UT analysis and the implications of a large phase in B_s mixing

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Plan of the Talk

1) ***Generalities on the UT analysis***
2) ***Status of the UT analysis within the SM***
3) ***Beyond the SM: the case of B_s***
4) ***Outlook***

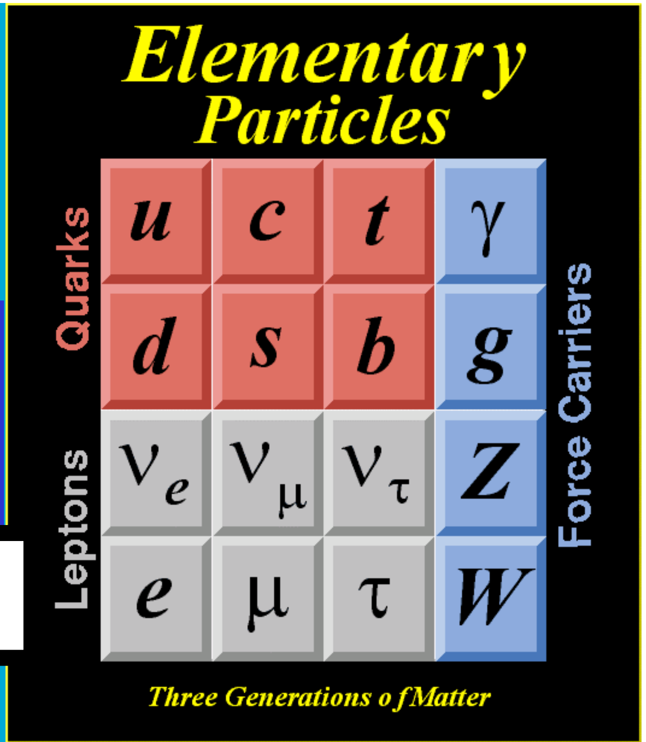
In the Standard Model the quark mass matrix, from which the CKM Matrix and ~~CP~~ originate, is determined by the Yukawa Lagrangian which couples fermions and Higgs

$$\mathcal{L}^{\text{quarks}} = \mathcal{L}^{\text{kinetic}} + \mathcal{L}^{\text{weak int}} + \mathcal{L}^{\text{yukawa}}$$

CP invariant

~~CP~~ and symmetry breaking are closely related !

QUARK MASSES ARE GENERATED BY DYNAMICAL SYMMETRY BREAKING



$$H = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}, \qquad H^C = i\tau_2 H^*$$

$$\phi^+ \to 0 \qquad \phi^0 \to \frac{V}{\sqrt{2}}$$

Charge +2/3

$$\mathcal{L}^{\text{yukawa}} \equiv \Sigma_{i,k=1,N} [\, Y_{i,k} (q^i_L H^C)\, U^k_R + X_{i,k} (q^i_L H)\, D^k_R + \text{h.c.} \,]$$

Charge -1/3

$$\Sigma_{i,k=1,N} [\, m^u_{i,k} (\overline{u}^i_L u^k_R) + m^d_{i,k} (\overline{d}^i_L d^k_R) + \text{h.c.} \,]$$

Diagonalization of the Mass Matrix

Up to singular cases, the mass matrix can always be diagonalized by 2 unitary transformations

$$u^i{}_L \to U^{ik}{}_L \, u^k{}_L \qquad\qquad u^i{}_R \to U^{ik}{}_R \, u^k{}_R$$

$$\mathbf{M' = U^{\dagger}{}_L \, M \, U_R} \qquad\qquad \mathbf{(M')^{\dagger} = U^{\dagger}{}_R \, (M)^{\dagger} \, U_L}$$

$$\mathcal{L}^{\mathbf{mass}} \equiv m_{\mathbf{up}} (\bar{u}_{\mathbf{L}} u_{\mathbf{R}} + \bar{u}_{\mathbf{R}} u_{\mathbf{L}}) + m_{\mathbf{ch}} (\bar{c}_{\mathbf{L}} c_{\mathbf{R}} + \bar{c}_{\mathbf{R}} c_{\mathbf{L}})$$

$$+ m_{\mathbf{top}} (\bar{t}_{\mathbf{L}} t_{\mathbf{R}} + \bar{t}_{\mathbf{R}} t_{\mathbf{L}})$$

$$L_{CC}^{weak\,int} = \frac{g_W}{\sqrt{2}} (J_\mu^- W_\mu^+ + h.c.)$$

$$\to \quad \frac{g_W}{\sqrt{2}} (\bar{u}_L \mathbf{V}^{CKM} \gamma_\mu d_L W_\mu^+ + \ldots)$$

N(N-1)/2 angles and (N-1)(N-2)/2 phases

N=3 3 angles + 1 phase KM

the phase generates complex couplings i.e. <u>CP violation;</u>

6 masses +3 angles +1 phase = 10 parameters

V_{ud}	V_{us}	V_{ub}
V_{cd}	V_{cs}	V_{cb}
V_{tb}	V_{ts}	V_{tb}

NO Flavour Changing Neutral Currents (FCNC) at Tree Level
(FCNC processes are good candidates for observing NEW PHYSICS)

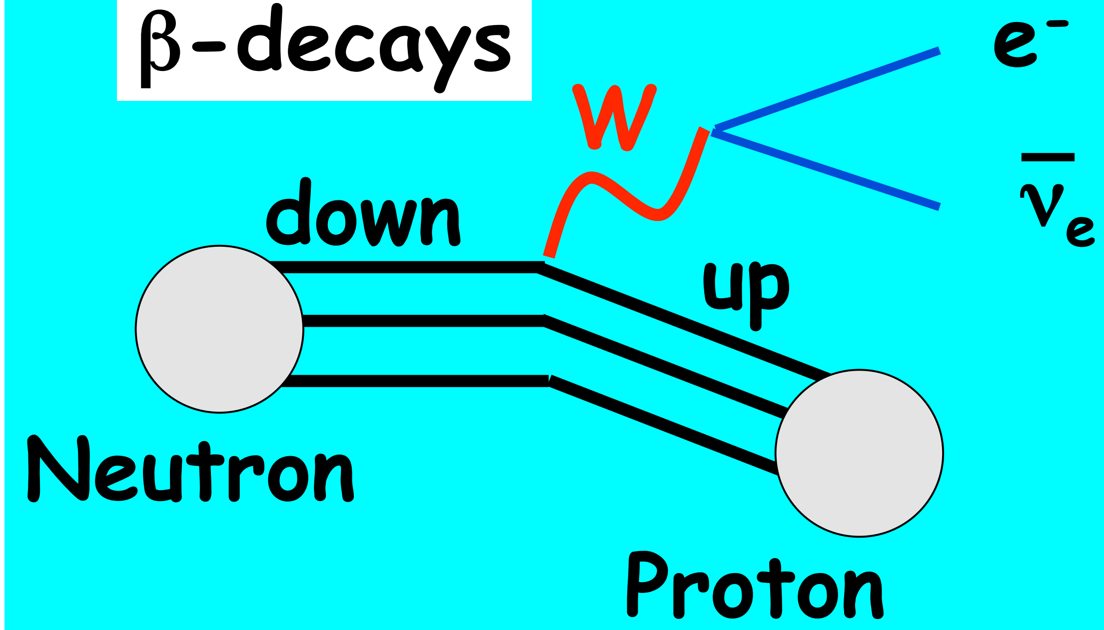
CP Violation is natural with three quark generations (Kobayashi-Maskawa)

With three generations all CP phenomena are related to the same unique parameter (δ)

V_{ud}	V_{us}	V_{ub}
V_{cd}	V_{cs}	V_{cb}
V_{td}	V_{ts}	V_{tb}

Quark masses & Generation Mixing

β-decays



$|V_{ud}|$

$|V_{ud}| = 0.9735(8)$

$|V_{us}| = 0.2196(23)$

$|V_{cd}| = 0.224(16)$

$|V_{cs}| = 0.970(9)(70)$

$|V_{cb}| = 0.0406(8)$

$|V_{ub}| = 0.00409(25)$

$|V_{tb}| = 0.99(29)$

(0.999)

The Wolfenstein Parametrization

$1 - 1/2\,\lambda^2$	λ	$A\,\lambda^3(\rho - i\,\eta)$
$-\lambda$	$1 - 1/2\,\lambda^2$	$A\,\lambda^2$
$A\,\lambda^3 \times (1 - \rho - i\,\eta)$	$-A\,\lambda^2$	1

V_{ub}

$+ O(\lambda^4)$

V_{td}

$\sin\theta_{12} = \lambda$

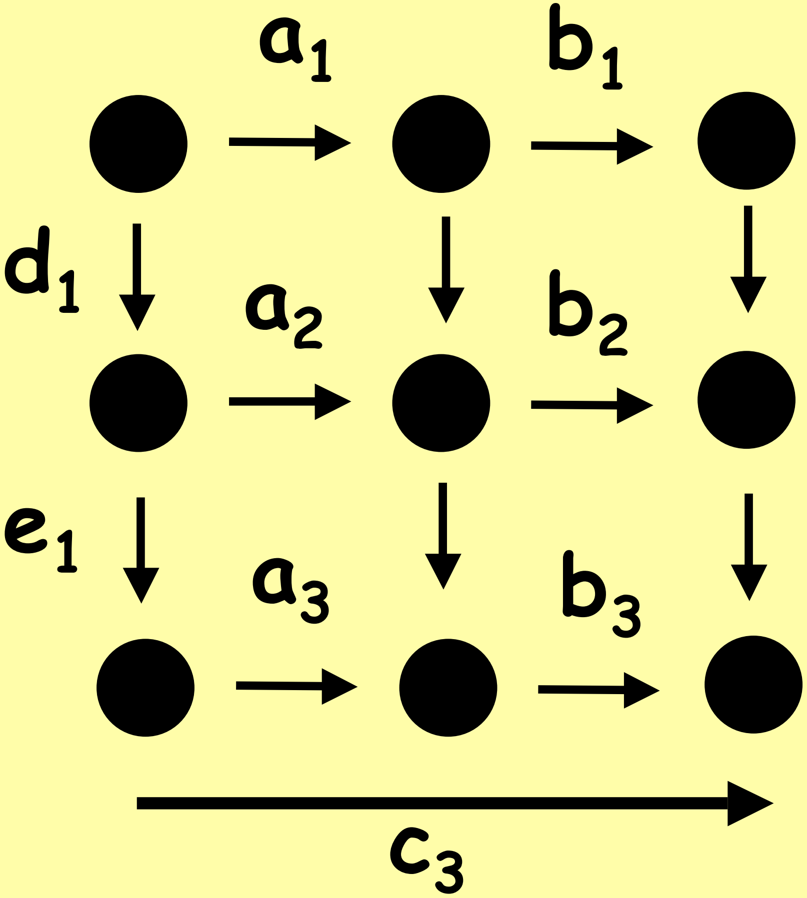
$\sin\theta_{23} = A\,\lambda^2$

$\sin\theta_{13} = A\,\lambda^3(\rho - i\,\eta)$

$\lambda \sim 0.2 \qquad A \sim 0.8$

$\eta \sim 0.2 \qquad \rho \sim 0.3$

The Bjorken-Jarlskog Unitarity Triangle



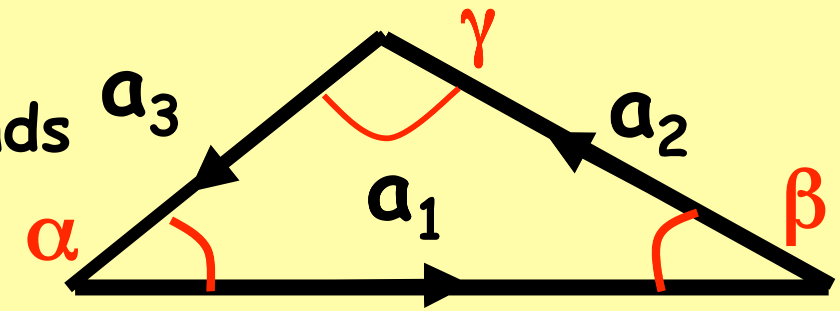
$|V_{ij}|$ is invariant under phase rotations

$$a_1 = V_{11} V_{12}^* = V_{ud} V_{us}^*$$

$$a_2 = V_{21} V_{22}^* \quad a_3 = V_{31} V_{32}^*$$

$$\boxed{\begin{array}{l} a_1 + a_2 + a_3 = 0 \\ (b_1 + b_2 + b_3 = 0 \text{ etc.}) \end{array}}$$

Only the orientation depends on the phase convention



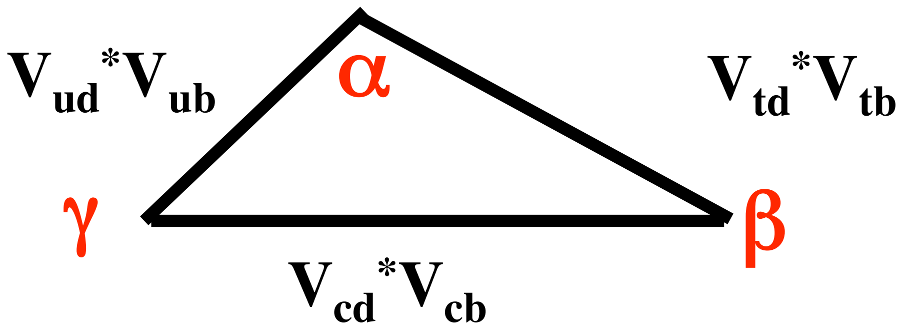
Physical quantities correspond to invariants under phase reparametrization i.e. $|a_1|, |a_2|, \ldots, |e_3|$ and the area of the Unitary Triangles

$$J = \mathrm{Im}\,(a_1 a_2^*) = |a_1\, a_2|\, \mathrm{Sin}\,\beta$$

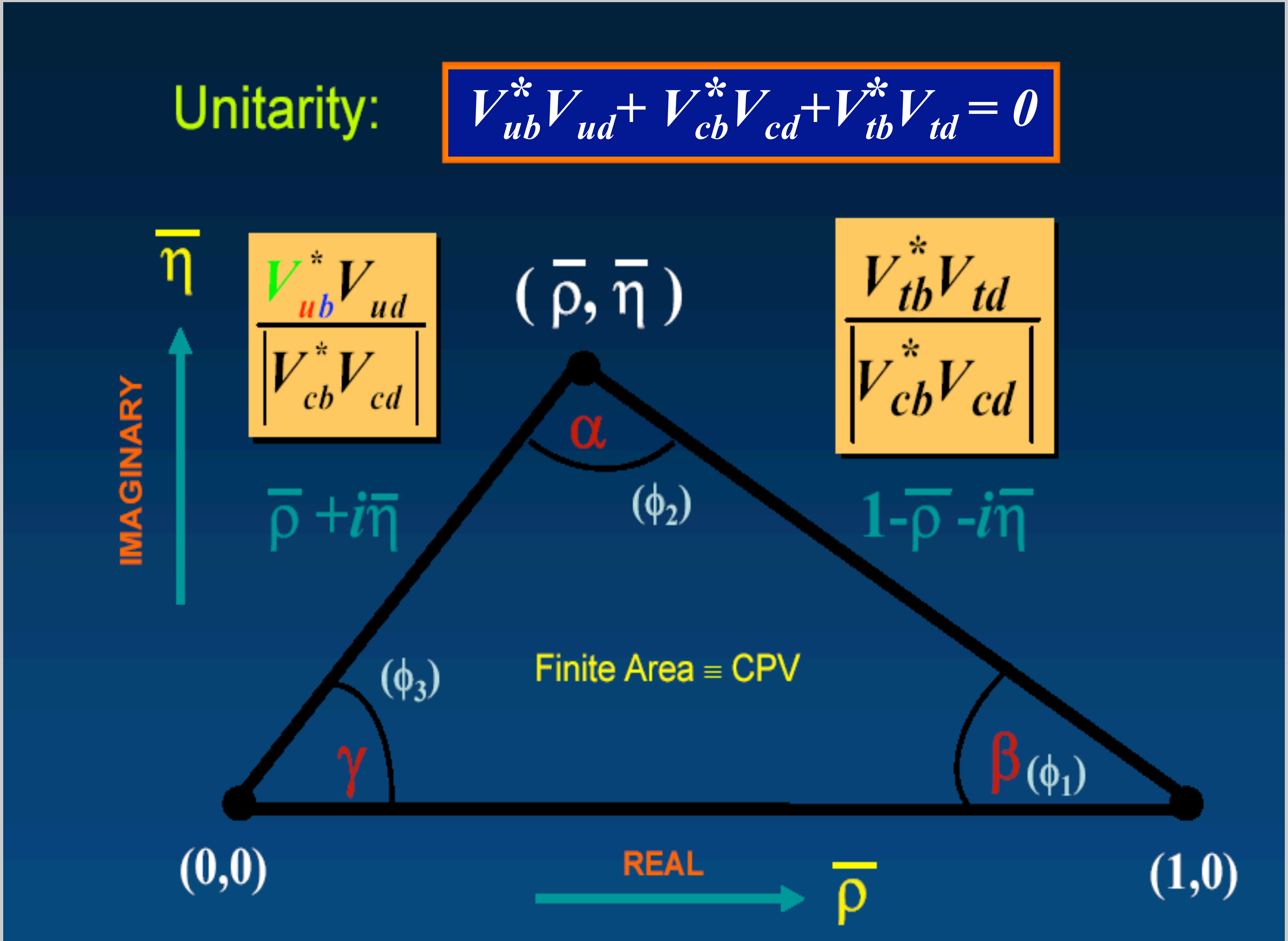
a precise knowledge of the moduli (angles) would fix J

$$\cancel{CP} \propto J$$

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



$$\boxed{\gamma = \delta_{CKM}}$$

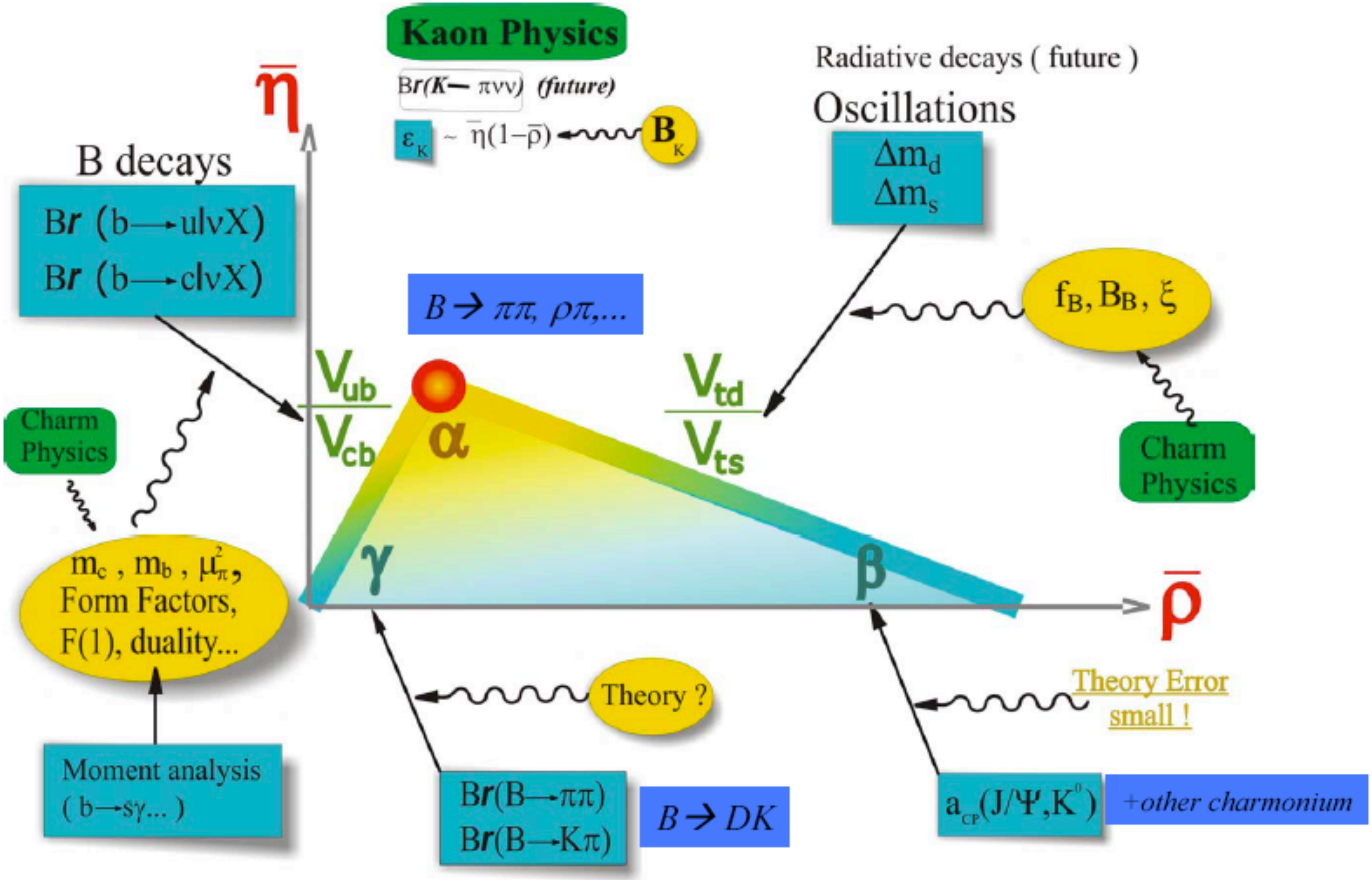


Unitarity:
$V^*_{ub}V_{ud}+V^*_{cb}V_{cd}+V^*_{tb}V_{td}=0$
$\bar{\eta}$
IMAGINARY
$\frac{V^*_{ub}V_{ud}}{|V^*_{cb}V_{cd}|}$
$(\bar{\rho},\bar{\eta})$
$\frac{V^*_{tb}V_{td}}{|V^*_{cb}V_{cd}|}$
α
(ϕ_2)
$\bar{\rho}+i\bar{\eta}$
$1-\bar{\rho}-i\bar{\eta}$
(ϕ_3)
Finite Area ≡ CPV
γ
$\beta\ (\phi_1)$
(0,0)
REAL
$\bar{\rho}$
(1,0)

