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Standard Model updates and new physics analysis with the Unitarity Triangle fit

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We present the summer 2011 update of the Unitarity Triangle (UT) analysis performed by the **UT***fit* Collaboration within the Standard Model (SM) and beyond. The increased accuracy on several of the fundamental constraints is starting to enhance some of the tensions amongst and within the constraints themselves. In particular, the long standing tension between exclusive and inclusive determinations of the V_{ub} and V_{cb} CKM matrix elements is now playing a major role. The SM expected values for $\sin 2\beta$ are thus extracted using either the inclusive or the exclusive inputs. We then present the generalisation the UT analysis to investigate new physics (NP) effects: in the NP analysis, both CKM and NP parameters are fitted simultaneously to obtain the possible NP contributions in any specific sector.

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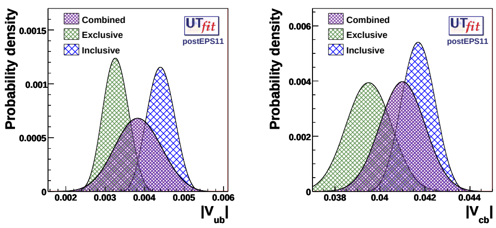
1. Standard Model Unitarity Triangle Analysis

We present the summer 2011 update of the Unitarity Triangle (UT) analysis performed by the **UT***fit* Collaboration following the method described in refs. [1]. We use the latest determinations of the theoretical and experimental parameters. The basic constraints are: $|V_{ub}/V_{cb}|$ from semileptonic B decays, Δm_d and Δm_s from $B^0_{d,s}$ oscillations, ε_K from K mixing, α from charmless hadronic B decays, γ and $2\beta+\gamma$ from charm hadronic B decays, and $\sin 2\beta$ from $B^0 \to J/\psi K^0$ decays [2]. On the theoretical side, the non-perturbative QCD parameters are taken from the recent lattice QCD determinations [3].



$[10^{-3}]$	**excl.**	**incl.**	**average**
$\mathbf{V_{ub}}$	(3.26 ± 0.30)	(4.40 ± 0.31)	(3.83 ± 0.57)
$\mathbf{V_{cb}}$	(39.5 ± 1.0)	(41.7 ± 0.7)	(41.0 ± 1.0)

Figure 1: V_{ub} and V_{cb} experimental inputs are shown as PDF and values.

For the inputs coming from the semileptonic B decays, we use the values shown in figure 1, where the averages are calculated *á la* PDG [4]. It is evident that exclusive and inclusive results persist to be only marginally compatible: for V_{ub} the discrepancy is at the level of about 2.6σ, while for V_{cb} it is $\sim 1.8\sigma$. This was already previously highlighted [5], but the increased experimental precisions are now enhancing the effect.

Using the above inputs and our Bayesian framework, we perform the global fit to extract the CKM matrix parameters $\bar\rho$ and $\bar\eta$: we obtain $\bar\rho = 0.132 \pm 0.020$ and $\bar\eta = 0.353 \pm 0.014$. The consistency of the picture is tested using compatibility plots. They compare two different p.d.f.'s: the one obtained from the UT fit without using the constraint being tested and the other from the direct measurement. Figure 2 shows some compatibility plots related to some key constraints. We can see how γ shows very good agreement with the rest of the fit like α (not shown) and V_{ub}, while $\sin 2\beta$ presents some effects of disagreement ($\sim 2.3\sigma$), like ε_K (not shown).

In this context of the global fit, the V_{ub} compatibility plot in figure 2 as well as figure 1 are calling for further tests: the current default fit uses the average V_{ub} and V_{cb} values, so it does not show any tension (unlike in the past [5]), but this is an artefact of the increased uncertainty on the average. So this tension is now better studied with separate global fits including either only exclusive values or only inclusive values. Figure 3 shows the results of these two fits. Moreover, from both configurations, we can extract $\sin 2\beta$ predictions (see figure 4), together with the prediction without using any semileptonic constraint.[1]

Finally, with the current default global fit, it is interesting to extract the **UT***fit* predictions[2] for $\mathrm{BR}(B \to \tau\nu)$ that is found to be $(0.83 \pm 0.08) \cdot 10^{-4}$ with a discrepancy of $\sim 2.3\sigma$ from the experimental measurement [2], and for $\mathrm{BR}(B_s \to \mu\mu)$ that is found to be $(3.55 \pm 0.28) \cdot 10^{-9}$.

