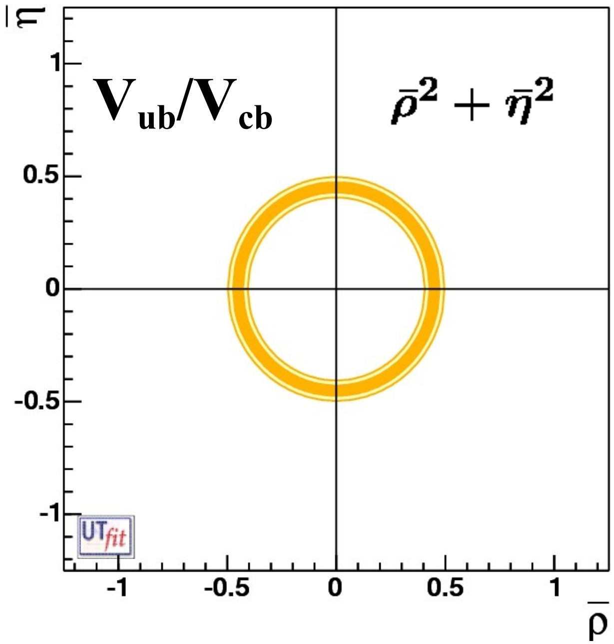
Impact of Δm_s on Unitarity Triangle Analysis

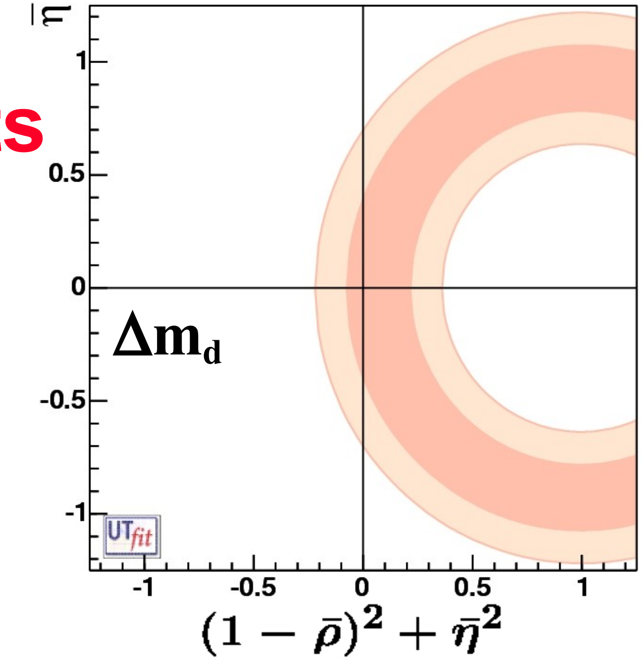
Marcella Bona
LAPP

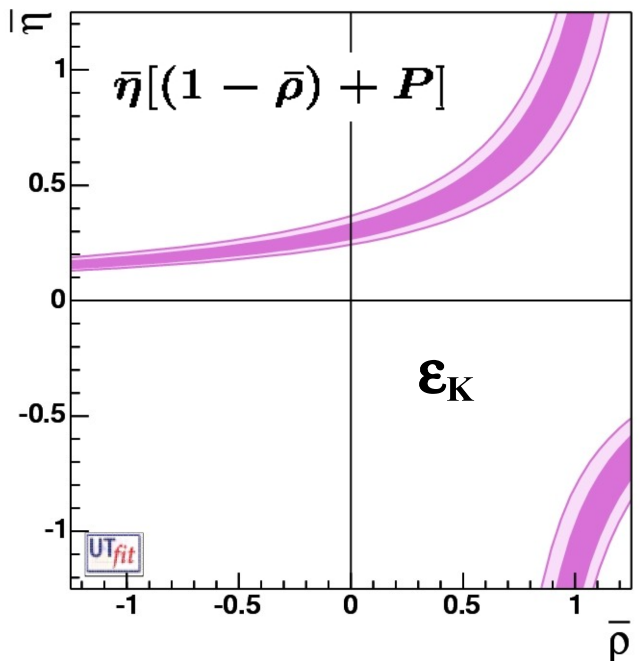
on behalf of the UT_{fit} Collaboration
http://www.utfit.org

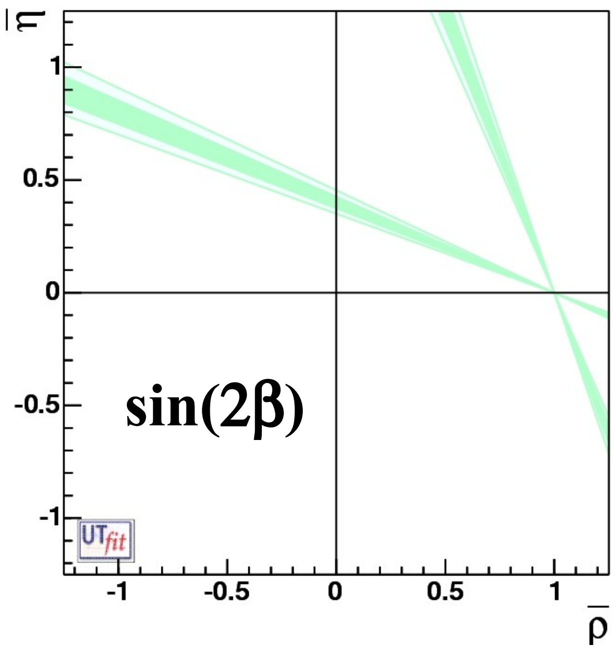
M. B., M. Ciuchini, E. Franco, V. Lubicz,
G. Martinelli, F. Parodi, M. Pierini, P. Roudeau,
C. Schiavi, L. Silvestrini, A. Stocchi, Vincenzo Vagnoni

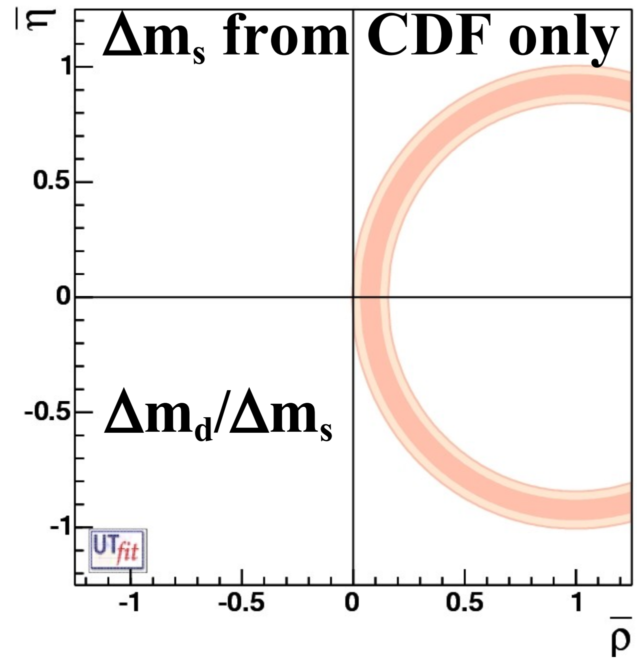
Classic constraints in the $\bar{\rho}$–$\bar{\eta}$ plane