Visualization of the unitarity of the CKM matrix

Unitarity Triangle in the (ρ–η) plane

From
A. Stocchi
ICHEP 2002



Measure	V_{CKM}	Other NP parameters
$\Gamma(b\to u)/\Gamma(b\to c)$	$\bar\rho^2+\bar\eta^2$	$\bar\Lambda, \lambda_1, F(1), \ldots$
ε_K	$\eta[(1-\bar\rho)+\ldots]$	B_K
Δm_d	$(1-\bar\rho)^2+\bar\eta^2$	$f_{B_d}^2 B_{B_d}$
$\Delta m_d/\Delta m_1$	$(1-\bar\rho)^2+\bar\eta^2$	ξ
$A_{CP}(B_d\to J/\psi K_s)$	$\sin 2\beta$	–

For details see:
UTfit Collaboration
hep-ph/0501199
hep-ph/0509219
hep-ph/0605213
hep-ph/0606167
http://www.utfit.org

$$Q^{EXP} = V_{CKM} \times \langle H_F|\hat{O}|H_I\rangle$$

classical UT analysis

sin 2β is measured directly from B $\rightarrow$ J/ψ K_s decays at Babar & Belle

$$\mathcal{A}_{J/\psi\, K_S} = \frac{\Gamma(B_d^0 \rightarrow J/\psi\, K_S\,, t) - \Gamma(\bar{B}_d^0 \rightarrow J/\psi\, K_S\,, t)}{\Gamma(B_d^0 \rightarrow J/\psi\, K_s\,, t) + \Gamma(\bar{B}_d^0 \rightarrow J/\psi\, K_S\,, t)}$$

$$\boxed{\mathcal{A}_{J/\psi\, K_S} = \sin 2\beta \quad \sin(\Delta m_d\, t)}$$

DIFFERENT LEVELS OF THEORETICAL UNCERTAINTIES (STRONG INTERACTIONS)

1) First class quantities, with reduced or negligible theor. uncertainties

$A_{CP}(B \to J/\psi K_s)$ $\quad \gamma$ *from* $B \to DK$

$K^0 \to \pi^0 \nu \bar{\nu}$

2) Second class quantities, with theoretical errors of O(10%) or less that can be reliably estimated

$\varepsilon_K \quad \Delta M_{d,s}$

$\Gamma(B \to c, u)$, $K^+ \to \pi^+ \nu \bar{\nu}$

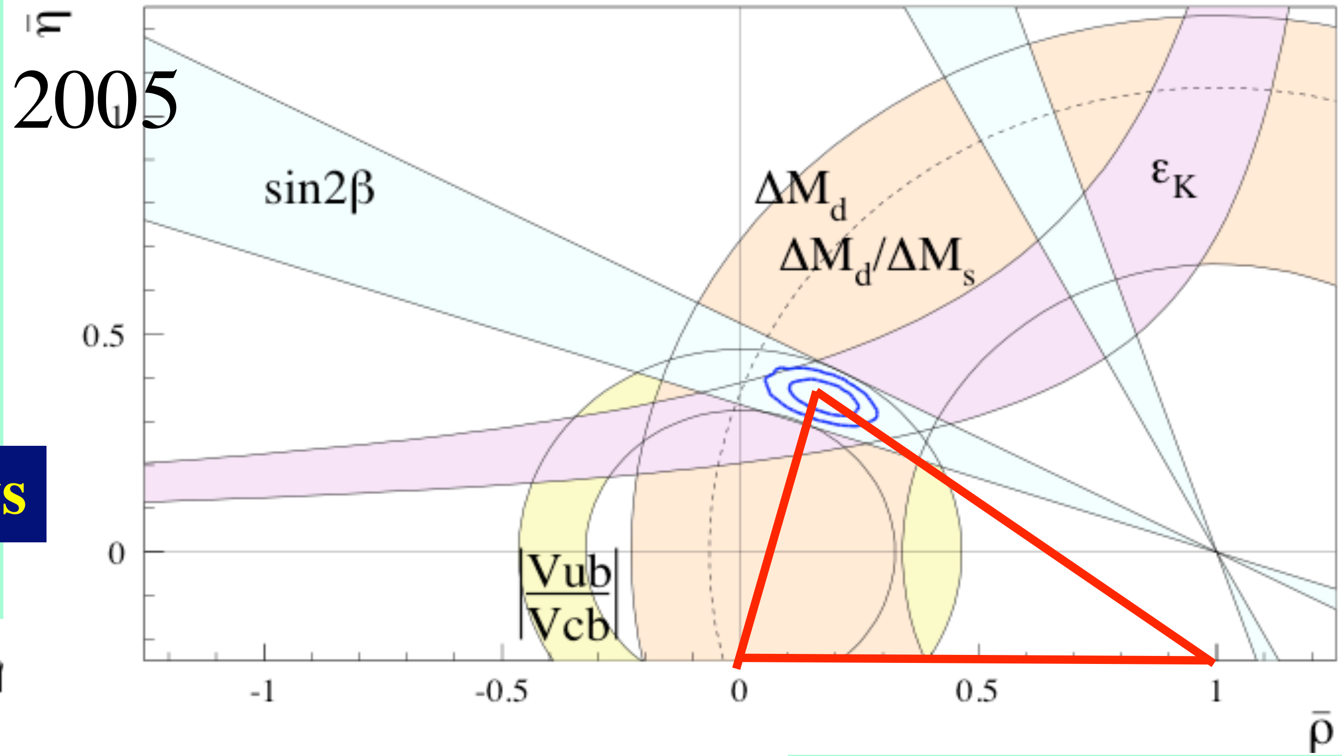
3) Third class quantities, for which theoretical predictions are model dependent (BBNS, charming, etc.)

In case of discrepacies we cannot tell whether is *new physics or we must blame the model*

$B \to K\pi \quad B \to \pi^0 \pi^0$

$B \to \phi K_s$

Unitary Triangle SM



semileptonic decays

Experimental co

Meas.	$V_{CKM}\times$other	$(\bar{\rho}, \bar{\eta})$
$\frac{b\to u}{b\to c}$	$\lvert V_{ub}/V_{cb}\rvert^2$	$\bar{\rho}^2+\bar{\eta}^2$
Δm_d	$\lvert V_{td}\rvert^2 f_{B_d}^2 B_{B_d}$	$(1-\bar{\rho})^2+\bar{\eta}^2$
$\frac{\Delta m_d}{\Delta m_s}$	$\left\lvert\frac{V_{td}}{V_{ts}}\right\rvert^2 \xi^2$	$(1-\bar{\rho})^2+\bar{\eta}^2$
ϵ_K	$f(A,\bar{\eta},\bar{\rho},B_K)$	$\propto \bar{\eta}(1-\bar{\rho})$
$A(J/\psi K^0)$	$sin2\beta$	$\frac{2\bar{\eta}(1-\bar{\rho})}{\sqrt{\bar{\eta}^2+(1-\bar{\rho})^2}}$

K^0 - $\overline{K}^0$ mixing

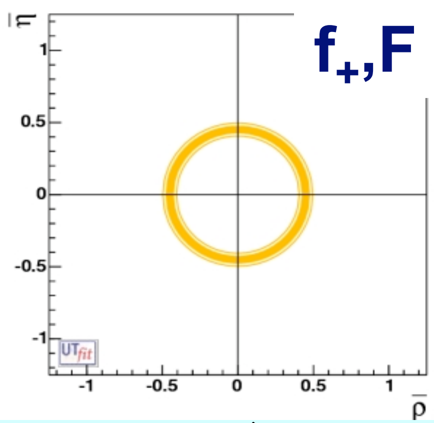
$B^0_{d,s}$ - $\overline{B}^0_{d,s}$ mixing

B_d Asymmetry

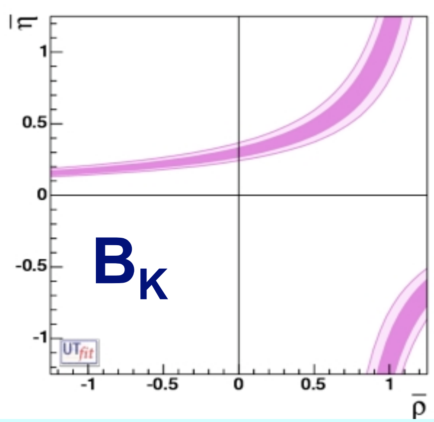
Classical Quantities used in the Standard UT Analysis

levels @ 68% (95%) CL

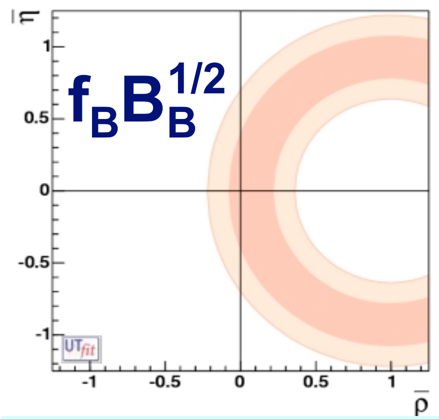
V_{ub}/V_{cb}



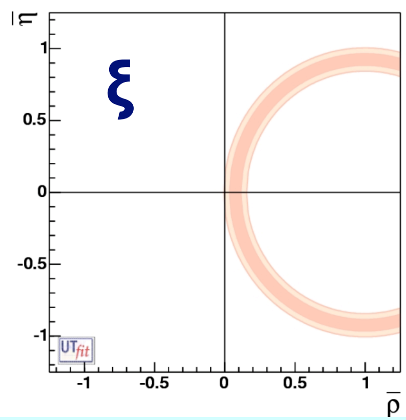
ε_K



Δm_d



$\Delta m_d/\Delta m_s$



UT-LATTICE

Inclusive vs Exclusive
Opportunity for lattice QCD
see later

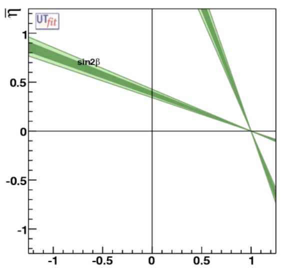
before
only a lower bound

New Quantities used in the UT Analysis

UT-ANGLES

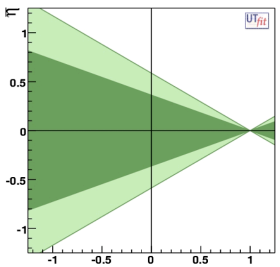
Several new determinations of UT angles are now available, thanks to the results coming from the B-Factory experiments

$\sin 2\beta$



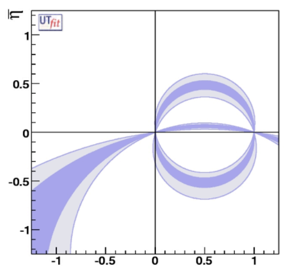
$B \to J/\Psi K^0$

$\cos 2\beta$



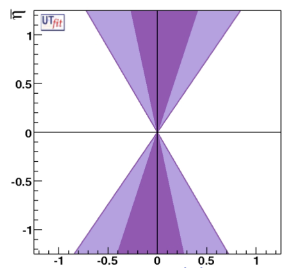
$B \to J/\Psi K^{*0}$

α



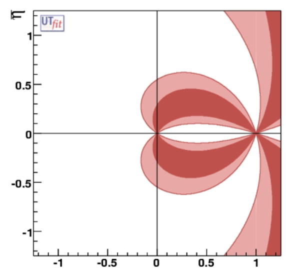
$B \to \pi\pi, \rho\rho$

γ



$B \to D^{(*)}K$

$\sin(2\beta+\gamma)$

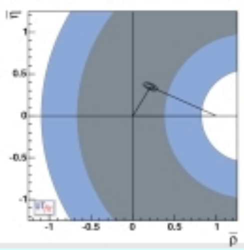


$B \to D^{(*)}\pi, D\rho$

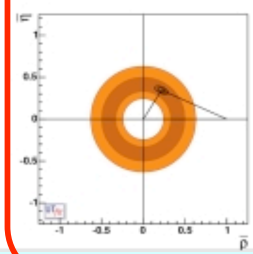
New Constraints from B and K rare decays (not used yet)

New bounds are available from rare B and K decays. They do not still have a strong impact on the global fit and they are not used at present.

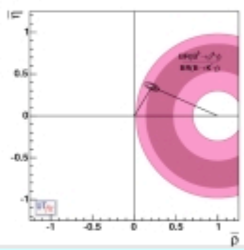
$K \to \pi \nu \bar{\nu}$



$B \to \tau \nu$



$(B \to \rho/\omega\, \gamma)/(B \to K^*\gamma)$



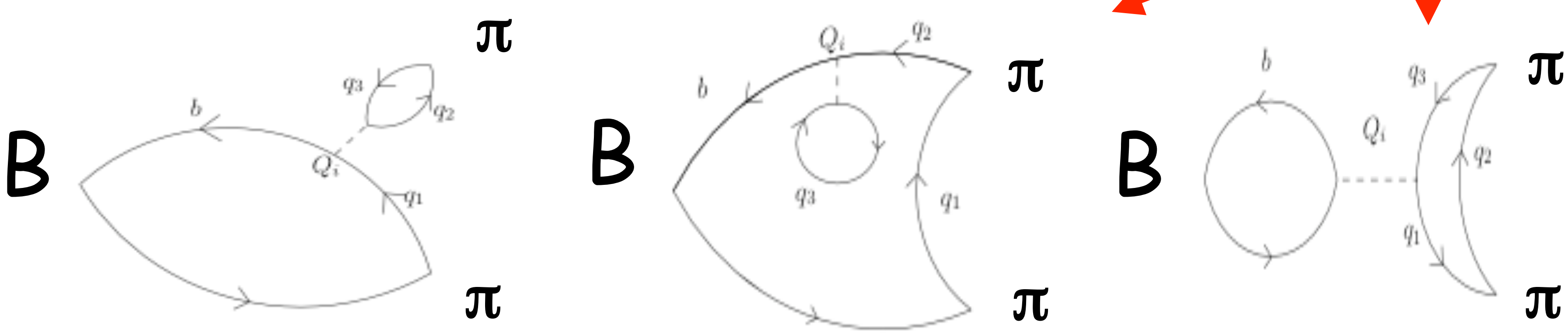
sin 2α from B -> ππ

$$\mathcal{A}_{CP} = \frac{Prob(B^0_{phys}(\Delta t)\to f) - Prob(\overline{B}^0_{phys}(\Delta t)\to f)}{Prob(B^0_{phys}(\Delta t)\to f) + Prob(\overline{B}^0_{phys}(\Delta t)\to f)} = C_f \cos\Delta m_d\, \Delta t + S_f \sin\Delta m_d\, \Delta t$$

$$C_f = \frac{1-|\lambda_f|^2}{1+|\lambda_f|^2}\,;\; S_f = -\frac{2\, Im\lambda_f}{1+|\lambda_f|^2}$$

$\Delta I = \frac{3}{2}, \frac{1}{2} \quad V_{ub}V^*_{ud} \sim O(\lambda^3)$ $\qquad$ $\Delta I = \frac{1}{2} \quad V_{tb}V^*_{td} \sim O(\lambda^3)$

$\Delta\mathcal{A}_t$



$\sin 2\alpha$ from B -> $\pi\pi$

$$\lambda_{\pi\pi} = e^{-2i\alpha}\left[\frac{1+\tau^*\,\Delta\mathcal{A}_t}{1+\tau\,\Delta\mathcal{A}_t}\right]$$

$$\tau = -\frac{1-\rho-i\eta}{\rho+i\eta}$$

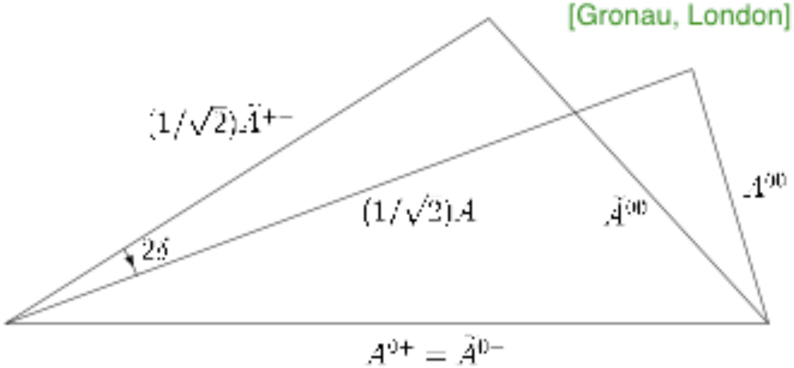
$$Arg[\lambda_{\pi\pi}] = 2\alpha_{eff} \neq 2\alpha$$

Isospin analysis: 6 measurements determine 5 hadronic parameters $+$ weak phase

Bose statistics $\Rightarrow \pi\pi$ in $I = 0, 2$

Triangle relations between B^+, B^0 $(B^-, \overline{B}^0)$ decay amplitudes

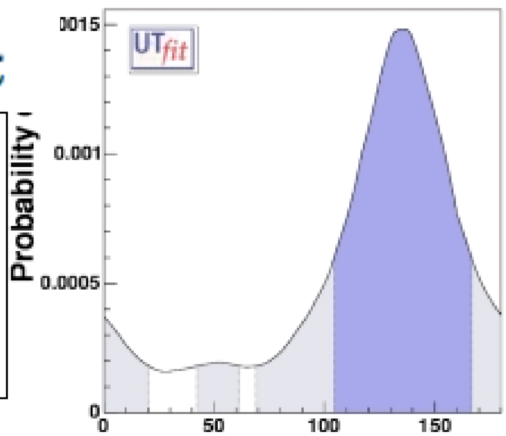
[Gronau, London]

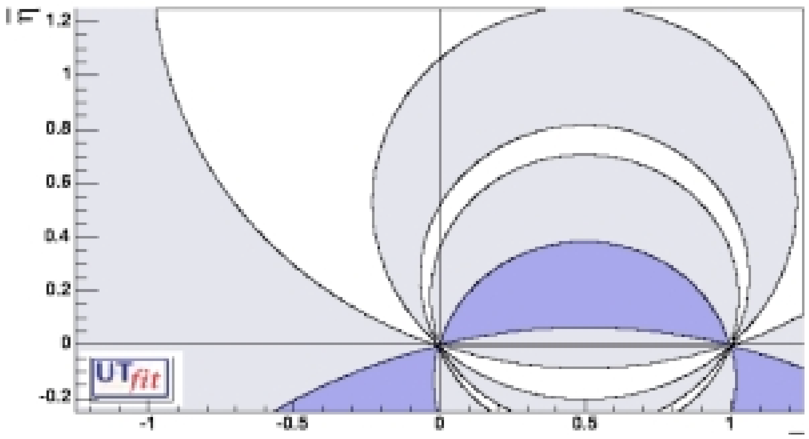


Fit to B→ππ

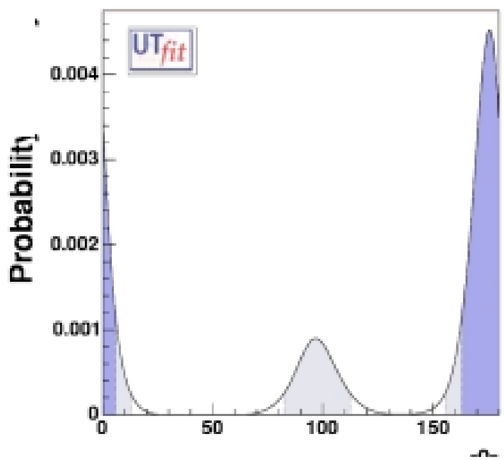
Channel	$BR^{th} \times 10^6$	$BR^{exp} \times 10^6$	$\mathcal{A}_{CP}^{th}$	$\mathcal{A}_{CP}^{exp}$	$\mathcal{S}^{th}$	$\mathcal{S}^{exp}$
$\pi^+\pi^-$	5.5 ± 0.4	5.4 ± 0.4	0.33 ± 0.11	0.37 ± 0.10	-0.54 ± 0.12	-0.50 ± 0.12
$\pi^+\pi^0$	5.7 ± 0.6	5.8 ± 0.6	0	0.01 ± 0.06	-	-
$\pi^0\pi^0$	1.42 ± 0.29	1.45 ± 0.29	0.07 ± 0.24	0.28 ± 0.39	-	-

