BaBar explores CP violation

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On behalf of the BaBar Collaboration

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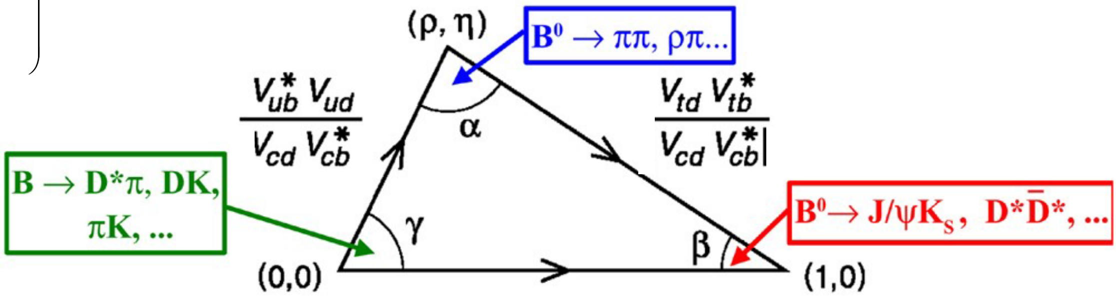
Outline

- Physics motivation
- PEPII & The BaBar Experiment
- Measurement of sin2β
  - Golden Modes ($b \to c\bar{c}s$)
  - Tree + Penguin modes ($b \to d\bar{d}s$)
  - Pure Penguin modes ($b \to s\bar{s}s$)
- Measurement of sin2$\alpha_{\text{effective}}$
  - CP violating asymmetries
    - $B \to \pi\pi$, $\rho\pi$
  - $B \to h\pi^0$, $\pi^0\pi^0$ branching ratios
- Direct CP asymmetries
- Conclusion

CP violation and the SM

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$



From CKM unitarity

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

UT

All angles related to η and ρ

New physics, ex: coupling between super-symmetric and SM fields introduce new phases which may reshape the unitarity triangle

CP asymmetry

B factories measure **time** dependent asymmetries between B^0 and $\overline{B}^0$ decay rates

CP violation in mixing

$$A_{f_{CP}}(t) = \frac{\Gamma\left(\overline{B}^0_{phys}(t) \to f_{CP}\right) - \Gamma\left(B^0_{phys}(t) \to f_{CP}\right)}{\Gamma\left(B^0_{phys}(t) \to f_{CP}\right) + \Gamma\left(\overline{B}^0_{phys}(t) \to f_{CP}\right)}$$

$$= \frac{2\Im m\,\lambda_{f_{cp}}}{1+\left|\lambda_{f_{cp}}\right|^2}\sin\left(\Delta m_d t\right) - \frac{1-\left|\lambda_{f_{cp}}\right|^2}{1+\left|\lambda_{f_{cp}}\right|^2}\cos\left(\Delta m_d t\right)$$

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

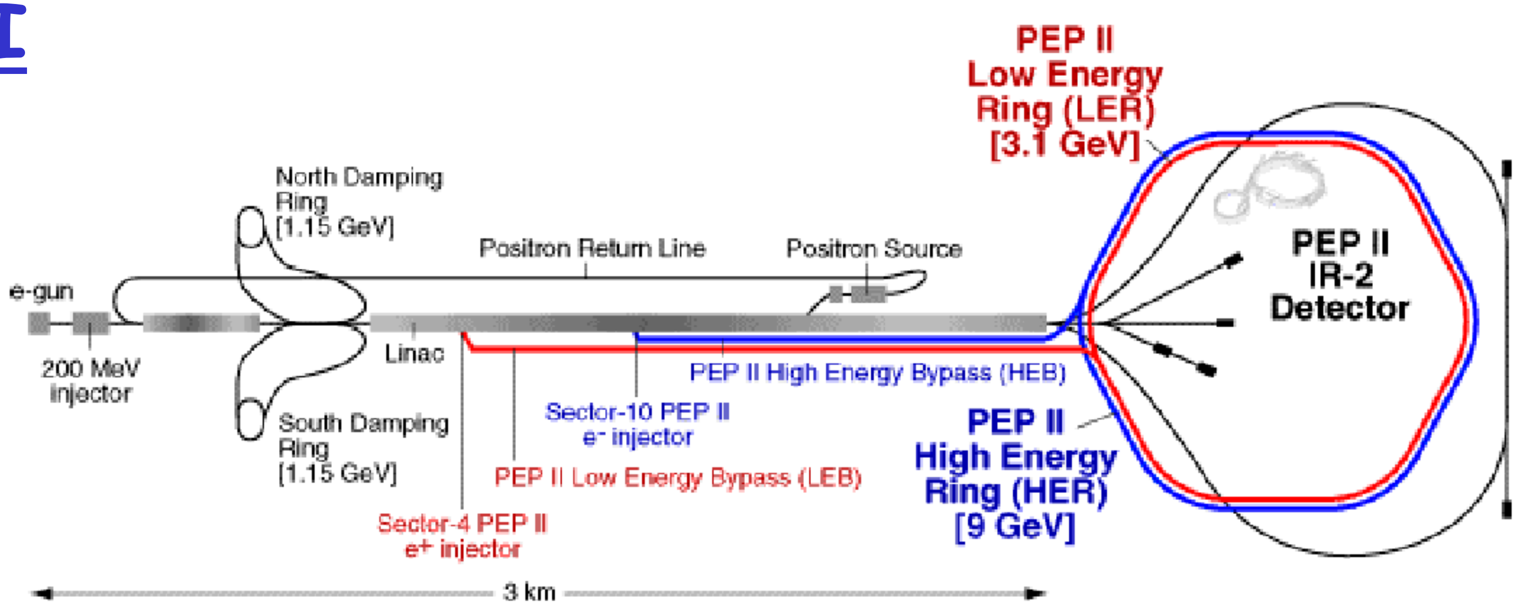
S_f

Interference between mixing and decay. (α,β,γ) measurement

C_f

Direct CP violation. Need more than one amplitude with different weak and strong phases.

PEPII

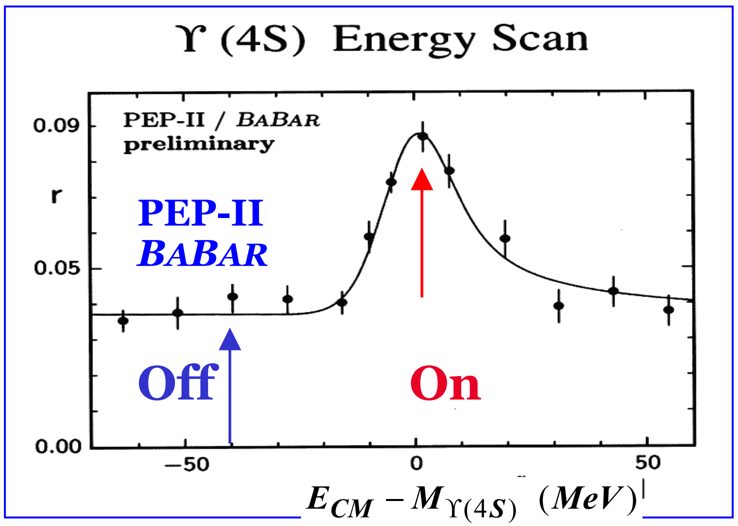


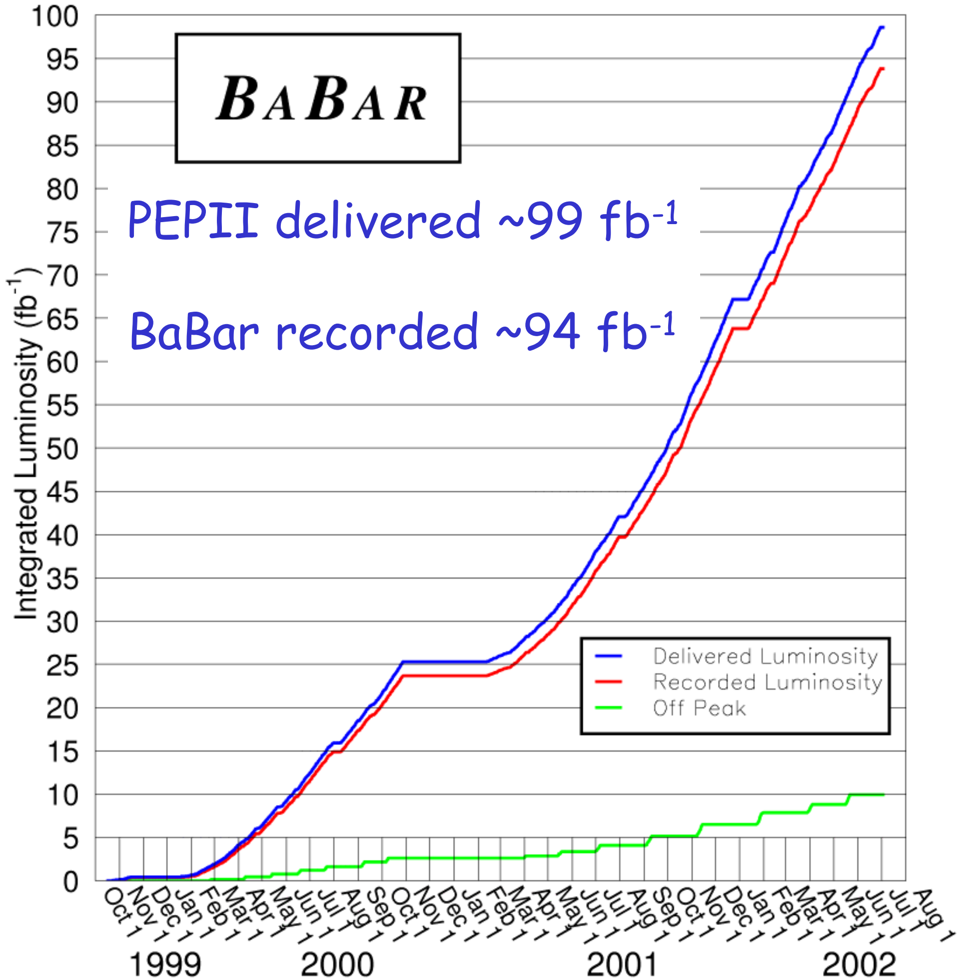
3.1 GeV e+ on 9 GeV e- cms boost $\langle\beta\gamma\rangle = 0.55$