[1] For an alternative indirect determination of $\sin 2\beta$, see ref. [6].

[2] These predictions could be extracted in a more accurate way using the complete analysis as in ref. [7]. See also predictions in ref. [8].

2. Beyond the Standard Model: Unitarity Triangle Analysis in presence of New Physics

We perform a full analysis of the UT with all the constraints studied for the classic SM UT analysis, but reinterpreting the experimental observables including possible model-independent NP contributions. The contribution of NP to $\Delta F = 2$ transitions can be parameterised in a model-independent way as:

$$C_{B_q} e^{2i\phi_{B_q}} = \frac{\langle B_q | H_{\text{eff}}^{\text{full}} | \bar{B}_q \rangle}{\langle B_q | H_{\text{eff}}^{\text{SM}} | \bar{B}_q \rangle} \quad \text{where in the SM:} \quad C_{B_{d,s}} = 1 \quad \phi_{B_{d,s}} = 0 \qquad (2.1)$$

being H_{eff}^{SM} the SM $\Delta F = 2$ effective Hamiltonian, H_{eff}^{full} its extension in a general NP model, and $q = d$ or s. Similarly, for the K-$\bar{K}$ system, we introduce parameters C_{ε_K} and $C_{\Delta m_K}$, where $C_{\varepsilon_K} = C_{\Delta m_K} = 1$ within the SM (see refs. [9] for details).

We add the following experimental inputs to extract information on the B_s system: the semileptonic asymmetry in B_s decays A_{SL}^s [10], the di-muon charge asymmetry $A_{\text{SL}}^{\mu\mu}$ [11], the measurement of the B_s lifetime from flavour-specific final states [2], the two-dimensional likelihood ratio for $\Delta\Gamma_s$ and ϕ_s from the time-dependent tagged angular analysis of $B_s \to J/\psi\phi$ decays [12].[3]

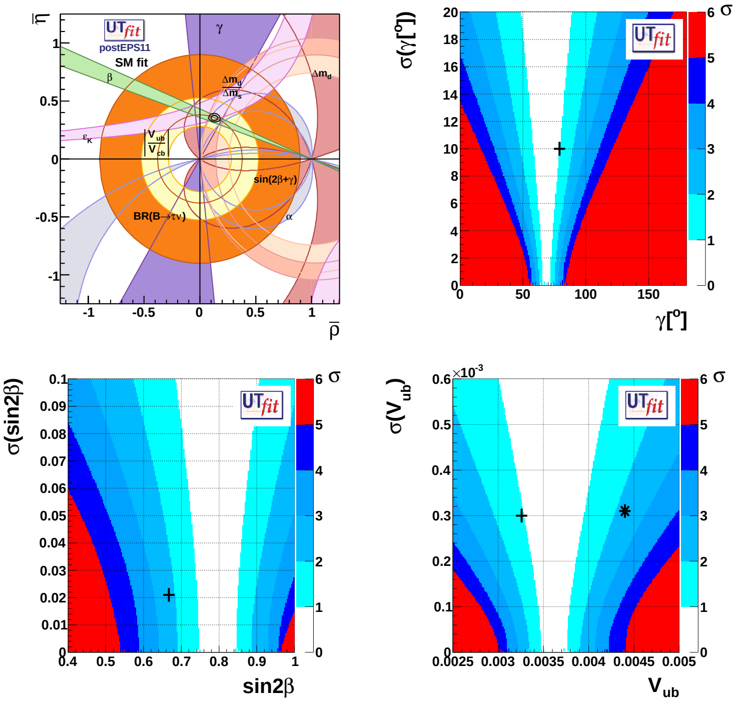


Figure 2: Left plot: $\bar{\rho}$-$\bar{\eta}$ plane where the black contours display the 68% and 95% probability regions selected by the SM global fit. The 95% probability regions selected by the single constraints are also shown. Three right plots: compatibility plots where the compatibility regions from 1σ to 6σ are displayed. The cross displays the position (value/error) of the measurement. From left to right: γ, $\sin 2\beta$ and V_{ub}. For V_{ub}, the cross is the exclusive value and the asterisk is the inclusive value.

