

CKM Fit 2004: stato e contributi dalle B-Factory



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per gli UTfitters

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**Incontri di Fisica delle Alte Energie
Torino, 15 Aprile 2004**

Settore dei quarks nel Modello Standard

10 parametri liberi

6 masse dei quark

4 parametri della matrice CKM

Nel MS, le interazioni deboli tra i quark sono descritte da una matrice unitaria 3 x 3:
la matrice CKM

diagonale → stessa famiglia ~ 1

V_{us} e V_{cd} → famiglia 1-2 ~ λ

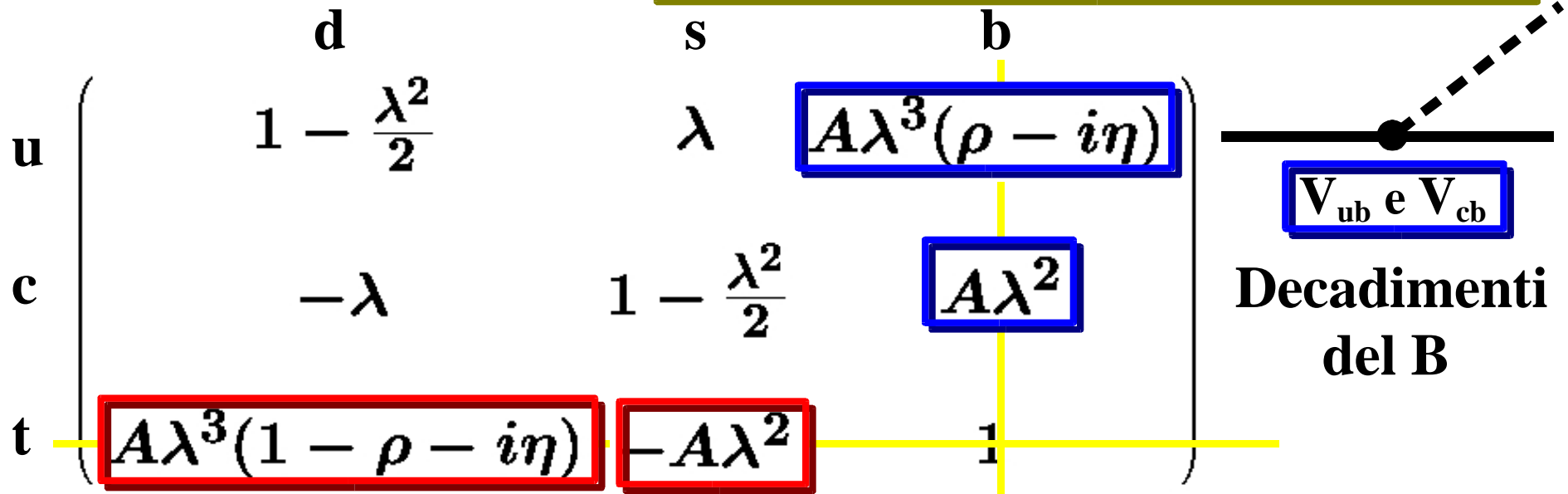
V_{cb} e V_{ts} → famiglia 2-3 ~ λ^2

V_{ub} e V_{td} → famiglia 1-3 ~ λ^3

$$(\bar{u} \quad \bar{c} \quad \bar{t}) \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

La matrice CKM:

parametrizzazione di Wolfenstein
 4 parametri: λ, A, ρ, η



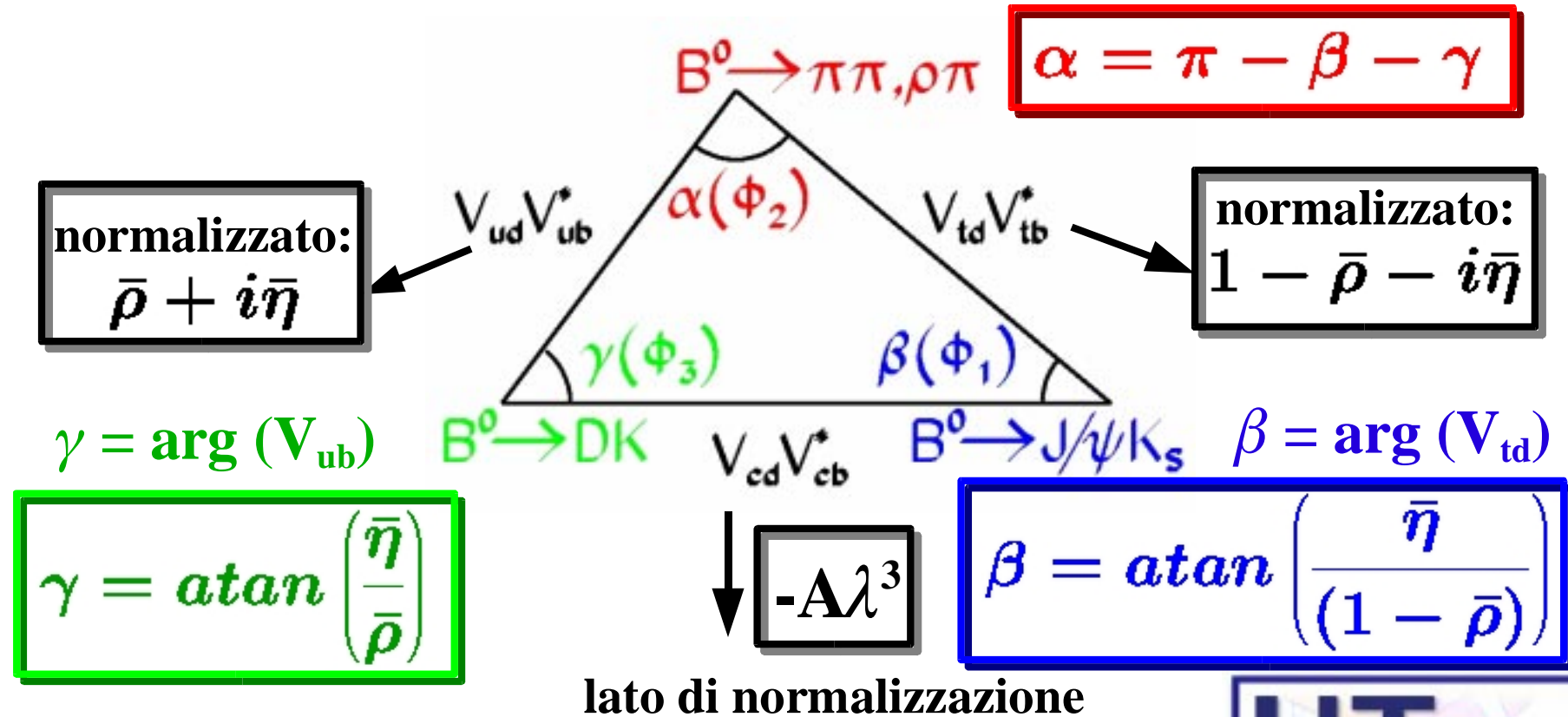
la fisica del B gioca un ruolo fondamentale nella determinazione di questi parametri



Il Triangolo Unitario:

ordine di grandezza: $\lambda^3 + \lambda^3 + \lambda^3$

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$



Il Metodo e gli Input:

teorema di Bayes

$$f(\bar{\rho}, \bar{\eta}, X | c_1, \dots, c_m) \sim \prod_{j=1, m} f_j(\mathcal{C} | \bar{\rho}, \bar{\eta}, X)^*$$

$$X \equiv x_1, \dots, x_n = m_t, B_K, F_B, \dots$$

$$\mathcal{C} \equiv c_1, \dots, c_m = \epsilon, \Delta m_d / \Delta m_s, A_{CP}(J/\psi K_S), \dots$$

$$\prod_{i=1, N} f_i(x_i) f_0(\bar{\rho}, \bar{\eta})$$

$(b \rightarrow u)/(b \rightarrow c)$	$\bar{\rho}^2 + \bar{\eta}^2$	$\bar{\Lambda}, \lambda_1, F(1), \dots$
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
$A_{CP}(J/\psi K_S)$	$\sin 2\beta$	—

Modello Standard +
OPE/HQET/
Lattice QCD
per passare
dai quark
agli adroni

m_t



λ	0.2240 ± 0.036	
V_{cb} inclusivo	$41.4 \pm 0.6 \pm 0.7 \cdot 10^{-3}$	} talk di D. Monorchio
V_{cb} esclusivo	$42.1 \pm 1.1 \pm 1.9 \cdot 10^{-3}$	
V_{ub} inclusivo	$4.09 \pm 0.46 \pm 0.36 \cdot 10^{-3}$	} talk di F. Gallo
V_{ub} esclusivo	$3.30 \pm 0.24 \pm 0.46 \cdot 10^{-3}$	
Δm_d	$0.502 \pm 0.007 \text{ ps}^{-1}$	LEP/SLD/CDF/B-Factory
Δm_s	$> 14.4 \text{ ps}^{-1}$	talk di A. Mazzone LEP/SLD/CDF-1
m_t	$167 \pm 5 \text{ GeV}$	CDF/D0
m_c	$1.3 \pm 0.1 \text{ GeV}$	
$f_{B_d} \sqrt{\hat{B}_{B_d}}$	$223 \pm 33 \pm 12 \text{ MeV}$	Lattice QCD
ξ	$1.24 \pm 0.04 \pm 0.06$	Lattice QCD
B_K	$0.86 \pm 0.06 \pm 0.14$	Lattice QCD
$\sin 2\beta$	0.739 ± 0.048	B-Factory talk di L. Vitale

