CKM OVERVIEW

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http://www.utfit.org

- Motivation
- Standard Fit in the Standard Model
- New Constraints and New Physics
- CKM fits beyond the Standard Model
- Conclusions

MOTIVATION

- The SM works beautifully up to a few hundred GeV's, but it must be an effective theory valid up to a scale $\Lambda \leq M_{planck}$:

$$\mathcal{L}(M_W) = \Lambda^2 H^\dagger H + \lambda \left(H^\dagger H\right)^2 + \mathcal{L}_{\rm SM}^{\rm gauge} + \mathcal{L}_{\rm SM}^{\rm Yukawa} + \frac{1}{\Lambda}\mathcal{L}^5 + \frac{1}{\Lambda^2}\mathcal{L}^6 + \ldots$$

EW scale

NP contribution to g-2, b→sγ, etc

NP contribution to EW precision, FCNC processes, CPV, etc.

How can we explore NP with processes involving only SM particles?

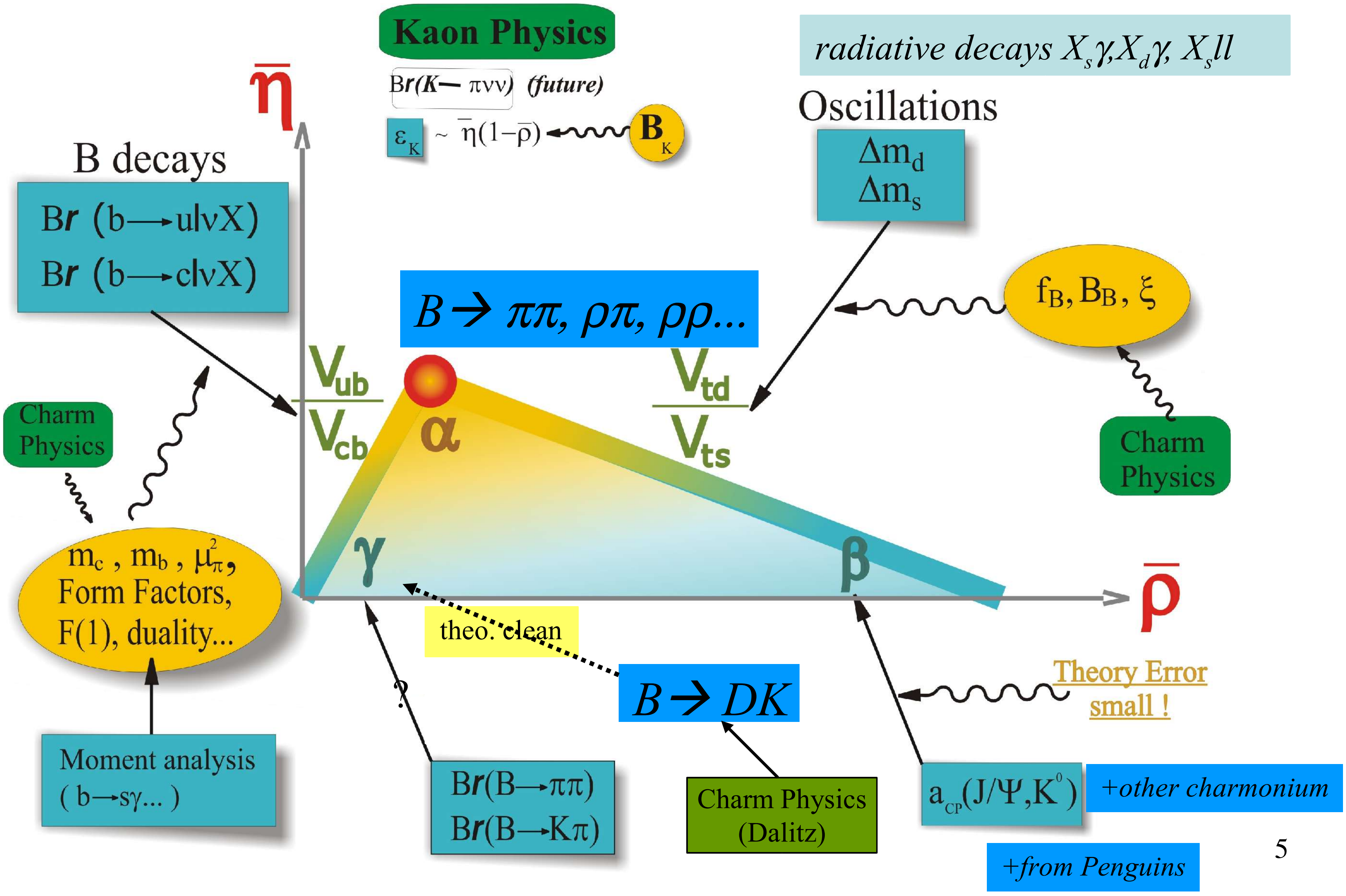
- EW gauge symmetry spontaneously broken
  - ⇨ tree-level relations between EW observables (masses, couplings, ...)
  - ⇨ quantum corrections computable and sensitive to higher-dim operators
  - ⇨ The LEP glorious legacy of precision EW fits: $\Lambda > 2\text{-}10$ TeV!!
- No tree-level FCNC (GIM mechanism) ⇨ quantum corrections computable and sensitive to higher-dim operators
  - ⇨ the UT in the B-factory era: $\Lambda > 4\text{-}6$ TeV!!

The CP violation mechanism of the SM is very peculiar

- CP symmetry is explicitly broken by the Yukawa couplings
- CP is not an approximate symmetry of the model. CP violation is suppressed by mixing angles, but there are $\mathcal{O}(1)$ effects
- A single source of CP violation in the weak interactions of quarks (but leptons wait behind the corner with more sources)
- Three-generations unitarity: CP violation from the measurement of CP conserving observables

All these features, if experimentally confirmed, provide strong constraints on New Physics

The Unitarity Triangle: $V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$



Kaon Physics

$Br(K \rightarrow \pi\nu\nu)$ *(future)*

$\varepsilon_K \sim \bar{\eta}(1-\bar{\rho})$ ← B_K

radiative decays $X_s\gamma, X_d\gamma, X_sll$

Oscillations

Δm_d
Δm_s

f_B, B_B, ξ

Charm Physics

B decays

$Br\ (b \rightarrow ul\nu X)$
$Br\ (b \rightarrow cl\nu X)$

Charm Physics

m_c , m_b , μ_π^2,
Form Factors,
F(1), duality...

Moment analysis
($b \rightarrow s\gamma$...)

$B \rightarrow \pi\pi, \rho\pi, \rho\rho$...

$\bar{\eta}$

$\frac{V_{ub}}{V_{cb}}$

$\frac{V_{td}}{V_{ts}}$

α

γ

β

$\bar{\rho}$

theo. clean

?

$B \rightarrow DK$

$Br(B \rightarrow \pi\pi)$
$Br(B \rightarrow K\pi)$

Charm Physics
(Dalitz)

Theory Error
small !

$a_{CP}(J/\Psi, K^0)$

+other charmonium

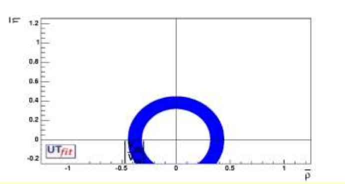
+from Penguins

The Standard UTfit

STD FIT

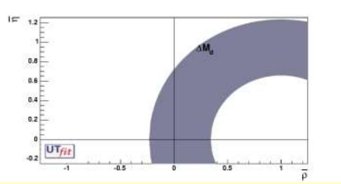
Parameter	*Value*	*Error(Gaussian)*	*Error(Flat)*
λ	**0.2258**	**0.014**	
V_{cb} ($\times 10^{-3}$) (excl.)	**41.4**	**2.1**	
V_{cb} ($\times 10^{-3}$) (incl.)	**41.6**	**0.7**	**0.6**
V_{ub} ($\times 10^{-4}$) (excl.)	**33.0**	**2.4**	**4.6**
V_{ub} ($\times 10^{-4}$) (incl.)	**47.0**	**4.4**	**-**
Δm_d (ps^{-1})	**0.502**	**0.006**	
Δm_s (ps^{-1})	**> 14.5 ps^{-1} 95%CL**	**sens.18.3 ps^{-1} 95% CL**	
m_t (GeV)	**168.5**	**4.3**	
m_c (GeV)	**1.3**		**0.1**
m_b (GeV)	**4.21**	**0.08**	**-**
$f_{B_s}\sqrt{\hat{B}_{B_s}}$ (MeV)	**276**	**38**	**-**
ξ	**1.24**	**0.04**	**0.06**
B_K	**0.79**	**0.04**	**0.09**
ε_K (10^{-3})	**2.280**	**0.013**	**-**
$\sin 2\beta$	**0.726**	**0.037**	

$$\lambda/(1-\lambda^2/2)\sqrt{\bar\rho^2+\bar\eta^2}=|V_{ub}/V_{cb}|$$



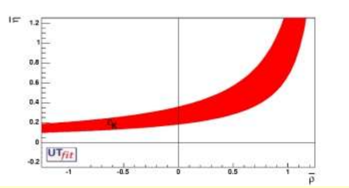
circle (0,0)

$$C_{\Delta M}\,B_s\,f^2_{B_s}\,\xi^{-2}\,A^2\lambda^6[(1-\bar\rho)^2+\bar\eta^2]=\Delta M_{B_d}$$



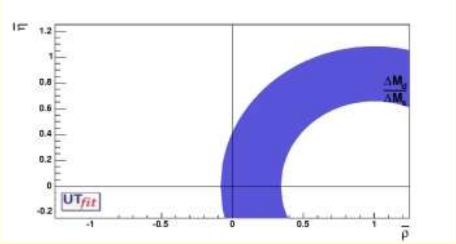
circle (1,0)

$$C_\epsilon\,B_K\,\lambda^6\bar\eta[(1-\bar\rho)A^2\lambda^4C_{tt}+C_{tc}+C_{cc}]=\varepsilon_K$$



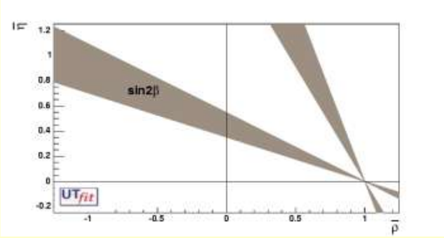
hyperbola

$$\frac{M_{B_d}}{M_{B_s}}\xi^{-2}\lambda^2[(1-\bar\rho)^2+\bar\eta^2]=\frac{\Delta M_{B_d}}{\Delta M_{B_s}}$$



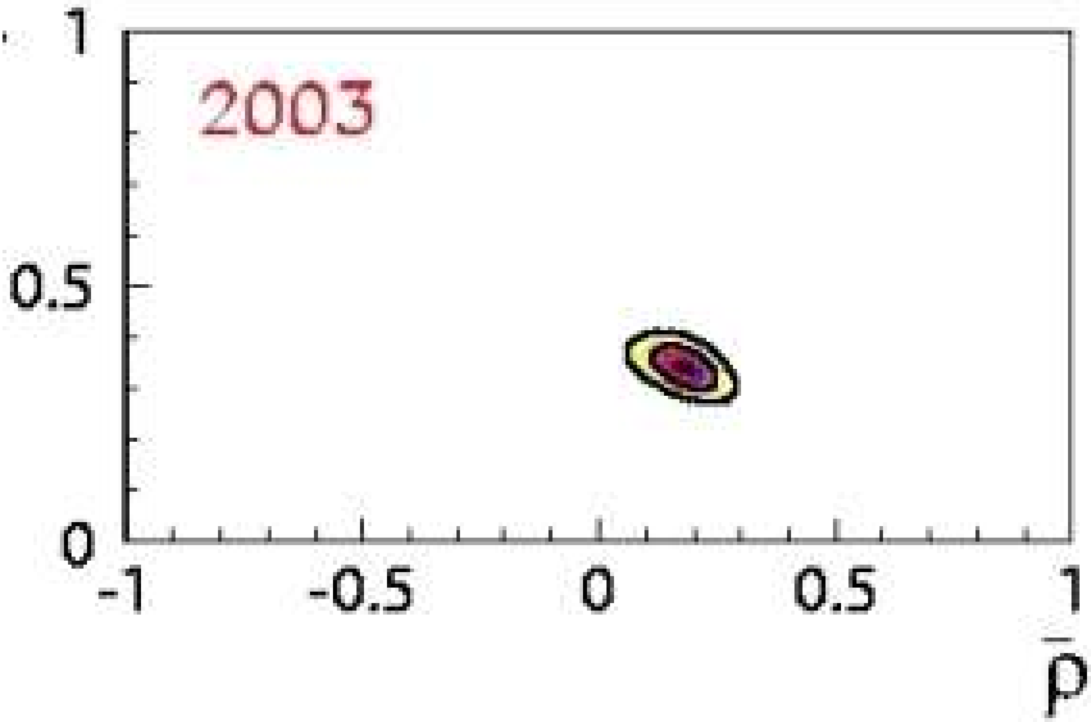
disc (1,0)

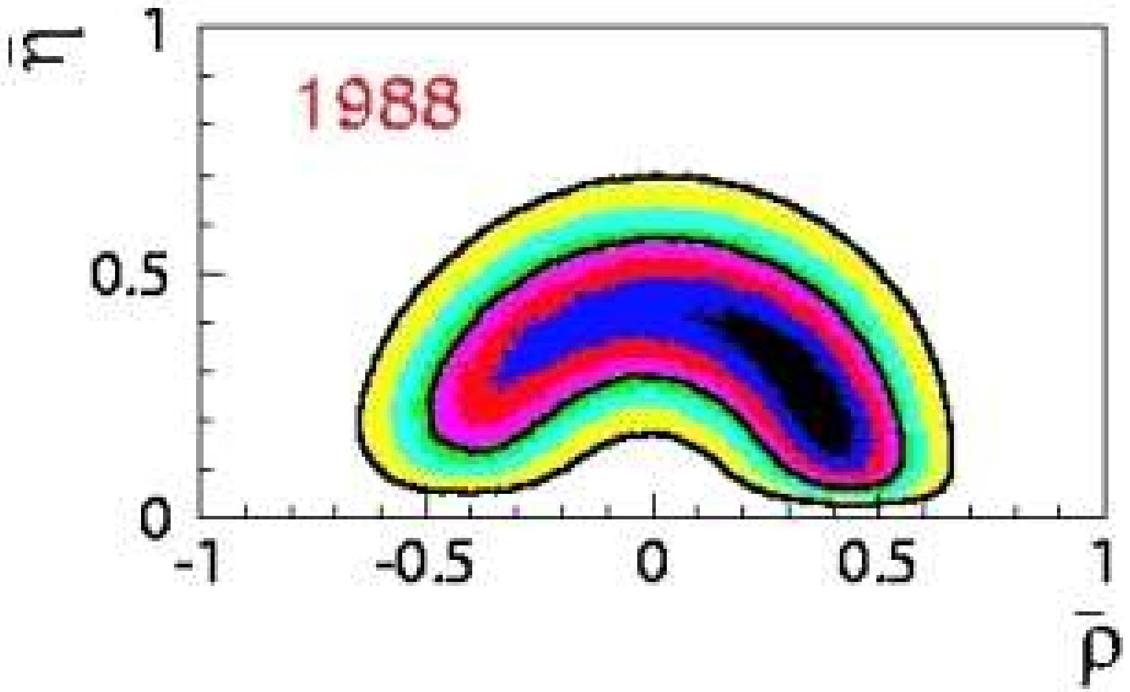
$$\frac{2\bar\eta(1-\bar\rho)}{(1-\bar\rho)^2+\bar\eta^2}=\sin 2\beta\left(A^t_{CP}(J/\psi K_S)\right)$$



4×angle β

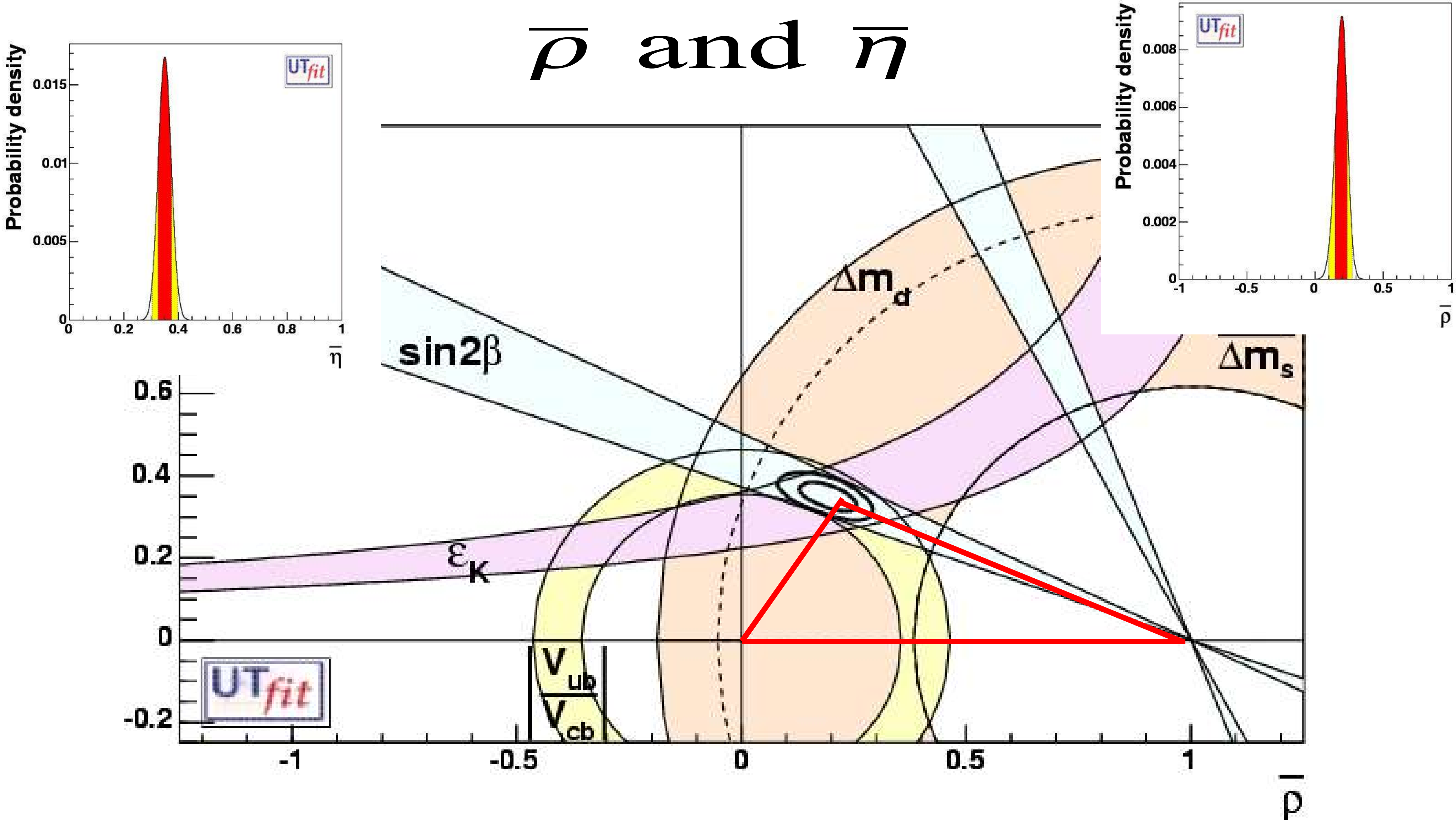
Progress of the UT analysis





End of parameter determination era, begin of precision test era: redundant determination of the triangle with new measurements from B-factories and test of new physics

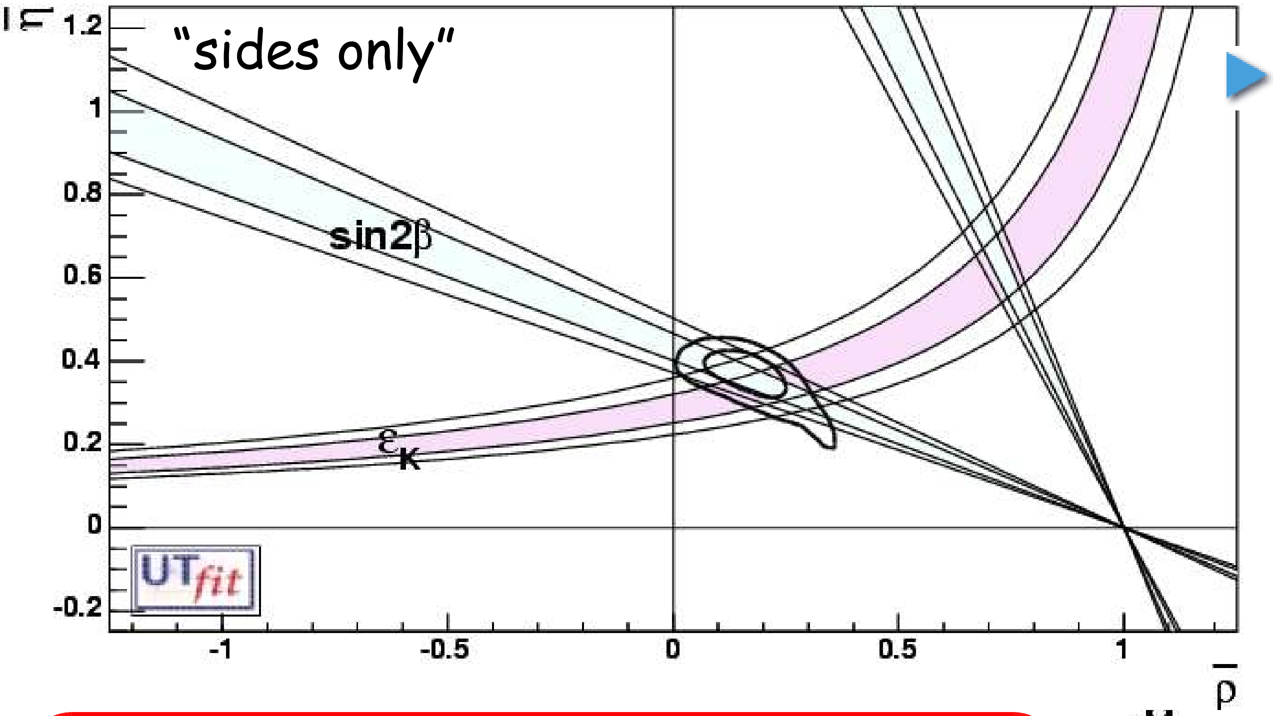
$\bar{\rho}$ and $\bar{\eta}$



$\bar{\rho} = 0.190 \pm 0.044$ [0.100, 0.271]@95% prob.

$\bar{\eta} = 0.349 \pm 0.024$ [0.303, 0.396]@95% prob.

