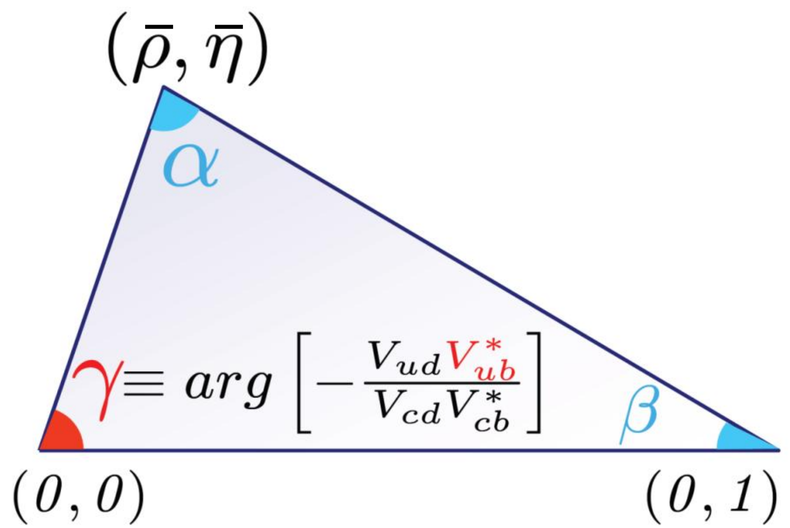


Measurement of the CKM angle γ/ϕ_3

Matteo Rama
Laboratori Nazionali di Frascati

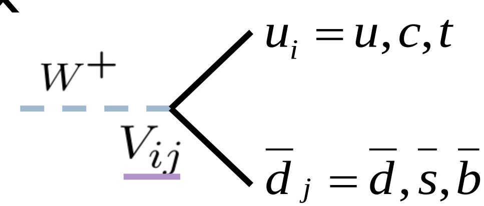
INFN Istituto Nazionale di Fisica Nucleare
SEZIONE DI PISA

Flavor Physics & CP Violation 2009
May 27 - June 1, 2009, Lake Placid, NY, USA

Quarks mixing and CKM matrix

- The electroweak coupling strength of $W^{\pm}$ to quarks is described by the CKM matrix

$$-\mathcal{L}_{W^\pm} = \frac{g}{\sqrt{2}}\, \overline{u_{Li}}\, \gamma^\mu\, (V_{\rm CKM})_{ij}\, d_{Lj}\, W_\mu^+ + \text{h.c.}$$

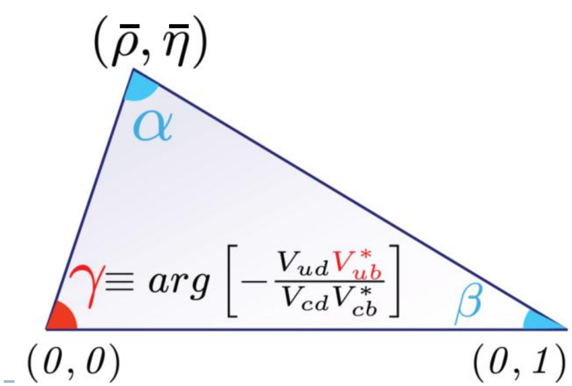


- 3x3 unitary matrix ➡ 4 parameters (after ad hoc choice of quark field phases): 3 real and 1 CP violating phase

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4)$$

- V is unitary: $VV^{+}=1$

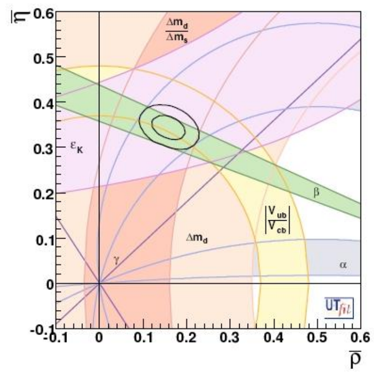
$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$



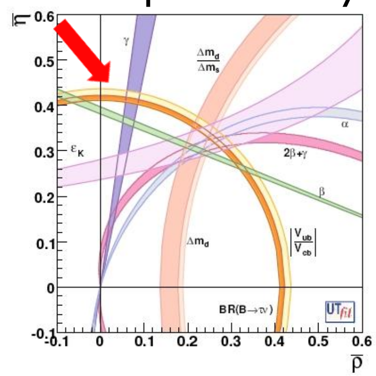
Why measure γ

- Importance of over-constraining the CKM matrix
  - precise measurement of Standard Model parameters
  - search for evidence of New Physics in discrepancies of redundant measurements

today



constraint with 75ab^{-1} at a SuperB factory

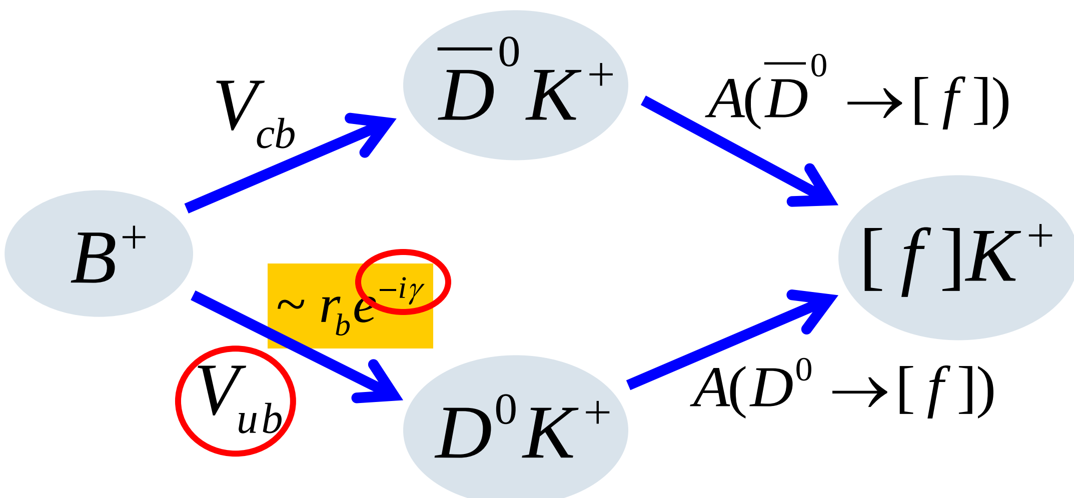


- CP violating parameter γ can be measured in tree decays
  - assuming that New Physics does not change tree-level processes, its determination is not affected by New Physics
  - together with the measurement of $|V_{ub}/V_{cb}|$ it gives a constraint in the rho-eta plane that must be met by any New Physics model

How to measure a phase

- Phases are measured in the interference of two amplitudes

$$|A_{\text{tot}}|^2 = |A_1 + A_2 e^{i\phi}|^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$



interference

$$\phi = \gamma + \delta$$

$\delta =$ strong phase from B and D decays

$$r_b \equiv \left| \frac{A(B^+ \to D^0 K^+)}{A(B^+ \to \overline{D}^0 K^+)} \right| \sim 0.1$$

