CP violation

(charm sector and γ measurements)

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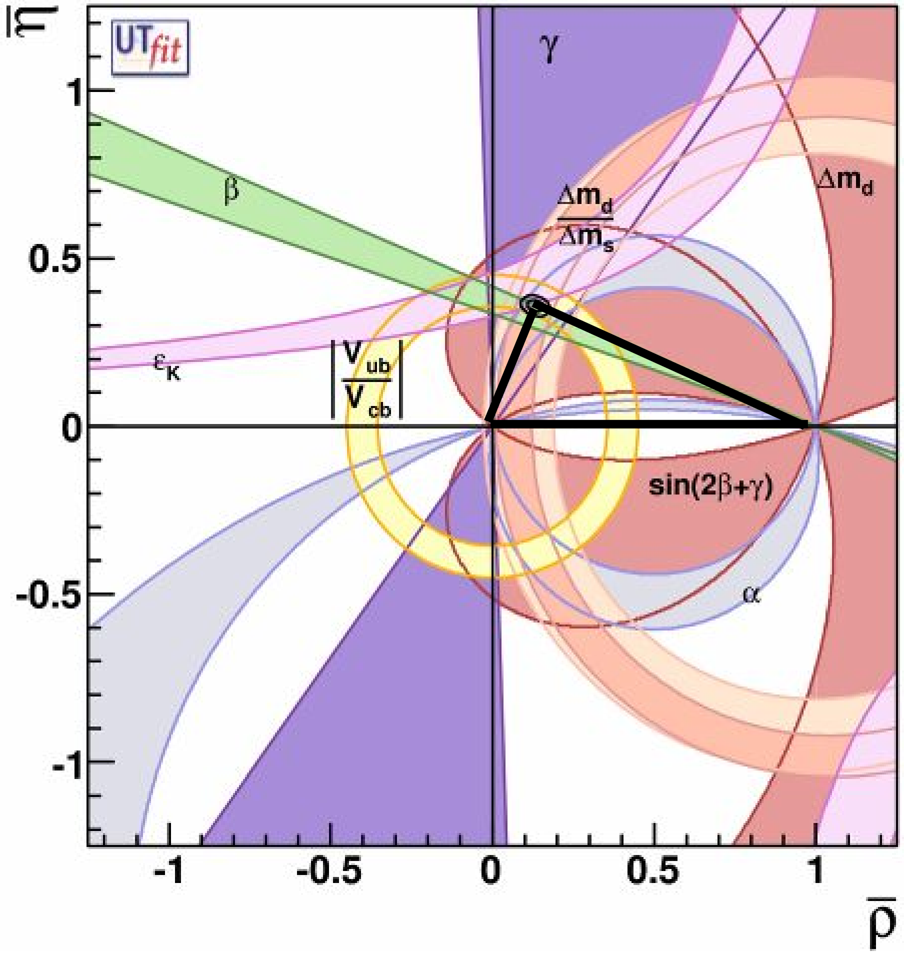
CNRS/IN2P3

Heavy Quarks and Leptons
Frascati, 13th October, 2010



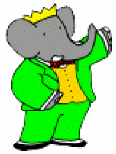
CP violation studies showed good agreement with the SM by now

In this talk:

- D^0 mesons mixing
- *CP* violation in charm
- γ measurements

See next talk by Yosuke Yusa for more *CP* violation results

Experiments providing most of analyses today

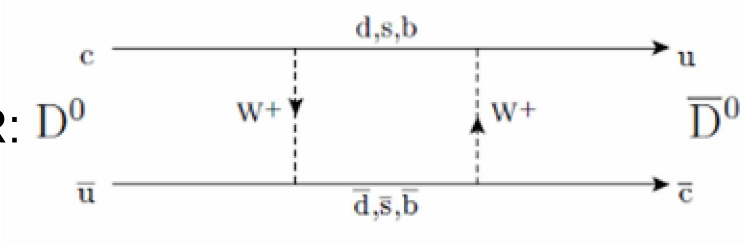


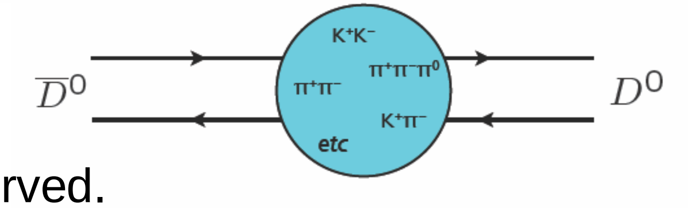
3.1 GeV e^+ 9 GeV e^- 468M BB pairs	3.5 GeV e^+ 8 GeV e^- 772M BB pairs

See talk by Luca Silvestrini for more phenomenological details

D^0 mixing

Flavor eigenstate	Mass eigenstate
$\|D^0(\bar{c}u)\rangle)$	$\|D^0(M_1, \Gamma_1)\rangle)$
$\|\overline{D^0}(cu)\rangle)$	$\|D^0(M_2, \Gamma_2)\rangle)$

SR: 

LR: 

$|D_1\rangle = p|D^0\rangle + q|\overline{D^0}\rangle$

$|D_2\rangle = p|D^0\rangle - q|\overline{D^0}\rangle$ If $p \neq q$, *CP* violation is observed.

For the studies several mixing observables are used:

$$x = \frac{M_1 - M_2}{\Gamma} \qquad y = \frac{\Gamma_1 - \Gamma_2}{2\Gamma}$$

In the Standard model
Mixing parameters ~ 10^{-2}
CP violation ~ 10^{-3}

First observed by BaBar and Belle

PRL 98 211802 (2007)
PRL 98 211803 (2007)

Confirmed by CDF
PRL 100 121802 (2008)

$D^0 \rightarrow K_s h^+ h^-$ results from BaBar

PRL 105 081803 (2010)

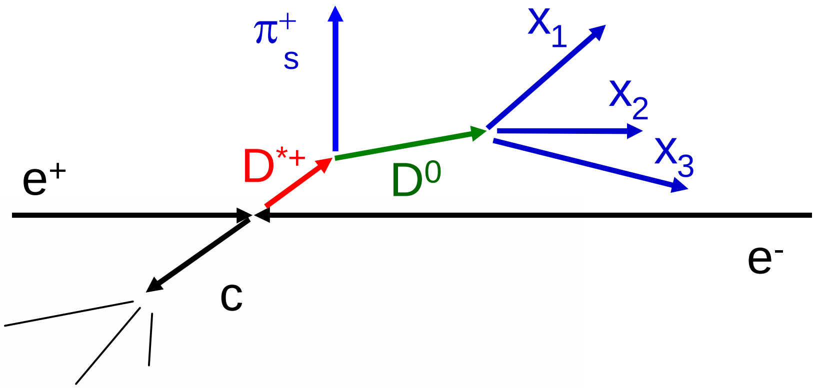
CP self-conjugate final state

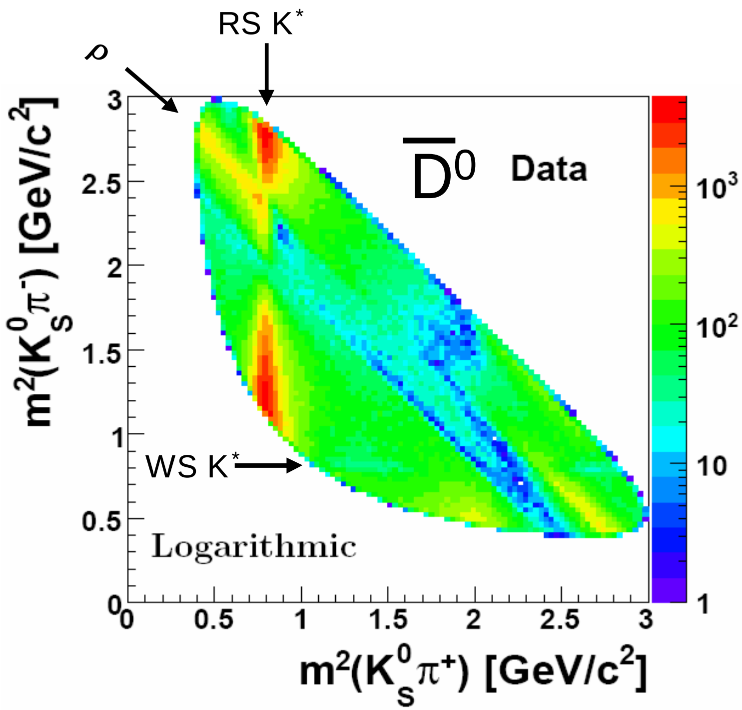
$D^0 \rightarrow K_s \pi^+ \pi^-$

$D^0 \rightarrow K_s K^+ K^-$

609M $c\bar{c}$ pairs. (468.5 fb^{-1})

Time-dependent Dalitz analysis





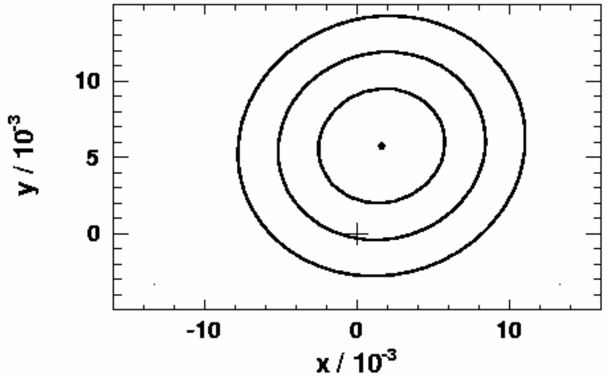
The most accurate measurement by now

No CPV is observed.

