Constraining new physics with Unitarity Triangle *fit*

Maurizio Pierini
Universita' Roma "La Sapienza" & INFN Roma
on behalf of UT*fit* Collaboration

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

http://www.utfit.org

The Method and the Inputs

$$f(\bar\rho,\bar\eta,X|c_1,...,c_m) \sim \prod_{j=1,m} f_j(\mathcal{C}|\bar\rho,\bar\eta,X) * \prod_{i=1,N} f_i(x_i) f_0(\bar\rho,\bar\eta)$$

Bayes Theorem

$X \equiv x_1,...,x_n = m_t, B_K, F_B, ...$

$\mathcal{C} \equiv c_1,...,c_m = \epsilon, \Delta m_d/\Delta m_s, A_{CP}(J/\psi K_S), ...$

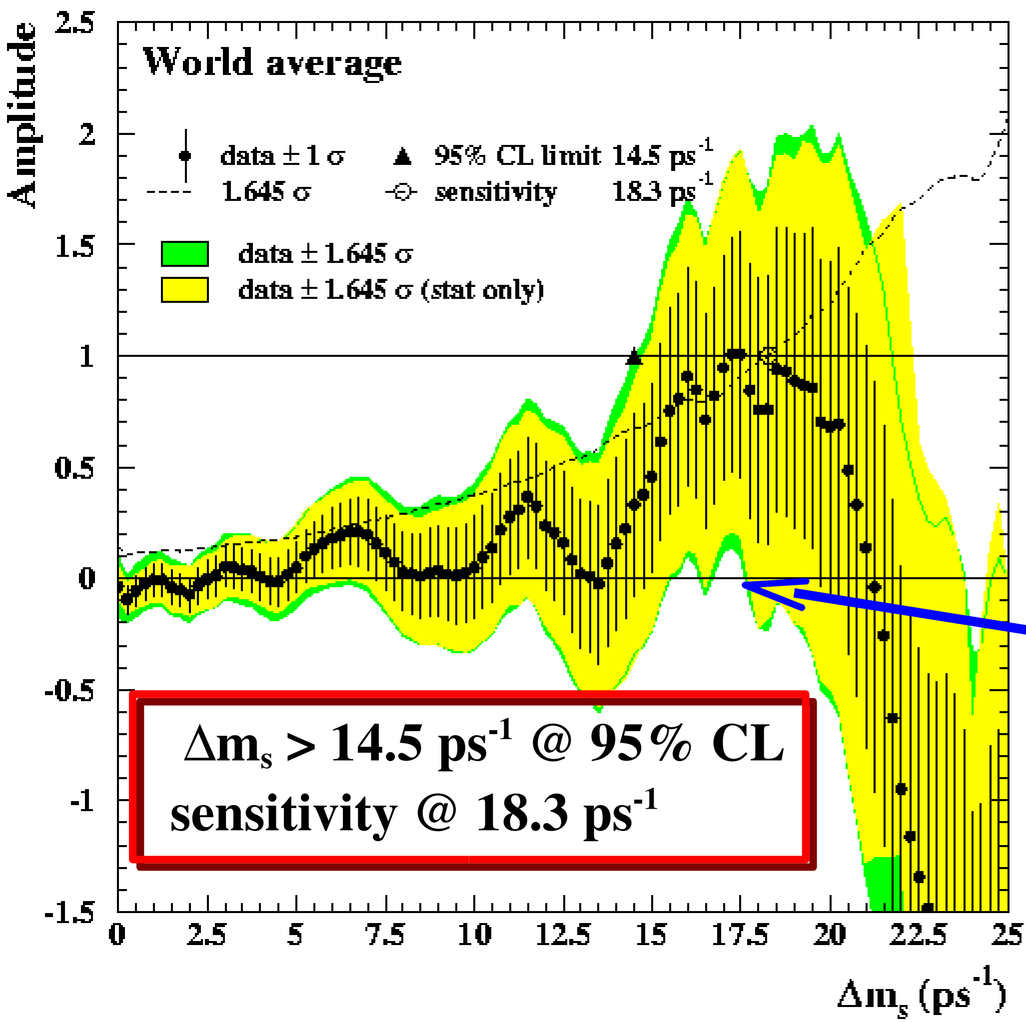
$(b \to u)/(b \to c)$	$\bar\rho^2 + \bar\eta^2$	$\bar\Lambda, \lambda_1, F(1), \ ...$
ϵ_K	$\bar\eta[(1-\bar\rho)+P]$	B_K
Δm_d	$(1-\bar\rho)^2+\bar\eta^2$	$f_B^2 B_B$
$\Delta m_d/\Delta m_s$	$(1-\bar\rho)^2+\bar\eta^2$	ξ
$A_{CP}(J/\psi K_S)$	$\sin 2\beta$	$-$

$\}, m_t$

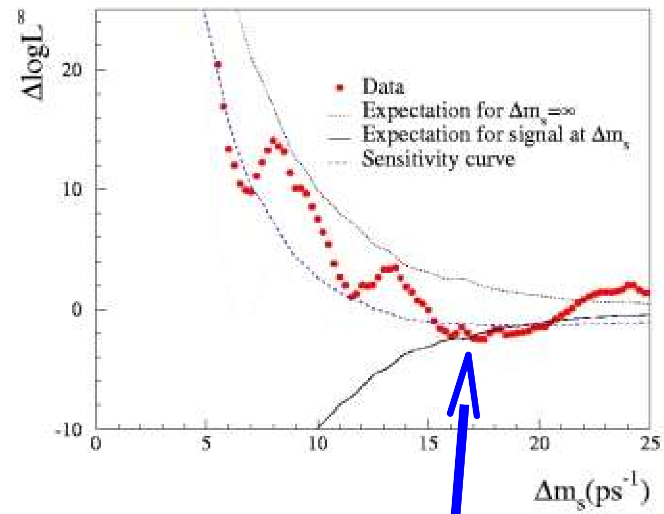
Standard Model +
OPE/HQET/
Lattice QCD
to go from
quarks
to hadrons

Experimental Inputs: Δm_s

$$P_{B_q^0 \to B_q^0(\bar{B}_q^0)} = \frac{1}{2} e^{-t/\tau_q} (1 \pm A \cos \Delta m_q t)$$



$\Delta m_s > 14.5\ ps^{-1}$ @ 95% CL
sensitivity @ 18.3 ps^{-1}



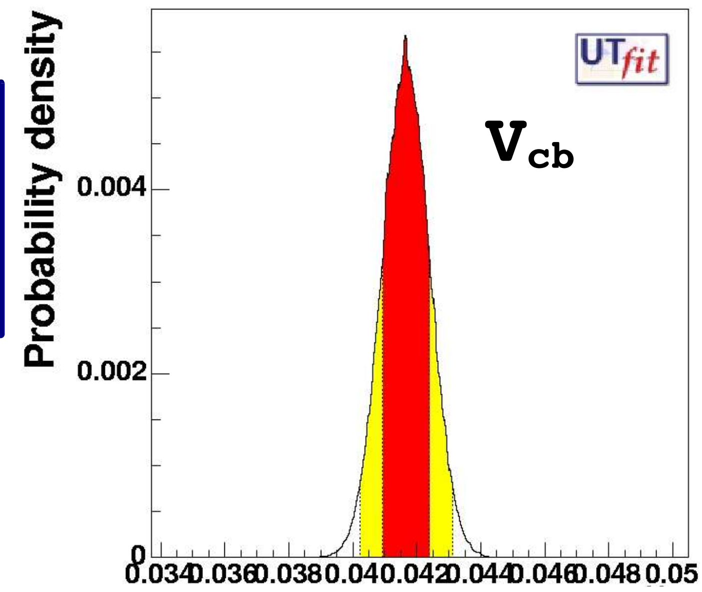
hint of a signal
@ $\Delta m_s \sim 17.5\ ps^{-1}$
with significance ~2σ

