Review of Recent Belle results

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MAD-HEP'07
Sept 13th, 2007

Outline

- angles of the unitarity triangle : ϕ_1, ϕ_2, ϕ_3
  SM measurements and hunt for new physics
- $B \to (\rho, \omega)\gamma$
- $B_s \to \phi\gamma$
- $B^0 \to D^{*-}\tau^+\nu$
- new particles...

Belle Collaboration

BINP
Chiba U.
U. of Cincinnati
Ewha Womans U.
Fu-Jen Catholic U.
U. of Giessen
Gyeongsang Nat'l U.
Hanyang U.
U. of Hawaii
Hiroshima Tech.
IHEP, Beijing
IHEP, Moscow

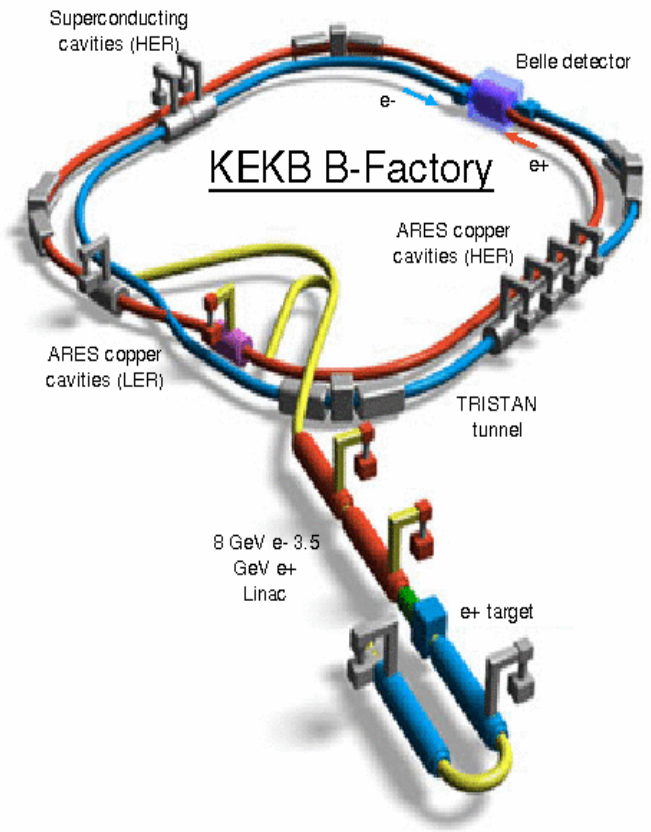
IHEP, Vienna
ITEP
Kanagawa U.
KEK
Korea U.
Krakow Inst. of Nucl. Phys.
Kyoto U.
Kyungpook Nat'l U.
EPF Lausanne
Jozef Stefan Inst. / U. of Ljubljana / U. of Maribor
U. of Melbourne

Nagoya U.
Nara Women's U.
National Central U.
National Taiwan U.
National United U.
Nihon Dental College
Niigata U.
Nova Gorica
Osaka U.
Osaka City U.
Panjab U.
Peking U.
Princeton U.
Riken
Saga U.
USTC

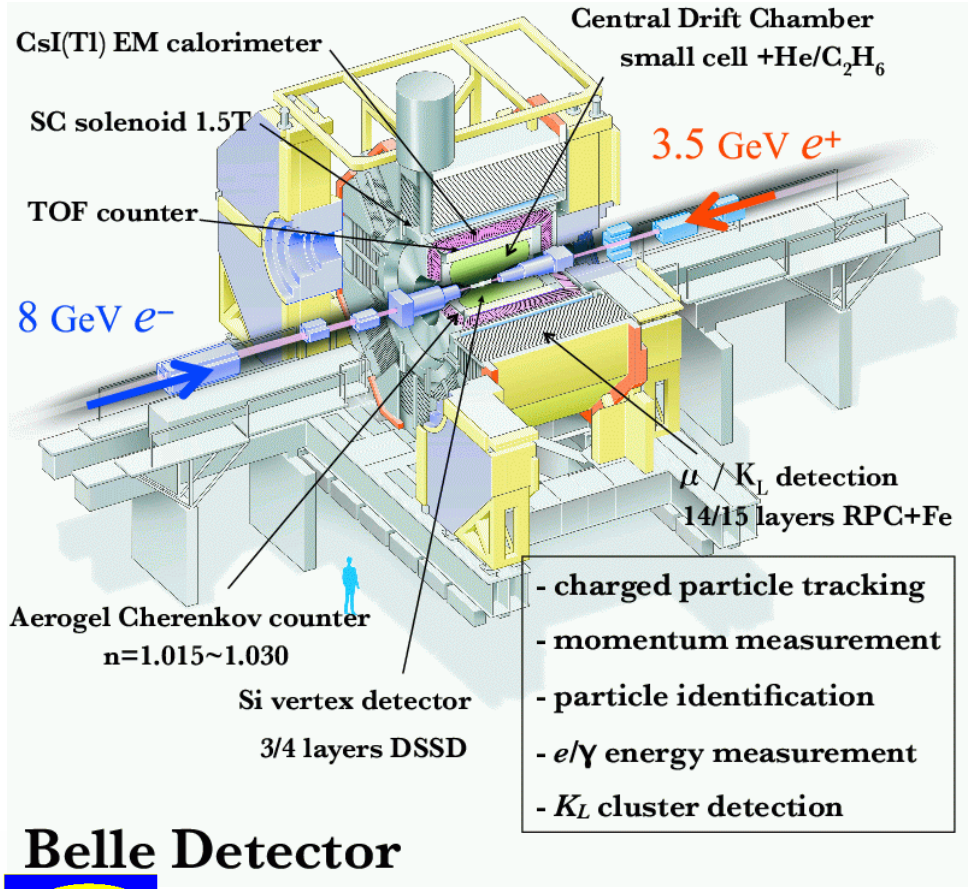
Seoul National U.
Shinshu U.
Sungkyunkwan U.
U. of Sydney
Tata Institute
Toho U.
Tohoku U.
Tohuku Gakuin U.
U. of Tokyo
Tokyo Inst. of Tech.
Tokyo Metropolitan U.
Tokyo U. of Agri. and Tech.
INFN Torino
Toyama Nat'l College
VPI
Yonsei U.

You are here

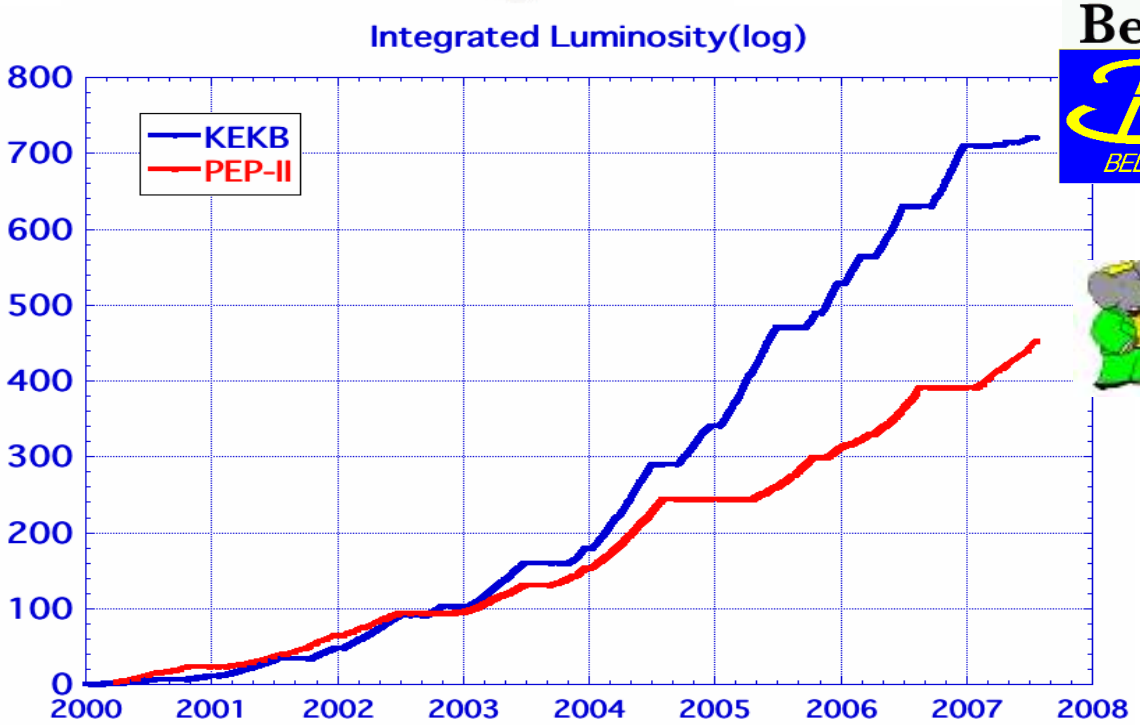
14 countries, 55 institutes, ~400 collaborators



8 GeV e^-
3.5 GeV e^+



Belle Detector



Luminosity

Peak	$1.71\times10^{34}/\mathrm{cm}^2/\mathrm{s}$
Integrated	$710\ \mathrm{fb}^{-1}$
	$605\ \mathrm{fb}^{-1}$ at $\Upsilon(4S)$
	~ 660 M $B\bar{B}$ pairs
	$23.6\ \mathrm{fb}^{-1}$ at $\Upsilon(5S)$
	~ 2.6 M B_s mesons
Daily	up to $1.2\ \mathrm{fb}^{-1}$

>200 publications (~40 in 2007)

KM ansatz: CPV is due to a complex phase in the quark mixing matrix:

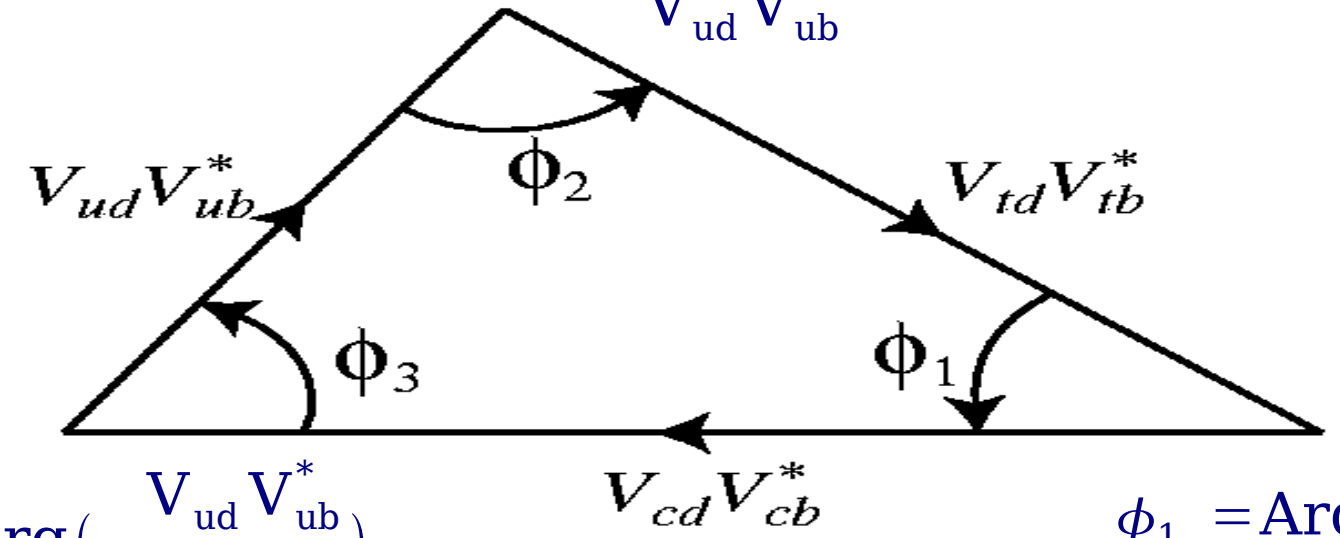
$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

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

The Unitarity Triangle

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

$$\phi_2 = \mathrm{Arg}\left(-\frac{V_{td}V_{tb}^{*}}{V_{ud}V_{ub}^{*}}\right)$$



$$\phi_3 = \mathrm{Arg}\left(-\frac{V_{ud}V_{ub}^{*}}{V_{cd}V_{cb}^{*}}\right)$$

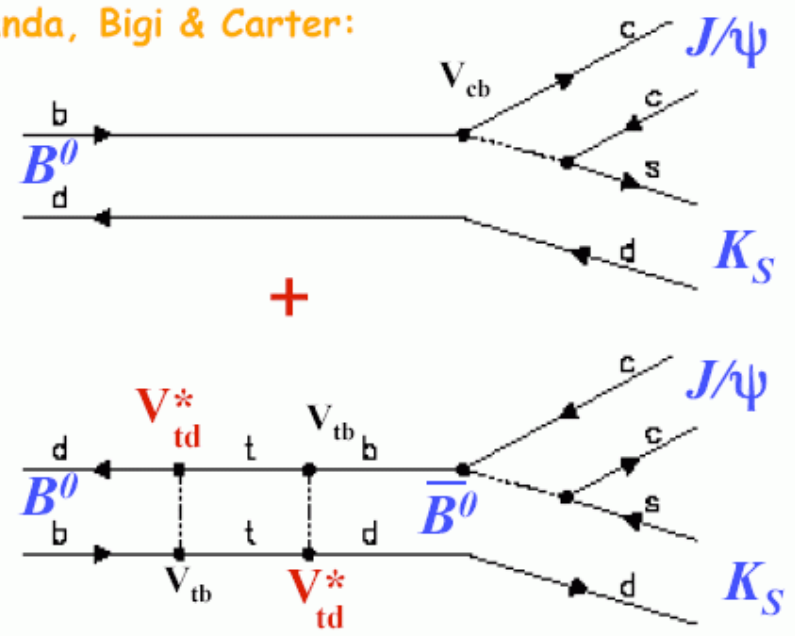
$$\phi_1 = \mathrm{Arg}\left(-\frac{V_{cd}V_{cb}^{*}}{V_{td}V_{tb}^{*}}\right)$$

- the phase $\phi_1 (V_{td}^{*})$: box (e.g. mixing)
- the phase $\phi_3 (V_{ub}^{*})$: rare B decays

Time−dependent CP asymmetries in decays to CP eigenstates

$\sin 2\phi_1$ from $B \to f_{CP} + B \leftrightarrow \bar{B} \to f_{CP}$ interf.

Sanda, Bigi & Carter:



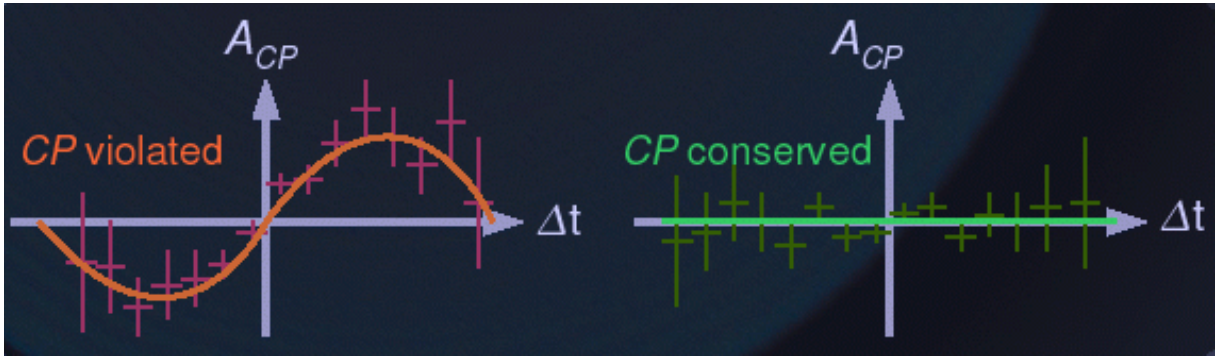
$$A_{CP}(f;t) = \frac{N(\bar{B}^0(t)\to f) - N(B^0(t)\to f)}{N(\bar{B}^0(t)\to f) + N(B^0(t)\to f)}$$

$$= S \sin \Delta m_d t + A \cos \Delta m_d t$$

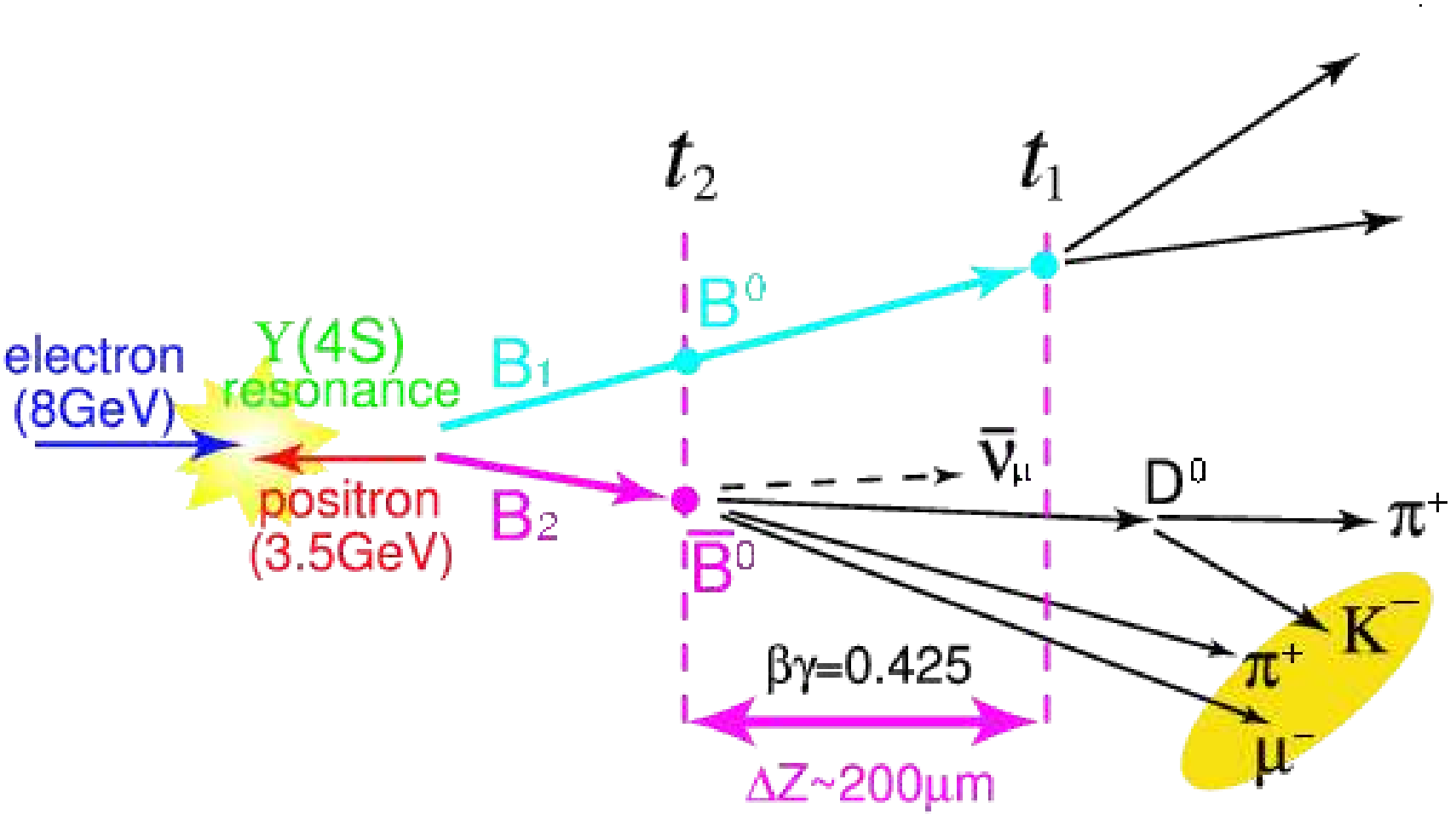
$$= \frac{2\,\mathrm{Im}\,\lambda}{|\lambda|^2+1} \sin \Delta m_d t + \frac{|\lambda|^2-1}{|\lambda|^2+1} \cos \Delta m_d t$$

$$\lambda = \frac{q}{p}\,\frac{A(\bar{B}^0\to f)}{A(B^0\to f)} = e^{-i2\phi_i}\frac{\bar{A}_f}{A_f}$$

- $A = 0$ and $S = -\xi_f \sin 2\phi_1$ for $(c\bar{c})K_{S/L}$ $(\xi_f = \mp 1)$
- $A = 0$ and $S = \sin 2\phi_2$ for $\pi^+\pi^-$ (if tree only)

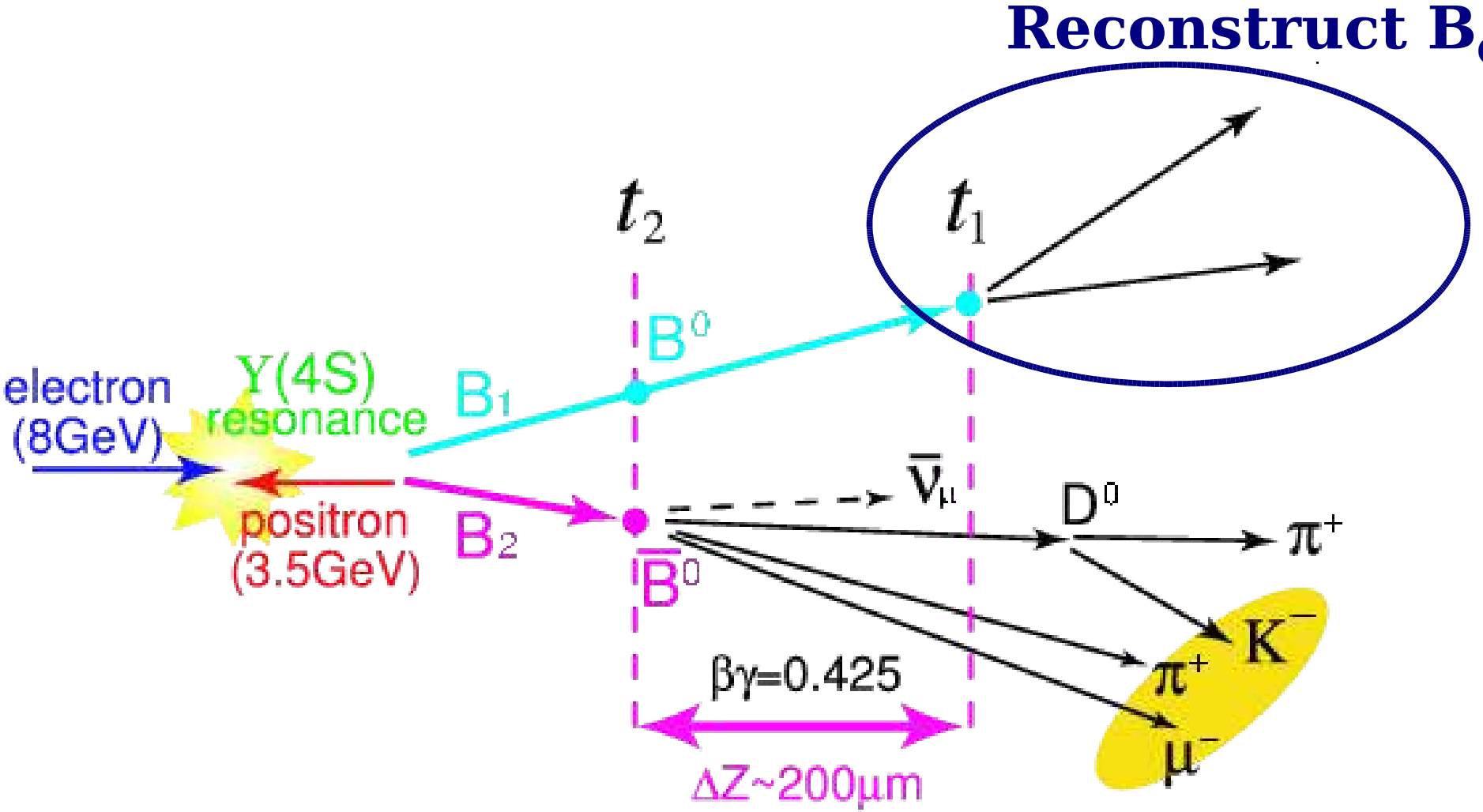


Measuring the CP parameters S and A



$$\frac{dP_{sig}}{dt}(\Delta t, q) = \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B}(1 + q(S\sin(\Delta m_d \Delta t) + A\cos(\Delta m_d \Delta t)))$$

Measuring the CP parameters S and A



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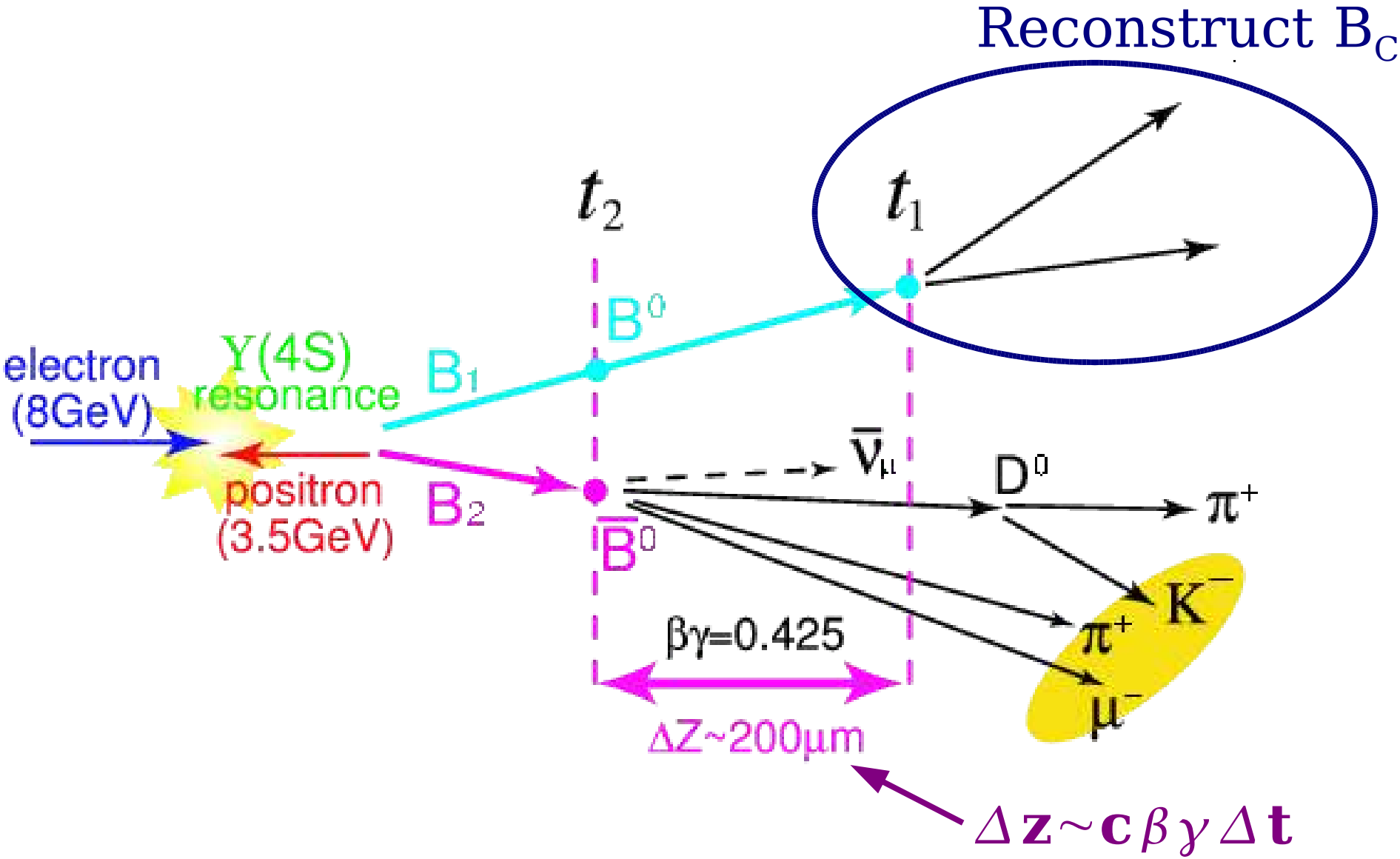