- 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

- Used in the analysis
  - 81.2 fb^{-1} on peak
  - 9.6 fb^{-1} off-peak

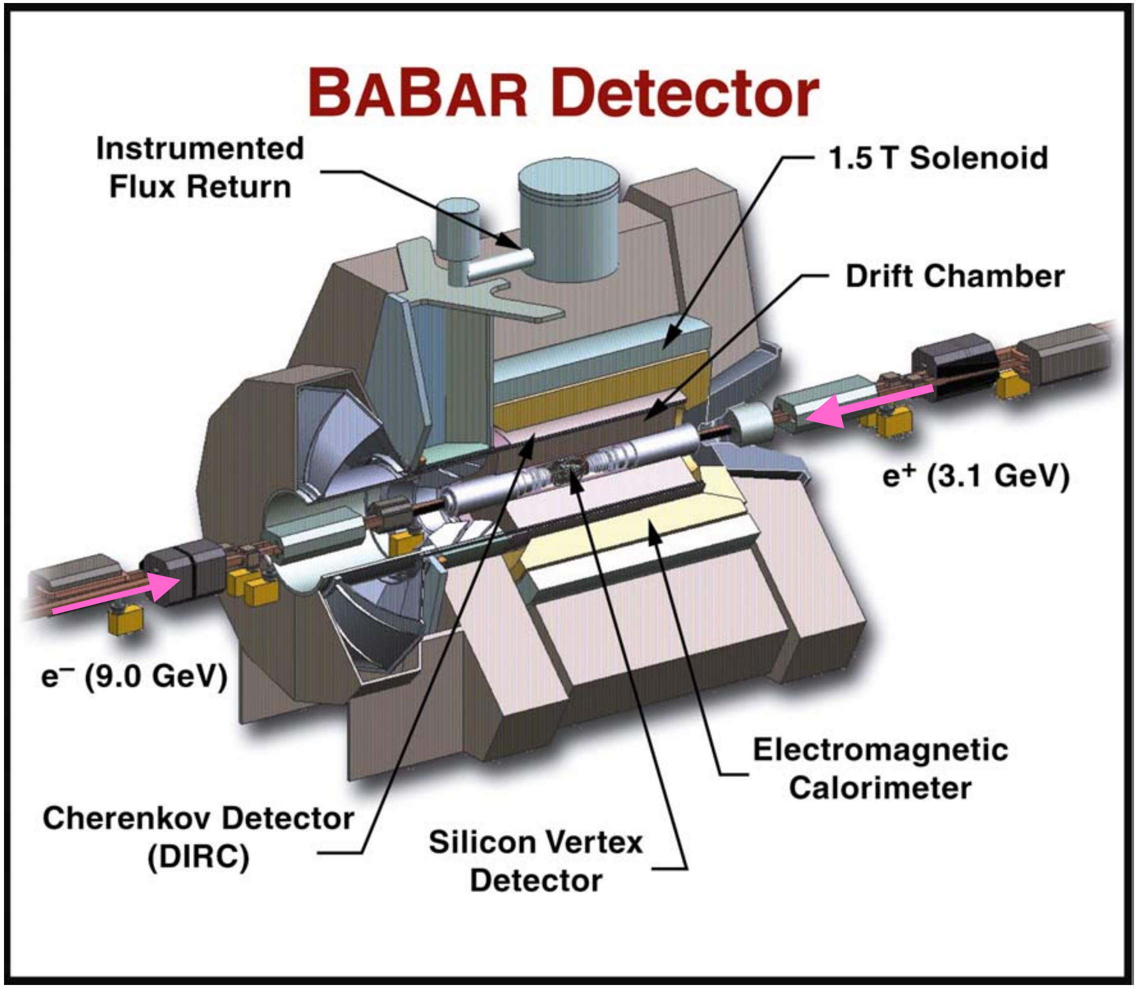




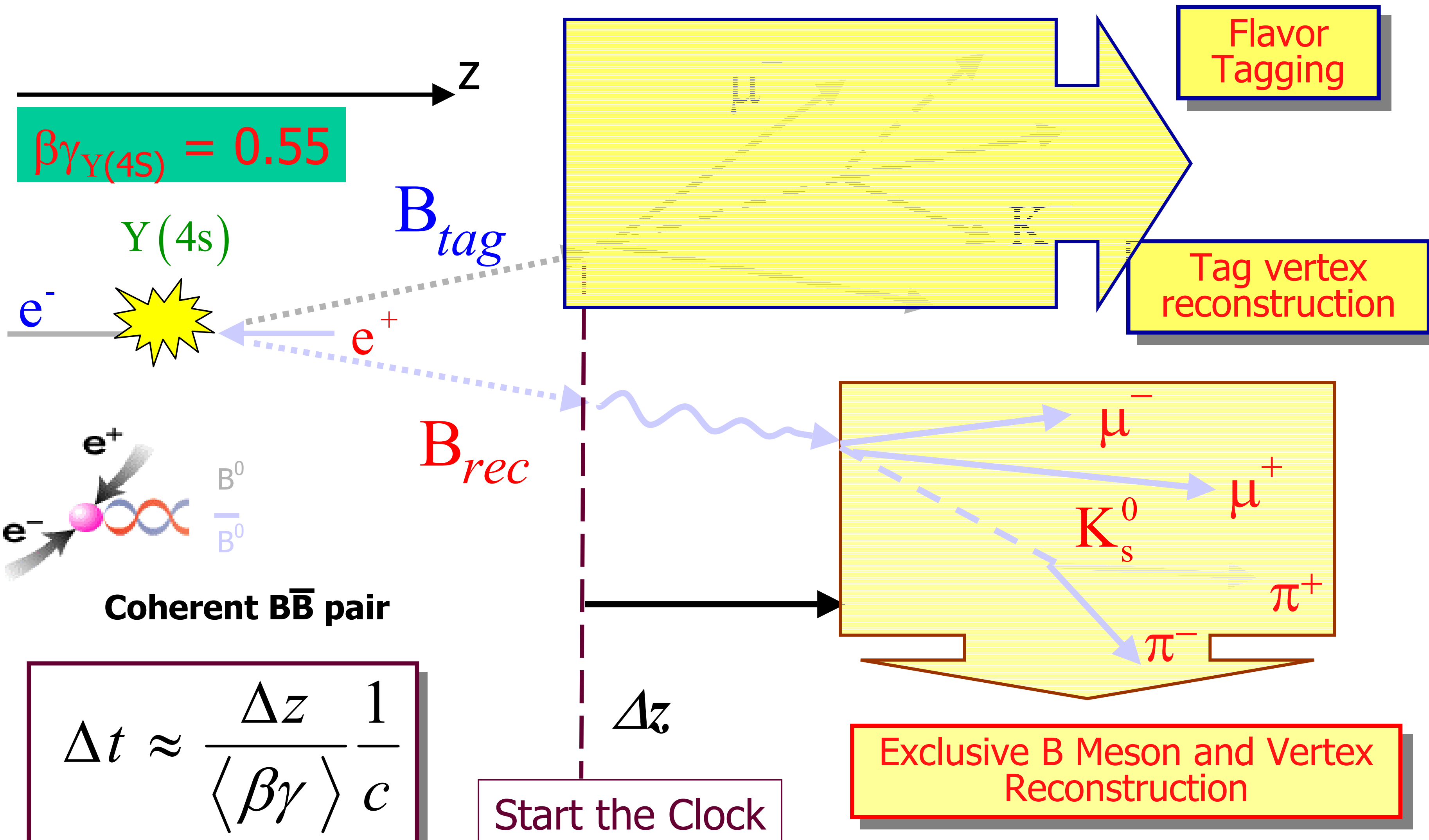
~88M $B\bar{B}$ pairs considered

The detector

- SVT: 5 double side layers, 97% efficiency, 15 μm z hit resolution
- DCH : 40 axial and stereo layers
- Tracking: $\sigma(p_T)/p_T = 0.13\ \% \times p_T\ +\ 0.45\ \%$, $\sigma(z_0) = 65\mu$ @ 1 GeV/c
- DIRC: 144 quartz bars
- EMC: 6580 CsI(Tl) crystals $\sigma_E/E = 2.3\ \%\cdot E^{-1/4} \oplus 1.9\ \%$
- IFR: 19 RPC layers, muon and K_L id



Experimental measurement



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

Tagging and Vertexing

- Lepton's and Kaon's sign tags B flavor
  - Improved effective tagging efficiency

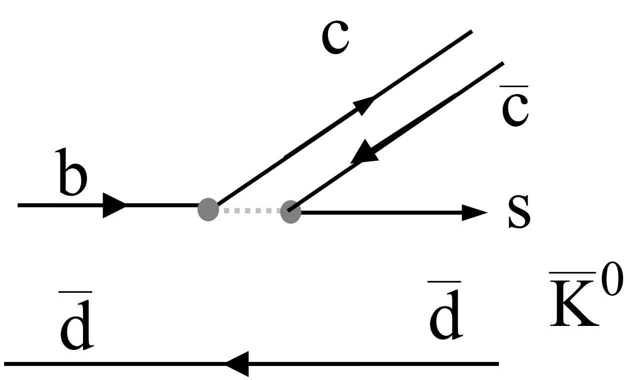
⇒ **Q=28.1 ± 0.7 %**

Compared to Q=26.0 ± 0.8

- Δz resolution 180μm

Tagging efficiency and vertex resolution measured from the data

$\sin 2\beta$ $(b \to c\bar{c}s)$



Charmonium states

η_{CP} = -1

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

η_{CP} = +1

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

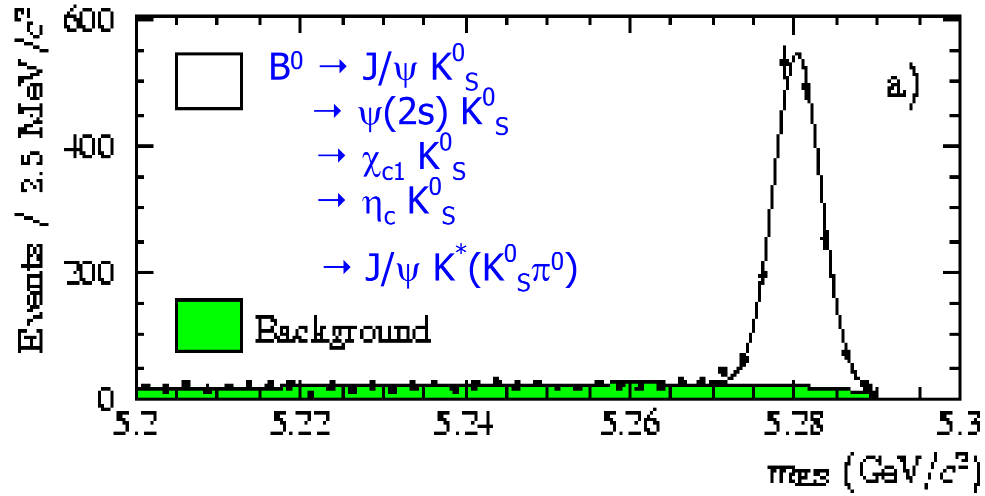
η_{CP} = $(1\text{-}2R_T)$

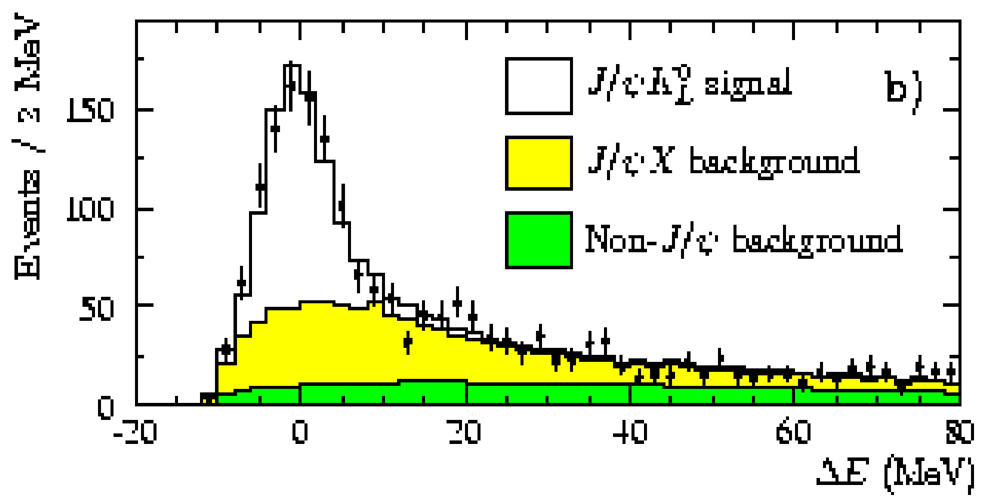
$B^0 \to J/\psi\, K^*(K^0_S\pi^0)$

$$A_{CP}(t) = \frac{f(\bar{B}^0_{phys} \to f_{CP}) - f(B^0_{phys} \to f_{CP})}{f(\bar{B}^0_{phys} \to f_{CP}) + f(B^0_{phys} \to f_{CP})} = -\eta_{CP} \sin 2\beta \sin(\Delta m \Delta t)$$

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
$\chi_c K_s$	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**

