WGV summary

φ_3/γ *from tree decays*

A.Bondar

on behalf of conveners and speakers of WGV

1.Unitarity Angle Gamma — T.Gershon

2. Gamma from charged B decays at Babar — V.Tisserand

3. Belle results for phi_3 measurements — A.Bondar

4. Gamma from neutral B decays at Babar — V.Sordini

5. Time-dependent CP asymmetry in B0->$D^{*-}\pi^{+}$ — M.Iwabuchi

6. CLEO_c Impact on ADS Determination of gamma — J.Libby

7. CLEO_c Impact on gamma from B->DK, D->$K_S\pi\pi$ — J.Rademacker

8. Measuring weak phases using B->D*V modes — R.Sinha

9. Test of flavor SU(3) symmetry and weak phase gamma from B->Kp — C-W.Chang

10.Gamma from UTFIT — V.Sordini

11.Gamma from CKM fitter — K.Trabelsi

12.Time dependent measurements of gamma at LHCb — A.Carbone

13.Gamma at LHCb with ADS/GLW strategies — A.Powell

14.Gamma at LHCb:Dalitz fit and global precision — G.Wilkinson

15.Prospects for gamma (phi_3) at the SuperKEKB — P.Krokovny

16. Prospects for gamma at Super Flavor Factory — F.Martinez-Vidal

Importance of γ

T.Gershon

- γ plays a unique role in flavour physics

  the only CP violating parameter that can be measured through tree decays (*)

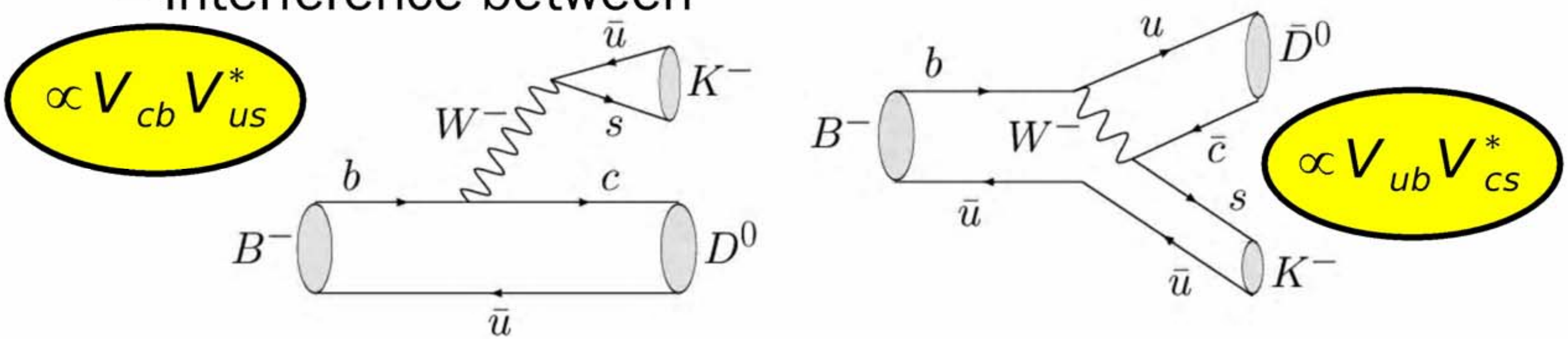
  (*) more-or-less

- A benchmark Standard Model reference point
  - doubly important after New Physics is observed
- How precise is precise enough?
  - 10% ⓧ At 3 sigma hardly exclude anything
  - 1% ☆ Seems the right level to test NP
  - 0.1% ⓧ Good luck if you can get the funding ...

How To Measure γ

T.Gershon

- Focus on theoretically pristine measurement
  - Interference between



- colour allowed
- final state contains D^0

- colour suppressed
- final state contains $\bar{D}^0$

Relative magnitude of suppressed amplitude is r_B

Relative weak phase is $-\gamma$, relative strong phase is δ_B

One Method, Many Modes

T.Gershon

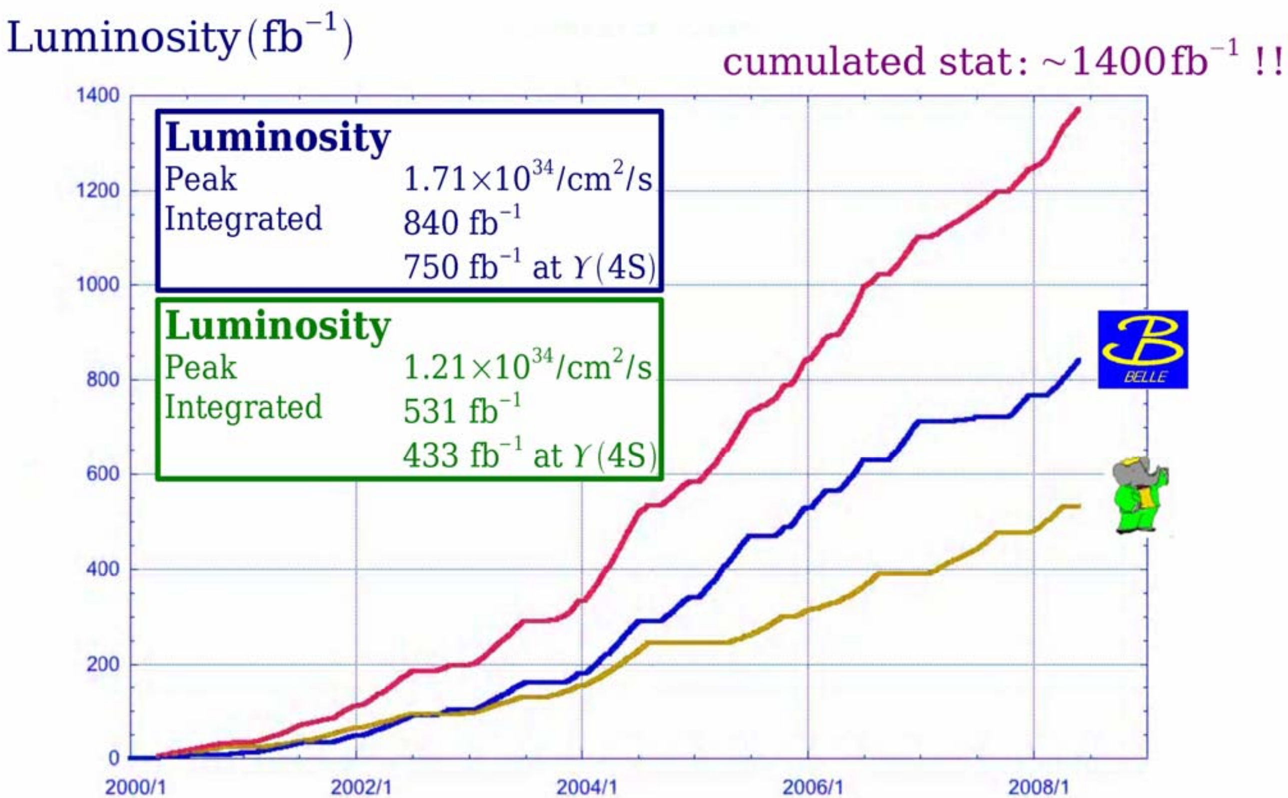
- $B \to DK$ with any D decay mode that is accessible to both D^0 and $\overline{D}^0$ is sensitive to γ
  - M.Gronau & D.Wyler, PLB 253, 483 (1991)
  - M.Gronau & D.London, PLB 265, 172 (1991)
  - D.Atwood, I.Dunietz and A.Soni, PRL 78, 3257 (1997); PRD 63, 036005 (2001)
- Different D decay modes in use
  - CP eigenstates (eg. K^+K^-, $K_S\pi^0$) "GLW"
  - Doubly-suppressed decays (eg. $K\pi$) "ADS"
  - Singly-suppressed decays (eg. KK^*) "GLS"
  - Three-body decays (eg. $K_s\pi^+\pi^-$) "GGSZ / Dalitz"
  - Other possibilities exist ...

T.Gershon

- Why has neither experiment published a combined constraint on γ from its $B \to DK$ measurements?
- What auxiliary measurements should be made?
  - eg. DK^* hadronic parameters in $DK_S\pi$ DP analysis?
- How can we solve the problem of model dependence in Dalitz plot analyses?
  - Will we reach necessary agreement to enable model independent analysis?
- How much data is needed before statistical issues in γ extraction become irrelevant?

B factories: BaBar and Belle

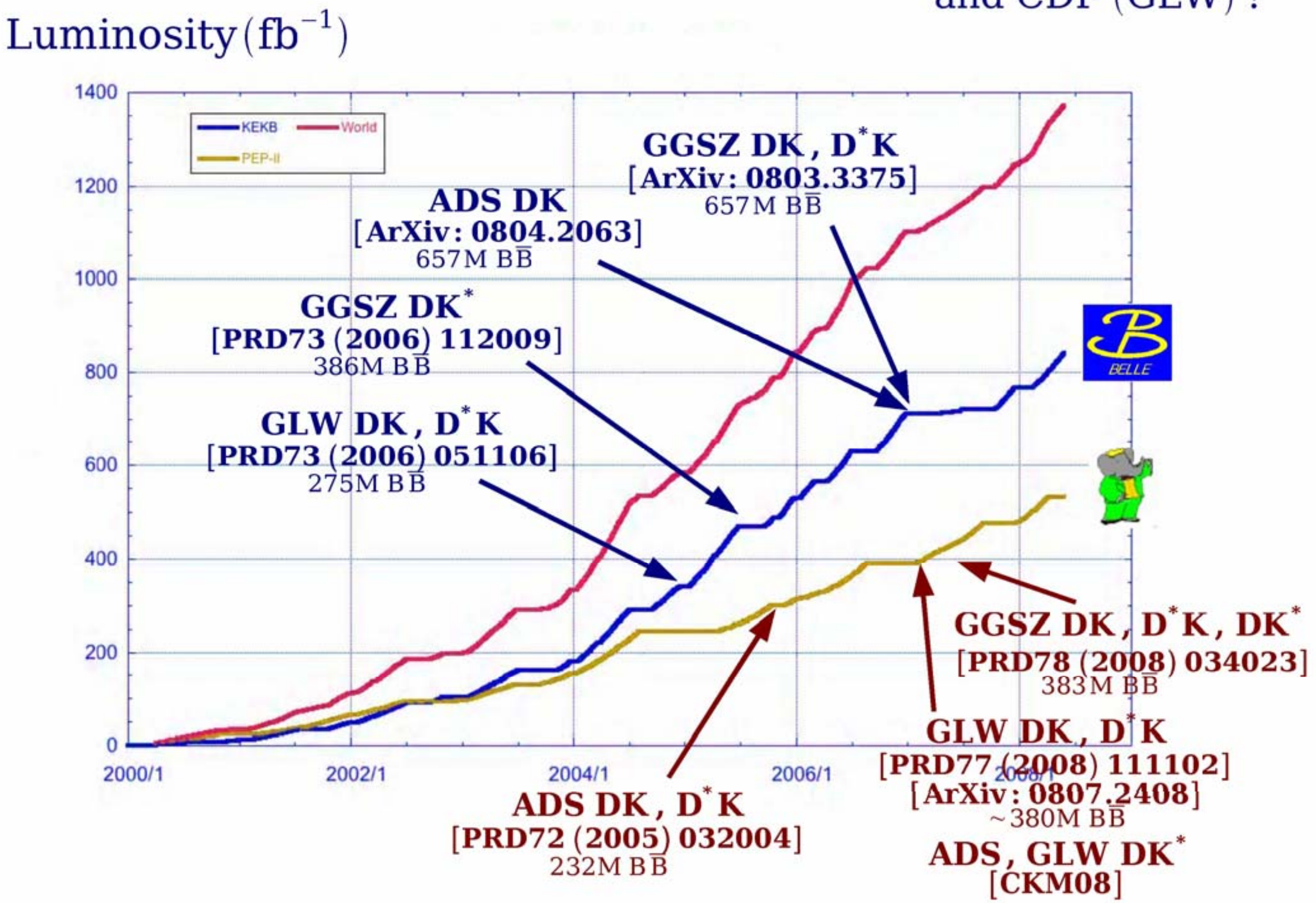
K.Trabelsi



B factories: BaBar and Belle

K.Trabelsi

and CDF (GLW) !



