UT*fit* : 10th anniversary update
2000-2010

UT*fit*

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INFN Roma Tre

Third Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics
July 5-7 2010, Capri, Italy

The UTfit Collaboration

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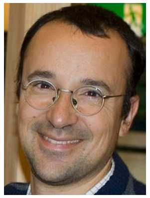

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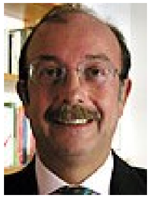

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cnrs dépasser les frontières

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The UTfit analyses

i) **SM**: UT+predictions ($\sin 2\beta$, Δm_s, β_s, BR($B \to \tau\nu$), etc.)
lattice parameters (B_K, f_{Bs}, B_{Bs}, f_{Bs}/f_{Bd}, B_{bs}/B_{Bd})

ii) **NP**: UT+$\Delta F=2$ NP amplitude parameters
UUT+MFV (low and high $\tan\beta$) scale
generic NP scale analysis
BR($B \to \tau\nu$) in the 2HDM and MSSM

Anniversary gift:

- new site at www.utfit.org (soon)
- all analyses enhanced & updated

Results of the SM analysis

preliminary Summer '10

SM determination of the Unitarity Triangle

$R_u\, e^{i\gamma} + R_t\, e^{-i\beta} = 1$

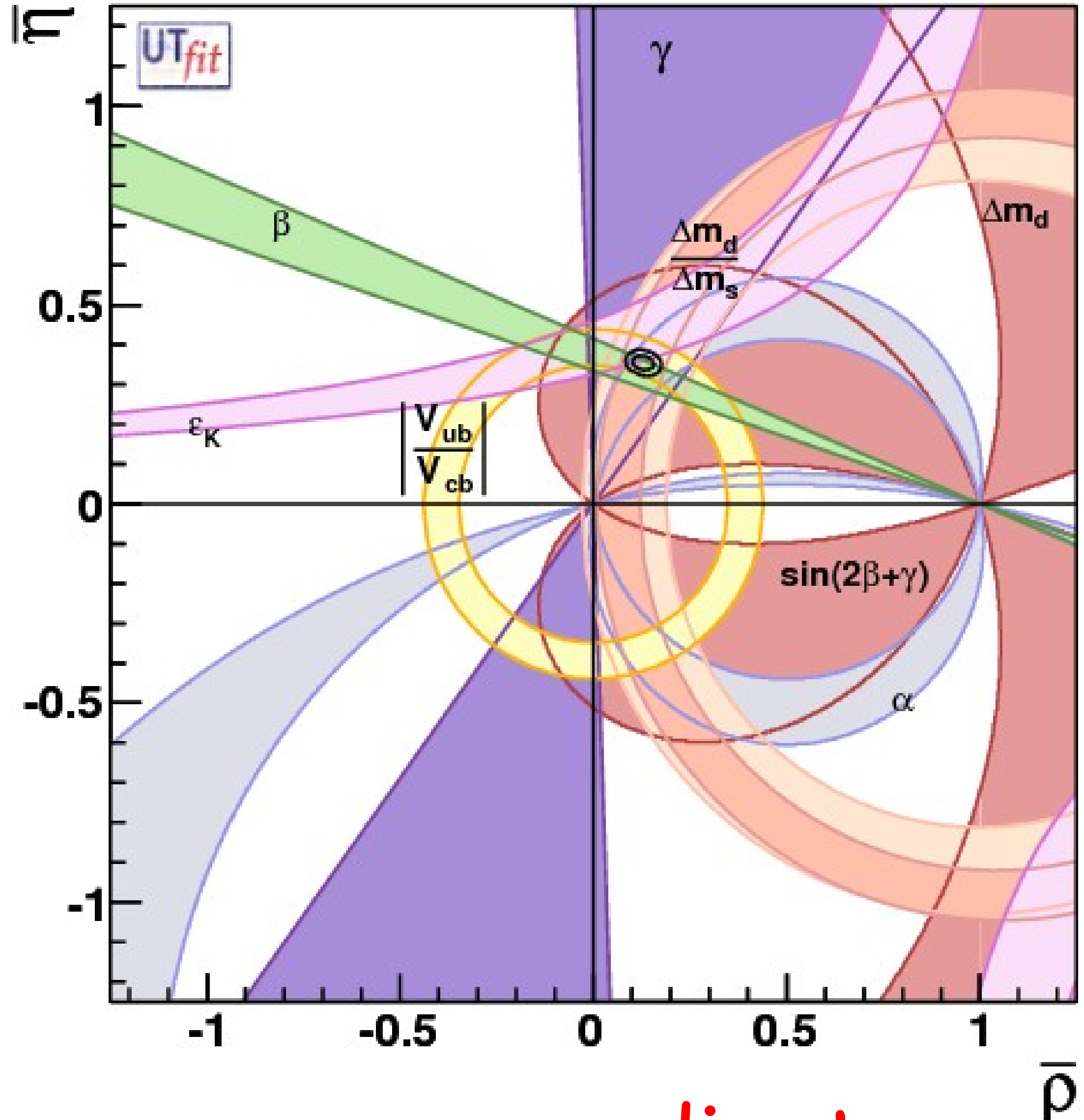
$R_u = 0.379 \pm 0.013$

$R_t = 0.939 \pm 0.021$

$\gamma = (69.8 \pm 3.1)^\circ$

$\beta = (22.15 \pm 0.75)^\circ$

$\alpha = (87.8 \pm 3.0)^\circ$



apex coordinates

$\bar{\rho} = 0.130 \pm 0.021$

$\bar{\eta} = 0.355 \pm 0.013$

The CKM matrix

$$\begin{pmatrix} 0.9742(2) & 0.2255(6) & 3.6(1)\cdot 10^{-3} e^{-i\,70(3)^\circ} \\ -0.2253(6) e^{i\,0.034(1)^\circ} & 0.9734(2) e^{-i\,0.0018(1)^\circ} & 4.12(4)\cdot 10^{-2} \\ 8.7(2)\cdot 10^{-3} e^{-i\,22.1(7)^\circ} & -4.04(4)\cdot 10^{-2} e^{i\,1.08(4)^\circ} & 0.99915(2) \end{pmatrix}$$

Standard parametrization (PDG)

$\sin\Theta_{12} = 0.2255 \pm 0.0006$ $\sin\Theta_{23} = (4.115 \pm 0.045)\cdot 10^{-2}$

