59±0.12 ps

□m_d=0.51 ± 0.09 ps^{-1}



B⁰□ □□ asymmetry

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

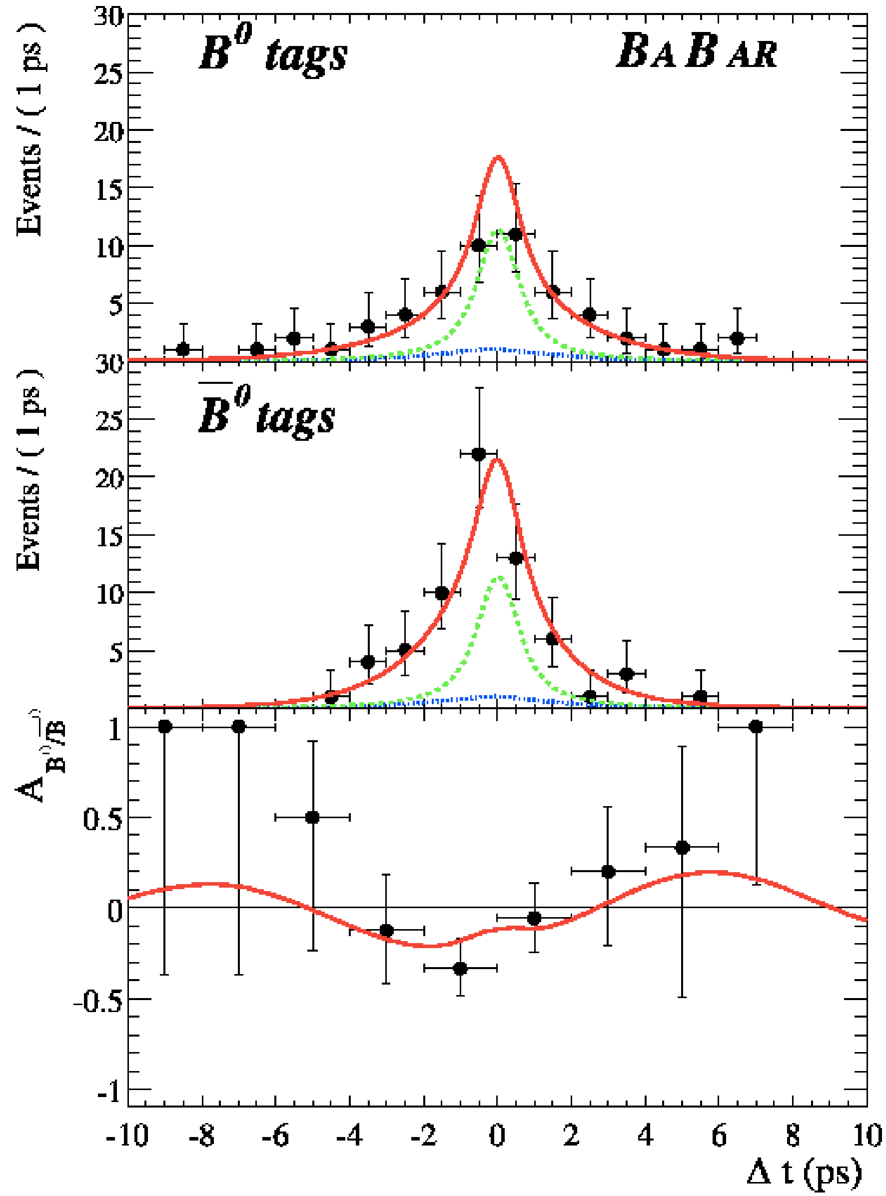
$$A_{CP}^{\square K} = +0.19^{+0.14}_{\square 0.14}(stat) \pm 0.11(syst)$$