GLW analysis

M. Gronau, D. London, D. Wyler PLB **253**, 483 (1991); PLB **265**, 172 (1991)

CP eigenstate of D-meson is used (D_{CP}).

CP-even: $D_1 \to K^+K^-, \pi^+\pi^-$,   CP-odd: $D_2 \to K_S\pi^0, K_S\omega, K_S\varphi, K_S\eta\ldots$

Double ratio:

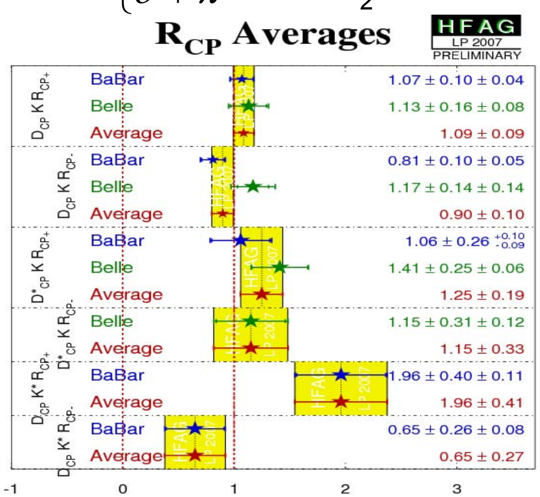
$$R_{CP\pm} = \frac{Br(B \to D_{CP\pm}K)/Br(B \to D_{CP\pm}\pi)}{Br(B \to D^0K)/Br(B \to D^0\pi)} = 1 + r_B^2 + 2r_B\cos\delta'\cos\varphi_3$$

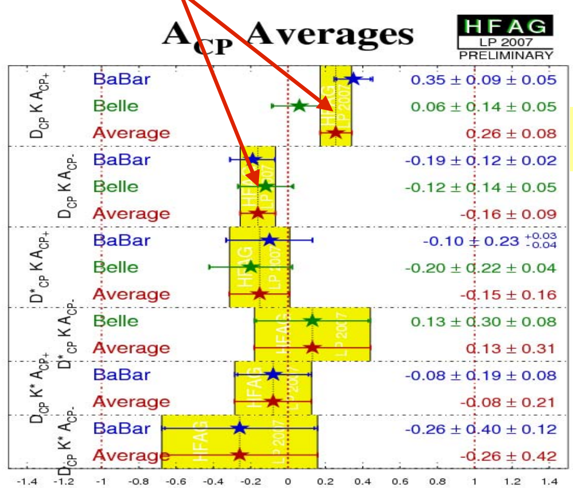
CP-asymmetry:

$$A_{CP\pm} = \frac{Br(B^+ \to D_{CP\pm}K^+) - Br(B^- \to D_{CP\pm}K^-)}{Br(B^+ \to D_{CP\pm}K^+) + Br(B^- \to D_{CP\pm}K^-)} = \frac{2r_B\sin\delta'\sin\varphi_3}{R_{CP\pm}}$$

$$\delta' = \begin{cases} \delta & \text{for } D_1 \\ \delta + \pi & \text{for } D_2 \end{cases}$$

$\Rightarrow$ $A_{1,2}$ have opposite signs





Alternative variables:

$$x_\pm = r_B\cos(\delta \pm \varphi_3) = \frac{R_{CP+}(1 \mp A_{CP+}) - R_{CP-}(1 \mp A_{CP-})}{4}$$

$$r_B^2 = \frac{R_{CP+} + R_{CP-} - 2}{2}$$

GLW : $B^- \to D^0_{CP} K^-$

PRD 77, 111102(R) (June 2008)

382×10^6 $B\bar{B}$

V.Tisserand

- Selection based on m_{ES} and event shape variables.
- Extended max. likelihood fit to ΔE and Cherenkov angle θ_C of the prompt track.
- Use of $B^- \to D^0\pi^-$ as normalization channel and control sample, and D^0 mass side-bands..
- No $D^0 \to K^0_S\phi$ mode (GGSZ $D^0 \to K^0_S K^+ K^-$)

$N_{CP+} = 239 \pm 21$
$N_{CP-} = 235 \pm 21$
$N_{K\pi} = 1872 \pm 51$

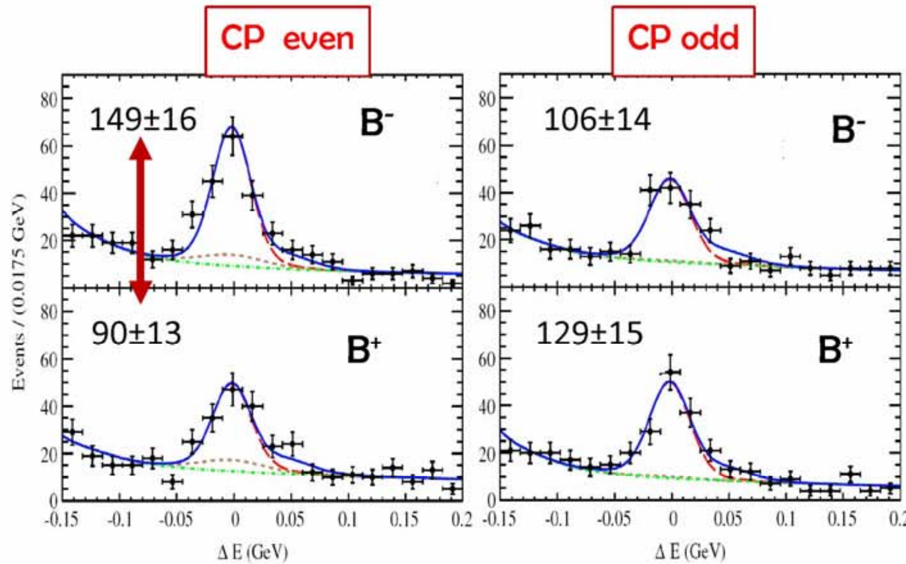
±stat.±syst.

$$A_{CP+} = 0.27 \pm 0.09 \pm 0.04$$
$$A_{CP-} = -0.09 \pm 0.09 \pm 0.02$$
$$R_{CP+} = 1.06 \pm 0.10 \pm 0.05$$
$$R_{CP-} = 1.03 \pm 0.10 \pm 0.05$$

$$x_+ = -0.09 \pm 0.05 \pm 0.02$$
$$x_- = +0.10 \pm 0.05 \pm 0.03$$
$$r_B^2 = +0.05 \pm 0.07 \pm 0.03$$

$$x_\pm = r_B \cos(\delta_B \pm \gamma) = \frac{R_{CP+}(1 \mp A_{CP+}) - R_{CP-}(1 \mp A_{CP-})}{4}$$

$$r_B^2 = \frac{R_{CP+} + R_{CP-} - 2}{2}$$



1. Direct CPV at 2.8 σ for CP+ decays
2. Not enough sensitivity to γ, but :
- most precise GLW measurement.
- $x_\pm$ compatible with GGSZ and as precise.

4

GLW : $B^- \to D^{*0}_{CP}[\to D^0\pi^0/\gamma]K^-$

arXiv:0807.2408 hep/ex (July 2008), submitted to PRD

383×10^6 $B\bar{B}$

V.Tisserand

- Selection based on m_{ES} and event shape variables.
- Extended max. likelihood fit to ΔE and dE/dx + Cherenkov PID of fast track.
- Use of $B^- \to D^{*0}\pi^-$ as normalization channel and control sample and D^0 mass side-bands.
- D^{*0} CP flips for $D^0\pi^0$ and $D^0\gamma$ same D^0 final states (PRD 70, 091503 (2004))

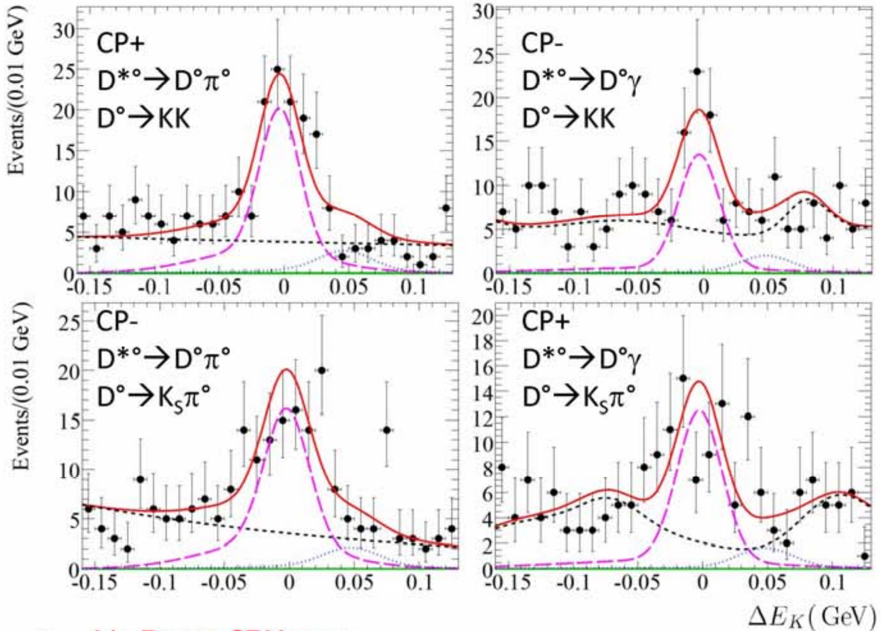
$N_{CP+}=244\pm22$
$N_{CP-}=225\pm23$
$N_{K\pi}=1410\pm57$

±stat.±syst.

$$A^*_{CP+} = -0.11 \pm 0.09 \pm 0.01$$
$$A^*_{CP-} = 0.06 \pm 0.10 \pm 0.02$$
$$R^*_{CP+} = 1.31 \pm 0.13 \pm 0.04$$
$$R^*_{CP-} = 1.10 \pm 0.12 \pm 0.04$$

$$x^*_+ = +0.09 \pm 0.07 \pm 0.02$$
$$x^*_- = -0.02 \pm 0.06 \pm 0.02$$
$$r^{*\,2}_B = +0.22 \pm 0.09 \pm 0.03$$

($K^0_S\phi$ removed for Cartesian coords.)



1. No Direct CPV seen.
2. Not enough sensitivity to γ, but :

- most precise D*K GLW measurement.
- $x^*_\pm$ compatible with GGSZ and as precise, r^*_B expected large.

V. Tisserand, LAPP, CKM08

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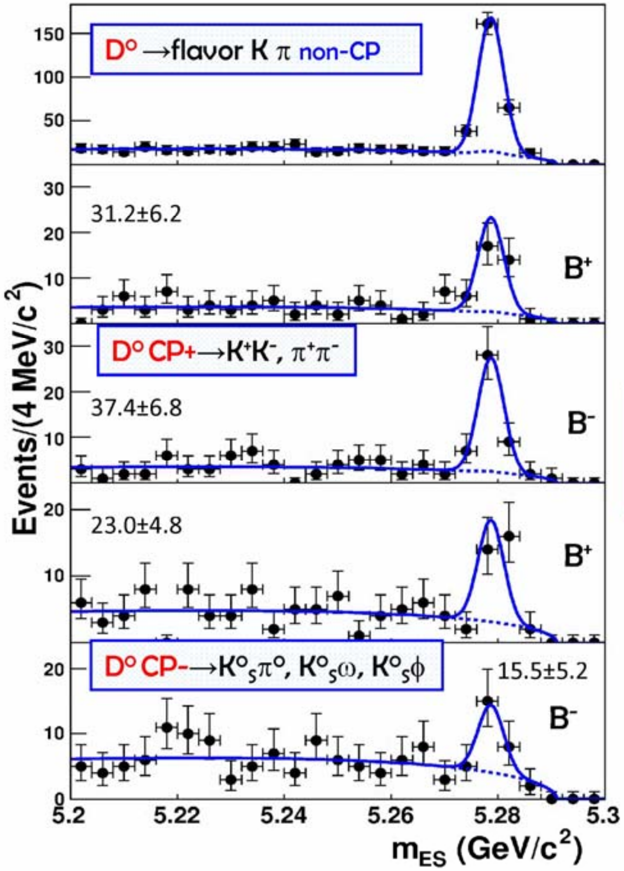
379x10⁶ $B\bar{B}$

GLW : $B^- \to D^0_{CP} K^{*-}[\to K^0_S \pi^-]$

NEW
PRELIMINARY

V.Tisserand



- Selection re-optimized and event shape in Neural Net wrt 2005 (higher eff'cy, bkg. rejection, and stat.)
- (peaking)-bkg. from ΔE and mD^0 sidebands.
- CP+ pollution for $K^0_S(K^+K^-)$non-ϕ & $K^0_S(\pi^+\pi^-\pi^0)$non-ω measured in the data.
- Vary by 2π the δ strong phases from S-wave $K\pi$ pairs in $K^{*-}[K^0_S\pi^-]$ decays.