[3] D0 Collaboration includes in its likelihood flavour U(3) symmetry assumptions on the strong phases reducing the result ambiguities.

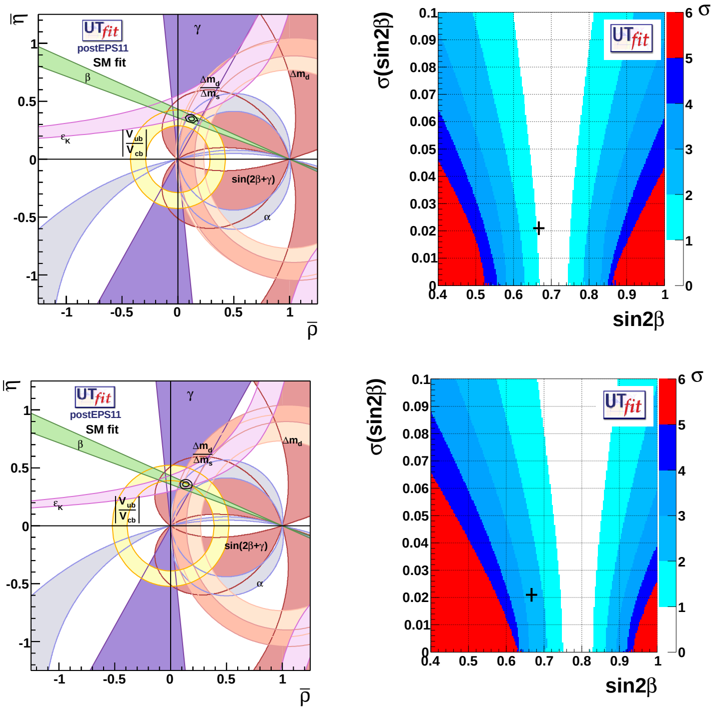
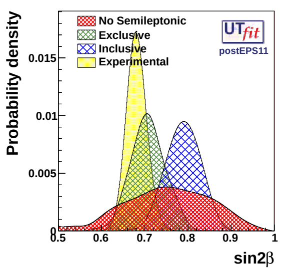


Figure 3: $\bar{\rho}$-$\bar{\eta}$ plane with the SM global fit results and compatibility plot for $\sin 2\beta$ using only exclusive inputs for both V_{ub} and V_{cb} (two left plots) and using only inclusive inputs (two right plots).



inputs used	$\sin 2\beta$ value	σ from $\sin 2\beta_{exp}$
no V_{ub}, no V_{cb}	0.76 ± 0.10	0.9
exclusive only	0.706 ± 0.041	0.8
inclusive only	0.916 ± 0.041	2.6

Figure 4: $\sin 2\beta$ expectation values from the global fit for three sets of inputs for $|V_{ub}/V_{cb}|$.

From the full NP analysis, the global fit selects a region of the $(\bar{\rho}, \bar{\eta})$ plane (left plot in figure 5, with $\bar{\rho} = 0.129 \pm 0.040$ and $\bar{\eta} = 0.392 \pm 0.055$) which is consistent with the results of the SM analysis. Together with the CKM parameters, we can also constrain the effective NP contributions in the three sectors. For K-$\bar{K}$ mixing the NP parameters are found in agreement with the SM expectations. The B_d system shows an effect about 1.2σ away from the SM, and in the B_s-meson sector we find the NP parameters to be about 1.6σ away from the SM (see plots in figure 5).

