Updates on Unitarity Triangle fits

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(ICHEP'24)

Prague
Czech
Republic

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www.utfit.org

M.Bona, M. Ciuchini, D. Derkach, F. Ferrari,
E. Franco, V. Lubicz, G. Martinelli, D. Morgante,
M. Pierini, L. Silvestrini, S. Simula, A. Stocchi,
C. Tarantino, V. Vagnoni, M. Valli and L. Vittorio

Plots and numbers updated for Summer 2024:
latest paper: Rendiconti Lincei. Scienze Fisiche e Naturali (2023) 34:37–57
https://doi.org/10.1007/s12210-023-01137-5

Unitarity Triangle analysis in the SM

- SM UT analysis:
  - All updated with Summer 2024 inputs
  - provide the best determination of CKM parameters
  - test the consistency of the SM ("*direct*" vs "*indirect*" determinations)
  - provide predictions (from data..) for SM observables

.. and beyond

- NP UT analysis:
  - Also all updated with Summer 2024 inputs
  - model-independent analysis
  - provides limit on the allowed deviations from the SM
  - obtain the NP scale

Usual method and 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
$A_{CP}(J/\psi K_S)$	$\sin 2\beta$	–

, $\mathbf{m_t}$

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

M. Bona *et al*. (UTfit Collaboration) JHEP 0507:028,2005 hep-ph/0501199

M. Bona *et al*. (UTfit Collaboration) JHEP 0603:080,2006 hep-ph/0509219

New inputs

- HFLAV updated numbers for lifetimes and mass differences
- Updated V_{ud} = 0.97431(16)
  - update in the determination from nuclear beta transitions (arXiv:2311.00044 [nucl-th])
- Updated V_{ub} and V_{cb} (see next slides)
- Updated unitarity triangle angles (see next slides)
- Updated ϕ_s from HFLAV (relevant for the NP run)

Summer 2024 update is ongoing..

V_{cb} and V_{ub}

Latest inputs from arXiv:2310.03680

$|V_{cb}|$ *(excl)* = (40.13 ± 0.55) 10^{-3}

$|V_{cb}|$ *(incl)* = (41.97 ± 0.48) 10^{-3}

from arXiv:2310.20324

from arXiv:2202.10285

$|V_{ub}|$ *(excl)* = (3.57 ± 0.23) 10^{-3}

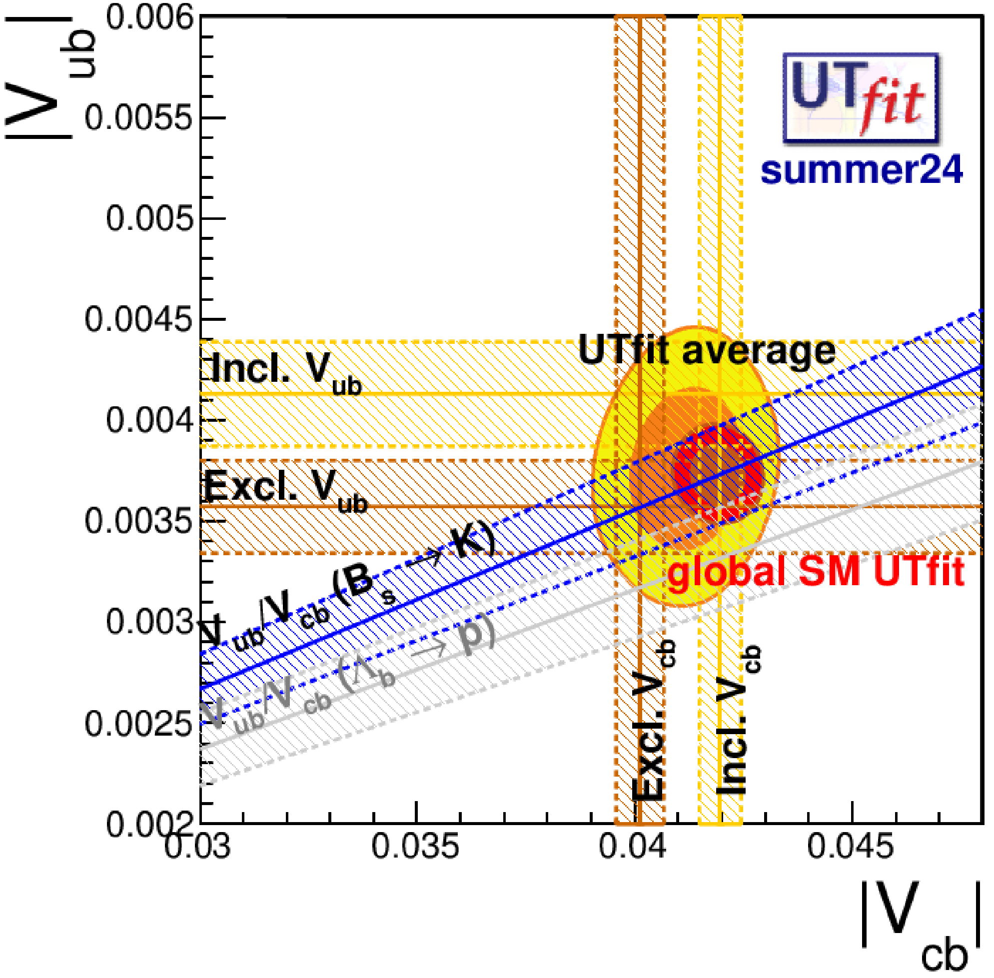
$|V_{ub}|$ *(incl)* = (4.13 ± 0.26) 10^{-3}

PDG 2024

from arXiv:2310.03680

$|V_{ub} / V_{cb}|$ = (8.7 ± 0.9) 10^{-2}

$|V_{ub} / V_{cb}|$ *(LHCb)* = (7.9 ± 0.6) 10^{-2} Λ_b, excluded following FLAG guidelines



V_{cb} and V_{ub}

Inputs to the global fit
from 2D à la D'Agostini averages

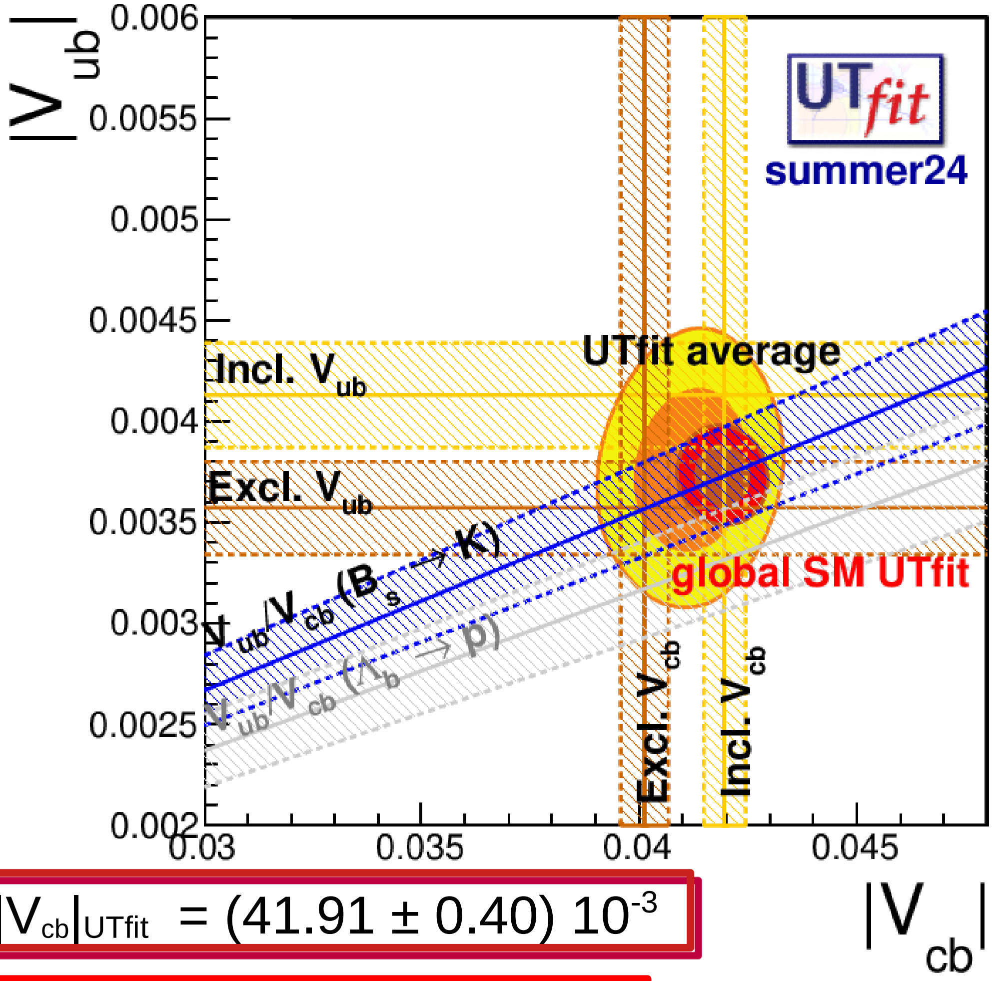
$|V_{cb}|_{UTfit} = (41.20 \pm 0.74)\ 10^{-3}$

$|V_{ub}|_{UTfit} = (3.84 \pm 0.35)\ 10^{-3}$

UTfit predictions:

$|V_{cb}|_{UTfit} = (42.19 \pm 0.48)\ 10^{-3}$

$|V_{ub}|_{UTfit} = (3.72 \pm 0.10)\ 10^{-3}$



UTfit full fit

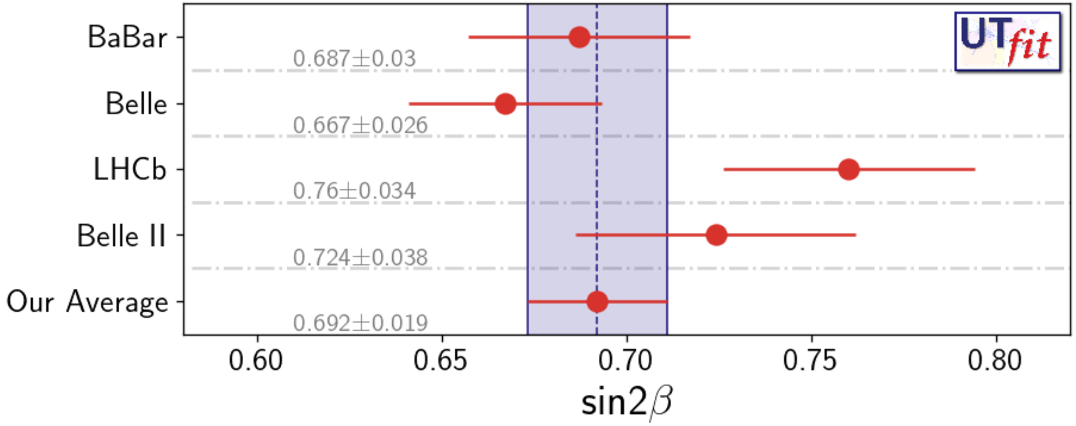
$|V_{cb}|_{UTfit} = (41.91 \pm 0.40)\ 10^{-3}$

$|V_{ub}|_{UTfit} = (3.73 \pm 0.09)\ 10^{-3}$

ϕ_1/β angle

- Averaged charmonium values from HFLAV
- Adding Belle II currently not included
- Average including updated correction due to Cabibbo-suppressed penguin contributions
  - Theoretical uncertainty comparable to experimental error
  - Correction of -0.01 ± 0.01