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

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

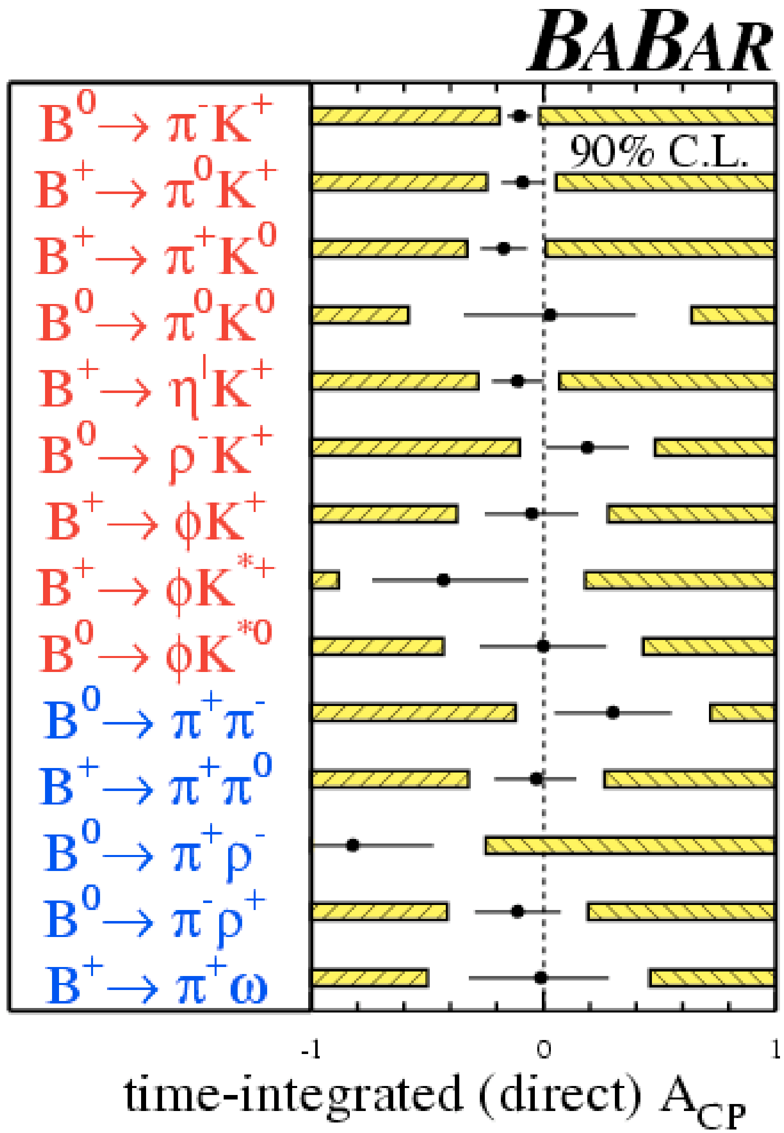
$$\square C_{\square\square} = 0.38^{+0.19}_{\square 0.20}(stat) \pm 0.11(syst)$$

$$\square S_{\square\square} = 0.15^{+0.25}_{\square 0.25}(stat) \pm 0.05(syst)$$



