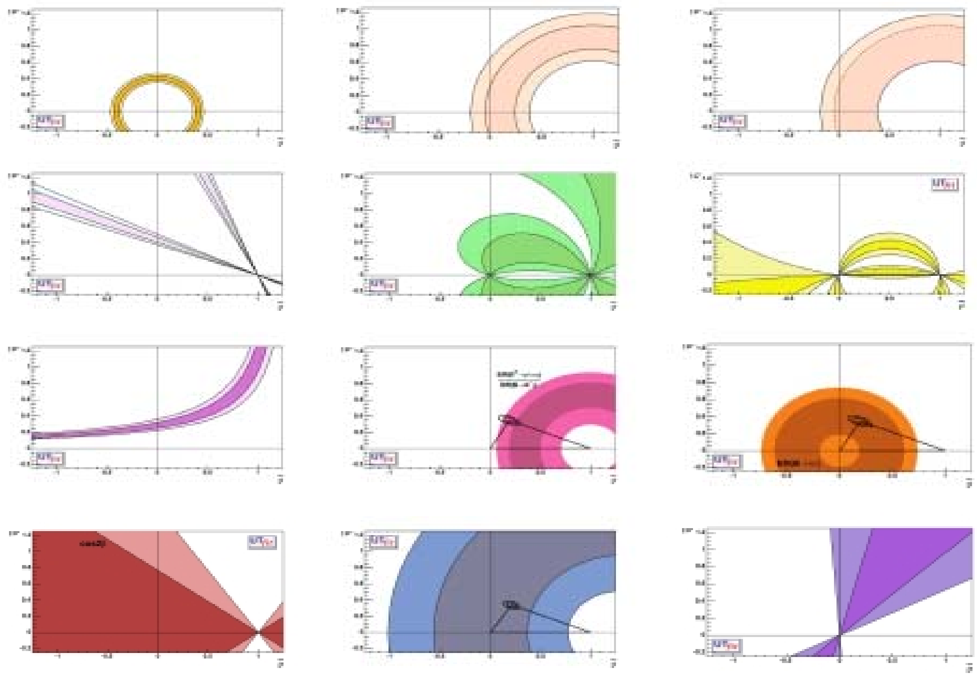
Testing New Physics with the Unitarity Triangle Fit



UTfit Collaboration

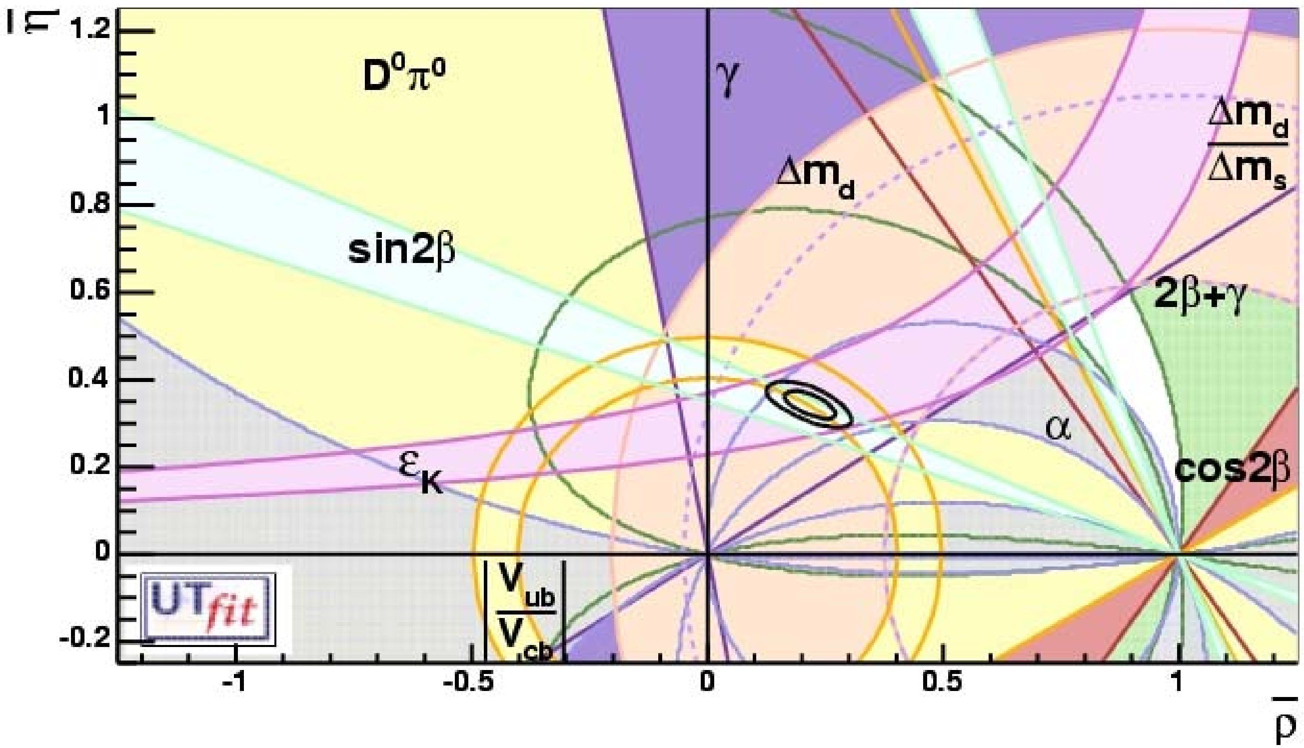
http://www.utfit.org

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

Recent papers:
M. Bona et al. hep-ph/0509219 in publication
M . Bona et al. (hep-ph/0501199) JHEP 0507 (2005) 028

Total Fit

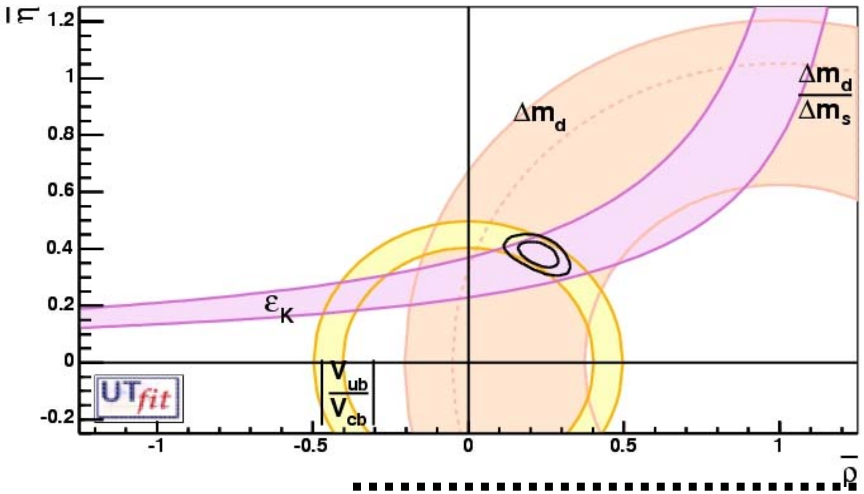
$\Delta m_d, \Delta m_s, V_{ub}, V_{cb}, \varepsilon_k + \cos 2\beta + \beta + \alpha + \gamma + 2\beta+\gamma$



$\bar{\rho} = 0.216 \pm 0.036$
[0.143, 0.288] @ 95% Prob.

$\bar{\eta} = 0.342 \pm 0.022$
[0.300, 0.385] @ 95% Prob.

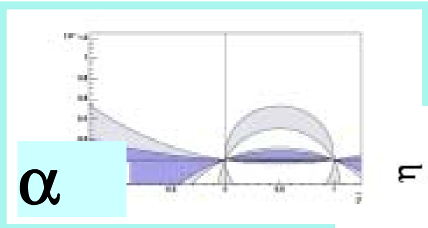
Sides + ε_K

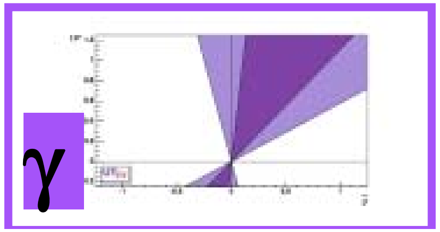


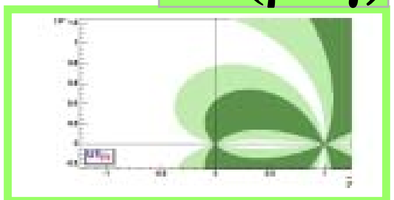
$\rho = 0.224 \pm 0.042$
[0.136, 0.306] @ 95% Prob.

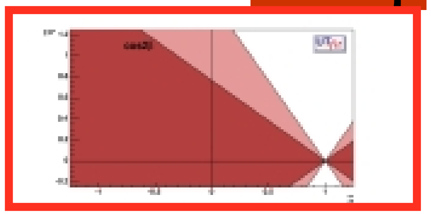
$\eta = 0.381 \pm 0.030$
[0.,320, 0.437] @ 95% Prob.

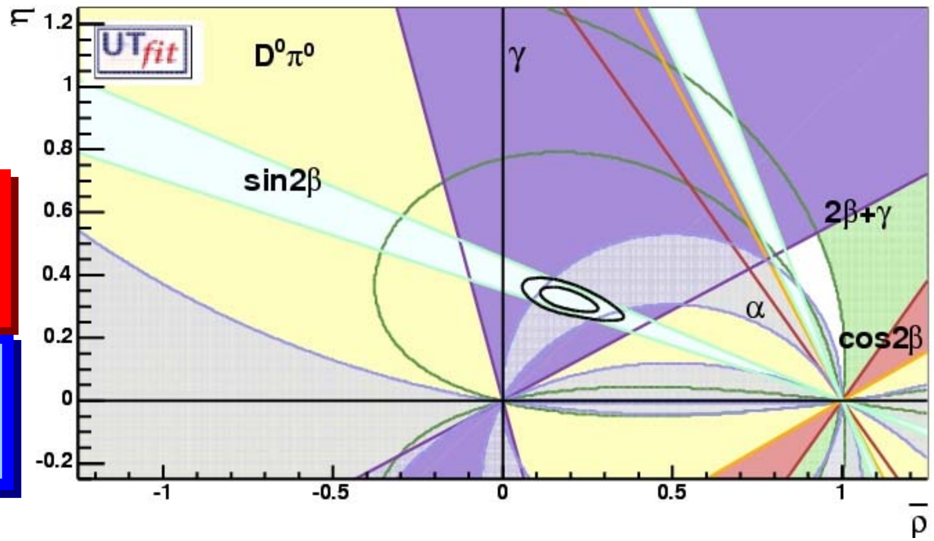
UT with angles only

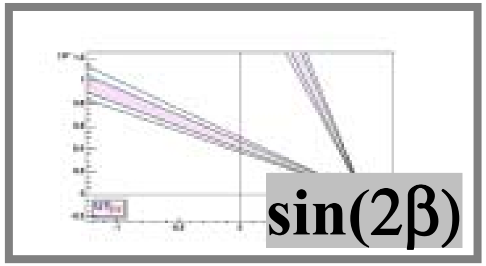


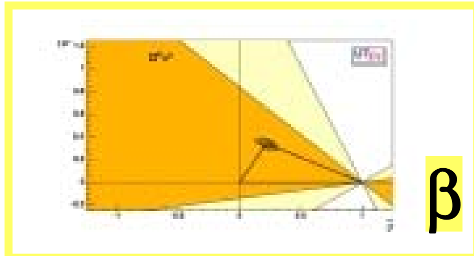








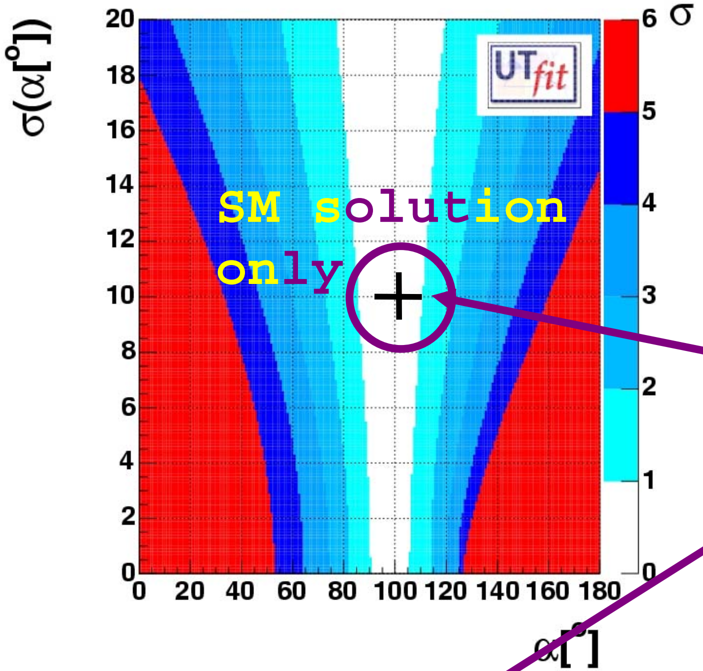




$\rho = 0.193 \pm 0.057$
[0.083, 0.321] @ 95% Prob.