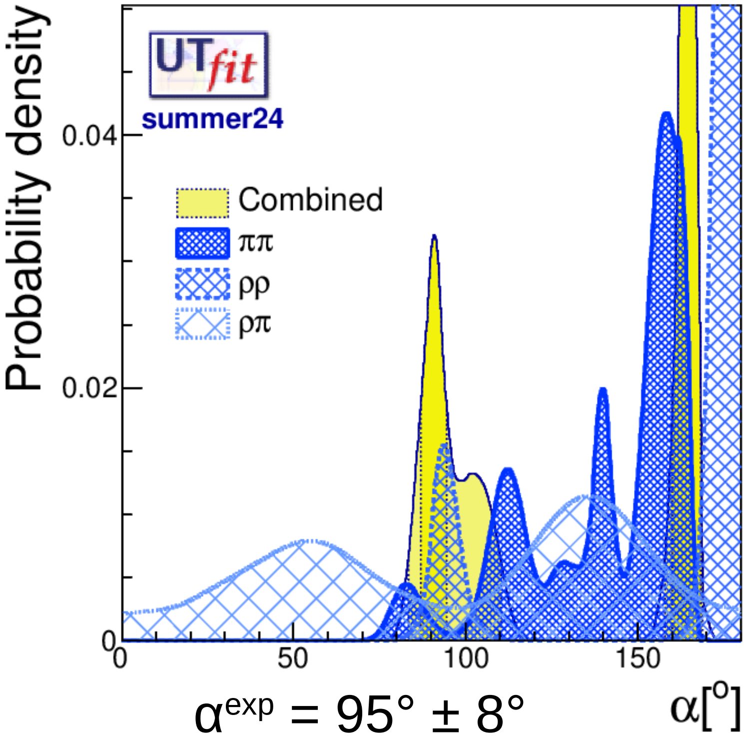
Ciuchini, Pierini, Silvestrini
https://arxiv.org/abs/hep-ph/0507290



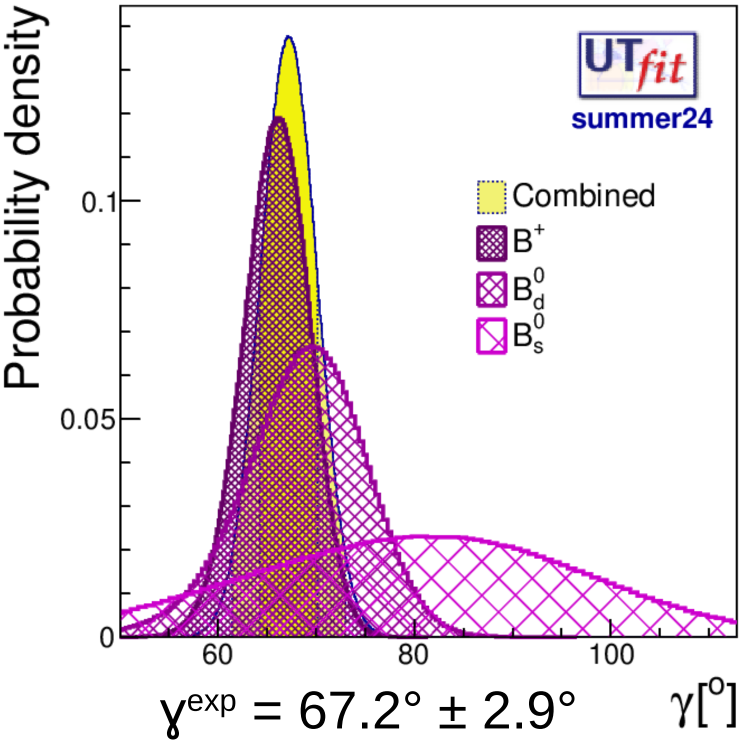
Basically from all charmonium
HFLAV PDG2024: 0.698 ± 0.017
adding Belle II: 0.724 ± 0.038
getting average: 0.702 +/- 0.016
Corrected with -0.01 +- 0.01
final number is **0.692 +/- 0.019**

ϕ_2/α and ϕ_3/γ angles

See new D mixing fit from Di Palma here at ICHEP24: https://indico.cern.ch/event/1291157/contributions/5903551/



$\alpha^{exp} = 95° \pm 8°$

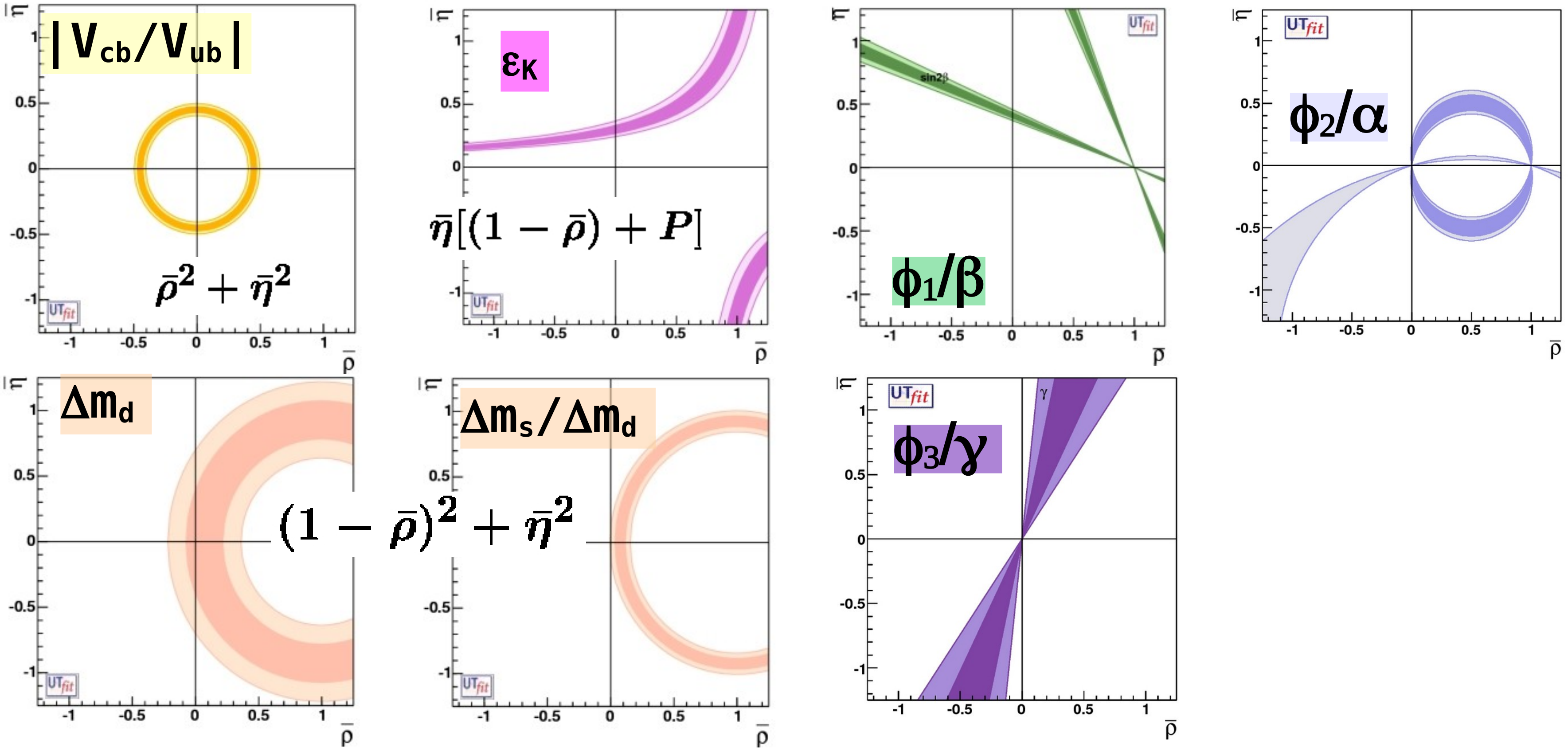


$\gamma^{exp} = 67.2° \pm 2.9°$

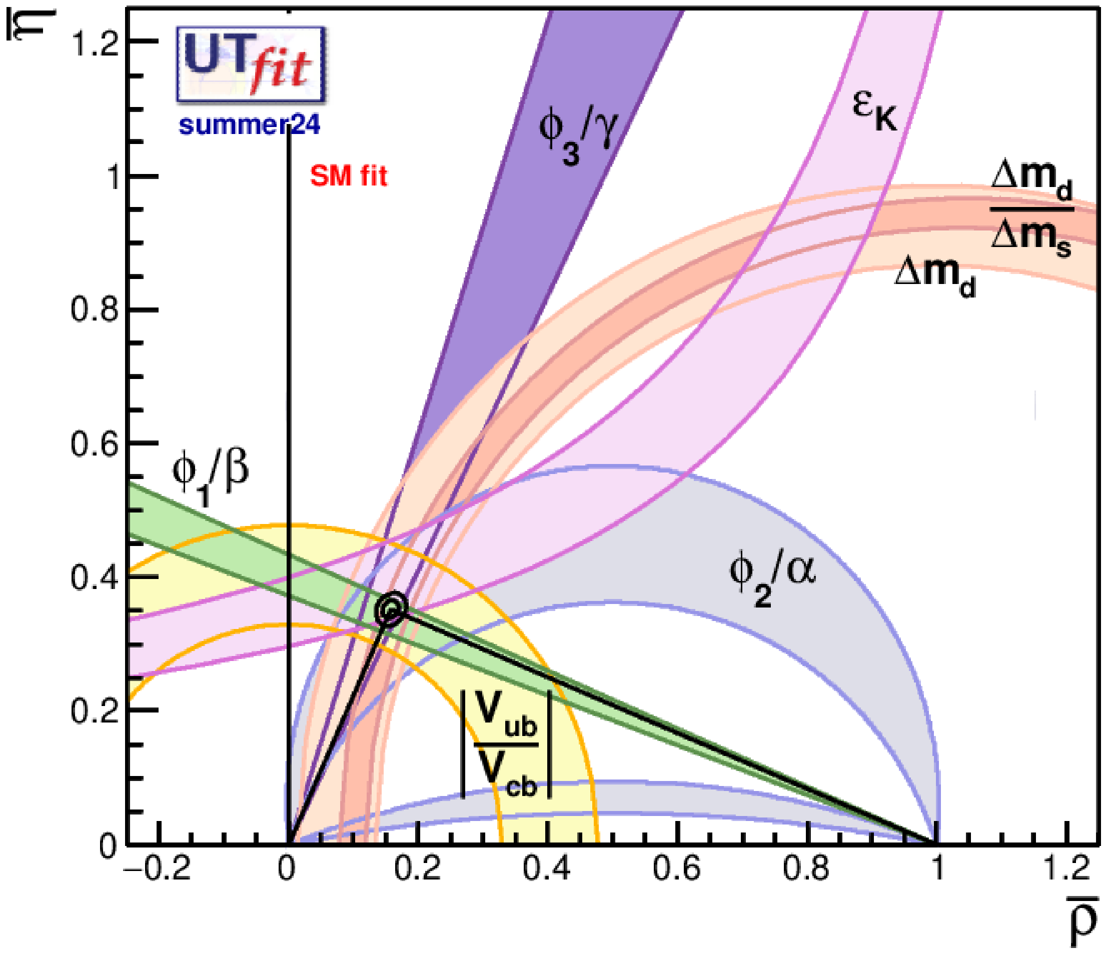
Updated BRs: $\pi^+\pi^-$ from HFLAV

Updated BR and CPV: $\pi^0\pi^0$ HFLAV + Belle II result (new from FPCP2024)