N_{CP+}=68.6±9.2
N_{CP-}=38.5±7.0
$N_{K\pi}$=231±17

±stat.±syst.

$$A^s_{CP+} = 0.09 \pm 0.13 \pm 0.05$$
$$A^s_{CP-} = -0.23 \pm 0.21 \pm 0.07$$
$$R^s_{CP+} = 2.17 \pm 0.35 \pm 0.09$$
$$R^s_{CP-} = 1.03 \pm 0.27 \pm 0.13$$

$$x_{s+} = 0.18 \pm 0.14 \pm 0.05$$
$$x_{s-} = 0.38 \pm 0.14 \pm 0.05$$

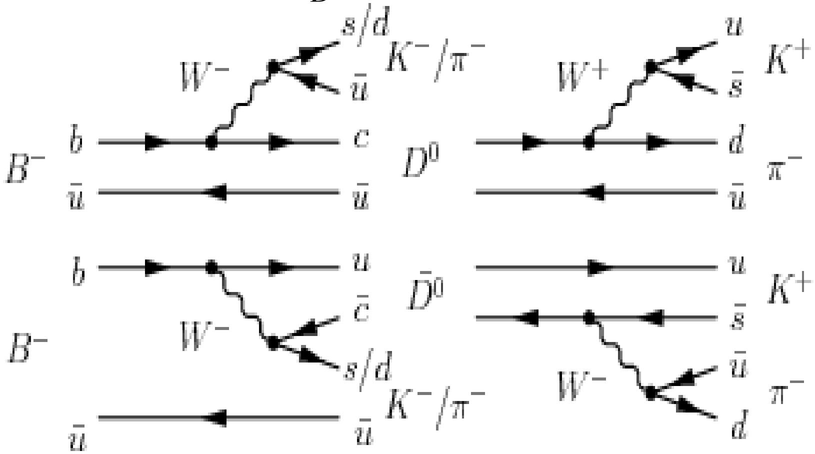
1. No Direct CPV seen.
2. Precision improved wrt 2005, results confirmed, world's only measurement.

ADS analysis

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

Enhance magnitude of CP violation by using Doubly Cabibbo-suppressed *D* decays

e.g. $B^- \to [K^+\pi^-]_D K^-$:

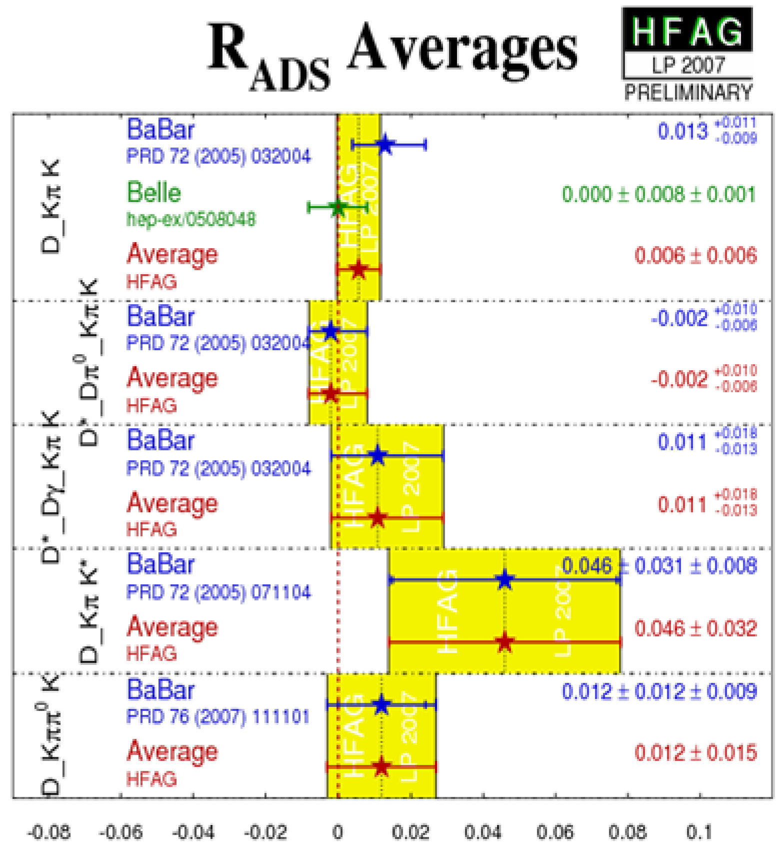


Observable:

$$R_{ADS} = \frac{Br(B \to D_{\text{supp}} K)}{Br(B \to D_{\text{fav}} K)} = r_B^2 + r_D^2 + 2 r_B r_D \cos\varphi_3 \cos\delta$$

where

$$\delta = \delta_B + \delta_D,\ \ r_D = \left| \frac{A(D^0 \to K^-\pi^+)}{A(D^0 \to K^+\pi^-)} \right| = 0.0578 \pm 0.0008$$

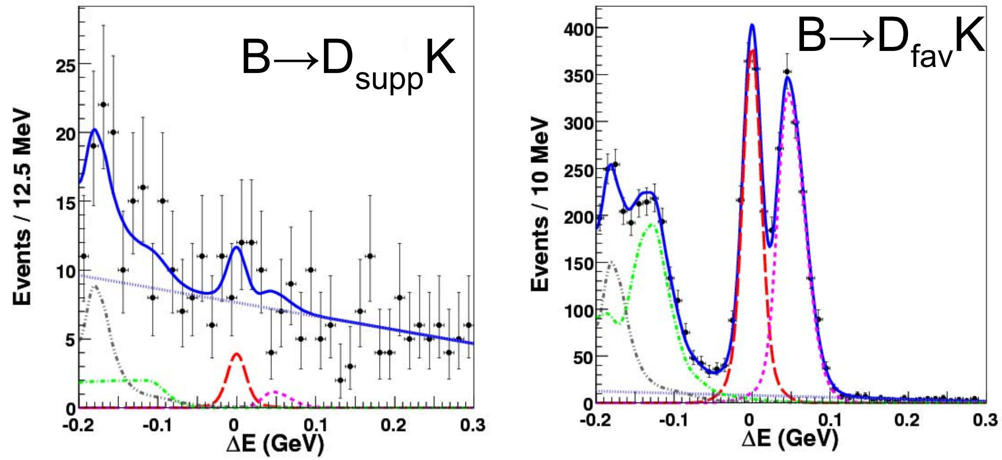


ADS analysis (Belle)

Belle collaboration, 657M BB pairs [arXiv: 0804:2063, submitted to PRD(RC)]

$B^- \to [K^-\pi^+]_D K^-$ (suppressed) and $B^- \to [K^+\pi^-]_D K^-$ (favored) modes are selected.

- Cut on M_{bc}, M_D, PID likelihood, event shape
- Fit ΔE to extract signal yield



$$R_{ADS} = (8.0^{+6.3}_{-5.7}\ {}^{+2.0}_{-2.8}) \times 10^{-3}$$

CP asymmetry:

$$A_{ADS} = -0.13^{+0.98}_{-0.88} \pm 0.26$$

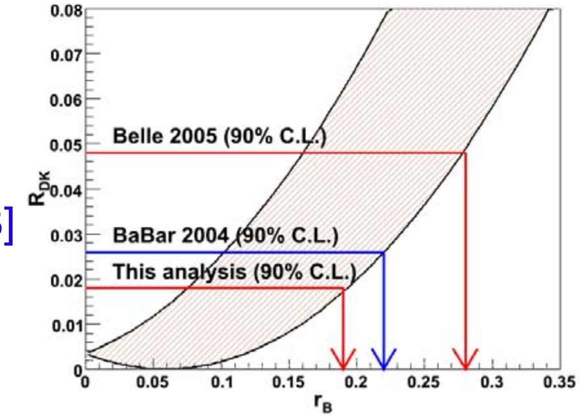
$r_B < 0.19$ at 90% CL

(with the conservative assumption cos φ_3 cos δ = –1)

Using CLEO measurement $\delta_D = (22^{+11}_{-12}\ {}^{+9}_{-11})^\circ$ [arXiv: 0802:2268]

and φ_3,δ_B measurements from Dalitz analysis,

tighter r_B constraint can be obtained.

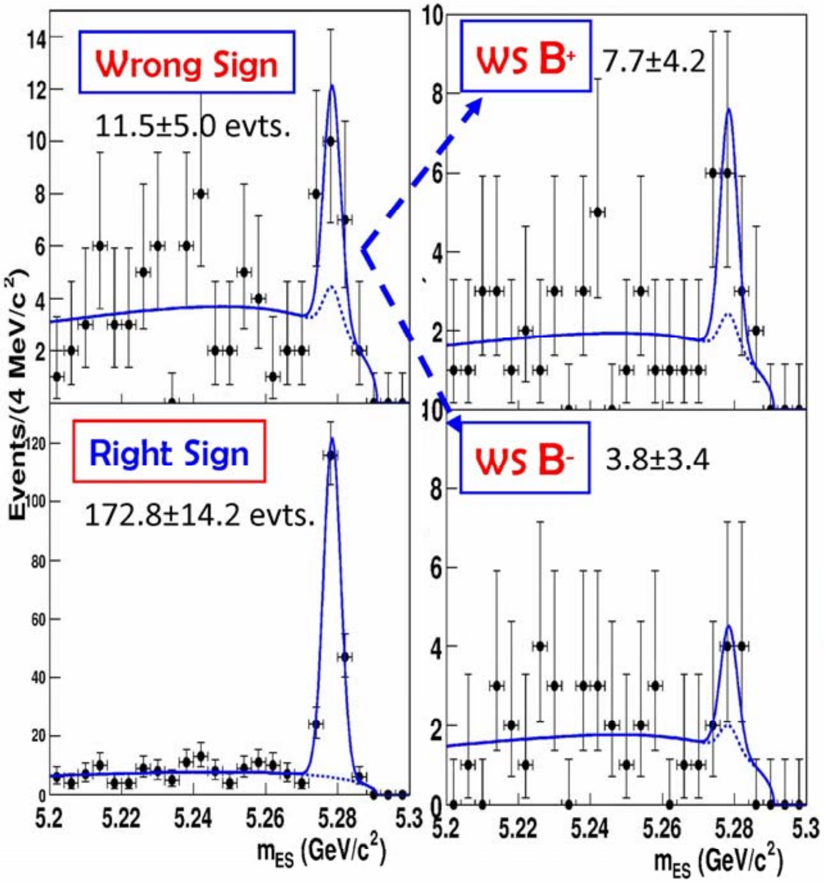


379x10^6 $B\bar{B}$

ADS : $B^- \to D^0[K^+\pi^-]\, K^{*-}[\to K^0_S\pi^-]$

NEW PRELIMINARY

V.Tisserand



- 11.5±5.0 WS ADS signal events.
- Accounts for $(K^0_S\,\pi^-)$non-K^* with S-waves pairs, directly determined from the data.
- Syst.: detector asymmetry, peaking bkg., and same final state bkgd. $(K^+\pi^-K^{*-}$ charmless bkg. ...).

±stat.±syst.

$$A^S_{ADS} = -0.34 \pm 0.45 \pm 0.16$$
$$R^S_{ADS} = 0.066 \pm 0.029 \pm 0.010$$

1. No Direct CPV seen.
2. Better precision wrt 2005 result, again unique in the world.

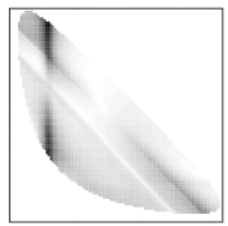
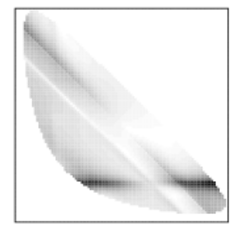
Dalitz analysis method

A. Giri, Yu. Grossman, A. Soffer, J. Zupan, PRD **68**, 054018 (2003)
A. Bondar, Proc. of Belle Dalitz analysis meeting, 24-26 Sep 2002.

$$\left|D^0\right\rangle + re^{i\theta}\left|\bar{D}^0\right\rangle$$

Using 3-body final state, identical for D^0 and $\bar{D}^0$: $K_s\pi^+\pi^-$.