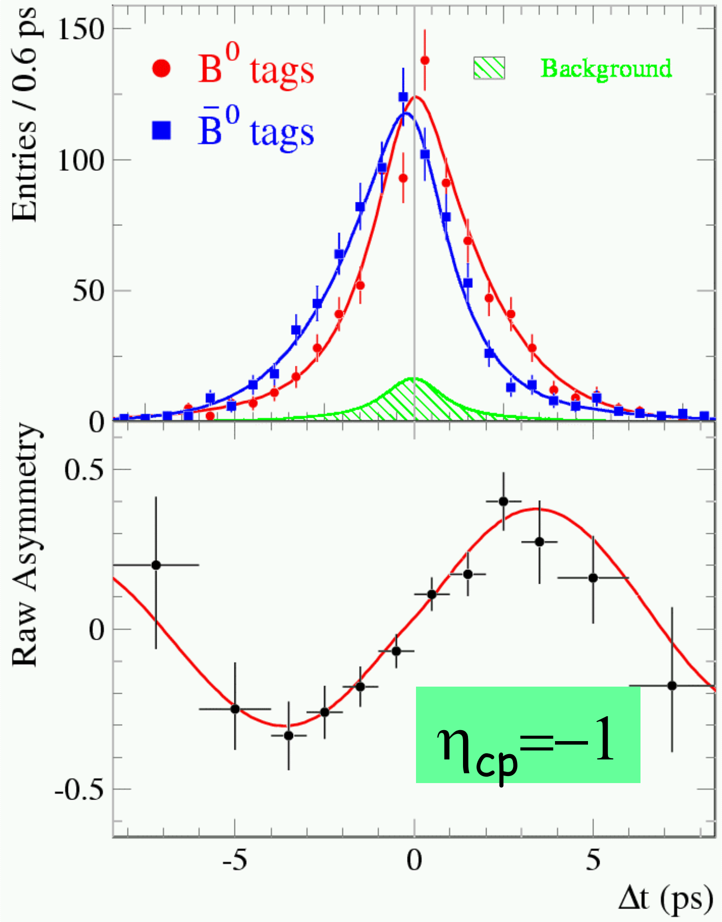


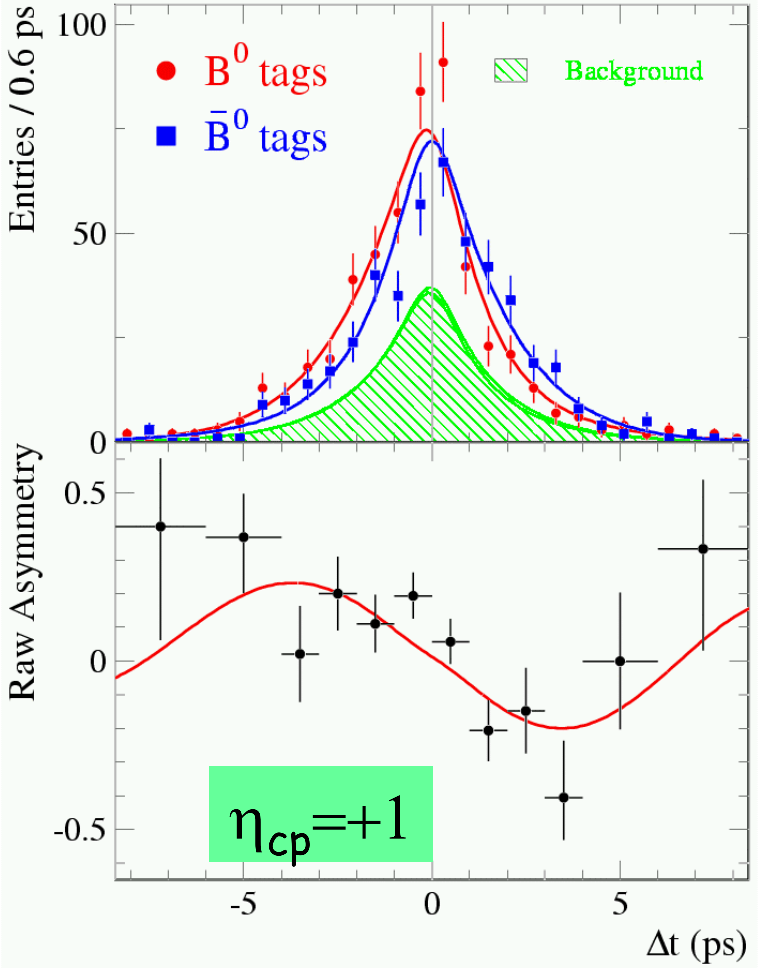


η_c has been added to the sample

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

CP asymmetries



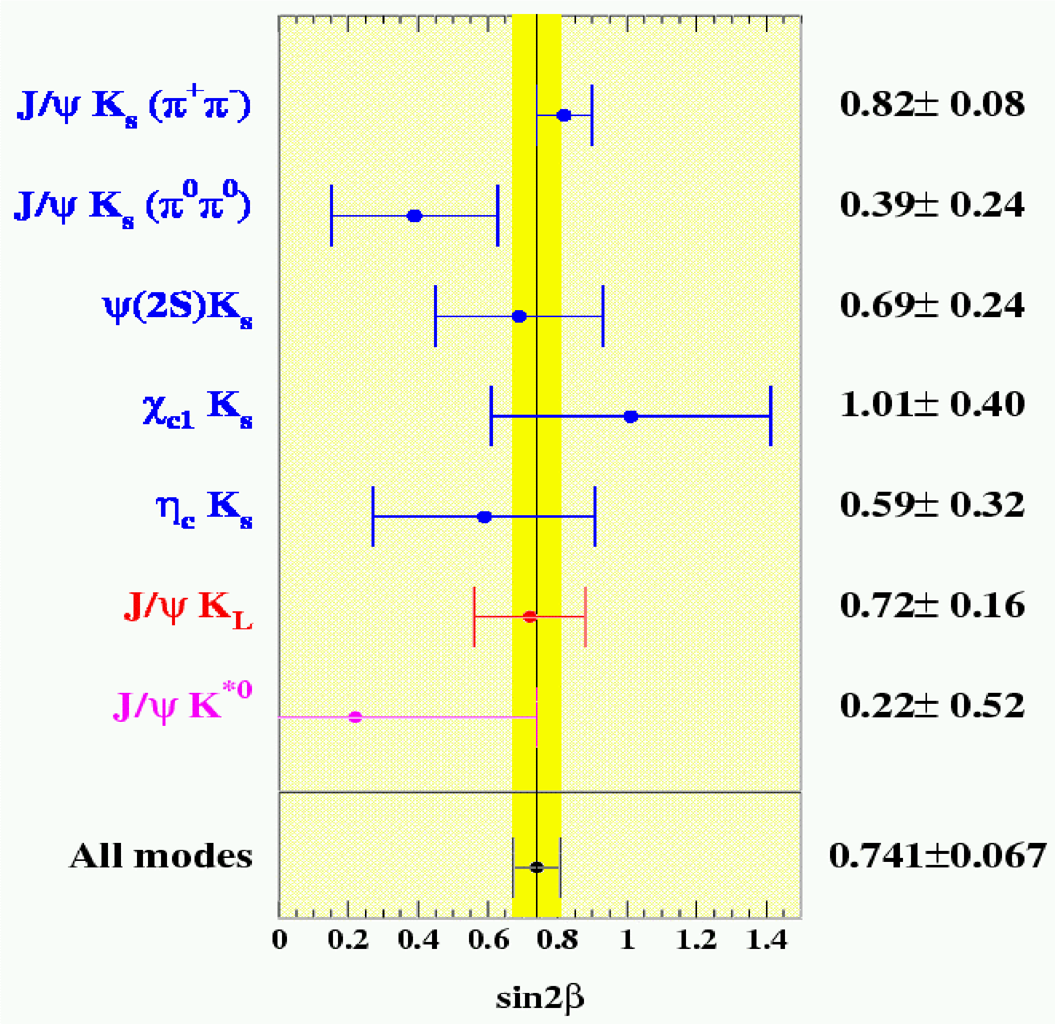


$\sin 2\beta = 0.755 \pm 0.074$ **$\sin 2\beta = 0.723 \pm 0.158$**

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

Submitted to PRL, hep-ex/0207042

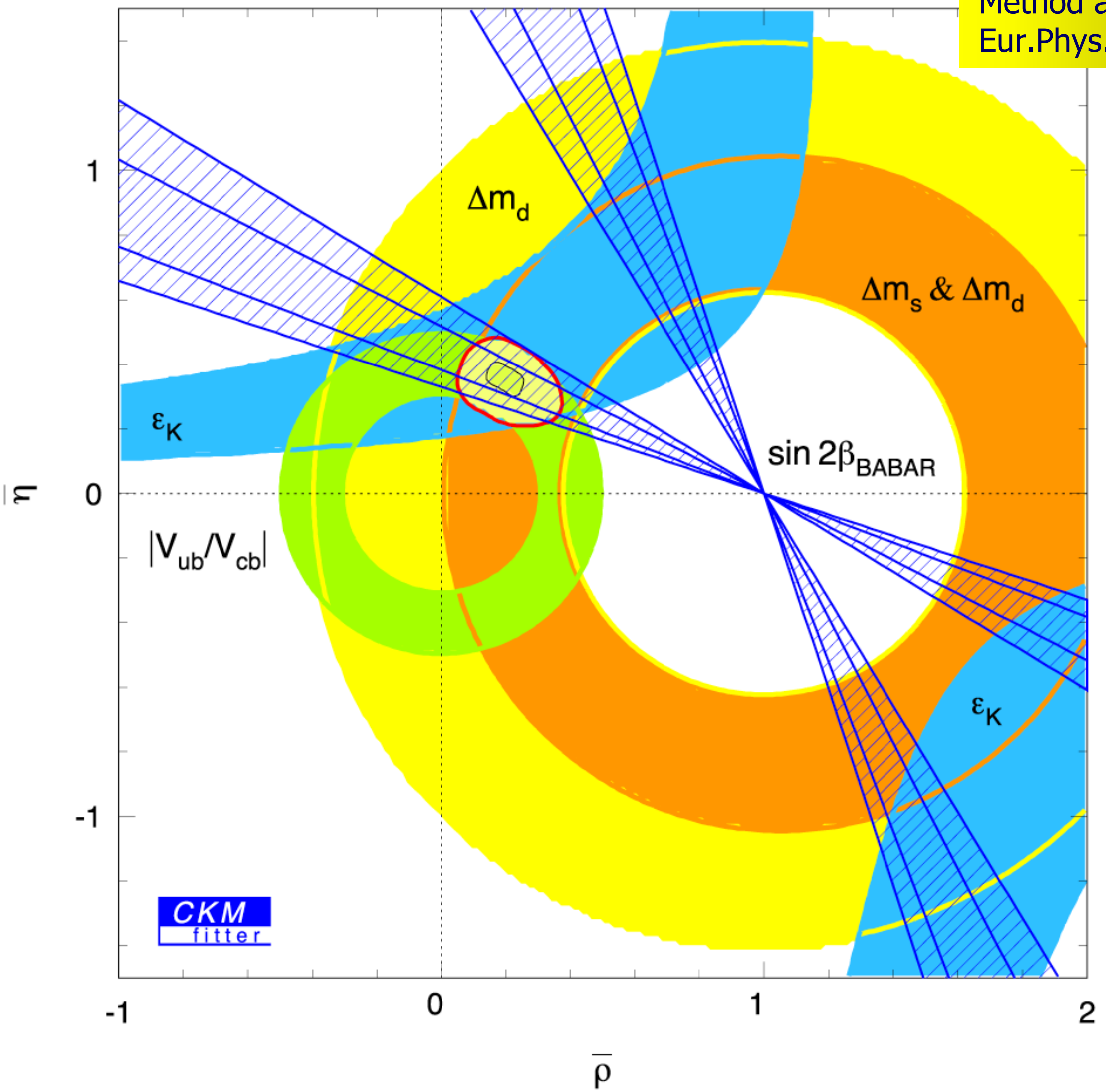
sin2β results (b→c$\bar{c}$s)



All consistent P(χ^2) = 57%

Constraining the ρ ,η plane

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



Beyond the Standard Model

- No direct CP violation in the SM

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

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

- Leave λ free and fit for $|\lambda|$ and S_f

Only $b \to (c\bar{c})K_s$

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

and

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

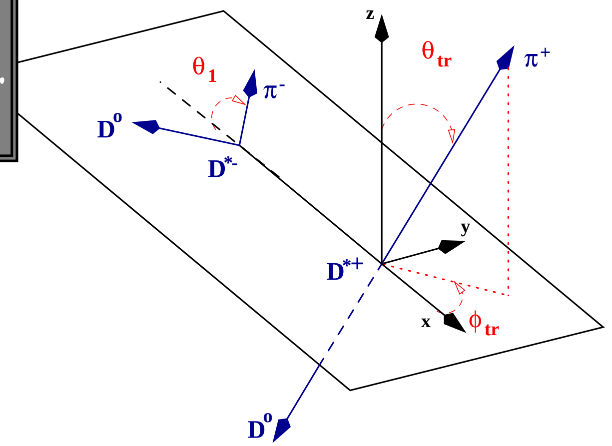
sin2β (b→c$\bar{c}$d) Cabibbo-suppressed modes

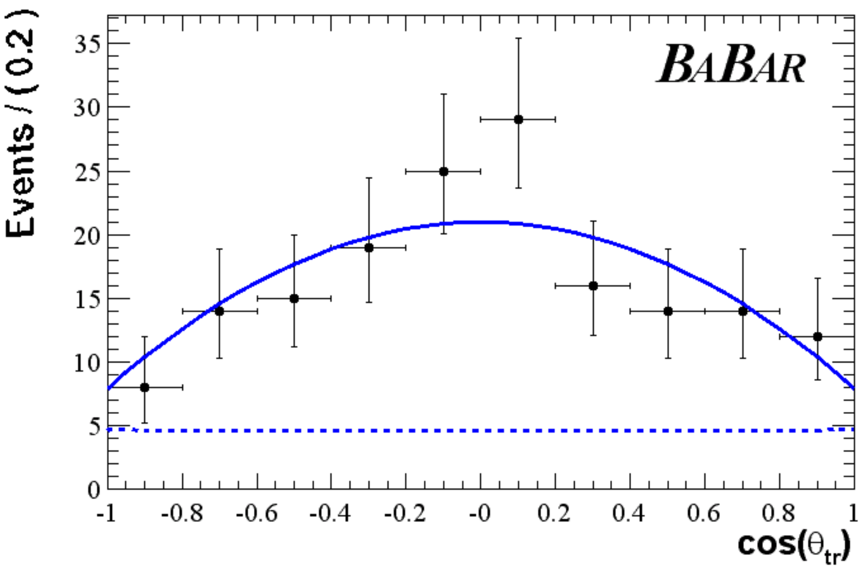
$B^0 \to D^{*+} D^{*-}$

- $D^{*+}D^{*-}$, is not a CP eigenstate (L=0,2 and L=1)
- CP odd fraction $R_\perp$
- Transversity analysis

$$R_\perp = \frac{|A_\perp|^2}{|A_0|^2 + |A_\parallel|^2 + |A_\perp|^2}$$

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

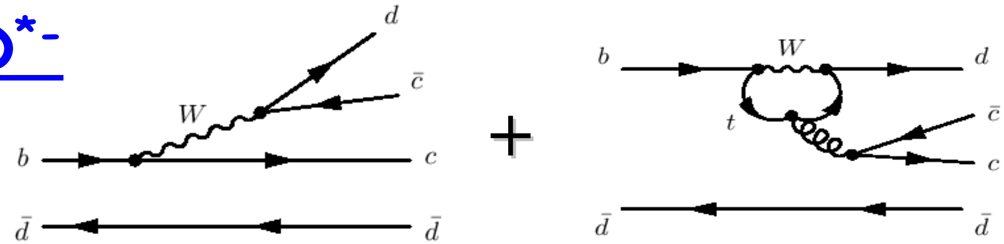




CP odd fraction

$R_\perp$ = 0.07 ± 0.06 ± 0.03

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



$-\sin 2\beta$

Small (< 0.1 T) penguin contribution expected

We measure :

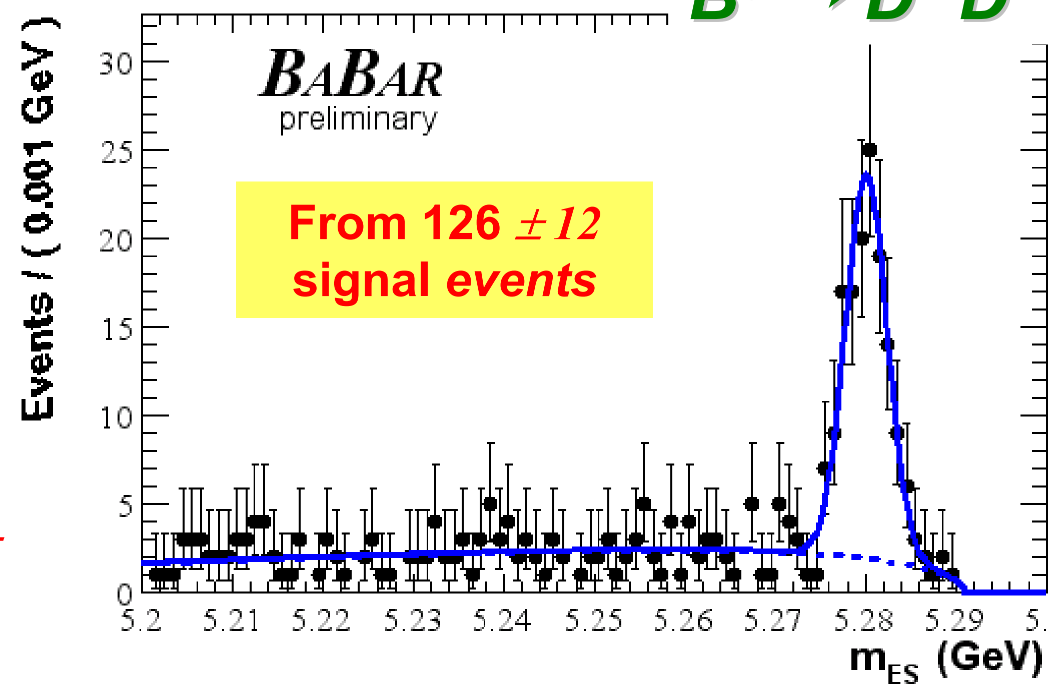
- $\mathrm{Im}(\lambda_+)$
- $|\lambda_+|$

