D mixing and CP violation at SuperB

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SuperB B&charm datasets

baseline:

- CM energy: 10.58 GeV (allowed range: from Psi(3770) toY(5S))
- Luminosity: $1x10^{36}$ $cm^{-2}s^{-1}$
- $\sigma(e^+e^- \rightarrow Y(4S))$: ~1.1 nb
  $\sigma(e^+e^- \rightarrow c\bar{c})$: ~1.3 nb
- Dataset (5 yrs @ nominal L): **75 ab^{-1}**
  ~$8x10^{10}$ $B\bar{B}$ + 10^{11} $c\bar{c}$

cf. Babar+Belle:
1.2 ab^{-1}

possible run at charm threshold:

- CM energy: 3.77 GeV, @ Psi(3770)
- Luminosity: $1x10^{35}$ $cm^{-2}s^{-1}$
- $\sigma(e^+e^- \rightarrow Psi(3370))$: ~6.4 nb
- Dataset (0.5-1 yr @ nominal L): **0.5-1.0 ab^{-1}**

cf. CLEO-c: 0.8 fb^{-1}
BESIII: 2.9 fb^{-1}
(5-10 fb^{-1} planned)

D mixing and CPV measurements at B-factories

time-integrated analyses at B-factories

$D^0 \rightarrow K^+K^-, \pi^+\pi^-$	★ LHCb BELLE CDF	*Search for CPV*
$D^0 \rightarrow \pi^+\pi^-\pi^0$	BELLE	*Search for CPV (phase space integrated and in DP regions)*
$D^0 \rightarrow K^+K^-\pi^0$		*Search for CPV*
$D^0 \rightarrow K^+K^-\pi^+\pi^-$		*Search for CPV using T odd correlations (assuming CPT conserved)*
$D^0 \rightarrow K_S\pi^0, K_S\eta, K_S\eta'$	BELLE	*Search for CPV*
$D^0 \rightarrow K^+\pi^-\pi^0, K^+\pi^-\pi^+\pi^-$	BELLE	*Search for CPV*
$D^0 \rightarrow K^{(*)}l\upsilon$	BELLE	*Mixing (x^2+y^2)*

Legend: ★ = CPV evidence > 3σ

from HFAG, 27 Dec 2011

time-dependent analyses at B-factories

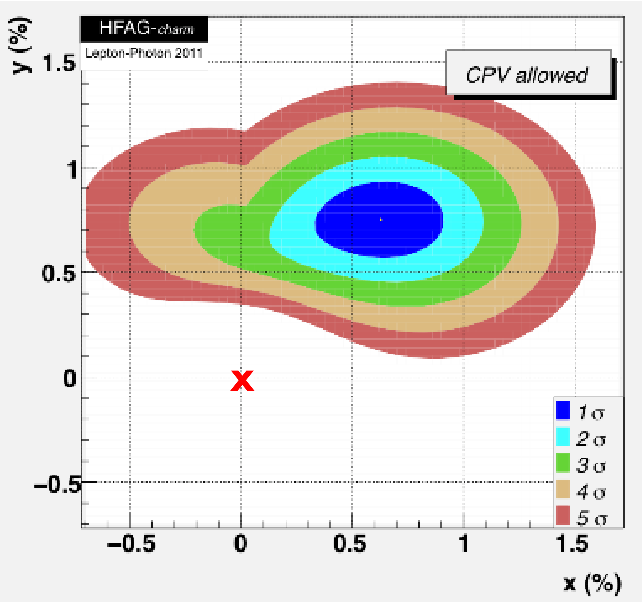
$D^0 \to K^+\pi^-$		★	BELLE	★ CDF II	*Mixing (x',y') and CPV*
$D^0 \to K^+K^-, \pi^+\pi^-$	LHCb	★	★ BELLE		*Mixing (y_{CP}) and CPV*
$D^0 \to K^+\pi^-\pi^0$		★			*Dalitz plot analysis. Mixing (x'',y'') and CPV*
$D^0 \to K_S\pi^+\pi^-$			BELLE		*Dalitz plot analysis. Mixing (x,y) and indirect CPV ($\lvert q/p \rvert$,ϕ)*
$D^0 \to K_S K^+ K^-$					
$D^0 \to K_S\phi$			BELLE		*Mixing (y_{CP})*

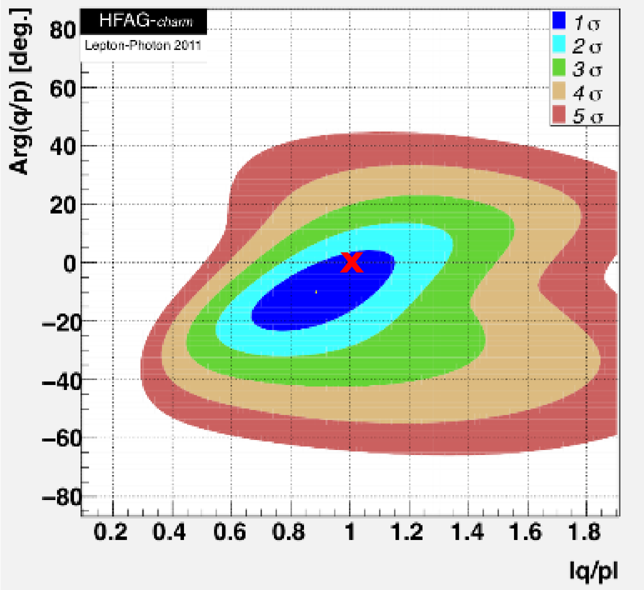
from HFAG, 27 Dec 2011

Legend: ★ = mixing evidence > 3σ

HFAG average of mixing results

updated on 4 Sep 2011





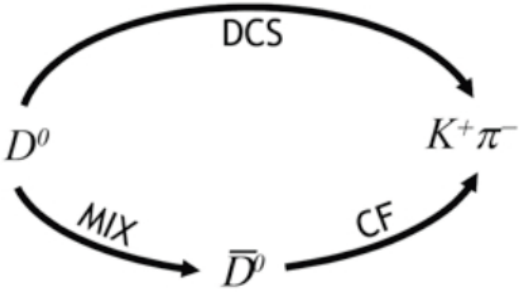
Parameter	No CPV	No direct CPV	CPV-allowed	CPV-allowed 95% C.L.
x (%)	$0.65\,^{+0.18}_{-0.19}$	$0.63\,\pm 0.19$	$0.63\,^{+0.19}_{-0.20}$	$[0.24,\ 0.99]$
y (%)	$0.74\,\pm 0.12$	$0.75\,\pm 0.12$	$0.75\,\pm 0.12$	$[0.52,\ 0.99]$
δ (°)	$21.3\,^{+9.8}_{-11.1}$	$22.5\,^{+9.9}_{-11.2}$	$22.4\,^{+9.7}_{-11.0}$	$[-2.2,\ 40.9]$
R_D (%)	$0.3308\,\pm 0.0080$	$0.3306\,\pm 0.0080$	$0.3311\,\pm 0.0081$	$[0.315,\ 0.347]$
A_D (%)	–	–	$-1.7\,\pm 2.3$	$[-6.3,\ 2.8]$
$\lvert q/p\rvert$	–	$1.02\,\pm 0.04$	$0.89\,^{+0.17}_{-0.15}$	$[0.61,\ 1.24]$
ϕ (°)	–	$-1.05\,^{+1.89}_{-1.94}$	$-10.1\,^{+9.4}_{-8.8}$	$[-27.2,\ 8.6]$
$\delta_{K\pi\pi}$ (°)	$18.0\,^{+21.7}_{-22.8}$	$19.4\,^{+21.8}_{-22.9}$	$19.5\,^{+21.8}_{-22.9}$	$[-26.1,\ 61.8]$
A_π	–	–	$0.22\,\pm 0.28$	$[-0.34,\ 0.76]$
A_K	–	–	$-0.20\,\pm 0.24$	$[-0.67,\ 0.27]$

$D\bar{D}$ mixing with $D^0 \rightarrow K^+\pi^-$

- First evidence of D mixing
- "Wrong sign" $K^+\pi^-$ final state as result of interference between double-Cabibbo-suppressed decay and D mixing followed by Cabibbo-allowed decay

time-dependent decay rate:

$$\frac{dN}{dt} \propto e^{-\Gamma t}\left(\underbrace{R_D}_{0.05\text{ x }0.05} + \underbrace{y'\sqrt{R_D}}_{0.01\text{ x }0.05}(\Gamma t) + \underbrace{\frac{x'^2+y'^2}{4}}_{0.01\text{ x }0.01}(\Gamma t)^2\right)$$