Oscillazioni del B: Δm_s

$$P_{B_q^0 \rightarrow B_q^0(\bar{B}_q^0)} = \frac{1}{2} e^{-t/\tau_q} (1 \pm A \cos \Delta m_q t)$$

si misura A per ogni Δm_s fissato:

$A=0 \rightarrow$ non c'e' oscillazione

$A=1 \rightarrow$ c'e' oscillazione

$\Delta m_s \sim$ escluso al 95% CL

$$\rightarrow A + 1.645\sigma_A < 1$$

sensitività: $1.645\sigma_A = 1$

$$\Delta m_s \propto f_{B_s}^2 B_{B_s} |V_{ts}|^2 \propto f_{B_s}^2 B_{B_s} |V_{cb}|^2$$

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

nel piano $\bar{\rho}-\bar{\eta}$ corrisponde ad un cerchio centrato in (1,0)

dato il fattore λ^2 , ci si aspetta

$$\Delta m_s \sim 20 \Delta m_d$$

necessaria un'eccellente risoluzione temporale

ALEPH I
(91-95, no D_sL adjusted)

ALEPH D.I
(91-95)

ALEPH B
(91-00)

CDF $\lambda^2 A$
(92-95)

DELPHI B+D h
(92-95)

DELPHI D, h+ η
(92-95)

DELPHI vtx
(92-00)

DELPHI I
(92-00)

OPAL I
(91-95)

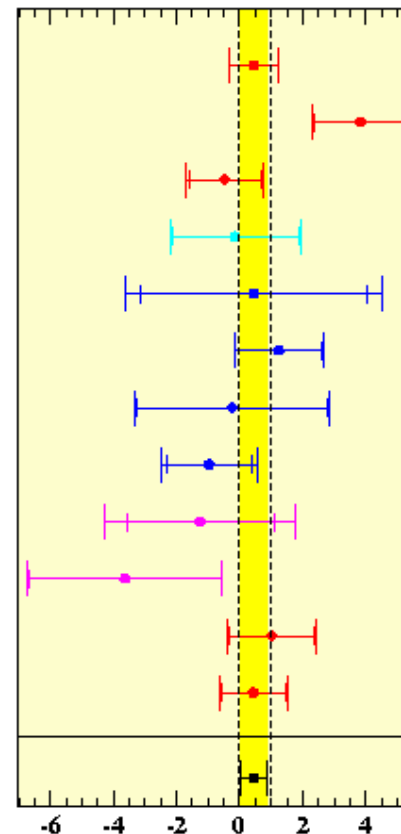
OPAL D.I
(91-95)

SLD D
(96-98)

SLD dipole
(96-98)