$Im(\lambda_+) = 0.31 \pm 0.43$ (stat) ± 0.13 (syst)

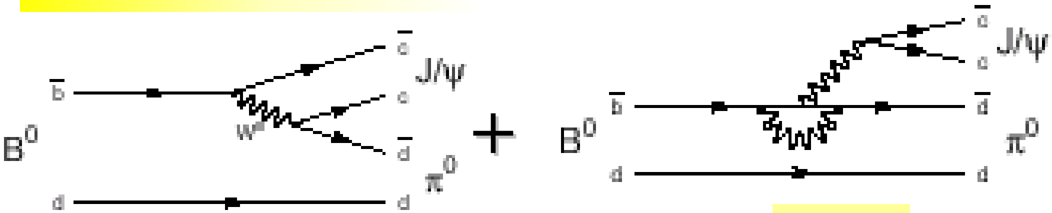
$-\sin 2\beta = -0.741 \pm 0.067$

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

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

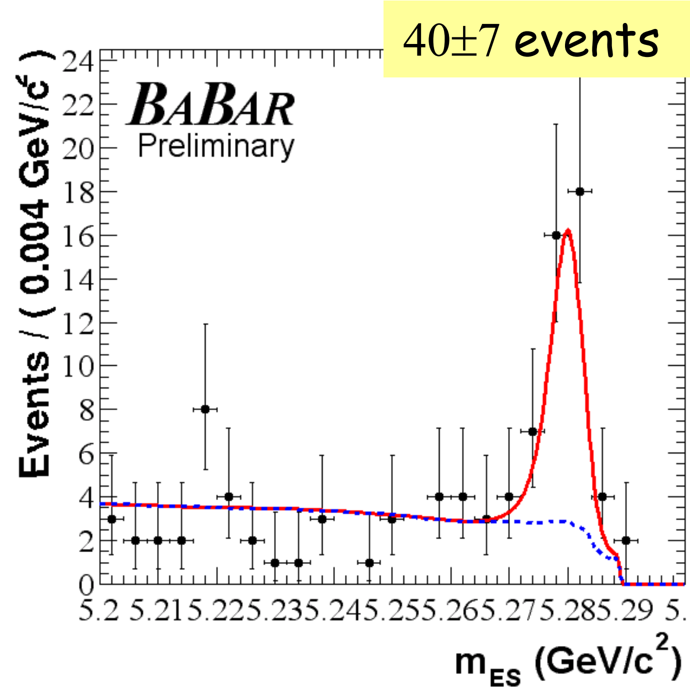


$B^0 \rightarrow J/\psi\ \pi^0$



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

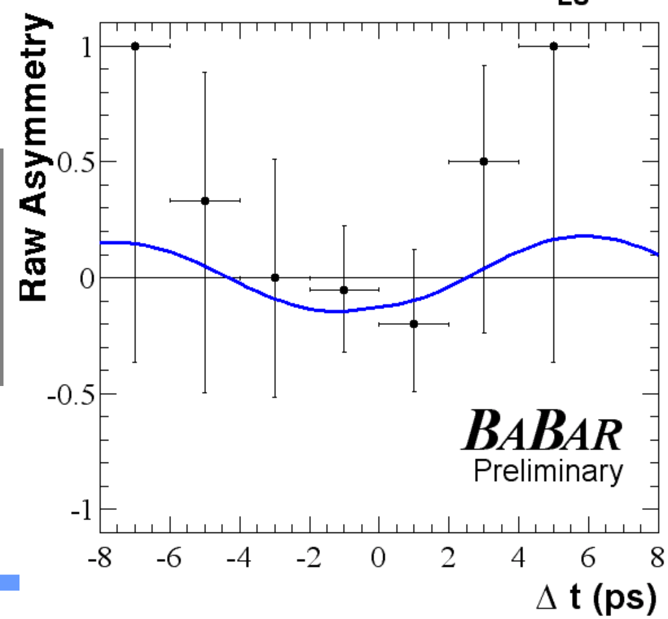
If no penguins we measure -sin2β



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

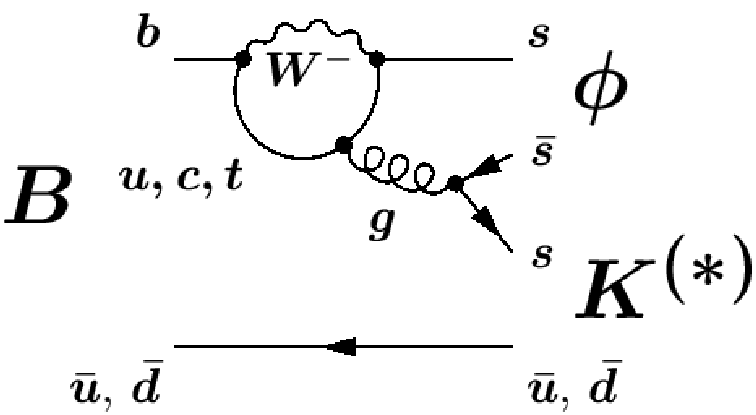
$$S_{J/\psi\pi^{0}} = 0.05 \pm 0.49(stat) \pm 0.16(syst)$$

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

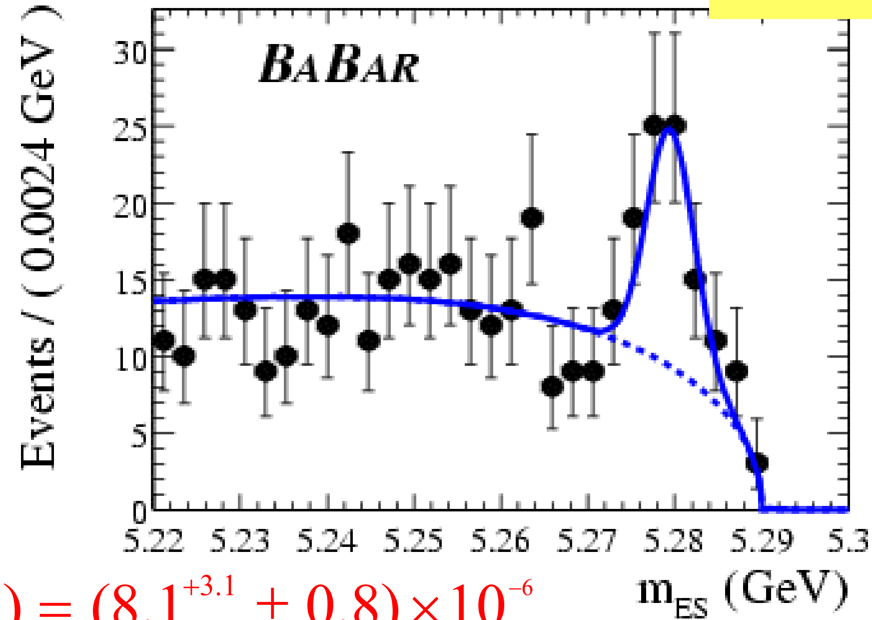


$B^0 \to \phi K^0_S$ pure penguin, tree highly suppressed

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



51 events



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

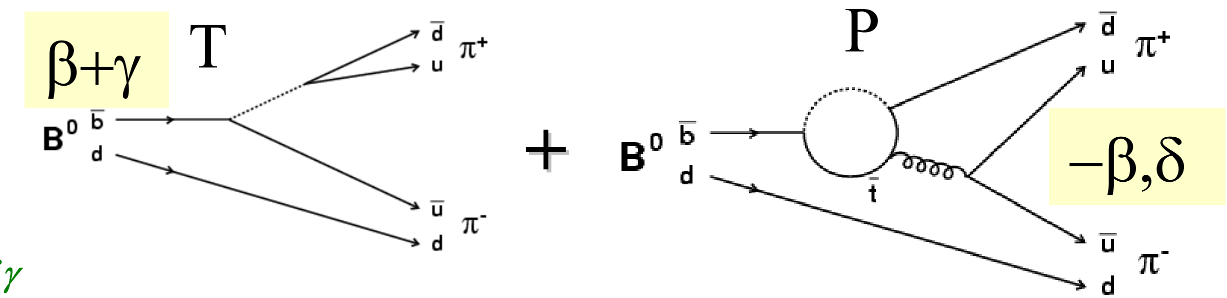
$$\sin 2\beta = -0.19^{+0.52}_{-0.50}(stat) \pm 0.09(syst)$$

Assuming $|\lambda|=1$

Measuring sin2α

Experimentalists measure $\alpha_{eff} \neq \alpha$ due to non negligible penguin contributions