Unitarity Triangle analysis in the SM:



Unitarity Triangle analysis in the SM:



levels @
95% Prob

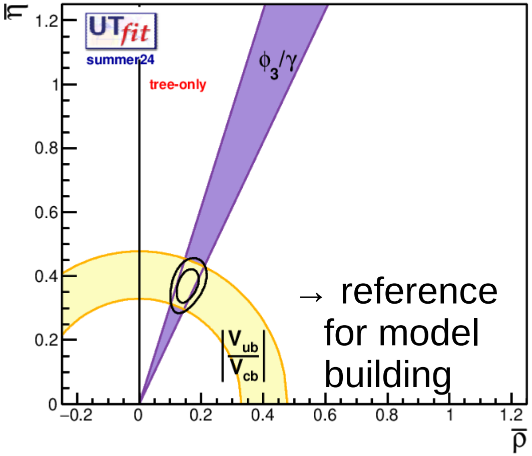
$\bar{\rho} = 0.158 \pm 0.009$
$\bar{\eta} = 0.352 \pm 0.010$

$\lambda = 0.2250 \pm 0.0007$
$A = 0.826 \pm 0.009$

Some interesting configurations

"Tree only"

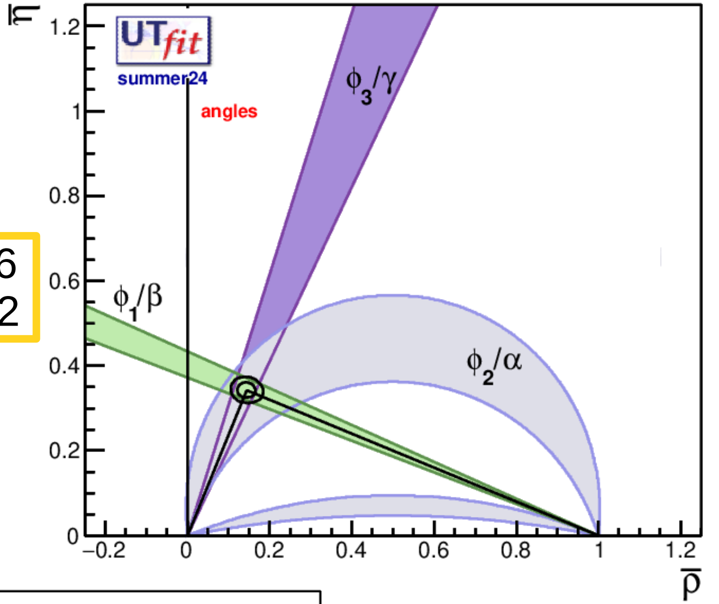
$\bar{\rho}$ = ±0.156 ± 0.024
$\bar{\eta}$ = ±0.372 ± 0.035



→ reference for model building

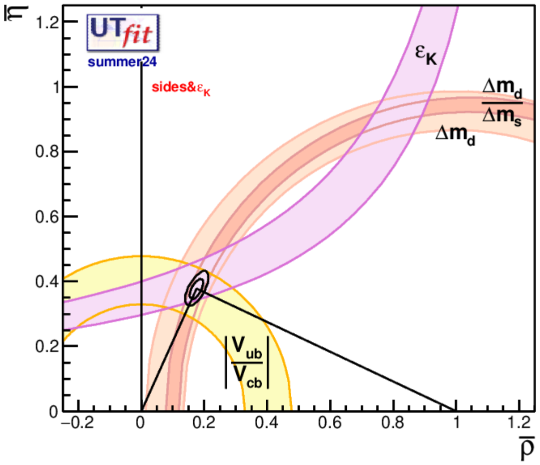
Angles only

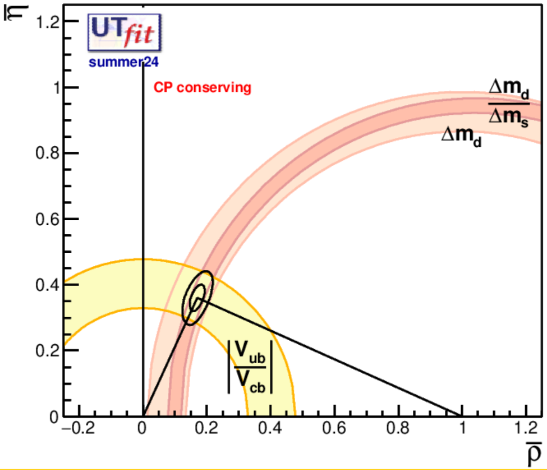
$\bar{\rho}$ = 0.144 ± 0.016
$\bar{\eta}$ = 0.343 ± 0.012



Sides and ε_K

$\bar{\rho}$ = 0.176 ± 0.015
$\bar{\eta}$ = 0.377 ± 0.022





CP conserving constraints

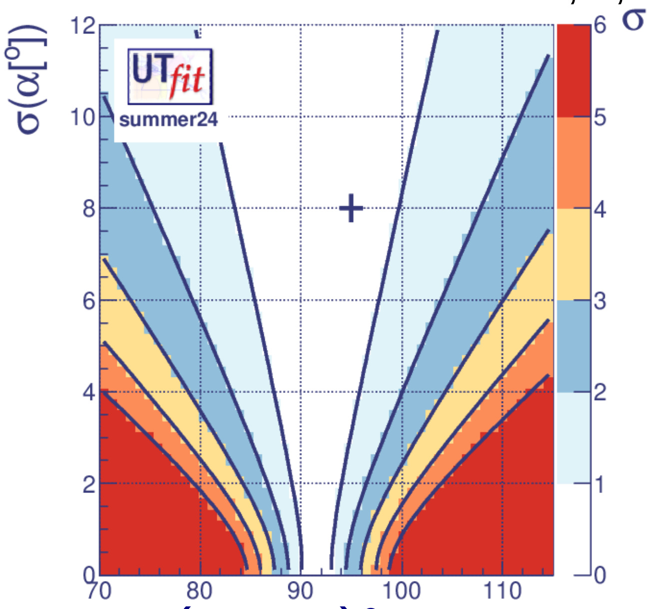
$\bar{\rho}$ = 0.170 ± 0.017
$\bar{\eta}$ = 0.361 ± 0.035

Compatibility plots

A way to “measure” the agreement of a single measurement with the indirect determination from the fit using all the other inputs: test for the SM description of the flavour physics

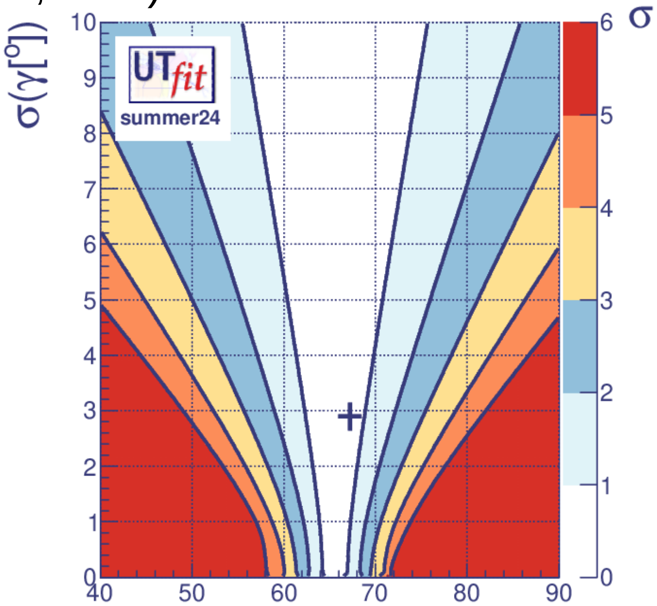
Colour code: agreement between the predicted values and the measurements at better than 1, 2, ...nσ

The cross has the coordinates (x,y)=(central value, error) of the direct measurement



α_{exp} = (95 ± 8)°

α_{UTfit} = (91.4 ± 1.4)°



γ_{exp} = (67.2 ± 2.9)°

γ_{UTfit} = (65.6 ± 1.4)°

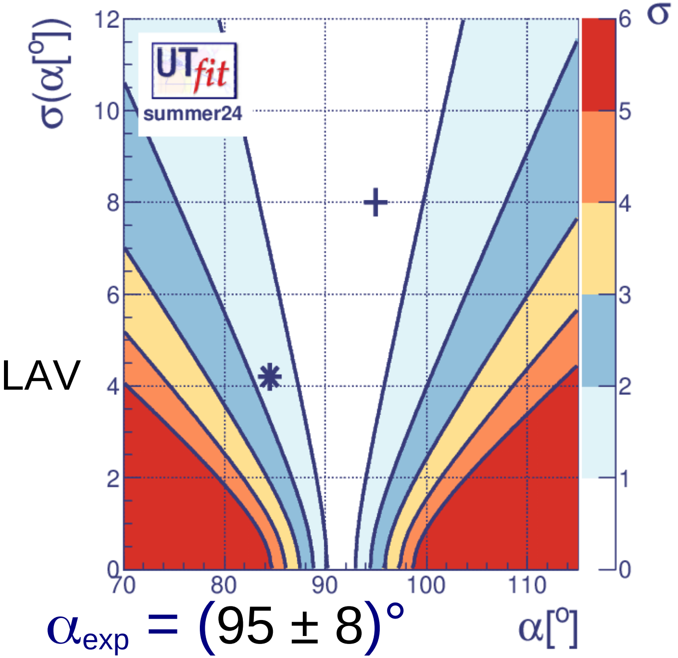
Compatibility plots

A way to "measure" the agreement of a single measurement with the indirect determination from the fit using all the other inputs: test for the SM description of the flavour physics

Colour code: agreement between the predicted values and the measurements at better than 1, 2, ...nσ

The cross has the coordinates (x,y)=(central value, error) of the direct measurement

$*$ = HFLAV



α_{exp} = (95 ± 8)°

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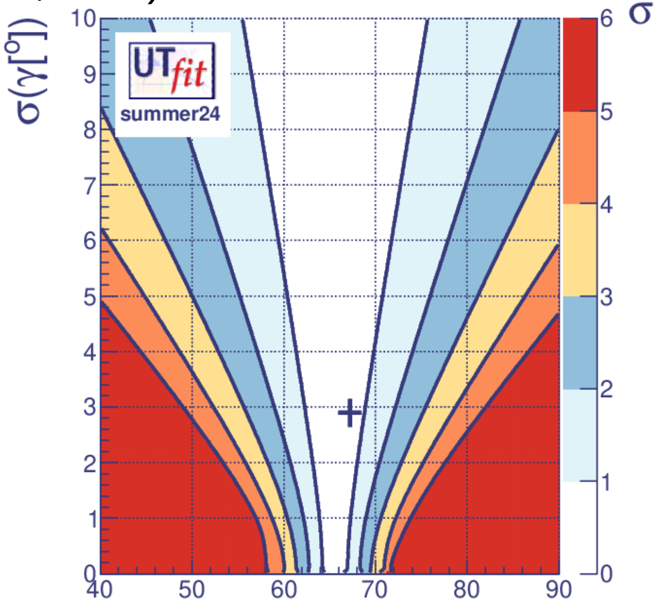
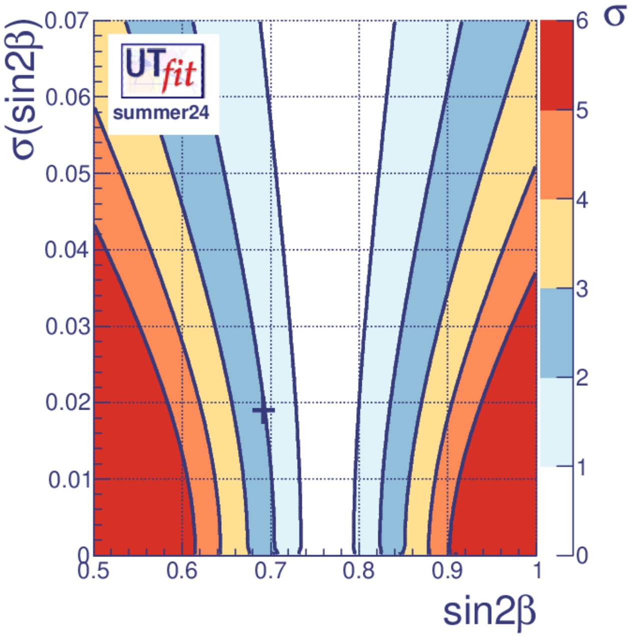


