Quark CP violation test from the B-factories

IPA

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CP violation


Cabibbo


Kobayashi


Maskawa

CP is violated in Standard model via quark mixing

$$V_{\mathrm{CKM}} \equiv V_L^u V_L^{d\dagger} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$


Wolfenstein

$$\begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho - i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

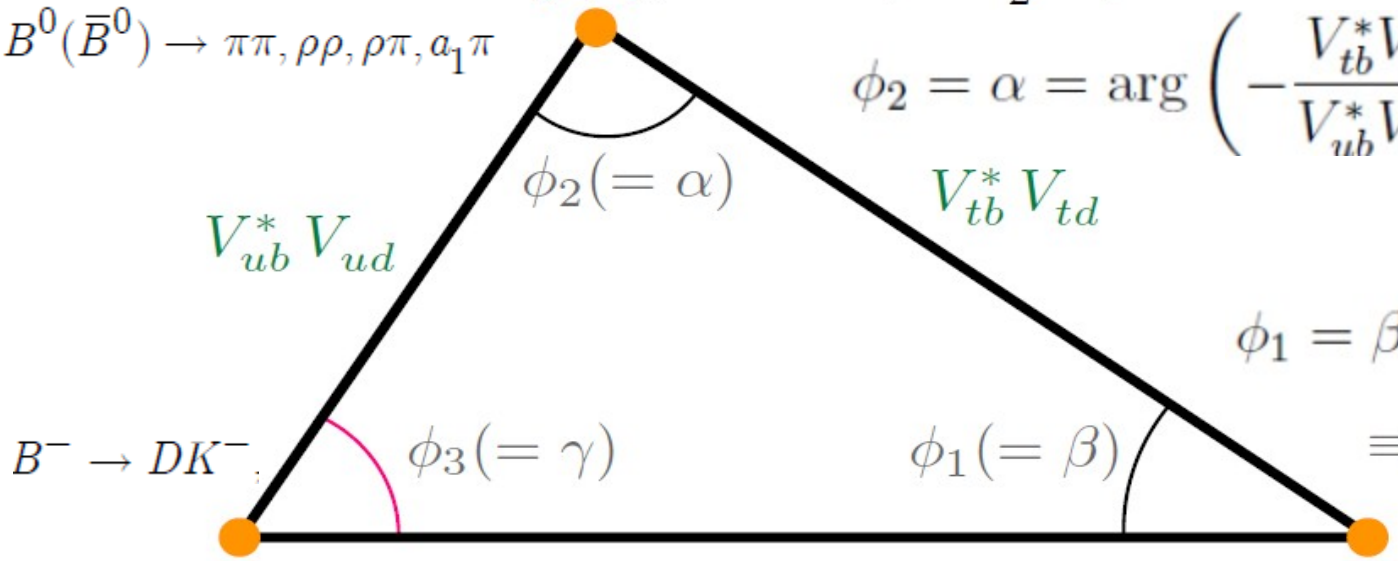
Unitarity triangle

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

$$(\boldsymbol{\rho}, \boldsymbol{\eta}) \cdot A\lambda^3 \cdot (1 - \tfrac{1}{2}\lambda^2)$$

$B^0(\bar{B}^0) \to \pi\pi, \rho\rho, \rho\pi, a_1\pi$

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



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

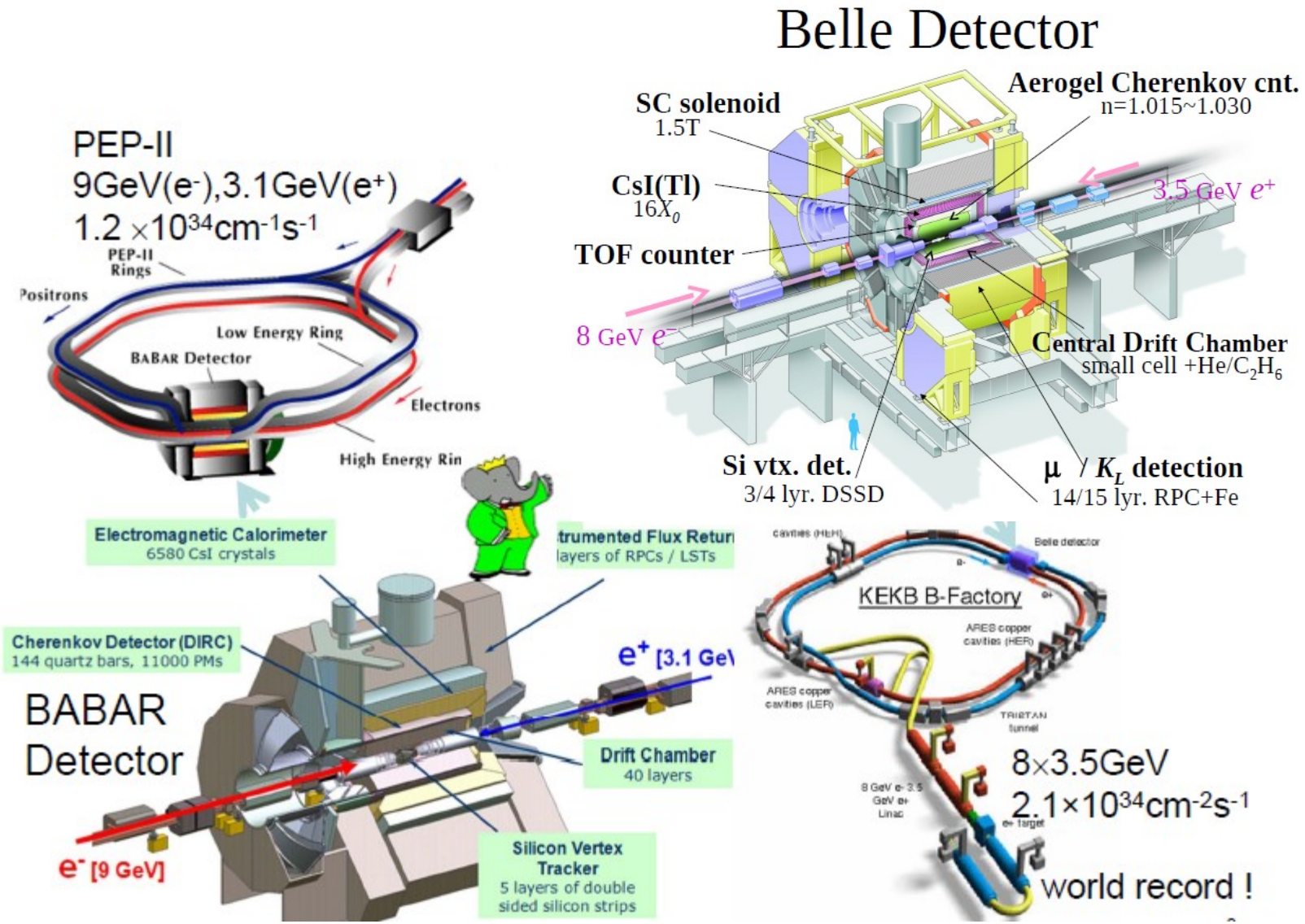
$$\equiv \beta$$

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

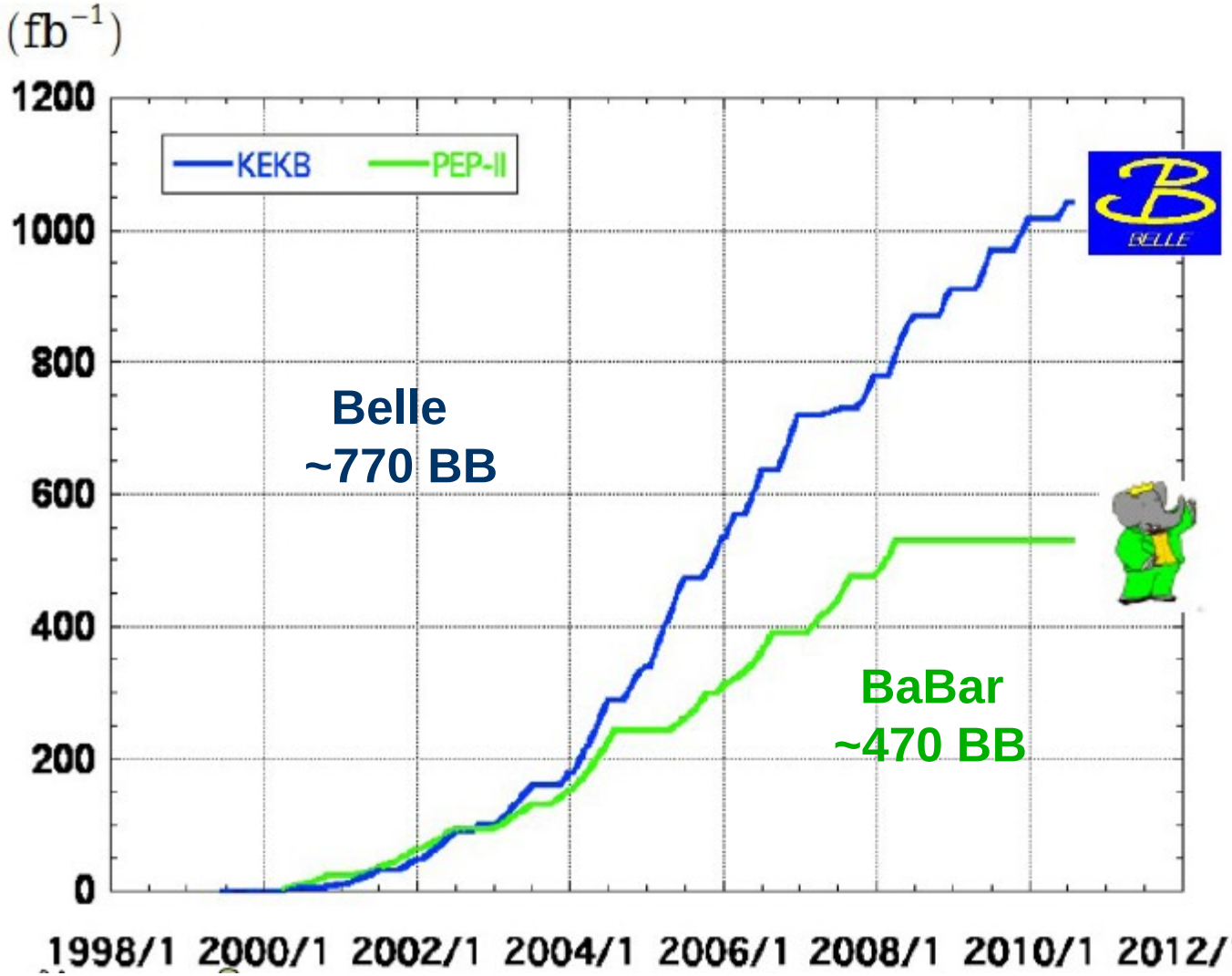
$B^0(\bar{B}^0) \to J/\psi\, K_{S,L}$

$\to \phi\, K_{S,L}$

B-factories


PEP-II
9GeV(e-),3.1GeV(e+)
1.2 ×10^34cm^-1s^-1
PEP-II Rings
Positrons
Low Energy Ring
BABAR Detector
Electrons
High Energy Rin
Electromagnetic Calorimeter
6580 CsI crystals
Belle Detector
SC solenoid
1.5T
CsI(Tl)
16X0
TOF counter
Aerogel Cherenkov cnt.
n=1.015~1.030
3.5 GeV e+
8 GeV e−
Central Drift Chamber
small cell +He/C2H6
Si vtx. det.
3/4 lyr. DSSD
μ / KL detection
14/15 lyr. RPC+Fe
trumented Flux Retur
layers of RPCs / LSTs
Cherenkov Detector (DIRC)
144 quartz bars, 11000 PMs
BABAR
Detector
e+ [3.1 GeV]
Drift Chamber
40 layers
e- [9 GeV]
Silicon Vertex
Tracker
5 layers of double
sided silicon strips
KEKB B-Factory
ARES copper
cavities (HER)
ARES copper
cavities (LER)
TRISTAN
tunnel
8×3.5GeV
2.1×10^34cm^-2s^-1
world record !