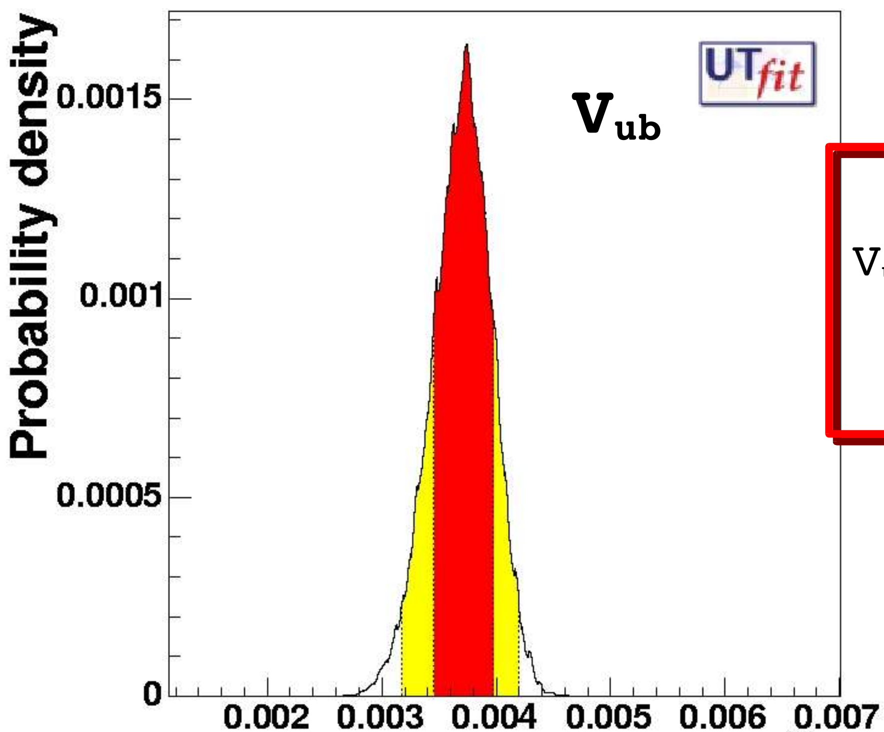
Experimental Inputs: V_{ub}&V_{cb}

$V_{cb}^{EXC}=(42.1 \pm 2.1(gauss))10^{-3}$

$V_{cb}^{INC}=(41.4 \pm 0.7\ (gauss) \pm 0.6)(flat)10^{-3}$

$V_{cb}=(41.6 \pm 0.7)10^{-3}$





$V_{ub}^{EXC}=(33.4 \pm 2.4(gauss) \pm 4.6(flat))10^{-4}$

$V_{ub}^{INC(LEP)}=(40.9 \pm 6.2\ (gauss) \pm 4.7(flat))10^{-4}$

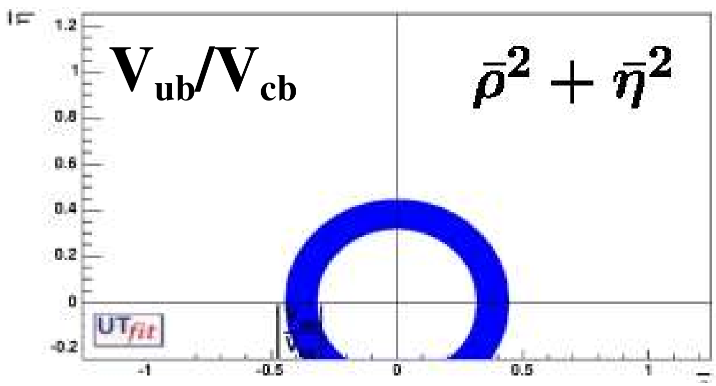
$V_{ub}^{INC(HFAG)}=(45.7 \pm 6.1\ (gauss))10^{-4}$

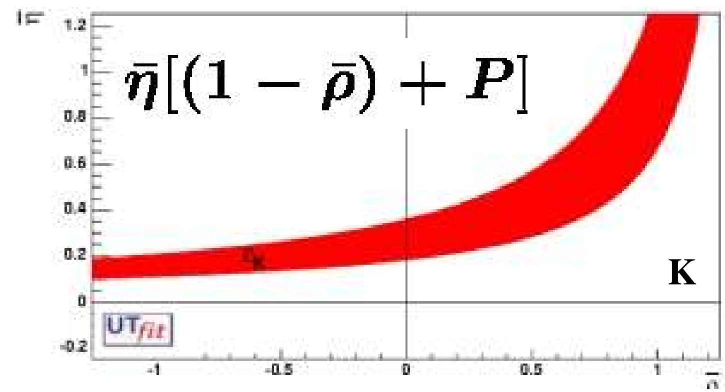
$V_{ub}=(37.4\ ^{+2.3}_{-2.8})10^{-4}$

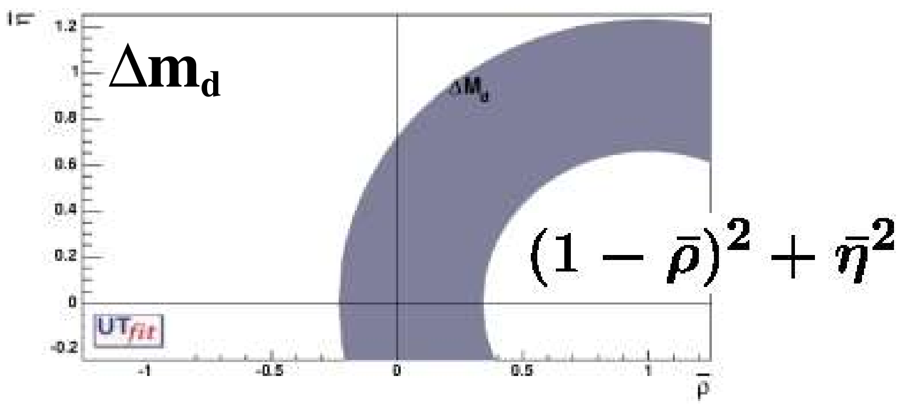
Other Inputs

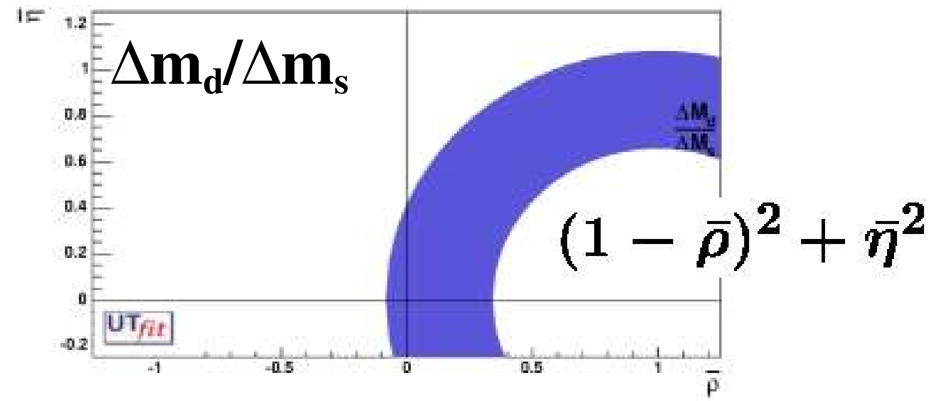
λ	0.2265 ± 0.020	
Δm_d	$0.502 \pm 0.007\ ps^{-1}$	LEP/SLD/CDF/B-Factories
Δm_s	$> 14.5\ ps^{-1}$	LEP/SLD/CDF-1
m_t	$171.0 \pm 4.4\ GeV$	CDF/D0
m_c	$1.3 \pm 0.1\ GeV$	
$f_{B_s}\sqrt{\hat{B}_{B_s}}$	$276 \pm 38\ MeV$	Lattice QCD
ξ	$1.24 \pm 0.04 \pm 0.06$	Lattice QCD
B_K	$0.86 \pm 0.06 \pm 0.14$	Lattice QCD
$\sin 2\beta$	0.739 ± 0.048	B-Factories