Dalitz distribution density: $dp(m^2_{K_S\pi^+}, m^2_{K_S\pi^-}) \sim |f_D|^2\, dm^2_{K_S\pi^+}\, dm^2_{K_S\pi^-}$

$f_D(m^2_{K_S\pi^+}, m^2_{K_S\pi^-}) = \Big|$  $+\, re^{i\delta \pm i\phi_3}$  $\Big|^2$

(assuming CP-conservation in D^0 decays)

If $f_D(m^2_{K_S\pi^+}, m^2_{K_S\pi^-})$ is known, parameters $(\varphi_3/\gamma, r_B, \delta)$ are obtained from the fit to Dalitz distributions of $D \rightarrow K_s\pi^+\pi^-$ from $B^\pm \rightarrow DK^\pm$ decays

Need to know a complex form of the D^0 decay amplitude, but only $|f_D|^2$ is obtained from $D^* \rightarrow D\pi$

$\Rightarrow$ Need to use model description, model uncertainty as a result

Fit results: 12 (3x4) Cartesian coordinates

PRD78, 034023 (2008)

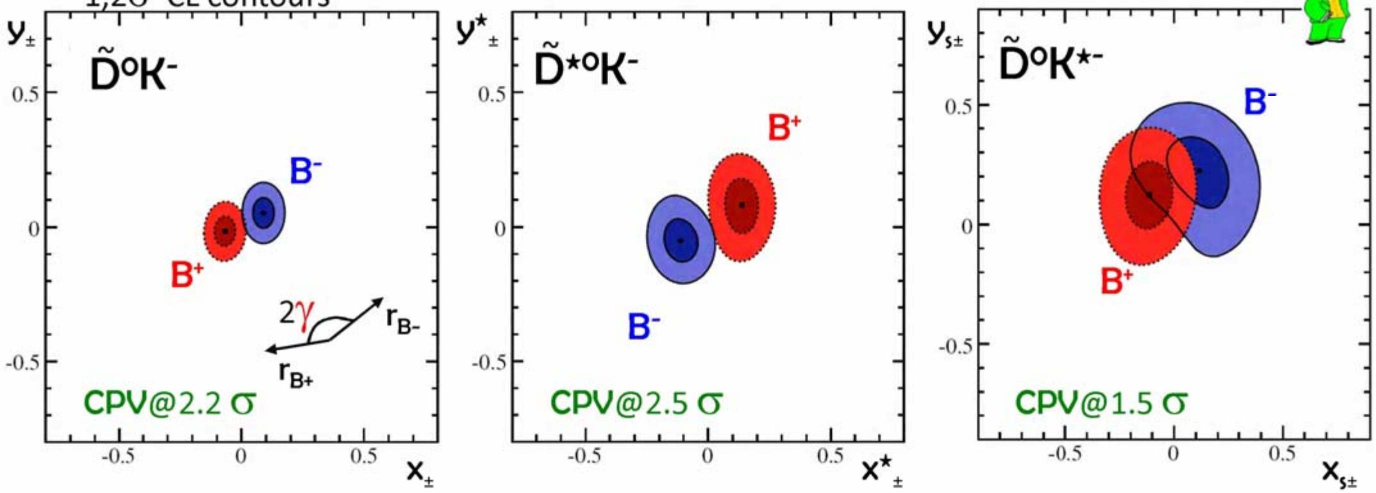
383×10^6 $B\bar{B}$

V.Tisserand

$$z^{(*)}_{(s)\pm} \equiv (x^{(*)}_{(s)\pm}, y^{(*)}_{(s)\pm}) = (\mathcal{Re}, \mathcal{Im})\{r^{(*)}_{s_B} e^{i(\delta^{(*)}_{(s)B} \pm \gamma)}\}$$

→ Almost Gaussian behavior near physical bounds ($r_B \approx 0$), better than the 7 physics params.

1,2σ CL contours



x-	$0.090 \pm 0.043 \pm 0.015 \pm 0.011$
y-	$0.053 \pm 0.056 \pm 0.007 \pm 0.015$
x+	$-0.067 \pm 0.043 \pm 0.014 \pm 0.011$
y+	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$

x*-	$-0.111 \pm 0.069 \pm 0.014 \pm 0.004$
y*-	$-0.051 \pm 0.080 \pm 0.009 \pm 0.010$
x*+	$0.137 \pm 0.068 \pm 0.014 \pm 0.005$
y*+	$0.080 \pm 0.102 \pm 0.010 \pm 0.012$

xs-	$0.115 \pm 0.138 \pm 0.039 \pm 0.014$
ys-	$0.226 \pm 0.142 \pm 0.058 \pm 0.011$
xs+	$-0.113 \pm 0.107 \pm 0.028 \pm 0.018$
ys+	$0.125 \pm 0.139 \pm 0.051 \pm 0.010$

±stat. ±syst.(exp.) ±syst.(Dalitz model)

$|z_{B+} - z_{B-}| \neq 0$ → direct CPV@ 3.0σ combined

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Dalitz : γ results for $B^- \to \tilde{D}^{(*)0} K^{(*)-}$

PRD78, 034023 (2008)

383×10^6 $B\bar{B}$

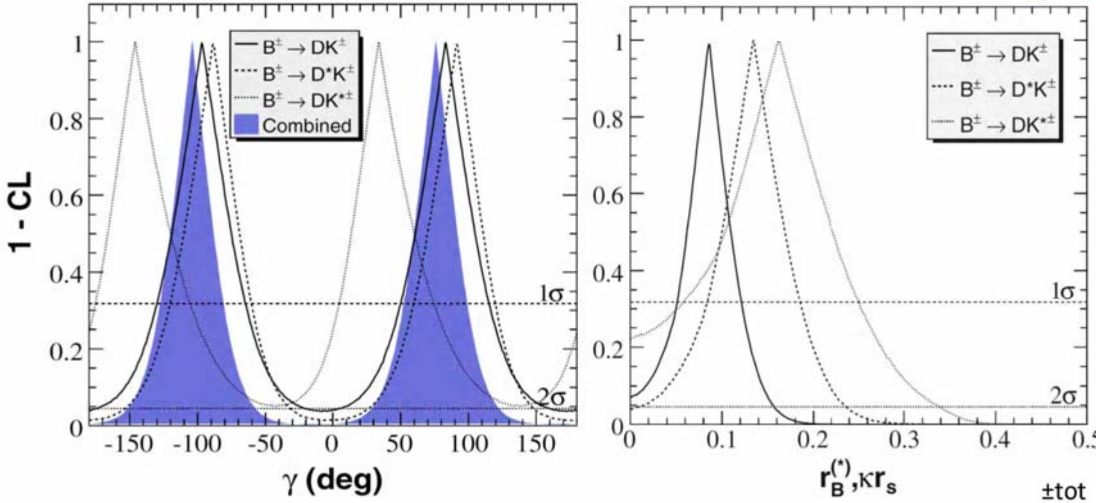
V Tisserand

From measured CP parameters: $(x_\pm, y_\pm)$, $(x^*_\pm, y^*_\pm)$, $(x_{s\pm}, y_{s\pm})$ perform combined fit to pseudo experiments : frequentist approach removing unphysical regions ($r_{B+} \neq r_{B-}$ ...)

extract 1D CL intervals

- r_B, r^*_B, r_{sB}
- δ_B, δ^*_B, δ_{sB}
- γ

Physics params



±tot {syst. exp., syst. model}

$$\gamma[\mathrm{mod}\ \pi] = (76^{+23}_{-24})^\circ \ \{5, 5\}^\circ$$

$r_B(DK) = (8.6 \pm 3.5)\% \ \{1.0, 1.1\}\%$

$r_B(D^*K) = (13.5 \pm 5.1)\% \ \{1.1, 0.5\}\%$

$\kappa r_B(DK^*) = (16.3^{+8.8}_{-10.5})\% \ \{3.7, 2.1\}\%$

➔ Statistics limited, small r_B ~10% favored (limits sensitivity to γ).

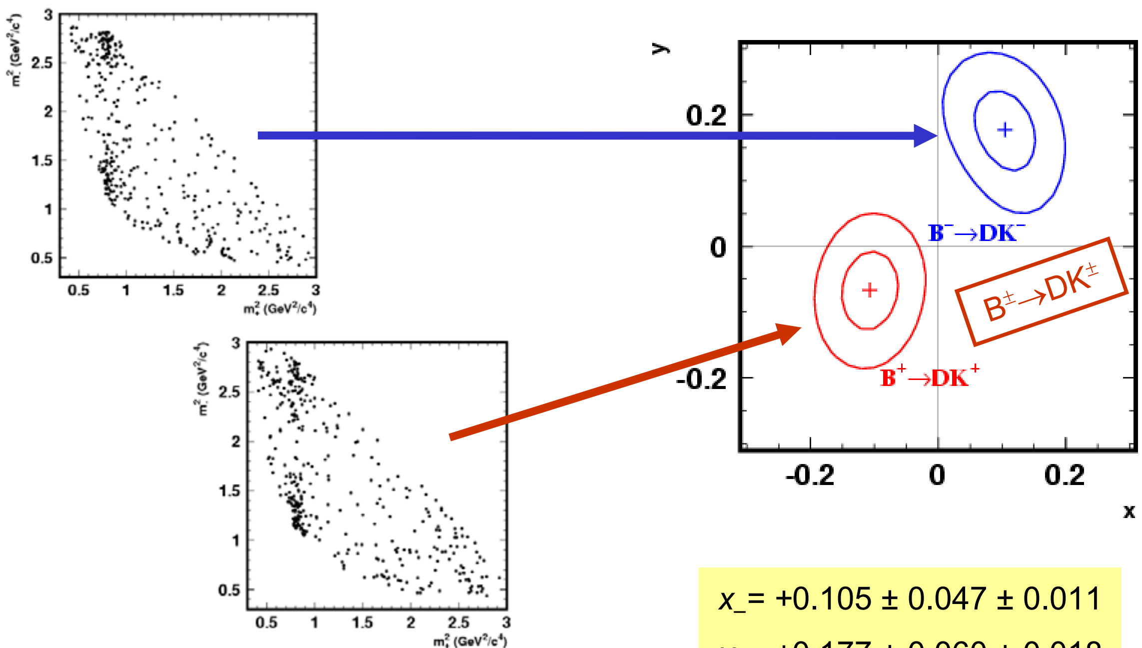
V. Tisserand, LAPP, CKM08 CKM-angle γ from charged B decays at BABAR 17

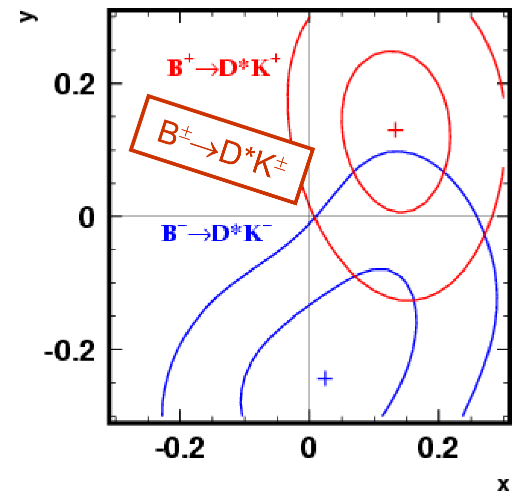
Belle Dalitz: fit results

Fit parameters are $x_{\pm} = r_B \cos(\pm\varphi_3+\delta)$ and $y_{\pm} = r_B \sin(\pm\varphi_3+\delta)$ [preliminary]

Unbinned maximum likelihood fit with event-by-event background treatment

(ΔE, M_{bc}, $|\cos\theta_{thr}|$, $\mathcal{F}$ included into likelihood)





Errors are statistical and experimental systematic. Model error not included.