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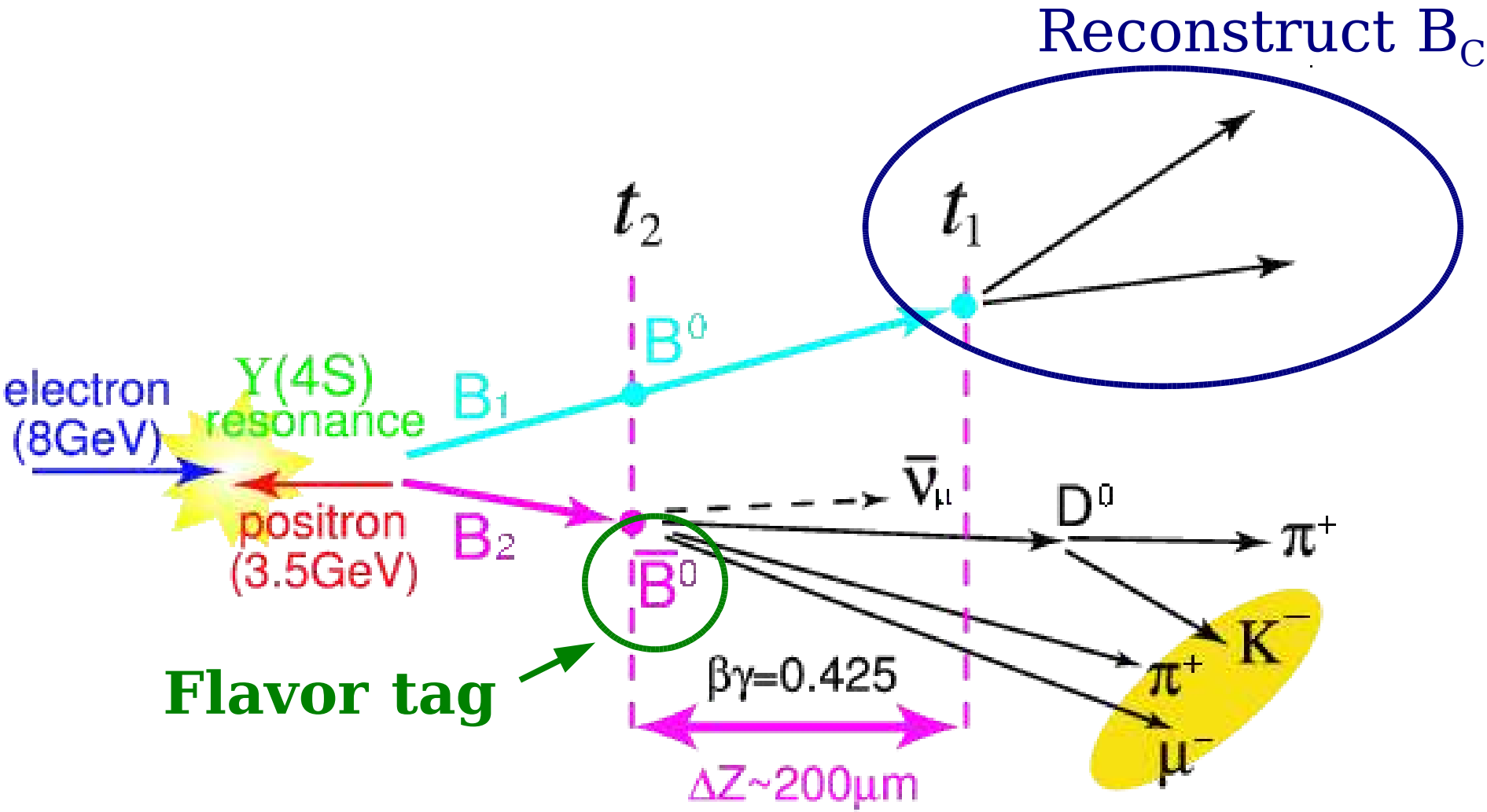
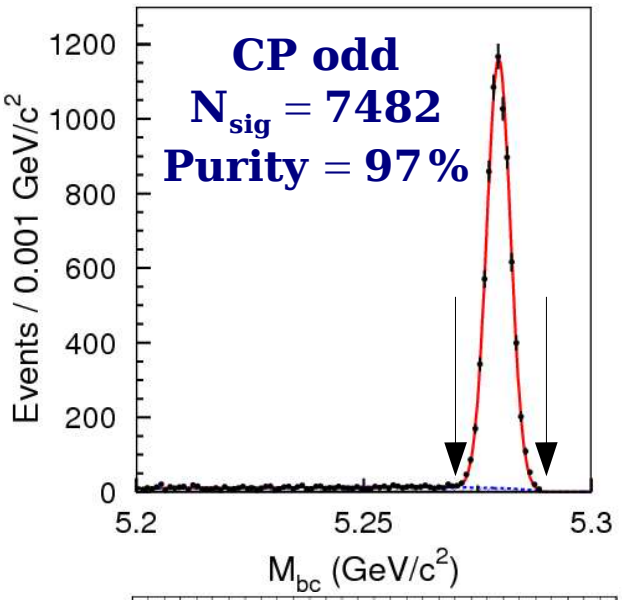


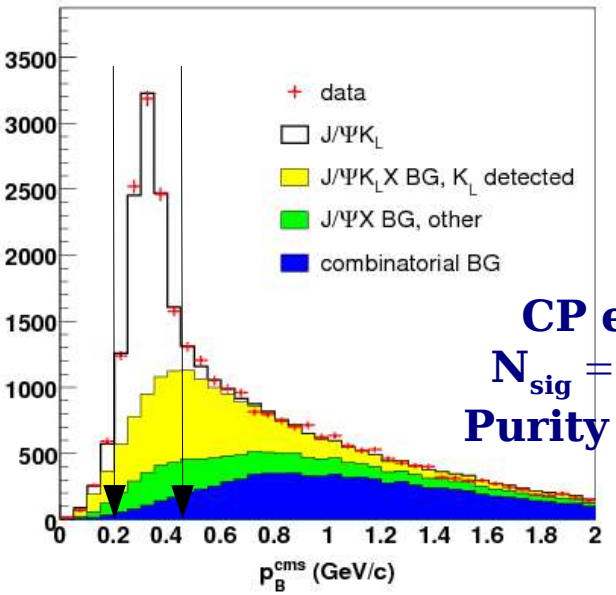
$$\Delta z \sim c\,\beta\gamma\,\Delta t$$

$$\frac{dP_{sig}}{dt}(\Delta t, q) = \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B}(1 + q(S\sin(\Delta m_d \Delta t) + A\cos(\Delta m_d \Delta t)))$$

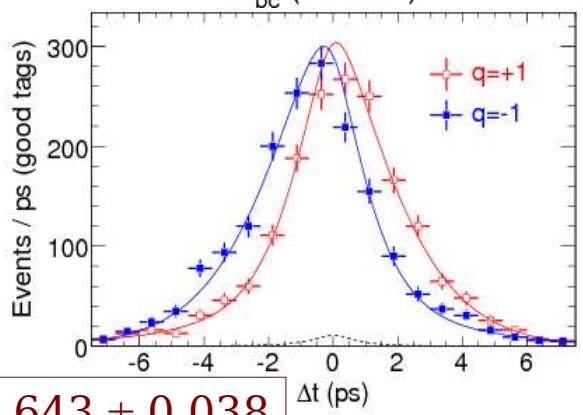
$J/\psi\ K_S$ and $J/\psi\ K_L$

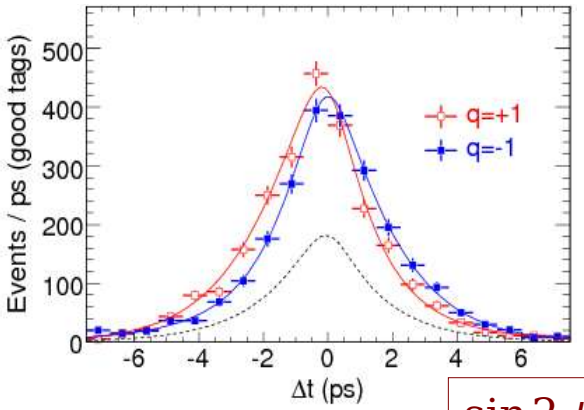
535×10^6 $B\bar{B}$ pairs
[PRL98 (2007) 031802]



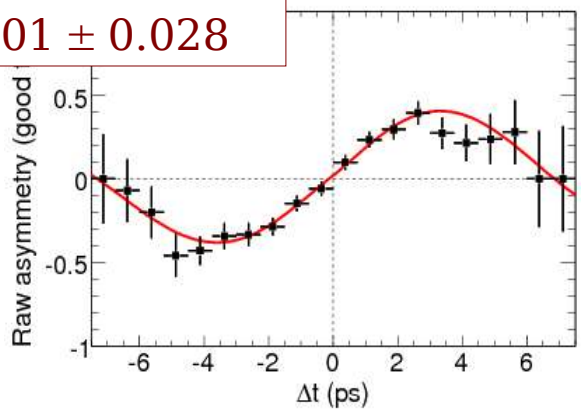


CP even
$N_{sig} = 6512$
Purity = 59%

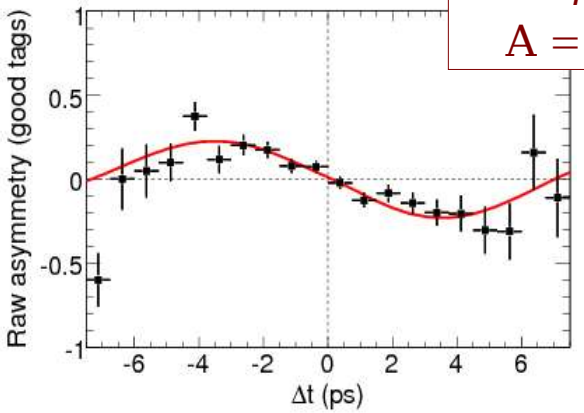




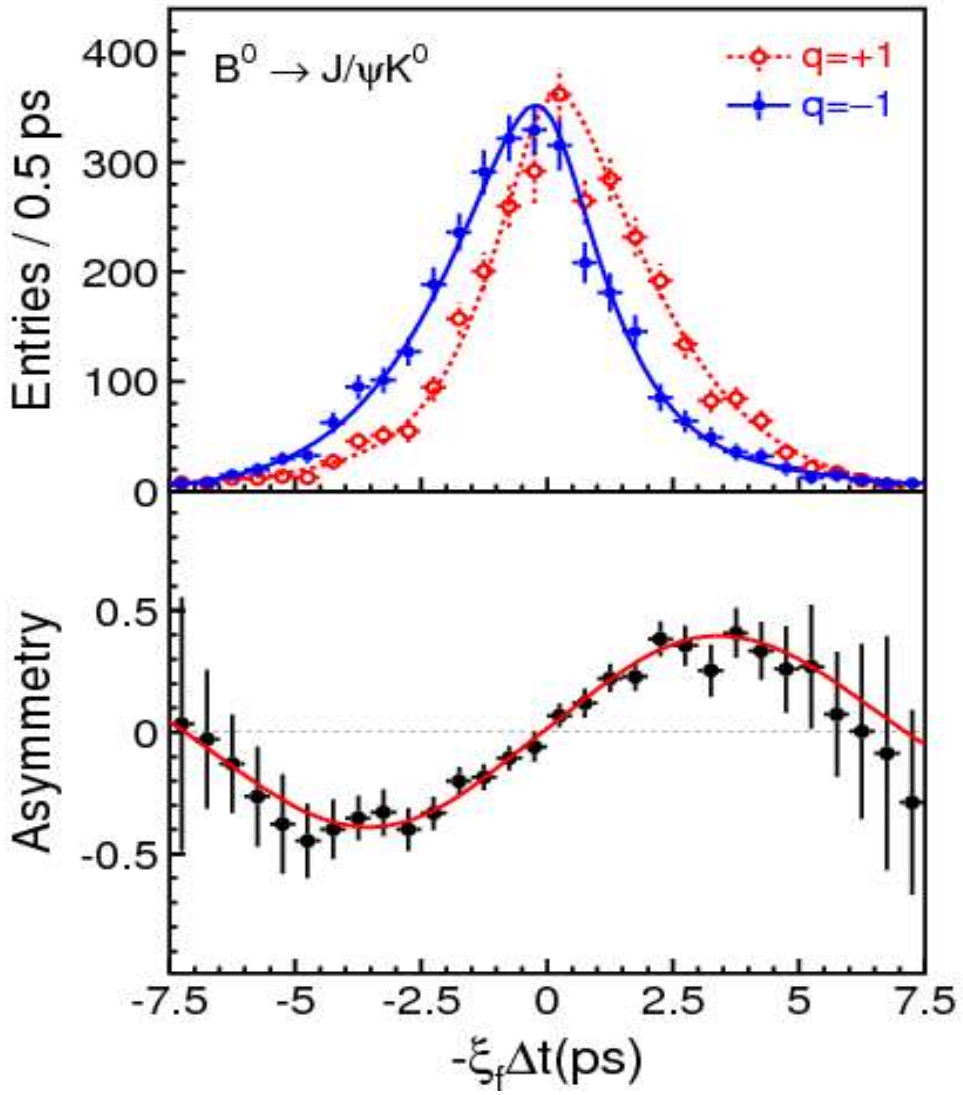
$\sin 2\phi_1 = 0.643 \pm 0.038$
$A = -0.001 \pm 0.028$



$\sin 2\phi_1 = 0.641 \pm 0.057$
$A = +0.045 \pm 0.033$



$\sin 2\phi_1$ with $J/\psi K^0$: la raison d'être of the B factories



$$\sin 2\phi_1 = 0.642 \pm 0.031 \pm 0.017$$

$$A = 0.018 \pm 0.021 \pm 0.014$$

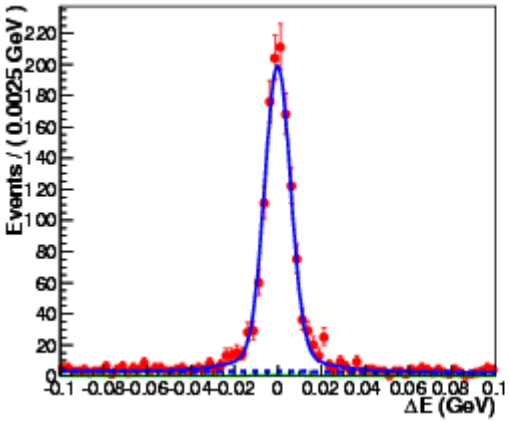
PRL98 (2007) 031802

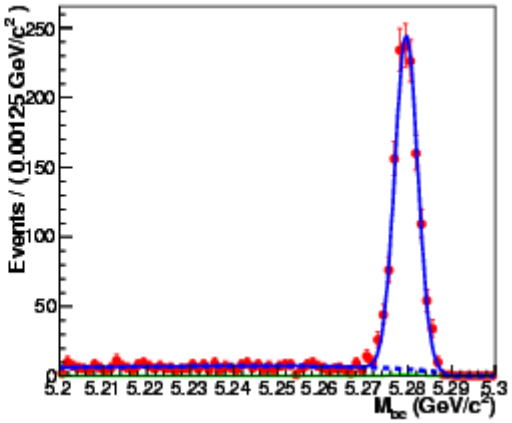
- anchor point of the SM
- still statistically limited !

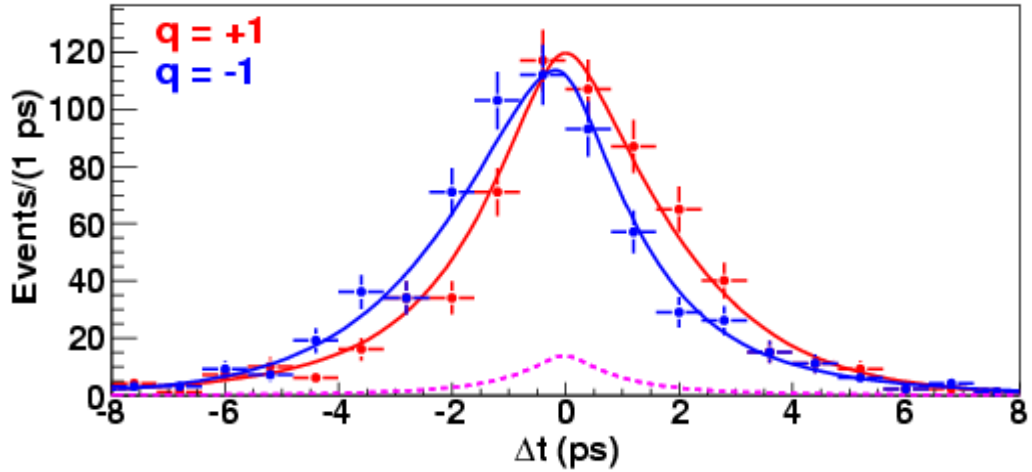
$\sin 2\phi_1$ with $\psi(2S)K^0_S$

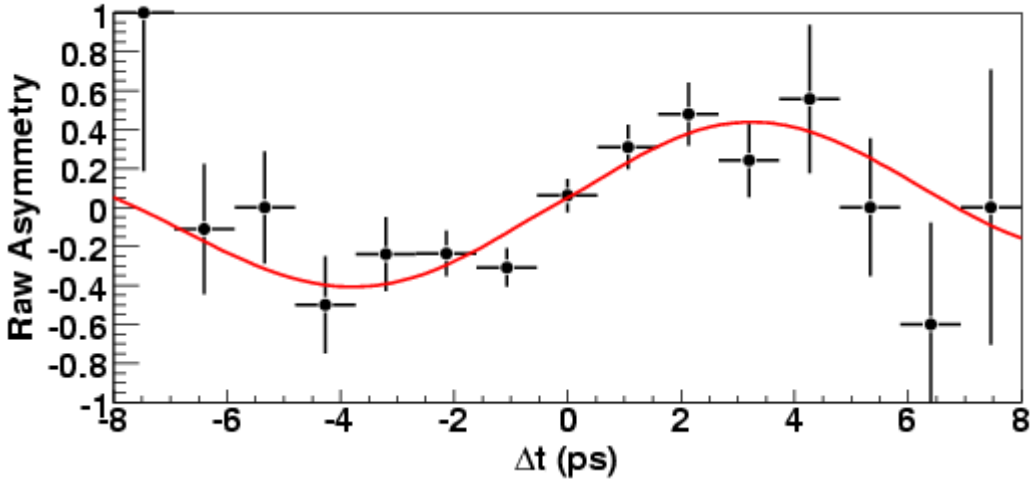
$\psi(2S) \to l^+ l^-$
$\psi(2S) \to J/\psi \pi^+ \pi^-$

657×10^6 $B\bar{B}$ pairs
[arXiv:0708.2604]
PRELIMINARY







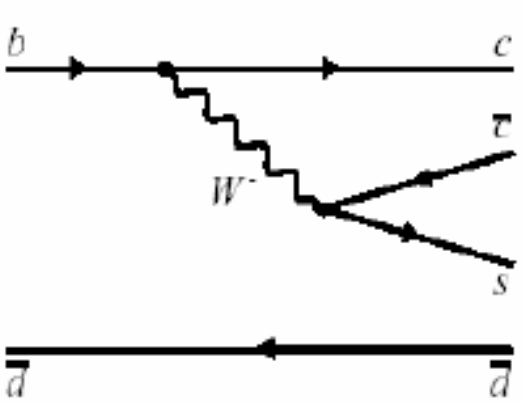


CP odd
$N_{sig} = 1392$
Purity = 94%

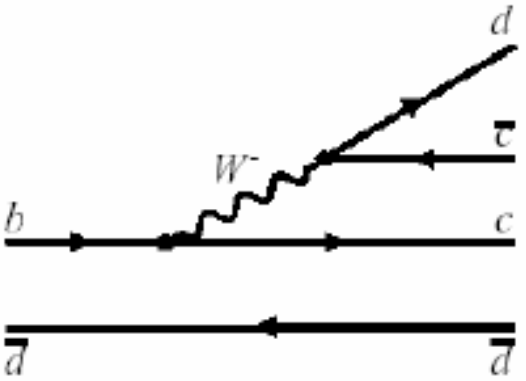
$$\sin 2\phi_1 = 0.72 \pm 0.09 \pm 0.03$$

$$A = 0.04 \pm 0.07 \pm 0.05$$

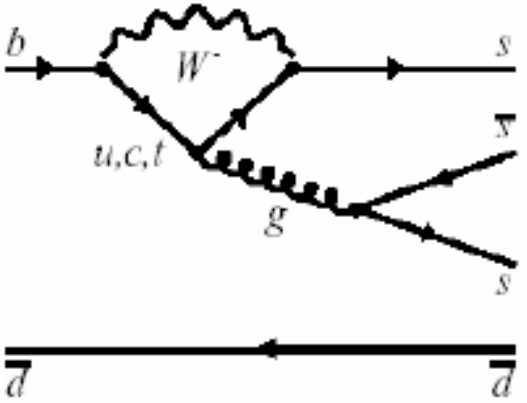
ϕ_1 in other modes



$J/\psi K_S^0, \psi(2S)K_S^0, \chi_{c1}K_S^0,$
$\eta_c K_S^0, J/\psi K_L^0,$
$J/\psi K^{*0}(K^{*0} \to K_S^0\pi^0)$



$D^{*+}D^-, D^+D^-$
$J/\psi\pi^0, D^{*+}D^{*-}$

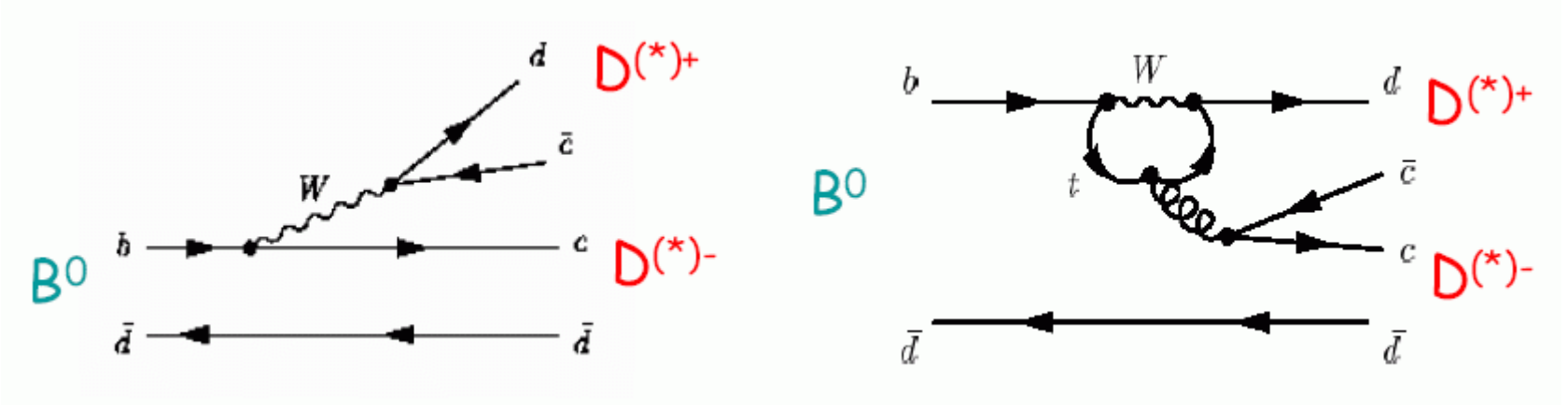


$\phi K^0, K^+K^-K_S^0,$
$K_S^0K_S^0K_S^0, \eta' K^0, K_S^0\pi^0,$
$\omega K_S^0, f_0(980)K_S^0$

increasing tree diagram amplitude

increasing sensitivity to new physics

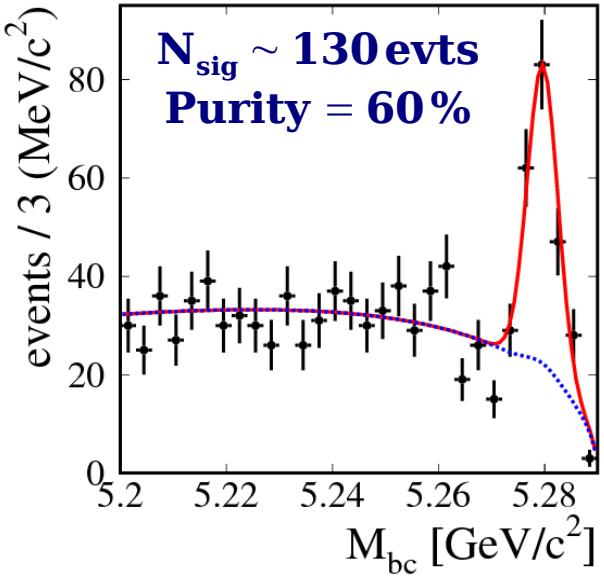
tCPV in D^+D^- decays

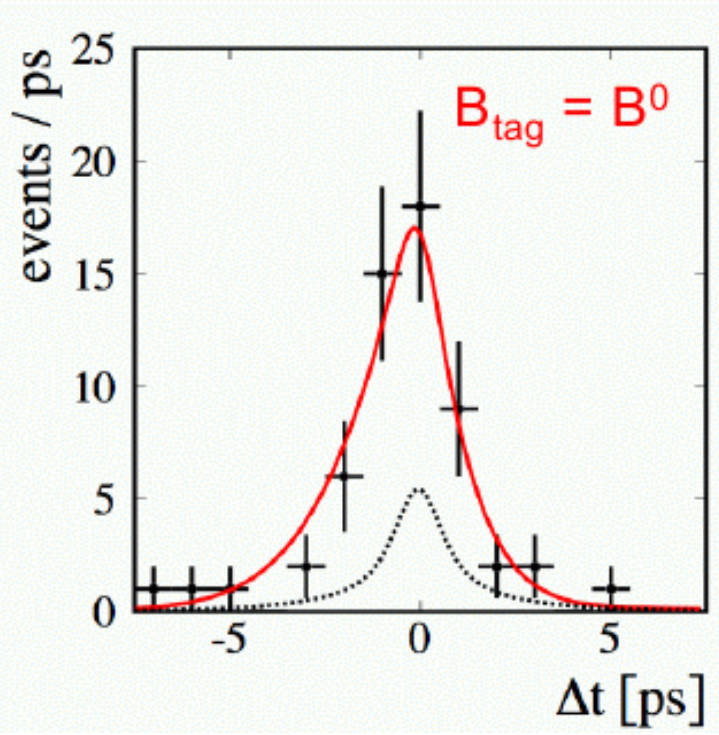


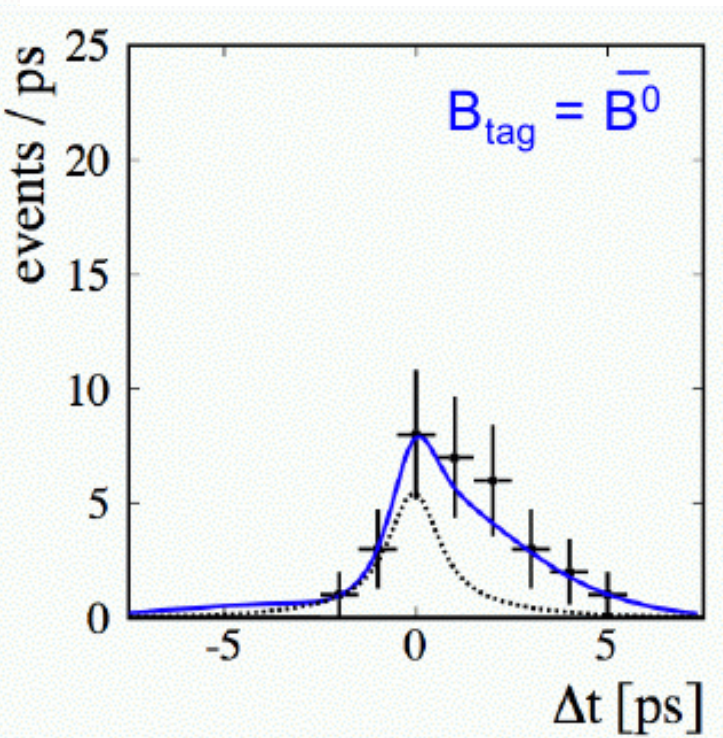
SM expectation : $S \approx -\sin 2\phi_1$, $A \approx 3\%$
Z.Z.Xing, PRD61 (2000) 014010