Integrated luminosity



> 1 ab^{-1}

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 25 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

~ 100 fb^{-1}

~ 550 fb^{-1}

On resonance:

$\Upsilon(4S)$: 424 fb^{-1}

$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

~ 49 fb^{-1}

Types of CP violation in B(D) system

-Direct CP violation in decay(neutral and charged)

$$\Gamma(B \to f) \neq \Gamma(\bar{B} \to \bar{f}) \qquad |\bar{\mathcal{A}}_{\bar{f}}/\mathcal{A}_f| \neq 1$$

-CP violation in mixing(neutral)

$$\Gamma(B \to \bar{B}) \neq \Gamma(\bar{B} \to B) \quad |B_{H,L}\rangle = p|B^0\rangle \pm q|\bar{B}^0\rangle \quad |q/p| \neq 1$$

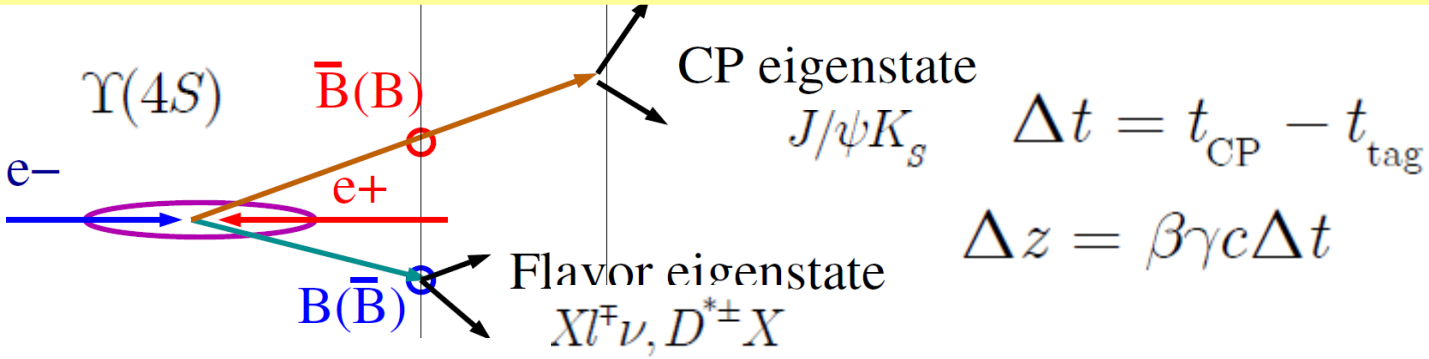
-CP violation via interference between mixing and decay(neutral)

$$\Gamma(B \to f_{CP}) \neq \Gamma(\bar{B} \to f_{CP}) \qquad \arg\left|\frac{q}{p}\frac{\bar{\mathcal{A}}_{\bar{f}}}{\mathcal{A}_f}\right| \neq 0$$

Mixing-induced CPV-measurement at B-factories

$$e^+e^- \to \Upsilon(4S) \to B^0\bar{B}^0(B^+B^-)$$

-Together with direct CPV assymmetric B-factory allows to measure mixing-induced CPV



-B-$\bar{B}$ are produced in quantum-entangele state

-Assymmetric B-factories allow to determine Δt via Δz

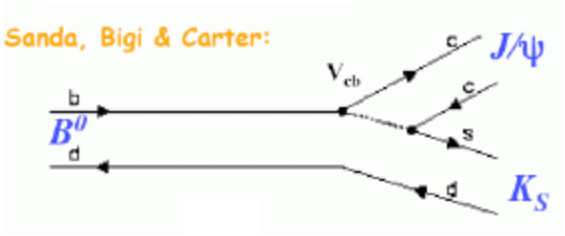
$$\text{Asymmetry}(\Delta t) = \frac{\Gamma(\bar{B} \to f_{CP}) - \Gamma(B \to f_{CP})}{\Gamma(\bar{B} \to f_{CP}) + \Gamma(B \to f_{CP})} = \mathcal{A}_{CP}\cos(\Delta m\,\Delta t) + \mathcal{S}_{CP}\sin(\Delta m\,\Delta t)$$

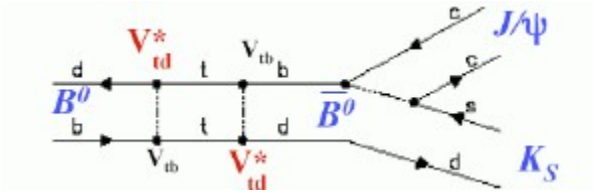
$$\mathcal{S}_{CP} = +\frac{2\text{Im}\lambda_{CP}}{1+|\lambda_{CP}|^2} \qquad \mathcal{A}_{CP} = -\frac{1-|\lambda_{CP}|^2}{1+|\lambda_{CP}|^2} \qquad \lambda_{CP} = \xi_{f_{CP}}\frac{q}{p}\frac{\bar{A}_{f_{CP}}}{A_{f_{CP}}}$$

B→charmonium+K⁰ mode ($\phi_1(\beta)$-angle)

Golden mode:

$B^0 \to J/\psi K^0_S$





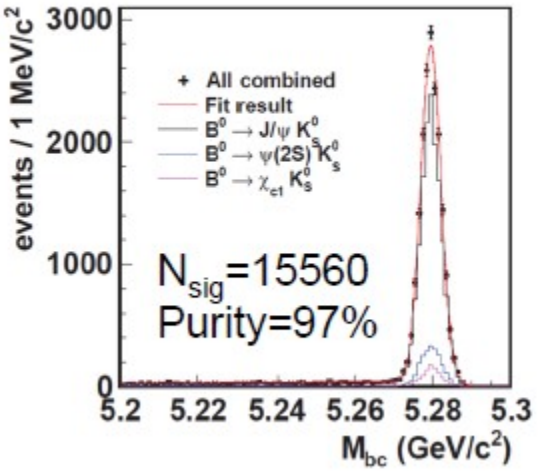
$\mathbf{A} = 0$ and $\mathbf{S} = -\xi_f \sin 2\beta$ for $(c\bar{c})K_{S/L}$ $(\xi_f = \mp 1)$

M_{bc} and ΔE are good kinematic variables

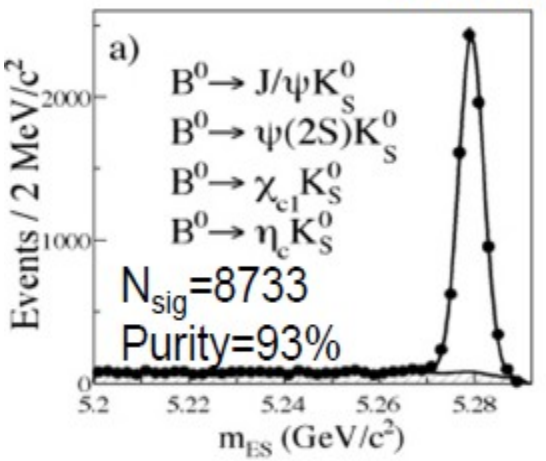
$$M_{bc} = \sqrt{\left(E^*_{beam}\right)^2 - \left(p^*_{B^0}\right)^2}$$

$$\Delta E = E^*_{B^0} - E^*_{beam}$$

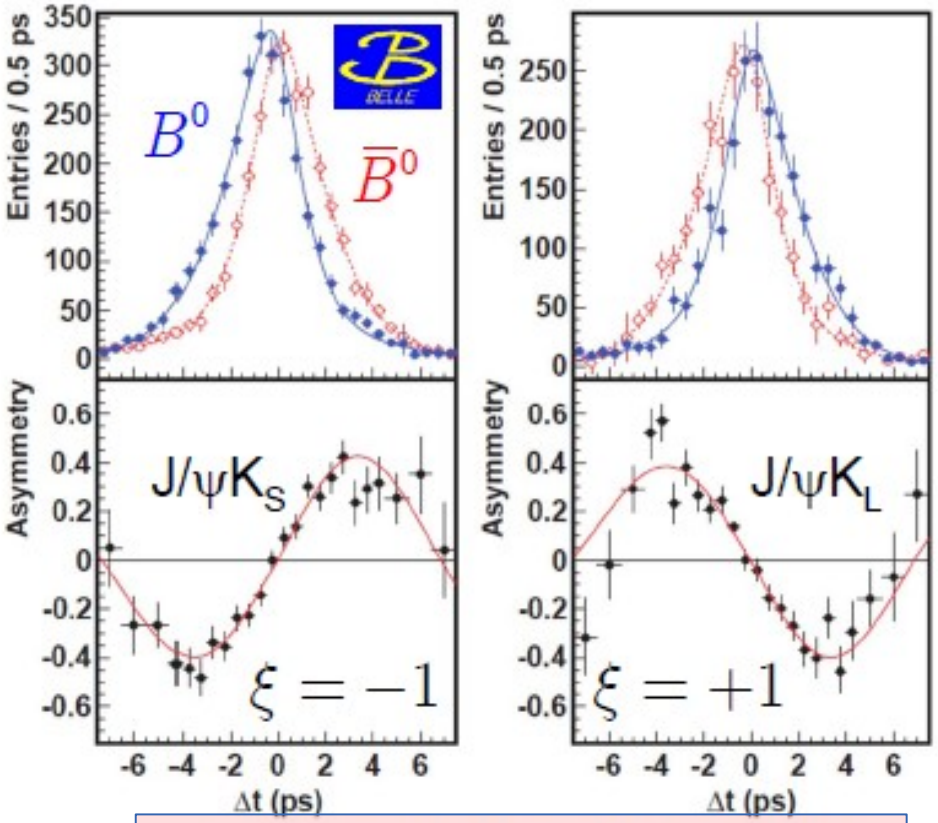
772MB$\bar{B}$

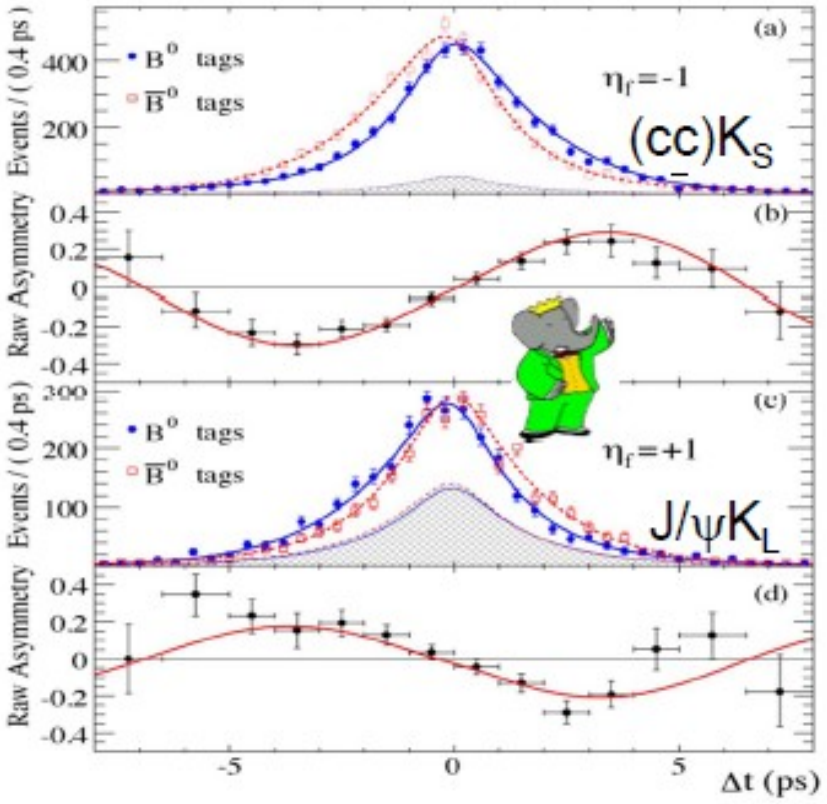


465MB$\bar{B}$



B→charmonium+K⁰ mode ($\phi_1(\beta)$-angle)