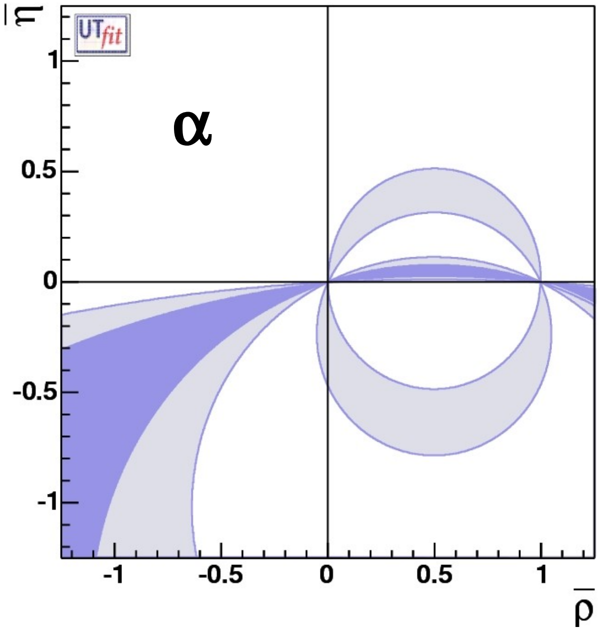


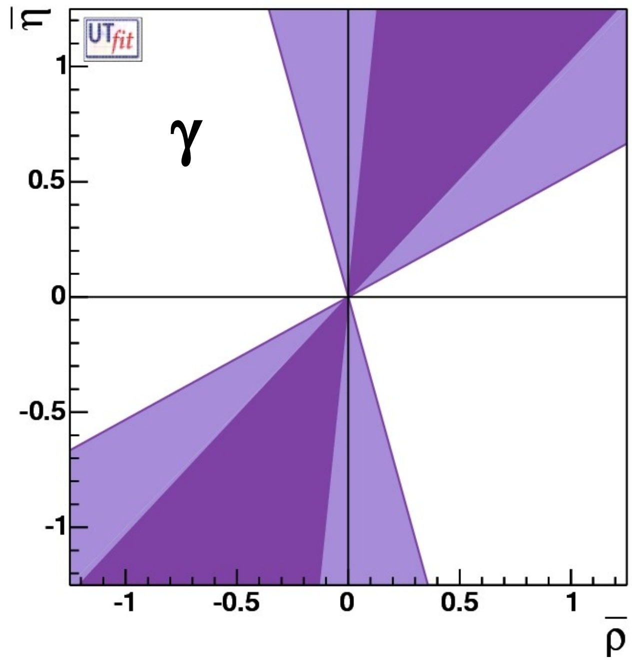


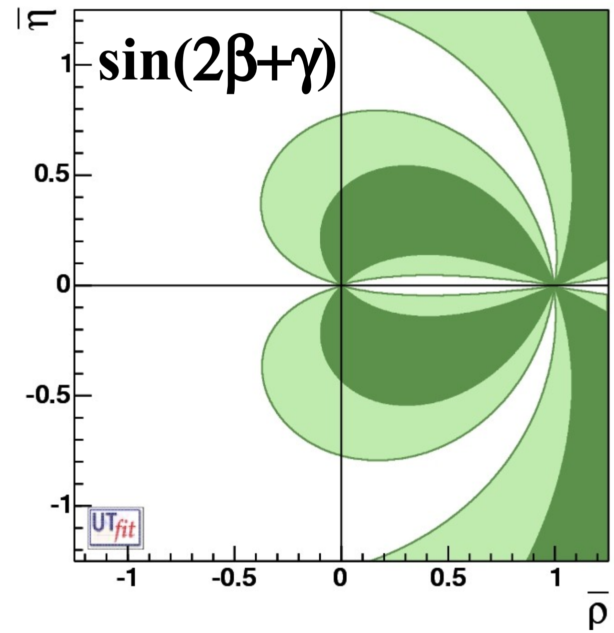


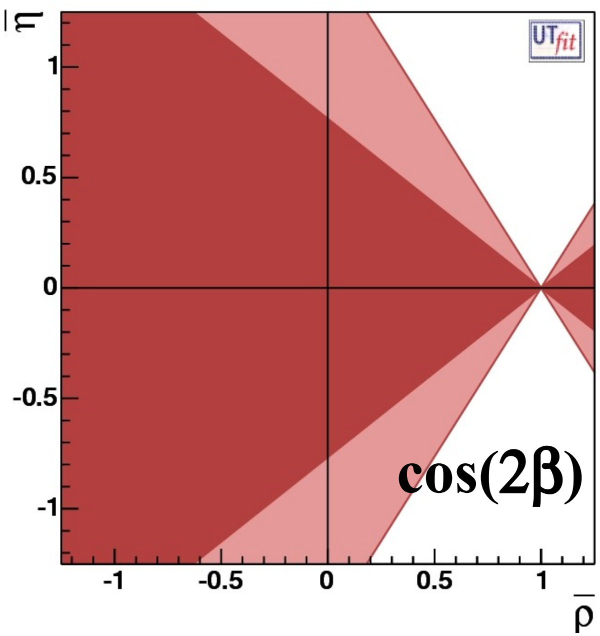


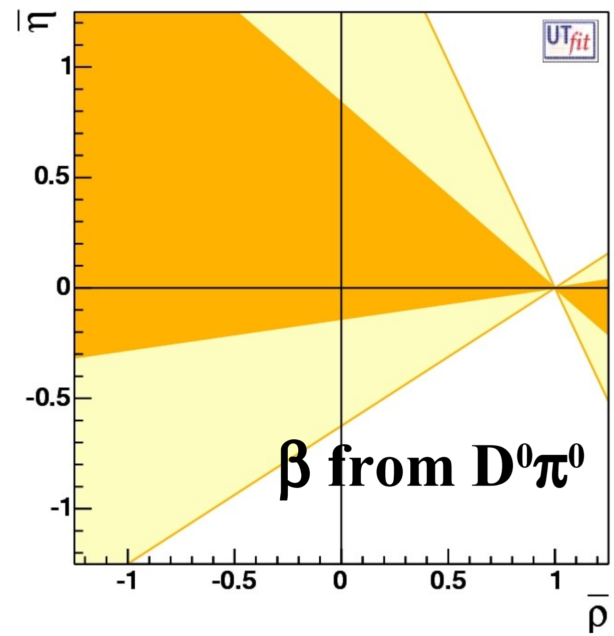
... and the other friends





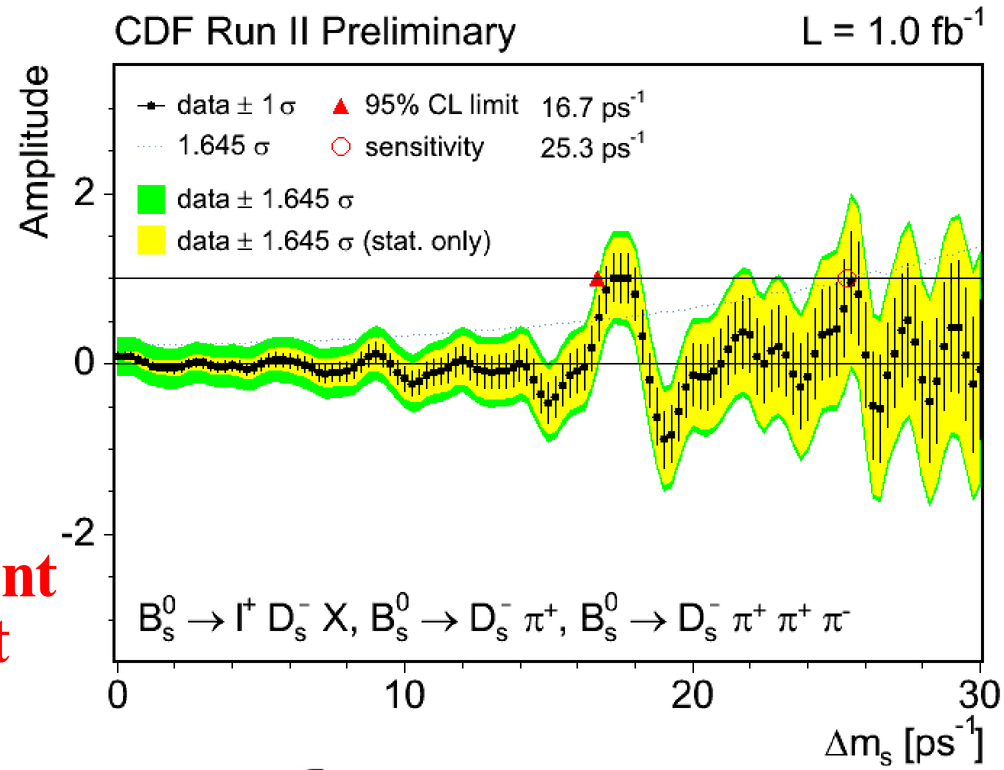




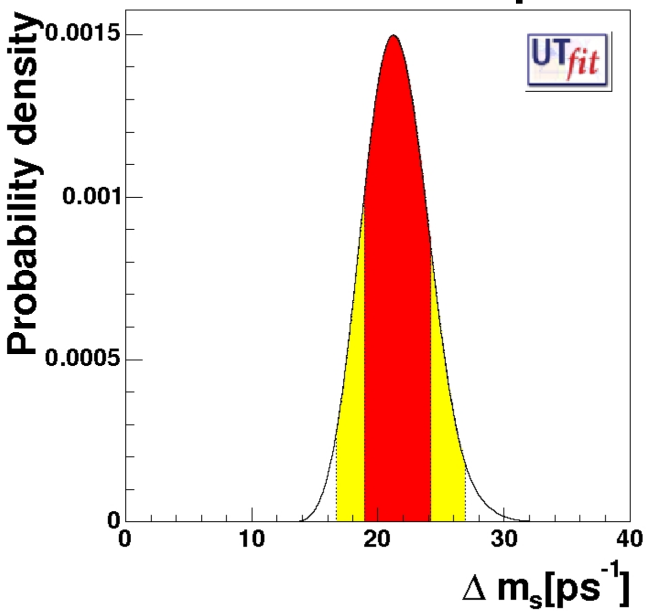


Crucial measurement of Δm_s from CDF

$\Delta m_s = 17.33^{+0.42}_{-0.21}(\text{stat}) \pm 0.07(\text{sys})$