$\sin\Theta_{13} = (3.61 \pm 0.12)\cdot 10^{-3}$ $\delta = (69.9 \pm 3.0)^\circ$

Wolfenstein parametrization

$\lambda = 0.2255 \pm 0.0006$ $A = 0.81 \pm 0.01$

$\rho = 0.132 \pm 0.021$ $\eta = 0.364 \pm 0.013$

SM predictions: B_d & K

	Prediction	Measurement	Pull(σ)
$\sin 2\beta$	0.761 ± 0.034	0.654 ± 0.026	+2.5
γ	$(69.8 \pm 3.1)^\circ$	$(73 \pm 11)^\circ$	< 1
α	$(86 \pm 4)^\circ$	$(94 \pm 7)^\circ$	-1.0
$\lvert V_{cb}\rvert \cdot 10^3$	42.6 ± 1.0	40.8 ± 0.5	+1.6
$\lvert V_{ub}\rvert \cdot 10^3$	3.59 ± 0.15	3.94 ± 0.26	-1.2
$\varepsilon_K \cdot 10^3$	1.894 ± 0.180	2.229 ± 0.010	-1.9
$B(B \to \tau\nu)$	$(79 \pm 7) \cdot 10^{-6}$	$(172 \pm 28) \cdot 10^{-6}$	-3.2

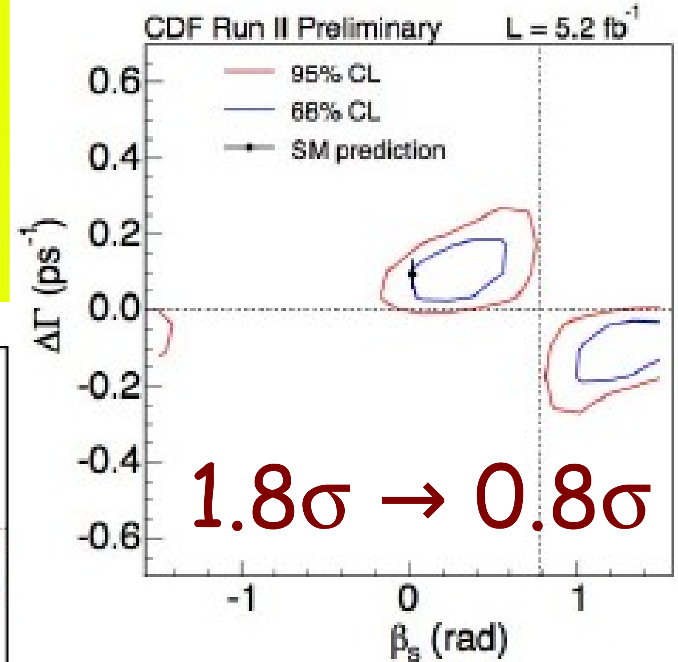
* the theory error in $\sin 2\beta$ from $B \to J/\Psi K$ is small and fully under control. A conservative bound obtained from data is included in the analysis
* $BR(B \to \tau\nu)$ wants a large $|V_{ub}|$. Its theoretical uncertainty, due to f_B, is controlled by the fit
* the ε_K deviation is triggered by improvements in B_K from the lattice and the inclusion of the ξ term à la Buras-Guadagnoli(+Isidori). Yet the ε_K formula is not under control at the few percent level
* $|V_{ub}|$ from semileptonic decays is debatable (incl. vs excl., models, f.f.,…). Yet a simple shift of the central value cannot reconcile $\sin 2\beta$ and $BR(B \to \tau\nu)$ (and ε_K)

SM predictions: B_s

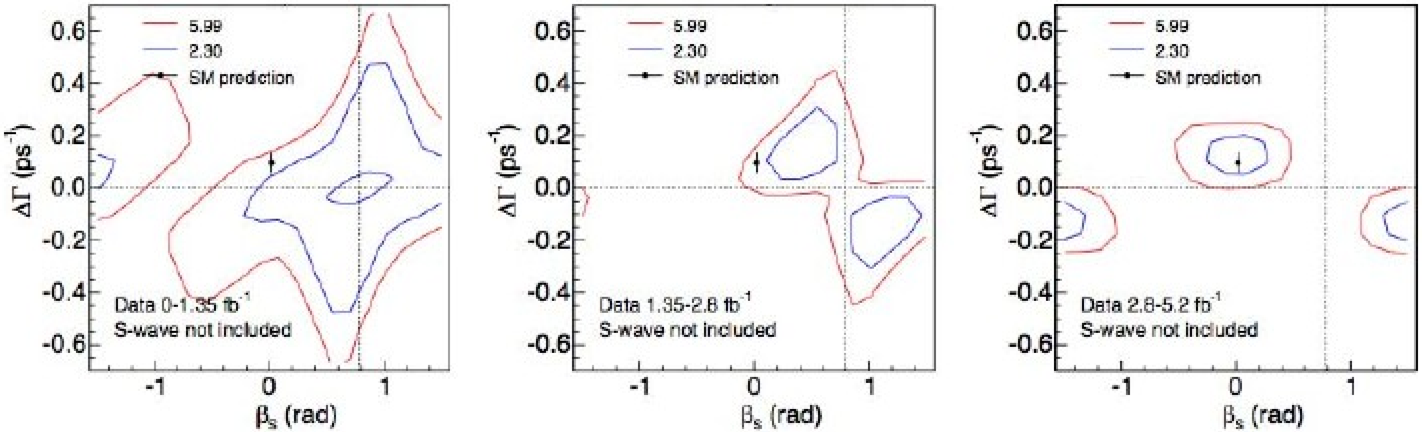
	Prediction	Measurement	Pull(σ)
Δm_s [ps^{-1}]	18.3 ± 1.2	17.77 ± 0.12	< 1
β_s	$(1.08 \pm 0.04)^\circ$	Tevatron	2.1
$\Delta\Gamma_s$ [ps^{-1}]	0.11 ± 0.02	average	0.0^*
$a^s_{SL} \cdot 10^5$	1.7 ± 0.4	-170 ± 910	< 1
$a_{\mu\mu} \cdot 10^4$	-1.7 ± 0.5	-95.7 ± 29.0	3.2