Testing the Standard Model: CPC vs CPV



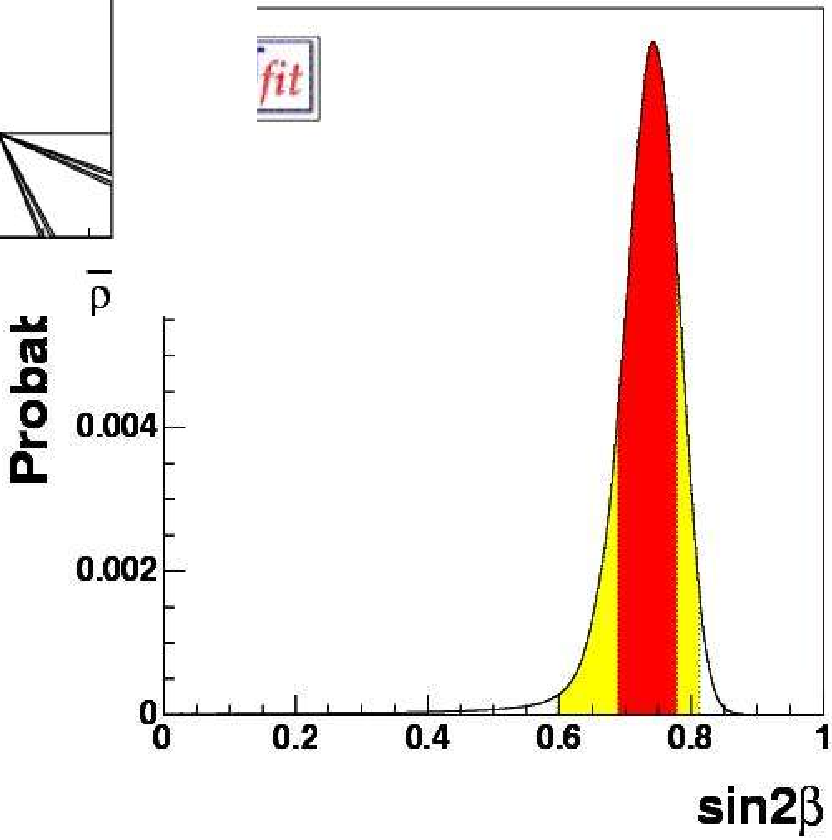
- Spectacular agreement between direct and indirect measurements

$$(\sin 2\beta)_{\text{sides}} = 0.732 \pm 0.044$$

$$(\sin 2\beta)_{\text{ind}} = 0.729 \pm 0.042$$

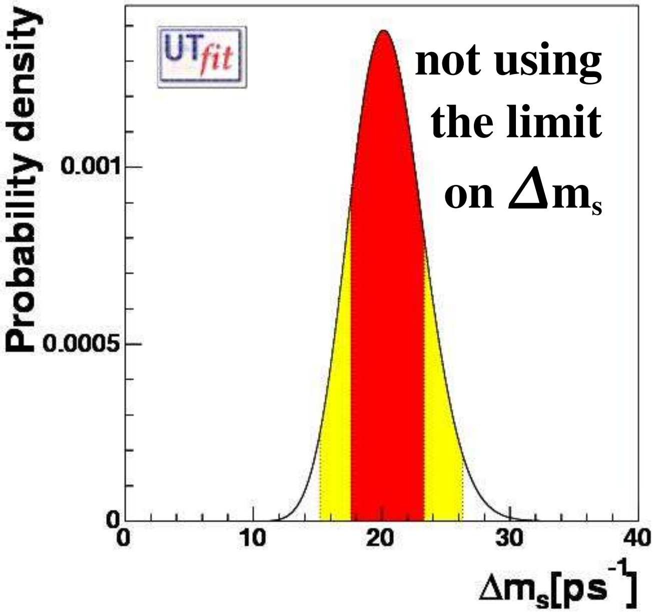
$$(\sin 2\beta)_{\text{dir}} = 0.725 \pm 0.037$$

$$\sin 2\beta = 0.728 \pm 0.028$$

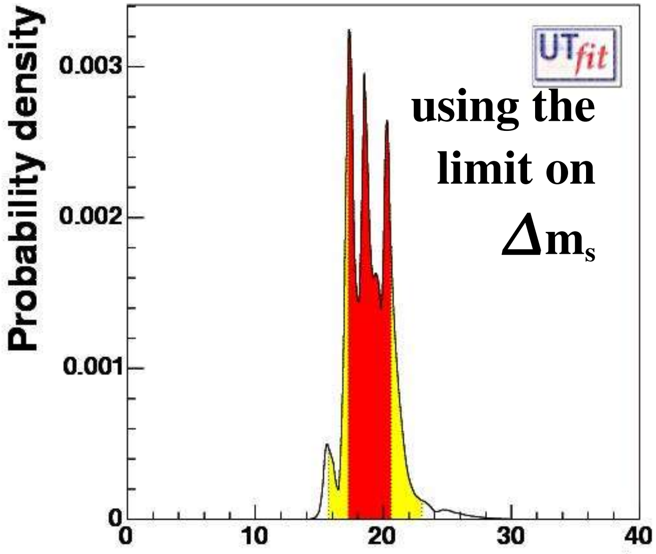


$B_s - \overline{B}_s$ mass difference

$\Delta m_s = 20.4 \pm 2.8$ ps^{-1}

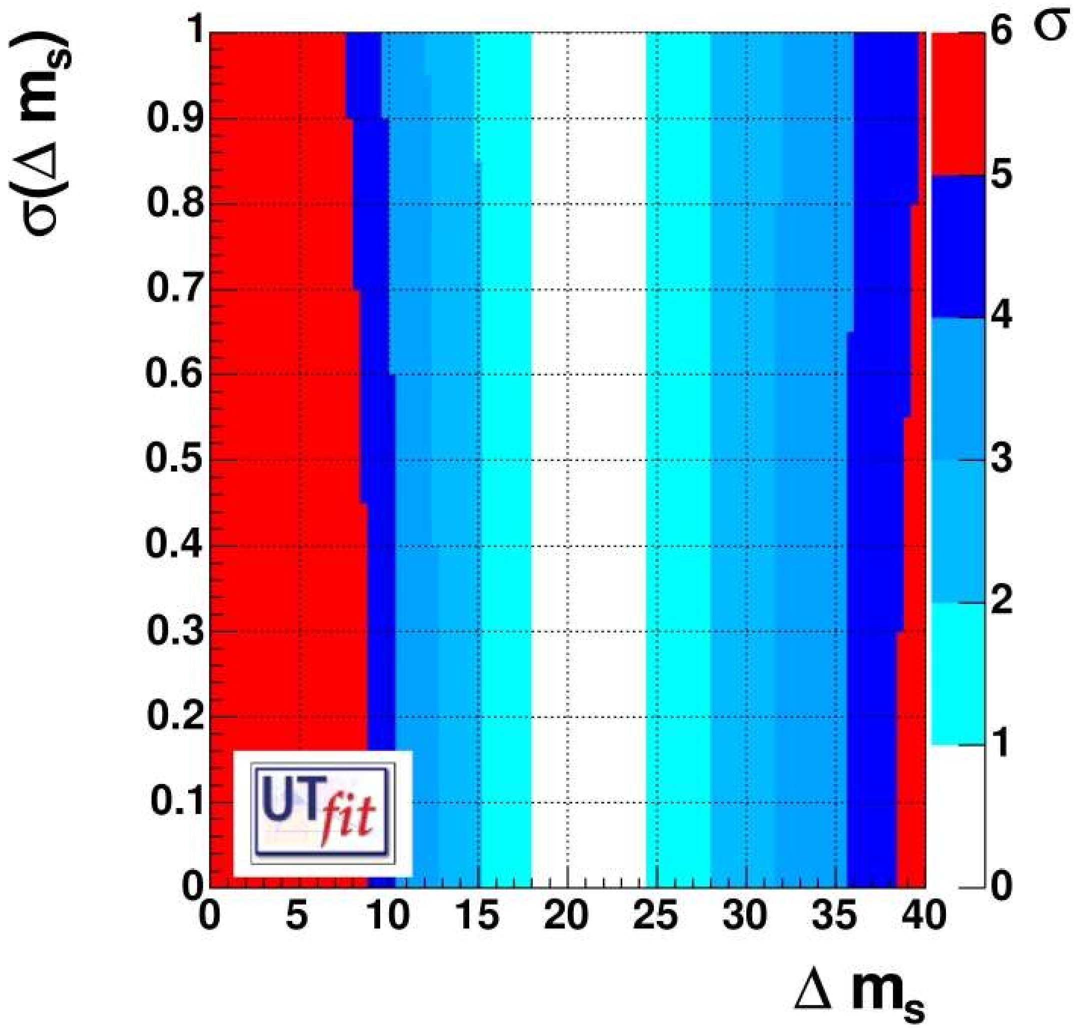


not using the limit on Δm_s



using the limit on Δm_s

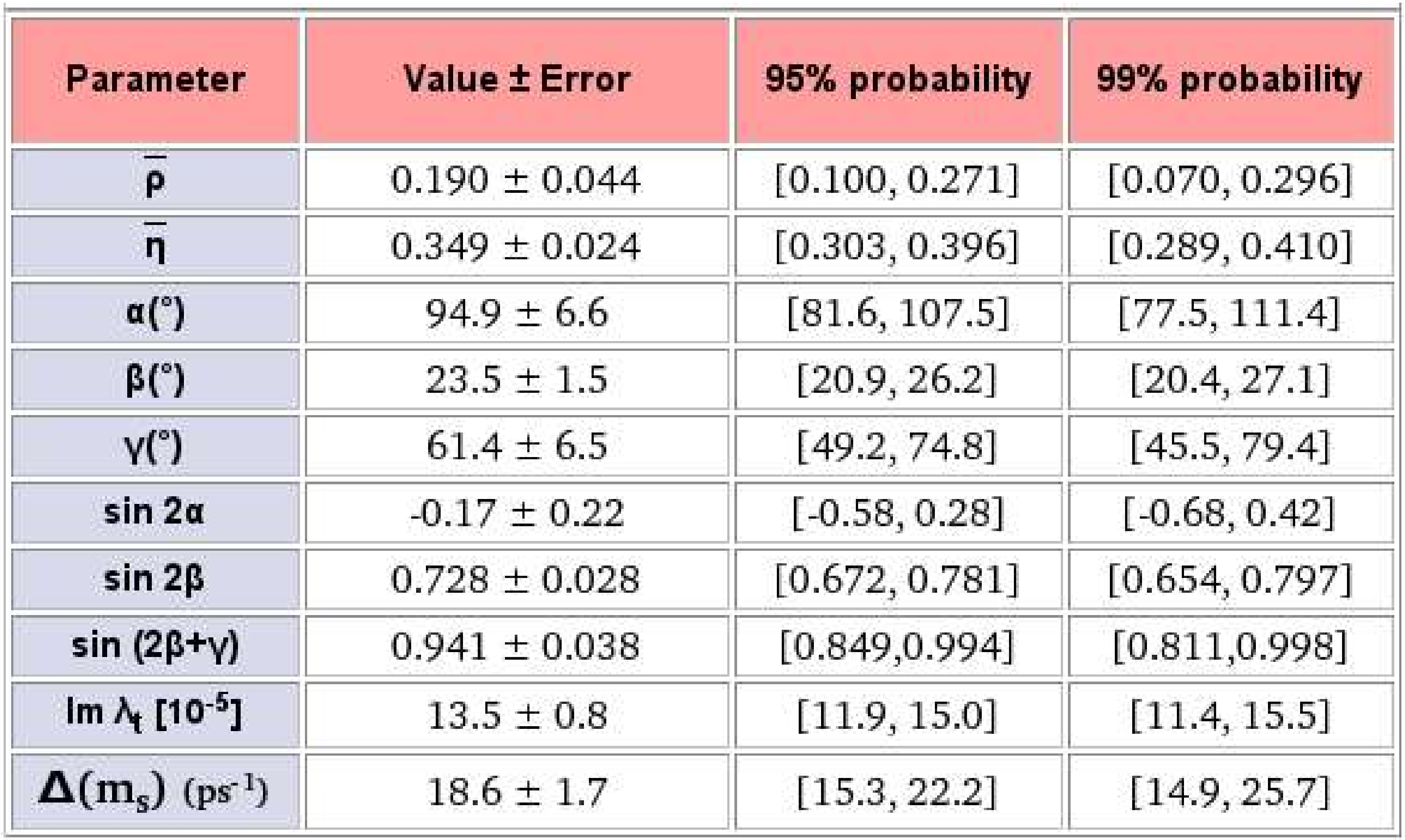
$\Delta m_s = 18.6 \pm 1.7$ ps^{-1}



$\Delta m_s > 31(38)$ ps^{-1} is new physics @3(5)σ

First NP signal from hadron colliders?

Many other results of the SM standard analysis



Parameter	Value ± Error	95% probability	99% probability
$\bar{\rho}$	0.190 ± 0.044	[0.100, 0.271]	[0.070, 0.296]
$\bar{\eta}$	0.349 ± 0.024	[0.303, 0.396]	[0.289, 0.410]
$\alpha(°)$	94.9 ± 6.6	[81.6, 107.5]	[77.5, 111.4]
$\beta(°)$	23.5 ± 1.5	[20.9, 26.2]	[20.4, 27.1]
$\gamma(°)$	61.4 ± 6.5	[49.2, 74.8]	[45.5, 79.4]
sin 2α	-0.17 ± 0.22	[-0.58, 0.28]	[-0.68, 0.42]
sin 2β	0.728 ± 0.028	[0.672, 0.781]	[0.654, 0.797]
sin (2β+γ)	0.941 ± 0.038	[0.849,0.994]	[0.811,0.998]
Im λ_t $[10^{-5}]$	13.5 ± 0.8	[11.9, 15.0]	[11.4, 15.5]
$\Delta(m_s)$ (ps^{-1})	18.6 ± 1.7	[15.3, 22.2]	[14.9, 25.7]

see UTfit http://www.utfit.org*

*just updated!

BEYOND THE STANDARD UTfit: NEW INGREDIENTS TO THE UT ANALYSIS & NEW PHYSICS

α from $\rho\rho/\rho\pi$ and SU(2) flavour symmetry

Parametrization of the $\rho\rho$ ($\pi\pi$) amplitudes (neglecting EWP)

Gronau, London, PRL65 (1990) 3381

$$A^{+-} = -T e^{-i\alpha} + P e^{i\delta_P}$$

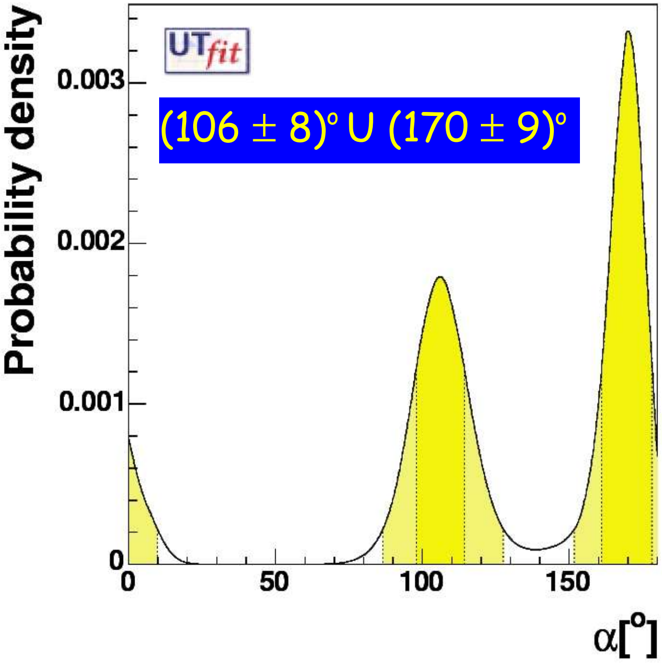
$$A^{+0} = -\frac{1}{\sqrt{2}} e^{-i\alpha} \left(T + T_c e^{i\delta_C} \right)$$

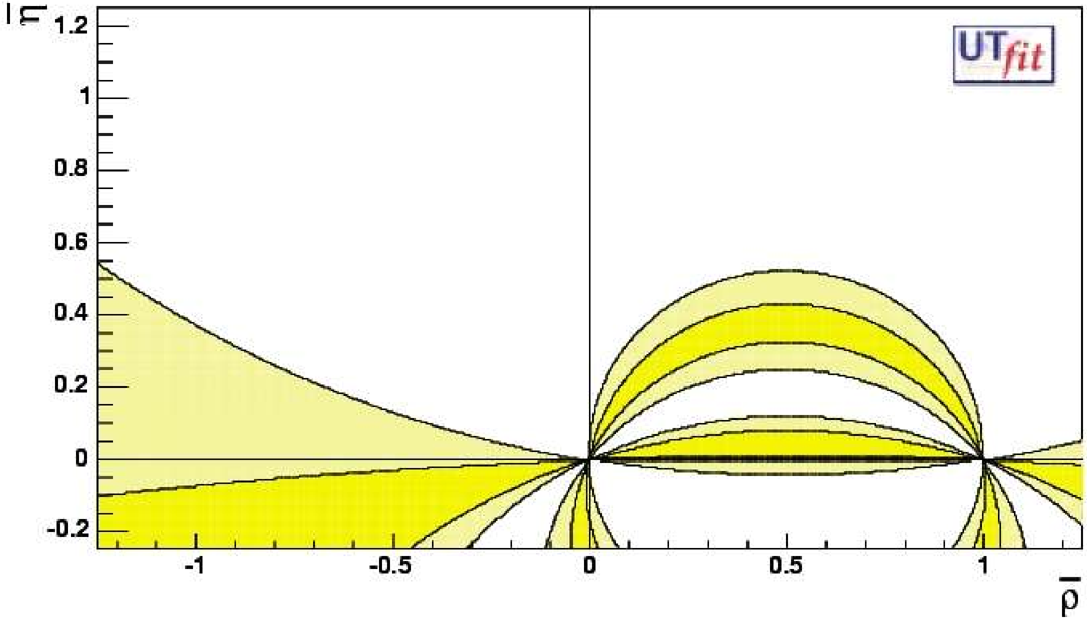
$$A^{00} = A^{+0} - \frac{1}{\sqrt{2}} A^{+-}$$

- 6 unknowns: T, T_C, P, δ_P, δ_C, α
- 6 observables: $3\times BR_{ave}$, C_{+-}, S_{+-}, C_{00}

+ time-dependent Dalitz plot study of $(\rho\pi)^0$ à la Snyder-Quinn

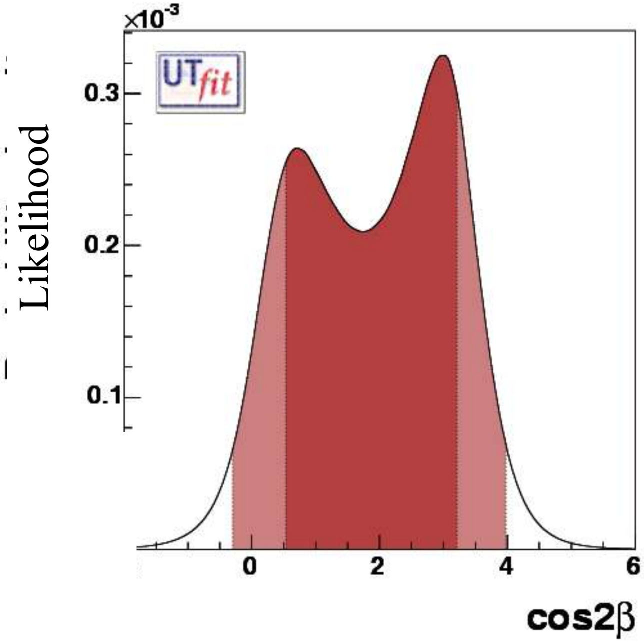
Snyder, Quinn, PRD48 (1993) 2139

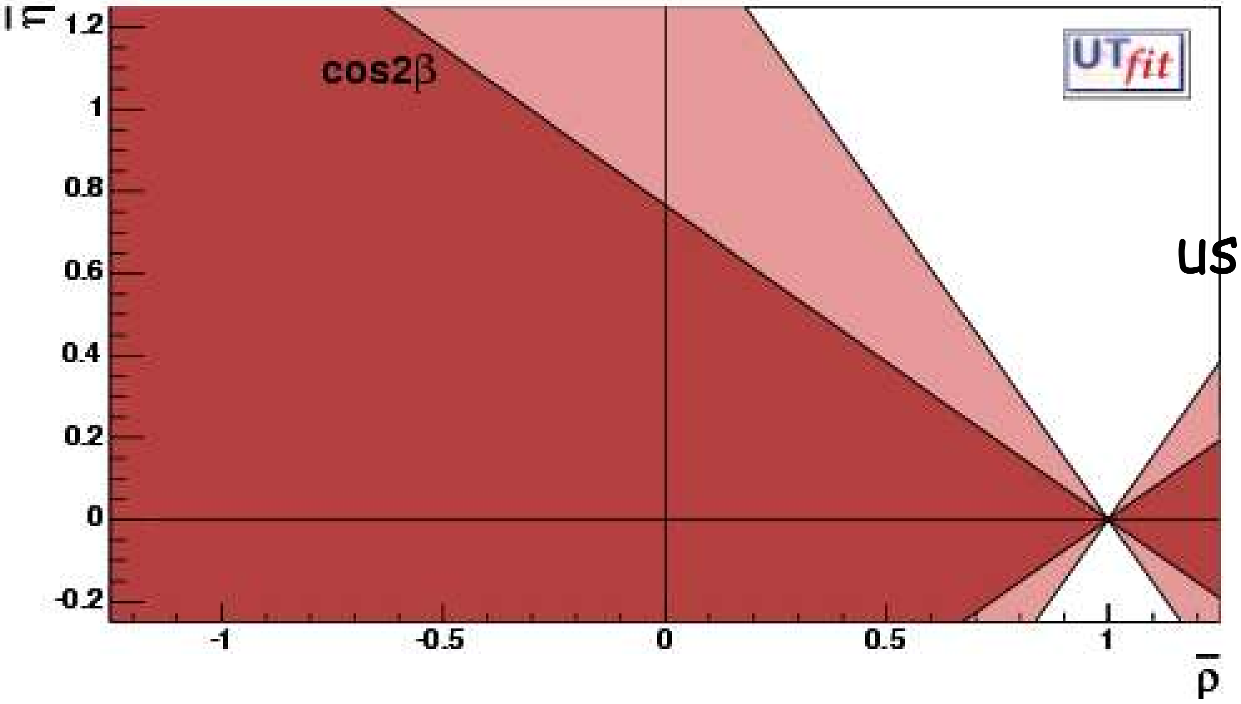




cos2β from $A_{CP}(B \to J/\psi\, K^*(K_S\pi^0))$

BaBar	$3.32^{+0.76}_{-0.96} \pm 0.27$
Belle	$0.31 \pm 0.91 \pm 0.11$
Skeptical	1.9 ± 1.3





using the prior |cos2β| ≤ 1

cos2β > 0

@87% prob.

γ from $B \rightarrow D^{(*)}K$

- **no penguins**

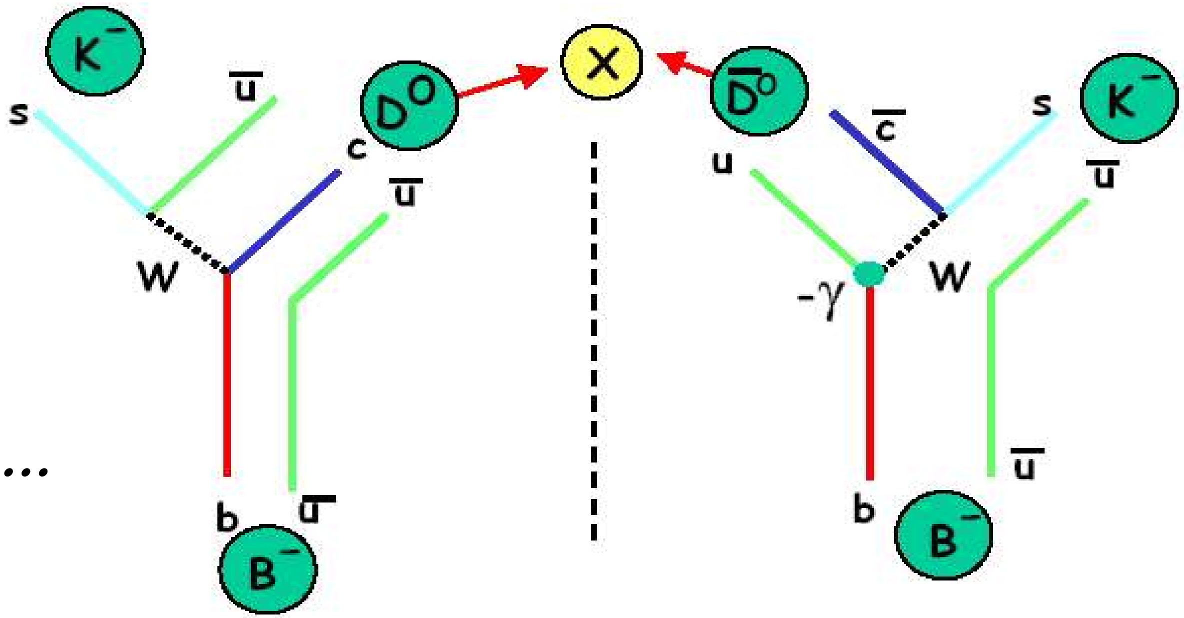
  four different flavours

- **many modes**

  $X_{CPES}=K_s\,\pi,\ K_s\,\rho,\ K_s\,\pi^+\,\pi^-,\ \ldots$

  $X_{CPNES}=K^+\,\pi^-,\ K^{+*}\,\pi^-,\ \ldots$

  $K^{+*}\,K^-,\ \pi^+\,\rho^-,\ \ldots$



GLW: X=CPES
ADS: X=$K^+\pi^-$ etc.