$\eta = 0.321 \pm 0.027$
[0.266, 0.376] @ 95% Prob.

Test of SM (I)

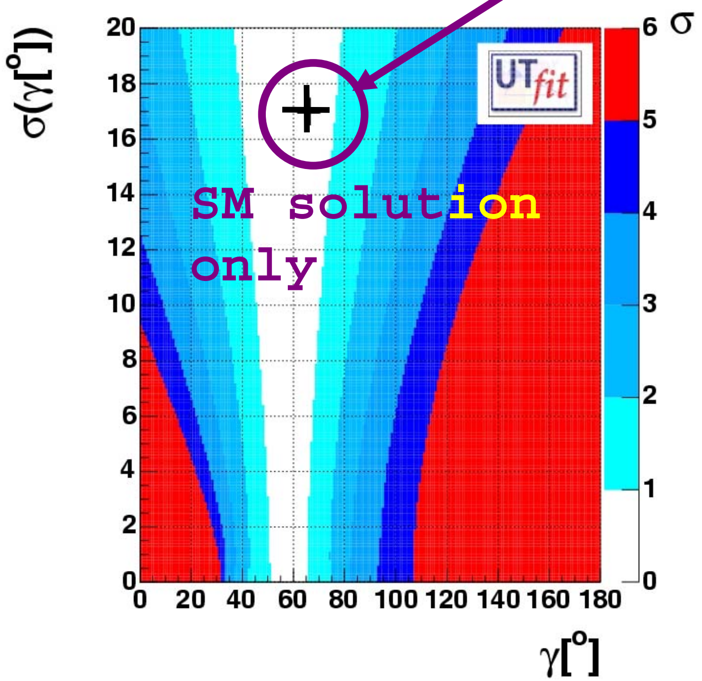


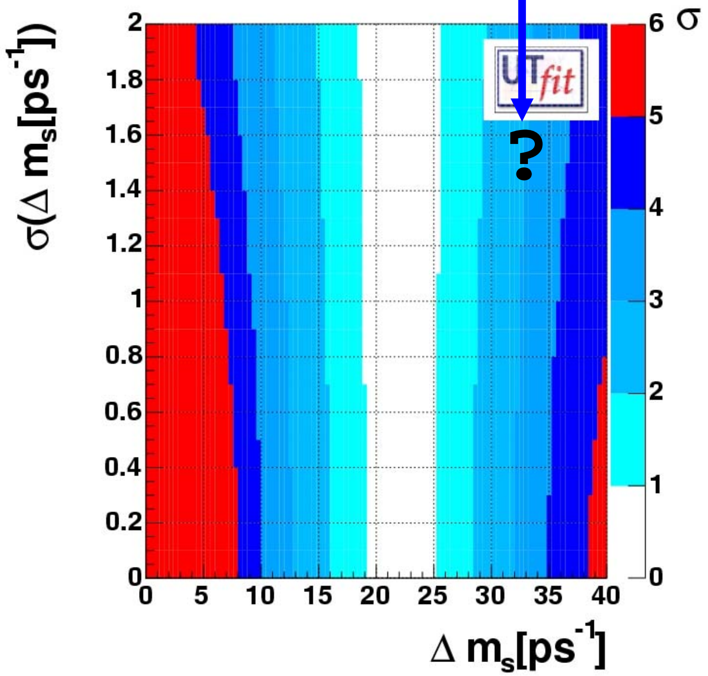
The presence of **New Physics** might appear as a **disagreement between** the new **measurements** and what the **fit predicts** (given by the color code).

α and γ (for the moment) are **OK**.

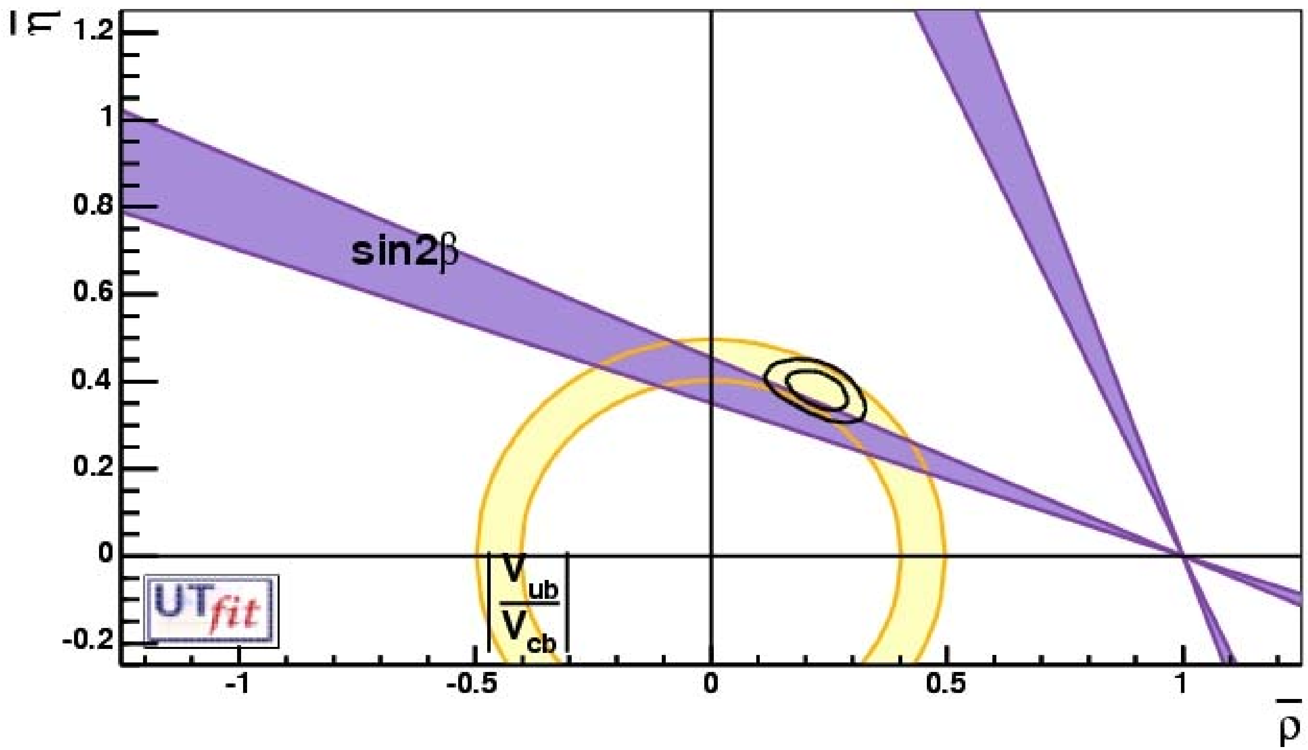
The **next validation** will come from

Δm_s for the b→s sector.





Test of SM (II)



sin2β=0.687±0.032
From direct measurement

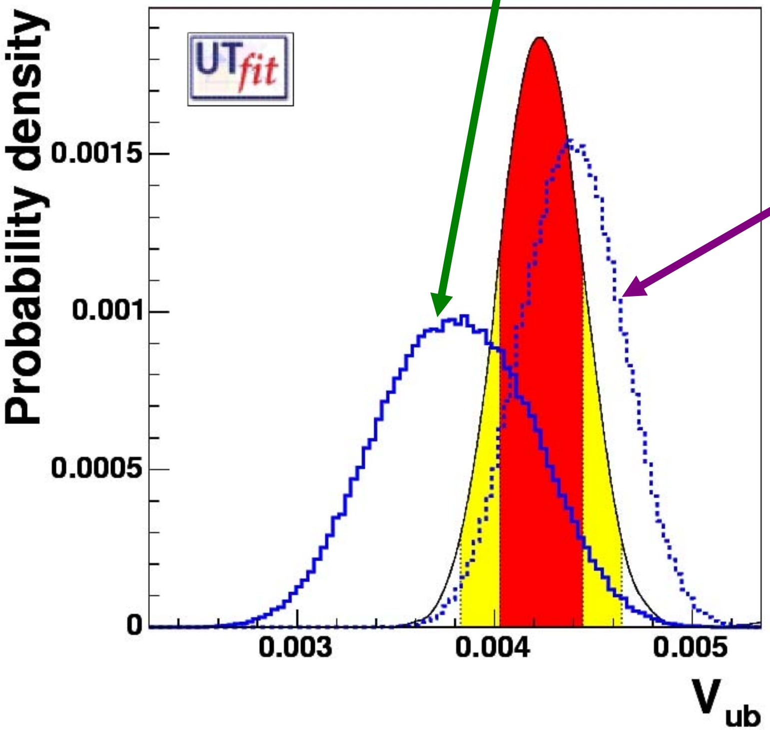
sin2β =0.791±0.034
from indirect determination

we have a weak sign of a disagreement

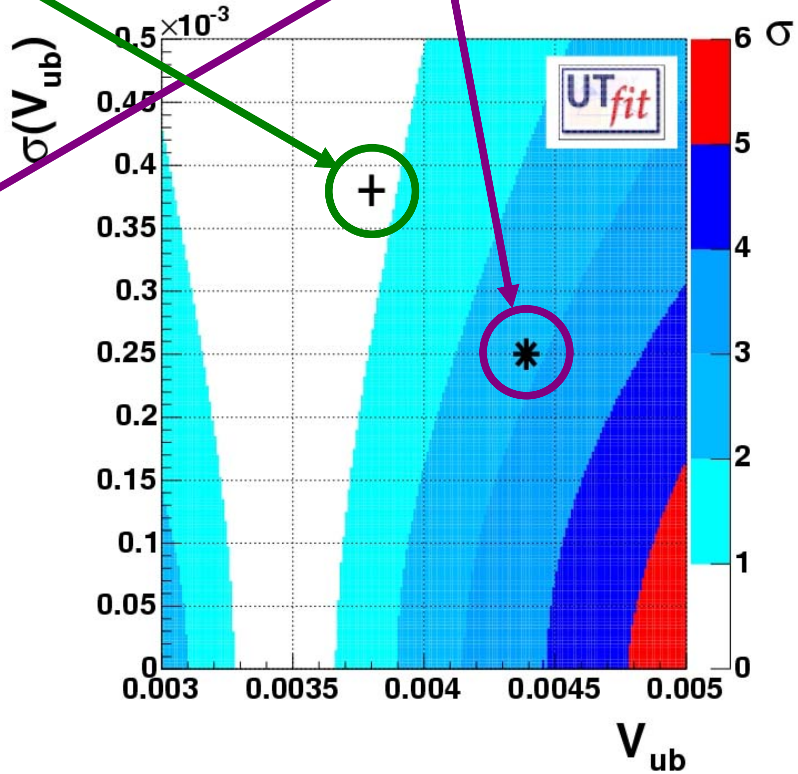
Tension in the fit

exclusive: BRs from HFAG;
form factor from quenched LQCD
$V_{ub}=(3.80\pm0.27\pm0.47)10^{-3}$

inclusive from HFAG
$V_{ub}=(4.38\pm0.19\pm0.27)10^{-3}$



incl.+excl.
$V_{ub} = (4.22 \pm 0.20)\ 10^{-3}$

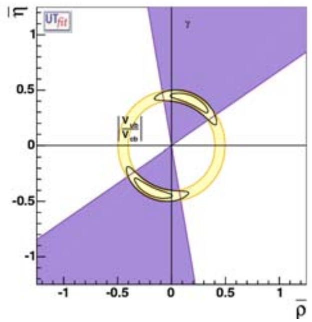


from all the other inputs:
$V_{ub} = (3.48 \pm 0.20)\ 10^{-3}$

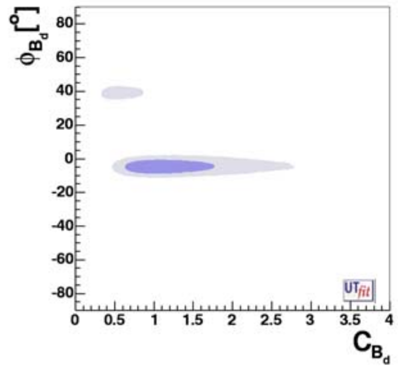
It can be interpreted as a problem with data, but it could be evidence of New Physics

Where do we really are on our knowledge of UT ?

