

# *CP* Violation and the CKM matrix: Assessing the Impact of the Asymmetric *B* Factories

<http://www.slac.stanford.edu/xorg/ckmfitter>

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**The whole paper:** [hep-ph/0406184](#) (Submitted to Eur.Phys.J.C)

I The CKM matrix and the UT triangle

V Constraints on  $2\beta + \gamma$  and  $\gamma$  from Tree Decays

II The Statistical Approach *R*fit

VI Charmless *B* Decays

III The Global CKM Fit

VII New Physics in *B* Transitions

IV Constraints from Kaon Physics

⇒ “Morceaux choisis”

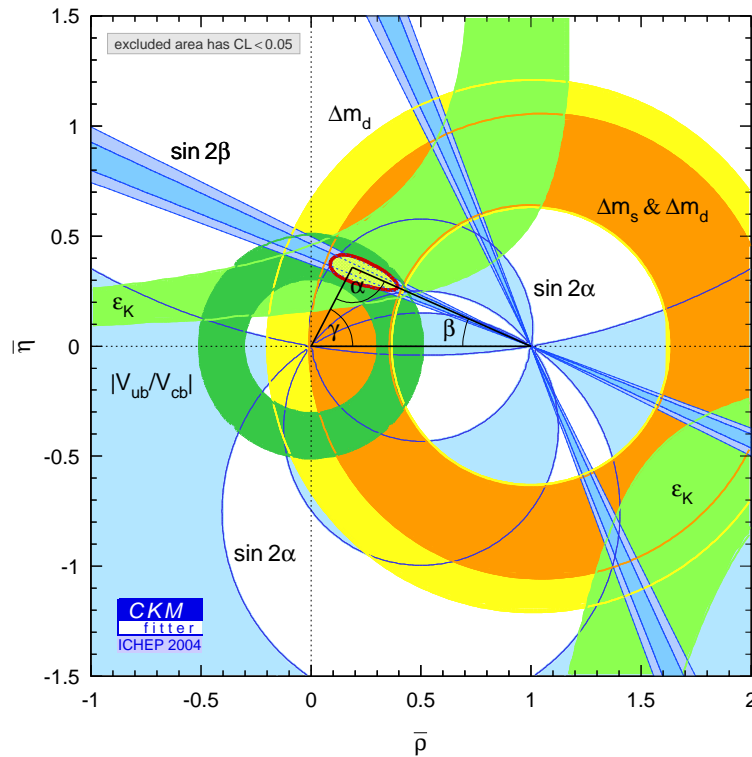
## The *R*fit scheme

- A frequentist statistical approach
  - Theoretical errors interpreted as allowed *R*ange
  - No *a priori* information used where there is none
- ⇒
- Probing the Standard Model
  - Metrology of the parameters
  - New Physics detection

## Updated results since our publication !

- $\sin 2\beta$
  - Charmless decays
- ⇒ Some results are preliminary (ICHEP'04)

## 2 The global CKM fit



### Inputs

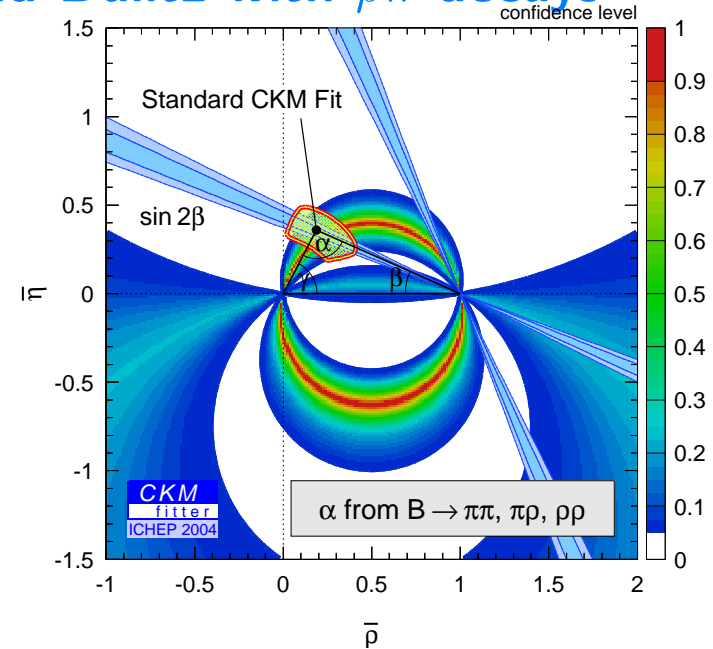
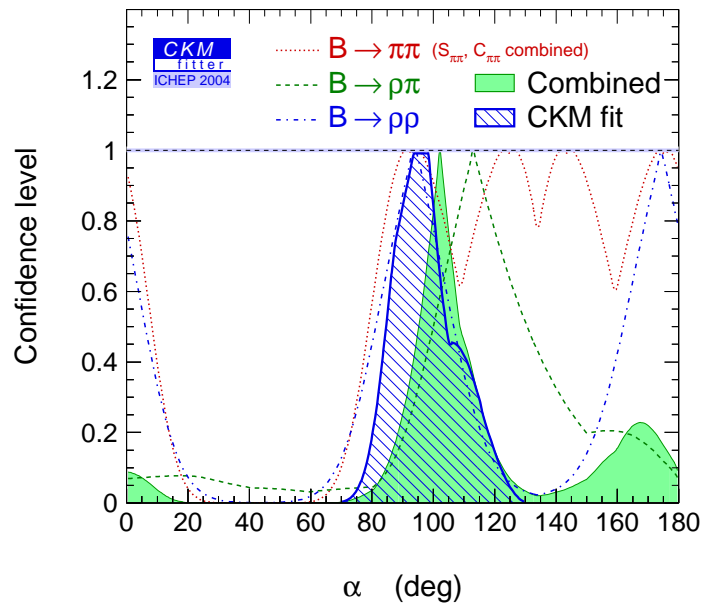
- CKM matrix elements:  $|V_{ud}|, |V_{us}|, |V_{cb}|, |V_{ub}|$
- Kaon system:  $|\epsilon_K|$
- $B$  oscillations:  $\Delta m_d, \Delta m_s$
- $B$  decays:
  - $\sin 2\beta$  ( $b \rightarrow c\bar{c}s$ ): **most precise constraint**, theo. clean
  - $\sin 2\alpha$  ( $B \rightarrow \rho\rho, \rho\pi, \pi\pi$ ): **new !**