•$B^0 \to \pi^+\pi^-$



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

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

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

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

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

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

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

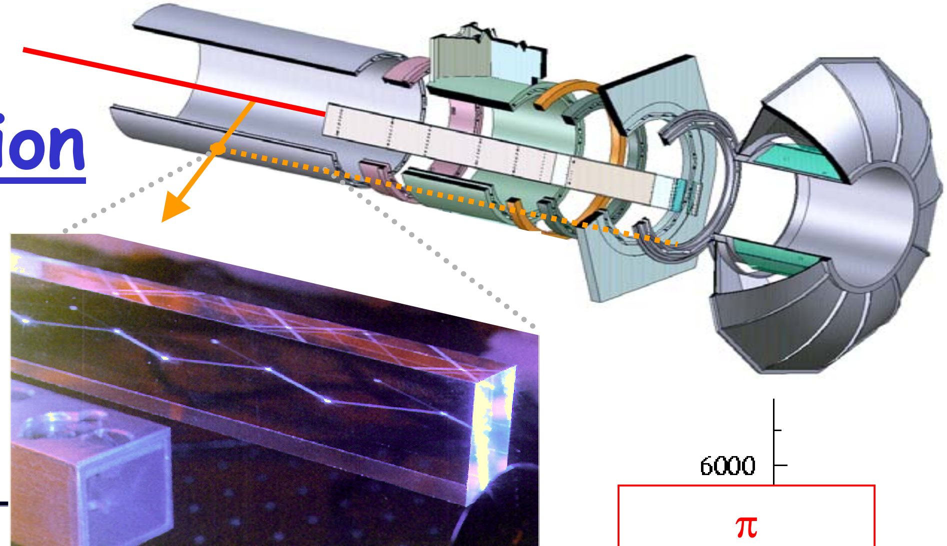
BUT

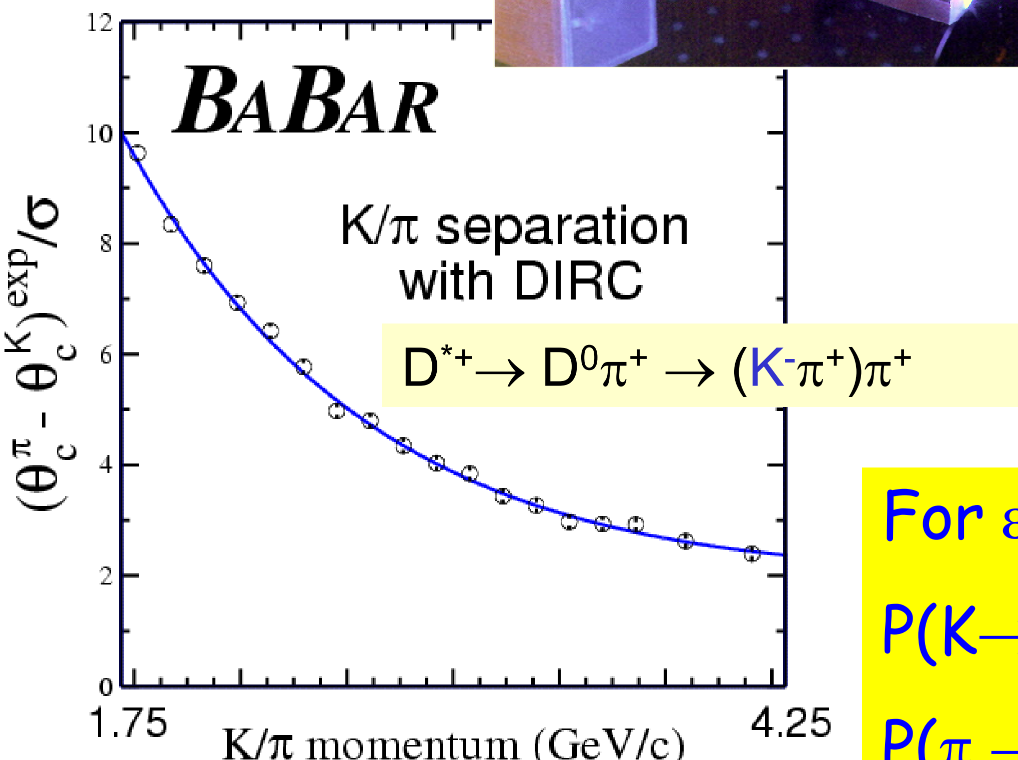
The key issue is

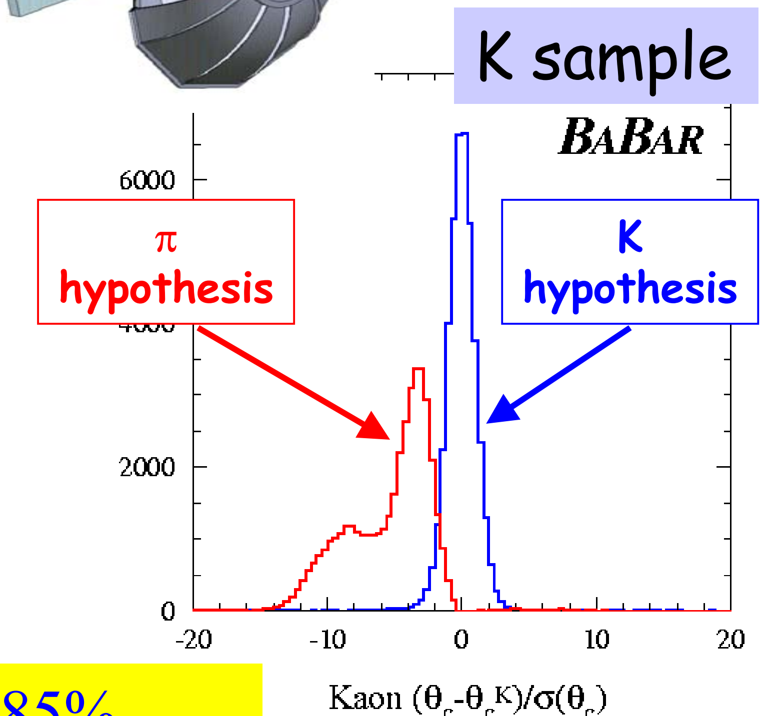
Particle Identification

First results presented last year

π-K separation







For ε=85%

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

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

Branching fractions and direct CP violation

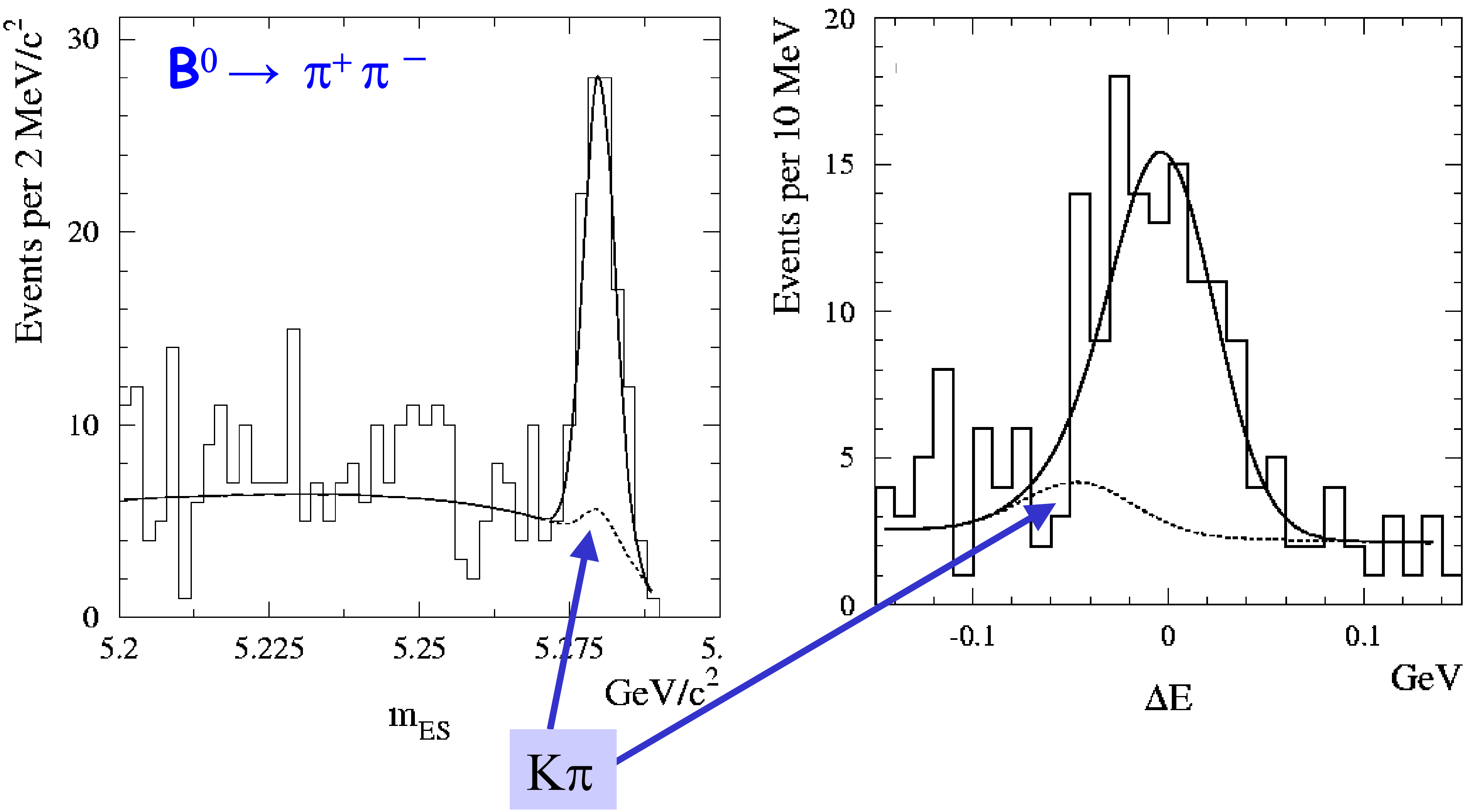
- Maximum Likelihood to extract branching ratios and $K\pi$ asymmetries
- No tagging or vertexing needed

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)	

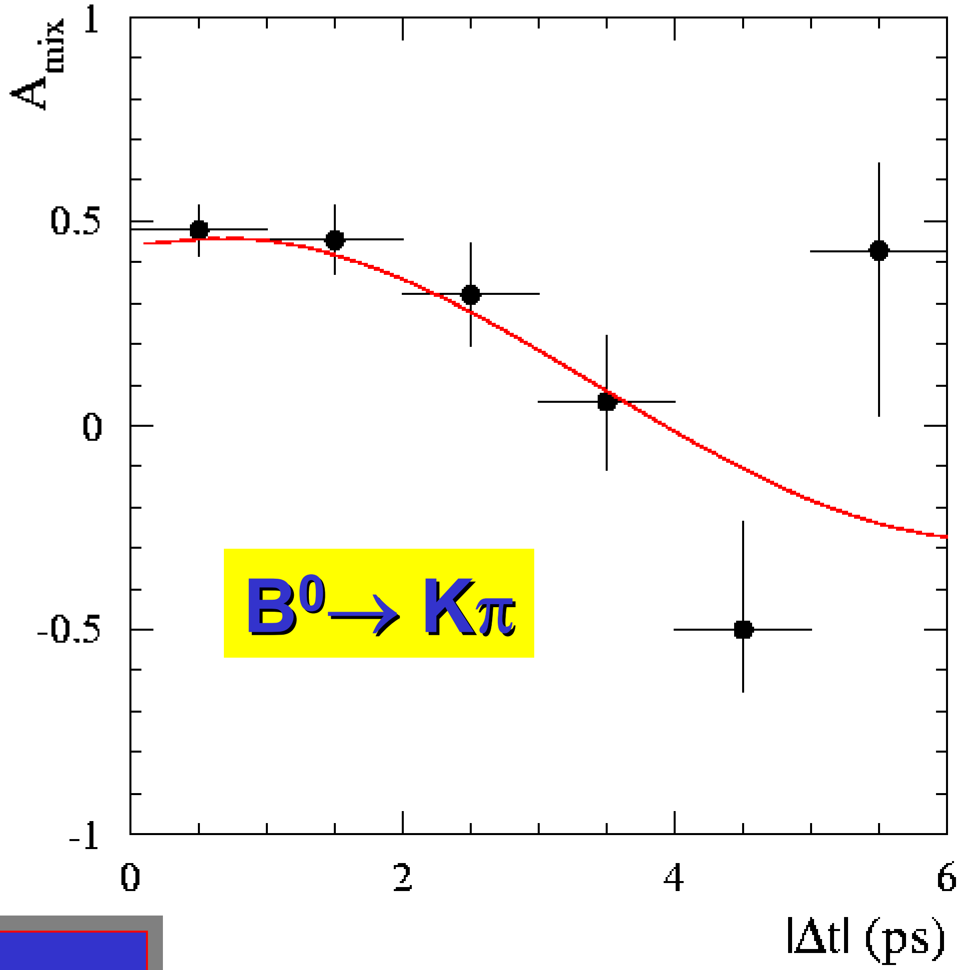
m_{es} and ΔE for $B^0 \to \pi^+ \pi^-$



Validation test

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

- Life time τ
- Δm_d



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

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

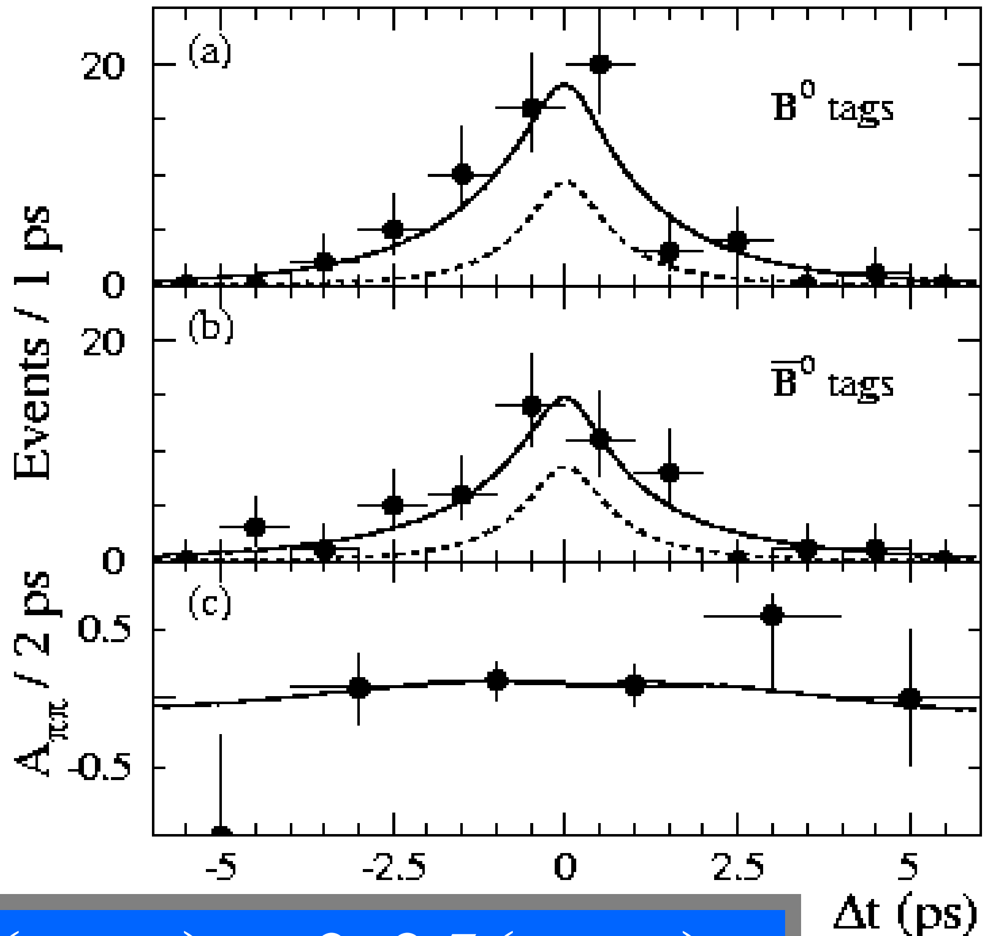
WA

τ=1.540±0.014 ps

Δm_d=0.503 ± 0.006 ps^{-1}

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

From unbinned maximum likelihood fit



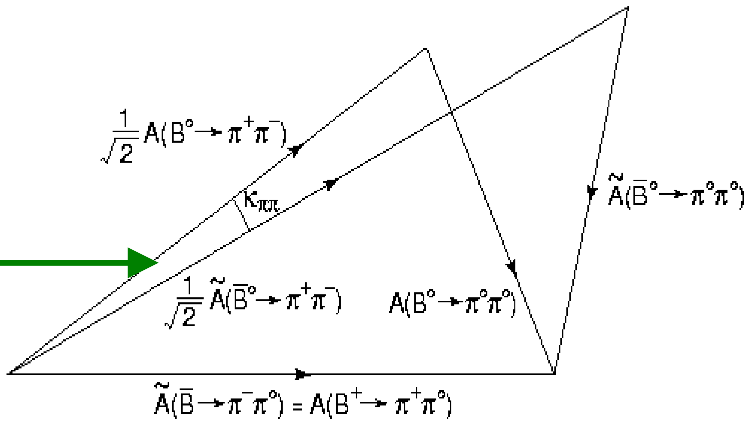
$$S_{\pi\pi} = 0.02 \pm 0.34(\boldsymbol{stat}) \pm 0.05(\boldsymbol{syst})$$