Fit with NP independent variables

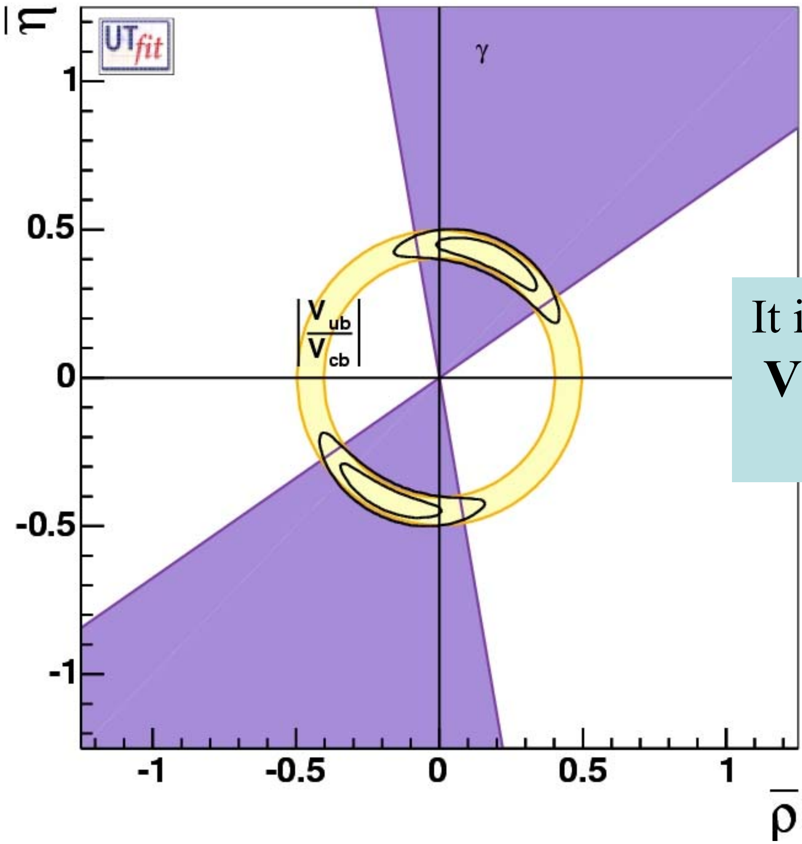


Fit in a NP model independent approach



Fit with NP independent variables

If we use only Tree level processes *-which can be assumed to be NP free-*



It is very important to improve
V_{ub}/V_{cb} from s.l decays
γ from tree level proceses

$\bar{\rho}$	± (0.18± 0.11)
$\bar{\eta}$	± (0.41 ± 0.05)

(similar plot in Botella et al. hep-ph/0502133)

Fit in a NP model independent approach

ΔF=2

Parametrizing NP physics in ΔF=2 processes →

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

$$\Delta m_d^{EXP} = C_q \Delta m_d^{SM}$$

$$A_{CP}(J/\Psi K^0) = \sin(2\beta + 2\phi_d)$$

$$\alpha^{EXP} = \alpha^{SM} - \phi_d$$

$$|\varepsilon_K|^{EXP} = C_\varepsilon |\varepsilon_K|^{SM}$$

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

Constraints

	ρ , η	C_d,φ_d	$C_{\varepsilon K}$	C_s,φ_s
V_{ub}/V_{cb}	X			
Δm_d	X	X		
ε_K	X		X	
ACP (J/Ψ K)	X	X		
α (ρρ,ρπ,ππ)	X	X		
γ (DK)	X			
Δm_s				X
ACP (J/Ψ ϕ)	~X			X
γ (D_sK)	X			X

Not yet available (applies to the last three rows: Δm_s, ACP (J/Ψ ϕ), γ (D_sK))

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 possible with 6 contraints and
5 free parameters (ρ, η, C_d,φ_d ,$C_{\varepsilon K}$)

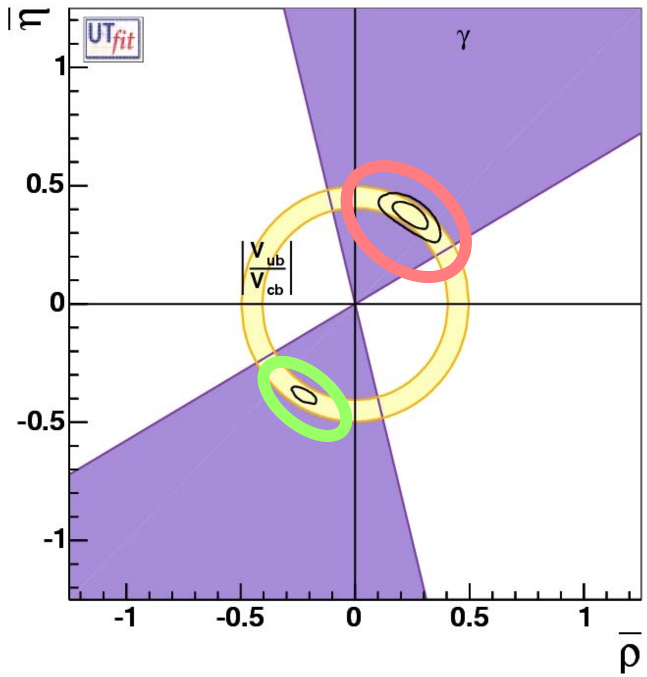
Fit in a NP model independent approach

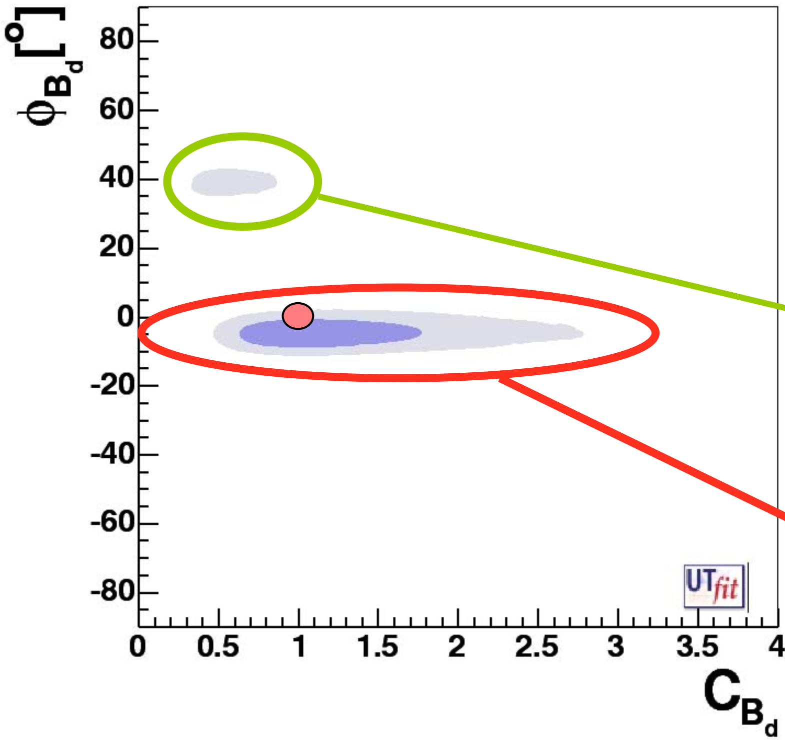
Using

V_{ub}/V_{cb} Δm_d ACP (J/Ψ K)

γ (DK) ε_K

α $\cos 2\beta$ A_{SL}





NP solution 4%

large NP with arbitrary phase

SM-like solution 96%

SM or small NP with arbitrary phase or large NP with SM phase.

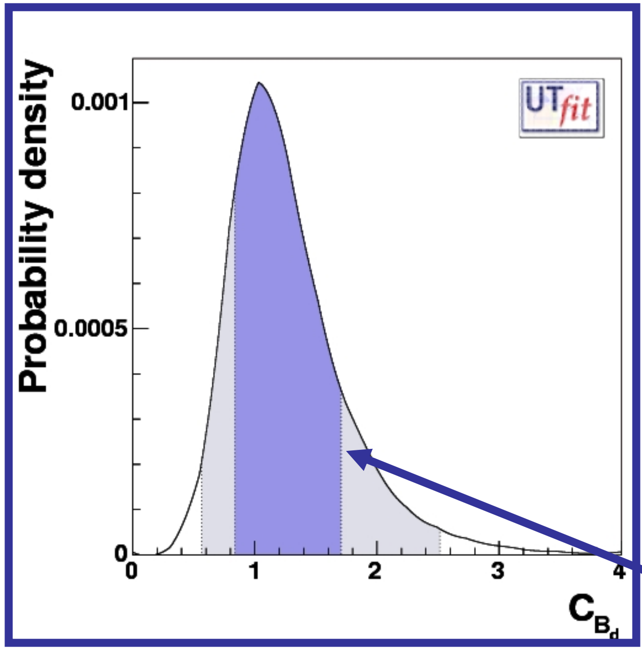
$$A_{\rm SL} \equiv \frac{\Gamma(\bar{B}^0 \to \ell^+ X) - \Gamma(B^0 \to \ell^- X)}{\Gamma(\bar{B}^0 \to \ell^+ X) + \Gamma(B^0 \to \ell^- X)}$$

$$A_{SL} = -\mathrm{Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{SM} \frac{\sin 2\phi_d}{C_d} + \mathrm{Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{SM} \frac{\cos 2\phi_d}{C_d}$$

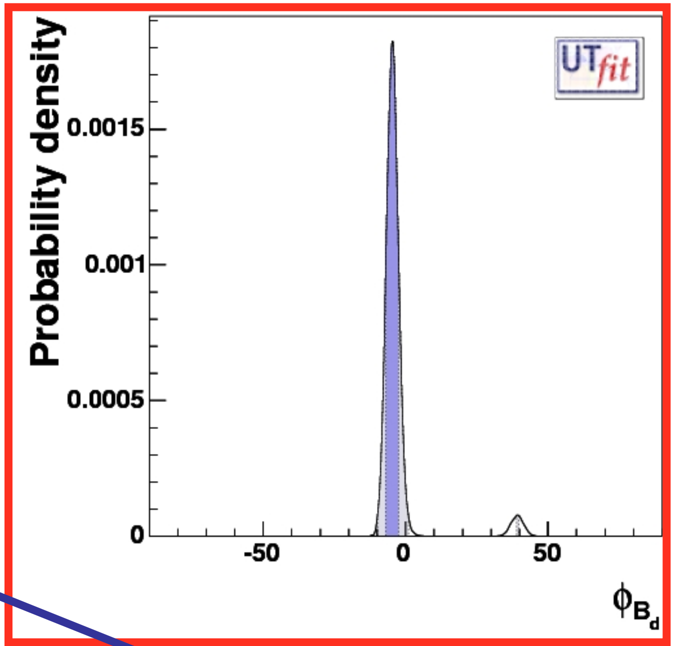
Laplace et al., PRD65 NLO effects included