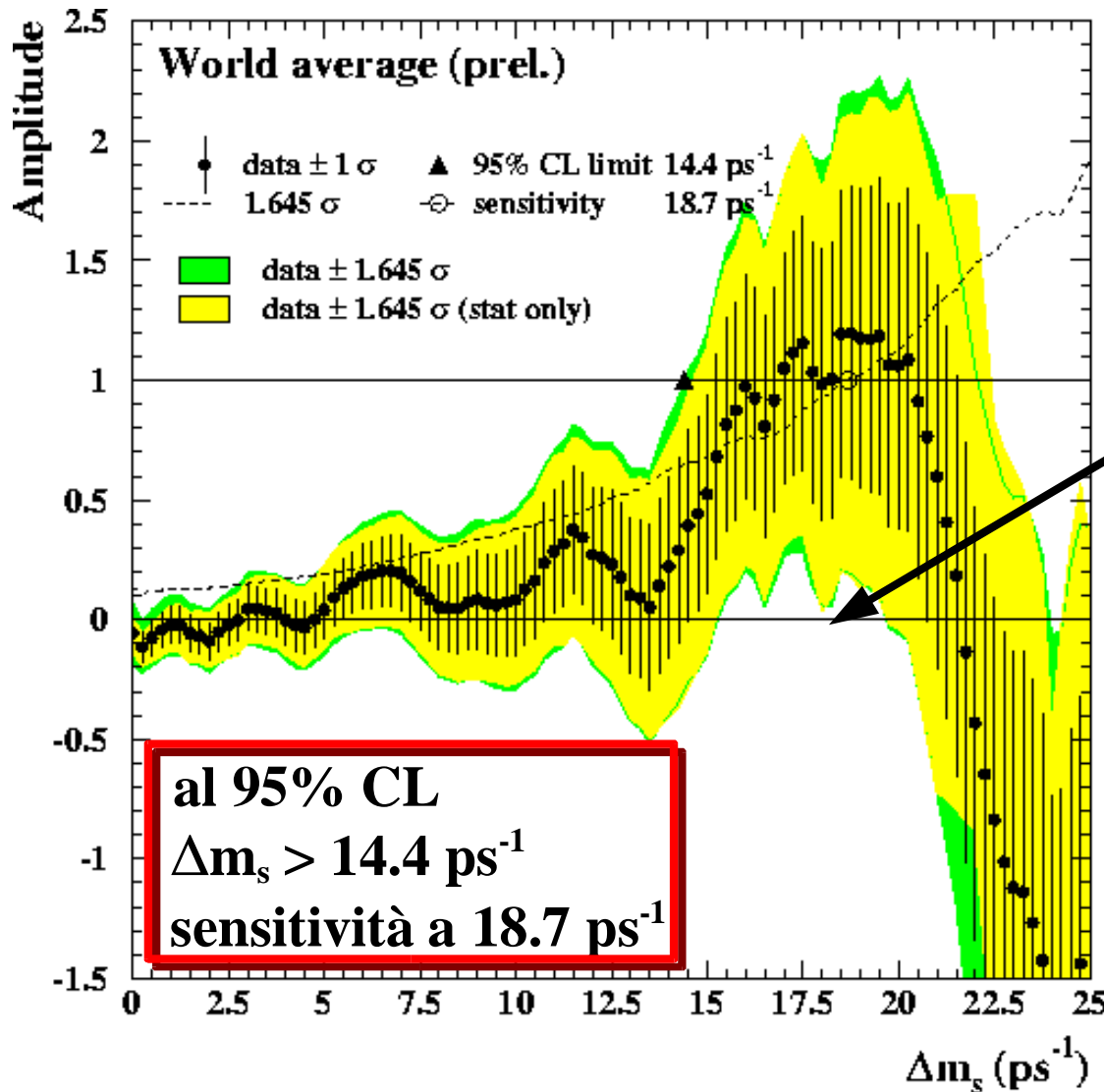
World average

Heavy Flavour
Averaging Group

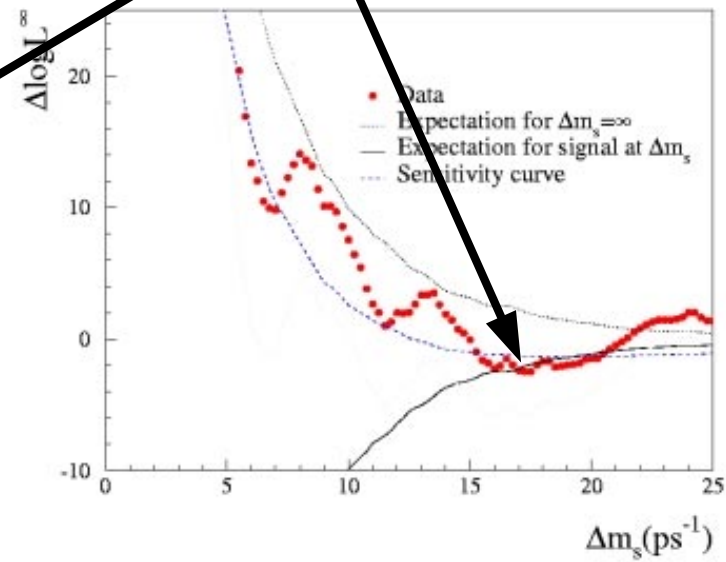


amplitude at $\Delta m_s = 15.0 \text{ ps}^{-1}$

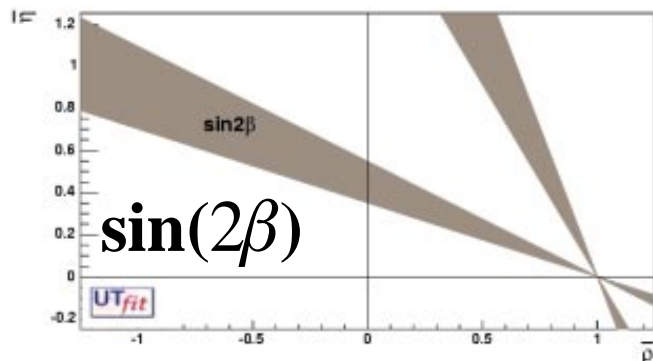
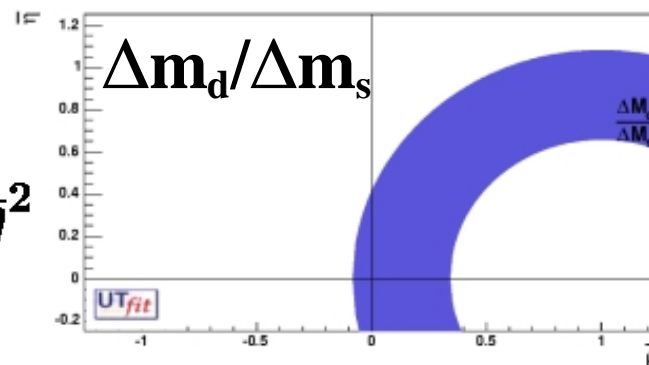
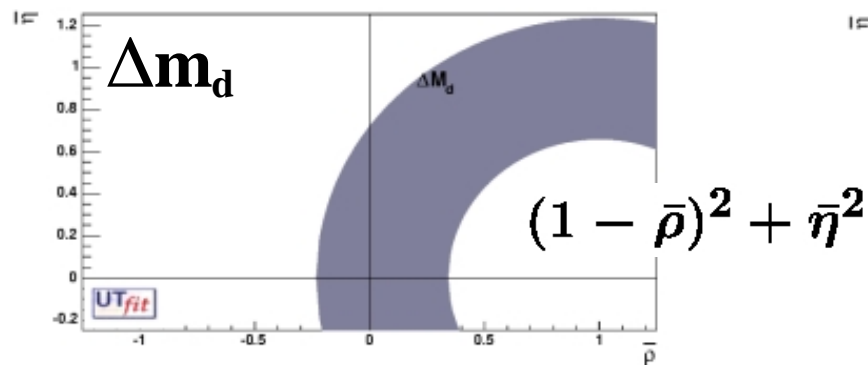
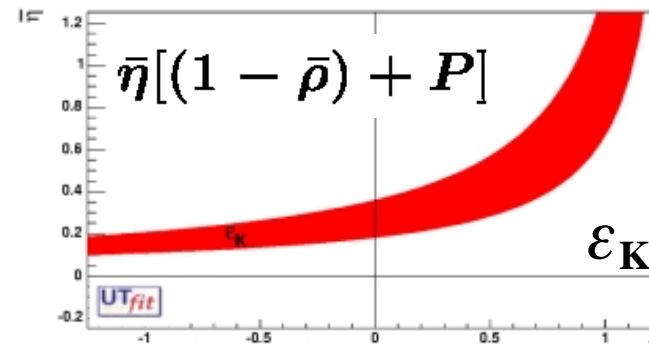
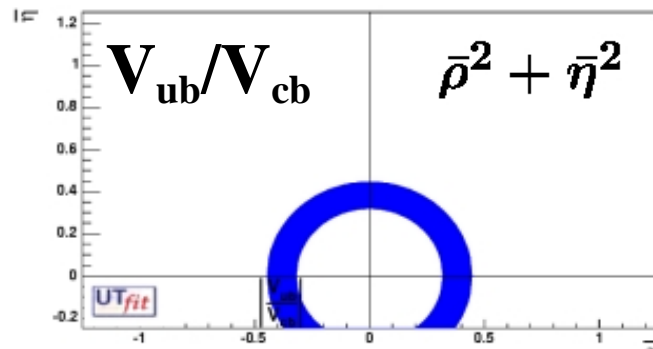
Oscillazioni del B: Δm_s



**possibile segnale
 a $\Delta m_s \sim 17.5 \text{ ps}^{-1}$
 con significanza $\sim 2\sigma$**



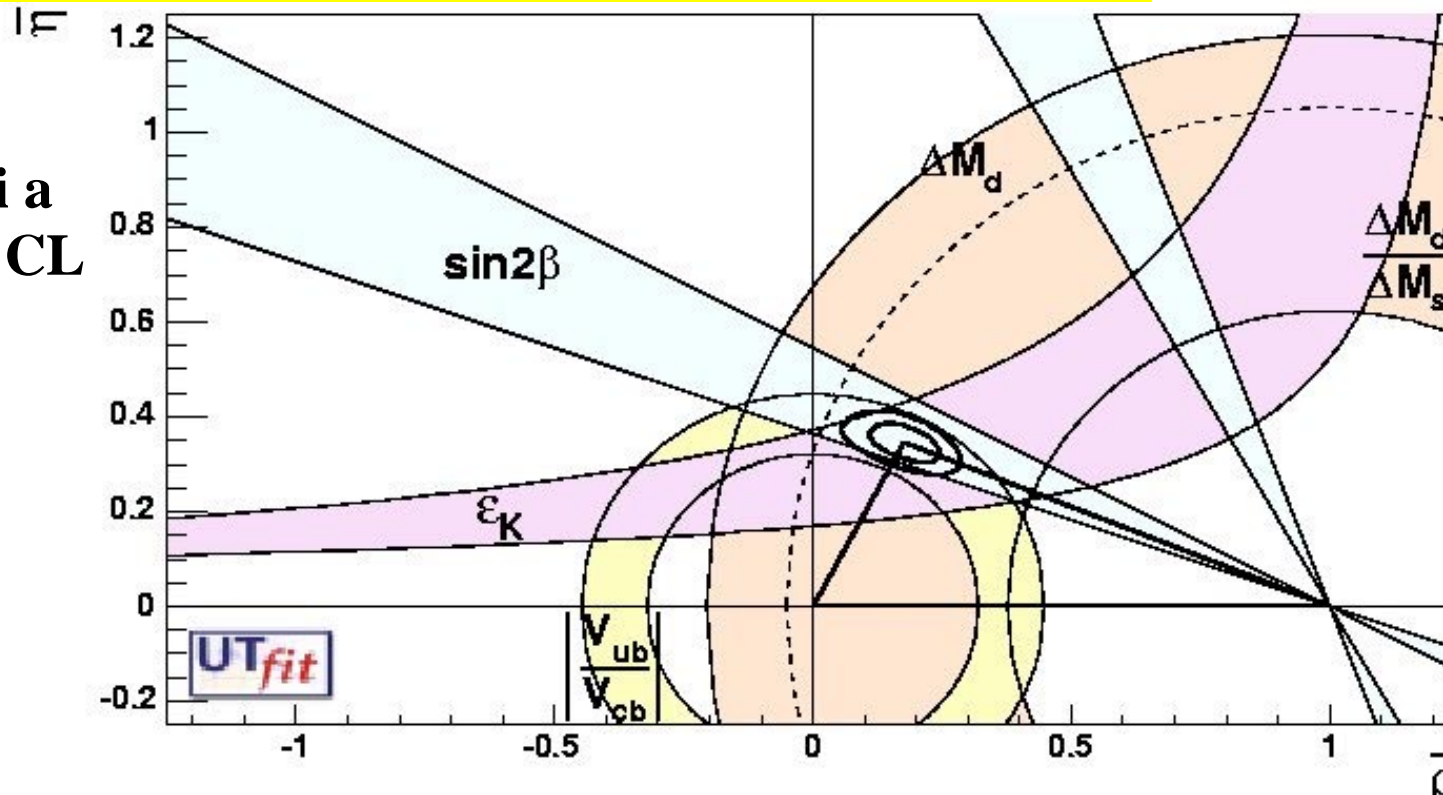
Riassumendo gli Input nel piano $\bar{\rho}$ - $\bar{\eta}$:



...e mettendo tutto insieme...

