Discrepancy in the Unitarity Triangle fit from $b \leftrightarrow s$ transitions

arXiv:0803.0659 [hep-ph]

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on behalf of Utfit Collaboration

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Beyond the SM: the "flavour problem"

The SM works beautifully up to a few hundred GeV. Several arguments suggest that it might be an effective theory up to some scale Λ

$$\mathcal{L}(M_W) = \Lambda^2 H^\dagger H + \lambda (H^\dagger H)^2_{SM} + \mathcal{L}^{gauge}_{SM} + \mathcal{L}^{Yukawa} + \mathcal{L}^5/\Lambda + \mathcal{L}^6/\Lambda^2$$

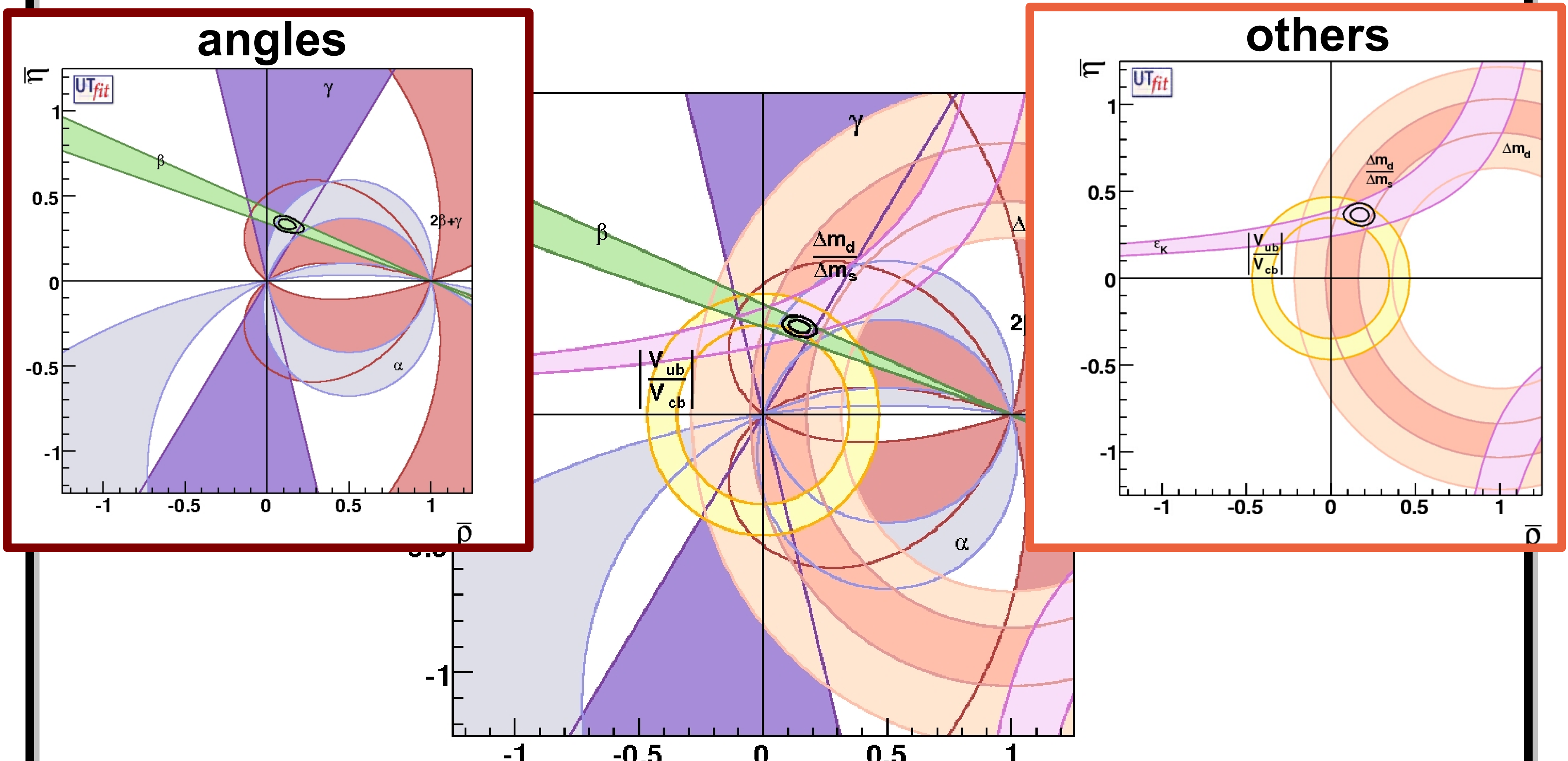
EW scale

NP contribution to EW precision, FCNC processes, CPV, g-2, $b \to s\gamma$, etc..

The new contributions, in general, introduce new sources of CP violation and flavour mixing. The consistency of the Standard Model becomes a puzzle in this framework.

We should see some discrepancy

Experimental situation

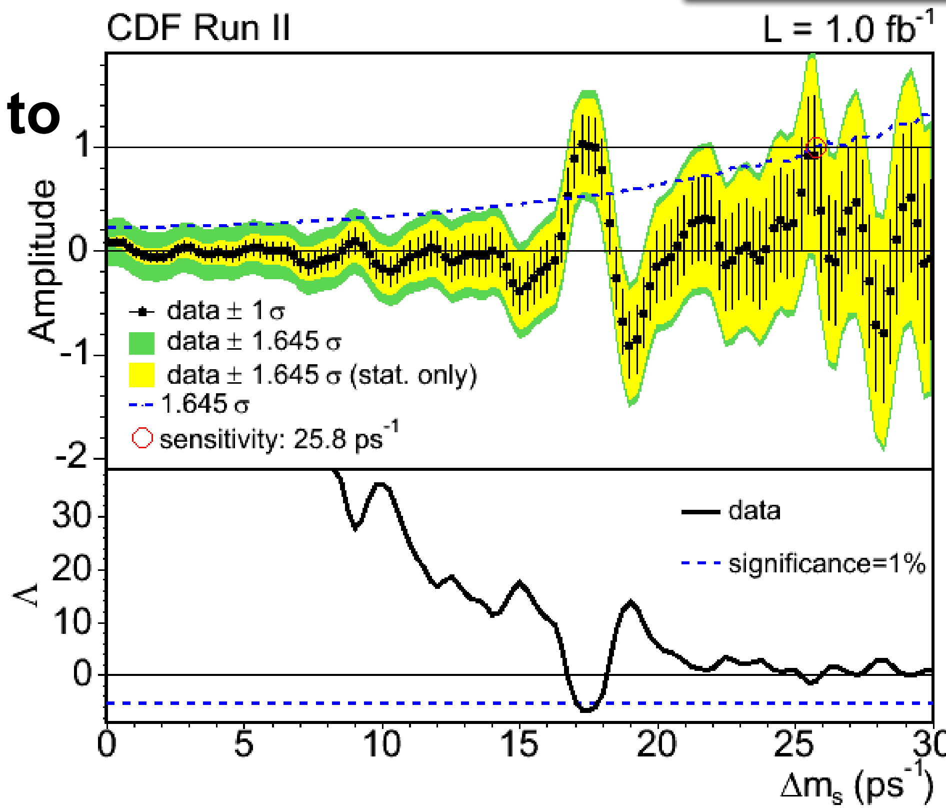


- Theory under control
- Data in agreement
- NP, if any, does not introduce **additional CP or flavour violation** in b ↔ d transitions

Experimental Novelties

TEVATRON experiments have started to test the b↔s sector with B_s mixing

- Measurement of Δm_s

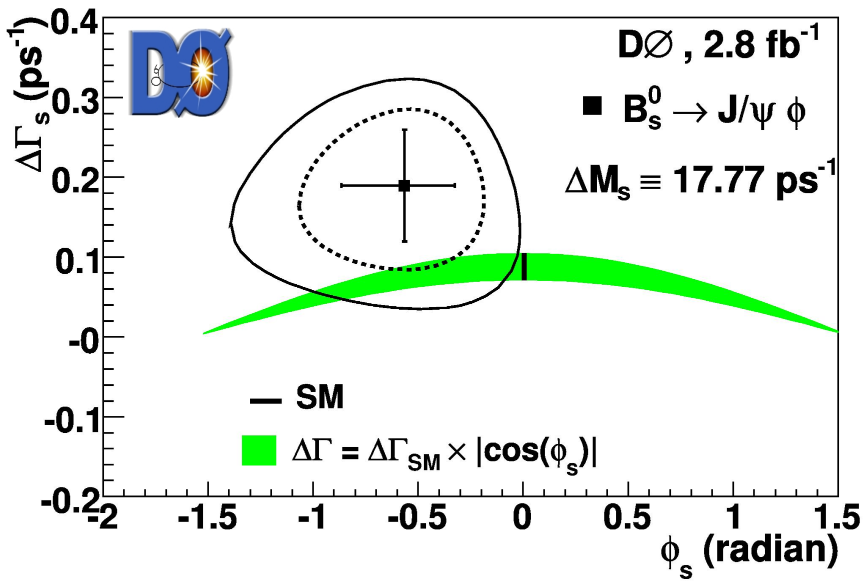


- Measurement of dilepton charge asymmetry
- Semileptonic asymmetry
- Measurement of $\Delta\Gamma_s/\Gamma_s$
- B_s lifetime measurement in flavour specific final states

Indirect constraints on the mixing phase

- 2D bound on β_s vs $\Delta\Gamma$ from tagged angular analysis of $B_s \to J/\psi\phi$ decays

Some discrepancy with Standard Model observed



$\phi_s = 2\beta_s$ vs $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$ (I)