New CDF measurement of β_s–$\Delta\Gamma_s$ not included yet

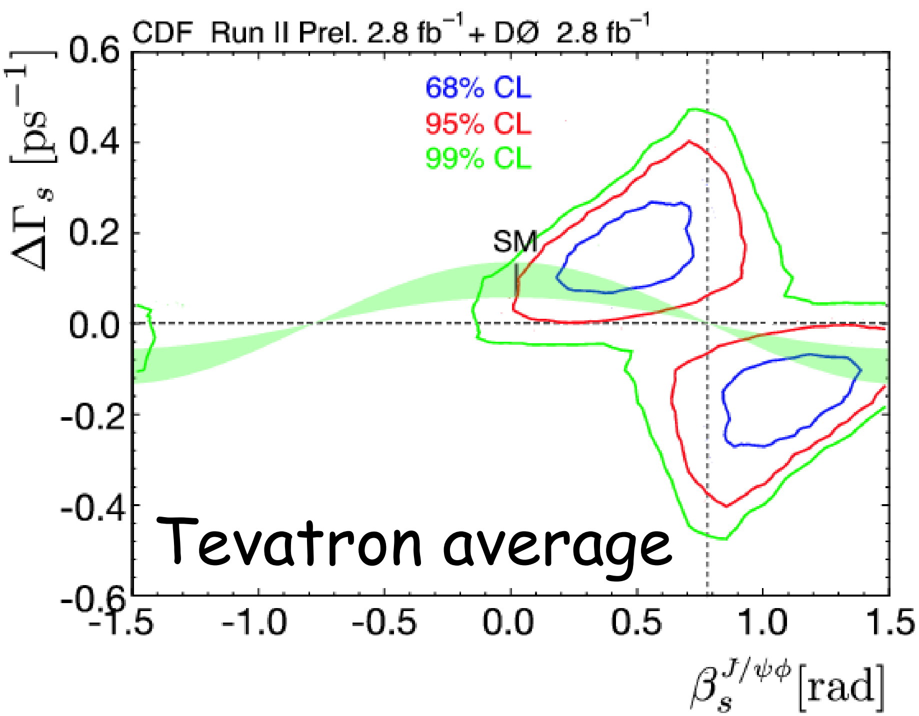
2010: “Great confusion under the sky”



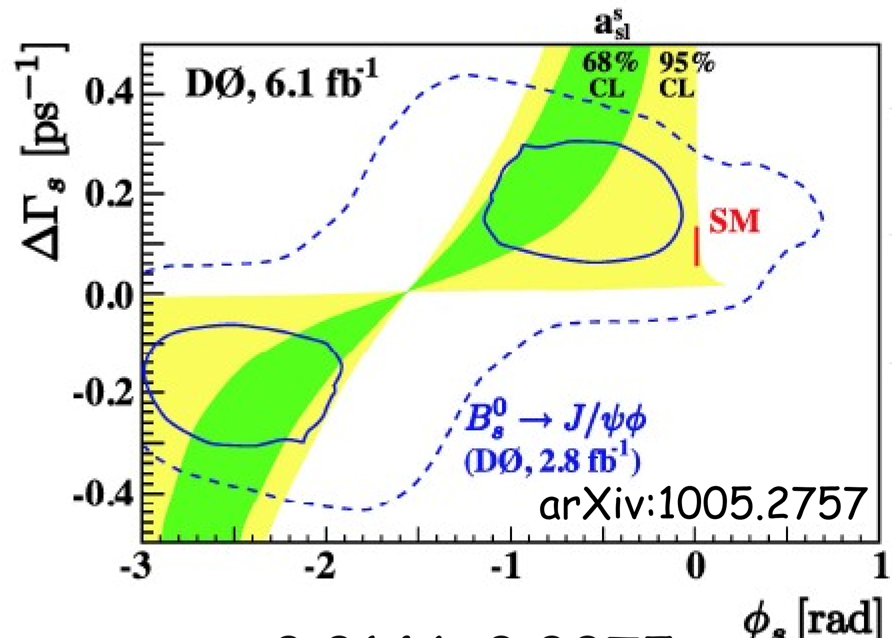
1.8σ → 0.8σ



CDF@FPCP '10



Tevatron average



arXiv:1005.2757

$a_{\mu\mu} \to a^s_{SL} = -0.0146 \pm 0.0075$

* the new CDF measurement of $B_s \to J/\Psi\phi$ reduces the significance of the deviation, but large values are still possible. The likelihood is not available yet, a CDF Bayesian study is also underway
* the new DØ measurement of $a_{\mu\mu}$ points to large β_s, but also to a large $\Delta\Gamma_s$ requiring a non-standard Γ_{12}. If confirmed, two options (both unlikely IMO):
  i. huge (tree-level-like) NP contributions to Γ_{12}: needed a factor ~2.5 (question: why in Γ_{12} only?)
  ii. bad failure of the OPE for Γ_{12}. Yet no evidence of it in lifetimes. If true, can we trust semileptonic decays to ~5% level or less?

UT parameters in the presence of NP

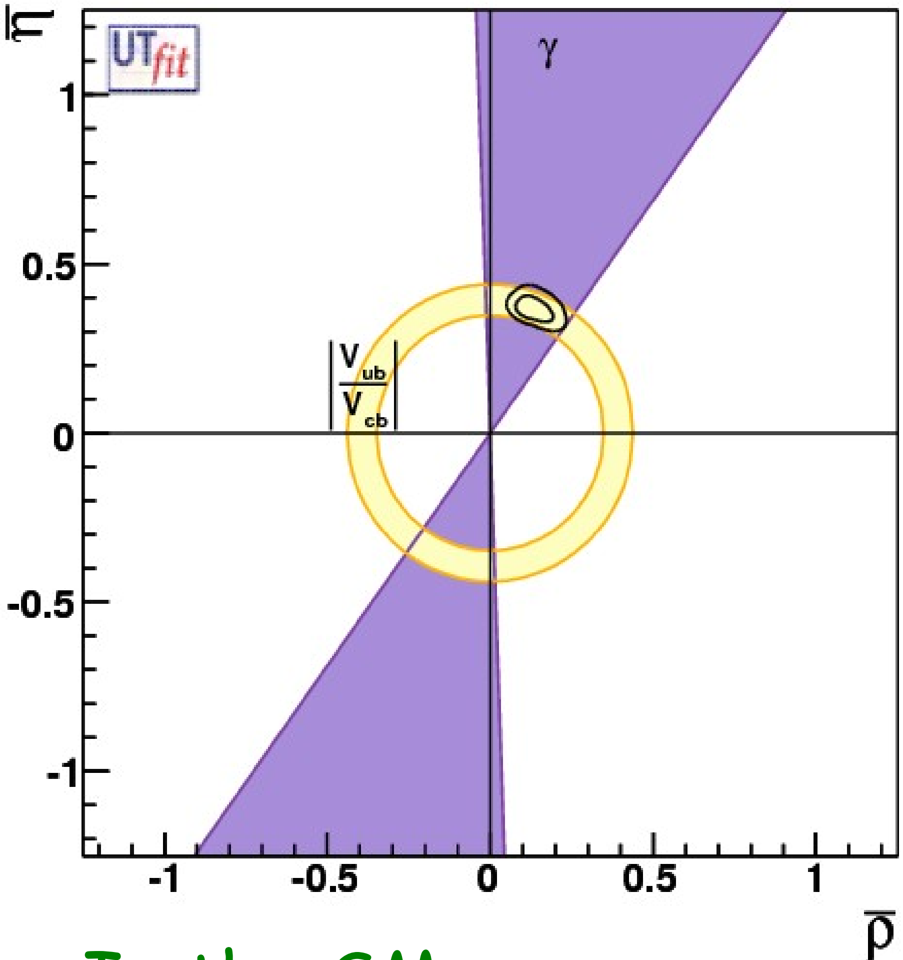
Model-independent determination of the CKM parameters

assumptions:
* three generations
* no NP in tree-level decays

(* no large NP EWP in $B \to \pi\pi$)