γ_{exp} = (67.2 ± 2.9)°

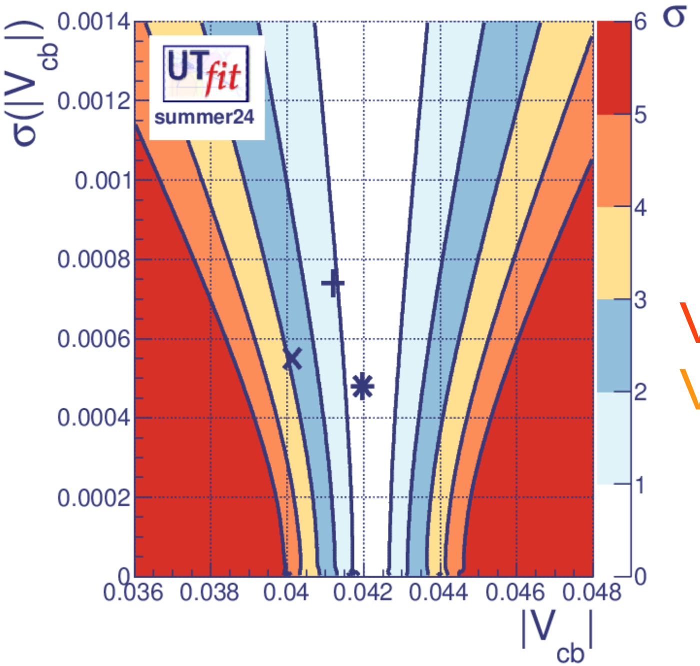
γ_{UTfit} = (65.6 ± 1.4)°

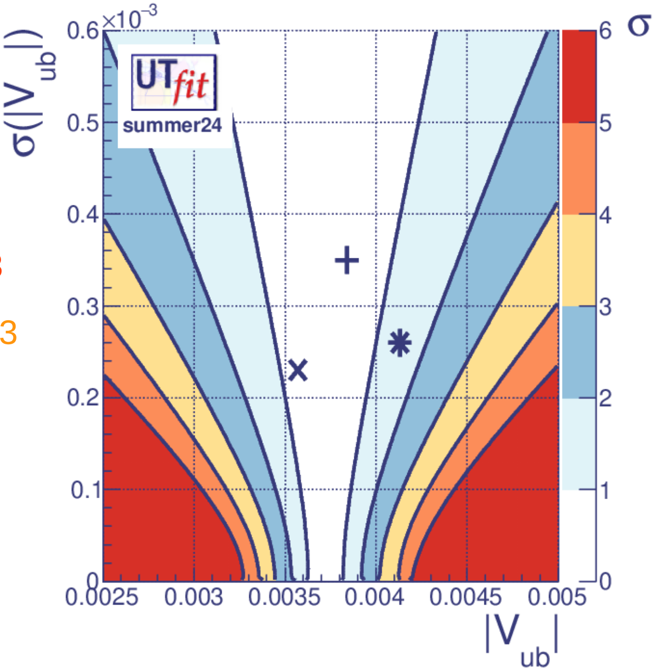
Checking the usual *tensions*..



$Vcb_{exp} = (41.20 \pm 0.74) \cdot 10^{-3}$

$Vcb_{UTfit} = (42.19 \pm 0.48) \cdot 10^{-3}$





$Vub_{exp} = (3.84 \pm 0.35) \cdot 10^{-3}$

$Vub_{UTfit} = (3.72 \pm 0.10) \cdot 10^{-3}$

$\sin 2\beta_{exp} = 0.692 \pm 0.019$

$\sin 2\beta_{UTfit} = 0.763 \pm 0.030$

x = exclusive

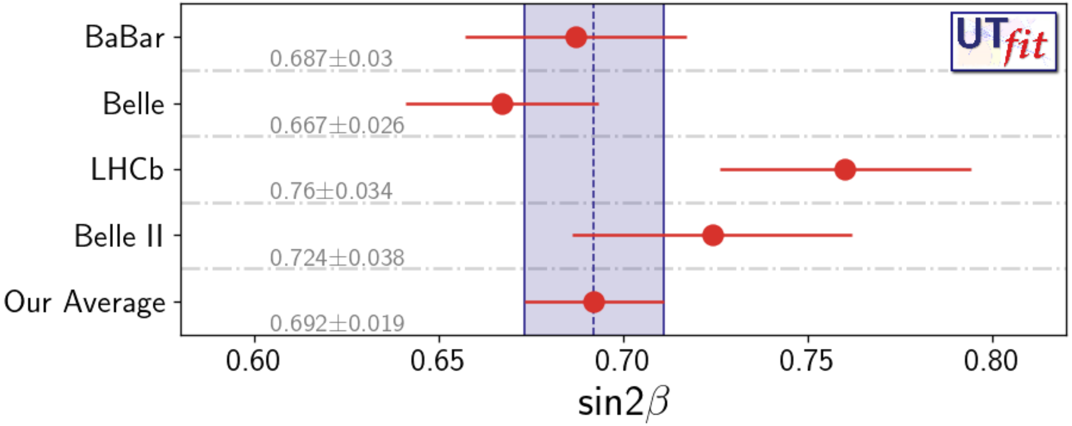
∗ = inclusive

Result summary

Observables	Measurement	Prediction	Pull (#σ)
$\sin 2\beta$	0.692 ± 0.019	0.763 ± 0.030	~ 2
γ	67.2 ± 2.9	65.6 ± 1.4	< 1
α	95 ± 8	91.4 ± 1.4	< 1
$\|V_{cb}\| \cdot 10^3$	41.20 ± 0.74	42.19 ± 0.48	~ 1.1
$\|V_{cb}\| \cdot 10^3$ (excl)	40.13 ± 0.55		~ 2.8
$\|V_{cb}\| \cdot 10^3$ (incl)	41.97 ± 0.48		< 1
$\|V_{ub}\| \cdot 10^3$	3.84 ± 0.35	3.72 ± 0.10	< 1
$\|V_{ub}\| \cdot 10^3$ (excl)	3.57 ± 0.23	-	< 1
$\|V_{ub}\| \cdot 10^3$ (incl)	4.13 ± 0.26	-	~ 1.4
$BR(B \to \tau\nu)[10^4]$	1.09 ± 0.24	0.88 ± 0.05	< 1

Another update on the ϕ_1/β angle

- In July 2024, HFLAV had a Winter2024 value update including latest LHCb (arXiv:2309.09728)
- So our average now will go from here



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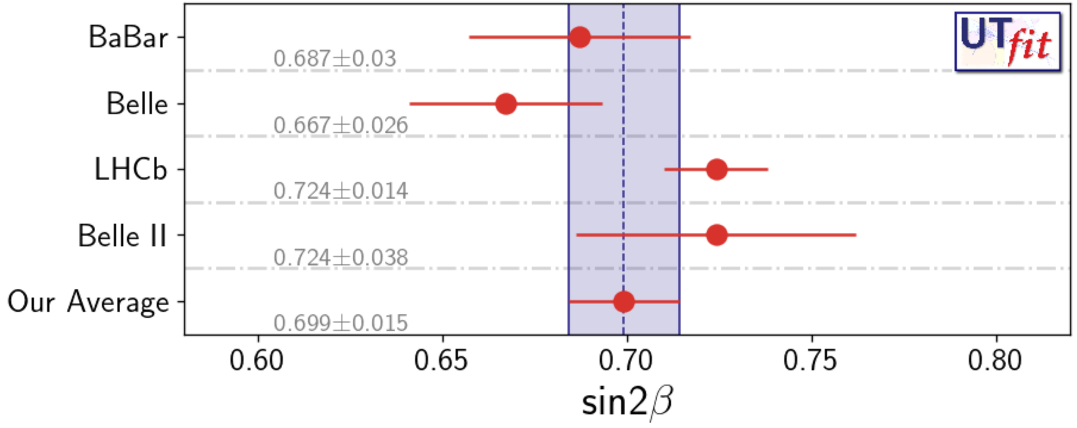
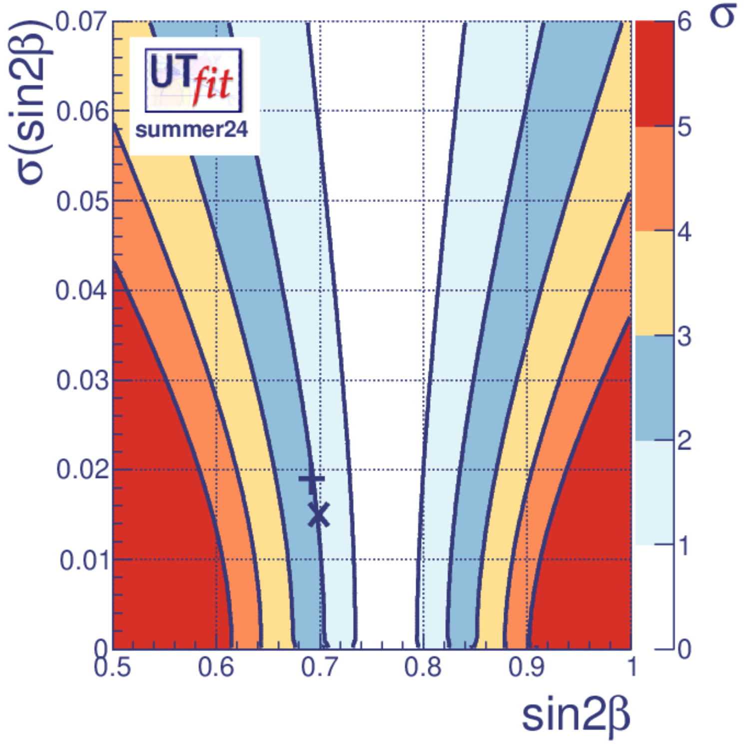


From all charmonium
HFLAV Winter2024: 0.708 ± 0.011
adding Belle II: 0.724 ± 0.038
getting average: 0.709 +/- 0.011
Corrected with -0.01 +- 0.01
final number is **0.699 +/- 0.015**

Another update on the ϕ_1/β angle

- In July 2024, HFLAV had a Winter2024 value update including latest LHCb (arXiv:2309.09728)



$\sin 2\beta_{exp}$ (HFLAV PDG 2024) = 0.692 ± 0.019

$\sin 2\beta_{exp}$ (HFLAV Winter 2024) = 0.699 ± 0.015

$\sin 2\beta_{UTfit} = 0.763 \pm 0.030$

Will be included in the ongoing summer24 update

To celebrate 20 years of.. “Bona *et al*“.. ehm.. UTfit!

