CKM Fit and Model independent constraints on physics Beyond the Standard Model

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http://www.utfit.org

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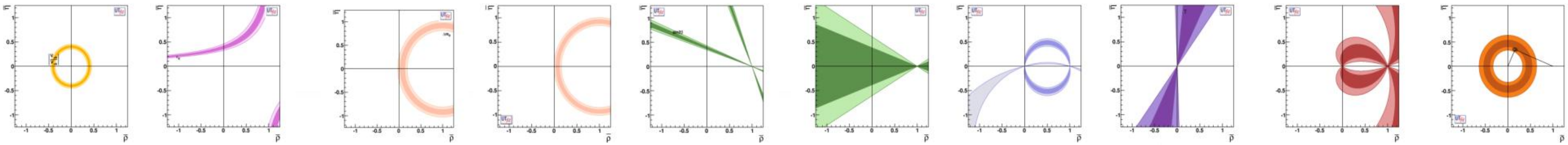
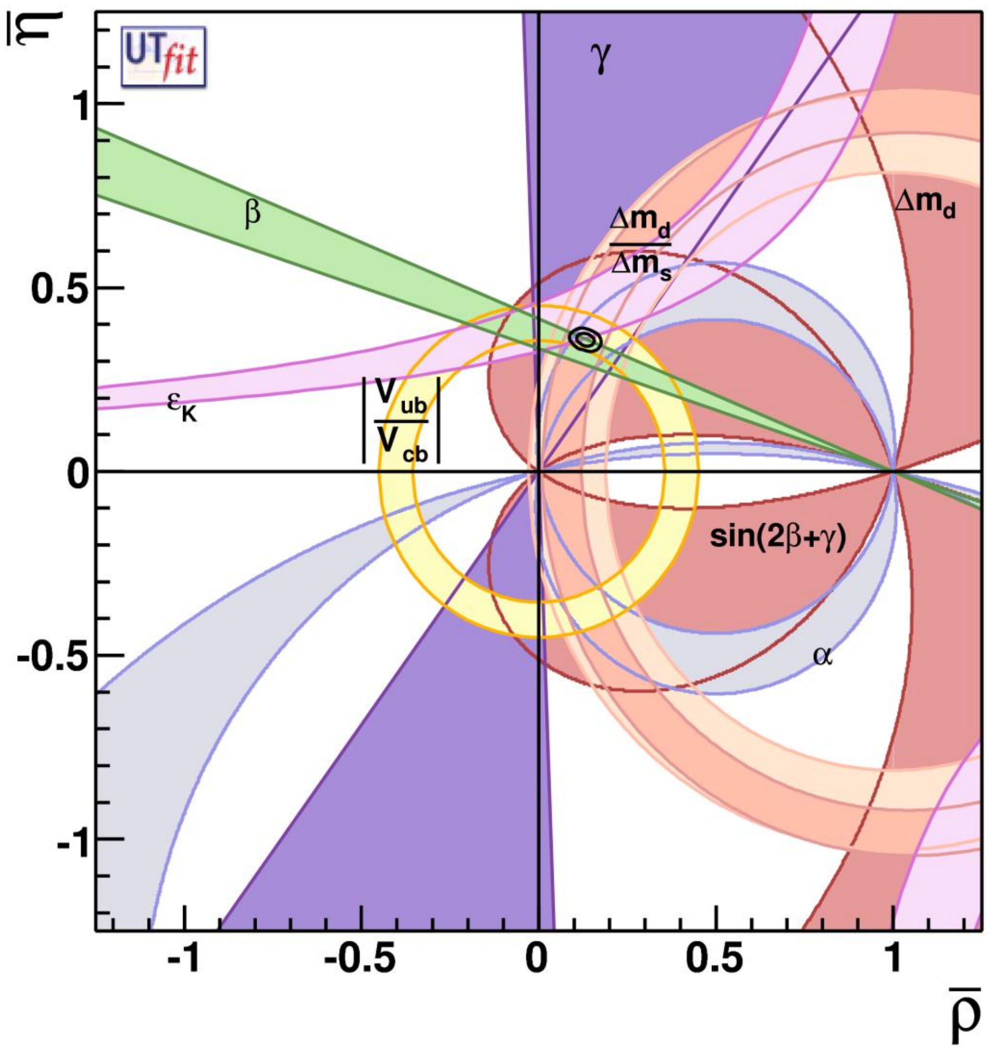
CKM 2010

Global Fit within the SM





Consistence on an over constrained fit of the CKM parameters

$\bar\rho = 0.132 \pm 0.020$

$\bar\eta = 0.358 \pm 0.012$

CKM matrix is the dominant source of flavour mixing and CP violation

These fits are continuously updated.

There are two statistical methods to perform these fits.The overall agreement between them is satisfactory, unless there is some important disagreement

Problem on γ combination

γ (many ADS/GLW/Dalitz..) measurements are all consistent

Most precise measurements (two Dalitz analyses) have an about 15^o error

Combining the measurements with

→the statistical method (frequentist) used by the Collaborations or UTfit we consistently get $\sigma(\gamma) \sim (11\text{-}12)^o$ (UTFit/stat. analysis a la Babar/Belle)

→CKMfitter statistical treatment you get $\sigma(\gamma) \sim (20\text{-}30)^o$ CKMFitter

Error on γ from CKMFitter is 2-3 times larger wrt the frequentist/bayesian method give due to their particular statistical treatement

Is the present picture showing a Model Standardissimo ?