Fit in a NP model independent approach

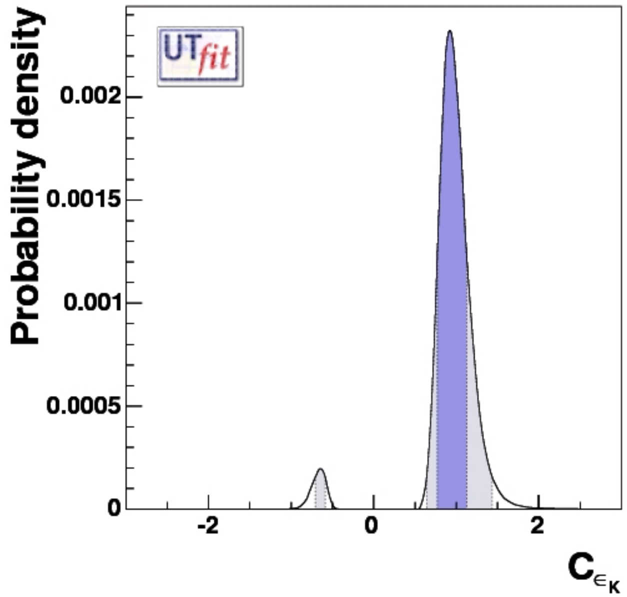
$C_{Bd} = 1.27 \pm 0.44$



$\phi_{Bd} = -(4.7 \pm 2.3)^o$



$C_\varepsilon = 0.95 \pm 0.18$



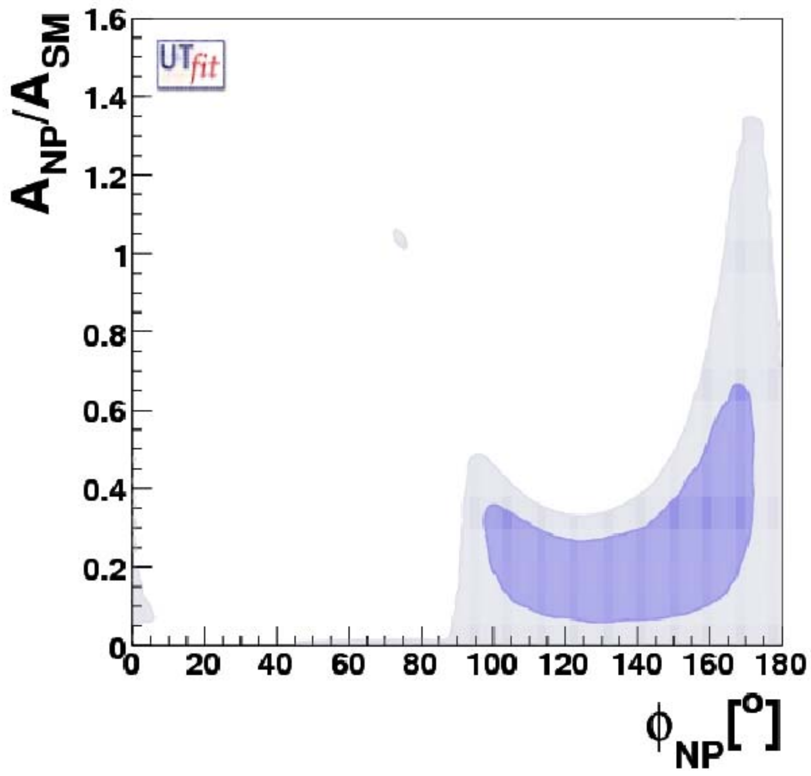
NP in $\Delta B=2$ and $\Delta S=2$ could be up to 50% wrt SM only if has the same phase of the SM

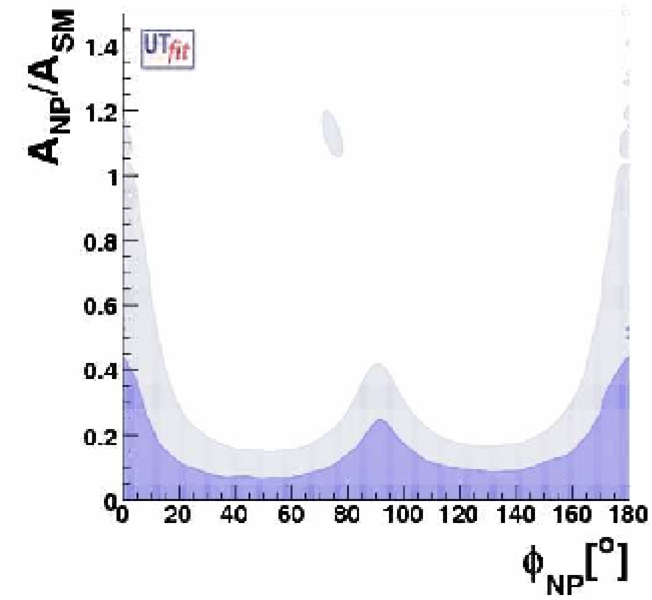
A_{NP}/A_{SM} vs ϕ_{NP}

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

With present data $A_{NP}/A_{SM} \neq 0$ @1σ

A_{NP}/A_{SM} ~1 only if ϕ_{NP}~0
A_{NP}/A_{SM} ~0-40% @95% prob.





sensitive to small effects

Artificially removing the present disagreement
~20% @ 95% prob for generic ϕ_{NP}

TWO POSSIBLE SCENARIOS

MFV	New CP in $b \to s$

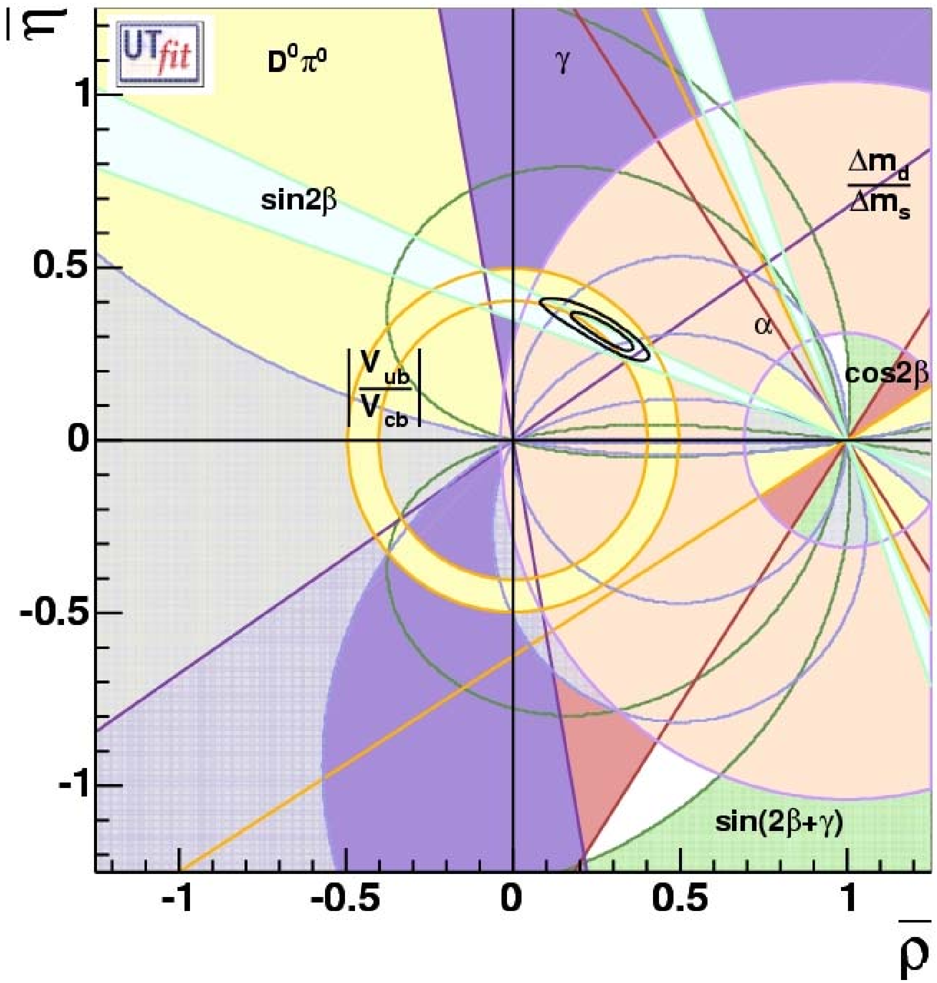
What to do ?

MFV	New CP in $b \to s$
- Improvements existing measurements	***- $\Delta F=1$ Penguins transitions*** *(not discussed in this talk)*
- Rare decays *(not discussed in this talk)*	***- The B_s physics (LHCb/Tevatron)***

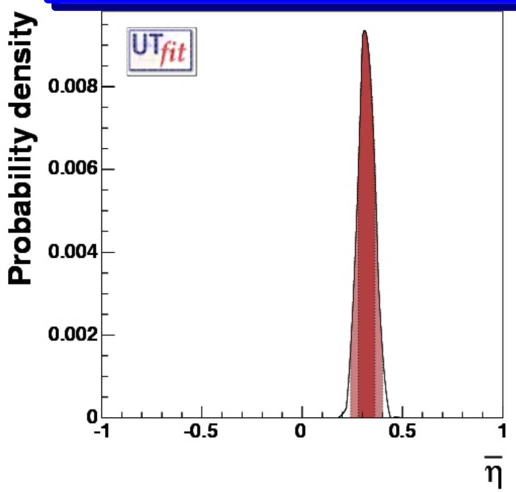
Universal UT_{fit}

Buras et al. hep-ph/0007085

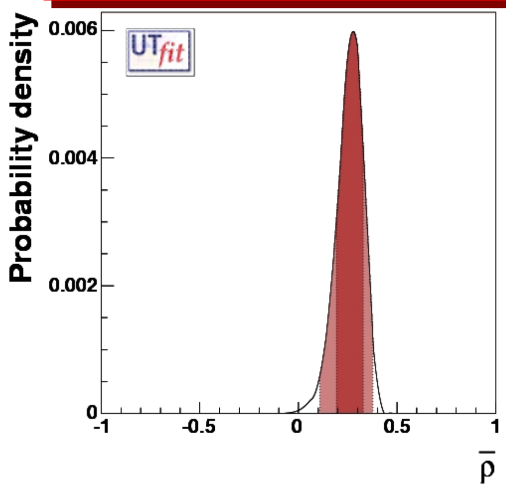
MFV = CKM is the only source of flavour mixing. ε_K and Δm_d are not used (sensitive to NP).



$\bar{\eta} = 0.319 \pm 0.039$ UUT$_{fit}$



$\bar{\rho} = 0.258 \pm 0.066$ UUT$_{fit}$

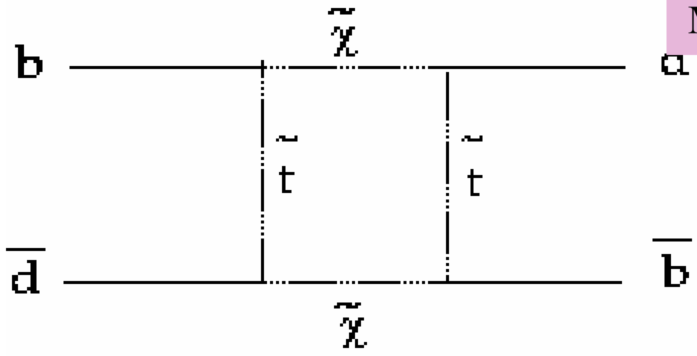


Almost as good as the SM !!