If *CP* conservation assumed:

$$x = (1.6 \pm 2.3_{stat} \pm 1.2_{syst} \pm 0.8_{mod}) \cdot 10^{-3},$$

$$y = (5.7 \pm 2.0_{stat} \pm 1.3_{syst} \pm 0.7_{mod}) \cdot 10^{-3}$$



$$A_{CP} = \frac{\Gamma_D - \Gamma_{\bar{D}}}{\Gamma_D + \Gamma_{\bar{D}}} \qquad \Gamma = \text{yields}$$

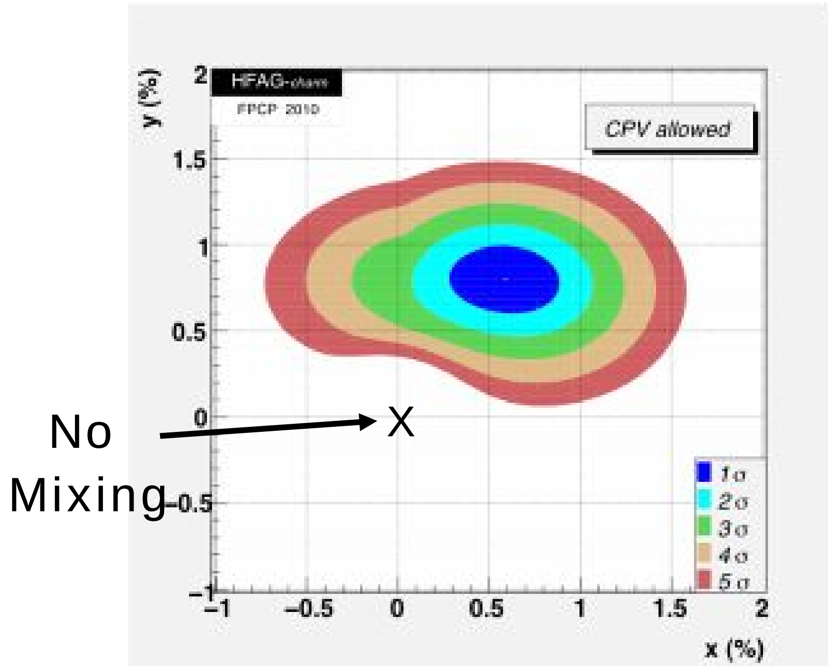
Possible bias from detector asymmetries can be estimated if use several decays at a time (see PRL 104,181602 (2010) for details):

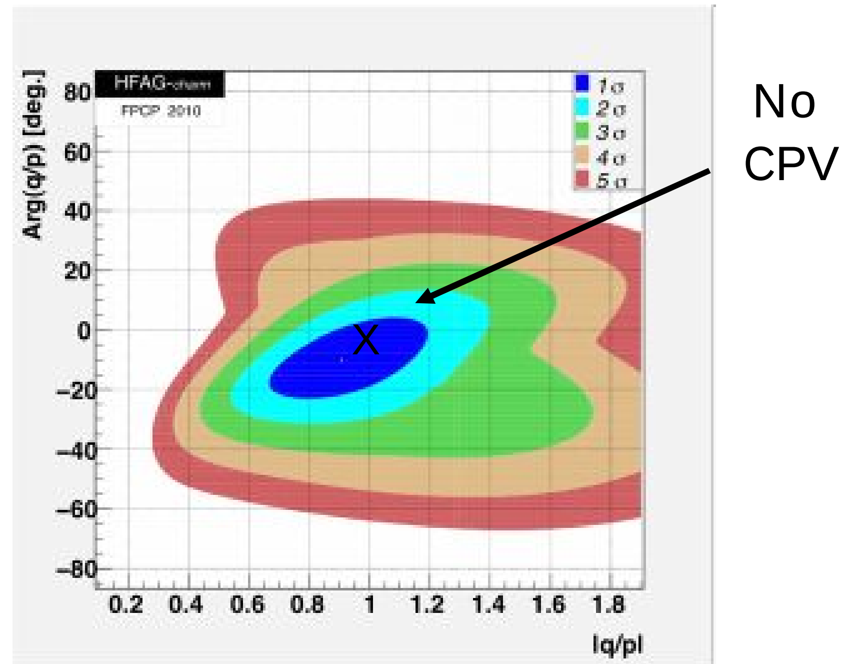
		Decay Mode	A_{CP} (%) (Belle)	A_{CP} (%)(other)	A_{CP} (%) (SM from K_S^0)
673 fb^{-1}	PRL 104,181602	$D^+ \to K_S^0\pi^+$	$-0.71 \pm 0.19 \pm 0.20$	$-1.3 \pm 0.7 \pm 0.3$	-0.332
		$D^+ \to K_S^0 K^+$	$-0.16 \pm 0.58 \pm 0.25$	$-0.2 \pm 1.5 \pm 0.9$	-0.332
		$D_s^+ \to K_S^0\pi^+$	$+5.45 \pm 2.50 \pm 0.33$	$+16.3 \pm 7.3 \pm 0.3$	$+0.332$
		$D_s^+ \to K_S^0 K^+$	$+0.12 \pm 0.36 \pm 0.22$	$+4.7 \pm 1.8 \pm 0.9$	-0.332
791 fb^{-1}	Preliminary	$D^0 \to K_S^0\pi^0$	$-0.28 \pm 0.19 \pm 0.10$	$+0.1 \pm 1.3$	-0.332
		$D^0 \to K_S^0\eta$	$+0.54 \pm 0.51 \pm 0.13$	N.A.	-0.332
		$D^0 \to K_S^0\eta'$	$+0.90 \pm 0.67 \pm 0.15$	N.A.	-0.332

Another solution: normalize CP asymmetry to CF channels

PRL 95,231801 (2005)

HFAG mixing and CPV summary



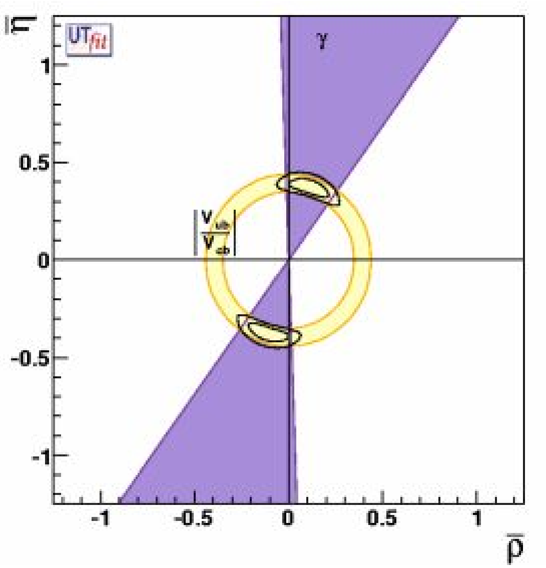


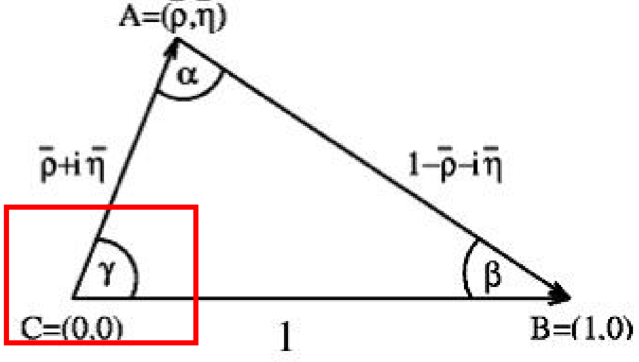
$$x = (0.59 \pm 0.20)\%$$
$$x \in [0.19, 0.97] @ 95\% \text{ C.L.}$$
$$y = (0.80 \pm 0.13)\%$$
$$y \in [0.54, 1.05] @ 95\% \text{ C.L.}$$

$$|q/p| = (0.91^{+0.19}_{-0.16})$$
$$|q/p| \in [0.60, 1.29] @ 95\% \text{ C.L.}$$
$$\arg(q/p) = (-10.0^{+9.3}_{-8.7})^\circ$$
$$\arg(q/p) \in [-26.9, 8.4] @ 95\% \text{ C.L.}$$

Evidence for mixing is >10σ
No evidence for *CPV*

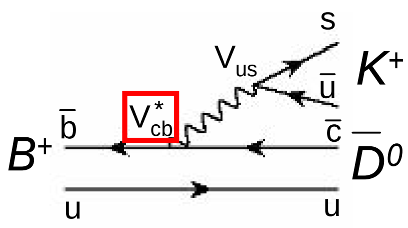
γ measurements

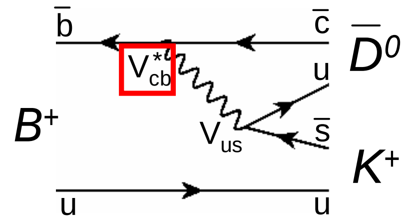




γ/ϕ_3 measurements from B→D$^{(*)}$K$^{(*)}$

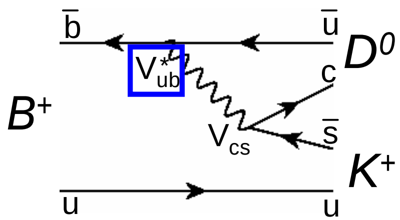
b→c

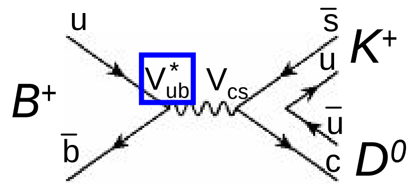




relative phase γ

b→u





Advantages:
- Only tree decays.
- Largely unaffected by the New Physics scenarios
- Clear theoretical interpretation

Disadvantages:
- Rare decays and low r_B

Related variables (depend on the *B* meson decay channel):

$$r_B = \frac{|A_{b\to u}|}{|A_{b\to c}|}$$

$r_B \sim 0.1$ For charged *B* mesons

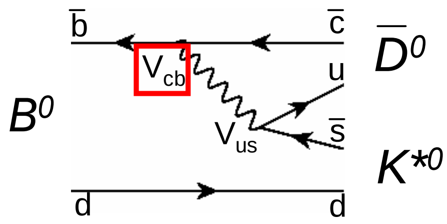
$r_B \sim 0.3$ For neutral *B* mesons

δ_B strong phase (*CP* conserving)

Experimentally not easy to measure.
Three ways to extract the information:
- GLW
- ADS
- Dalitz

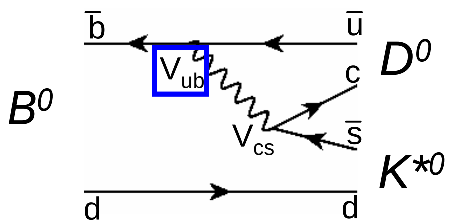
γ/ϕ_3 measurements from $B \rightarrow D^{(*)}K^{(*)}$