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

From α_{eff} to α

Isospin analysis is required to extract α

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



- Need to measure

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

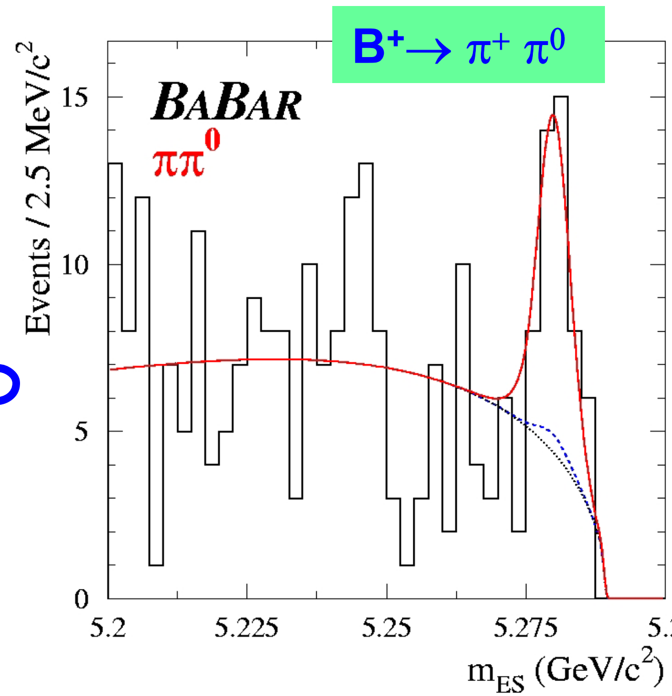
➢ Or put a limit on $BR(B^0 \to \pi^0\pi^0)$

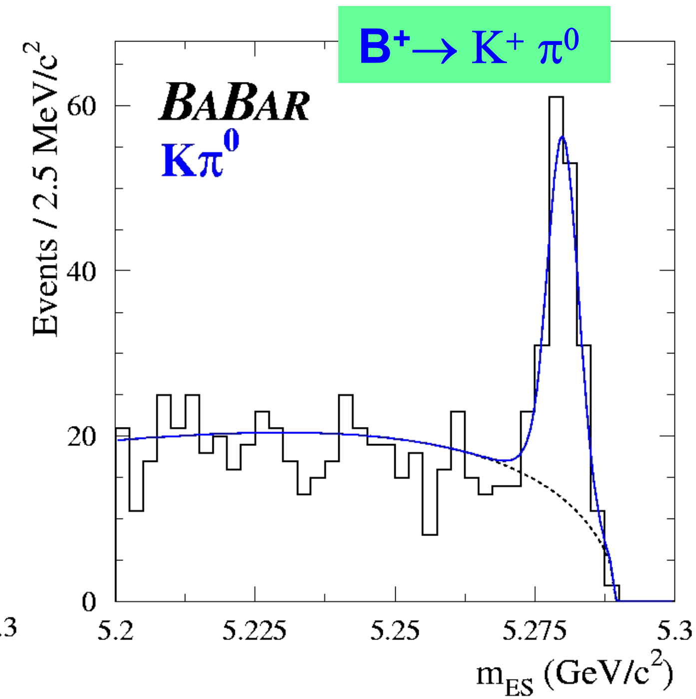
$$\left|2\alpha - 2\alpha_{eff}\right| \le \arccos\left[\frac{1}{\sqrt{1 - C_{\pi\pi}^2}}\left(1 - 2\frac{BR\left(\pi^0\pi^0\right)}{BR\left(\pi^\pm\pi^0\right)}\right)\right]$$

Grossman-Quinn
Charles

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

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





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

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

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

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

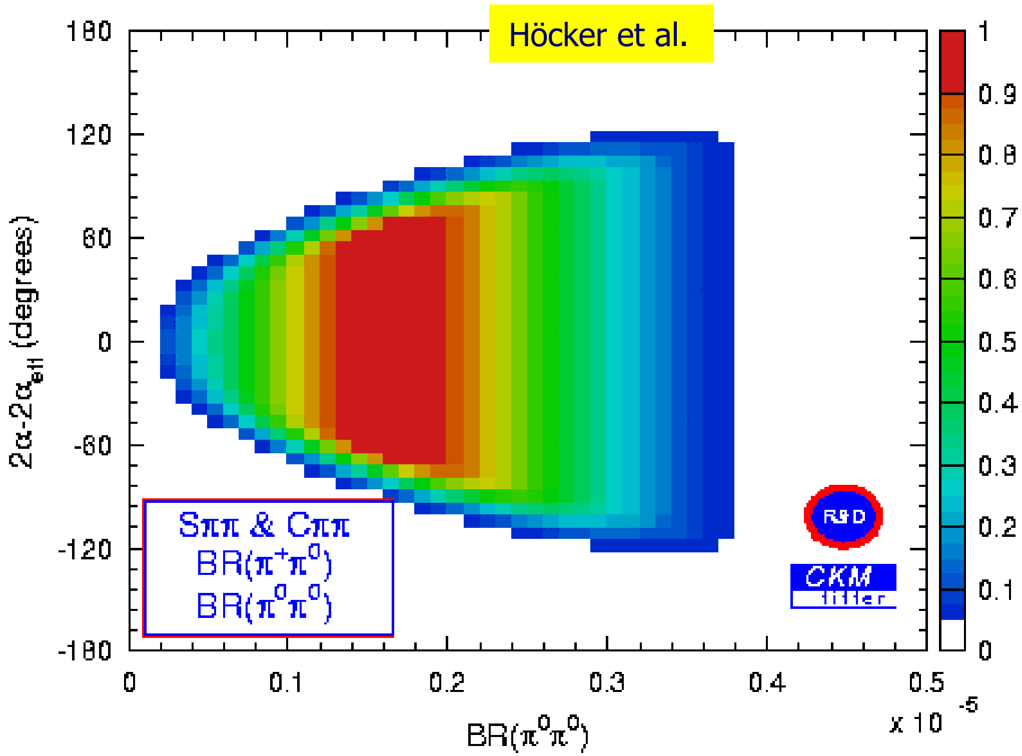
Central Value :

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

Measuring alpha ?

From $BR(B^0 \to \pi^0 \pi^0)$ limit

$$|\alpha - \alpha_{eff}| < 51^0 \text{ at } 90\% \, CL$$

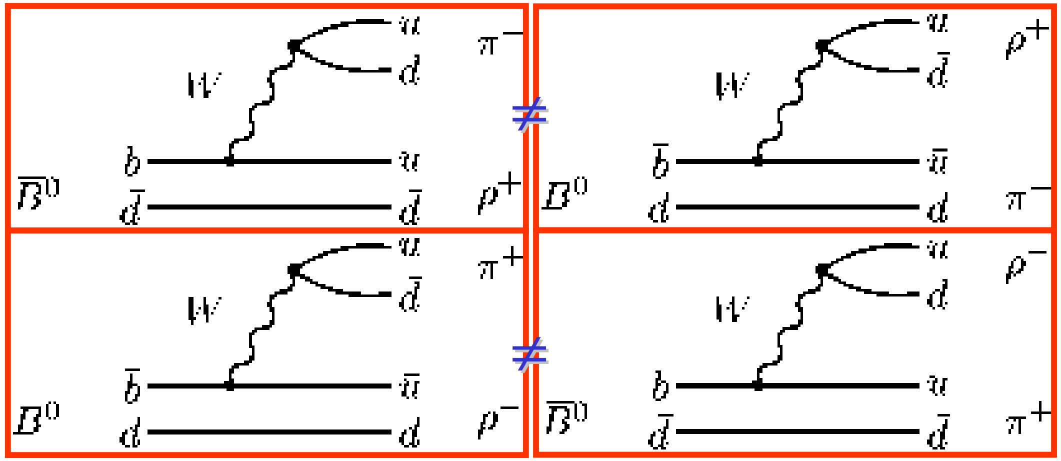


If the BR($B \to \pi^0\pi^0$) is indeed as high as 1.6×10^{-6} the "Grossman-Quinn" bound will not constrain enough α and

Isospin analysis is then necessary

• $B^0 \rightarrow \rho\pi$

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



Not a CP eigenstate

Four amplitudes

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

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

$B^0 \to \rho\pi$

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

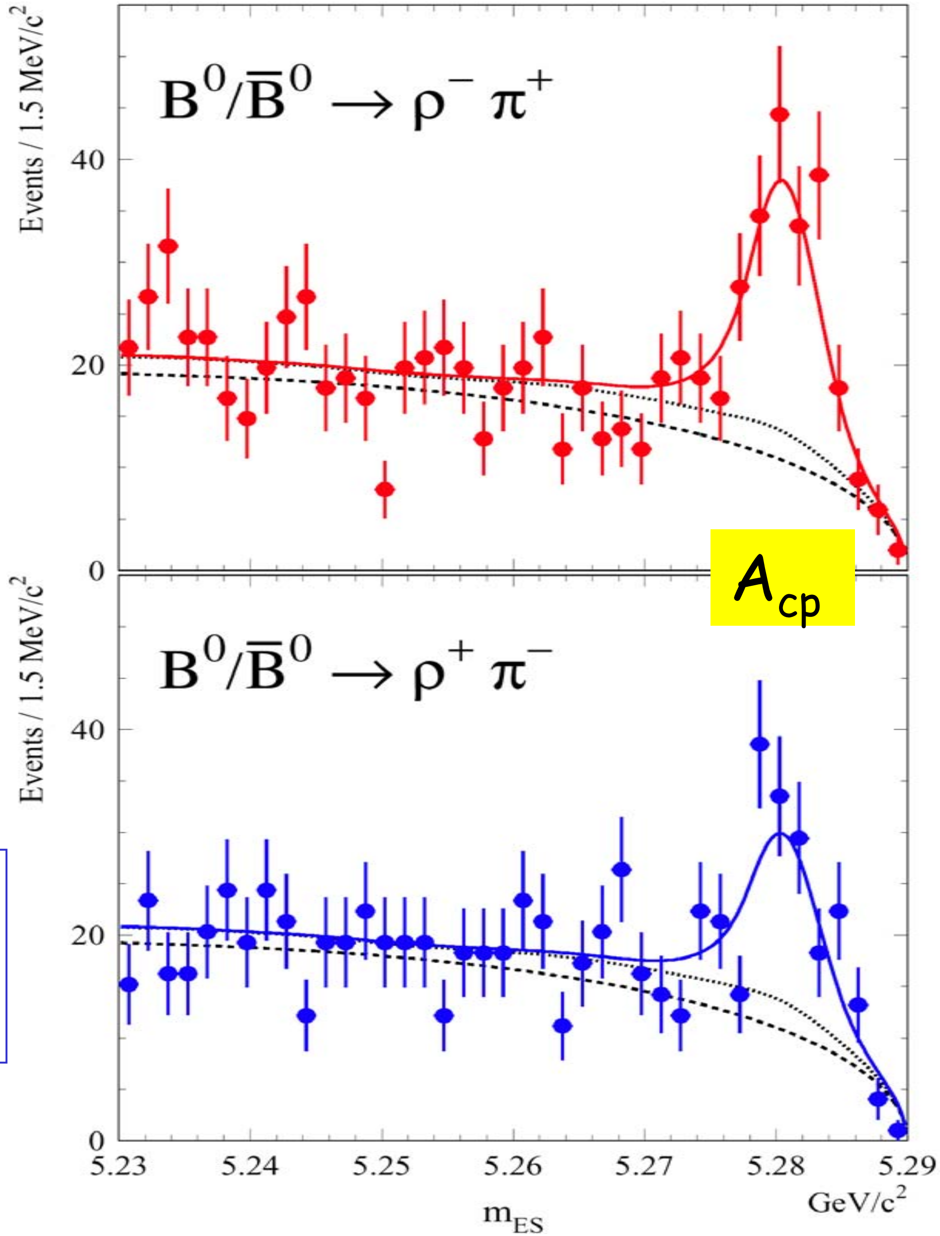
$$N_{\rho\pi} = 413^{+34}_{-33}$$

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

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

τ=1.59±0.12 ps

Δm_d=0.51 ± 0.09 ps^{-1}



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

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

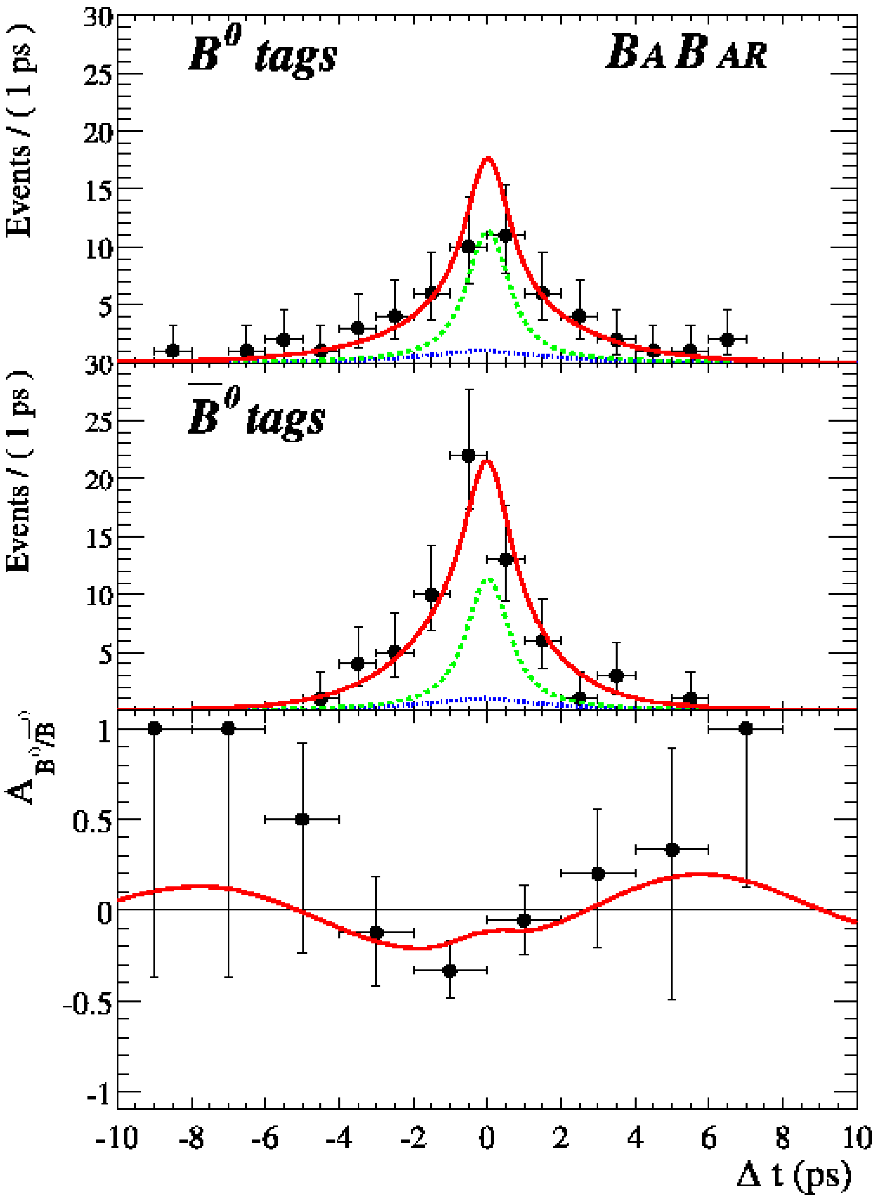
$$A_{CP}^{\rho K} = 0.19^{+0.14}_{-0.14}(stat) \pm 0.11(syst)$$