Starting point for studies of rare decays see for instance : Bobeth et al. hep-ph/0505110

MFV

In models with one Higgs doublet or low/moderate tanβ
(D'Ambrosio et al. hep-ph/0207036)
NP enters as additional contribution in top box diagram



$$S_0(x_t) -> S_0(x_t) + \delta S_0(x_t)$$

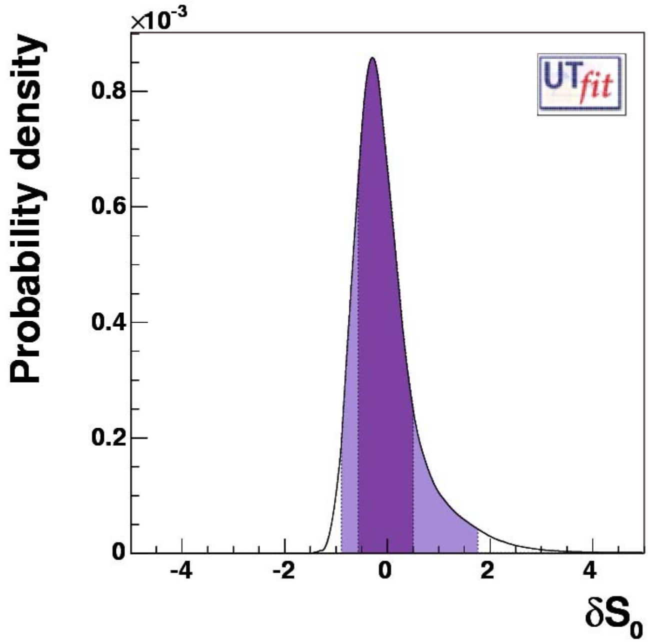
$$\delta S_0(x_t) = 4a\left(\frac{\Lambda_0}{\Lambda}\right)^2 \qquad \Lambda_0 = 2.4 TeV$$

Λ_0 is the equivalent SM scale

$$\Lambda_0 > 5.1 TeV \quad @95\% \qquad for \quad positive \quad \delta S(x_t)$$

$$\Lambda_0 > 3.6 TeV \quad @95\% \qquad for \quad negative \quad \delta S(x_t)$$

$$\Lambda / \Lambda_0 \sim 2$$

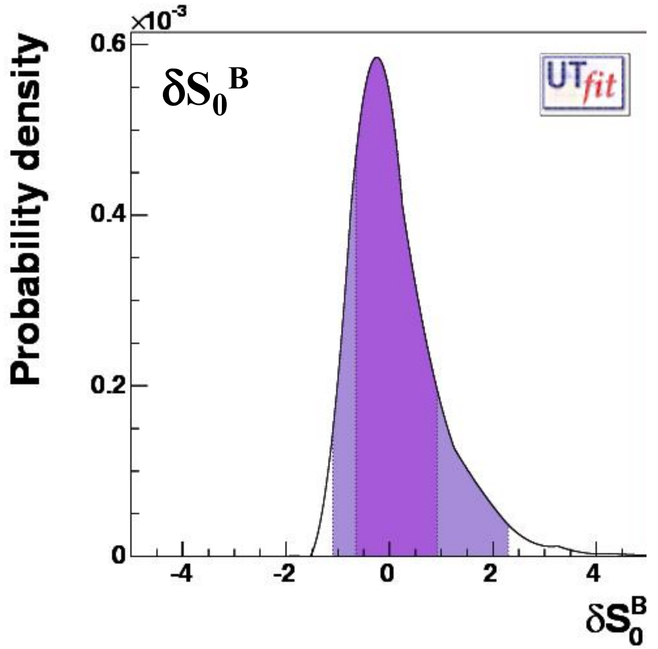


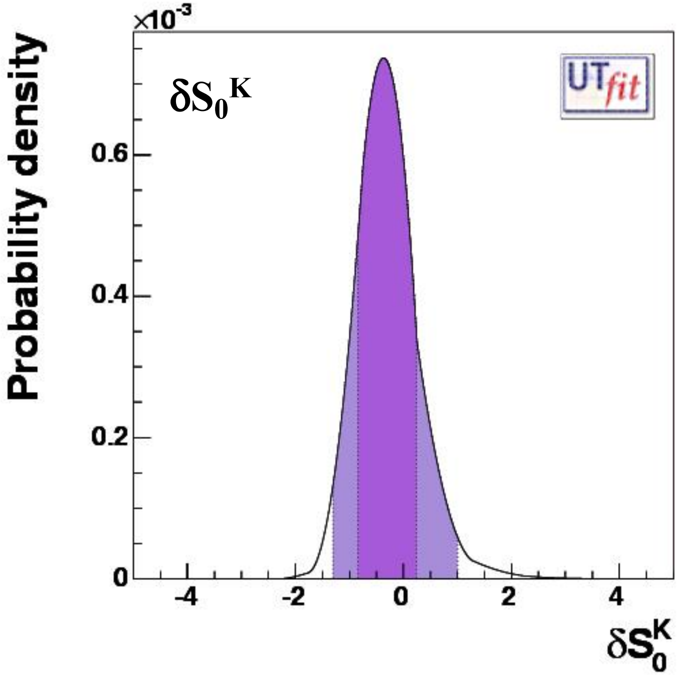
δS_0 = -0.03 ± 0.54
[-0.90, 1.79] @95% Prob.

To be compared with tested scale using for instance b->sγ (9-12Tev)
D'Ambrosio et al. hep-ph/0207036

2Higgs + large tanβ $\rightarrow$ also bottom Yukawa coupling must be considered

$\delta S_0^B \neq \delta S_0^K$





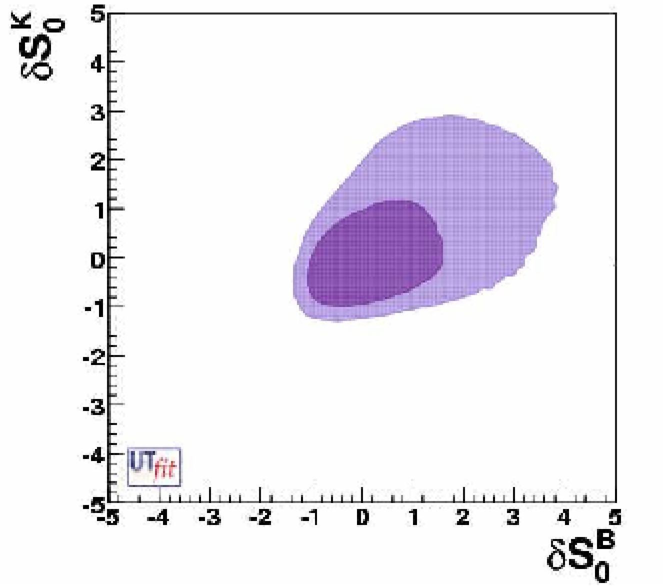
$\Lambda > 2.6$ TeV @ 95% for $\delta S_0(x_t) > 0$

$\Lambda > 4.9$ TeV @ 95% for $\delta S_0(x_t) < 0$

$\Lambda > 3.2$ TeV @ 95% for $\delta S_0(x_t) > 0$

$\Lambda > 4.9$ TeV @ 95% for $\delta S_0(x_t) < 0$

Could give infomation on the tanβ regime …not yet at the present



Correlation coefficient =0.52

CKM Matrix in ≤2010-where we will be

CKM2010

We have supposed that

- **B Factories** will collect $2ab^{-1}$
- two years data taking at **LHCb** ($4fb^{-1}$)

Inputs

$\beta < 1°$ from charmonium

$\alpha \sim 7°$

$\gamma \sim 5°$ *(half B-factories/half LHCb)*

$\sin 2\chi \pm 0.045$

$V_{ub} \sim 5\%$

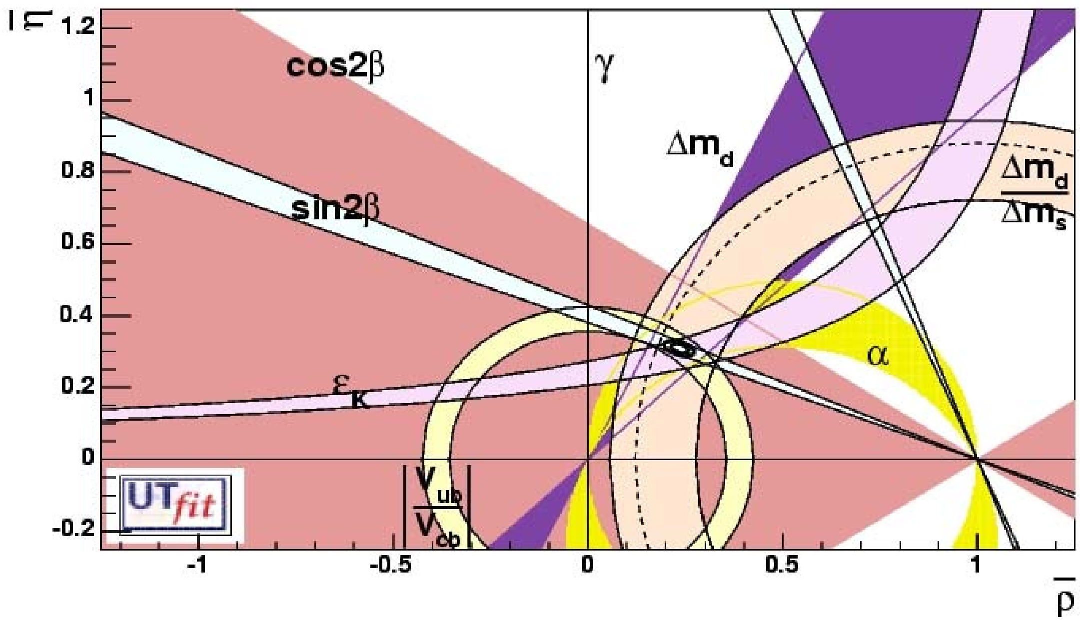
$V_{cb} \sim 1\%$

Δm_s at $0.3 ps^{-1}$ *(Tevatron or/and LHCb)*

$f_B\sqrt{B_B} \sim 5\%$

$\xi \sim 3\%$

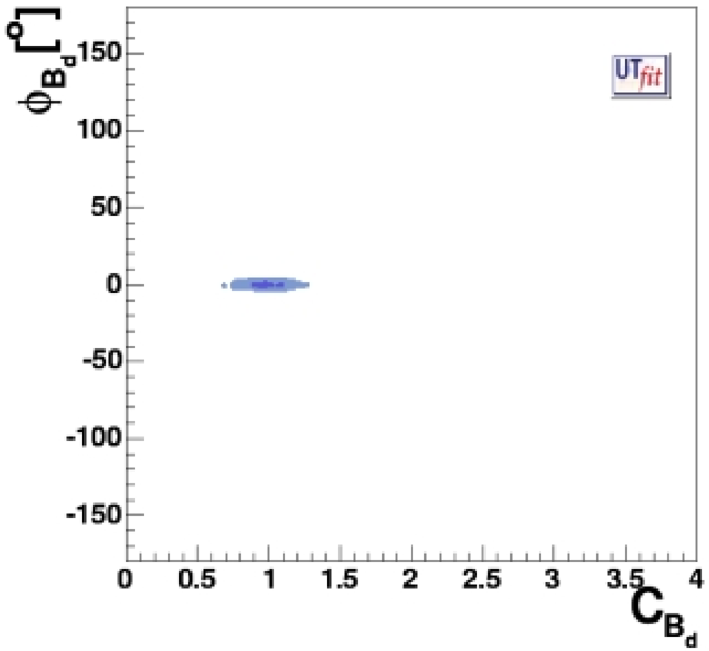
$B_K \sim 5\%$

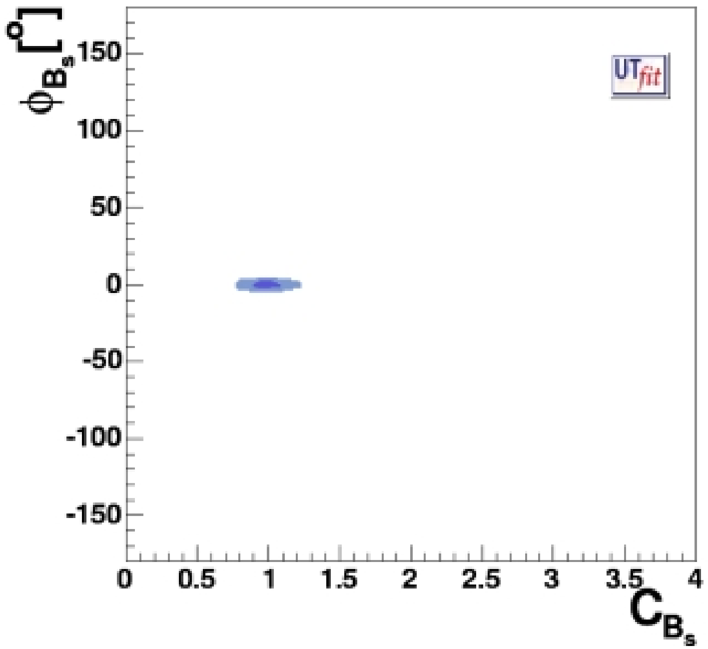


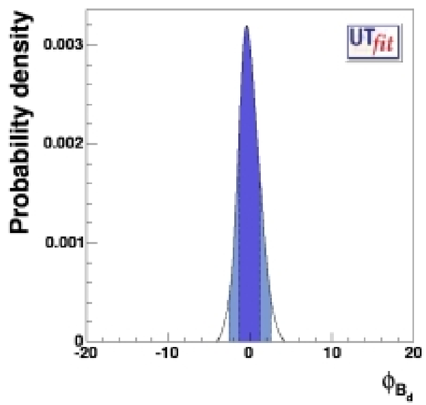
Outputs

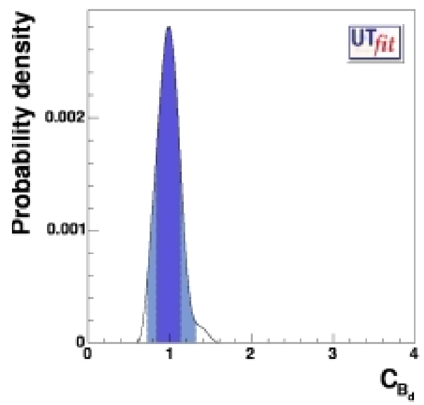
sin(2β)	0.694 ± 0.012
sin(2α)	-0.543 ± 0.093
γ[°]	51.7 ± 3.0
$\bar{\rho}$	0.240 ± 0.017
$\bar{\eta}$	0.307 ± 0.010

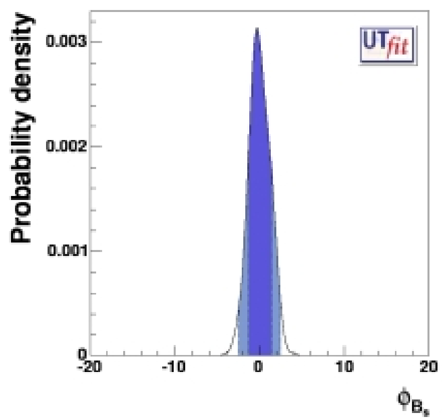
In the « sad » hypotesis the SM still work in 2010….