$b \rightarrow c$ (V_{cb}, real)



relative phase γ

$b \rightarrow u$ ($V_{ub} = |V_{ub}|\, e^{-i\gamma}$)



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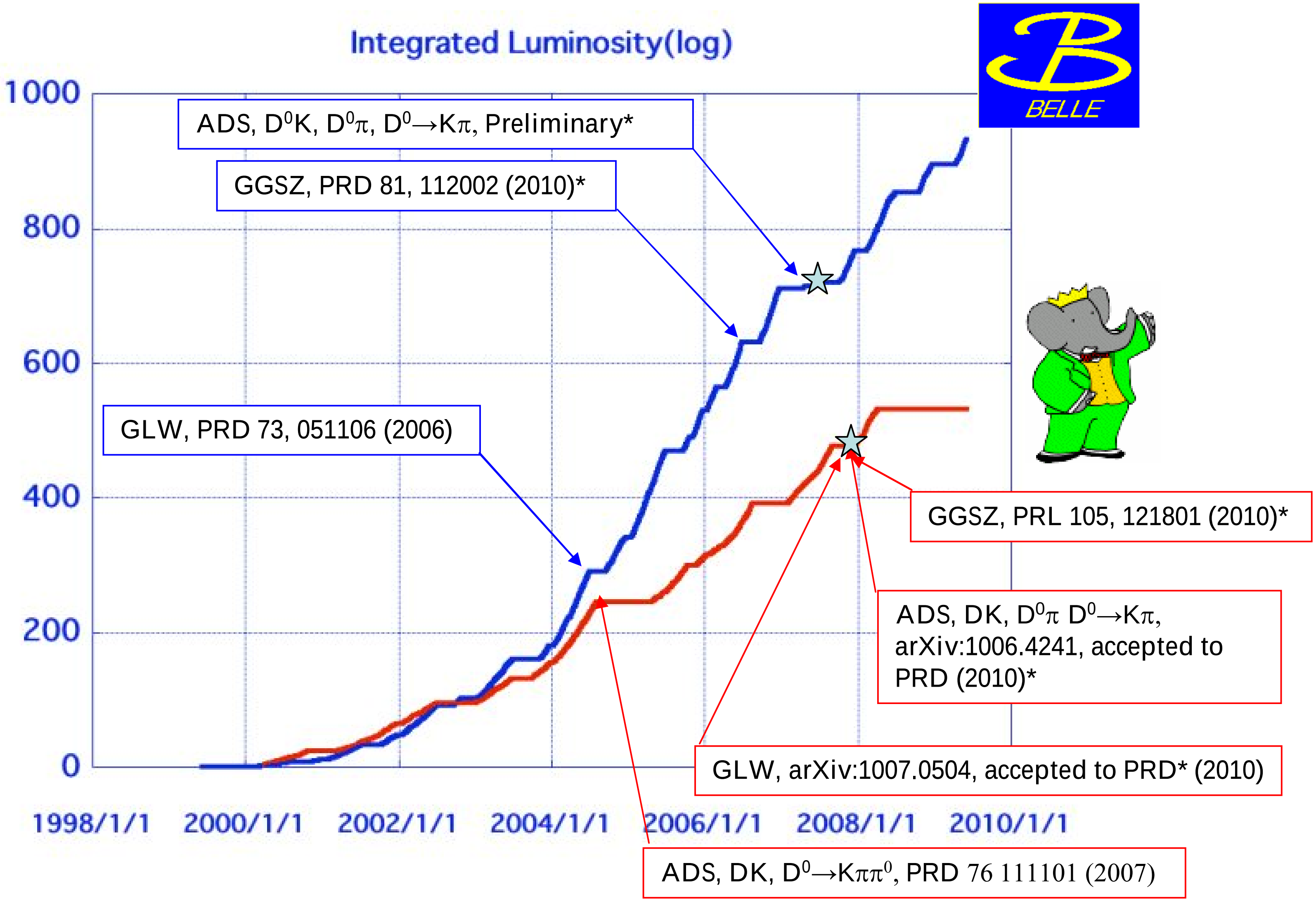
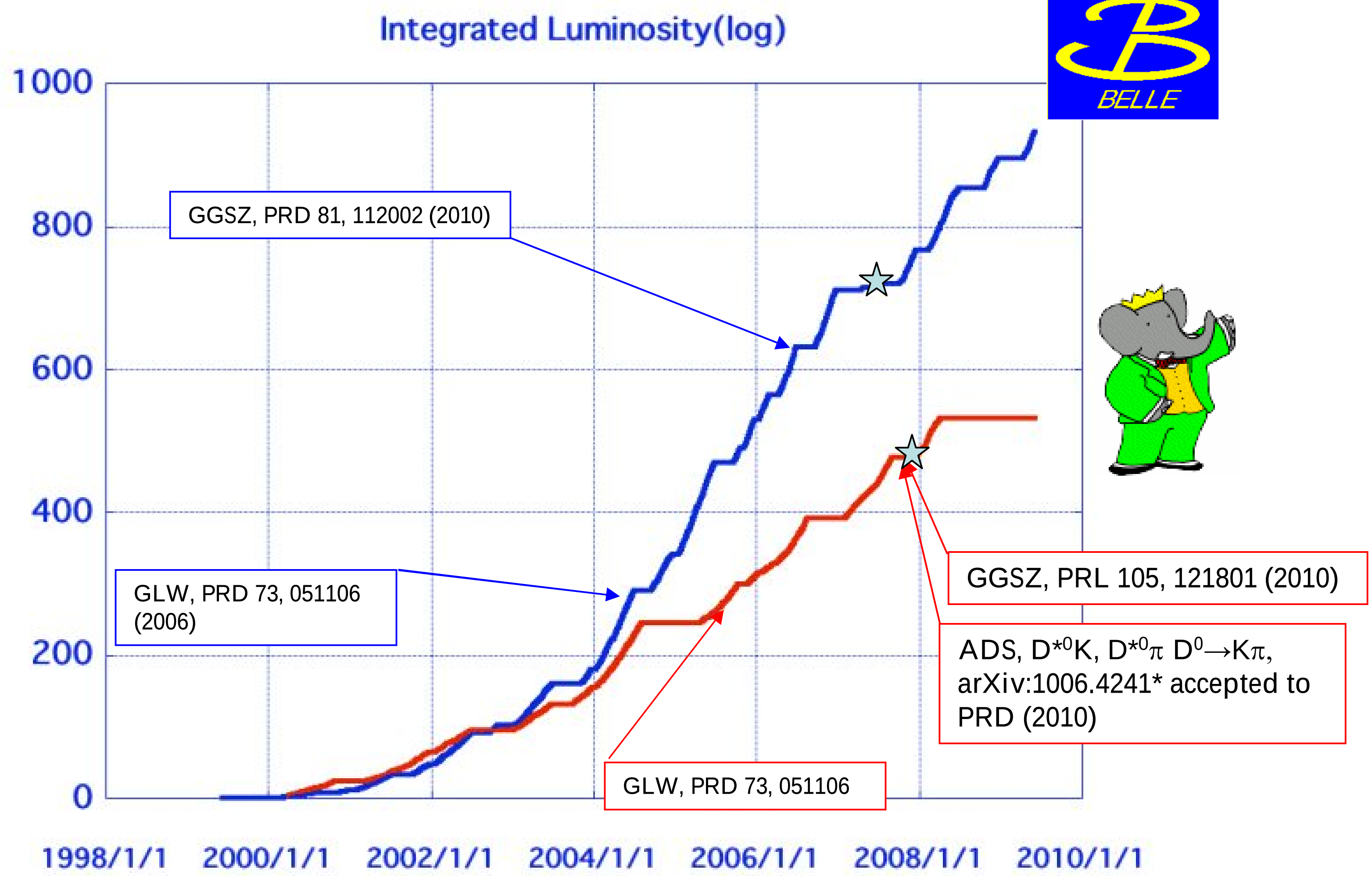
Results from B→D^0K^+