- Angular analysis as a function of proper time and b-tagging
- Similar to B_d measurement in $B_d \to J/\psi K^*$
- Additional sensitivity from the $\Delta\Gamma_s$ terms (negligible for B_d)

$$\frac{d^4P(t,\vec{w})}{dt\,d\vec{w}} \propto |A_0|^2\, T_+ f_1(\vec{w}) + |A_{\parallel}|^2\, T_+ f_2(\vec{w})$$
$$+ |A_{\perp}|^2\, T_- f_3(\vec{w}) + |A_{\parallel}||A_{\perp}|\, U_+ f_4(\vec{w})$$
$$+ |A_0||A_{\parallel}| \cos(\delta_{\parallel})\, T_+ f_5(\vec{w})$$
$$+ |A_0||A_{\perp}|\, V_+ f_6(\vec{w})$$

$$T_{\pm} = e^{-\Gamma t} \times [\cosh(\Delta\Gamma t/2) \mp \cos(2\beta_s)\sinh(\Delta\Gamma t/2)$$
$$\mp \eta \sin(2\beta_s)\sin(\Delta m_s t)],\quad \eta = +1(-1) \text{ for } P(\bar{P})$$

$$U_{\pm} = \pm e^{-\Gamma t} \times [\sin(\delta_{\perp} - \delta_{\parallel})\cos(\Delta m_s t)$$
$$- \cos(\delta_{\perp} - \delta_{\parallel})\cos(2\beta_s)\sin(\Delta m_s t)$$
$$\pm \cos(\delta_{\perp} - \delta_{\parallel})\sin(2\beta_s)\sinh(\Delta\Gamma t/2)]$$

$$V_{\pm} = \pm e^{-\Gamma t} \times [\sin(\delta_{\perp})\cos(\Delta m_s t)$$
$$- \cos(\delta_{\perp})\cos(2\beta_s)\sin(\Delta m_s t)$$
$$\pm \cos(\delta_{\perp})\sin(2\beta_s)\sinh(\Delta\Gamma t/2)]$$

Dunietz et al.
Phys.Rev.D63:114015,2001

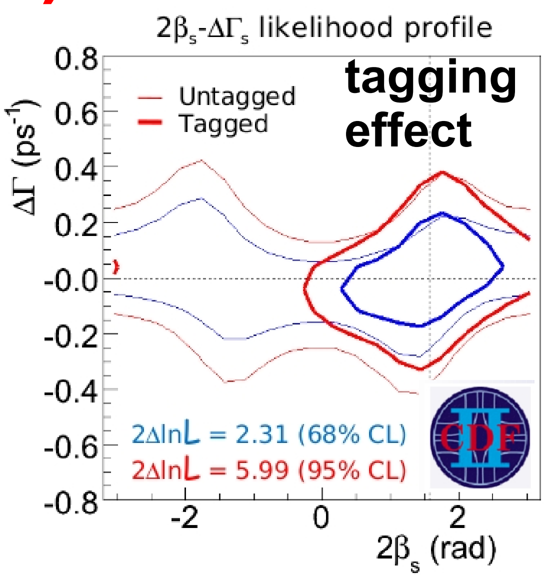
Ambiguities for
$\phi_s \to \pi - \phi_s$,
$\Delta\Gamma_s \to -\Delta\Gamma_s$,
$\cos(\delta_{\perp} - \delta_{\parallel}) \to -\cos(\delta_{\perp} - \delta_{\parallel})$

- transversity basis: $W(\theta, \varphi, \psi)$
- θ and φ: direction of the μ^+ from J/ψ decay
- ψ: between the decay planes of J/ψ and ϕ

$\phi_s = 2\beta_s$ vs $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$ (II)

Results from the Tevatron Collaborations:

- **D0: arXiv:0802.2255 [hep-ex]**
  - $\tau_s = 1.52 \pm 0.06$ *(stat)* ± 0.01 *(syst)* ps
  - $\Delta\Gamma_s = 0.19 \pm 0.07$ *(stat)* $^{+0.02}_{-0.01}$ *(syst)* ps^{-1}
  - $\phi_s = -2\beta_s = -0.57\ ^{+0.24}_{-0.30}$ *(stat)* $^{+0.07}_{-0.02}$ *(syst)* rad

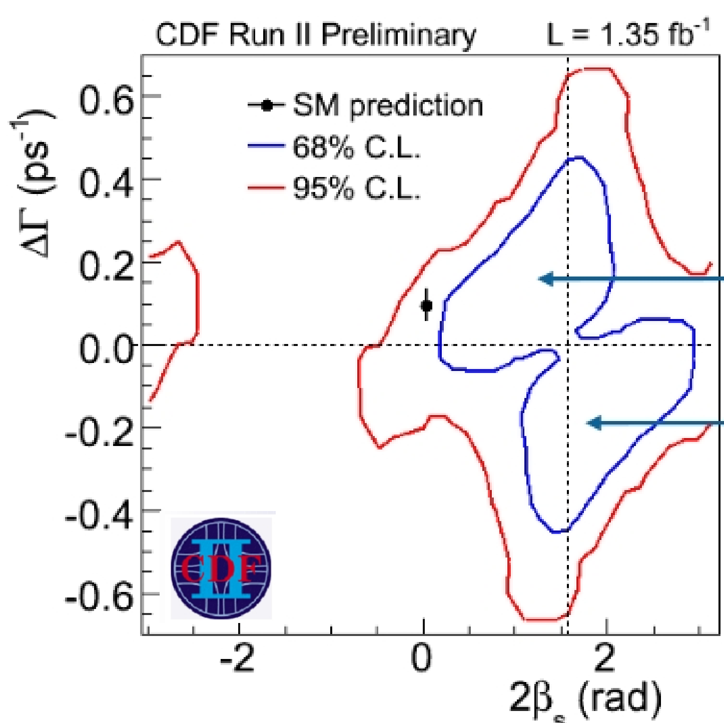


- **CDF: arXiv:0712.2397 [hep-ex]**
  - **Feldman-Cousins likelihood ratio ordering with systematics included**

Standard Model expectations:
(arXiv:hep-ph/0612167)

$\Delta\Gamma_s = 0.096 \pm 0.039\ ps^{-1}$
$2\beta_s = 0.04 \pm 0.01$ rad

Standard Model
p_{value} = 15% (1.5σ)



strong phases can separate the two minima

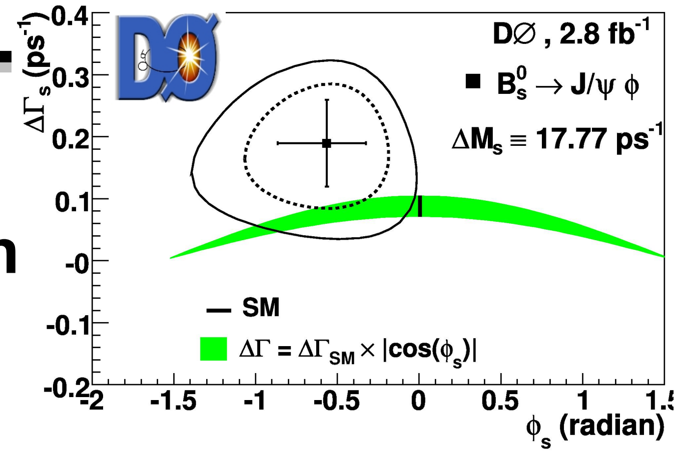
$\cos(\delta_\perp) < 0$
$\cos(\delta_\perp - \delta_\parallel) > 0$

$\cos(\delta_\perp) > 0$
$\cos(\delta_\perp - \delta_\parallel) < 0$

Δm_s constraint to $17.77 +/- 0.12\ ps^{-1}$

G. Gomez-Ceballos

Modeling D0 data (I)



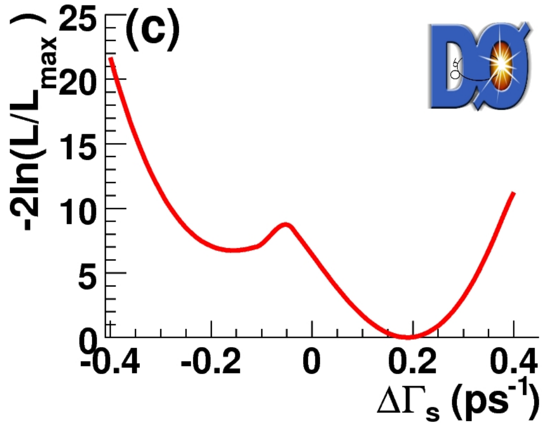
Unlike for CDF, it was not possible to obtain the 2D likelihood from D0.
We use three different approaches:

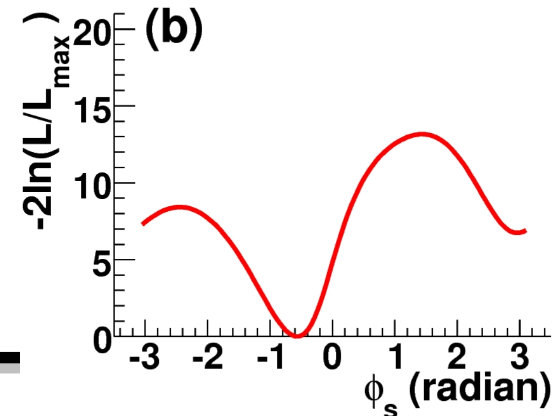
Default result: take the quoted result + 7x7 correlation matrix and marginalize the 5 nuisance parameters (flat priors used)

To include non-Gaussian tails:

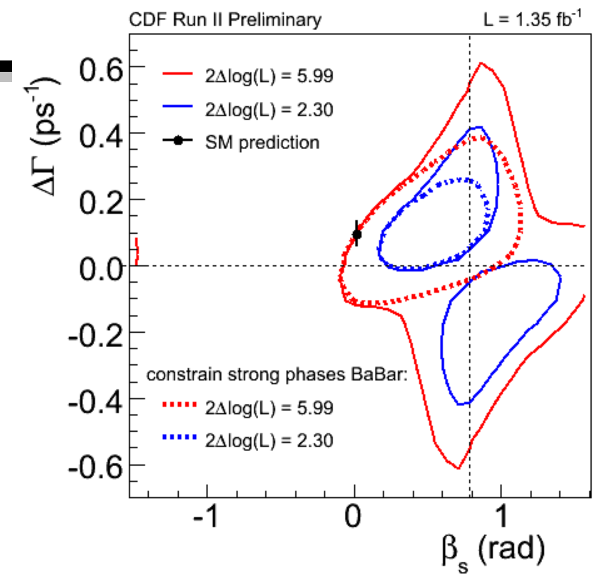
1) scale errors such that they agree with the quoted "2σ" ranges: [-0.06, 1.20] → 0.38
Pessimistic: the tail is on the opposite side w.r.t. SM but we extend it on the SM side.