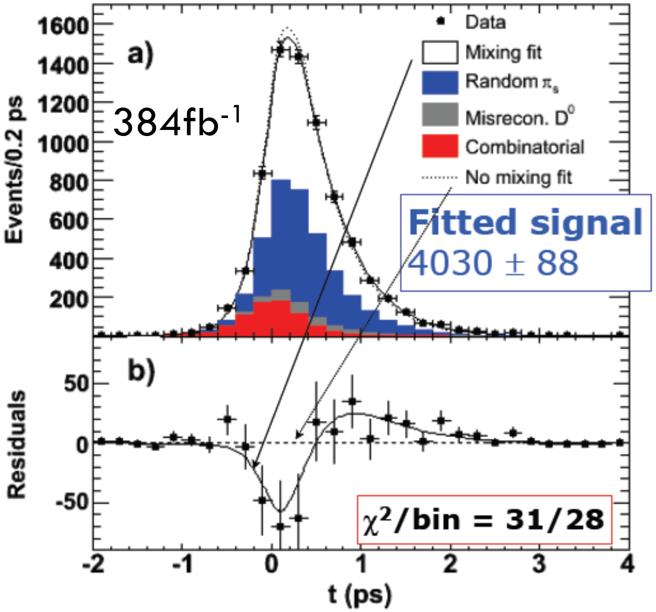
$$\frac{A(D^0 \rightarrow K^+\pi^-)}{A(D^0 \rightarrow K^-\pi^+)} = \sqrt{R_D}e^{i\delta}$$

$$y' = -x\sin\delta + y\cos\delta$$
$$x' = x\cos\delta + y\sin\delta$$

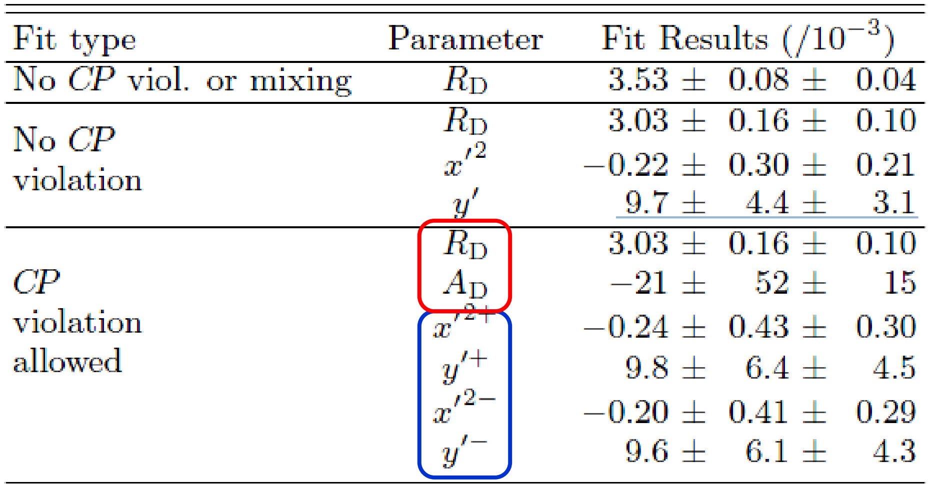
From the proper time distribution R_D, y' and x'^2 are measured

the phase between the D^0 and $\bar{D}^0$ amplitude must be provided externally to derive x,y from x',y'

Babar measurement of mixing with $D^0 \rightarrow K\pi$



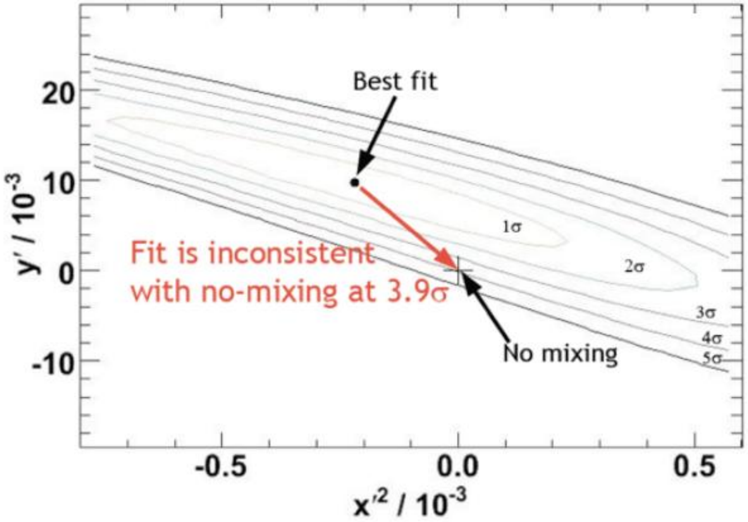
Phys. Rev. Lett. 98, 211802 (2007)



Fit type	Parameter	Fit Results ($/10^{-3}$)
No *CP* viol. or mixing	R_D	3.53 ± 0.08 ± 0.04
No *CP* violation	R_D	3.03 ± 0.16 ± 0.10
	x'^2	−0.22 ± 0.30 ± 0.21
	y'	9.7 ± 4.4 ± 3.1
CP violation allowed	R_D	3.03 ± 0.16 ± 0.10
	A_D	−21 ± 52 ± 15
	x'^{2+}	−0.24 ± 0.43 ± 0.30
	y'^{+}	9.8 ± 6.4 ± 4.5
	x'^{2-}	−0.20 ± 0.41 ± 0.29
	y'^{-}	9.6 ± 6.1 ± 4.3

$$R_D = \sqrt{R_D^+ R_D^-} \qquad A_D = \frac{R_D^+ - R_D^-}{R_D^+ + R_D^-}$$

Separate fits for flavor-tagged D^0 and $\overline{D^0}$ are sensitive to CP violation in mixing and decay



evidence of D mixing at 3.9 σ
no evidence of CPV found

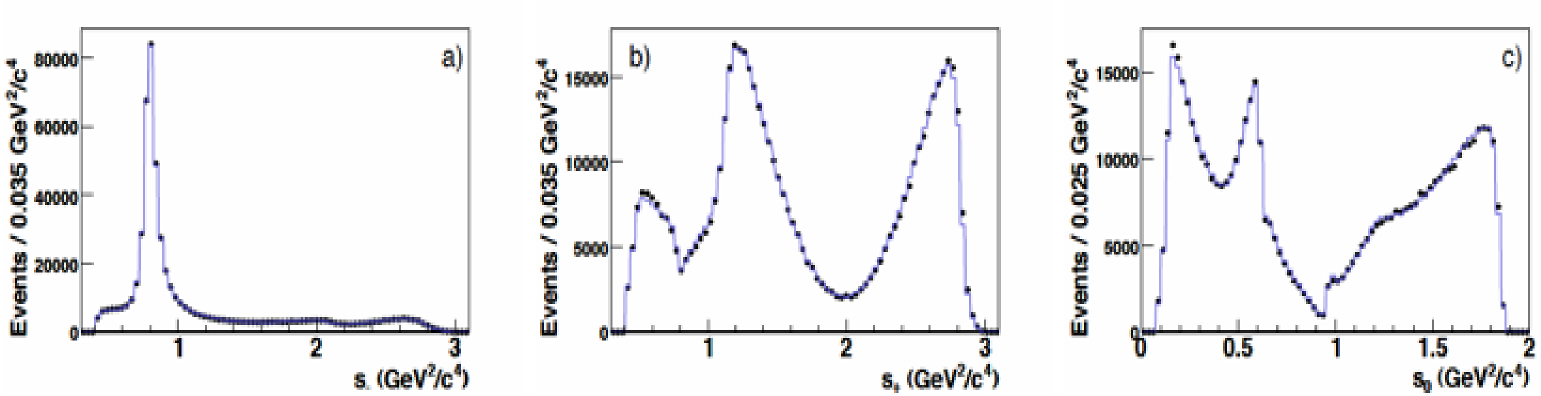
$D\bar{D}$ mixing with $D^0 \rightarrow K_S\pi^+\pi^-$

- At present most powerful method to measure x and y at the same time
- Same principle as $D \rightarrow K\pi$, but " R_D " and " y' " is a function of the position in the final state Dalitz plot.

$$\frac{dN_f(s_{12},s_{13},t)}{ds_{12}ds_{13}dt} \propto e^{-\Gamma t}\left\{|A_f|^2 + \left[y\underbrace{\mathrm{Re}(A_f^*\bar{A}_f)} - x\underbrace{\mathrm{Im}(A_f^*\bar{A}_f)}\right](\Gamma t) + \frac{x^2+y^2}{4}(\Gamma t)^2|\bar{A}_f|^2\right\}$$

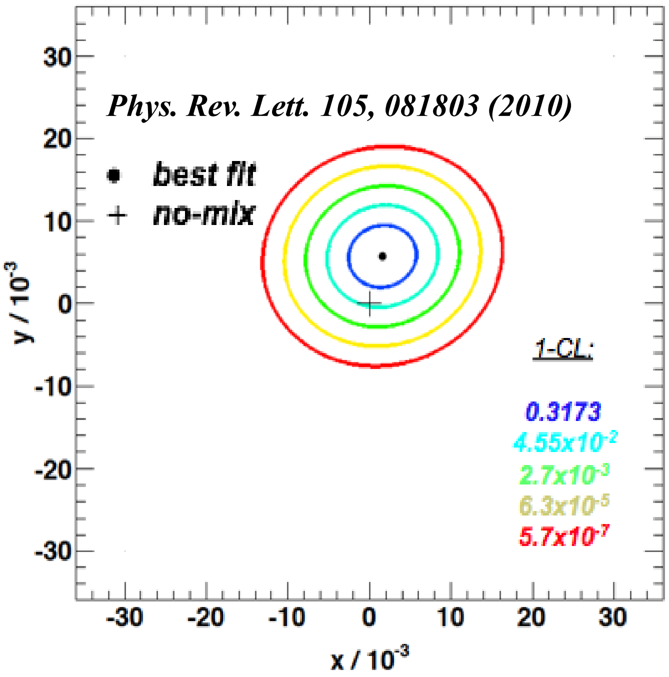
$$A_f = A(s_{12},s_{13}) \qquad \bar{A}_f = \bar{A}(s_{12},s_{13}) \qquad (s_{12},s_{13}) = \text{Dalitz plot location}$$