Direct CP measurements summary

No evidence for direct CP violation yet

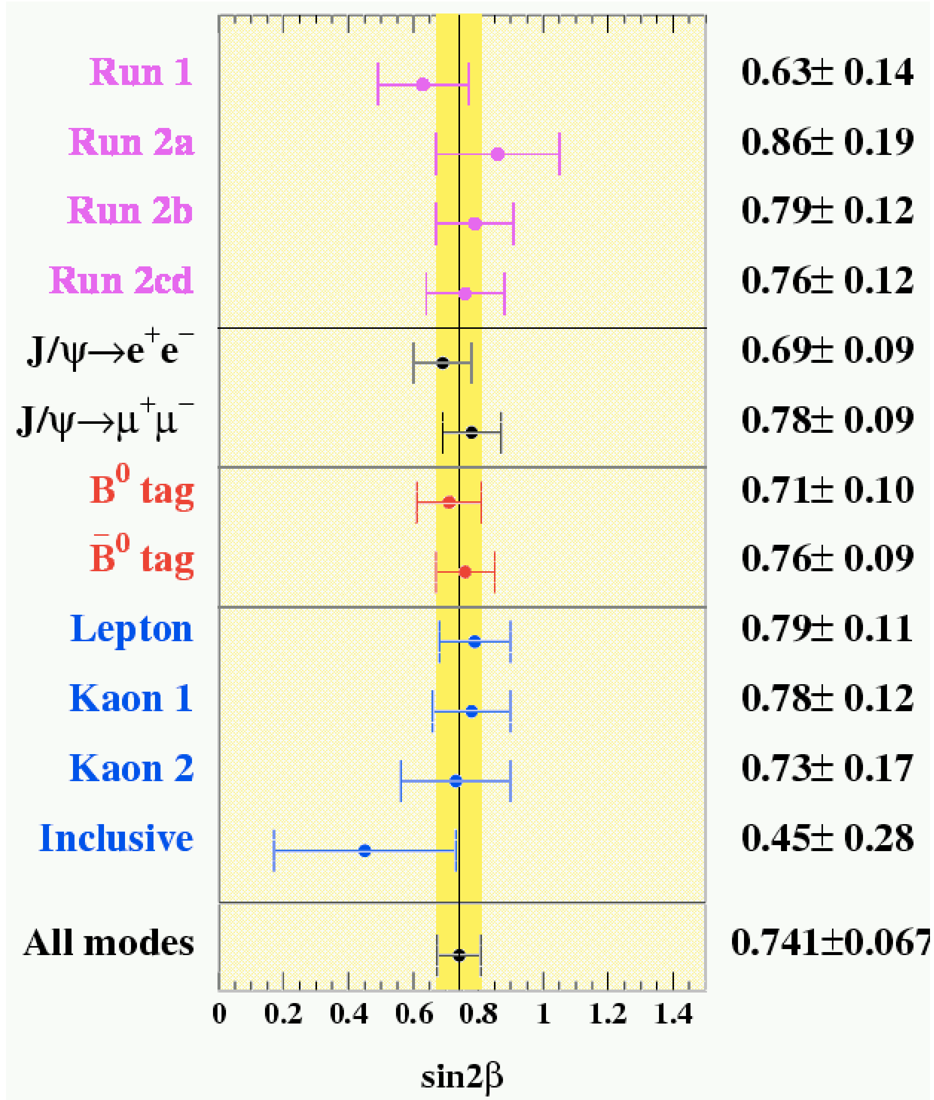


Conclusions:

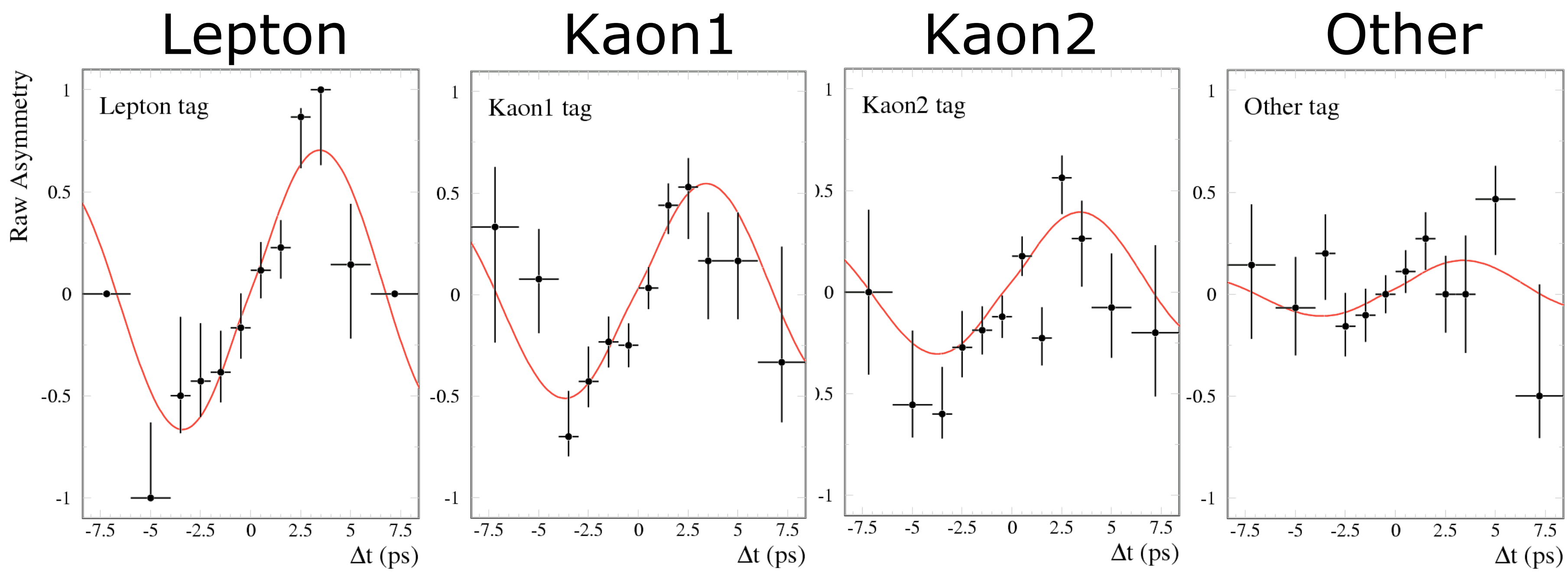
- Measurement of $\sin 2\beta = 0.741 \pm 0.067 \pm 0.033$
- Measurements in T+P and P modes
- Time dependent asymmetries for $B^0 \to \pi^+\pi^-$ and $B^0/\overline{B}^0 \to \rho^\pm\pi^\pm$ being measured
- Building blocks, $BR(B^0 \to \pi^0\pi^0$ and $B^+ \to \pi^+\pi^0)$, for an α isospin analysis are on place