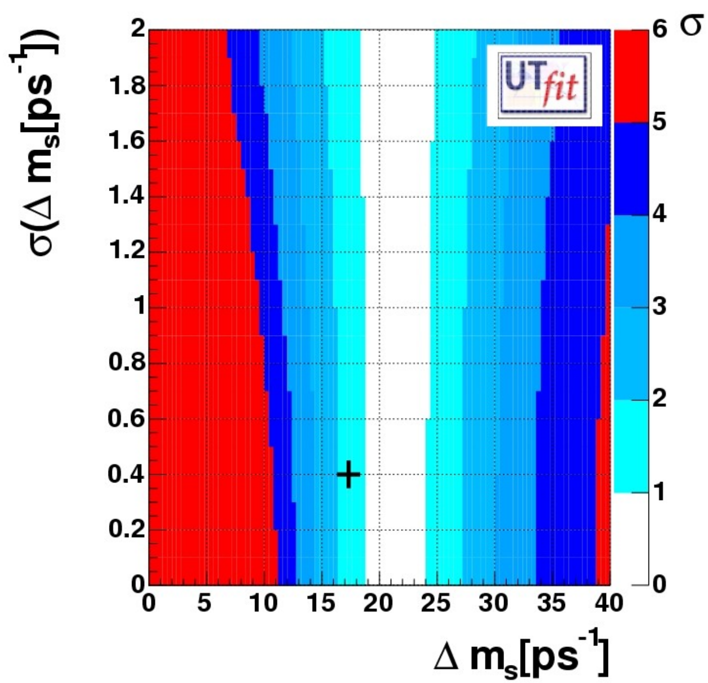


Δm_s prediction from SM UT fit without using the Δm_s measurements as input



$\Delta m_s = (21.5 \pm 2.6)\ \text{ps}^{-1}$

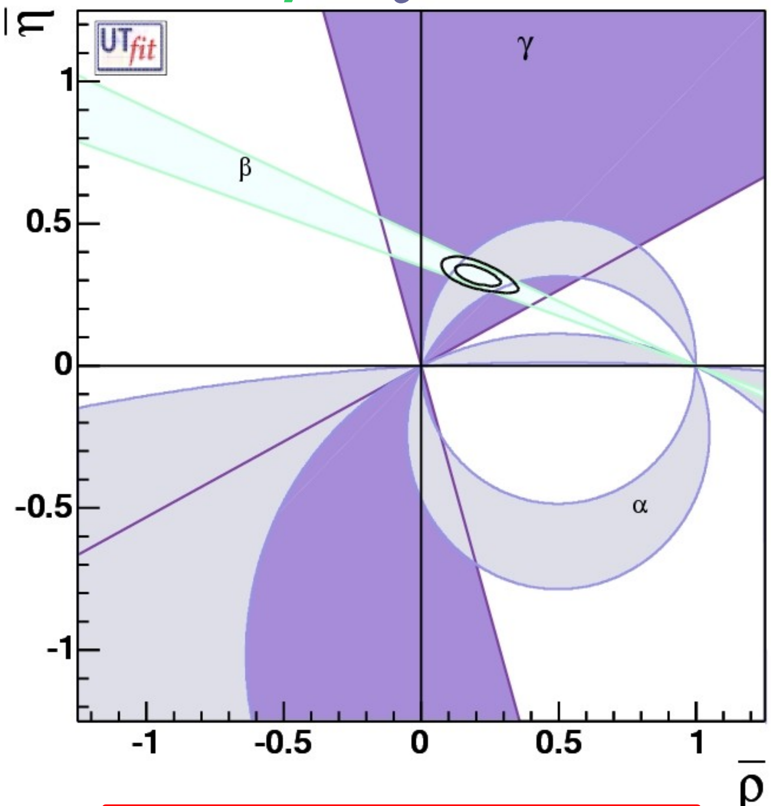
good agreement with the rest of the fit.



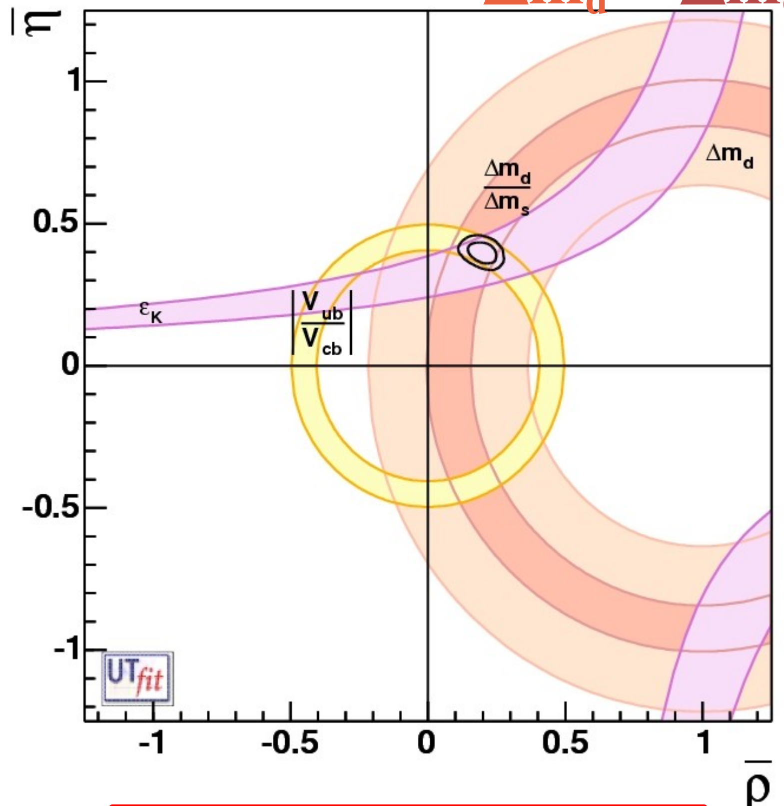
Once the basic test is done (agreement between prediction and measurement), Δm_s can be used to constrain the NP