Model dependent approach. Requires parameterization of the D^0 decay amplitude in the Dalitz plot.



both x and y are measured from the proper time distribution

Babar measurement of mixing with $D^0 \rightarrow K_S\pi^+\pi^-$



Combined $K_S\pi^+\pi^-$ + $K_SK^+K^-$ fit results assuming CP conservation:

$$x = [0.16 \pm 0.23(\text{stat.}) \pm 0.12(\text{syst.}) \pm 0.08(\text{model})]\,\%$$

$$y = [0.57 \pm 0.20(\text{stat.}) \pm 0.13(\text{syst.}) \pm 0.07(\text{model})]\,\%$$

Currently very good sensitivity compared to other methods

Difficult to reduce the model uncertainty futher
It will dominate at next generation B-factories

The method can be extended to other 3-body states, e.g. $K^+\pi^-\pi^0$

$$x'' = x\cos\delta_{K\pi\pi^0} + y\sin\delta_{K\pi\pi^0} \qquad y'' = -x\sin\delta_{K\pi\pi^0} + y\cos\delta_{K\pi\pi^0}$$

$$\delta_{K\pi\pi^0} = \arg\left(\frac{A(D^0 \to K^+\rho^-)}{A(\overline{D}^0 \to K^+\rho^-)}\right)$$

Method pioneered by BaBar Collaboration:
Phys.Rev.Lett.103:211801,2009

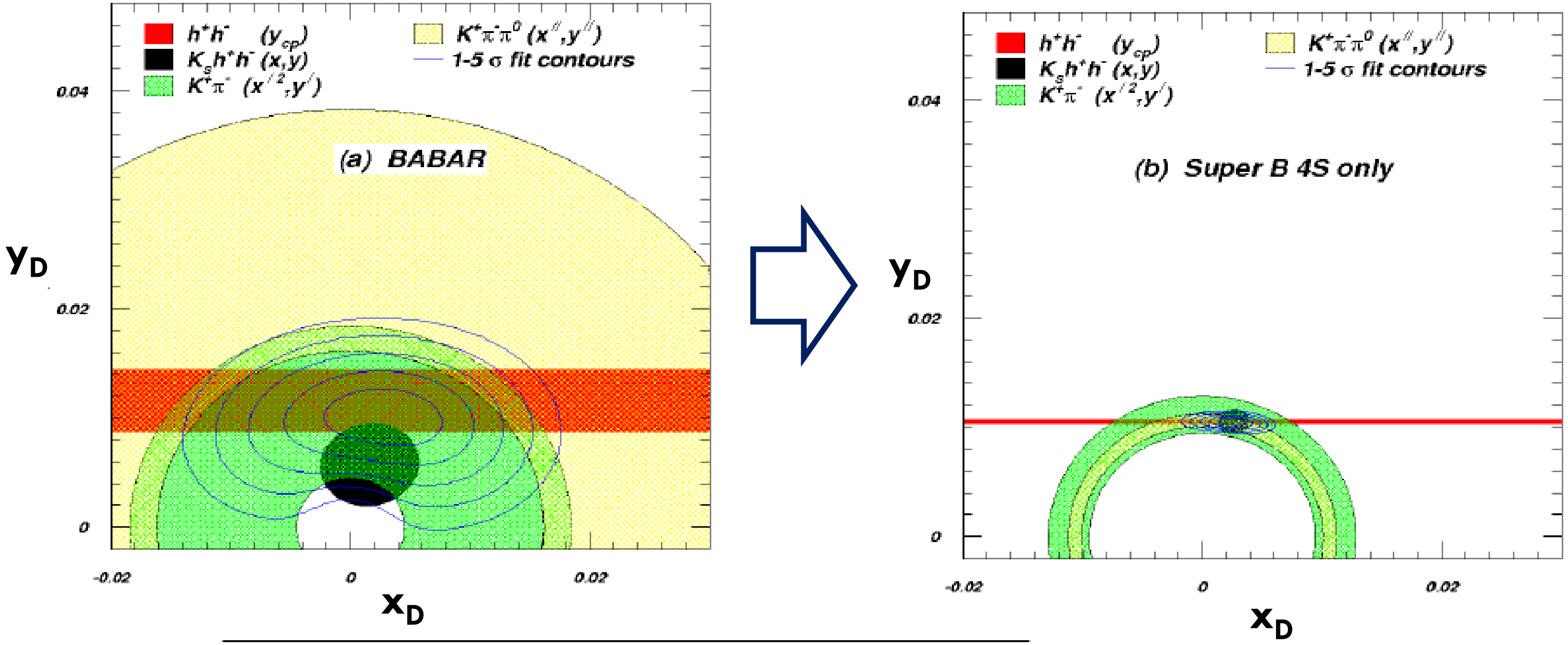
D mixing and CPV sensitivity studies at SuperB

Sensitivity projections at SuperB

- Estimates made by extrapolating the Babar results to the SuperB dataset ($75ab^{-1}$)
- Statistical error scales as $1/\sqrt{\text{integrated luminosity}}$
- Reasonable to assume the same for systematics
  - mostly determined from data and scalable with statistics
  - except for:

irreducible systematic uncertainty associated to the Dalitz model in $D^0 \rightarrow Ks\ h^+h^-$ ($h=\pi$, K) analysis, around 0.5×10^{-3} in x and y

Sensitivity projections



Babar **(0.48ab^{-1})**

SuperB **(75ab^{-1})**

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(a)	$3.01^{+3.12}_{-3.39}$	$10.10^{+1.69}_{-1.72}$	$41.3^{+22.0}_{-24.0}$	43.8 ± 26.4
Stat.	(2.76)	(1.36)	(18.8)	(22.4)
(b)	$xxx^{+0.72}_{-0.75}$	$xxx \pm 0.19$	$xxx^{+3.7}_{-3.4}$	$xxx^{+4.6}_{-4.5}$
Stat.	(0.18)	(0.11)	(1.3)	(2.9)

x→x/4 y→y/8

no input from external measurements of strong phases included

x precision limited by D→Kshh Dalitz model systematic

Using Ψ(3770) data to constrain the strong phases

J^{CP} (Ψ(3770))=1^{--} BF(Ψ(3770)→D$\bar{\text{D}}$) =50%

- At the generic time t the D and $\bar{\text{D}}$ states evolve coherently:

$$|f(t)\rangle = \frac{1}{\sqrt{2}}\left(|D^0(\boldsymbol{k},t)\rangle|\bar{D}^0(-\boldsymbol{k},t)\rangle - |\bar{D}^0(\boldsymbol{k},t)\rangle|D^0(-\boldsymbol{k},t)\rangle\right)$$

- The time dependence of their subsequent decays to f_1 and f_2 is:

$$\frac{d\Gamma[\Psi(3770)\to f(t)\to(t_1,f_1)(t_2,f_2)]/d\Delta t}{e^{-\Gamma|\Delta t|}\mathcal{N}_{f_1f_2}} =$$

$$\left(|a_+|^2+|a_-|^2\right)\cosh(y\Gamma\Delta t)+\left(|a_+|^2-|a_-|^2\right)\cos(x\Gamma\Delta t)$$

$$-2\mathcal{R}e((a_+^*a_-)\sinh(y\Gamma\Delta t)+2\mathcal{I}m(a_+^*a_-)\sin(x\Gamma\Delta t)$$

$$a_+ \equiv \bar{A}_{f_1}A_{f_2}-A_{f_1}\bar{A}_{f_2} \qquad a_- \equiv \frac{p}{q}A_{f_1}A_{f_2}-\frac{q}{p}\bar{A}_{f_1}\bar{A}_{f_2}$$

$\Delta t = t_2 - t_1$

$$A_f = \langle f\,|\,H\,|\,D^0\rangle$$

$$\bar{A}_f = \langle f\,|\,H\,|\,\bar{D}^0\rangle$$

- D$\bar{\text{D}}$ coherence gives access to interference terms not accessible at Y(4S)

f_1 = CP+/-, $K^+\pi^-$, Ksh^+h^-, … **+** f_2 = CP+/-, $K^+\pi^-$, Ksh^+h^-, …

Using Ψ(3770) data to constrain the strong phases

- Interference terms accessible at $D\overline{D}$ threshold allow measurements of strong phases ($\delta_{K\pi}$, $\delta_{K\pi\pi 0}$, $\delta_{K3\pi}$):