2) use the 1D profile likelihood given by D0.
Conservative: the uncertainty on ϕ_s enters on ϕ_s likelihood directly, as well as in the $\Delta\Gamma$ one (as a nuisance parameter) and vice versa

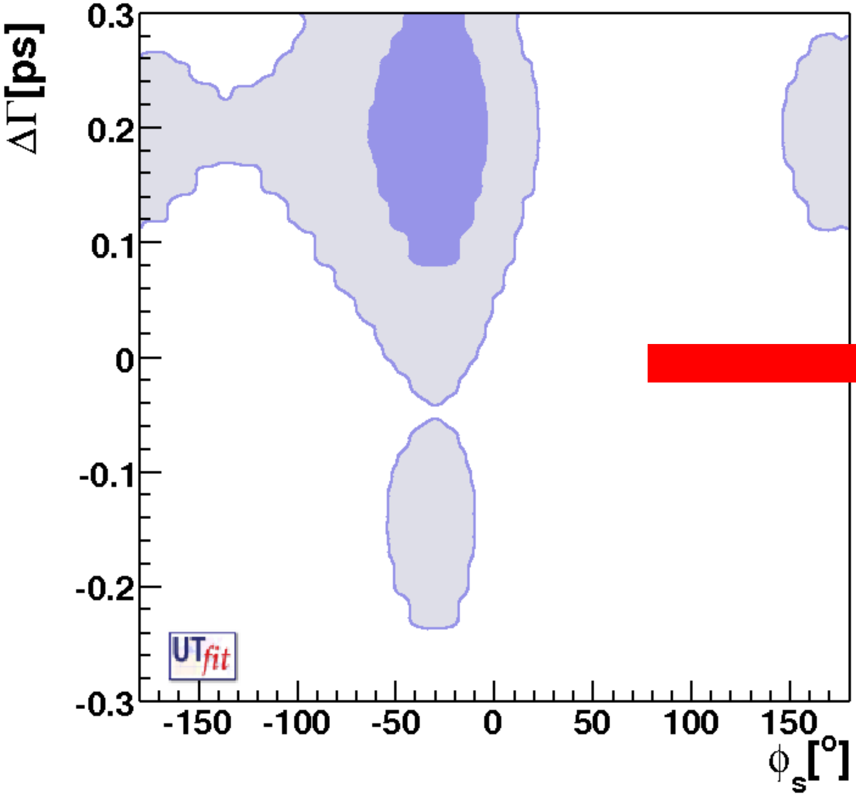


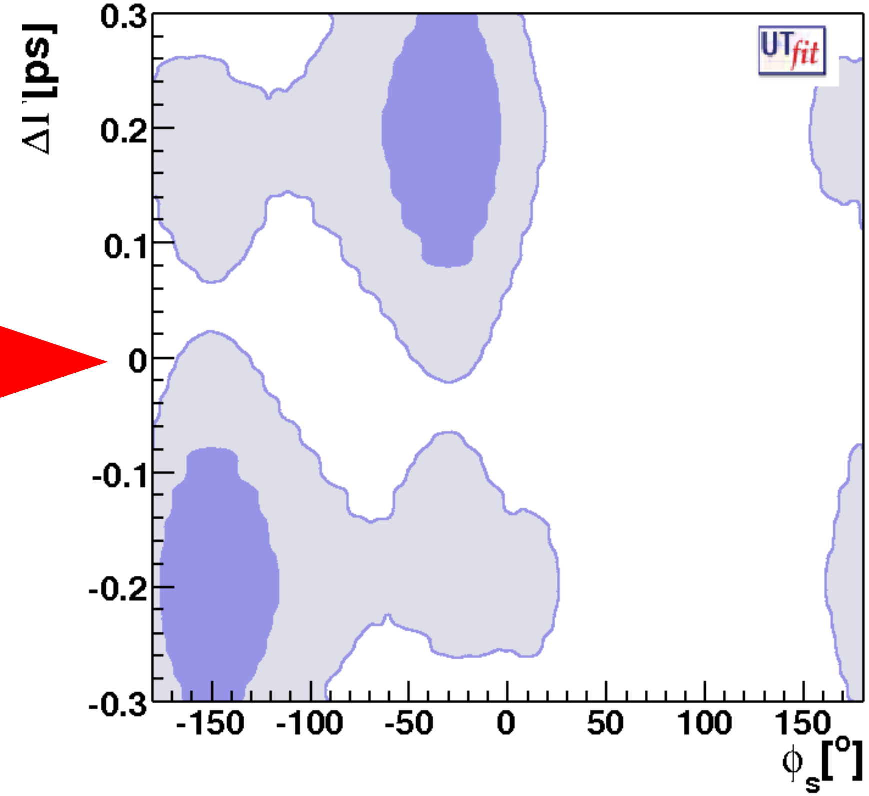


Modeling D0 data (II)



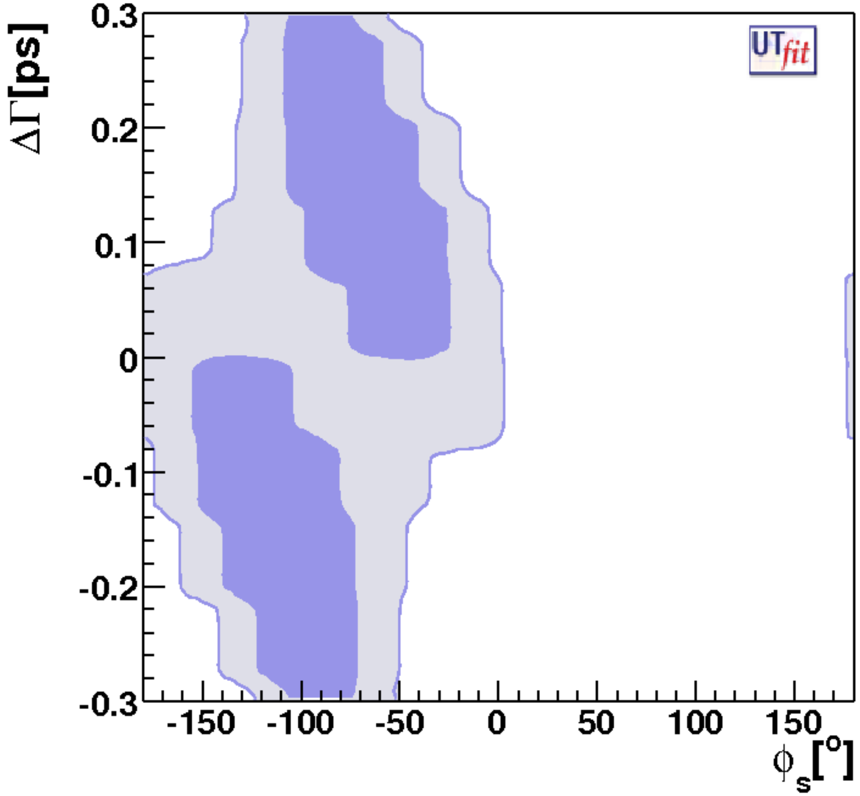
- Strong phase from $B_d \rightarrow J\psi K^*$ + SU(3) (consistent with naive factorization)
- The phase better determined by the fit than by the assumption. But the ambiguity is lost
- The problem: the ϕ singlet component is ignored
- To be conservative, we put it back in the data by mirroring the likelihood before marginalizing for the nuisance parameters