performed with 535×10^6 $B\bar{B}$

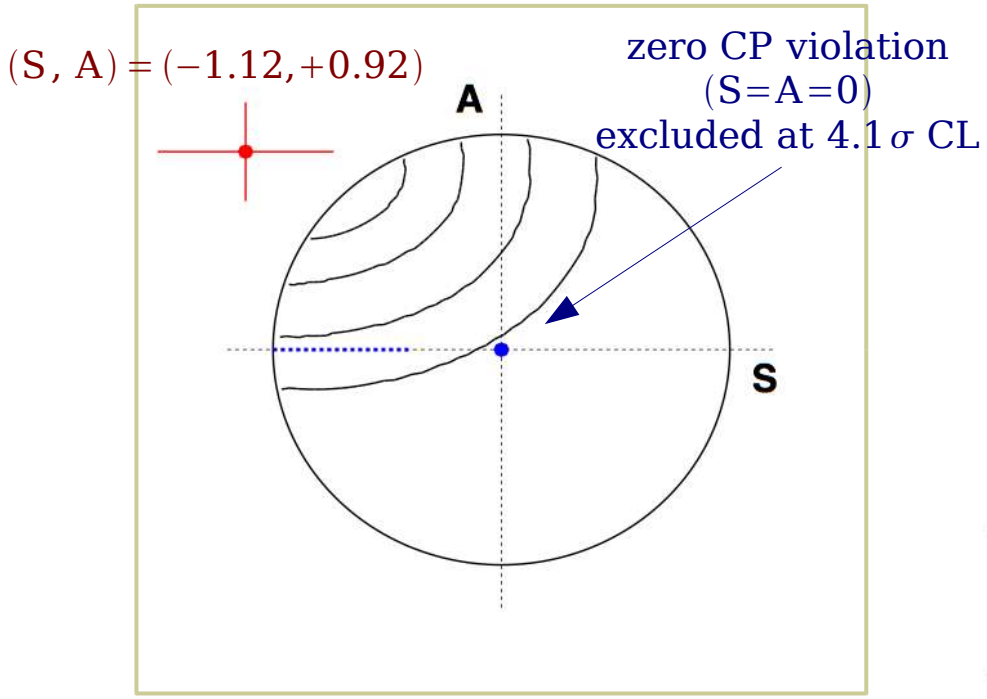
$S = -1.13 \pm 0.37 \pm 0.09$
$A = 0.91 \pm 0.23 \pm 0.06$



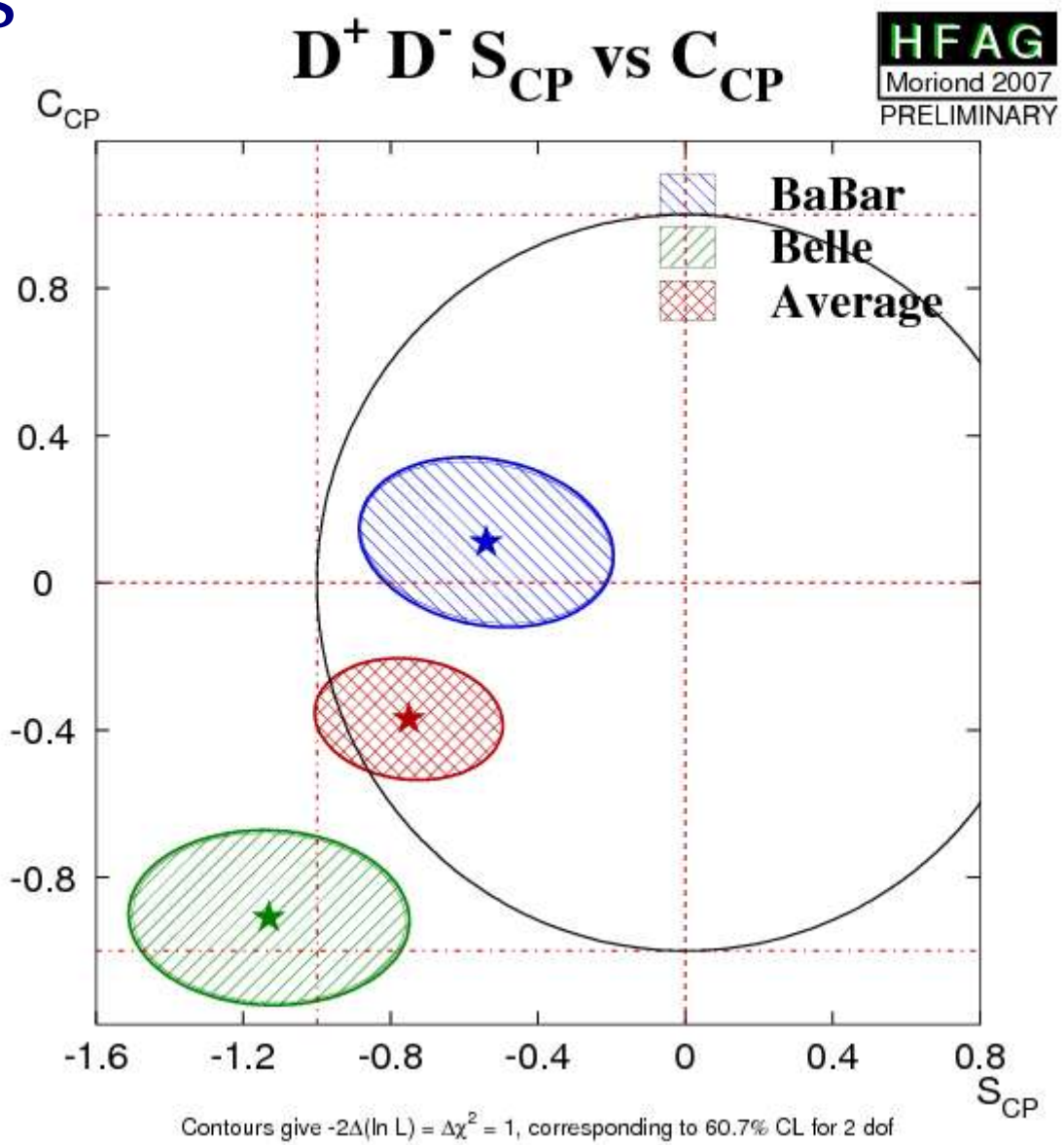




tCPV in D^+D^- decays

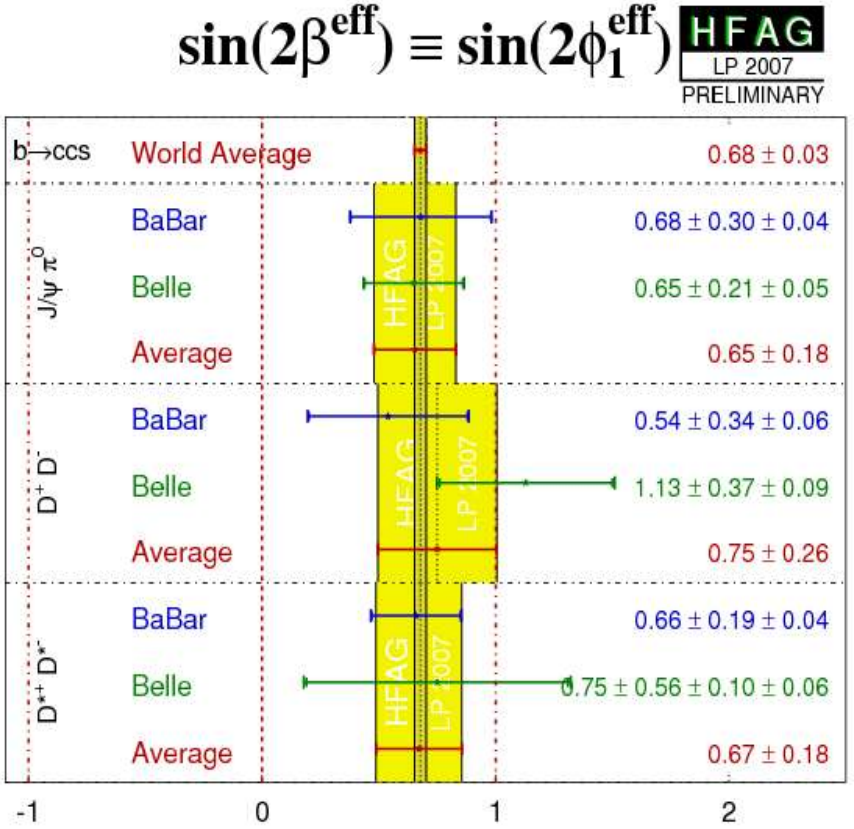


[**PRL98, 221802 (2007)**]



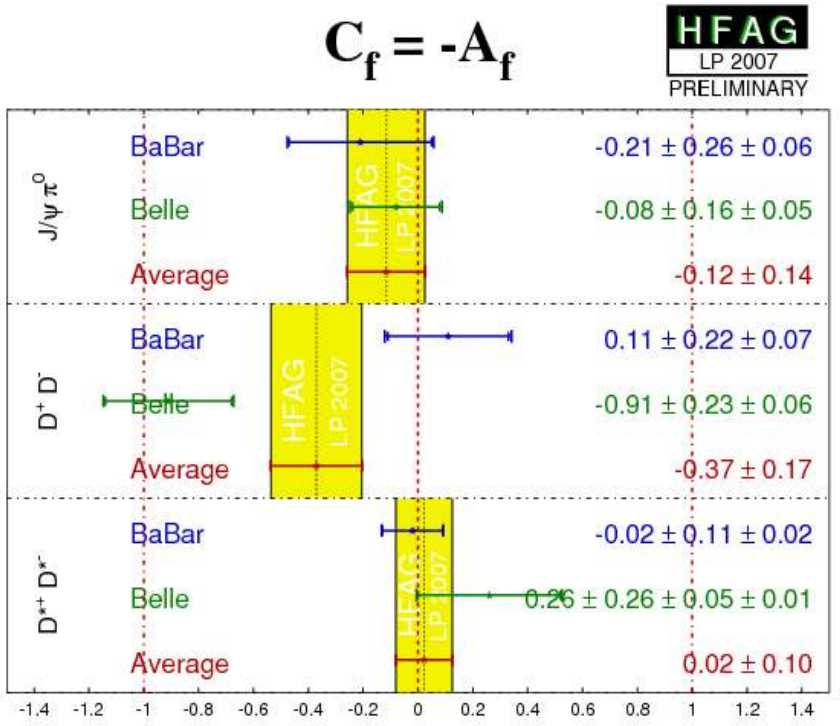
- First evidence of CP violation in D^+D^- decays
- Evidence (@ 3.2 σ) of direct CPV... but
  not indicated by other measurements
  need to check other modes (D^+D^0 etc...)

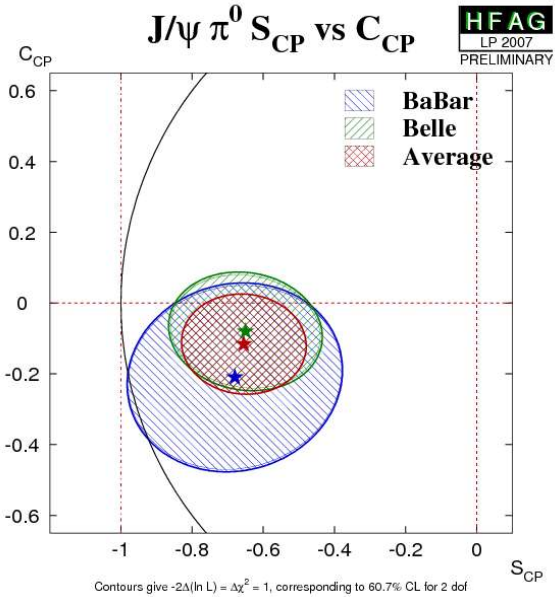
S and A in $b \to c\bar{c}d$ modes



(*)

(**)





(*) [**arXiv:0708.0304**] **submitted to PRD(RC)**

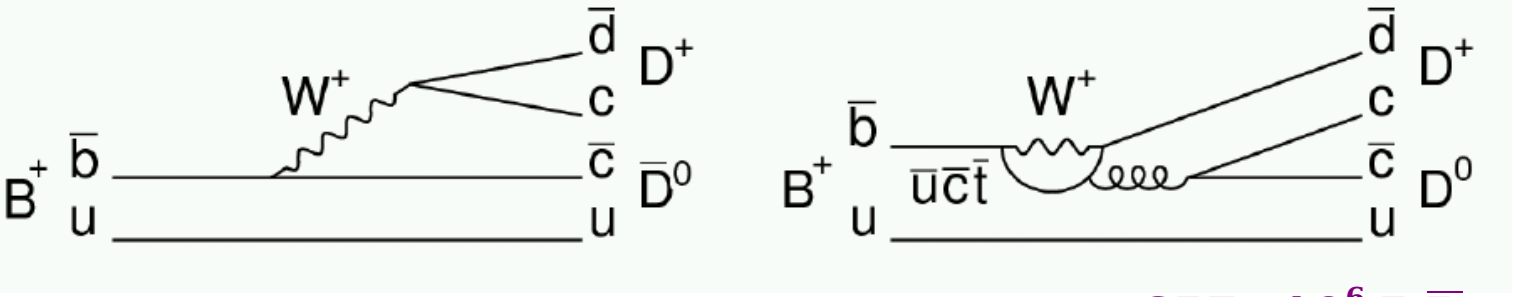
(**) [**PRL98, 221802 (2007)**]

good agreement with $b \to c\bar{c}s$ modes result

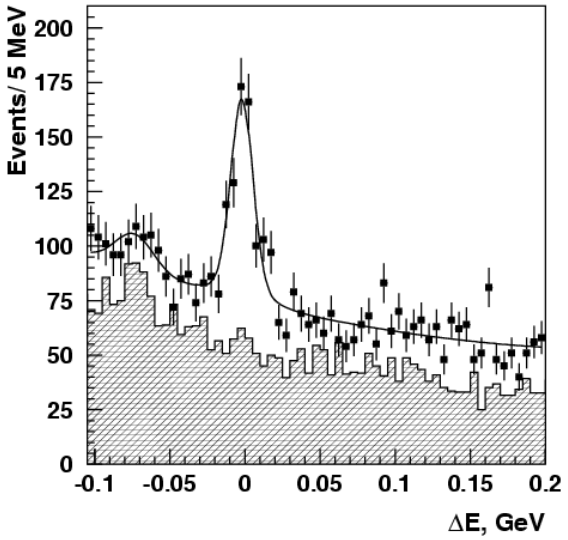
$S = -\sin 2\phi_1$, $A = 0$

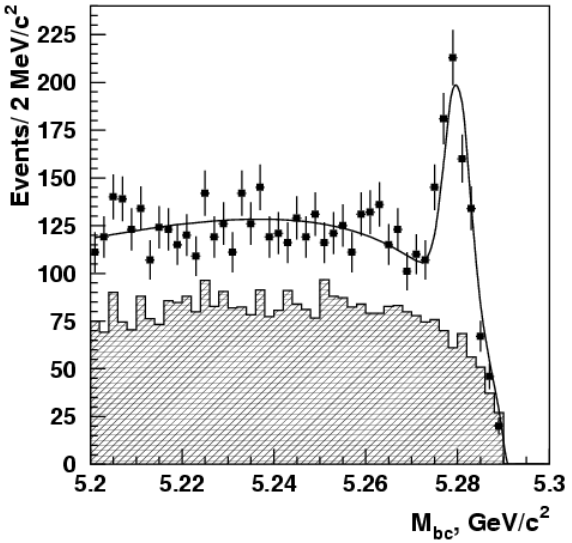
more info needed for A in $D^+ D^-$ mode

$B^+ \to D^+ D^0$ mode



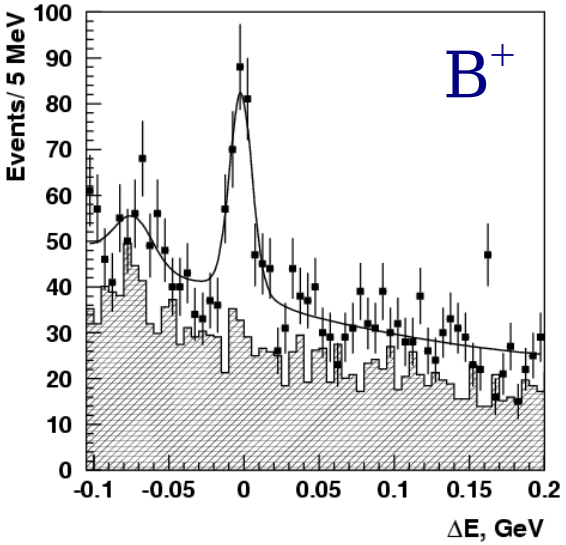
657×10^6 $B\bar{B}$ pairs
[arXiv:0708.1668]
PRELIMINARY

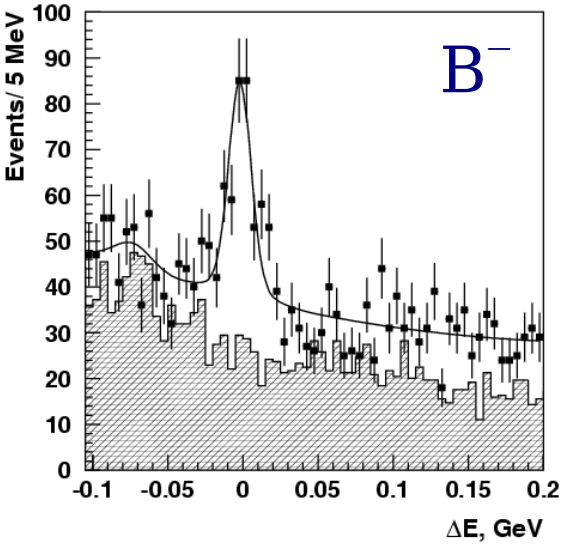




$\mathrm{Br}(B^+ \to D^+ \bar{D}^0) = (3.85 \pm 0.31 \pm 0.38) \times 10^{-4}$

BaBar [PRD73, 112004 (2006)]
$(3.8 \pm 0.6 \pm 0.5) \times 10^{-4}$
Belle [PRL95, 041803 (2005)]
$(4.8 \pm 0.8 \pm 0.6) \times 10^{-4}$



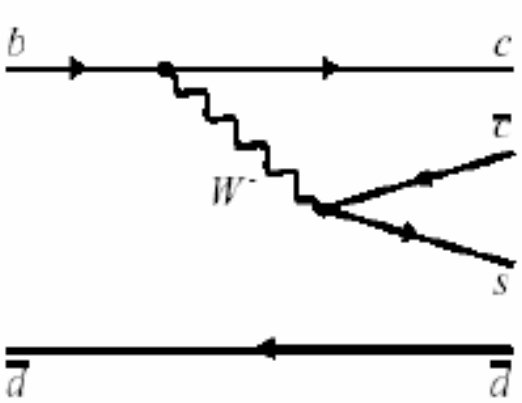


$A_{CP}(B^+ \to D^+ \bar{D}^0) = (0.00 \pm 0.08 \pm 0.02)$

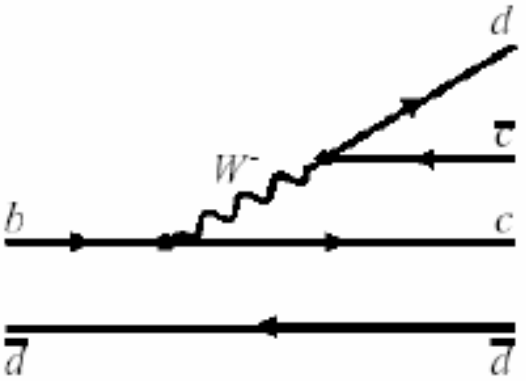
no direct CP observed

$\mathrm{Br}(B^0 \to D^0 \bar{D}^0) < 0.42 \times 10^{-4}$ @ 90% C.L.

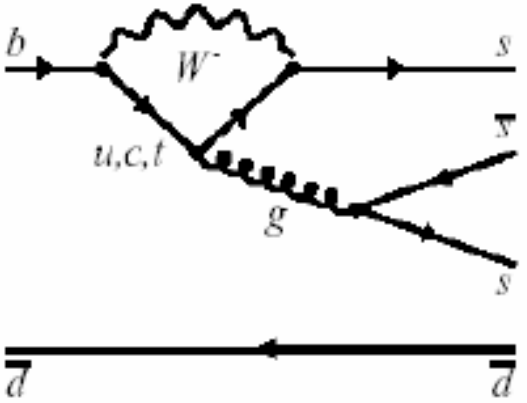
ϕ_1 in other modes



$J/\psi K_S^0, \psi(2S)K_S^0, \chi_{c1}K_S^0,$
$\eta_c K_S^0, J/\psi K_L^0,$
$J/\psi K^{*0}(K^{*0} \to K_S^0\pi^0)$



$D^{*+}D^-, D^+D^-$
$J/\psi\pi^0, D^{*+}D^{*-}$

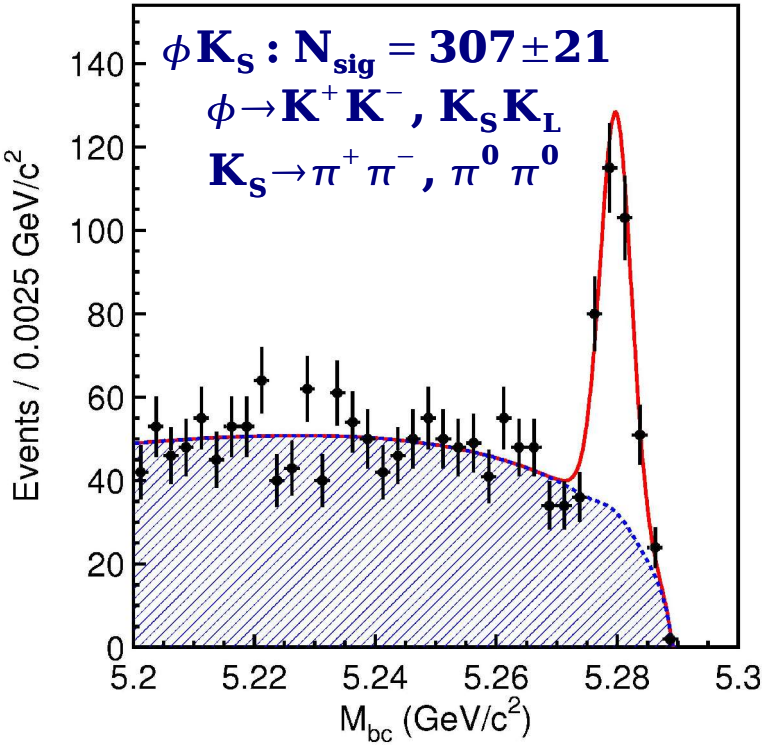


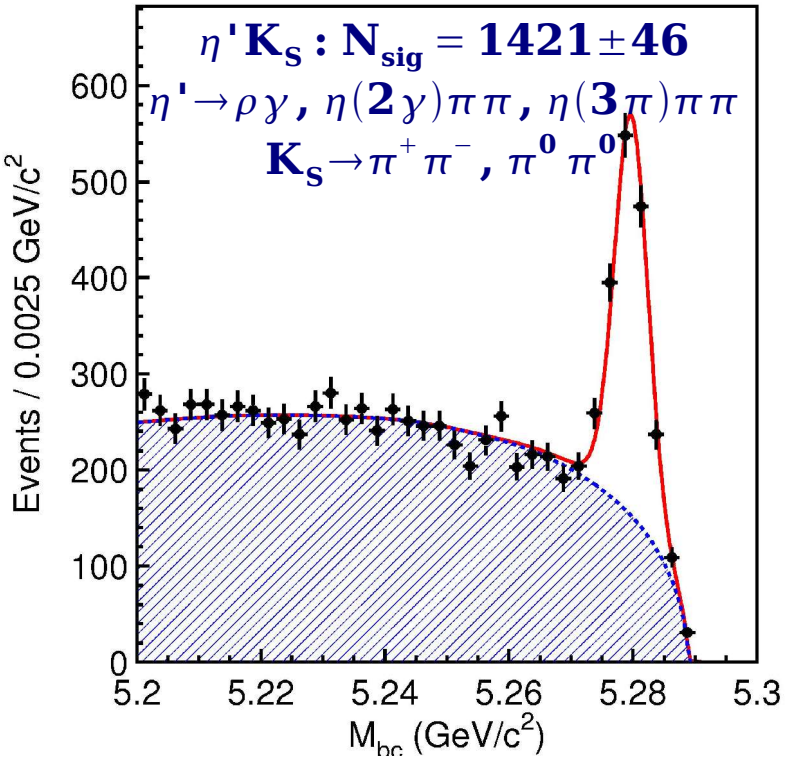
$\phi K^0, K^+K^-K_S^0,$
$K_S^0K_S^0K_S^0, \eta' K^0, K_S^0\pi^0,$
$\omega K_S^0, f_0(980)K_S^0$