Example: CP-tagged $D^0 \rightarrow K^+\pi^-$ decays:

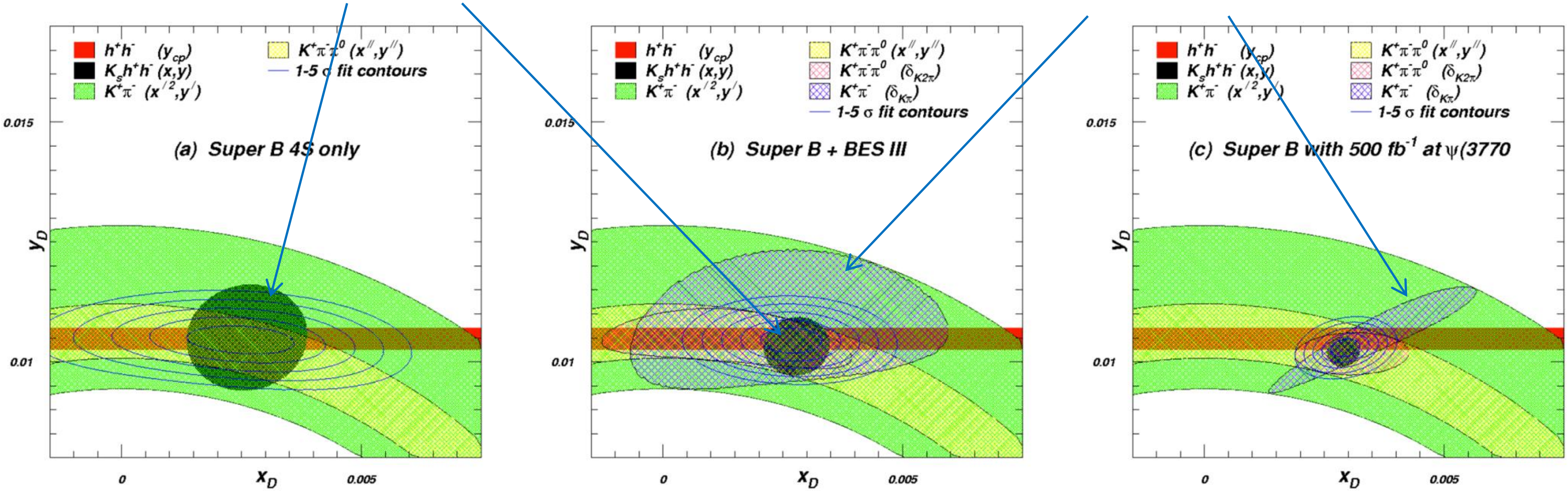
$$\int R(S_\pm, K^-\pi^+; t)e^{-\Gamma|t|}dt \propto 1 \pm 2\boxed{\sqrt{R_D}\cos\delta_{K\pi}} + R_D$$

- Also provide measurement of δ as a function of Dalitz plot position:
  - this helps reducing the Dalitz model uncertainties for 3-body decay modes $K_S h^+ h^-$
- We take results from CLEO-c as a basis for projection:
  - *D. M. Asner et al., Phys Rev D78, 012001(2008), 0802.2268.* Kπ
  - *N. Lowrey et al, Phys Rev D80, 031105 (2009), 0903.4853* $K\pi\pi^0$, $K3\pi$
- In the following projections we assume that new data from threshold will reduce the model uncertainty
  - BESIII – factor 3 improvement in model uncertainty
  - SuperB @ Ψ(3770) 500fb^{-1} – factor 10 improvement

SuperB sensitivity using Ψ(3770) data

Dalitz plot model uncertainty shrinks

information on strong phases is added



Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(b)	$xxx^{+0.72}_{-0.75}$	$xxx \pm 0.19$	$xxx^{+3.7}_{-3.4}$	$xxx^{+4.6}_{-4.5}$
Stat.	(0.18)	(0.11)	(1.3)	(2.9)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(c)	$xxx \pm 0.42$	$xxx \pm 0.17$	$xxx \pm 2.2$	$xxx^{+3.3}_{-3.4}$
Stat.	(0.18)	(0.11)	(1.3)	(2.7)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(d)	$xxx \pm 0.20$	$xxx \pm 0.12$	$xxx \pm 1.0$	$xxx \pm 1.1$
Stat.	(0.17)	(0.10)	(0.9)	(1.1)

Uncertainty in x_D improves more than that of y_D

using a model independent approach

D→3-body model independent approach

- A. Bondar, A. Pluektov, V. Vorobiev have proposed a model independent analysis of 3-body D0 decays for mixing and CPV. See Phys Rev D82, 034033 (2010)

Sensitivity relies on the variation of the yields vs time in different regions of the Dalitz plot. Decays in different bins can be considered as 'independent channels.'
No amplitude analysis.

time dependence
for flavor-tagged
D^0 decays

$$\begin{aligned}\frac{d\Gamma_i[D^0_{\rm phys}\to f]/dt}{e^{-\Gamma t}\mathcal{N}_f} &= \Bigg[\left(T_i+\left|\frac{q}{p}\right|^2\bar{T}_i\right)\cosh(\Gamma y t)+\left(T_i-\left|\frac{q}{p}\right|^2\bar{T}_i\right)\cos(\Gamma x t)\\ &+\ 2\left(c_i\sqrt{T_i\bar{T}_i}\left|\frac{q}{p}\right|\cos\phi-s_i\sqrt{T_i\bar{T}_i}\left|\frac{q}{p}\right|\sin\phi\right)\sinh(\Gamma y t)\\ &-\ 2\left(c_i\sqrt{T_i\bar{T}_i}\left|\frac{q}{p}\right|\sin\phi+s_i\sqrt{T_i\bar{T}_i}\left|\frac{q}{p}\right|\cos\phi\right)\sin(\Gamma x t)\Bigg]\end{aligned}$$

where:

$$A_f = |A_f|e^{i\delta_f} \qquad \bar{A}_f = |\bar{A}_f|e^{i\bar{\delta}_f}$$

$$\int_i |A_f|^2 d\mathcal{P} = T_i \qquad \int_i |\bar{A}_f|^2 d\mathcal{P} = \bar{T}_i$$

measurable at Psi(3770) or left floating in fit

$$\frac{\int_i \mathcal{R}e(A_f^*\bar{A}_f)d\mathcal{P}}{\sqrt{T_i\bar{T}_i}} = \frac{\int_i |A_f||\bar{A}_f|\cos(\bar{\delta}_f-\delta_f)d\mathcal{P}}{\sqrt{T_i\bar{T}_i}} = c_i$$

$$\frac{\int_i \mathcal{I}m(A_f^*\bar{A}_f)d\mathcal{P}}{\sqrt{T_i\bar{T}_i}} = \frac{\int_i |A_f||\bar{A}_f|\sin(\bar{\delta}_f-\delta_f)d\mathcal{P}}{\sqrt{T_i\bar{T}_i}} = s_i$$

measured at Psi(3770)

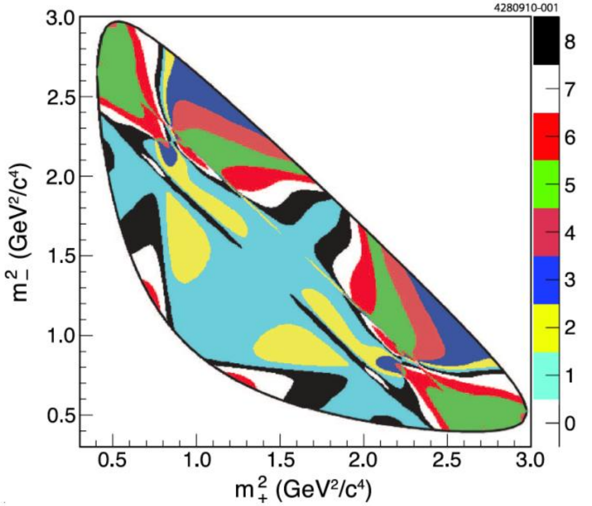
goal:
extract
x
y
|q/p|
ϕ

Determination of c_i,s_i at $\Psi(3770)$

- ci, si determination requires DD coherent production. The method has been proved to work well by CLEO-c. **Phys. Rev. D 82, 112006 (2010).**

- c_i, s_i from time integrated analysis of $\Psi(3770)$ data is affected by $O(x^2,y^2)$ approximations

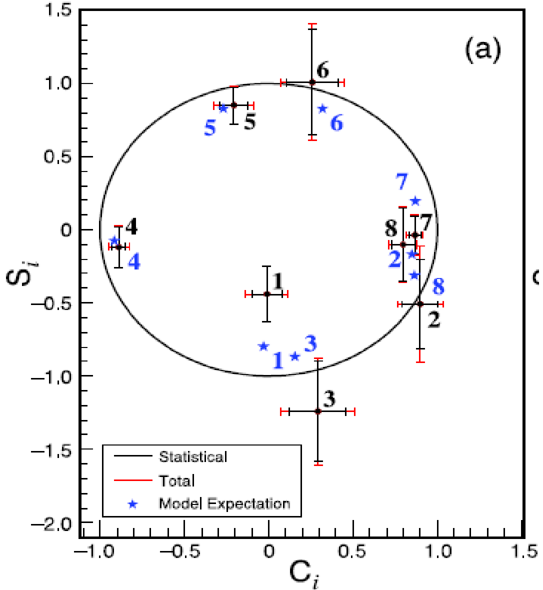
$D^0 \rightarrow K^0_S \pi^+ \pi^-$



the $i^{\rm th}$ bin is defined by the condition

$$2\pi(i-3/2)/\mathcal{N} < \Delta\delta_D(m^2_+, m^2_-) < 2\pi(i-1/2)/\mathcal{N},$$

Good agreement between BaBar Dalitz model expectation and CLEO-c model independent determination of D^0-$\bar{D}^0$ relative phases.