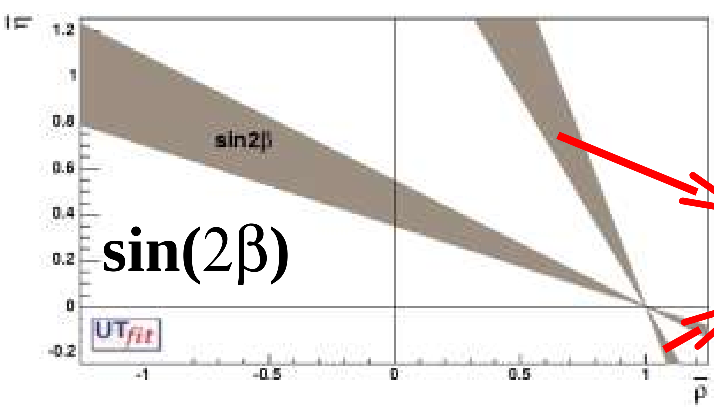
The inputs in the ρ-η plane









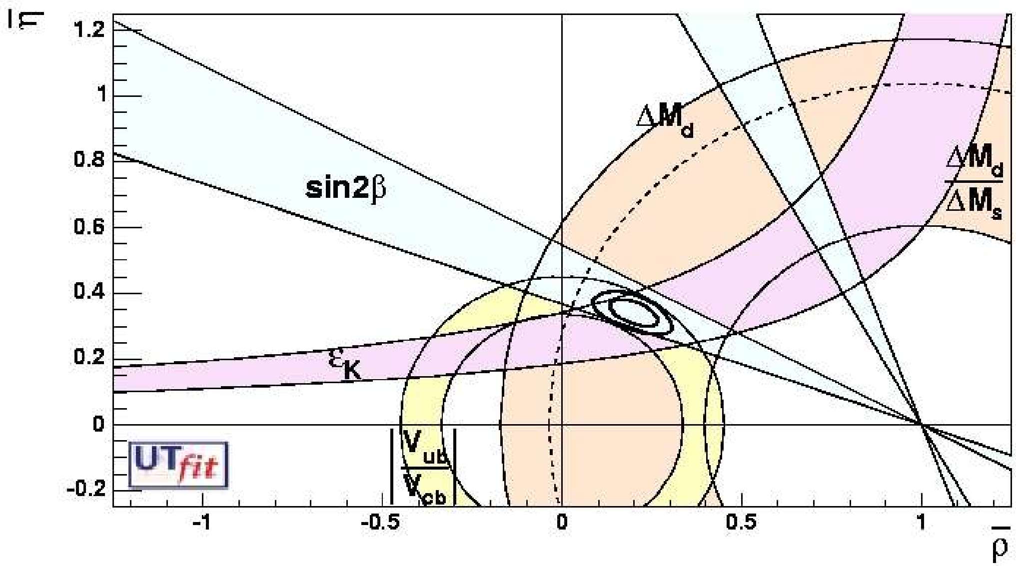


...and putting all together...

excluded by cos(2β) measurement from J/ψ K*

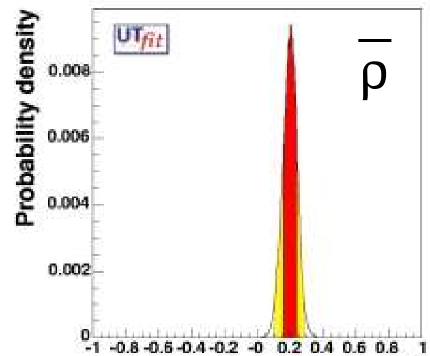
Results from the Standard Fit

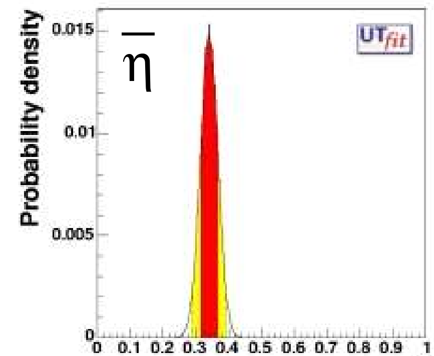
all constraints



$\bar{\eta} = 0.341 \pm 0.027$

$\bar{\rho} = 0.204 \pm 0.044$





$\bar{\eta} = 0.360 \pm 0.039$

$\bar{\rho} = 0.168 \pm 0.057$

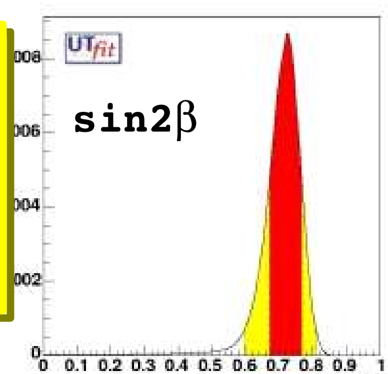
only sides

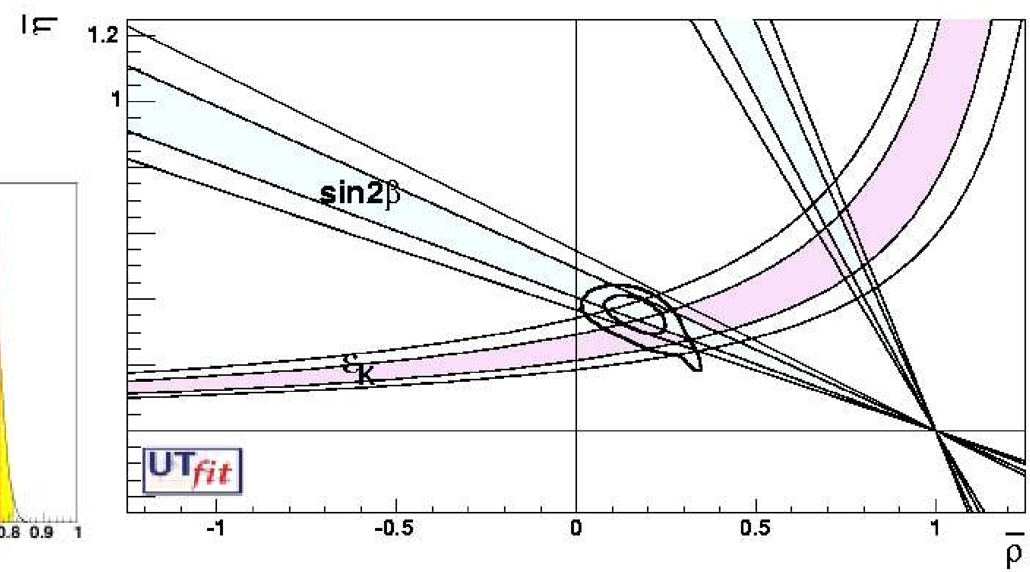
(no CP violating processes)

sin2β = 0.726 +0.042 −0.054
(from UT sides)

sin2β = 0.706 +0.045 −0.051
(from UT sides + εk)

sin2β = 0.723 +0.031 −0.035
(all constraints)





We can still have new physics...