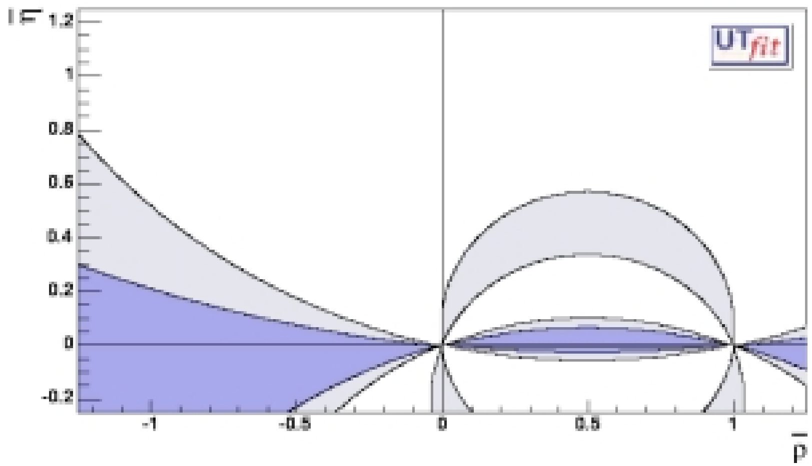
$B \to \rho\pi$





$B \to \rho\rho$



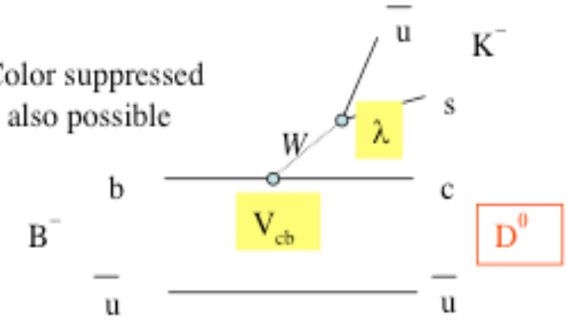


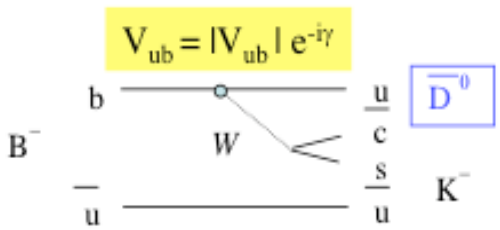
$B \to DK \quad B \to DK^*$

Direct CP violation occurs because there are two different ways of reaching the same final state

In this particular case sensitive to γ: D^0 and $\overline{D}^0$ are involved

Color suppressed also possible





$$A(B^- \to D^0 K^-) = A_B \qquad A(B^- \to \overline{D}^0 K^-) = A_B r_B e^{i(\delta_B - \gamma)}$$

$$A(B^+ \to \overline{D}^0 K^+) = A_B \qquad A(B^+ \to D^0 K^+) = A_B r_B e^{i(\delta_B + \gamma)}$$

A_B strong amplitude (the same for V_{ub} and V_{cb} mediated transitions

$\delta_B = \delta_1 - \delta_2$ strong phase difference between V_{ub} and V_{cb} mediated transitions

$$r_B = \left| \frac{A(B^- \to \overline{D}^0 K^-)}{A(B^- \to D^0 K^-)} \right|$$

GLW (Gronau,London,Wyler) Method $\quad |D^0_{CP\pm}\rangle = \frac{1}{\sqrt{2}}\left(|D^0\rangle \pm |\overline{D}^0\rangle \right)$ **Look at D^0(CP) states**

$$\sqrt{2}A(B^+ \to D^0_{CP+}K^+) = A(B^+ \to D^0 K^+) + A(B^+ \to \overline{D}^0 K^+)$$
$$\sqrt{2}A(B^- \to D^0_{CP+}K^-) = A(B^- \to D^0 K^-) + A(B^- \to \overline{D}^0 K^-)$$
$$\sqrt{2}A(B^+ \to D^0_{CP-}K^+) = A(B^+ \to D^0 K^+) - A(B^+ \to \overline{D}^0 K^+)$$
$$\sqrt{2}A(B^- \to D^0_{CP-}K^-) = A(B^- \to D^0 K^-) - A(B^- \to \overline{D}^0 K^-)$$

ADS (Atwood, Dunietz, Soni) Method $\quad D^0$ and $\overline{D}^0 \to f$ **D^0 and $\overline{D}^0$ give the same final**

GLW (Gronau,London,Wyler) Method

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

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

ADS (Atwood, Dunietz, Soni) Method (only Babar)

$$R_{ADS} = \frac{\Gamma(B^- \to [K^+\pi^-]_D K^-) + \Gamma(B^+ \to [K^-\pi^+]_D K^+)}{\Gamma(B^- \to [K^-\pi^+]_D K^-) + \Gamma(B^+ \to [K^+\pi^-]_D K^+)}$$
$$= r_{DCS}^2 + r_B^2 + 2 r_B r_{DCS} \cos\gamma \cos(\delta_B + \delta_D)$$

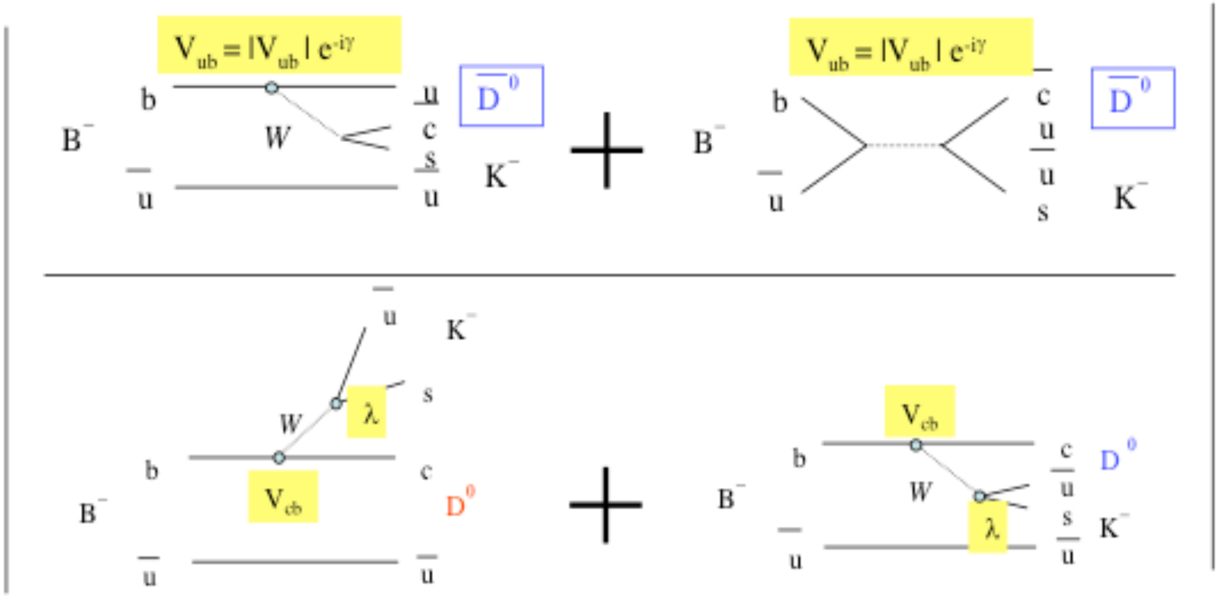
$$A_{ADS} = \frac{\Gamma(B^- \to [K^+\pi^-]_D K^-) - \Gamma(B^+ \to [K^-\pi^+]_D K^+)}{\Gamma(B^- \to [K^+\pi^-]_D K^-) + \Gamma(B^+ \to [K^-\pi^+]_D K^+)}$$
$$= 2 r_B r_{DCS} \sin\gamma \sin(\delta_B + \delta_D) / R_{ADS}$$

$$r_{DCS} = \left| \frac{A(D^0 \to K^+\pi^-)}{A(D^0 \to K^-\pi^+)} \right|$$

$(3.62 \pm 0.29)10^{-3}$

r_B is a crucial parameter. It drives the sensitivity on γ

What about r_B ? $\quad r_B = \left|\frac{A(B^- \to \bar{D}^0 K^-)}{A(B^- \to D^0 K^-)}\right|$



$$= \left|\frac{C + A}{T + \bar{C}}\right|$$

$$r_B = |RB \times RCT| = \left|\frac{V_{ub}V_{cs}^*}{V_{cb}V_{us}^*}\right|\left|\frac{C + A}{T + \bar{C}}\right| = \sqrt{\bar{\eta}^2 + \bar{\rho}^2}\left|\frac{C + A}{T + \bar{C}}\right| \qquad RB = 0.36 \pm 0.04$$

Evaluation can be done if Annihilation diagram is neglected $\quad RCT \approx \sqrt{\frac{Br(\bar{B}^0 \to D^0 \bar{K}^0)}{Br(B^- \to D^0 K^-)}} = 0.34 \pm 0.10 \quad$ $r_B = 0.12 \pm 0.04$

Beyond this approx. If |A/C|~0.3 (max?) (+- 30% according to the interference between A and C)

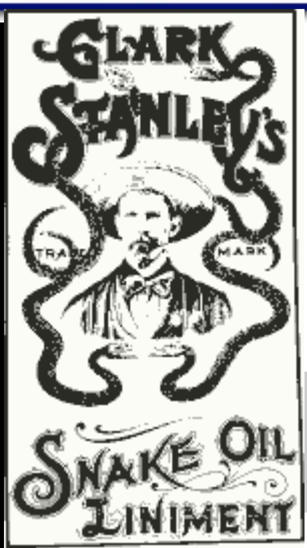
$r_B = 0.12 \pm 0.04(stat) \pm 0.04(theo.)$

Conclusions : should be measured on data

Repeat with several f_{CP} final states

THE COLLABORATION

M.Bona, M.Ciuchini, E.Franco, V.Lubicz,
G.Martinelli, F.Parodi,M.Pierini,
P.Roudeau, C.Schiavi,L.Silvestrini,
V. Sordini, A.Stocchi, V.Vagnoni

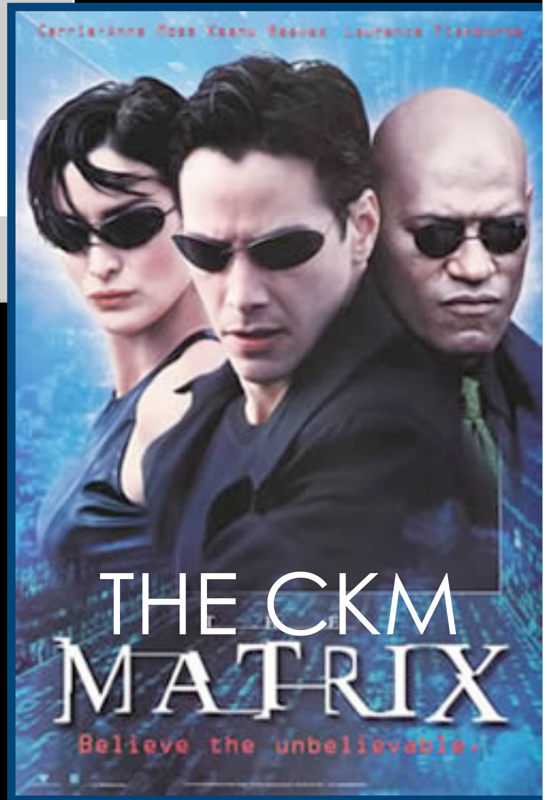


Cern, Roma, Genova, Orsay, Bologna

2008 (2009) ANALYSES

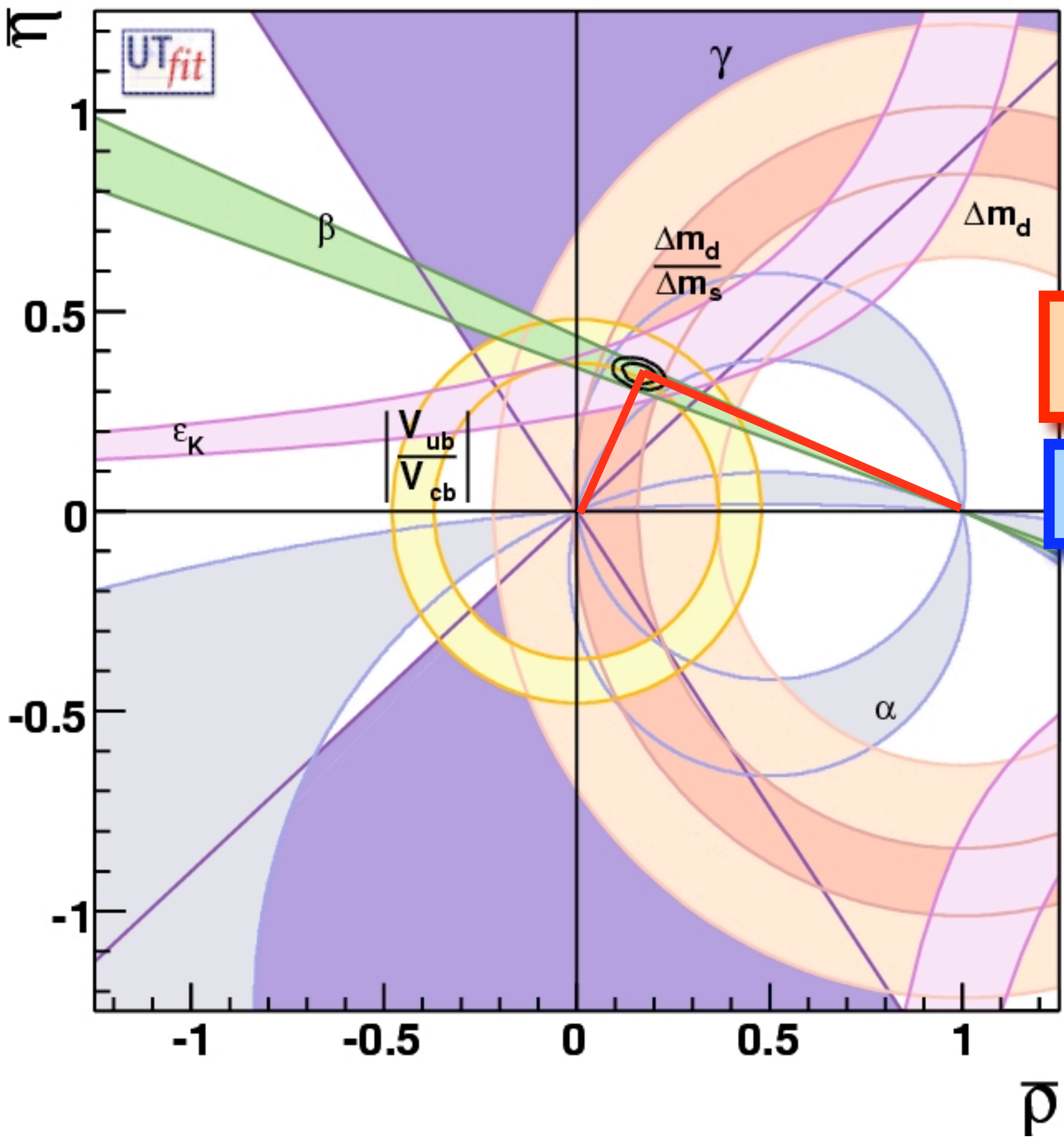
- New quantities included
- Upgraded exp. numbers (after ICHEP '08)
- (CDF) & D0 new measurements

www.utfit.org



Results for ρ and η & related quantities

With the constraint fromΔm_s



contours @ 68% and 95% C.L.

ρ = 0.155 ± 0.022

η = 0.342 ± 0.014

$\alpha = (92.0 \pm\ 3.4)^0$
$\sin 2\beta = 0.695 \pm 0.020$
$\gamma = (65.6 \pm\ 3.3)^0$

A closer look to the analysis:

1) (some) Predictions vs Postdictions (past)
2) Lattice vs angles
3) V_{ub} inclusive, V_{ub} exclusive vs sin 2β
4) Experimental determination of lattice parameters

Comparison of $\sin 2\beta$ from direct measurements (Aleph, Opal, Babar, Belle, D0 and CDF) and UT analysis

$$\sin 2\beta_{measured} = \mathbf{0.668 \pm 0.028}$$

$$\sin 2\beta_{UTA} = 0.731 \pm 0.036$$

correlation (tension) with V_{ub}, see later

$$\sin 2\beta_{UTA} = 0.698 \pm 0.066$$

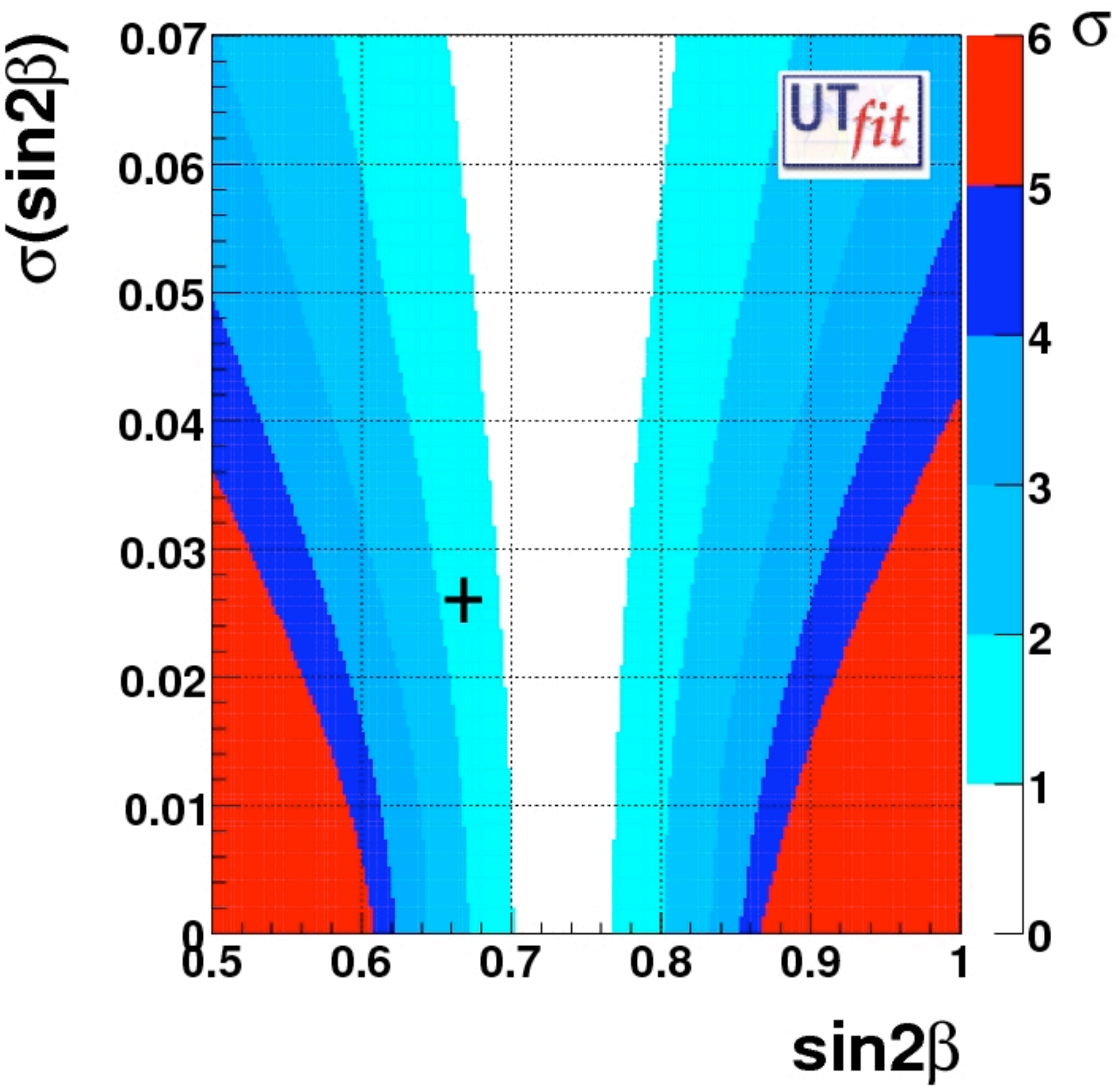
prediction from Ciuchini et al. (2000)

$$\sin 2\beta_{UTA} = 0.65 \pm 0.12$$

Prediction 1995 from Ciuchini,Franco,G.M.,Reina,Silvestrini

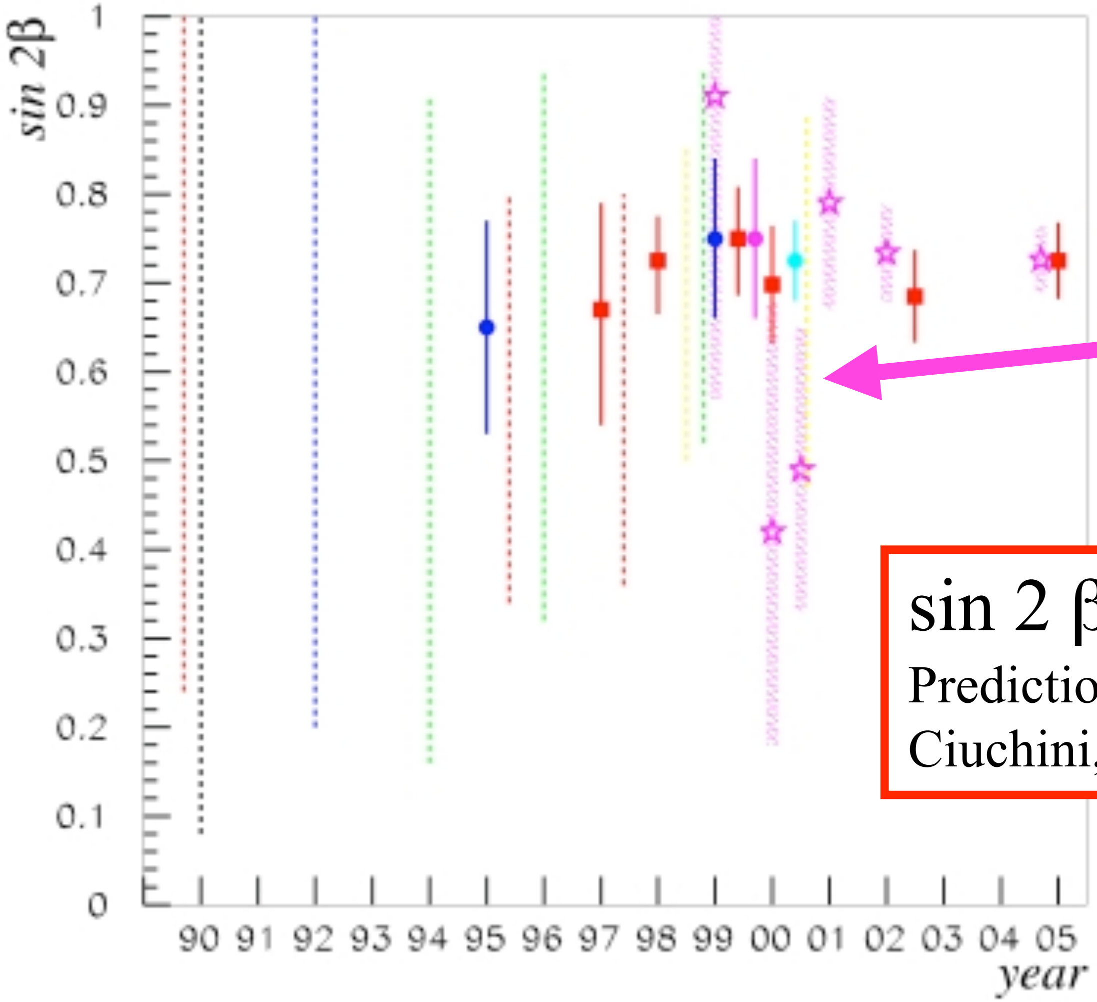
$$\sin 2\beta_{tot} = 0.695 \pm 0.020$$

Very good agreement
no much room for physics beyond the SM !!