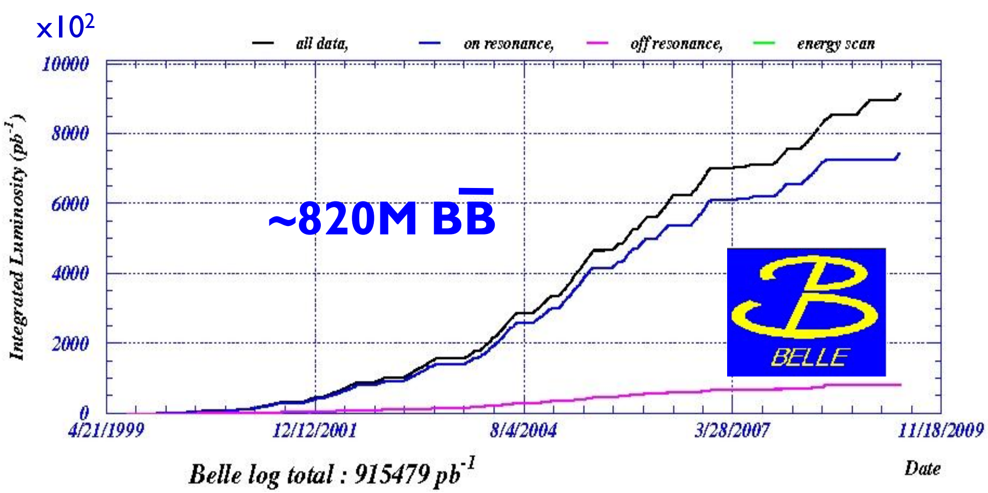
- The unknowns are: γ, r_b and δ

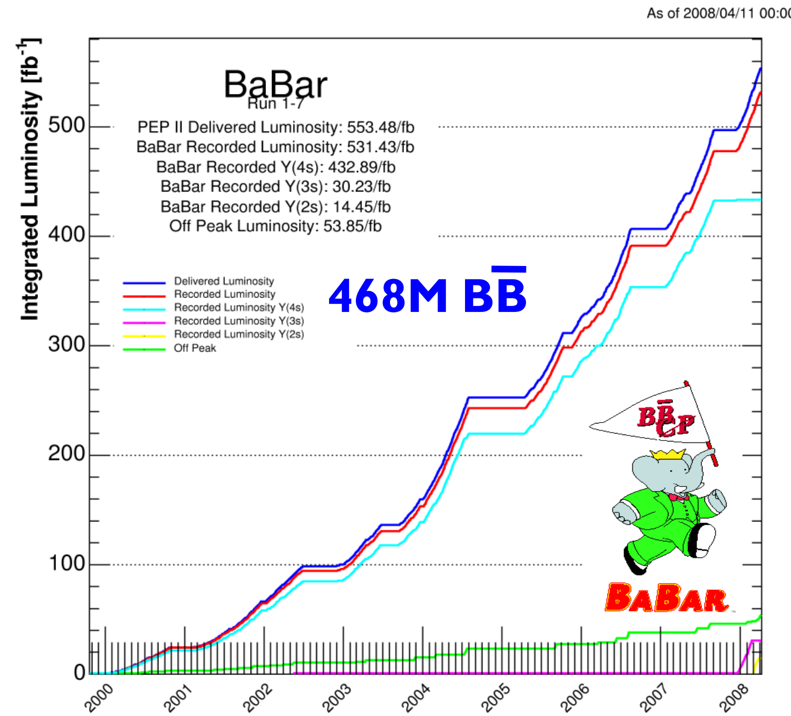
- Same principle applies to several other processes: $B^0 \to D^{(*)+}\pi^-$, $B^0 \to D^0 K^{(*)0}$, $B_s \to D_s K$, …

Current experiments

- asymmetric e+e- colliders PEP-II (US) and KEK (Japan) at Y(4S) CM energy
- Y(4S)→B$\bar{B}$ decays detected by general purpose BaBar and Belle detectors

1300 M B$\bar{B}$ decays overall





PEP-II ops ended April 7th 08

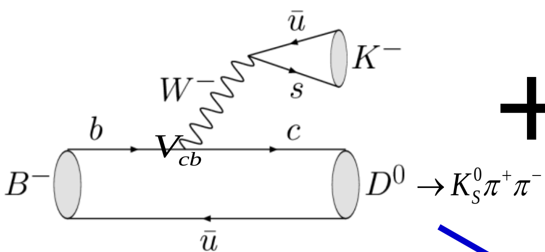
Methods using B→DK decays

- GLW:
  - D^0 mesons reconstructed into two-body CP eigenstates K^+K^-, $\pi^+\pi^-$ (even), $K_s\pi^0$, $K_s\omega$ (odd)
- ADS:
  - D^0 mesons reconstructed into doubly Cabibbo suppressed decays $K^+\pi^-$, $K^+\pi^-\pi^0$, …
- Dalitz (GGSZ):
  - D^0 mesons reconstructed into 3-body decays $K_s\pi^+\pi^-$, $K_sK^+K^-$, $\pi^+\pi^-\pi^0$, etc. and Dalitz plot fitted to determine how the strong phase of D^0 decay amplitude varies in the Dalitz plane } most powerful method nowadays
- Different B decays $D^0K^\pm$, $D^{*0}K^\pm$, $D^0K^{*\pm}$ and flavour-tagged D^0K^{*0}. They depend on different hadronic factors (r_b, δ_b)
- Strategy: combine as many channels as possible to improve the overall sensitivity to γ

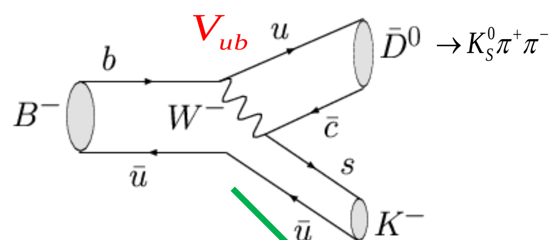
Dalitz method

D. Atwood et al., PRL78, 3257 (1997); A. Giri et al., PRD68, 054018 (2003)

- The interference varies as function of the position in the D^0 Dalitz plot



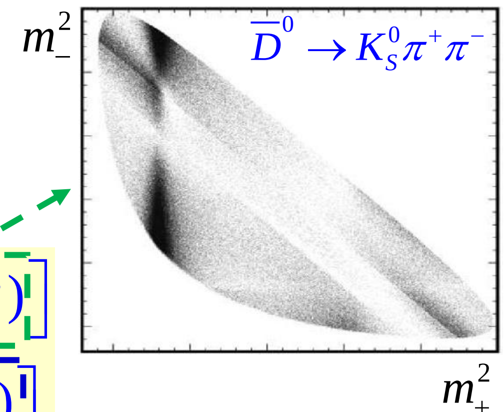
+

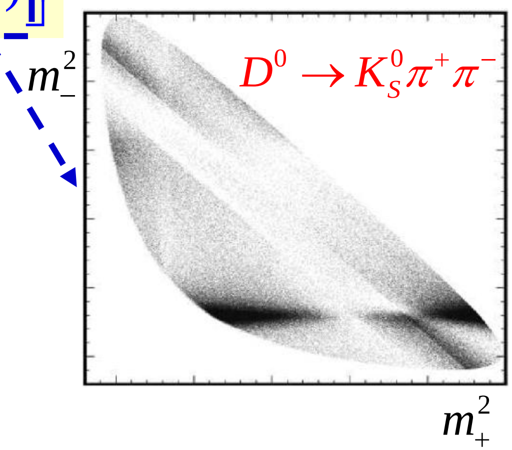


$$A_-(m_-^2,m_+^2) = \left|A(B^- \to D^0 K^-)\right| \left[A_D(m_-^2,m_+^2) + r_B e^{i\delta_B} e^{-i\gamma} A_D(m_+^2,m_-^2)\right]$$

$$A_+(m_-^2,m_+^2) = \left|A(B^+ \to \bar{D}^0 K^+)\right| \left[A_D(m_+^2,m_-^2) + r_B e^{i\delta_B} e^{+i\gamma} A_D(m_-^2,m_+^2)\right]$$

$$m_\pm^2 \equiv m^2(K_S^0\pi^\pm)^2$$





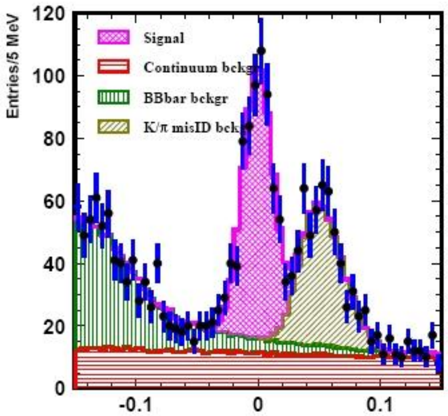
- $A_D(m_-^2,m_+^2)$ is measured with a Dalitz plot analysis of high statistics samples of flavour-tagged D^0 and $\bar{D}^0$
- The B^+ and B^- yields are measured as a function of the position in the D^0 Dalitz plot (ML fit)
- Unknowns: γ, rb and δ_b

Dalitz: reconstructed modes

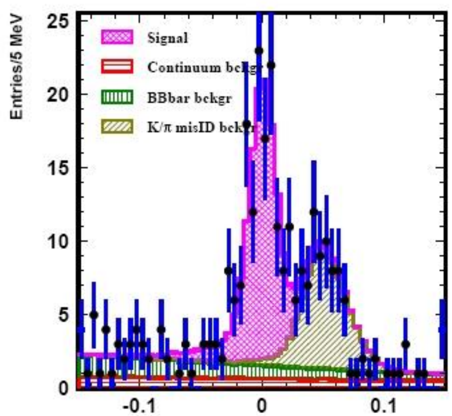
Decays	D^0K	$D^{*0}[D^0\pi^0]K$	$D^{*0}[D^0\gamma]K$	$D^0K^*[K_s\pi]$
$D^0 \to K_s\pi\pi$	383M 657M	383M 657M	383M	383M 386M
$D^0 \to K_sKK$	383M	383M	383M	---