Angles vs no angles

$\beta + \gamma + \alpha$



$\epsilon_K + V_{ub}/V_{cb} +$
$\Delta m_d + \Delta m_d/\Delta m_s$



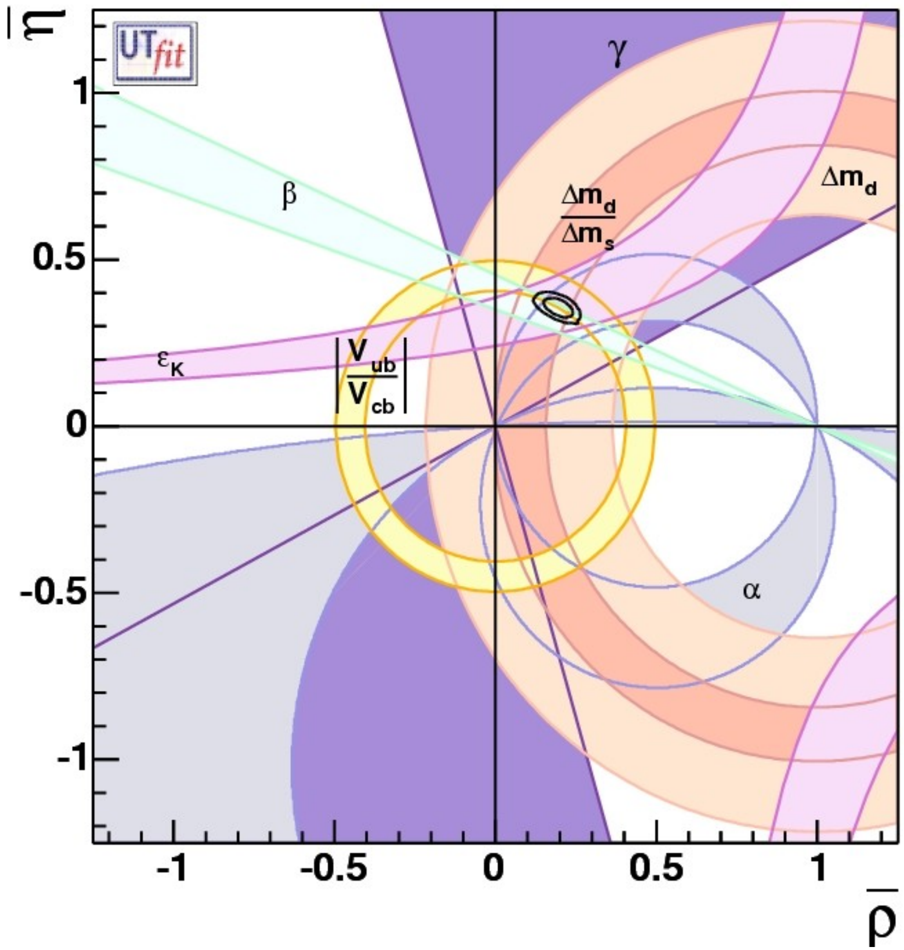
$\bar{\rho} = 0.204 \pm 0.055$

$\bar{\eta} = 0.317 \pm 0.025$

$\bar{\rho} = 0.197 \pm 0.035$

$\bar{\eta} = 0.389 \pm 0.025$

Fit results in Standard Model scenario



$\bar{\rho} = 0.197 \pm 0.031$

$\bar{\eta} = 0.351 \pm 0.020$

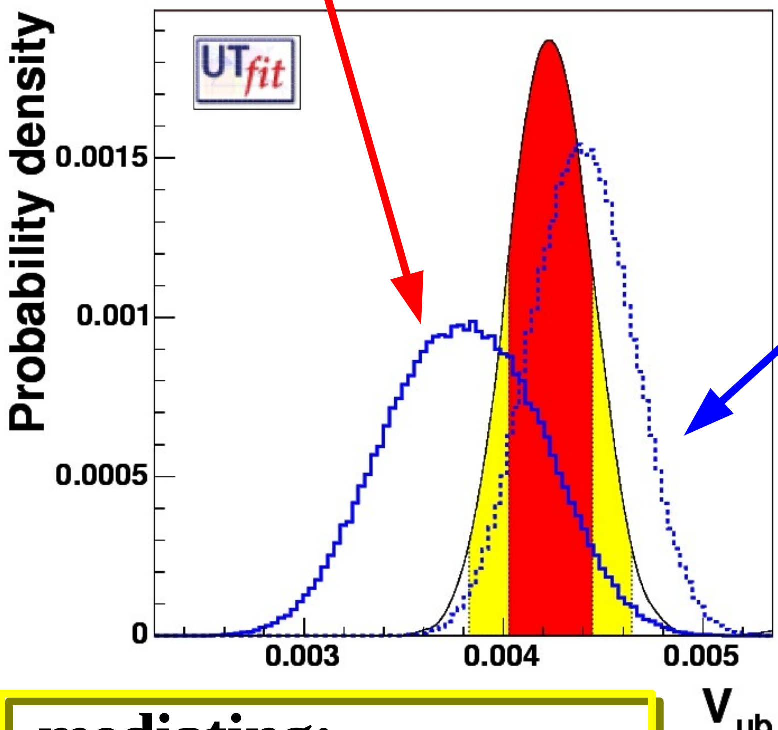
Clear tension in the fit between β and V_{ub}/V_{cb}

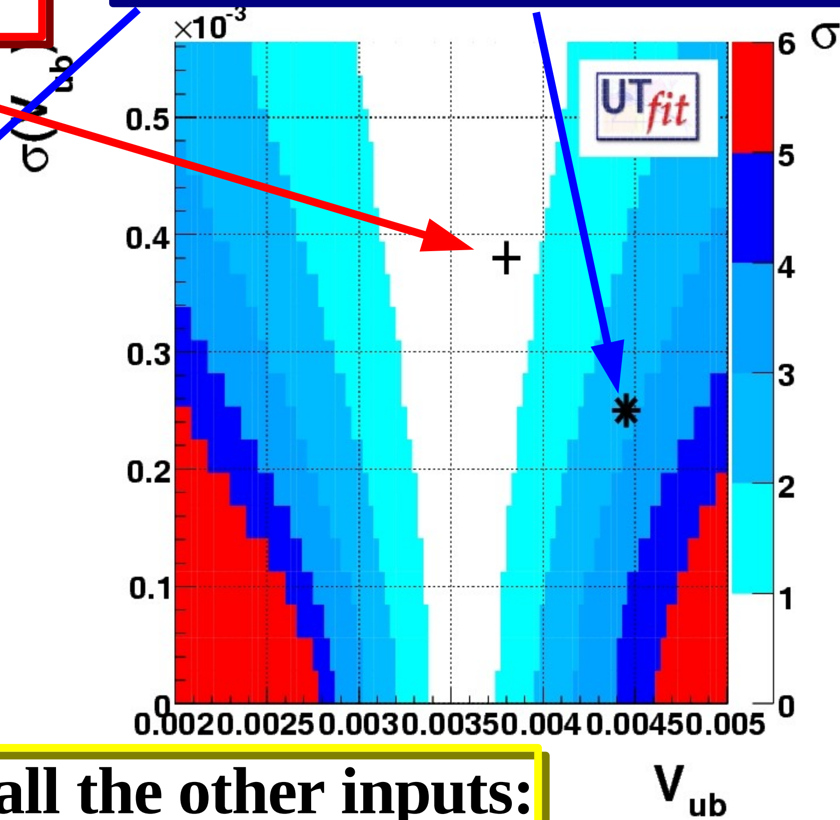
Slight inconsistence in the fit due to large value of V_{ub} from HFAG

V_{ub}

exclusive value:
semileptonic BRs from HFAG
form factors from quenched LQCD
$V_{ub} = (3.80 \pm 0.27 \pm 0.47)\ 10^{-3}$