σ(sin2β)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.5
0.6
0.7
0.8
0.9
1
sin2β
σ
6
5
4
3
2
1
0
UTfit

Theoretical predictions of Sin 2 β in the years



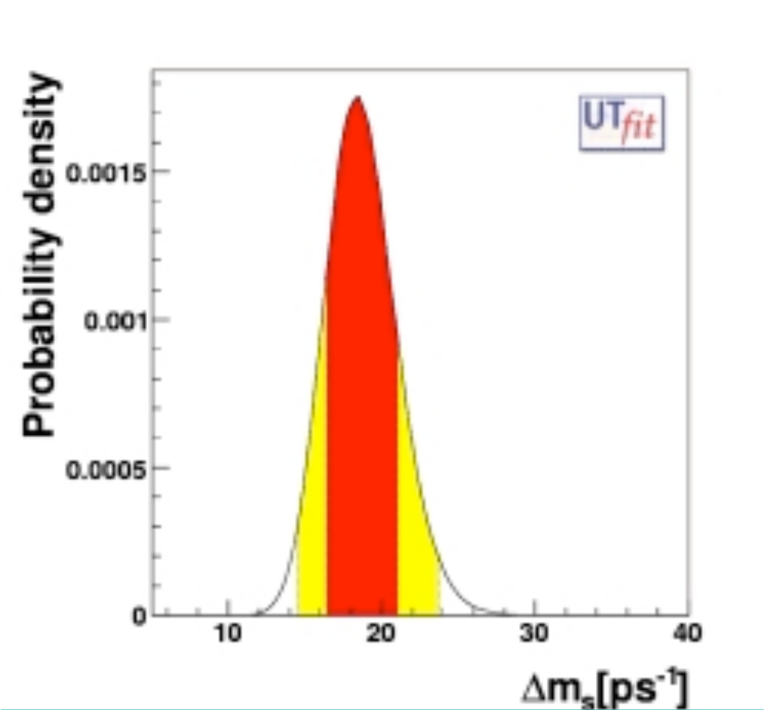
predictions exist since '95

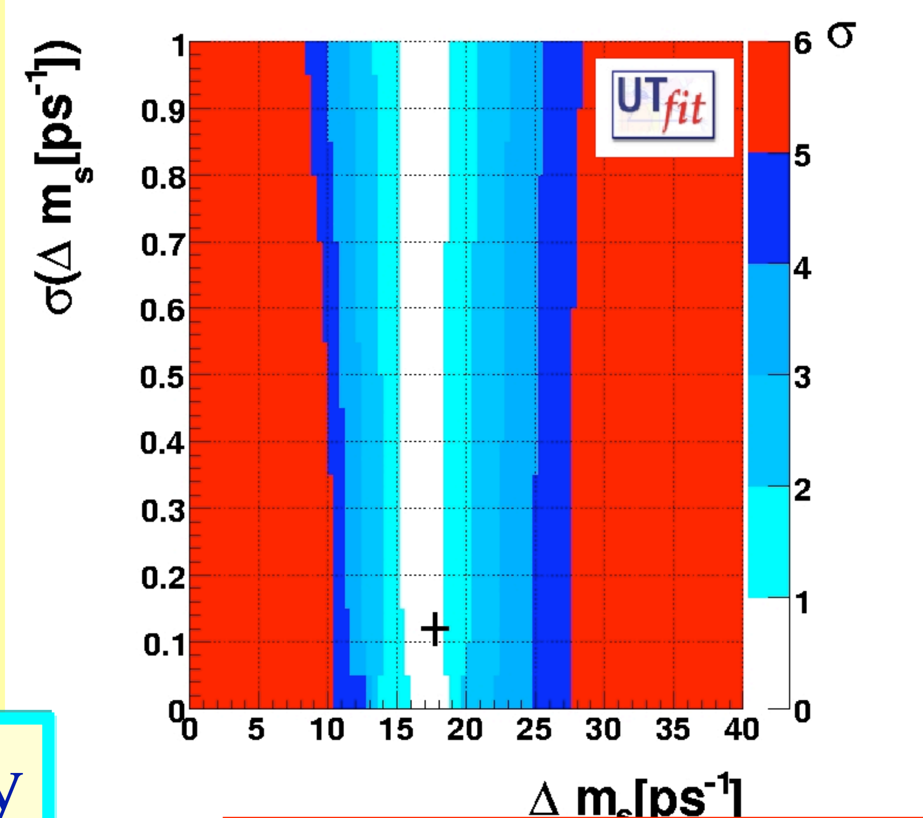
experiments

$\sin 2\,\beta_{UTA} = 0.65 \pm 0.12$

Prediction 1995 from Ciuchini,Franco,G.M.,Reina,Silvestrini

NEWS from NEWS(Standard Model)
The opening of the B_s era





Δm_s Probability Density

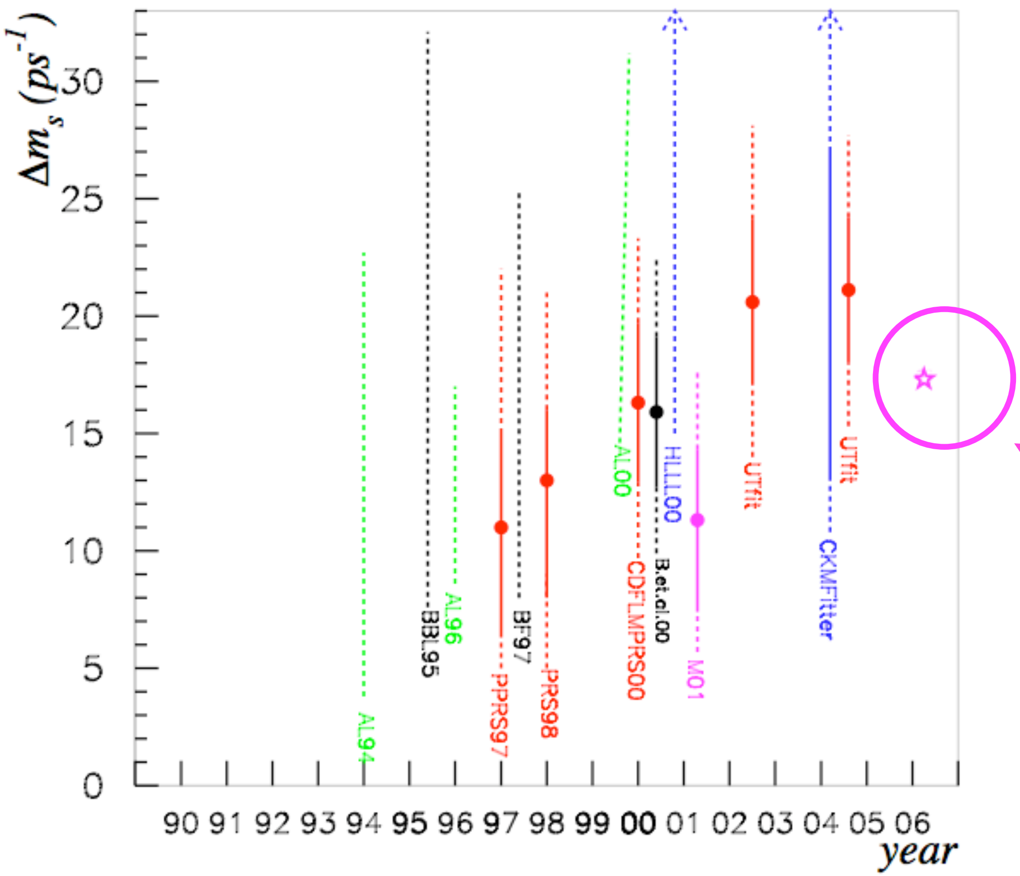
$\Delta m_s = 17.5 \pm 2.1 \ ps^{-1}$ *INDIRECT*

$\Delta m_s = 17.77 \pm 0.12\, ps^{-1}$ *DIRECT*

$\Delta m_s = (16.3 \pm 3.4)\ ps^{-1}$

Ciuchini et. al. 2000

Theoretical predictions of Δm_s in the years



predictions exist since '97

CDF

A GREAT SUCCESS OF (QUENCHED) LATTICE QCD CALCULATIONS

A closer look to the analysis:

1) **Predictions vs Postdictions**
2) **Lattice vs angles**
3) **V_{ub} inclusive, V_{ub} exclusive vs sin 2β**
4) **Experimental determination of lattice parameters**

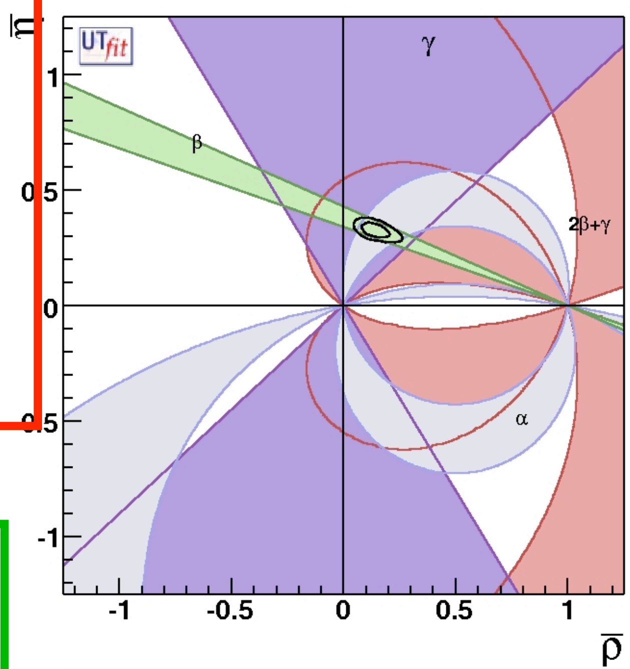
The UT-angles fit does not depend on theoretical calculations (treatement of errors is not an issue)

Comparable accuracy due to the precise sin2β value and substantial improvement due to the new Δm_s measurement

<u>Crucial to improve measurements of the angles, in particular γ</u> (tree level NP-free determination)

Still imperfect agreement in $\bar{\eta}$ due to sin2β and V_{ub} tension

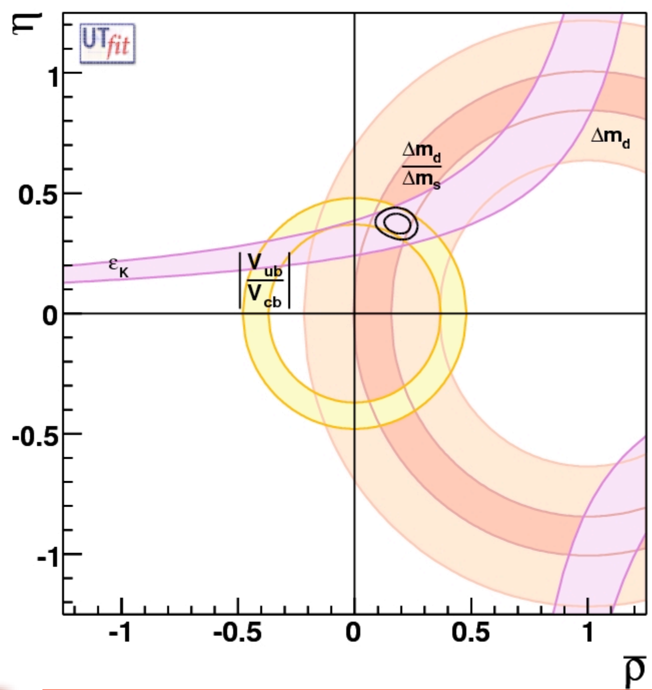
UT-angles



$\rho = 0.120 \pm 0.034$

$\eta = 0.335 \pm 0.020$

UT-lattice



$\rho = 0.175 \pm 0.027$

$\eta = 0.360 \pm 0.023$

ANGLES VS LATTICE 2008

A closer look to the analysis:

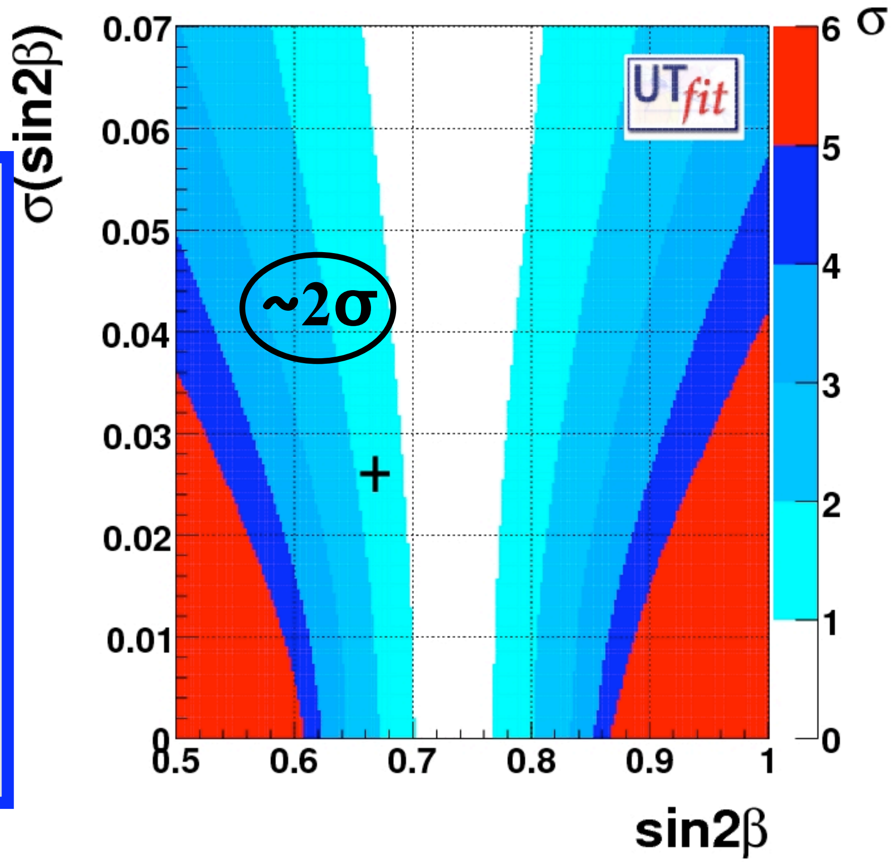
1) Predictions vs Postdictions
2) Lattice vs angles
3) V_{ub} inclusive, V_{ub} exclusive vs sin 2β
4) Experimental determination of lattice parameters

Correlation of $\sin 2\beta$ with V_{ub}

$$\sin 2\beta_{measured} = 0.668 \pm 0.028$$

$$\sin 2\beta_{UTA} = 0.731 \pm 0.036$$

Although compatible, these results show that there is a ``tension" . This is due to the correlation of Vub with $\sin 2\beta$



V_{UB} PUZZLE

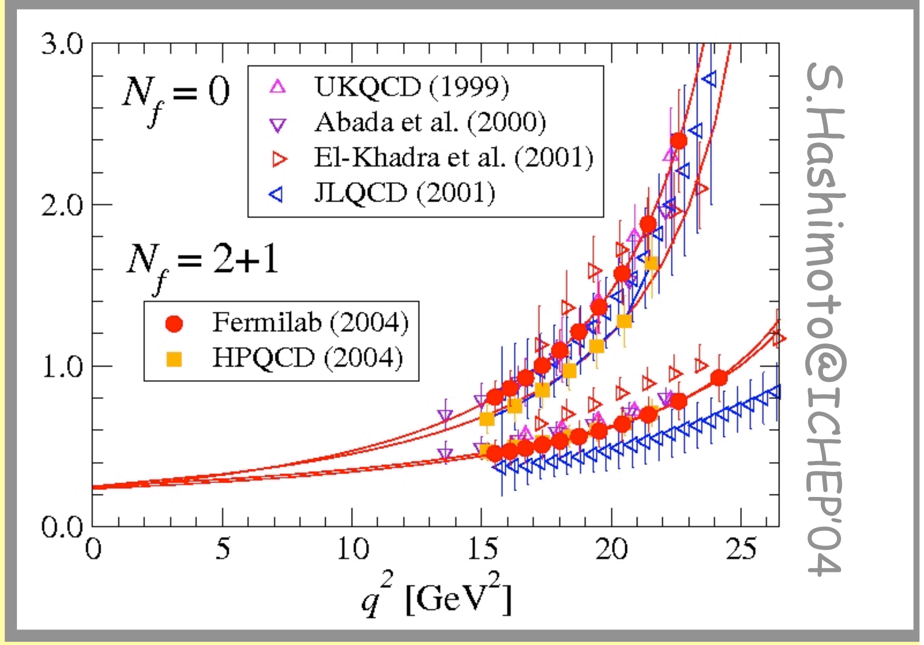
$\lvert V_{ub}\rvert \times 10^4$	excl.	35.0	4.0	Lattice QCDSR
$\lvert V_{ub}\rvert \times 10^4$	incl.	44.9	3.3	HQET+Model
$\lvert V_{ub}\rvert \times 10^4$	average	40.9	2.5	

Inclusive: uses non perturbative parameters most **not** from lattice QCD (fitted from the lepton spectrum)

$$\bar{\Lambda} \quad \lambda_1 \sim \frac{\bar{b}\vec{D}^2 b}{2m_b} \quad \lambda_2 \sim \frac{\bar{b}\sigma_{\mu\nu}G^{\mu\nu}b}{2m_b}$$

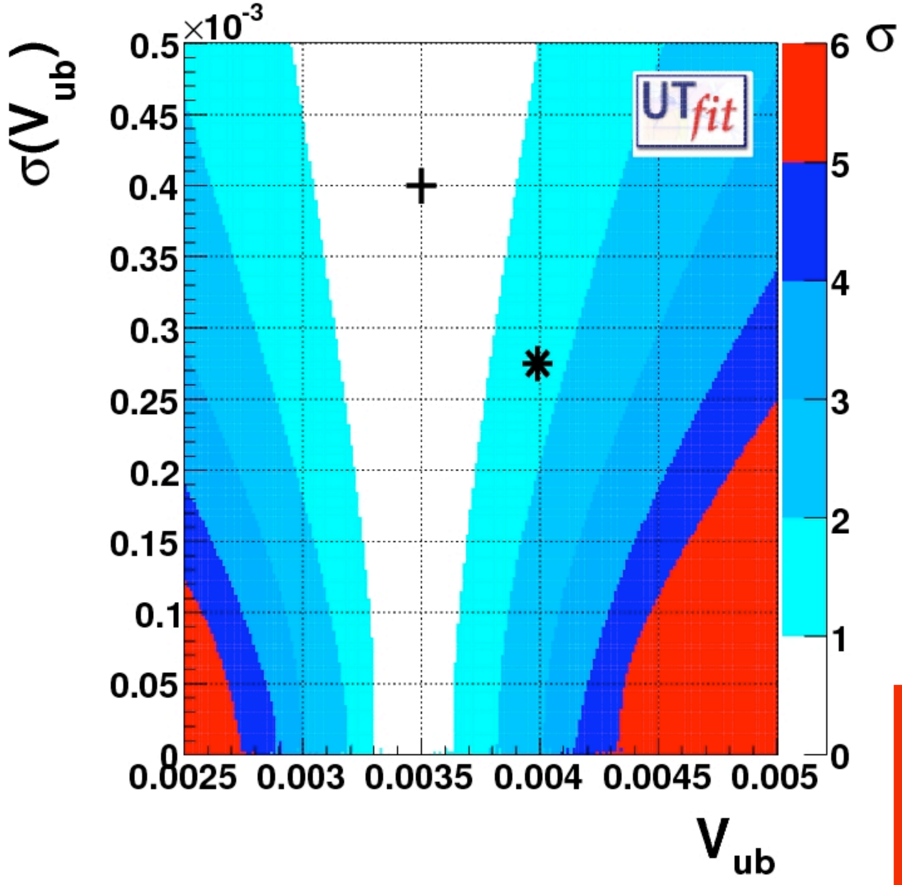
Exclusive: uses non perturbative form factors from LQCD and QCDSR

$$f^+(q^2) \quad V(q^2) \quad A_{1,2}(q^2)$$



Tension between inclusive Vub and the rest of the fit

Tension between inclusive Vub and the rest of the fit



INCLUSIVE $V_{ub} = (43.1 \pm 3.9)\ 10^{-4}$

Model dependent in the threshold region (BLNP, DGE, BLL)