- ...because $b \to d$ ad $b \to s$ transitions are not strongly constrained
- ...because part of the impressive agreement of UT*fit* comes from the parametrization, which assumes Standard Model
- ...because we can follow a very simple model independent generalization beyond Standard Model

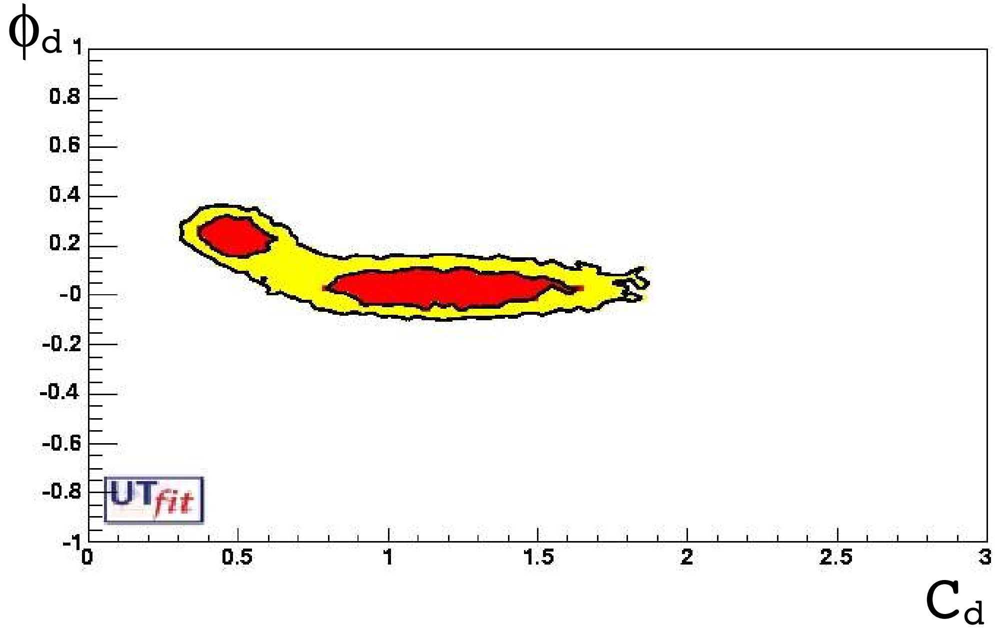
We parameterize deviations from the Standard Model in loop dominated processes as

Model independent assumptions

J. M. Soares and L. Wolfenstein, Phys. Rev. D **47** (1993) 1021.
N. G. Deshpande, B. Dutta and S. Oh, Phys. Rev. Lett. **77** (1996) 4499 [arXiv:hep-ph/9608231].
J. P. Silva and L. Wolfenstein, Phys. Rev. D **55** (1997) 5331 [arXiv:hep-ph/9610208].
A. G. Cohen *et al.*, Phys. Rev. Lett. **78** (1997) 2300 [arXiv:hep-ph/9610252].
Y. Grossman, Y. Nir and M. P. Worah, Phys. Lett. B **407** (1997) 307 [arXiv:hep-ph/9704287].

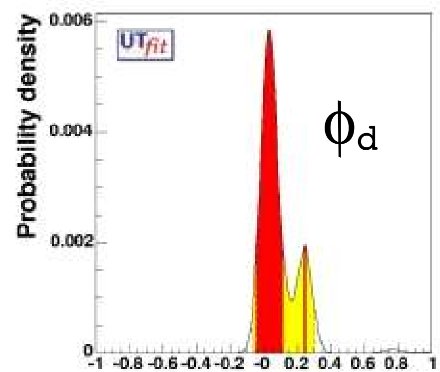
- $|\varepsilon_K|^{EXP} = C_\varepsilon \cdot |\varepsilon_K|^{SM}$
- $\Delta m_d^{EXP} = C_d \cdot \Delta md^{SM}$
- $\Delta m_s^{EXP} = C_s \cdot \Delta ms^{SM}$
- $A_{CP}(J/\psi K^0) = \sin(2\beta + \phi_d)$

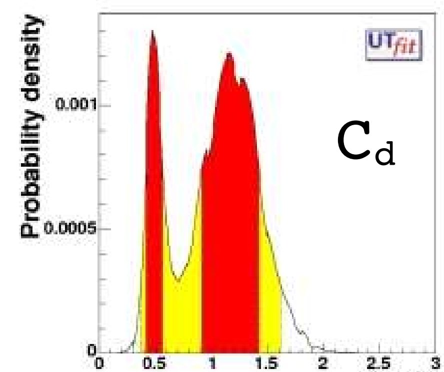
... in $\bar{B}_d$–B_d Mixing...