$x_- = +0.105 \pm 0.047 \pm 0.011$

$y_- = +0.177 \pm 0.060 \pm 0.018$

$x_+ = -0.107 \pm 0.043 \pm 0.011$

$y_+ = -0.067 \pm 0.059 \pm 0.018$

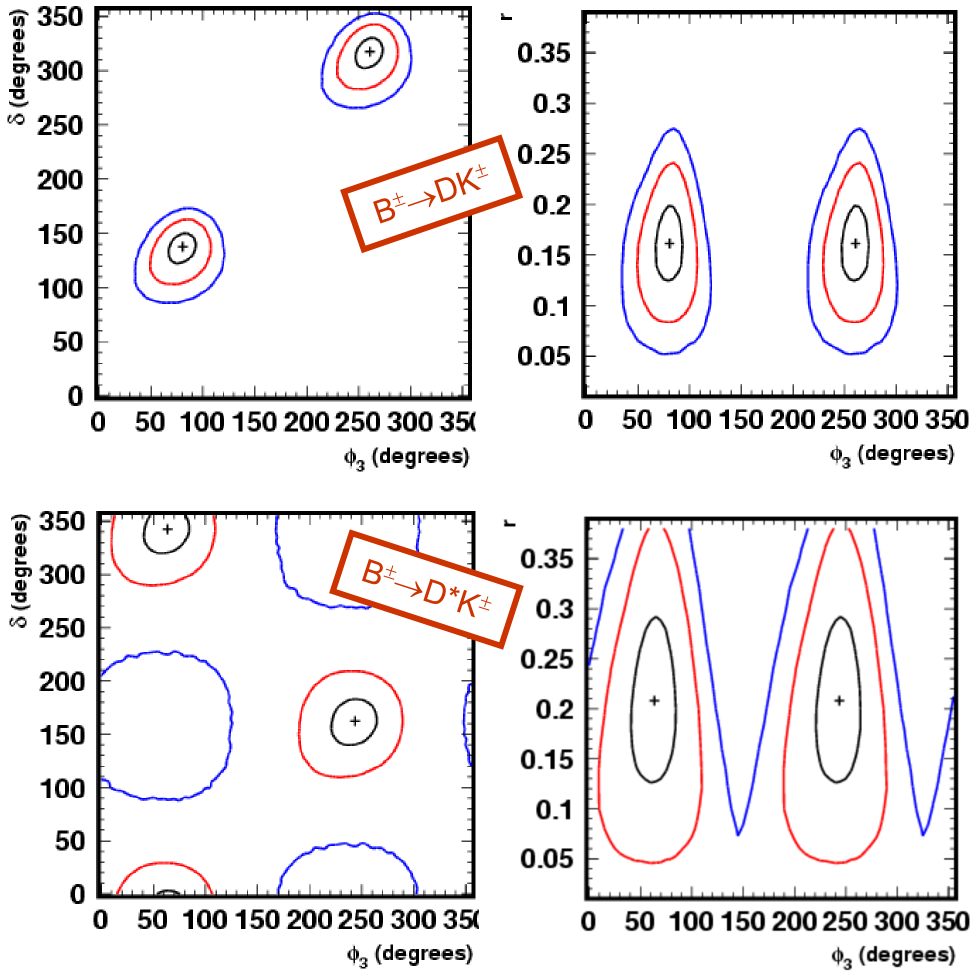
$x_- = +0.024 \pm 0.140 \pm 0.018$

$y_- = -0.243 \pm 0.137 \pm 0.022$

$x_+ = +0.133 \pm 0.083 \pm 0.018$

$y_+ = +0.130 \pm 0.120 \pm 0.022$

Belle Dalitz: fit results



[preliminary]

$B^{\pm}\to DK^{\pm}$ only:

$$\varphi_3 = 81^{+13^\circ}_{-15} \pm 5^\circ(\text{syst}) \pm 9^\circ(\text{model})$$

$B^{\pm}\to D^{*}K^{\pm}$ only:

$$\varphi_3 = 64^{+21^\circ}_{-23} \pm 4^\circ(\text{syst}) \pm 9^\circ(\text{model})$$

$B^{\pm}\to DK^{\pm}$, $B^{\pm}\to D^{*}K^{\pm}$ combined:

$$\varphi_3 = 76^{+12^\circ}_{-13} \pm 4^\circ(\text{syst}) \pm 9^\circ(\text{model})$$

$$r_{DK} = 0.16 \pm 0.04 \pm 0.01(\text{syst}) \pm 0.05(\text{model})$$

$$r_{D^*K} = 0.21 \pm 0.08 \pm 0.01(\text{syst}) \pm 0.05(\text{model})$$

$$\delta_{DK} = 136^{+14^\circ}_{-16} \pm 4^\circ(\text{syst}) \pm 23^\circ(\text{model})$$

$$\delta_{D^*K} = 343^{+20^\circ}_{-22} \pm 4^\circ(\text{syst}) \pm 23^\circ(\text{model})$$

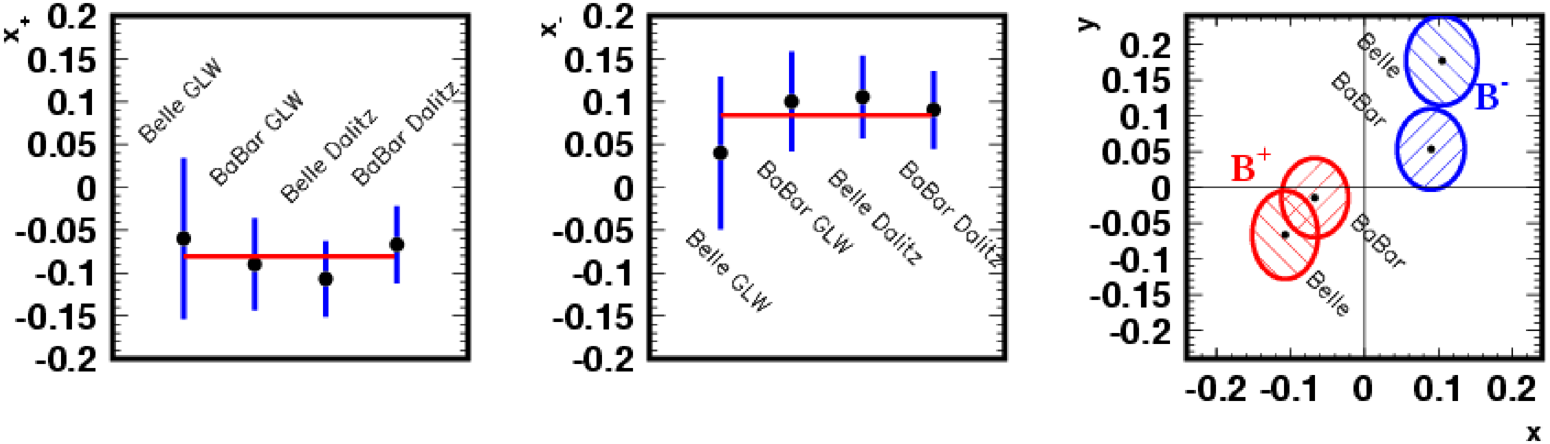
Model error estimate is the same as in previous analysis.

Stat. CL of CPV: ($1\text{-}5.5\cdot10^{-4}$) or 3.5σ !

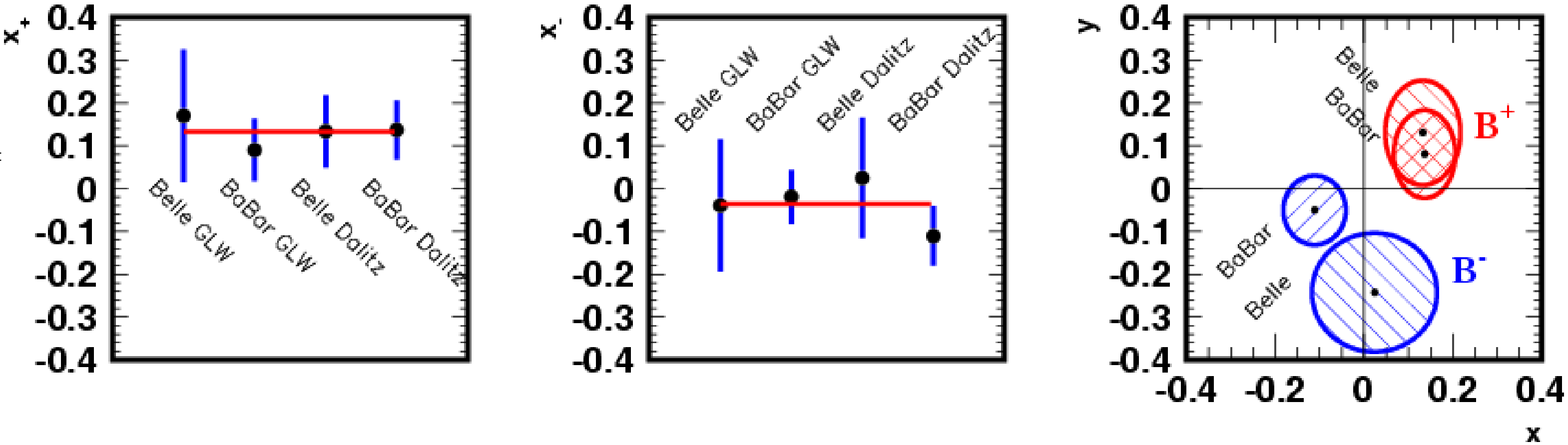
Comparison of measurements

GLW and Dalitz methods in Cartesian variables (x,y):

$B^{\pm}\to DK^{\pm}$



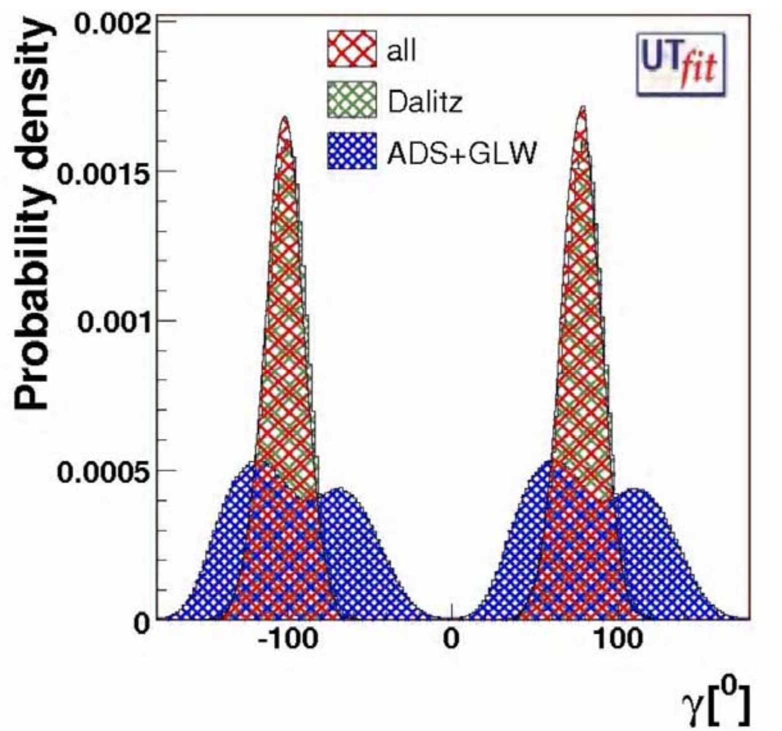
$B^{\pm}\to D^{*}K^{\pm}$

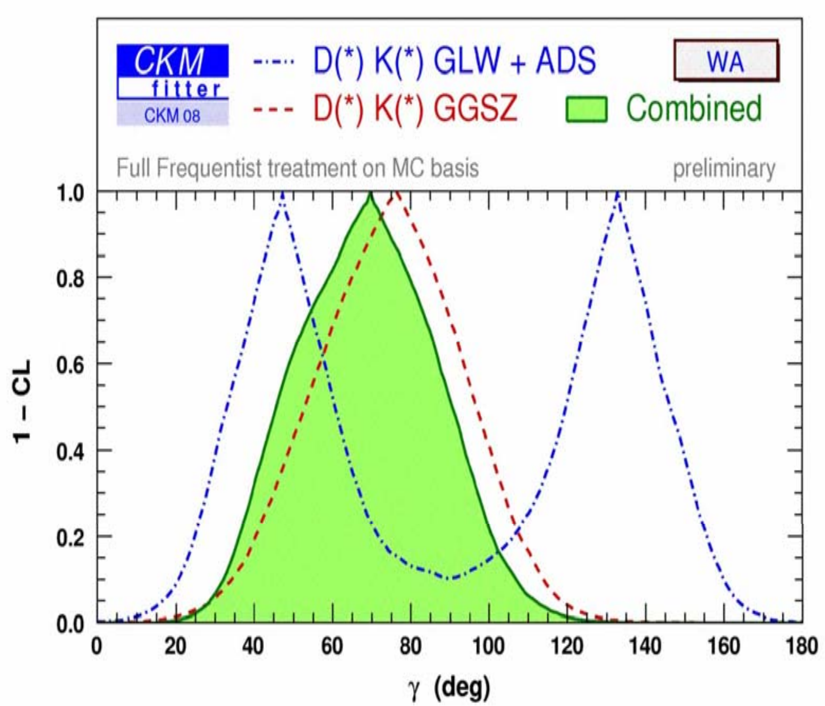


UT_{fit} vs CKM_{fitter}

V.Sordini

K.Trabelsi





$$\gamma = (78 \pm 12)^{\circ}, [2\sigma] = (54^{\circ}, 100^{\circ})$$

$$\gamma = (70^{+27}_{-29})^{\circ}, [2\sigma] = (29^{\circ}, 113^{\circ})$$

Model-independent analysis

Model-independent way: obtain D^0 decay strong phase from $\psi(3770)\to D\overline{D}$ data

$$P_D(m_+^2, m_-^2) = |f_D(m_+^2, m_-^2)|^2 \qquad \overline{P}_D(m_+^2, m_-^2) = |f_D(m_-^2, m_+^2)|^2$$

$$P_{B^\pm}(m_+^2, m_-^2) = |f_D + (x+iy)\bar{f}_D|^2 = P_D + r_B^2\overline{P}_D + 2\sqrt{P_D\overline{P}_D}[x_\pm C + y_\pm S] \qquad (1)$$

where
$$x_\pm = r_B\cos(\delta \pm \varphi_3)$$
$$y_\pm = r_B\sin(\delta \pm \varphi_3)$$
Free parameters