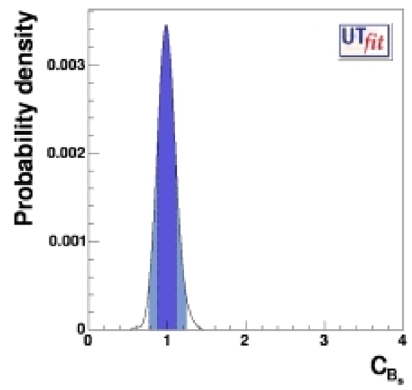












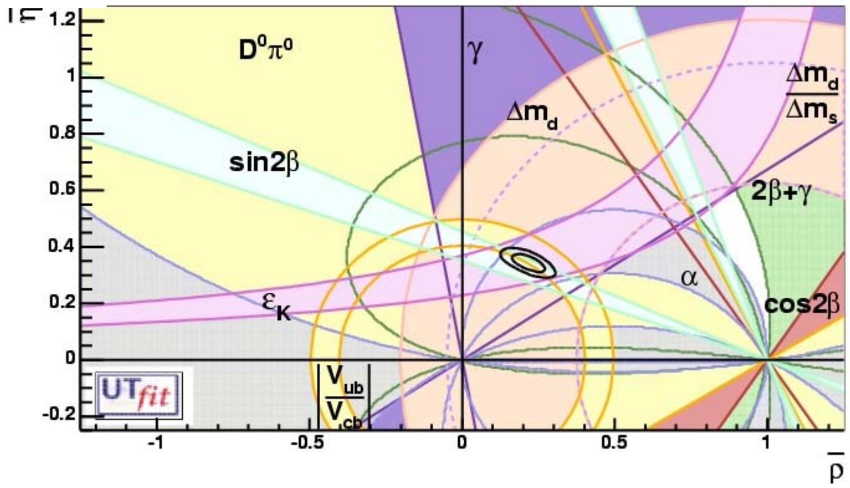
$\varphi_{Bd} = (-0.1 \pm 1.3)^o$ $C_{Bd} = 0.98 \pm 0.14$ $\varphi_{Bs} = (0.0 \pm 1.3)^o$ $C_{Bs} = 0.99 \pm 0.12$

VERY IMPORTANT in $\leq$ 2010 : same and impressive precision on $b \to d$ and $b \to s$ transitions

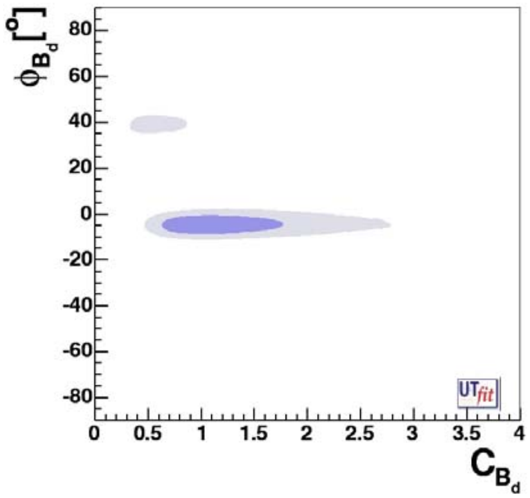
Conclusions

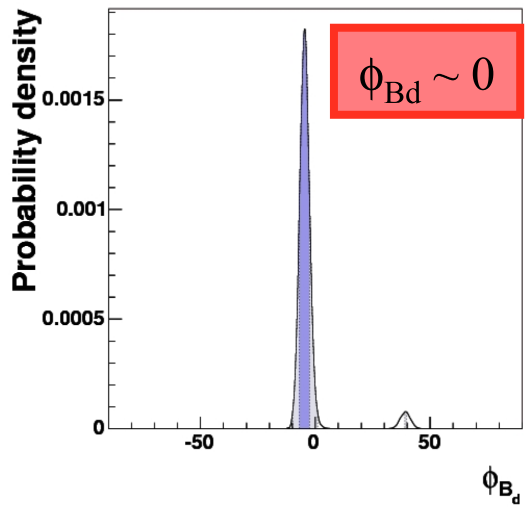
UT*fits* are in a mature age with recent precise measurement of UT sides and angles

The SM CKM picture of CP violation and FCNC is strongly supported by data



Generic NP in the b → d start to be quite constrained

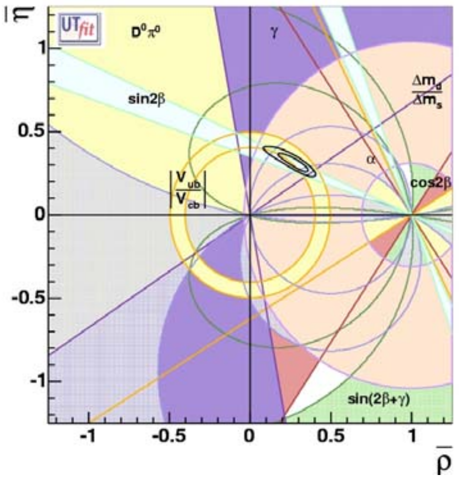


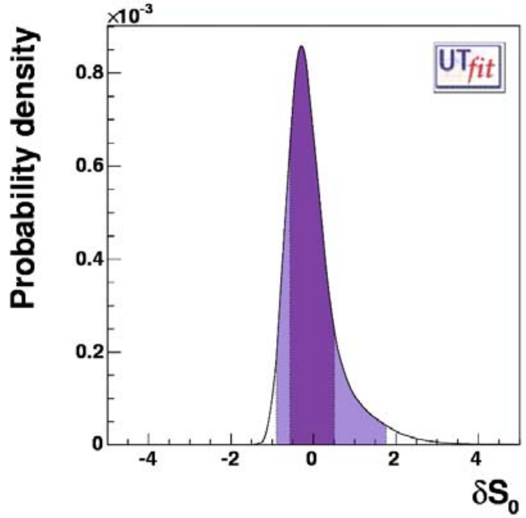


$\phi_{Bd} \sim 0$

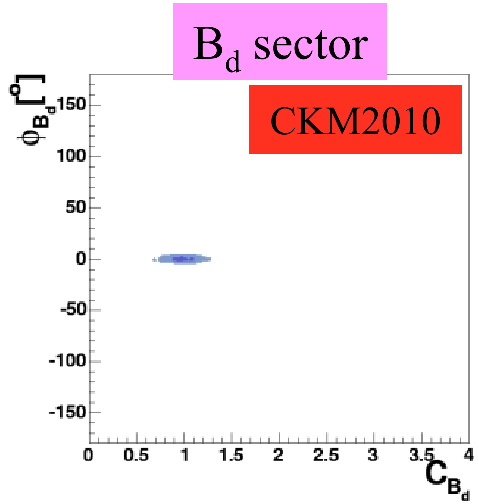
At least in this sector, we are beyond the alternative to CKM picture, and we should look at « corrections ».

Studied predented in MFV.
We start to test interesting NP scales.

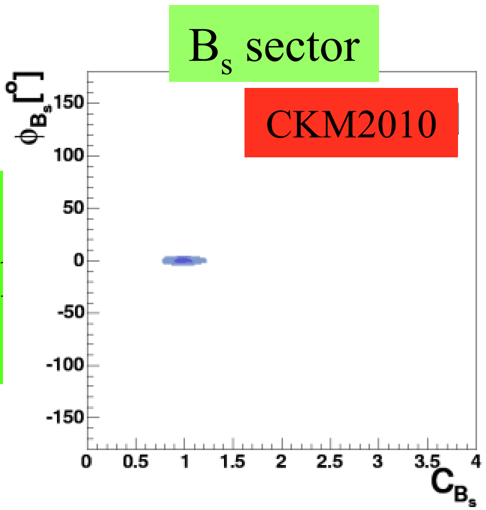




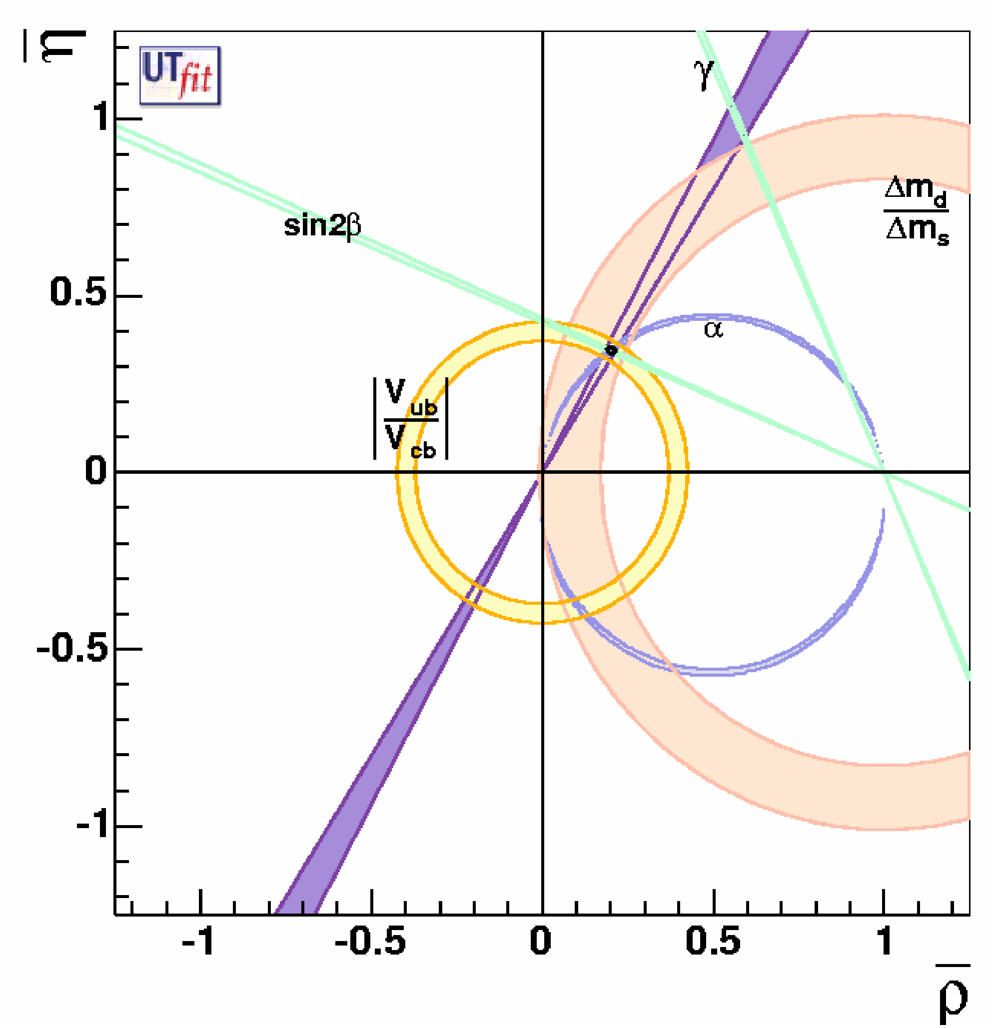
We need precision measurements to test NP and to push the NP scale in interesting ranges and to play the complementarity at LHC