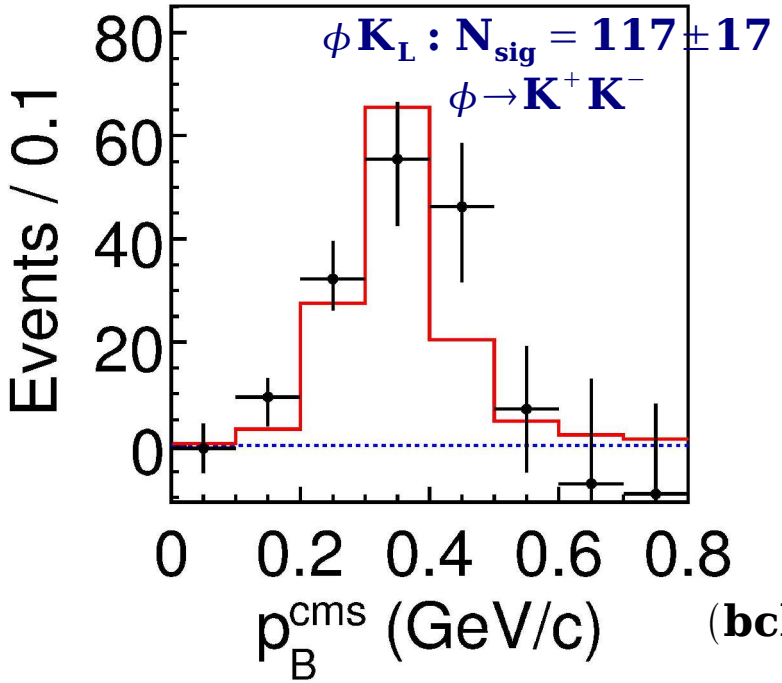
increasing tree diagram amplitude

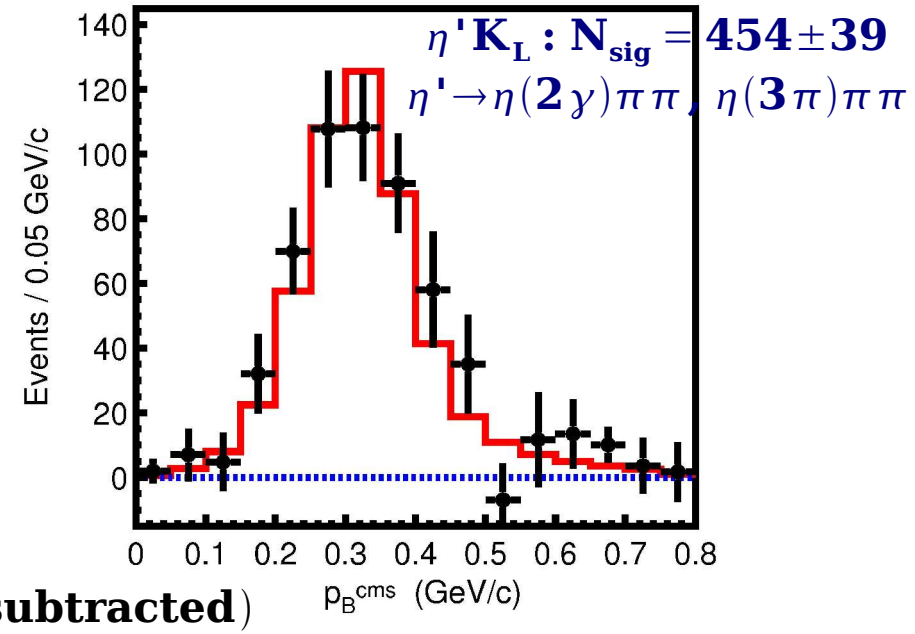
increasing sensitivity to new physics

Examples of b→s modes: $\phi K^0, \eta' K^0$ [PRL98 (2007) 031802]







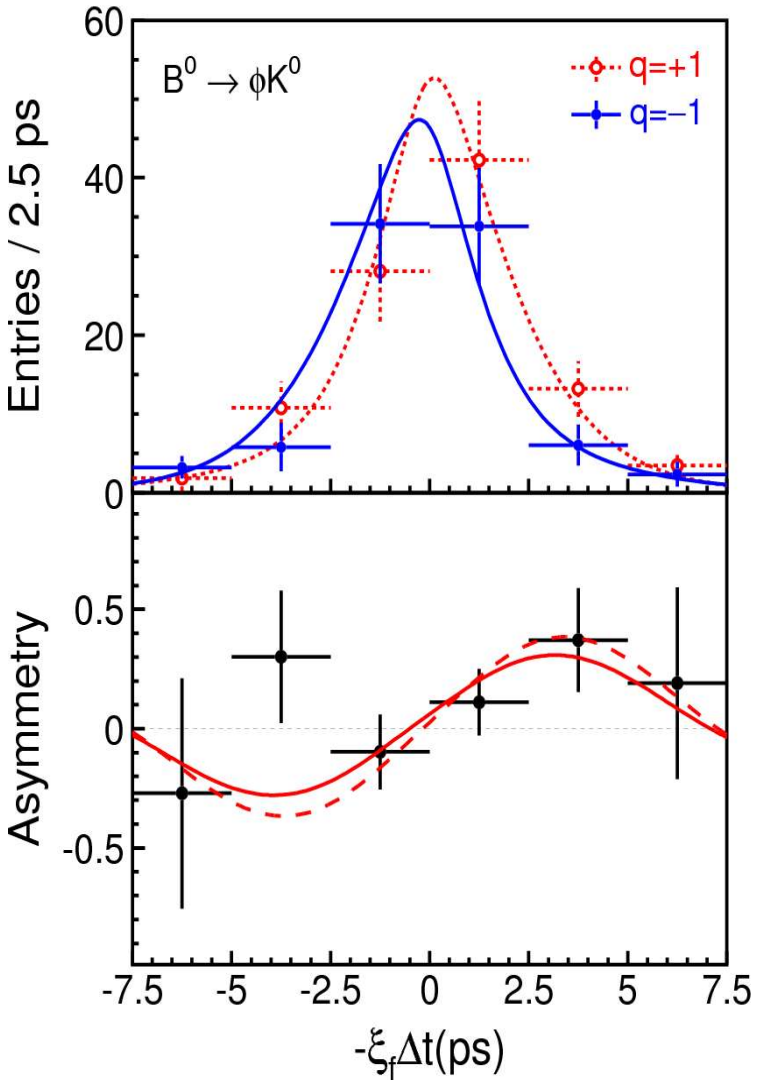


(**bckg subtracted**)

Examples of $b \to s$ modes: $\phi K^0, \eta' K^0$ [PRL98 (2007) 031802]

$$''\sin 2\phi_1'' = 0.50 \pm 0.21 \pm 0.06$$

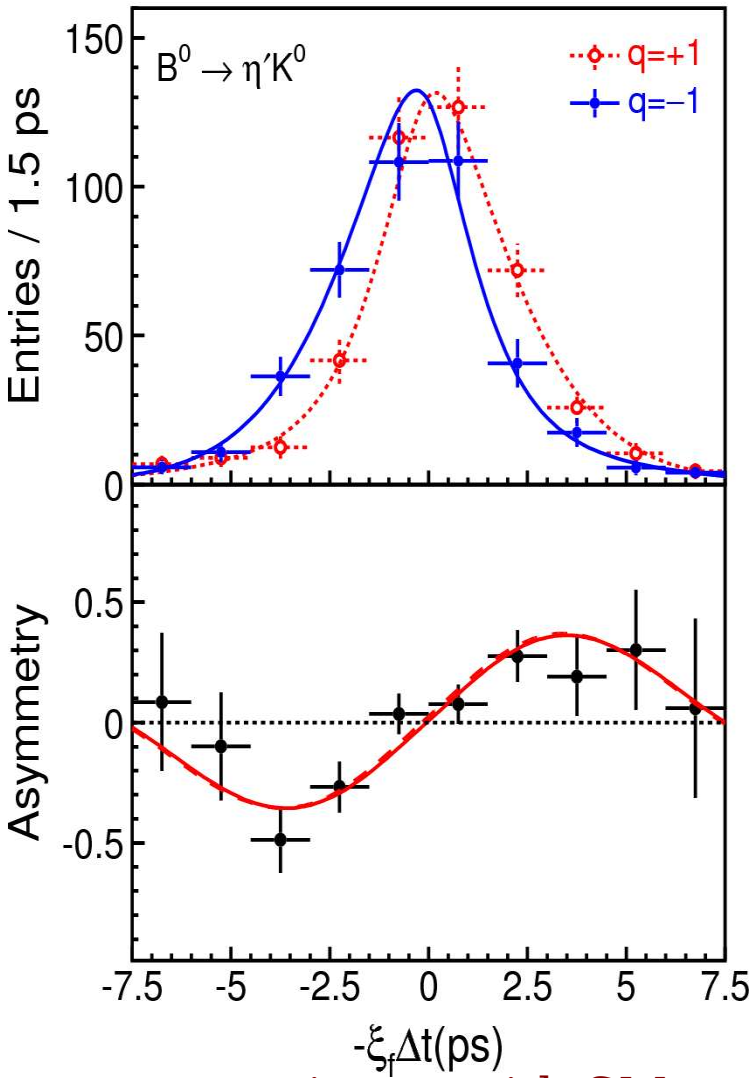
$$A = 0.07 \pm 0.15 \pm 0.05$$



consistent with SM ($\sim 1\sigma$ lower)
consistent with previous measurement

$$''\sin 2\phi_1'' = 0.64 \pm 0.10 \pm 0.04$$

$$A = -0.01 \pm 0.07 \pm 0.05$$

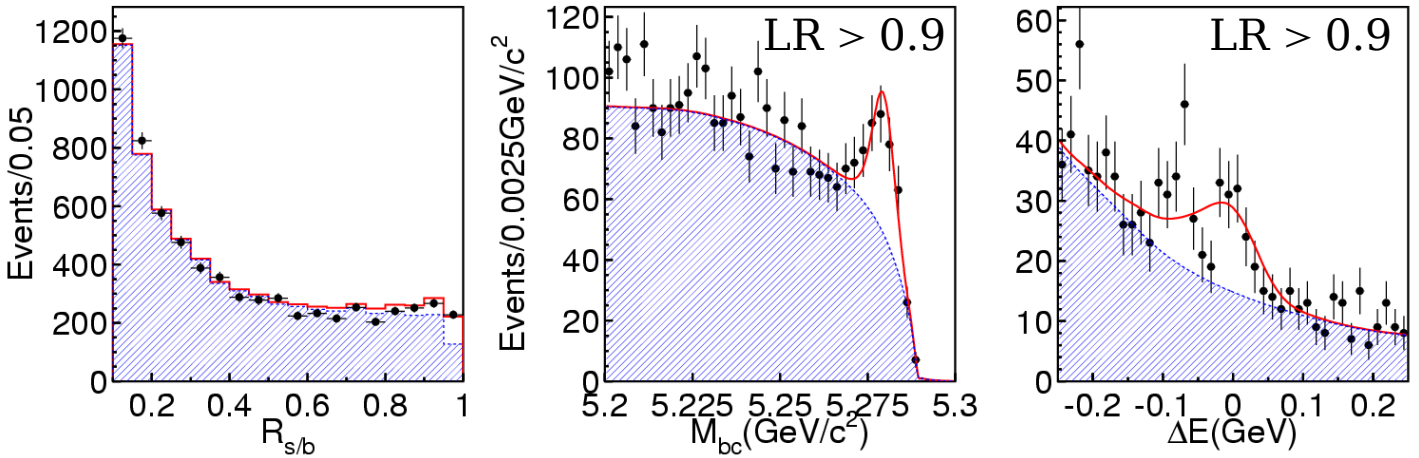


consistent with SM
first observation of CPV (5.6σ)
in a single $b \to s$ mode

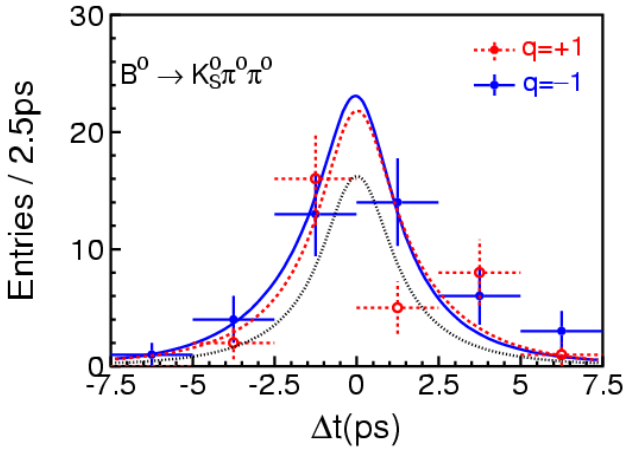
$K^0_S\pi^0\pi^0$ mode

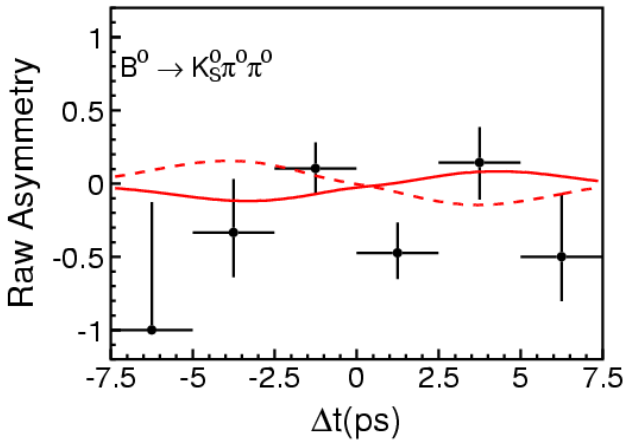
$657\times10^6\,B\bar{B}$ pairs
[arXiv:0708.1790] **PRELIMINARY**

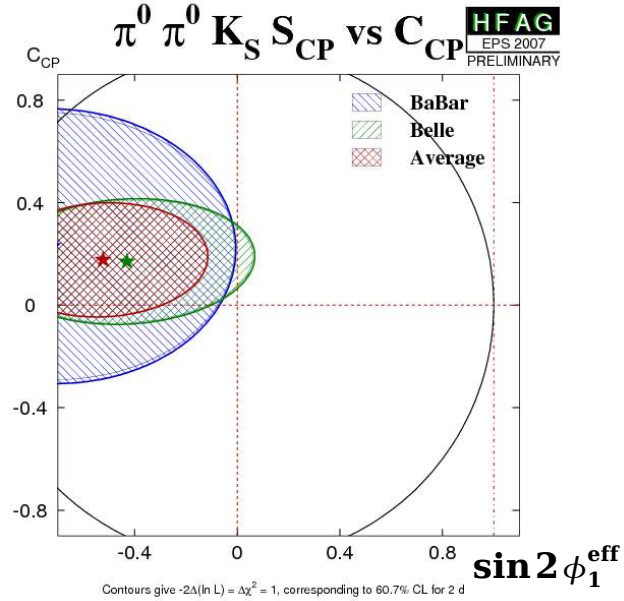
- CP even regardless of any resonance structure
  [T.Gershon and M.Hazumi, PLB596, 163 (2004)]
- SM: $S=-\sin 2\phi_1$ and $A=0$
  $\Delta\sin 2\phi_1 = 0.034^{+0.020}_{-0.025}$ [H−Y.Chang, hep−ph/0702252]
- $K^0_S\pi^0\pi^0$: CP−side vertex with K_S+IP, high background ($2\pi^0$)



Signal yield = 307±32 (with vtx = 129±21)





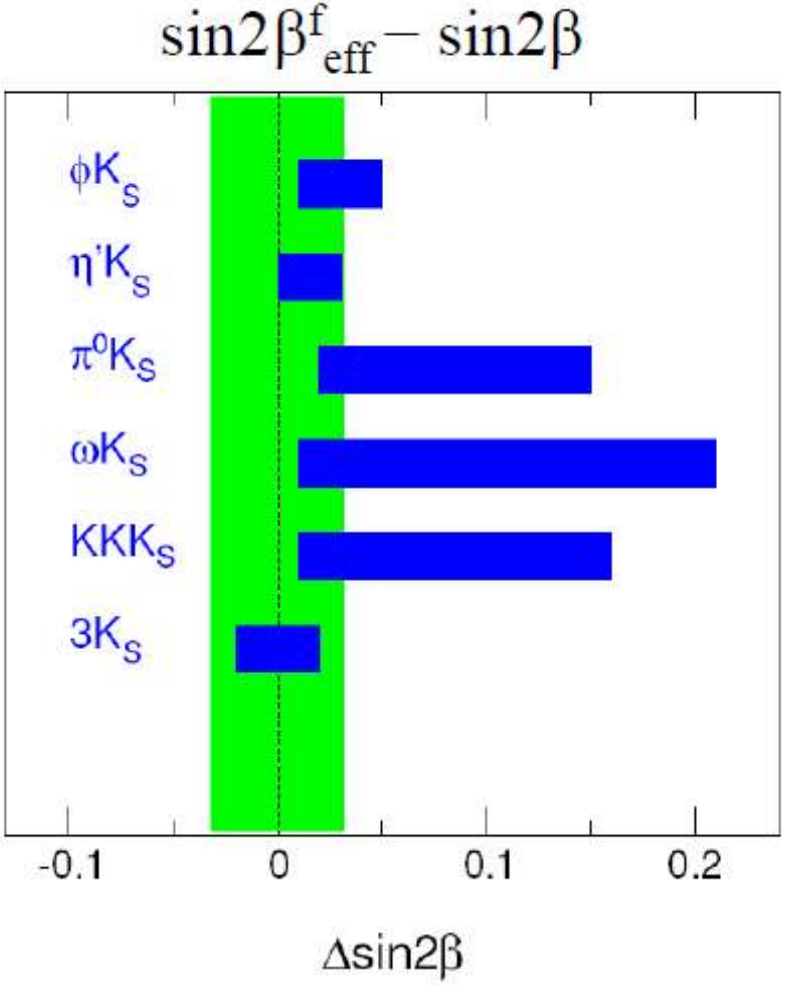


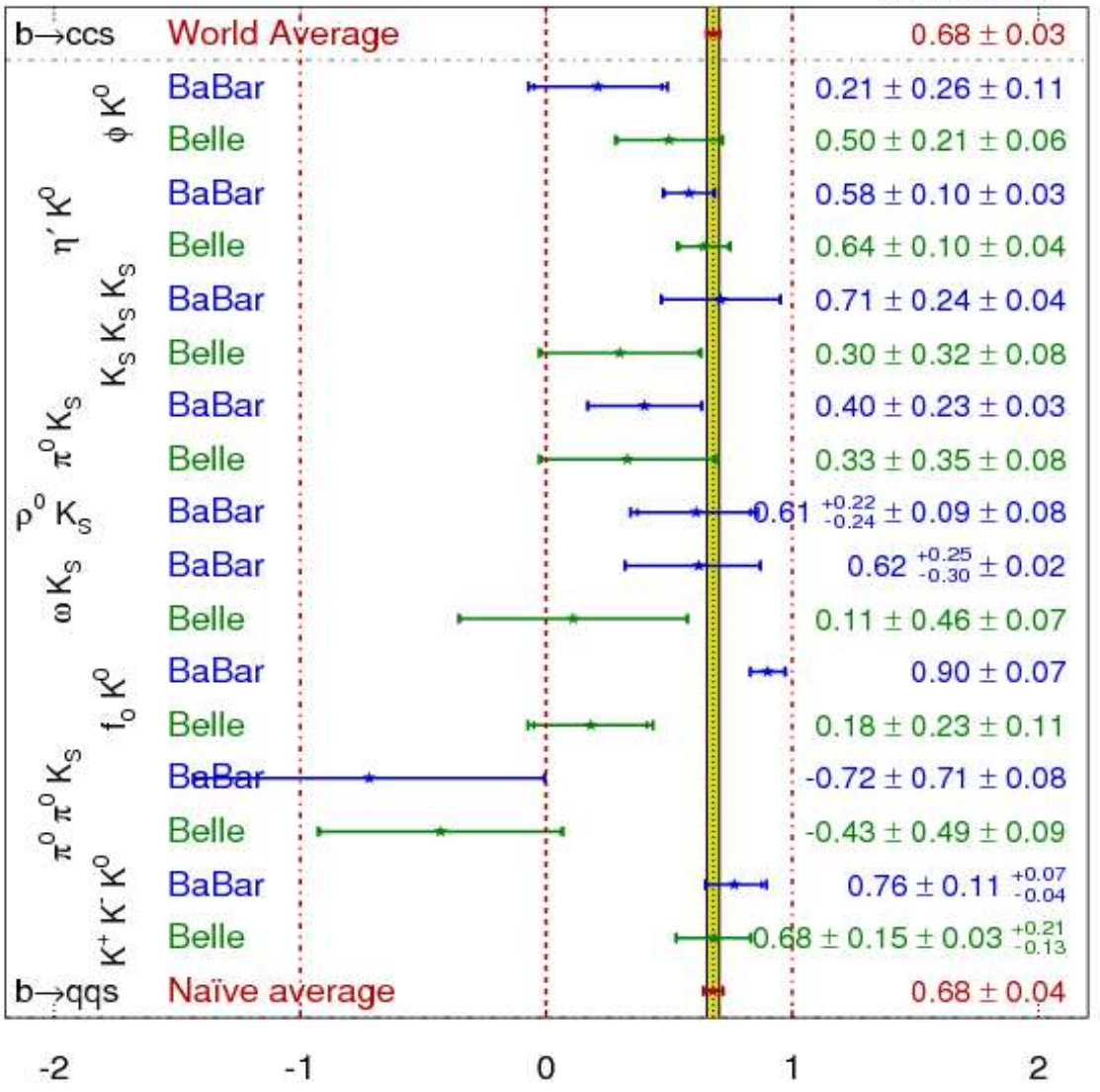
$S = +0.43 \pm 0.49 \pm 0.09$

$A = -0.17 \pm 0.24 \pm 0.06$

ϕ_1 with b→s penguins (summary)

some of recent QCDF estimates



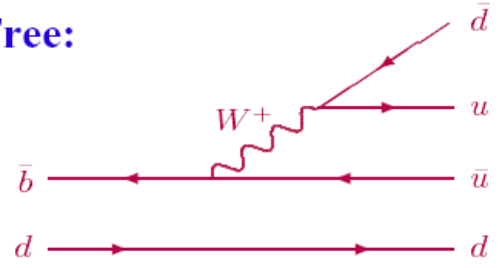


PRL98 (2007) 031802
hep-ex/0609006 submitted to PRD(RC)

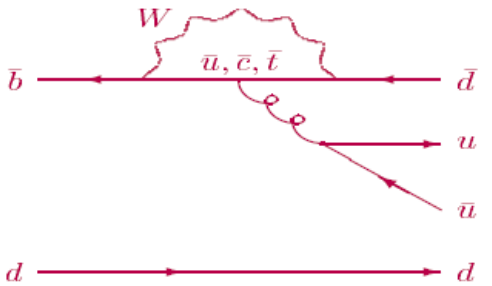
More statistics crucial
for mode-by-mode studies

ϕ_2 determination:

Tree:



Penguin:



$$A(t) = S_{\pi^+\pi^-}\sin(\Delta m\, t) + A_{\pi^+\pi^-}\cos(\Delta m\, t)$$

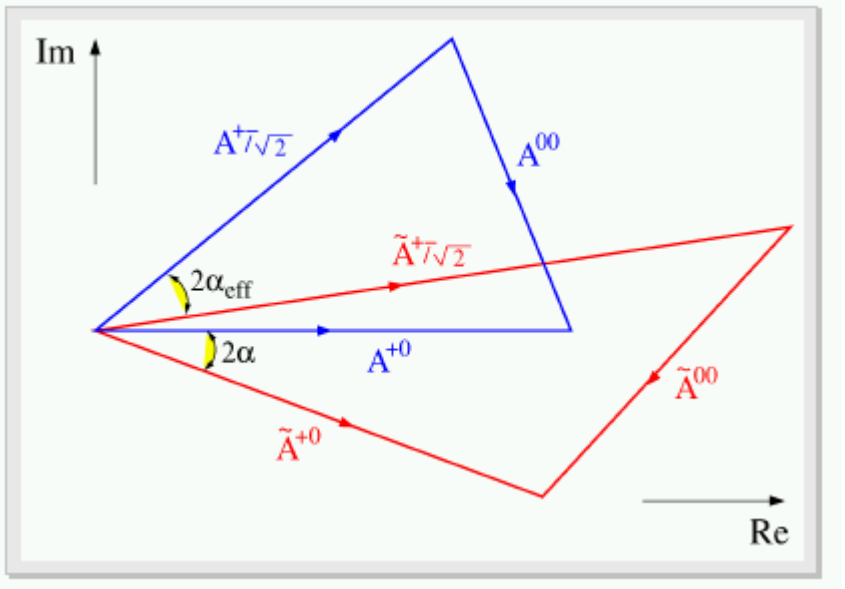
$$= \sqrt{1-A^2_{\pi^+\pi^-}}\,\sin 2\phi_2^{\text{eff}}\,\sin(\Delta m\, t) + A_{\pi^+\pi^-}\cos(\Delta m\, t)$$

from time dependent CP, we can measure ϕ_2^{eff},
but we want ϕ_2 !