But with a different modelling of the threshold region [U.Aglietti et al., 0711.0860] $V_{ub} = (36.9 \pm 1.3 \pm 3.9)\ 10^{-4}$

EXCLUSIVE $V_{ub} = (34.0 \pm 4.0)\ 10^{-4}$

Form factors from LQCD and QCDSR

V_{UB} PUZZLE

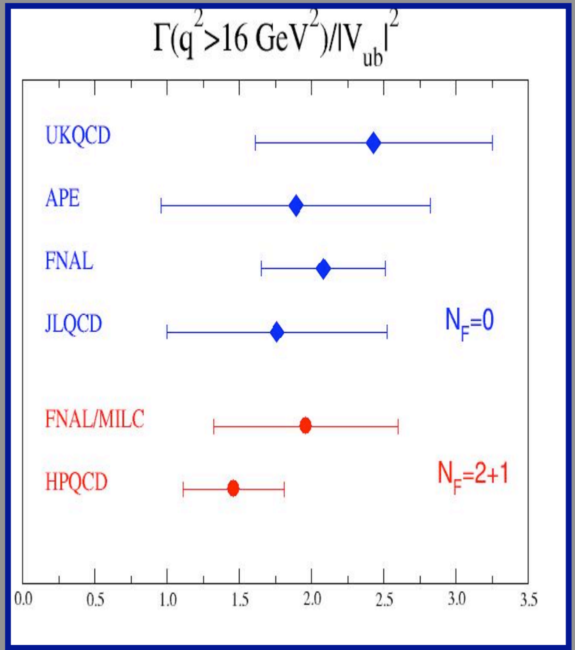
Khodjamirian

Recent $|V_{ub}|$ determinations from $B \to \pi l \nu_l$

[ref.]	$f^+_{B\pi}(q^2)$ calculation	$f^+_{B\pi}(q^2)$ input	$\lvert V_{ub}\rvert \times 10^3$
Okamoto et al.	lattice ($n_f = 3$)	-	3.78±0.25±0.52
HPQCD	lattice ($n_f = 3$)	-	3.55±0.25±0.50
Arnesen et al.	-	lattice⊕SCET	$3.54 \pm 0.17 \pm 0.44$
BecherHill	-	lattice	$3.7 \pm 0.2 \pm 0.1$
Flynn et al	-	lattice ⊕ LCSR	$3.47 \pm 0.29 \pm 0.03$
Ball, Zwicky	LCSR	-	$3.5 \pm 0.4 \pm 0.1$
this work	LCSR	-	$3.5 \pm 0.4 \pm 0.2 \pm 0.1$

V_{UB} PUZZLE

LATTICE QCD:
improve V_{ub} excl. to solve the tension



Beneke CERN '08

$|V_{ub}|$ crisis (about to be resolved?)

- $|V_{ub}| f_+^{B\pi}(0) = (9.1 \pm 0.6 \pm 0.3) \times 10^{-4}$ from semileptonic $B \to \pi l \nu$ spectrum + form factor extrapolation (Ball, 2006)
  Also lattice results (HPQCD) tend to small values.
- $|V_{ub}| f_+^{B\pi}(0) = (8.1 \pm 0.4\,(?)) \times 10^{-4}$ from $B \to \pi^+\pi^-, \pi^+\pi^0, \pi\rho, \ldots$ + factorization
  (MB, Neubert, 2003; Arnesen et al, 2005; MB, Jäger, 2005)

$\Longrightarrow$ $|V_{ub}| \simeq 3.5 \times 10^{-4}$, in contrast to determination from moments of inclusive $b \to u\ell\nu$ decay, which was $|V_{ub}| \simeq (4.5 \pm 0.3) \times 10^{-4}$.

But: according to (Neubert, LP07) $|V_{ub}| \simeq (3.7 \pm 0.3) \times 10^{-4}$ after reevaluation of m_b input and omitting $B \to X_s\gamma$ moments!

Hadronic Parameters From UTfit

1) Predictions vs Postdictions
2) Lattice vs angles
3) V_{ub} inclusive, V_{ub} exclusive vs $\sin 2\beta$
4) Experimental determination of lattice parameters

IMPACT of the NEW MEASUREMENTS on LATTICE HADRONIC PARAMETERS

$$f_{B_s}\hat{B}_{B_s}^{1/2} \qquad \xi \qquad \hat{B}_K$$

Comparison between experiments and theory

Comparison between experiments and theory

exps vs predictions

$f_{B_s}\sqrt{B_{B_s}} = 270 \pm 30$ MeV

lattice

$f_{B_s}\sqrt{B_{B_s}}=265 \pm 4$ MeV

UTA 2% ERROR !!

$\xi = 1.25 \pm 0.06$ **UTA**

$\xi = 1.21 \pm 0.04$

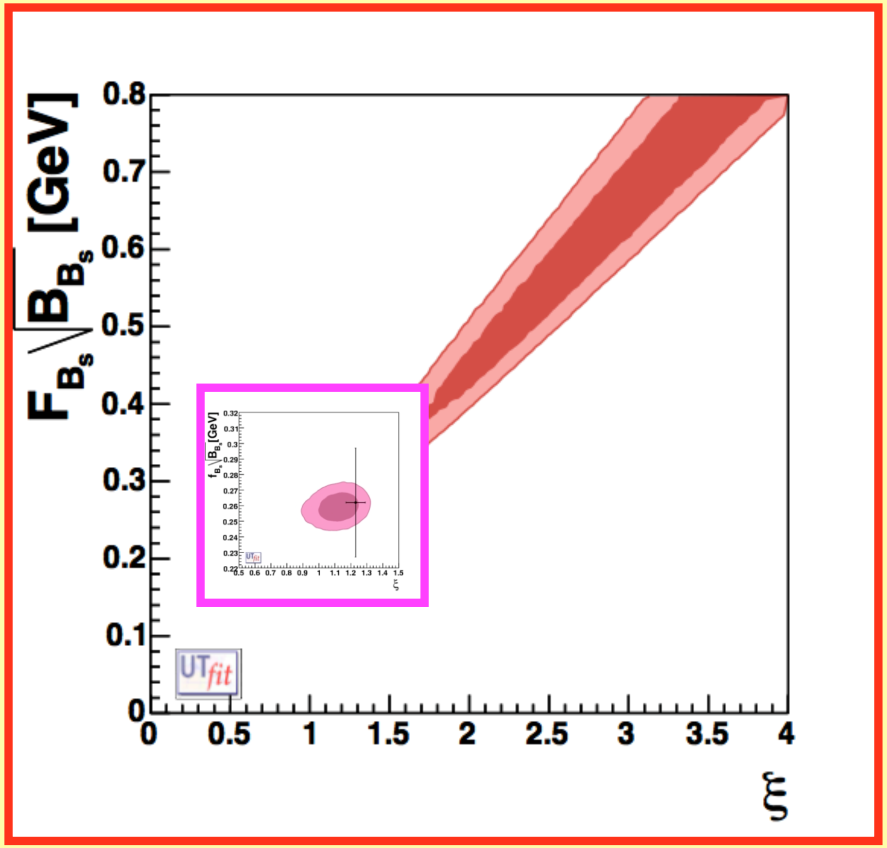
lattice

$B_K = 0.75 \pm 0.07$

$B_K = 0.75 \pm 0.07$

V. Lubicz and C. Tarantino 0807.4605

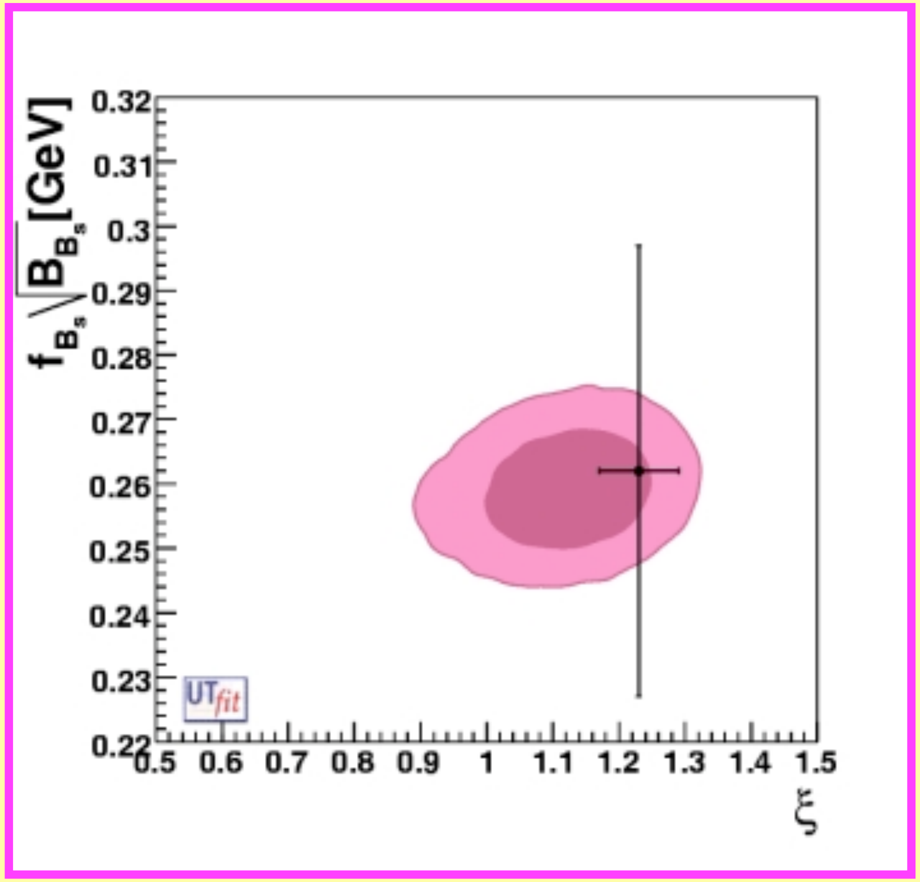
SPECTACULAR AGREEMENT (EVEN WITH QUENCHED LATTICE QCD)



$F_{B_s}\sqrt{B_{B_s}}$ [GeV]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
ξ
UTfit

OLD

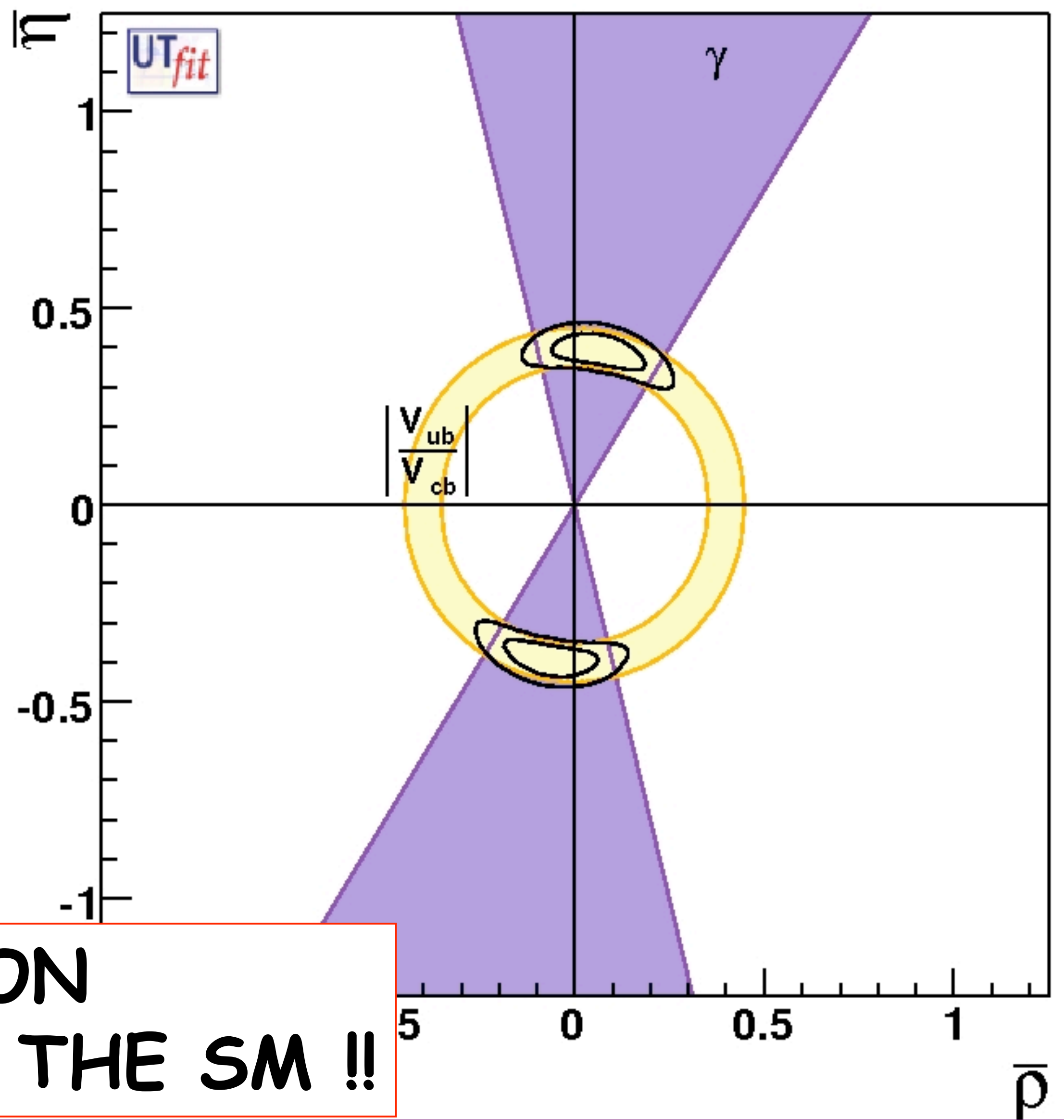
NEW



$f_{B_s}\sqrt{B_{B_s}}$ [GeV]
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
ξ
UTfit

…. beyond the Standard Model

Only tree level processes Vub/Vcb and B-> DK(*)



CP VIOLATION
PROVEN IN THE SM !!

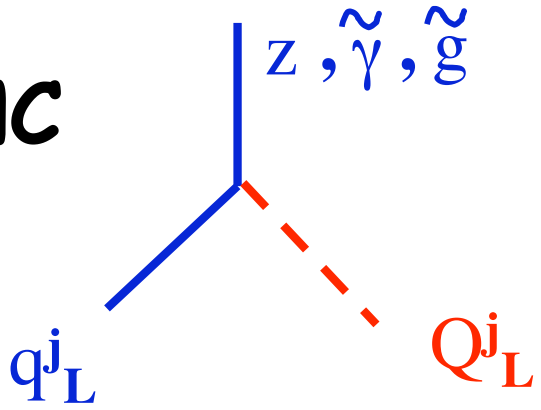
$$Q^{EXP} = V_{CKM}\langle F|\hat{O}|I\rangle$$

$$Q^{EXP} = \sum_i C^i_{SM}(M_W, m_t, \alpha_s)\langle F|\hat{O}_i|I\rangle + \sum_{i'} C^{i'}_{Beyond}(\tilde{m}_\beta, \alpha_s)\langle F|\hat{O}_{i'}|I\rangle$$

In general the mixing mass matrix of the SQuarks (SMM) is not diagonal in flavour space analogously to the quark case We may either

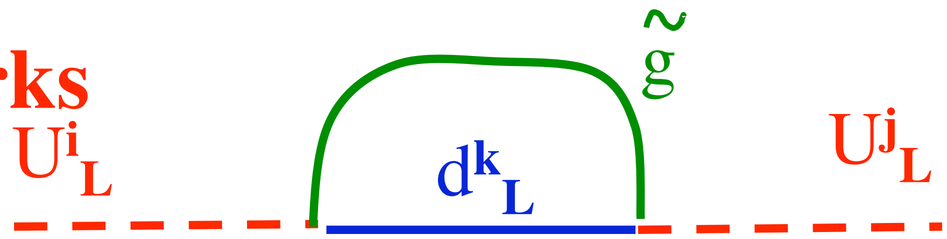
Diagonalize the SMM

FCNC

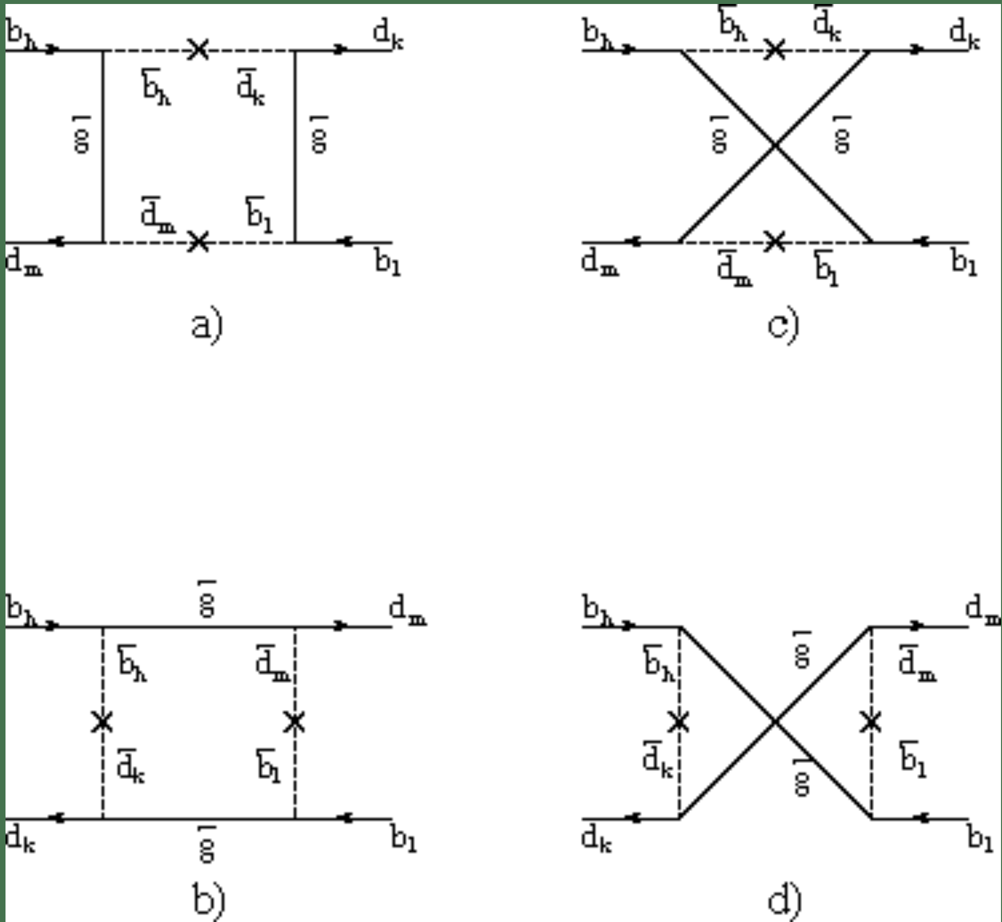


or Rotate by the same matrices the SUSY partners of the u- and d- like quarks

$(Q^j_L)' = U^{ij}_L \, Q^j_L$



In the latter case the Squark Mass Matrix is not diagonal



$$(m^2_Q)_{ij} = m^2_{average}\, 1_{ij} + \Delta m_{ij}^2 \qquad \delta_{ij} = \Delta m_{ij}^2 / m^2_{average}$$

New local four-fermion operators are generated

$Q_1 = (\bar{b}_L^A \gamma_\mu d_L^A)(\bar{b}_L^B \gamma_\mu d_L^B)$ SM

$Q_2 = (\bar{b}_R^A d_L^A)(\bar{b}_R^B d_L^B)$

$Q_3 = (\bar{b}_R^A d_L^B)(\bar{b}_R^B d_L^A)$

$Q_4 = (\bar{b}_R^A d_L^A)(\bar{b}_L^B d_R^B)$

$Q_5 = (\bar{b}_R^A d_L^B)(\bar{b}_L^B d_R^A)$

+ those obtained by $L \leftrightarrow R$

Similarly for the s quark e.g.