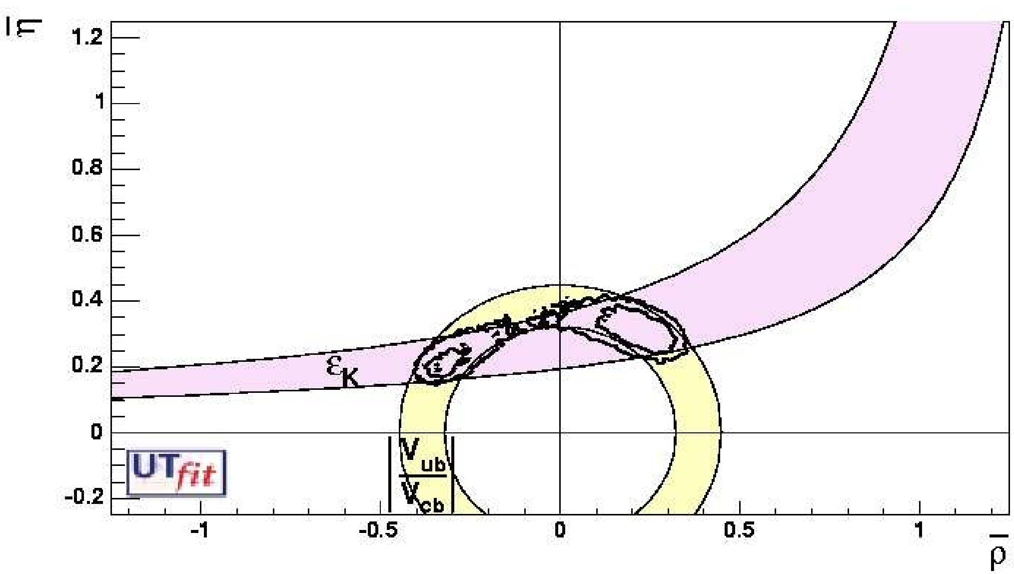


Even if the fit shows a good agreement a “NP” solution is present

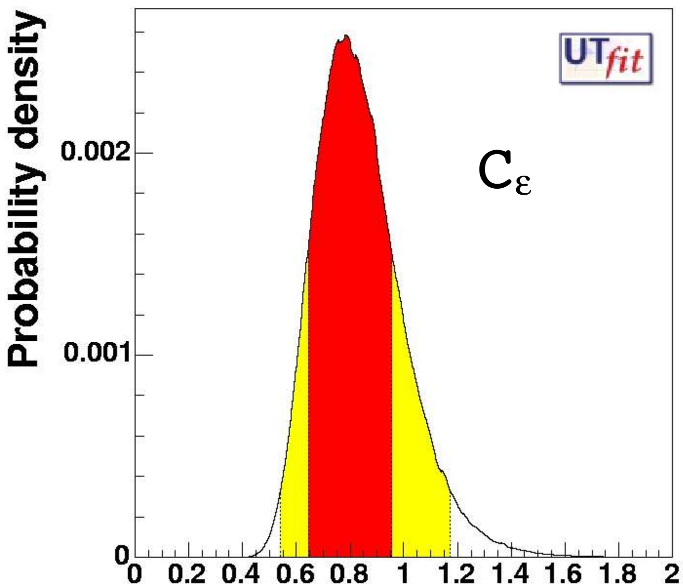
68% contour
95% contour

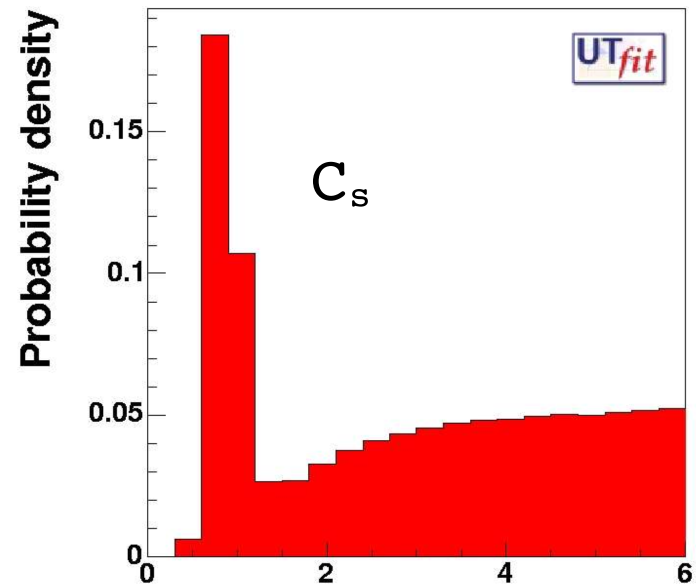






...in $\bar{B}_s - B_s$ Mixing or in K sector





$C_\varepsilon = 1.30 \pm 0.24$

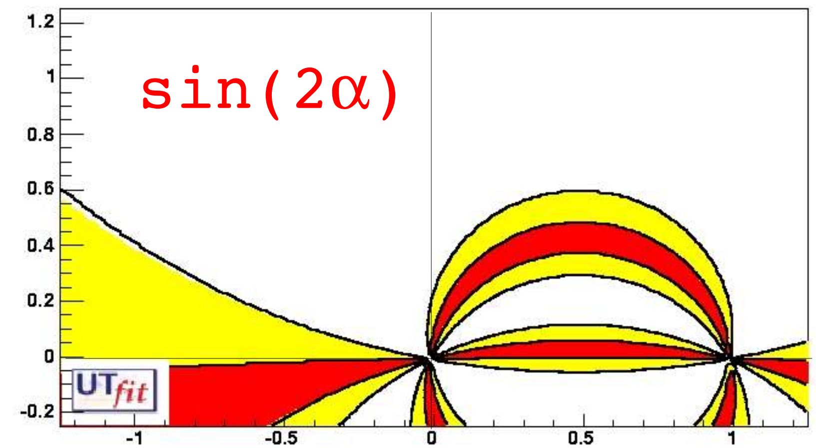
[0.874,1.806]@ 95%

No bound on C_s

(we just have a limit on Δm_s)

New inputs from B-factories: α

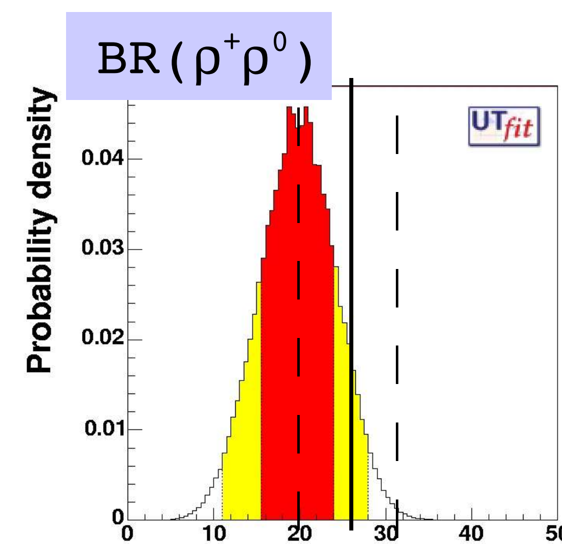
- $\pi^+\pi^-$ & $\rho^+\rho^-$: using SU(2)symmetry (Gronau & London Phys. Rev. Lett. 65, 3381-3384 (1990))
- BR measurements of $\rho^+\rho^0$ and $\rho^0\rho^0$ (UL) stongly constrains penguin pollution ($|\alpha - \alpha_{eff}|^{\rho\rho} < 17°$ from Grossman Quinn bound Phys.Rev.D58:017504,1998)



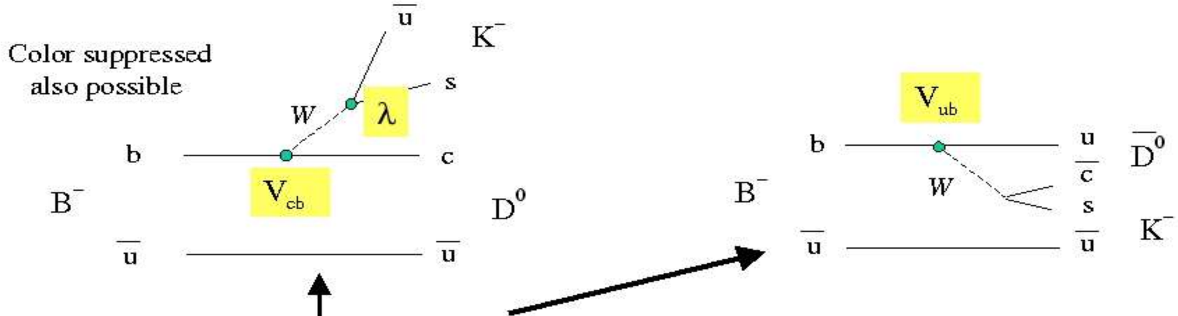
68% contour
95% contour

$$\sin^2 \delta \leq \frac{BR(B^0 \to \pi^0\pi^0) + BR(\bar{B}^0 \to \pi^0\pi^0)}{BR(B^+ \to \pi^+\pi^0) + BR(B^- \to \pi^-\pi^0)}$$

- Effect larger in $\pi^+\pi^-$ ($|\alpha - \alpha_{eff}|^{\pi\pi} < 43$)° but there is some information. We used *BaBar* numbers for this exercise (waiting for a more clear situation) and SU(2) amplitudes.



- One should chek the hypoteses looking at a-posteriori pdf's for the inputs used. For example, we see a (not significative) hint of SU(2) breaking in $\rho\rho$



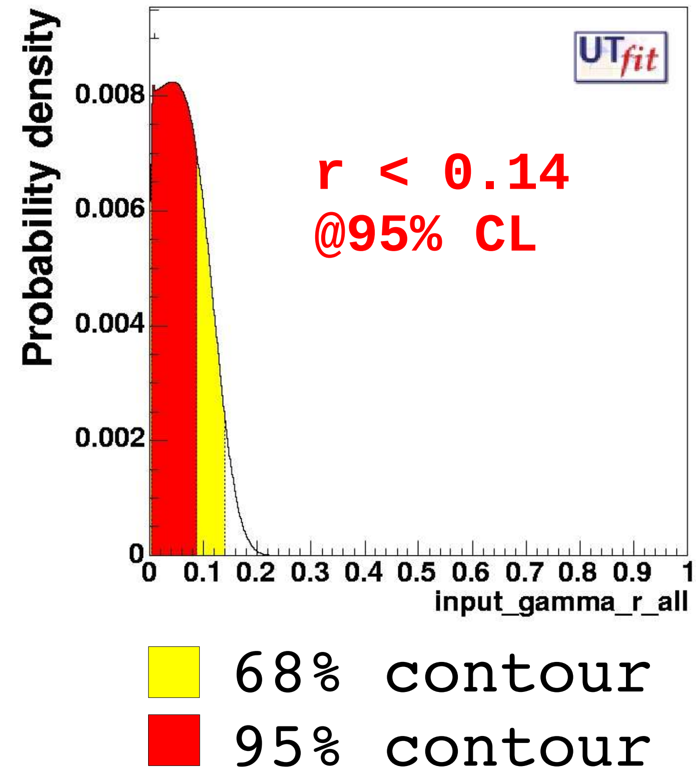
$$A_-(B^- \to f) = v_1 A_1 e^{i\alpha_1} + v_2 A_2 e^{i\alpha_2} \quad , \quad A_+(B^+ \to \bar{f}) = v_1^* A_1 e^{i\alpha_1} + v_2^* A_2 e^{i\alpha_2}$$

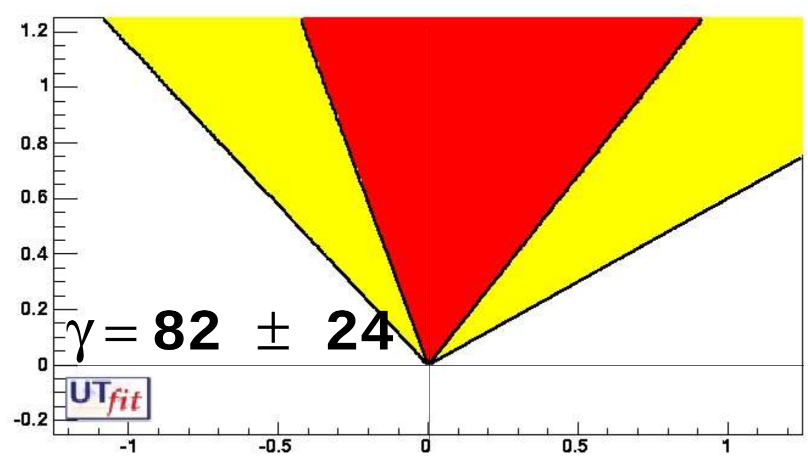
- **two different ways to decay but same final state (using different decays of D0)**
- **sensitivity to value of r**

$$r \equiv r(DK^-) = \frac{|A_1||v_1|}{|A_2||v_2|} = \frac{|A_1||V_{ub}|}{|A_2||V_{cb}|\lambda} = \frac{|A_1|}{|A_2|}R_b \qquad R_b = \sqrt{\bar{\rho}^2 + \bar{\eta}^2}$$

the larger, the better...