Isospin analysis: [Gronau-London, PRL65, 3381 (1990)]

$$A_{+-} + \sqrt{2}\,A_{00} = \sqrt{2}\,A_{+0}$$
$$\overline{A}_{+-} + \sqrt{2}\,\overline{A}_{00} = \sqrt{2}\,\overline{A}_{+0}$$

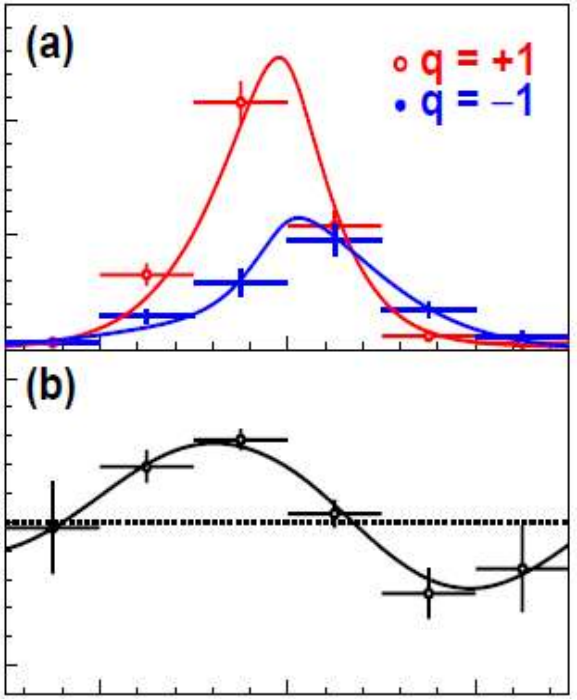
ϕ_2 can be resolved up to
an 8−fold ambiguity

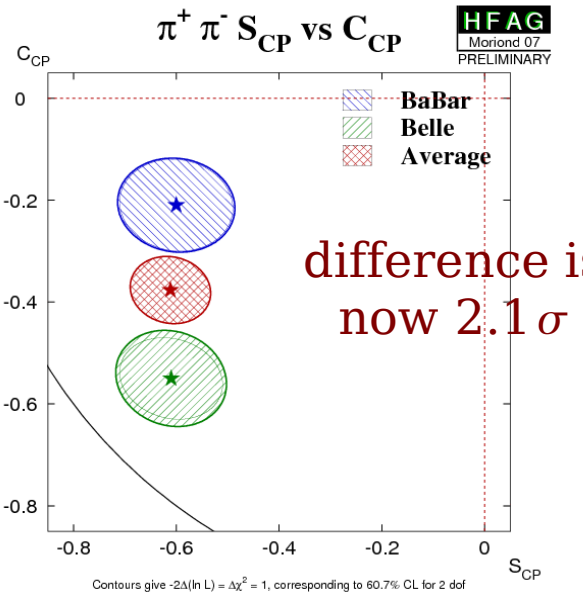


$\rho^+\rho^-$: ~100% longitudinally polarized (similar isospin analysis)

ϕ_2: $\pi\pi$ system (6 observables for 6 parameters)

$(\mathrm{Br}(B\to\pi^+\pi^-), S_{\pi^+\pi^-}, A_{\pi^+\pi^-}, \mathrm{Br}(B\to\pi^+\pi^0), \mathrm{Br}(B\to\pi^0\pi^0), A_{\pi^0\pi^0})$





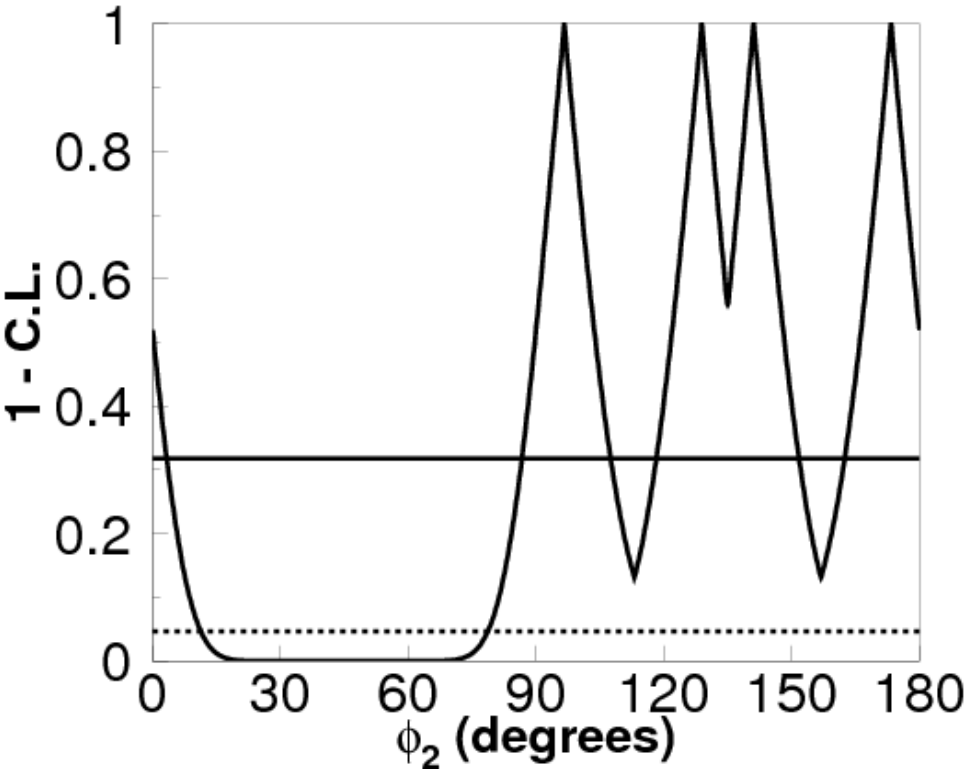
difference is now 2.1σ

$$A = +0.55 \pm 0.08 \pm 0.05$$

$$S = -0.61 \pm 0.10 \pm 0.04$$

Direct CPV @ 5.5σ

PRL 98, 221801 (2007)

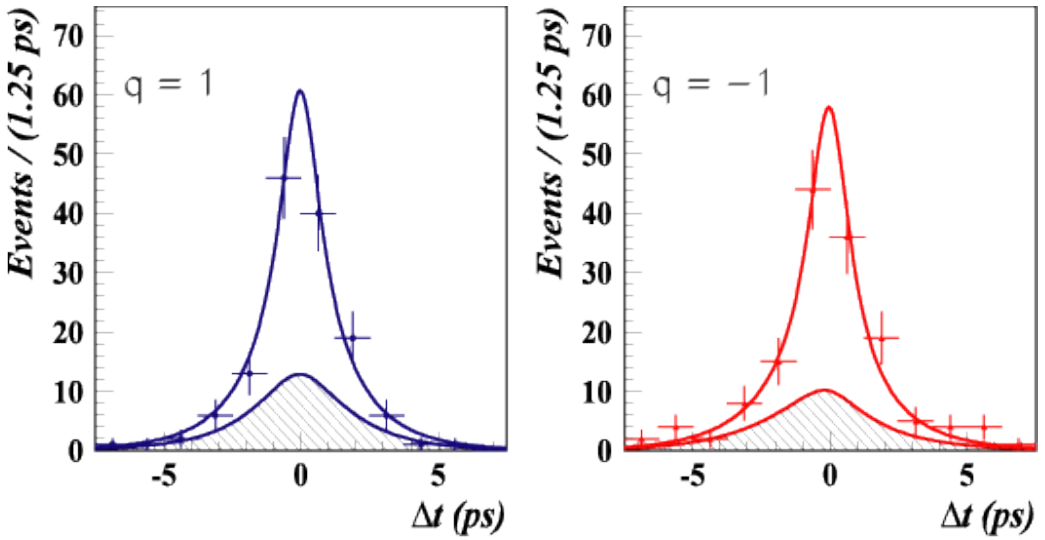


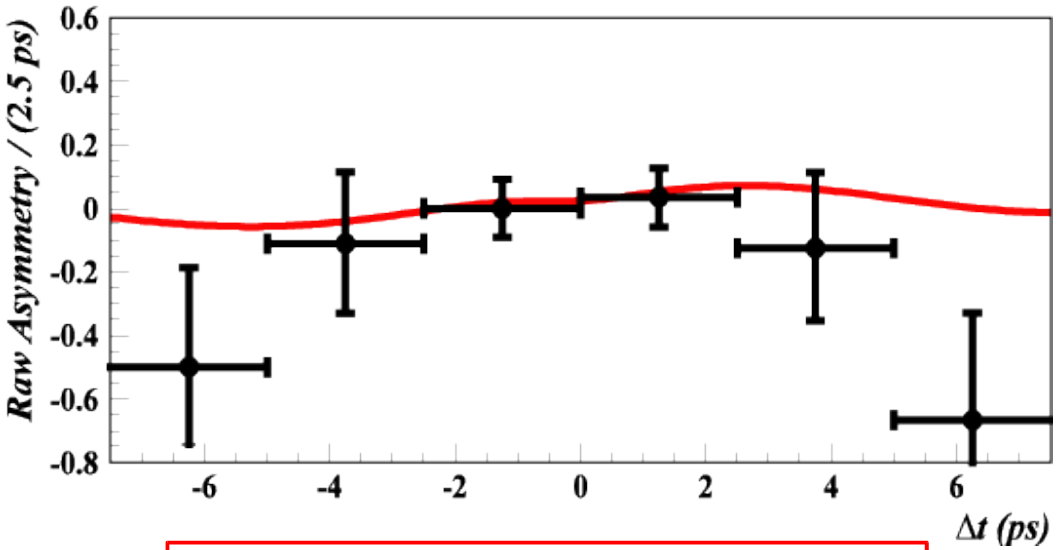
$\phi_2 = (97 \pm 11)^\circ$

(standard peak, @ 1σ)

$\rho\rho$ system (5 observables for 6 parameters)

$$(\mathrm{Br}(B\to\rho^+\rho^-),\ S_{\rho^+\rho^-},\ C_{\rho^+\rho^-},\ \mathrm{Br}(B\to\rho^+\rho^0),\mathrm{Br}(B\to\rho^0\rho^0)) + f_L$$

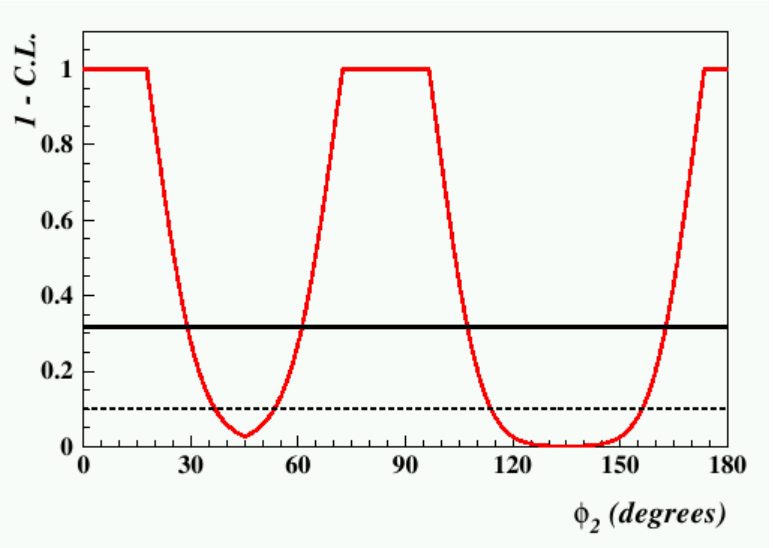




$$A = +0.16 \pm 0.21 \pm 0.07$$

$$S = +0.19\ ^{+0.29\,+0.07}_{-0.30\,-0.06}$$

PRD 76, 011104 (R) (2007)



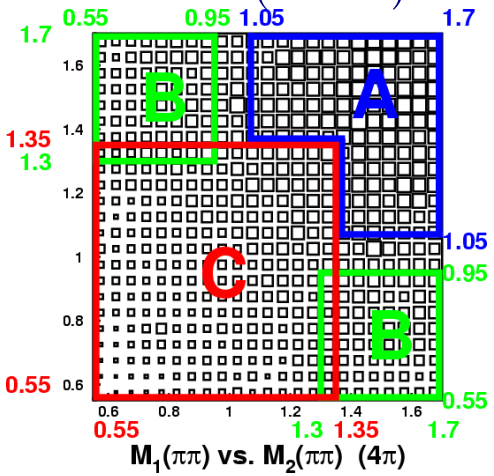
$62^\circ < \phi_2 < 106^\circ$ @ 68% C.L.

Until now, using $\mathrm{BR}(B^0\to\rho^0\rho^0)$
from BaBar [PRL98, 111801 (2007)]
$(1.07\pm0.33\pm0.19)\times10^{-6}$
3.5σ significance
$f_L = (0.87\pm0.13\pm0.14)$

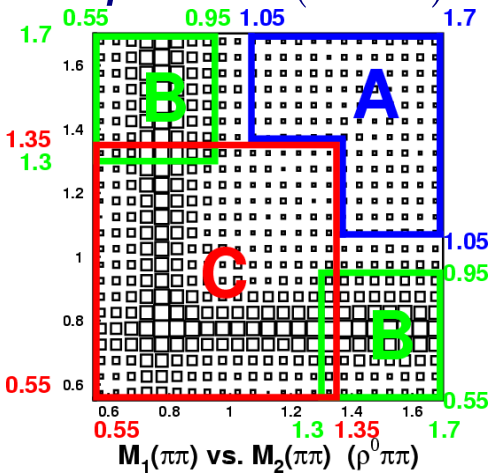
$\rho^0\rho^0$ mode

520×10^6 $B\bar{B}$ pairs
[arXiv:0708.2006] PRELIMINARY

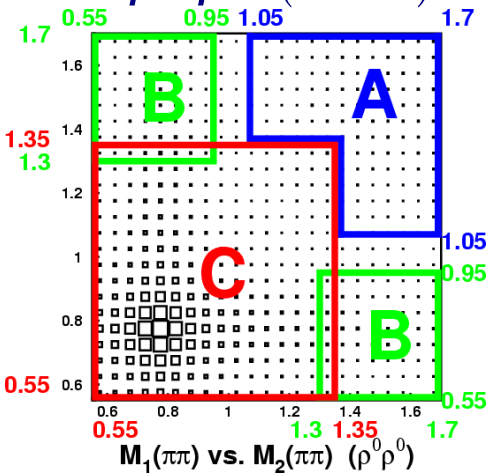
4π (MC)



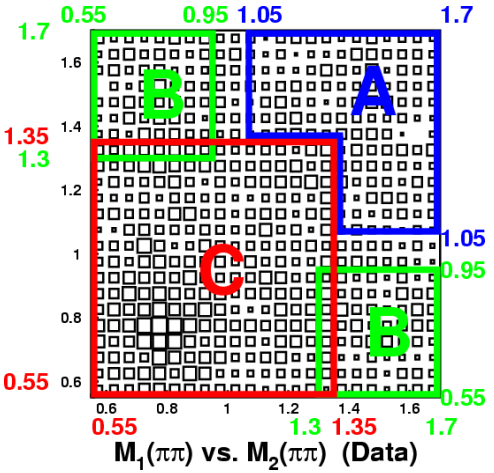
$\rho^0\pi\pi$ (MC)



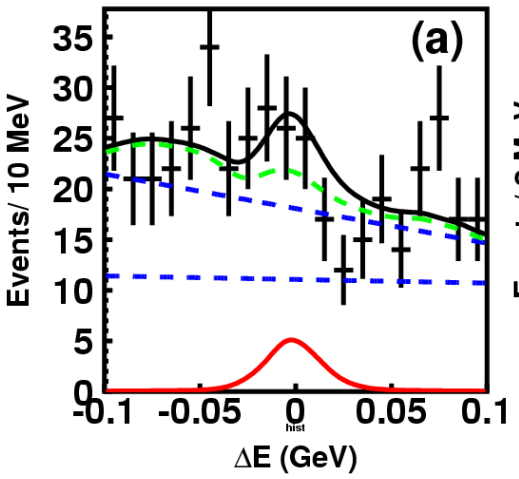
$\rho^0\rho^0$ (MC)

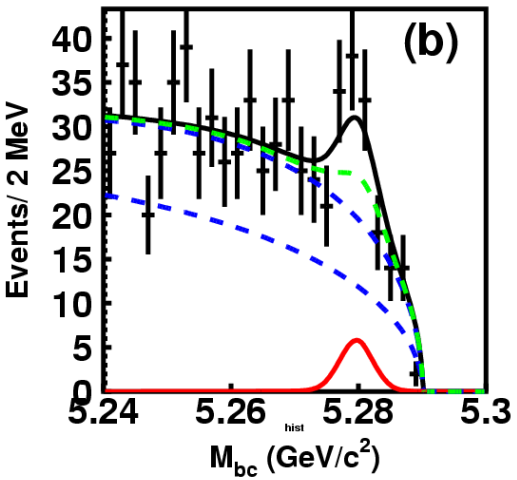


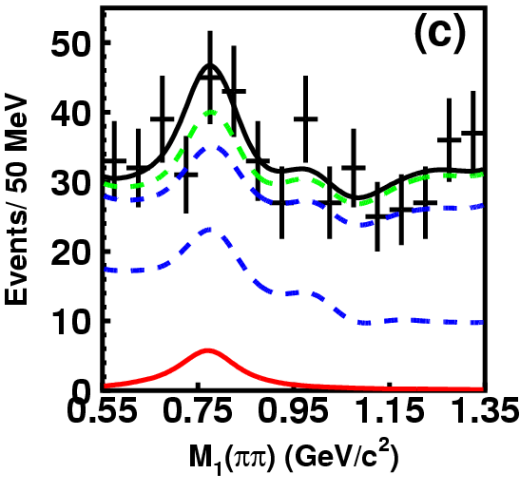
Data

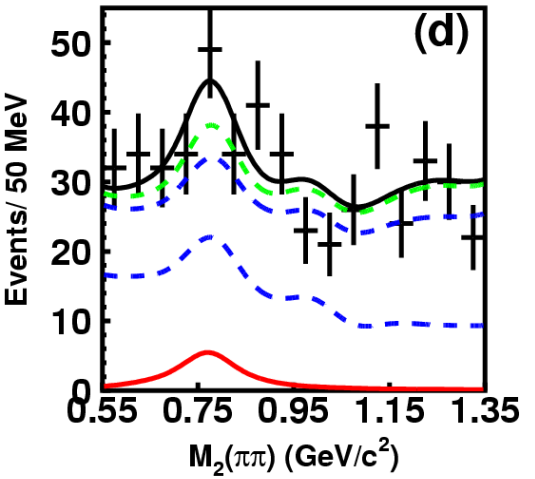


$4-\dim(\Delta E, M_{bc}, M_{\pi\pi}, M_{\pi\pi})$ fit:









1.8 σ significance

$BR(B^0\to\rho^0\rho^0)=(0.9\pm0.4^{+0.3}_{-0.4})\times10^{-6}$

$<1.6\times10^{-6}$ @ 90%C.L.

2.1 σ significance

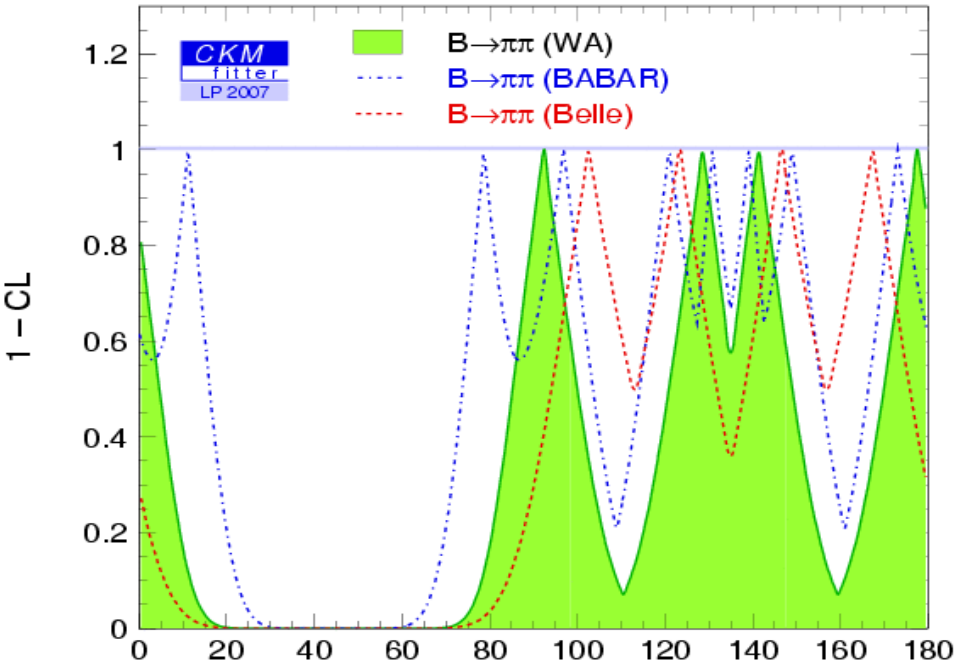
$BR(B^0\to4\pi)=(10.2\pm4.7^{+2.3}_{-1.5})\times10^{-6}$

$<17.3\times10^{-6}$ @ 90%C.L.

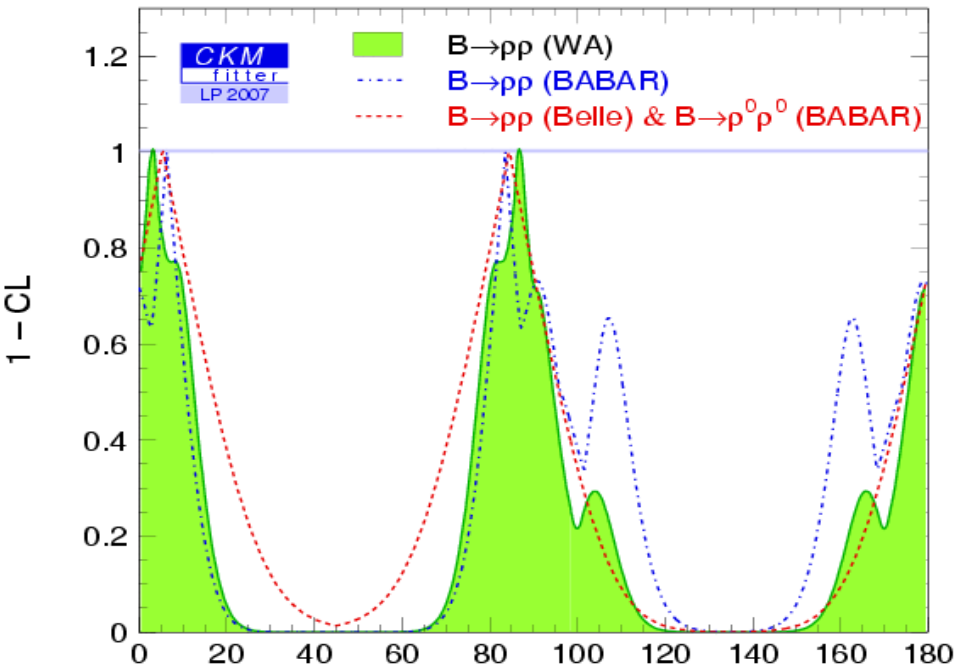
$BR(\rho^0\rho^0)$ is small !

SU(2) triangle even more squashed

ϕ_2 determination
(summary for $\pi\pi$ and $\rho\rho$ system)



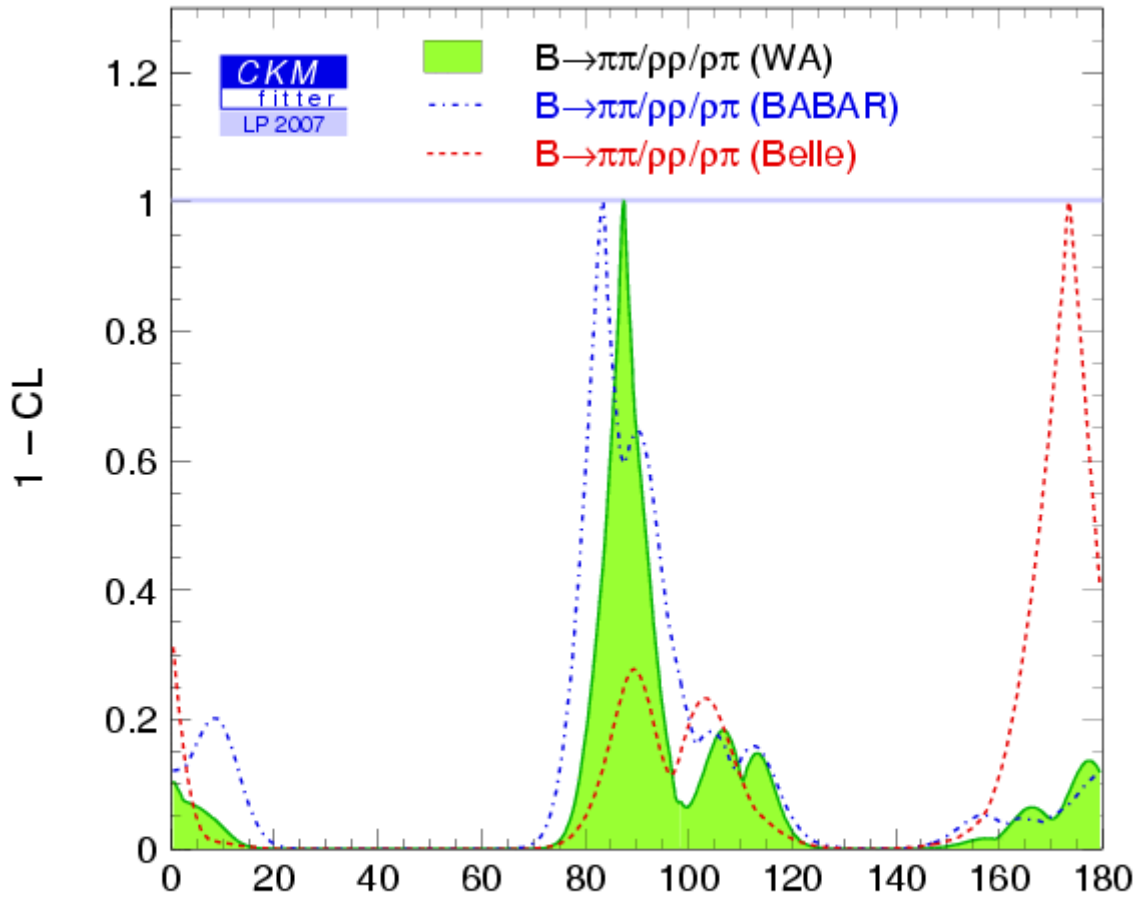
$\phi_2 = (93.5^{+12.1}_{-10.0})^\circ$
(standard peak, @ 1σ)



$\phi_2 = (86.5^{+10.9}_{-11.2})^\circ$

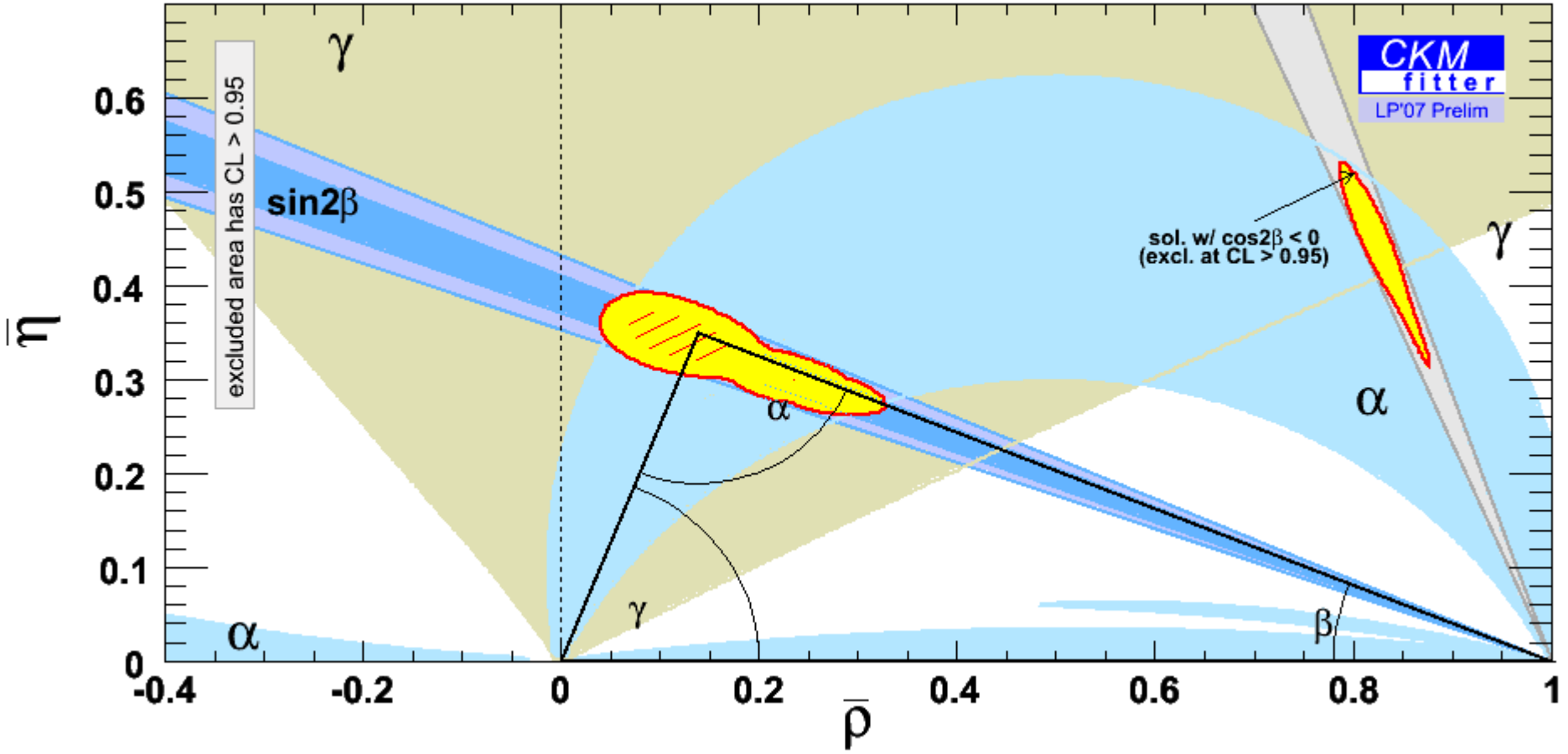
ϕ_2 determination
(including $\pi\pi$, $\rho\pi$ and $\rho\rho$ information)