inclusive value: from HFAG
$V_{ub} = (4.45 \pm 0.20 \pm 0.26)\ 10^{-3}$



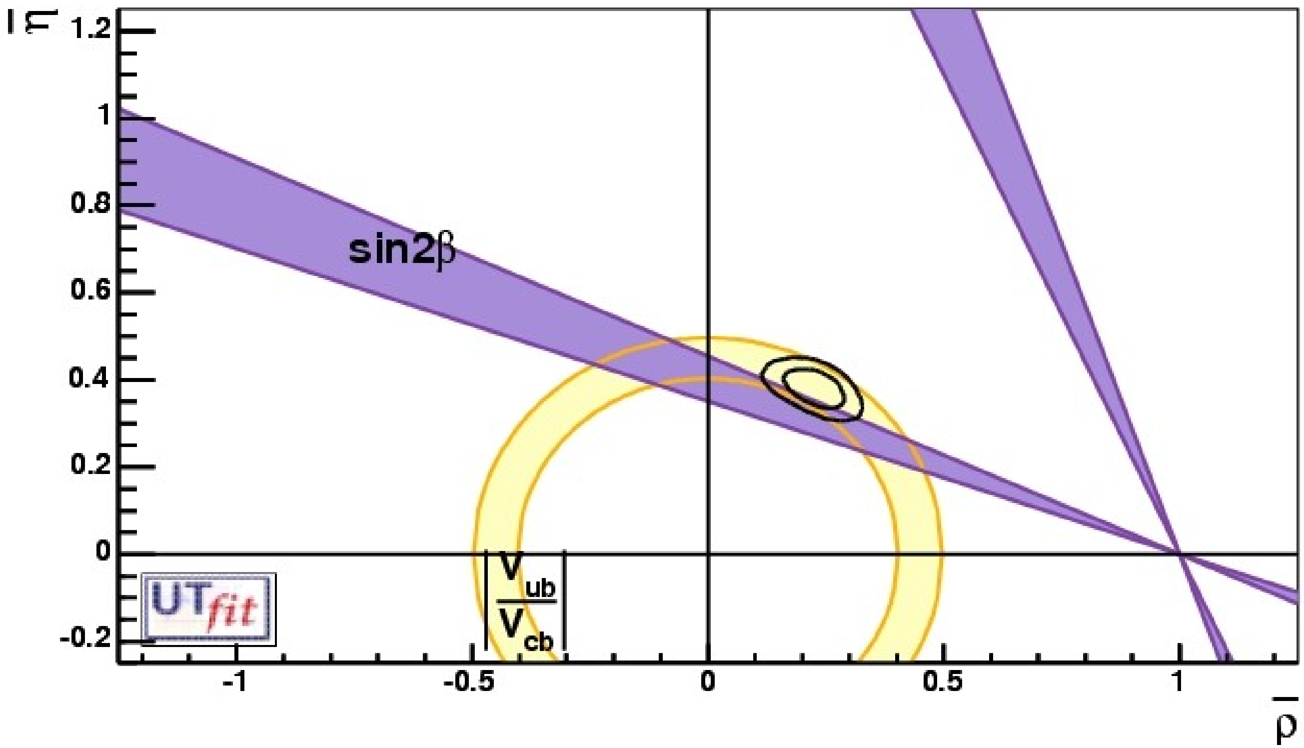


mediating:
$V_{ub} = (4.22 \pm 0.20)\ 10^{-3}$

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

Inconsistence in detail: $\sin 2\beta$ and V_{ub}

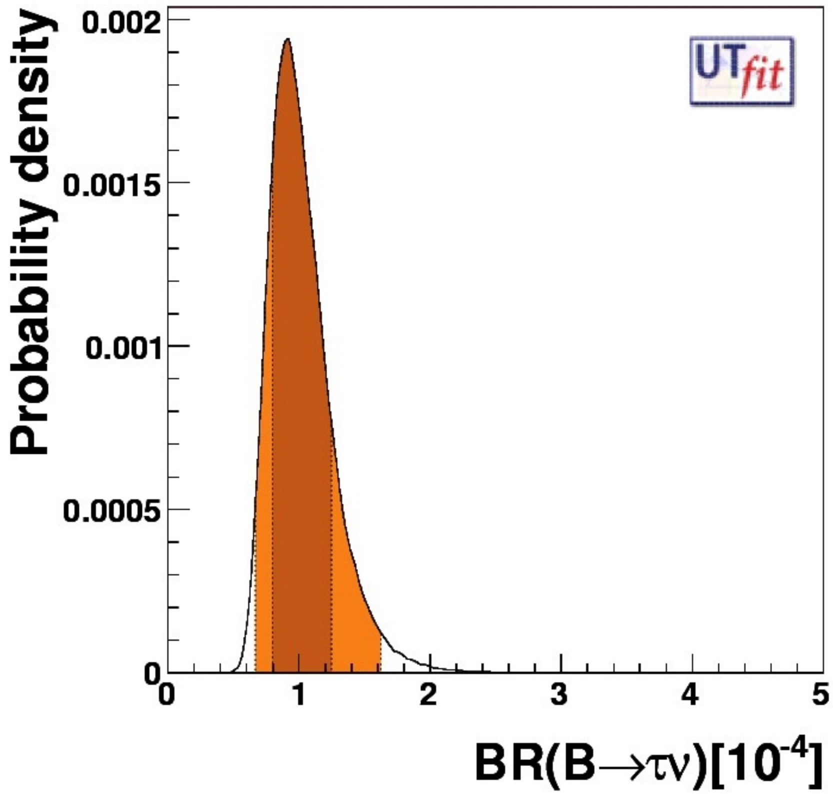
If we take it seriously, we need to go beyond the SM

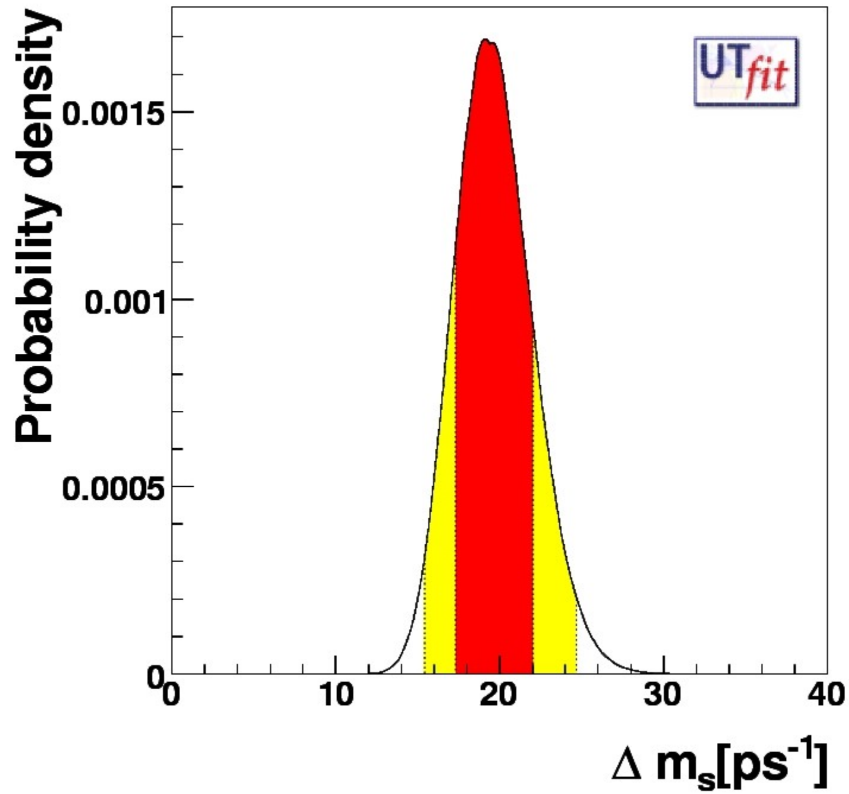


$\sin 2\beta = 0.687 \pm 0.032 \pm 0.013$
From direct measurement

$\sin 2\beta = 0.790 \pm 0.031$
from indirect determination

Indirect measurements "taking out" the tension





$$BR(B \to \tau\nu_\tau)_{\rm All} = (1.41 \pm 0.33) \times 10^{-4}$$
$$BR(B \to \tau\nu_\tau)_{V_{ub}-\rm excl} = (1.02 \pm 0.22) \times 10^{-4}$$
$$BR(B \to \tau\nu_\tau)_{V_{ub}-\rm incl} = (1.53 \pm 0.41) \times 10^{-4}$$

$$\Delta m_s\ ({\rm All}) = (21.3 \pm 2.7){\rm ps}^{-1}$$
$$\Delta m_s\ (V_{ub} - {\rm excl}) = (19.4 \pm 2.5){\rm ps}^{-1}$$
$$\Delta m_s\ (V_{ub} - {\rm incl}) = (21.7 \pm 2.8){\rm ps}^{-1}$$

Fit with NP-independent constraints

using Tree-level processes assumed to be NP free

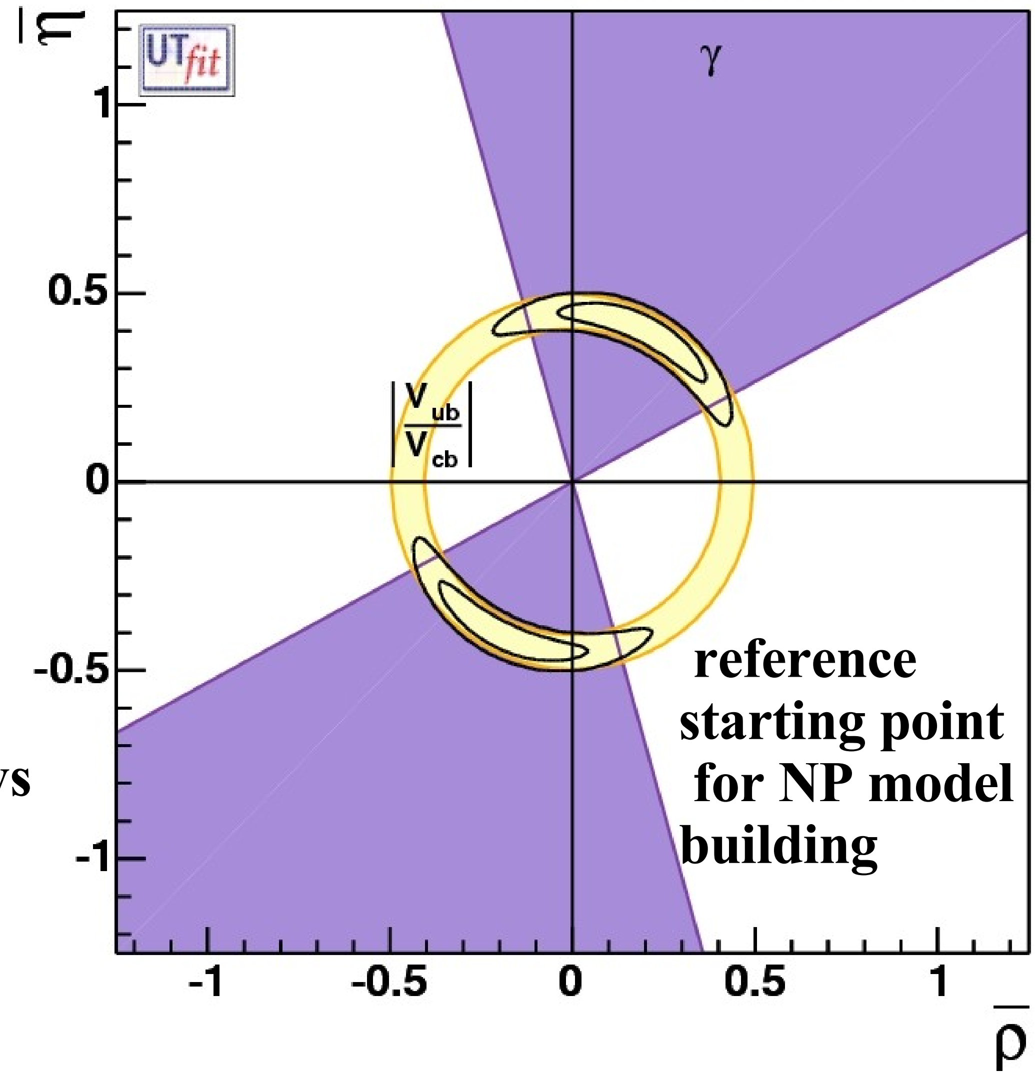
******the effect of the D0-D0 mixing is negligible wrt the actual error***

$$\bar{\rho} = \pm\, 0.18 \pm 0.11$$

$$\bar{\eta} = \pm\, 0.41 \pm 0.05$$

very important to improve:

- V_{ub}/V_{cb} from semileptonic decays
- <u>γ from tree level processes</u>



New Physics model independent parametrization in |ΔF|=2 transitions

The mixing processes being characterized by a single amplitude, they can be parametrized in a general way by means of two parameters

$$C_{B_q} e^{2i\phi_{B_q}} = \frac{\langle B_q^0 | H_{eff}^{full} | \bar{B}_q^0 \rangle}{\langle B_q^0 | H_{eff}^{SM} | \bar{B}_q^0 \rangle} \qquad q = d,\ s$$

- H^{SM}_{eff} includes only SM box diagrams while H^{full}_{eff} includes New Physics contributions as well

Four “independent” observables (C=1, ϕ=0 in SM)

- C_{Bd}, ϕ_{Bd}, C_{Bs}, ϕ_{Bs}

For the neutral kaon mixing case, it is convenient to introduce only one parameter

$$C_{\varepsilon_K} = \frac{\mathrm{Im}\langle K^0 | H_{eff}^{full} | \bar{K}^0 \rangle}{\mathrm{Im}\langle K^0 | H_{eff}^{SM} | \bar{K}^0 \rangle}$$

5 additional parameters

- Δm_K is not considered since the long distance effects are not well controlled

Allowing for NP in |ΔF|=2 transitions the additional parameters are left free in the fit

$$\Delta m_d^{exp} = C_{B_d} \Delta m_d^{SM}$$

$$\Delta m_s^{exp} = C_{B_s} \Delta m_s^{SM}$$

$$\beta^{exp} = \beta^{SM} + \phi_{B_d}$$

$$\alpha^{exp} = \alpha^{SM} - \phi_{B_d}$$

$$\chi^{exp} = \chi^{SM} - \phi_{B_s}$$

$$\varepsilon_K^{exp} = C_{\varepsilon_K} \varepsilon_K^{SM}$$

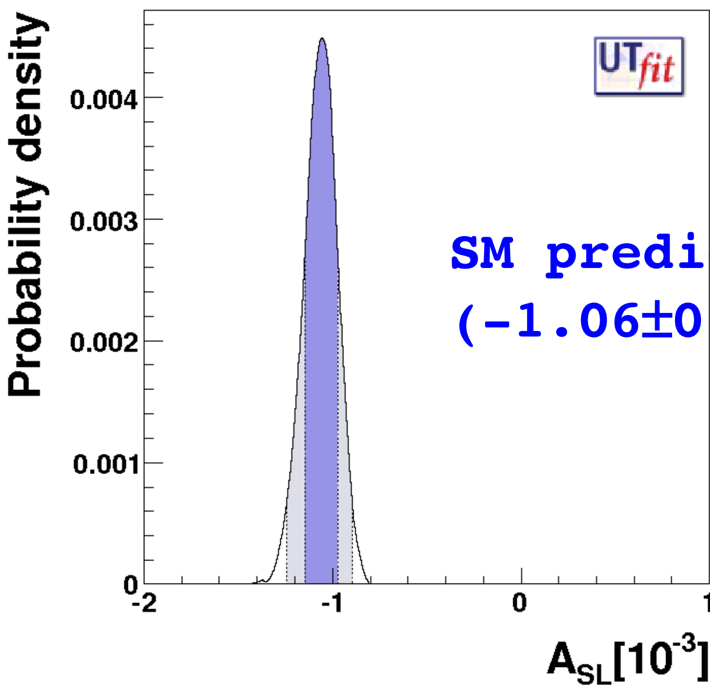
	ρ, η	C_{Bd}, ϕ_{Bd}	$C_{\varepsilon K}$	C_{Bs}, ϕ_{Bs}
V_{ub}/V_{cb}	X			
γ (DK)	X			
ε_K	X		X	
sin2β	X	X		
Δm_d	X	X		
α (ρρ, ρπ, ππ)	X	X		
A_{SL} B_d	X	X		
Δm_s				X
A_{CH}		X		X

A_{SL} in B_d decays

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

$$= -{\rm Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\sin 2\phi_{B_d}}{C_{B_d}} + {\rm Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\cos 2\phi_{B_d}}{C_{B_d}}$$

This is the only observable that is sensitive to NP effect on both the size and the phase of B mixing



SM prediction
$(-1.06\pm0.09)10^{-3}$

Direct measurement
$(-0.3\pm5.0)10^{-3}$
Larger Values in case of contribution from New Physics

μμ asymmetry in $B_{d,s}$ decays from D0

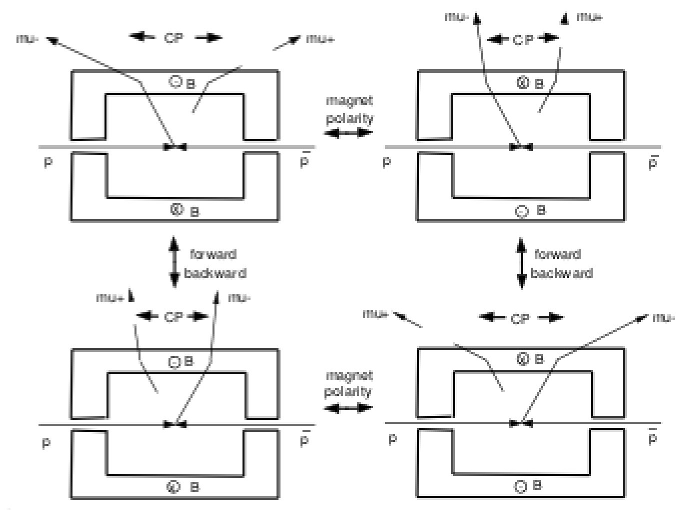
$$A = \frac{(\chi - \bar{\chi})(P_1 - P_3 + 0.3P_8')}{\xi(P_1 + P_3) + (1-\xi)P_2 + 0.28\cdot P_7 + 0.5\cdot P_8' + 0.69\cdot P_{13}} = (-1.3 \pm 1.2 \pm 0.8)10^{-3}$$

$$\chi = f_d \frac{\beta_d}{\langle\beta\rangle}\chi_d + f_s \frac{\beta_s}{\langle\beta\rangle}\chi_s$$

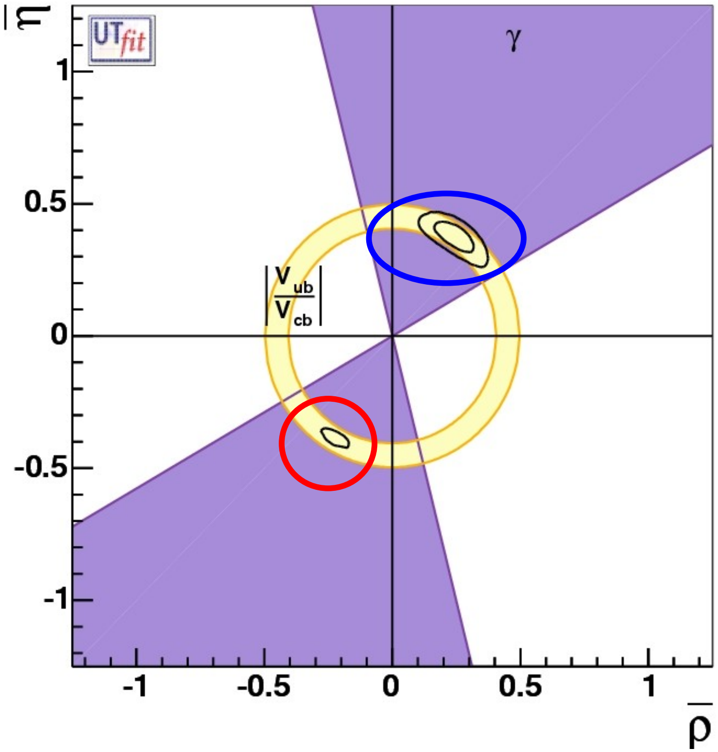
$$\bar{\chi} = f_d \frac{\beta_d}{\langle\beta\rangle}\bar{\chi}_d + f_s \frac{\beta_s}{\langle\beta\rangle}\chi_s$$

admixture of B_d and B_s
dependent on $\bar{\rho}$ and $\bar{\eta}$
and on NP effects
(C_{Bd}, ϕ_{Bd}, C_{Bs}, ϕ_{Bs})

First available bound on
$\overline{B}$s-Bs mixing phase!!!