Belle

$B \to D^0K$, $D \to K_s\pi\pi$



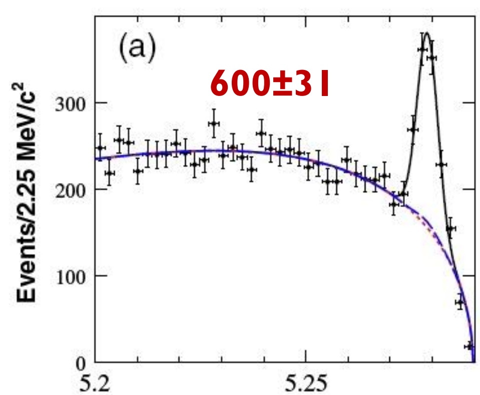
$B \to D^{*0}K$, $D \to K_s\pi\pi$



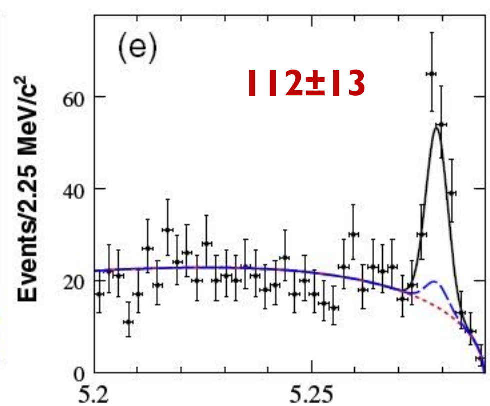
$$\Delta E = E_B^* - E_{beam}^*$$

BaBar

$B \to D^0K$, $D \to K_s\pi\pi$



$B \to D^0K$, $D \to K_sKK$



$$m_{ES} = \sqrt{E_{beam}^{*2} - p_B^{*2}}$$

Dalitz: results

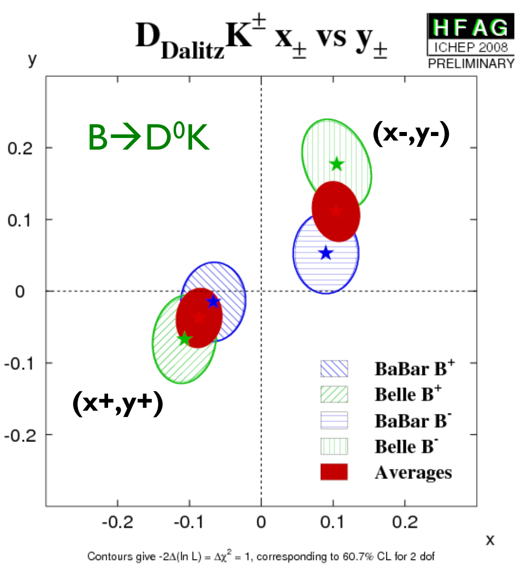
- Extract the *cartesian coordinates* instead of γ, r_b, δ_b (likelihood unbiased and Gaussian-shaped with x,y)

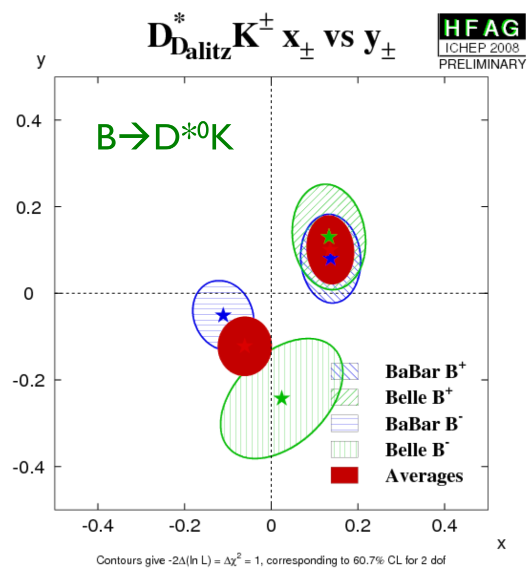
$$x_\mp = r_B \cos(\delta_B \mp \gamma)$$
$$y_\mp = r_B \sin(\delta_B \mp \gamma)$$

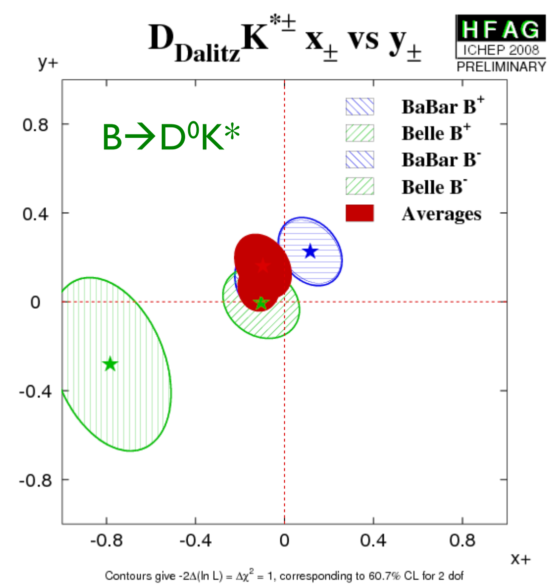
$$\begin{cases} \Gamma(B^+) \propto |f_+|^2 + (x_+^2 + y_+^2)|f_-|^2 + 2x_+ \mathrm{Re}(f_+ f_-^*) + 2y_+ \mathrm{Im}(f_+ f_-^*) \\ \Gamma(B^-) \propto |f_-|^2 + (x_-^2 + y_-^2)|f_+|^2 + 2x_- \mathrm{Re}(f_- f_+^*) + 2y_- \mathrm{Im}(f_- f_+^*) \end{cases}$$

$(x_\pm, y_\pm)$ 4 variables, 3 indep.
$x_+^2 + y_+^2 = x_-^2 + y_-^2$

$$f_\mp \equiv A_D(m_\mp^2, m_\pm^2)$$



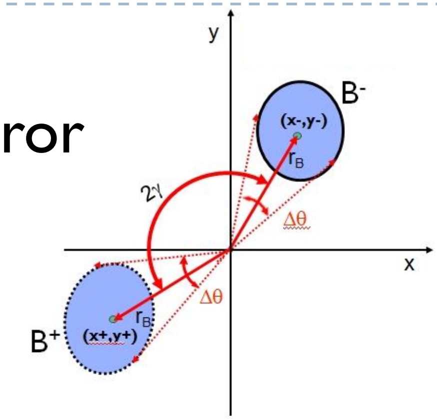


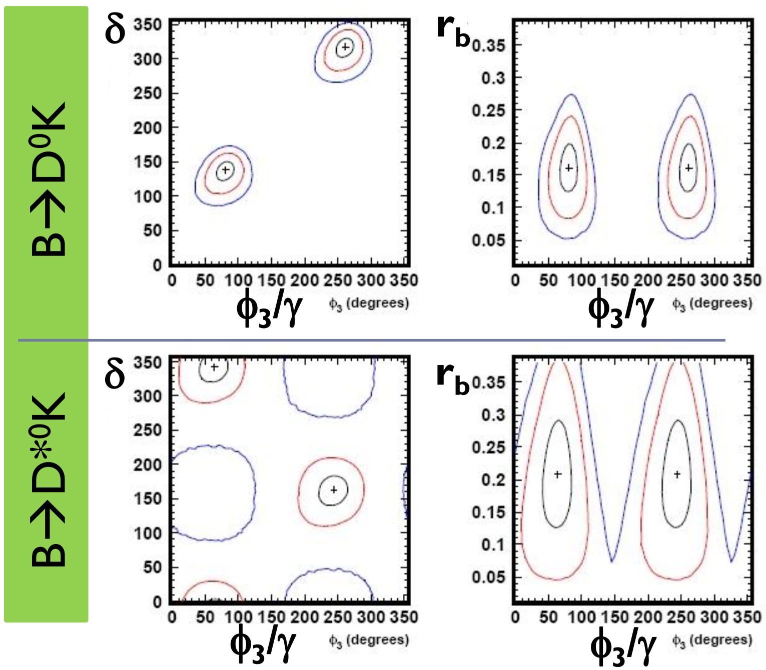


Dalitz: from x,y to $\gamma(\phi_3)$

- $\{\gamma, r_b, \delta_b)$ extracted from $\{x_\pm, y_\pm\}$
- frequentist stat. procedure to evaluate the error

PRD73, 112009 (2006)





3.5σ stat significance of CPV

$$\gamma(DK) = (80.8^{+13.1}_{-14.8} \pm 5.0 \pm 8.7)^\circ$$
$$\gamma(D^*K) = (63.8^{+20.8}_{-22.9} \pm 4.7 \pm 8.7)^\circ$$

DK only
D*K only

$$\delta_b(DK) = (137.4^{+13.0}_{-15.7} \pm 4.0 \pm 22.9)^\circ$$
$$\delta_b(D^*K) = (342^{+21.4}_{-22.9} \pm 3.7 \pm 22.9)^\circ$$

$$r_b(DK) = 0.161^{+0.040}_{-0.038} \pm 0.011 \pm 0.049$$
$$r_b^*(D^*K) = 0.208^{+0.085}_{-0.083} \pm 0.015 \pm 0.049$$