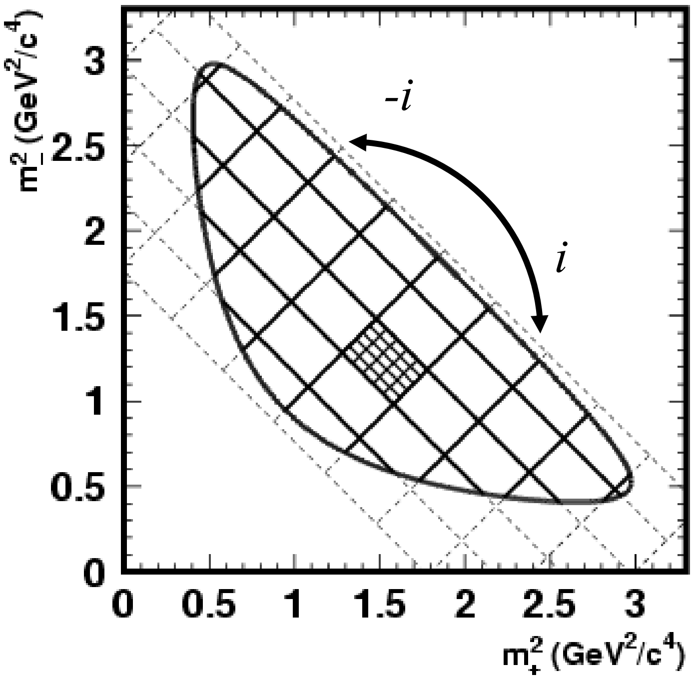
$$C(m_+^2, m_-^2) = \cos(\delta_D(m_+^2, m_-^2) - \delta_D(m_-^2, m_+^2))$$
$$S(m_+^2, m_-^2) = \sin(\delta_D(m_+^2, m_-^2) - \delta_D(m_-^2, m_+^2))$$
Unknown, can be obtained from charm data:

$D_{CP}\to K_S\pi^+\pi^-$:
$$P_{CP\pm}(m_+^2, m_-^2) = |f_D \pm \bar{f}_D|^2 = P_D + \overline{P}_D \pm 2\sqrt{P_D\overline{P}_D}C \qquad (2)$$

$\psi(3770)\to(K_S\pi^+\pi^-)_D\,(K_S\pi^+\pi^-)_D$:
$$P_{Corr}(m_+^2, m_-^2, m_+'^2, m_-'^2) = |f_D\bar{f}'_D - \bar{f}_D f'_D|^2 = P_D\overline{P}'_D + \overline{P}_D P'_D - 2\sqrt{P_D\overline{P}_D P'_D\overline{P}'_D}(CC' + SS') \qquad (3)$$

Binned analysis: D_{CP}

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



Number of events in D^0-plot: K_i

Number of events in B-plot

$$\langle N\rangle_i = h_B[K_i + r_B^2 K_{-i} + 2\sqrt{K_i K_{-i}}(xc_i + ys_i)] \qquad (4)$$

Number of events in D_{CP}-plot

$$\langle M\rangle_i = h_{CP}[K_i + K_{-i} \pm 2\sqrt{K_i K_{-i}}\, c_i] \qquad (5)$$

$$c_i = \frac{\int_{\mathcal{D}i} \sqrt{p\bar{p}} \cos\Delta\delta(\mathcal{D})d\mathcal{D}}{\sqrt{\int_{\mathcal{D}i} p d\mathcal{D} \int_{\mathcal{D}i} \bar{p} d\mathcal{D}}} \equiv <\cos\Delta\delta(\mathcal{D})>_{\mathcal{D}i}$$

$$s_i = <\sin\Delta\delta(\mathcal{D})>_{\mathcal{D}i}$$

$$c_i^2 + s_i^2 \le 1$$

($=1$ if bin size is small enough)

Binned analysis: $D_{\rm CP}$

[A. Bondar, A.Poluektov, hep-ph/0703267]

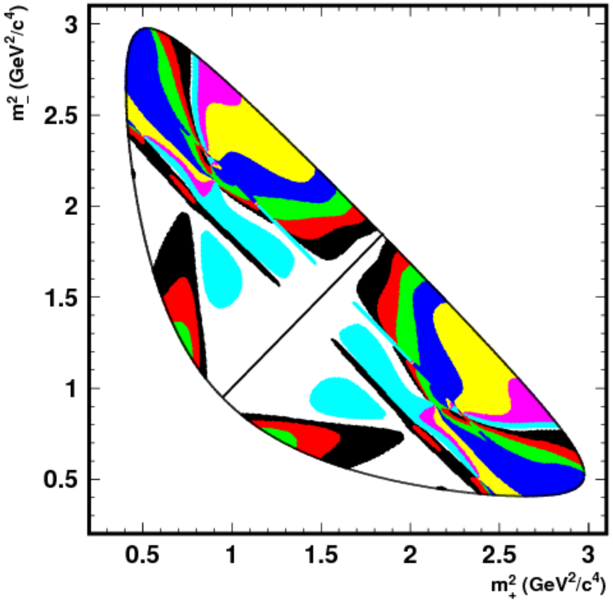
To use the limited CLEO-c data:

- Find binning with optimal sensitivity
- Get rid of bias due to $s_i = \pm\sqrt{1-c_i^2}$

} Satisfy simultaneously for binning with $c_i^2 + s_i^2 \approx 1$

Good approximation: uniform binning in $\Delta\delta_D$:

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



But the optimal binning depends on D^0 model. $\Rightarrow$ bias if it differs from actual one (same ~10°).

$s_i = \pm\sqrt{1-c_i^2}$ causes unavoidable model sensitivity. Reduces as data increases (by applying finer binning).

Binned analysis: $(K_S\pi^+\pi^-)^2$

2 correlated Dalitz plots, 4 dimensions:

$$\langle M\rangle_{ij} = h[K_i K_{-j} + K_j K_{-i} - 2\sqrt{K_i K_{-i} K_j K_{-j}}(c_i c_j + s_i s_j)] \qquad (6)$$

Can use maximum likelihood technique:

$$-2\log\mathcal{L} = -2\sum \log p_{Poisson}(M_{ij}, \langle M\rangle_{ij}) \to \min \qquad (7)$$

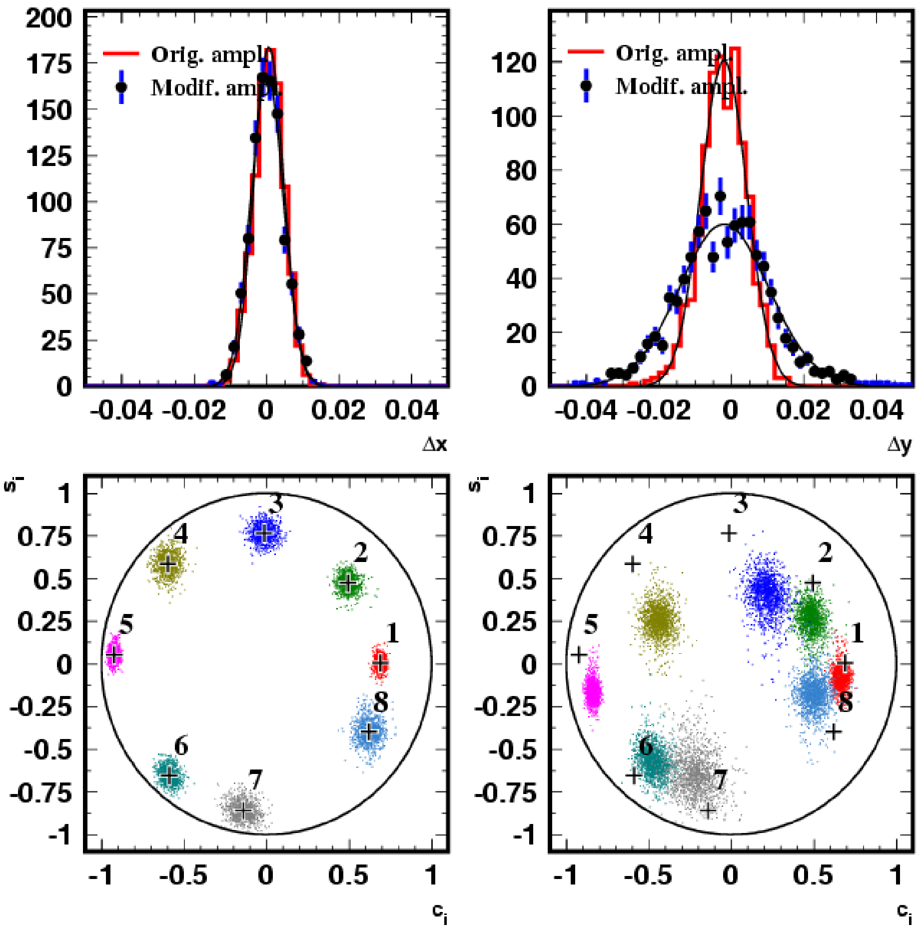
with c_i and s_i as free parameters.

For the same binning as in D_{CP}, number of bins is $\mathcal{N}^2$ (instead of $\mathcal{N}$), but the number of unknowns is the same.

With Poisson PDF, it's OK to have N_{ij}<1.
Can obtain both c_i and s_i.

It's convenient to use combined likelihood of $(K_s\pi^+\pi^-)^2$ and B data to account for errors in c_i and s_i.

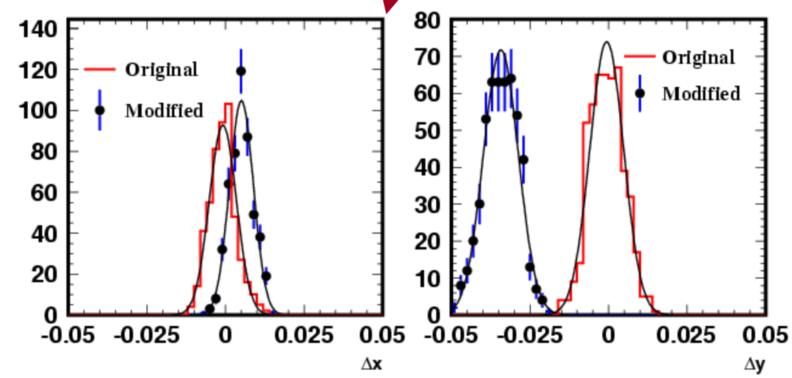
MC simulation of the bias in ϕ_3 measurement



Model dependence for 2x8 bins in $(K_s\pi^+\pi^-)^2$ case:

No bias when changing the model, but stat. error degrades.