$(\bar{s}_R^A d_L^A)(s_R^B d_L^B)$

$$\langle \bar{K}^0 | O_1(\mu) | K^0 \rangle = \frac{8}{3} M_K^2 f_K^2 B_1(\mu) ,$$

$$\langle \bar{K}^0 | O_2(\mu) | K^0 \rangle = -\frac{5}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2 B_2(\mu) ,$$

$$\langle \bar{K}^0 | O_3(\mu) | K^0 \rangle = \frac{1}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2 B_3(\mu) ,$$

$$\langle \bar{K}^0 | O_4(\mu) | K^0 \rangle = 2 \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2 B_4(\mu) ,$$

$$\langle \bar{K}^0 | O_5(\mu) | K^0 \rangle = \frac{2}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2 B_5(\mu) ,$$

B_s mixing , a road to New Physics (NP) ?

The Standard Model contribution to CP violation in B_s mixing is well predicted and rather small

- $\sin 2\beta_s = 0.037 \pm 0.002$ (SM or MFV)
- $\sin 2\beta_s = 0.041 \pm 0.004$ (Arbitrary NP)

The phase of the mixing amplitudes can be extracted from $B_s \to J/\Psi\ \varphi$ with a relatively small th. uncertainty. A phase very different from 0.04 implies **NP in B_s mixing**

Main Ingredients and General Parametrizations

$$H^{\Delta F=2} = \hat{m} - \frac{i}{2}\hat{\Gamma} \quad A = \hat{m}_{12} = \langle \bar{M} | \hat{m} | M \rangle \quad \Gamma_{12} = \langle \bar{M} | \hat{\Gamma} | M \rangle$$

Neutral Kaon Mixing

$$Re\, A_K = C_{\Delta m_K}\, Re\, A_K^{SM} \qquad Im\, A_K = C_\varepsilon\, Im\, A_K^{SM}$$

B_d and B_s mixing

$$A_q e^{2i\phi_q} \equiv C_{B_q} e^{2i\phi_{B_q}} \times A_q^{SM} e^{2i\phi_q^{SM}} = \left(1 + \frac{A_q^{NP}}{A_q^{SM}} e^{2i(\phi_q^{NP} - \phi_q^{SM})}\right) \times A_q^{SM} e^{2i\phi_q^{SM}}$$

$$C_{B_s} e^{2i\phi_{B_s}} = \frac{A_s^{SM} e^{-2i\beta_s} + A_s^{NP} e^{2i(\phi_s^{NP} - \beta_s)}}{A_s^{SM} e^{-2i\beta_s}} = \frac{\langle \bar{B}_s | H_{eff}^{full} | B_s \rangle}{\langle \bar{B}_s | H_{eff}^{SM} | B_s \rangle}$$

$$\begin{aligned} \frac{\Gamma_{12}^q}{A_q} = -2\frac{\kappa}{C_{B_q}} \Bigg\{ & e^{i2\phi_{B_q}} \left(n_1 + \frac{n_6 B_2 + n_{11}}{B_1}\right) - \frac{e^{i(\phi_q^{SM} + 2\phi_{B_q})}}{R_t^q} \left(n_2 + \frac{n_7 B_2 + n_{12}}{B_1}\right) \\ & + \frac{e^{i2(\phi_q^{SM} + \phi_{B_q})}}{R_t^{q^2}} \left(n_3 + \frac{n_8 B_2 + n_{13}}{B_1}\right) + e^{i(\phi_q^{Pen} + 2\phi_{B_q})} C_q^{Pen} \left(n_4 + n_9 \frac{B_2}{B_1}\right) \\ & - e^{i(\phi_q^{SM} + \phi_q^{Pen} + 2\phi_{B_q})} \frac{C_q^{Pen}}{R_t^q} \left(n_5 + n_{10} \frac{B_2}{B_1}\right) \Bigg\} \end{aligned}$$

C_q^{Pen} and ϕ_q^{Pen} parametrize possible NP contributions to Γ^q_{12} from b -> s penguins

SM		SM+NP
$(V_{ub}/V_{cb})^{SM}$ γ^{SM}	**tree level**	$(V_{ub}/V_{cb})^{SM}$ γ^{SM}
β^{SM} α^{SM} Δm_d	***Bd Mixing***	$\beta^{SM}+\phi_{Bd}$ $\alpha^{SM}-\phi_{Bd}$ $C_{Bd}\Delta m_d$
Δm_s^{SM} $-\beta_s^{SM}$	***Bs Mixing***	$C_{Bs}\Delta m_s^{SM}$ $-\beta_s^{SM}+\phi_{Bs}$
ε_K^{SM} Δm_K^{SM}	***K Mixing***	$C_{\varepsilon_K}\,\varepsilon_K^{SM}$ $C_{\Delta mK}\,\Delta m_K^{SM}$

Physical observables

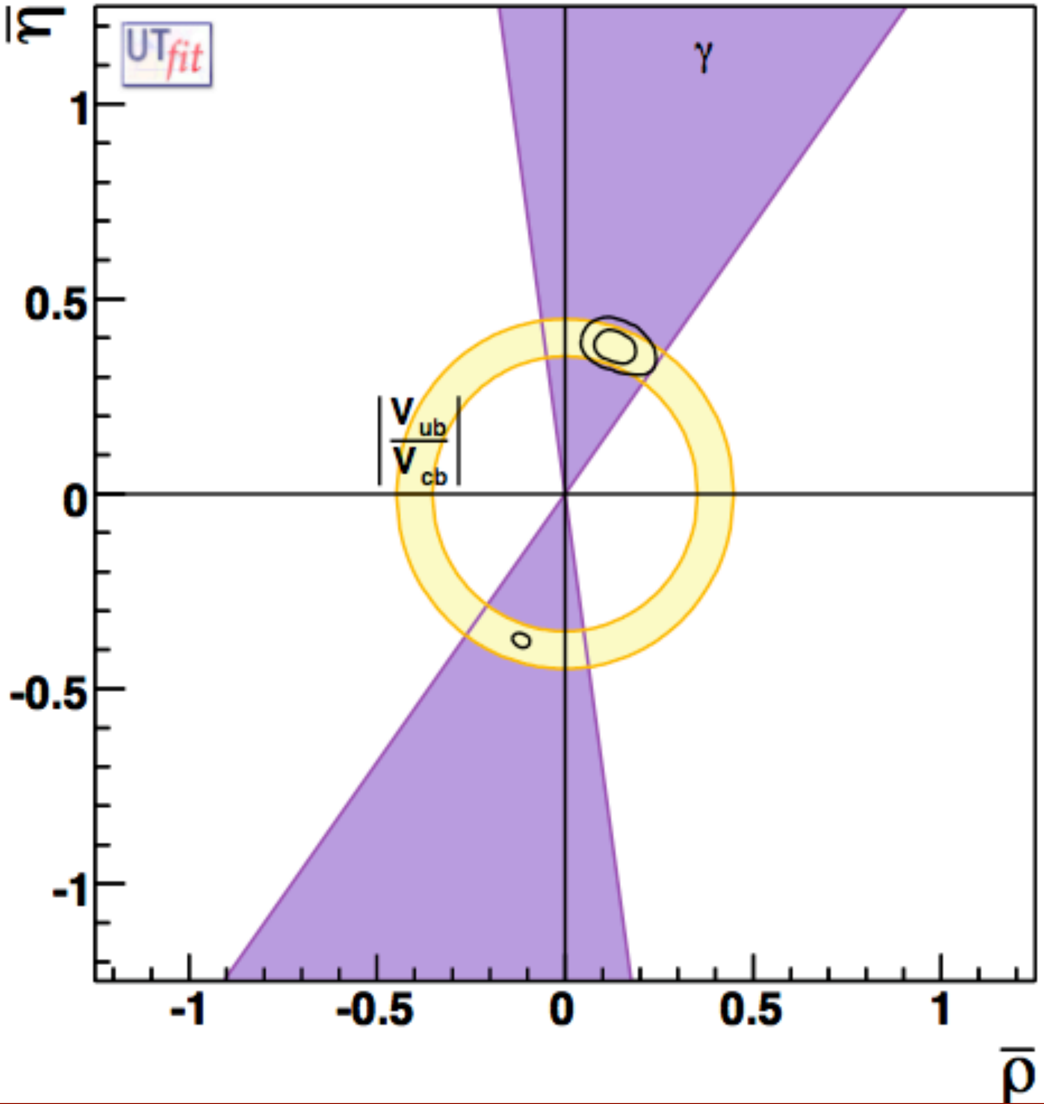
$$\Delta m_s = |A_s| = C_{B_s} \Delta m_s^{SM}$$

$$2\phi_s = -\arg A_s = 2\,(\beta_s - \phi_{B_s})$$

$$A_{SL}^s = \frac{\Gamma(\bar{B}_s \to l^+ X) - \Gamma(B_s \to l^- X)}{\Gamma(\bar{B}_s \to l^+ X) + \Gamma(B_s \to l^- X)} = Im\left(\frac{\Gamma_{12}^s}{A_s}\right)$$

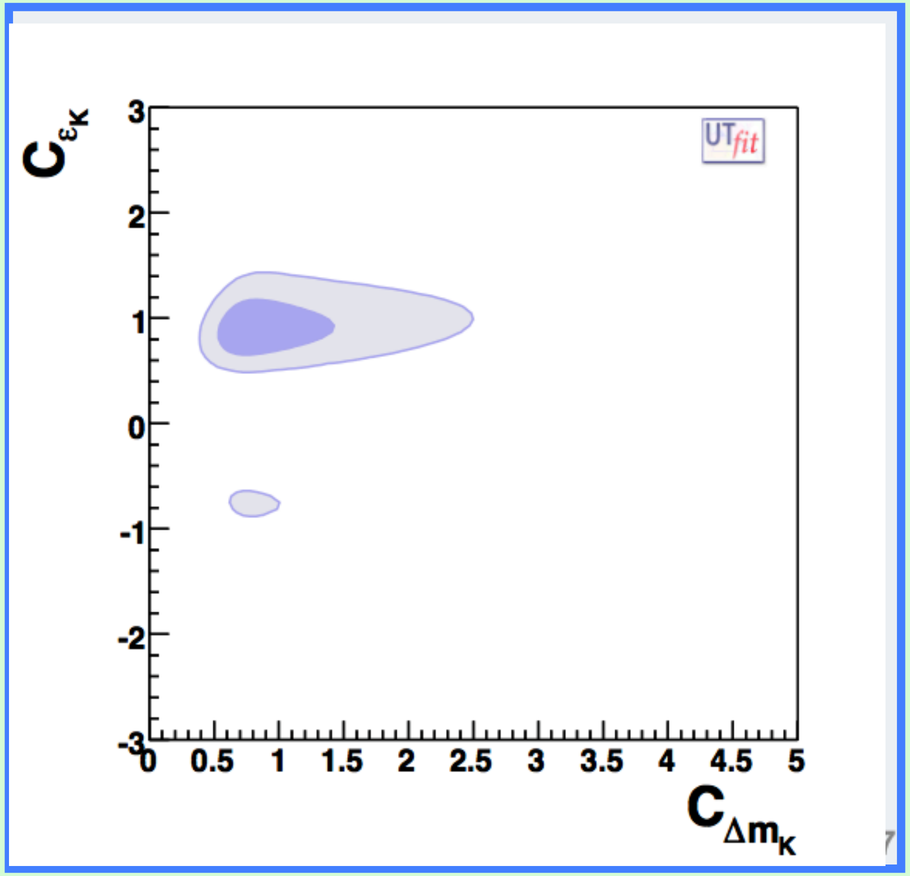
$$A_{SL}^{\mu\mu} = \frac{f_d \chi_{d0} A_{SL}^d + f_s \chi_{s0} A_{SL}^s}{f_d \chi_{d0} + f_s \chi_{s0}}$$

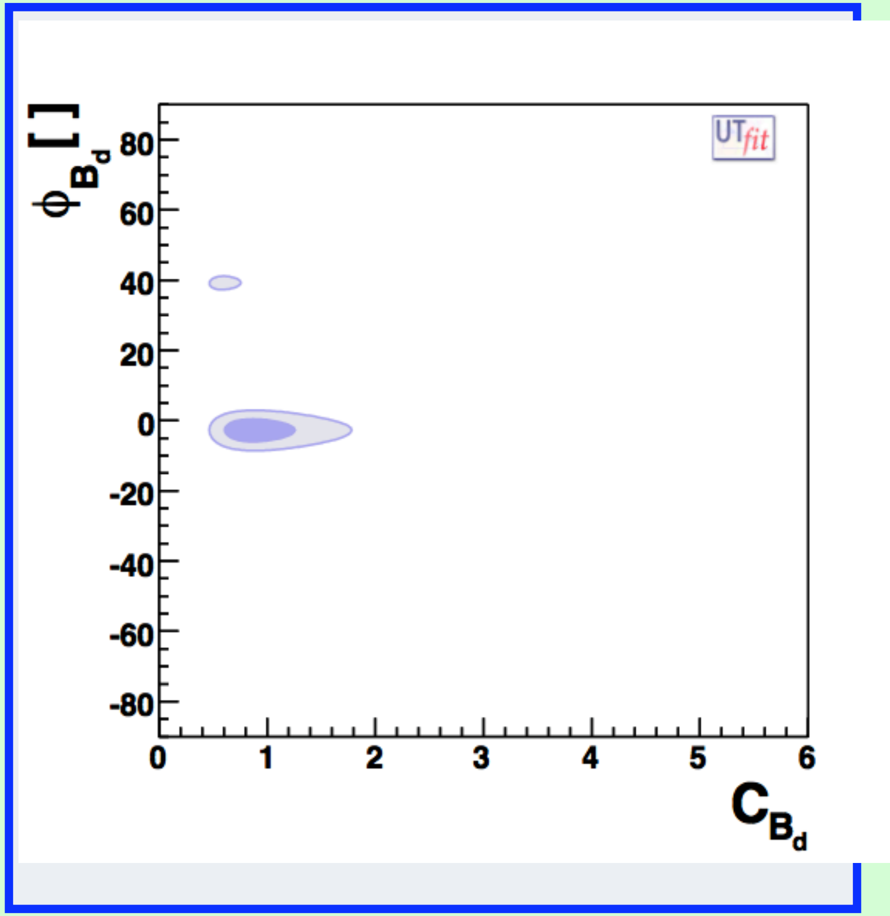
$$\frac{\Delta\Gamma_s}{\Delta m_s} = Re\left(\frac{\Gamma_{12}^s}{A_s}\right) \qquad \tau_{B_s}^{FS} = \frac{1}{\Gamma_S} \frac{1 + (\Delta\Gamma_s / 2\Gamma_s)^2}{1 - (\Delta\Gamma_s / 2\Gamma_s)^2}$$



UTfit
γ
$\left|\frac{V_{ub}}{V_{cb}}\right|$
$\bar{\eta}$
$\bar{\rho}$
1
0.5
0
-0.5
-1

Results for Kaon and Bd mixing





$C\varepsilon_K = 0.90 \pm 0.13$

$C_{Bd} = 0.86 \pm 0.23$

$\Phi_{Bd} = (-2.6 \pm 2.0)^0$

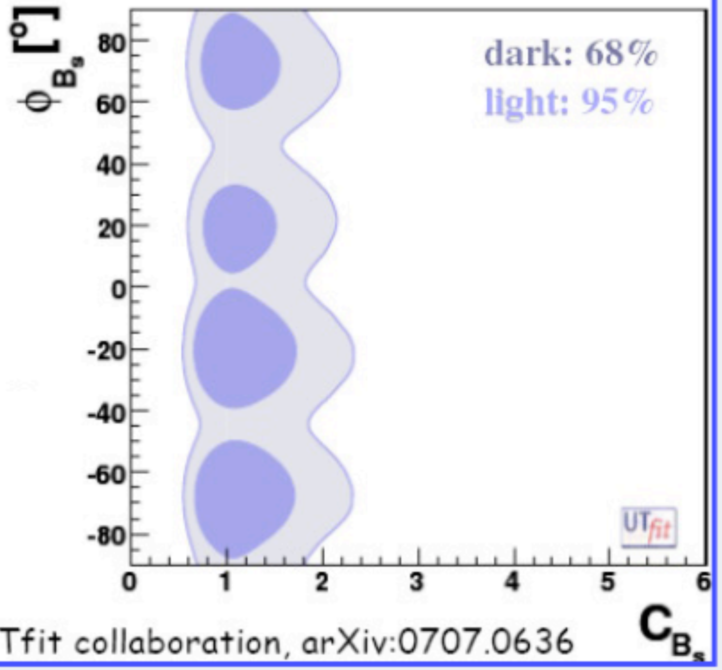
Experimental measurements

Δm_s [ps^{-1}]	17.77 ± 0.12	
$A_{\rm SL}^{s} \times 10^2$	-0.20 ± 1.19	New!
$A_{\rm SL}^{\mu\mu} \times 10^3$	-4.3 ± 3.0	
$\tau_{B_s}^{\rm FS}$ [ps]	1.461 ± 0.032	

Tagged analysis of $B_s \to J/\Psi\phi$ from CDF and D0: use 2D likelihood for $\Delta\Gamma_s$ vs ϕ_s New!

$B_s \to J/\Psi\ \varphi$: 2007 untagged time dependent angular analysis

Γ_s and ϕ_s from the **untagged** time-dependent angular analysis of $B_s \to J/\psi\ \phi$



UTfit collaboration, arXiv:0707.0636

TAGGED	UNTAGGED
2-fold ambiguity	*4-fold ambiguity*
$(\pi-\phi, -\Delta\Gamma_s, \pi-\delta_{1,2})$	$(\pi+\phi, -\Delta\Gamma_s, \pm\delta_{1,2})$
	$(-\phi, \Delta\Gamma_s, \pm(\pi-\delta_{1,2}))$
$\phi = 2\phi_s$	$(\pi-\phi, -\Delta\Gamma_s, \pm(\pi-\delta_{1,2}))$

$C_{B_s} = 1.11 \pm 0.32$

$\phi_{B_s} = (-69\pm14)^\circ \cup (-20\pm14)^\circ \cup (20\pm5)^\circ \cup (72\pm8)^\circ$

In 2008 both CDF and DØ published the tagged time-dependent angular analysis of $B_s \to J/\psi\ \phi$

2D likelihood ratio for $\Delta\Gamma$ and ϕ_s

2-fold ambiguity present, no assumption on the strong phases

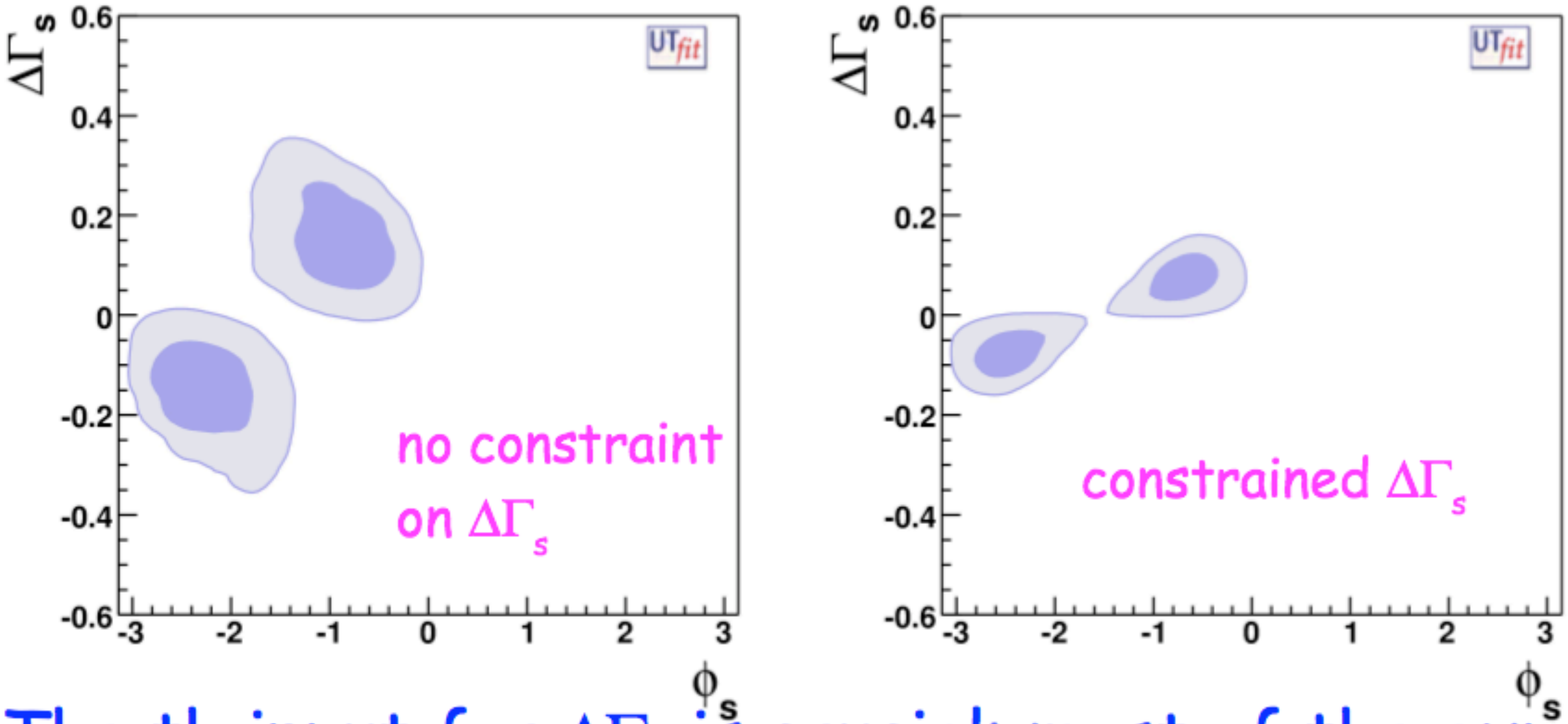
arXiv:0712.2397

7-parameter fit + correlation matrix or 1D likelihood profiles of $\Delta\Gamma$ and ϕ_s

2-fold ambiguity removed using strong phases from B -> J/Ψ K* + SU(3) + ?