### Some fit results

- $\bar{\rho}_{\text{fit}} = 0.22^{+0.06}_{-0.13}$
- $\bar{\eta}_{\text{fit}} = 0.334^{+0.030}_{-0.029}$
- $\sin 2\beta_{\text{fit}} = 0.67^{+0.18}_{-0.08}$  (WA measurement:  $\sin 2\beta_{[c\bar{c}]} = 0.726 \pm 0.037$ )
- $\gamma_{\text{fit}} = (57 \pm 9)^\circ$  (Belle:  $\gamma = (81 \pm 25)^\circ$  with  $B^+ \rightarrow D^{(*)0} K^+$ )
- $\alpha_{\text{fit}} = (98 \pm 16)^\circ$  ... what about the measurement ?

### 3.1 Charmless decays: NEW $\alpha$ measurement

Isospin analysis with  $B \rightarrow \pi\pi$ ,  $\rho\rho$  and Dalitz with  $\rho\pi$  decays

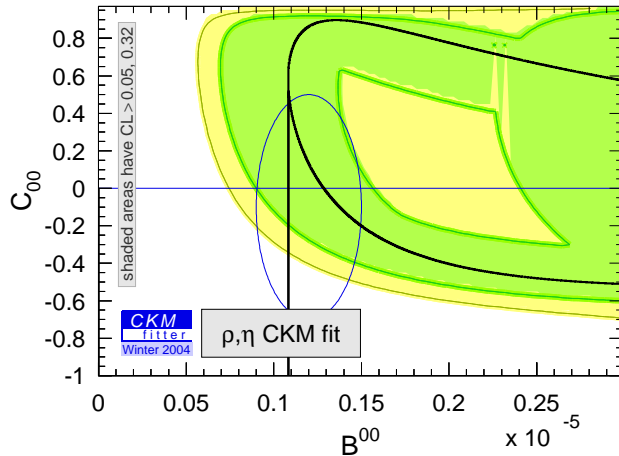


- $B \rightarrow \pi\pi$ : triangular isospin relation, Penguin important  
 $\Rightarrow \sin^2(\alpha - \alpha_{\text{eff}}) \leq (\mathcal{B}^{00} - \mathcal{B}_{\text{GLSS}}^{00}) \times X$   
 Improvement thanks to the  $C_{\pi\pi}^{00}$  measurement (see M. Cristinziani's talk)
- $B \rightarrow \rho\rho$ : Penguin much smaller than in  $\pi\pi$   
 $\Rightarrow$  More precise measurement (see C. Dallapiccola's talk)
- $B \rightarrow \rho\pi$ : Dalitz analysis (pentagonal isospin relation)  
 $\Rightarrow$  Hypotheses needed