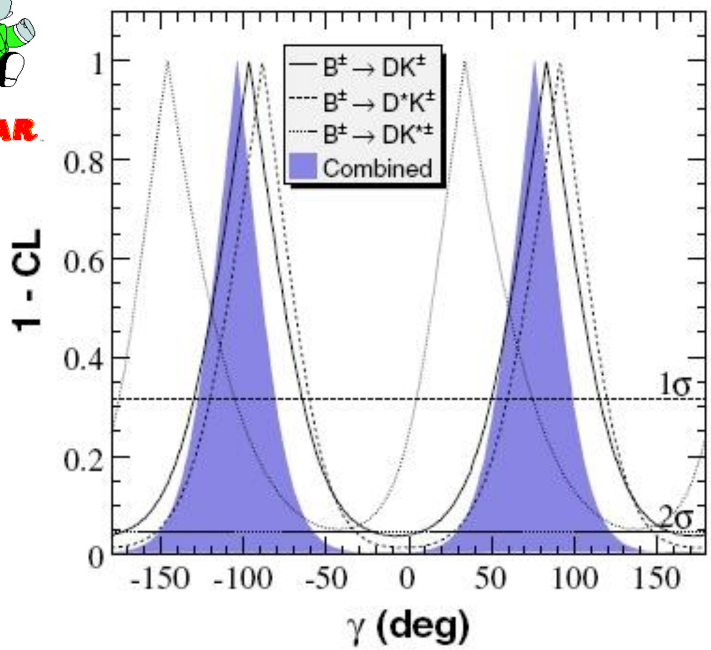
$$\gamma\,(\mathrm{mod}\,180^\circ) = (\,76\,^{+12}_{-13} \pm 4 \pm 9\,)^\circ$$

stat syst model

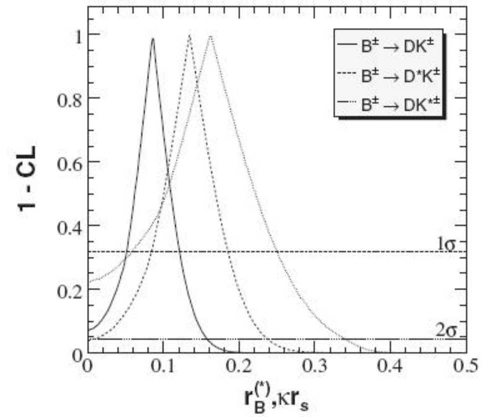
Dalitz: from x,y to $\gamma(\phi_3)$

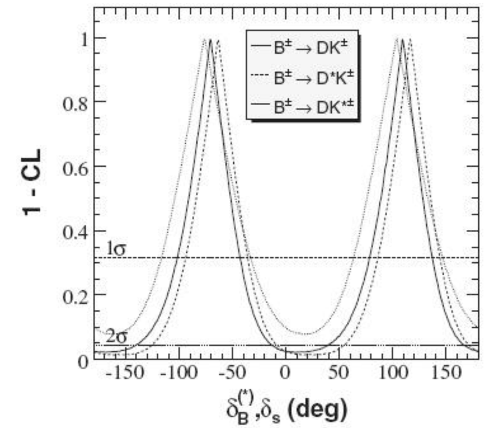
- Use frequentist method to obtain the physical parameter γ, r_b, δ_b from (x,y)

PRD78, 034023 (2008)



3.0σ stat significance of CPV





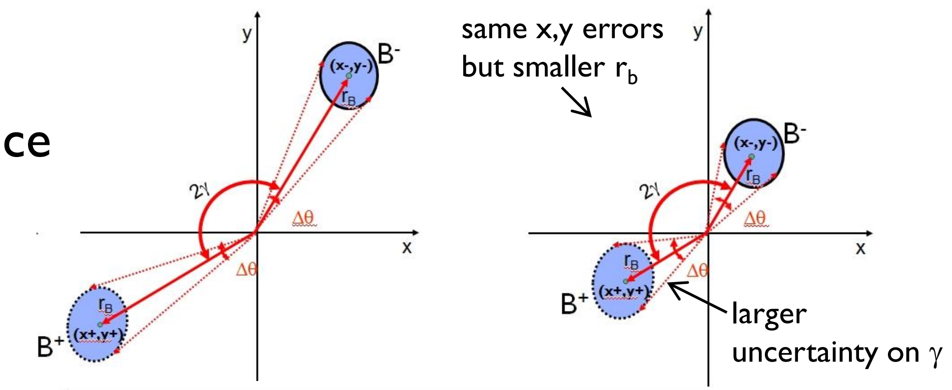
$$r_b(DK) = 0.086 \pm 0.035$$
$$r_b^*(D^*K) = 0.135 \pm 0.051$$
$$\kappa r_s(DK^*) = 0.163^{+0.088}_{-0.105}$$

$$\delta_b(DK) = (109^{+28}_{-31})^\circ$$
$$\delta_b(D^*K) = (-63^{+28}_{-30})^\circ$$
$$\delta_s(DK^*) = (104^{+43}_{-41})^\circ$$

$$\gamma\,(\text{mod}\,180^\circ) = (\,76 \pm \underbrace{22}_{\text{stat}} \pm \underbrace{5}_{\text{syst}} \pm \underbrace{5}_{\text{model}}\,)^\circ$$

Dependence on r_b of $\sigma(\gamma)$

- The error on γ scales roughly as $1/r_b$
- This is the origin of the large difference in the statistical errors of BaBar and Belle



BELLE

Parameter	$B^+ \to DK^+$	$B^+ \to D^* K^+$
x_-	$+0.105 \pm 0.047 \pm 0.011$	$+0.024 \pm 0.140 \pm 0.018$
y_-	$+0.177 \pm 0.060 \pm 0.018$	$-0.243 \pm 0.137 \pm 0.022$
x_+	$-0.107 \pm 0.043 \pm 0.011$	$+0.133 \pm 0.083 \pm 0.018$
y_+	$-0.067 \pm 0.059 \pm 0.018$	$+0.130 \pm 0.120 \pm 0.022$

BABAR

Parameters	$B^- \to \tilde{D}^0 K^-$
x_-, x_-^*, x_{s-}	$0.090 \pm 0.043 \pm 0.015 \pm 0.011$
y_-, y_-^*, y_{s-}	$0.053 \pm 0.056 \pm 0.007 \pm 0.015$
x_+, x_+^*, x_{s+}	$-0.067 \pm 0.043 \pm 0.014 \pm 0.011$
y_+, y_+^*, y_{s+}	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$

errors on x,y are comparable

BELLE

$$r_b(DK) = 0.161^{+0.040}_{-0.038} \pm 0.011 \pm 0.049$$
$$r_b^*(D^*K) = 0.208^{+0.085}_{-0.083} \pm 0.015 \pm 0.049$$

BABAR

$$r_b(DK) = 0.086 \pm 0.035$$
$$r_b^*(D^*K) = 0.135 \pm 0.051$$

central values of r_b are significantly dfferent

BELLE

$$\gamma\,(\mathrm{mod}\,180°) = (76^{+12}_{-13} \pm 4 \pm 9)°$$

BABAR

$$\gamma\,(\mathrm{mod}\,180°) = (76 \pm 22 \pm 5 \pm 5)°$$

- The "$1/r_b$" effect should reduce as more data are analyzed ($\sigma(r_b)/r_b$ decreases)

GLW method

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

- D^0 to K^+K^-, $\pi^+\pi^-$ (CP+) and $K_S\pi^0$, $K_S\omega$, $K_S\phi$ (CP-)
- measure B^+ and B^- yields to determine the GLW observables:

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

$$A_{CP\pm} \equiv \frac{\Gamma(B^- \to D^0_{CP\pm}K^-) - \Gamma(B^+ \to D^0_{CP\pm}K^+)}{\Gamma(B^- \to D^0_{CP\pm}K^-) + \Gamma(B^+ \to D^0_{CP\pm}K^+)} = \pm 2r_b \sin\gamma \sin\delta_b / R_{CP\pm}$$

4 observables (3 independent), 3 unknowns: r_b, δ_b, γ

- GLW-Dalitz relation:

$$x_\pm = \frac{R_{CP+}(1 \mp A_{CP+}) - R_{CP-}(1 \mp A_{CP-})}{4}, \quad r_b^2 = x_\pm^2 + y_\pm^2 = \frac{R_{CP+} + R_{CP-} - 2}{2},$$

BABAR

$$x_+ = -0.09 \pm 0.05(\text{stat}) \pm 0.02(\text{syst}),$$
$$x_- = +0.10 \pm 0.05(\text{stat}) \pm 0.03(\text{syst}),$$
$$r_b^2 = +0.05 \pm 0.07(\text{stat}) \pm 0.03(\text{syst}).$$

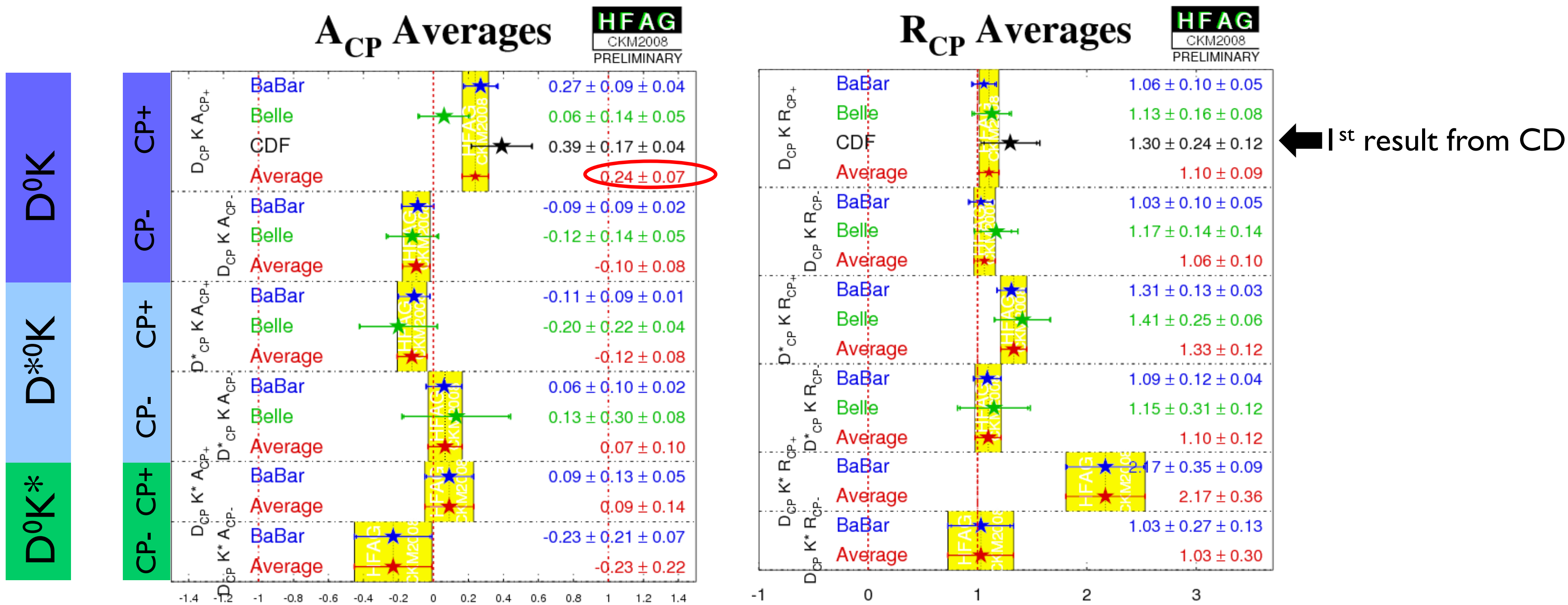
GLW (382M) ⟷ Dalitz (383M)