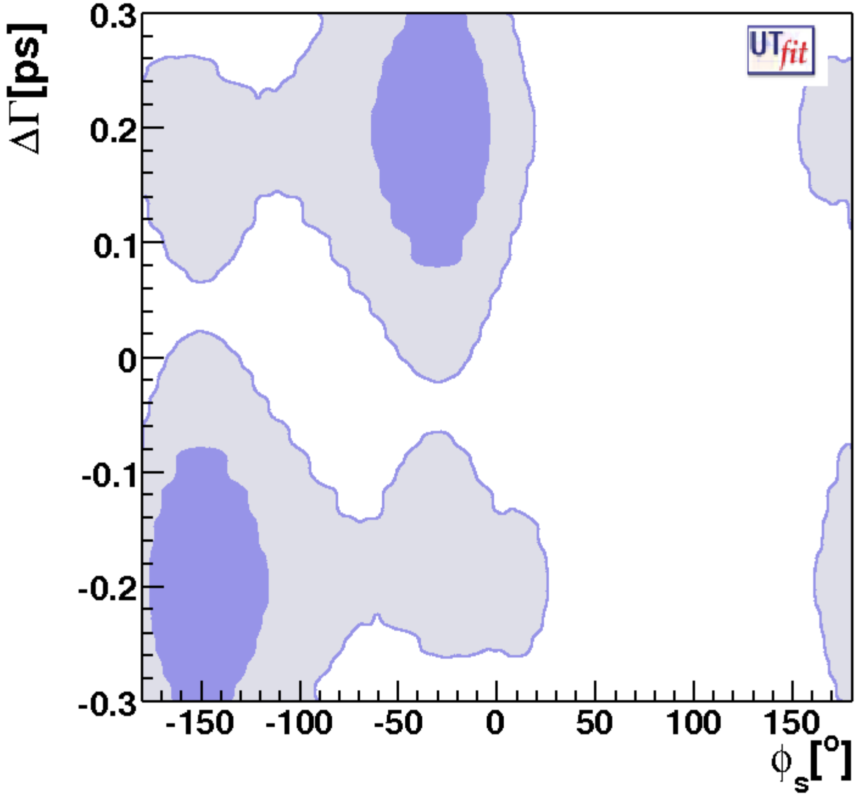


Comparing the measurements

CDF tagged measurement



D0 tagged measurement



- CDF bound directly provided by the experiment
- D0 bound obtained from the 7 dimensional result as previously explained (profile likelihood case shown here)
- The two measurements are in very good agreement

"Tree level" fit

B factories are constraining the UT with tree-level processes

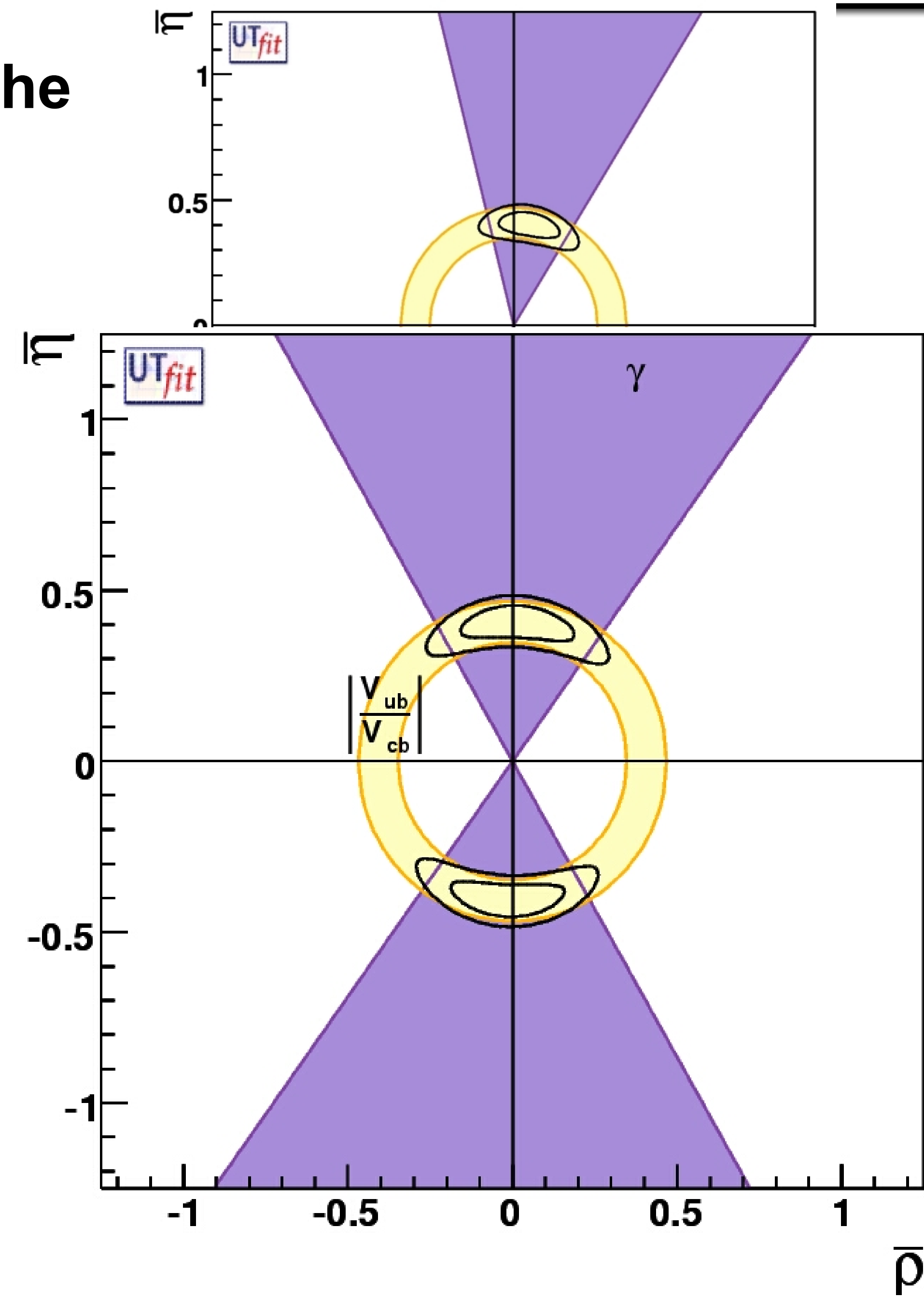
Assuming no NP at tree level
(the effect of the $\bar{D}^0$-D^0 mixing to γ are small wrt the present error and can be accounted for in the future)

We can determine $\bar{\rho}$ and $\bar{\eta}$ regardless of NP

$$\bar{\rho} = \pm\, 0.18 \pm 0.11$$

$$\bar{\eta} = \pm\, 0.41 \pm 0.05$$

Values in agreement with SM within the errors



Including NP in UT analysis (I)

Consider for example Bs mixing process.
Given the SM amplitude, we can define

$$C_{B_s} e^{-2i\phi_{B_s}} = \frac{\langle \overline{B}_s | H_{eff}^{SM} + H_{eff}^{NP} | B_s \rangle}{\langle \overline{B}_s | H_{eff}^{SM} | B_s \rangle} = 1 + \frac{A_{NP} e^{-2i\phi_{NP}}}{A_{SM} e^{-2i\beta_s}}$$

All NP effects can be parameterized in terms of one complex parameter for each meson mixing, to be determined in a simultaneous fit with the CKM parameters (now there are enough experimental constraints to do so).
For kaons we use *Re* and *Im*, since the two exp. constraints ε_K and Δm_K are directly related to them (with distinct theoretical issues)

J. M. Soares and L. Wolfenstein, Phys. Rev. D 47 (1993) 1021;
N. G. Deshpande *et al.* hep-ph/9608231
J. P. Silva and L. Wolfenstein, hep-ph/9610208
A. G. Cohen *et al.*, hep-ph/9610252]
Y. Grossman, Y. Nir and M. P. Worah, hep-ph/9704287

UTfit

Including NP in UT analysis (II)

	ρ, η	C_{Bd}, ϕ_{Bd}	$C_{\varepsilon K}$	C_{Bs}, ϕ_{Bs}
V_{ub}/V_{cb}	X			
γ (DK)	X			
ε_K	X		X	
$\sin 2\beta$	X	X		
Δm_d	X	X		
α ($\rho\rho,\rho\pi,\pi\pi$)	X	X		
A_{SL} B_d	X	X X		
$\Delta\Gamma_d/\Gamma_d$	X	X X		
$\Delta\Gamma_s/\Gamma_s$	X			X X
Δm_s				X
A_{CH}	X	X X		X X

model independent assumptions

SM → **SM+NP**

tree level

$(V_{ub}/V_{cb})^{SM}$ $(V_{ub}/V_{cb})^{SM}$

γ^{SM} γ^{SM}

Bd Mixing

β^{SM} $\beta^{SM}+\phi_{Bd}$

α^{SM} $\alpha^{SM}-\phi_{Bd}$

Δm_d $C_{Bd}\Delta m_d$

Bs Mixing

Δm_s^{SM} $C_{Bs}\Delta m_s^{SM}$

β_s^{SM} $\beta_s^{SM}+\phi_{Bs}$

K Mixing

ε_K^{SM} $C_{\varepsilon K}\varepsilon_K^{SM}$

M. Bona *et al.* (UTfit) Phys.Rev.Lett.97:151803,2006

NP-specific constraints

$$-\mathrm{Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\mathrm{SM}}\frac{\sin 2\phi_{B_d}}{C_{B_d}}+\mathrm{Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\mathrm{SM}}\frac{\cos 2\phi_{B_d}}{C_{B_d}}$$

- **semileptonic asymmetry A_{SL}:**

  sensitive to NP effect on both size and phase of B mixing

Laplace et al. Phys.Rev.D 65:094040,2002

- **same-side dilepton charge asymmetry A_{CH}:**

  admixture of B_d and B_s dependent on $\bar{\rho}$ and $\bar{\eta}$ and on NP effects

$$\frac{1}{4}\left(A_{\mathrm{SL}}^{d}+\frac{f_s\chi_{s0}}{f_d\chi_{d0}}A_{\mathrm{SL}}^{s}\right)$$

- **lifetime τ_s in flavour-specific final states:**

  fit for a single exponential for B_s and $\bar{B}_s$

  the average lifetime is a function of the width and width difference

$$\tau_{B_s}^{FS}=\frac{1}{\Gamma_s}\frac{1-\left(\frac{\Delta\Gamma_s}{2\Gamma_s}\right)^2}{1+\left(\frac{\Delta\Gamma_s}{2\Gamma_s}\right)^2}$$