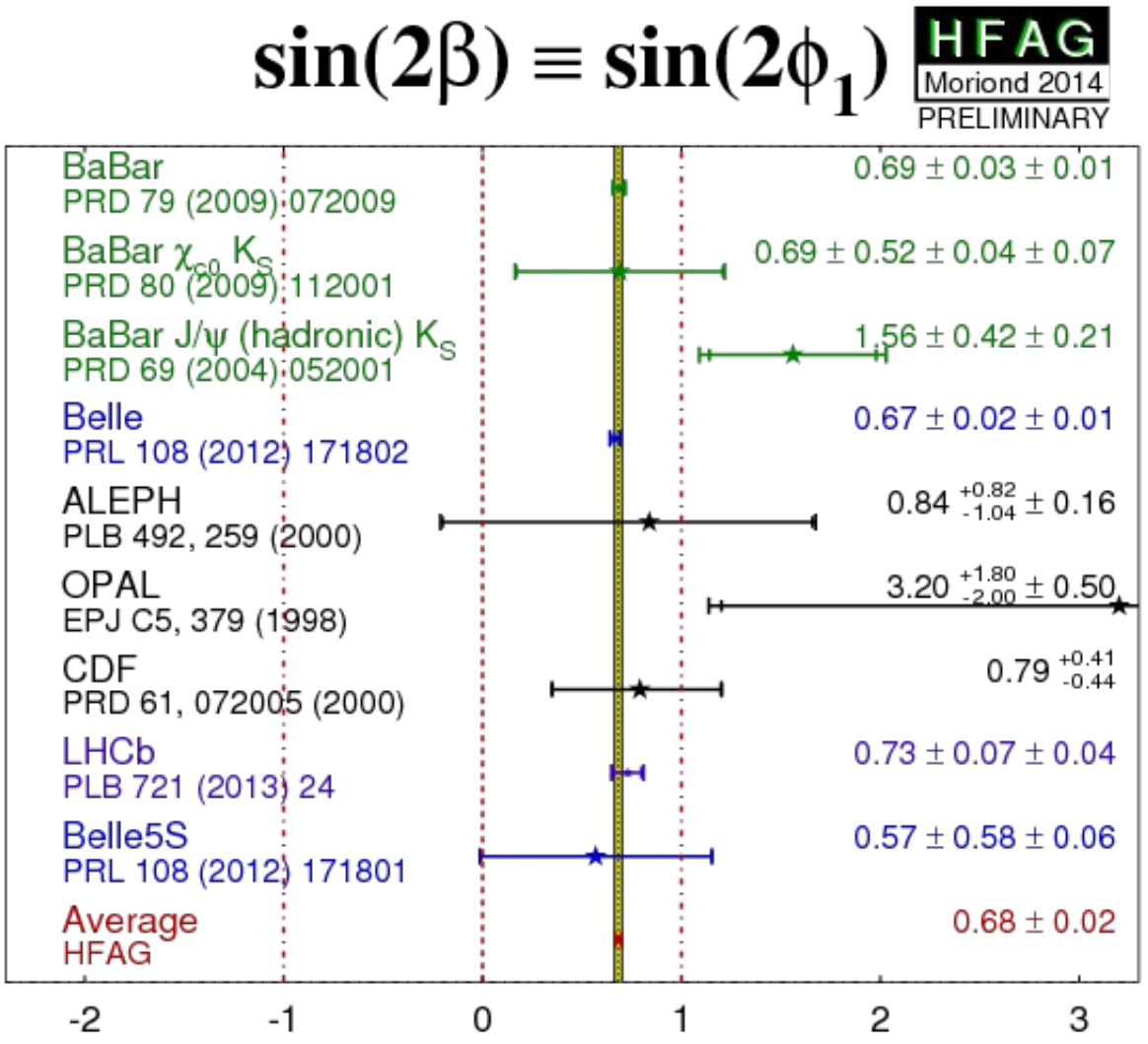
$\sin 2\phi_1 = 0.667 \pm 0.023 \pm 0.012$
$A_f = 0.006 \pm 0.016 \pm 0.012$

PRL 108, 171802(2012)

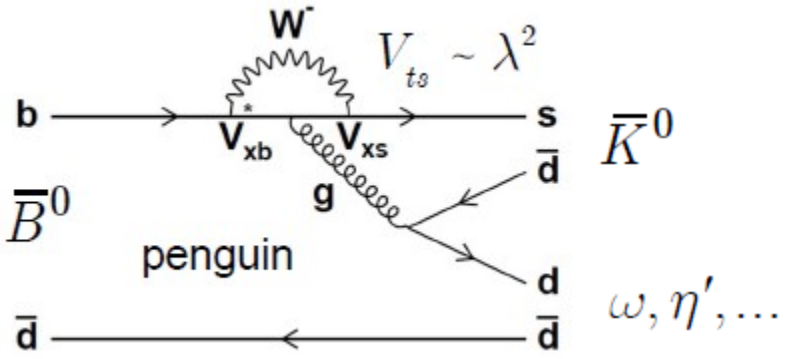
$\sin 2\phi_1 = 0.687 \pm 0.028 \pm 0.012$
$A_f = -0.024 \pm 0.020 \pm 0.016$

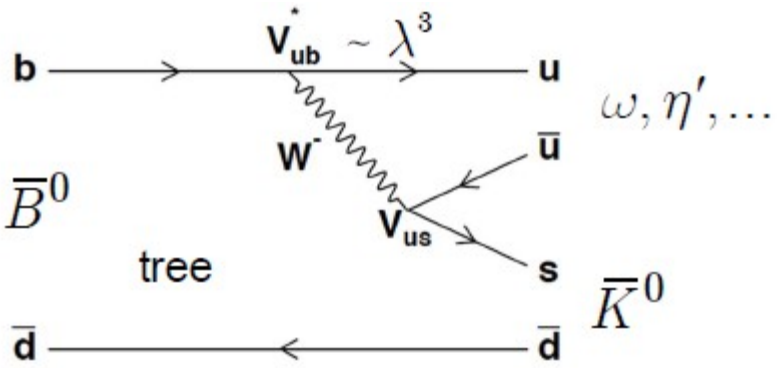
PRD 79, 072009(2009)

B→charmonium+K^0 mode ($\phi_1(\beta)$-angle)



New penguin B→ω(η')+K⁰ modes





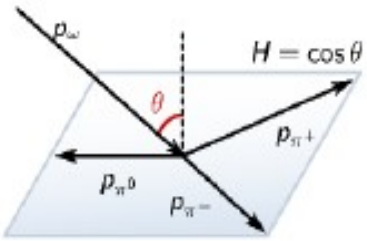
- SM predicts for $b \to d\bar{d}s$: $A_{CP} \approx 0$; $S_{CP} \approx \xi_{CP} \sin 2\phi_1$
- Tree amplitude $b \to u\bar{u}s$ is Cabibbo- and color-suppressed
- Penguin amplitude can be contributed by new heavy particles
- Observation of ϕ_1^{eff} different from ϕ_1 – clear signal of New Physics

$B \to \omega K^0$

- $B^0 \to \omega K_s$ is CP=-1 final state
- Extended maximum likelihood fit with 7 variables:

M_{bc}, ΔE, $\mathcal{F}_{B\bar{B}/qq}(\mathcal{LR}_{B\bar{B}/qq})$, $m_{3\pi}$ $(\omega \to \pi^+\pi^-\pi$

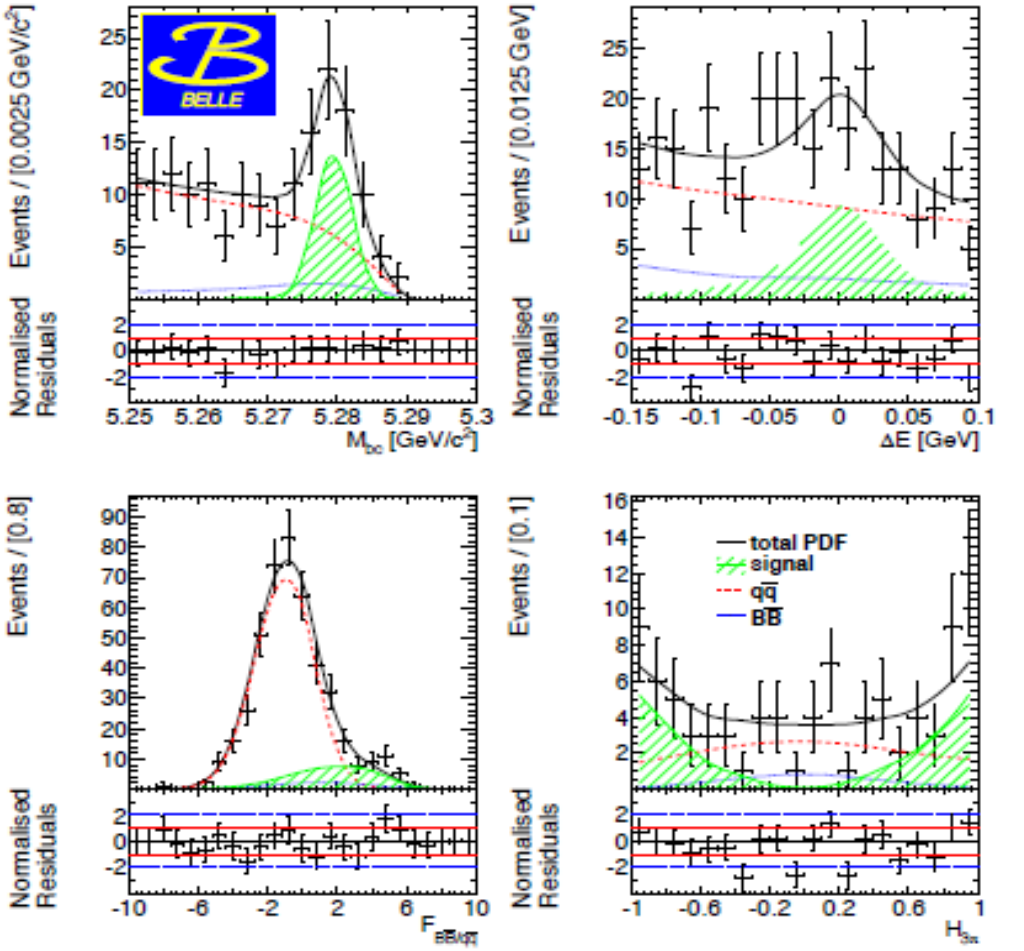
$\cos\theta_{3\pi}^{\rm Hel}$, Δt, q (flavour)



$$\mathcal{BR}(B^0 \to \omega K^0)$$

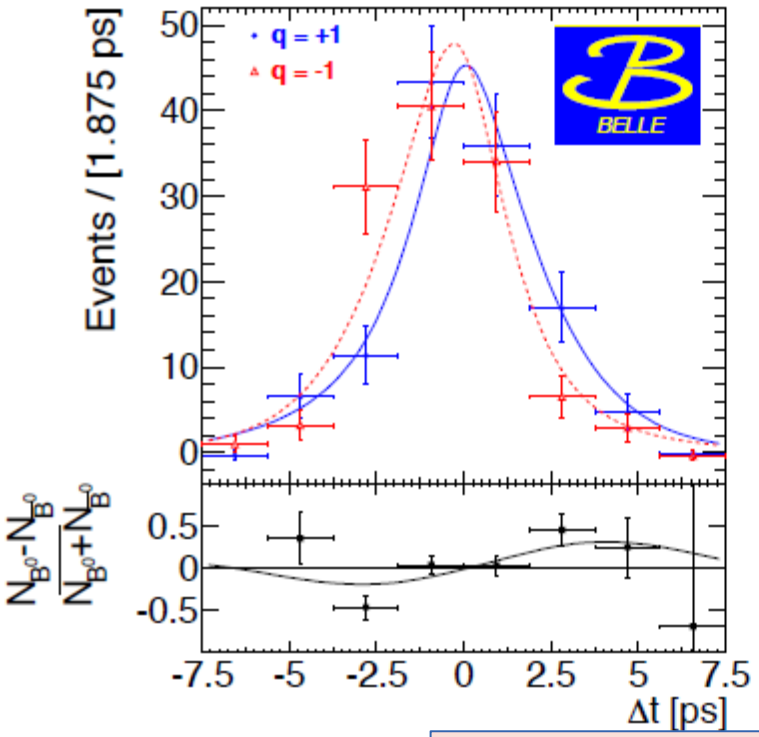
$$(4.5 \pm 0.4 \pm 0.3) \times 10^{-6}$$