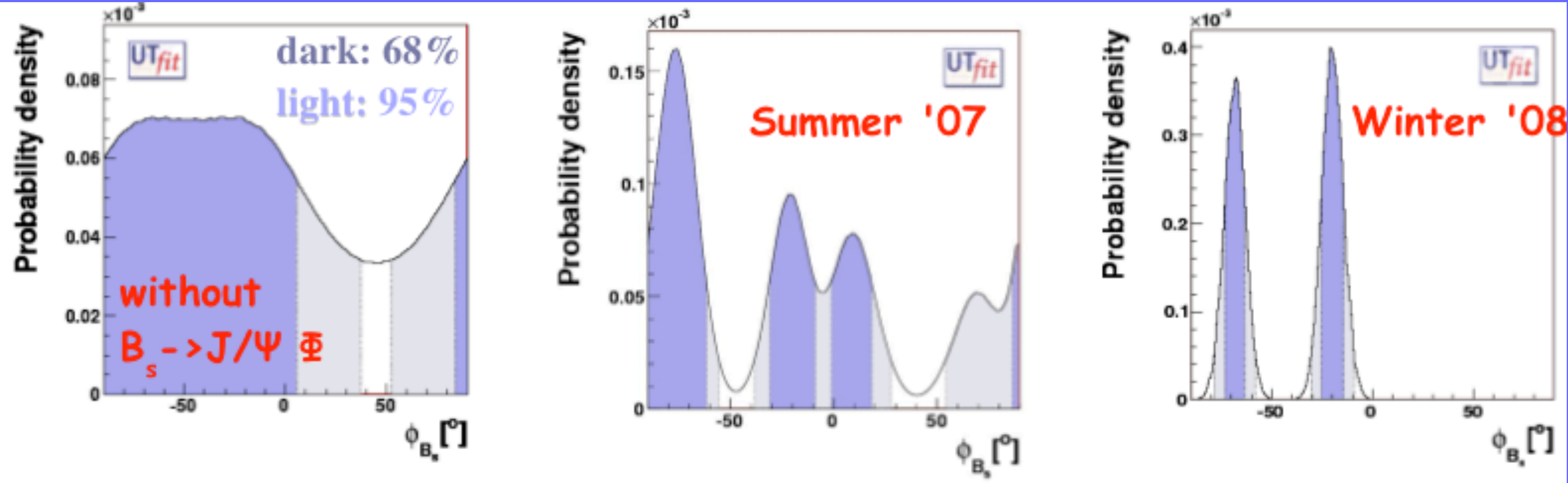
arXiv:0802.2255

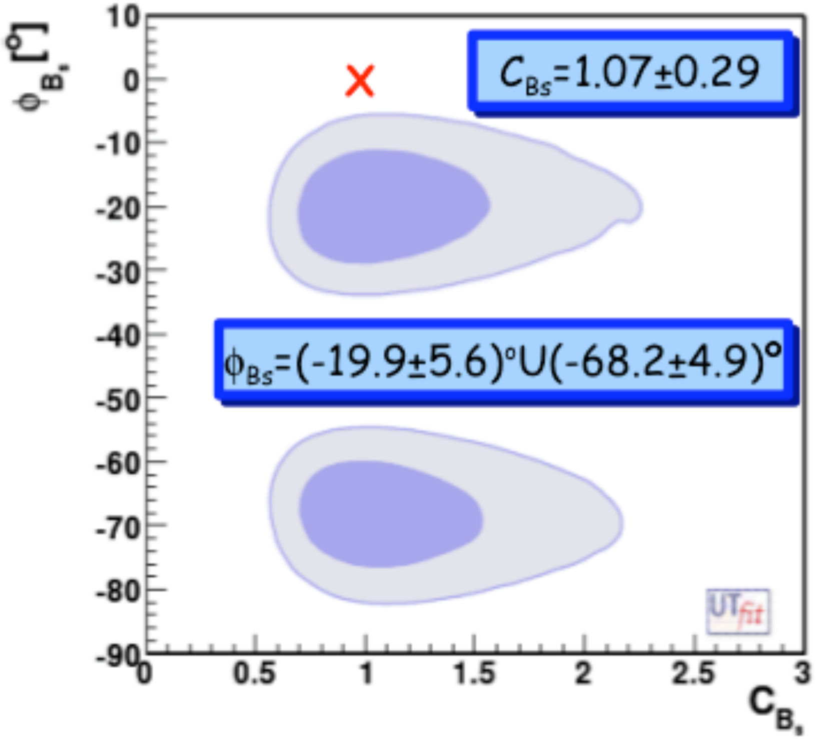
Utfit Coll. combined all the available exp. info with some maquillage on the D0 results to remove the assumptions on the strong phases and deal with the 1D pdf for $\Delta\Gamma_s$ and ϕ_s



The th input for $\Delta\Gamma_s$ is crucial: most of the exp allowed region has a too large $|\Delta\Gamma_s|$.

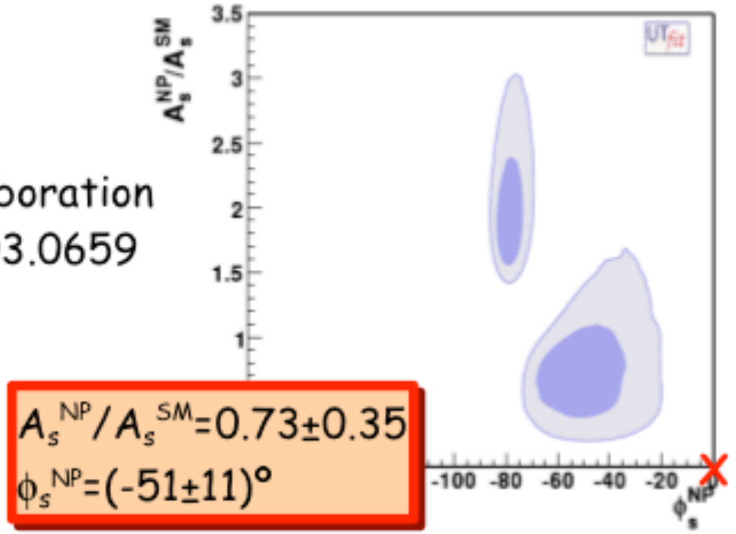
We use a conservative estimate of the SM error and allow NP to enter $\Delta\Gamma_s$ through NP penguins.





SM@99.7% probability
(equivalent to the Gaussian 3σ level)
for any treatment of the DØ data

UTfit collaboration
arXiv:0803.0659



In 2008 both CDF and DØ published the <u>tagged</u> time-dependent angular analysis of $B_s \to J/\psi\ \phi$

UTfit

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7-parameter fit + correlation matrix or 1D likelihood profiles of $\Delta\Gamma$ and ϕ_s

2-fold ambiguity removed using strong phases from B -> J/Ψ K* + SU(3) + ?

arXiv:0802.2255

ICHEP'08 UPDATE

1. DØ released the 2D likelihood scan w/o assumptions on the strong phases
2. New measurement of A_{SL}^s, now $A_{SL}^s = (-0.20 \pm 1.19)\ \%$

Enlarged data sample: 1.35 fb^{-1} -> 2.8 fb^{-1}

opposite-side tagging only (equivalent to ~2 fb^{-1})

CDF analysis: SM compatibility 15%(1.5σ)->7%(1.8σ)

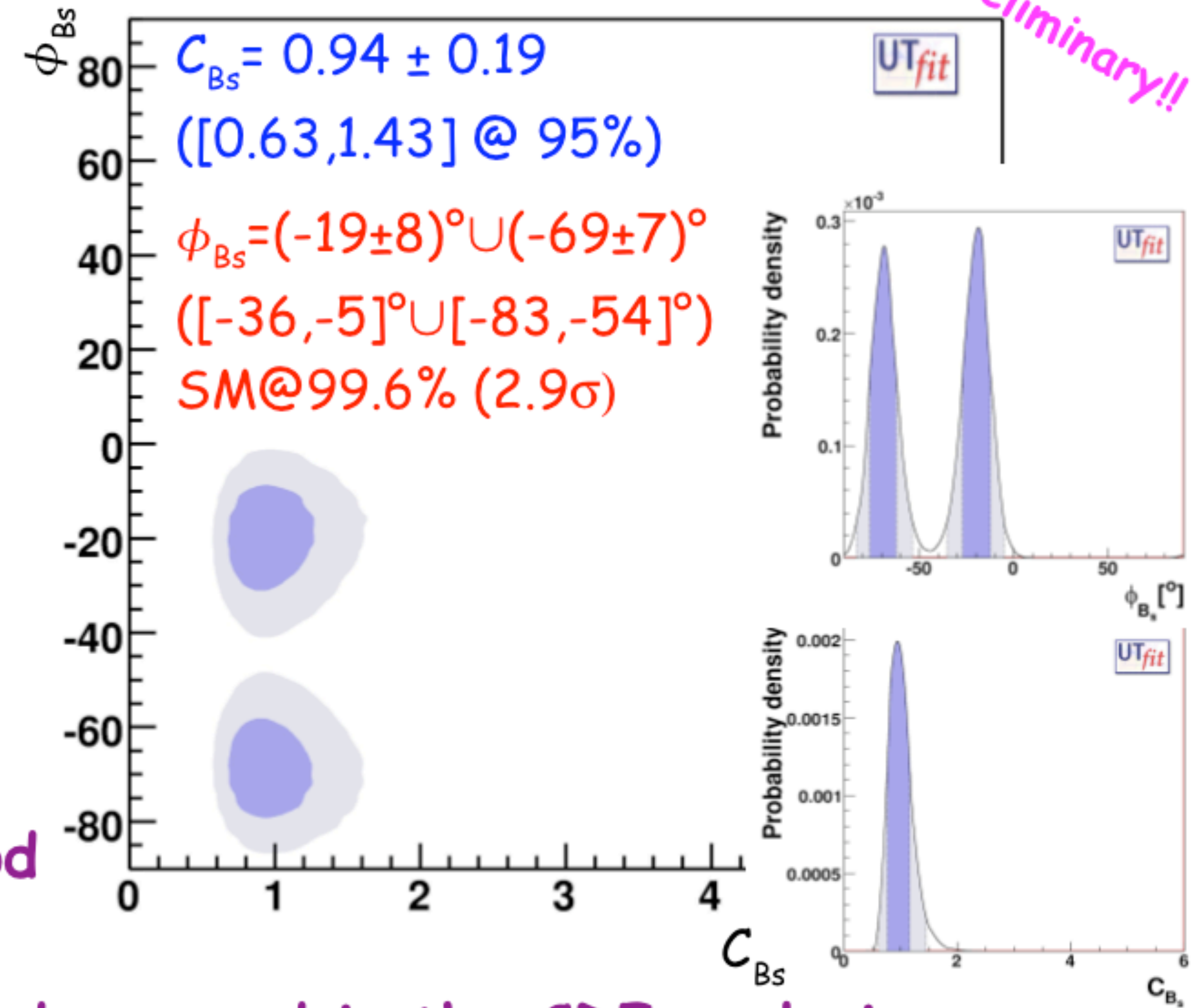
ICHEP '08 update (ii)

preliminary!!

Including the reanalysis of the DØ data

SM @ $3\sigma \rightarrow 2.9\sigma$

New CDF data not included: new CDF likelihood "not ready yet"



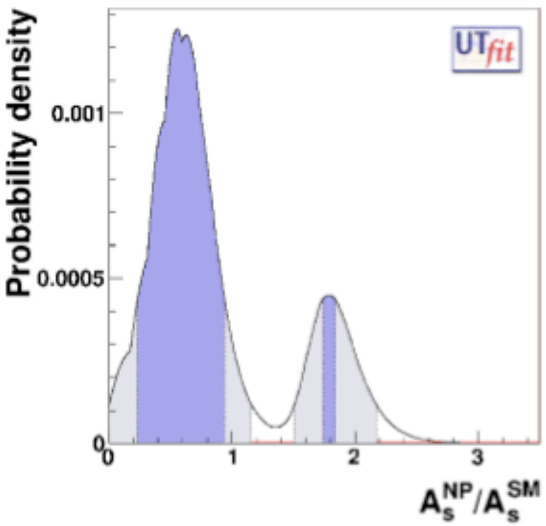
SM compatibility decreased in the CDF analysis

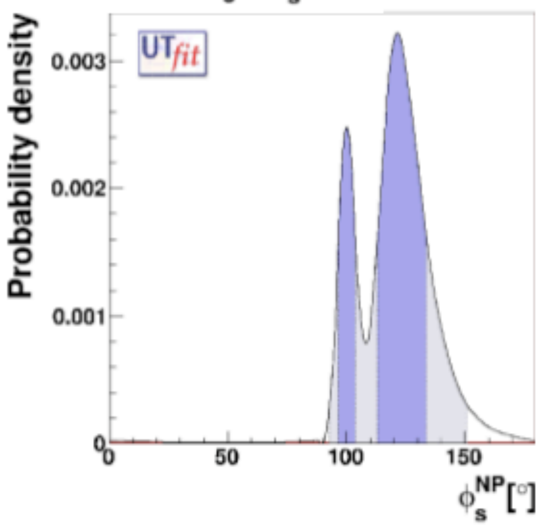
The two solutions for ϕ_s correspond to two regions for A_s^{NP} and ϕ_s^{NP}:

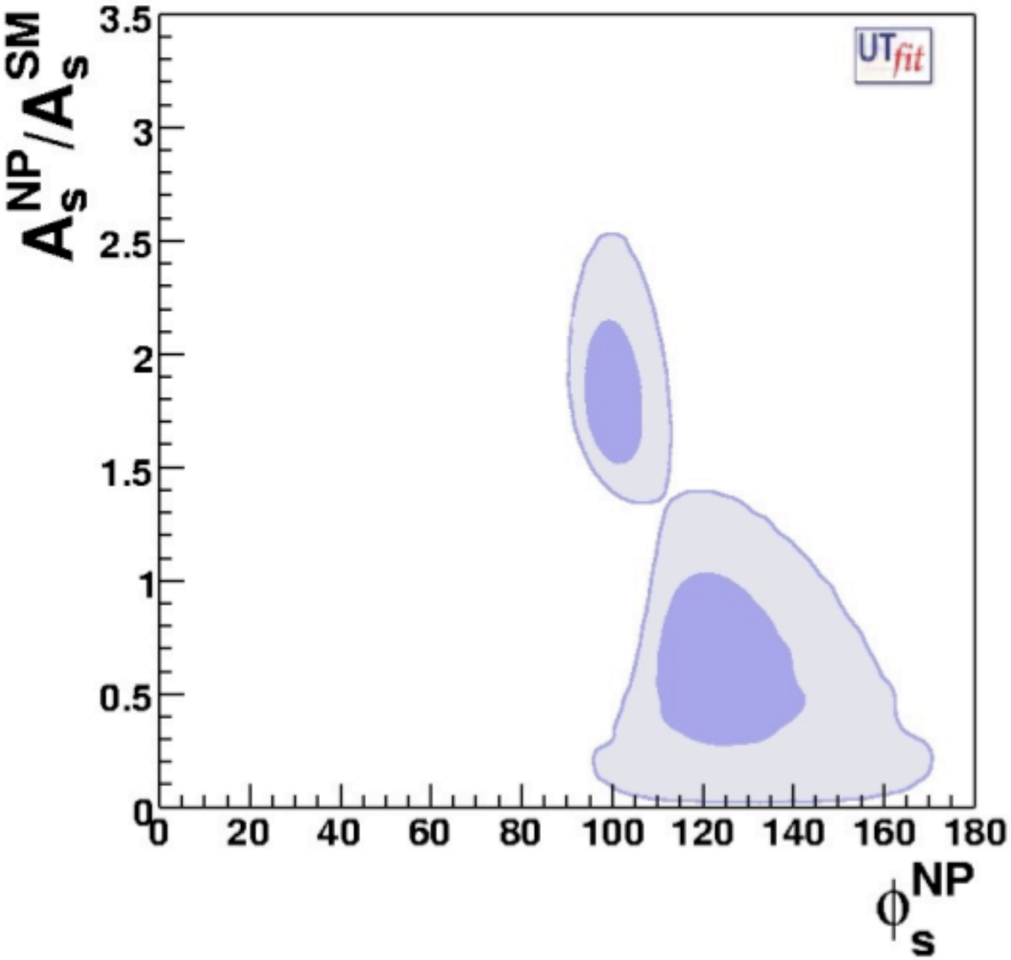
$A_s^{NP}/A_s^{SM}=0.6\pm0.4$ & $\phi_{NP}=(123\pm10)^\circ$

$A_s^{NP}/A_s^{SM}=1.8\pm0.1$ & $\phi_{NP}=(100\pm3)^\circ$

requires NP with new sources of CP violation!







We find non standard CP violation in Bs mixing @ 2.9 σ
➔ New Physics

A pattern of NP contributions to flavour violation emerges:

1 <-> 2 suppressed

1 <-> 3 $\leq$ O(10%)

2 <-> 3 O(1)

CKMFitter 2.5 σ 0810.3139

HFAG 2.2 σ 0808.1297 CDF 1.5 σ -> 1,7 σ

1. *We expect a correlation between b <->s mixing and b -> s penguin transitions (this could be helpful for S_{peng} or $A_{k\pi}$ [Beneke,Buchalla et al.; Buras et al; London et al; Lunghi & Soni, Feldmann et al.])*
2. *If confirmed MFV models, including the simplest realizations of the MSSM, are ruled out*
3. *Large NP contributions to b <->s transitions can be accomodated in non abelian flavour models - SU(3)- given the large breaking due to the top quark mass*
4. *GUT's correlate a large mixing in ν oscillations with a large b <->s mixing*

Effective Hamiltonian: In general NP give rise to new local four-fermion operators

$Q_1 = (\bar{b}_L^{\,A}\, \gamma_\mu\, d_L^{\,A})\ (\bar{b}_L^{\,B} \gamma_\mu\, d_L^{\,B})$ SM

$Q_2 = (\bar{b}_R^{\,A}\, d_L^{\,A})\ (\bar{b}_R^{\,B}\, d_L^{\,B})$

$Q_3 = (\bar{b}_R^{\,A}\, d_L^{\,B})\ (\bar{b}_R^{\,B}\, d_L^{\,A})$

$Q_4 = (\bar{b}_R^{\,A}\, d_L^{\,A})\ (\bar{b}_L^{\,B}\, d_R^{\,B})$

$Q_5 = (\bar{b}_R^{\,A}\, d_L^{\,B})\ (b_L^{\,B}\, d_R^{\,A})$

+ those obtained by L $\leftrightarrow$ R

Similarly for the s quark e.g.