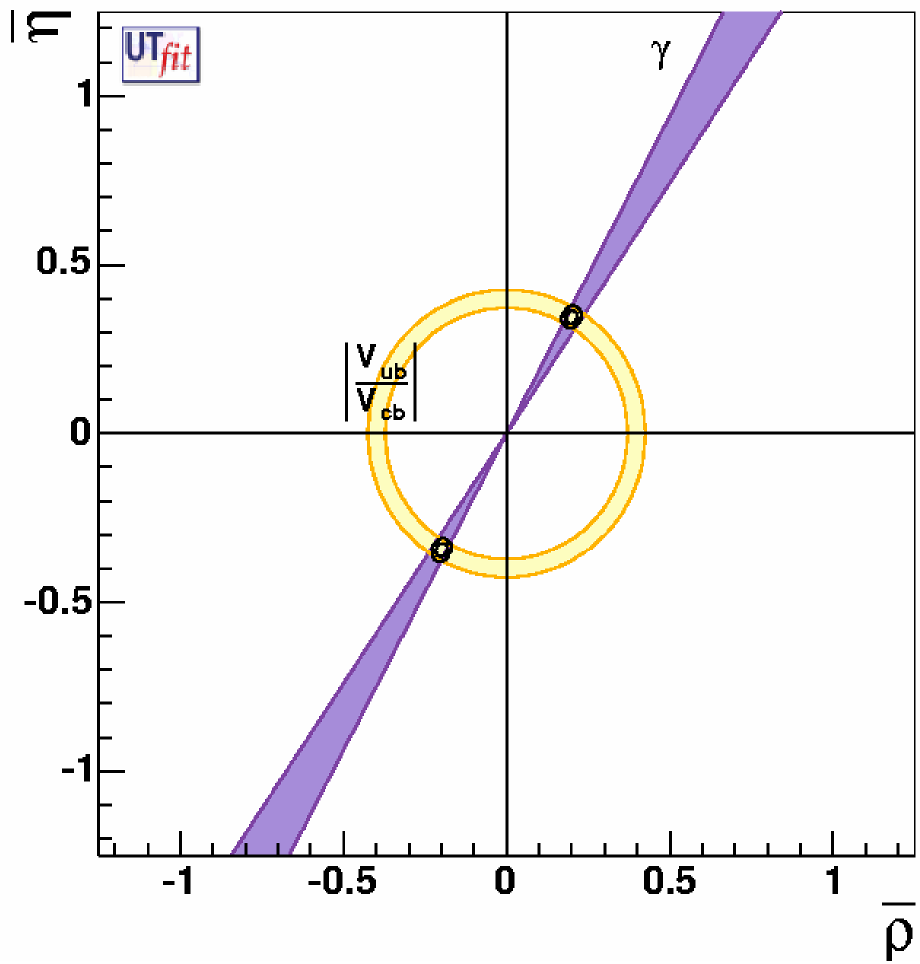


What about the b→s ΔB=2 sector ? Still large room for NP. LHCb plays the central role on it.



and if SuperB…..





Plots from preliminary work from M.Pierini,MCiuchini….

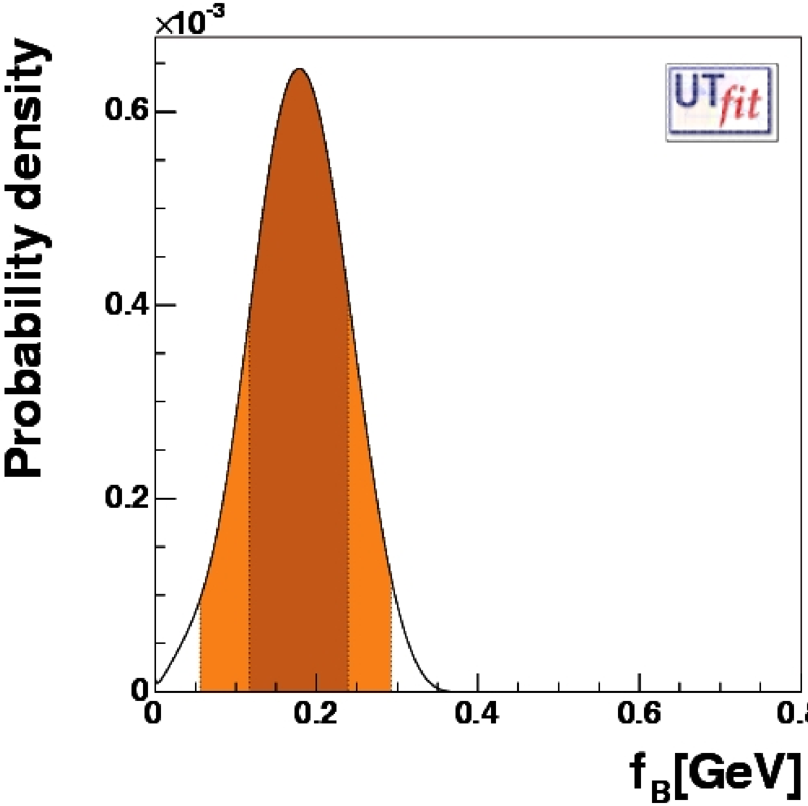
BACKUP SLIDES

Next Step: Rare Decays (I)

$B \to \tau\nu$

$$\mathcal{B}(B \to \ell\nu) = \frac{G_F^2 m_B m_\ell^2}{8\pi}\left(1 - \frac{m_\ell^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

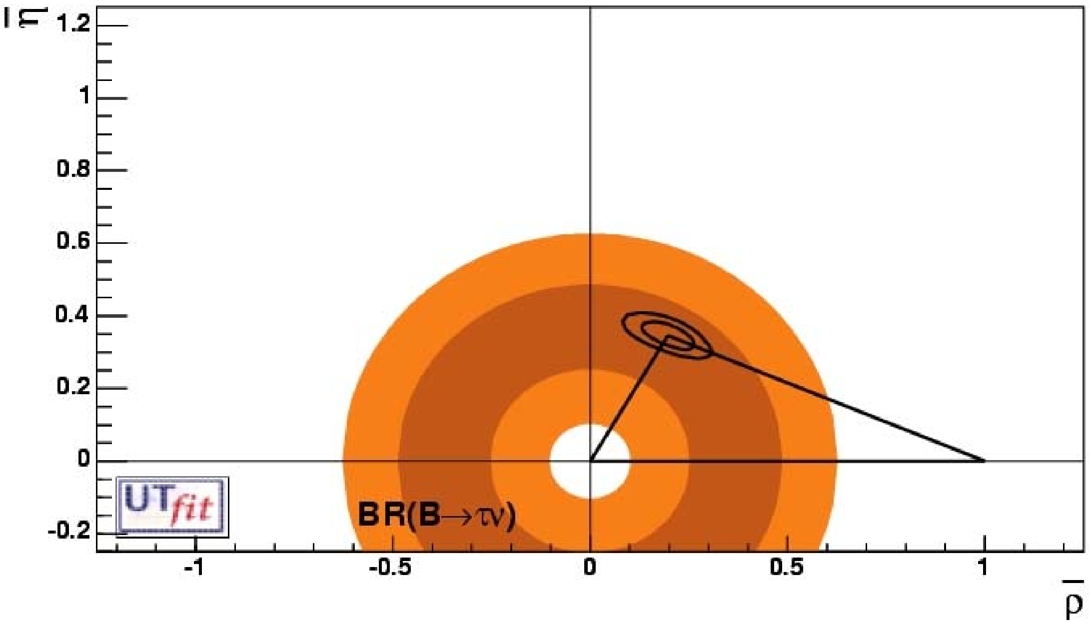
$< 1.8\ 10^{-4}$ @ 90% CL



Assuming f_B :

Constraint on $R_b = \bar{\rho}^2 + \bar{\eta}^2$

R_b **= 0.37 ± 0.13**



Next Step: Rare Decays (II)

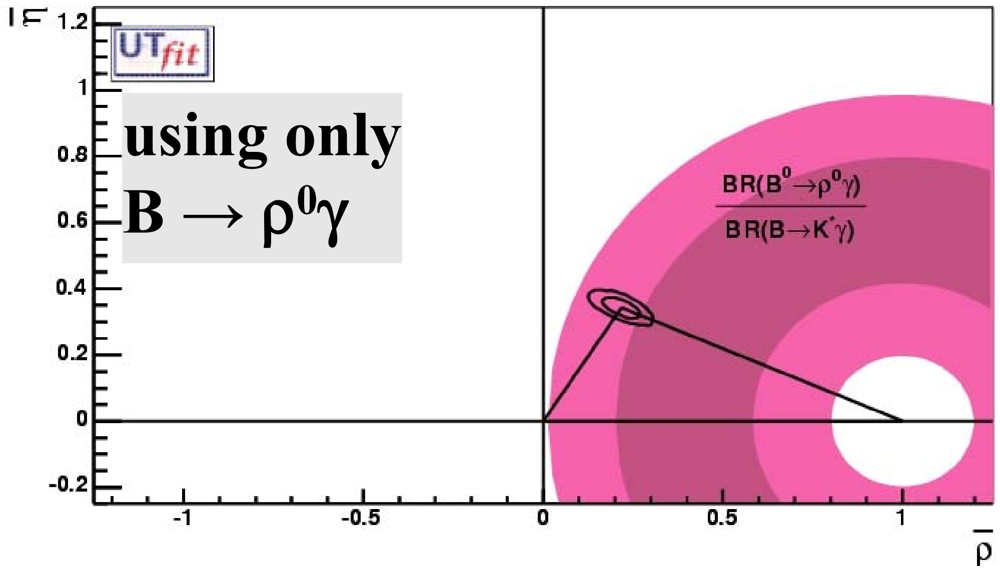
$$\frac{BR(B \to \rho\gamma)}{BR(B \to K^*\gamma)}$$

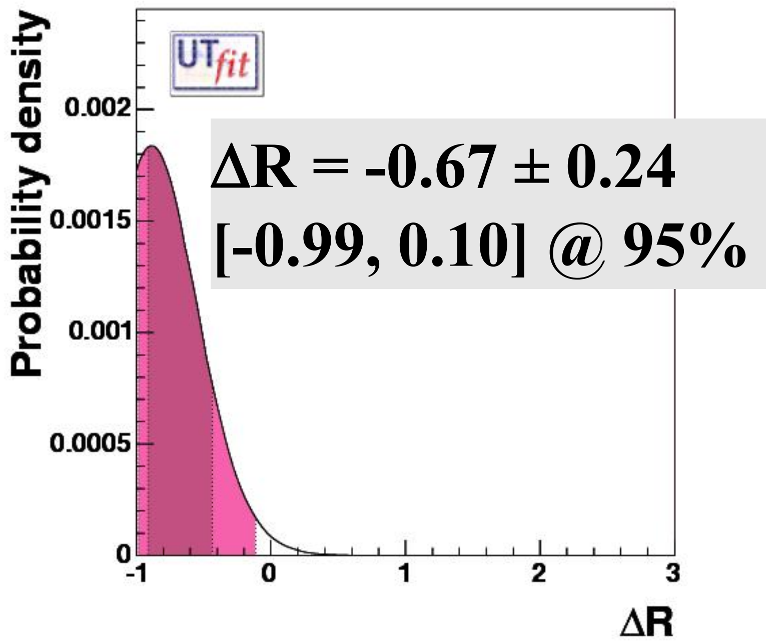
$$R = c_\rho^2 \frac{r_m}{\xi^2} \frac{|a_7^c(\rho\gamma)|^2}{|a_7^c(K^*\gamma)|^2} \frac{|V_{td}|^2}{|V_{ts}|^2}(1+\Delta R)$$

caveat: * SU(3) breaking effect
* Λ_{QCD}/m_b corrections B(~cosα) to ρ/ω γ (smaller for B^0 than B^+)

Using the $|V_{td}/V_{ts}|$ value from the SM, we can extract ΔR.

$|V_{td}/V_{ts}| = 0.10 \pm 0.45$
[0.02,0.18] @ 95% Prob.