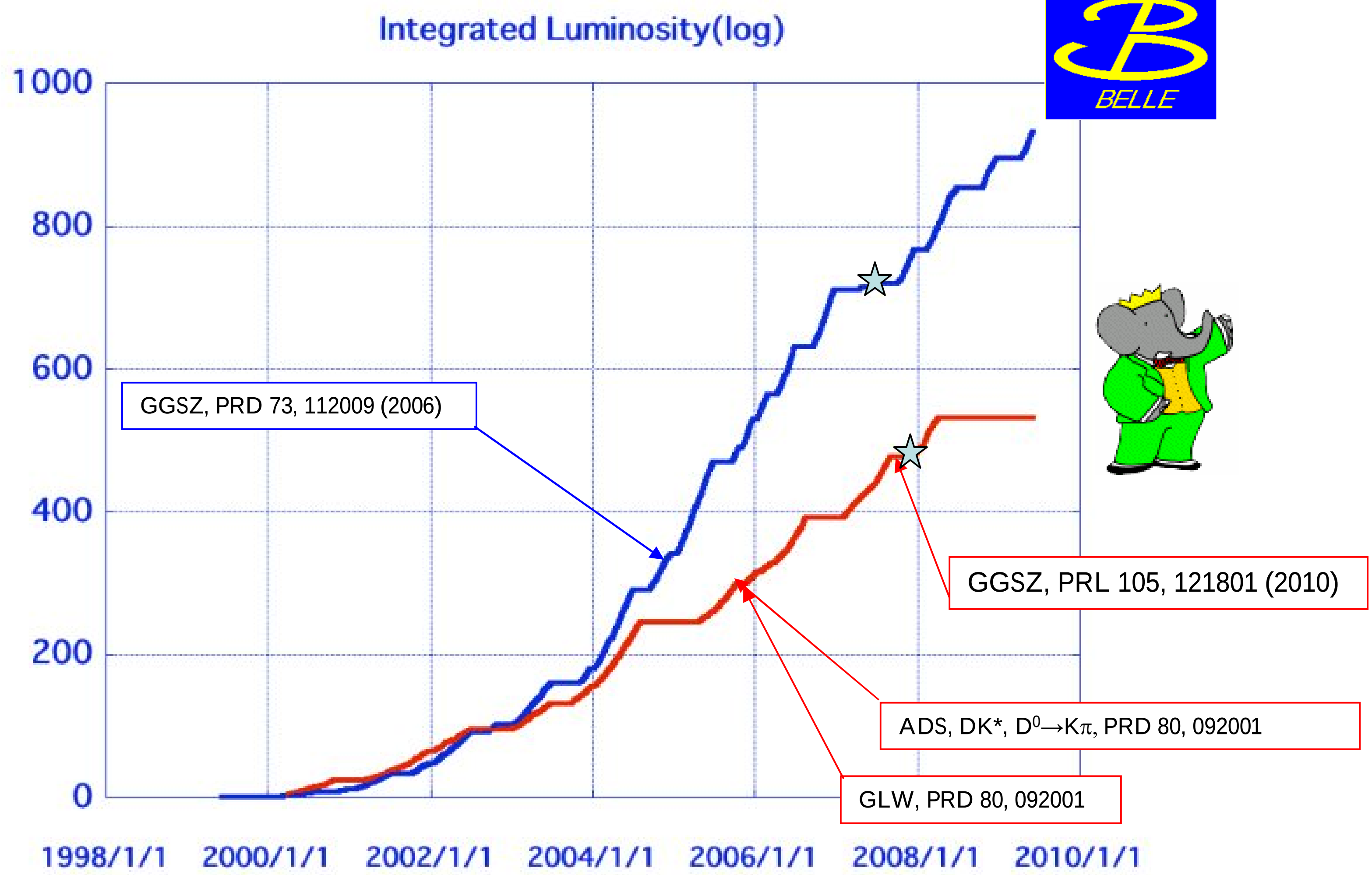


* = in this talk

Results from B→$D^{*0}K^+$



Results from B→D^0K^{*+}



A. Giri, Yu. Grossman, A. Soffer, J. Zupan, PRD 68, 054018 (2003)

Dalitz Method

Modes:

$K_s\pi^+\pi^-$

$K_sK^+K^-$

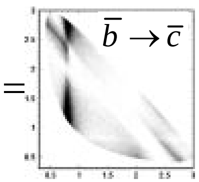
$\pi^+\pi^-\pi^0$

$$x_\pm = \mathrm{Re}(r_B e^{i(\delta\pm\gamma)}) = r_B\cos(\delta\pm\gamma)$$

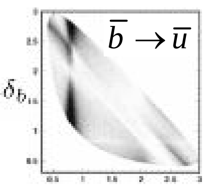
$$y_\pm = \mathrm{Im}(r_B e^{i(\delta\pm\gamma)}) = r_B\sin(\delta\pm\gamma)$$

$\overline{D}^0 \to K_S^0\pi^+\pi^-$ $\quad D^0 \to K_S^0\pi^+\pi^-$

$$A_D^{B+}(m^2_{K_S\pi^+}, m^2_{K_S\pi^-}) =$$

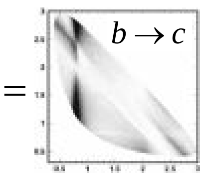


$$+\ r_b\, e^{+i\gamma+i\delta_b}$$

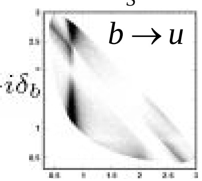


$D^0 \to K_S^0\pi^+\pi^-$ $\quad \overline{D}^0 \to K_S^0\pi^+\pi^-$

$$A_D^{B-}(m^2_{K_S\pi^+}, m^2_{K_S\pi^-}) =$$



$$+\ r_b\, e^{-i\gamma+i\delta_b}$$



Advantages:

- large interferences in some Dalitz regions
- strong phases varying over the Dalitz plane

ADS Method

Modes:

$K^+\pi^-$,

$K^+\pi^-\pi^0$,

$K^+\pi^-\pi^+\pi^-$

$$R_{ADS} = \frac{\Gamma([K^+\pi^-\pi^0]K^-) + \Gamma([K^-\pi^+\pi^0]K^+)}{\Gamma([K^-\pi^-\pi^0]K^-) + \Gamma([K^+\pi^+\pi^0]K^+)}$$

$$A_{ADS} = \frac{\Gamma([K^+\pi^-\pi^0]K^-) - \Gamma([K^-\pi^+\pi^0]K^+)}{\Gamma([K^+\pi^-\pi^0]K^-) + \Gamma([K^-\pi^+\pi^0]K^+)}$$

GLW Method

D^0 Modes:

CP+

CP-

$$R_{CP\pm} = \frac{\Gamma(B^- \to D^0_{CP\pm}K^-) + \Gamma(B^+ \to D^0_{CP\pm}K^+)}{2\Gamma(B^+ \to D^0 K^+)}$$

$$A_{CP\pm} = \frac{\Gamma(B^- \to D^0_{CP\pm}K^-) - \Gamma(B^+ \to D^0_{CP\pm}K^+)}{\Gamma(B^- \to D^0_{CP\pm}K^-) + \Gamma(B^+ \to D^0_{CP\pm}K^+)}$$

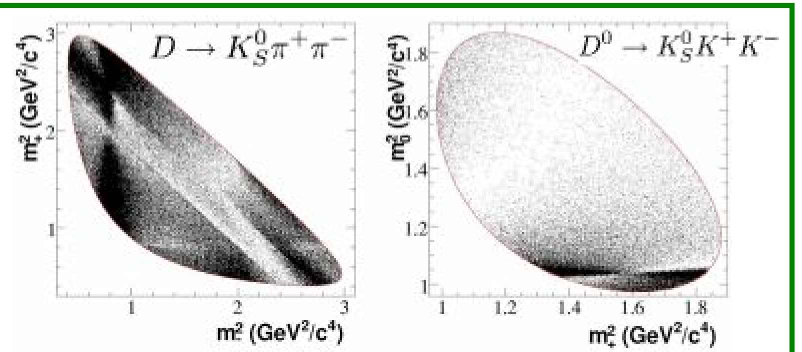
PRL 105, 121801 (2010)

Dalitz Method

BaBar $425\ fb^{-1}$ (468 MBB)

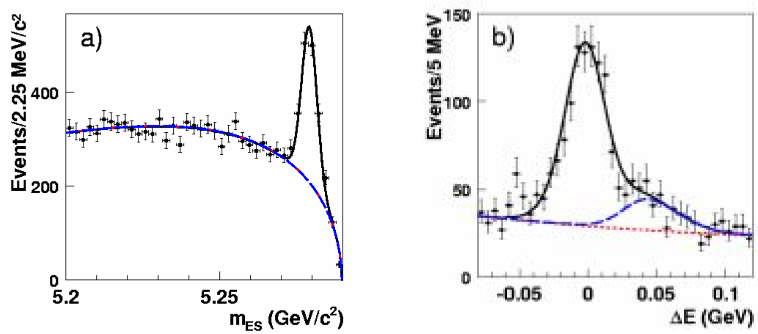
BaBar only!

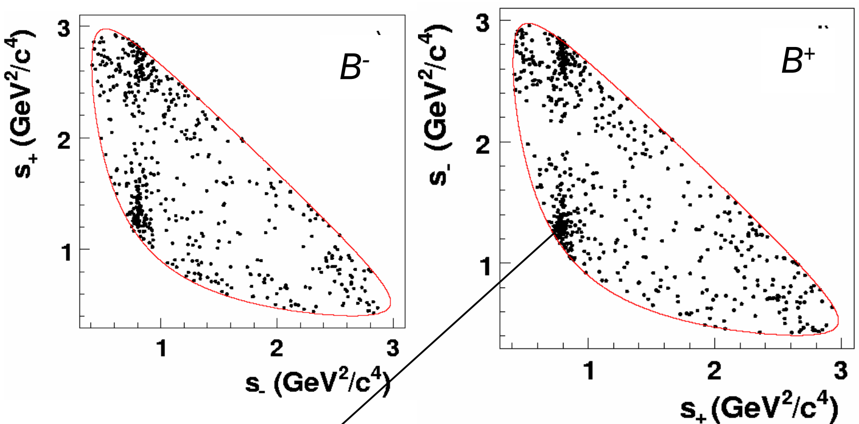
$$D \to K_S^0 \pi^+ \pi^-, \quad K_S^0 K^+ K^-$$



Signal is separated from background using m_{ES}, *Fisher* (on event shape variables), *ΔE*, *(s−, s+)* (invariant masses of $K_s\pi^+$ and $K_s\pi^-$)

$$m_{ES} = \sqrt{E_{\text{beam}}^2 - p_B^2} \qquad \Delta E = E_B - E_{\text{beam}}$$





Resonance structure provides an important information on the phases

The reconstruction efficience is 22%

Fit for yields and *CP* violating parameters

PRD 81, 112002 (2010)

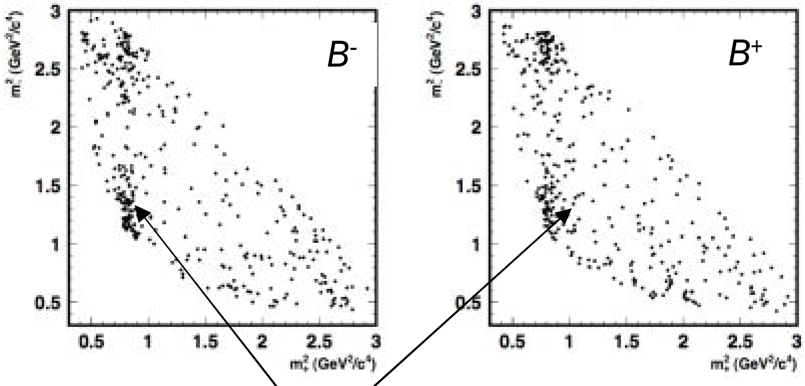
Dalitz Method

Belle 605 fb^{-1}
(657 MBB)