Model dependence for 2x8 bins in D_{cp} case:



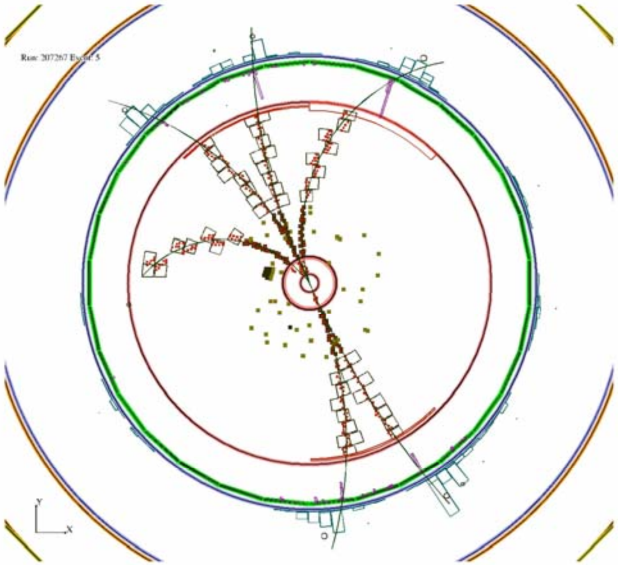
CLEO-c

$e^+e^- \rightarrow \psi(3770) \rightarrow D\bar{D}$

J.Rademacker

CLEAN-c

- Threshold production of correlated DD.
- Final state must be CP-odd,
- ...and flavour-neutral.
- That gives us access to both amplitude and phase across the Dalitz plot.



$\psi(3770) \rightarrow D^0(K_S\pi^+\pi^-)\bar{D}^0(K^+\pi^-)$

Jonas Rademacker (University of Bristol) for CLEO-c; CKM 2008, Roma 8

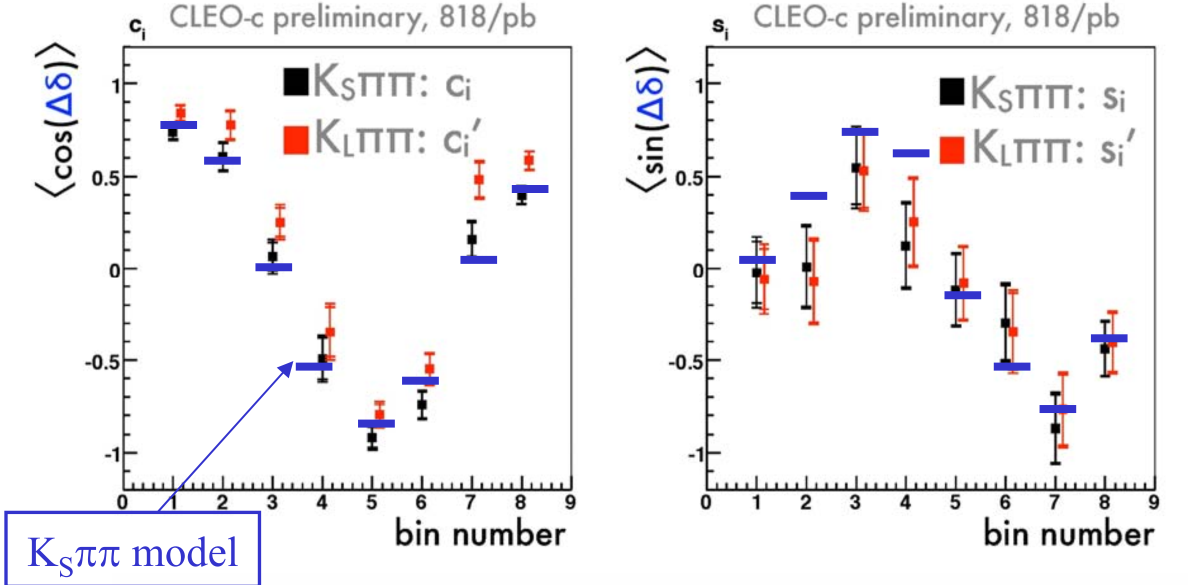
Event Yield Summary

J.Rademacker

CLEO-c preliminary, 818/pb

- Yields in 818 pb^{-1}, all with $B/S < 0.1$:
  - flavour-tagged: 12k $K_L\pi^+\pi^-$, 4k $K_S\pi^+\pi^-$.
  - 517 CP-odd $K_L\pi^+\pi^-$ 311 CP-even $K_S\pi^+\pi^-$
    322 CP-even $K_L\pi^+\pi^-$ 471 CP-odd $K_S\pi^+\pi^-$
  - 1.2k $K_L\pi^+\pi^-$ vs $K_S\pi^+\pi^-$, 475 $K_S\pi^+\pi^-$ vs $K_S\pi^+\pi^-$
- (Note: larger reconstruction efficiency for $K_L\pi^+\pi^-$, but fewer suitable tag modes)
- Nomenclatura trap: Often, esp. within CLEO-c, we refer to “CP-even-tagged” $K_S\pi^+\pi^-$. This is $K_S\pi^+\pi^-$ with CP-even D on the OTHER side. So that’s a CP-odd $K_S\pi^+\pi^-$. In this slide CP refers to the CP of the $K_S\pi^+\pi^-$ (not the tag).

The Result



Fit errors (include $\sigma_{statistical} \oplus$ errors on Δc_i, Δs_i constraints):
c_i: 0.04-0.11
c_i': 0.04-0.14
s_i: 0.15-0.23
s_i': 0.16-0.23

- Results of combined fit in terms of c_i, s_i in $K_S\pi\pi$ and c_i', s_i' in $K_L\pi\pi$.
- Each series of results (black / red) contains full information from both $K_S\pi\pi$ and $K_L\pi\pi$ data, related by Δc_i, Δs_i.
- Systematic errors:
  c_i: 0.02-0.06
  c_i': 0.02-0.07
  s_i: 0.04-0.10
  s_i': 0.06-0.10

Summary: CLEO-c's impact on γ

J.Rademacker

- CLEO-c's quantum-correlated D-Dbar pairs give model-independent access to c_i, s_i.
- Including $K_L\pi\pi$ in addition to $K_S\pi\pi$ significantly increases statistics at small systematic cost.
- With CLEO-c 818/pb of data, replace 4°–9° model error on γ from $B^\pm \to D(K_S\pi\pi)K^\pm$ with a statistical error:

$$\sigma_{\text{CLEO-input}}(\gamma) \sim 1^\circ\text{–}2^\circ$$ CLEO-c preliminary, 818/pb

- Significant reduction in systematics at BaBar/BELLE
- Crucial for LHCb and LHCb-Upgrade, Super-B.

J.Libby

Results

First determination with 281 pb^{-1}

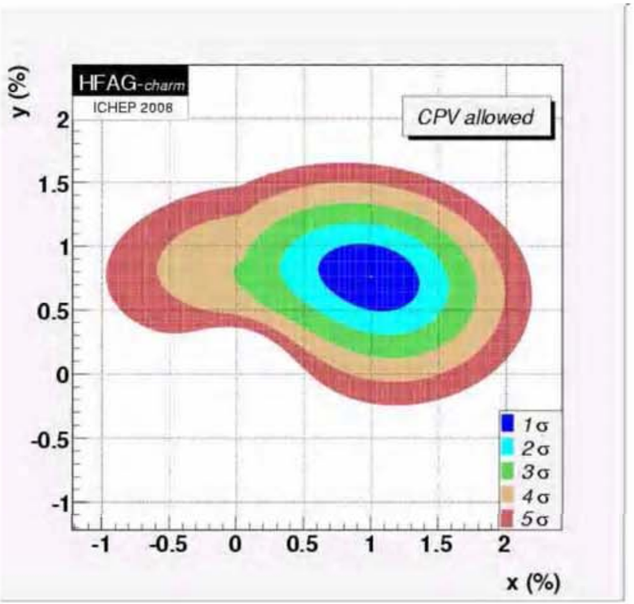
PRL 100, 221801 (2008)
PRD 78, 012001 (2008)

Parameter	Standard Fit	Extended Fit
y (10^{-3})	$-45 \pm 59 \pm 15$	$6.5 \pm 0.2 \pm 2.1$
r^2 (10^{-3})	$8.0 \pm 6.8 \pm 1.9$	$3.44 \pm 0.01 \pm 0.09$
$\cos\delta$	$1.03 \pm 0.19 \pm 0.06$	$1.10 \pm 0.35 \pm 0.07$
x^2 (10^{-3})	$-1.5 \pm 3.6 \pm 4.2$	$0.06 \pm 0.01 \pm 0.05$
$x \sin\delta$ (10^{-3})	0 (fixed)	$4.4 \pm 2.4 \pm 2.9$
$\chi^2_{\text{fit}}/\text{ndof}$	$30.1/46$	$55.3/57$

- Standard fit result important component in average of charm mixing
- Extended fit leads to measurement of:

$$\delta = \left(22^{+11+9}_{-12-11}\right)^\circ$$

From likelihood scan of physically allowed region



- Future improvements:
  - Full $\psi(3770)$ data set – 818 pb^{-1}
  - WS semileptonics vs. $K\pi$
  - Additional K^0_L modes
  - C-even information from 4170 MeV data

J.Libby

Multi-body ADS

Mode	Branching Ratio
$K\pi$	3.89%
$K\pi\pi^0$	13.9%
$K3\pi$	8.1%

- $B \to D(K\pi\pi\pi)K$ and $B \to D(K\pi\pi^0)K$ can also be used for ADS analyses
  - Significantly larger branching fractions than $B \to D(K\pi)K$
- However, need to account for the resonant substructure
  - In principle each point in the phase space has a different strong phase associated with it
- Atwood and Soni [PRD **68** 033003 (2003)] showed how to modify the usual ADS equations for this case
  - Introduce **coherence parameter $R_{K3\pi}$** which dilutes interference term sensitive to γ

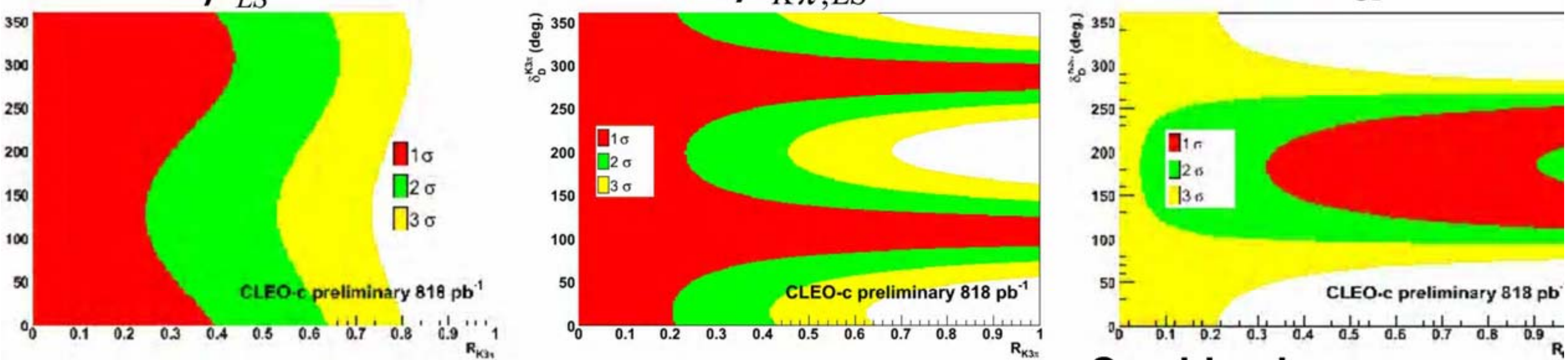
$$\Gamma(B^- \to (K^+\pi^-\pi^-\pi^+)_D K^-) \propto r_B^2 + (r_D^{K3\pi})^2 + 2 r_B r_D^{K3\pi} R_{K3\pi} \cos(\delta_B + \delta_D^{K3\pi} - \gamma)$$

- $R_{K3\pi}$ ranges from
  - 1=coherent (dominated by a single mode) to
  - 0=incoherent (several significant components)