$\bar{\rho} = 0.139 \pm 0.040$

$\bar{\eta} = 0.368 \pm 0.026$



In the SM was:

$\bar{\rho} = 0.130 \pm 0.021$

$\bar{\eta} = 0.355 \pm 0.013$

Parameterization of generic NP contributions to the mixing amplitudes

K mixing amplitude (2 real parameter):

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

B_d and B_s mixing amplitudes (2+2 real parameters):

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

$$\phi_d^{SM} = \beta, \quad \phi_s^{SM} = -\beta_s$$

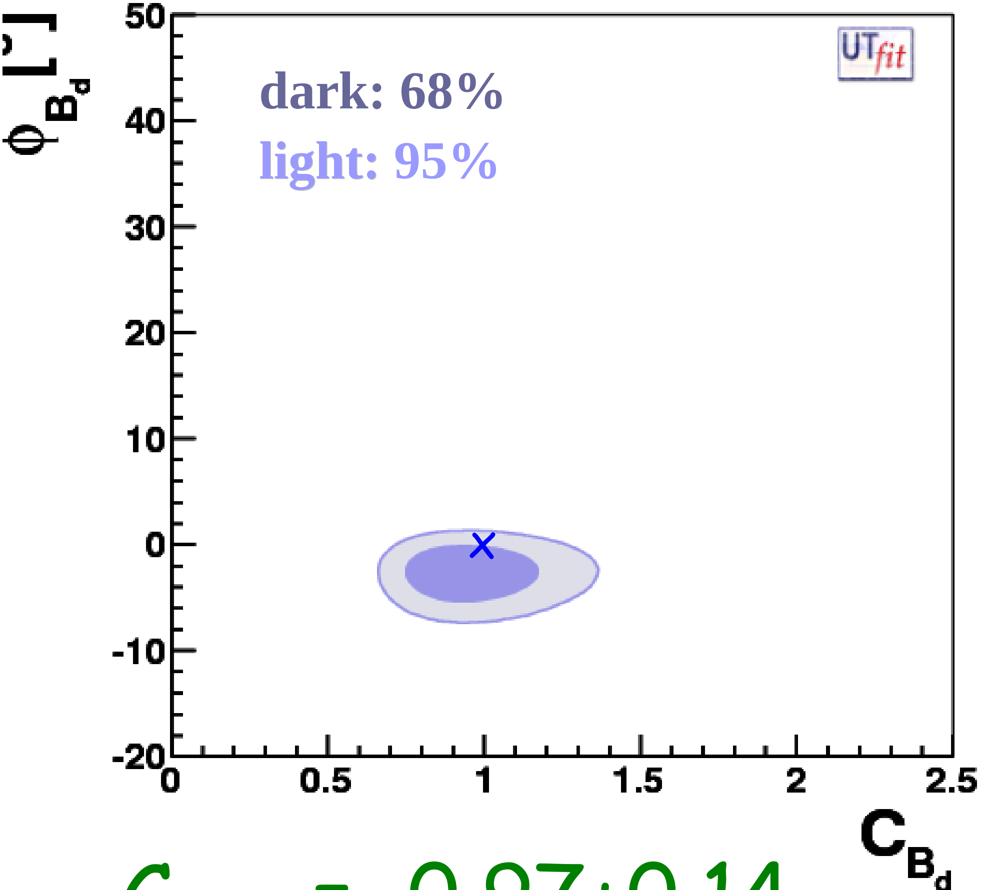
Observables:

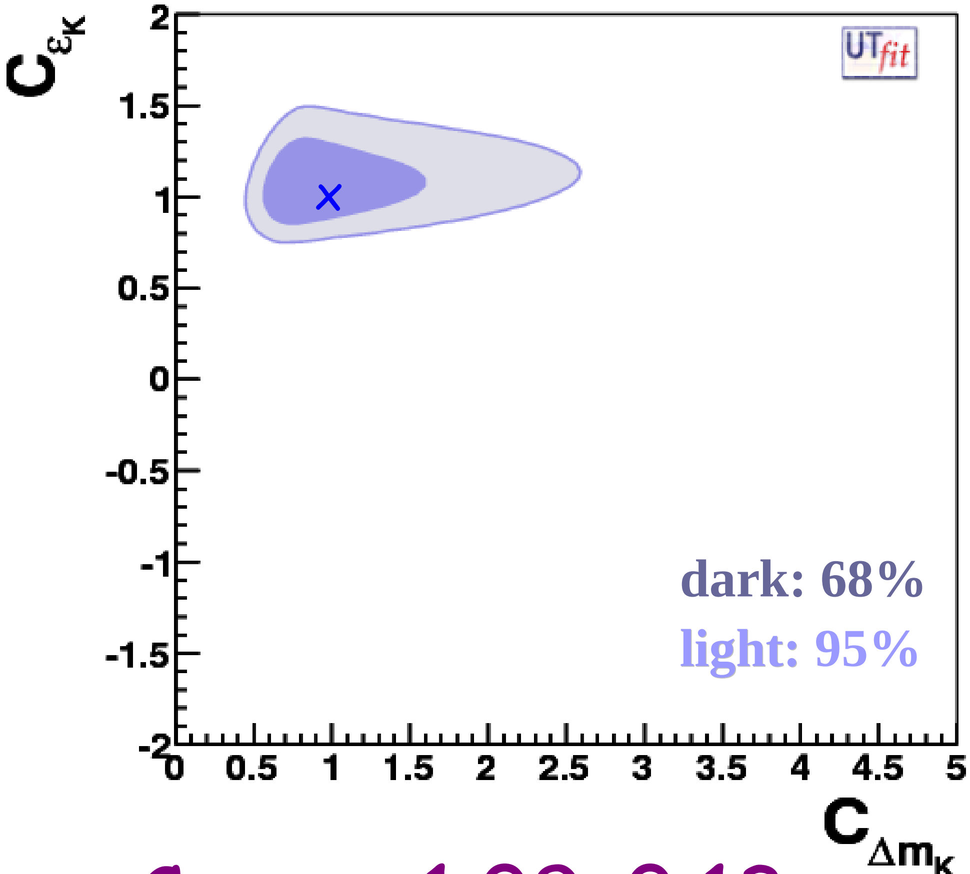
$$\Delta m_{q/K} = C_{B_q/\Delta m_K} (\Delta m_{q/K})^{SM} \qquad \varepsilon_K = C_{\varepsilon}\,\varepsilon_K^{SM}$$