- **we use GLW (Phys.Lett.B265:172-176,19 and ADS (Phys.Rev.Lett.78:3257-3260,1 method (see http://www.utfit.org for details)together with *Belle* measurement with the new promising Dalitz method (Phys.Rev.D68:054018,2003)**

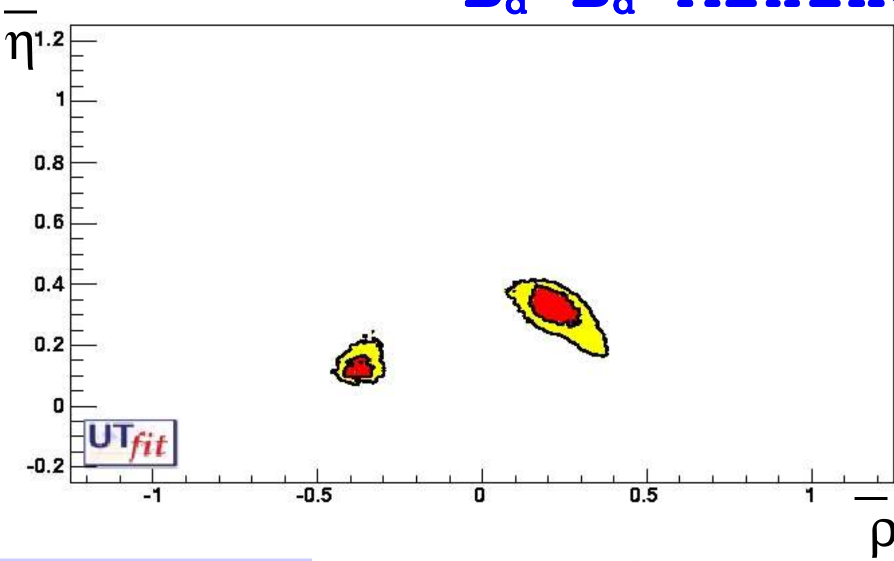


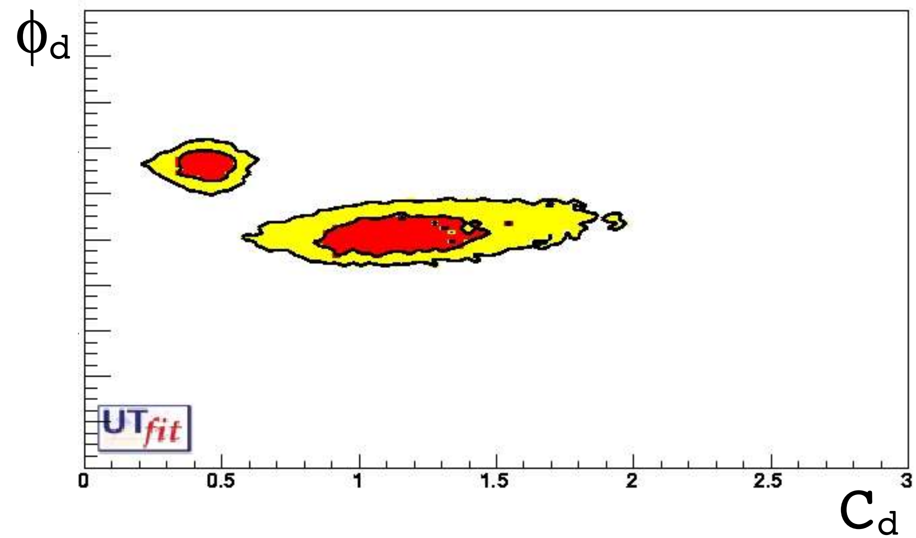


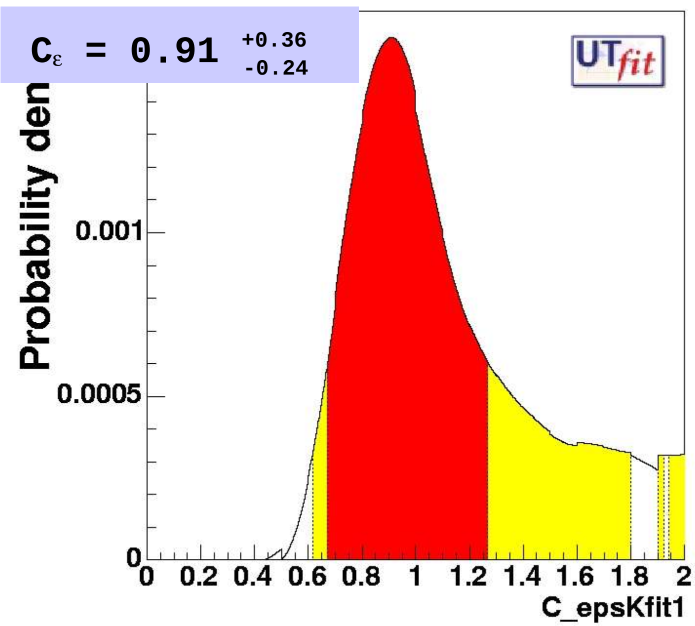
Using these new constrains ...