similar $x_\pm$ errors
no $y_\pm$ from GLW

BABAR

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_+	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$

GLW results



HFAG: http://www.slac.stanford.edu/xorg/hfag/

D⁰K GLW results can be translated into $x_+ = -0.082 \pm 0.045$, $x_- = 0.103 \pm 0.045$, $r_b^2 = 0.08 \pm 0.07$ *

Exercise:

* Gershon@CKM08

Combining GLW & Dalitz gives $x_+ = -0.085 \pm 0.026$, $x_- = 0.103 \pm 0.027$

$x_- - x_+ = 0.189 \pm 0.037$ **5.1σ from zero***

GLW + Dalitz w/o model error

ADS method

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

- D^0 to $K^+\pi^-$, $K^+\pi^-\pi^0$ or $K^+\pi^+\pi^+\pi^-$ (doubly-suppressed)

suppressed $\quad$ favored

$$B^+ \to D^{(*)0} K^{(*)+} \quad + \quad D^0 \to f$$

favored $\quad$ suppressed

$$B^+ \to \overline{D}^{(*)0} K^{(*)+} \quad + \quad \overline{D}^0 \to f$$

same final state

Large interference ~O(1)

- measure B^+ and B^- yields to determine the ADS observables:

$$R_{ADS} \equiv \frac{\Gamma(B^- \to D[\to f]K^-) + \Gamma(B^+ \to D[\to \bar{f}]K^+)}{\Gamma(B^- \to D[\to \bar{f}]K^-) + \Gamma(B^+ \to D[\to f]K^+)} = r_b^2 + r_D^2 + 2 r_b r_D \cos(\delta_b + \delta_D)\cos\gamma$$

$$A_{ADS} \equiv \frac{\Gamma(B^- \to D[\to f]K^-) - \Gamma(B^+ \to D[\to \bar{f}]K^+)}{\Gamma(B^- \to D[\to f]K^-) + \Gamma(B^+ \to D[\to \bar{f}]K^+)} = 2 r_b r_D \sin(\delta_b + \delta_D)\sin\gamma / R_{ADS}$$

$$r_D = \left| \frac{A(\overline{D}^0 \to f)}{A(D^0 \to f)} \right|$$

($r_D(K^+\pi^-)$=0.06)

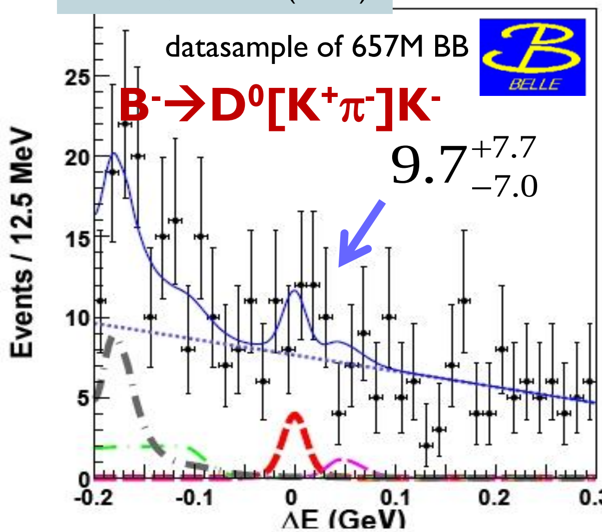
$$\delta_D = \arg\left[\frac{A(\overline{D}^0 \to f)}{A(D^0 \to f)} \right]$$

- ADS method useful at present to constrain r_b

ADS results

- Limits on r_b derived from R_{ADS}
  Measurement of Belle below

PRD78, 071901 (2008)



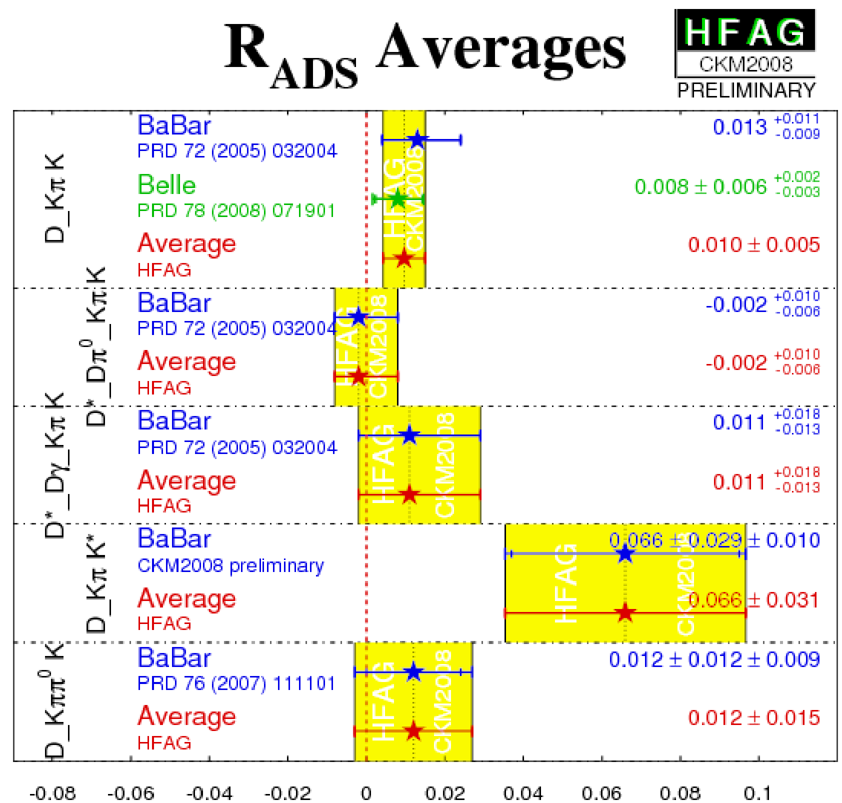
$R_{ADS}(D^0K)<0.19\ 10^{-3}$ @90%CL

$$R_{ADS} = r_b^2 + r_D^2 + 2 r_b r_D \cos(\delta_b + \delta_D)\cos\gamma$$

assuming $\cos(\delta_b+\delta_d)$=-1 and +2σ shift in r_d

conservative upper limit

r_b<0.19 @90% CL

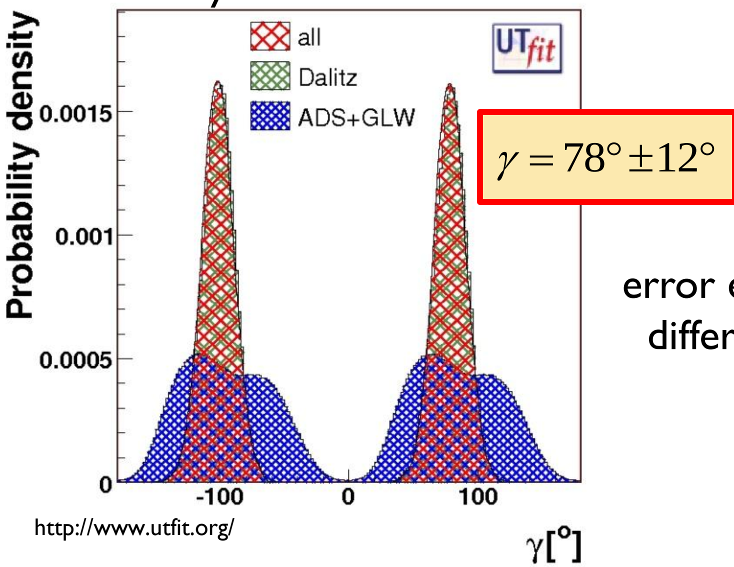


- No evidence of signal observed in any modes. Upper limits on R_{ADS} translated to upper limits on r_b