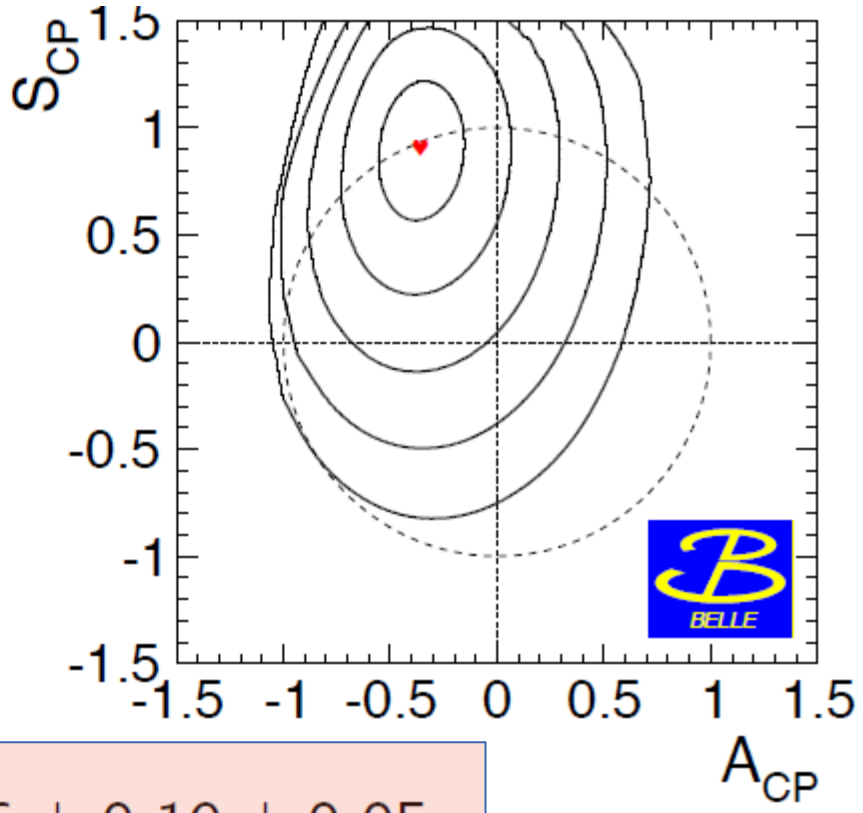
772×10^6 $B\bar{B}$-pairs



$B \to \omega K^0$

PRD 90, 012002 (2014)





$$\mathcal{A}_{CP} = -0.36 \pm 0.19 \pm 0.05$$
$$\mathcal{S}_{CP} = +0.91 \pm 0.32 \pm 0.05$$

-First evidence of CP violation in $B^0 \to \omega K_s$

-Consistent with SM

$B \to \eta' K^0$

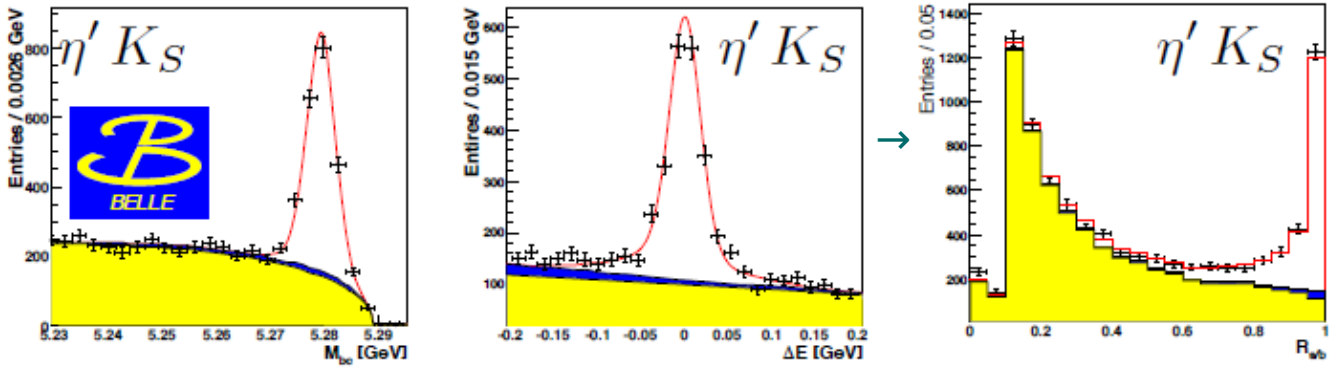
Two modes: $B^0 \to \eta' K_S$ (CP=-), $B^0 \to \eta' K_L$ (CP=+)

Decay chain:

$$\eta' \to \eta\pi^+\pi^- \quad \eta' \to \rho^0\gamma \quad \rho^0 \to \pi^+\pi^-$$
$$\eta \to \gamma\gamma,\ \eta \to \pi^+\pi^-\pi^0$$
$$K_S^0 \to \pi^+\pi^- \text{ or } \pi^0\pi^0$$

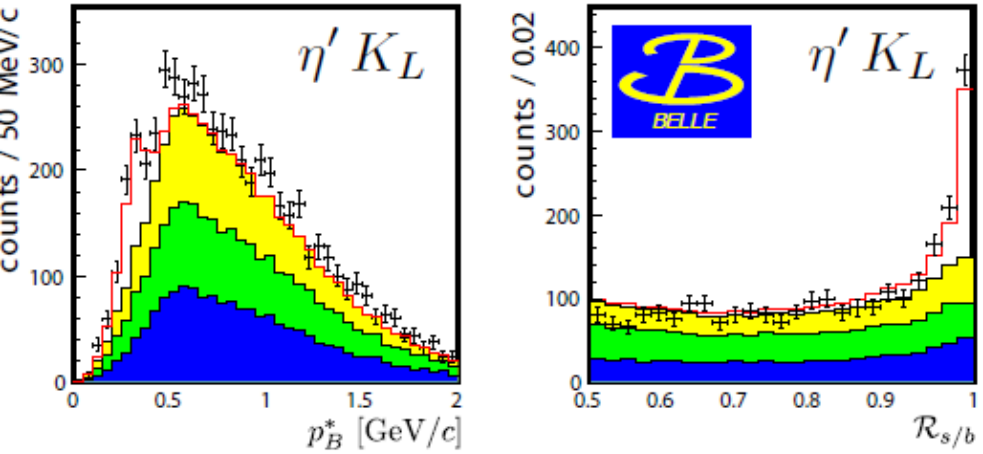
$B^0 \to \eta' K_S$:ΔE,Mbc, RS/B

$B^0 \to \eta' K_L$:p_B^{cms}, RS/B



— total
■ $b \to u, d, s, c$ BG
■ $q\bar{q}$ BG

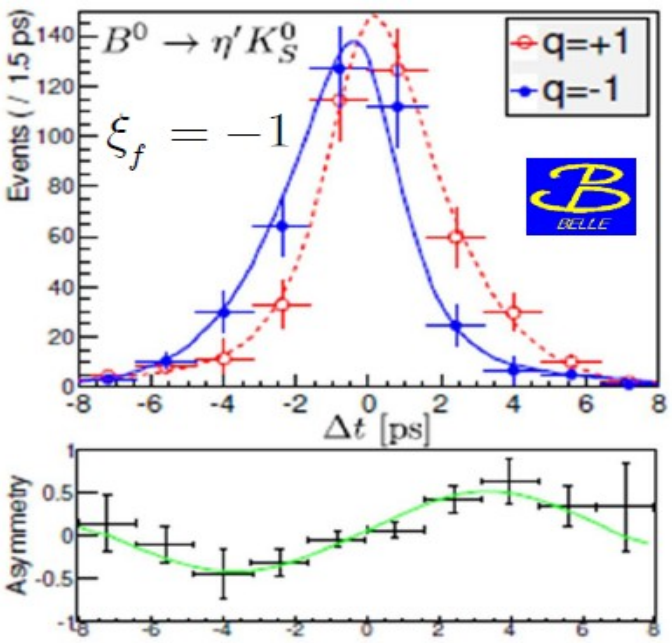
$\eta' K_S \quad 2506.3 \pm 63.1$

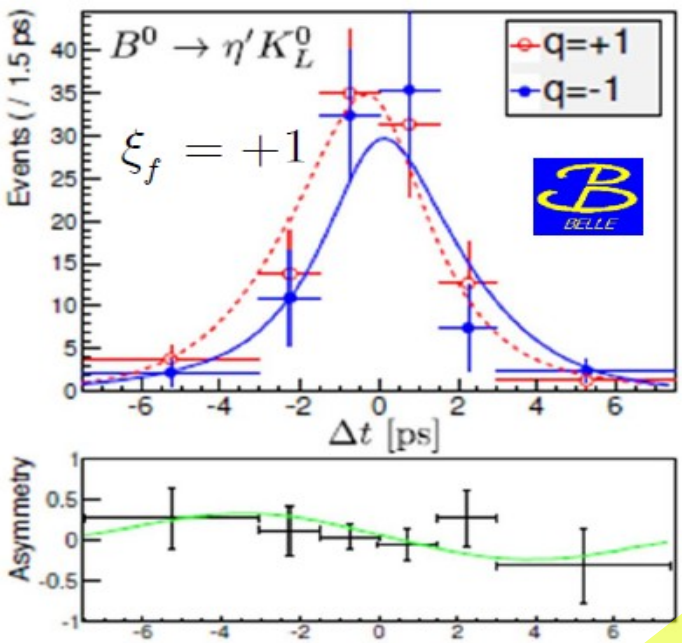


— total
■ comb. BG with fake η′
■ comb. BG with fake K_L^0
■ comb. BG with real η′ and K_L^0

$\eta' K_L \quad 1041.7 \pm 41.1$

$B \to \eta' K^0$





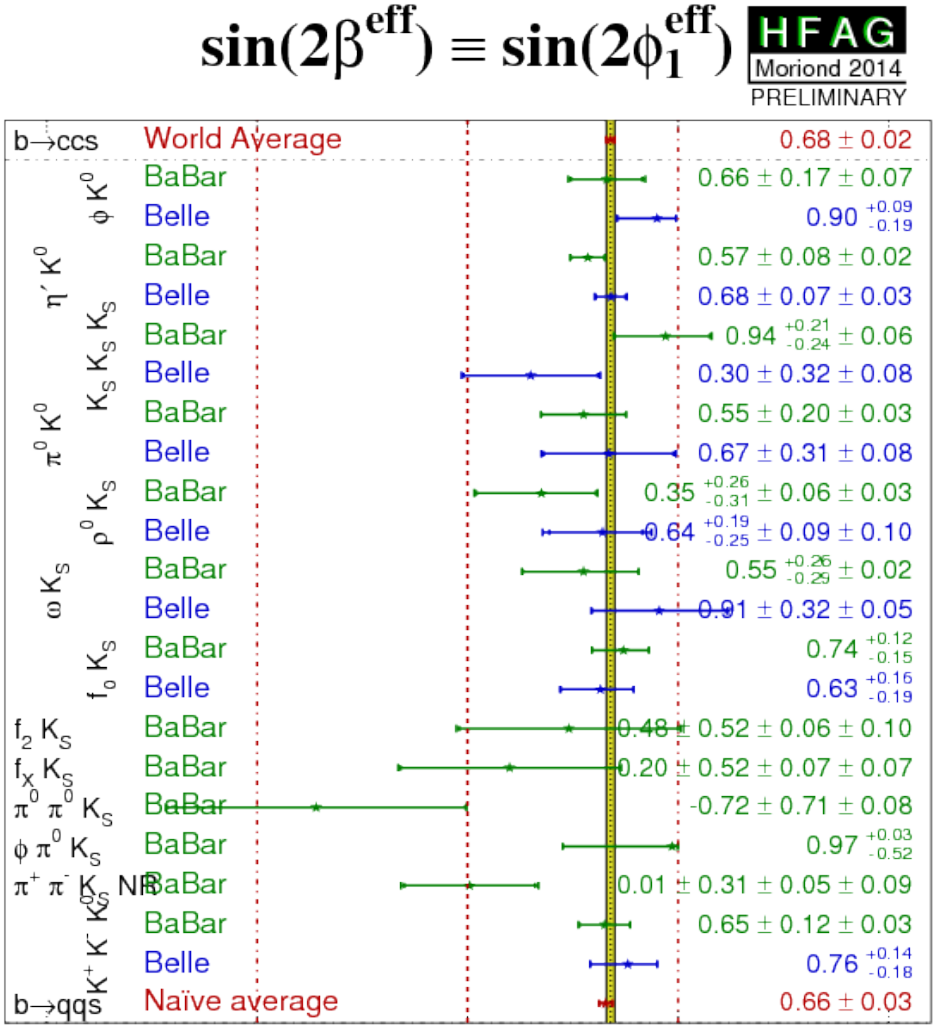
Preliminary

Decay mode	$-\xi_f \mathcal{S}_f$	$\mathcal{A}_f$
$\eta' K^0_S$	$+0.71 \pm 0.07$	$+0.02 \pm 0.05$
$\eta' K^0_L$	$+0.46 \pm 0.21$	$+0.09 \pm 0.14$
$\eta' K^0$	$+0.68 \pm 0.07 \pm 0.03$	$+0.03 \pm 0.05 \pm 0.04$