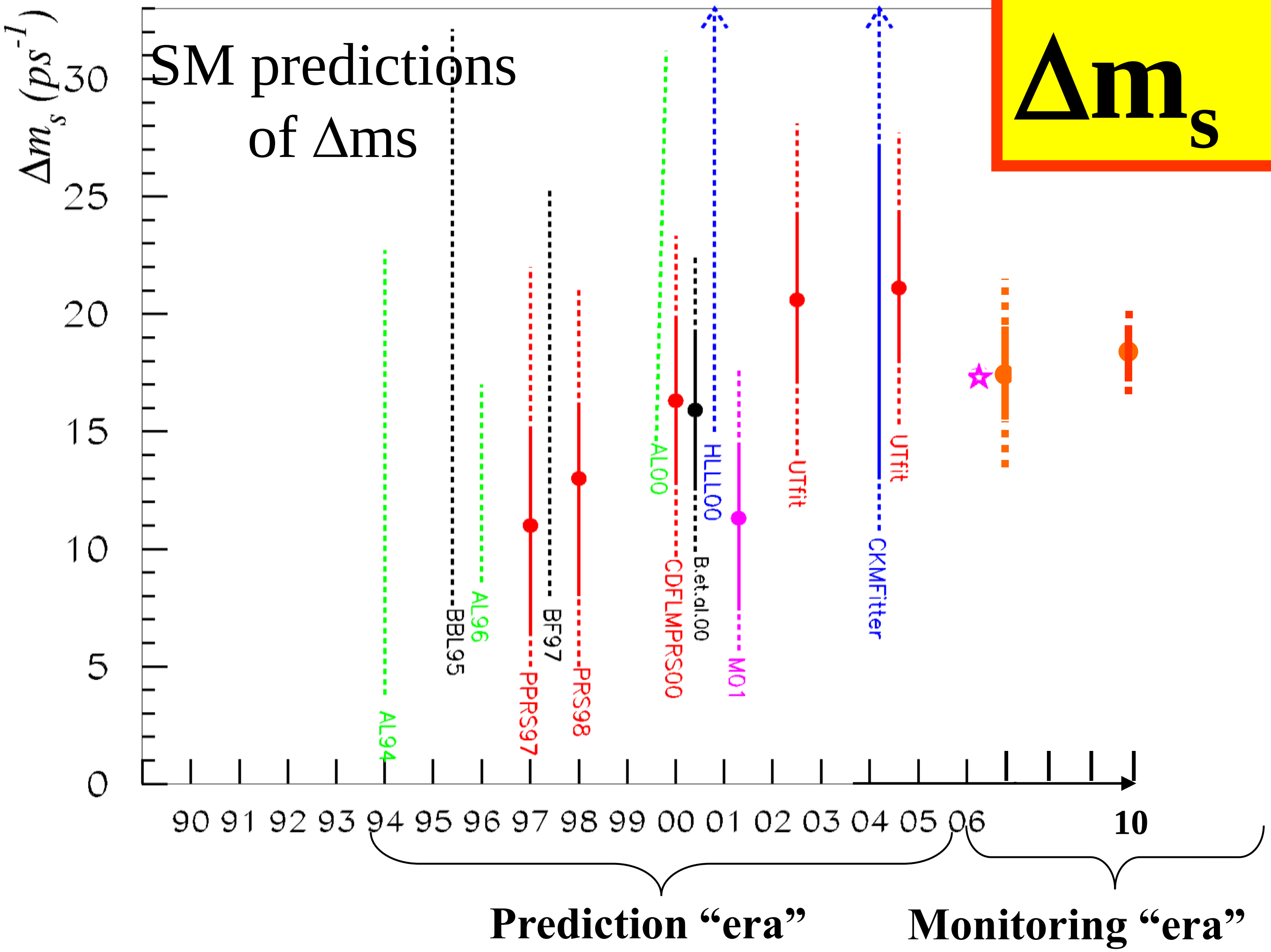
An evidence, an evidence, my kingdom for an evidence