Dunietz et al., hep-ph 0012219

- **$\Delta\Gamma$ for B_d and B_s**

  on B_d not effective: experimental error x10 the precision of the fit

  the experimental measurement of $\Delta\Gamma_s$ actually measures $\Delta\Gamma_s\cos(\beta_s+\phi_{Bs})$

  NP can only decrease the experimental result wrt the SM value

  experimental WA > SM expectation (NP suppressed)

$$\frac{\Delta\Gamma_q}{\Delta m_q}=-2\frac{\kappa}{C_{B_q}}\Bigg\{\cos 2\phi_{B_q}\left(n_1+\frac{n_6B_2+n_{11}}{B_1}\right)-\frac{\cos\left(\phi_q^{\mathrm{SM}}+2\phi_{B_q}\right)}{R_t^q}\left(n_2+\frac{n_7B_2+n_{12}}{B_1}\right)+\frac{\cos\left(2(\phi_q^{\mathrm{SM}}+\phi_{B_q})\right)}{R_t^{q^2}}\left(n_3+\frac{n_8B_2+n_{13}}{B_1}\right)+\cos\left(\phi_q^{\mathrm{Pen}}+2\phi_{B_q}\right)C_q^{\mathrm{Pen}}\left(n_4+n_9\frac{B_2}{B_1}\right)-\cos\left(\phi_q^{\mathrm{SM}}+\phi_q^{\mathrm{Pen}}+2\phi_{B_q}\right)\frac{C_q^{\mathrm{Pen}}}{R_t^q}\left(n_5+n_{10}\frac{B_2}{B_1}\right)\Bigg\}$$

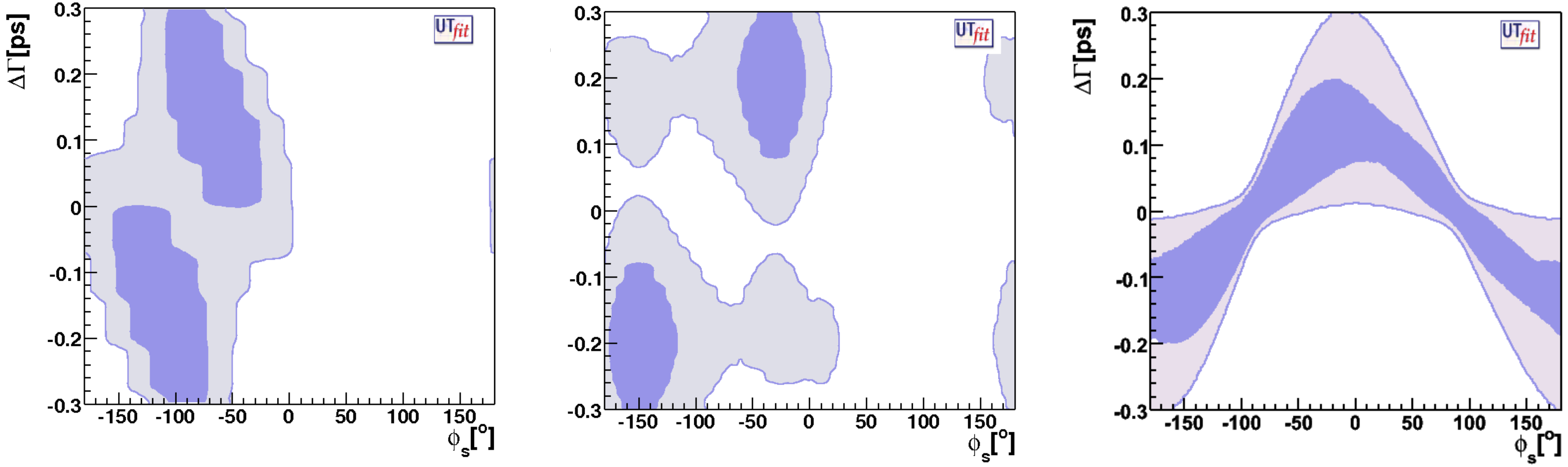
B meson mixing matrix element NLO calculation Ciuchini et al. JHEP 0308:031,2003.

More than two measurements (I)

CDF tagged measurement

D0 tagged measurement

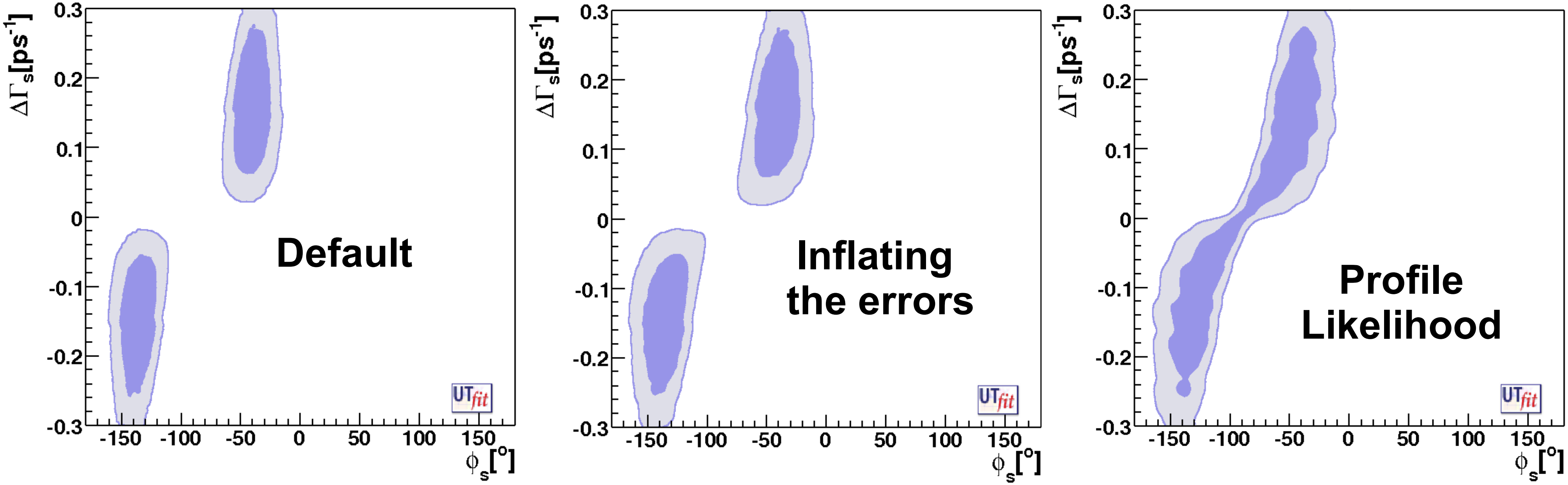
Our analysis (using A_{SL}, A_{CH}, τ_{Bs}, $\Delta\Gamma/\Gamma$)



- CDF and D0 measurements consider $\Delta\Gamma$ and β_s as uncorrelated parameters
- In our analysis, we enforce the dependence of $\Delta\Gamma$ from SM and NP parameters
- There is more physics information in our fit than in a simple combination of the two experimental results

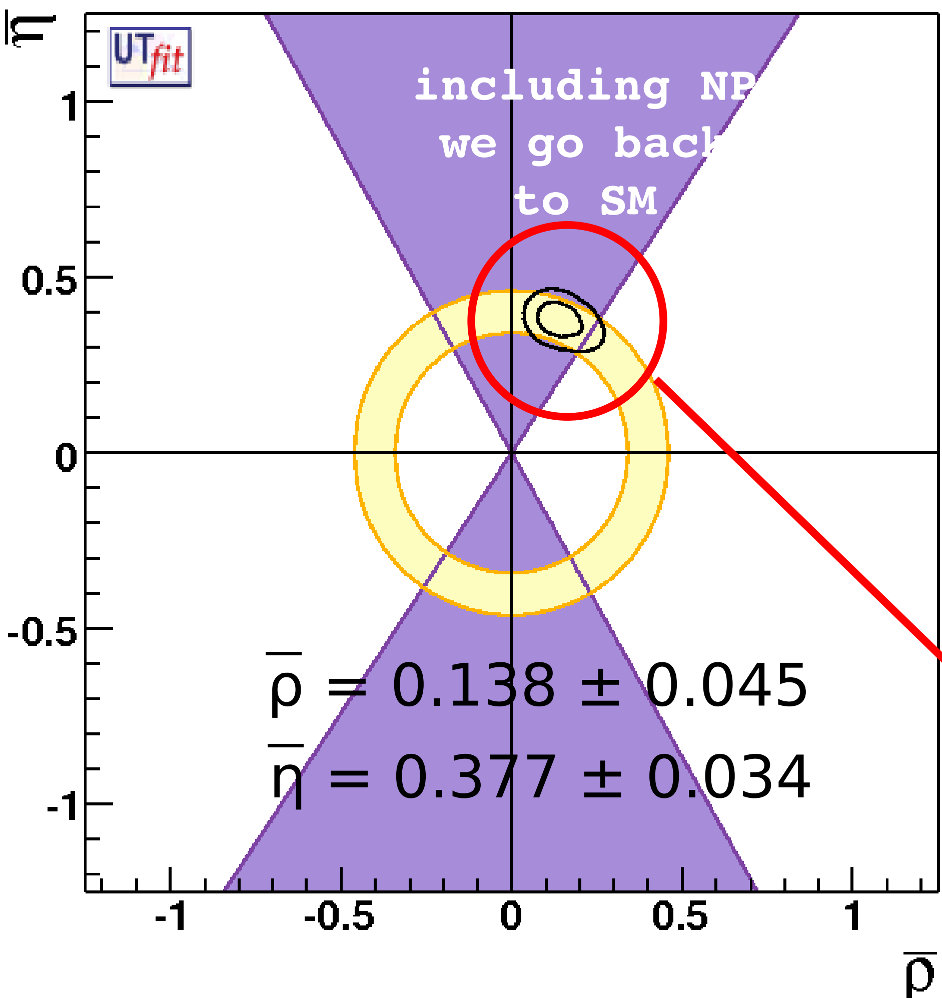
Dependence on the D0 data model

results from all constraints: only the D0 data treatment is changing



- The details on how we model D0 are crucial on the side **opposite** to the SM prediction
- The distance from the SM value depends on the approach, but not by O(1) effects
- A reduction of the significance is expected when going from the default to the conservative approaches