2004

arXiv:hep-ph/0501199v2 4 Feb 2005

The 2004 UT*fit* Collaboration Report
on the Status of the Unitarity Triangle
in the Standard Model

UT*fit* Collaboration :

M. Bona[a], M. Ciuchini[b], E. Franco[c], V. Lubicz[b], G. Martinelli[c], F. Parodi[d], M. Pierini[e], P. Roudeau[e], C. Schiavi[d], L. Silvestrini[c], and A. Stocchi[e]

[a] Dip. di Fisica, Università di Torino and INFN, Sezione di Torino
Via P. Giuria 1, I-10125 Torino, Italy
[b] Dip. di Fisica, Università di Roma Tre and INFN, Sezione di Roma III
Via della Vasca Navale 84, I-00146 Roma, Italy
[c] Dip. di Fisica, Università di Roma “La Sapienza” and INFN, Sezione di Roma
Piazzale A. Moro 2, 00185 Roma, Italy
[d] Dip. di Fisica, Università di Genova and INFN, Sezione di Genova
Via Dodecaneso 33, 16146 Genova, Italy
[e] Laboratoire de l’Accélérateur Linéaire
IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex

Before UTfit!

1995

CERN-TH.7514/94
ROME prep. 94/1024

An Upgraded Analysis of ϵ'/ϵ at the Next-to-Leading Order

M. Ciuchini[a], E. Franco[b], G. Martinelli[c,*], L. Reina[d] and L. Silvestrini[e]
[a] INFN, Sezione Sanità, V.le Regina Elena 299, 00161 Roma, Italy.
[b] Dip. di Fisica, Università degli Studi di Roma "La Sapienza" and INFN, Sezione di Roma, P.le A. Moro 2, 00185 Roma, Italy.
[c] Theory Division, CERN, 1211 Geneva 23, Switzerland.
[d] Brookhaven National Laboratory, Physics Department, Upton, NY 11973
[e] Dip. di Fisica, Univ. di Roma "Tor Vergata" and INFN, Sezione di Roma II, Via della Ricerca Scientifica 1, I-00133 Rome, Italy.

Abstract

An upgraded analysis of ϵ, x_d and ϵ'/ϵ, using the latest determinations of the relevant experimental and theoretical parameters, is presented. Using the recent determination of the top quark mass, $m_t = (174 \pm 17)$ GeV, our best estimate is $\epsilon'/\epsilon = 3.1 \pm 2.5$, which lies in the range given by E731. We describe our determination of ϵ'/ϵ and make a comparison with other similar studies. A detailed discussion of the matching of the full theory to the effective Hamiltonian, written in terms of lattice operators, is also given.

1999

BUHEP-99-24
RM3-TH/99-9
ROME 99/1267

Combined analysis of the unitarity triangle and CP violation in the Standard Model

M. Ciuchini[a], E. Franco[b], L. Giusti[c], V. Lubicz[a], G. Martinelli[b]
[a] Dipartimento di Fisica, Università di Roma Tre and INFN, Sezione di Roma III, Via della Vasca Navale 84, I-00146 Rome, Italy
[b] Dipartimento di Fisica, Università di Roma "La Sapienza" and INFN, Sezione di Roma, P.le A. Moro 2, I-00185 Rome, Italy
[c] Department of Physics, Boston University, Boston, MA 02215 USA.

Abstract

We perform a combined analysis of the unitarity triangle and of the CP violating parameter ε'/ε using the most recent determination of the relevant experimental data and, whenever possible, hadronic matrix elements from lattice QCD. We discuss the rôle of the main non-perturbative parameters and make a comparison with other recent analyses. We use lattice results for the matrix element of Q_8 obtained without reference to the strange quark mass. Since a reliable lattice determination of the matrix element of Q_6 is still missing, the theoretical predictions for ε'/ε suffer from large uncertainties. By evaluating this matrix element with the vacuum-saturation approximation, we typically find as central value $\varepsilon'/\varepsilon = (4 \div 7) \times 10^{-4}$. We conclude that the experimental data suggest large deviation of the value of the matrix element of Q_6 from the vacuum-saturation approximation, possibly due to penguin contractions.

October 1999

LAL 99-03
March 1999
DELPHI 99-27 CONF 226

Constraints on the parameters of the CKM matrix by End 1998

F. Parodi[(a)], P. Roudeau[(b)] and A. Stocchi[(b)]
[(a)] **Dipartimento di Fisica, Universitá di Genova and INFN**
Via Dodecaneso 33, 16146 Genova, Italy
[(b)] **Laboratoire de l'Accélérateur Linéaire**
IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex

2000

LAL 00-77
ROME1-1307/00
RM3-TH/00-16

2000 CKM-TRIANGLE ANALYSIS
A Critical Review with Updated Experimental Inputs and Theoretical Parameters

M. Ciuchini[(a)], G. D'Agostini[(b)], E. Franco[(b)], V. Lubicz[(a)], G. Martinelli[(b)], F. Parodi[(c)], P. Roudeau[(d)] and A. Stocchi[(d)]
[(a)] **Università di Roma Tre and INFN, Sezione di Roma III,**
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[(b)] **Università "La Sapienza" and Sezione INFN di Roma,**
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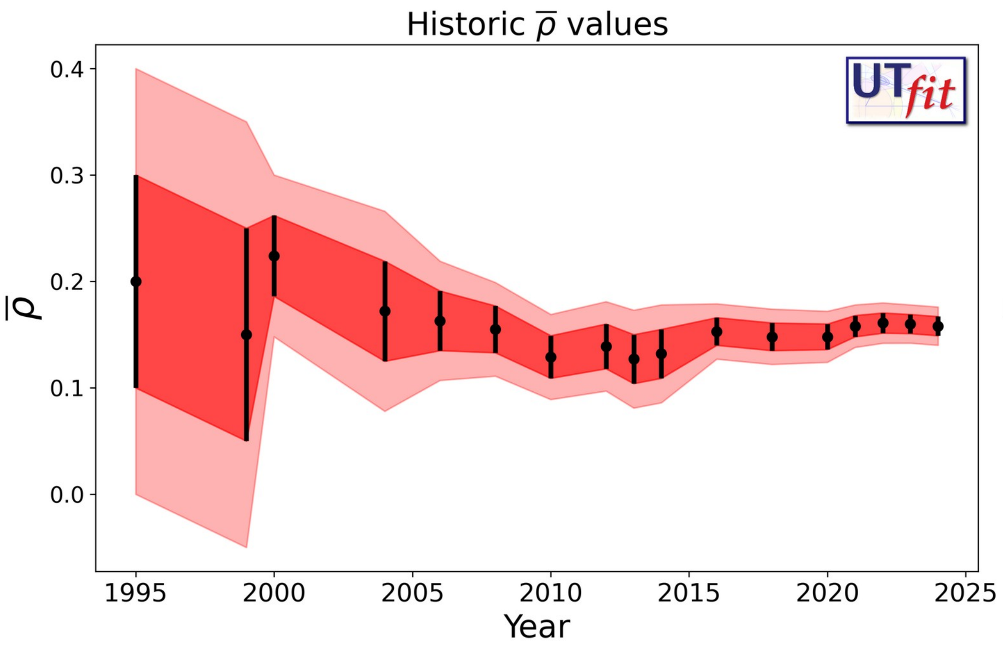
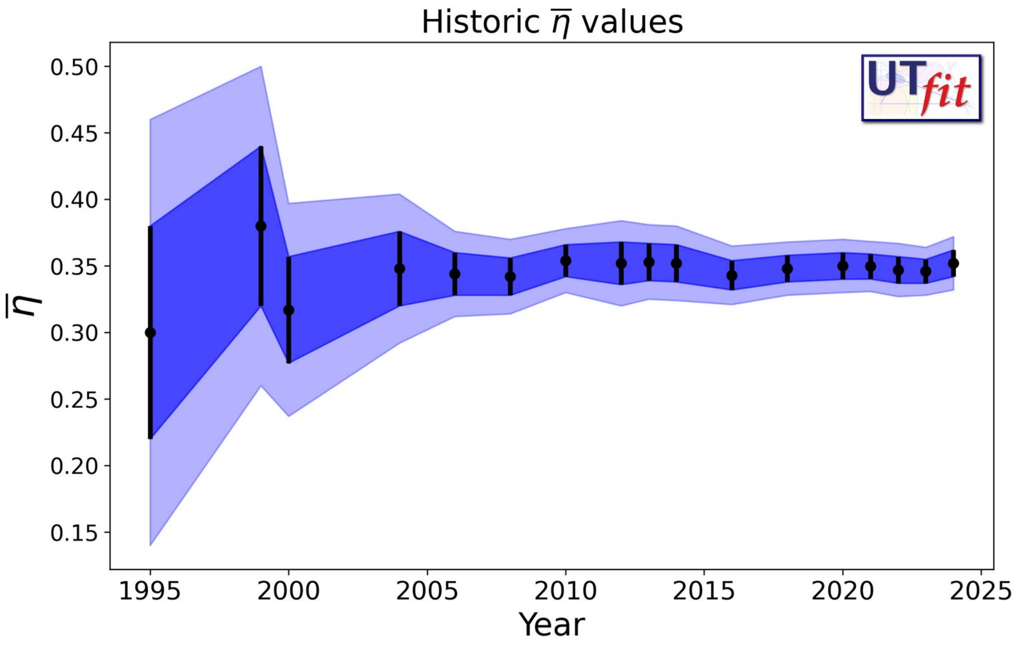
IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex

Abstract

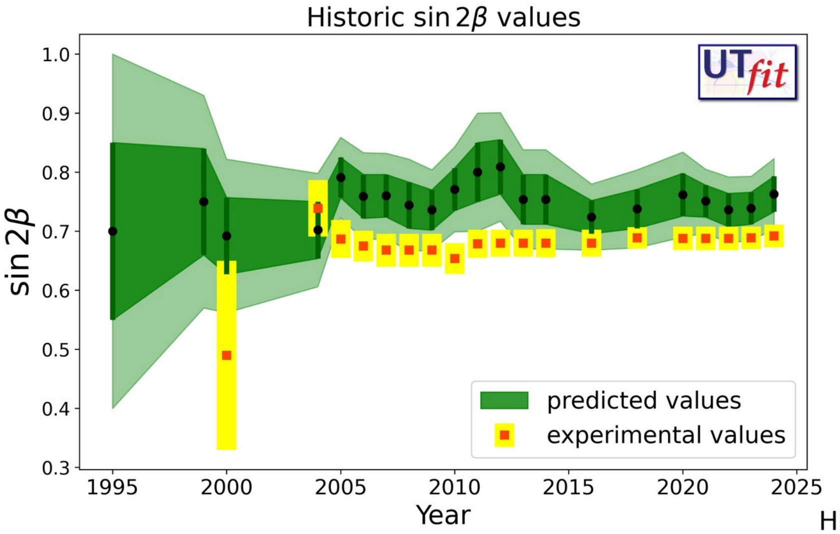
Within the Standard Model, a review of the current determination of the sides and angles of the CKM unitarity triangle is presented, using experimental constraints from the measurements of $|\varepsilon_K|$, $|V_{ub}/V_{cb}|$, Δm_d and from the limit on Δm_s, available in September 2000. Results from the experimental search for $B^0_s - \bar{B}^0_s$ oscillations are introduced in the present analysis using the likelihood. Special attention is devoted to the determination of the theoretical uncertainties. The purpose of the analysis is to infer regions where the parameters of interest lie with given probabilities. The BaBar "*95% C.L. scanning*" method is also commented.