... we can switch on NP in more than one sector

$\bar{B}_d - B_d$ Mixing and K sector





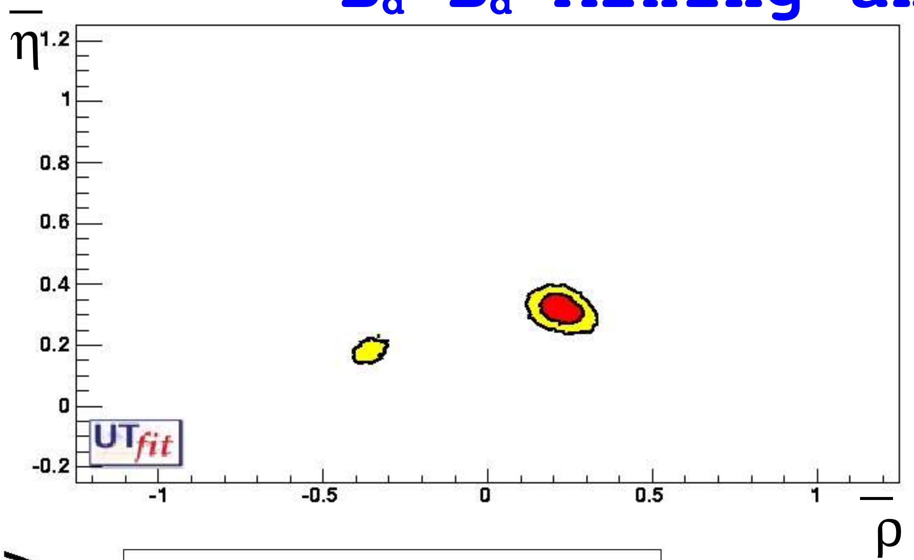


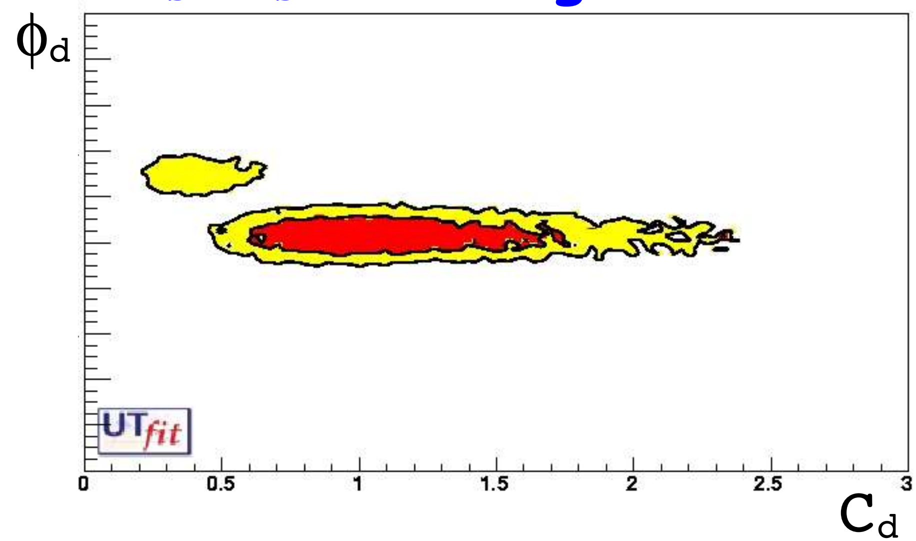
- The NP solution still survives in the B_d sector...
- ...waiting for a better determination of γ
- The effect is not significative in the K sector

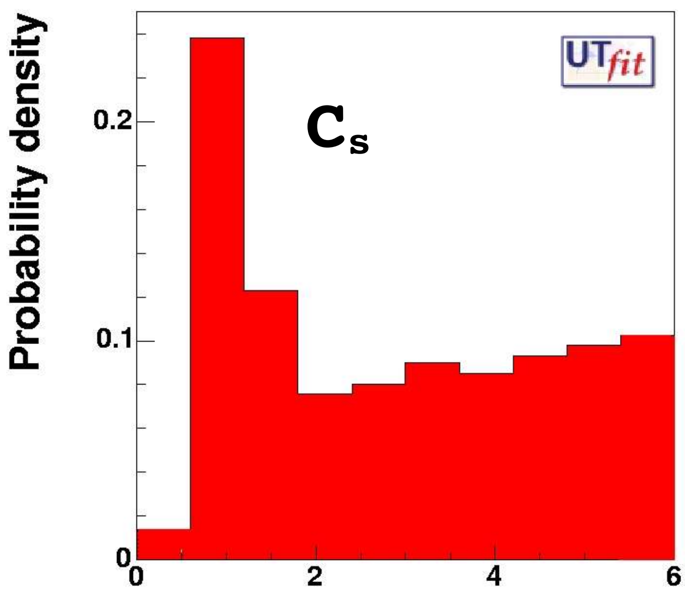
Using these new numbers ...

... we can switch on NP in more than one sector

$\bar{B}_d - B_d$ Mixing and $\bar{B}_s - B_s$ Mixing





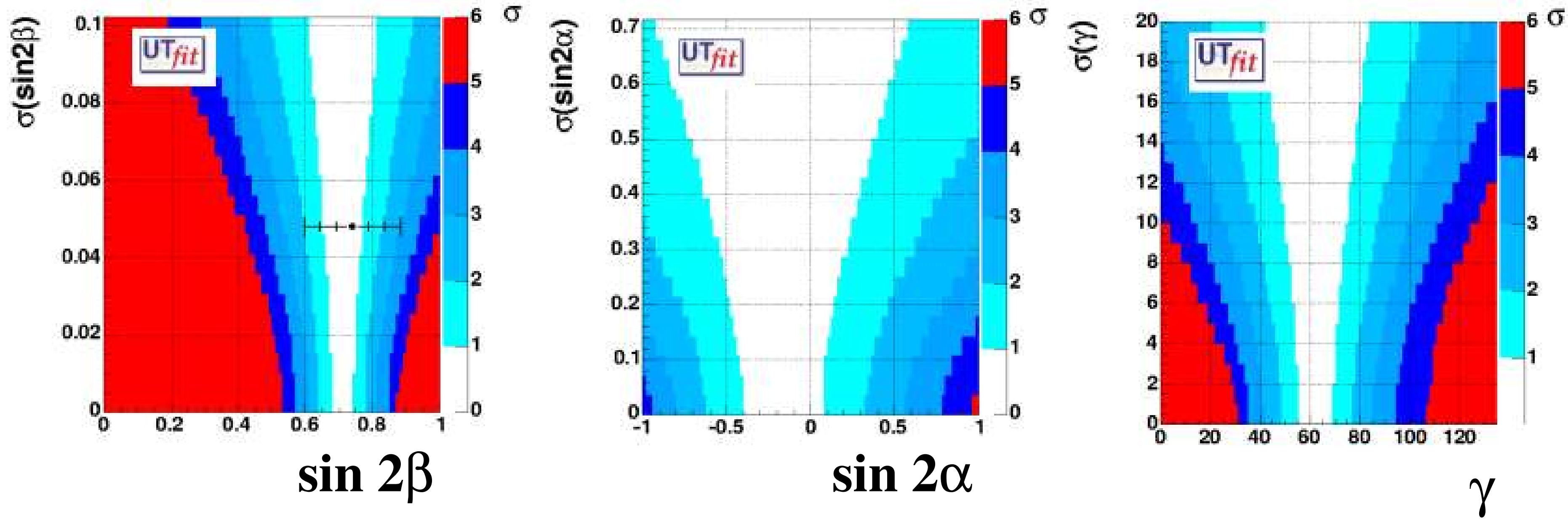


- The NP solution still survives in the B_d sector...
- The B_s sector is not bounded from the actual experimental results (since we just have a limit on Δm_s)

Compatibility plots (I)

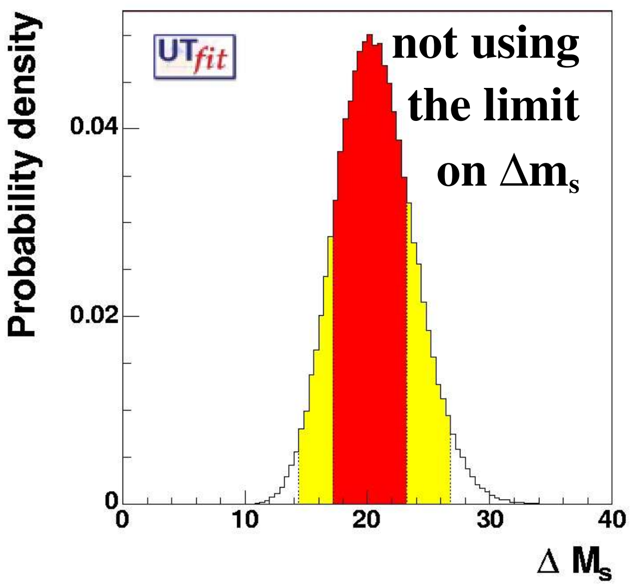
In order *to quantify disagreement*, we use the a-posteriori pdf's from the Standard Model UT*fit*