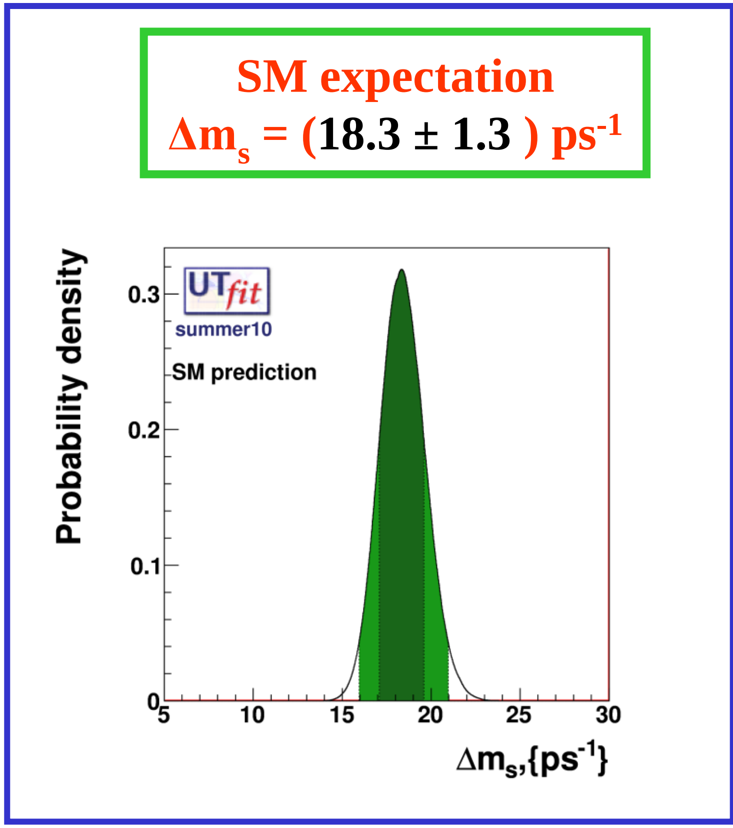
From Shakespeare's *Richard III*

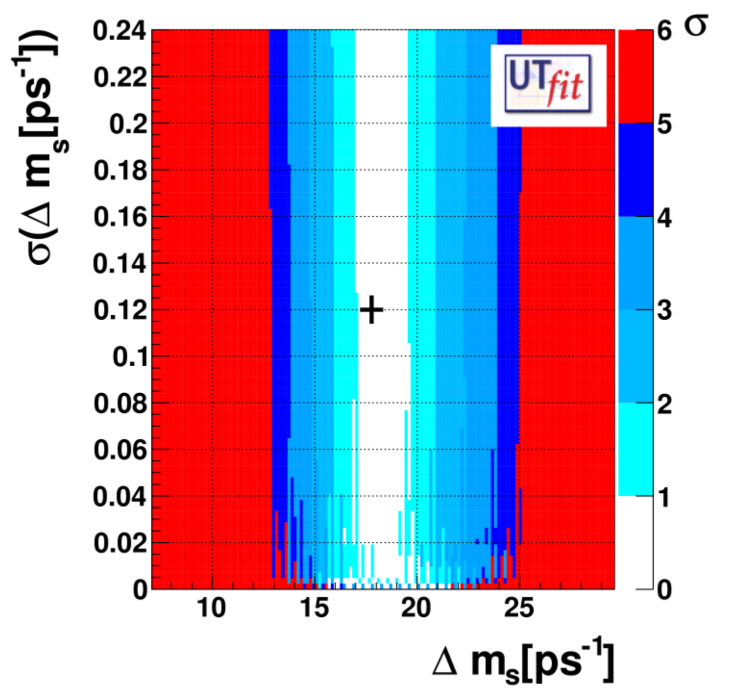
In this talk we address the question
by examine :

1) **Possible tensions in the present SM Fit ?**
2) **Fit of NP-$\Delta F=2$ parameters in a Model "independent" way**
3) **"Scale" analysis in $\Delta F=2$**

Δm_s







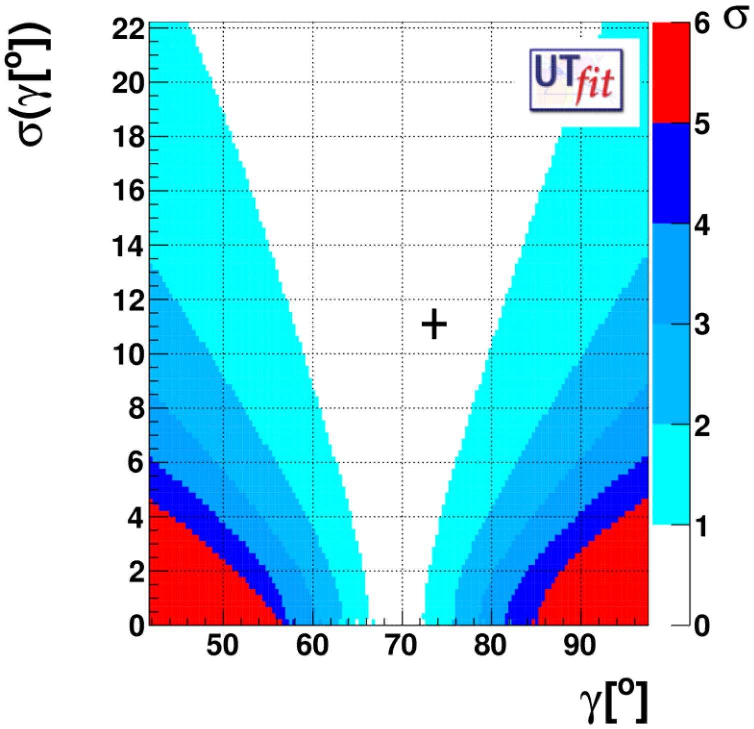
Legenda

agreement between the predicted values and the measurements at better than :