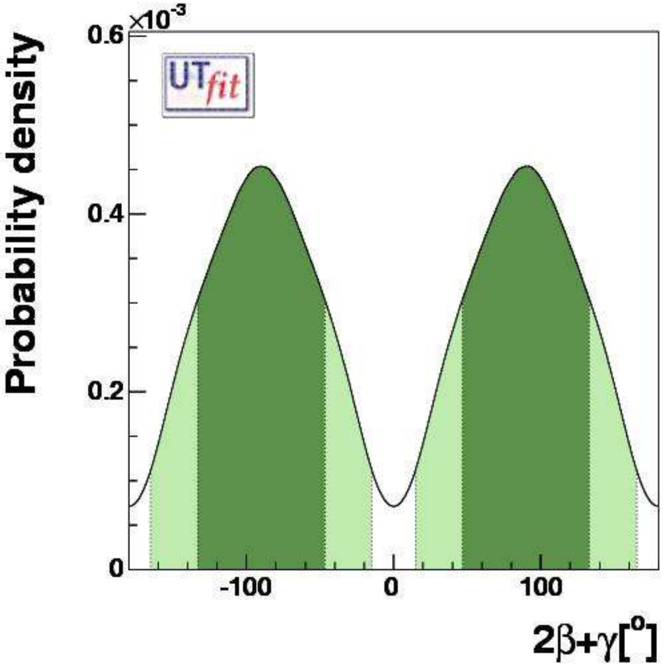
Charged B: CP violation in the decay

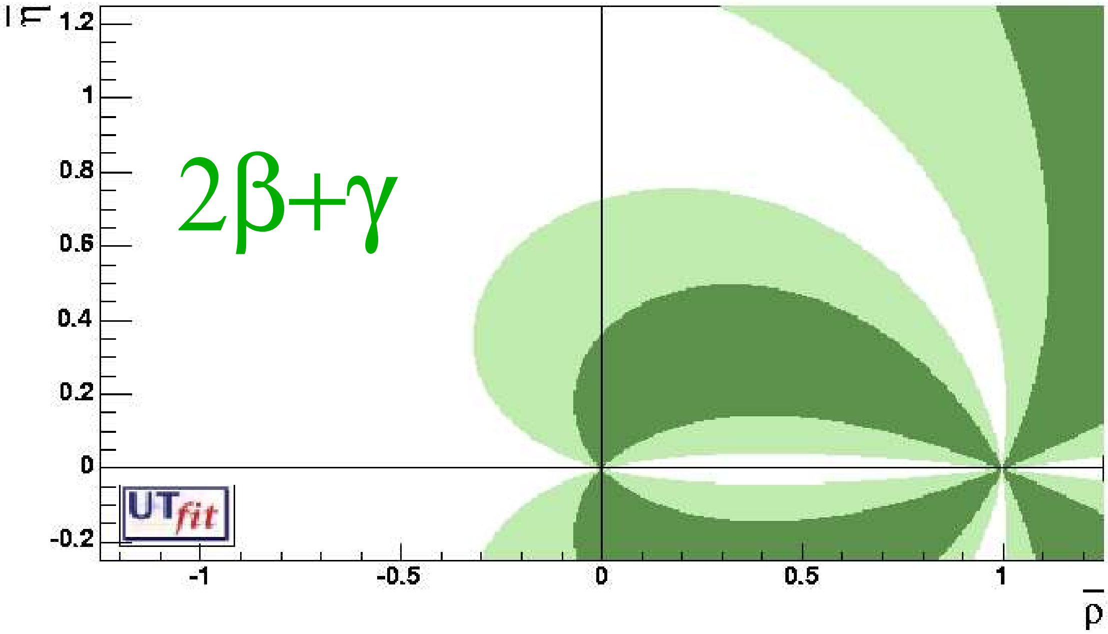
$\Rightarrow\ \gamma$

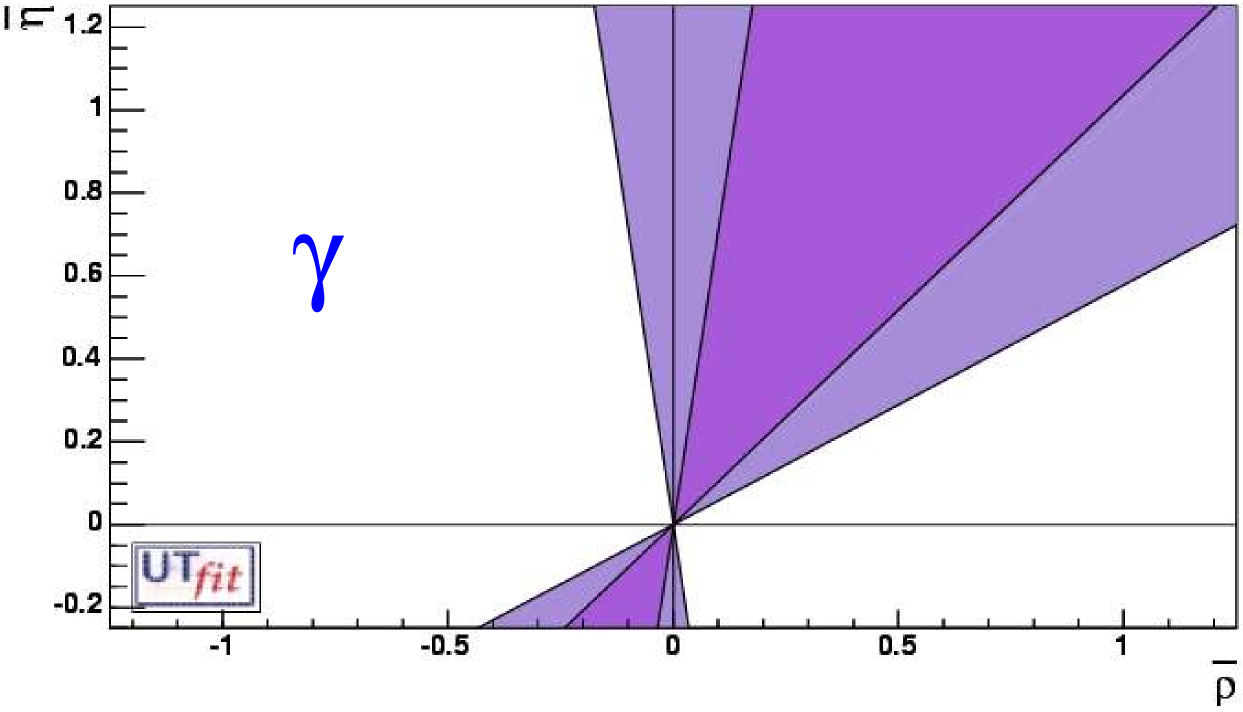
+ **GGSZ: Dalitz plot analysis of $D^0 \rightarrow$ 3-body modes, ex. $K_s\pi^+\pi^-$**

Neutral B: CP violation in the interference between mixing and decay

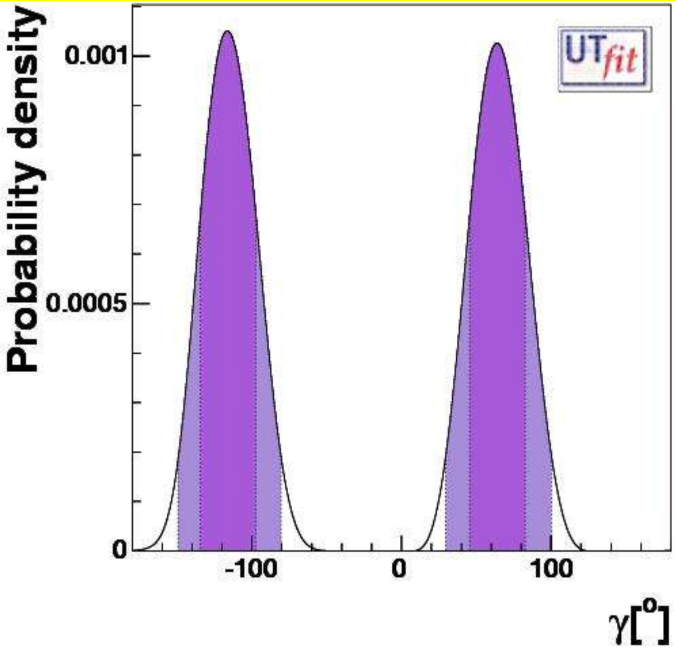
$\Rightarrow\ \sin(2\beta+\gamma)$



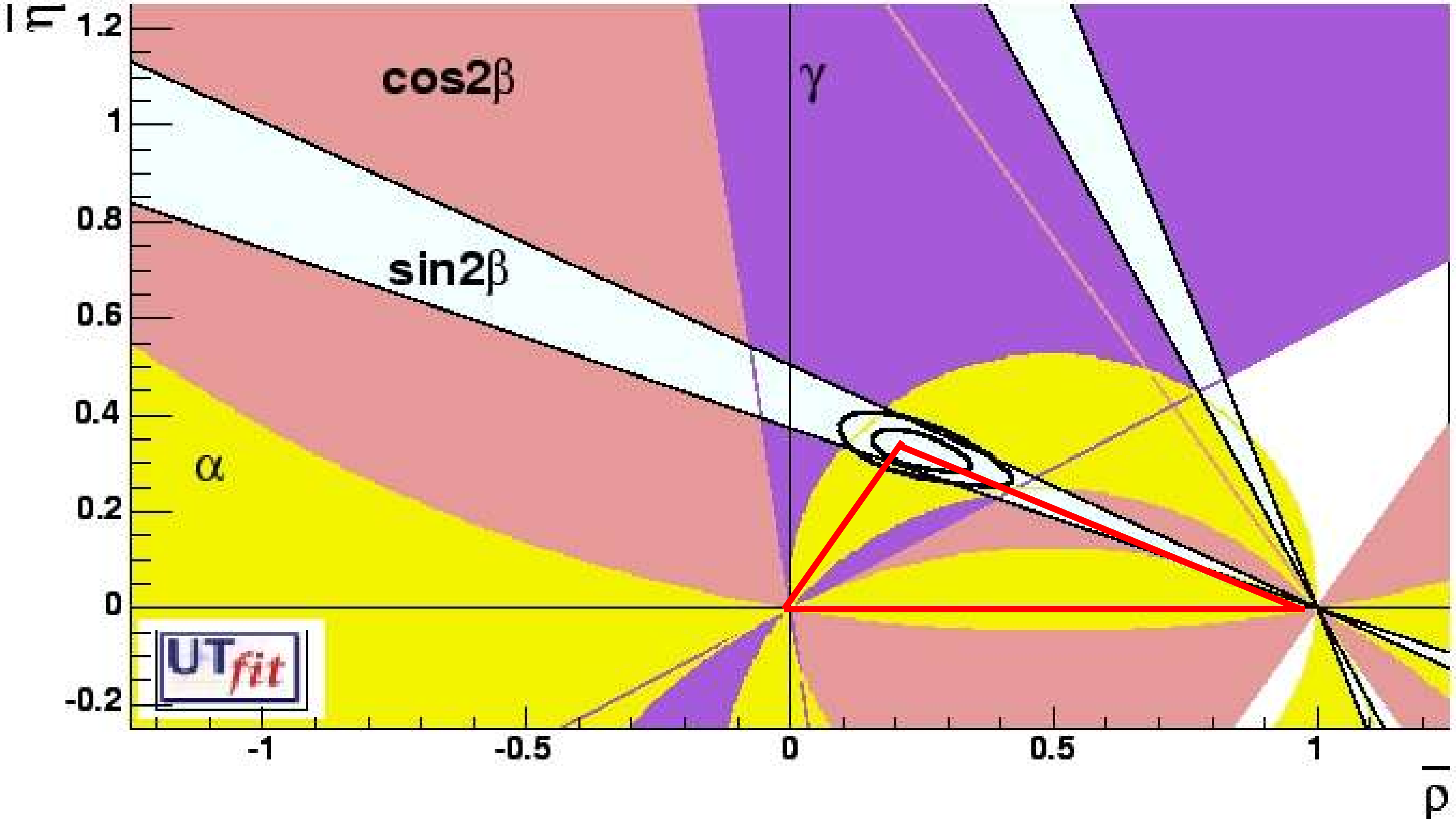




(64.0±18.2)° U (-116.0±18.2)°



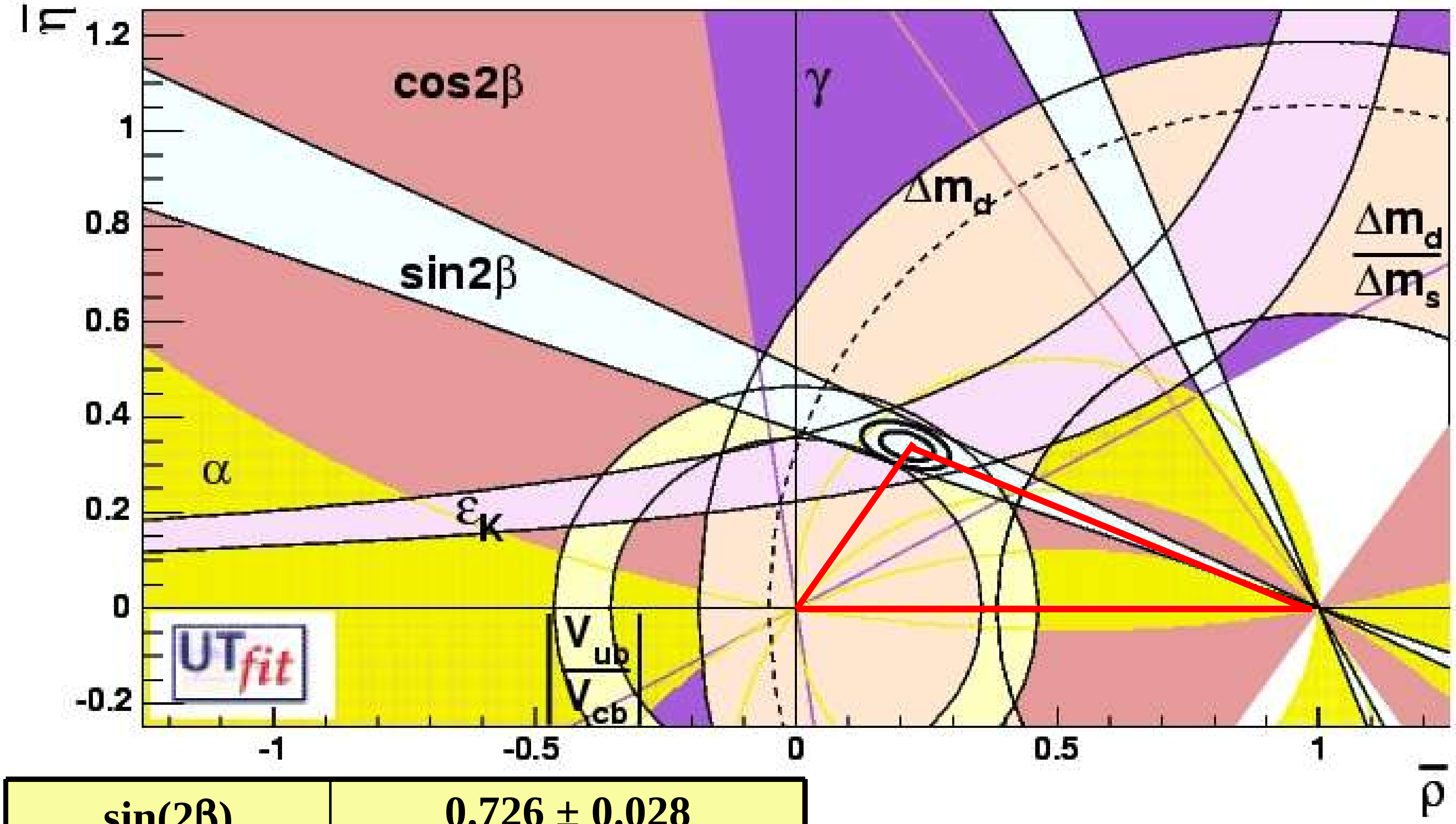
$\overline{\rho}$ and $\overline{\eta}$: angles only



$$\overline{\rho} = 0.246 \pm 0.063 \quad [0.123,\ 0.384]@95\%\ \text{prob.}$$

$$\overline{\eta} = 0.325 \pm 0.030 \quad [0.265,\ 0.388]@95\%\ \text{prob.}$$

$\overline{\rho}$ and $\overline{\eta}$: all together



$\sin(2\beta)$	0.726 ± 0.028
$\sin(2\alpha)$	-0.29 ± 0.17
$\gamma[°]$	58.1 ± 5.0
$\overline{\rho}$	0.210 ± 0.035
$\overline{\eta}$	0.339 ± 0.021

Excellent agreement with CKMfitter group:

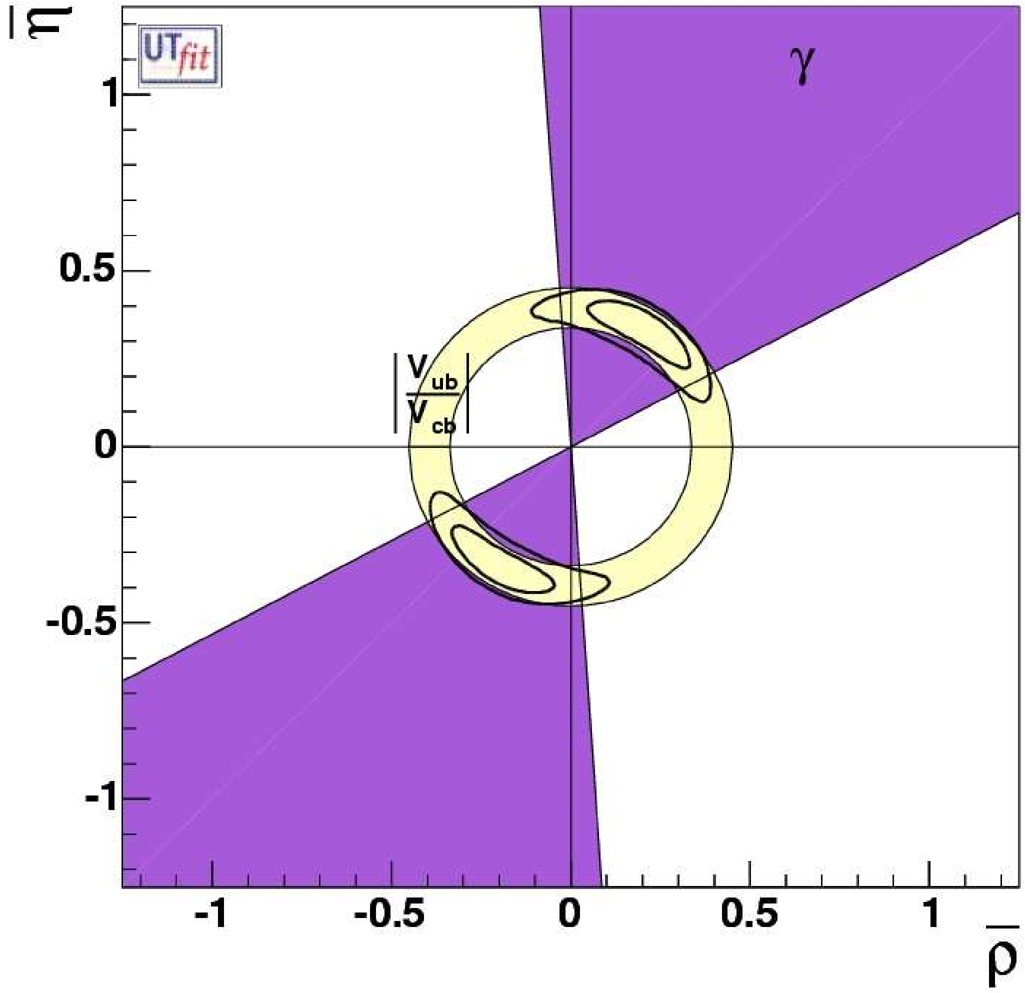
$\overline{\rho} = 0.207^{+0.035}_{-0.045}$

$\overline{\eta} = 0.339^{+0.026}_{-0.021}$

New physics in the UT analysis

Assumptions: (1) 3-generations unitarity

(2) no new physics in tree-level processes



$\bar{\rho}$ = ± 0.21 ± 0.10

$\bar{\eta}$ = ± 0.36 ± 0.06

$\sin 2\beta =$ 0.724±0.074
-0.556±0.089

$\alpha =$ (95±15)° U (-43±15)°

Any model of new physics must satisfy these constraints

A more ambitious strategy:

1. **Add most general NP to all sectors**
2. **Use all available info**
3. **Constrain simultaneously ρ, η and NP contributions**

UTfit coll., hep-ph/0506xxx

Only possible thanks to the new measurements of CKM angles!!!

General parametrization of the mixing amplitudes

$$B_q - \overline{B}_q \text{ mixing:} \quad A_{B_q} = C_q e^{2i\phi_q} A_{B_q}^{\text{SM}}$$

$$K - \overline{K} \text{ mixing:} \quad \text{Im}\, A_K = C_\varepsilon \text{Im}\, A_K^{\text{SM}}$$

$$(\Delta M_q) = C_q (\Delta M_q)^{SM}$$

$$A_{CP}(J/\Psi K_S) = \sin 2(\beta + \phi_d)$$

$$\alpha^{exp} = \alpha - \phi_d$$

(3) assume NP in ΔB=1 decays is SU(2) invariant

Use: α, sin 2β, cos 2β, γ and

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

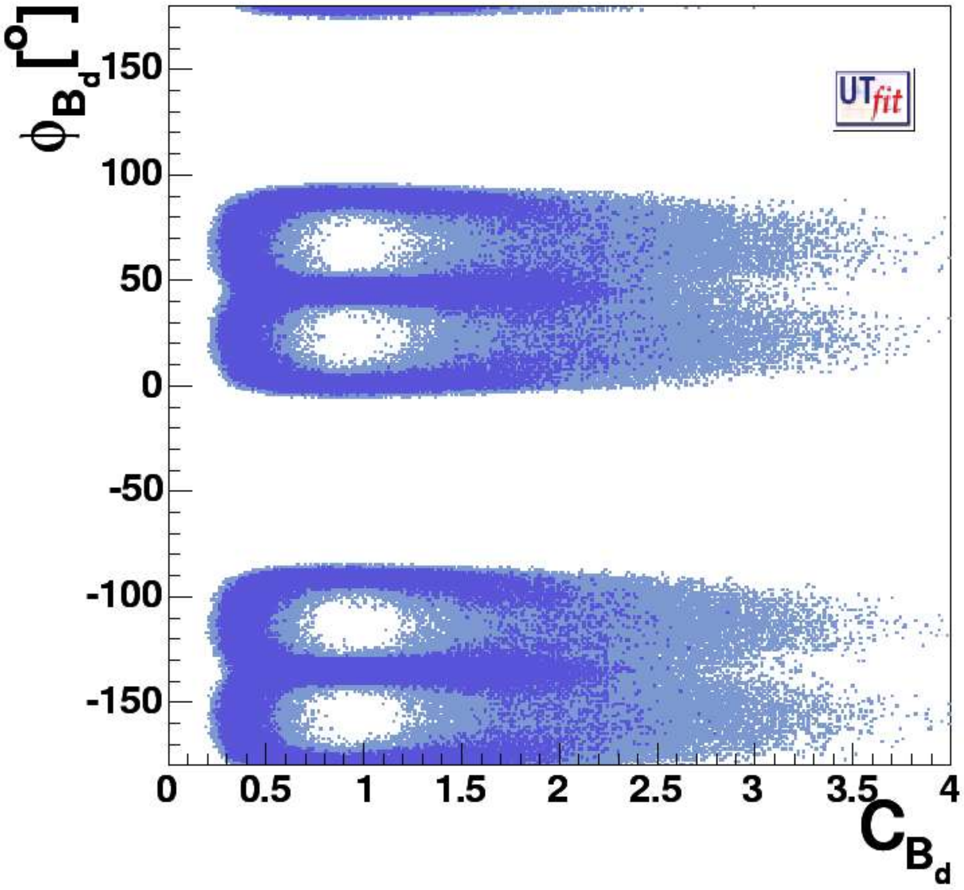
$$A_{SL} = -\text{Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{SM} \frac{\sin 2\phi_d}{C_d} + \text{Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{SM} \frac{\cos 2\phi_d}{C_d}$$