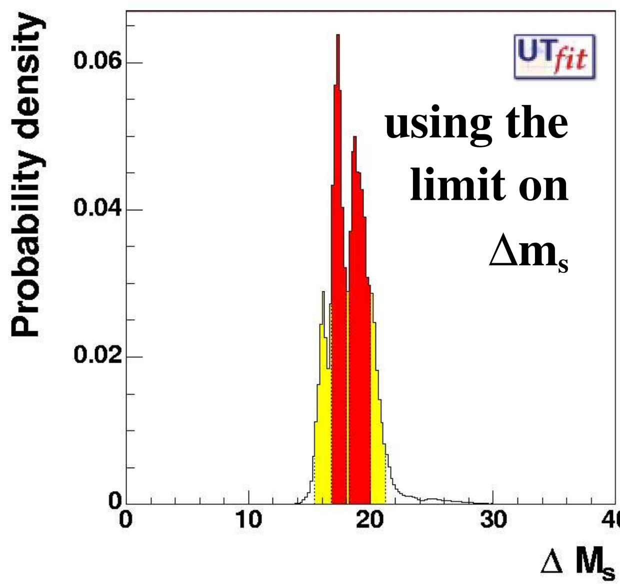
red: 5σ exclusion zone

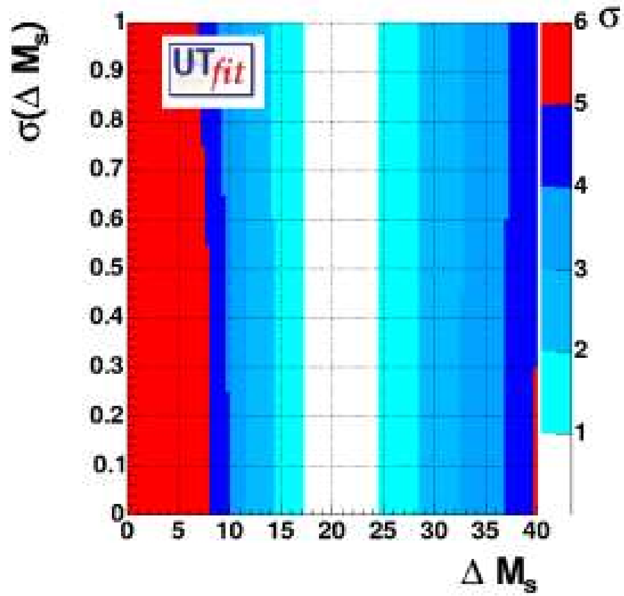


comparison between the indirect determination and a (hypothetical) direct experimental determination

Compatibility plots (II)







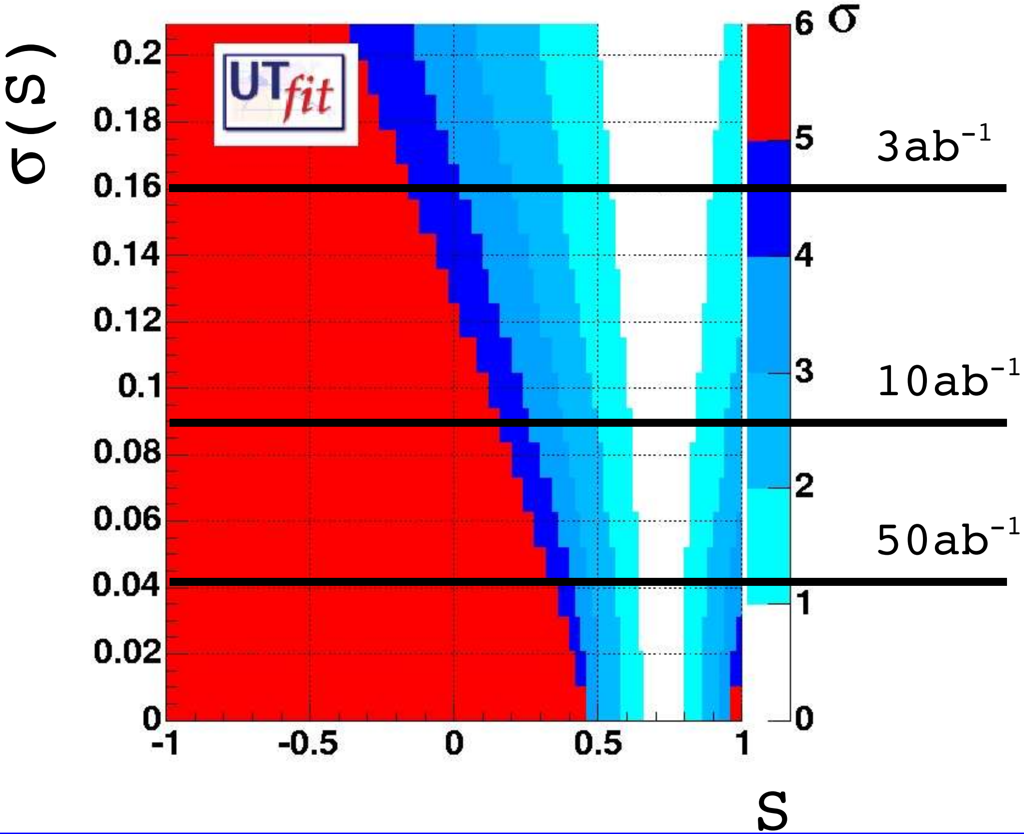
$\Delta m_s = 20.5 \pm 3.2\ ps^{-1}$
[14.4, 27.1] @ 95% CL

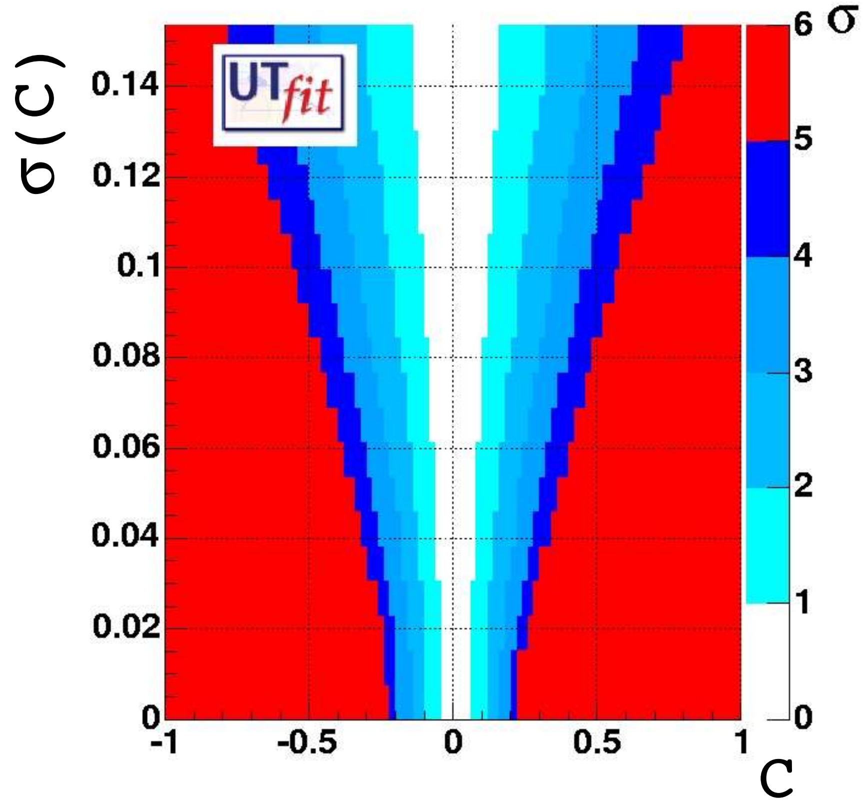
$\Delta m_s = 18.0 \pm 1.6\ ps^{-1}$
[15.5, 21.6] @ 95% CL

if $\Delta m_s > 30\ ps^{-1}$
new physics @ 3σ

Indirect determination and compatibility plot for Δm_s

Compatibility plots for ϕK_S





Using Charming Penguins model from Ciuchini et al. (Phys.Lett. B515 (2001) 33-41) and constraints from BR and CP asymmetries of $B^0 \to \phi K^0$ and $B^\pm \to \phi K^\pm$

Conclusions

- The picture coming from UT*fit* to CKM matrix shows a (too) good consistency
- Moving to a more general parameterization, a second solution arises in the B_d sector...
- ... which is not killed by the new measurements (α and γ) coming from the B factory
- The situation is less interesting for K ad B_s sector
- Even in the standard fit, one can quantify disagreement between Standard Model and next measurements with the compatibility plots ...
- ... which can be used also in a more complete description of ϕK_S beyond the naïve description ($S(\phi K_S) \sim \sin(2\beta)$) together with a model for the decay (Charming penguins here)
- It comes out that a Super B factory would help (both on $S(\phi K_S)$ and $C(\phi K_S)$)