Risultato del Fit Standard:

livelli a
95% CL



$$\bar{\rho} = 0.185^{+0.035}_{-0.055}$$

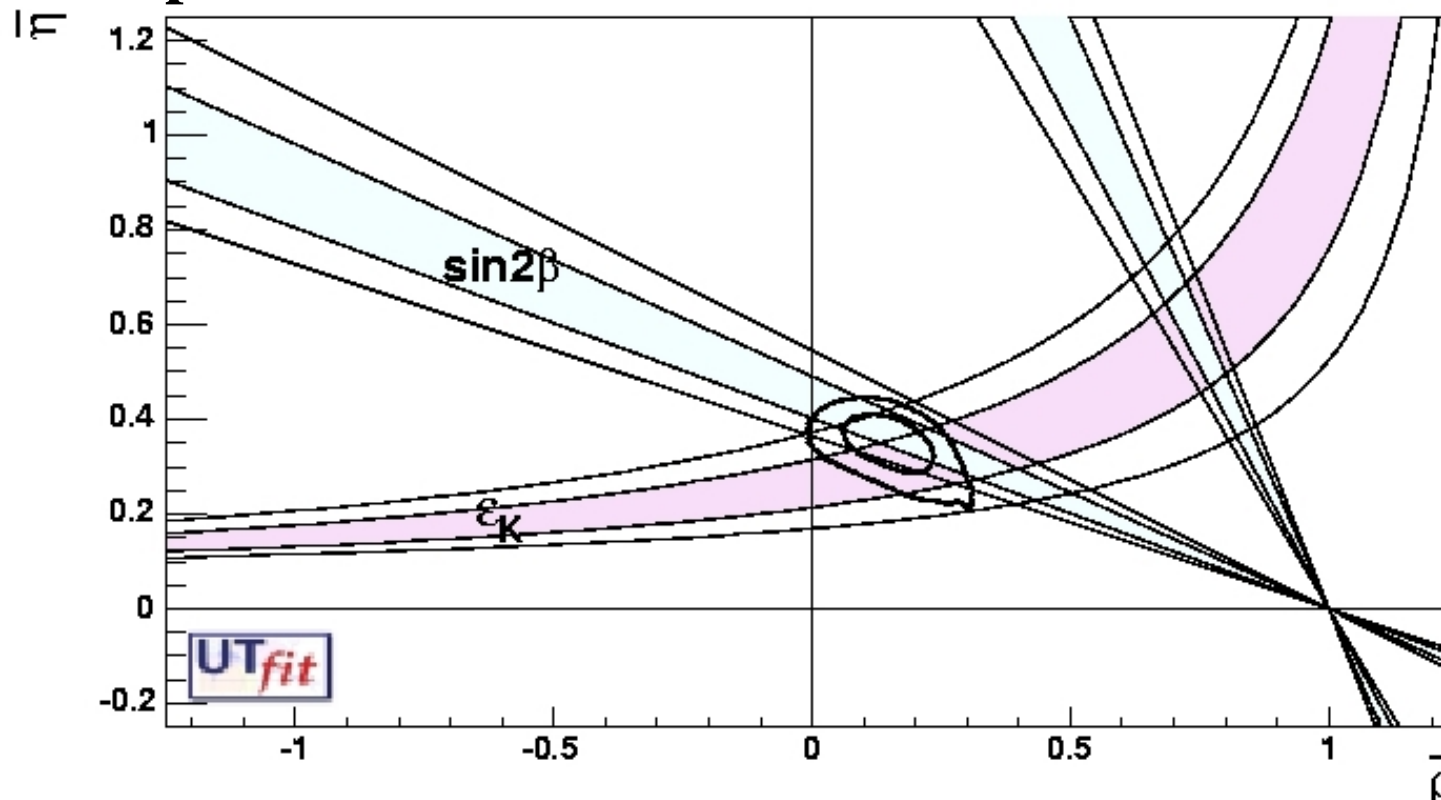
[0.08, -0.26] @ 95% CL

$$\bar{\eta} = 0.346 \pm 0.026$$

[0.292, -0.396] @ 95% CL

Test cruciale del Modello Standard:

includendo nel calcolo dell'area solo i lati e sovrapponendo le aree permesse dalla violazione di CP nei B e nei K:

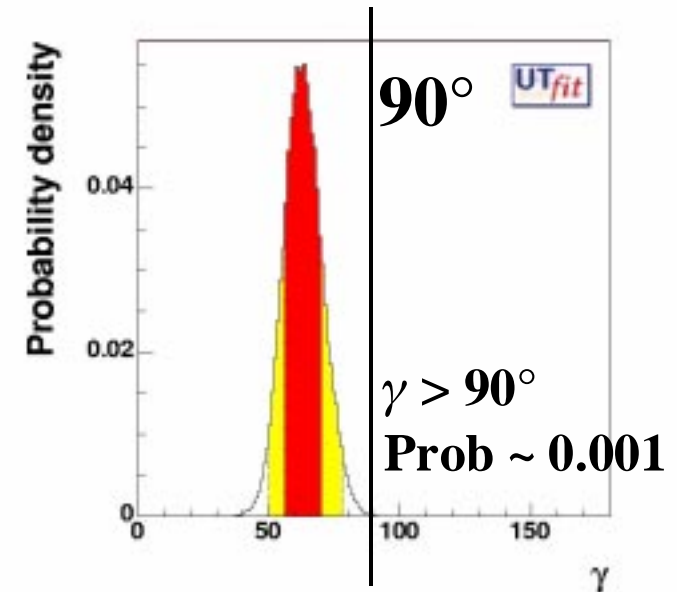
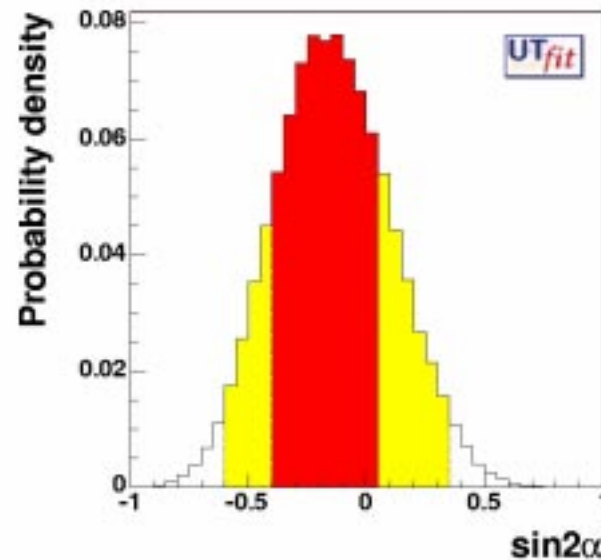
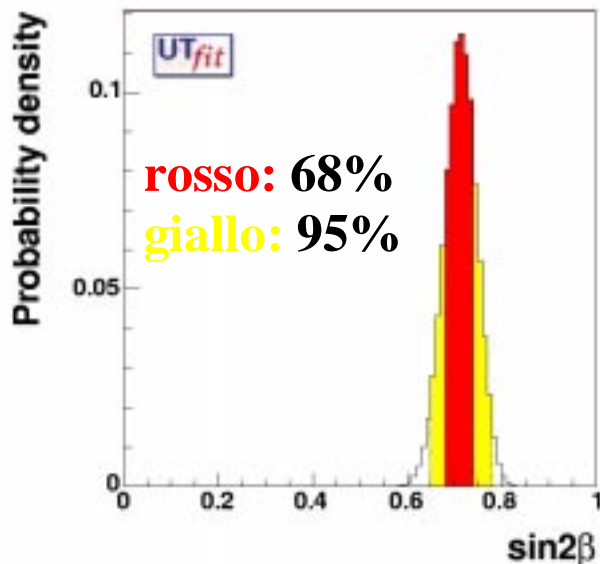


$$\left\{ \begin{array}{l} \sin 2\beta = 0.739 \pm 0.048 \text{ valore sperimentale dal charmonio} \\ \sin 2\beta = 0.715^{+0.045}_{-0.055} \text{ dalle sole informazioni sui lati} \end{array} \right.$$

A posteriori per $\sin 2\alpha$, $\sin 2\beta$ e γ :



si può fare una determinazione indiretta:



$$\sin 2\beta = 0.715^{+0.25}_{-0.35}$$

[0.65, 0.78] @ 95% CL

$$\sin 2\alpha = -0.13^{+0.18}_{-0.28}$$

[-0.60, 0.35] @ 95% CL

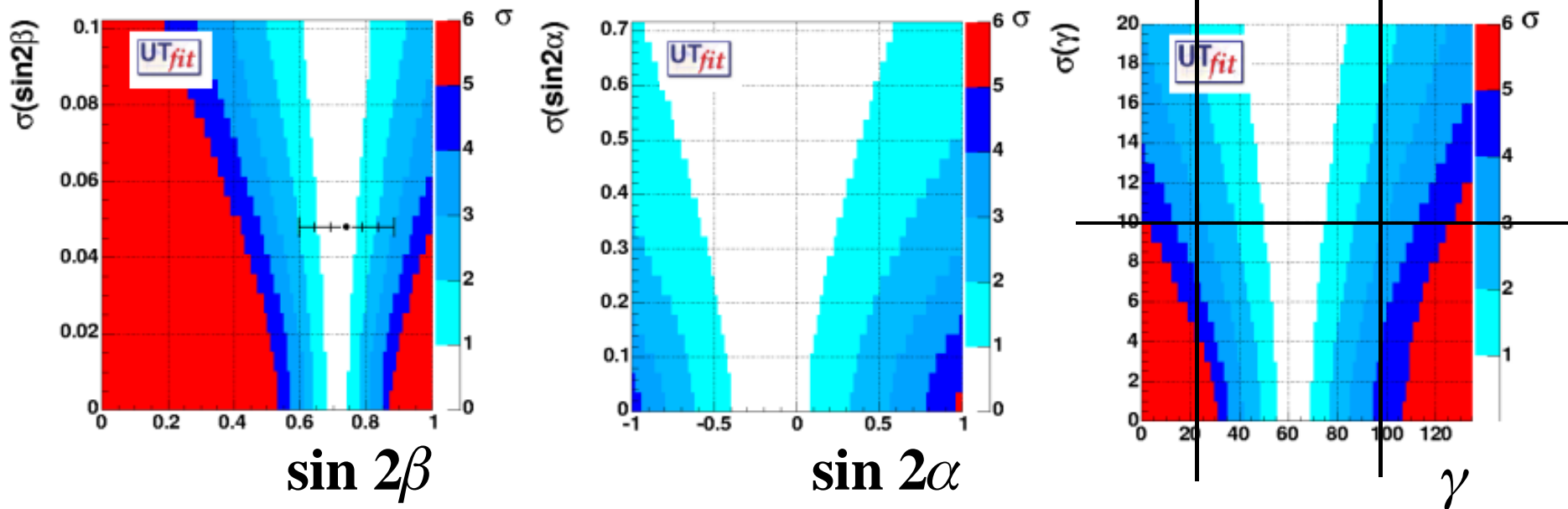
$$\gamma = 64^\circ \pm 7^\circ$$

[50, 78] @ 95% CL

Plot di compatibilità:

rosso: escluso a 5σ

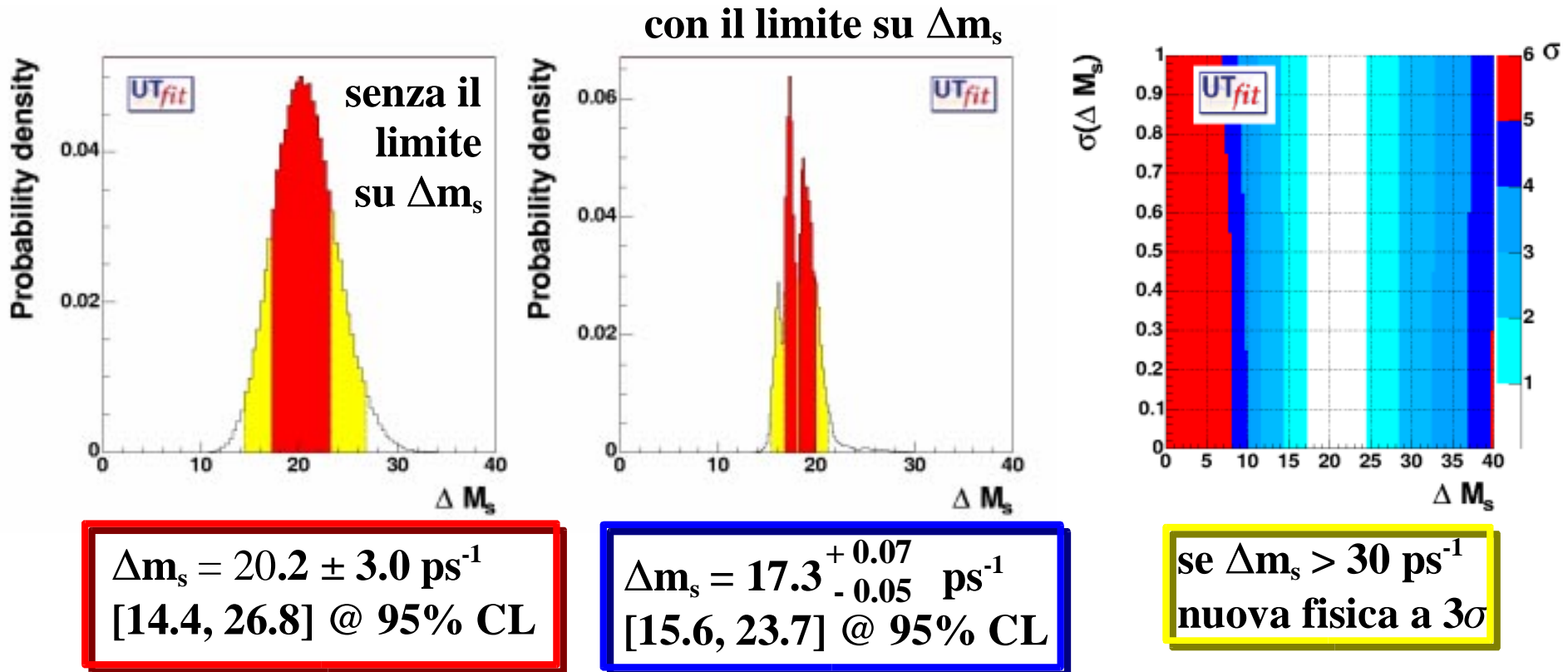
$\gamma > 100^\circ$ } nuova fisica
 $\gamma < 25^\circ$ } a più di 3σ



confronto tra la determinazione indiretta ed una possibile determinazione diretta sperimentale



A posteriori e compatibilità per Δm_s :



Nuovi Input: $\sin 2\alpha$

talk di
G. Cavoto

analisi dipendente dal tempo $\pi\pi$ e $\rho\rho$:

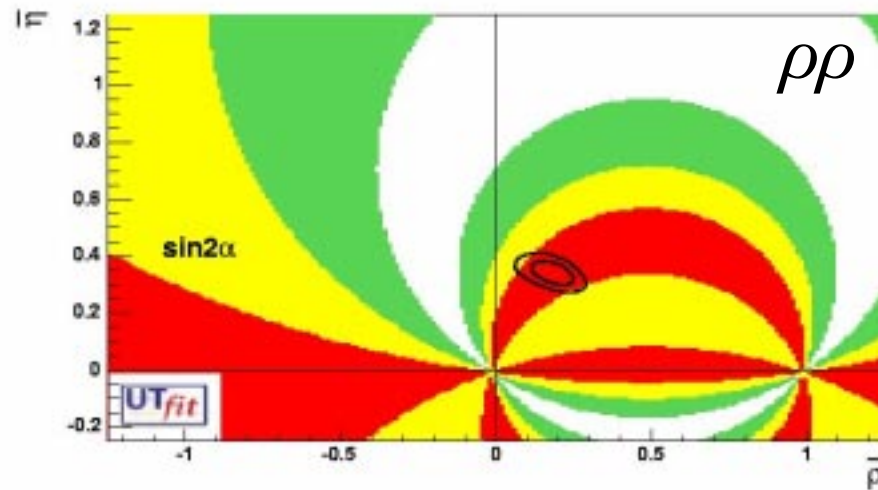
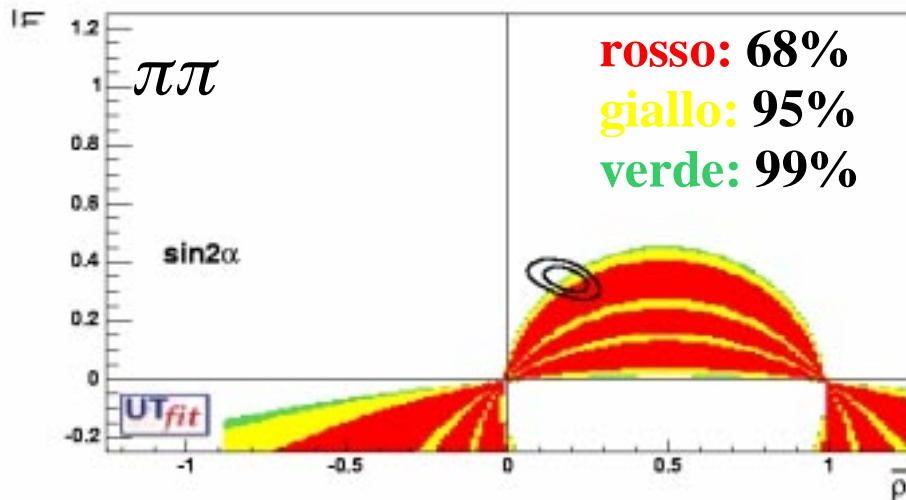
misure di $2\alpha_{\text{eff}} = 2\alpha + \delta$