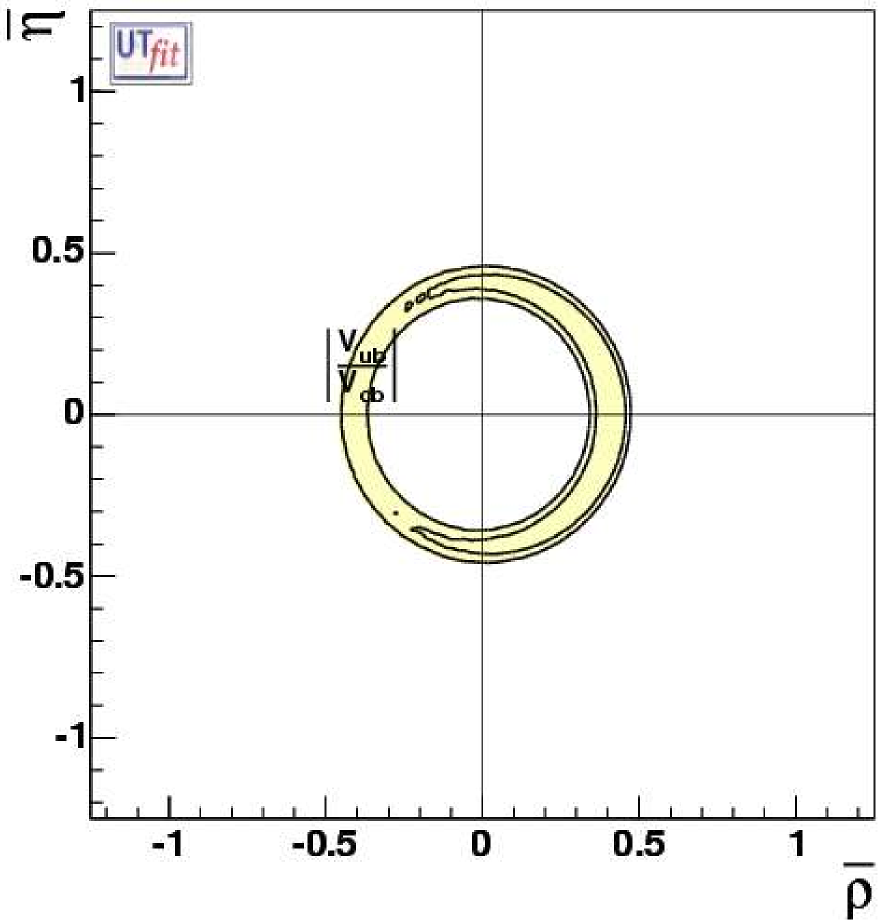
Laplace, Ligeti, Nir & Perez

Exploiting the redundancy of the fit, we look for bounds on 3 additional real parameters: $C_\varepsilon, \ \{C_d, \ \phi_d\}$

Using:

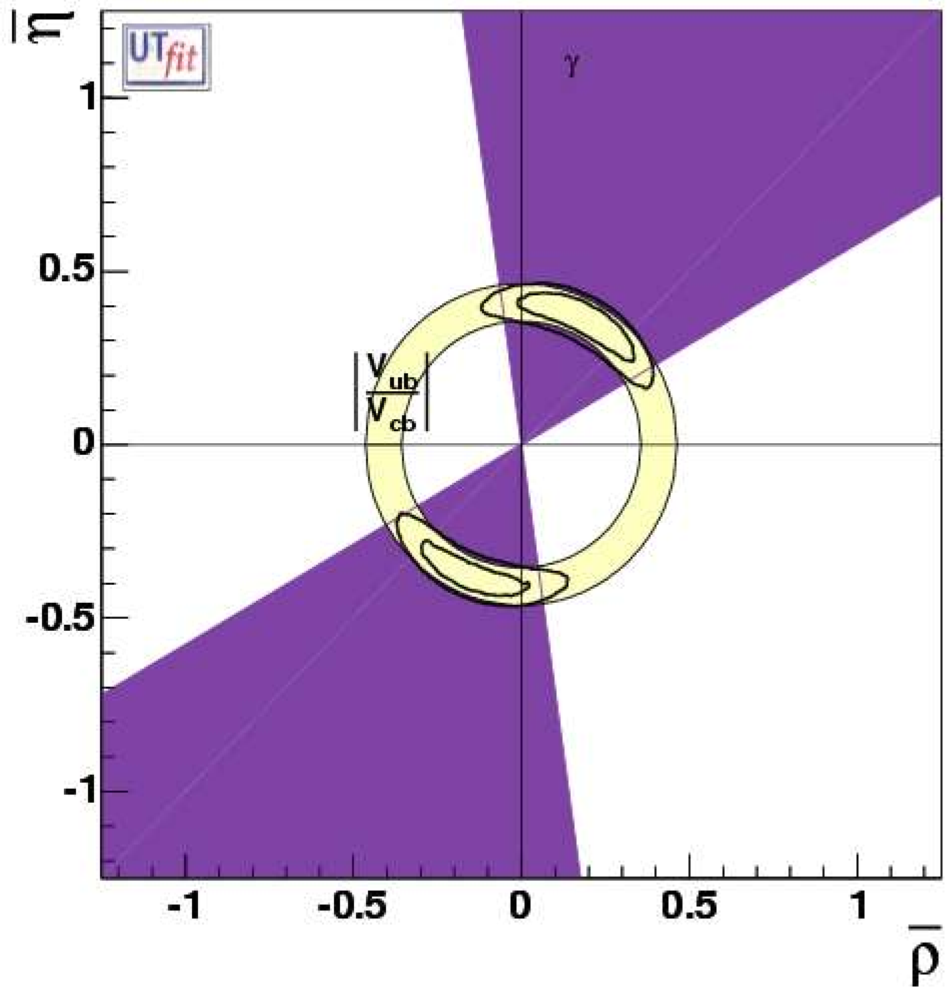
- ε, Δm_d, $\sin 2\beta$

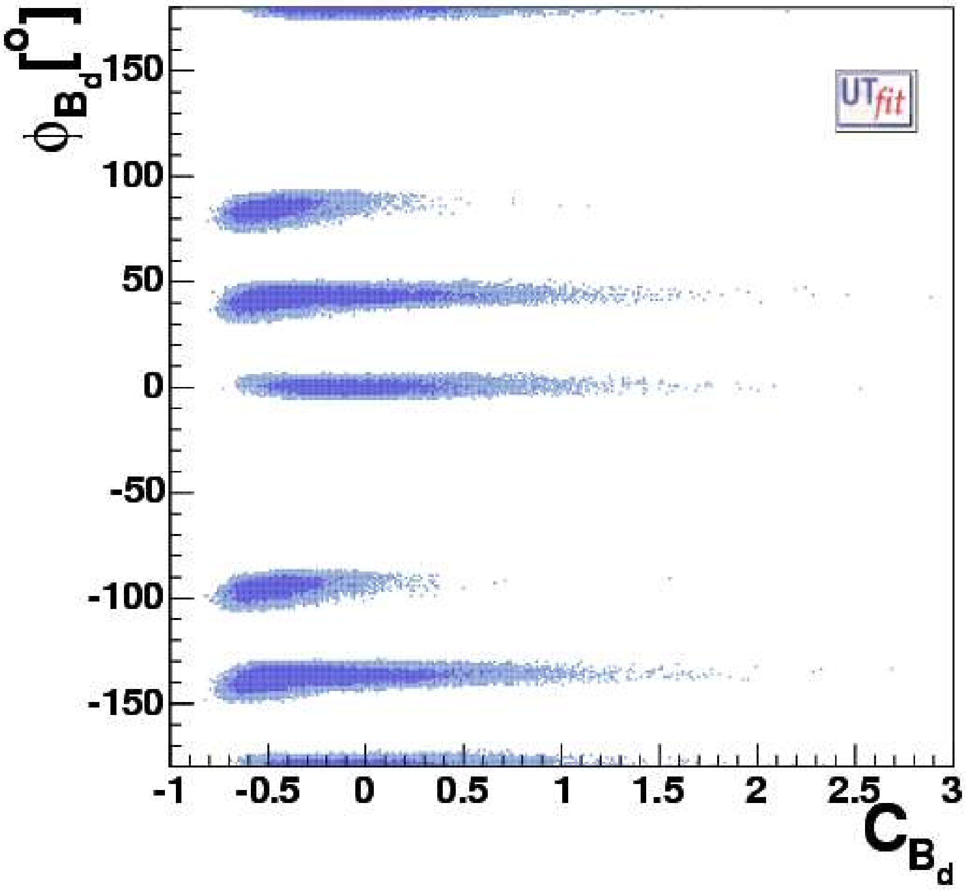




Using:

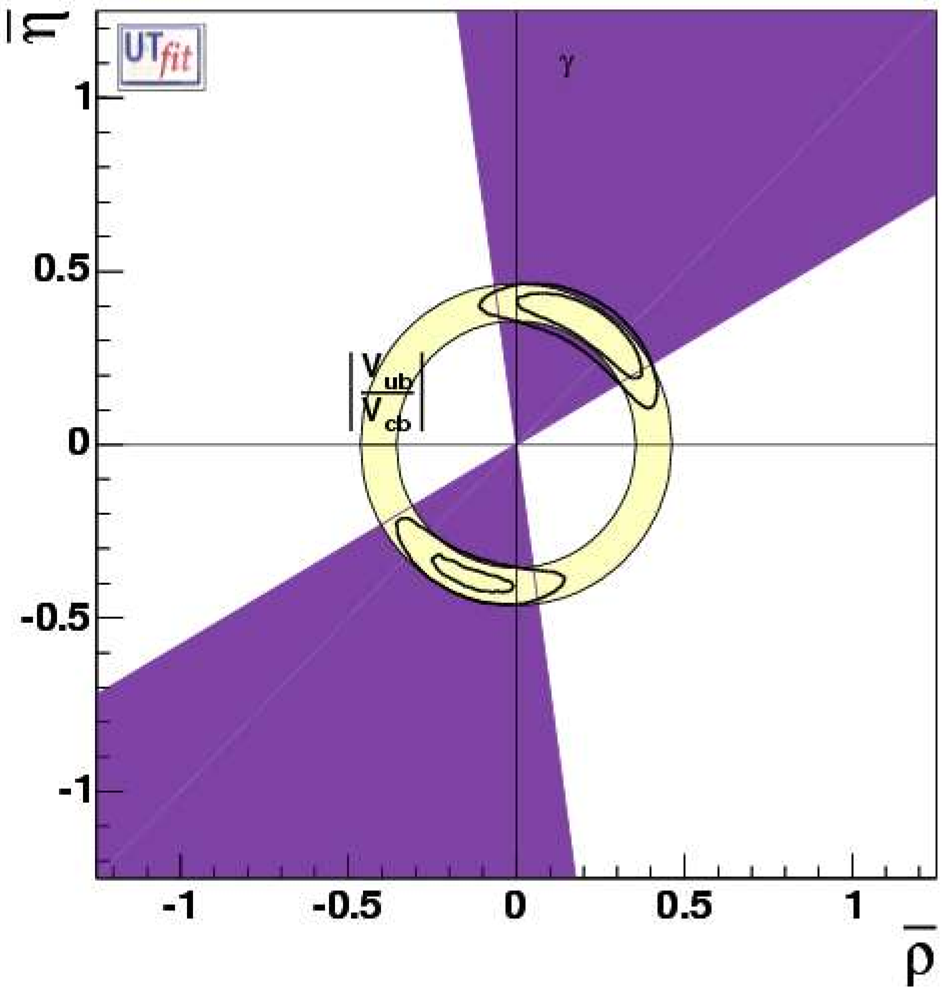
- ε, Δm_d, $\sin 2\beta$
- γ

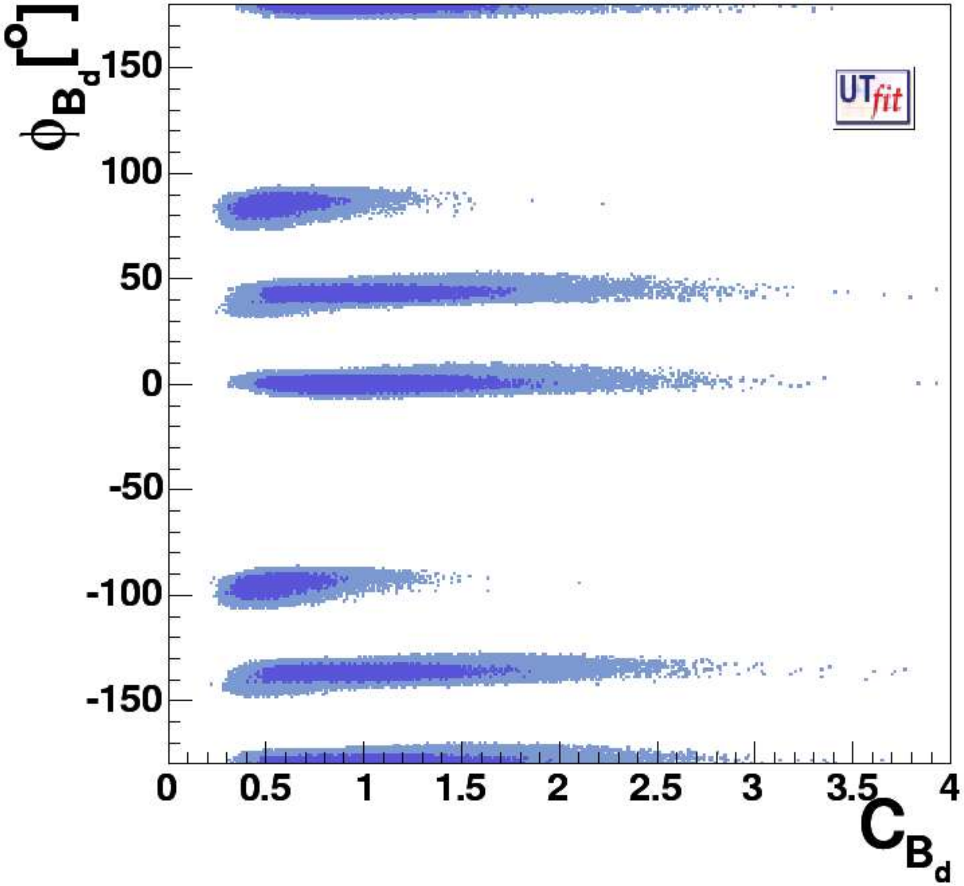




Using:

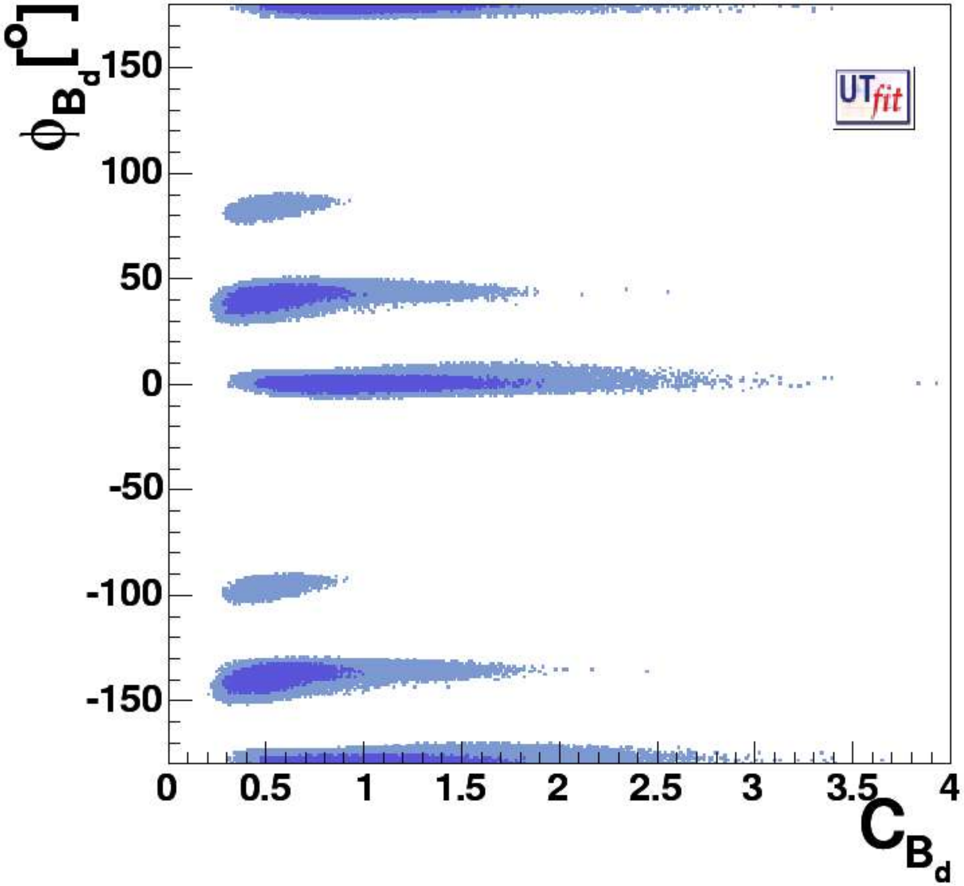
- ε, Δm_d, $\sin 2\beta$
- γ, A_{SL}

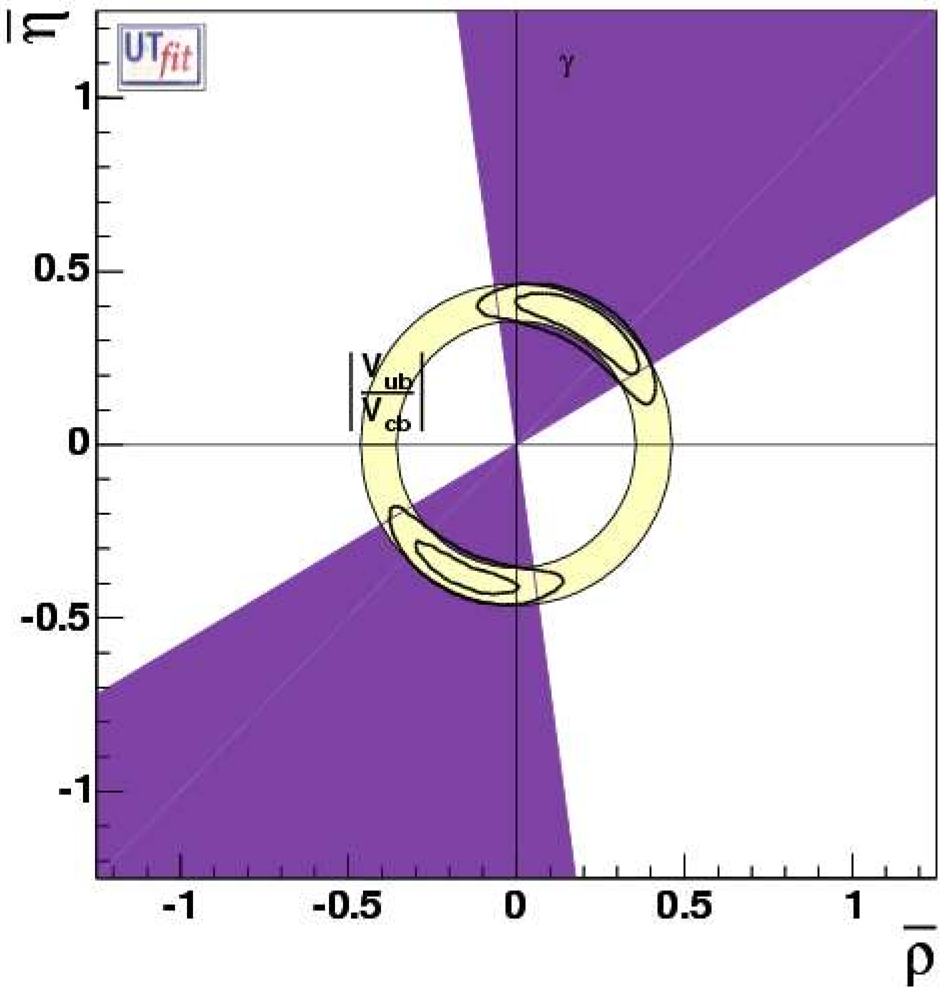




Using:

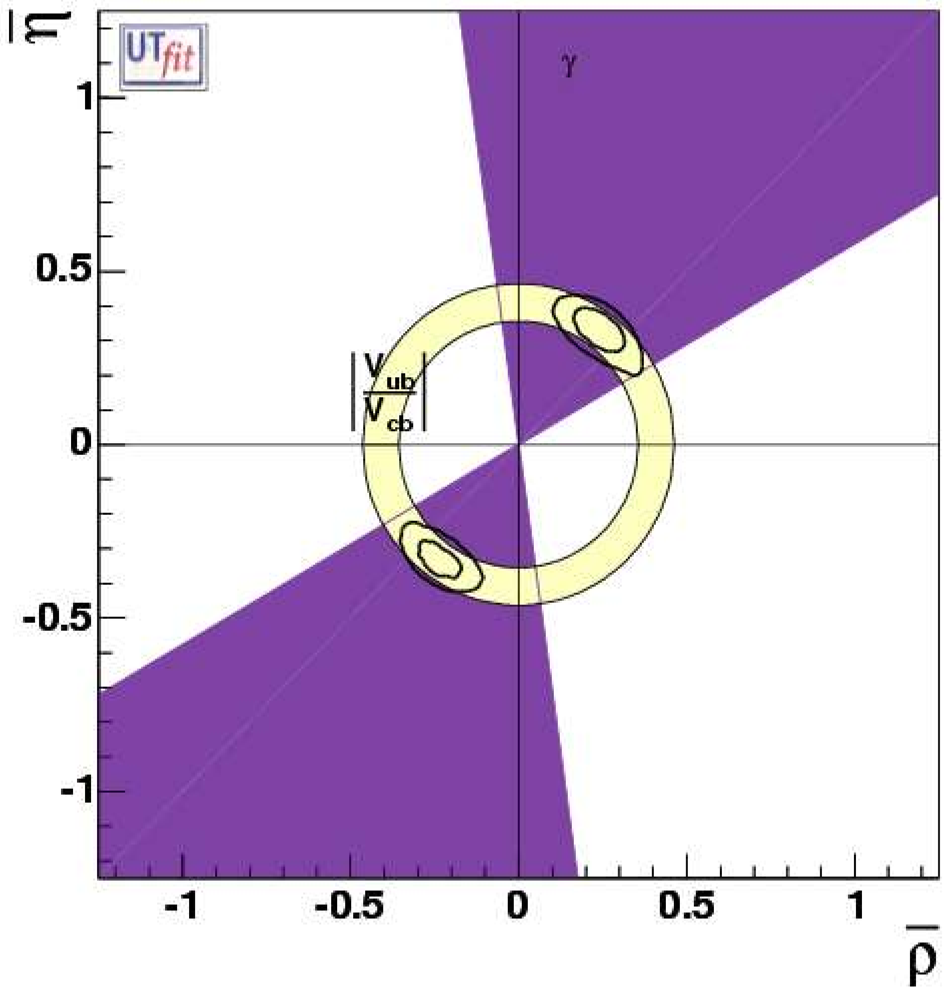
- ε, Δm_d, $\sin 2\beta$
- γ, $\cos 2\beta$

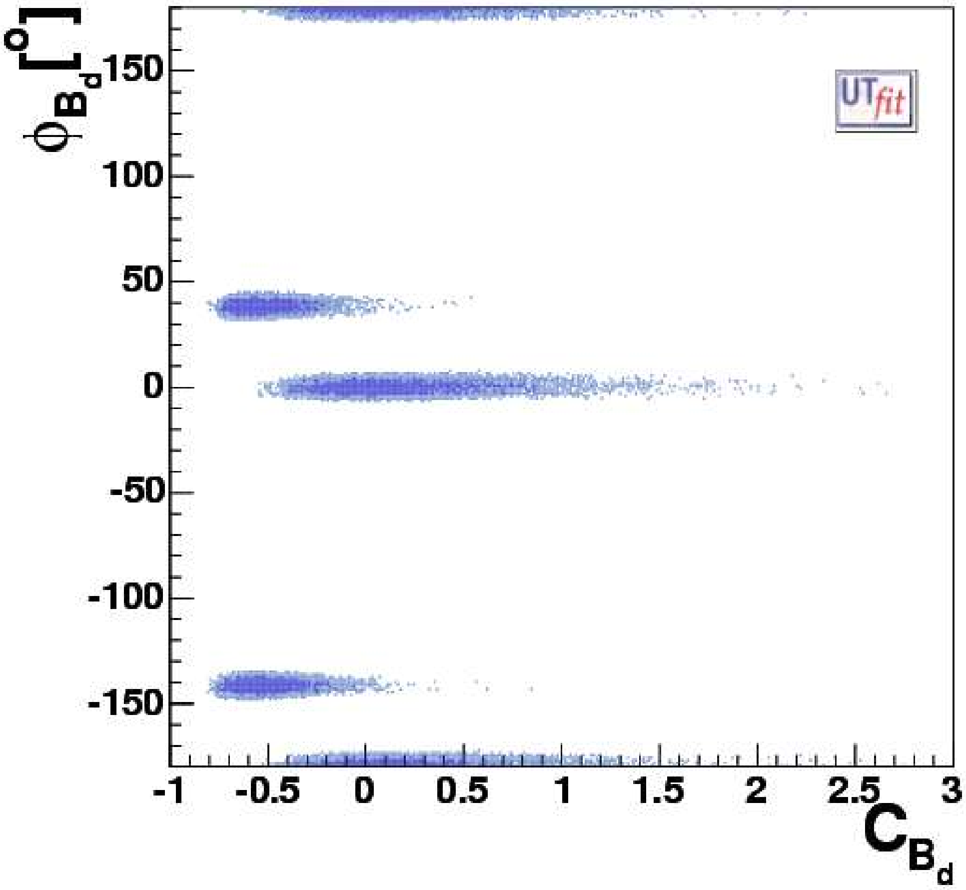




Using:

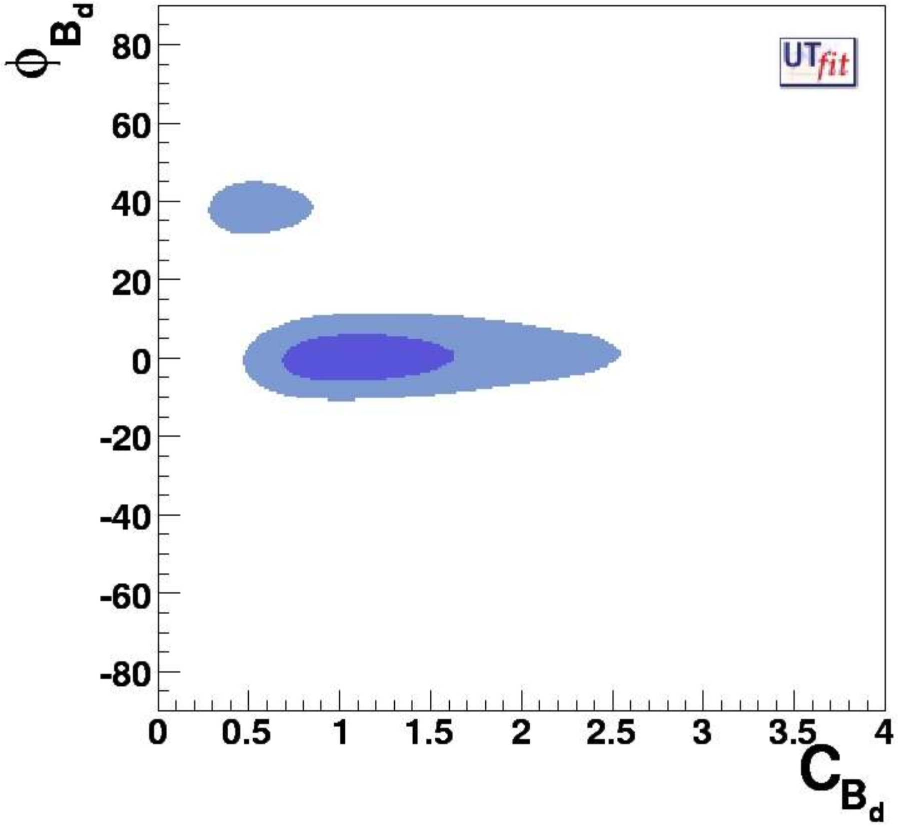
- ε, Δm_d, $\sin 2\beta$
- γ, α

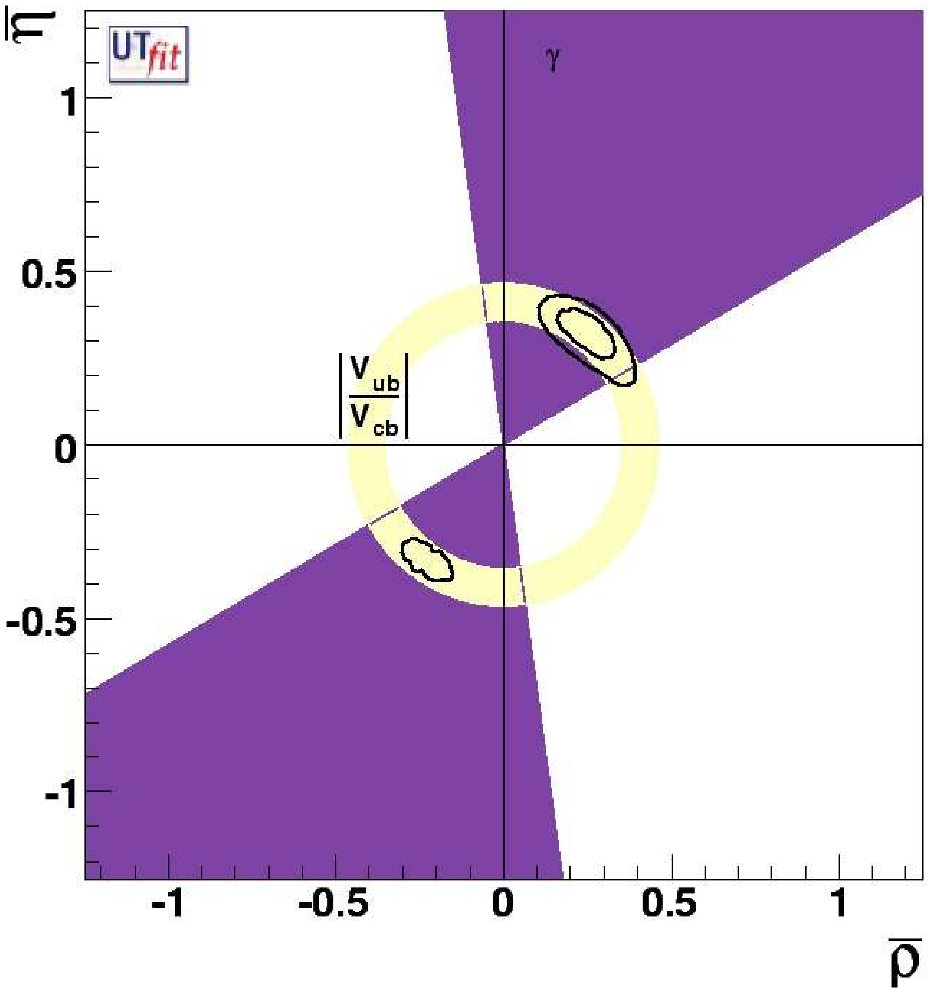


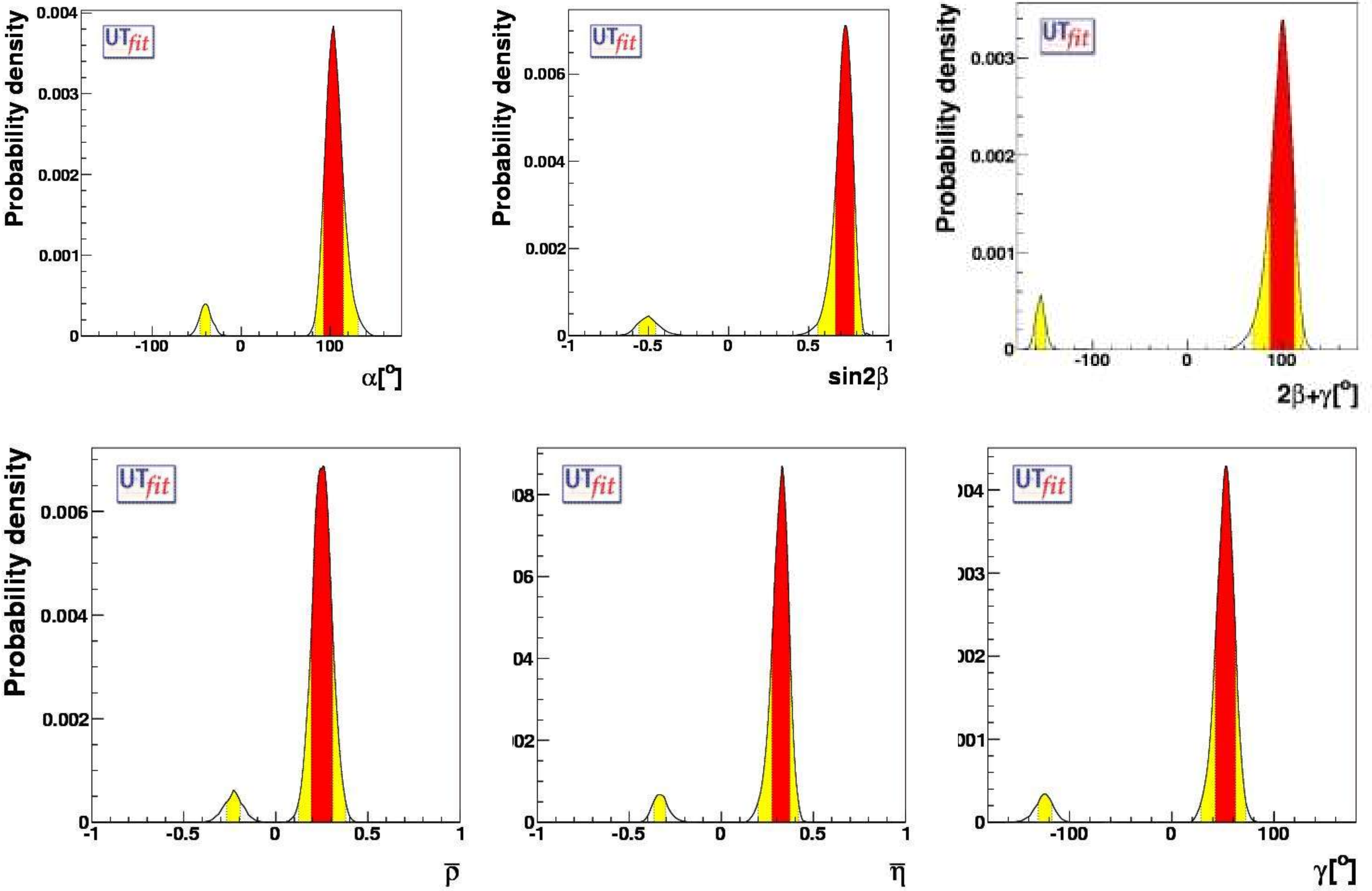


Using:

- ε, Δm_d, $\sin 2\beta$
- α, $\cos 2\beta$ & A_{SL}





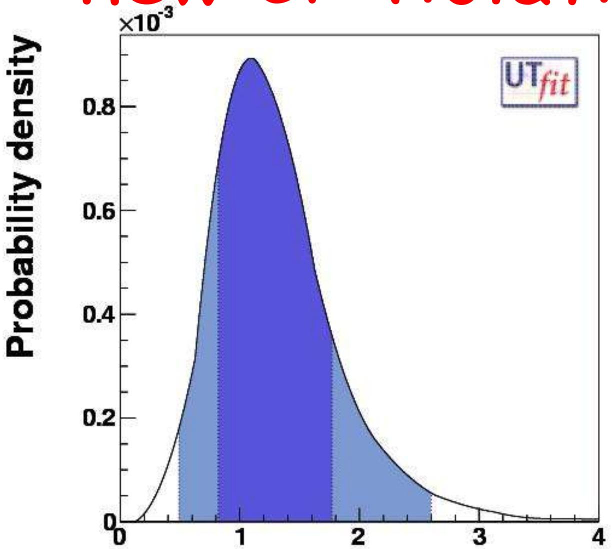

UTfit
Probability density
0.004
0.003
0.002
0.001
0
-100
0
100
α[°]
Probability density
0.006
0.004
0.002
0
-1
-0.5
0
0.5
1
sin2β
Probability density
0.003
0.002
0.001
0
-100
0
100
2β+γ[°]
Probability density
0.006
0.004
0.002
0
-1
-0.5
0
0.5
1
$\bar{\rho}$
)08
)06
)04
)02
0
-1
-0.5
0
0.5
1
$\bar{\eta}$
)04
)03
)02
)01
0
-100
0
100
γ[°]

The most important message of this talk:

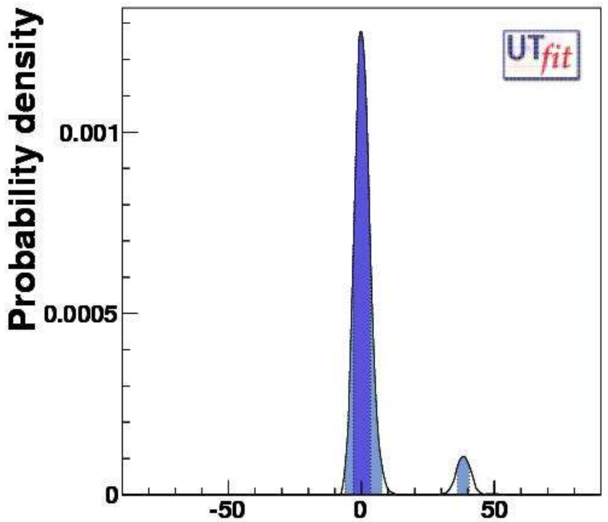
New Physics in ΔB=2 and ΔS=2 can be up to ~50% of the SM only if NP has the same phase of the SM, otherwise it has to be at most ~ 10%.

This is a completely general result.

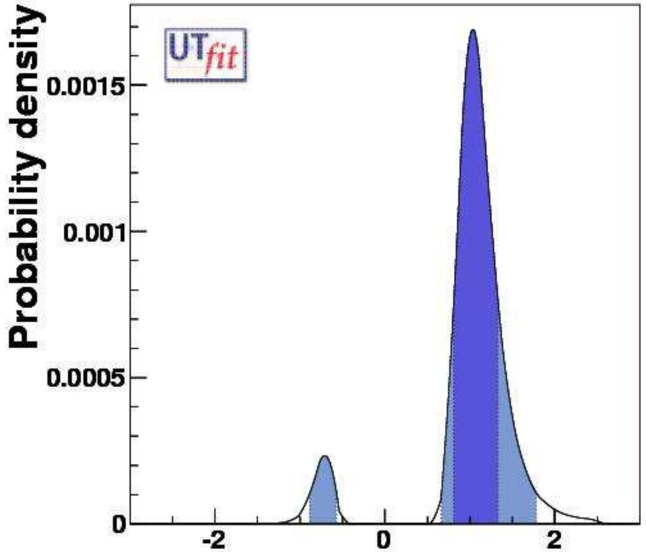
Only two ways out: Minimal Flavour Violation or new CP violation only in b → s transitions.



$C_{Bd} = 1.29 \pm 0.47$



$\phi_{Bd} = 0.1 \pm 3.2$

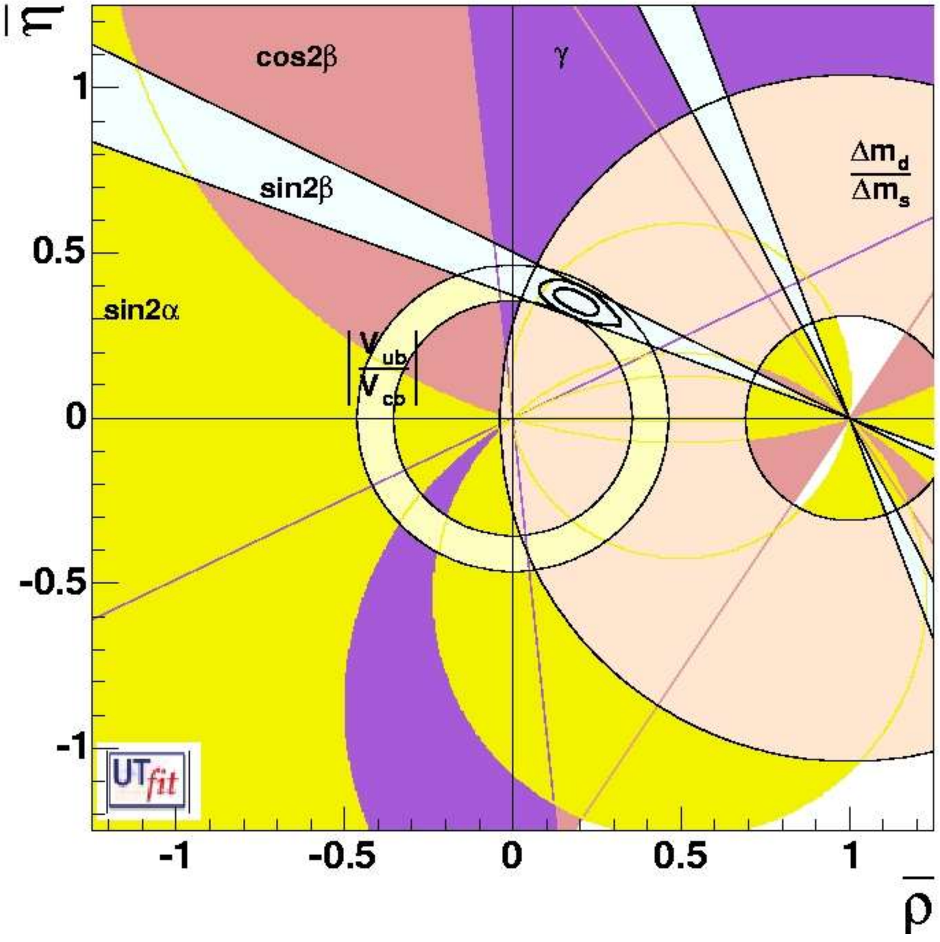


$C_\varepsilon = 1.07 \pm 0.26$

The Universal Unitarity Triangle

Buras et al., hep-ph/0007085

(4) Minimal Flavour Violation: all FV in the Yukawa couplings



UUT determined by processes insensitive to NP contributions:

- no ε_K
- $\Delta M_d/\Delta M_s$ only

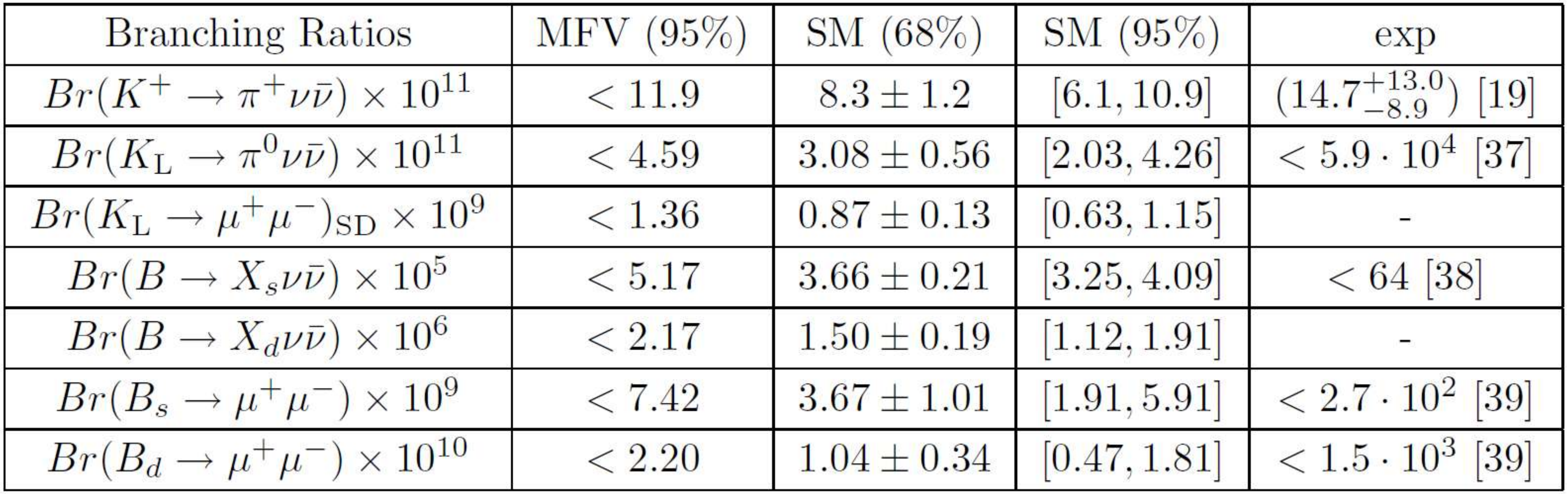
$\bar{\rho}$	0.191 ± 0.046	$[0.097, 0.285]$
$\bar{\eta}$	0.353 ± 0.028	$[0.296, 0.408]$
$sin2\beta$	0.733 ± 0.029	$[0.675, 0.786]$
$\alpha[^\circ]$	94.7 ± 7.4	$[80.2, 110.1]$
$\gamma[^\circ]$	61.9 ± 7.1	$[47.0, 75.9]$
$(2\beta+\gamma)[^\circ]$	109.4 ± 7.8	$[92.5, 123.8]$

valid in any MFV model

UUT starting point for MFV studies of rare decays

Results of a model-independent MFV analysis of rare K & B decays

C. Bobeth et al., hep-ph/0505110



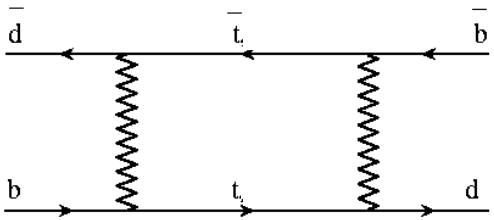
Branching Ratios	MFV (95%)	SM (68%)	SM (95%)	exp
$Br(K^+ \to \pi^+ \nu\bar{\nu}) \times 10^{11}$	< 11.9	8.3 ± 1.2	$[6.1, 10.9]$	$(14.7^{+13.0}_{-8.9})$ [19]
$Br(K_{\rm L} \to \pi^0 \nu\bar{\nu}) \times 10^{11}$	< 4.59	3.08 ± 0.56	$[2.03, 4.26]$	$< 5.9 \cdot 10^4$ [37]
$Br(K_{\rm L} \to \mu^+ \mu^-)_{\rm SD} \times 10^9$	< 1.36	0.87 ± 0.13	$[0.63, 1.15]$	-
$Br(B \to X_s \nu\bar{\nu}) \times 10^5$	< 5.17	3.66 ± 0.21	$[3.25, 4.09]$	< 64 [38]
$Br(B \to X_d \nu\bar{\nu}) \times 10^6$	< 2.17	1.50 ± 0.19	$[1.12, 1.91]$	-
$Br(B_s \to \mu^+ \mu^-) \times 10^9$	< 7.42	3.67 ± 1.01	$[1.91, 5.91]$	$< 2.7 \cdot 10^2$ [39]
$Br(B_d \to \mu^+ \mu^-) \times 10^{10}$	< 2.20	1.04 ± 0.34	$[0.47, 1.81]$	$< 1.5 \cdot 10^3$ [39]

MFV: an effective theory approach

D'Ambrosio et al., hep-ph/0207036

- classification of the dim-6 operators built with the SM fields and 1 or 2 Higgs doublets under the assumption that the flavour violation dynamics is determined by ordinary Yukawa couplings

1H: Universal NP effect in the ΔF=2 Inami-lim function of the top

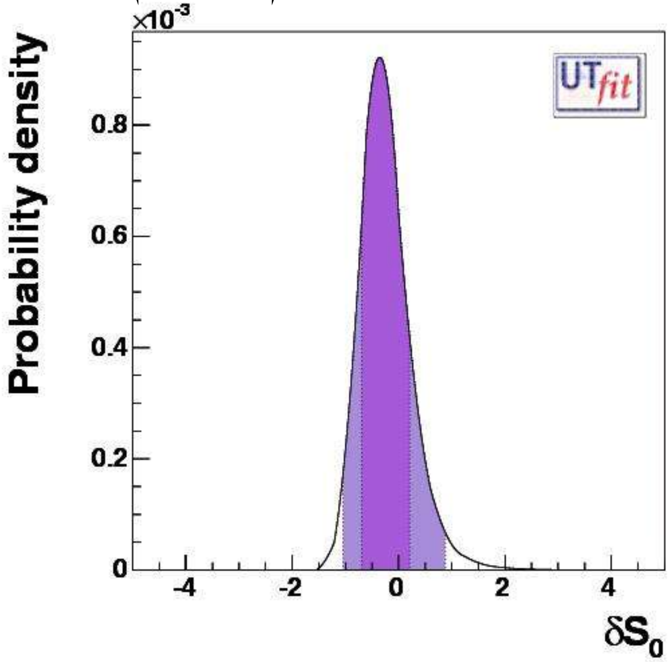


$$S_0(x_t)\to S_0(x_t)+\delta S_0, \quad |\delta S_0|=O\left(4\frac{\Lambda_0^2}{\Lambda^2}\right), \quad \Lambda_0\sim 2.4 \text{ TeV}$$

We can bound the NP scale Λ:

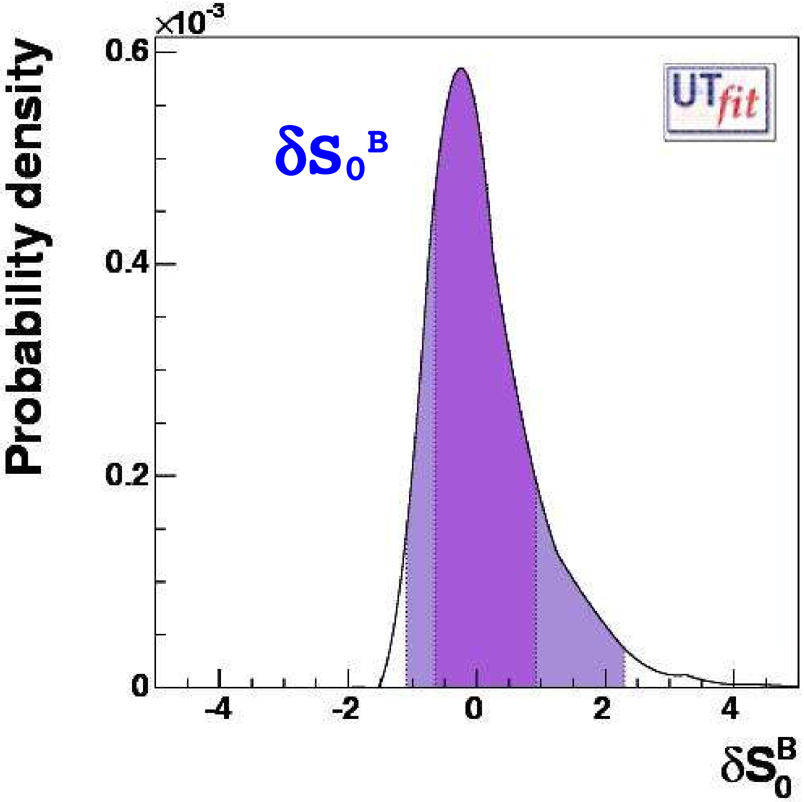
Λ > 6.0 TeV @95% prob. for positive δS_0

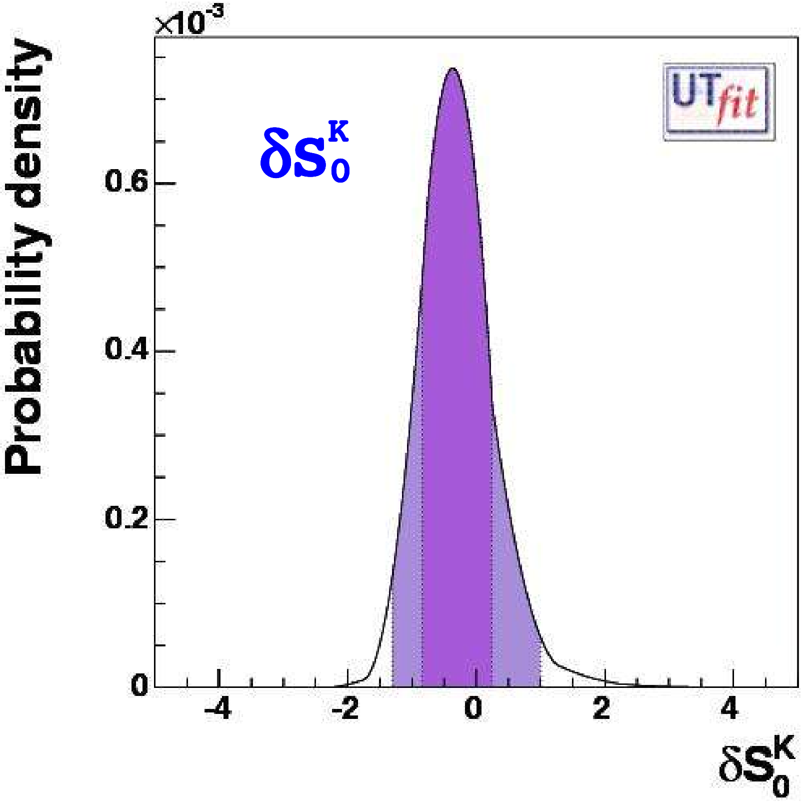
Λ > 4.6 TeV @95% prob. for negative δS_0



2H + large tanβ: terms proportional to the bottom Yukawa coupling are enhanced and cannot be neglected any more

$$\delta S_0^B \neq \delta S_0^K$$





Λ > 3.6 TeV @95% prob. for $\delta S_0 > 0$

Λ > 4.6 TeV @95% prob. for $\delta S_0 < 0$

Λ > 5.0 TeV @95% prob. for $\delta S_0 > 0$

Λ > 4.3 TeV @95% prob. for $\delta S_0 < 0$

Where does NP hide?

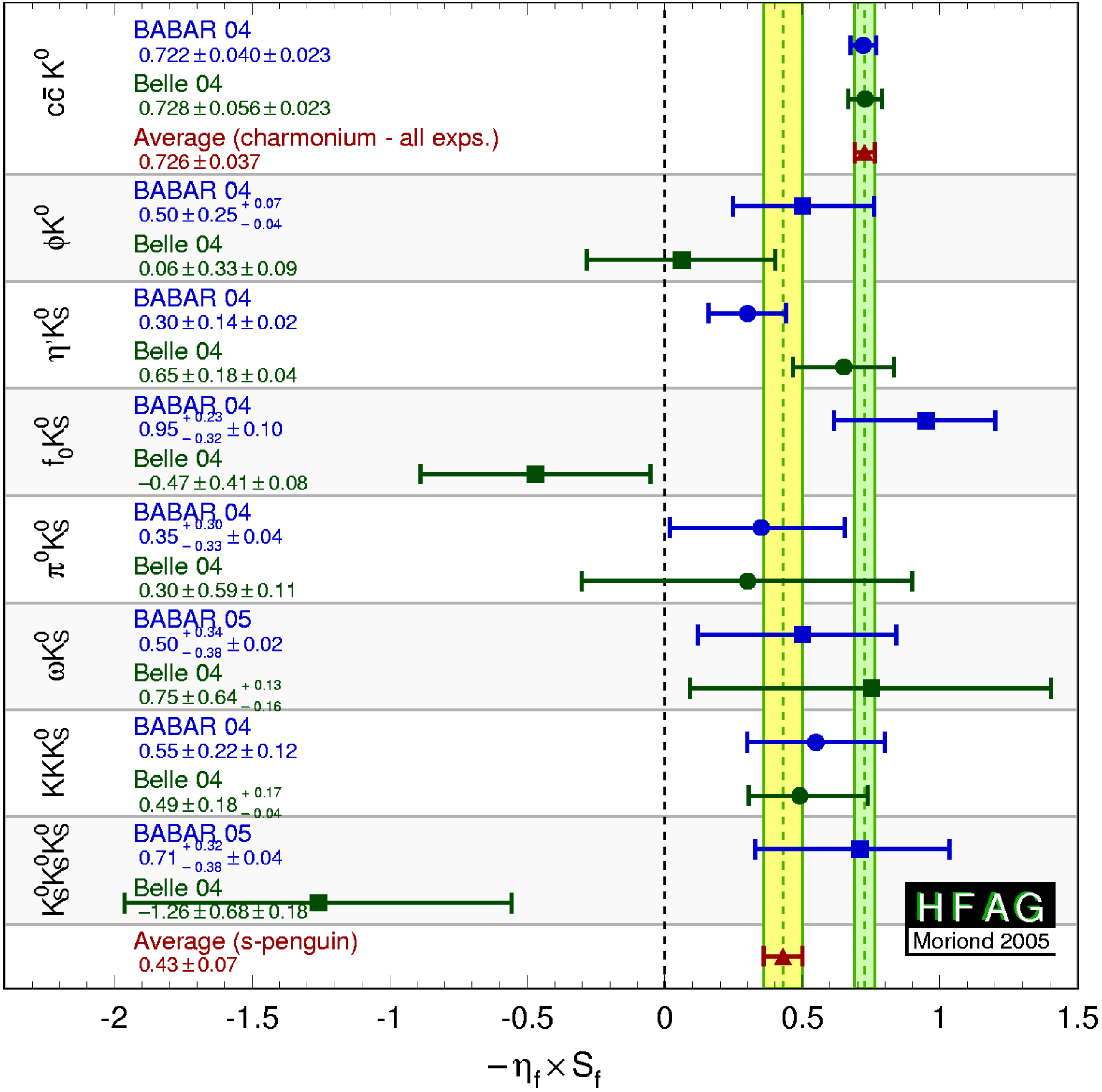
- NP in s → d and/or b → d transitions is
  - strongly constrained by the UT fit
  - "unnecessary", given the great success and consistency of the fit

- NP in b → s transitions is
  - much less (un-) constrained by the UT fit
  - natural in many flavour models, given the strong breaking of family SU(3)

    Pomarol, Tommasini; Barbieri, Dvali, Hall; Barbieri, Hall; Barbieri, Hall, Romanino; Berezhiani, Rossi; Masiero, Piai, Romanino Silvestrini; …
  - hinted at by ν's in SUSY-GUTs

    Baek, Goto, Okada, Okumura; Moroi; Akama, Kiyo, Komine, Moroi; Chang, Masiero, Murayama; Hisano, Shimizu; Goto, Okada, Shimizu, Shindou, Tanaka; …

The last resort: NP in b → s modes



Obs. #1:

These modes should not be averaged in the SM

They measure the same S=S(ccK) only if one amplitude is dominant

Obs. #2:

These modes should not be averaged beyond SM

They do not get in general the same NP contribution

THESE MODES SHOULD NOT BE AVERAGED

Conclusions

- The SM is (surprisingly enough) extremely successful in reproducing all available data
- Thanks to the recent progress, NP in ΔB=2 and ΔS=2 transitions is strongly constrained, testing scales above the TeV
- Hadron colliders will tell us whether SM, MFV or New Flavour & CPV in b → s ...

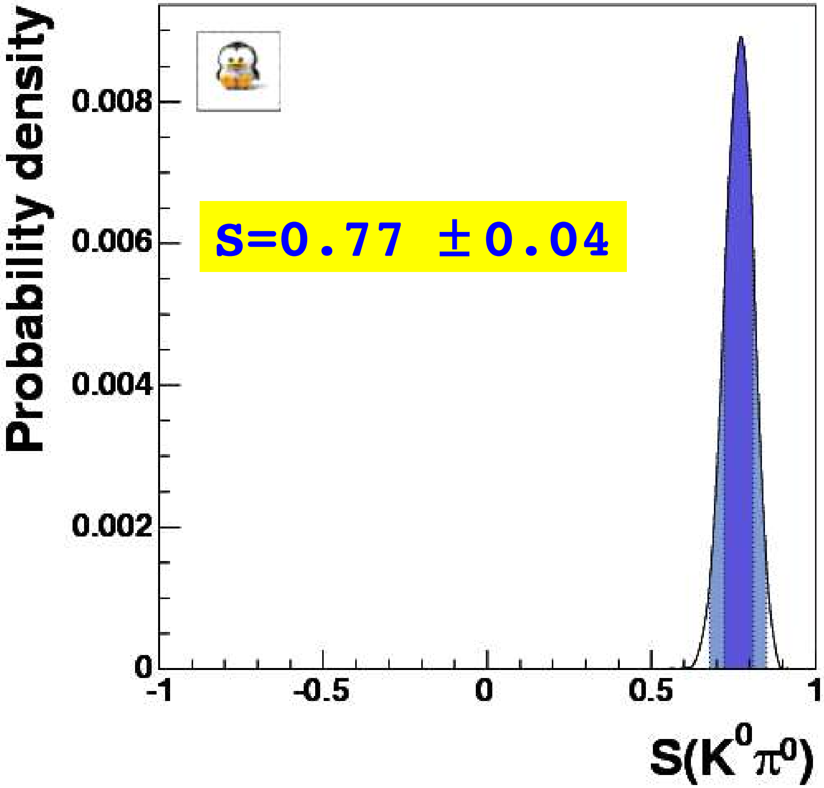
BACKUP SLIDES

Ciuchini et al., hep-ph/0104026
Buras, Silvestrini, hep-ph/9812392

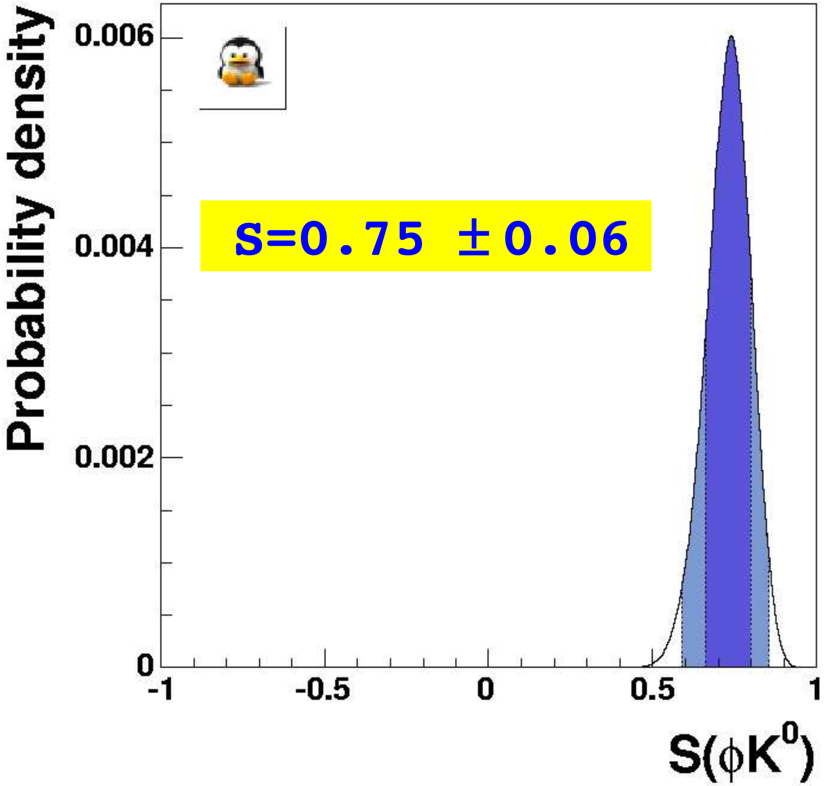
For example,
with the charming penguins parametrization:

$$\mathcal{A}(B^0 \to \phi K^0) = - V_{ts} V_{tb}^* \times P_1'(c) - V_{us} V_{ub}^* \times \{P_1'^{GIM}(u-c)\}$$

$$\mathcal{A}(B^0 \to K^0 \pi^0) = - V_{ts} V_{tb}^* \times P_1(c) - V_{us} V_{ub}^* \times \{E_2+P_1^{GIM}(u-c)\}$$



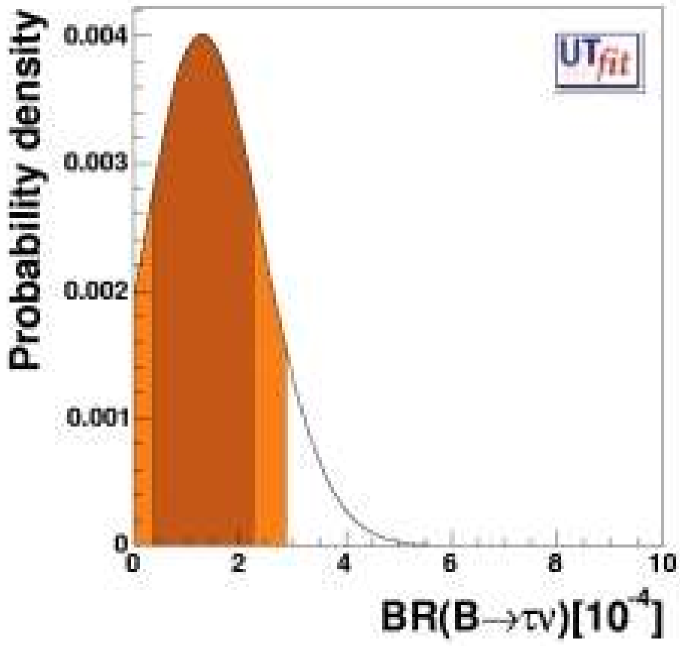
S=0.77 ± 0.04

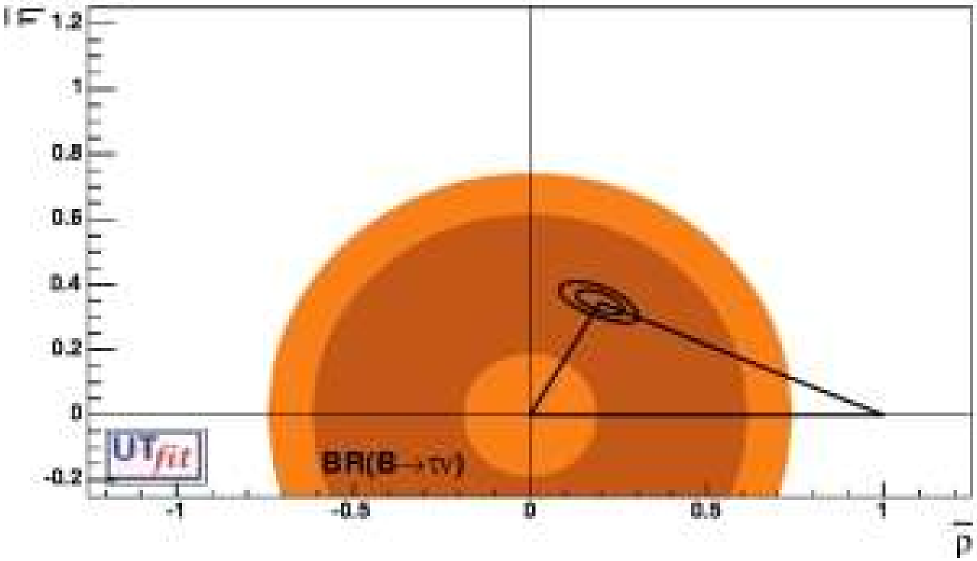


S=0.75 ± 0.06

small deviations from S_{ccK} (model-dependent)

$B \to \tau\nu$ & f_B

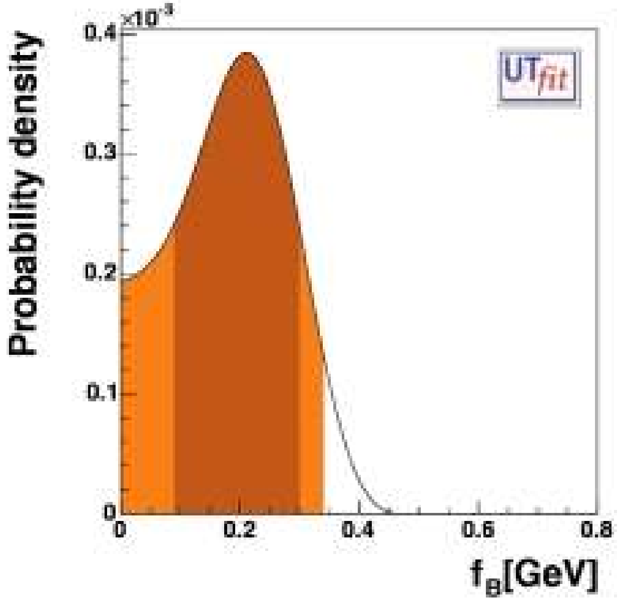




$f_B = 0.20 \pm 0.10$ GeV from UTfit

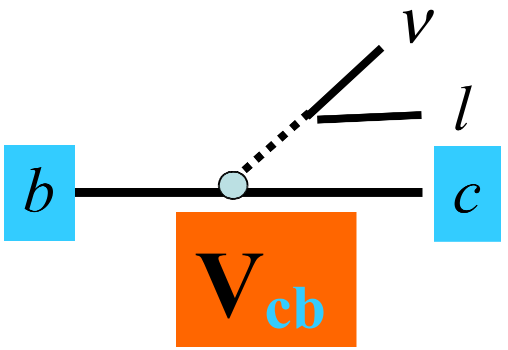
$f_B = 0.192 \pm 0.026 \pm 0.009$ GeV Lattice QCD

$B \to \tau\nu$ not competitive yet



V_{cb} - Inclusive Method

$\Gamma_{sl} = (0.434 \times (1 \pm 0.018))\ 10^{-10}\ MeV$ 2%



$$\Gamma_{sl}\,(b \rightarrow c l^{-} \nu) = \frac{Br_{sl}}{\tau_b} = |V_{cb}|^2 \; F$$

f(μ^2_π , $m_{b,}$, m_c α_s , ρ_D(or $1/m_b{}^3$))

m_b (also named $\overline{\Lambda}$) μ^2_π (λ_1 Fermi movement)

Based on ***OPE***

Moments of distributions

HADRONIC mass,

LEPTON Momentum ,

Photon energy b→ s γ

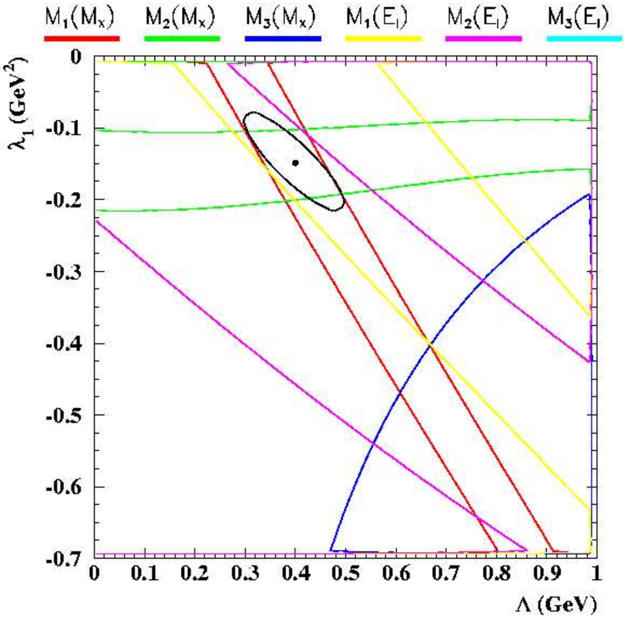
$M_{b,kin}$(1GeV) = 4.59 ± 0.08 ± 0.01GeV → 4.23(mb(mb))

$m_{c,kin.}$ (1GeV) = 1.13 ± 0.13 ± 0.03GeV

$\mu_\pi{}^2$ = 0.31 ± 0.07 ± 0.02GeV²

$\rho_D{}^2$ = 0.05 ± 0.04 ± 0.01GeV²

→terms $1/m_b{}^3$ (under control?)/small !



V_{cb}(inclusive)= (41.4 ± 0.6 ± 0.7(theo.)) 10^{-3}

Exp + (μ^2_π , $m_{b,}$, ρ_D ….absorbed !)