The UT*fit* beyond the SM



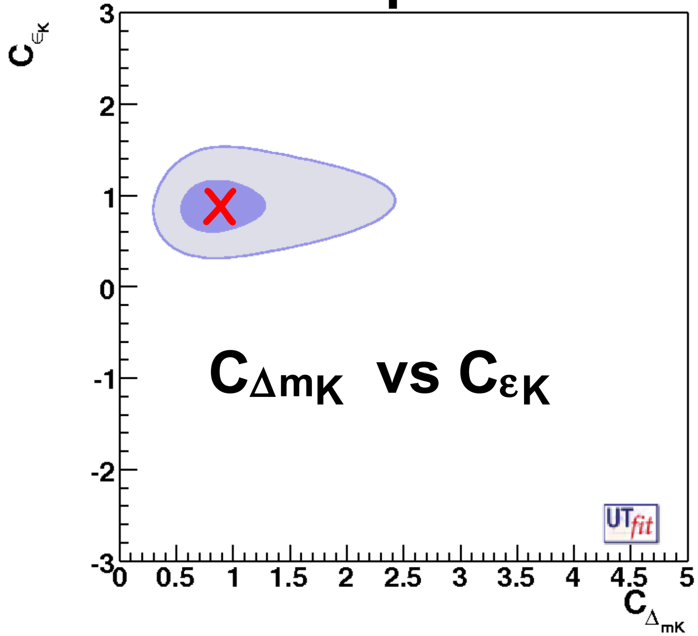
Parameter	68% Probability	95% Probability
$\alpha[°]$	86 ± 7	$[74, 103]$
$\beta[°]$	23.9 ± 2.0	$[19.6, 28.1]$
$\gamma[°]$	70 ± 7	$[54, 83]$
$\mathrm{Re}\lambda_t[10^{-5}]$	-32.5 ± 2.0	$[-36.5, -28.0]$
$\mathrm{Im}\lambda_t[10^{-5}]$	15.0 ± 1.3	$[12.5, 17.5]$
$\|V_{ub}\|[10^{-3}]$	3.92 ± 0.28	$[3.36, 4.44]$
$\|V_{cb}\|[10^{-2}]$	4.15 ± 0.07	$[4.02, 4.28]$
$\|V_{td}\|[10^{-3}]$	8.8 ± 0.5	$[7.7, 9.7]$
$\|V_{td}/V_{ts}\|$	0.217 ± 0.011	$[0.189, 0.238]$
R_b	0.407 ± 0.030	$[0.348, 0.464]$
R_t	0.943 ± 0.047	$[0.826, 1.032]$
$\sin 2\beta$	0.739 ± 0.044	$[0.638, 0.829]$
$\sin 2\beta_s$	0.0403 ± 0.0037	$[0.0319, 0.0482]$

Allowing for NP we go back to the SM solution

This is the crucial starting point and what boosted the precision of this analysis: the uncertainty on CKM parameters with NP was the limiting factor. great success of the B factories program

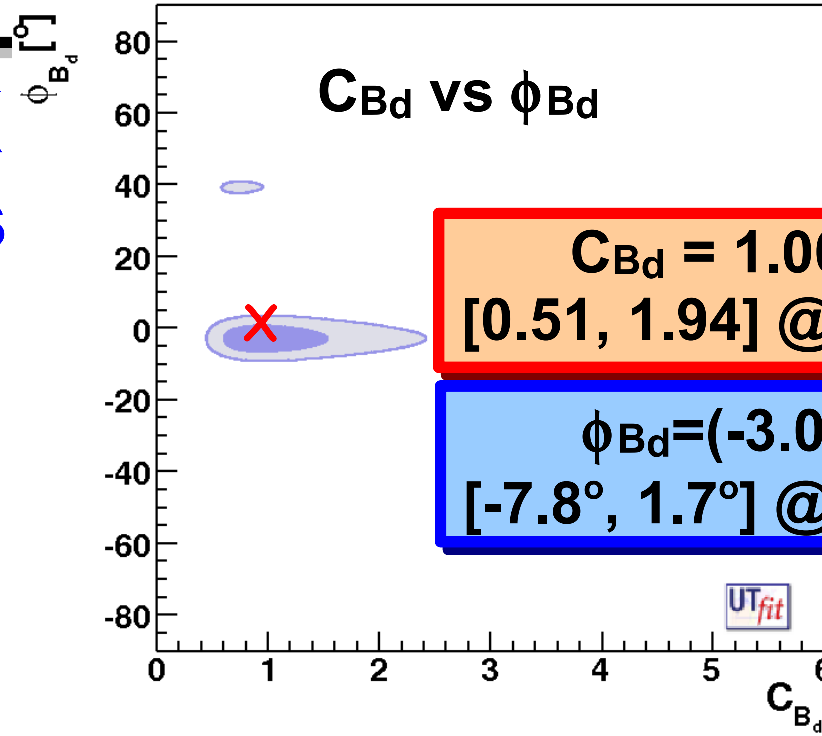
New Physics in K and B_d sectors

X SM expectation



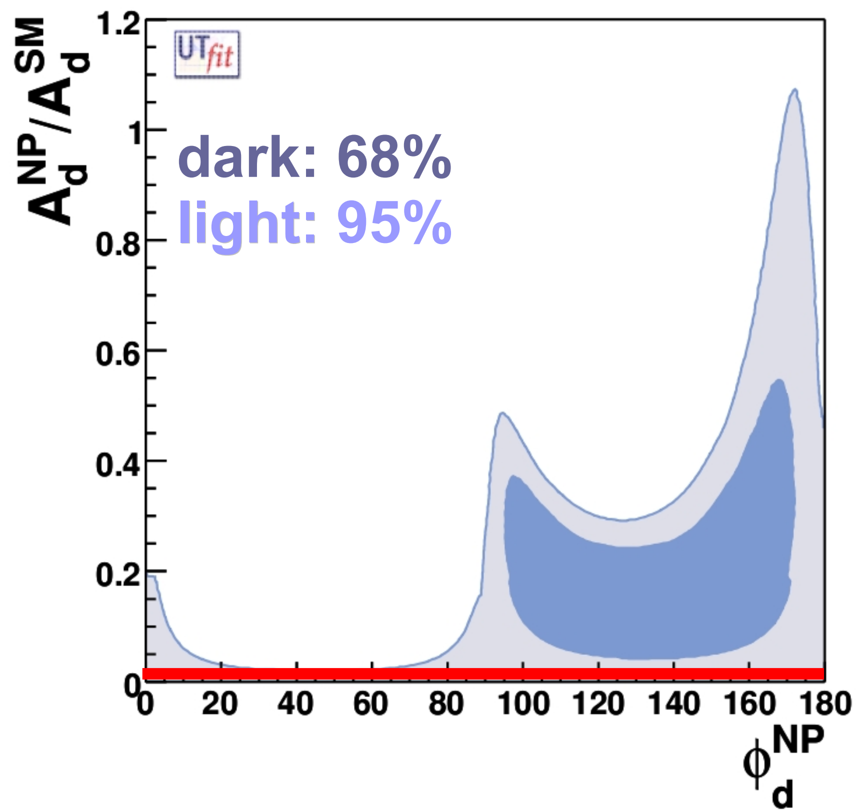
$C_{\Delta mK} = 0.93 \pm 0.32$
[0.51, 2.08] @ 95% Prob.

$C_{\epsilon K} = 0.88 \pm 0.13$
[0.63, 1.24] @ 95% Prob.



$C_{Bd} = 1.00 \pm 0.32$
[0.51, 1.94] @ 95% Prob.