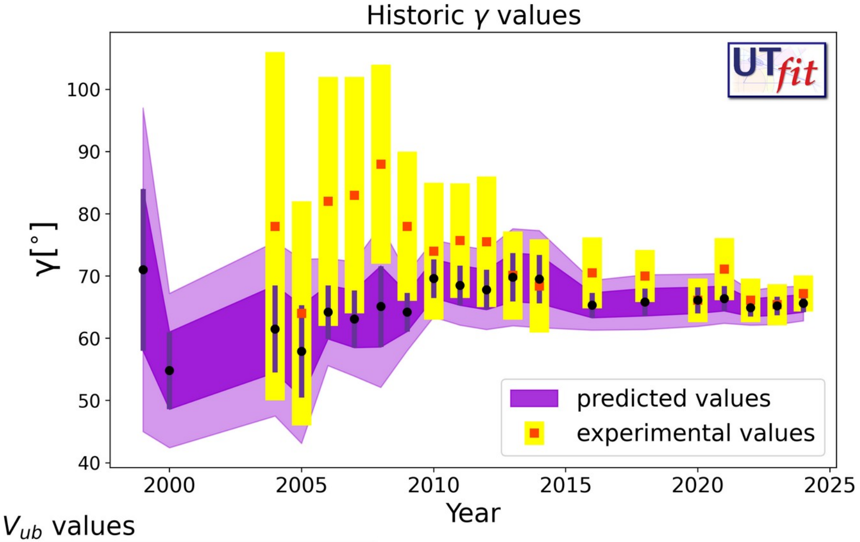
UTfit results across the years:

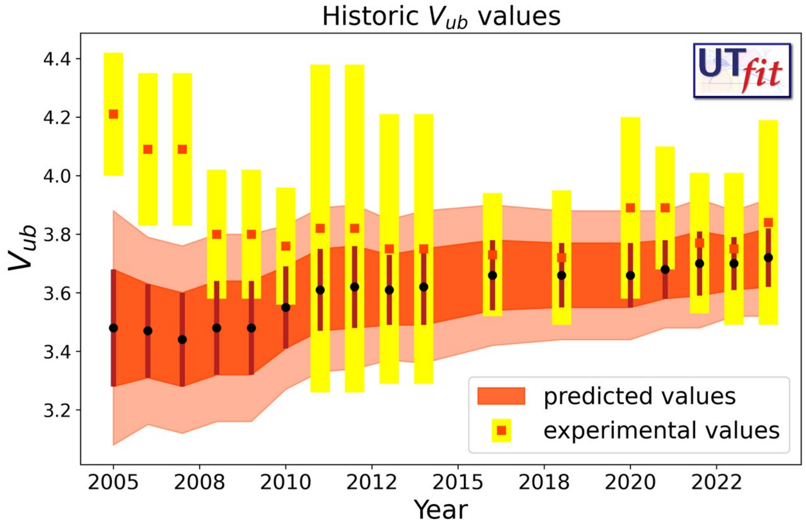




UTfit and experimental results across the years:







UT analysis including new physics

fit simultaneously for the CKM and the NP parameters (generalized UT fit)

- find out NP contributions to ΔF=2 transitions

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

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

$\Delta m_{q/K} = C_{B_q/\Delta m_K} (\Delta m_{q/K})^{SM}$	$\varepsilon_K = C_\varepsilon \varepsilon_K^{SM}$
$A_{CP}^{B_d \to J/\psi K_s} = \sin 2(\beta + \phi_{B_d})$	$A_{CP}^{B_s \to J/\psi\phi} \sim \sin 2(-\beta_s + \phi_{B_s})$

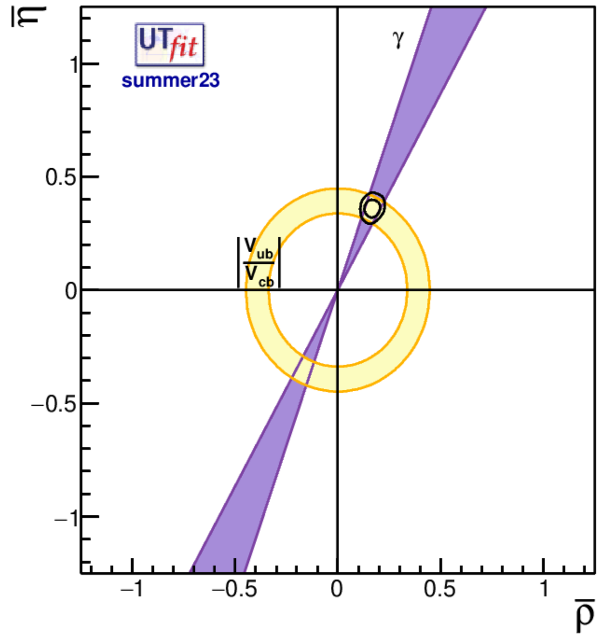
To be updated with summer24 results:

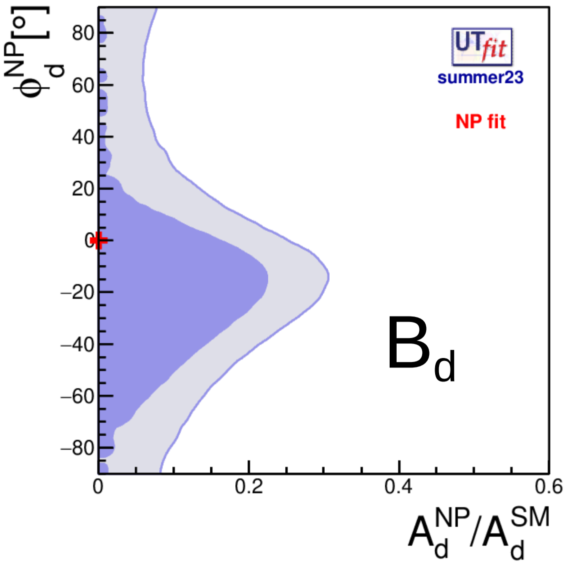
New HFLAV averages on $\phi_s = 2\beta_s$ from the angular analysis of $B_s \to J/\psi\phi$

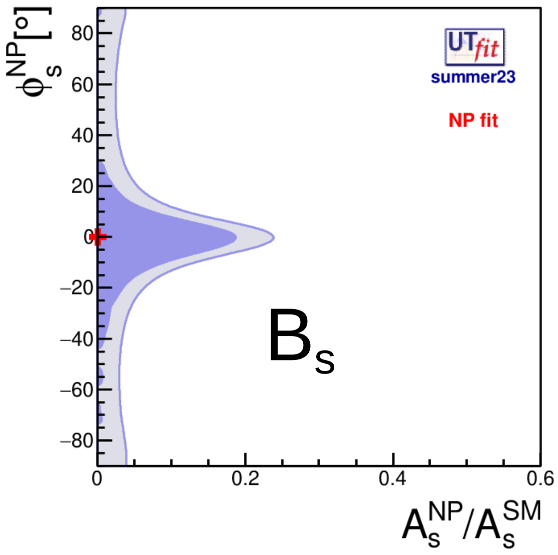
ϕ_s = -0.060 ± 0.014 rad

From the NP fit we get

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







$\bar{\rho} = 0.167 \pm 0.025$

$\bar{\eta} = 0.361 \pm 0.027$

The ratio of NP/SM amplitudes is:

< 20% @68% prob. (30% @95%) in B_d mixing

< 20% @68% prob. (25% @95%) in B_s mixing

Testing the new-physics scale

M. Bona *et al*. (UTfit)
JHEP 0803:049,2008
arXiv:0707.0636

R G E

At the high scale
new physics enters according to its specific features

At the low scale
use OPE to write the most general effective Hamiltonian.
the operators have different chiralities than the SM
NP effects are in the Wilson Coefficients C

$$\mathcal{H}_{\rm eff}^{\Delta B=2} = \sum_{i=1}^{5} C_i Q_i^{bq} + \sum_{i=1}^{3} \tilde{C}_i \tilde{Q}_i^{bq}$$

$$\begin{aligned}
Q_1^{q_i q_j} &= \bar{q}_{jL}^{\alpha} \gamma_\mu q_{iL}^{\alpha} \bar{q}_{jL}^{\beta} \gamma^\mu q_{iL}^{\beta} \,, \\
Q_2^{q_i q_j} &= \bar{q}_{jR}^{\alpha} q_{iL}^{\alpha} \bar{q}_{jR}^{\beta} q_{iL}^{\beta} \,, \\
Q_3^{q_i q_j} &= \bar{q}_{jR}^{\alpha} q_{iL}^{\beta} \bar{q}_{jR}^{\beta} q_{iL}^{\alpha} \,, \\
Q_4^{q_i q_j} &= \bar{q}_{jR}^{\alpha} q_{iL}^{\alpha} \bar{q}_{jL}^{\beta} q_{iR}^{\beta} \,, \\
Q_5^{q_i q_j} &= \bar{q}_{jR}^{\alpha} q_{iL}^{\beta} \bar{q}_{jL}^{\beta} q_{iR}^{\alpha} \,.
\end{aligned}$$

$$C_i(\Lambda) = F_i \frac{L_i}{\Lambda^2}$$

F_i: function of the NP flavour couplings
L_i: loop factor (in NP models with no tree-level FCNC)
Λ: NP scale (typical mass of new particles mediating $\Delta F=2$ processes)

Results from the Wilson coefficients

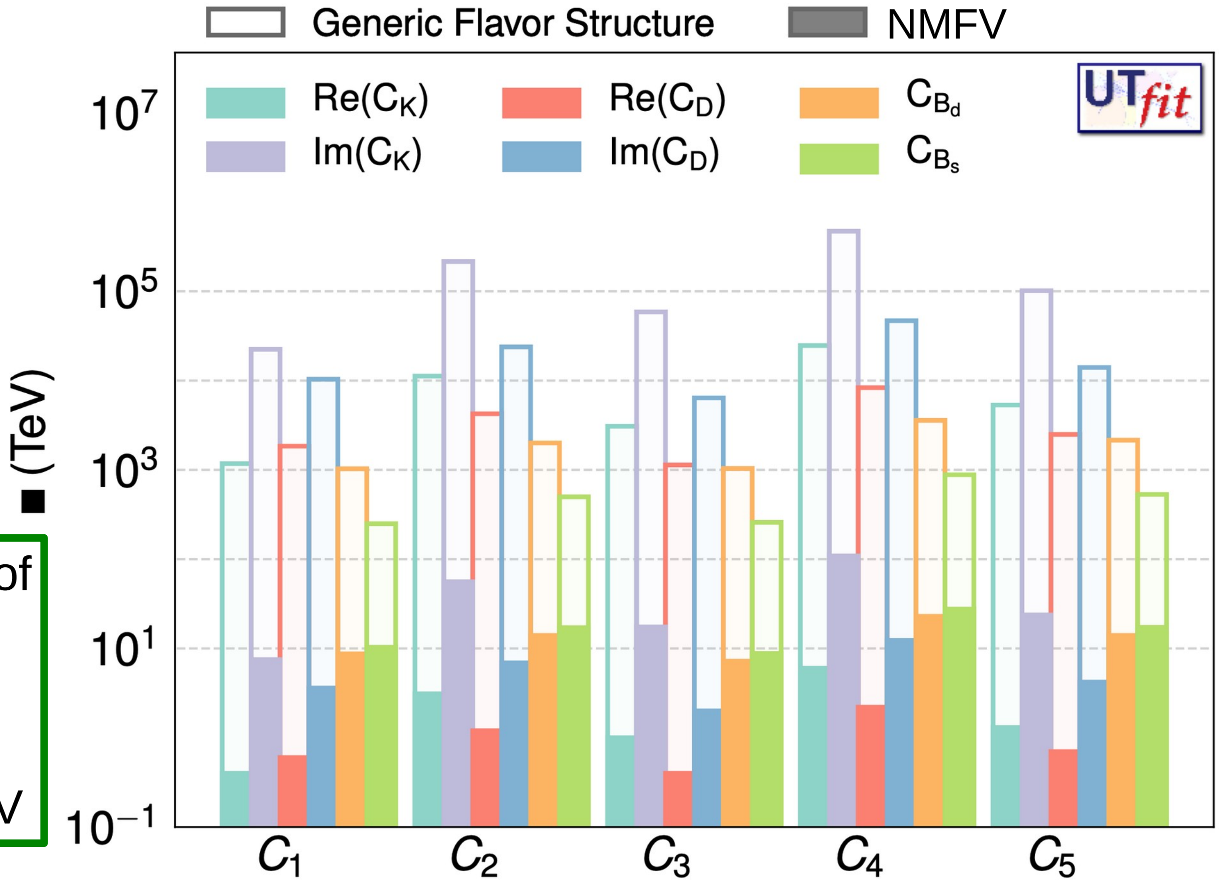
Generic:
$C(\Lambda) = \alpha/\Lambda^2$, F_i~1, arbitrary phase