-most precise measurement of penguin amplitude

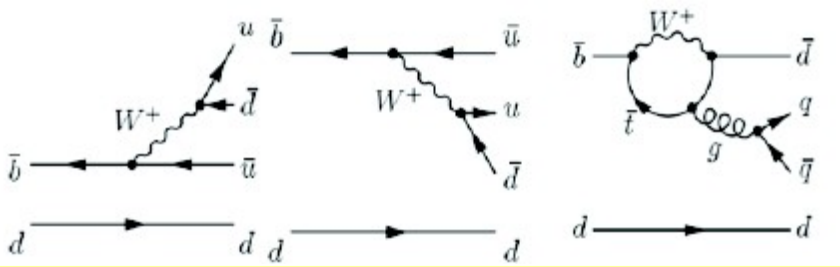
-consistent with SM

Summary of penguin modes for Φ_1



No evidence of New Physics at current level sensitivity

$B^0 \to \pi^+\pi^-$, Measurement of $\Phi_2(\alpha)$

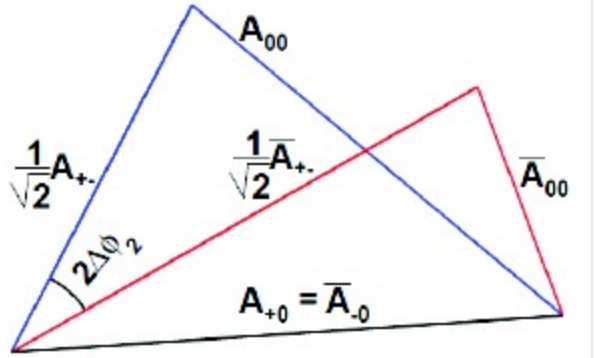


- Both tree and penguin amplitudes contribute
- No clean Φ_2 extraction

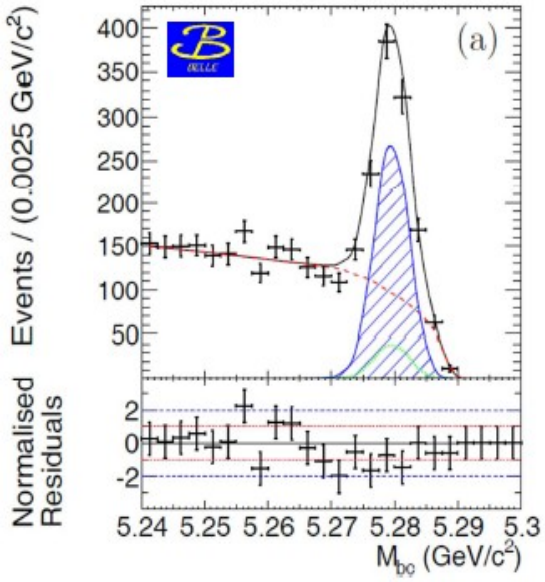
$B^0 \to \pi^+\pi^-$

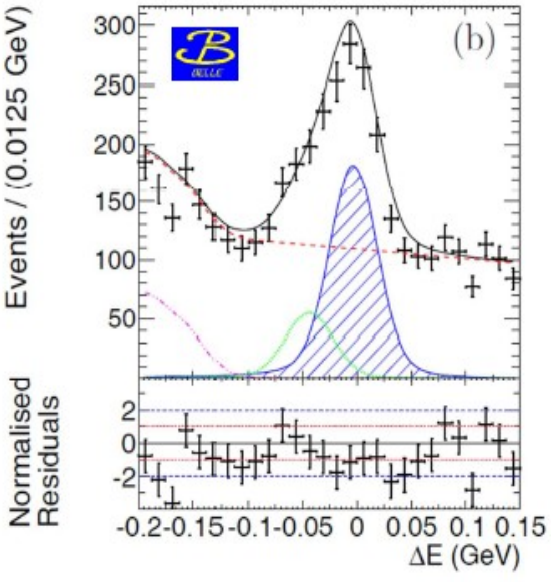
- Extended maximum likelihood fit with 7 variables:

$$\mathcal{S}_{CP} \sim \sin(2\phi_2 + 2\Delta\phi_2)$$



$$A_{+0} = \frac{1}{\sqrt{2}}A_{+-} + A_{00}, \quad \bar{A}_{-0} = \frac{1}{\sqrt{2}}\bar{A}_{+-} + \bar{A}_{00}$$

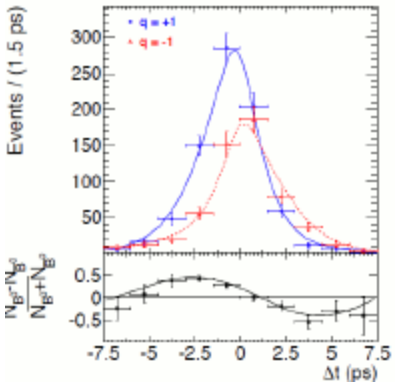




$$\begin{aligned}
&\mathcal{B}(B^0 \to \pi^+\pi^-)\\
&\mathcal{B}(B^0 \to \pi^0\pi^0)\\
&\mathcal{B}(B^+ \to \pi^+\pi^0)\\
&\mathcal{A}_{CP}(B^0 \to \pi^+\pi^-)\\
&\mathcal{S}_{CP}(B^0 \to \pi^+\pi^-)\\
&\mathcal{A}_{CP}(B^0 \to \pi^0\pi^0)
\end{aligned}$$

8-fold ambiguity

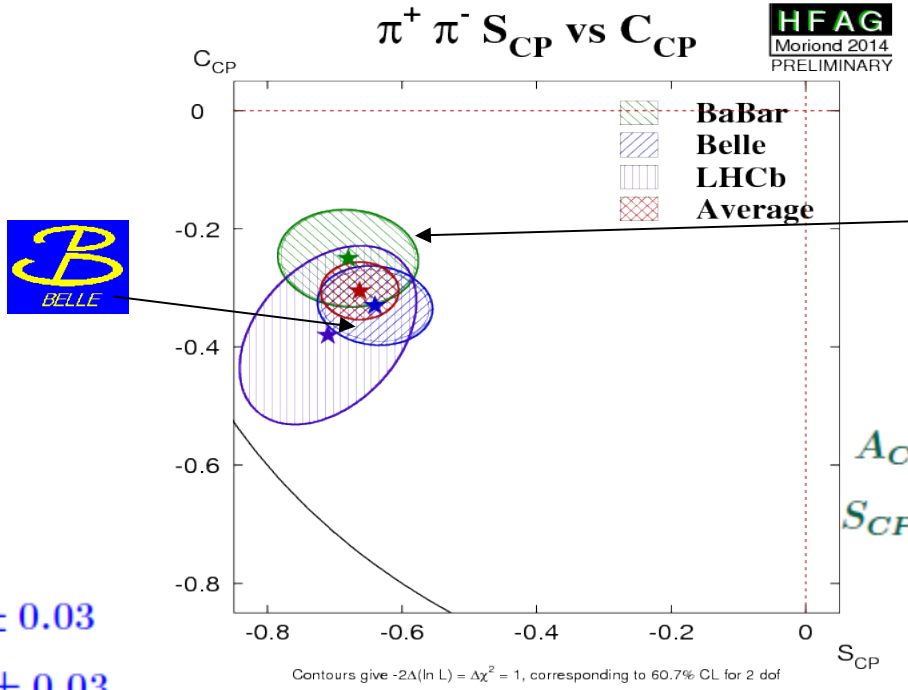
$B^0 \to \pi^+\pi^-$, Measurement of $\Phi_2(\alpha)$



$772 \times 10^6 B\bar{B}$

$A_{CP} = 0.33 \pm 0.06 \pm 0.03$

$S_{CP} = -0.64 \pm 0.08 \pm 0.03$



$467 \times 10^6 B\bar{B}$

$A_{CP} = 0.25 \pm 0.08 \pm 0.02$

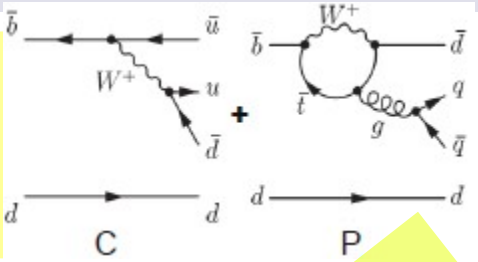
$S_{CP} = -0.68 \pm 0.10 \pm 0.03$

PRD 88, 092003(2013)

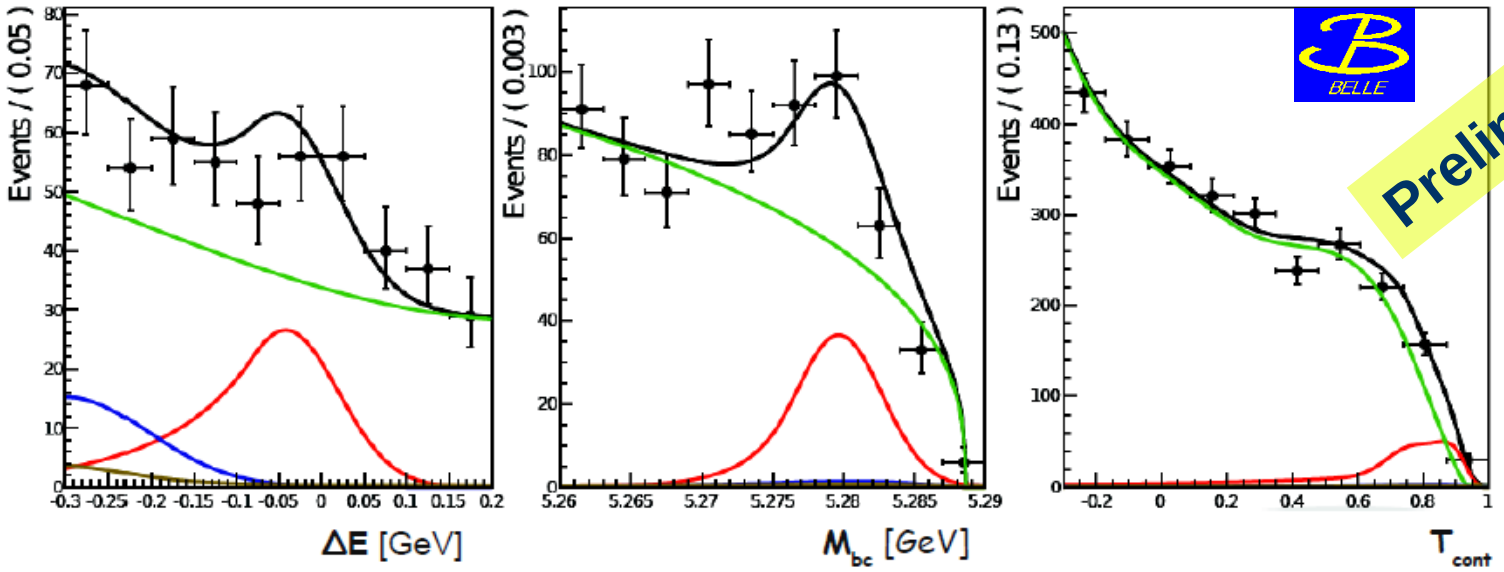
PRD 87, 052009(2013)

$B^0 \to \pi^0\pi^0$, Measurement of $\Phi_2(\alpha)$

- Simultaneous fit: ΔE, M_{bc}, T_{con}
- Essential background from offtime ECL showers
- Suppressed by using ECL timing information