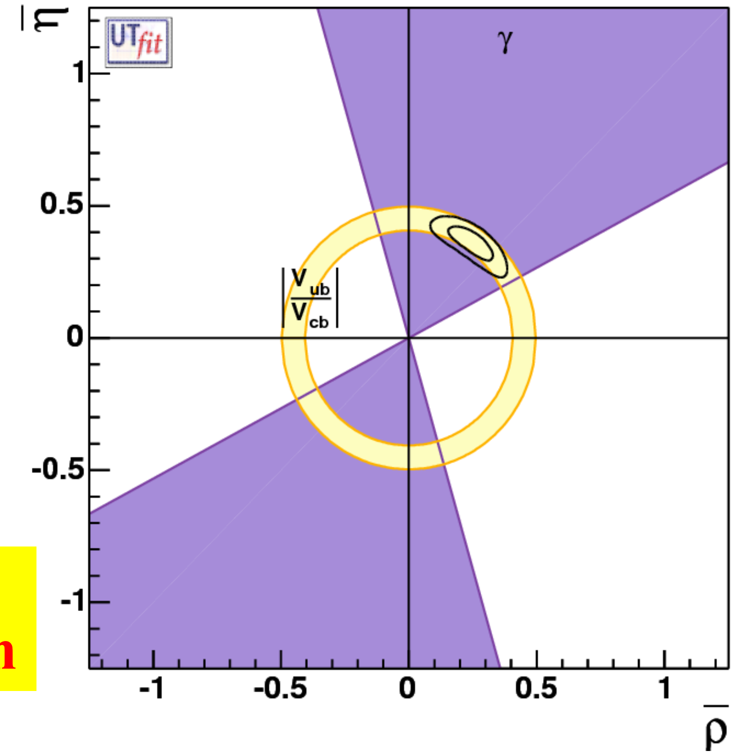
Asymmetry effects in the detector (P's) studied with different configurations of magnetic filed



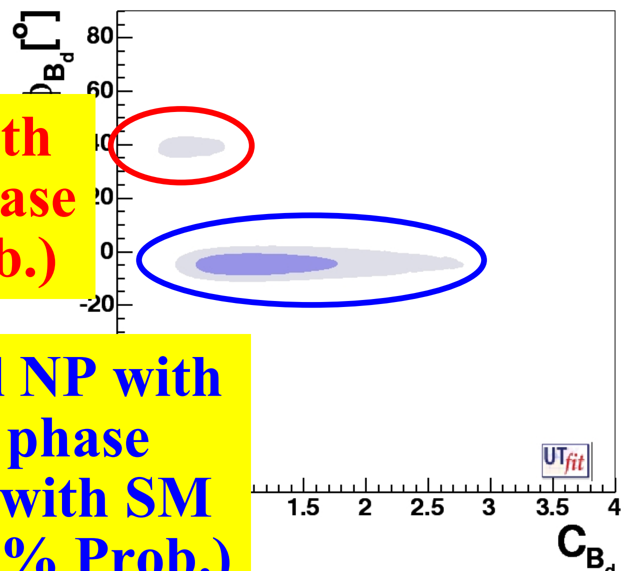
Switching on NP

← 2005

2006 →

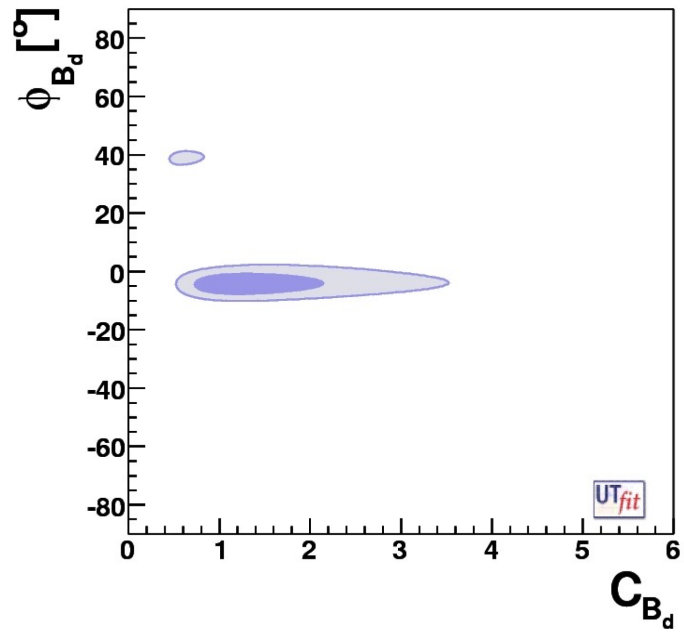


no more second solution

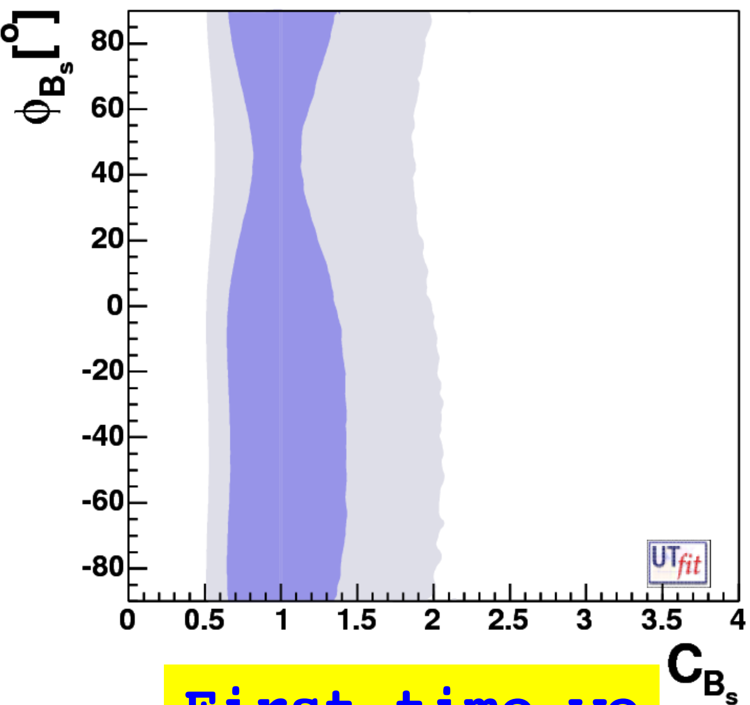


large NP with arbitrary phase (~4.3% Prob.)

SM or small NP with arbitrary phase or large NP with SM phase (~95.7% Prob.)