T_i, $\overline{T}_i$, two possibilities:

- Measured from a time-integrated analysis at $\Psi(3770)$ [affected by $O(x^2,y^2)$ approx]
- Left floating as unknowns in the time-dependent analysis at Y(4S) together with x, y and the CP parameters (larger stat error, smaller systematic error)

sensitivity study

- Sensitivity studies for mixing and CPV with model independent approach
  - assume perfect proper time resolution and no background
  - assume very precise determination of ci, si (2×10^6 flavor tagged $D^0 \rightarrow K_S \pi^+ \pi^-$ decays at $\Psi(3770)$)
  - SuperB predictions scaled from current B-factories assuming 1/sqrt(N)

Phys Rev D82, 034033 (2010)

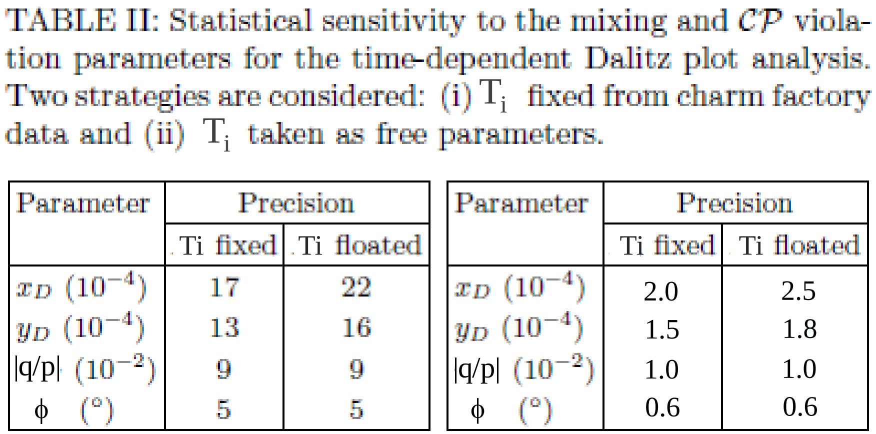


TABLE II: Statistical sensitivity to the mixing and CP violation parameters for the time-dependent Dalitz plot analysis. Two strategies are considered: (i) T_i fixed from charm factory data and (ii) T_i taken as free parameters.

Parameter	Precision	
	Ti fixed	Ti floated
x_D (10^{-4})	17	22
y_D (10^{-4})	13	16
$\|q/p\|$ (10^{-2})	9	9
ϕ (°)	5	5

Parameter	Precision	
	Ti fixed	Ti floated
x_D (10^{-4})	2.0	2.5
y_D (10^{-4})	1.5	1.8
$\|q/p\|$ (10^{-2})	1.0	1.0
ϕ (°)	0.6	0.6

B factories

1M signal events

SuperB

75M signal events

The model-independent method can be applied to other 3-body decays such as $D \rightarrow K^+ \pi^- \pi^0$

investigating the possibility of time-dependent measurements at charm threshold

time-dependent measurements at Ψ(3770)

- Current design of SuperB machine allows running at Ψ(3770) with asymmetric beams. We want to investigate the possibility of time-dependent measurements at Ψ(3770) and evaluate the sensitivity to mixing and CPV parameters.
- Unique feature of SuperB to be evaluated
  - additional tag states (e.g. CP tag) other than flavor eigenstates exploiting DDbar coherence
  - low background environment compared to Y(4S)

term accessible
at symmetric machines
used to measure $\delta_{K\pi}$

example: $D^0 \rightarrow K^+\pi^-$ with CP tag

$$
\begin{aligned}
R_{odd}(S_\eta, K^-\pi^+;\Delta t) = \left|A_{S_\eta} A_{K^-\pi^+}\right|^2 \Bigg\{ & 2\left(1 + 2\eta\sqrt{R_D}\cos\delta_{K\pi} + R_D\right) \\
& + \left[\left(\eta\left|\frac{p}{q}\right|\cos\phi + \sqrt{R_D}\cos(\delta_{K\pi}-\phi)\left(\left|\frac{q}{p}\right| + \left|\frac{p}{q}\right|\right) + R_D\left|\frac{q}{p}\right|\cos\phi\right) y \right. \\
& \left. + \left(-\eta\left|\frac{p}{q}\right|\sin\phi + \sqrt{R_D}\sin(\delta_{K\pi}-\phi)\left(\left|\frac{q}{p}\right| - \left|\frac{p}{q}\right|\right) + R_D\left|\frac{q}{p}\right|\sin\phi\right) x \right](\Gamma\Delta t) \\
& + \frac{1}{2}\left[\left(\left(1 + \left|\frac{p}{q}\right|^2\right) + 2\eta\sqrt{R_D}\left(\cos\delta_{K\pi} + \cos(\delta_{K\pi} - 2\phi)\right) + R_D\left(1 + \left|\frac{q}{p}\right|^2\right)\right) y^2 \right. \\
& \left. - \left(\left(1 - \left|\frac{p}{q}\right|^2\right) + 2\eta\sqrt{R_D}\left(\cos\delta_{K\pi} - \cos(\delta_{K\pi} - 2\phi)\right) + R_D\left(1 - \left|\frac{q}{p}\right|^2\right)\right) x^2 \right](\Gamma\Delta t)^2 \Bigg\}
\end{aligned}
$$

term only accessible
with time-dependent
measurement

overview of sensitivity study

- Estimate sensitivity from time-dependent measurements at $\Psi(3770)$ vs CM boost, and compare with expectations at Y(4S)
- Consider 2-body decays. 3-body decays next step.
- For $\Psi(3770)$:
  - Extrapolate CLEO-c yields to SuperB dataset (**$0.5ab^{-1}$**)
  - Correct by SuperB geometrical eff. vs CM boost
  - evaluate proper time resolution function vs CM boost
- For Y(4S):
  - Extrapolate Babar yields to SuperB dataset (**$75ab^{-1}$**)
  - assume proper time resolution ~0.15ps