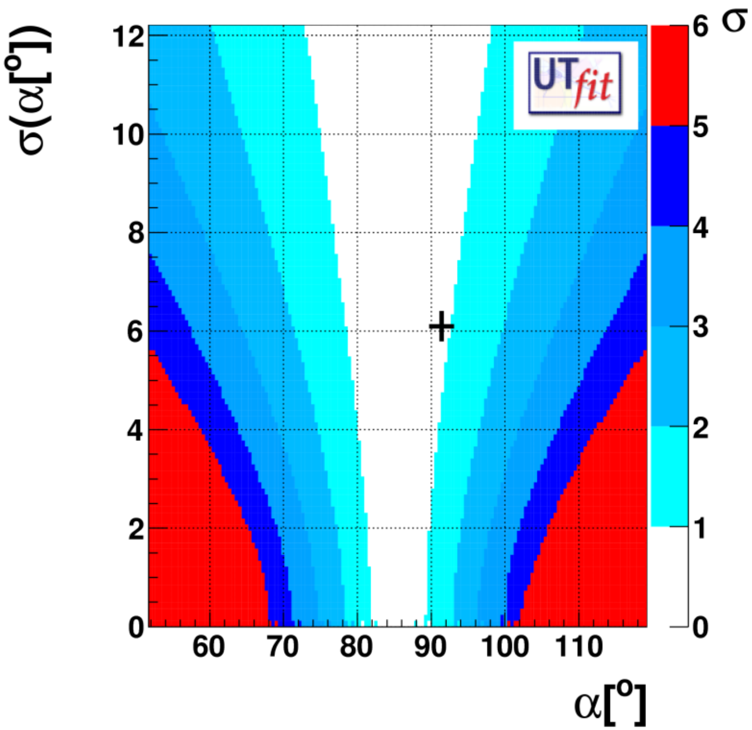
1σ 3σ 5σ

2σ 4σ 6σ

γ

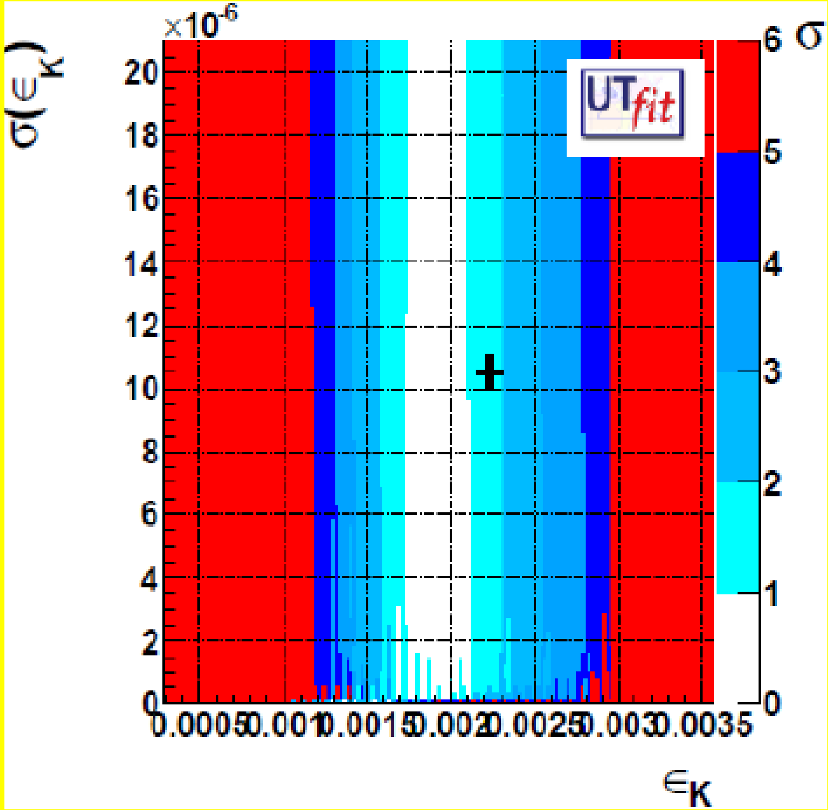


α



γ, α, Δm_s deviations within 1σ

ε_K



Three "news" ingredients

1) Buras&Guadagnoli BG&Isidori corrections

$$\varepsilon_K = \sin\phi_\varepsilon e^{i\phi_\varepsilon}\left[\frac{\operatorname{Im} M_{12}^{(6)}}{\Delta m_K} + \beta_\xi\right]$$

→ Decrease the SM prediction by 6%

2) Improved value for BK

→ BK=0.731 0.07±0.35

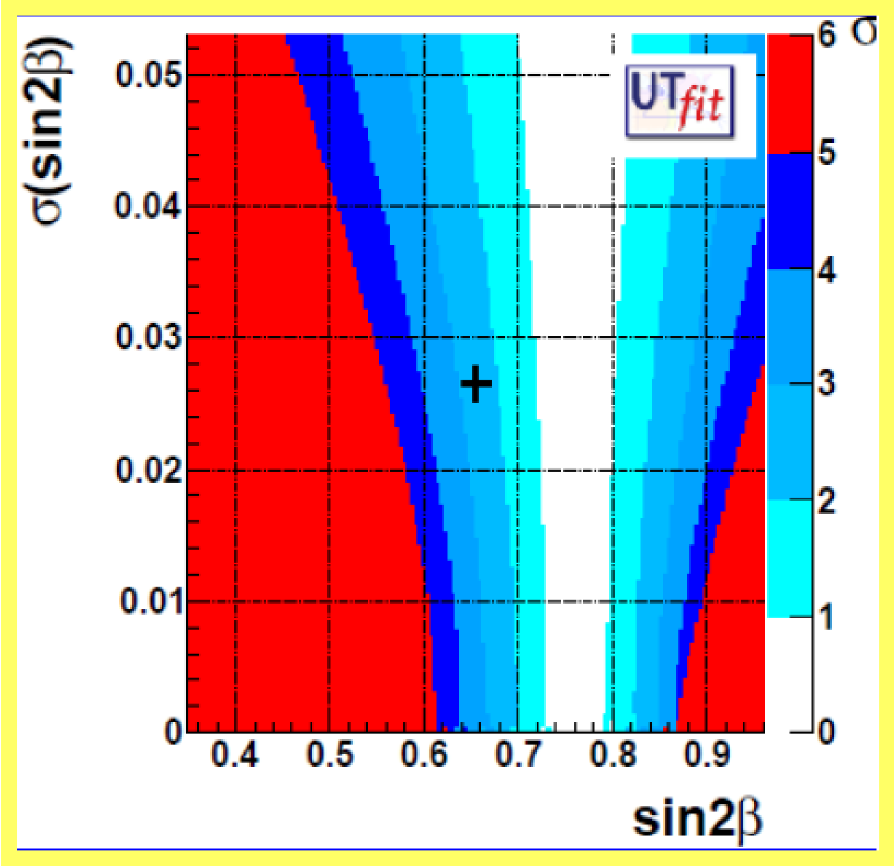
3) Brod&Gorbhan charm-top contribution at NNLO