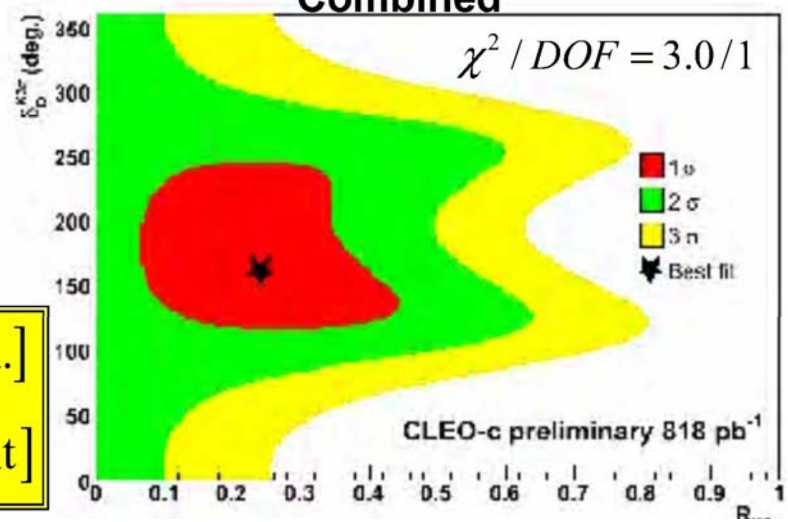
J.Libby

K3π likelihood scans

$\rho_{LS}^{K3\pi}$ $\rho_{K\pi,LS}^{K3\pi}$ Δ_{CP}



Combined



- Fit to observables and external constraints on D mixing parameters and branching fractions
  - Correlations included
- 2D likelihood shows regions R and δ space

Preliminary

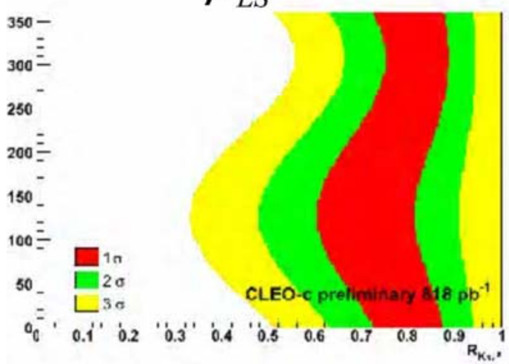
$$R_{K3\pi} = 0.24^{+0.21}_{-0.17} \quad [R_{K3\pi} < 0.57 \text{ at } 95\% \text{ c.l.}]$$

$$\delta_D^{K3\pi} = \left(161^{+85}_{+48}\right)^\circ \quad [\text{No } 95\% \text{ c.l. constraint}]$$

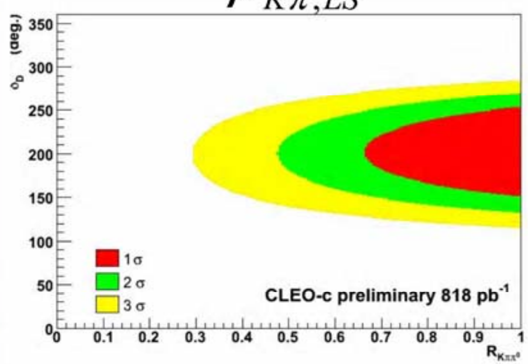
J.Libby

$K\pi\pi^0$ likelihood scans

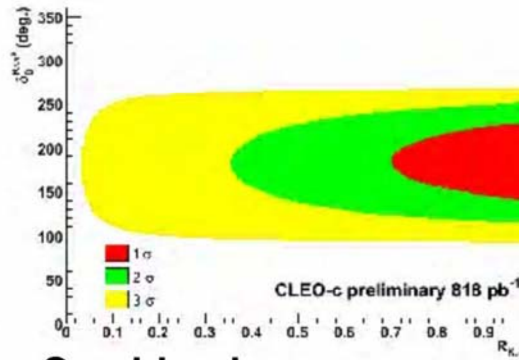
$\rho_{LS}^{K\pi\pi^0}$



$\rho_{K\pi,LS}^{K\pi\pi^0}$



Δ_{CP}



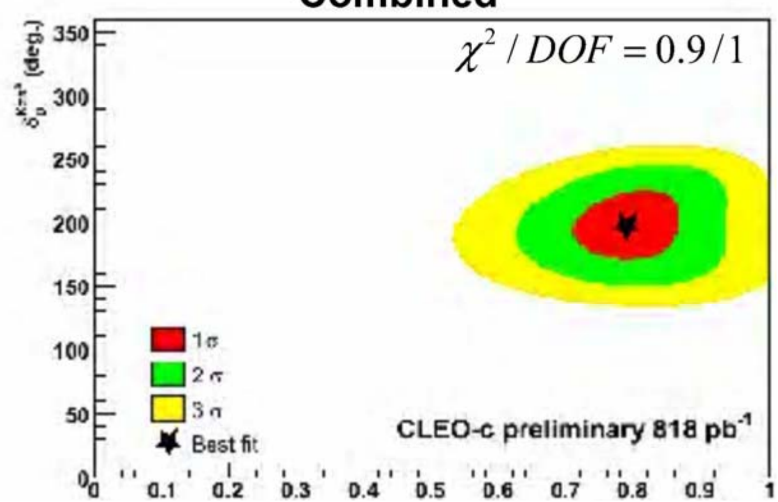
Preliminary

$$R_{K\pi\pi^0} = 0.79 \pm 0.08$$

$$\delta_D^{K\pi\pi^0} = \left(197^{+28}_{-27}\right)^\circ$$

Coherence observed!

Combined



G.Wilkinson

LHCb Global Sensitivity to γ

With $B \to DK$ methods perform global fit of common parameters. In addition consider results from B^0 and B_s time dependent analyses. (LHCb-2008-031)

Input measurements considered:

$B^- \to D^0 K^-$:

- $D^0 \to K\pi$, KK, $\pi\pi$ (LHCb-2008-011)
- $D^0 \to K\pi\pi\pi$ (LHCb-2007-004)
- $D^0 \to K_S\pi\pi$ (LHCb-2007-048)

$B^0 \to D^0 K^{*0}$

- $D^0 \to K\pi$, KK, $\pi\pi$ (LHCb-2007-050)

Time dependent measurements:

- $B^0 \to D\pi$ (LHCb-2007-044)
- $B_s \to D_s K$ (LHCb-2007-041)

Summary of event yields in 2 fb^{-1}

Channel	Signal	Background
$B^\pm \to D(K^\pm\pi^\mp)K^\pm$	56k	35k
$B^+ \to D(K^-\pi^+)K^+$	680	780
$B^- \to D(K^+\pi^-)K^-$	400	780
$B^+ \to D(K^+K^- + \pi^+\pi^-)K^+$	3.3k	7.2k
$B^- \to D(K^+K^- + \pi^+\pi^-)K^-$	4.4k	7.2k
$B^\pm \to D(K^\pm\pi^\mp\pi^+\pi^-)K^\pm$	61k	40k
$B^+ \to D(K^-\pi^+\pi^+\pi^-)K^+$	470	1.2k
$B^- \to D(K^+\pi^-\pi^+\pi^-)K^-$	350	1.2k
$B^0 \to D(K^+\pi^-)K^{*0}$, $\bar{B}^0 \to D(K^-\pi^+)\bar{K}^{*0}$	3.4k	1.7k
$B^0 \to D(K^-\pi^+)K^{*0}$	350	850
$B^0 \to D(K^+\pi^-)\bar{K}^{*0}$	230	850
$B^0 \to D(K^+K^- + \pi^+\pi^-)K^{*0}$	150	500
$\bar{B}^0 \to D(K^+K^- + \pi^+\pi^-)\bar{K}^{*0}$	550	500
$B^\pm \to D(K^0_S\pi^+\pi^-)K^\pm$	5k	4.7k
$B_s, \bar{B}_s \to D_s^\mp K^\pm$	6.2k	4.3k
$B^0, \bar{B}^0 \to D^\mp\pi^\pm$	1,300k	290k

G.Wilkinson

Sensitivity to γ including all measurement

Results shown as function of δ_{B^0}, least well known parameter. Sensitivity of $B^0 \to D^0 K^{*0}$ improves by factor of two in going from $\delta_{B^0} = 45 \to 180^\circ$. Residual dependence remains in global fit, but diluted due to other measurements.

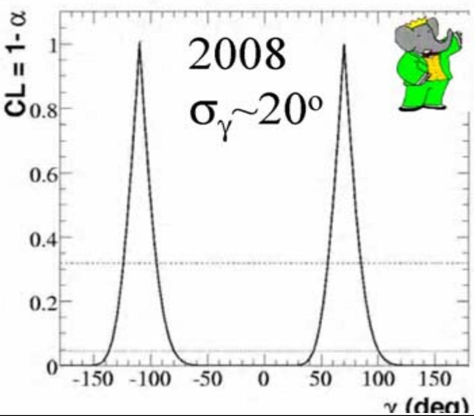
δ_{B^0} (°)	0	45	90	135	180
σ_γ for 0.5 fb^{-1} (°)	8.1	10.1	9.3	9.5	7.8
σ_γ for 2 fb^{-1} (°)	4.1	5.1	4.8	5.1	3.9
σ_γ for 10 fb^{-1} (°)	2.0	2.7	2.4	2.6	1.9

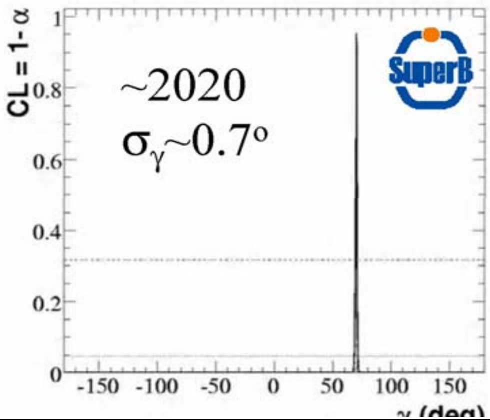
Weight (in %) of each contributing analysis with 2 fb^{-1} for two values of δ_{B^0}:

Analysis	$\delta_{B^0} = 0^\circ$	$\delta_{B^0} = 45^\circ$
$B^- \to D^0(hh)K^-$, $B^- \to D^0(K^\pm\pi^\mp\pi^+\pi^-)K^-$	25	38
$B^- \to D^0(K^0_S\pi^+\pi^-)K^-$	12	25
$B^0 \to D^0(hh)K^{*0}$	44	8
$B_s \to D_s^\mp K^\pm$	16	24
$B^0 \to D^\mp\pi^\pm$	3	5

F.Martinez-Vidal

- Measurement of γ at the B Factories was unexpected
  - r_B ratios confirmed to be ~0.1 (and >0) $\Rightarrow$ reliable predictions
  - $\delta\gamma \sim 20^o$ now, largely dominated by $B^+ \to D^{(*)}K^{(*)+}$ Dalitz
  - $\delta\gamma \sim 10^o$ after final analyses and combinations of current B Factories
- SSF can reach $\delta\gamma \sim 1^o$ and below with:
  - Combination of charged modes: $B^+ \to D^{(*)}K^{(*)+}$. Self-tagging neutral modes, e.g. $B^0 \to D^{(*)}K^{(*)0}$, may help
  - Combination of methods: Dalitz, GLW, ADS
  - Use of correlated data (CP tagged $K_S\pi\pi$,K_SKK and doubly tagged $K_S\pi\pi$,K_SKK)
    - SFF is a unique facility to provide large samples of correlated charm data
      - Enough with **3 months of data taking at ψ''(3770)** over a 5 years period
      - Key data also for other analyses (e.g. D-mixing and CPV in charm)
    - **<u>Only way to reach sub degree precision</u>**





Instead of Conclusion

CKM'08 Book

Working Group V Gamma(phi3) from tree decays approx 12 pages

Recall AIM of the book is legacy of the B-factories.

Conveners are requesting very short (up to 1 page) write-up on the following topics from the persons listed below:

Proposed Table of Contents and contributors

INTRO, motivation etc	(T. Gershon & A. Soni)
Theoretical remarks on D*V	(R.Sinha)
BELLE recent results	(A. Bondar)
BABAR ..Recent Results	(V. Tisserand)
Gamma from fits	(V. Sordini & K. Trabelsi)
CLEO-c inputs for gamma	(J. Libby and J. Rademacker)
LHCb Outlook for gamma (phi3)	(G. Wilkinson)
Prospects for gamma from SuperKEKB	(P.Krokovny)
Prospects for gamma from SuperFlavorFactory	(F. Martinez-Vidal)

Total ~ 10 pages

Deadline Oct. 15 th PLEASE SEND to us