$$|\alpha_{\text{eff}} - \alpha|_{\pi\pi} < 43.0^\circ \text{ @ 95\% CL}$$

$$|\alpha_{\text{eff}} - \alpha|_{\rho\rho} < 17.0^\circ$$

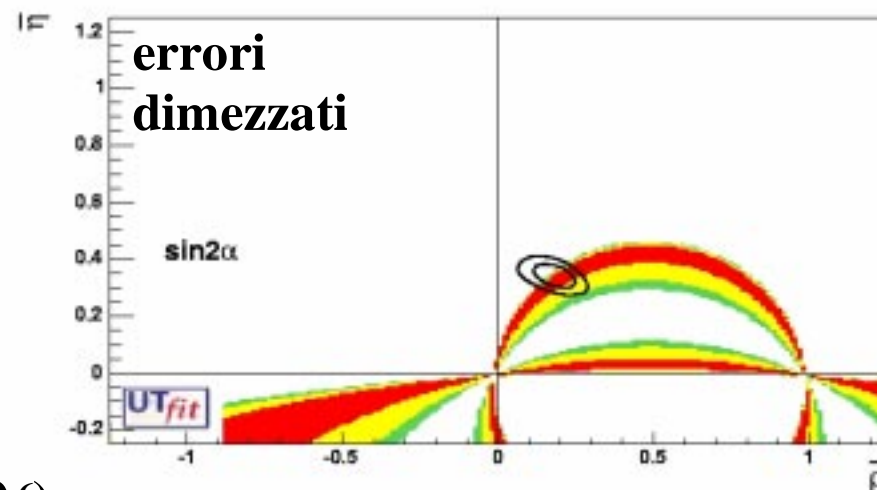
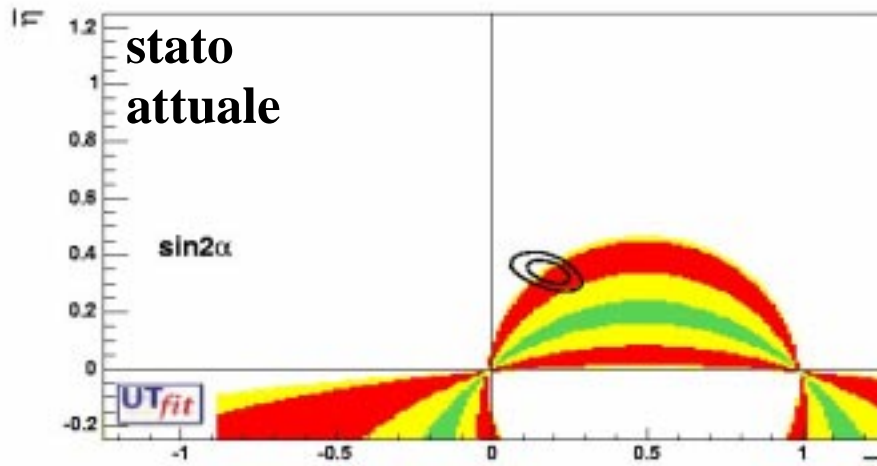
Grossman-Quinn bound:

$$\sin^2 \delta \leq \frac{BR(B^0 \rightarrow \pi^0\pi^0) + BR(\bar{B}^0 \rightarrow \pi^0\pi^0)}{BR(B^+ \rightarrow \pi^+\pi^0) + BR(B^- \rightarrow \pi^-\pi^0)}$$



Nuovi Input: $\sin 2\alpha$ (II)

mettendo insieme $\pi\pi$ e $\rho\rho$ e proiettando a 4 volte la statistica:



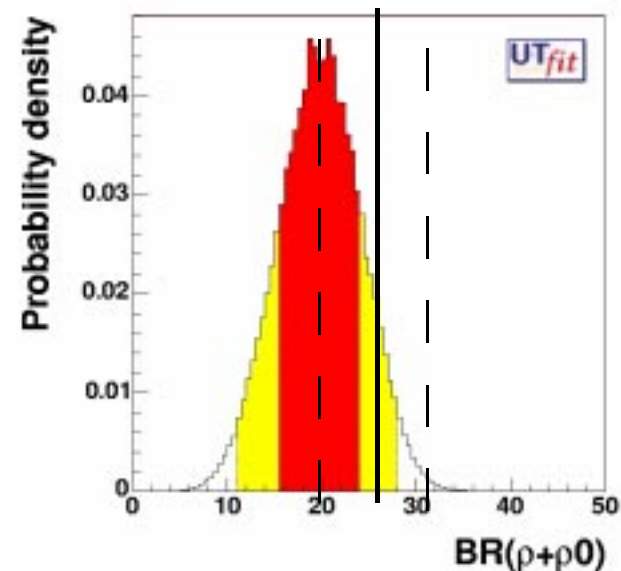
con un valore piccolo di $\rho^0\rho^0$ ($< 1.0 \cdot 10^{-6}$)

→ rottura di SU(2)

→ cessa la validità dei bound

invece di usare i bound meglio parametrizzare le ampiezze di decadimento ed aggiungere i BR come input, oltre ad S e C

→ si può mettere in evidenza la rottura di SU(2)

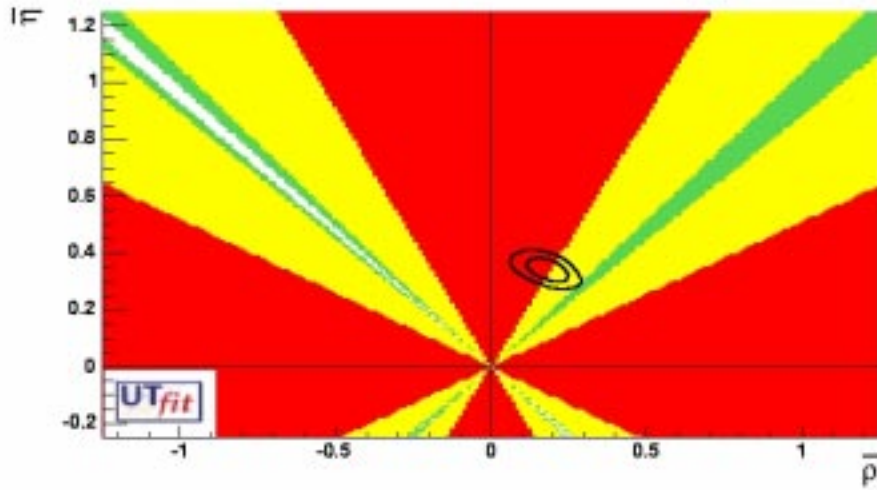


Nuovi Input: γ

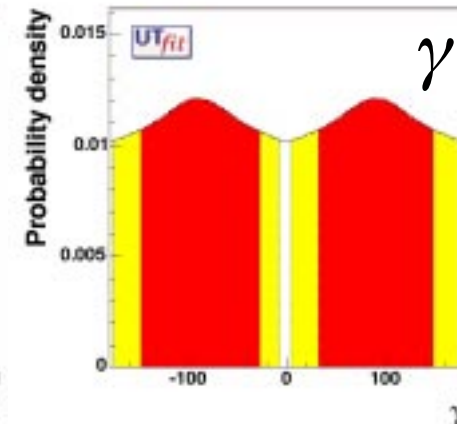
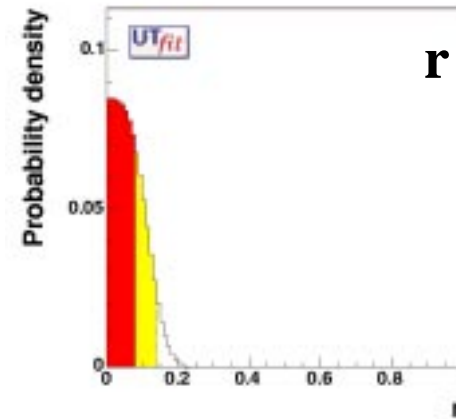
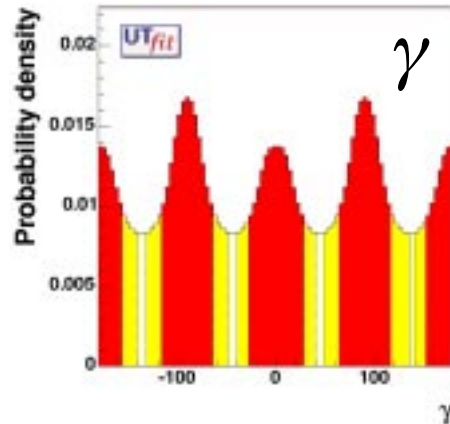
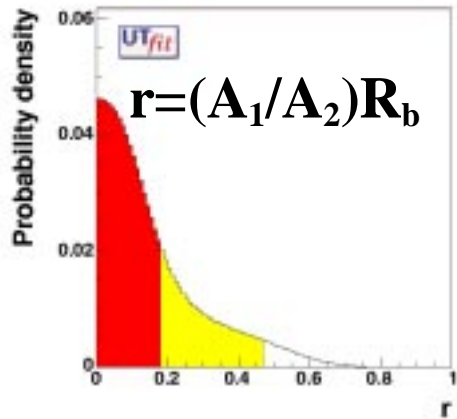
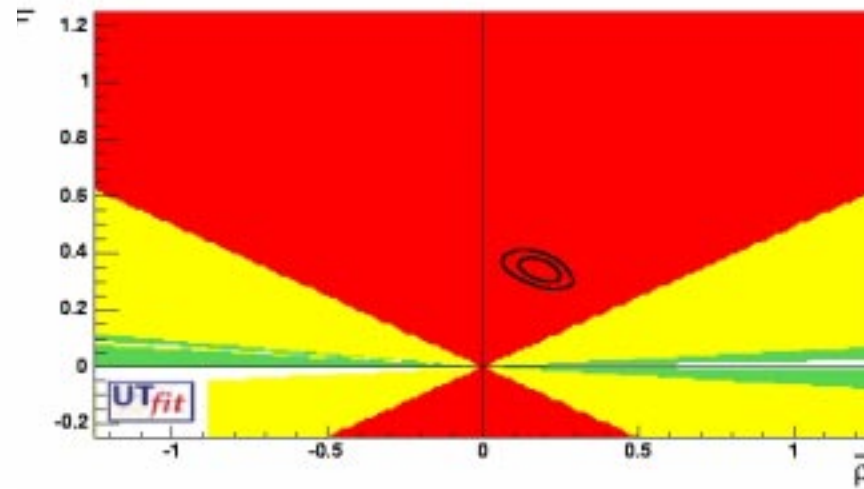
decadimenti $B^\pm \rightarrow D_{CP}K^\pm$