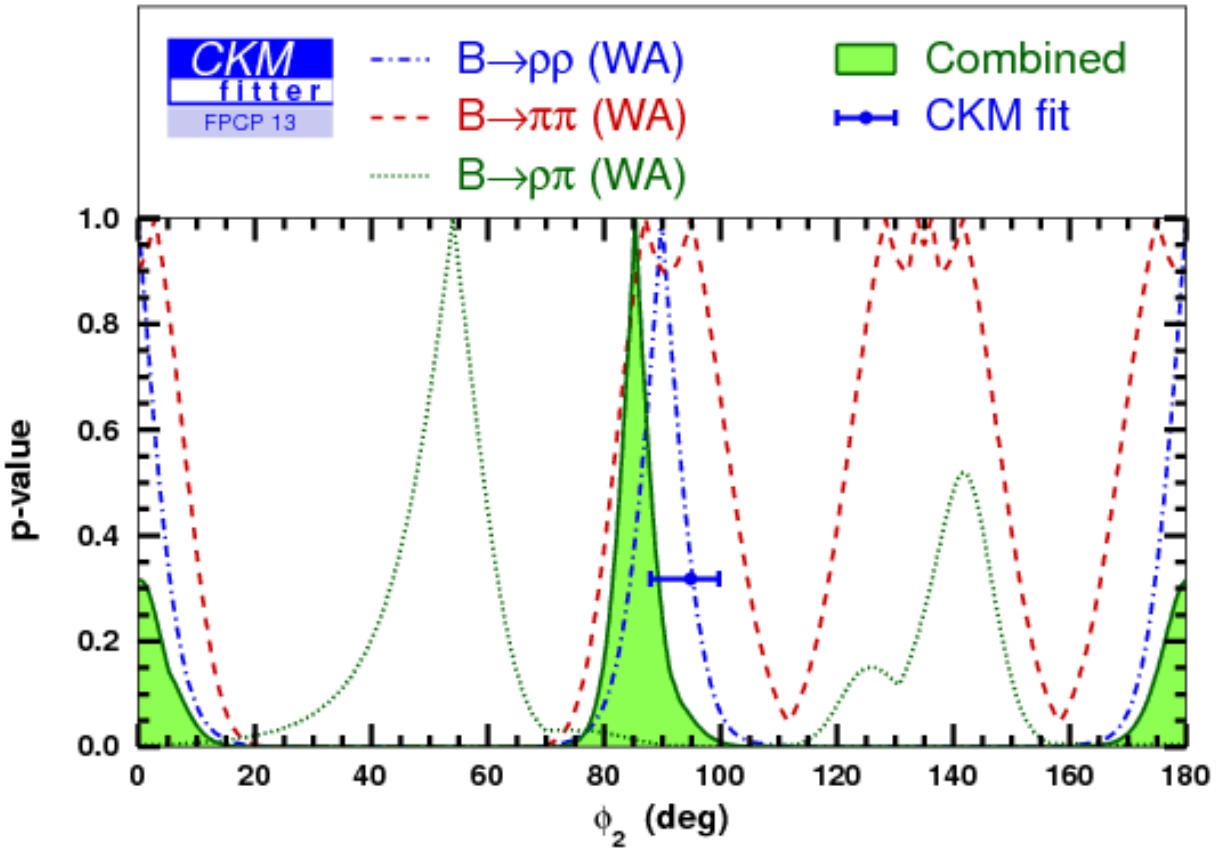
t



$$\mathcal{B}(B^0 \to \pi^0\pi^0) = (0.90 \pm 0.12_{\rm stat} \pm 0.10_{\rm syst}) \times 10^{-6} \quad (6.7\sigma)$$

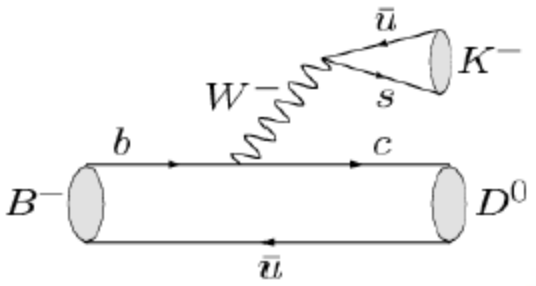
Consistent with SM

Measurement of $\Phi_2(\alpha)$

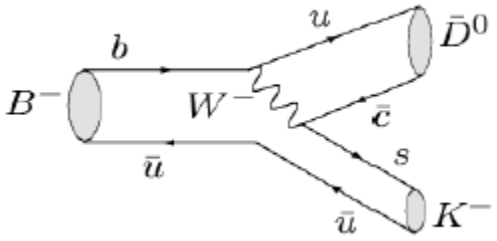


$$\Phi_2 = \alpha = (85.4^{+4.0}_{-3.8})^\circ$$

Measurement of $\Phi_3(\gamma)$



color allowed $\propto A\lambda^3$



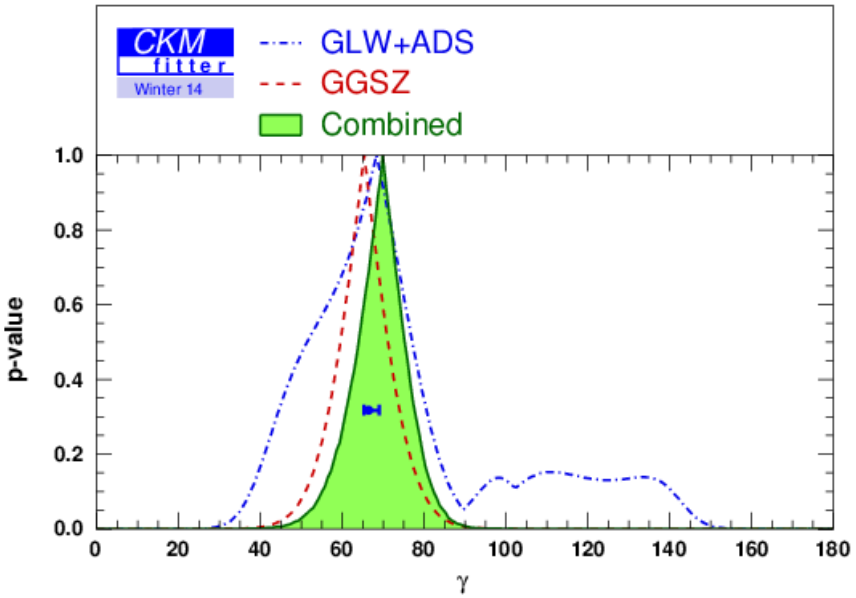
color suppressed $\propto A\lambda^3(\rho - i\eta)$

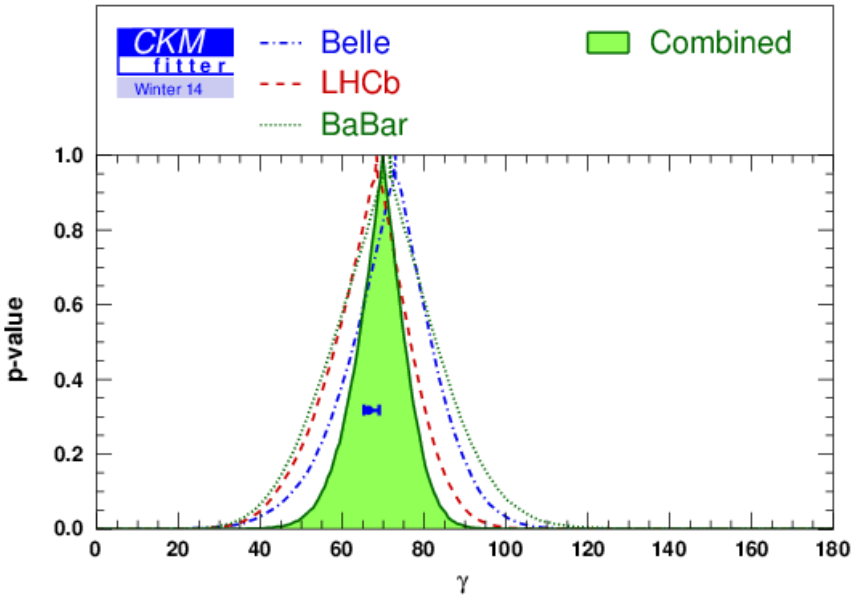
Decays $B^{\pm} \to D^{(*)0}K^{(*)\pm}$

There are several techniques of $\Phi_3(\gamma)$ extraction from $B^- \to (\bar{D})^0 K^-$:

- GLW: Using D eigenstates:$|D_{1,2}\rangle \propto |D^0\rangle \pm |\bar{D}^0\rangle$ K^+K^-, $\pi^+\pi^-$, $K_S\pi^0$
  Gronau and London PLB 253, 483 (1991)
  Gronau and Wyler PLB 265,172 (1991)
- ADS: Using $|K^+\pi^-\rangle$ (CF for D and DCS for $\bar{D}$)$K\pi$
  Atwood, Danietz and Sony PRL 78, 3257(1997)
- GGSZ: Using Dalitz analysis of three-body decays $K_S\pi^+\pi^-$, $K_SK^+K^-$
  Giri, Grossman, Soffer and Zupan PRD 68, 054018(2003)
  Bondar, Proc.BINP Dalitz analysis meeting(2002)

Measurement of $\Phi_3(\gamma)$





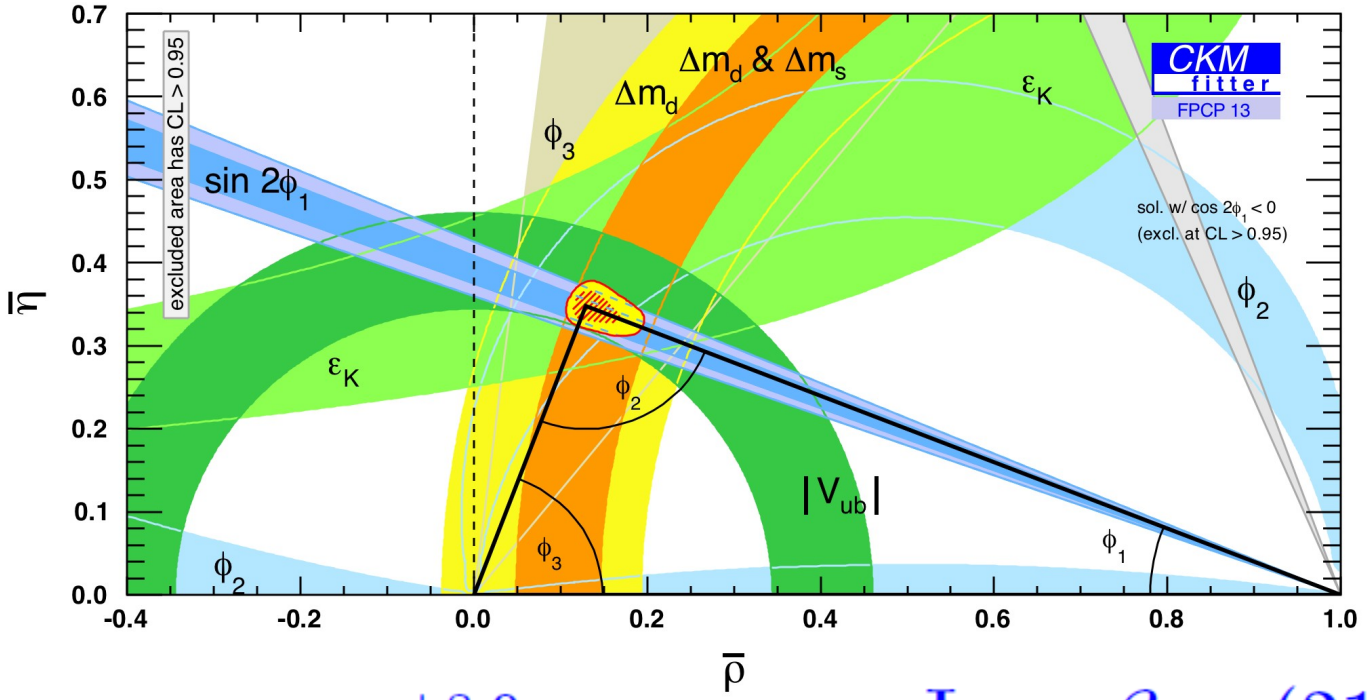
$$\Phi_3(\gamma) = (69^{+17}_{-16})^\circ$$

$$\Phi_3(\gamma) = (68^{+15}_{-14})^\circ$$

$$\Phi_3(\gamma) = (67^{+12}_{-12})^\circ$$

Results of B-factories and LHCB

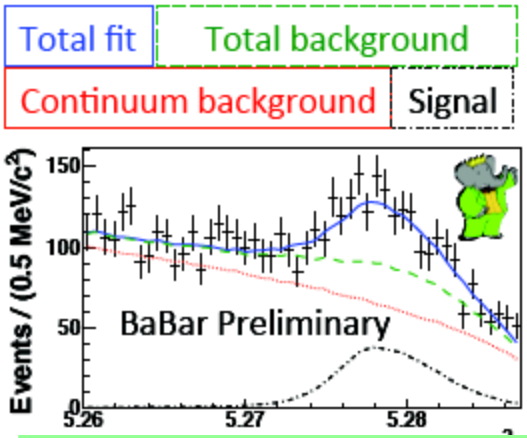
$$\Phi_2 = \alpha = (85.4^{+4.0}_{-3.8})^\circ$$



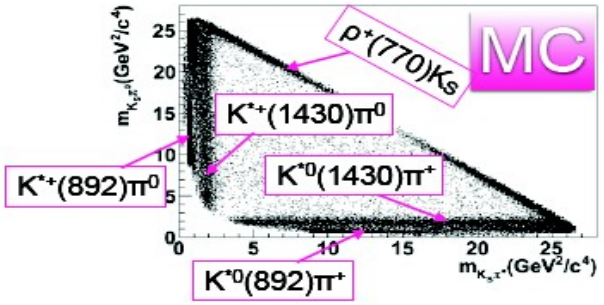
$$\Phi_3 = \gamma = (68.0^{+8.0}_{-8.5})^\circ$$

$$\Phi_1 = \beta = (21.5^{+0.8}_{-0.7})^\circ$$

Direct CPV in Dalitz $B^+ \to K_s \pi^0 \pi^+$



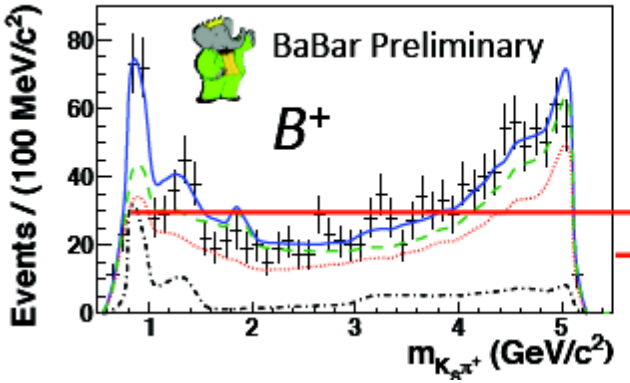
- Several resonances
- overlapping resonances give sensitivity to phases
- Isobar model for resonance description