→ enanchement of 3%

(not included yet in this analysis)

-1.7σ devation

$\sin 2\beta$



$\sin 2\beta = 0.654 \pm 0.026$
From direct measurement

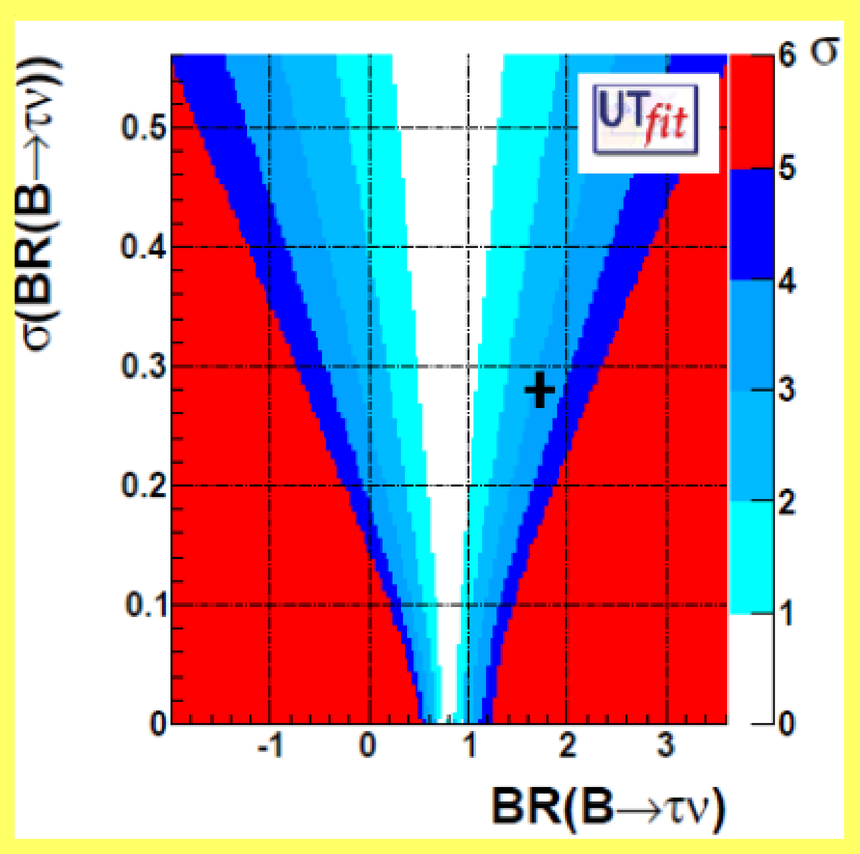
$\sin 2\beta = 0.771 \pm 0.036$
from indirect determination

+2.6σ deviation

You have to consider the theoretical error on the $\sin 2\beta$

		agreement
0.021	(CPS)(2005-updated)	2.2σ
- 0.047	(FFJM)(2008)	1.6 σ

Br(B→τν)



Br(B→τν) =(1.72± 0.28)10^{-4}
From direct measurement

Br(B→τν) =(0.805± 0.071)10^{-4}
SM prediction

-3.2σ deviation

Nota Bene

→ To accommodate Br(B→τν) we need large value of V_{ub}
→ To accommodate sin2β we need lower value of V_{ub}

Summary Table of the Pulls

	Prediction	Measurement	Pull
γ	(69.6 3.1)	(74 11)	-0.4
α	(85.4 3.7)	(91.4 6.1)	-0.8
$\sin 2\beta$	0.771 0.036	0.654 0.026	+2.6 → +2.2
V_{ub} $[10^3]$	3.55 0.14	3.76 0.20 *	-0.9
V_{cb} $[10^3]$	42.69 0.99	40.83 0.45 *	+1.6
ε_K $[10^3]$	1.92 0.18	2.23 0.010	-1.7
$Br(B \rightarrow \tau\ \nu)$	0.805 0071	1.72 0.28	-3.2
Δm_s (ps^{-1})	17.77 0.12	18.3 1.3	-0.4

*** Both in V_{cb} and V_{ub} there is some tensions between Inclusive and Exclusive determinations. The measurements shown is the average of the two determinations**

NP model independent Fit $\Delta F=2$

Parametrizing NP physics in ΔF=2 processes

$$C_q e^{2i\varphi_d} = \frac{A^{NP}_{\Delta B=2} + A^{SM}_{\Delta B=2}}{A^{SM}_{\Delta B=2}}$$

Soares, Wolfenstein PRD47;
Deshpande,Dutta, Oh PRL77;
Silva, Wolfenstein PRD55;
Cohen et al. PRL78;
Grossman, Nir, Worah PLB407;
Ciuchini et al. @ CKM Durham

$$\Delta m_d^{EXP} = C_{B_d} \Delta m_d^{SM} \qquad f(\rho,\eta,C_{B_d},QCD..)$$

$$A_{CP}(J/\Psi,K^0) = \sin(2\beta + 2\phi_{B_d}) \qquad f(\rho,\eta,\phi_{B_d})$$

$$\alpha^{EXP} = \alpha^{SM} - \phi_{B_d} \qquad f(\rho,\eta,\phi_{B_d})$$

$$|\varepsilon_K|^{EXP} = C_\varepsilon |\varepsilon_K|^{SM} \qquad f(\rho,\eta,C_\varepsilon,QCD..)$$

$$\Delta m_s^{EXP} = C_{B_s} \Delta m_s^{SM} \qquad f(\rho,\eta,C_{Bs},QCD..)$$

$$A_{CP}(J/\Psi,\phi) = \sin(2\beta_s - 2\phi_{B_s}) \qquad f(\rho,\eta,\phi_{B_s})$$

...