Combined :  $\alpha = (102^{+12}_{-10})^\circ$

## 3.2 Charmless decays: testing models

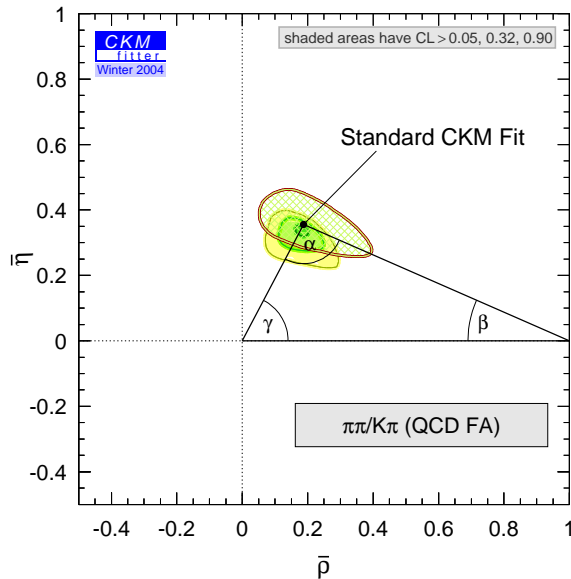
### Standard Model :-)



- $B^0 \rightarrow \pi^0 \pi^0$ :  $(\mathcal{B}^{00}, C_{\pi\pi}^{00})$  plane
- No need to deal with mirror sol. of  $\alpha$
- Errors extrapolated at  $1 \text{ ab}^{-1}$

⇒ Still a long way to exclude SM

### QCD Factorisation BBNS (*Nucl. Phys.* **B606**, 245 (2001))



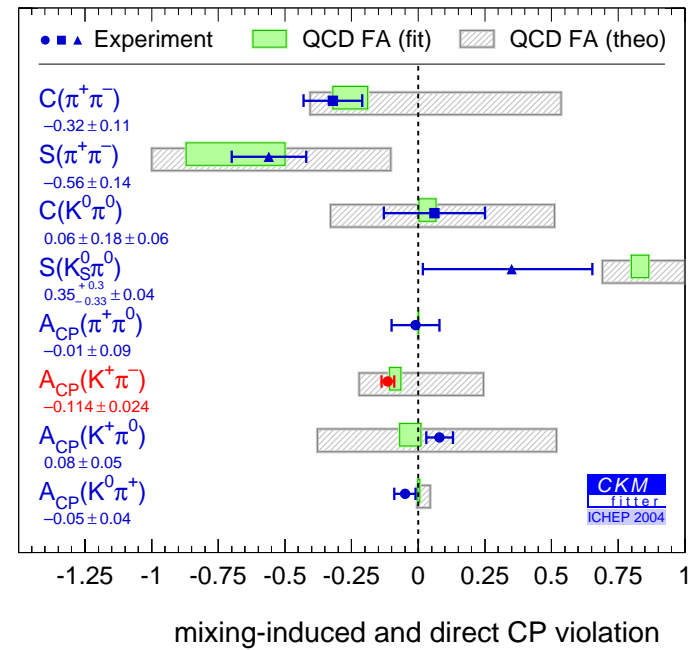
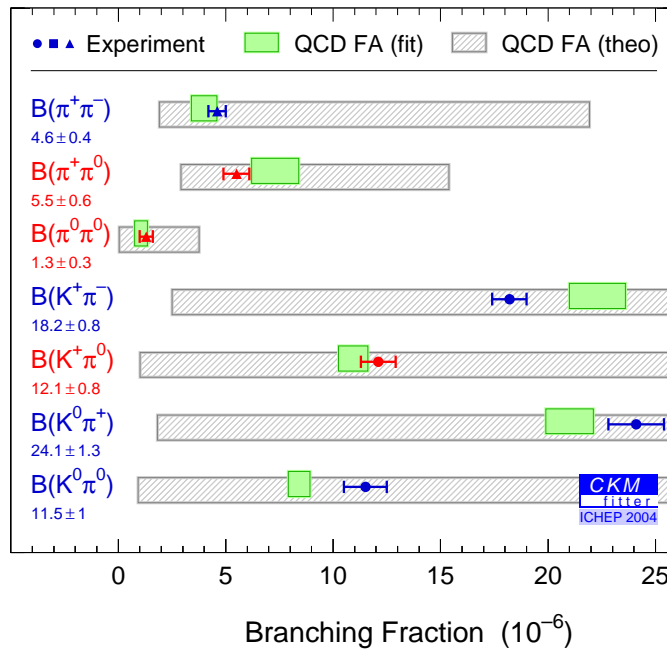
- Combined fit with  $B \rightarrow \pi\pi$  and  $K\pi$
- $\bar{\rho} = 0.182^{+0.045}_{-0.047}$
- $\bar{\eta} = 0.332^{+0.032}_{-0.036}$
- $\gamma = (62^{+6}_{-9})^\circ$ : close to  $\gamma_{\text{fit}}$

⇒ Impressive agreement with the standard CKM fit and competitive precision !!