$$a_{CP}^{B_d \to J/\psi K_S} \to \sin 2(\beta + \phi_{B_d}) \qquad a_{CP}^{B_s \to J/\psi \phi} \to -\beta_s + \phi_{B_s}$$

$$a_{SL}^q = \mathrm{Im}\left(\Gamma_{12}^q / A_q\right) \qquad \Delta\Gamma^q / \Delta m_q = \mathrm{Re}\left(\Gamma_{12}^q / A_q\right)$$

Results for the NP parameters (i)





C_{B_d} = 0.97±0.14

[0.72, 1.30]

ϕ_{B_d} = (-2.8±1.7)°

[-6.5, 0.53]°

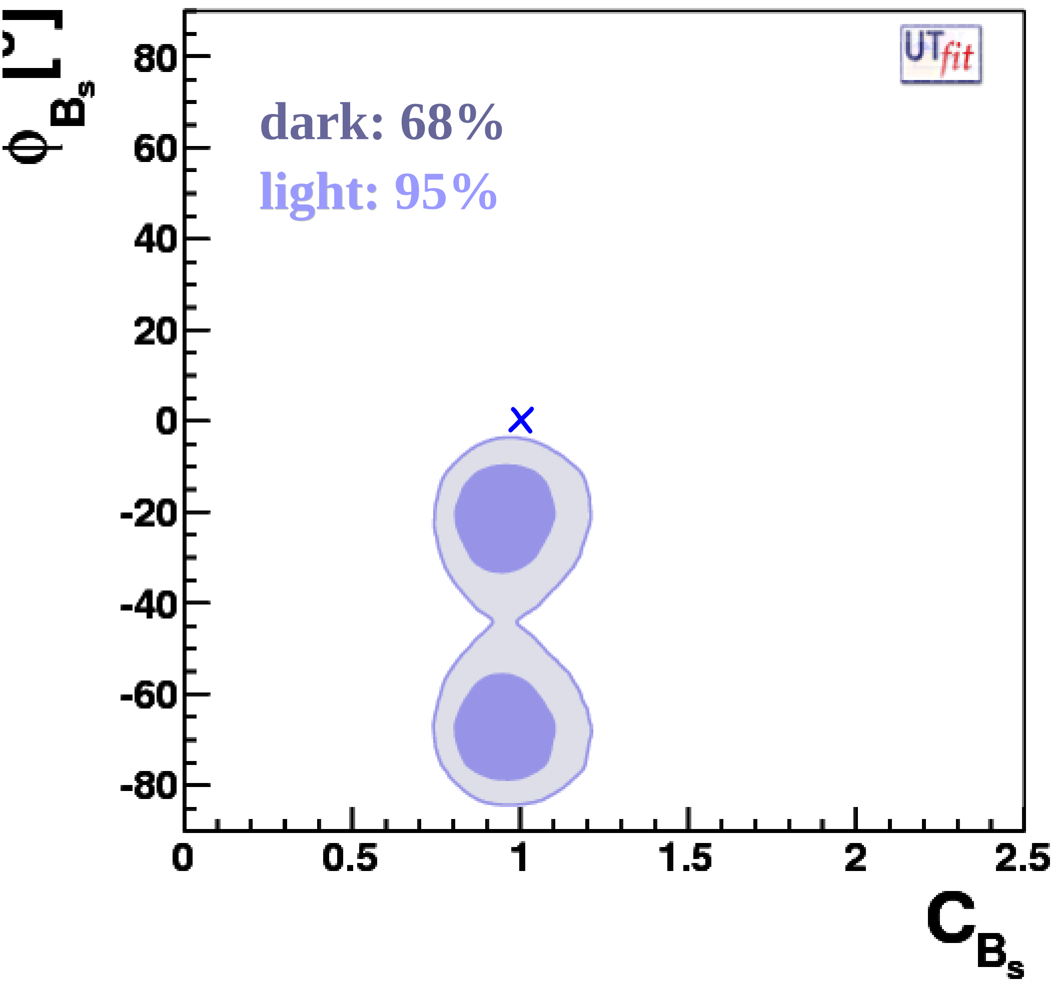
C_{ε_K} = 1.09±0.13

[0.86, 1.39]

$C_{\Delta m_K}$ = 1.17±0.42

[0.61, 2.43]

Results for the NP parameters (ii)



C_{B_s}= 0.96±0.10

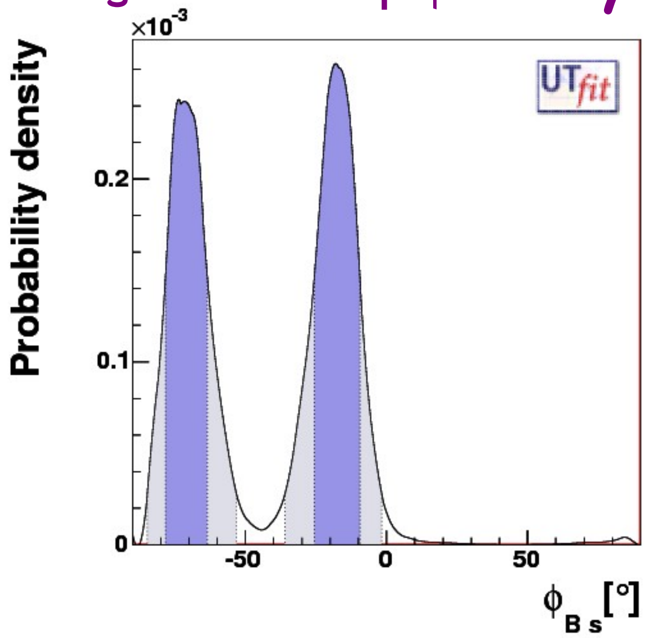
[0.79, 1.18]