$\rho\pi$ analysis
449×10^6 $B\overline{B}$
PRL 98, 221602 (2007)



$$\phi_2 = (87.5^{+6.2}_{-5.4})^\circ \ @\ 1\sigma$$
$$(87.5^{+31.4}_{-10.5})^\circ \ @\ 2\sigma$$

Angles determination

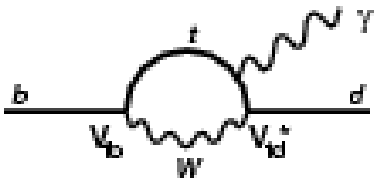


Improved measurements of $B \to \rho \gamma$ and $\omega \gamma$

First observed by Belle, confirmed by BaBar, now with 1.7×data

[PRL 96, 221601 (2006)] $(657 \times 10^6\ B\bar{B})$

(a) loop diagram



(b) annihilation diagram

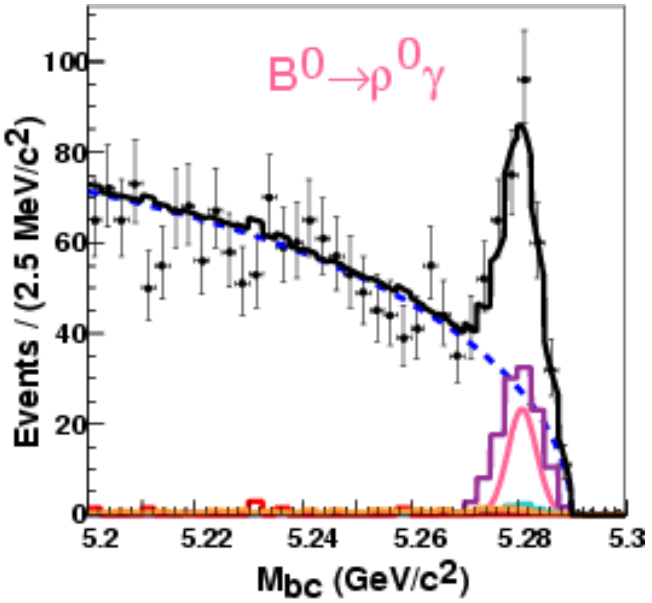
- $B \to K^* \gamma$ is a severe background

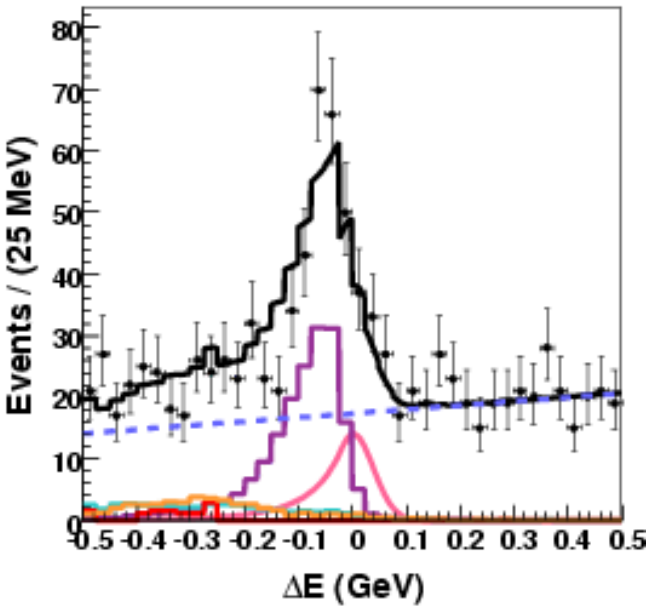
  K-id fake rate > $Br(B \to \rho \gamma)/Br(B \to K^* \gamma)$
- $M_{K\pi}$ is now in the fit for $B^0 \to \rho^0 \gamma$ (M_{bc}-ΔE -$M_{K\pi}$ fit)

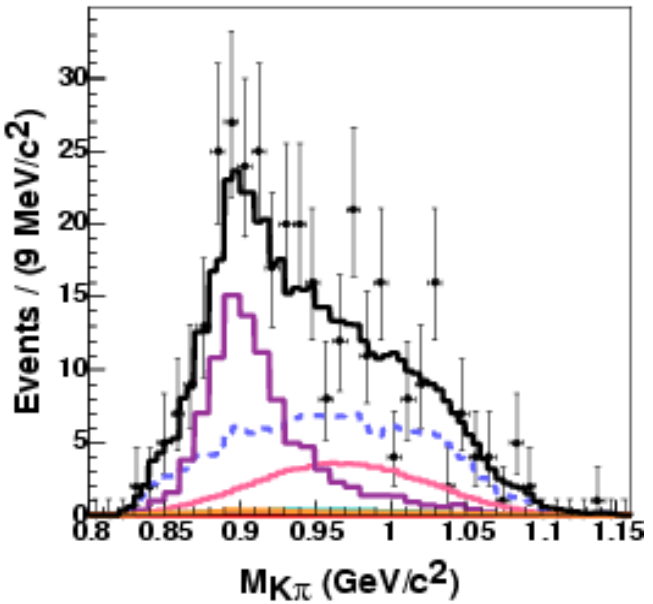
  $M_{K\pi}$: $\pi\pi$ mass with m_K assignment for $\pi/\Delta E$: separation of ~50 MeV
- Excellent sample to fix signal (and background) shape

$B^0 \to \rho^0 \gamma$ (74^{+17}_{-16}) events

PRELIMINARY



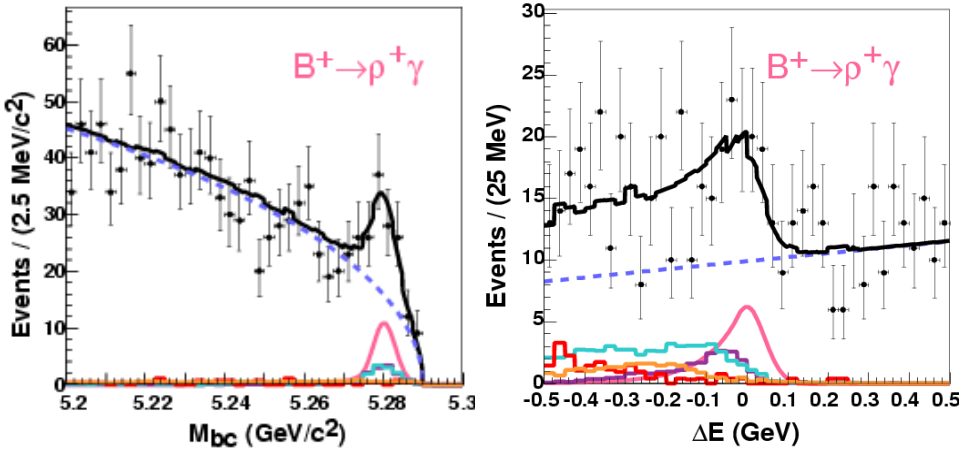




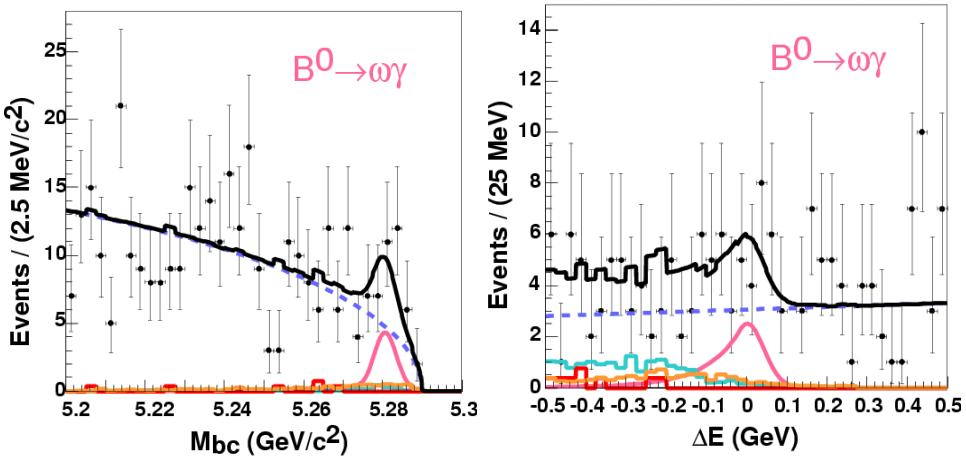
Improved measurements of $B \to \rho \gamma$ and $\omega \gamma$

PRELIMINARY

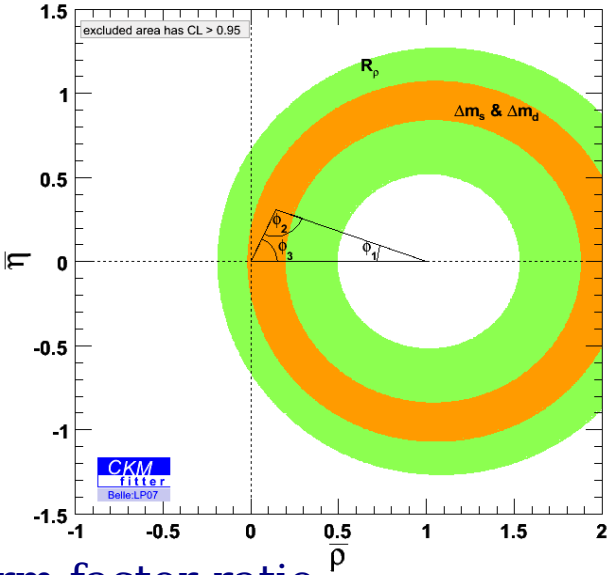
$B^+ \to \rho^+ \gamma$ (44^{+15}_{-14}) events



$B^0 \to \omega \gamma$ (17^{+8}_{-7}) events



	$Br(10^{-7})$	(Σ)
$B^+ \to \rho^+ \gamma$	$8.6^{+3.0+0.7}_{-2.8-0.8}$	(3.2σ)
$B^0 \to \rho^0 \gamma$	$7.6 \pm 1.7 \pm 0.6$	(4.9σ)
$B^0 \to \omega \gamma$	$4.2^{+2.0}_{-1.8} \pm 0.4$	(2.6σ)
$B \to \rho \gamma$	$11.9 \pm 2.4 \pm 1.2$	(5.5σ)
$B \to (\rho, \omega) \gamma$	$11.3 \pm 2.0 \pm 1.1$	(5.9σ)



Combined Br with assumption:

$\Gamma_{B \to (\rho, \omega)\gamma} = \Gamma_{B \to \rho \gamma} = \Gamma_{B^+ \to \rho^+ \gamma} = 2\Gamma_{B^0 \to \rho^0 \gamma} = 2\Gamma_{B^0 \to \omega \gamma}$

ξ, form factor ratio

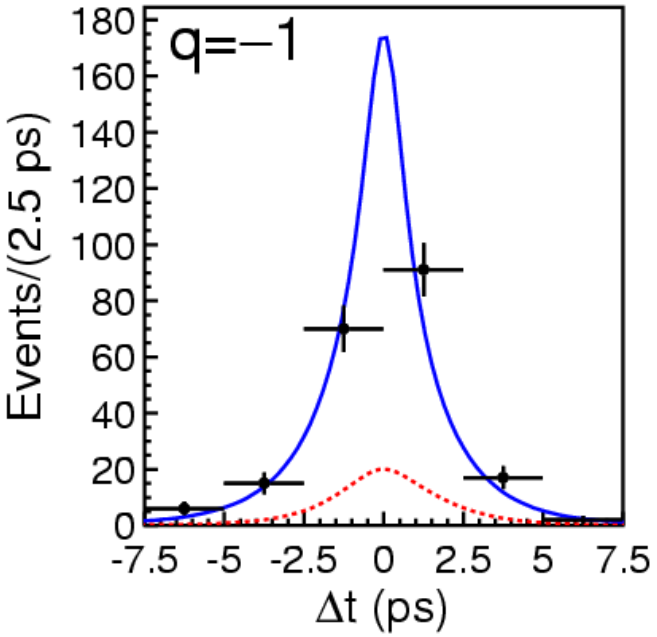
ΔR, isospin violation factor

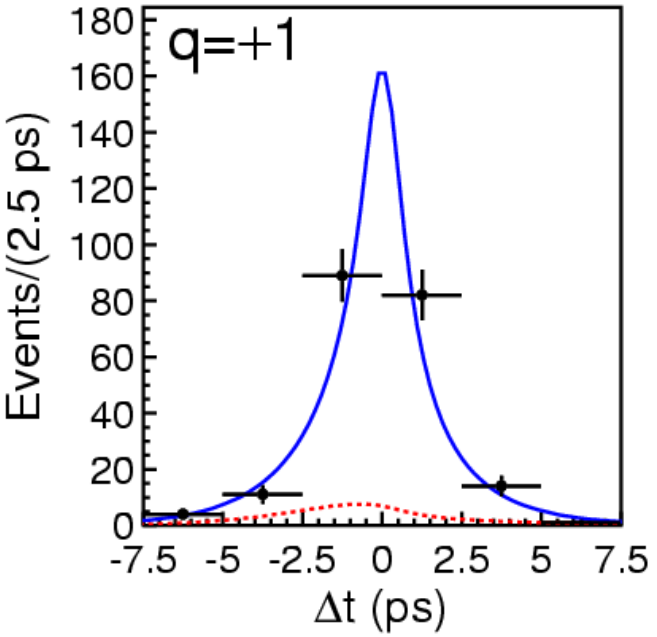
$$R = \frac{Br(B \to (\rho, \omega)\gamma)}{Br(B \to K^* \gamma)} = \left| \frac{V_{td}}{V_{ts}} \right|^2 \frac{(1 - m^2_{(\rho, \omega)}/m^2_B)^3}{(1 - m^2_{K^*}/m^2_B)^3} \xi^2 [1 + \Delta R]$$

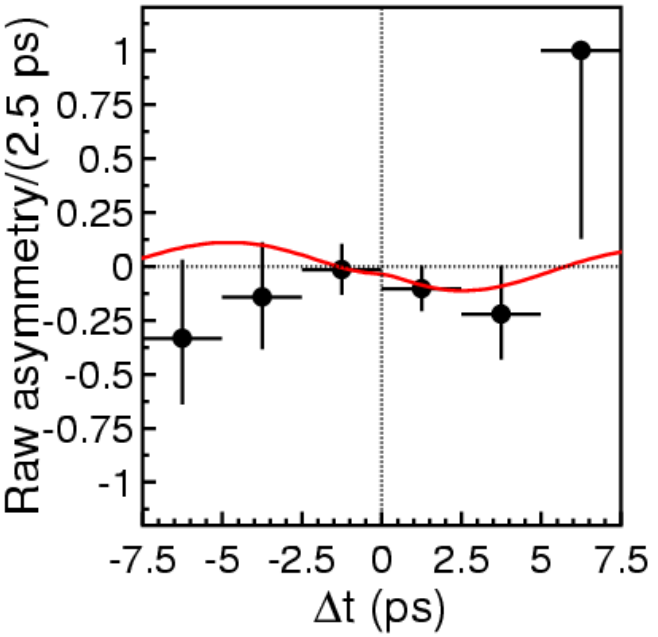
CPV in $B^0 \to \rho^0 \gamma$

- First CPV in $b \to d\gamma$!
- $S_{\rho^0\gamma} \sim 0$ in SM
  - $\arg(V_{td})$ in mixing and decay cancel
  - suppression due to photon polarization
- $A_{\rho^0\gamma}$ could be non−zero in SM

PRELIMINARY



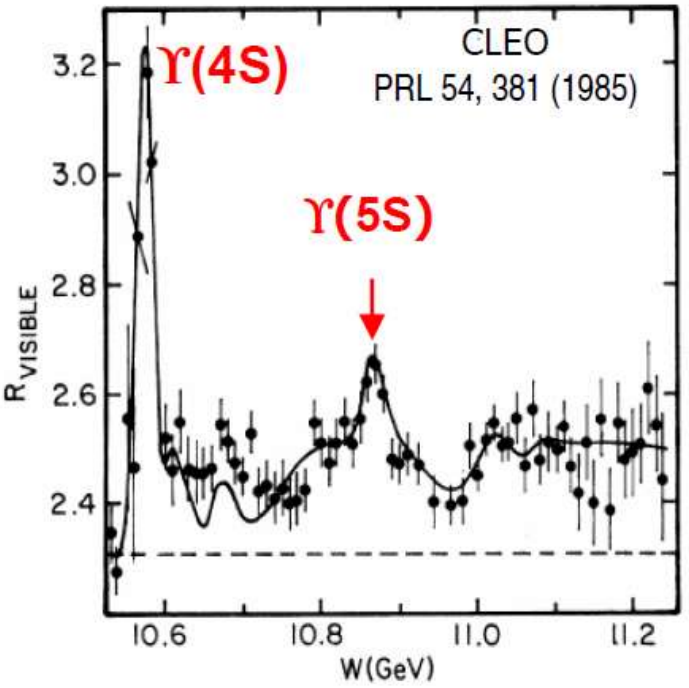


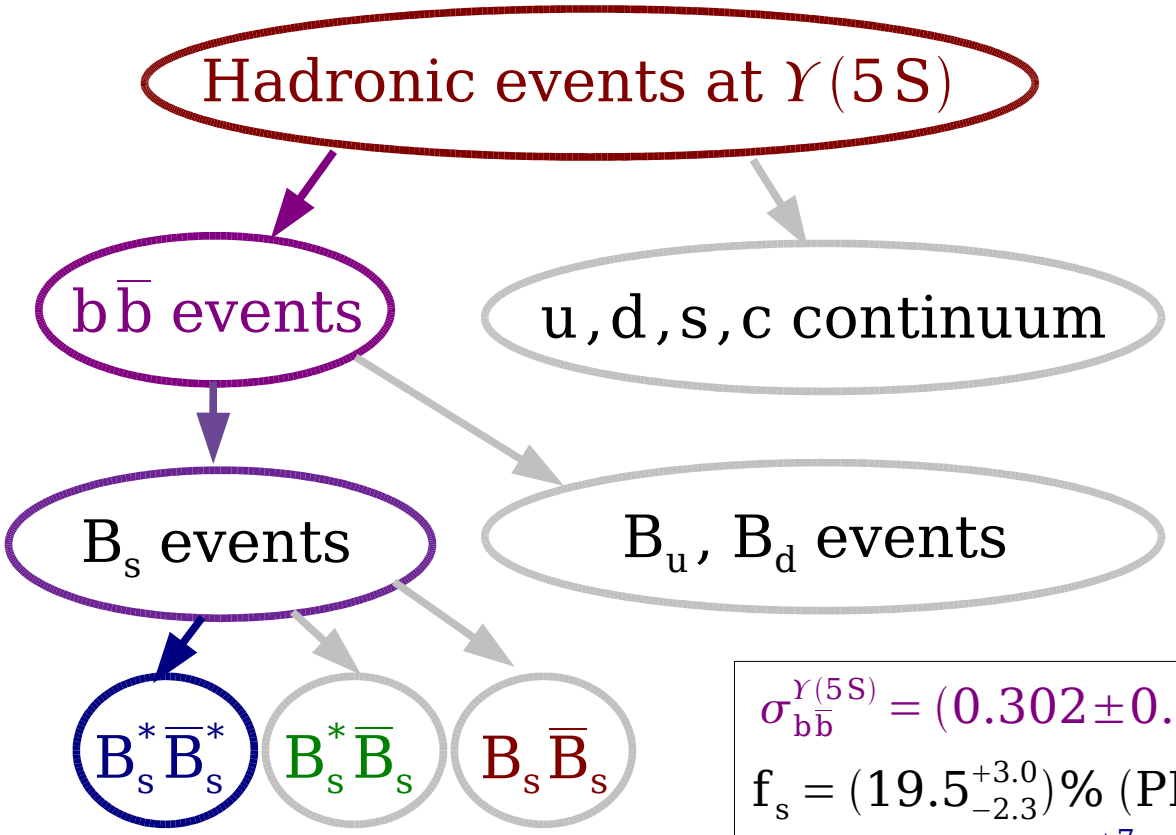


$$S_{\rho^0\gamma} = -0.83 \pm 0.65 \pm 0.18, \quad A_{\rho^0\gamma} = -0.44 \pm 0.49 \pm 0.14$$

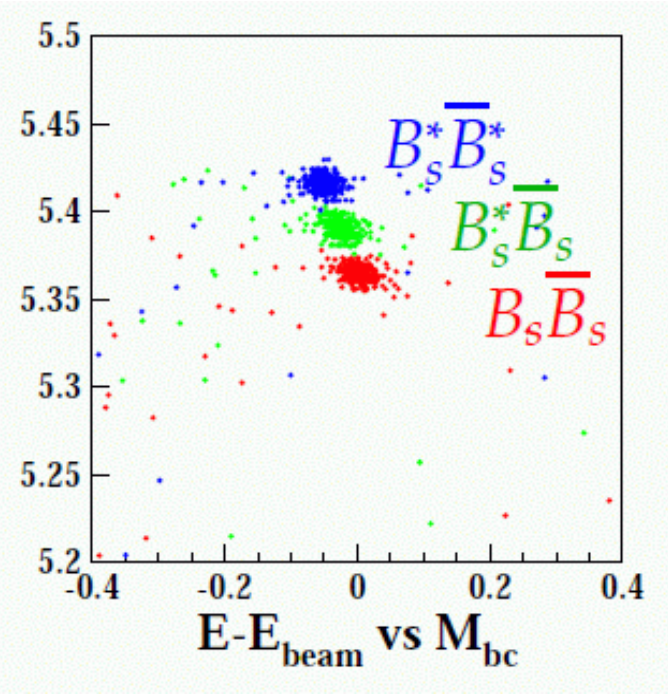
Radiative decays at $\Upsilon(5S)$

$1.9\,\text{fb}^{-1}$ in June'05
$23.6\,\text{fb}^{-1}$ in June'06 (3% of Belle data)
$\rightarrow N(B_s) = (2.6 \pm 0.5) \times 10^6$





$B_s^* \bar{B}_s^*$, $B_s^* \bar{B}_s$, $B_s \bar{B}_s$
are well separated



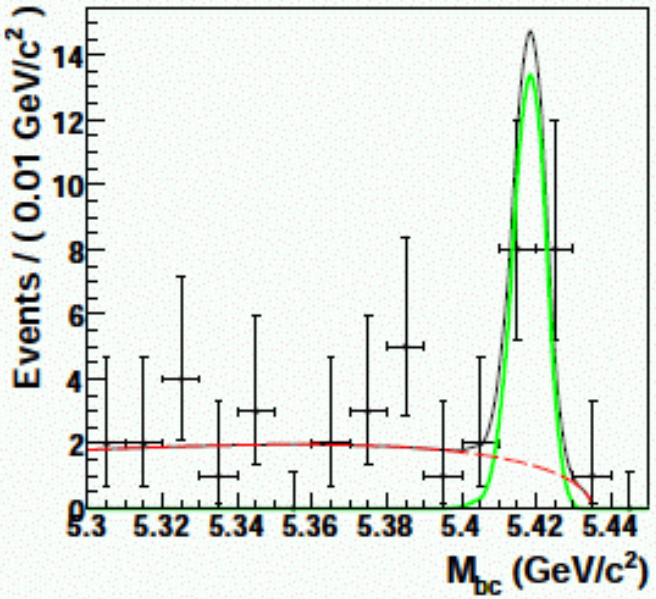
$\sigma_{b\bar{b}}^{\Upsilon(5S)} = (0.302 \pm 0.015)$ nb
$f_s = (19.5^{+3.0}_{-2.3})\%$ (PDG2007)
$f_{B_s^* \bar{B}_s^*} = (93^{+7}_{-9})\%$

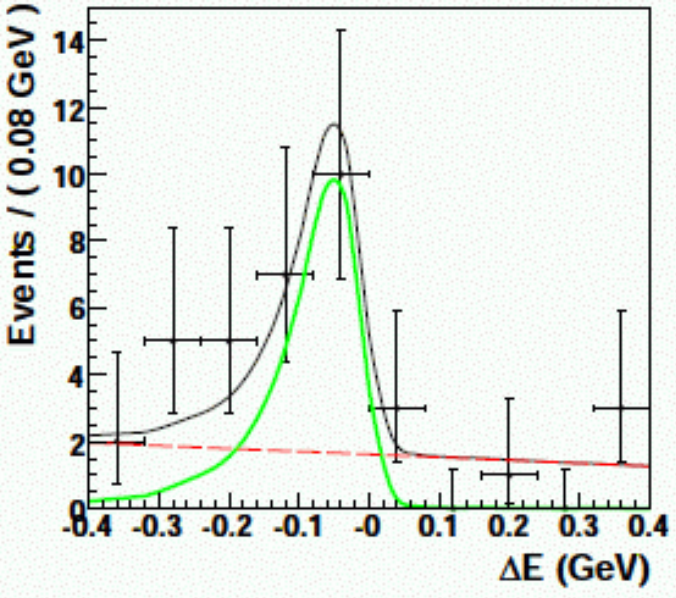
$B_s \to \phi\gamma$

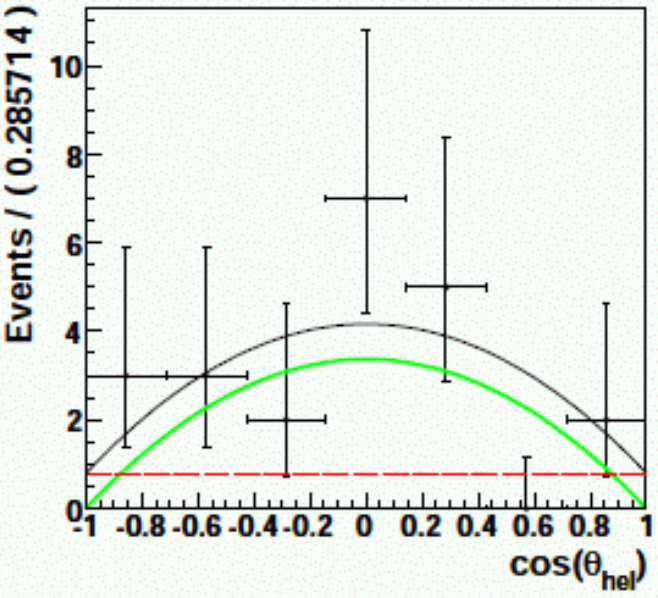
- Analogy to $B \to K^* \gamma$, first rare decay from B_s
- Fit to M_{bc}, ΔE and $\cos\theta_{hel}$
- SM: $Br(B_s \to \phi\gamma) = (3.94 \pm 1.07 \pm 0.53) \times 10^{-5}$
  (Ball et al, PRD75, 054004 (2007))

$$Br(B_s \to \phi\gamma) = (5.7^{+1.8+1.2}_{-1.5-1.7}) \times 10^{-5} \quad (5.5\sigma)$$