Pert. QCD. α_s , terms $1/m_b{}^4$

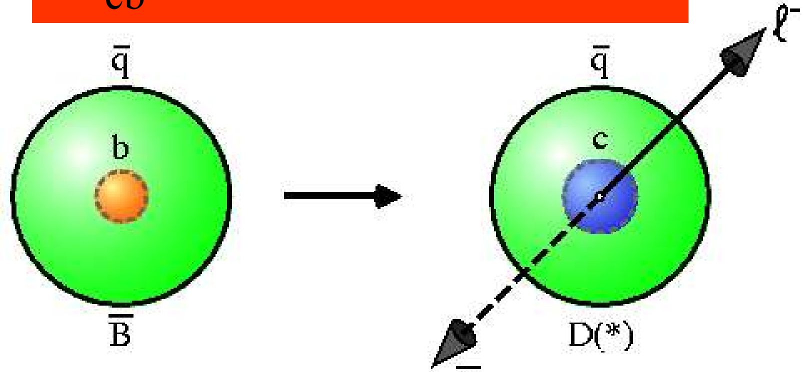
hep-ph/0210027 C.Bauer,Z.Ligeti,M.Luke,A.Manohar

hep-ph/0210319, M.Battaglia et al. (P.Gambino,N.Uraltsev)

hep-ph/0302262 D. Benson,I.Bigi,T.Mannel,N.Uralstev

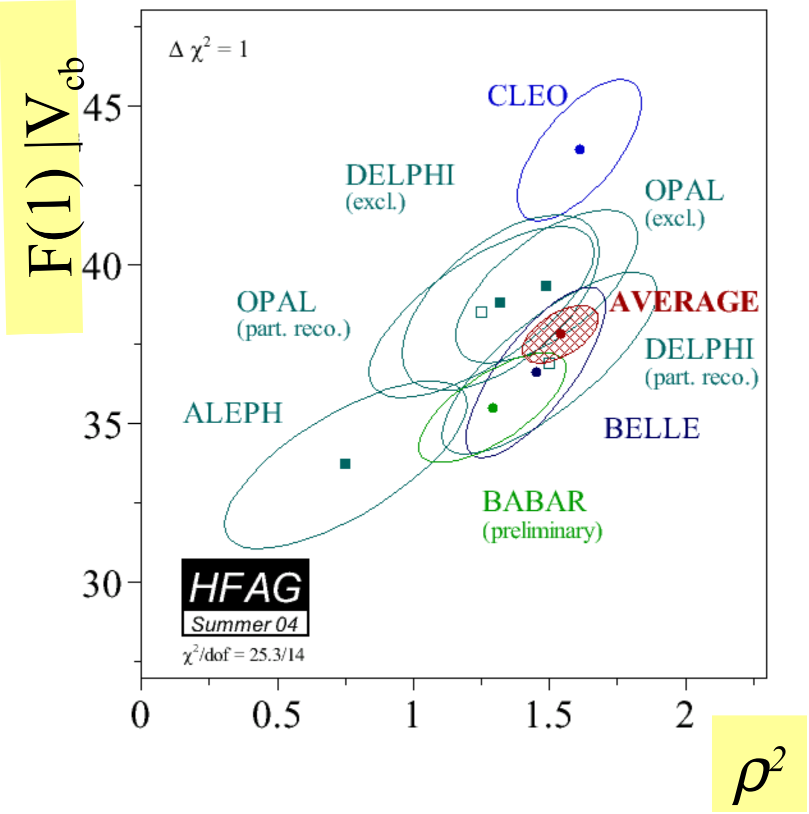
V_{cb}-Exclusive Method

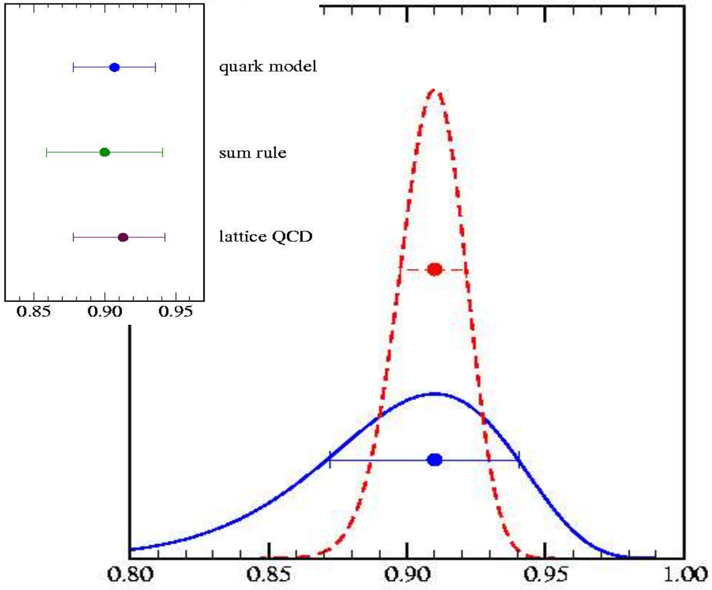
Based on ***HQET***



$$\frac{d\Gamma}{dw} \text{ ¿ } \frac{G_F^2}{48\pi^2} |V_{cb}|^2 \ |F(w)|^2 \ G(w)$$

At zero recoil (w=1),
as $M_Q \rightarrow \infty$ F(1) → 1



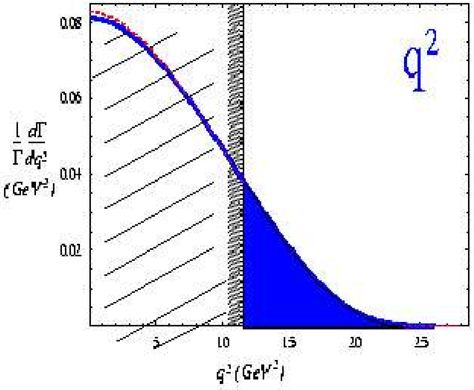


F(1) ~ 0.91 **± 0.04**

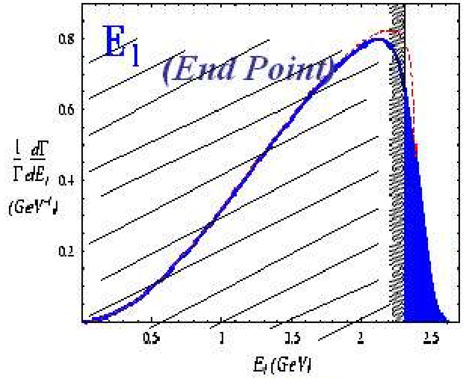
V_{cb}(exclusive)= (41.5± 1.0 ± 1.8) 10^{-3}

V_{ub} Inclusive methods

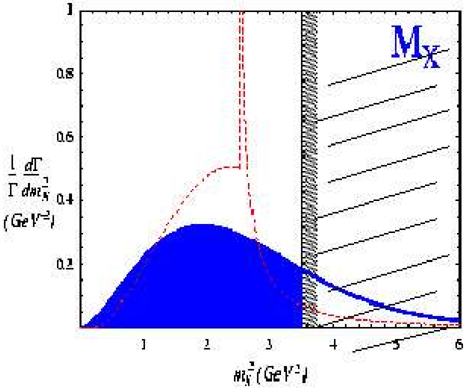
$B \rightarrow X_u l^+ \nu$



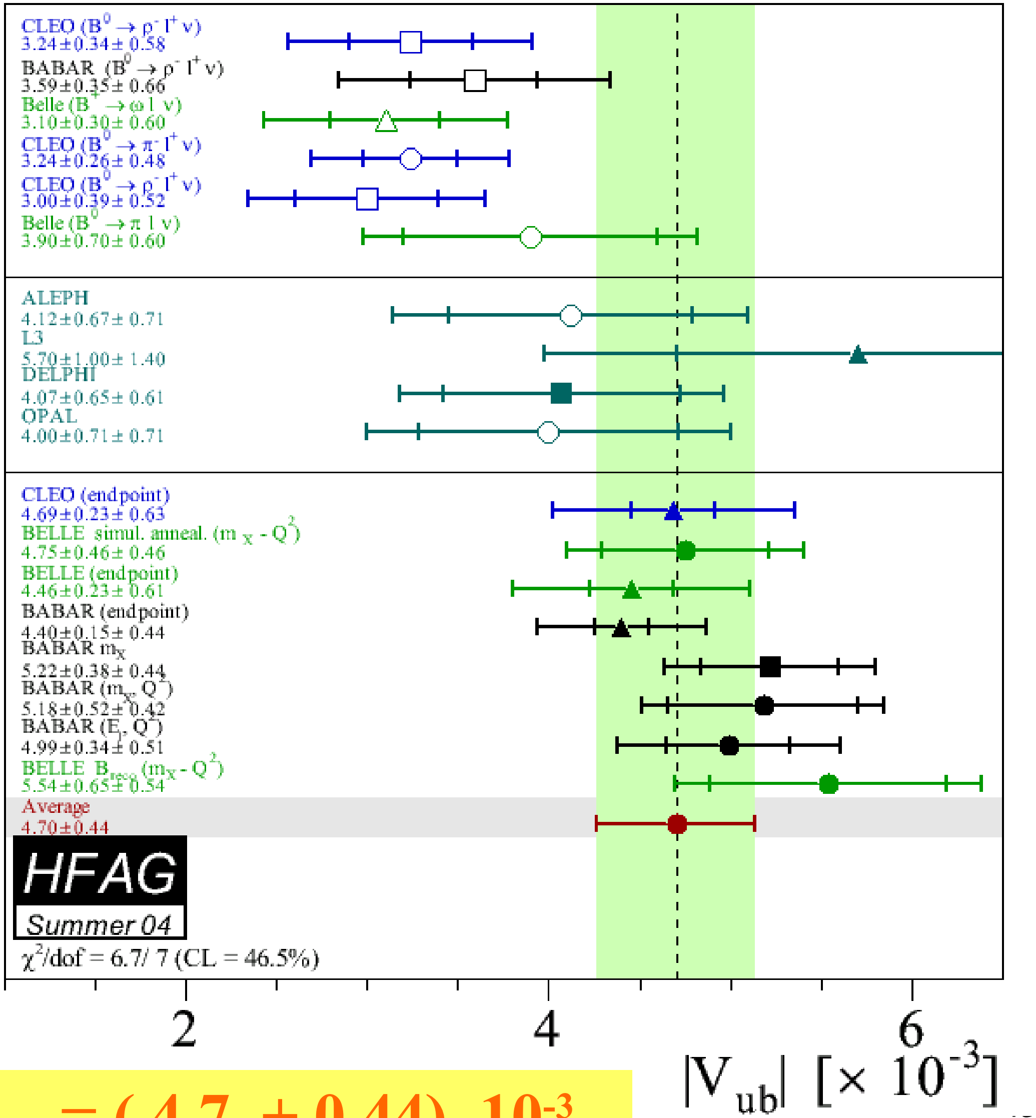
$$M_{\ell\nu}^2 = q^2 > (M_B - M_D)^2$$



$$E_\ell > \frac{M_B^2 - M_D^2}{2M_B}$$

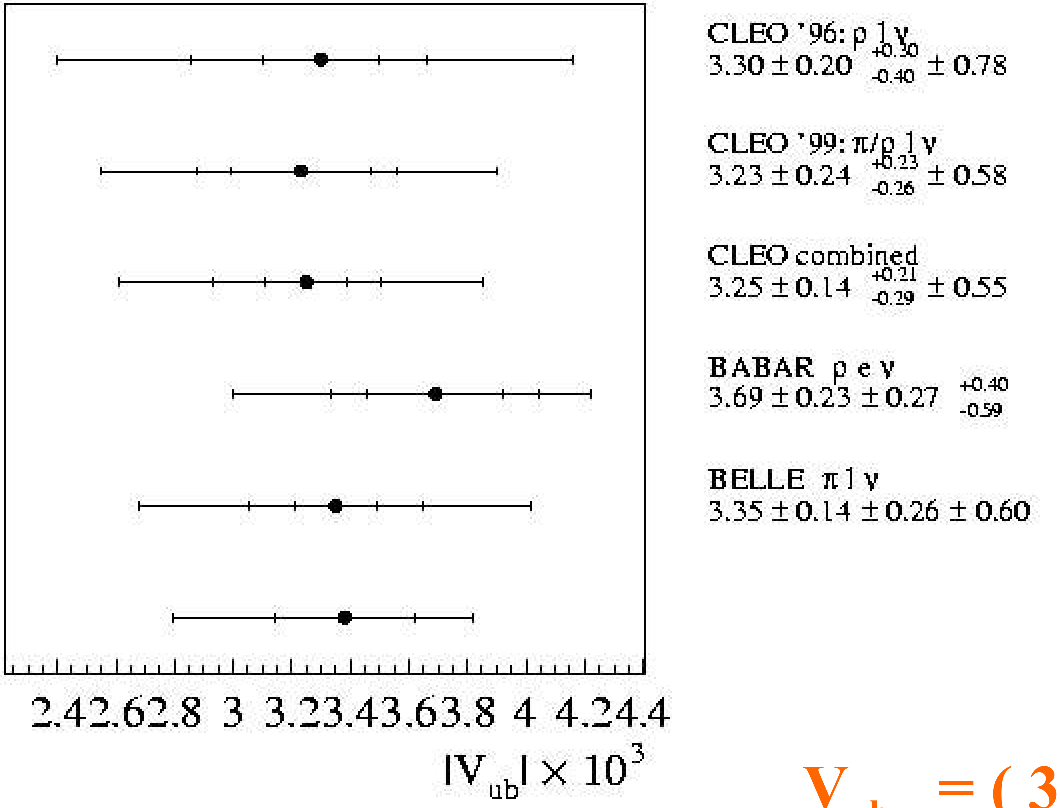


$$M_{uq} < M_{cq}$$



$V_{ub} = (4.7 \pm 0.44)\ 10^{-3}$

Exclusive methods B → $(\pi,\rho,\omega)\, l\ \nu$



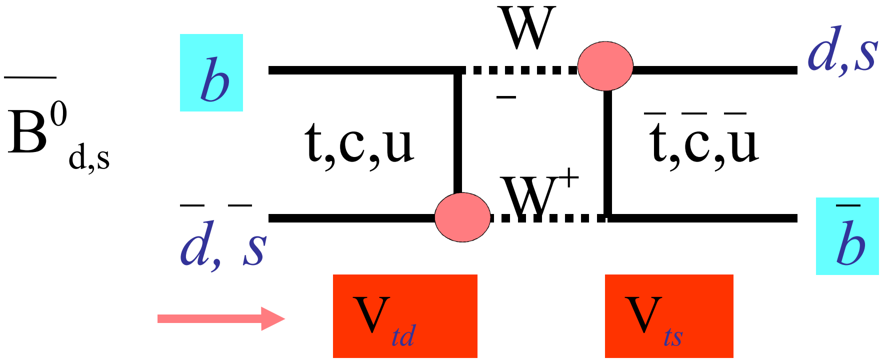
…

Common to all analyses

$$V_{ub} = (\,3.30 \pm 0.24 \pm 0.46)\ 10^{-3}$$

Error : dominated by form factor errors as F(1) in V_{cb}

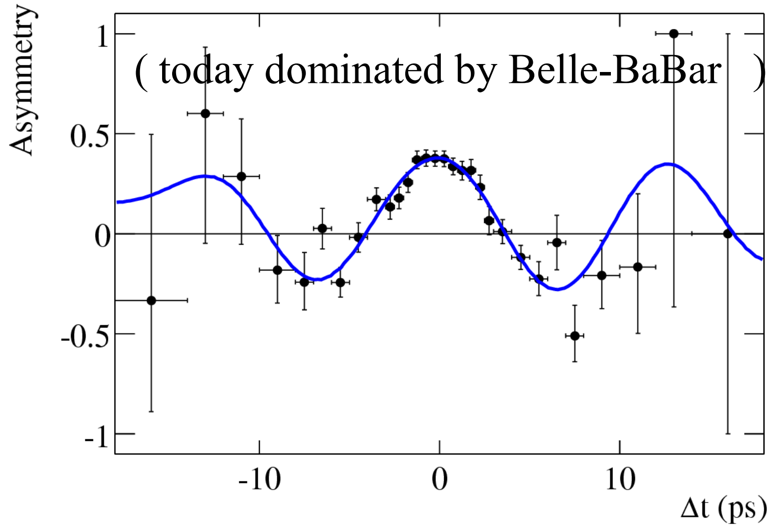
Oscillations in $B^0{}_d$ system : $\Delta \mathbf{m_d}$



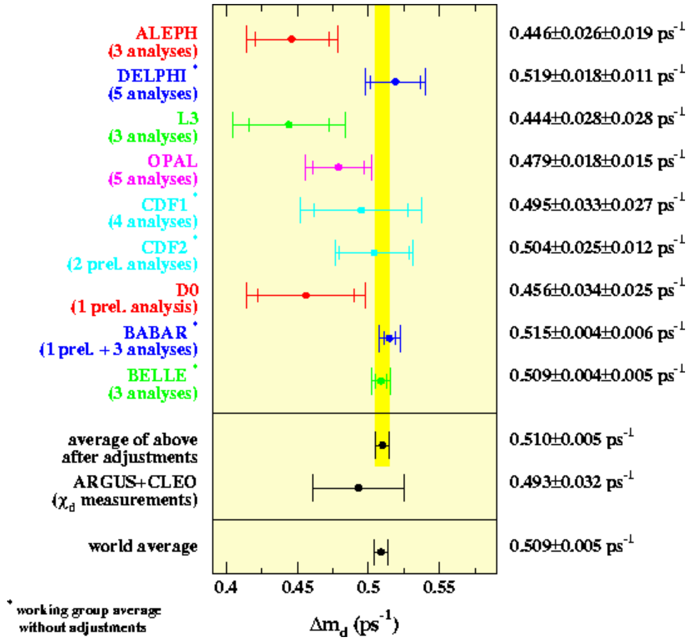
$$P_{B_q^0 \to B_q^0(\overline{B_q^0})} \text{ ¿ } \frac{1}{2} e^{-t/\tau_q}(1 \pm \cos \Delta m_q t)$$

$$\Delta m_d \propto f_{B_d}^2 B_{B_d} |V_{cb}|^2 \lambda^2 |V_{td}|^2$$

$$\propto f_{B_d}^2 B_{B_d} |V_{cb}|^2 \lambda^2 \boxed{((1-\overline{\rho})^2 + \overline{\eta}^2)}$$



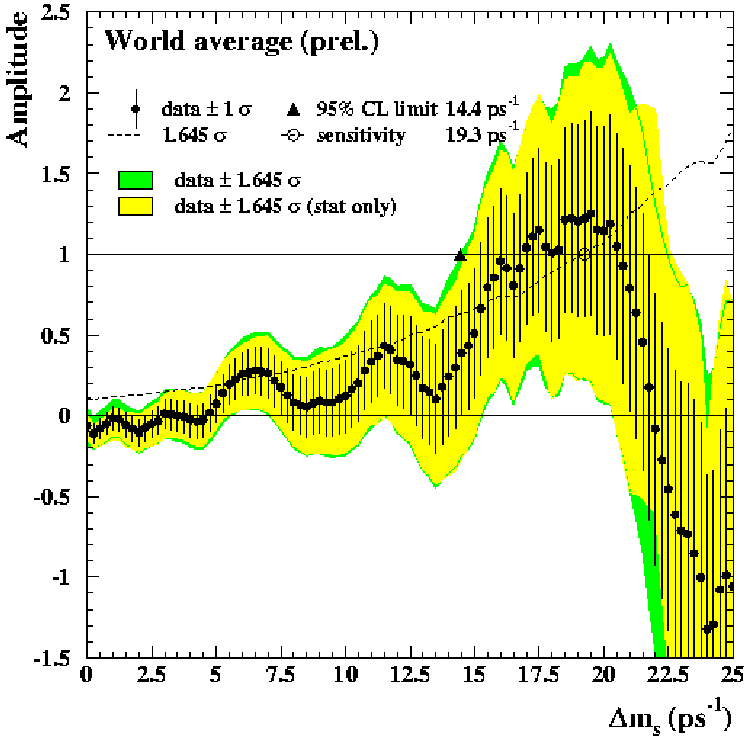
(today dominated by Belle-BaBar)



$\Delta \mathbf{m_d}$ = 0.502 ± 0.006 ps^{-1}
LEP/SLD/CDF/B-factories

Precise measurement (1.2%)

Oscillations in B^0_s system : $\mathbf{\Delta m_s}$



$\Delta m_s > 14.4$ ps^{-1} at 95% CL

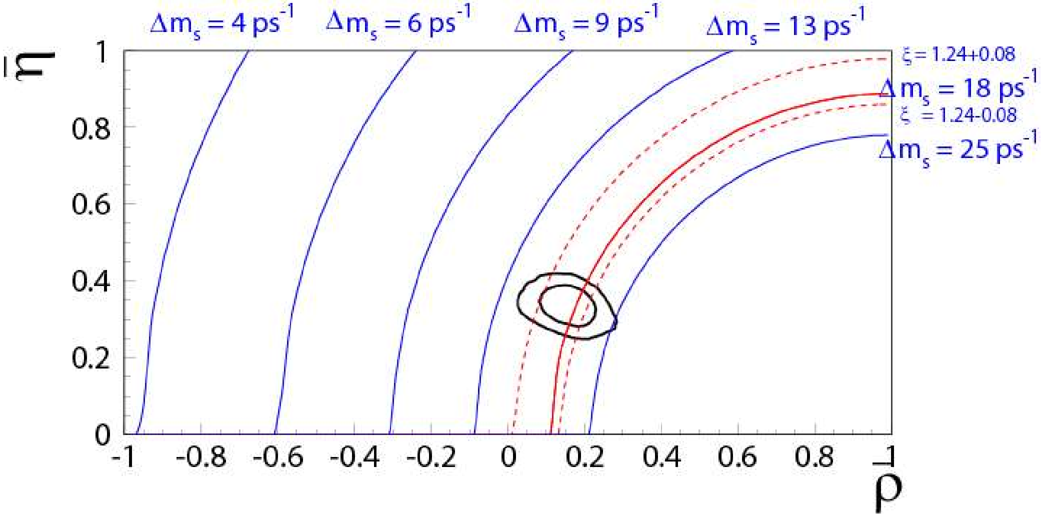
Sensitivity at 19.3 ps^{-1}

LEP/SLD/CDF-I

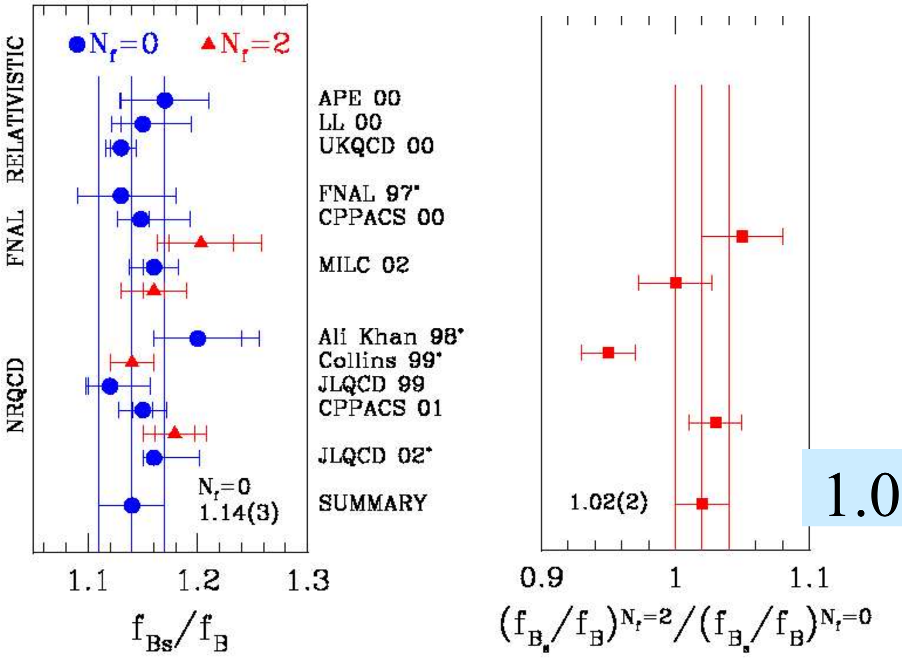
$$\Delta m_s \propto f^2_{B_s} B_{B_s} |V_{td}|^2 \propto f^2_{B_s} B_{B_s} |V_{cb}|^2$$

$$\frac{\Delta m_d}{\Delta m_s} ¿ \frac{f^2_{B_d} B_{B_d}}{f^2_{B_s} B_{B_s}} \lambda^2 ((1-\bar{\rho})^2+\bar{\eta}^2)$$

$1/\xi^2$



ξ



1.02±0.02

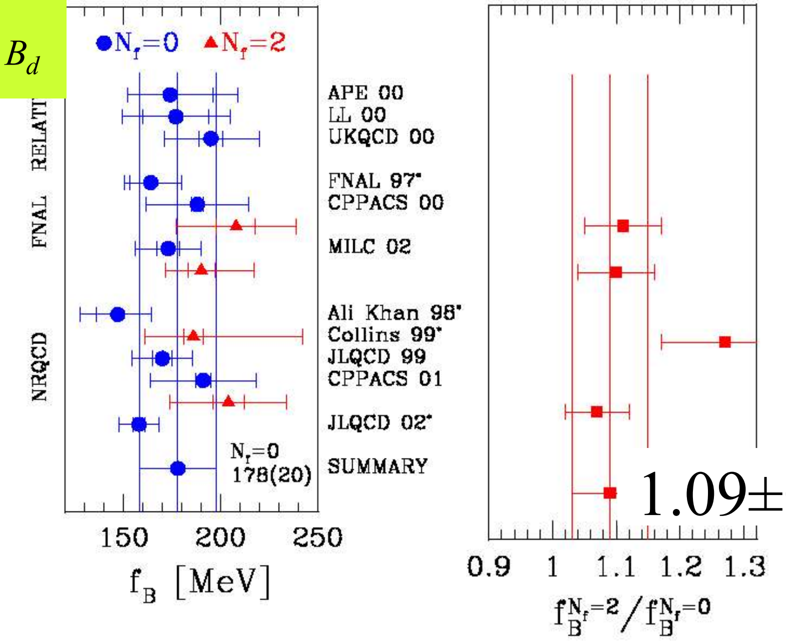
Calculation partially unquenched
(N_f=2 or 2+1) in agreement

$$\frac{f_{B_s}}{f_{B_d}} = 1.18 \pm 4^{+12}_{-0}, \quad \frac{B_{B_s}}{B_{B_d}} = 1.00 \pm 0.03$$

$$\xi = \frac{f_{B_s}\sqrt{\hat{B}_{B_s}}}{f_{B_d}\sqrt{\hat{B}_{B_d}}} = 1.24 \pm 0.04 \pm 0.06$$