ϕ_{Bs}= (-20±8)°U(-68±8)°

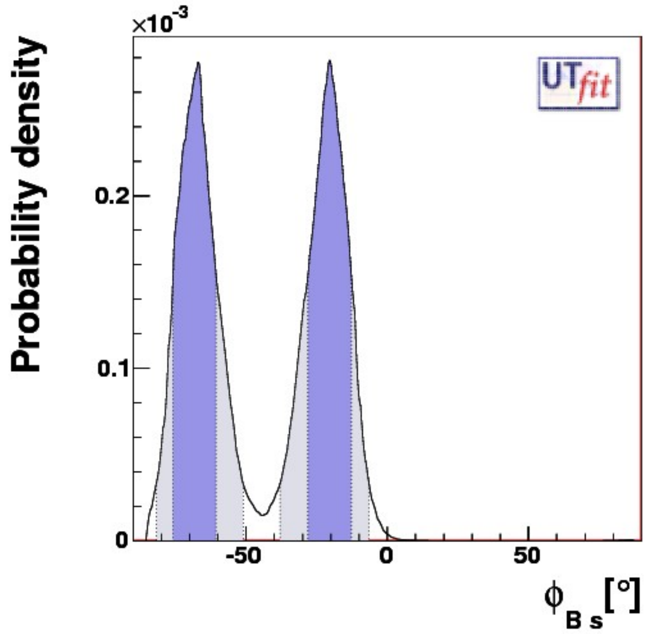
[-38, -6]°U[-82, -51]°

Deviation from the SM is at 2.5s (including $a_{\mu\mu}$ from DØ but not the new CDF measurement)