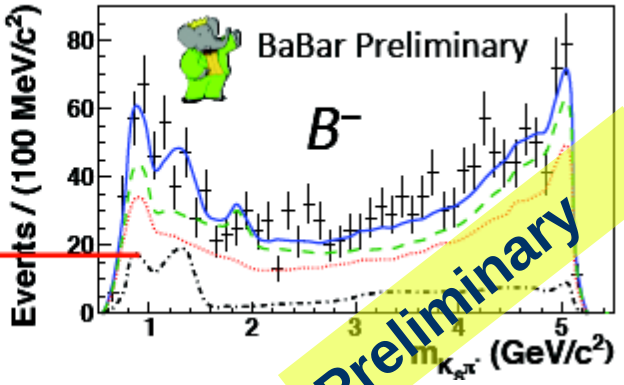


- D→Kπ background is suppressed by veto
- DP is subdividedd in regions described by different pdf's
- 32 000 events
- 1014+-63 signal events

Decay channel	A_{CP}
$K^0\pi^+\pi^0$	$0.07 \pm 0.05 \pm 0.03 \pm 0.04$
$K^{*0}(892)\pi^+$	$-0.12 \pm 0.21 \pm 0.08 \pm 0.11$
$K^{*+}(892)\pi^0$	$-0.52 \pm 0.14 \pm 0.04 \pm 0.04$
$K_0^{*0}(1430)\pi^+$	$0.14 \pm 0.10 \pm 0.04 \pm 0.14$
$K_0^{*+}(1430)\pi^0$	$0.26 \pm 0.12 \pm 0.08 \pm 0.12$
$\rho^+(770)K^0$	$0.21 \pm 0.19 \pm 0.07 \pm 0.30$

- First evidence CPV in $B^+ \to K^{*+}\pi^0$ (3.4σ)
- A_{cp} $B^+ \to K^{*0}\pi^+$ consistent with 0





Preliminary

CPV in mixing

PRL 111, 102802(2013)

- Reco: Partial reconstruction of $B^0 \to D^{*-} l^+ \nu_l$
- Tag: Using charged Kaon tag

Tag-Reco assymmetry

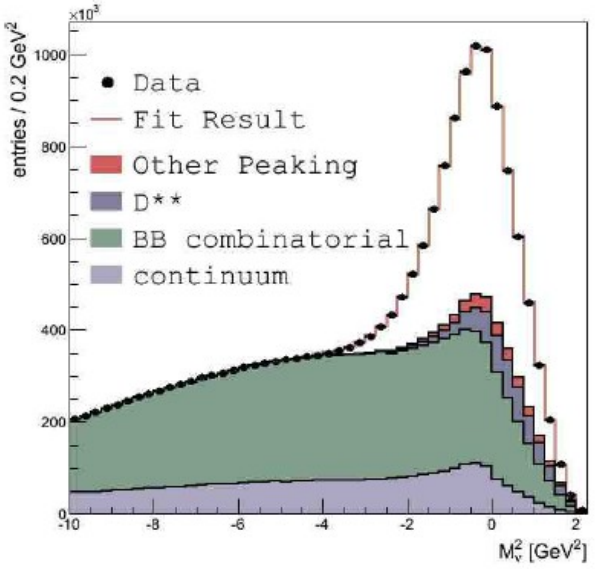
$$A_T = \frac{N(\ell^+ K_T^+) - N(\ell^- K_T^-)}{N(\ell^+ K_T^+) + N(\ell^- K_T^-)} \approx \mathcal{A}_{r\ell} + \mathcal{A}_K + \mathcal{A}_{CP}$$

Kaon from Reco side

$$A_R = \frac{N(\ell^+ K_R^+) - N(\ell^- K_R^-)}{N(\ell^+ K_R^+) + N(\ell^- K_R^-)} \approx \mathcal{A}_{r\ell} + \mathcal{A}_K + \mathcal{A}_{CP}\chi_d.$$

Lepton assymmetry (without Tag)

$$A_\ell \approx \mathcal{A}_{r\ell} + \mathcal{A}_{CP}\chi_d.$$



$$\mathcal{A}_{CP} \equiv \frac{N(B^0B^0) - N(\bar{B}^0\bar{B}^0)}{N(B^0B^0) + N(\bar{B}^0\bar{B}^0)}$$

$$= (0.06 \pm 0.17^{+0.38}_{-0.32})\%$$

$$\Delta_{CP} = 1 - |q/p| =$$

$$(0.29 \pm 0.84^{+1.88}_{-1.61}) \times 10^{-3}$$

CPV in D mesons

-At B-factories production of D mesons is of the same order as of B

-CPV in charm expected to be small

-Flavor tagged D are taken from $D^{*+} \to D^0 \pi^+_{slow}$

-Observables: $M_{K\pi}$ and $\Delta M = M_{K\pi\pi slow} - M_{K\pi}$

Experimental techniques:

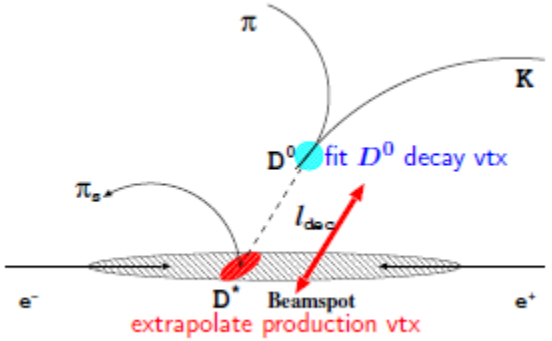
-Time-dependent analysis:

Difference in decay time distribution of D-f and $\overline{D}$-f

-Time integrated analysis:

Difference in time-integrated decay rates of D-f and $\overline{D}$-f

$$t = \frac{l_{dec}}{c\beta\gamma}\ , \qquad \beta\gamma = \frac{p_{D^0}}{M_{D^0}}$$



Study of $D^0 \to K_S \pi^- \pi^+$

PRD 89, 091103R(2014)

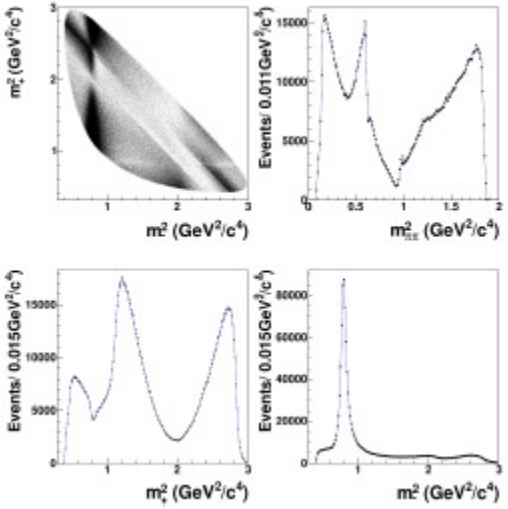
921 fb^{-1}

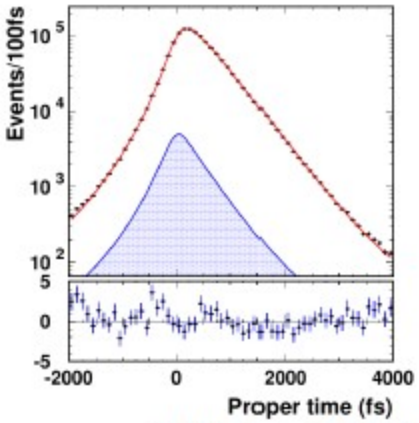
Decay $D^0 \to K_S \pi^+ \pi^-$ includes many intermediate states:

Resonance	Amplitude	Phase (deg)	Fit fraction
$K^*(892)^-$	1.590 ± 0.003	131.8 ± 0.2	0.6045
$K_0^*(1430)^-$	2.059 ± 0.010	-194.6 ± 1.7	0.0702
$K_2^*(1430)^-$	1.150 ± 0.009	-41.5 ± 0.4	0.0221
$K^*(1410)^-$	0.496 ± 0.011	83.4 ± 0.9	0.0026
$K^*(1680)^-$	1.556 ± 0.097	-83.2 ± 1.2	0.0016
$K^*(892)^+$	0.139 ± 0.002	-42.1 ± 0.7	0.0046
$K_0^*(1430)^+$	0.176 ± 0.007	-102.3 ± 2.1	0.0005
$K_2^*(1430)^+$	0.077 ± 0.007	-32.2 ± 4.7	0.0001
$K^*(1410)^+$	0.248 ± 0.010	-145.7 ± 2.9	0.0007
$K^*(1680)^+$	1.407 ± 0.053	86.1 ± 2.7	0.0013
$\rho(770)$	1 (fixed)	0 (fixed)	0.2000
$\omega(782)$	0.0370 ± 0.0004	114.9 ± 0.6	0.0057
$f_2(1270)$	1.300 ± 0.013	-31.6 ± 0.5	0.0141
$\rho(1450)$	0.532 ± 0.027	80.8 ± 2.1	0.0012
$\pi\pi$ S-wave			0.1288

$$\frac{dN_{D\to f}}{dt} e^{-\Gamma t} |A(m_-^2, m_+^2) + \frac{q}{p}(\frac{y+ix}{2}\Gamma t)\bar{A}(m_-^2, m_+^2)|$$

- Unbinned maximum likelihood fit in 3D: t, m_-^2, m_+^2
- Signal – model with 16 resonances
- Background from sidebands





$\tau = (410.3 \pm 0.6)$ fs
consistent with W.A.

Fit type	Parameter	Fit result
No CPV	$x(\%)$	$0.56 \pm 0.19^{+0.03+0.06}_{-0.09-0.09}$
	$y(\%)$	$0.30 \pm 0.15^{+0.04+0.03}_{-0.05-0.06}$
CPV	$x(\%)$	$0.56 \pm 0.19^{+0.04+0.06}_{-0.08-0.08}$
	$y(\%)$	$0.30 \pm 0.15^{+0.04+0.03}_{-0.05-0.07}$
	$\lvert q/p \rvert$	$0.90^{+0.16+0.05+0.06}_{-0.15-0.04-0.05}$
	$\arg(q/p)(^\circ)$	$-6 \pm 11 \pm 3^{+3}_{-4}$

No evidence of CPV

Study of time-integrated CPV in $D^+ \to K^+K^-\pi^+$

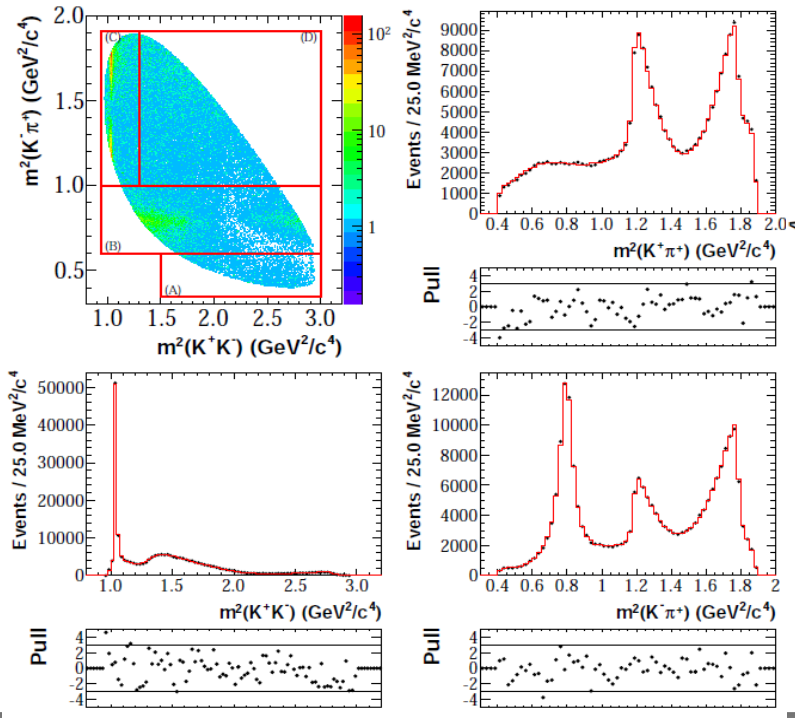
PRD 87, 052010(2013)