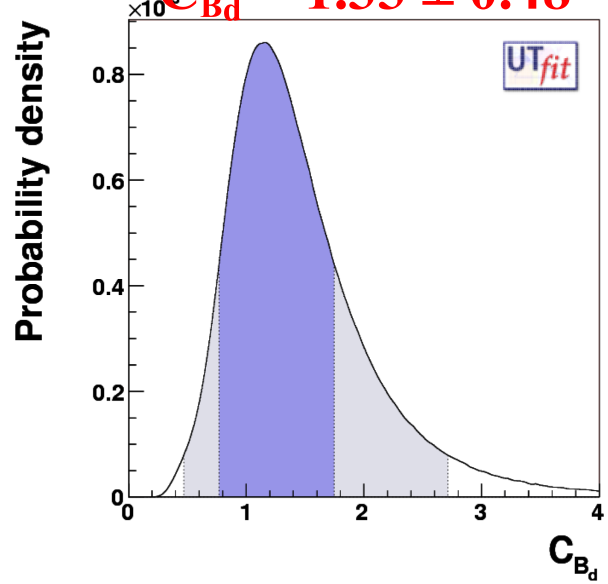


bounds on NP parameters

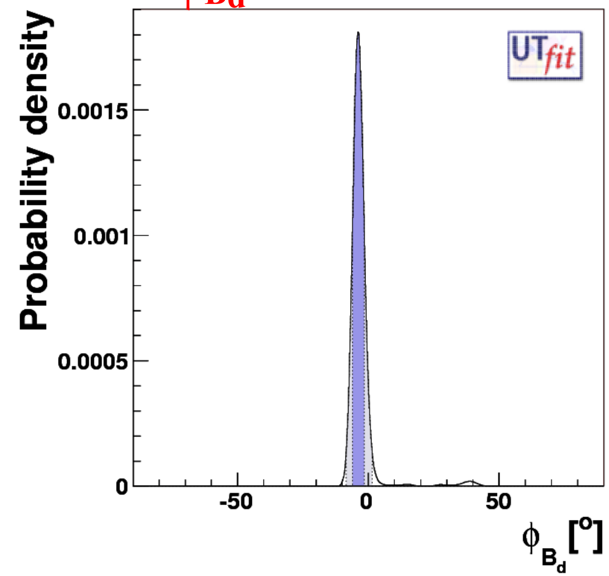


First time we can bound NP in Bs

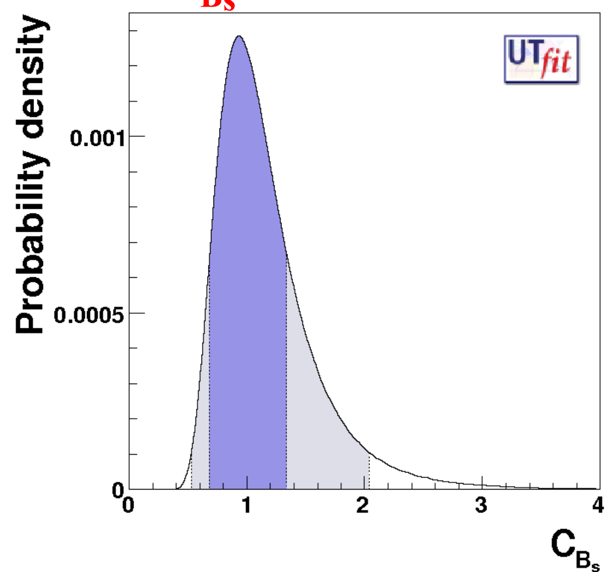
$C_{Bd} = 1.33 \pm 0.48$



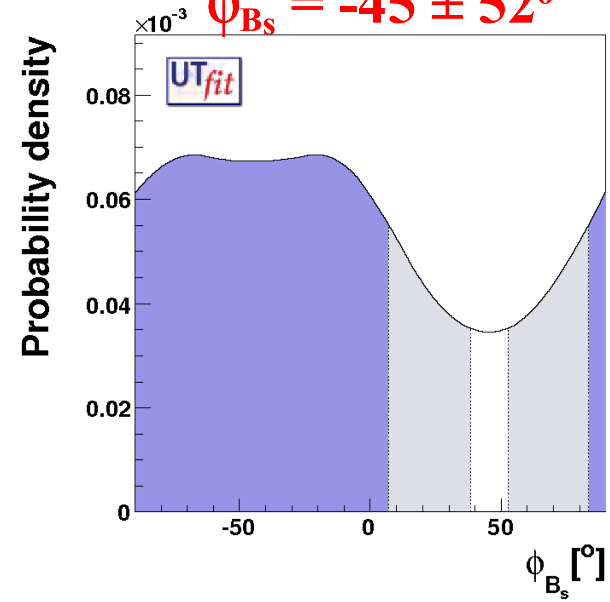
$\phi_{Bd} = -4.2 \pm 2.2^o$



$C_{Bs} = 1.10 \pm 0.33$



$\phi_{Bs} = -45 \pm 52^o$



Fla

What to say/hope then?

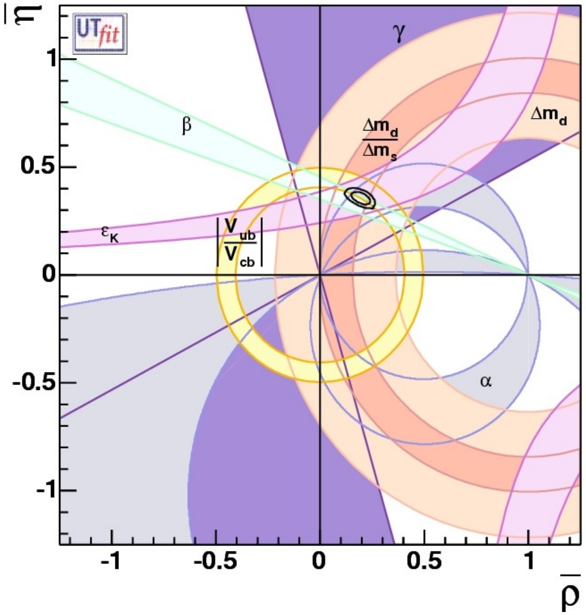
New Physics in the $b \to d$ sector (now also in the $b \to s$) starts to be quite constrained and most probably will not come as an alternative to the CKM picture, but rather as a «correction»

Basically two scenarios

Minimal Flavour Violation: the only source of flavour violation is in the SM Yukawa couplings (implies $\phi=0$)

New Physics couplings between third and second families ($b \to s$ sector) are stronger with respect to the $b \to d$ ones (?)

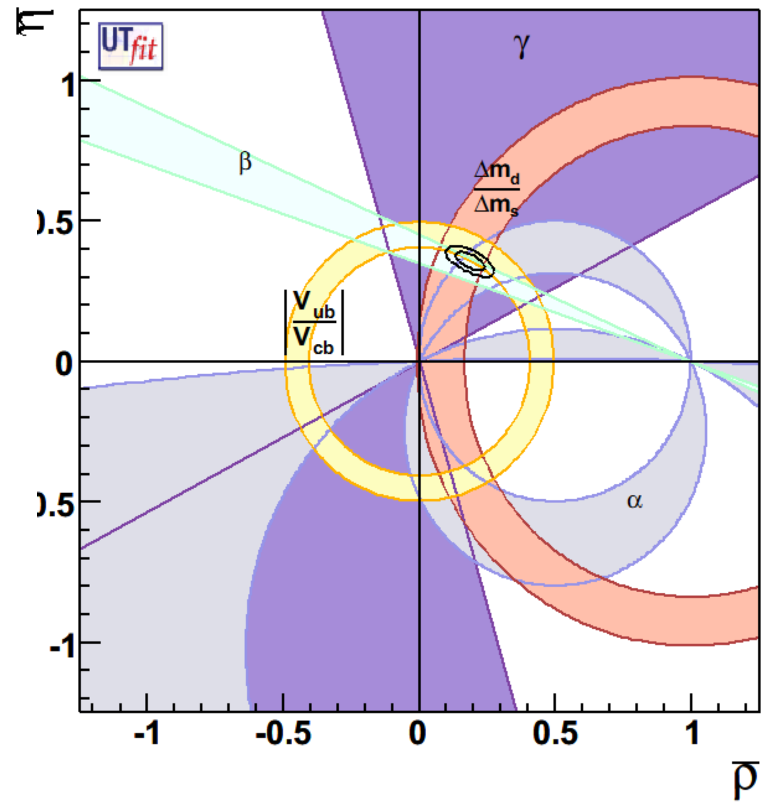
Flavour physics needs to improve existing measurements in the B_d sector and perform precise measurement in the B_s sector



Universal Unitarity Triangle (UUT)

comparable precision

Parameter	Output	Parameter	Output
$\bar{\rho}$	0.187 ± 0.037	$\bar{\eta}$	0.357 ± 0.023
$\alpha[^\circ]$	93.7 ± 6.0	$\beta[^\circ]$	23.7 ± 1.0
$\gamma[^\circ]$	62.3 ± 5.7	Δm_s [ps^{-1}]	20.4 ± 5.6
$\sin 2\beta$	0.735 ± 0.023	Imλ_t [10^{-5}]	14.5 ± 0.9
$V_{ub}[10^{-3}]$	3.94 ± 0.15	$V_{cb}[10^{-2}]$	4.19 ± 0.07
$V_{td}[10^{-3}]$	8.4 ± 0.4	$\|V_{td}/V_{ts}\|$	0.204 ± 0.009
R_b	0.405 ± 0.015	R_t	0.887 ± 0.040



Conclusions (I)

- **A large set of new bounds from B factories allows over-constraining the Unitarity Triangle**
  - Standard Model is "sadly" showing an impressive consistency in the CKM sector
  - If NP will show up, it will appear as a correction to the SM rather than as a revolution
  - The only tension in the fit comes from a slight disagreement between $\sin 2\beta$ and V_{ub}
- **B_s mixing magnitude from CDF puts another milestone to the hope for large NP contributions**
  - even if the mixing phase still remains open

Conclusions (II)

- By using only the constraints from $|V_{ub}|/|V_{cb}|$ and γ, we have a ("NP free") tree level determination of ρ and η
  - This is a starting reference point for NP model building, since all the NP models have to agree with it
- Adopting a NP model independent parametrization, we fit SM (ρ and η) and NP (corrections to SM in mixing amplitudes and phases) together
  - Constributions of NP to the B_d mixing phase are already very constrained
    - → same phase of SM
- Still NP hunting hope in b→s penguins and B_s mixing phase
- Also with the mixing magnitudes, a crucial point is the reduction of uncertainties in lattice quantities