$(\bar{s}_R^{\,A}\, d_L^{\,A})\ (s_R^{\,B}\, d_L^{\,B})$

$$\langle \bar{K}^0 | O_1(\mu) | K^0 \rangle = \frac{8}{3} M_K^2 f_K^2\, B_1(\mu)\ ,$$

$$\langle \bar{K}^0 | O_2(\mu) | K^0 \rangle = -\frac{5}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2\, B_2(\mu)\ ,$$

$$\langle \bar{K}^0 | O_3(\mu) | K^0 \rangle = \frac{1}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2\, B_3(\mu)\ ,$$

$$\langle \bar{K}^0 | O_4(\mu) | K^0 \rangle = 2 \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2\, B_4(\mu)\ ,$$

$$\langle \bar{K}^0 | O_5(\mu) | K^0 \rangle = \frac{2}{3} \left(\frac{M_K}{m_s(\mu) + m_d(\mu)} \right)^2 M_K^2 f_K^2\, B_5(\mu)\ ,$$

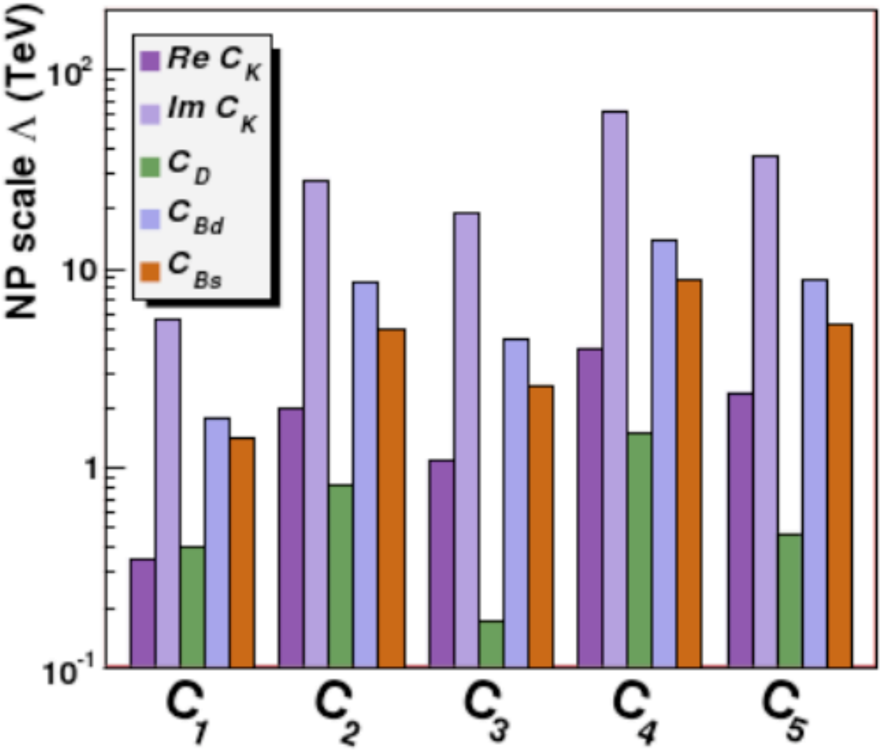
Upper bounds on the coefficients can be derived from the data, using theoretical estimates of the hadronic matrix elements

$$\mathcal{H}_{eff}^{\Delta B=2} = \sum_{i=1}^{8} C_i(\mu,\Lambda) Q_i(\mu)$$

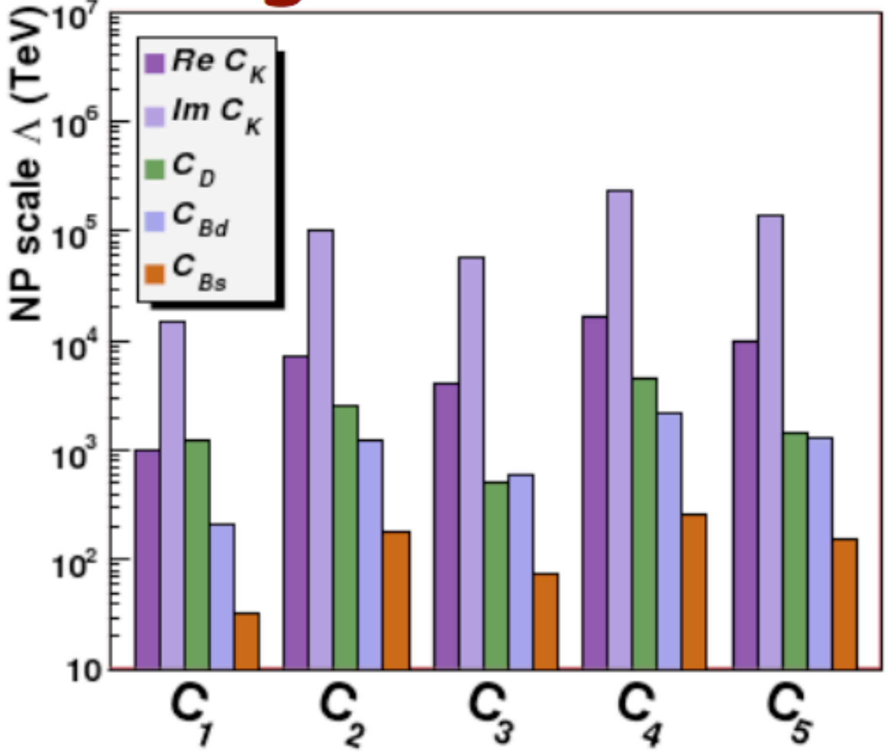
$$C_i(\mu,\Lambda) = (1, \alpha_s^2, \alpha_W^2) \frac{F_i}{\Lambda^2}$$

MFV	next-to-MFV	generic
- $F_1 = F_{SM} \sim (V_{tq} V_{tb}^*)^2$ - $F_{i \neq 1} = 0$	- $\lvert F_i \rvert \sim F_{SM}$ - arbitrary phases	- $\lvert F_i \rvert \sim 1$ - arbitrary phases

MFV



generic FV



Contributions of the $\Delta F=2$ operators to the lower bound on the NP scale in the tree/strong interacting case

Present lower bound on the NP scale

ta (TeV@95%)

Scenario	strong/tree	α_s loop	α_W loop
MFV	5.5	0.5	0.2
NMFV	62	6.2	2
General	24000	2400	800

$\Delta F=2$ operator with flipped chirality have enhanced Wilson coefficients (and uncertain matrix elements) and can probe NP scales beyond LHC reach

B only (pre-Tevatron)

strong/tree	α_s loop	α_W loop
–	–	–
14	1.4	0.4
2200	220	66

In the presence of a NP evidence, also an upper bound is provided

From the B_s system (TeV@95%)

Scenario	strong/tree	α_s loop	α_W loop
NMFV	35	4	2
General	800	80	30

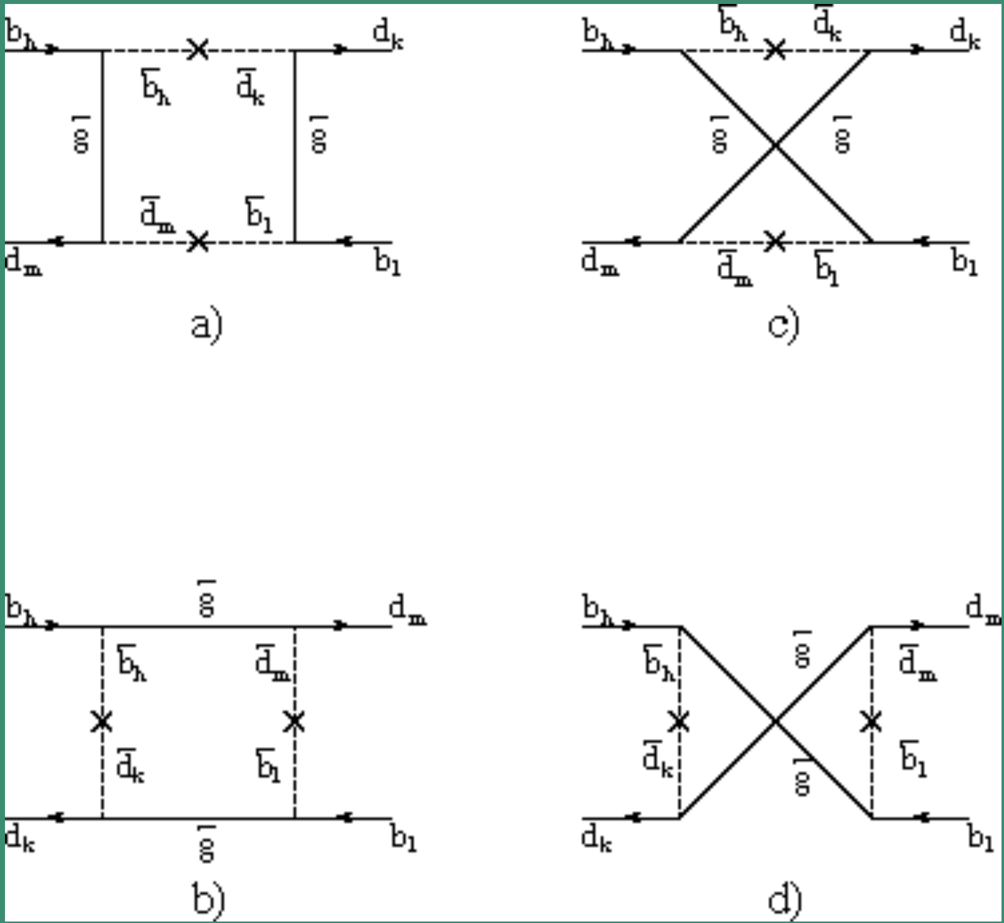
UPPER BOUND << lower bound

⇓

The pattern of NP flavour couplings cannot be SM-like nor general

Data suggest some hierarchy in NP, stronger than in the SM (e.g. some SUSY-GUTs)

MSSM with generic soft SUSY-breaking



Dominant gluino contributions

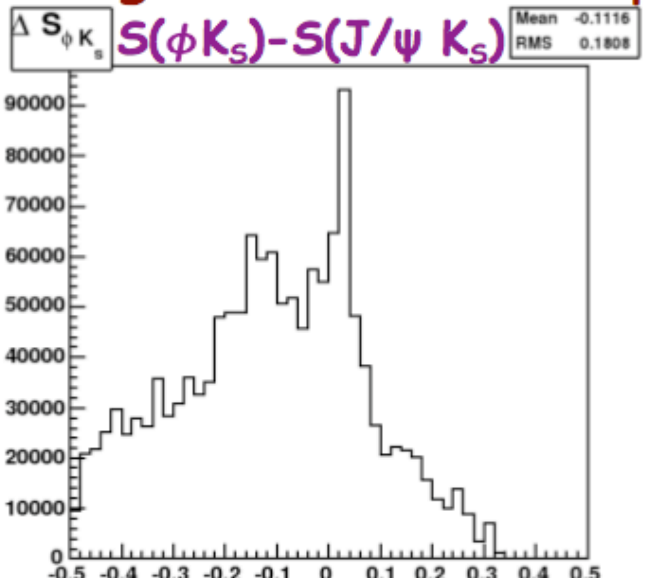
Mass insertion approximation

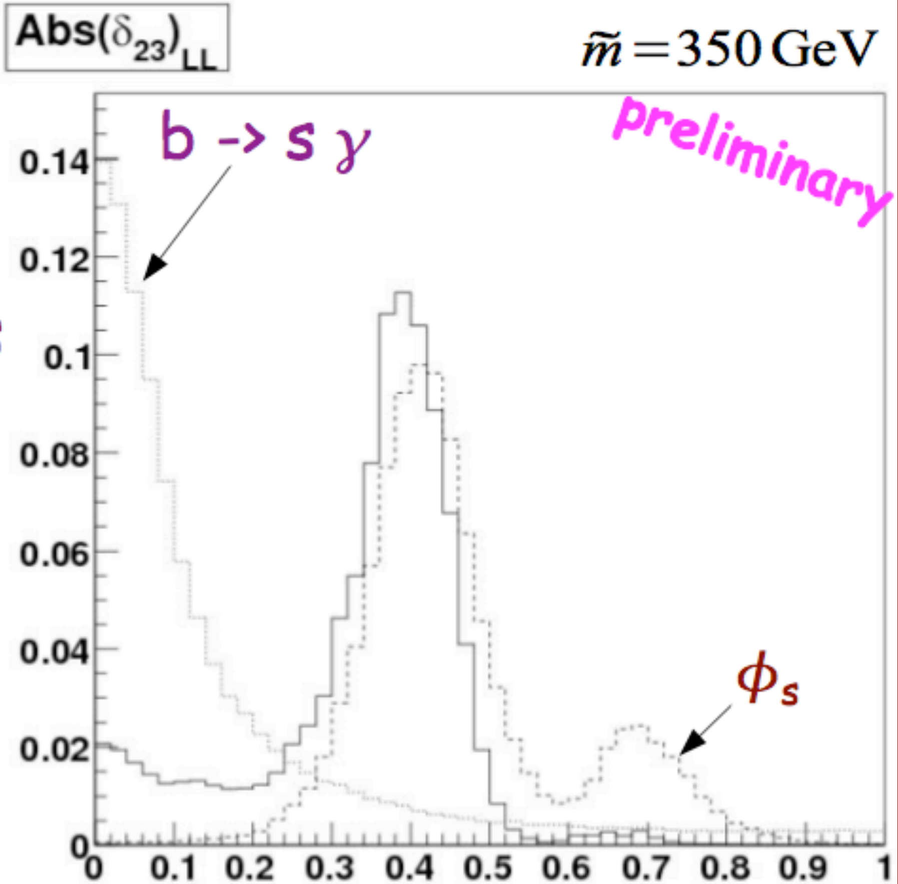
All results preliminary

* chirality-flipping mass insertions are strongly bounded by $b \to s\,\gamma$: they are too small to produce the measured ϕ_s

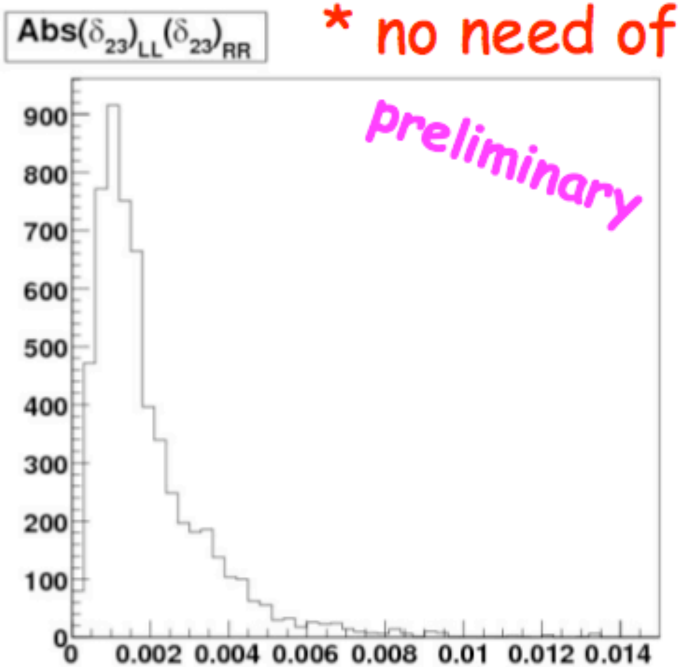
case #1: single mass insertion, e.g. $(\delta_{23})_{LL}$

* large MI needed for ϕ_s: tension with $b \to s\,\gamma$
* MI saturates at 1: upper bound $\tilde{m} < O(1\ \mathrm{TeV})$
* huge effect in b->s penguins



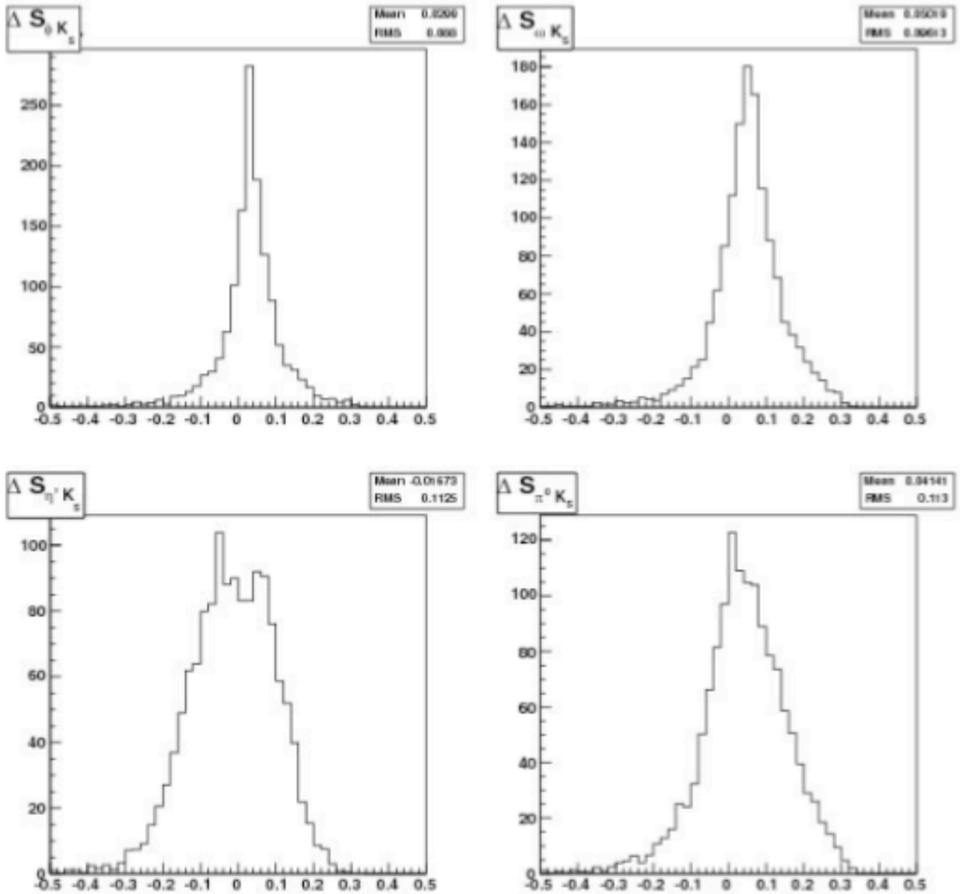


case #2: double mass insertion, $(\delta_{23})_{LL}$ & $(\delta_{23})_{RR}$



* no need of large MIs: $(\delta_{23})_{LL} \sim (\delta_{23})_{RR} \sim 3\text{-}4 \cdot 10^{-2}$

  b -> s γ is no longer a problem



* large effects in b->s penguins still possible (larger if LR MIs are also switched on)

$b \rightarrow s$ & $\tau \rightarrow \mu\gamma$ in SUSY GUTS

When SUSY is broken at a scale larger than M_{GUT} SQuark and SLepton masses unify including the non-diagonal coupling $(\delta_{ij})_{LL}$, $(\delta_{ij})_{RR}$

The following relations holds at M_Z (Ciuchini et al. hep-ph/0307191)

$$(\delta^d_{ij})_{RR} \simeq \frac{m^2_L}{m^2_D} (\delta^l_{ij})_{LL}$$

$$(\delta^{u,d}_{ij})_{LL} \simeq \frac{m^2_E}{m^2_Q} (\delta^l_{ij})_{RR}$$

$$(\delta^u_{ij})_{RR} \simeq \frac{m^2_E}{m^2_U} (\delta^l_{ij})_{LL}$$

$$(\delta^d_{ij})_{LR} \simeq \frac{m^2_{L_{ave}}}{m^2_{Q_{ave}}} \frac{m_b}{m_\tau} (\delta^l_{ij})^*_{RL}$$

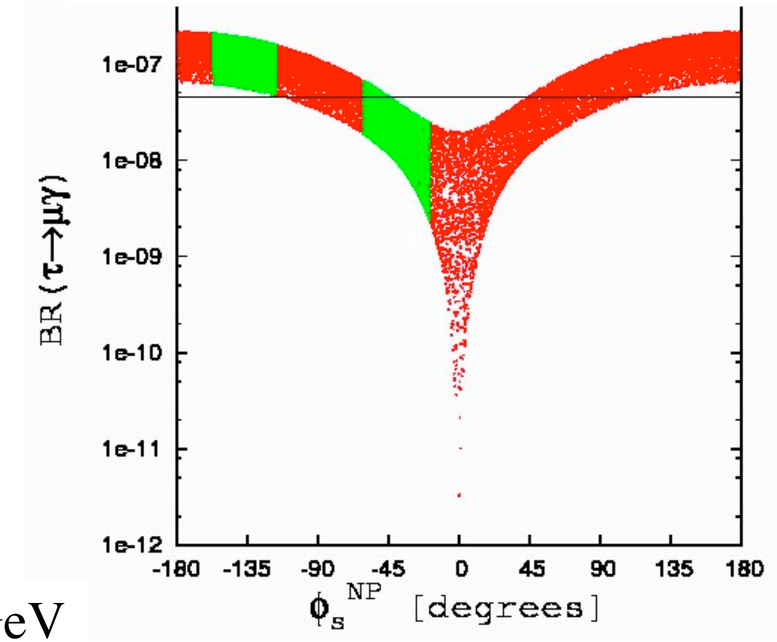
$b \to s$ & $\tau \to \mu\gamma$ in SUSY GUTS

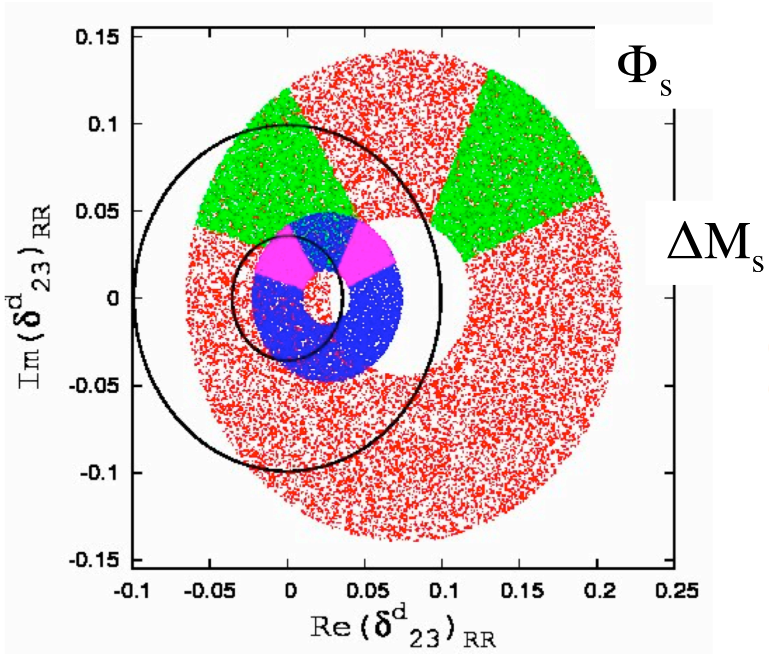
Parry, Zhang, arXiv:0710.5443v2

mass insertion analysis in a SUSY-GUT scheme

- RG-induced $(\delta_{23})_{LL}$
- explicit $(\delta_{23})_{RR}$

Limits from Belle and Babar < 4.5 & 6.8 10^{-8}





m_{sq}=500 GeV

In the UTfit range for the B_s mixing phase:

$BR(\tau \to \mu\gamma) > 3 \times 10^{-9}$!!

CONCLUSIONS

The evidence (strong suggestion, hint, ..) of a large Bs mixing phase survives to a second run of measurements

The upgraded UTFit analysis gives a 2.9 σ deviation from the SM (new CDF measurements still to be included)

In this framework MFV ruled out; MSSM could work with LL and RR insertions without conflict with b -> s γ

Within SUSY GUT a large BR(τ -> $\mu\gamma$) is expected