Group		ρ , η	C_d	φ_d	C_s	φ_s	$C_{\varepsilon K}$
Tree processes	γ (DK)	X					
	V_{ub}/V_{cb}	X					
1↔3 family	Δm_d	X	X				
	ACP (J/Ψ K)	X		X			
	ACP (Dπ(ρ),DKπ)	X		X			
	A_{SL}		X	X			
	α (ρρ,ρπ,ππ)	X		X			
	A_{CH}		X	X	X	X	
2↔3 family	τ(Bs), $\Delta\Gamma_s/\Gamma_s$				X	X	
	Δm_s				X		
	ASL(Bs)				X	X	
	ACP (J/Ψ φ)	~X				X	
1↔2 familiy	ε_K	X					X

5 new free parameters

C_s, φ_s	B_s mixing
C_d, φ_d	B_d mixing
$C_{\varepsilon K}$	K mixing

Today :
fit is <u>overcontrained</u>
Possible to fit <u>7 free parameters</u>
(ρ, η, C_d,φ_d ,C_s,φ_s, $C_{\varepsilon K}$)

SM analysis → **NP-ΔF=2 analysis**

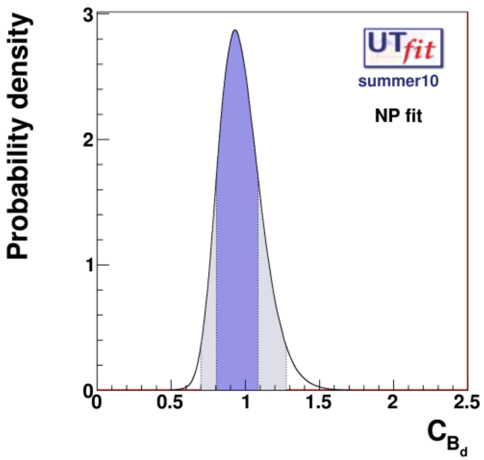
$\rho = 0.132 \pm 0.020$ → $\rho = 0.135 \pm 0.040$

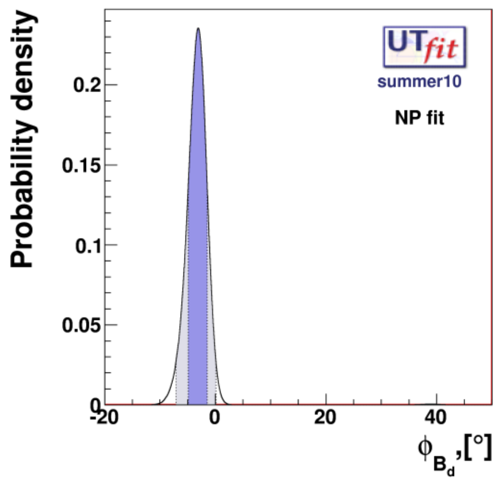
$\eta = 0.358 \pm 0.012$ → $\eta = 0.374 \pm 0.026$

ρ,η fit quite precisely in NP-ΔF=2 analysis and consistent with the one obtained on the SM analysis [error double]

(main contributors tree-level γ and V_{ub})

Please consider these numbers when you want to get CKM parameters in presence of NP in ΔF=2 amplitudes (all sectors 1-2,1-3,2-3)