### 3.3 QCD Factorization Data Driven

## Predictions for the $\pi\pi$ and $K\pi$ System

- Fit on each variable, ignoring its measurement
- Standard CKM fit included



Measurement from *BABAR*  $C_{\pi\pi}^{00} = -0.12 \pm 0.56$   
 Prediction  $C_{\pi\pi}^{00} = 0.06 \pm 0.12$

⇒ Fair agreement between predictions and experimental measurements !

**WARNING !!** Radiative corrections mostly not accounted for

# 4 New Physics in $B^0\bar{B}^0$ mixing

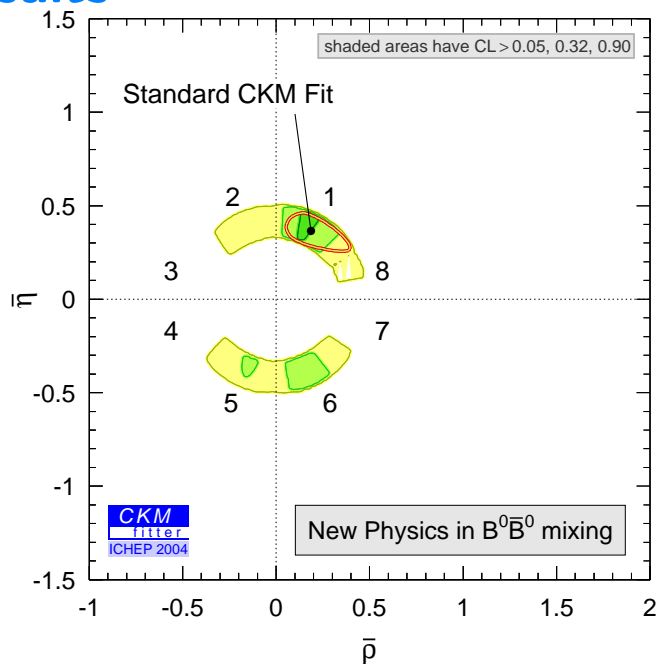
## Analysis and inputs

- Two additional parameters: (Phys. Lett. **B407**, 307 (1997))

$$r_d^2 e^{i2\theta_d} = \frac{\langle B^0 | \mathcal{H}_{\text{eff}}^{\text{full}} | \bar{B}^0 \rangle}{\langle B^0 | \mathcal{H}_{\text{eff}}^{\text{SM}} | \bar{B}^0 \rangle} \implies \text{Model independent}$$

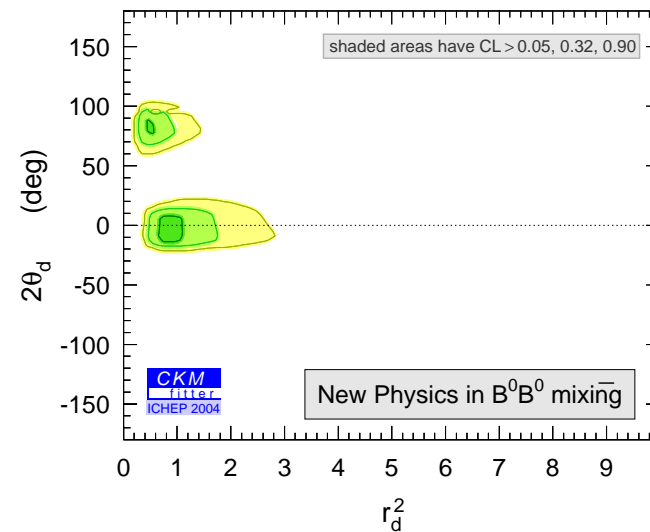
- Constraints on CKM ( $\bar{\rho}$  and  $\bar{\eta}$ ) and NP ( $r_d^2$  and  $2\theta_d$ )
- Inputs: SM:  $|V_{ub}|$ ,  $|V_{cb}|$ ,  $\tan \gamma$  ( $B^+ \rightarrow D^{(*)0} K^+$ ); NP:  $|\sin(2\beta + 2\theta_d + (2)\gamma)|$  ( $B^0 \rightarrow D^{(*)\pm} \pi^\mp / B \rightarrow \rho\rho$ ),  $\sin(2\beta + 2\theta_d)$  ( $B^0 \rightarrow J/\psi K^0$ ),  $\Delta m_d(r_d^2)$ ,  $A_{\text{SL}}(r_d^2)$

## Results



$$\oplus \cos(2\beta + 2\theta_d) (B^0 \rightarrow J/\psi K^{*0})$$

SM values:  $r_d^2 = 1$  and  $2\theta_d = 0$



- $\implies$  Preferred region consistent with SM
- $\implies$  NP in  $B^0\bar{B}^0$  mixing significantly constrained
- $\implies$  Would largely benefit from improved measurements of  $\alpha$  and  $\gamma$