3. Conclusions

We have presented the UT analysis updated with the more recent results presented in this conference. The current tension between exclusive and inclusive determinations of the V_{ub} and V_{cb} CKM matrix elements are at the level of about 2.6σ and $\sim 1.8\sigma$, respectively. Expectation values for the rare B decays have also been extracted from the full fit: $\mathrm{BR}(B \to \tau\nu) = (0.83 \pm 0.08) \cdot$

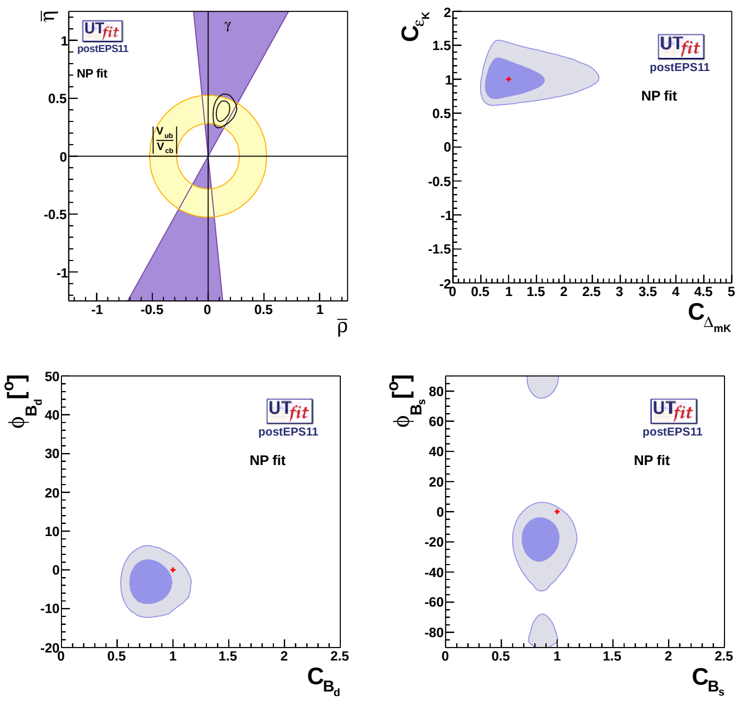


Figure 5: From left to right: determination of $\bar{\rho}$ and $\bar{\eta}$ from all the constraints (68% and 95% total probability black contours are shown, together with 95% probability regions from the tree-only constraints); 68% (dark) and 95% (light) probability regions in the $C_{\varepsilon_K} - C_{\Delta m_K}$, $\phi_{B_d} - C_{B_d}$, and $\phi_{B_s} - C_{B_s}$ planes. The red cross represents the SM expectation.

10^{-4} and $\mathrm{BR}(B_s \to \mu\mu) = (3.55 \pm 0.28) \cdot 10^{-9}$. Finally we have generalised the UT analysis to investigate NP effects: the NP parameters result to be consistent with the SM hypothesis with the biggest discrepancy in the B_s-meson sector at the level of about 1.6σ.

References

[1] M. Ciuchini *et al.*, JHEP **0107** (2001) 013; M. Bona *et al.* [UTfit Collaboration], JHEP **0507** (2005) 028.

[2] The Heavy Flavour Averaging Group (HFAG), http://www.slac.stanford.edu/xorg/hfag/.

[3] V. Lubicz, PoS **LAT2009** (2009) 013; J. Laiho, E. Lunghi and R. S. Van de Water, Phys. Rev. D **81** (2010) 034503; G. Colangelo *et al.*, Eur. Phys. J. C **71** (2011) 1695.

[4] K. Nakamura *et al.* [Particle Data Group], J. Phys. G **37** (2010) 075021, and 2011 partial update.

[5] M. Bona *et al.* [UTfit Collaboration], JHEP **0610** (2006) 081.

[6] E. Lunghi and A. Soni, Phys. Lett. B **666** (2008) 162.

[7] M. Bona *et al.* [UTfit Collaboration], Phys. Lett. B **687** (2010) 61.

[8] A. J. Buras, M. Nagai and P. Paradisi, JHEP **1105** (2011) 005.

[9] M. Bona *et al.* [UTfit Collaboration], JHEP **0603** (2006) 080; M. Bona *et al.* [UTfit Collaboration], Phys. Rev. Lett. **97** (2006) 151803; M. Bona *et al.* [UTfit Collaboration], JHEP **0803** (2008) 049.

[10] V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **82** (2010) 012003 [Erratum-ibid. D **83** (2011 PHRVA,D83,119901.2011) 119901].

[11] V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **84**, 052007 (2011).

[12] D0 Collaboration, Conference Note D0 Note 6093-CONF (2010).