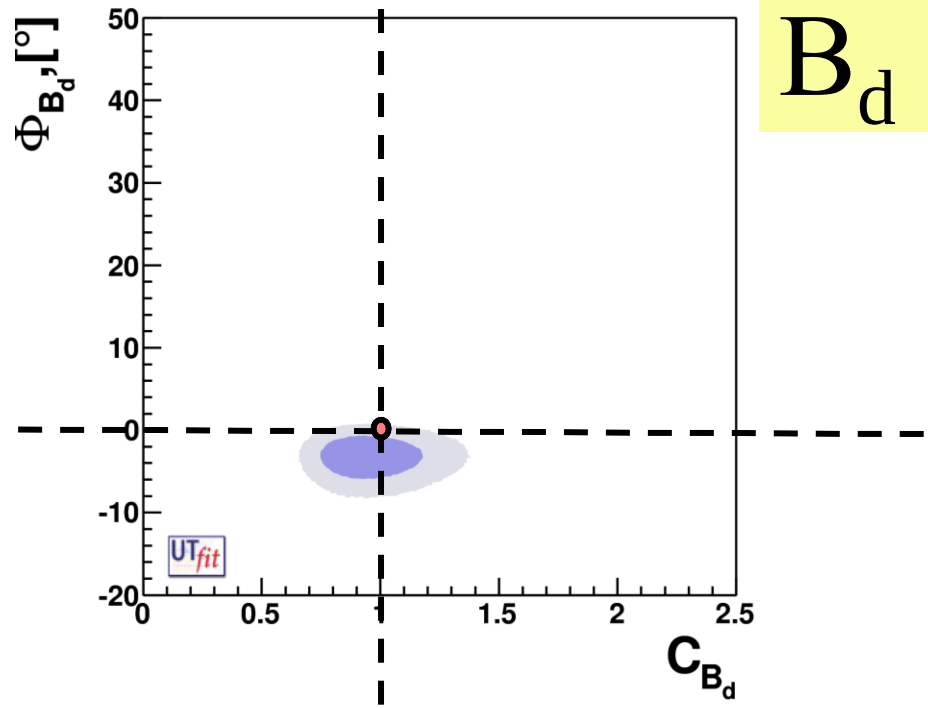


C_{Bd} = 0.95   0.14
[0.70,1.27]@95%

ϕ_{Bd} = -(3.1 ± 1.7)°
[-7.0,0.1]° @95%

1.8σ deviation

B_d

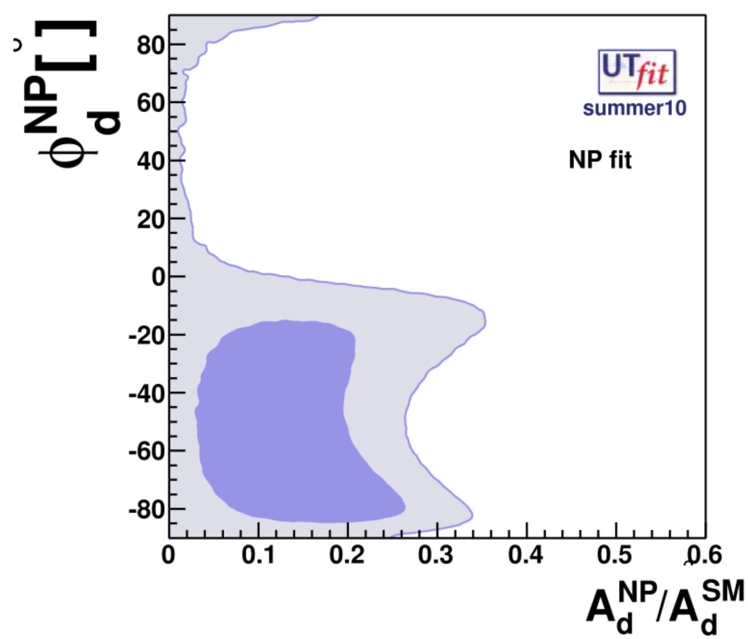


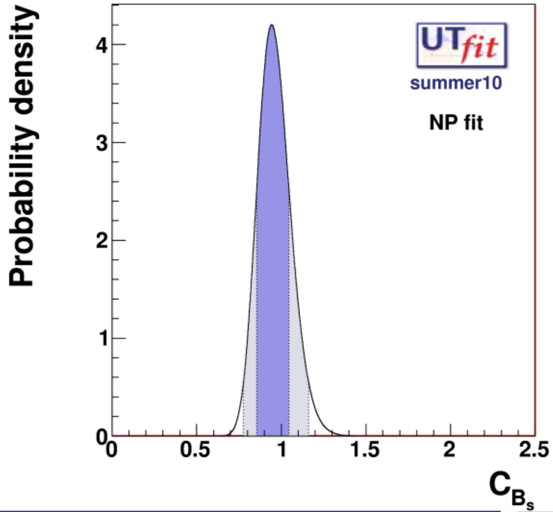
1.8σ agreement takes into account the theoretical error on sin2β

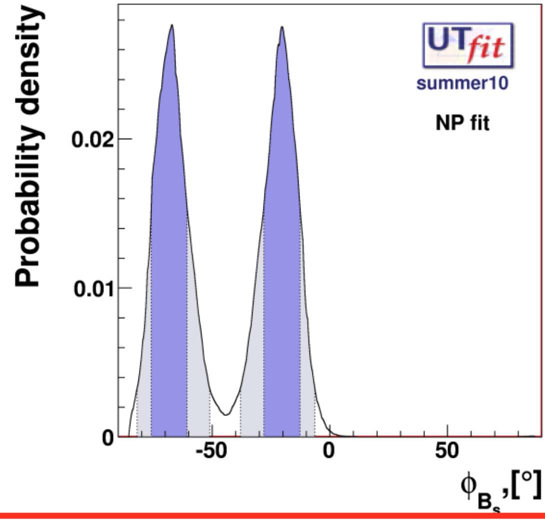
$$C_{B_d} e^{2i\phi_{B_d}} = \frac{A_{SM} e^{2i\beta} + A_{NP} e^{2i(\beta+\phi_{NP})}}{A_{SM} e^{2i\beta}}$$

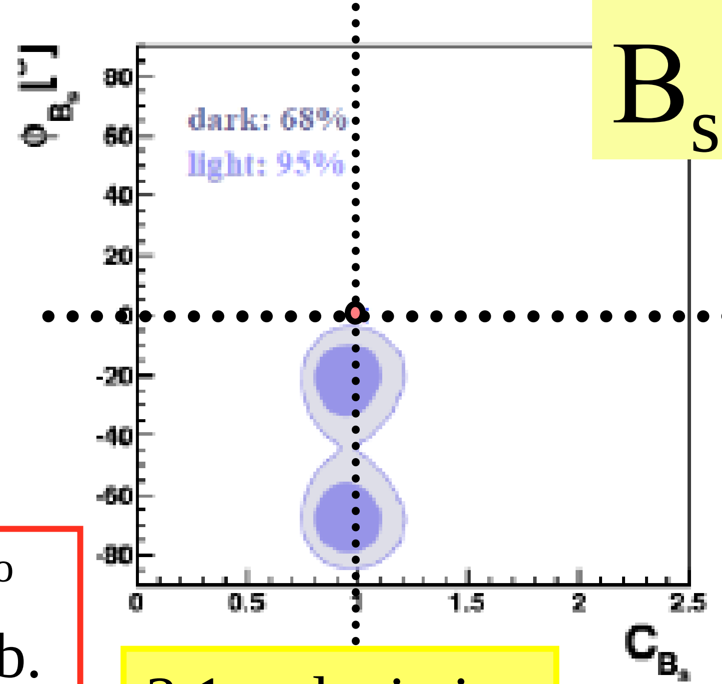
With present data A_{NP}/A_{SM}=0 @ 1.5σ

A_{NP}/A_{SM} ~0-30% @95% prob.