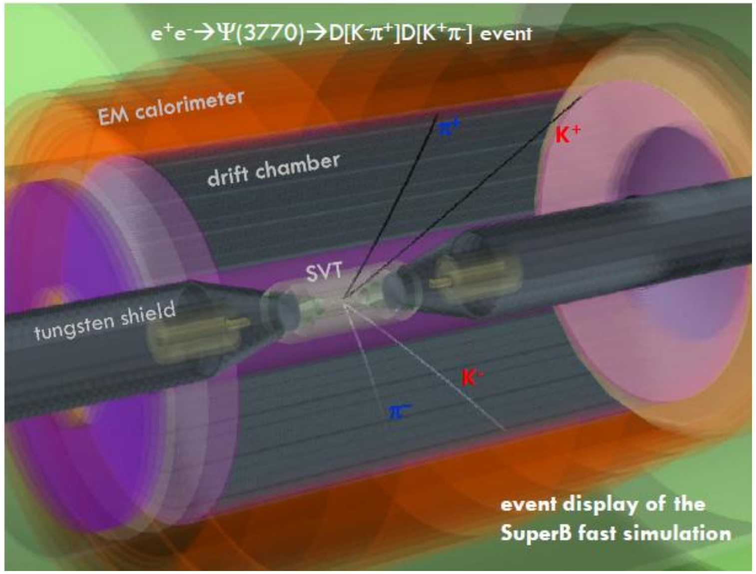
Double tags @ $\Psi(3770)$

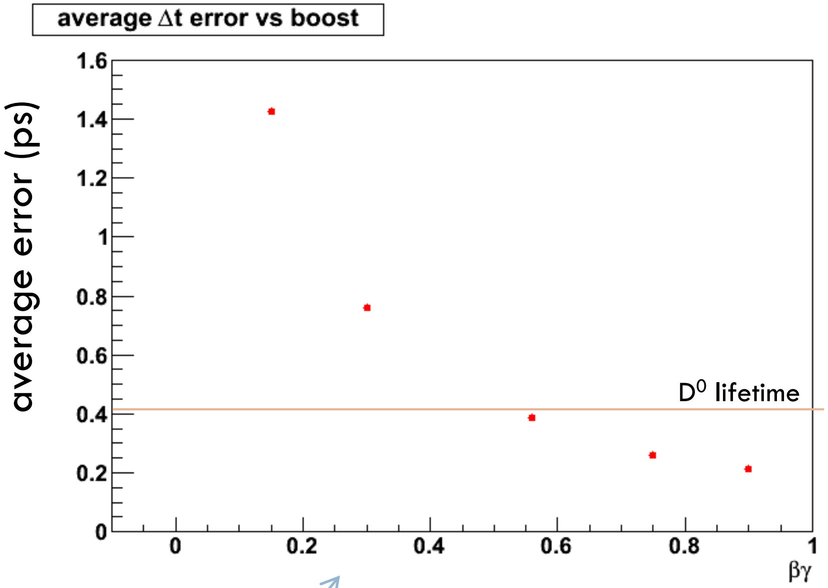
Modes with D* tag @ $\Upsilon(4S)$

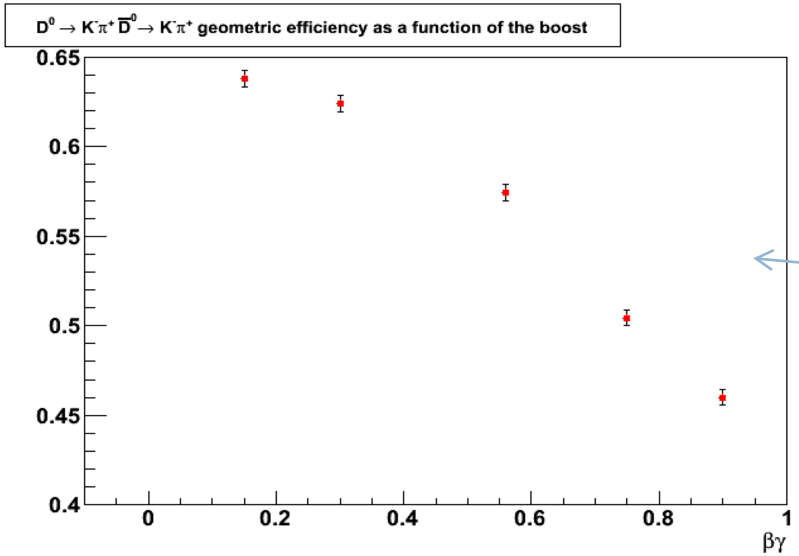
	CP–	Kπ	*l*X
CP+	X	X	XX
CP–		X	XX
Kπ		X	XX
*l*X			XX

- Strategy
  - Generate O(100) datasets for both $\Psi(3770)$ and Y(4S), and for each fit simultaneously for the mixing and CPV parameters: x, y, arg(q/p), |q/p|
  - Assumed CP conservation in decay
  - D→Kπ strong phase kept fixed

simulation



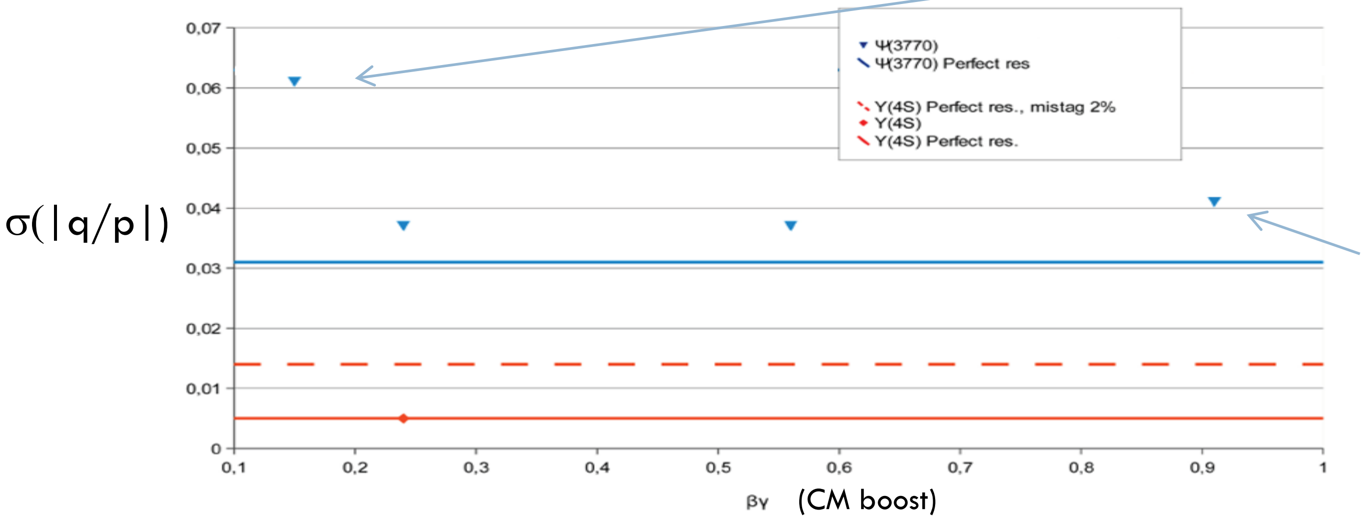




- SuperB fast simulation study
- Δt resolution improves with increasing boost
- geometric efficiency worsens with increasing boost
- look for best compromise between good time reso. and reco. efficiency

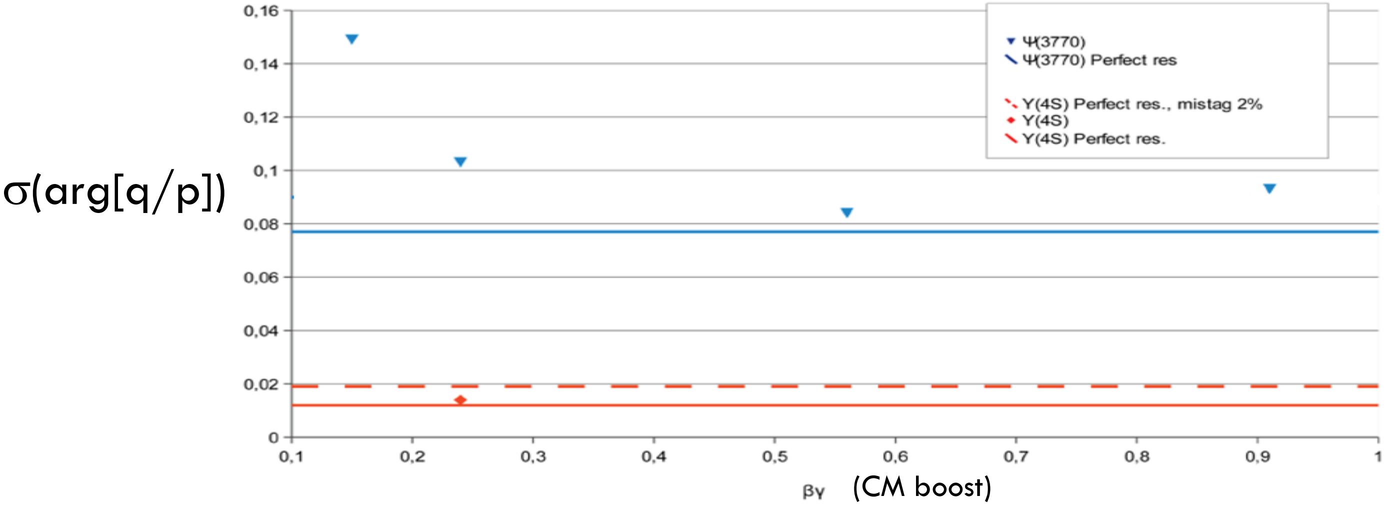
preliminary results

examples:



error diverges because proper time resolution is poor

error increases because reconstruction efficiency decreases



time-dep study at $\Psi(3770)$: preliminary results

Parameter	**Sensitivity @ $\Upsilon(4S)$ with time resolution, no mistag. 75 ab^{-1}**	**Best sensitivity @ $\psi(3770)$ with time resolution ($\beta\gamma$=0.56), no mistag. 0.5 ab^{-1}**
x	0.017%	0.11%
y	0.008%	0.05%
Arg(q/p)	0.8 deg	4.8 deg
|q/p|	0.5%	3.7%

run size might actually be 1ab^{-1}

- Best sensitivity at $\Psi(3770)$ for intermediate boost, $\beta\gamma$~0.3-0.6
- error per ab^{-1} at $\Psi(3770)$ ~ ½ error per ab^{-1} at Y(4S) (2-body only, no mistag)
- error at $\Psi(3770)$ [0.5ab^{-1}] ~ 6x error at $\Upsilon(4S)$ [75ab^{-1}] (2-body only, no mistag)
- Next steps: addition of 3-body decays (with model-indep analysis), backgrounds, mistag

Summary

- SuperB is also a charm factory: unique opportunity to search for new physics.

- Sensitivity studies to assess the SuperB physics reach in the charm sector are ongoing. Here we have mostly focused on mixing and CPV in time-dependent measurements.

- Data at charm threshold play important role to improve sensitivities and reduce systematic errors.