DP analysis has sensitivity to both magnitudes and phases of mixing amplitudes

$$A(\cos(\theta_{\rm CM})) \equiv \frac{N_{D^+}/\epsilon_{D^+} - N_{D^-}/\epsilon_{D^-}}{N_{D^+}/\epsilon_{D^+} + N_{D^-}/\epsilon_{D^-}}$$

$$A_{CP} \equiv \frac{A(\cos(\theta_{\rm CM})) + A(-\cos(\theta_{\rm CM}))}{2}$$

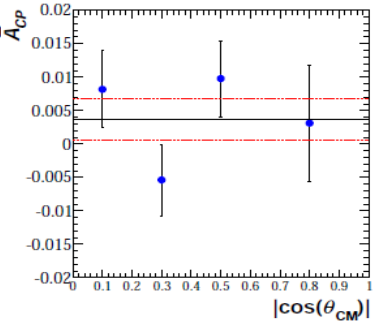
Detector asymmetry is taken into account D^+/D^- from M_D fit



Model independent (4 DP regions)

Dalitz plot region	$N(D^+)$	$\epsilon(D^+)[\%]$	$N(D^-)$	$\epsilon(D^-)[\%]$	$A_{CP}[\%]$
(A) Below $\bar{K}^*(892)^0$	1882 ± 70	7.00	1859 ± 90	6.97	$-0.7 \pm 1.6 \pm 1.7$
(B) $\bar{K}^*(892)^0$	36770 ± 251	7.53	36262 ± 257	7.53	$-0.3 \pm 0.4 \pm 0.2$
(C) $\phi(1020)$	48856 ± 289	8.57	48009 ± 289	8.54	$-0.3 \pm 0.3 \pm 0.5$
(D) Above $\bar{K}^*(892)^0$ and $\phi(1020)$	25616 ± 244	8.01	24560 ± 242	8.00	$1.1 \pm 0.5 \pm 0.3$

Model dependent



Resonance	r_{CP} (%)	$\Delta\phi$ (°)
$\bar{K}^*(892)^0$	0. (FIXED)	0. (FIXED)
$\phi(1020)$	$0.35^{+0.82}_{-0.82} \pm 0.60$	$7.43^{+3.55}_{-3.50} \pm 2.35$
$\bar{K}_0^*(1430)^0$	$-9.40^{+5.65}_{-5.36} \pm 4.42$	$-6.11^{+3.29}_{-3.24} \pm 1.39$
NR	$-14.30^{+11.67}_{-12.57} \pm 5.98$	$-2.56^{+7.01}_{-6.17} \pm 8.91$
$\kappa(800)$	$2.00^{+5.09}_{-4.96} \pm 1.85$	$2.10^{+2.42}_{-2.45} \pm 1.01$
$a_0(1450)^0$	$5.07^{+6.86}_{-6.54} \pm 9.39$	$4.00^{+4.04}_{-3.96} \pm 3.83$

$$A_{CP} = (0.37 \pm 0.30 \pm 0.15)\%$$

ACP in $D^0 \to \pi^0\pi^0$ and $D^0 \to K^0_S\pi^0$

- Flavor tag with pion sign $D^{*+} \to D^0\pi^+_{slow}$
- A_{CP} from corrected raw assymetry

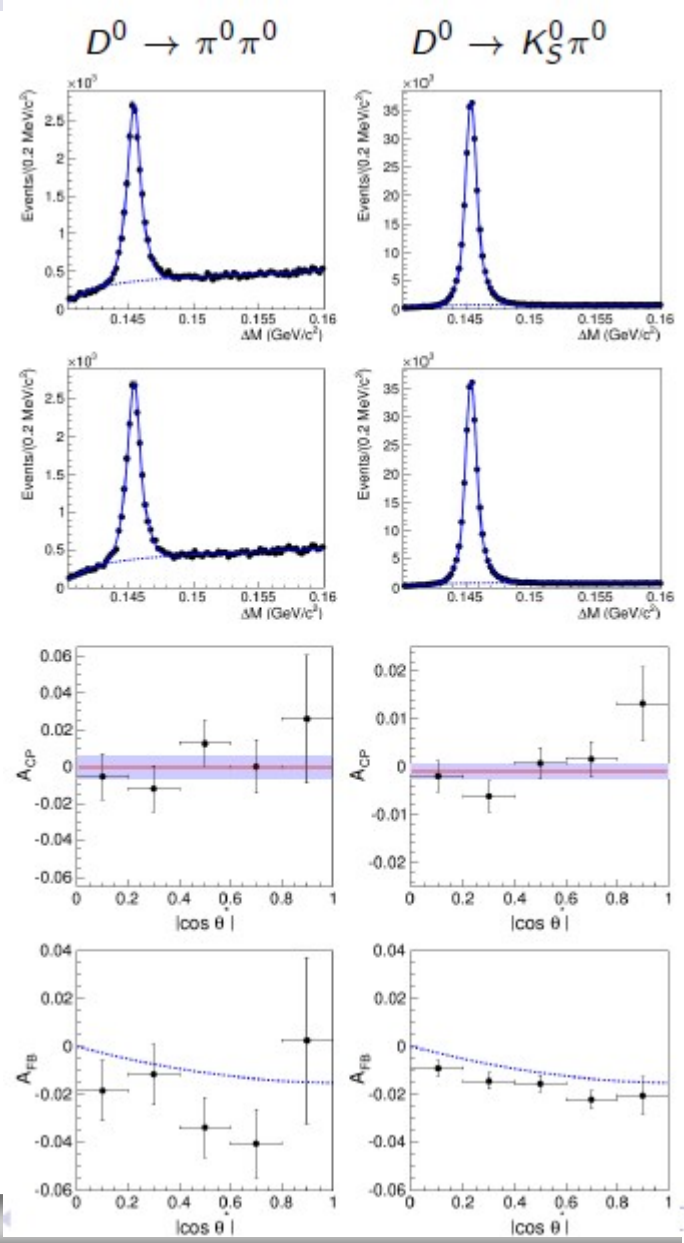
$$A_{\rm rec} = \frac{N_{\rm rec}^{D^{*+}\to D^0\pi_s^+} - N_{\rm rec}^{D^{*-}\to \bar{D}^0\pi_s^-}}{N_{\rm rec}^{D^{*+}\to D^0\pi_s^+} + N_{\rm rec}^{D^{*-}\to \bar{D}^0\pi_s^-}}$$

$$A_{\rm raw} = A_{CP} + A_{FB} + A_{\epsilon}^{\pi_{\rm slow}} \; (+ \; A_{\rm mat}^{K^0})$$

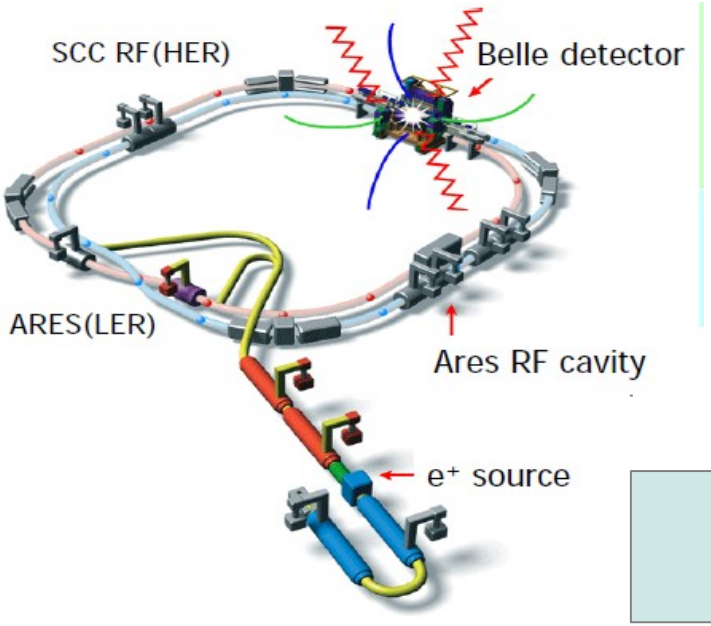
- $D^0/\bar{D}^0$ yields from fit to ΔM in $(cos\Theta^*,\ p_T^{\pi_s},\ cos\theta_{\pi_s})$
- Results consistent with 0

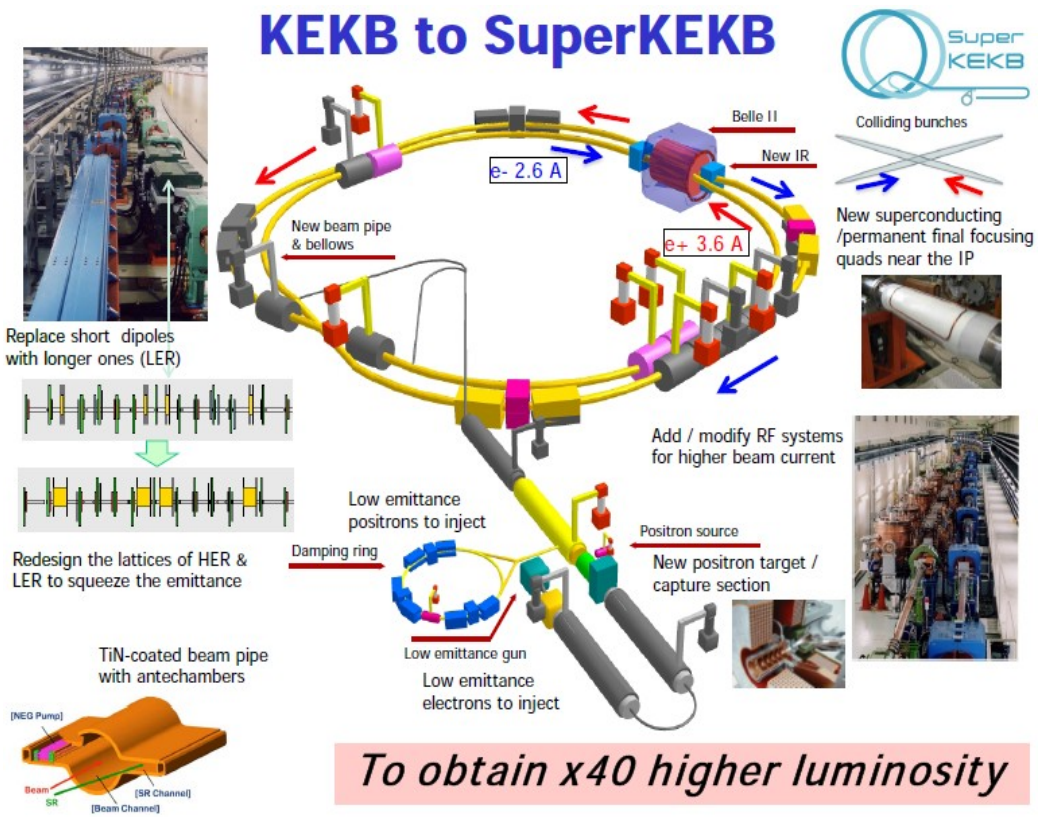
$$A_{CP}^{\pi^0\pi^0} = (-0.03 \pm 0.64 \pm 0.10)\%$$
$$A_{CP}^{K^0_S\pi^0} = (-0.21 \pm 0.16 \pm 0.07)\%$$

PRL 112, 211601(2014)



KEKB upgrade





Energy:	**3.5 GeV (e+)**	**8 GeV (e-)**
Current:	**1.6 A**	**1.2 A**
Crossing angle/2:	**11 mrad**	
Luminosity:	**2.1×10^{34} $cm^{-2}s^{-1}$**	

Energy:	**4 GeV (e+)**	**7 GeV (e-)**
Current:	**3.6 A**	**2.6 A**
Crossing angle/2:	**41 mrad**	
Luminosity:	**8×10^{35} $cm^{-2}s^{-1}$**	

Summary

-Data of CPV in B and D mesons are well described by SM via the CKM mechanism

-Angles of Unitarity triangle have been measured with high accuracy ($<1^o$, $\sim 4^o$, $\sim 8^o$)

-B-factories continue to analyse full data sets

-Search for CPV (and NP) is performed in penguin dominated charmless decays

-Search of CPV continues in D decays

-Even more exciting results will be obtained after Belle II at superKEKB will start