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

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

$$\Delta C_{\rho\pi} = 0.38^{+0.19}_{-0.20}(stat) \pm 0.11(syst)$$

$$\Delta S_{\rho\pi} = 0.15^{+0.25}_{-0.25}(stat) \pm 0.05(syst)$$



$B^0 \to \rho\pi$ Direct CP Violation

$$A_{+-} = \frac{N(\overline{B^0_{\rho\pi}} \to \rho^+\pi^-) - N(B^0_{\rho\pi} \to \rho^-\pi^+)}{N(\overline{B^0_{\rho\pi}} \to \rho^+\pi^-) + N(B^0_{\rho\pi} \to \rho^-\pi^+)}$$

$$A_{-+} = \frac{N(\overline{B^0_{\rho\pi}} \to \rho^-\pi^+) - N(B^0_{\rho\pi} \to \rho^+\pi^-)}{N(\overline{B^0_{\rho\pi}} \to \rho^-\pi^+) + N(B^0_{\rho\pi} \to \rho^+\pi^-)}$$

A_{+-} = -0.82±0.31(stat) ± 0.16(syst)

A_{-+} = -0.11 ± 0.16 (stat) ± 0.09(syst)

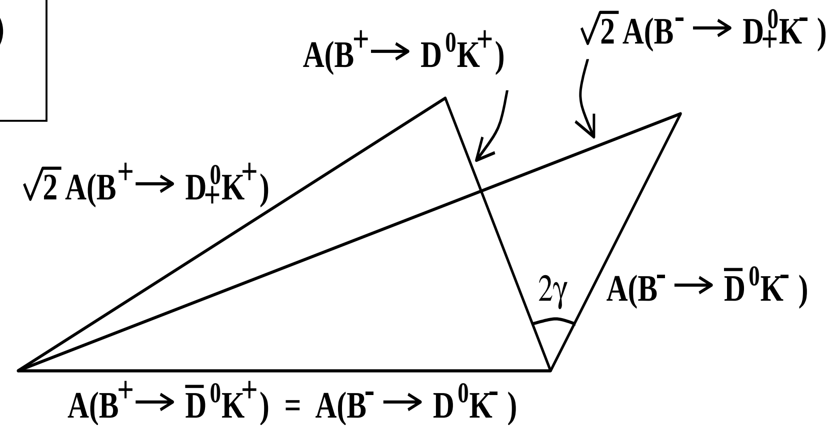
$B^- \to D^0_{(CP)} K^-$

“future” goal is γ

$$A(B^+ \to \overline{D}^0 K^+) = |\overline{A}|\, e^{i\delta_1} \qquad (V^*_{cb} V_{us})$$

$$A(B^+ \to D^0 K^+) = |A|\, e^{i\delta_2} e^{i\gamma} \qquad (V^*_{ub} V_{cs})$$

$$R \equiv \frac{Br(B^- \to D^0 K^-)}{Br(B^- \to D^0 \pi^-)} = (8.31 \pm 0.35 \pm 0.20)\%$$

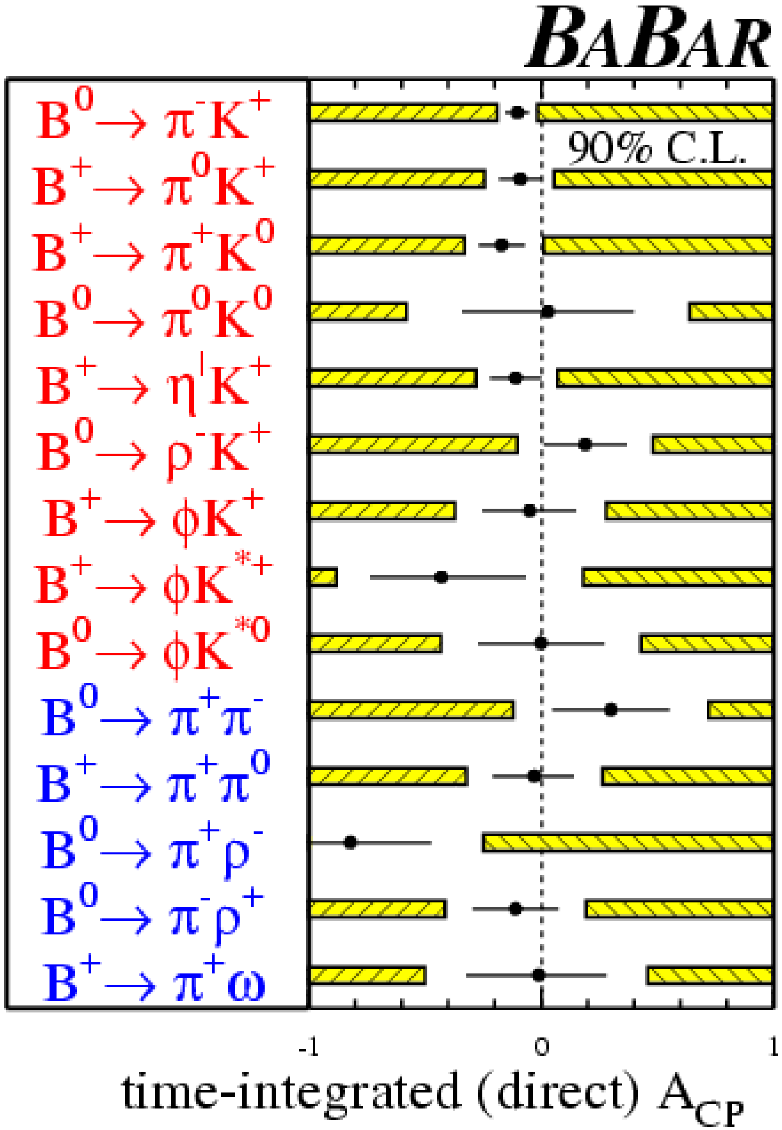


and

$$A_{CP} \equiv \frac{Br(B^- \to D^0_{CP} K^-) - Br(B^+ \to D^0_{CP} K^+)}{Br(B^- \to D^0_{CP} K^-) + Br(B^+ \to D^0_{CP} K^+)} = 0.17 \pm 0.23^{+0.09}_{-0.07}$$

Direct CP measurements summary

No evidence for direct CP violation yet



Conclusions

- Measurement of $\sin 2\beta = 0.741 \pm 0.067 \pm 0.033$
- New modes, T+P or P, may open the window on new physics
- Time dependent asymmetries for $B^0 \rightarrow \pi^+\pi^-$ and $B^0/\overline{B^0} \rightarrow \rho^{\pm}\pi^{\pm}$
- Building blocks, BR($B^0 \rightarrow \pi^0\pi^0$ and $B^+ \rightarrow \pi^+\pi^0$), for an isospin analysis are on place

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

Backup slides

Strategy for measuring $\phi=(\alpha,\beta,\gamma)$

- Extract $\sin 2\phi$ or (S_f) from theoretically clean modes. 'Only' tree diagram contributions.
  - $C_f=0$ and no direct CP violation is expected
  - Test unitarity as foreseen from the SM
- Use modes where the tree contribution is not dominant, to explore new frontiers in physics.
  - Penguin bring extra weak and strong phases
  - $C_f \neq 0$ in general.
  - $S_f \neq \sin(2\phi)$

Analysis techniques

• Continuum background is rejected using topological variables ex:

- $\cos(\theta_s)$ angle between sphericity axes of B and remaining tracks.
- Fisher discriminant from L_0 and L_2 $\quad L_j = \sum_i p_i \left|\cos\vartheta_i\right|^j$

• Time resolution functions and effective tagging efficiency are measured directly from the data, using Cabibbo favored fully reconstructed B decays, ~ 25K events.

• Simultaneous unbinned maximum likelihood fit, using CP signal events and B flavor sample to extract branching ratios, asymmetries or CP parameters.

- (m_{es}, ΔE, F,…) PDFs for signal and background are the input parameters for the fit
- PDFs determined using control samples or Monte Carlo

Variables used

➢Beam – energy substituted mass

$$m_{es} = \sqrt{(s/2 + \overrightarrow{p_i}\,\overrightarrow{p_B})^2 / E_i^2 - p_B^2}$$

s,p_i and E_i cm kinematic variables in the lab frame

p_B and E_B B candidate

➢ ΔE

$$\Delta E = E_B^* - \sqrt{s}\big/2$$

Fully reconstructed B sample

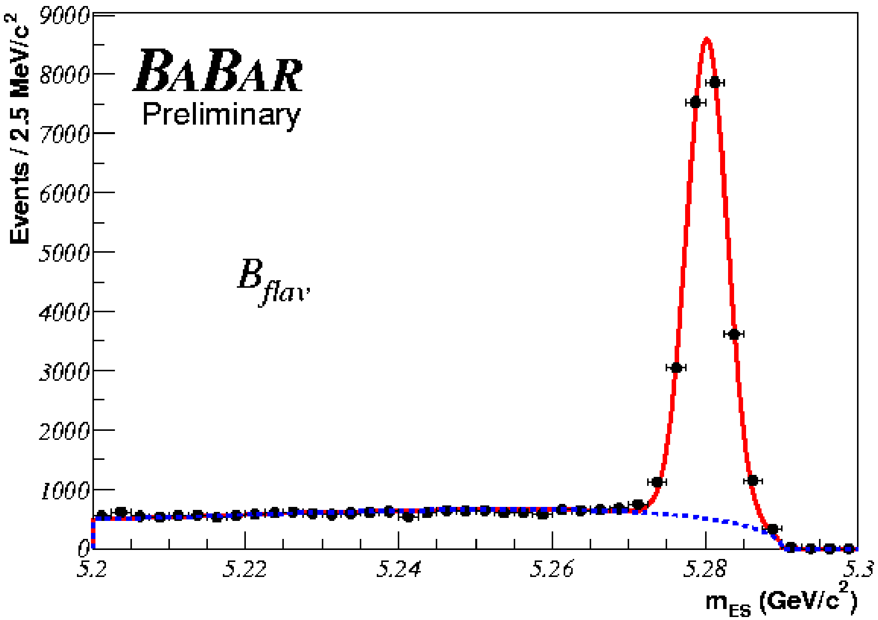
- Time resolution functions and effective tagging efficiency are measured directly from the data, using Cabbibo favored fully reconstructed B decays, (b → c$\bar{u}$d or b → c$\bar{c}$s).