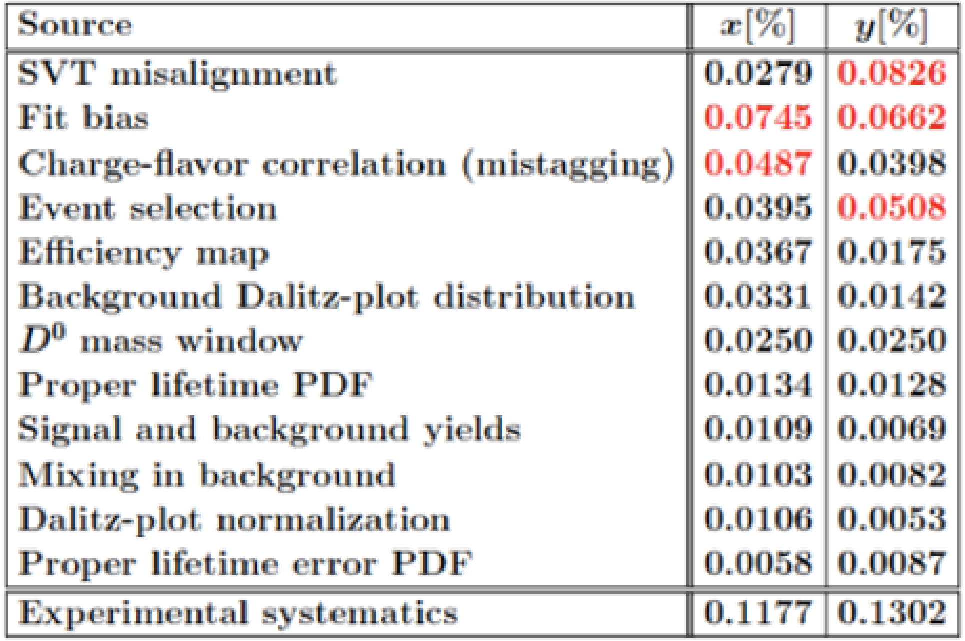
- Expected sensitivity at SuperB including threshold data:
  - error on x,y ~ 10^{-4}
  - error on $|q/p| \sim 10^{-2}$; error on $\arg(q/p) \sim 1$deg

- Feasibility and impact of time-dependent measurements at charm threshold under evaluation

BACKUP

Babar $D^0 \rightarrow K_S\pi^+\pi^-$ mixing

Experimental systematics

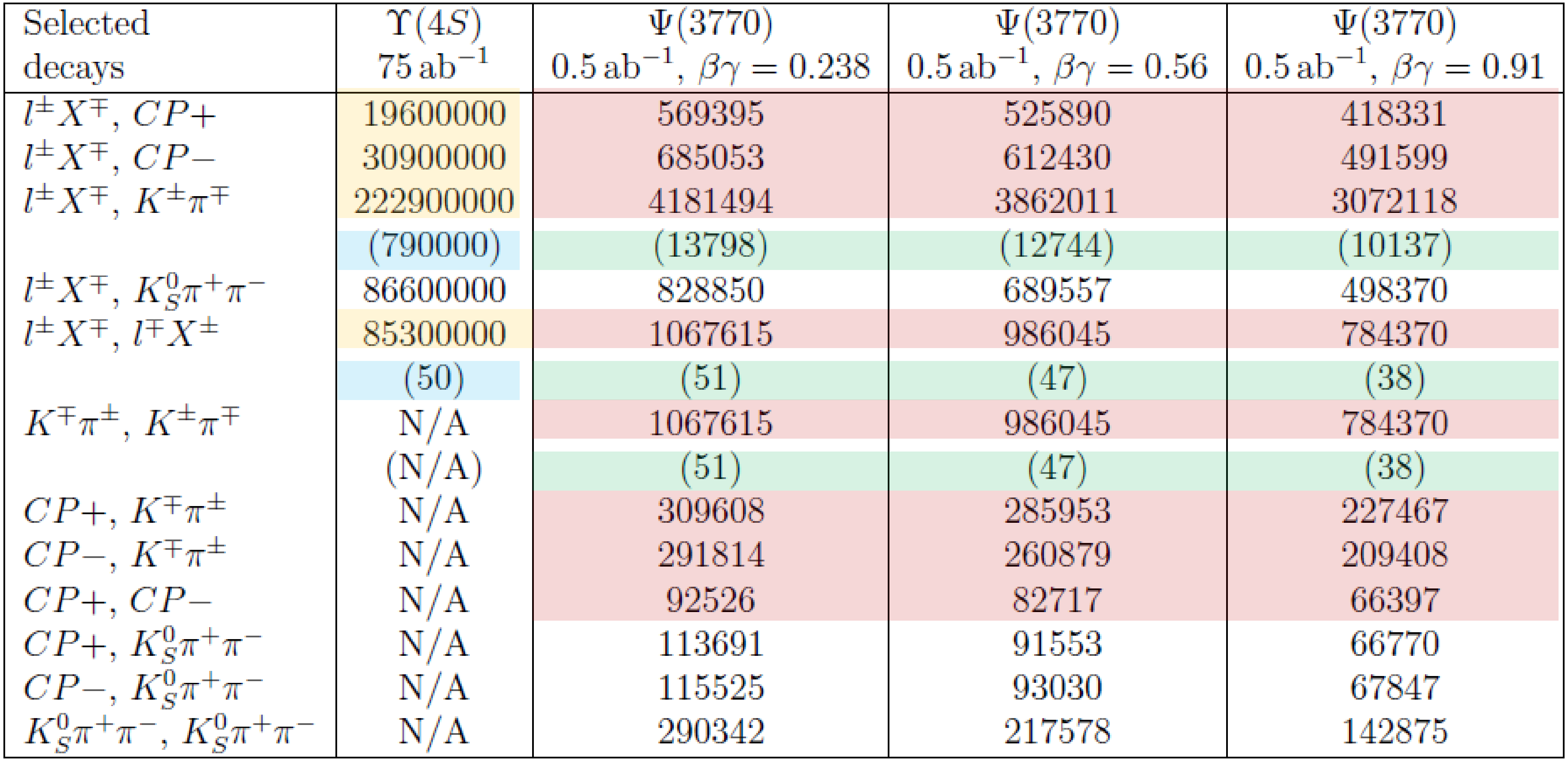


Source	$x[\%]$	$y[\%]$
SVT misalignment	0.0279	0.0826
Fit bias	0.0745	0.0662
Charge-flavor correlation (mistagging)	0.0487	0.0398
Event selection	0.0395	0.0508
Efficiency map	0.0367	0.0175
Background Dalitz-plot distribution	0.0331	0.0142
D^0 mass window	0.0250	0.0250
Proper lifetime PDF	0.0134	0.0128
Signal and background yields	0.0109	0.0069
Mixing in background	0.0103	0.0082
Dalitz-plot normalization	0.0106	0.0053
Proper lifetime error PDF	0.0058	0.0087
Experimental systematics	0.1177	0.1302

D^0 decay amplitude model systematics

Dominated by uncertainty on K*(892), K-matrix, Kπ Lass parameters	0.0678	0.0532
Total	0.0830	0.0685

Sensitivity studies at Ψ(3770): num. of events

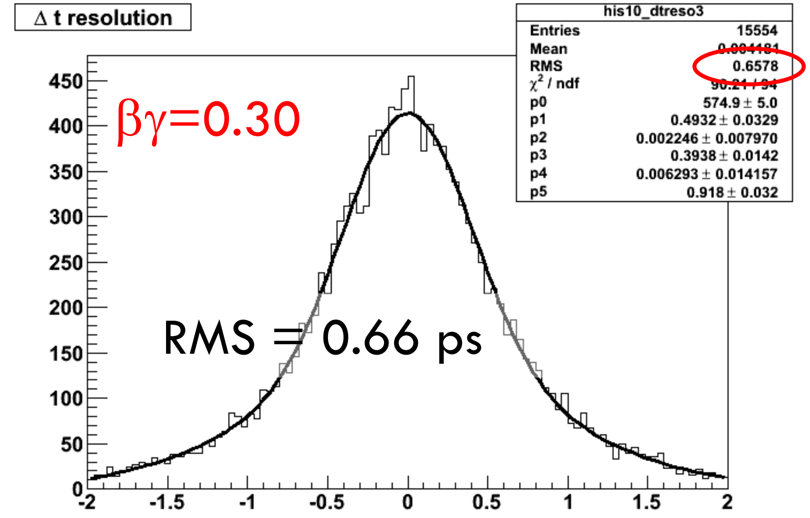


		LB $\psi(3770)$	IB $\psi(3770)$	HB $\psi(3770)$
Selected decays	$\Upsilon(4S)$ $75\,\text{ab}^{-1}$	$\Psi(3770)$ $0.5\,\text{ab}^{-1}$, $\beta\gamma = 0.238$	$\Psi(3770)$ $0.5\,\text{ab}^{-1}$, $\beta\gamma = 0.56$	$\Psi(3770)$ $0.5\,\text{ab}^{-1}$, $\beta\gamma = 0.91$
$l^{\pm}X^{\mp}$, $CP+$	19600000	569395	525890	418331
$l^{\pm}X^{\mp}$, $CP-$	30900000	685053	612430	491599
$l^{\pm}X^{\mp}$, $K^{\pm}\pi^{\mp}$	222900000	4181494	3862011	3072118
	(790000)	(13798)	(12744)	(10137)
$l^{\pm}X^{\mp}$, $K^0_S\pi^+\pi^-$	86600000	828850	689557	498370
$l^{\pm}X^{\mp}$, $l^{\mp}X^{\pm}$	85300000	1067615	986045	784370
	(50)	(51)	(47)	(38)
$K^{\mp}\pi^{\pm}$, $K^{\pm}\pi^{\mp}$	N/A	1067615	986045	784370
	(N/A)	(51)	(47)	(38)
$CP+$, $K^{\mp}\pi^{\pm}$	N/A	309608	285953	227467
$CP-$, $K^{\mp}\pi^{\pm}$	N/A	291814	260879	209408
$CP+$, $CP-$	N/A	92526	82717	66397
$CP+$, $K^0_S\pi^+\pi^-$	N/A	113691	91553	66770
$CP-$, $K^0_S\pi^+\pi^-$	N/A	115525	93030	67847
$K^0_S\pi^+\pi^-$, $K^0_S\pi^+\pi^-$	N/A	290342	217578	142875