α ~ 1 for strongly coupled NP

$\Lambda > 4.7\ 10^5$ TeV

$\alpha \sim \alpha_W$ in case of loop coupling through weak interactions

$\Lambda > 1.4\ 10^4$ TeV



NMFV:
$C(\Lambda) = \alpha \times |F_{SM}|/\Lambda^2$, F_i~$|F_{SM}|$, arbitrary phase

α ~ 1 for strongly coupled NP

$\Lambda > 108$ TeV

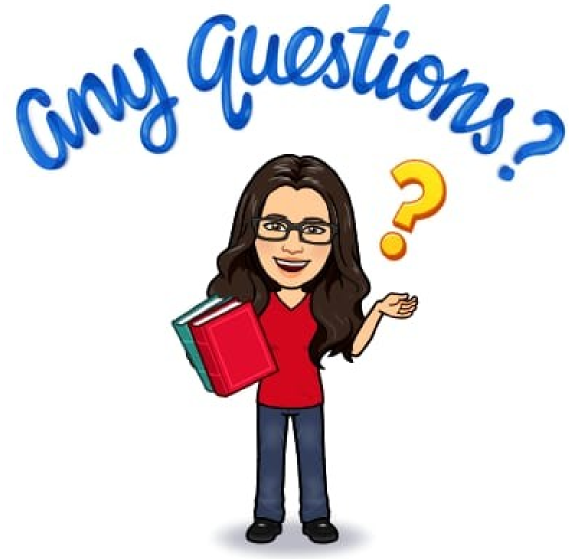
$\alpha \sim \alpha_W$ in case of loop coupling through weak interactions

$\Lambda > 3.2$ TeV

for lower bound for loop-mediated contributions, simply multiply by α_s (~ 0.1) or by α_W (~ 0.03).

conclusions

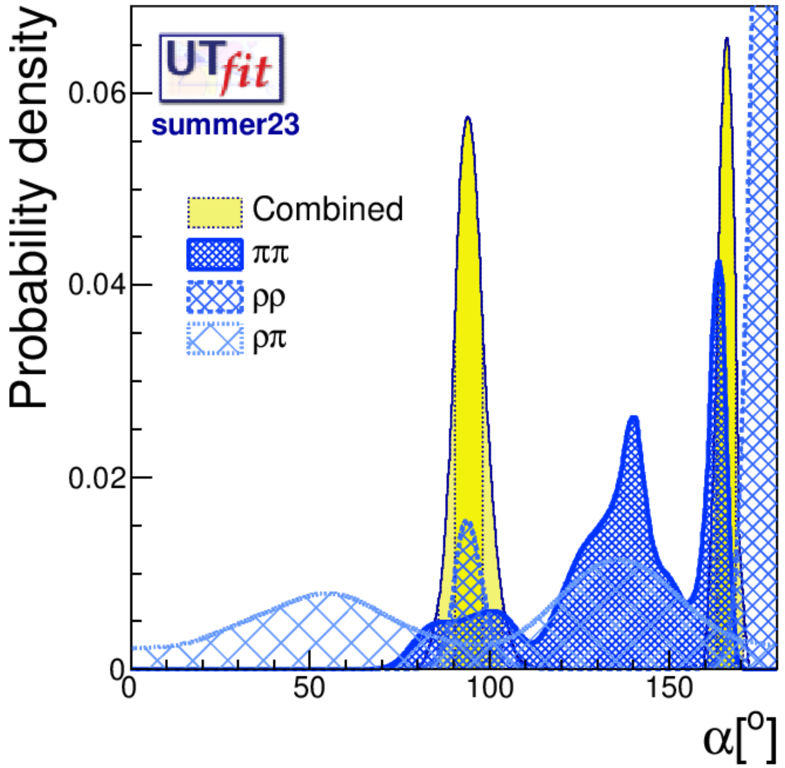
- Update is ongoing for the summer24 UT fit
- Already including major updates, will include everything coming out at this conference
- Website will be updated this summer with the new results
- NP analysis also included in the update



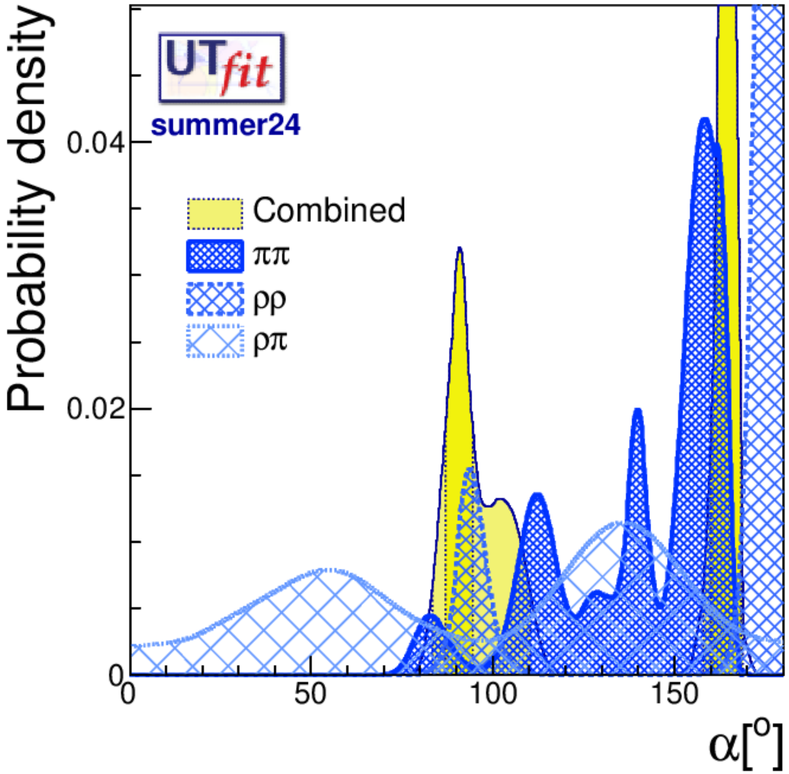
or

Back up slides

ϕ_2/α angle

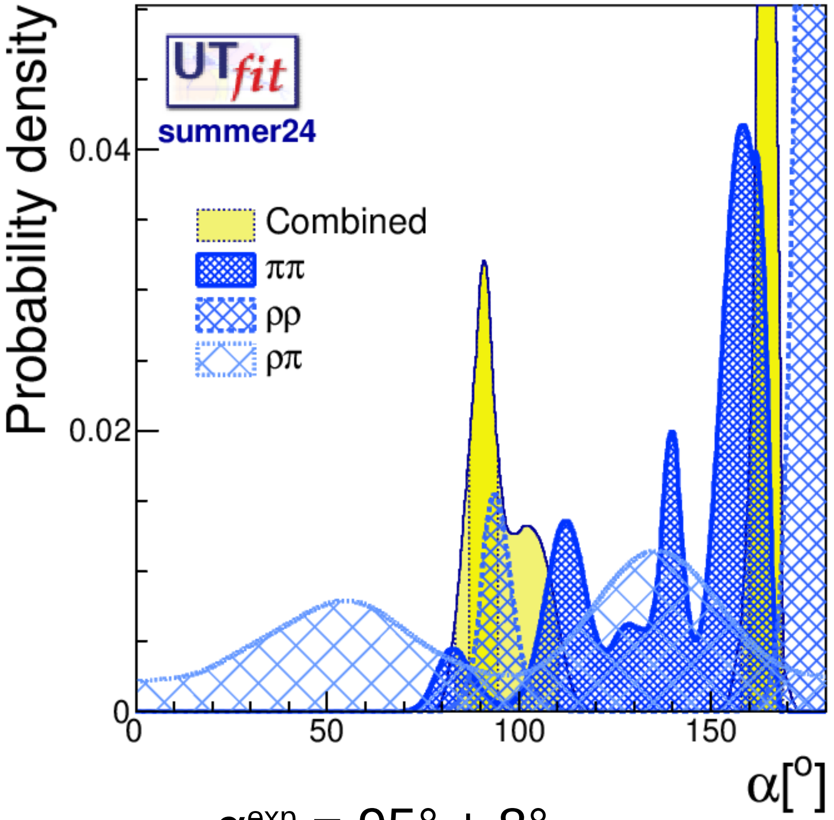


α_{exp}^{SM} = 93.8° ± 4.5°

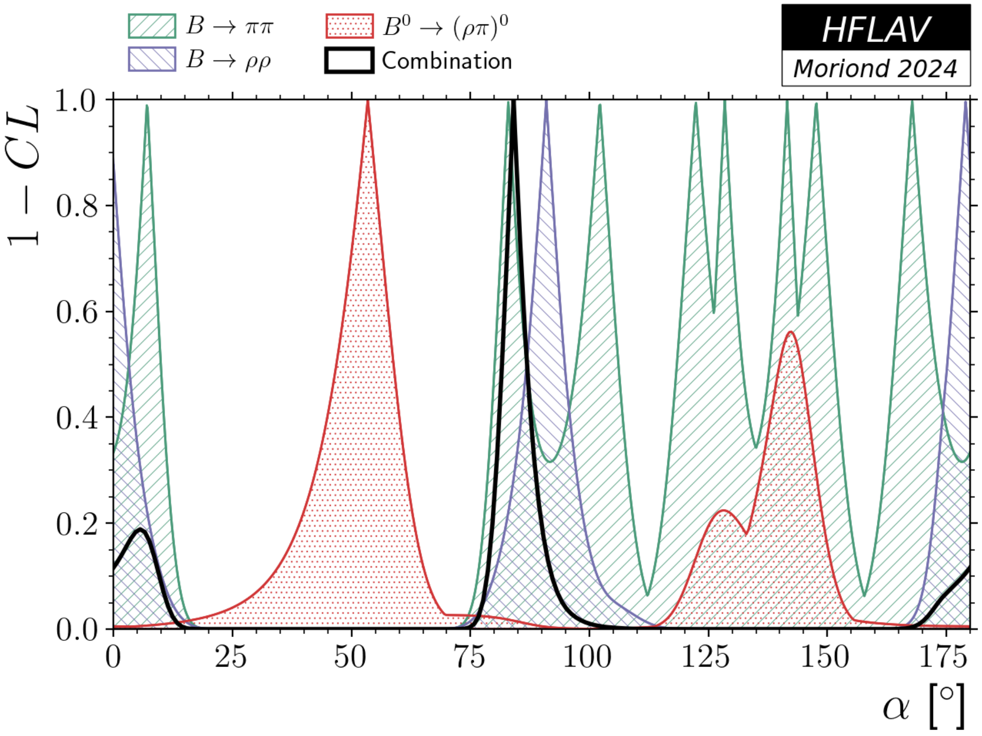


α_{exp}^{SM} = 95° ± 8°

ϕ_2/α angle



$\alpha^{exp} = 95° \pm 8°$



$\alpha_{HFLAV} = 84.5° \pm 4.2°$

UT analysis including new physics

fit simultaneously for the CKM and
the NP parameters (generalized UT fit)