B±→DK altogether

World average combination

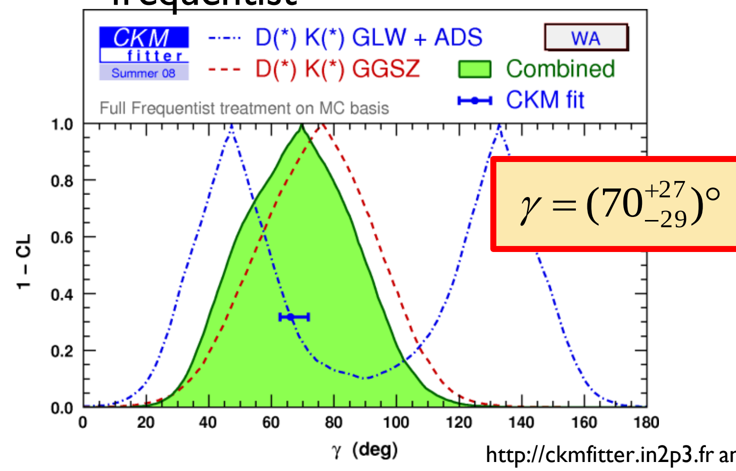
Bayesian



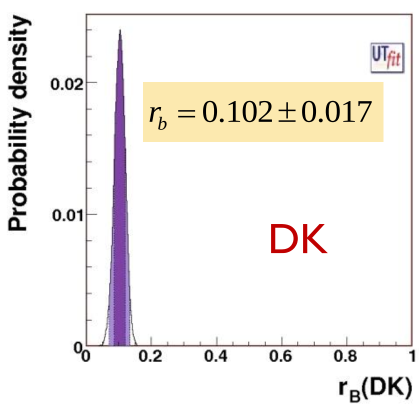
http://www.utfit.org/

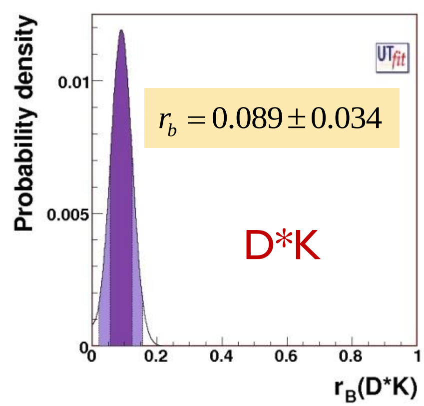
error estimate varies with different philosophies…

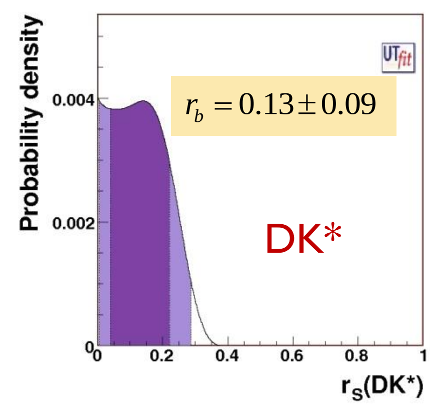
frequentist



http://ckmfitter.in2p3.fr and K. Trabelsi at CKM08



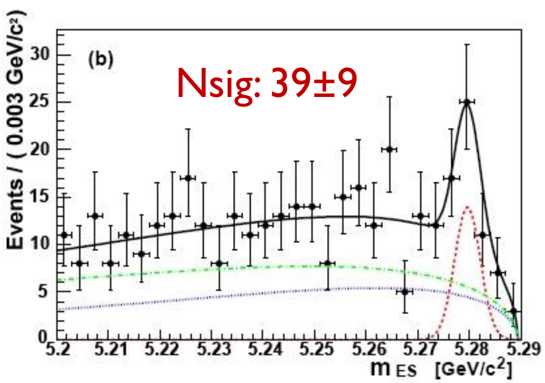


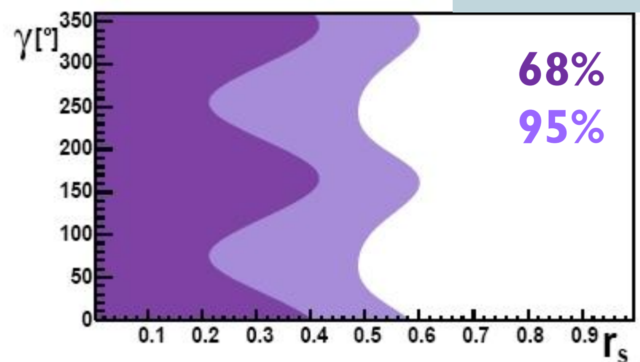


Dalitz method with $B^0 \rightarrow D^0 K^{*0}$

- Same concept as the charged B analysis, with the flavour of $K^{*0} \rightarrow K^+\pi^-$ tagging the B^0 flavour
- Main features
  - w.r.t. charged B mode: much lower signal yield but expected larger r_b (~0.3) (usually called r_s)
  - $D^0 \rightarrow K_s\pi^+\pi^-$ with same Dalitz model used for the charged B measurement
  - likelihood fit (m_{ES} and event shape variables) to separate signal from background
  - fit to the $D^0 \rightarrow K_s\pi^+\pi^-$ Dalitz plot to constrain γ, δ_b and r_s
  - data sample: 371M $B\bar{B}$

PRD79, 072003 (2009)
arXiv:0805.2001v2





promising for next B-factories

68% CL

$$\gamma = (162 \pm 56)^\circ \text{ or } (342 \pm 56)^\circ;$$
$$\delta_S = (62 \pm 57)^\circ \text{ or } (242 \pm 57)^\circ;$$
$$r_S < 0.30;$$

→ using r_s likelihood in PRD74,031101 (2006)

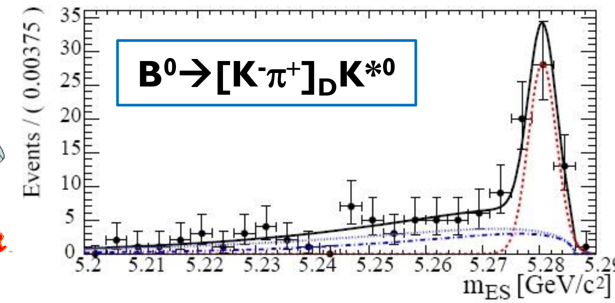
ADS with $B^0 \to D^0 K^{*0}$

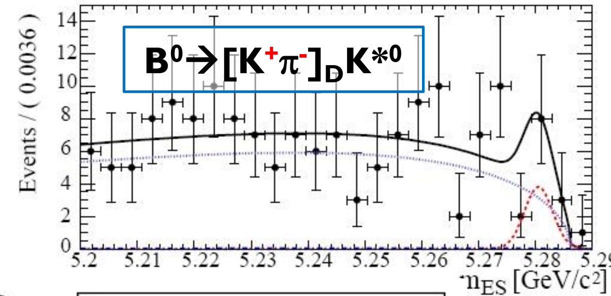
arXiv:0904.2112v1
sub. to PRD (RC)

- Selection of $B^0 \to D^0 K^{*0}[K^+\pi^-]$, $D^0 \to K^+\pi^-$, $K^+\pi^-\pi^0$ and $K^+\pi^+\pi^+\pi^-$
- No evidence of signal on data set of 465M $B\bar{B}$

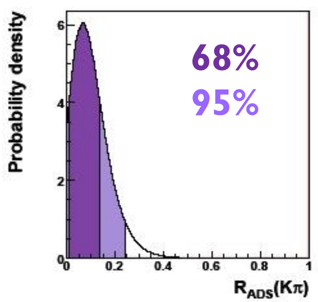
$$N_{sig}(tot) = 24^{+14}_{-11} \quad \text{(2.2 } \sigma \text{ stat only)}$$

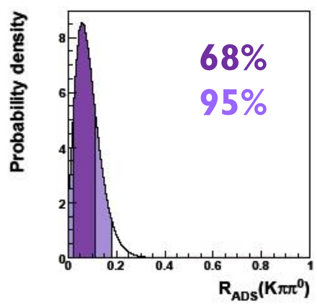
- Set limits on R_{ADS} (95%CL)

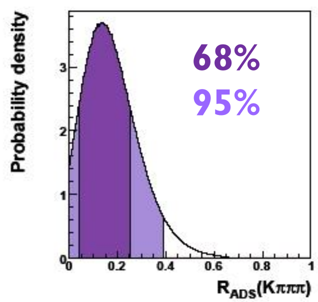




$R_{ADS}(K\pi) < 0.244$ $\quad$ $R_{ADS}(K\pi\pi^0) < 0.181$ $\quad$ $R_{ADS}(K\pi\pi\pi) < 0.391$