Next Step: Rare Decays (III)

D'Ambrosio, Isidori
hep-ph/0112135

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

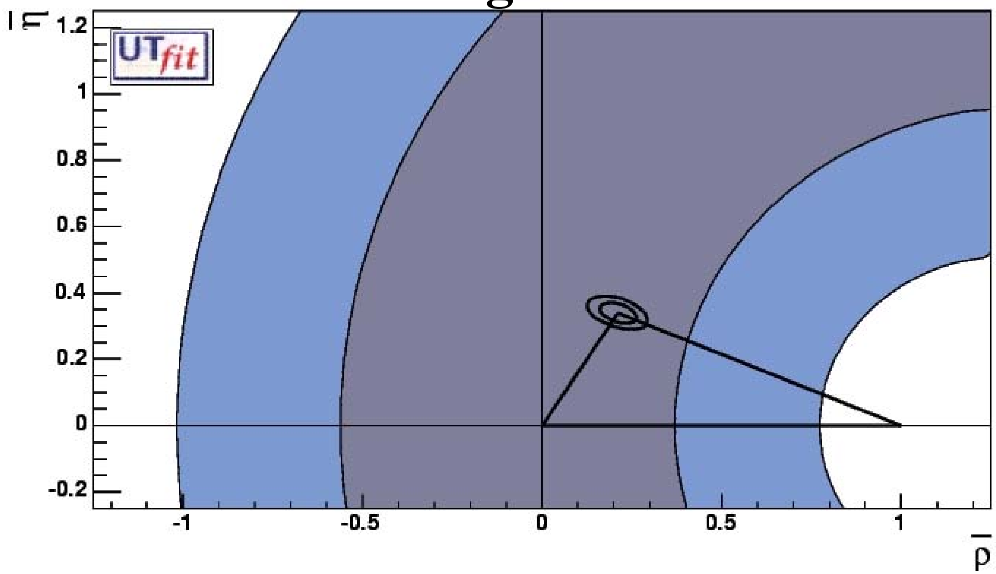
$$\underbrace{(\sigma\bar{\eta})^2 + (\bar{\rho} - \bar{\rho}_0)^2}_{} = \frac{\sigma BR(K^+ \to \pi^+ \nu\bar{\nu})}{\bar{\kappa}_+ |V_{cb}|^4 X^2(x_t)}$$

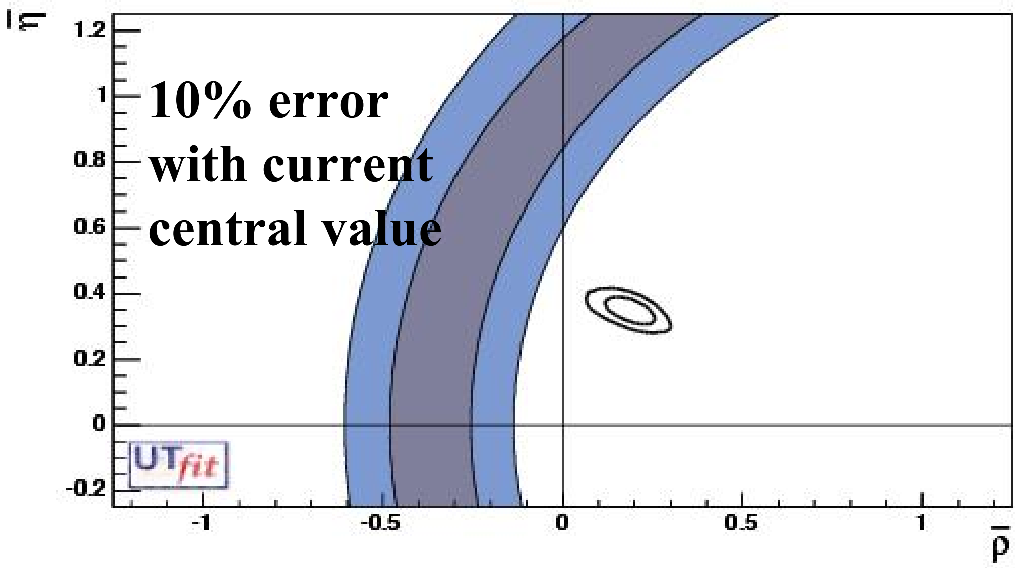
ellipse centered in (ρ^0, 0)

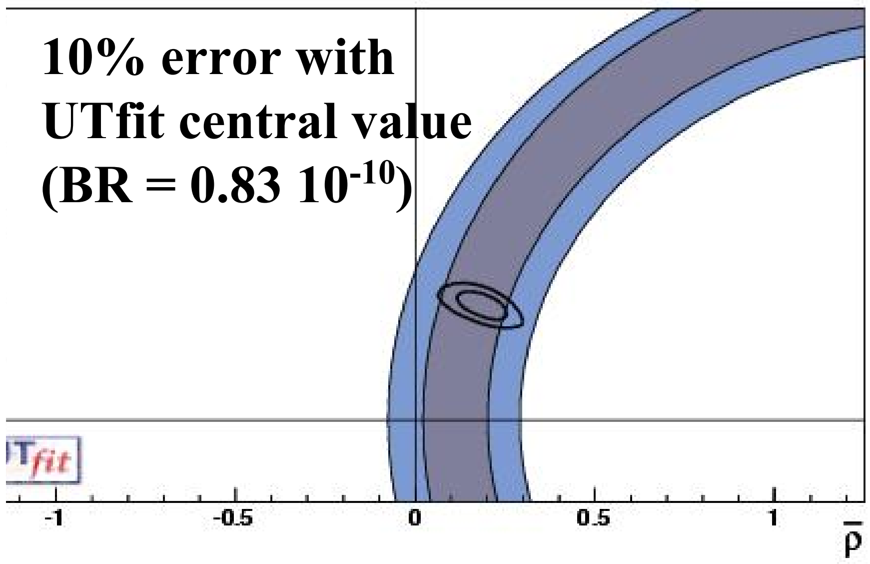
latest result from E949:

$BR(K^{\pm} \to \pi^{\pm}\nu\bar{\nu}) = 1.47^{+1.30}_{-0.89}\ 10^{-10}$

with 3 signal events







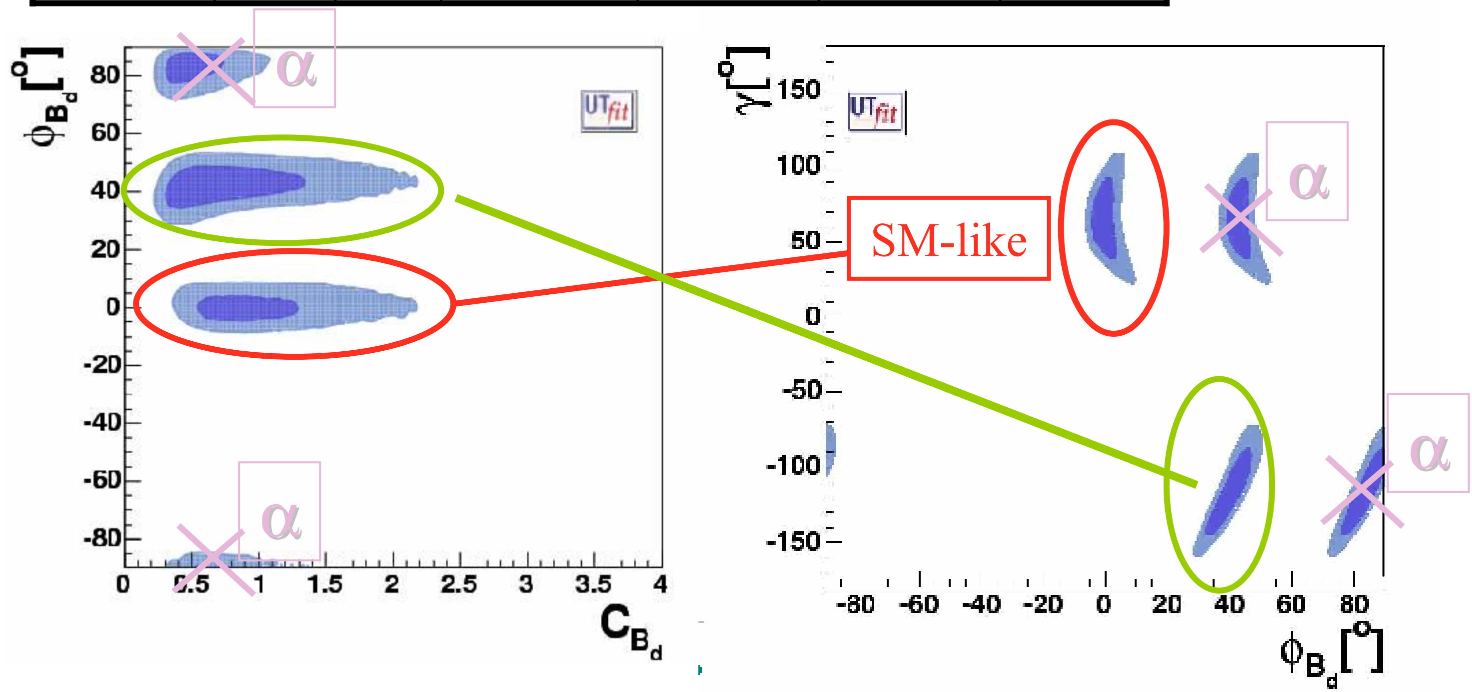
Using

Fit in a NP model independent approach

V_{ub}/V_{cb} Δm_d ACP (J/Ψ K)

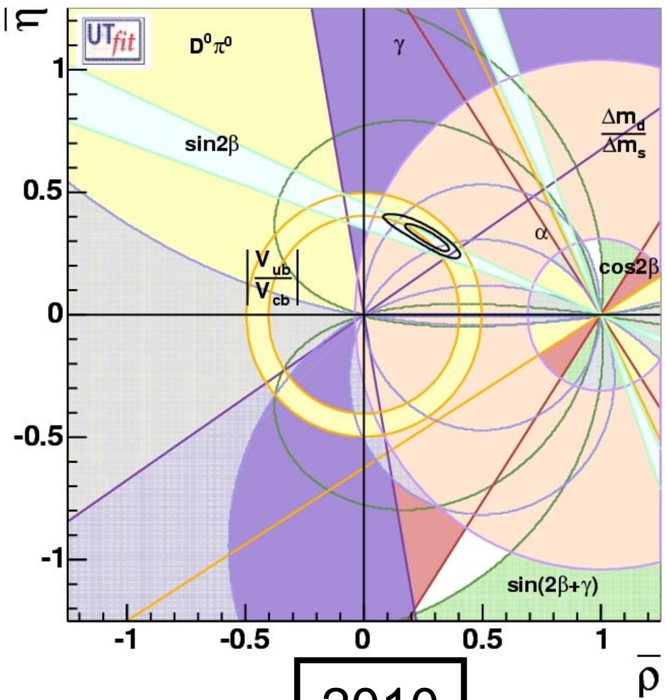
γ (DK) ε_K

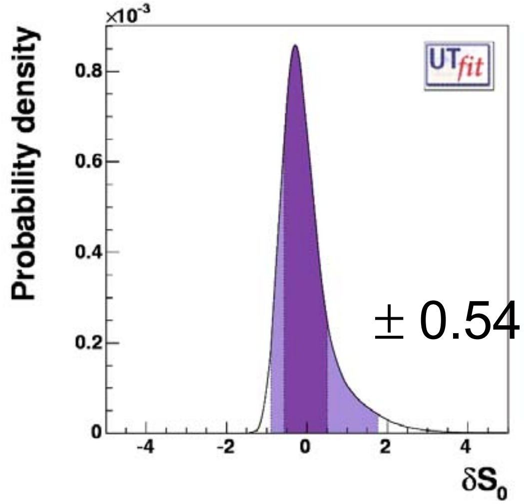
	γ	C_d	$\cos 2(\beta+\phi)$	$\sin 2(\alpha-\phi)$	$\sin(2\beta+\phi)$	A_{SL}
SM-LIKE	60^o	1	0.68	-0.23	0.96	OK
NP1	60^o	1	-0.68	0.96	-0.23	OK
NP2	120^o	0.4	0.68	-0.23	-0.96	10^{-2}
NP3	120^o	0.4	-0.68	0.96	0.23	0K



In MFV

Now





2010