BaBar starts exploring the exciting physics for which it has been built

Backup slides


Run 1
0.63± 0.14
Run 2a
0.86± 0.19
Run 2b
0.79± 0.12
Run 2cd
0.76± 0.12
J/ψ→e+e−
0.69± 0.09
J/ψ→μ+μ−
0.78± 0.09
B0 tag
0.71± 0.10
B̄0 tag
0.76± 0.09
Lepton
0.79± 0.11
Kaon 1
0.78± 0.12
Kaon 2
0.73± 0.17
Inclusive
0.45± 0.28
All modes
0.741±0.067
0
0.2
0.4
0.6
0.8
1
1.2
1.4
sin2β

CP asymmetry in the tagging categories for the (cc) K_s sample



sin2	Lepton	Kaon1	Kaon2	Other
sin2	0.79 ± 0.11	0.78 ± 0.12	0.73 ± 0.17	0.45 ± 0.28

Systematic Errors for $\sin 2\beta$

Largest source comes from backgrounds

- CP of Argus BG is zero in default fit. Attempt to fit for it in SB. Difference is systematic (very conservative).
- Klong BG contributions
  - Composition of $J/\psi X$ BG : 0.007
  - Shape/reslution of ΔE : 0.007

Some improvements over last iteration

- Switched from PDG 2000 to PDG 2002 for B lifetime and Δm_d. PDG uncertainties down by x2 (thanks to us). Both were 0.010 last time.
- Peaking BG now split by mode. $J/\psi K_s$ has the lowest (0.3%, others >1.2%). Was 0.013, now 0.007.
- MC bias correction (or MC statistics). Used x7 more MC this time. We understand part of the bias. Was 0.014, now 0.010.

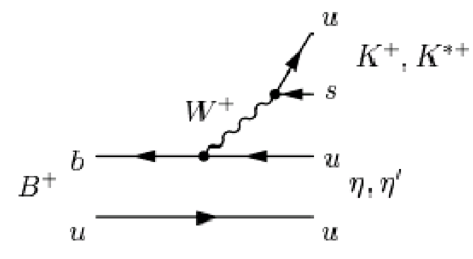
Source	$\delta \sin 2\beta$
CP and Mix BG	0.017
Klong BG	0.015
Δt meas. and RF	0.017
Signal Dilutions	0.012
Fit bias correction	0.010
B lifetime	0.004
Δm_d	0.003
Total	**0.033**

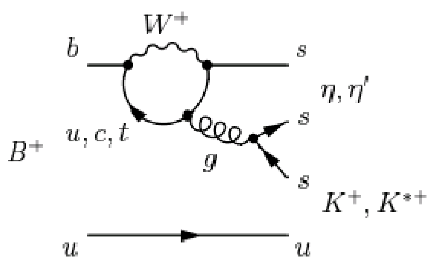
Total from winter 2002 result (56 fb^{-1}) was 0.035

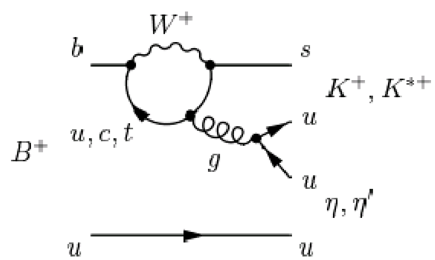
Pure or dominated penguin decays (II)

B^0□ □'K^0_S : tree is color and Cabbibo suppressed

B^+ □ □'K^+ : tree is Cabbibo suppressed







- Still working on that