PRELIMINARY



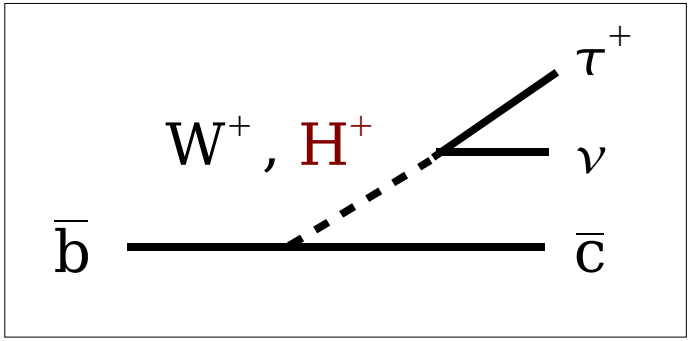




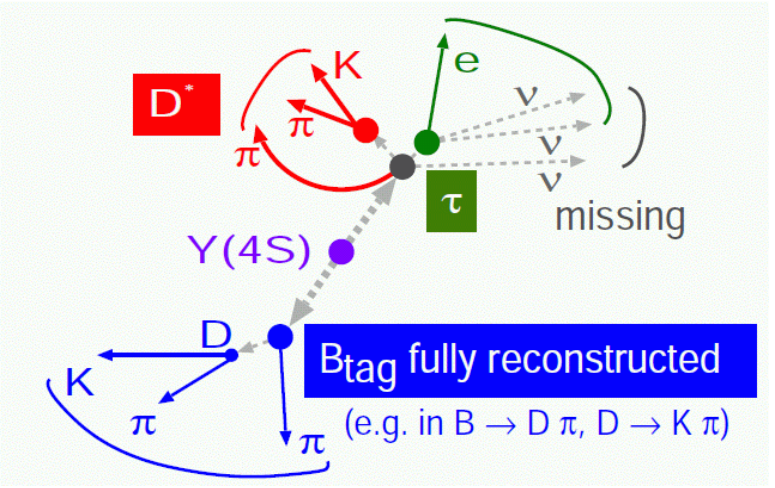
- No signal found in $B_s \to \gamma\gamma$ ($Br(B_s \to \gamma\gamma) < 8.6 \times 10^{-6}$ (90% CL))

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

$535 \times 10^6 B\bar{B}$ pairs
[arXiv:0706.4429]
submitted to PRL

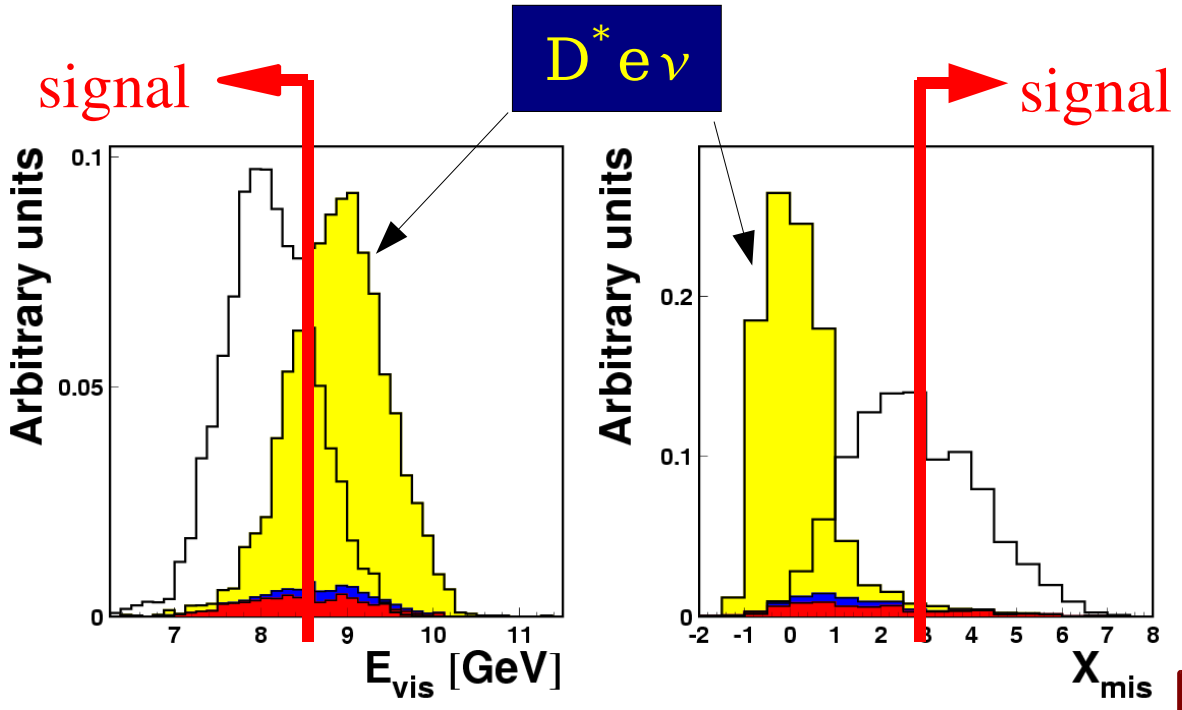


$D^{*-} \to \bar{D}^0 \pi^-$, $\bar{D}^0 \to K^+ \pi^- (\pi^0)$
$\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$, $\tau^+ \to \pi^+ \bar{\nu}_\tau$
Other B fully reconstructed

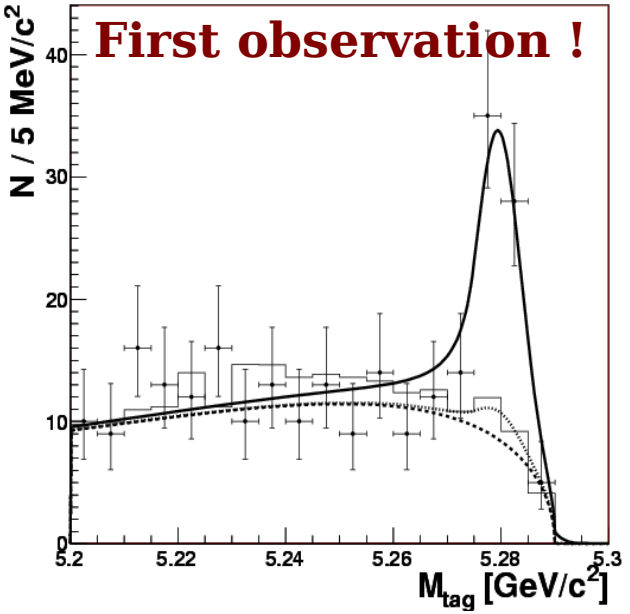


Non−zero missing mass, small E_{vis}

$$X_{mis} = \frac{E^*_{beam} - E_{D^*} - E_{e,\pi} - \left|\vec{p}_{D^*} + \vec{p}_{e,\pi}\right|}{\sqrt{E^{*\,2}_{beam} - M_B^2}}$$



Measure the B−tag yield



$$BR(B^0 \to D^{*-} \tau^+ \nu) = (2.02^{+0.40}_{-0.37} \pm 0.37)\%$$

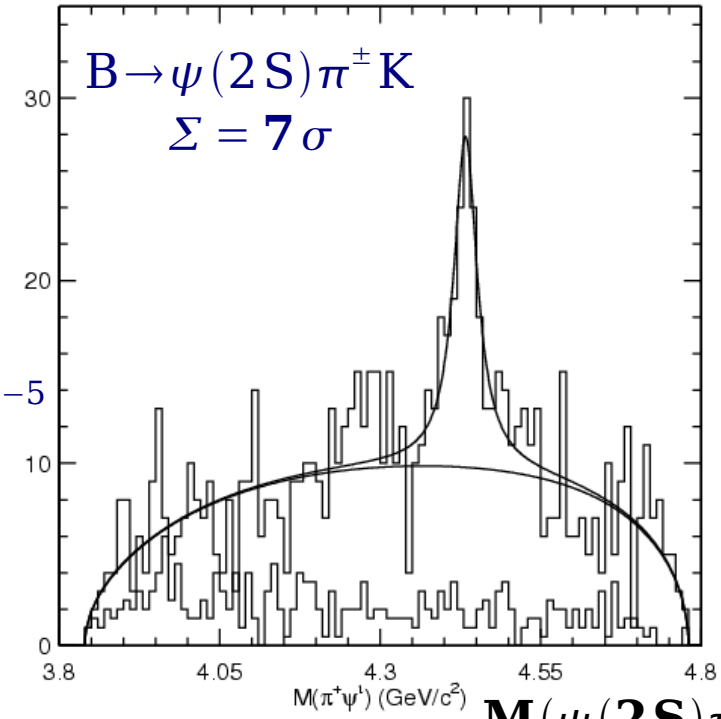
New Particles search

arXiv:0708.1790
PRELIMINARY

Z(4430)
the first charged charmonium-like state

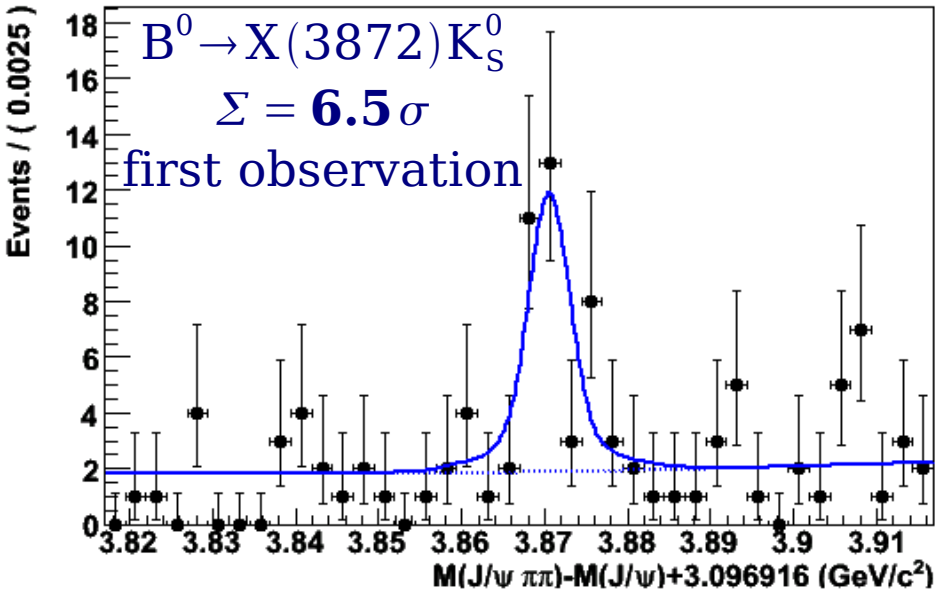
$$\mathbf{M} = (\mathbf{4433} \pm \mathbf{4}(\mathbf{stat}) \pm \mathbf{1}(\mathbf{syst}))\ \mathbf{MeV}$$
$$\Gamma = (\mathbf{44}^{+\mathbf{17}\,+\mathbf{30}}_{-\mathbf{13}\,-\mathbf{11}})\ \mathbf{MeV}$$

$$BR(B \to KZ) \times BR(Z \to \psi(2S)\pi^+) = (4.1 \pm 1.0 \pm 1.3)10^{-5}$$



$\mathbf{M}(\psi(\mathbf{2S})\pi^\pm)$

BELLE-CONF-0711
PRELIMINARY



$$\Delta M = (0.22 \pm 0.90 \pm 0.27)\ \text{MeV}$$

$$\frac{BR(B^0 \to XK^0)}{BR(B^- \to XK^-)} = 0.94 \pm 0.24 \pm 0.10$$

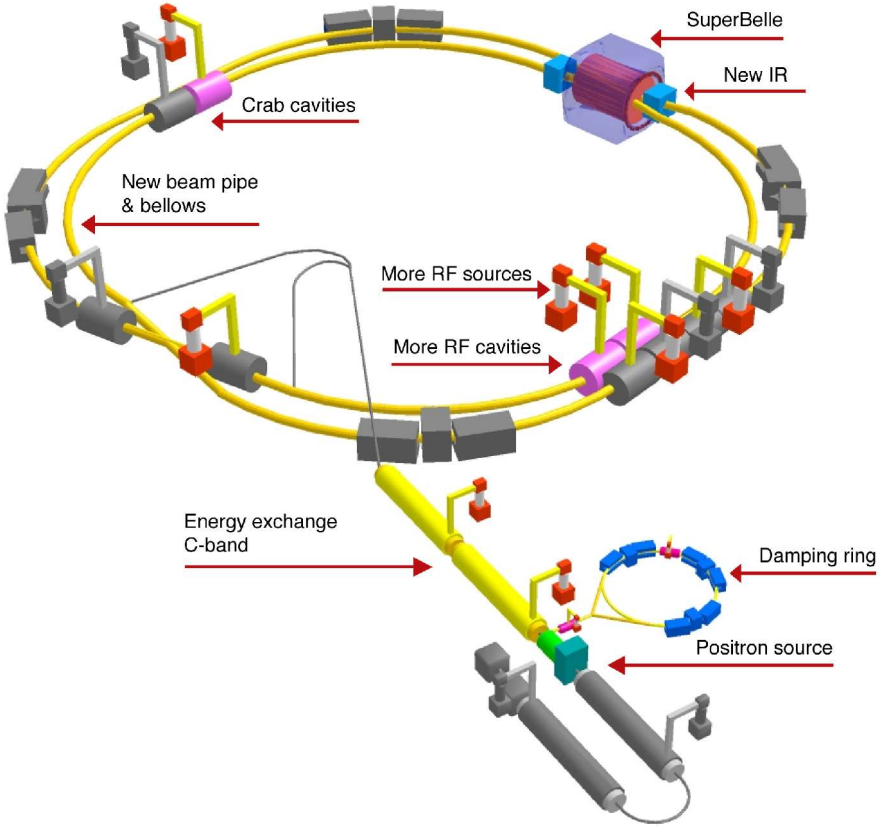
...and also ...

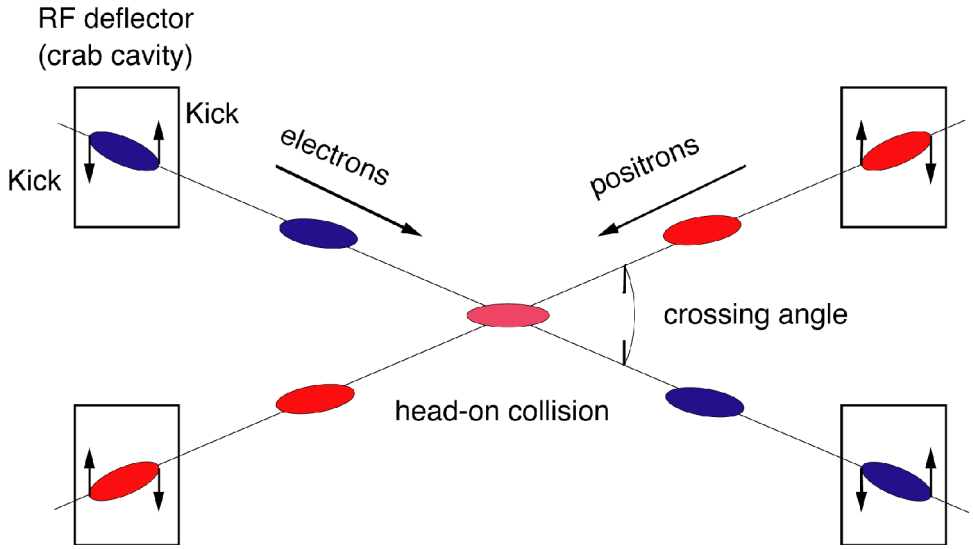
$Y \to J/\psi\pi\pi$ [arXiv:0707.2541]
$Y \to \psi(2S)\pi\pi$ [arXiv:0707.2541]
$X(4160) \to D^*D^*$ [BELLE-CONF-0705]
...

In conclusion,
lot of results this summer…on the way for 1 ab^{-1}

First step towards Super B: Crab crossing

Crab cavities installed in January'07
luminosity goal = $3\times10^{34}/cm^2/s$



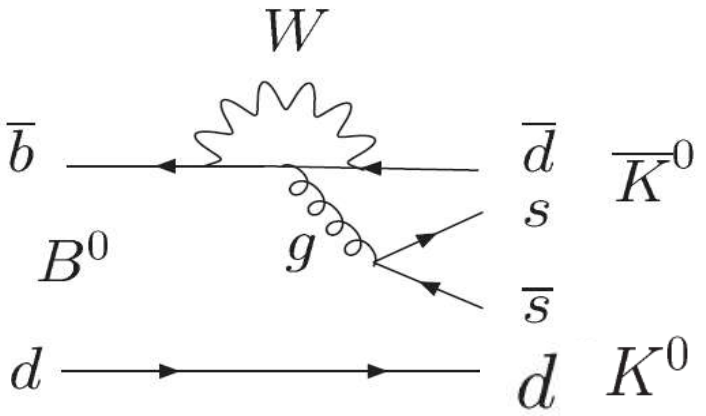


Backup Slides

$K^0_S K^0_S$ mode

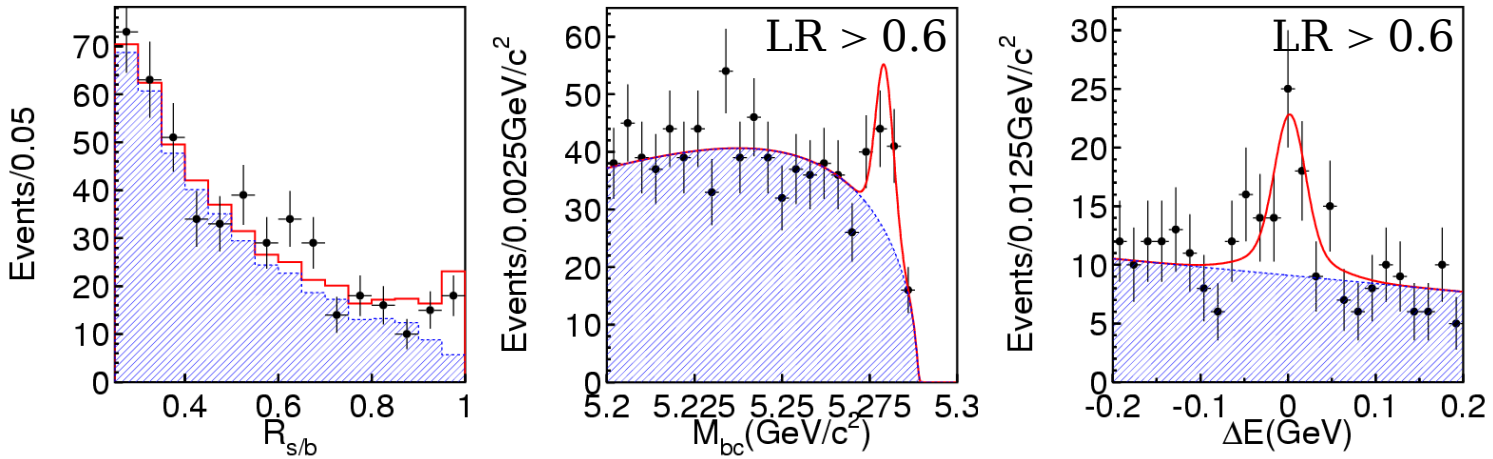
$657\times10^6 B\bar{B}$ pairs
[arXiv:0708.1790]
PRELIMINARY

- $b\to d q\bar{q}$ penguin
  assuming top-quark dominance
  ($b\to t\to d$ penguin phase cancels mixing phase)

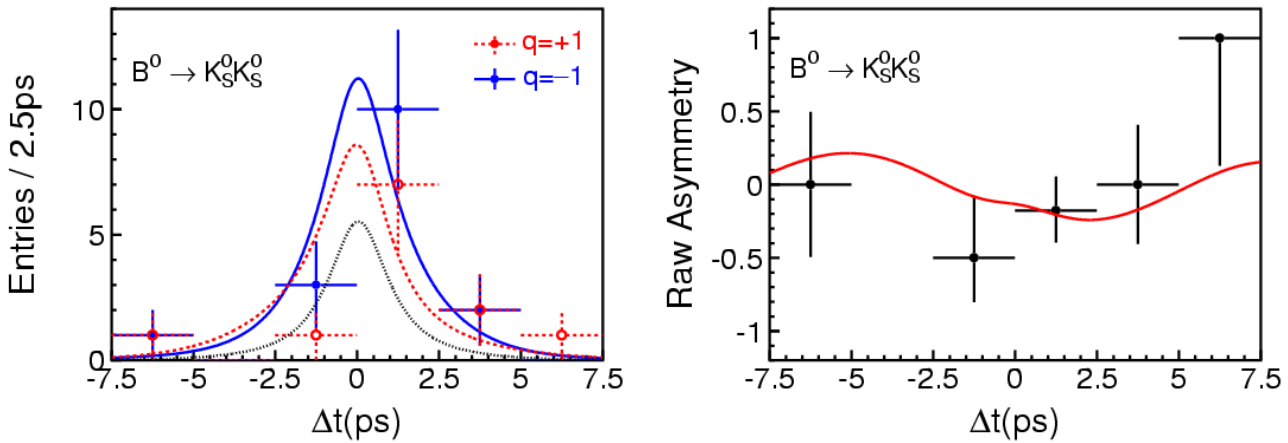


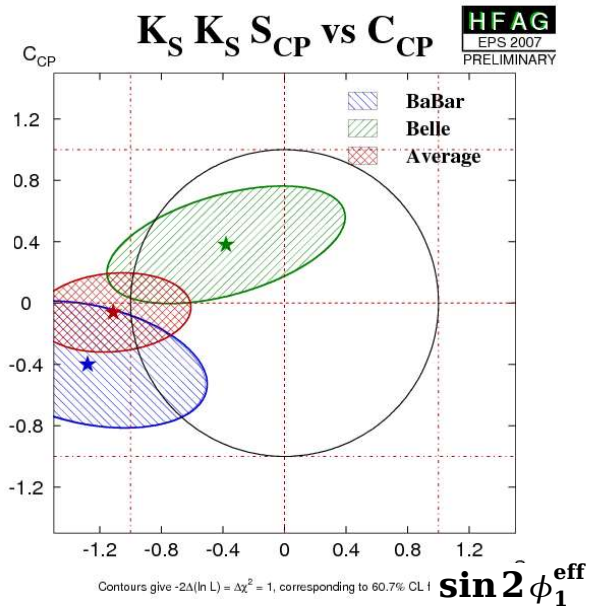
- SM: S=0 and A=0
  $0.02<S<0.13,\ 0.15<A<0.17$

[R.Fleischer and S.Recksiegel, Eur.Phys.J.C38, 251 (2004)]



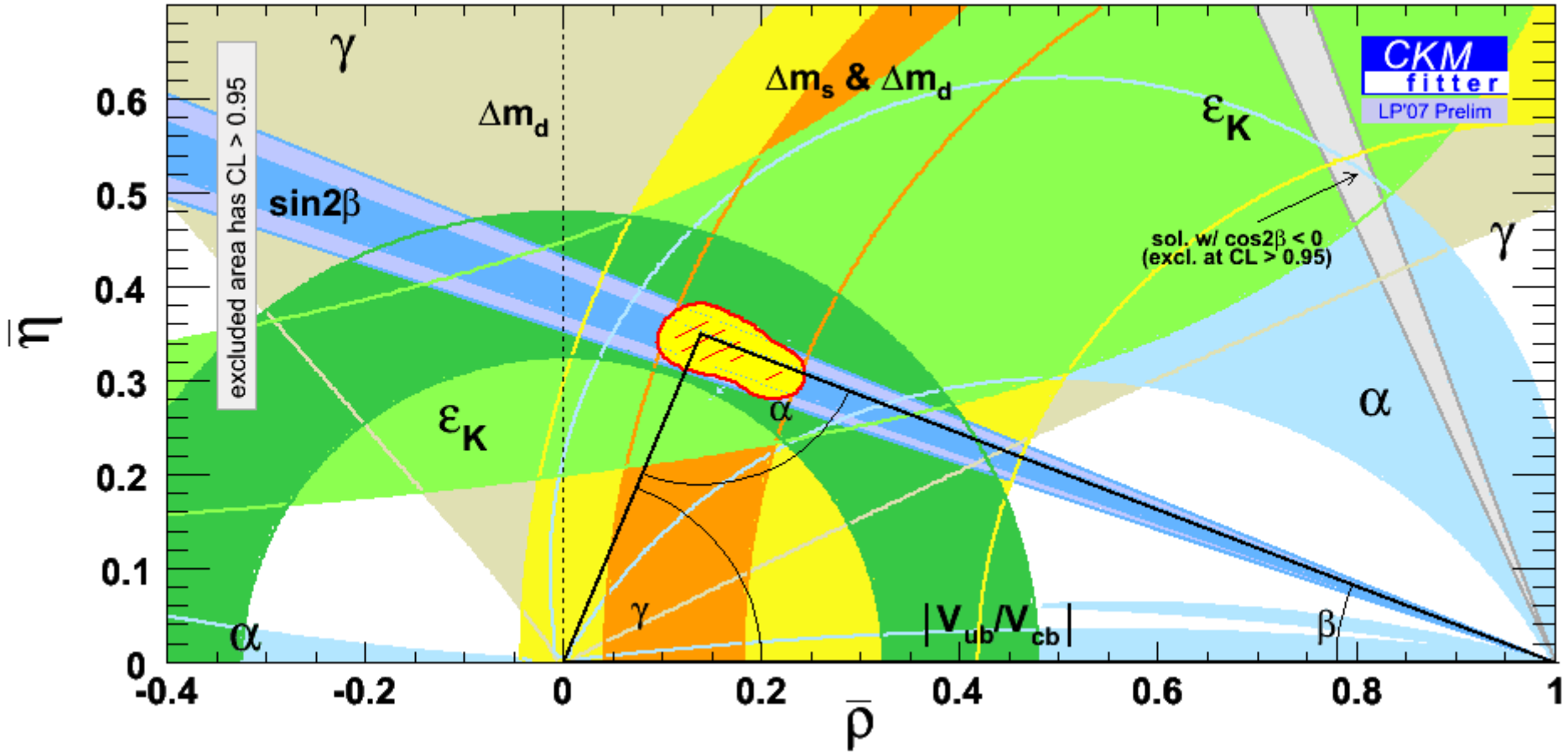
Signal yield = 58±11 (with vtx = 33±6)