🟨	🟥	Favored # of events
🟦	🟩	Suppressed # of events
$\Upsilon(4S)$	$\psi(3770)$	

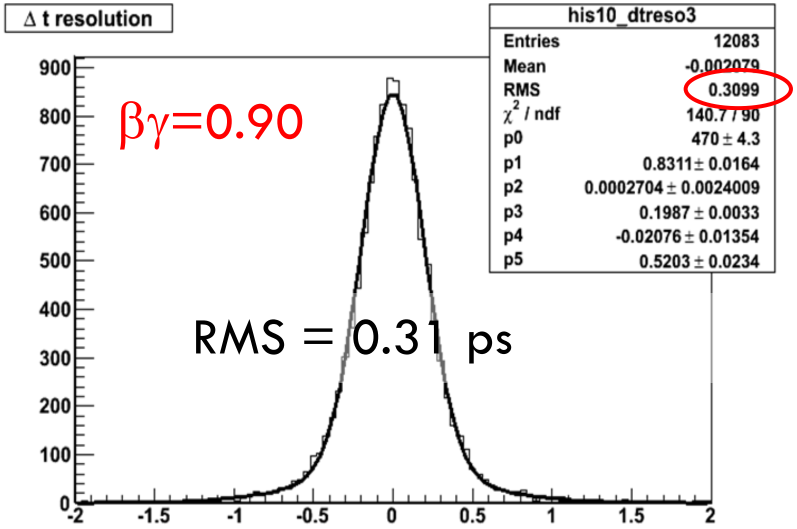
FastSim studies: Δt resolution

examples:



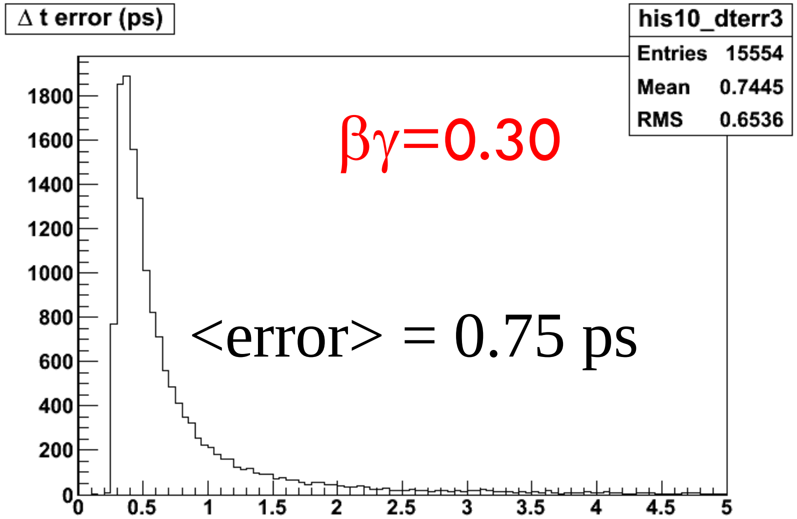
βγ=0.30

RMS = 0.66 ps



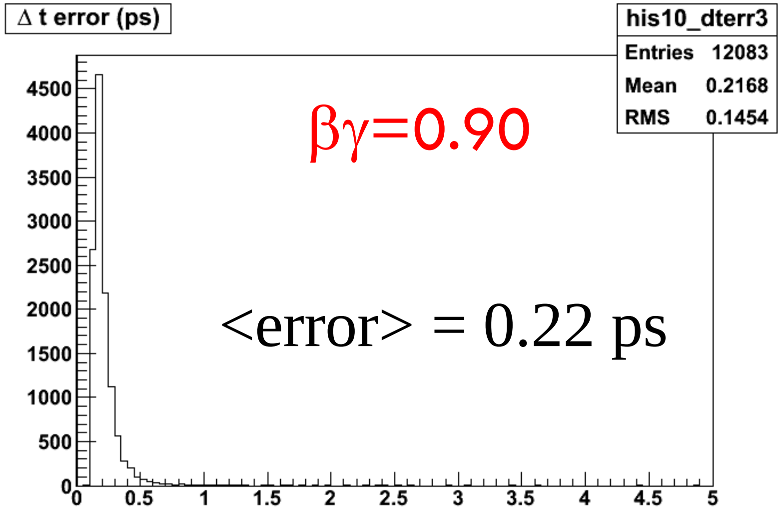
βγ=0.90

RMS = 0.31 ps



βγ=0.30

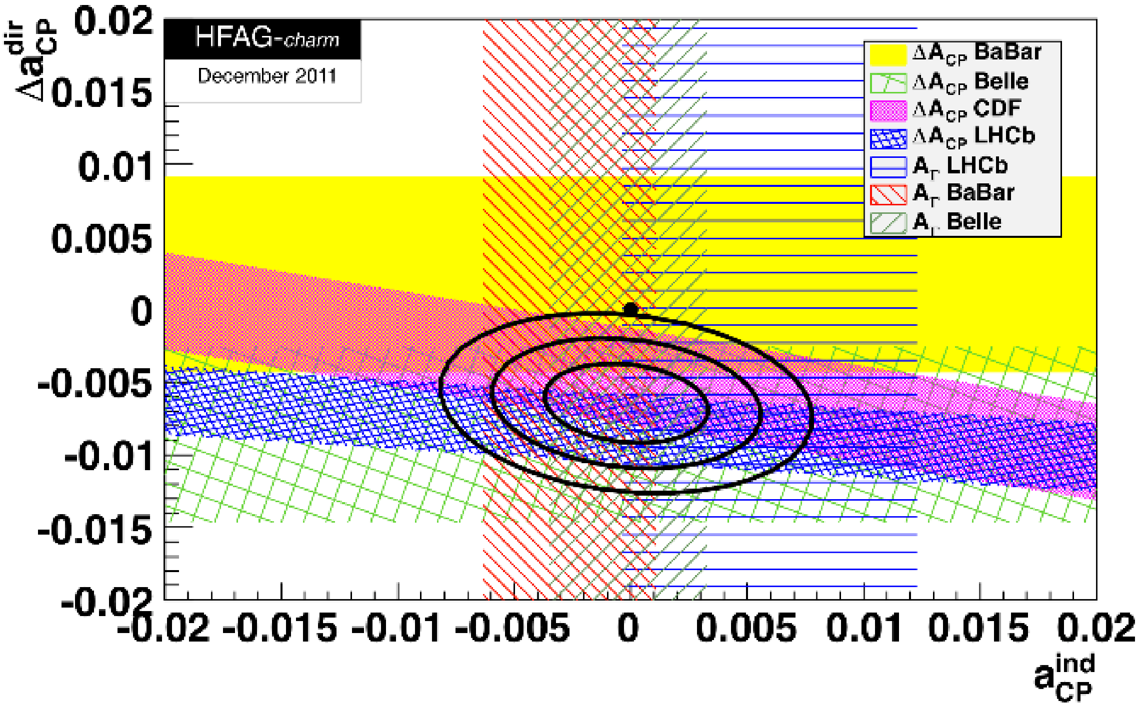
<error> = 0.75 ps



βγ=0.90

<error> = 0.22 ps

CPV in $D^0 \rightarrow K^+K^-, \pi^+\pi^-$



385fb^{-1} @ Babar

$$a_{CP}^{KK} = (0.00 \pm 0.34\,(\mathrm{stat.}) \pm 0.13\,(\mathrm{syst.}))\%$$
$$a_{CP}^{\pi\pi} = (-0.24 \pm 0.52\,(\mathrm{stat.}) \pm 0.22\,(\mathrm{syst.}))\%$$

PRL100,061803 (2008)

$$\Delta Y = [-0.26 \pm 0.36(\mathrm{stat}) \pm 0.08(\mathrm{syst})]\%$$

PRD78,011105 (R) (2008)