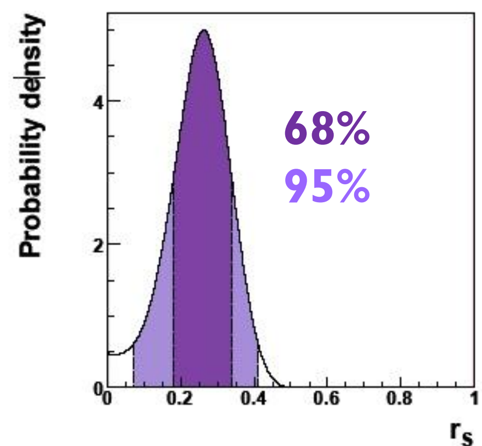






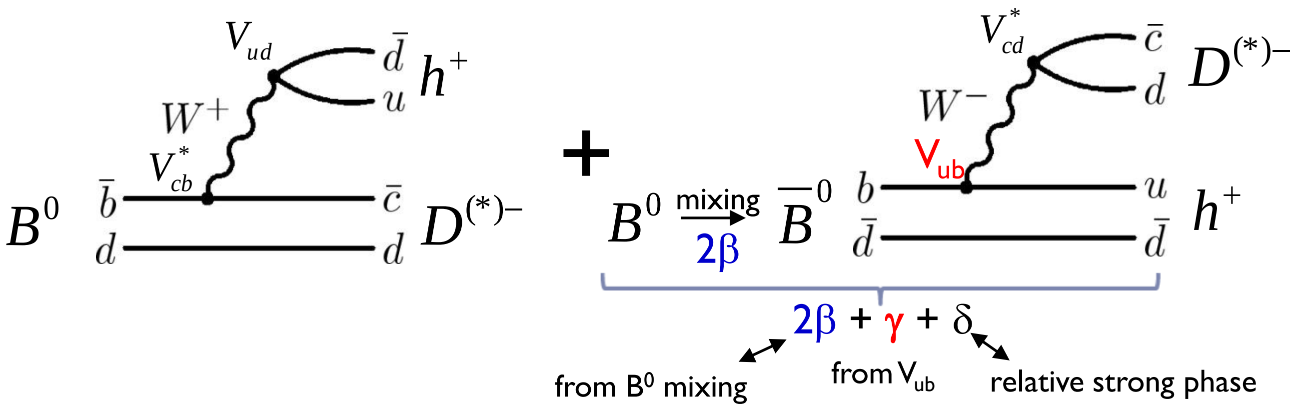
- Combining all modes and using external inputs:

r_b in [0.18, 0.34] @68% CL
r_b in [0.07,0.41] @95% CL



r_D from PDG, $\delta_D(K\pi)$ $\delta_D(K\pi\pi^0)$ $\delta_D(K\pi\pi\pi)$ from CLEO-c

$\sin(2\beta+\gamma)$ with $B^0 \to D^{(*)}\pi^\pm/\rho^\pm$



$$P(B^0 \to D^{(*)\mp}h^\pm, \Delta t) \propto 1 \pm C\cos(\Delta m_d \Delta t) + S^\mp \sin(\Delta m_d \Delta t)$$
$$P(\overline{B}^0 \to D^{(*)\mp}h^\pm, \Delta t) \propto 1 \mp C\cos(\Delta m_d \Delta t) - S^\pm \sin(\Delta m_d \Delta t)$$

$$S^\pm = \frac{2r}{1+r^2}\sin(2\beta+\gamma\pm\delta)$$
$$C = \frac{1-r^2}{1+r^2} \cong 1$$
$$r = \left|\frac{A(\overline{B}^0 \to D^{(*)-}h^+)}{A(B^0 \to D^{(*)-}h^+)}\right| \sim 0.02$$

- $S^\pm$ and C measured from time-dependent rates
- r too small to be extracted from C ➔ r fixed using external input + SU(3)
- Effect of b→u vs. b→c interference in Btag must be taken into account.

$$S^\pm \to a \mp c \mp \eta b$$

($\eta=\pm1$ for $D^{(*)\mp}h^\pm$)

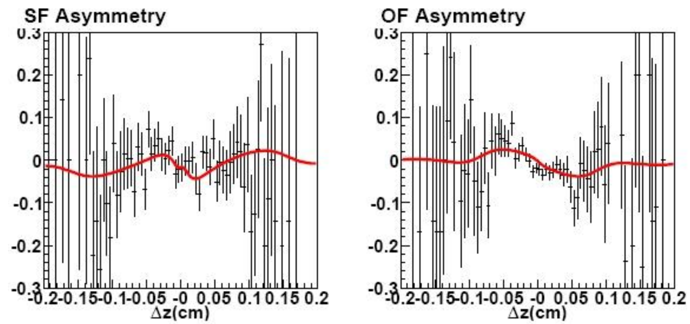
$$a^\mu = 2r^\mu \sin(2\beta+\gamma)\cos\delta^\mu\,, \qquad \mu \in \{D\pi, D^*\pi, D\rho\}$$
$$b_i = 2r_i' \sin(2\beta+\gamma)\cos\delta_i'\,,$$
$$c_i^\mu = 2\cos(2\beta+\gamma)(r^\mu \sin\delta^\mu - r_i'\sin\delta_i')\,.$$

0 with lepton tag

sin(2β+γ) with $B^0 \to D^{(*)}\pi^\pm/\rho^\pm$

$$\mathcal{A}^{SF} = \frac{N_{\pi^- l^-}(\Delta z) - N_{\pi^+ l^+}(\Delta z)}{N_{\pi^- l^-}(\Delta z) + N_{\pi^+ l^+}(\Delta z)}$$

$$\mathcal{A}^{OF} = \frac{N_{\pi^+ l^-}(\Delta z) - N_{\pi^- l^+}(\Delta z)}{N_{\pi^+ l^-}(\Delta z) + N_{\pi^- l^+}(\Delta z)}$$

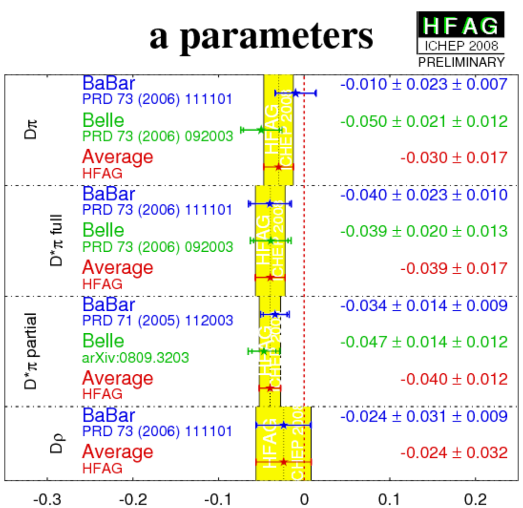


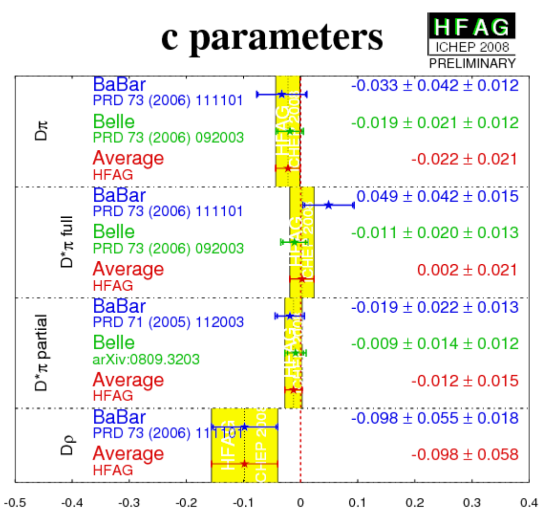
- Partial reconstruction of $D^{*+}\pi^-$ (D^0 not reconstructed)
- lepton tag analysis based on 657M BB
- 50196±286 signal candidates

arXiv:0809.3203v1

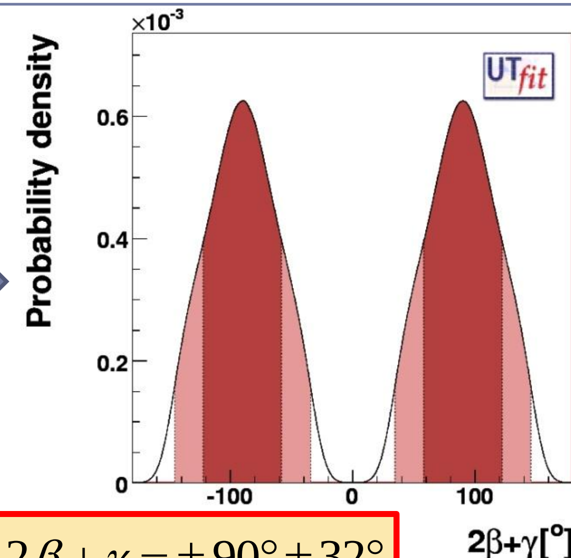
$$S^+ = +0.057 \pm 0.019 \pm 0.012$$
$$S^- = +0.038 \pm 0.020 \pm 0.010$$

$$a = -0.047 \pm 0.014 \pm 0.012$$
$$c = -0.009 \pm 0.014 \pm 0.012$$





a+c WA



$$2\beta + \gamma = \pm 90^\circ \pm 32^\circ$$

Future experiments and perspectives

- B-factories have collected about 1300M $B\bar{B}$, allowing CKM test at ~10% level precision
- Next generation B-factories are needed to go down to the 1% level
  - LHCb expected to start operations this year
  - e^+e^- SuperB factories proposed in Italy and Japan
- Will γ measurements be systematic-limited? In general, no.
  - Dalitz model uncertainties seem hard to reduce below ~5°, but a model independent analysis is possible . It benefits from $\psi(3770) \rightarrow D\bar{D}$ data of CLEOc and BESIII