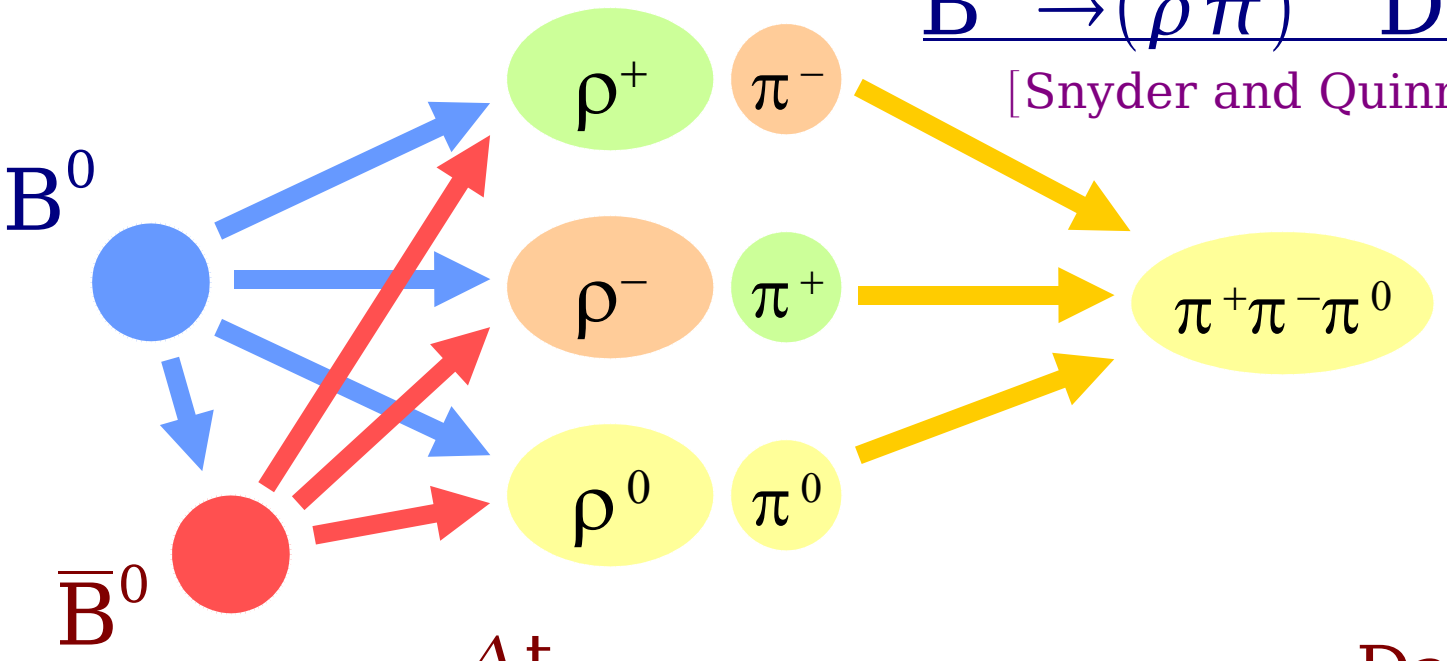
$S = -0.38 \pm 0.77 \pm 0.08$

$A = -0.38 \pm 0.38 \pm 0.05$


CKM fitter
LP'07 Prelim
excluded area has CL > 0.95
γ
Δm_d
Δm_s & Δm_d
ε_K
sin2β
sol. w/ cos2β < 0
(excl. at CL > 0.95)
γ
α
ε_K
α
γ
|V_ub/V_cb|
β
α
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
η̄
ρ̄

$B^0 \to (\rho\pi)^0$ Dalitz Analysis

[Snyder and Quinn, PRD48, 2139 (1993)]



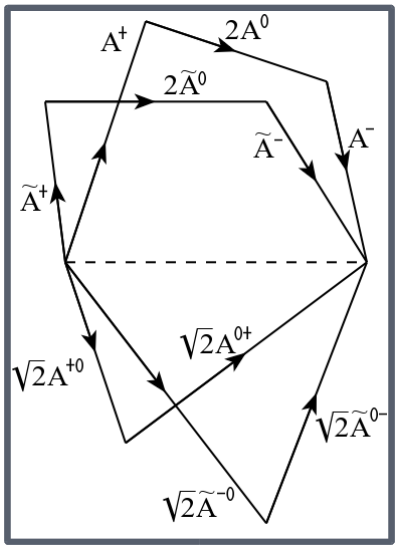
449×10^6 $B\overline{B}$
PRL 98, 221602 (2007)

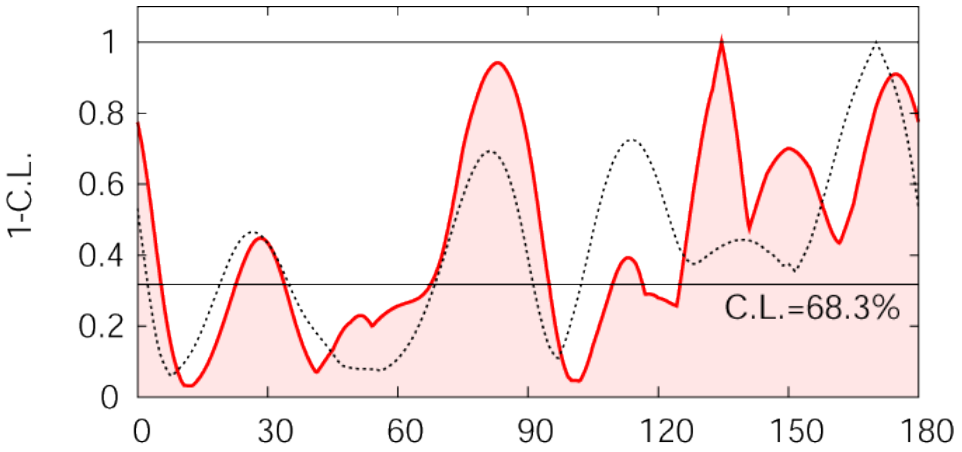
Δt Dalitz

Interference by $B^0\overline{B}^0$ oscillation + Interference between ρ^+, ρ^-, ρ^0

Various (24) patterns of interferences → information on relative phases

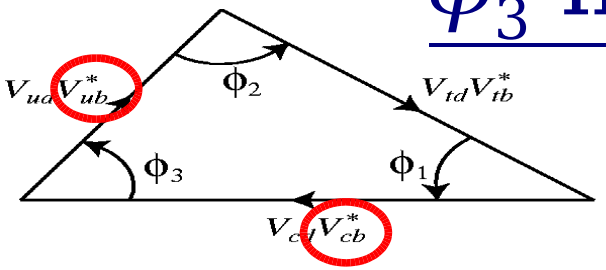
(Dalitz + pentagon analysis)



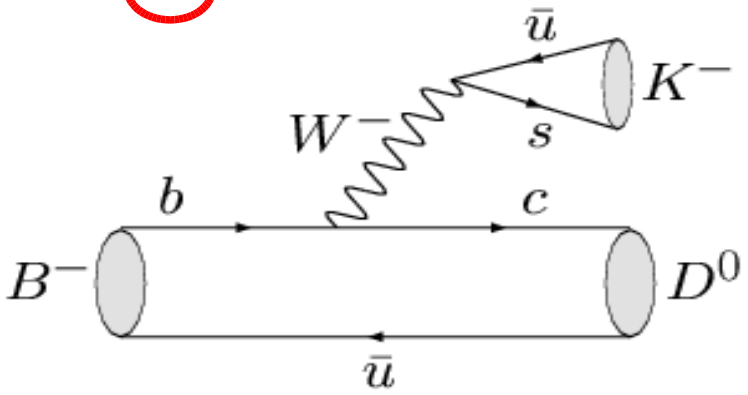


$68^\circ < \phi_2 < 95^\circ$

ϕ_3 measurement from $B^{\pm} \to DK^{\pm}$



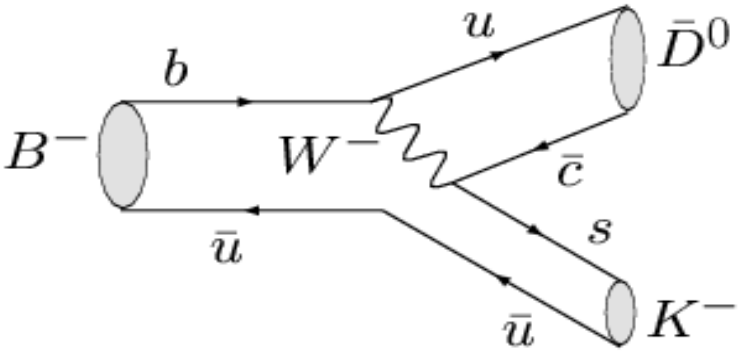
Access ϕ_3 via interference between $B^- \to D^0 K^-$ and $B^- \to \bar{D}^0 K^-$



color allowed

$B^- \to D^0 K^- \sim V_{cb} V_{us}^*$

$\sim \mathbf{A}\lambda^3$



color suppressed

$B^- \to \bar{D}^0 K^- \sim V_{ub} V_{cs}^*$

$\sim \mathbf{A}\lambda^3(\rho + \mathbf{i}\eta)$

$$r_B = \frac{|A_{suppressed}|}{|A_{favoured}|} \sim \frac{|V_{ub}V_{cs}^*|}{|V_{cb}V_{us}^*|} \times [\text{color supp}] = 0.1\text{-}0.2$$

- Reconstruct D in final states accessible to both D^0 and $\bar{D}^0$

$D = D_{CP}$ **GLW method (Gronau-London-Wyler)**

$D = D_{WS}$ (doubly−cabbibo suppressed) **ADS method (Atwood-Dunietz-Soni)**

$D \to K_S \pi^+ \pi^-$ **GGSZ method (Giri-Grossman-Soffer-Zupan) [PRD68, 054018('03)]**

$B \to D^{(*)} K^{(*)}$ Dalitz analysis

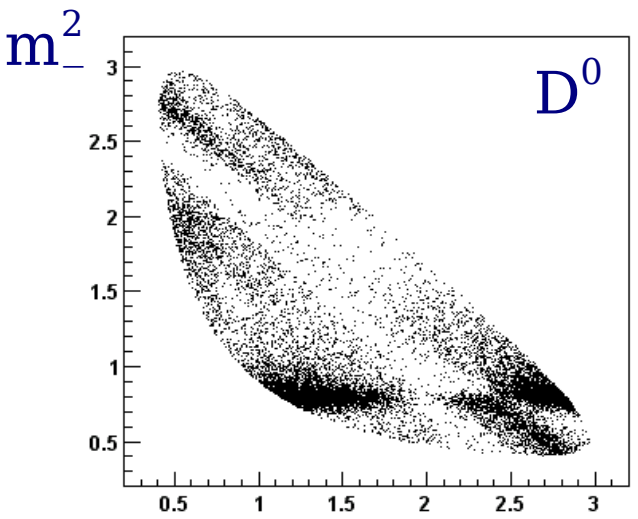
Reconstruction of three−body final states $D^0, \overline{D}^0 \to K_S \pi^+ \pi^-$

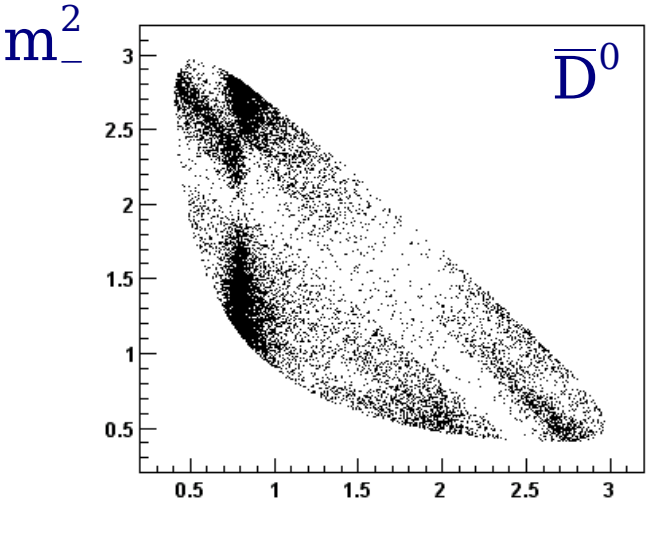
Amplitude for each Dalitz point is described as:

$$\overline{D}^0 \to K_S \pi^+ \pi^- \sim f(m_+^2, m_-^2)$$
$$D^0 \to K_S \pi^+ \pi^- \sim f(m_-^2, m_+^2)$$

$$B^+ \to (K_S \pi^+ \pi^-)_D K^+ : f(m_+^2, m_-^2) + r e^{i(\delta_B + \phi_3)} f(m_-^2, m_+^2)$$

$m_- = M(K_S \pi^-)$
$m_+ = M(K_S \pi^+)$





$$B^- \to (K_S \pi^+ \pi^-)_D K^- : f(m_-^2, m_+^2) + r e^{i(\delta - \gamma)} f(m_+^2, m_-^2)$$

Simultaneous fit of B^+ and B^- to extract parameters r_B, ϕ_3 and δ_B

Note: 2 fold ambiguity on ϕ_3: $(\phi_3, \delta_B) \to (\phi_3 + \pi, \delta_B + \pi)$

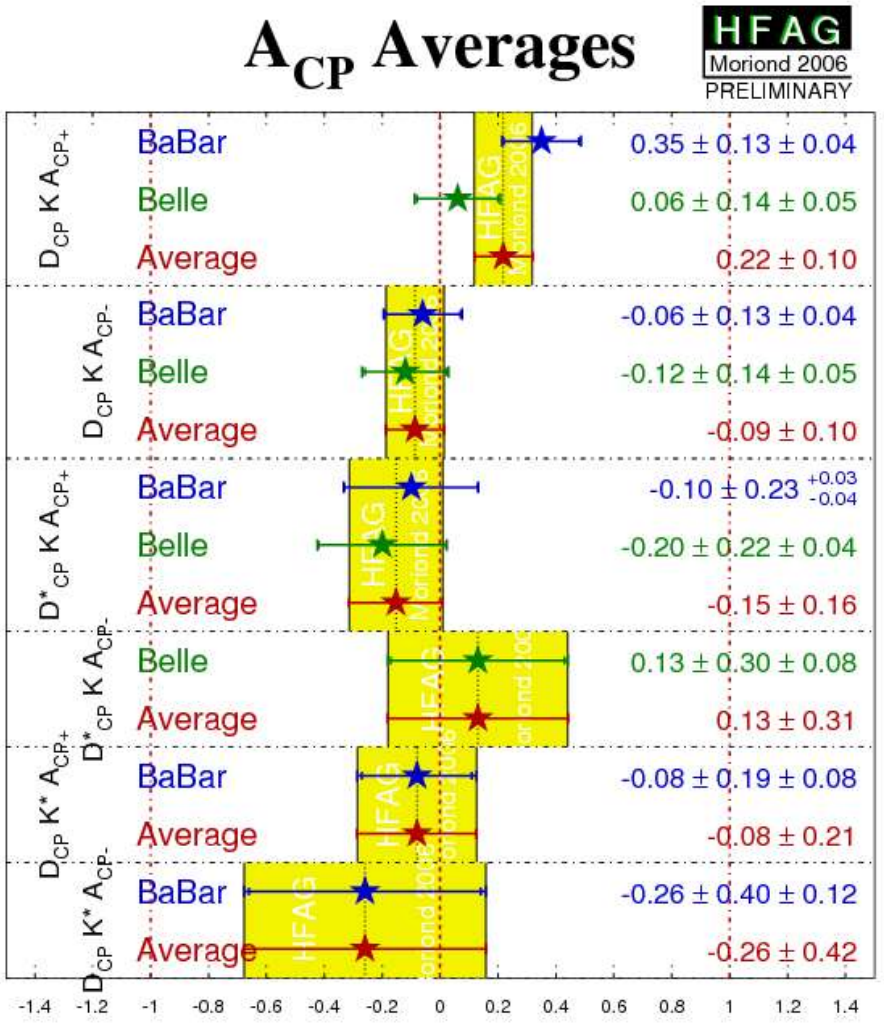
GLW method

$B^+ \to D K^+$ with D → CP eigenstates

(for example $D^0 \to K^+K^-$, $\pi^+\pi^-$, $K_S\pi^0$)

PRD73 (2006) 051106

$275\times10^6 B\bar{B}$



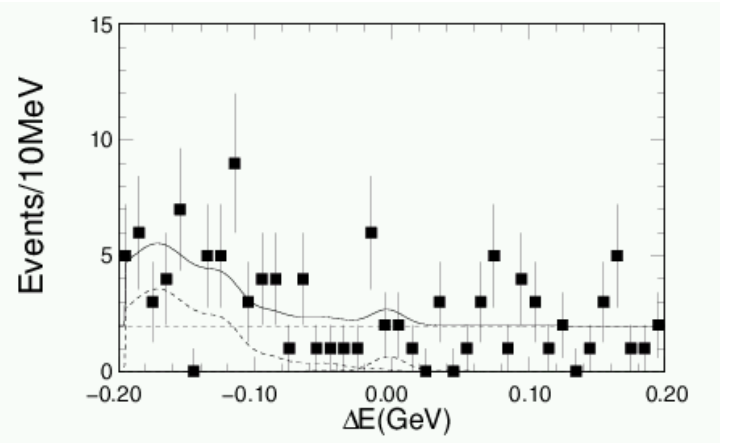
ADS method

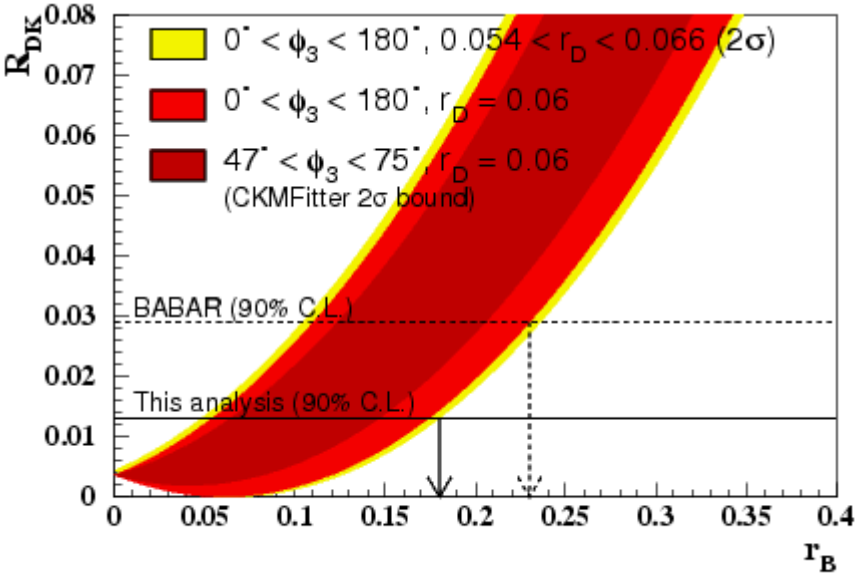
$B^+ \to D K^+$ with D is DCSD

(for example $D^0 \to K^+\pi^-$)

hep−ex/0508048

$385\times10^6 B\bar{B}$





these 2 methods request more statistics...

(helps though if combining with Dalitz method)

$B \to (\rho, \omega)\gamma$ results

Belle
this summer result

	$Br(10^{-7})$	(Σ)
$B^+ \to \rho^+ \gamma$	$8.6^{+3.0+0.7}_{-2.8-0.8}$	(3.2σ)
$B^0 \to \rho^0 \gamma$	$7.6 \pm 1.7 \pm 0.6$	(4.9σ)
$B^0 \to \omega \gamma$	$4.2^{+2.0}_{-1.8} \pm 0.4$	(2.6σ)
$B \to \rho \gamma$	$11.9 \pm 2.4 \pm 1.2$	(5.5σ)
$B \to (\rho, \omega)\gamma$	$11.3 \pm 2.0 \pm 1.1$	(5.9σ)

BaBar
PRL98, 151802(2007)

$Br(10^{-7})$	(Σ)
$11.0^{+3.7}_{-3.3} \pm 0.9$	(3.8σ)
$7.9^{+2.2}_{-2.0} \pm 0.6$	(4.9σ)
$4.2^{+2.4}_{-2.0} \pm 0.5$	(2.2σ)
$13.6^{+2.9}_{-2.7} \pm 0.9$	(6.0σ)
$12.5^{+2.5}_{-2.4} \pm 0.9$	(6.4σ)

Belle
PRL96, 221601 (2006)

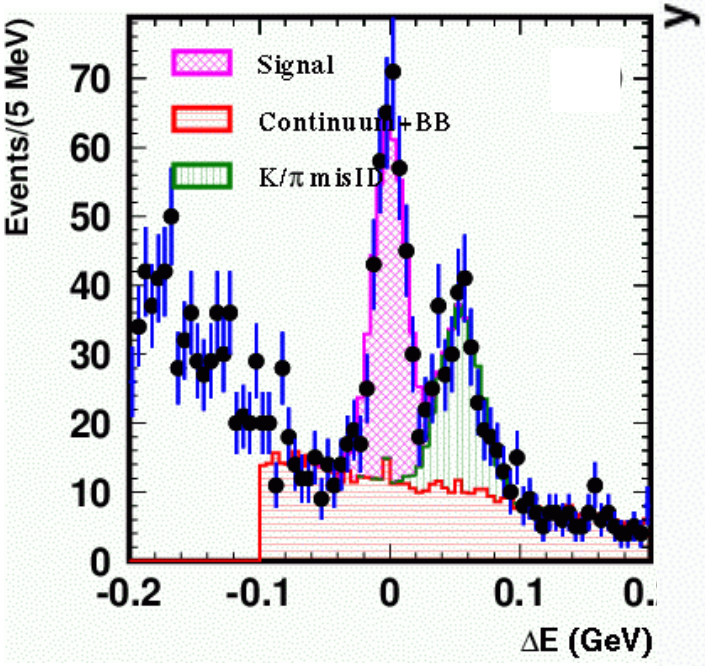
	$Br(10^{-7})$	(Σ)
$B^+ \to \rho^+ \gamma$	$5.5^{+4.2+0.9}_{-3.6-0.8}$	(1.6σ)
$B^0 \to \rho^0 \gamma$	$12.5^{+3.7+0.7}_{-3.3-0.6}$	(5.2σ)
$B^0 \to \omega \gamma$	$5.6^{+3.4+0.5}_{-2.7-1.0}$	(2.3σ)
$B \to (\rho, \omega)\gamma$	$13.2^{+3.4+1.0}_{-3.1-0.9}$	(5.1σ)

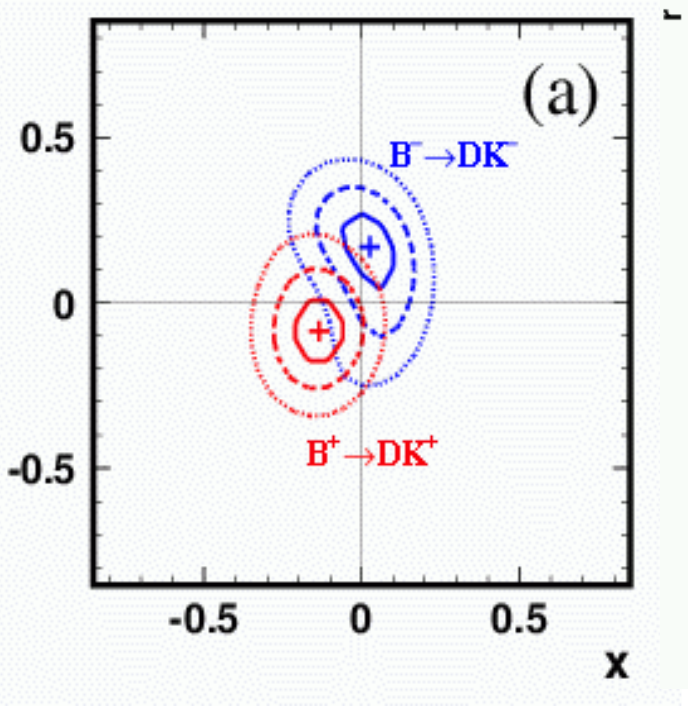
$B \to D^{(*)} K^{(*)}$ Dalitz analysis

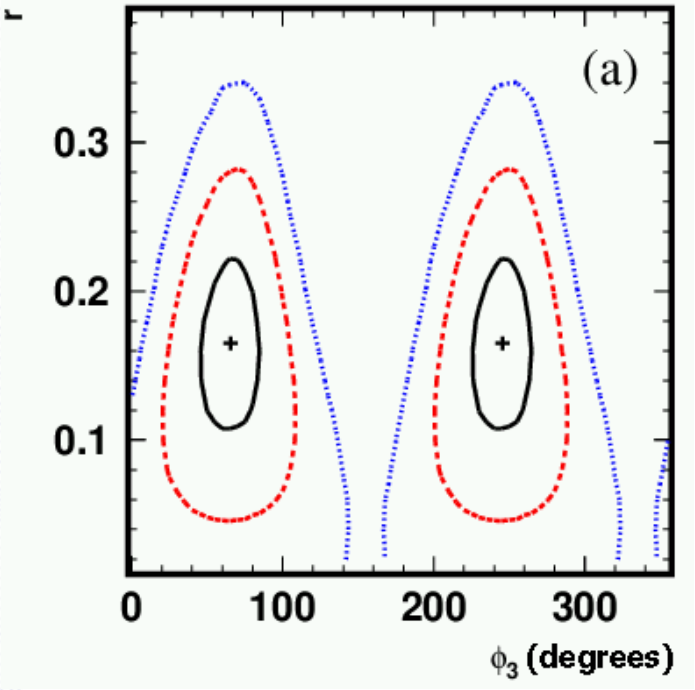
[PRD73, 112009 (2006)]

$385 \times 10^6\ B\bar{B}$

$\mathbf{B^{\pm} \to DK^{\pm}}$ $\quad (x_{\pm}, y_{\pm}) = (r_B \cos(\delta_B \pm \phi_3), r_B \sin(\delta_B \pm \phi_3))$







$N(DK^{\pm}) = 331 \pm 17$

$\phi_3 = 66^{\circ}\ ^{+19^{\circ}}_{-20^{\circ}}(\text{stat})$

Combined the 3 modes: DK, D^*K, DK^*

$$\phi_3 = \mathbf{53^{\circ}\ ^{+15^{\circ}}_{-18^{\circ}}(stat) \pm 3^{\circ}(syst) \pm 9^{\circ}(model)}$$

$$\mathbf{r_B(DK) = 0.159^{+0.054}_{-0.050} \pm 0.012 \pm 0.049}$$

$$\mathbf{r_B(D^*K) = 0.175^{+0.108}_{-0.099} \pm 0.013 \pm 0.049}$$

$$\mathbf{r_B(DK^*) = 0.564^{+0.216}_{-0.155} \pm 0.041 \pm 0.084}$$