**talk di
M. Zito**

metodo GLW: A^\pm, R^\pm



aggiungendo ADS: $+R_{ADS}$



Nuovi Input: $\sin(2\beta+\gamma)$

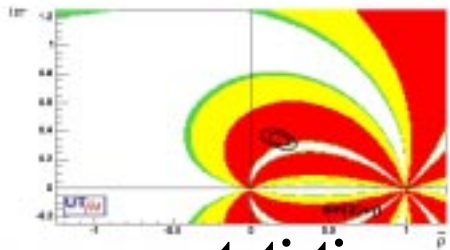
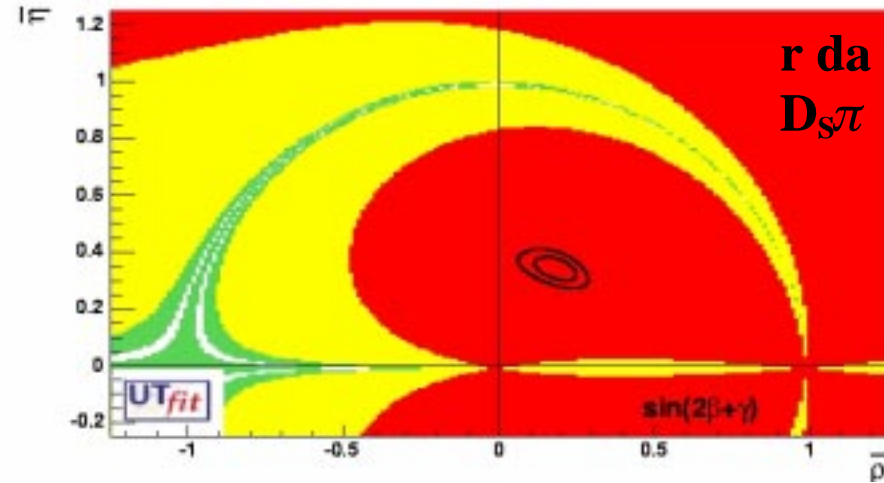
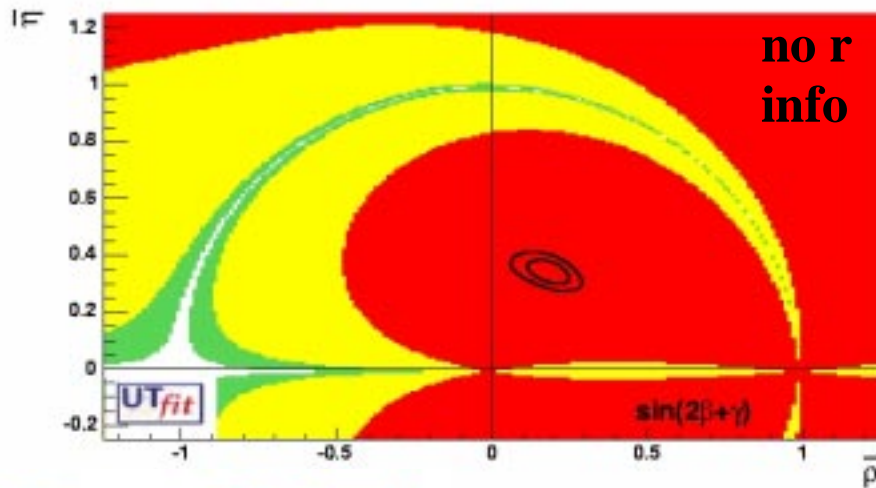
$$B^0 \rightarrow D^{\pm(*)}\pi^{\pm}$$

talk di
M. Zito

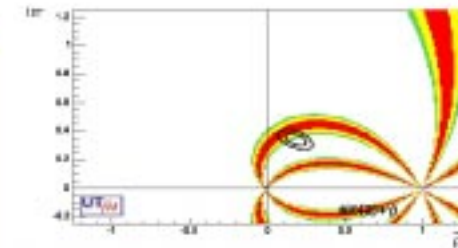
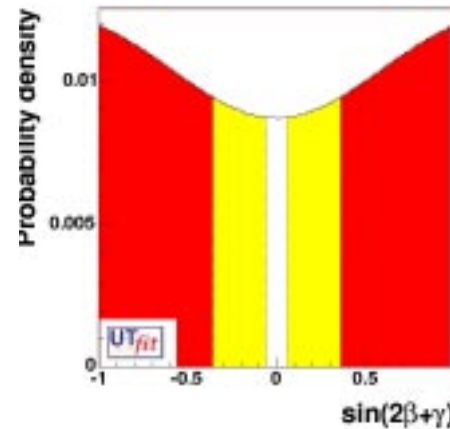
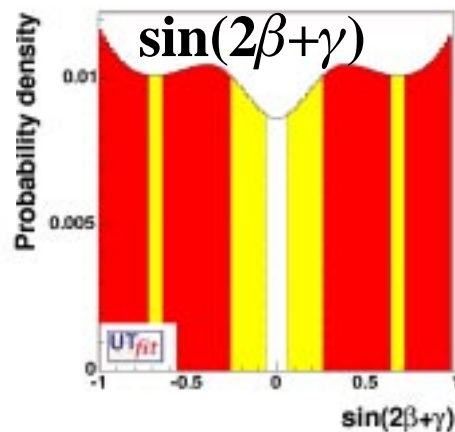
$$a^{(*)} = 2r^{(*)}\sin(2\beta+\gamma)\cos\delta^{(*)}$$

$$c^{(*)} = 2r^{(*)}\cos(2\beta+\gamma)\sin\delta^{(*)} \text{ (tag leptónico)}$$

valori medi da HFAG



con statistica
infinita



Nuovi input: $K^\pm \rightarrow \pi^\pm \nu \bar{\nu}$

D'Ambrosio, Isidori
hep-ph/0112135

$$(\sigma\bar{\eta})^2 + (\bar{\rho} - \bar{\rho}_0)^2 = \frac{\sigma BR(K^+ \rightarrow \pi^+ \nu \bar{\nu})}{\bar{K}_+ |V_{cb}|^4 X^2(x_t)}$$