Chiral extrapolation : light quarks simulated typically in a range [$m_s/2$ - m_s]

$f_{B_d}\sqrt{\hat{B}_{B_d}}$



1.09±0.06

Calculation partially unquenched
(N_f=2 or 2+1) in agreement

$$f_{B_d}\sqrt{\hat{B}_{B_d}} = 223\pm33\pm12MeV$$

$(Sum-Rules \quad f_{B_d} = 208\pm27MeV, B_{B_d} = 1.67\pm0.23)$

(syst not correlated ~m_b)

$\hat{B}_K$

1.05±0.15 unquenching factor

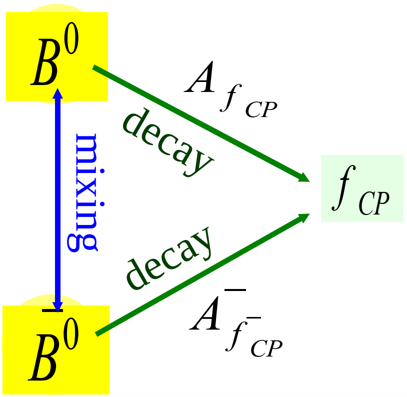
1.05±0.05 SU(3) effects factor

$$\hat{B}_K = 0.86\pm0.06\pm0.14$$

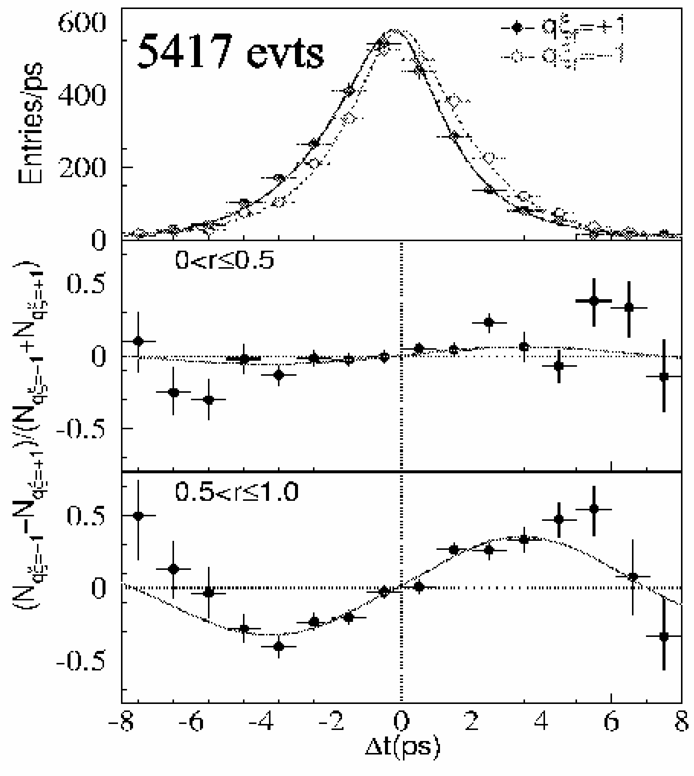
±0.09

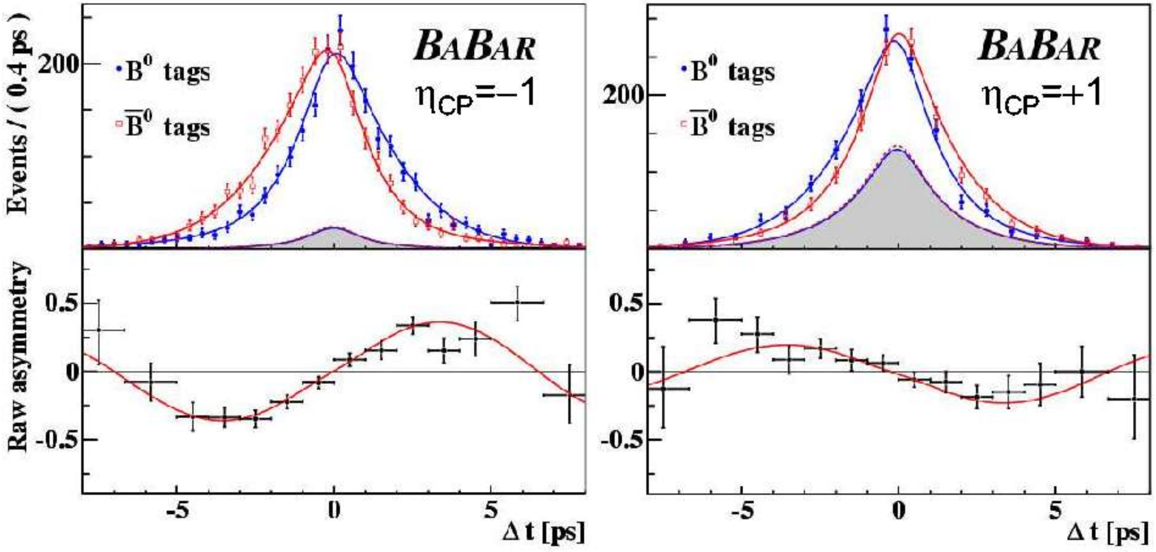
$\sin 2\beta$

CP violation comes from interference between decays with and without mixing



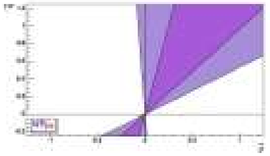
$$
\begin{aligned}
a_{f_{CP}}(t) &= \frac{\Gamma(B^0_{phys}(t)\to f_{CP}) - \Gamma(B^0_{phys}(t)\to f_{CP})}{\Gamma(B^0_{phys}(t)\to f_{CP}) + \Gamma(B^0_{phys}(t)\to f_{CP})} \\
&= C_{f_{CP}}\cos(\Delta m_d t) + S_{f_{CP}}\sin(\Delta m_d t) \\
&\sim -\ \eta_{J/\psi K^0_{S,L}}\ \sin 2\beta \sin(\Delta m_d t)
\end{aligned}
$$

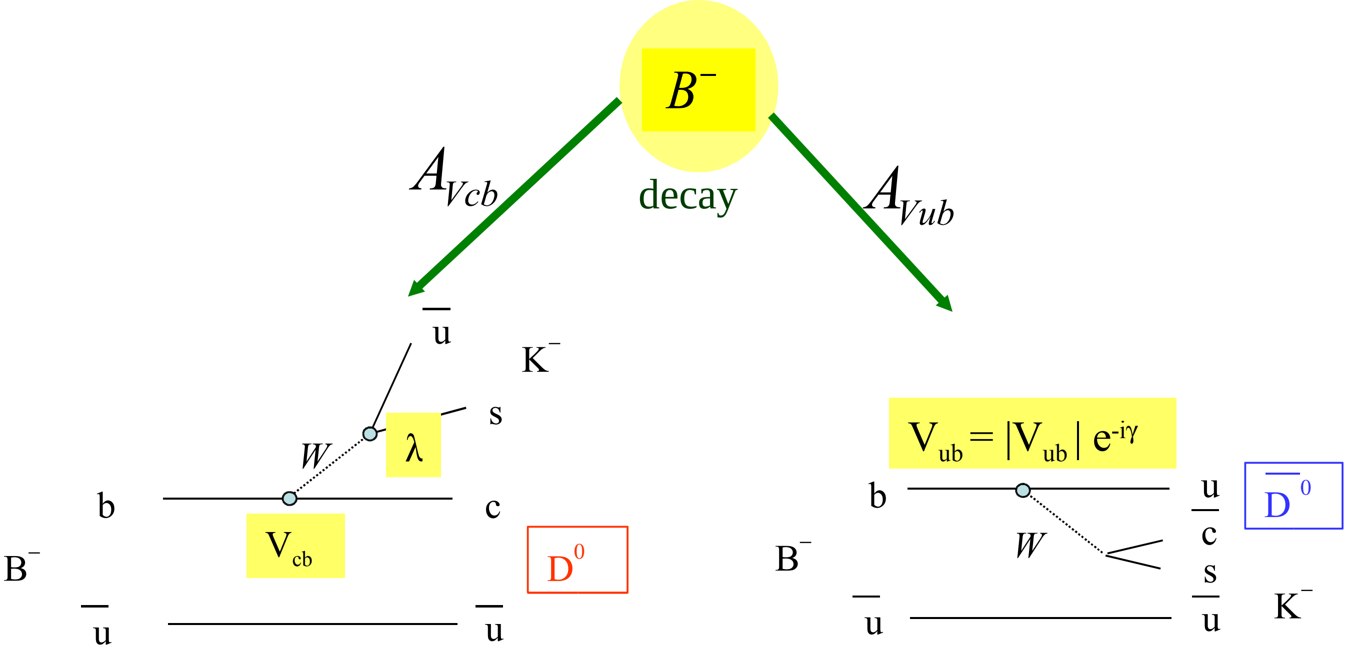




$$\boxed{\sin 2\beta = 0.729 \quad \pm 0.037}$$

angle γ





$$A(B^- \to D^0 K^-) = A_B$$

$$A(B^+ \to D^0 K^+) = A_B$$

$$A(B^- \to D^0 K^-) = A_B r_B e^{i(\delta_B - \gamma)}$$

$$A(B^+ \to D^0 K^+) = A_B r_B e^{i(\delta_B + \gamma)}$$

A_B	strong amplitude (the same for V_{ub} and V_{cb} mediated transitions
$\delta_B = \delta_1 - \delta_2$	strong phase difference between V_{ub} and V_{cb} mediated transitions

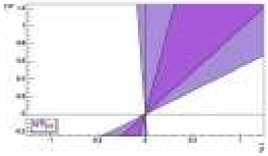
$$r_B = \frac{A(B^- \to D^0 K^-)}{A(B^- \to D^0 K^-)}$$

r_B is a crucial parameter. It drives the sensitivity on γ

GLW (Gronau,London,Wyler) Method

angle γ

$$A_{CP\pm} = \frac{\Gamma(B^+ \to D^0_{CP\pm}K^+) - \Gamma(B^- \to D^0_{CP\pm}K^-)}{\Gamma(B^+ \to D^0_{CP\pm}K^+) + \Gamma(B^- \to D^0_{CP\pm}K^-)} = \frac{\pm 2 r_B \sin\gamma \sin\delta_B}{1 + r_B{}^2 \pm 2 r_B \cos\gamma \cos\delta_B}$$



$$R_{CP\pm} = \frac{\Gamma(B^+ \to D^0_{CP\pm}K^+) + \Gamma(B^- \to D^0_{CP\pm}K^-)}{\Gamma(B^+ \to D^0 K^+) + \Gamma(B^- \to D^0 K^-)} = 1 + r_B{}^2 \pm 2 r_B \cos\gamma \cos\delta_B$$

ADS (Atwood, Dunietz, Soni) Method (only Babar)

$$R_{ADS} = \frac{\Gamma(B^+ \to (K^-\pi^+)_D K^+) - \Gamma(B^- \to (K^+\pi^-)_D K^-)}{\Gamma(B^+ \to (K^+\pi^-)_D K^+) + \Gamma(B^- \to (K^-\pi^+)_D K^-)} = r_B{}^2 + r^2_{DCS} + 2 r_B\, r_{DCS} \cos\gamma \cos(\delta_B + \delta_D)$$

$$r_{DCS} \equiv \sqrt{\frac{BR(D^0 \to K^-\pi^+)}{BR(D^0 \to K^+\pi^-)}}$$

$(3.62 \pm 0.29)10^{-3}$

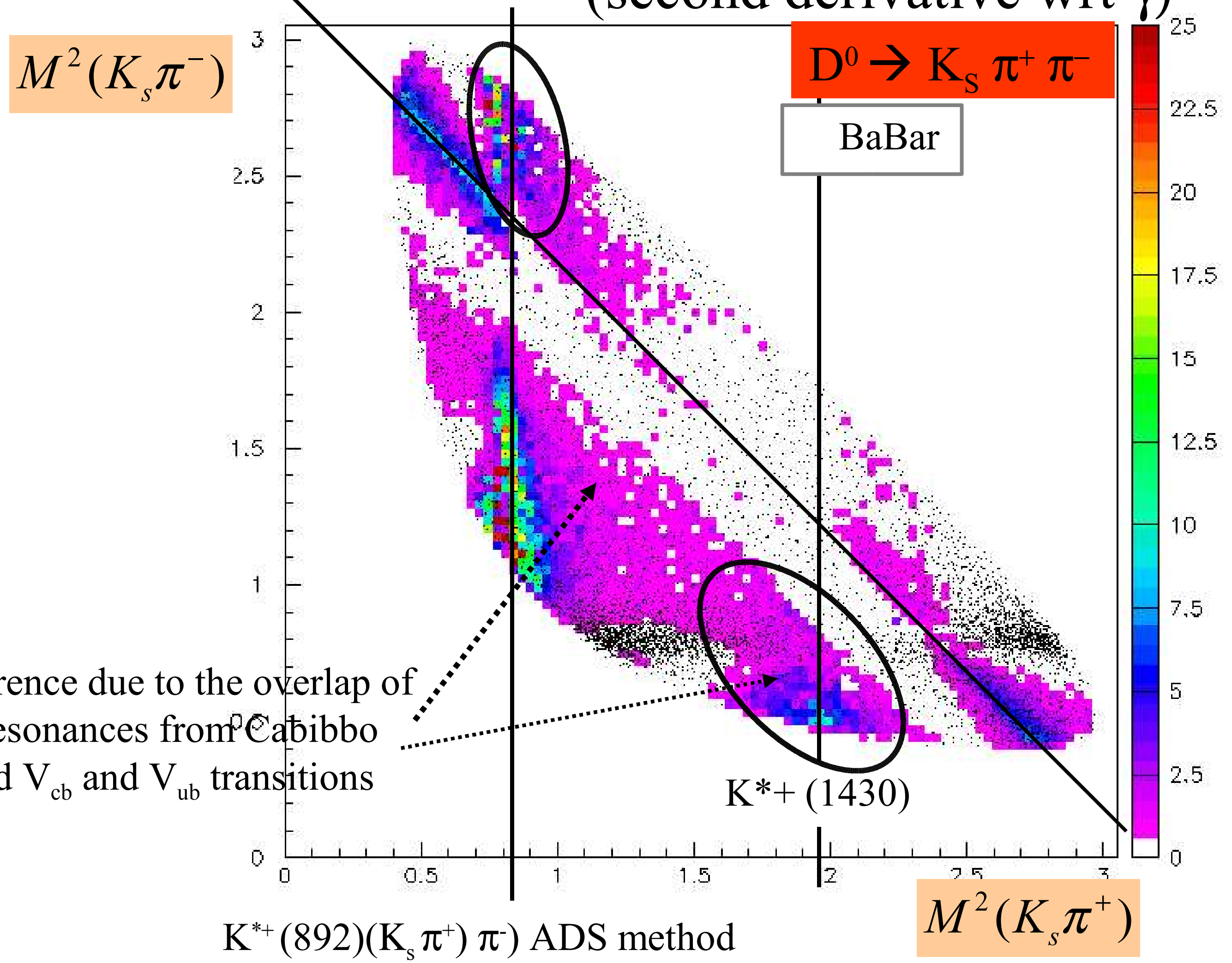
Dalitz Method - GGSZ

angle γ

new technique which makes use of the D0 three-body decays

Plot of the weights

(second derivative wrt γ)

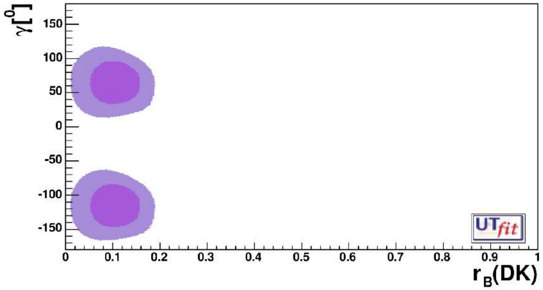


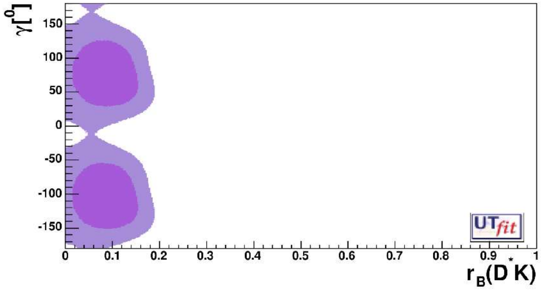
$K_s\rho(\pi^+\pi^-)$ CP-GLW method

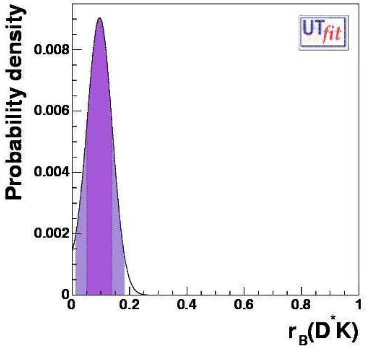
Interference due to the overlap of large resonances from Cabibbo allowed V_{cb} and V_{ub} transitions

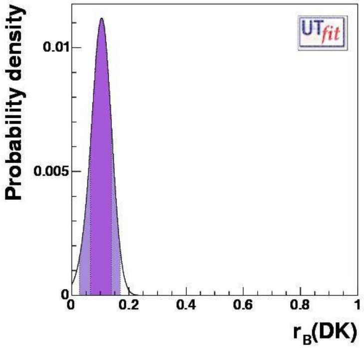
K*+ (1430)

$K^{*+}(892)(K_s\pi^+)\ \pi^-)$ ADS method

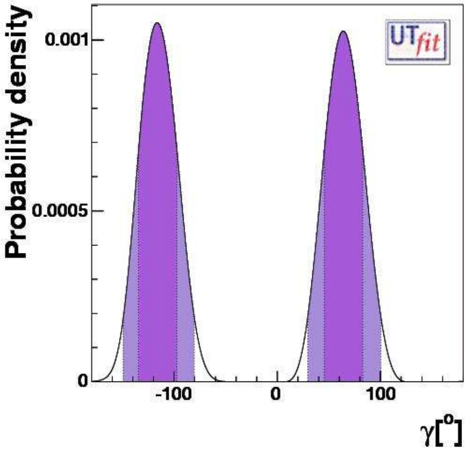








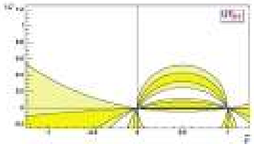
r_{DK} = 0.10 ± 0.04 ([0.03,0.17] @95% CL) **r_{D^*K} = 0.09 ± 0.04 ([0.01, 0.18] @95% CL)**



= 64.0 ± 18.2 ([30.1,99.8] @ 95% CL)

= -116.0 ± 18.2 ([-149.7,-80.4] @ 95% CL)

angle α



sin2α with SU(2) analysis

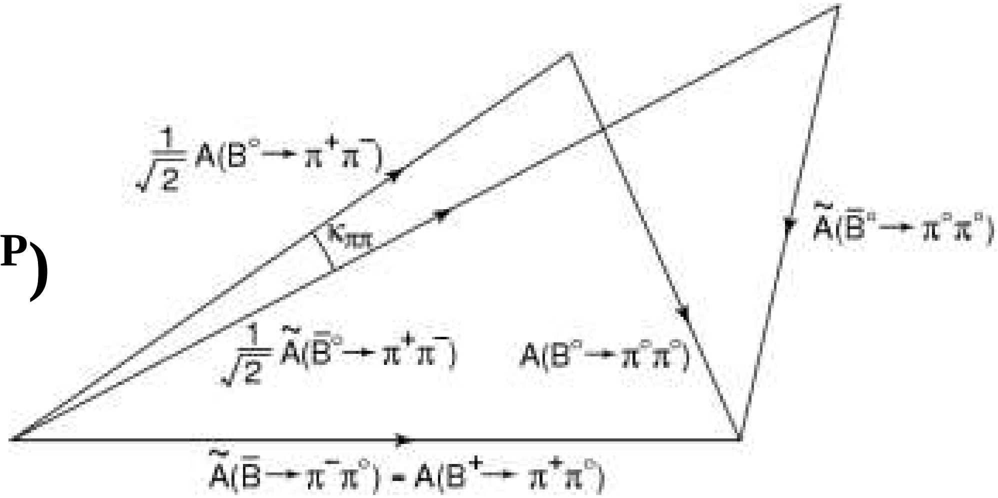
Starting from the SU(2) amplitudes:

Gronau-London, Phys. Rev. Lett. 65, 3381–3384 (1990)

$$A^{+-} = -Te^{-i\alpha} + Pe^{i\delta_P}$$

$$A^{+0} = -1/\sqrt{2}\, e^{-i\alpha} (T + T_C\, e^{i\delta_C})$$

$$A^{00} = -1/\sqrt{2}\, (T_C\, e^{i\delta_C}\, e^{-i\alpha} + Pe^{i\delta_P})$$

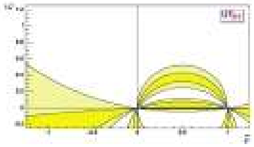


unknowns: T, P, T_C, δ_P, δ_{T_C}, α

observables: 3x BR, C_{+-}, S_{+-}, *C_{00}*

even if the system is not closed yet
we start to have relevant information

angle α



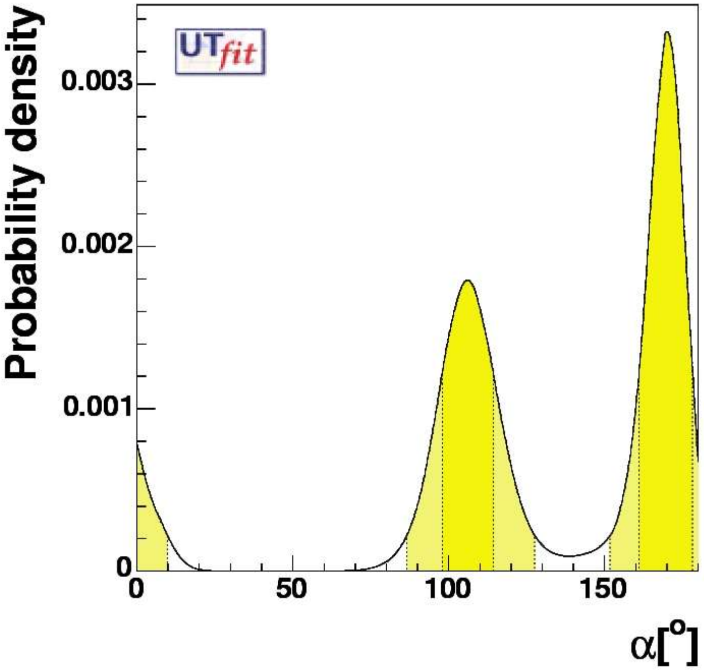
Experimental situation for the ππ,ρρ,ρπ decays mode

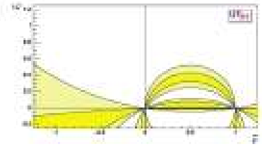
experimental inputs:

HFAG

Observable	ππ			ρρ		
	BaBar	Belle	Average	BaBar	Belle	Average
C	-0.09 ± 0.16	-0.56 ± 0.13	-0.37 ± 0.10	-0.03 ± 0.20	-	-0.03 ± 0.20
S	-0.30 ± 0.17	-0.67 ± 0.17	-0.50 ± 0.12	-0.33 ± 0.24	-	-0.33 ± 0.24
BR(+-) (10^{-6})	4.7 ± 0.6	4.4 ± 0.7	4.6 ± 0.4	30.0 ± 6.0	-	30.0 ± 6.0
BR(+0) (10^{-6})	5.8 ± 0.7	5.0 ± 1.3	5.5 ± 0.6	22.5 ± 8.1	31.7 ± 9.8	26.4 ± 6.4
f_L(+0)	-	-	-	0.975 ± 0.045	-	0.975 ± 0.045
BR(00) (10^{-6})	1.17 ± 0.34	2.32 ± 0.53	1.51 ± 0.28	0.54 ± 0.41	-	0.54 ± 0.41
f_L(00)	-	-	-	1.00 (assumed)		
$(\rho\pi)^0$				BaBar result		

angle α





$= (106 \pm 8)^{o}$ U $(170 \pm 9)^{o}$