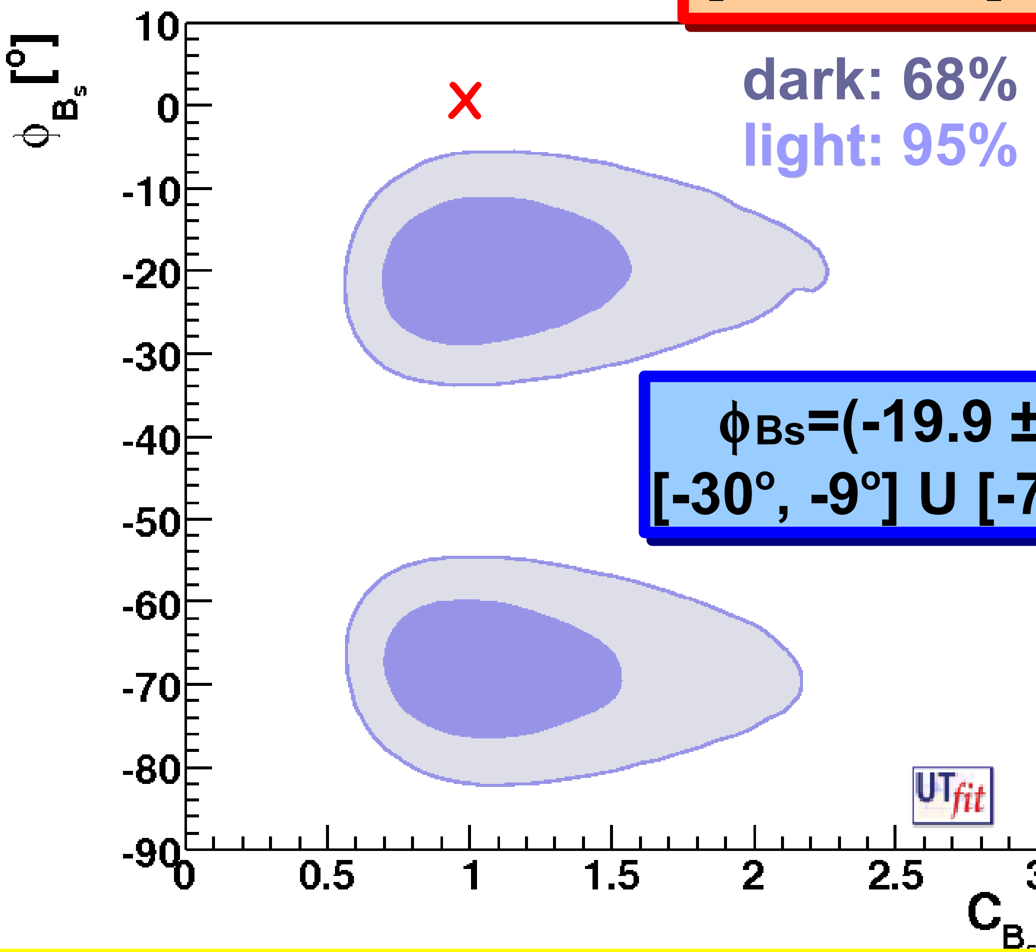
$\phi_{Bd} = (-3.0 \pm 2.2)°$
[-7.8°, 1.7°] @ 95% Prob.

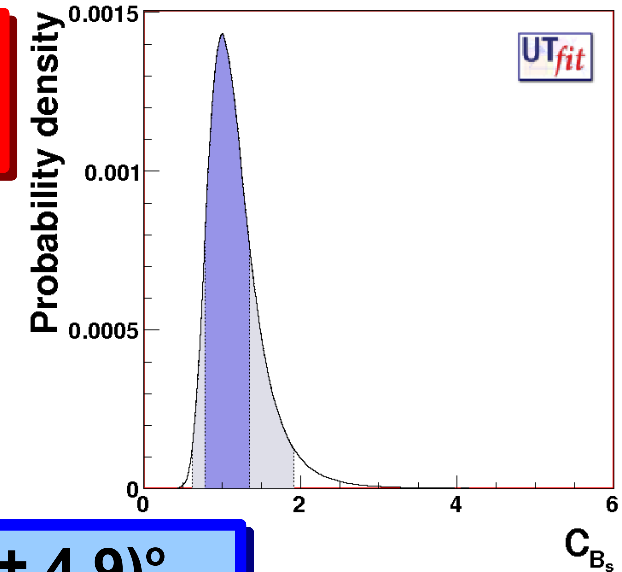


New Physics in the B_s sector

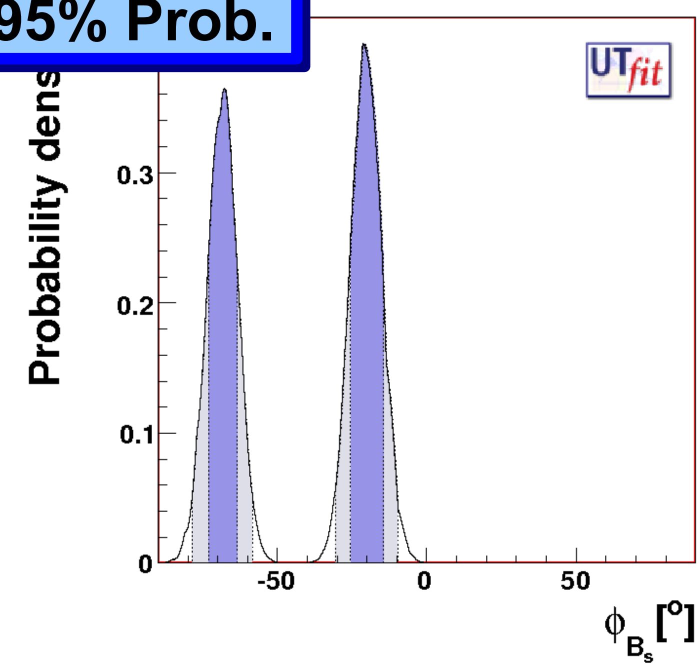
X SM expectation

C_{Bs} = 1.07 ± 0.29
[0.62, 1.93] @ 95% Prob.





ϕ_{Bs}=(-19.9 ± 5.6)°U(-68.2 ± 4.9)°
[-30°, -9°] U [-78°, -58°]@ 95% Prob.

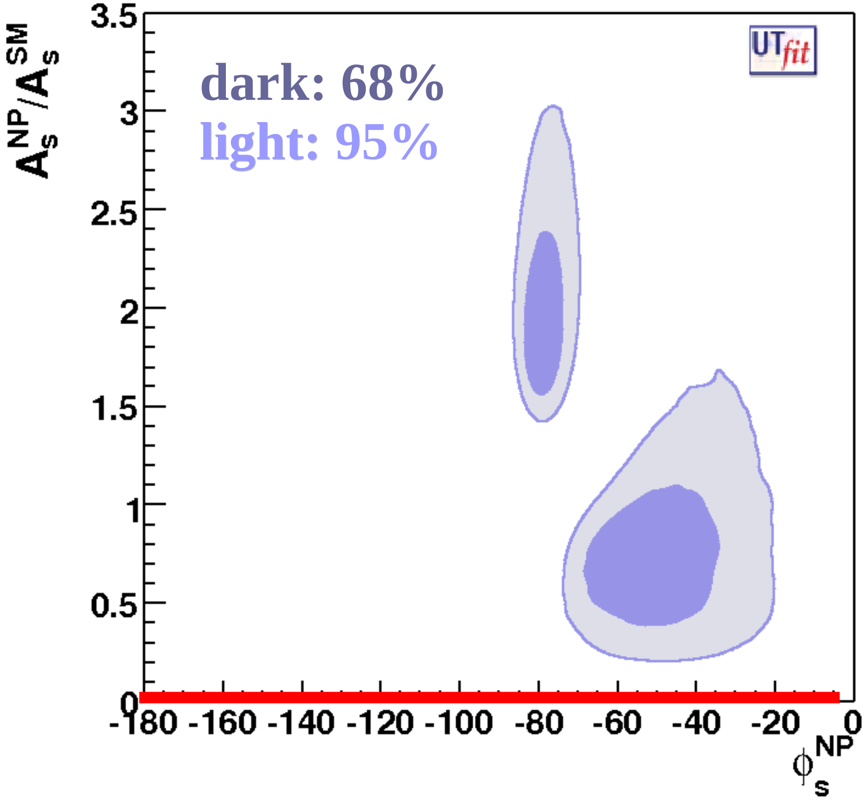


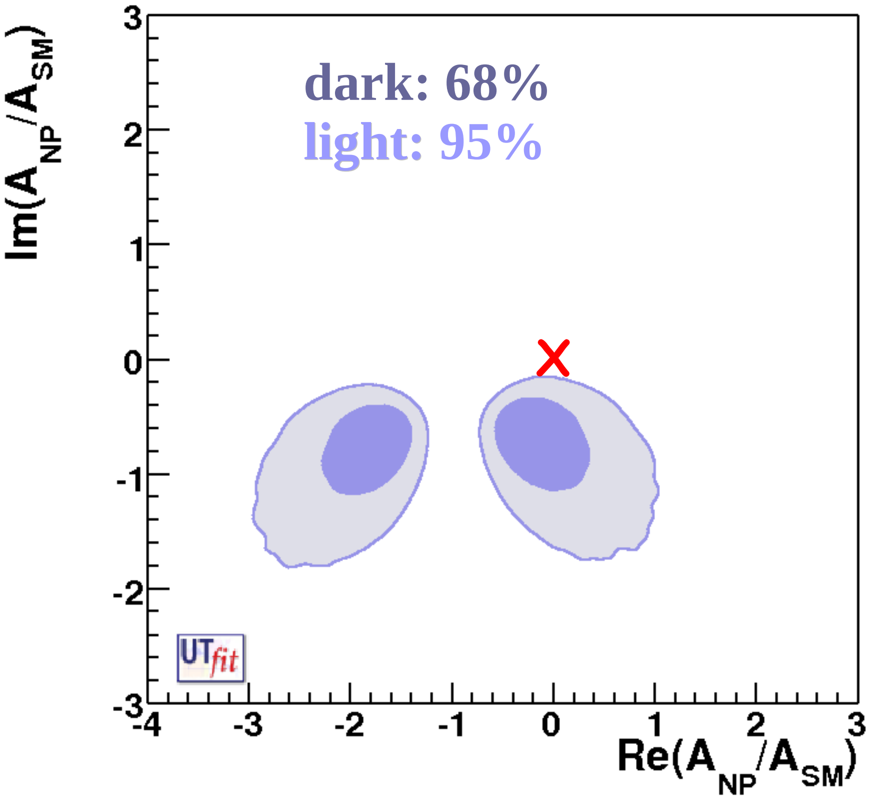
ϕ_{Bs}<0 @ 99.7% probability
(equivalent to the Gaussian 3σ threshold)
for any approach we tried on D0 data