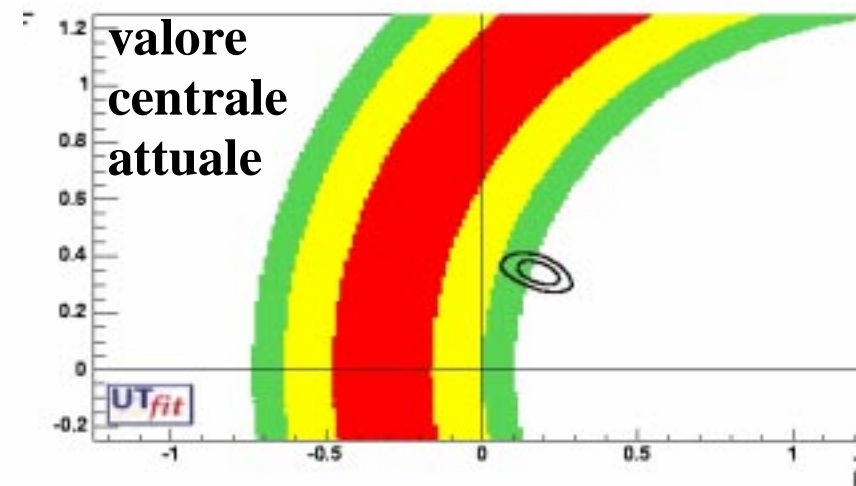
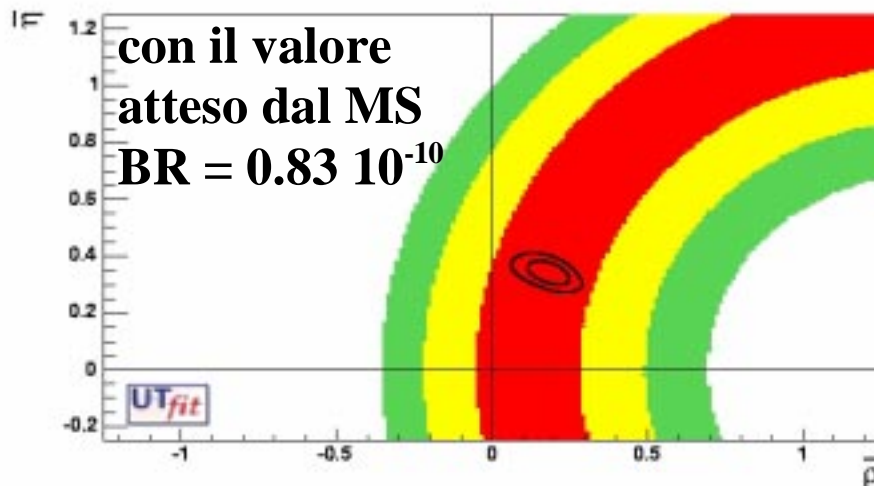
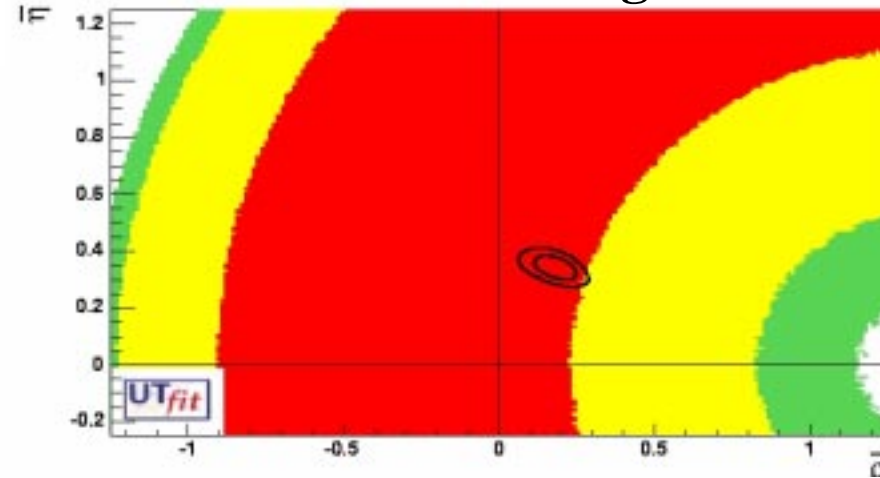
ellisse centrata in $(\rho^0, 0)$

recente risultato da E949:

$$BR(K^\pm \rightarrow \pi^\pm \nu \bar{\nu}) = 1.47^{+1.30}_{-0.89} 10^{-10}$$

con ~50 eventi di segnale

con 3 eventi di segnale

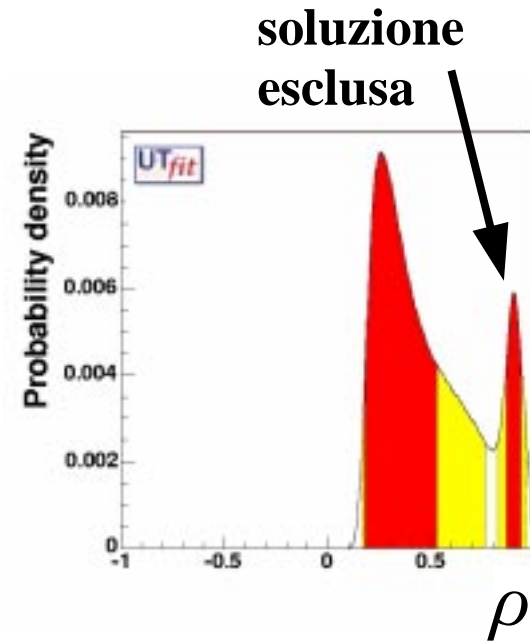
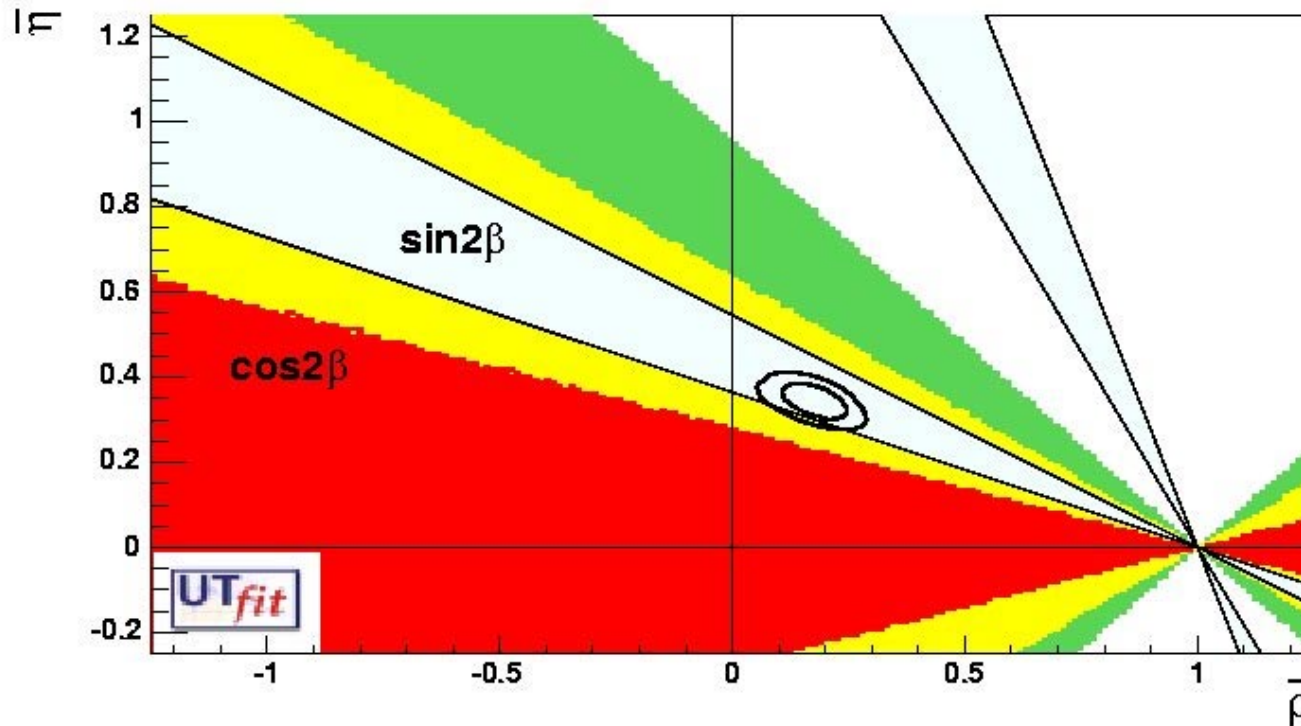
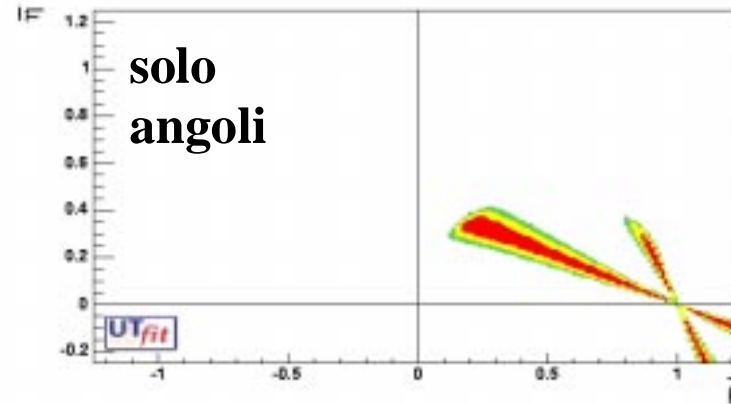


Nuovi input: $\cos 2\beta$

talk di
L. Vitale

nuovo risultato di BaBar

$$\cos 2\beta = +3.32^{+0.76}_{-0.96} \pm 0.27$$



Conclusioni:

- **Nella configurazione classica:**
 - $|V_{ub}/V_{cb}|$, Δm_d , Δm_s , ε_K , $\sin 2\beta$
 - **i risultati dell'UTfit sono in buon accordo con le previsioni del Modello Standard**
- **Nuovi input dalle B-Factory:**
 - $\sin 2\alpha$, γ , $\sin(2\beta+\gamma)$, $\cos 2\beta$, ...
- **e dai decadimenti rari del K:**
 - $K^\pm \rightarrow \pi^\pm \nu \bar{\nu}$, ...
- **l'overconstraining dalle nuove misure può mettere in evidenza nuova fisica**
 - **c'è ancora spazio per qualche sorpresa...**

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