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

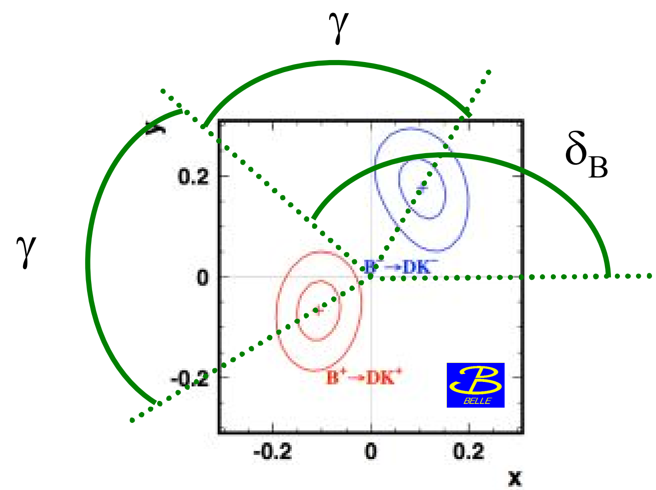
Signal events yield

	Belle $(K_s\pi\pi)$ 657 MBB	BaBar $(K_s\pi\pi)$ 468 MBB	BaBar (K_sKK) 468 MBB
$B^\pm \to DK^\pm$	757 ± 30	920 ± 35	142 ± 14

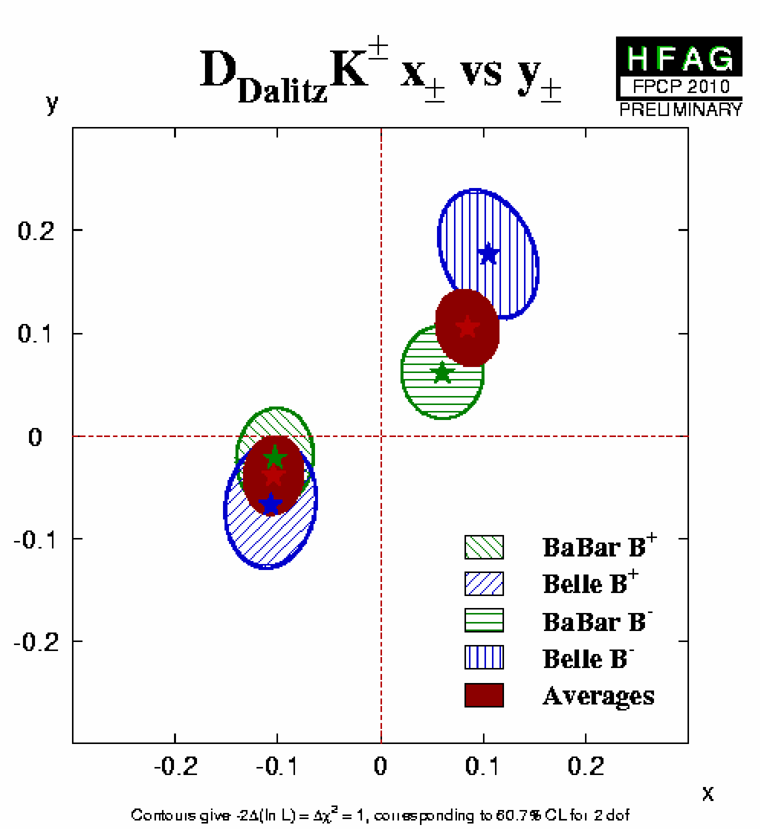


Resonance structure provides an important information on the phases

$$x_\pm = \mathrm{Re}(r_B e^{i(\delta \pm \gamma)}) = r_B \cos(\delta \pm \gamma)$$
$$y_\pm = \mathrm{Im}(r_B e^{i(\delta \pm \gamma)}) = r_B \sin(\delta \pm \gamma)$$



Dalitz Method

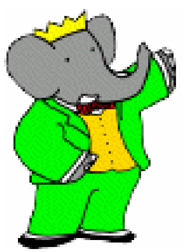


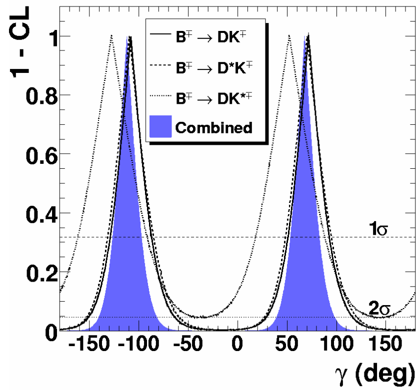
Not an easy task to average the results, the model errors are not easy to be combined

Main differences in $D^0 \to K_s\pi^+\pi^-$:
– BaBar: K-matrix formalism for $\pi\pi$ S-wave, LASS model for $K\pi$ S-wave.
– Belle: Includes σ_1 and σ_2 $\pi\pi$ scalar resonances. $K^{*0}(1430)$ for $K\pi$ Swave.

BaBar result also includes $D^0 \to K_s K^+ K^-$

γ/ϕ_3 from Belle/BaBar





Parameter	68.3% CL	95.4% CL
γ (°)	68^{+15}_{-14} {4, 3}	[39, 98]
r_B (%)	9.6 ± 2.9 {0.5, 0.4}	[3.7, 15.5]
r^*_B (%)	$13.3^{+4.2}_{-3.9}$ {1.3, 0.3}	[4.9, 21.5]
κr_s (%)	$14.9^{+6.6}_{-6.2}$ {2.6, 0.6}	< 28.0
δ_B (°)	119^{+19}_{-20} {3, 3}	[75, 157]
δ^*_B (°)	-82 ± 21 {5, 3}	[−124, −38]
δ_s (°)	111 ± 32 {11, 3}	[42, 178]

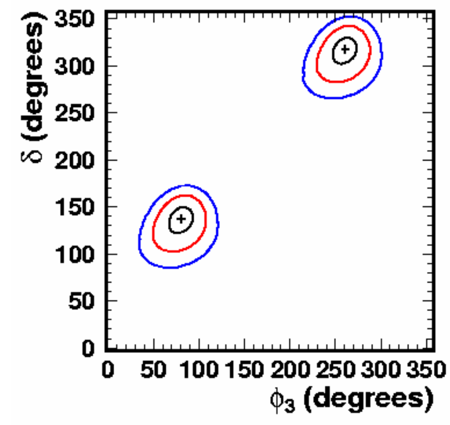
BaBar obtains

$\gamma = (68\ ^{+15}_{-14} \pm 4 \pm 3)°$

(from DK^-, D^*K^-, DK^{*-})

PRL 105, 121801 (2010)

BELLE



Parameter	$B^+ \to DK^+$ mode	$B^+ \to D^*K^+$ mode
ϕ_3	$(80.8^{+13.1}_{-14.8} \pm 5.0 \pm 8.9)°$	$(73.9^{+18.9}_{-20.2} \pm 4.2 \pm 8.9)°$
r	$0.161^{+0.040}_{-0.038} \pm 0.011^{+0.050}_{-0.010}$	$0.196^{+0.073}_{-0.072} \pm 0.013^{+0.062}_{-0.012}$
δ	$(137.4^{+13.0}_{-15.7} \pm 4.0 \pm 22.9)°$	$(341.7^{+18.6}_{-20.9} \pm 3.2 \pm 22.9)°$

Belle obtains

$\phi_3 = (78\ ^{+11}_{-12} \pm 4 \pm 9)°$

(from DK^- and D^*K^-)

PRD 81, 112002 (2010)

Dalitz Method

Modes:

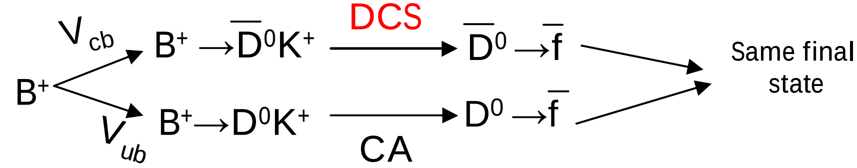
$K_S\pi^+\pi^-$ $\qquad x_\pm = r_B \cos(\delta \pm \gamma)$

$K_S K^+ K^-$ $\qquad y_\pm = r_B \sin(\delta \pm \gamma)$

$\pi^+\pi^-\pi^0$

D. Atwood, I. Dunietz and A. Soni, PRL 78, 3357 (1997).

Interplay between Doubly-Cabibbo-Suppressed and Cabibbo allowed *D* meson decay



ADS Method

Branching fraction of processes is quite low ($\sim 10^{-7}$)

D^0 Modes:

$K^+\pi^-$,

$K^+\pi^-\pi^0$,

$K^+\pi^-\pi^+\pi^-$

$$R_{ADS} = \frac{\Gamma([\bar{f}]K^-) + \Gamma([\bar{f}]K^+)}{\Gamma([f]K^-) + \Gamma([f]K^+)} = r_B^2 + r_D^2 + 2k_D r_B r_D \cos(\delta_B + \delta_D)\cos\gamma$$

$$A_{ADS} = \frac{\Gamma([\bar{f}]K^-) - \Gamma([\bar{f}]K^+)}{\Gamma([f]K^-) + \Gamma([f]K^+)} = 2k_D r_B r_D \cos(\delta_B + \delta_D)\cos\gamma / R_{ADS}$$

$$r_D = \frac{|A_{c\to u}|}{|A_{c\to s}|}$$

Parameters:
$\{\gamma;\ r_B;\ \delta_B\}$

$$k_D e^{i\delta_D} = \frac{\int A_D \bar{A}_D e^{i(\bar{\delta}(m) - \delta(m))} dm}{\sqrt{\int |A_D|^2\, dm \int |\bar{A}_D|^2\, dm}}$$

External Inputs:
$\{r_D;\ \delta_D;\ k_D\}$

CDF also gave the results with this type of analysis

Belle 711 fb^{-1} (772 MBB)

PRELIMINARY

Two decay chains:

$B^- \to D^0 h^-, D^0 \to K^- \pi^+$ Same sign

$B^- \to D^0 h^-, D^0 \to K^+ \pi^-$ Opposite sign

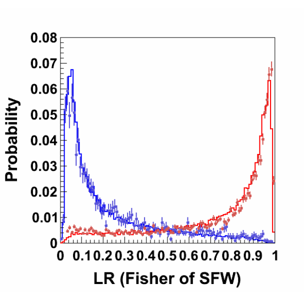
$h = K, \pi$

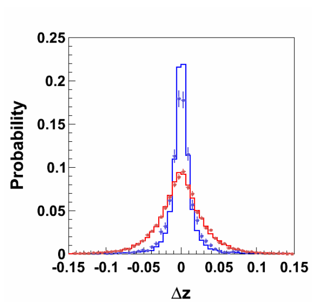
Simultaneous fit to ΔE and NeuroBayes neural network to *Dh* sample