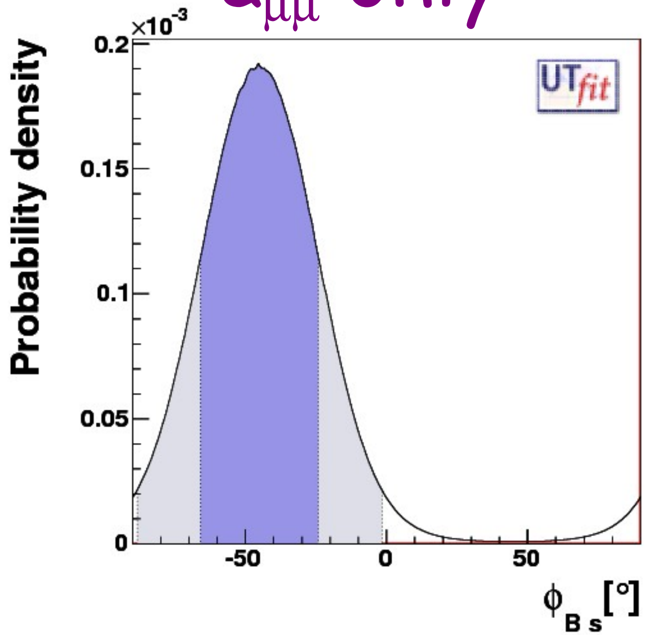
$B_s \to J/\psi\phi$ only



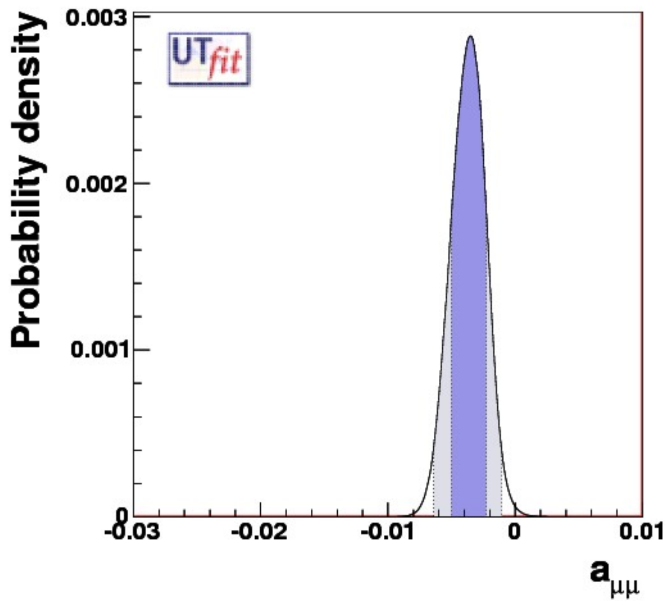
all constraints



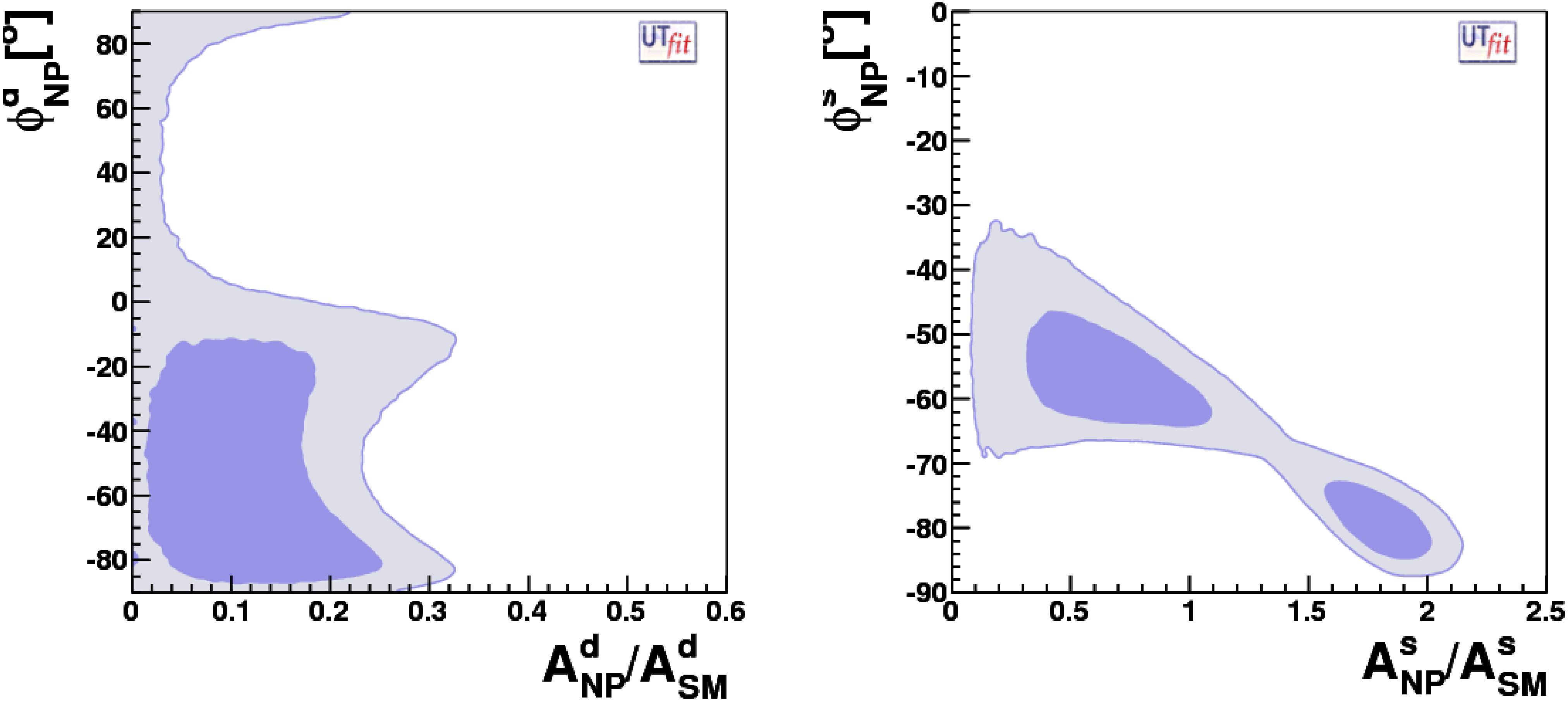
$a_{\mu\mu}$ only



$a_{\mu\mu} = (-3.7\pm1.4)\cdot10^{-3}$



Implications for the NP amplitudes



The ratio of NP/SM contributions is:

< 30% @95% p. (preferred ~10%) in B_d mixing

< 220% @95% p. (preferred ~60% & ~180%) in B_s

see also Lunghi & Soni, Buras et al., Ligeti et al.

Conclusions (i)

* SM UT analysis (still) displays a good overall consistency and no significant failure
* Yet tensions are present in BR($B \rightarrow \tau\nu$) and sin2β (and to a lesser extent in ε_K)
* The two tensions pull $|V_{ub}|$ in opposite directions: no "V_{ub} explanation" possible
* Predictions for B_s physics also show tensions in $a_{\mu\mu}$ and in ϕ_s from $B_s \rightarrow J/\psi\phi$
* $a_{\mu\mu}$ and $B_s \rightarrow J/\psi\phi$ point to large but different value of ϕ_s (assuming standard Γ_{12})

Conclusions (ii)

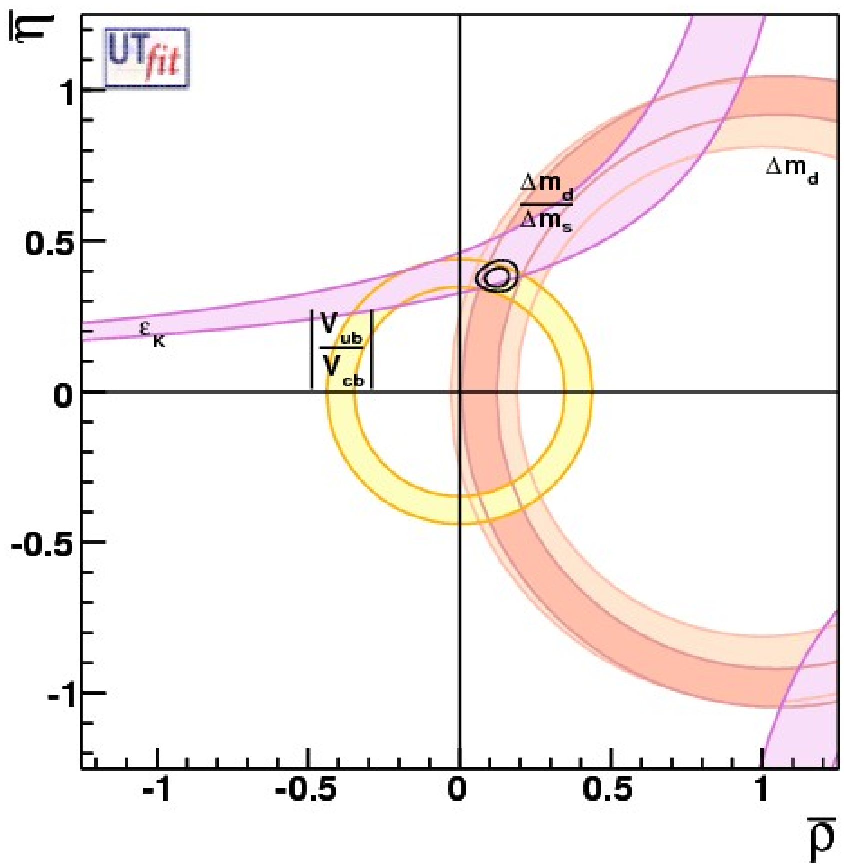
* $a_{\mu\mu}$ also point to a non-standard Γ_{12} (tree-level new physics or failure of the OPE?)
* general UT analysis provides a NP-friendly determination of the CKM parameters
* NP contribution to the B_d mixing amplitude are at 10% level (<30%@95% p.), to B_s mixing at 60% or 180% (<220%@95% p.)
* present tensions suggest non-MFV new physics contributions