- add most general loop NP to all sectors
- use all available experimental info
- find out NP contributions to ΔF=2 transitions

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

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

$\Delta m_{q/K} = C_{B_q/\Delta m_K} (\Delta m_{q/K})^{SM}$	$\varepsilon_K = C_\varepsilon \varepsilon_K^{SM}$
$A_{CP}^{B_d \to J/\psi K_s} = \sin 2(\beta + \phi_{B_d})$	$A_{CP}^{B_s \to J/\psi \phi} \sim \sin 2(-\beta_s + \phi_{B_s})$
$A_{SL}^q = \mathrm{Im}(\Gamma_{12}^q / A_q)$	$\Delta\Gamma^q / \Delta m_q = \mathrm{Re}(\Gamma_{12}^q / A_q)$

new-physics-specific constraints

semileptonic asymmetries in B^0 and B_s:
sensitive to NP effects in both size and phase.

$$A^s_{\rm SL} \equiv \frac{\Gamma(\bar{B}_s \to \ell^+ X) - \Gamma(B_s \to \ell^- X)}{\Gamma(\bar{B}_s \to \ell^+ X) + \Gamma(B_s \to \ell^- X)} = \text{Im}\left(\frac{\Gamma^s_{12}}{A^{\rm full}_s}\right)$$

HFLAV from Cleo, BaBar, Belle, D0 and LHCb

same-side dilepton charge asymmetry:
admixture of B_s and B_d so sensitive to NP effects in both.

D0 arXiv:1106.6308

$$A^{\mu\mu}_{\rm SL} \times 10^3 = -7.9 \pm 2.0$$

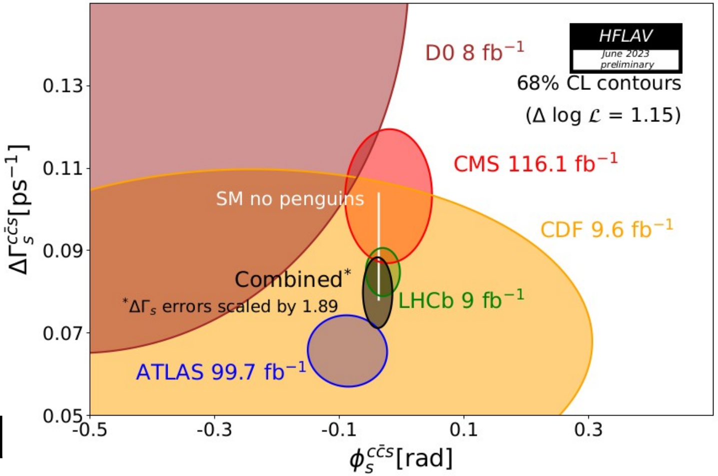
$$A^{\mu\mu}_{\rm SL} = \frac{f_d \chi_{d0} A^d_{\rm SL} + f_s \chi_{s0} A^s_{\rm SL}}{f_d \chi_{d0} + f_s \chi_{s0}}$$

lifetime τ^{FS} in flavour-specific final states:
average lifetime is a function to the width and the width difference

$$\tau^{FS}(B_s) = 1.527 \pm 0.011 \text{ ps}$$ HFLAV

$\phi_s=2\beta_s$ vs $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$
angular analysis as a function of proper time and b-tagging

$$\phi_s = -0.039 \pm 0.016 \text{ rad}$$



Testing the new-physics scale

$$C_i(\Lambda) = F_i \frac{L_i}{\Lambda^2}$$

The dependence of C on Λ changes depending on the flavour structure.
We can consider different flavour scenarios:

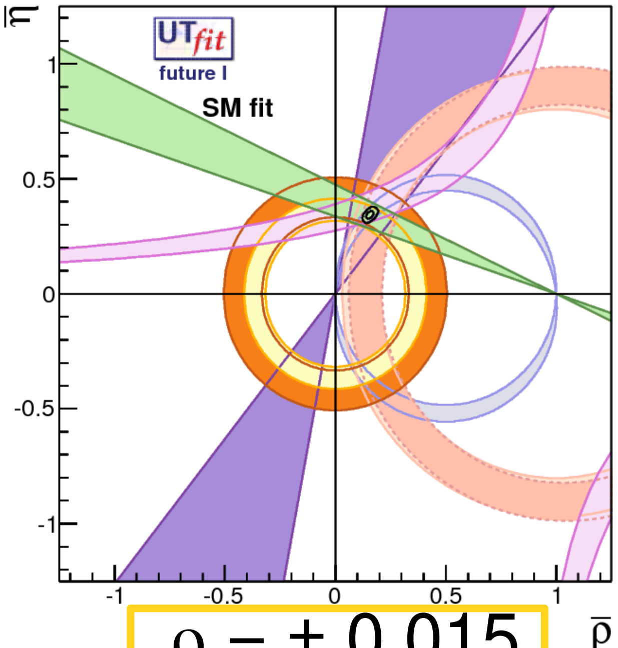
- Generic: $C(\Lambda) = \alpha/\Lambda^2$ $F_i \sim 1$, arbitrary phase
- NMFV: $C(\Lambda) = \alpha \times |F_{SM}|/\Lambda^2$ $F_i \sim |F_{SM}|$, arbitrary phase
- MFV: $C(\Lambda) = \alpha \times |F_{SM}|/\Lambda^2$ $F_1 \sim |F_{SM}|$, $F_{i\neq1} \sim 0$, SM phase

α (L_i) is the coupling among NP and SM
- $\alpha \sim 1$ for strongly coupled NP
- $\alpha \sim \alpha_W$ (α_S) in case of loop coupling through weak (strong) interactions

If no NP effect is seen lower bound on NP scale Λ

F is the flavour coupling and so
F_{SM} is the combination of CKM factors for the considered process

Old future predictions..



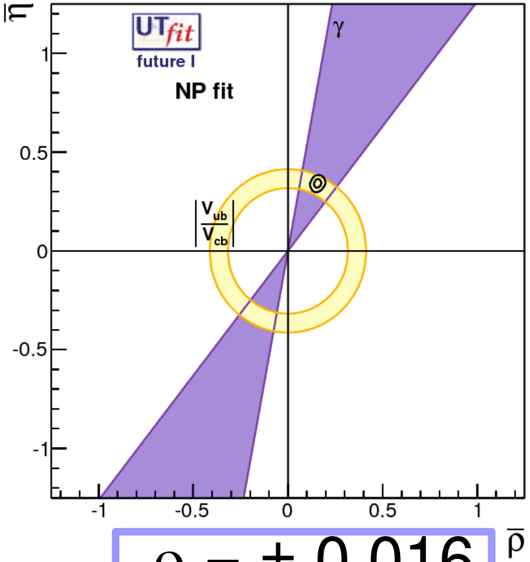
$\rho = \pm\ 0.015$
$\eta = \pm\ 0.015$

$\bar{\rho} = 0.160 \pm 0.009$
$\bar{\eta} = 0.346 \pm 0.009$

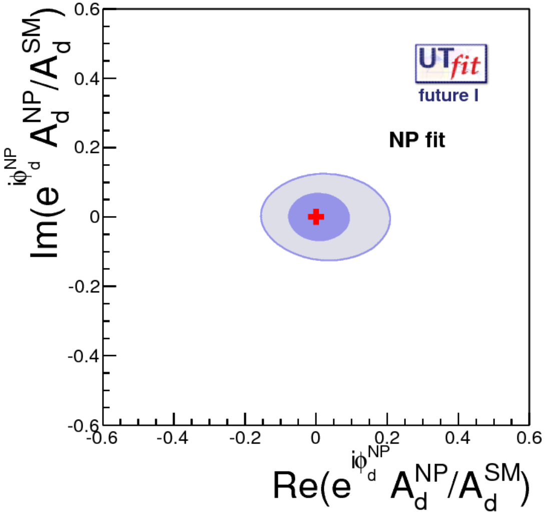
current sensitivity

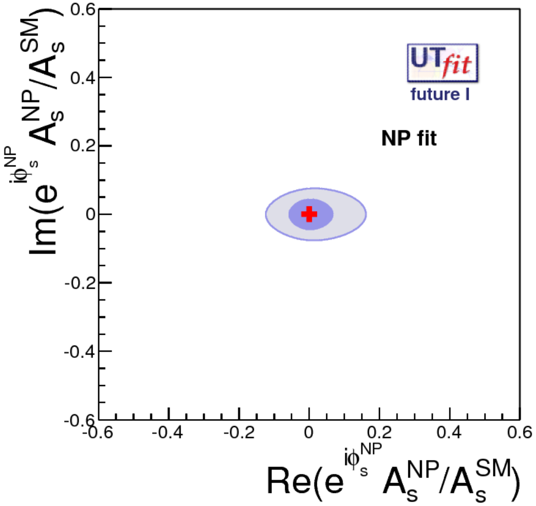
$\bar{\rho} = 0.167 \pm 0.025$
$\bar{\eta} = 0.361 \pm 0.027$

future I scenario:
errors from
Belle II at 5/ab
+ LHCb at 10/fb



$\rho = \pm\ 0.016$
$\eta = \pm\ 0.019$





Lattice result summary (summer22)

We obtain the predictions for the lattice parameters in different configurations in the fit:

- only lattice parameters ratios
  - (F_{Bs}/F_B, B_{Bs}/B_{Bd} used)
- only B parameters
  - (B_{Bs}^1, B_{Bs}/B_{Bd} used)
- only decay constants f
  - (f_{Bs}, f_{Bs}/f_B included)

Observables	Measurement	Prediction
B_K	0.756 ± 0.016	0.840 ± 0.053
No B lattice		
$f_B\sqrt{B_{Bd}}$	(0.2142 ± 0.0056)	0.212 ± 0.010
$f_{Bs}\sqrt{B_{Bs}}$	(0.2607 ± 0.0061)	0.259 ± 0.010
ξ	(1.217 ± 0.014)	1.225 ± 0.033
Ratios only		
f_{Bs}	0.2301 ± 0.0012	0.227 ± 0.009
B_{Bs}	1.284 ± 0.059	1.30 ± 0.10
B pars only		
f_{Bs}/f_{Bd}	1.208 ± 0.005	1.215 ± 0.028
f_{Bs}	0.2301 ± 0.0012	0.228 ± 0.008
f pars only		
B_{Bs}/B_{Bd}	1.015 ± 0.021	1.017 ± 0.028
B_{Bs}	1.284 ± 0.059	1.290 ± 0.065