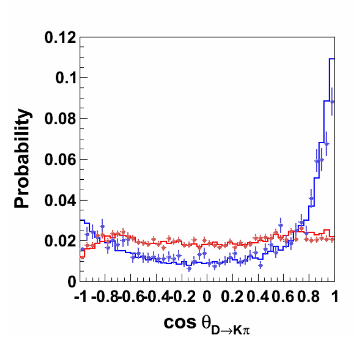
NeuroBayes neural network (NB), 10 inputs:

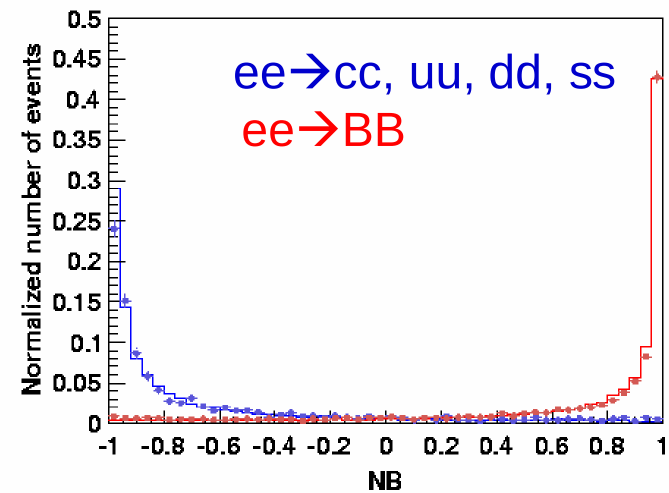
- LR for Fisher of SFW moments
- Vertex separation between reconstructed B and the other B (Δz)
- Decay angle for $D \to K\pi$

Etc…









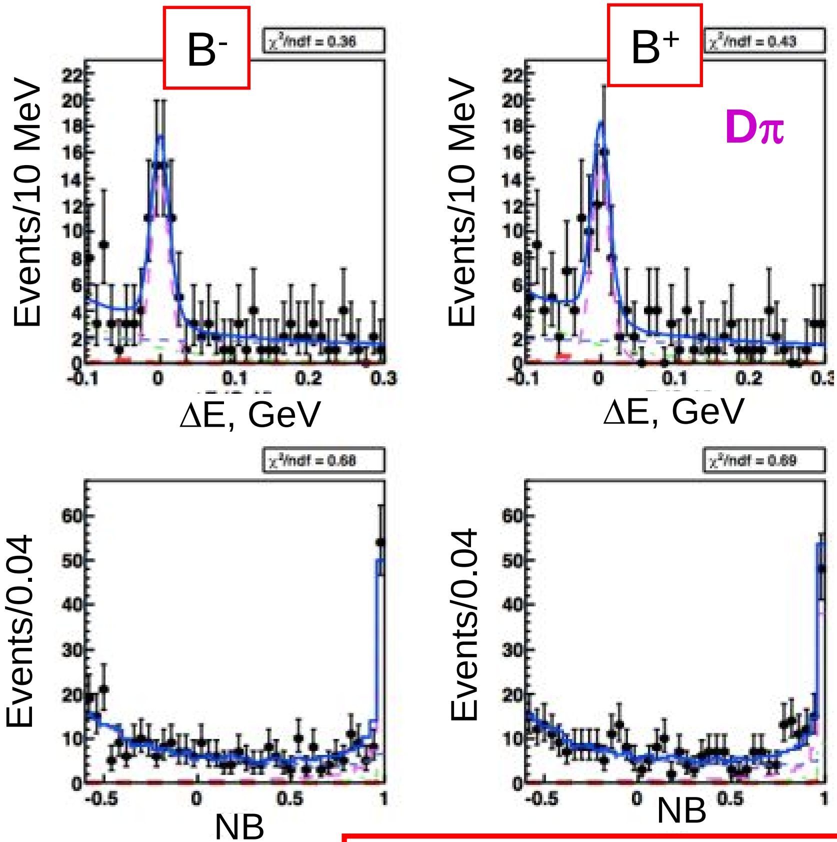
Fit region: NB>-0.6,-0.1<ΔE<0.3 GeV

γ/ϕ_3 measurements with ADS from BELLE

Belle 711 fb^{-1}
(772 MBB)

$B^- \to D^0\pi^-, D^0 \to K^-\pi^+$

PRELIMINARY



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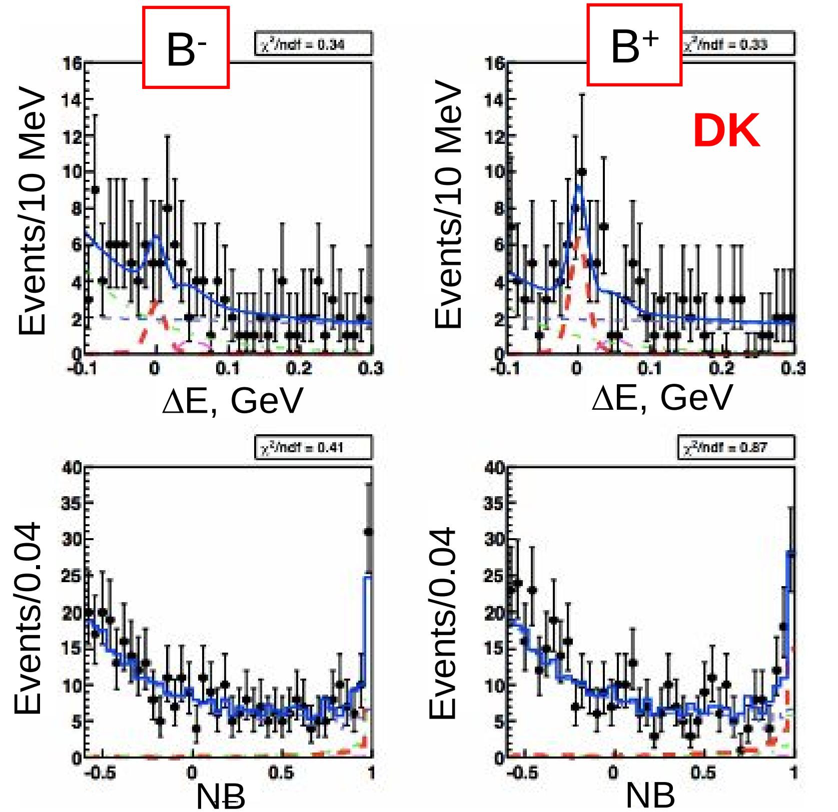
PRELIMINARY



Projections for signal region NB>0.5, |ΔE|<0.04 GeV, respectively

ADS *B*→*Dh* summary

	772 MBB	657 MBB	468 MBB
$\mathcal{R}_{DK}$ $[\times 10^{-2}]$	$1.62 \pm 0.42\ ^{+0.16}_{-0.19}$ *	$0.78\ ^{+0.62}_{-0.57}\ ^{+0.20}_{-0.28}$	$1.1 \pm 0.6 \pm 0.2$
$\mathcal{R}_{D\pi}$ $[\times 10^{-3}]$	$3.28 \pm 0.37\ ^{+0.22}_{-0.23}$ *	$3.40\ ^{+0.55}_{-0.53}\ ^{+0.15}_{-0.22}$	$3.3 \pm 0.6 \pm 0.4$
$\mathcal{A}_{DK}$	$-0.39 \pm 0.26\ ^{+0.06}_{-0.04}$	$-0.1\ ^{+0.8}_{-1.0} \pm 0.4$	$-0.86 \pm 0.47\ ^{+0.12}_{-0.16}$
$\mathcal{A}_{D\pi}$	$-0.04 \pm 0.11\ ^{+0.01}_{-0.02}$	$-0.02\ ^{+0.15}_{-0.16} \pm 0.04$	$0.03 \pm 0.17 \pm 0.04$

All the values are very consistent with yet leading statistical error

* Most precise measurements to date with a significance 8.4σ (including syst).

* First evidence is obtained with a significance 3.8σ (including syst).

R_{ADS} (DK) = (2.25 ± 0.84(stat) ± 0.79(syst))·10^{-2}
R_{ADS} (Dπ) = (4.1± 0.8(stat) ± 0.4(syst)) ·10^{-3}
A_{ADS} (DK) = -0.63 ± 0.40(stat) ± 0.23(syst)
A_{ADS} (Dπ) = 0.22 ± 0.18(stat) ± 0.06(syst)

@CKM workshop

PRELIMINARY

γ/ϕ_3 measurements with GLW

Dalitz Method

Modes:

$K_S\pi^+\pi^-$

$K_SK^+K^-$

$\pi^+\pi^-\pi^0$

$$x_\pm = r_B\cos(\delta\pm\gamma)$$

$$y_\pm = r_B\sin(\delta\pm\gamma)$$

ADS Method

Modes:

$K^+\pi^-$,

$K^+\pi^-\pi^0$,

$K^+\pi^-\pi^+\pi^-$

$$R_{ADS} = \frac{\Gamma([K^+\pi^-\pi^0]K^-)+\Gamma([K^-\pi^+\pi^0]K^+)}{\Gamma([K^-\pi^-\pi^0]K^-)+\Gamma([K^+\pi^+\pi^0]K^+)}$$

$$A_{ADS} = \frac{\Gamma([K^+\pi^-\pi^0]K^-)-\Gamma([K^-\pi^+\pi^0]K^+)}{\Gamma([K^+\pi^-\pi^0]K^-)+\Gamma([K^-\pi^+\pi^0]K^+)}$$

M. Gronau, D. London, D. Wyler, PLB253,483 (1991); PLB 265, 172 (1991)

Theoretically very clean to determine γ (with four observable)

Many D^0 Modes reconstructed:

$$CP+: D^0 \to K^+K^-, \pi^+\pi^-$$

$$CP-: D^0 \to K_S^0\pi^0, K_S^0\omega, K_S^0\phi, (K_S^0\eta)$$

CDF also gave the results with this type of analysis

GLW Method

D^0 Modes:

CP+

CP-

$$R_{CP\pm} = \frac{\Gamma(B^-\to D^0_{CP\pm}K^-)+\Gamma(B^+\to D^0_{CP\pm}K^+)}{2\Gamma(B^+\to D^0K^+)} = 1 + r_B^2 \pm 2r_B\cos\gamma\cos\delta_B$$

$$A_{CP\pm} = \frac{\Gamma(B^-\to D^0_{CP\pm}K^-)-\Gamma(B^+\to D^0_{CP\pm}K^+)}{\Gamma(B^-\to D^0_{CP\pm}K^-)+\Gamma(B^+\to D^0_{CP\pm}K^+)} = \pm 2r_B\cos\gamma\cos\delta_B / R_{CP\pm}$$

4 observables (3 independent) and 3 unknowns

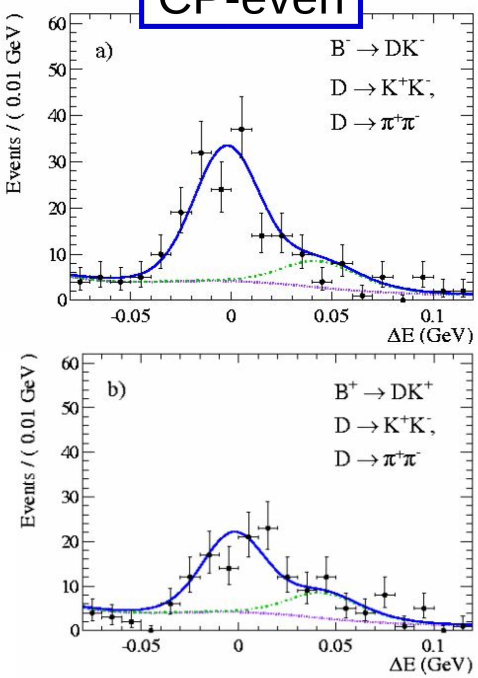
GLW, arXiv:1007.0504, acc to PRD

BaBar 425 fb^{-1}
(468 MBB)

ML fit to {m_{ES}, ΔE, Fisher(same vars as GGSZ + ratio of 2nd and 0th order Fox-Wolfram moments)}

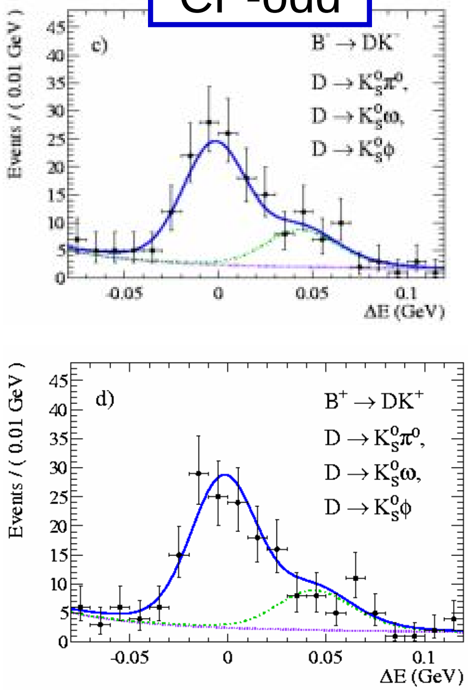
Simultaneous fit to the subsamples corresponding to different D decays

CP-even



N_{CP+}=477±28

CP-odd



N_{CP-}=506±26

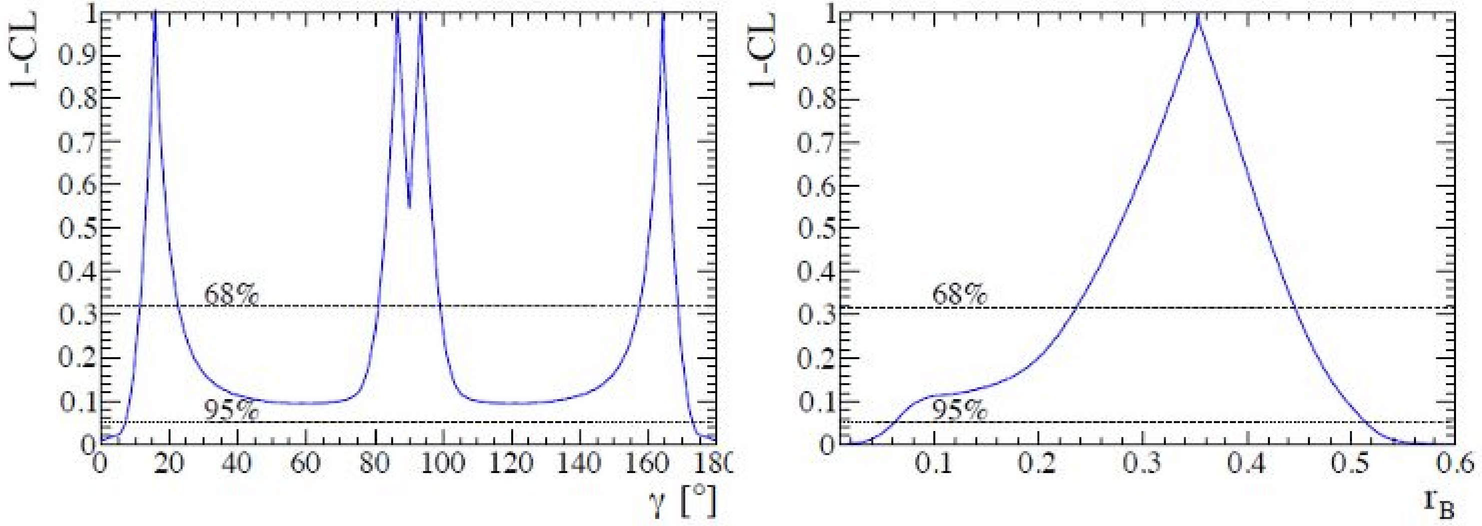
$A_{CP+} = 0.25 \pm 0.06 \pm 0.02$
$A_{CP-} = -0.09 \pm 0.07 \pm 0.02$
$R_{CP+} = 1.18 \pm 0.09 \pm 0.05$
$R_{CP-} = 1.07 \pm 0.08 \pm 0.04$

Direct CPV at 3.6σ
in $B \rightarrow D_{CP+}K$ decays !

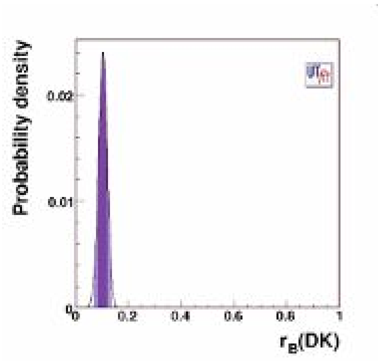
γ/ϕ_3 measurements with the GLW method from BaBar

Frequentist interpretation gives:

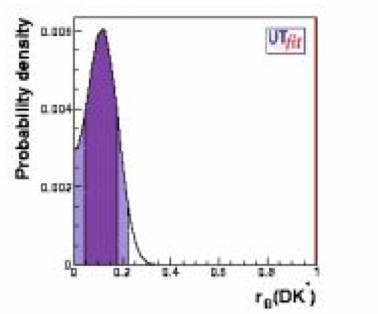
	γ mod 180 [°]	r_B
68% CL	[11.3, 22.7]	[0.24, 0.45]
	[80.9, 99.1]	
	[157.3, 168.7]	
95% CL	[7.0, 173.0]	[0.06, 0.51]



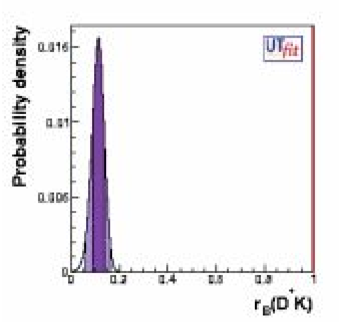
Large value of r_B is favored (but large uncertainty: less than 2σ from 0)



$$r_B(D^0K^+) = (0.106 \pm 0.016)$$



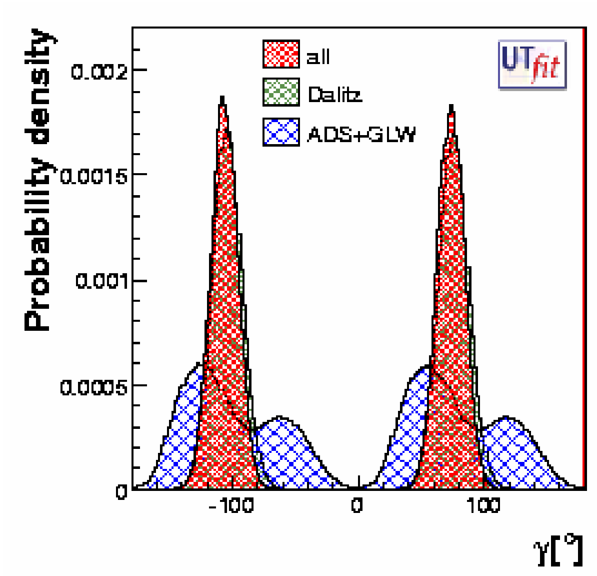
$$r_B(D^0K^{*+}) = (0.11 \pm 0.07)$$



$$r_B(D^{*0}K^+) = (0.113 \pm 0.025)$$

The combination of all the methods can be performed giving

$$\gamma = (74 \pm 11)^\circ$$



Conclusions

No significant *CP* violation in charm sector is observed

The D^0 mixing is confirmed with more than 10σ evidence

γ/ϕ_3 measurements

Several analyses with $>3\sigma$ CPV evidence in a single measurement

The combination can be performed separately. Big contributors are DK decay modes using Dalitz method.