$$B^0 \rightarrow D^{(*)-}\pi^+/\rho^+/a_1^+$$

$$B^- \rightarrow D^{(*)0}\pi^-$$

$$B^0 \rightarrow J/\psi K^{*0}(K^+\pi^-)$$

$$B^+ \rightarrow J/\psi K^+,\ \psi(2S)K^+$$



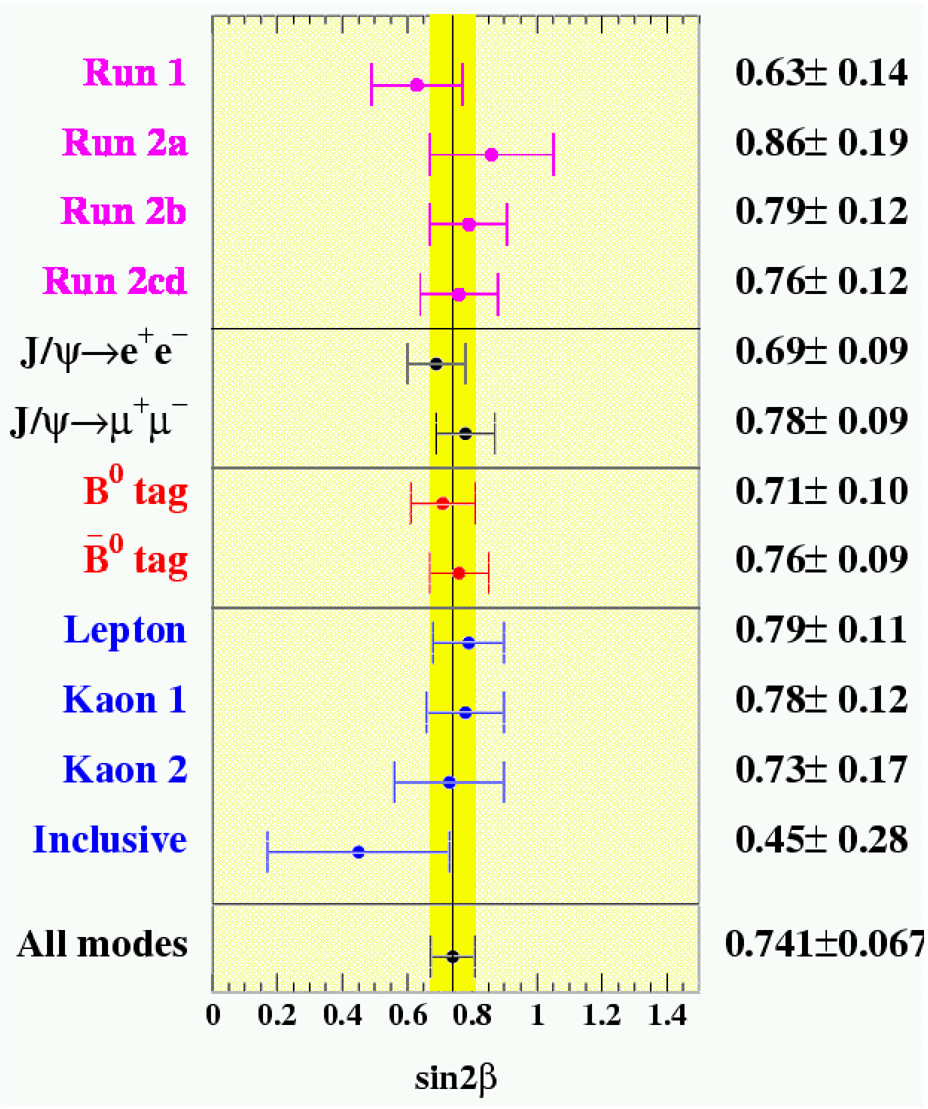
Effective tagging efficiency Q

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

$$\begin{cases} l^- \to \overline{B}^0 & l^+ \to B^0 \\ K^- \to \overline{B}^0 & K^+ \to B^0 \end{cases}$$

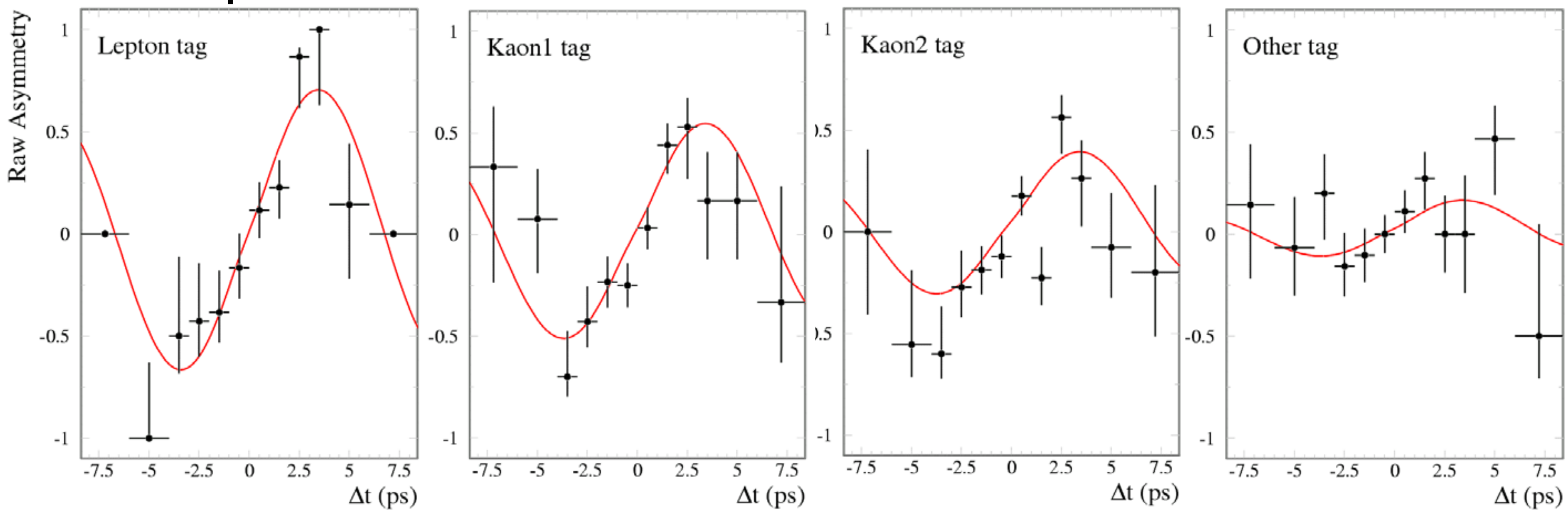
Tagging Performance				
Category	Efficiency (ε)	Mistag Fr. (ω)	δ Mistag	$Q=\varepsilon(1-2\omega)^2$
Lepton	9.1 ± 0.2	3.3 ± 0.6	-1.4 ± 1.1	7.9 ± 0.3
Kaon I	16.7 ± 0.2	9.9 ± 0.7	-1.1 ± 1.1	10.7 ± 0.4
Kaon II	19.8 ± 0.3	20.9 ± 0.8	-4.2 ± 1.1	6.7 ± 0.4
Inclusive	20.0 ± 0.3	31.6 ± 0.9	-2.0 ± 1.2	2.7 ± 0.3
Total	65.6 ± 0.5			28.1 ± 0.7

Improved effective tagging efficiency compared to the past. 7% equivalent more luminosity


Run 1
Run 2a
Run 2b
Run 2cd
$J/\psi \to e^+e^-$
$J/\psi \to \mu^+\mu^-$
B^0 tag
$\bar{B}^0$ tag
Lepton
Kaon 1
Kaon 2
Inclusive
All modes
0.63± 0.14
0.86± 0.19
0.79± 0.12
0.76± 0.12
0.69± 0.09
0.78± 0.09
0.71± 0.10
0.76± 0.09
0.79± 0.11
0.78± 0.12
0.73± 0.17
0.45± 0.28
0.741±0.067
0
0.2
0.4
0.6
0.8
1
1.2
1.4
$\sin 2\beta$

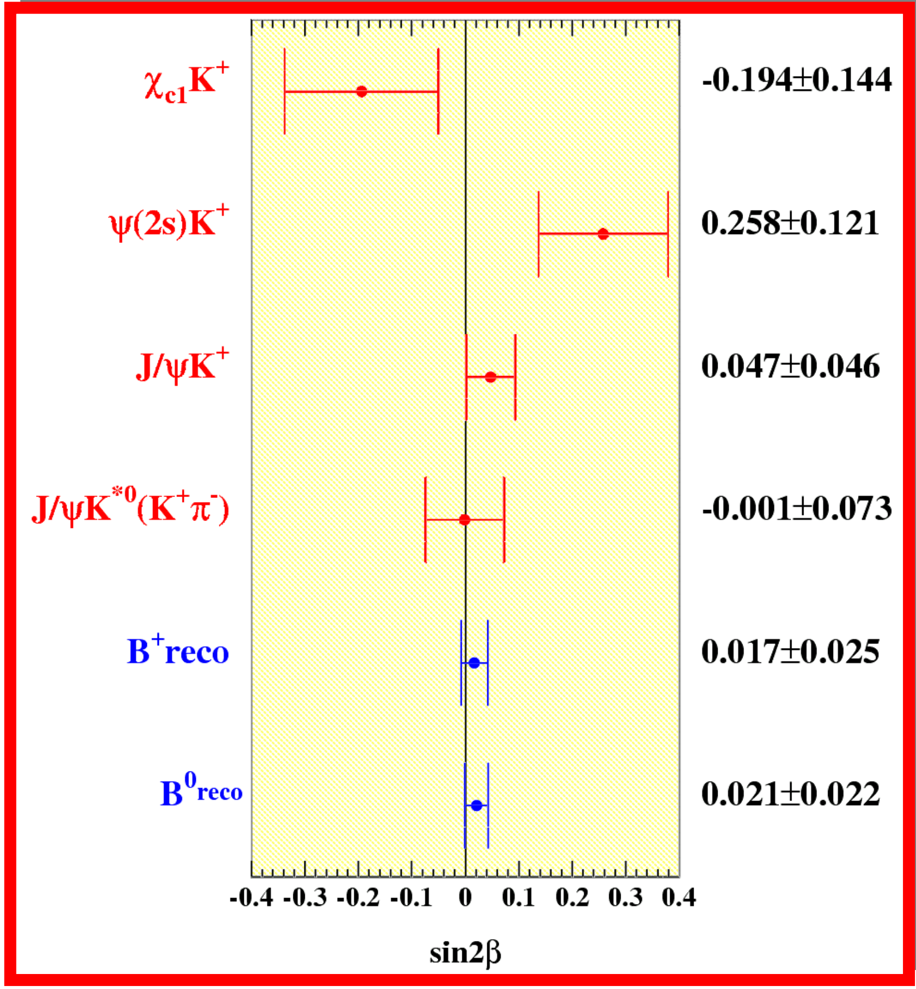
CP asymmetry in the tagging categories for the (cc) K_s sample

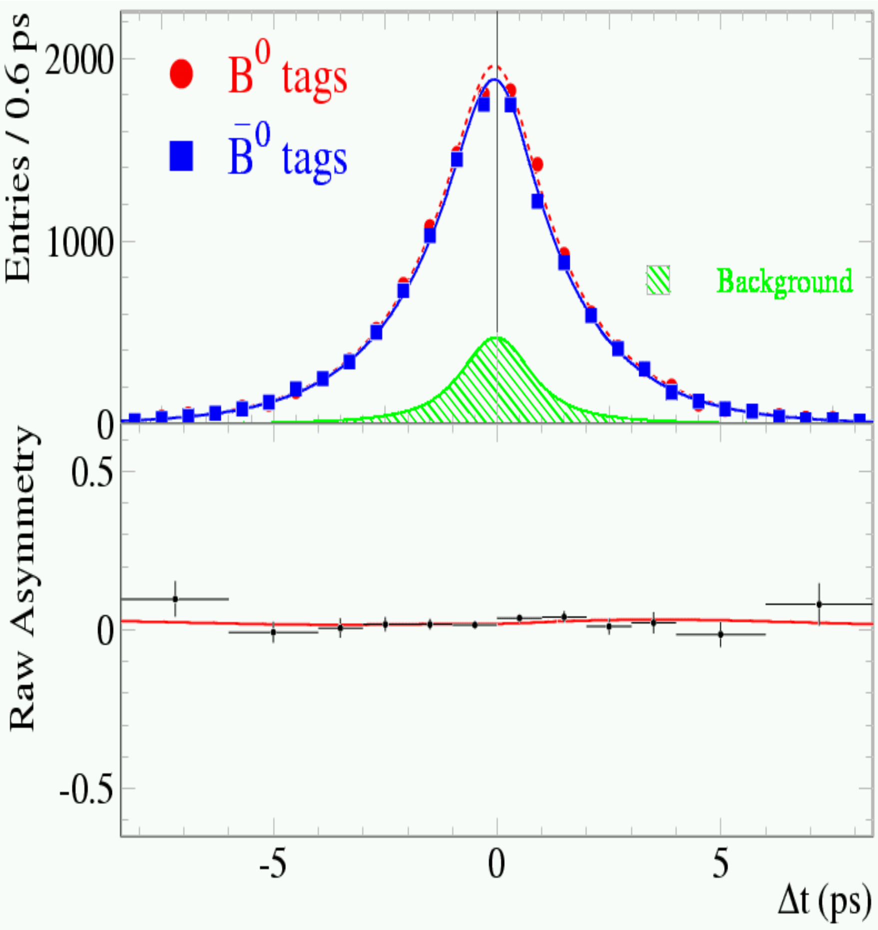
Lepton | Kaon1 | Kaon2 | Other



sin2β	0.79 ± 0.11	0.78 ± 0.12	0.73 ± 0.17	0.45 ± 0.28

Control sample asymmetry





No asymmetry observed as expected

Systematic Errors for sin2β

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.

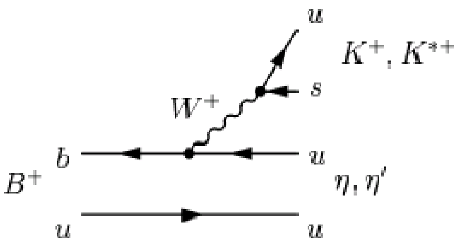
Source	$\delta \sin 2\beta$
CP and Mix BG	0.017
Klong BG	0.015
Δt meas. and RF	0.017
Signal Dilutions	0.012
Fit bias correction	0.010
B lifetime	0.004
Δm_d	0.003
Total	**0.033**

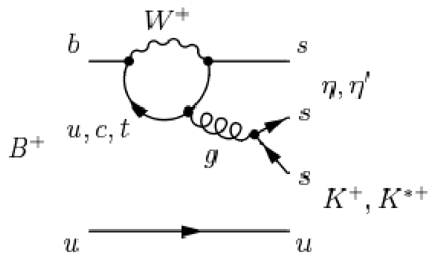
Total from winter 2002 result (56 fb^{-1}) was 0.035

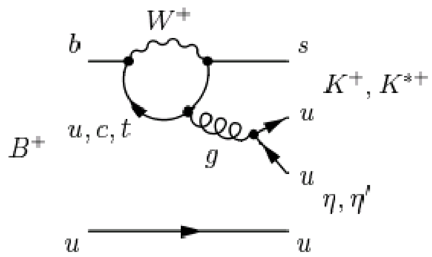
Pure or dominated penguin decays (II)

$B^0 \to \eta' K^0_S$: tree is color and Cabbibo suppressed

$B^+ \to \eta' K^+$: tree is Cabbibo suppressed







- Still working on that