Backup

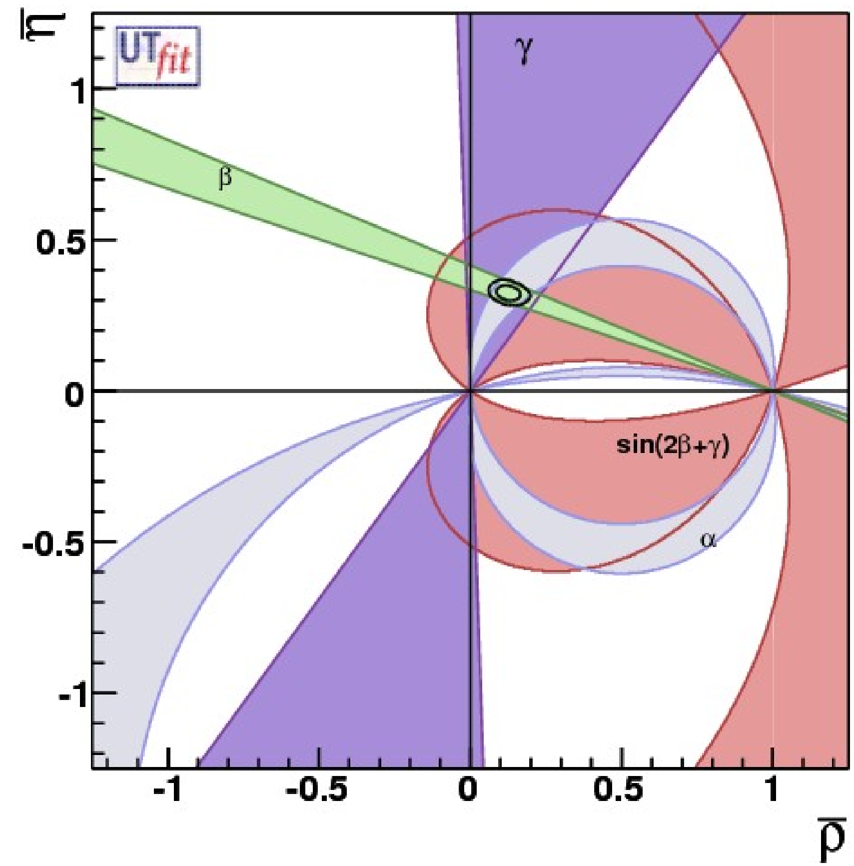
predictions of the hadronic parameters

LQCD inputs used:

F.F., B_K, B_{Bs}, B_{Bs}/B_{Bd} f_{Bs}, f_{Bs}/f_{Bd}



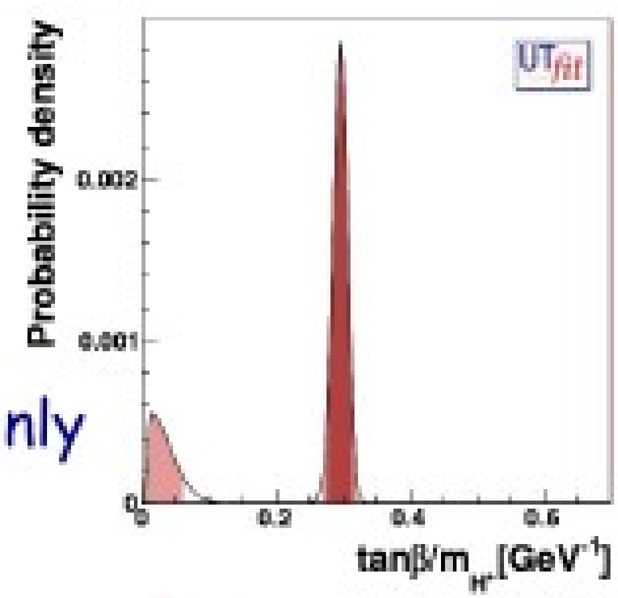
independent of lattice



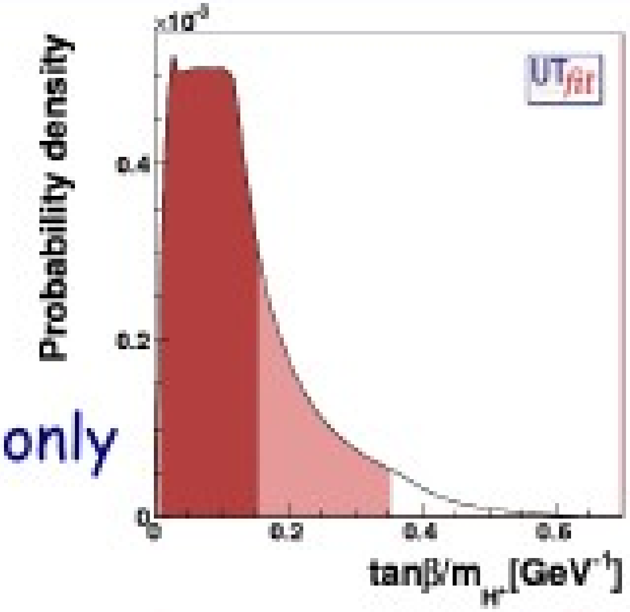
UT lattice+UT angles:

<u>SM</u> determination of hadronic parameters

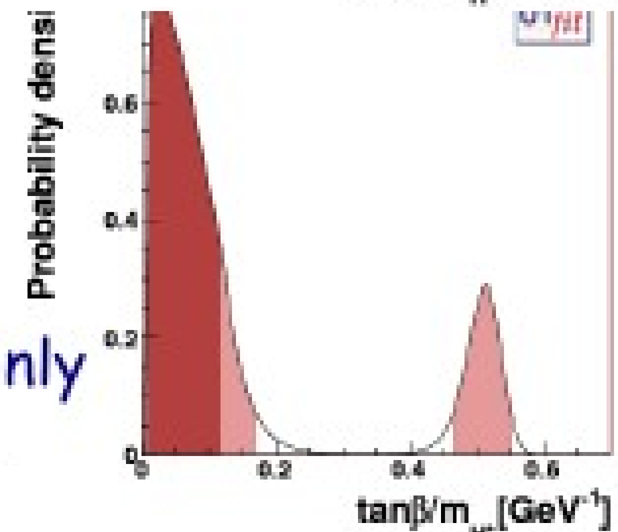
Two Higgs Doublet Model II



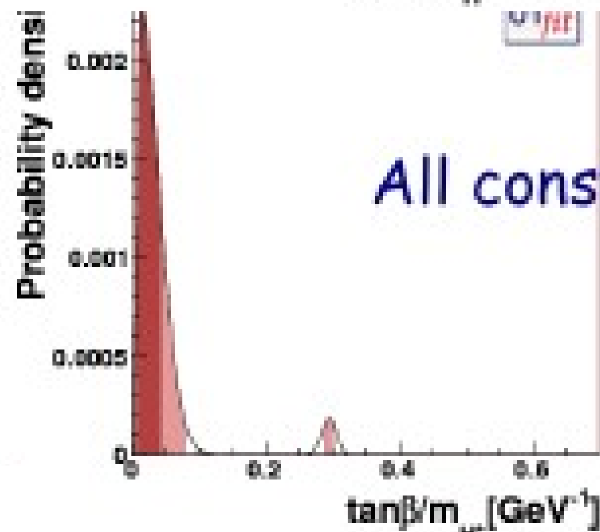
$B \to \tau\nu$ only



$B_s \to \mu\mu$ only



$B \to D\tau\nu$ only



All constraints

Additional constraints:

* $BR(B_s \to \mu\mu) < 5.8\times10^{-8}$ @95% C.L.
* $\Delta m_s = (17.77 \pm 0.12)\ ps^{-1}$

* additional constraints exclude the "fine-tuned" region at very large $\tan\beta$
* bound similar to 2HDM

$$\tan\beta < 7.3 m_{H^+}/(100\ \mathrm{GeV})$$

In addition:
$BR(B_s\to\mu\mu) < 19\times10^{-9}$ (5xSM) @95% prob.