The combination of all the method gives

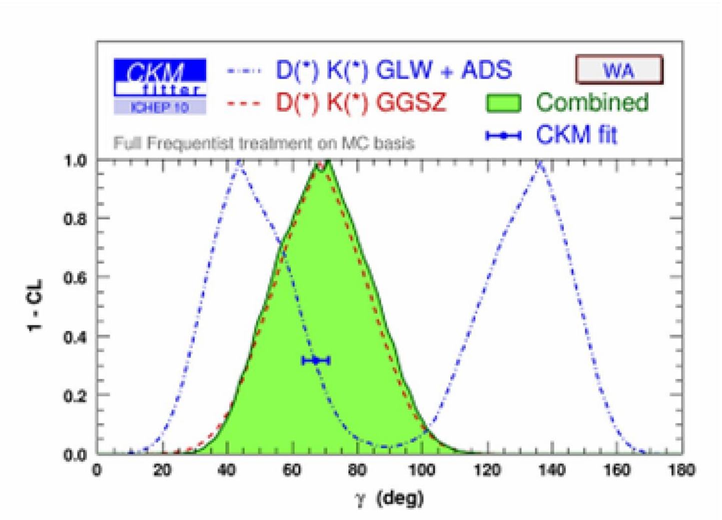
$$\gamma = (74 \pm 11)^\circ \text{ (Bayesian approach)}$$

$$\gamma = (73^{+21}_{-25})^\circ \text{ (Frequentist approach)}$$

Well compatible with the prediction from SM

$$\gamma = (69.6 \pm 3.0)^\circ \text{ (Bayesian approach)}$$

$$\gamma = (67.2\ ^{+3.7}_{-3.7})^\circ \text{ (Frequentist approach)}$$



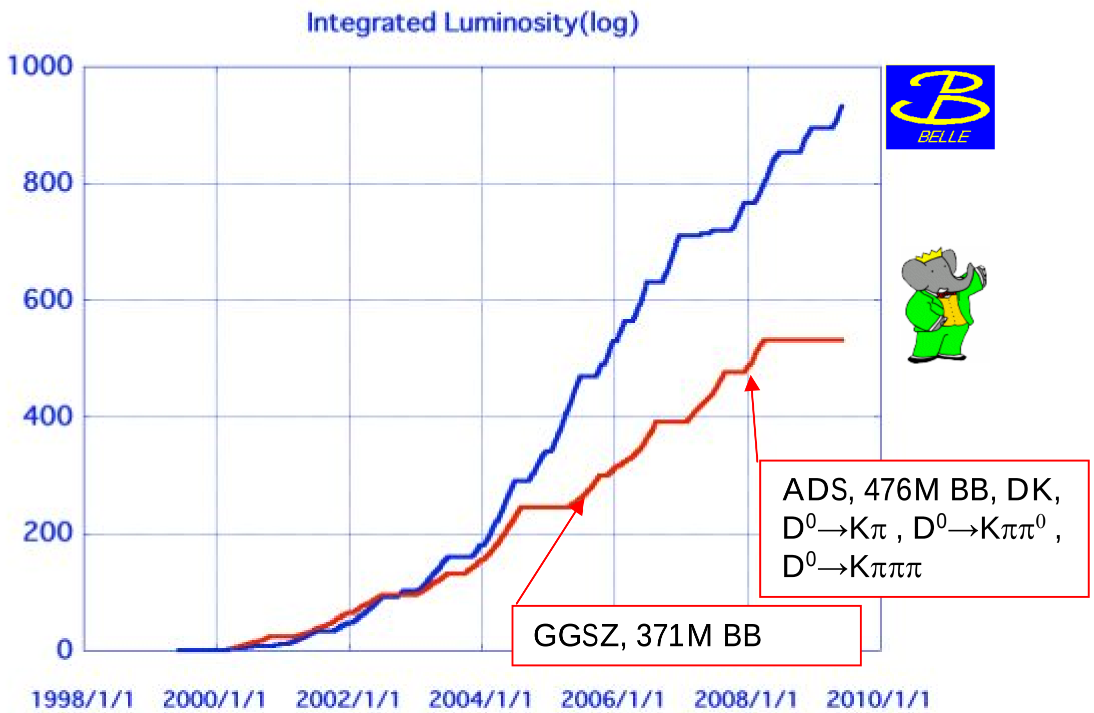
Need to reduce the error in order to see possible deviations:

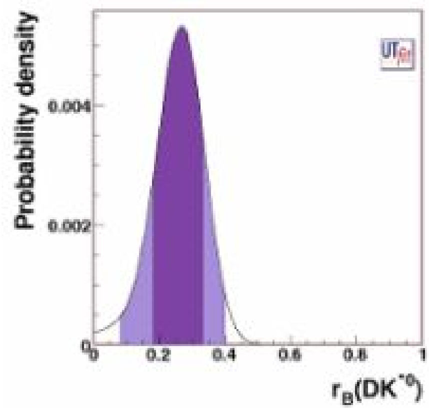
Backup

Breakdown of the systematic uncertainties for BELLE ADS

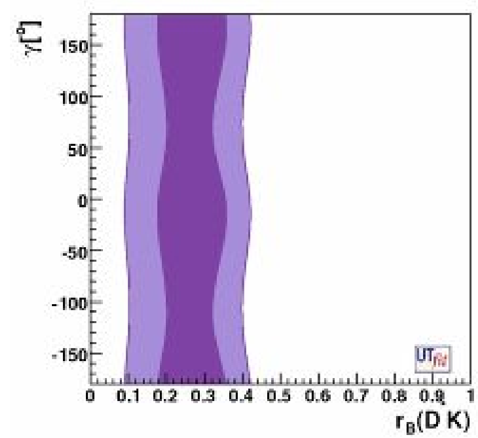
Source	$\mathcal{R}_{DK}$	$\mathcal{R}_{D\pi}$	$\mathcal{A}_{DK}$	$\mathcal{A}_{D\pi}$
Fit	${}^{+9.7}_{-6.3}\%$	${}^{+6.5}_{-5.3}\%$	${}^{+0.05}_{-0.04}$	${}^{+0.009}_{-0.018}$
(ΔE-PDF	${}^{+4.4}_{-3.6}\%$	${}^{+2.4}_{-2.3}\%$	± 0.02	± 0.003)
($\mathcal{NB}$-PDF	${}^{+4.2}_{-1.6}\%$	${}^{+4.0}_{-2.8}\%$	${}^{+0.02}_{-0.01}$	${}^{+0.001}_{-0.010}$)
(Yield and asymmetry	$\pm 1.1\%$	$\pm 0.1\%$	± 0.01	± 0.005)
Peaking backgrounds	${}^{+0.7}_{-9.9}\%$	${}^{+0.0}_{-4.1}\%$	${}^{+0.03}_{-0.00}$	${}^{+0.002}_{-0.000}$
Efficiency	$\pm 1.7\%$	$\pm 1.5\%$	$\cdots$	$\cdots$
Detector asymmetry	$\cdots$	$\cdots$	± 0.02	± 0.005

γ/ϕ_3 measurements from $B^0 \rightarrow DK^{*0}$





$$r_B(D^0 K^{*0}) = (\, 0.26 \pm 0.076 \,)$$



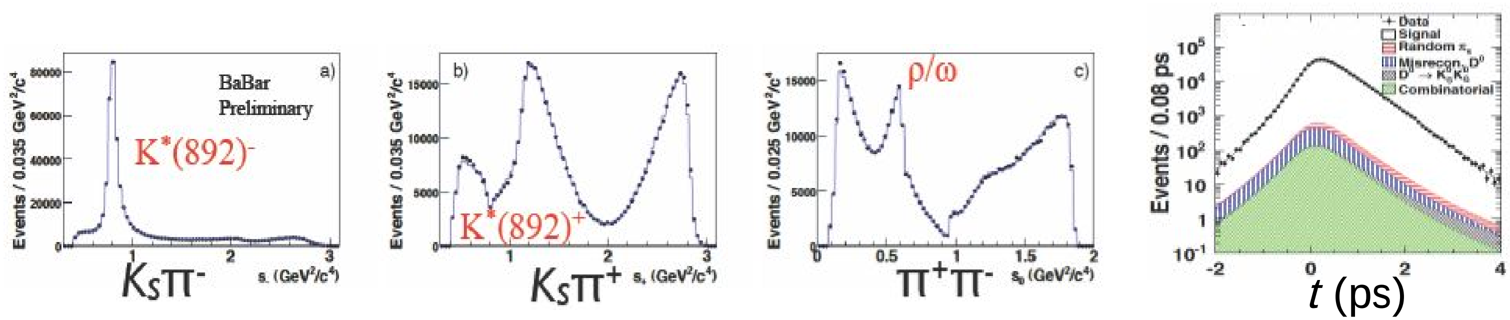
Promising channel at future experiments for measuring γ due to large value of r_B.
More statistics needed
D sector measurements play an important role.

$D^0 \rightarrow K_s h^+ h^-$ results from BaBar

PRL 105 081803 (2010)

$K_s \pi^+ \pi^-$

Signal : 541K
purity 98.5%

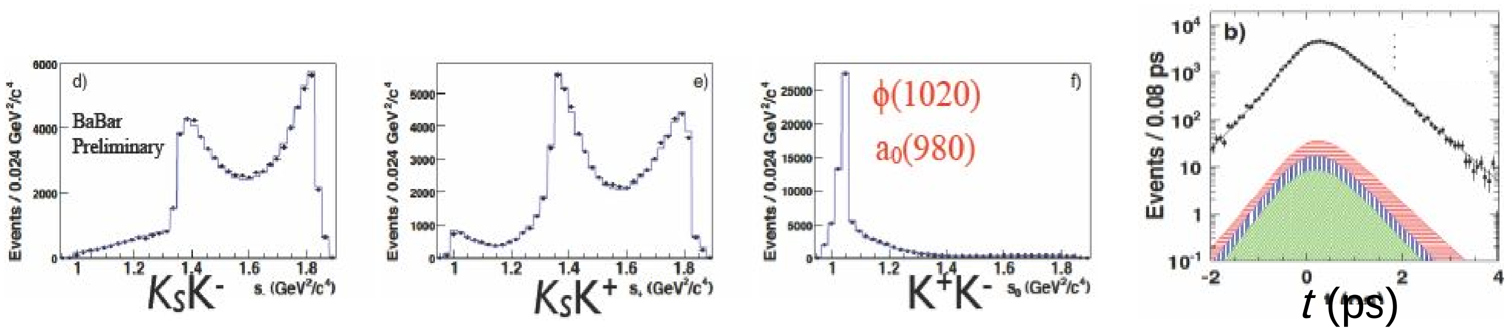


$\mathcal{A}_f$:

S-wave $\pi^+\pi^-$	**S-wave $K^0\pi^-$**	**P- and D-waves**
K-matrix model	LASS model	Breit-Wigner model

$K_s K^+ K^-$

Signal : 80K
purity 99.2%



$\mathcal{A}_f$:

S-wave K^+K^-	Coupled-channel Breit-Wigner a0(980)
All other waves	Breit-Wigners