    PRD68,054018 (2003)

    arXiv:0801.0840v2
  - Effects of charm mixing and CPV are small and under control PRD72, 031501(2005)
  - Decays that at present have a weak constraining power or are not reconstructed at all (e.g., $B_s \rightarrow D_s K$) might give significant contributions at next machines
- An uncertainty of about 2-3° is expected at LHCb on $10fb^{-1}$, and 1-2° at e^+e^- SuperB factories on $75ab^{-1}$

LHCB-2008-031

SuperB CDR, arXiv:0709.0451

Summary

- Many measurements have been performed to improve the overall precision on γ/ϕ_3
- There is evidence of CP violation in charged B→DK
- Charged B→DK 'Dalitz' is currently the most sensitive method
  - $\sigma(\gamma) \sim 10\div20^\circ$
  - Fluctuations in $\sigma(\gamma)$ due to the "$1/r_b$" effect should decrease as more data are analyzed and $\sigma(r_b)/r_b$ decreases
  - On larger datasets a model-independent approach can possibly be used to eliminate the Dalitz model systematics
- New measurements are expected this year. Stay tuned.

backup slides

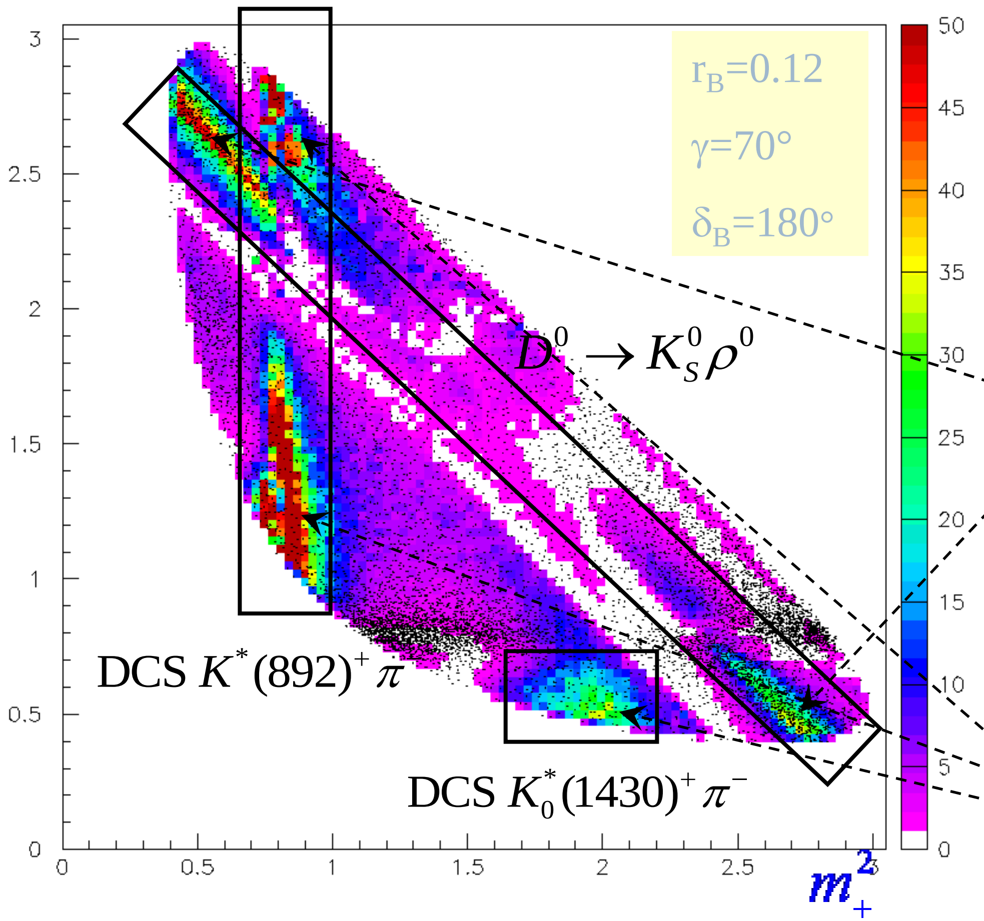
Sensitivity to γ over the Dalitz plot

- Sensitivity varies strongly over the Dalitz plane
- 2[nd] derivative of the log(L) event-by-event weighs the event

$$\sigma^2(\gamma) \sim \frac{1}{\frac{d^2 \ln(L)}{d\gamma^2}}$$

$$\text{weight} = \frac{d^2 \ln(L)}{d\gamma^2}$$

events: points (weight = 1)



Interference of $B^- \to D^0[\to K^0_S \rho^0]K^-$ with $B^- \to \overline{D}^0[\to K^0_S \rho^0]K^-$ ≡ GLW like

Interference of $B^- \to D^0[\to K^{*+}\pi^-]K^-$ (suppressed) with $B^- \to \overline{D}^0[\to K^{*+}\pi^-]K^-$ ≡ ADS like

x,y results of $B \rightarrow D^{(*)0}K^{(*)}$, $D^0 \rightarrow K_s\pi\pi/K_sKK$

BELLE

657M $B\bar{B}$

Parameter	$B^+ \to DK^+$	$B^+ \to D^*K^+$
x_-	$+0.105 \pm 0.047 \pm 0.011$	$+0.024 \pm 0.140 \pm 0.018$
y_-	$+0.177 \pm 0.060 \pm 0.018$	$-0.243 \pm 0.137 \pm 0.022$
x_+	$-0.107 \pm 0.043 \pm 0.011$	$+0.133 \pm 0.083 \pm 0.018$
y_+	$-0.067 \pm 0.059 \pm 0.018$	$+0.130 \pm 0.120 \pm 0.022$

BELLE

PRD73, 112009 (2006)

Parameter	$B^+ \to DK^+$ mode	$B^+ \to D^*K^+$ mode
ϕ_3	$80.8^\circ\ ^{+13.1^\circ}_{-14.8^\circ} \pm 5.0^\circ \pm 8.7^\circ$	$63.8^\circ\ ^{+20.8^\circ}_{-22.9^\circ} \pm 4.7^\circ \pm 8.7^\circ$
r	$0.161^{+0.040}_{-0.038} \pm 0.011 \pm 0.049$	$0.208^{+0.085}_{-0.083} \pm 0.015 \pm 0.049$
δ	$137.4^\circ\ ^{+13.0^\circ}_{-15.7^\circ} \pm 4.0^\circ \pm 22.9^\circ$	$342.0^\circ\ ^{+21.4^\circ}_{-22.9^\circ} \pm 3.7^\circ \pm 22.9^\circ$

PRD78, 034023 (2008)

BABAR

Parameters	$B^- \to \tilde{D}^0 K^-$	$B^- \to \tilde{D}^{*0} K^-$	$B^- \to \tilde{D}^0 K^{*-}$
x_-, x_-^*, x_{s-}	$0.090 \pm 0.043 \pm 0.015 \pm 0.011$	$-0.111 \pm 0.069 \pm 0.014 \pm 0.004$	$0.115 \pm 0.138 \pm 0.039 \pm 0.014$
y_-, y_-^*, y_{s-}	$0.053 \pm 0.056 \pm 0.007 \pm 0.015$	$-0.051 \pm 0.080 \pm 0.009 \pm 0.010$	$0.226 \pm 0.142 \pm 0.058 \pm 0.011$
x_+, x_+^*, x_{s+}	$-0.067 \pm 0.043 \pm 0.014 \pm 0.011$	$0.137 \pm 0.068 \pm 0.014 \pm 0.005$	$-0.113 \pm 0.107 \pm 0.028 \pm 0.018$
y_+, y_+^*, y_{s+}	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$	$0.080 \pm 0.102 \pm 0.010 \pm 0.012$	$0.125 \pm 0.139 \pm 0.051 \pm 0.010$

BABAR

383M $B\bar{B}$

Source	x_-	y_-	x_+	y_+	x_-^*	y_-^*	x_+^*	y_+^*	x_{s-}	y_{s-}	x_{s+}	y_{s+}
m_{ES}, ΔE, $\mathcal{F}$ shapes	0.001	0.001	0.001	0.002	0.002	0.004	0.004	0.005	0.003	0.002	0.001	0.004
Real D^0 fractions	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.002	0.004	0.001	0.001
Charge-flavor correlation	0.002	0.002	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.001	0.001
Efficiency in the Dalitz plot	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.003	0.001	0.005
Background Dalitz plot shape	0.012	0.007	0.013	0.003	0.010	0.007	0.007	0.007	0.014	0.006	0.012	0.005
$B^- \to D^{*0}K^-$ cross feed	...	...	...	...	0.003	0.002	0.007	0.001	...	...	...	...
CP violation in $D\pi$ and $B\bar{B}$ bkg	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.004	0.006	0.002	0.003	0.001
Non-K^* $B^- \to \tilde{D}^0 K_S^0 \pi^-$ decays	...	...	...	...	...	...	...	...	0.035	0.058	0.025	0.045
Total experimental	0.015	0.007	0.014	0.006	0.014	0.009	0.014	0.010	0.039	0.058	0.028	0.051