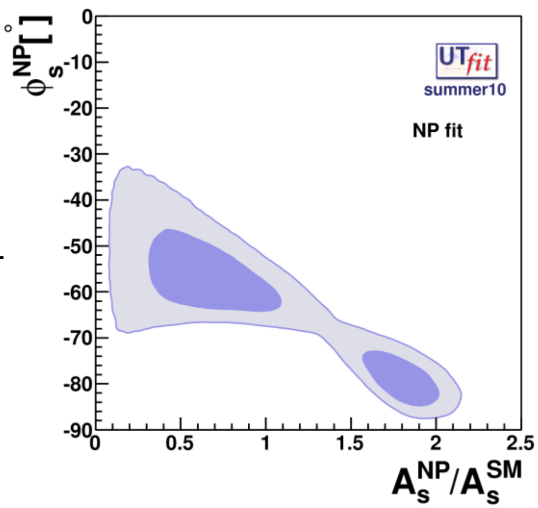
B_s

C_{Bs} = 0.95   0.10
[0.78,1.16]@95%

ϕ_{Bs} = (-20 ± 8)^o U (-68 ± 8) ^{o}
[-38,-6] U [-81,-51] 95% prob.

3.1σ deviation

$$C_{Bs} e^{2i\varphi_{Bs}} = \frac{A_{SM} e^{-2i\beta_s} + A_{NP} e^{-2i(\varphi_s^{NP} - \beta_s)}}{A_{SM} e^{-2i\beta_s}}$$



New results tends to reduce the deviation

**New : CDF new measurement reduces the significance of the disagreement.
Likelihood not available yet for us.**

**New : $a_{\mu\mu}$ from D0 points to large βs, but also large ΔΓs → not standard Γ_{12} ??
(NP in Γ_{12} / bad failure of OPE in Γ_{12}.. Consider that it seems to work on Γ_{11} (lifetime)**

Effective Theory Analysis $\Delta F=2$

Effective Hamiltonian in the mixing amplitudes

$$H_{eff}^{\Delta B=2} = \sum_{i=1}^{5} C_i(\mu) Q_i(\mu) + \sum_{i=1}^{3} \tilde{C}_i(\mu) \tilde{Q}_i(\mu)$$

$$Q_1 = \bar{q}_L^\alpha \gamma_\mu b_L^\alpha \, \bar{q}_L^\beta \gamma^\mu b_L^\beta \qquad \text{(SM/MFV)}$$

$$Q_2 = \bar{q}_R^\alpha b_L^\alpha \, \bar{q}_R^\beta b_L^\beta \qquad Q_3 = \bar{q}_R^\alpha b_L^\beta \, \bar{q}_R^\beta b_L^\alpha$$

$$Q_4 = \bar{q}_R^\alpha b_L^\alpha \, \bar{q}_L^\beta b_R^\beta \qquad Q_5 = \bar{q}_R^\alpha b_L^\beta \, \bar{q}_L^\beta b_R^\alpha$$

$$\tilde{Q}_1 = \bar{q}_R^\alpha \gamma_\mu b_R^\alpha \, \bar{q}_R^\beta \gamma^\mu b_R^\beta$$

$$\tilde{Q}_2 = \bar{q}_L^\alpha b_R^\alpha \, \bar{q}_L^\beta b_R^\beta \qquad \tilde{Q}_3 = \bar{q}_L^\alpha b_R^\beta \, \bar{q}_L^\beta b_R^\alpha$$

$$C_j(\Lambda) = \frac{LF_j}{\Lambda^2} \Rightarrow \Lambda = \sqrt{\frac{LF_j}{C_j(\Lambda)}}$$

$C(\Lambda)$ coefficients are extracted from data

L is loop factor and should be :
L=1 tree/strong int. NP
$L=\alpha_s^2$ or α_W^2 for strong/weak perturb. NP

$F_1=F_{SM}=(V_{tq}V_{tb}^*)^2$
$F_{j=1}=0$

MFV

$|F_j| = F_{SM}$
arbitrary phases

NMFV

$|F_j| = 1$
arbitrary phases

Flavour generic

Main contribution to present lower bound on NP scale come from $\Delta F=2$ chirality-flipping operators (Q_4) which are RG enhanced

Preliminary

From Kaon sector @ 95% [TeV]			
Scenario	Strong/tree	α_s loop	α_W loop
MFV (low tanβ)	8	0.8	0.24
MFV (high tanβ)	4.5	0.45	0.15
NMFV	107	11	3.2
Generic	~470000	~47000	~14000

From Bd&Bs sector @ 95% [TeV]			
Scenario	Strong/tree	α_s loop	α_W loop
MFV(high tanβ)	6.4	0.6	0.2
NMFV	8	0.8	0.25
Generic	3300	330	100

Conclusions

CKM matrix is the dominant source of flavour mixing and CP violation
$\sigma(\rho)\sim 15\%$ $\sigma(\eta)\sim 4\%$

Nevertheless there are tensions here and there that should be continuously and quantitatively monitored : $\sin 2\beta$ $(+2.2\sigma)$, ε_K (-1.7σ) , $Br(B\rightarrow\tau\,\nu)$ $-(3.2\sigma)$

To render these tests more effective we need to
improved the single implied measurements but also the predictions

Model Independent fit show some discrepancy on the NP phase parameters
$\phi_{Bd} = -(3.1 \pm 1.7)^o$ $\phi_{Bs} = (-20 \pm 8)^o \cup (-68 \pm 8)^o$

Effective Theory analysis quantify the known “flavor problem”.