The NP Amplitude

$$C_{B_s} e^{-2i\phi_{B_s}} = \frac{\langle \overline{B}_s | H_{eff}^{SM} + H_{eff}^{NP} | B s \rangle}{\langle \overline{B}_s | H_{eff}^{SM} | B_s \rangle} = 1 + \frac{A_s^{NP} e^{-2i\phi_s^{NP}}}{A_s^{SM} e^{-2i\beta_s}}$$

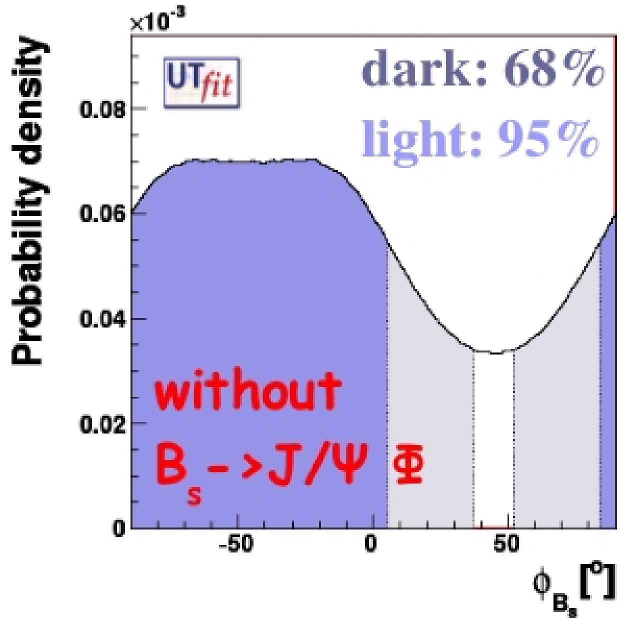
X SM expectation

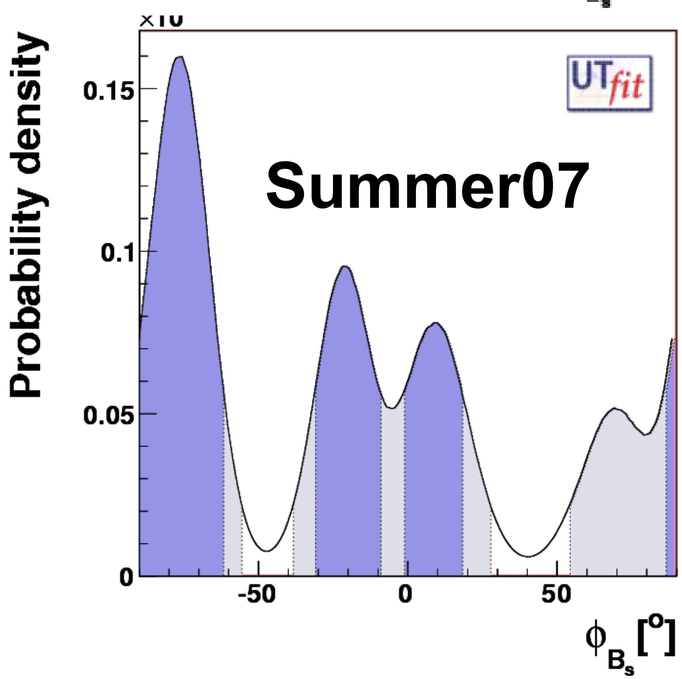


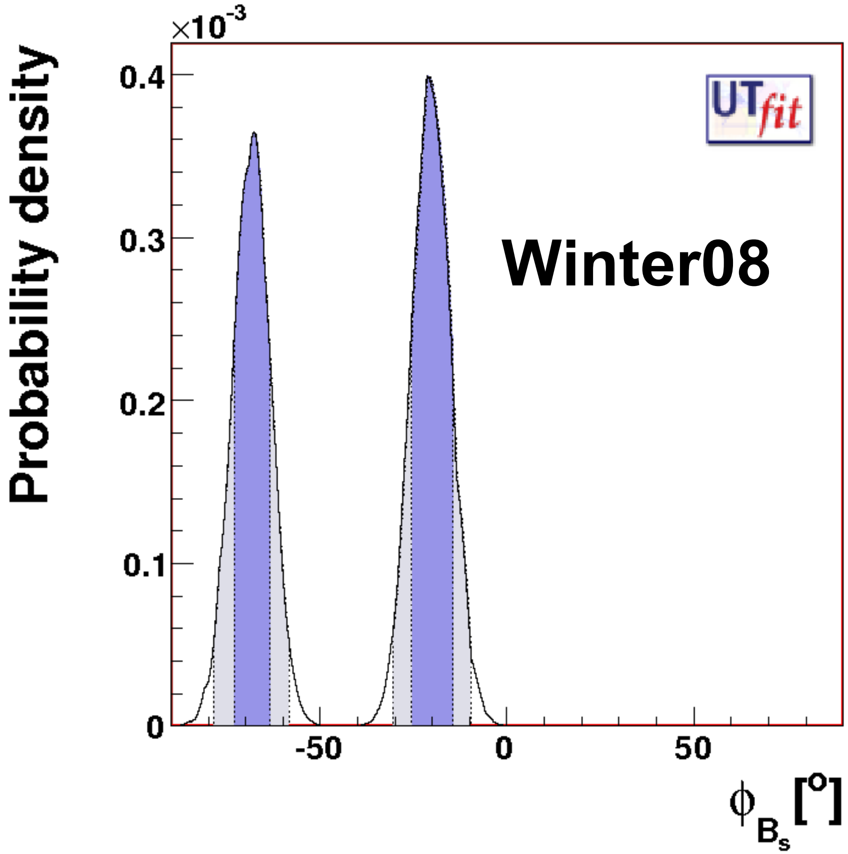


The discrepancy emerges in all the different parameterization

Did the result move by a lot?





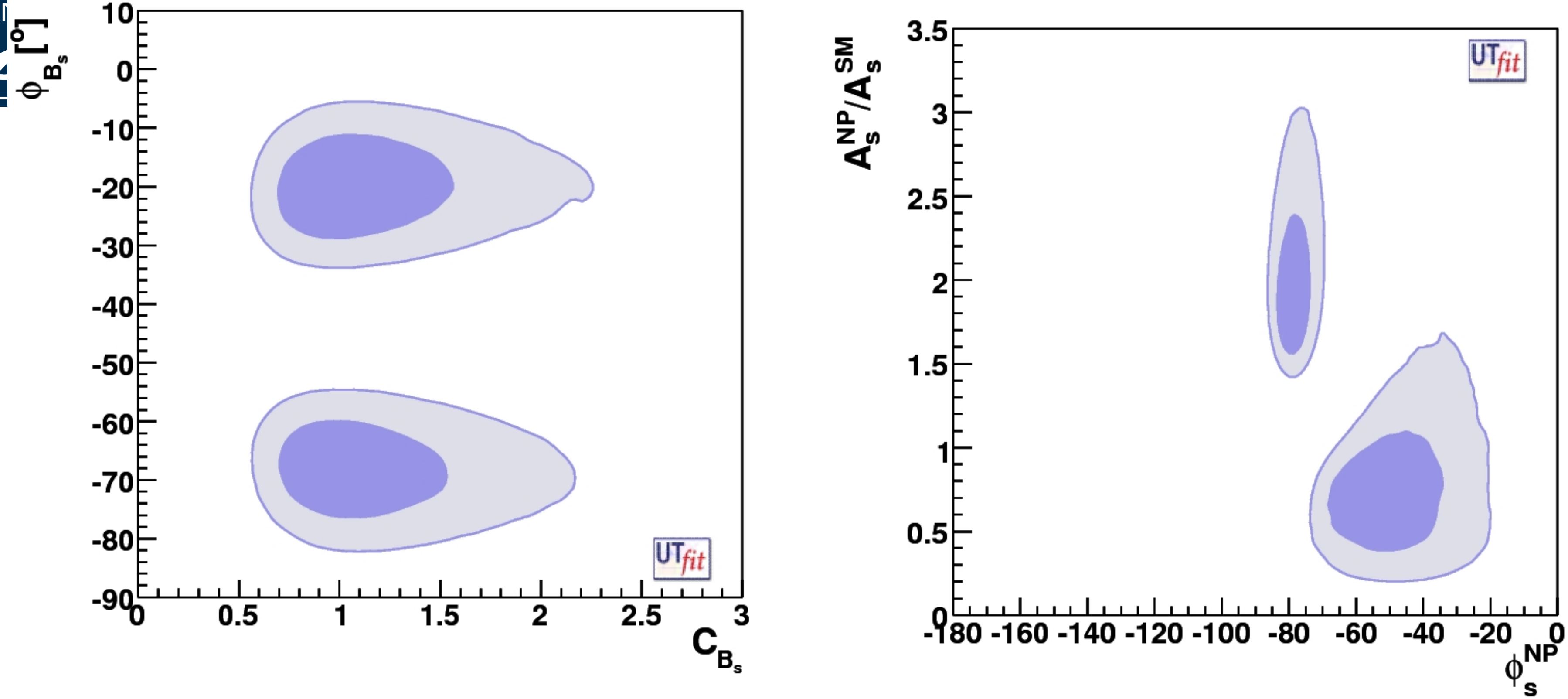


The two most probable peaks last summer are those that survived.

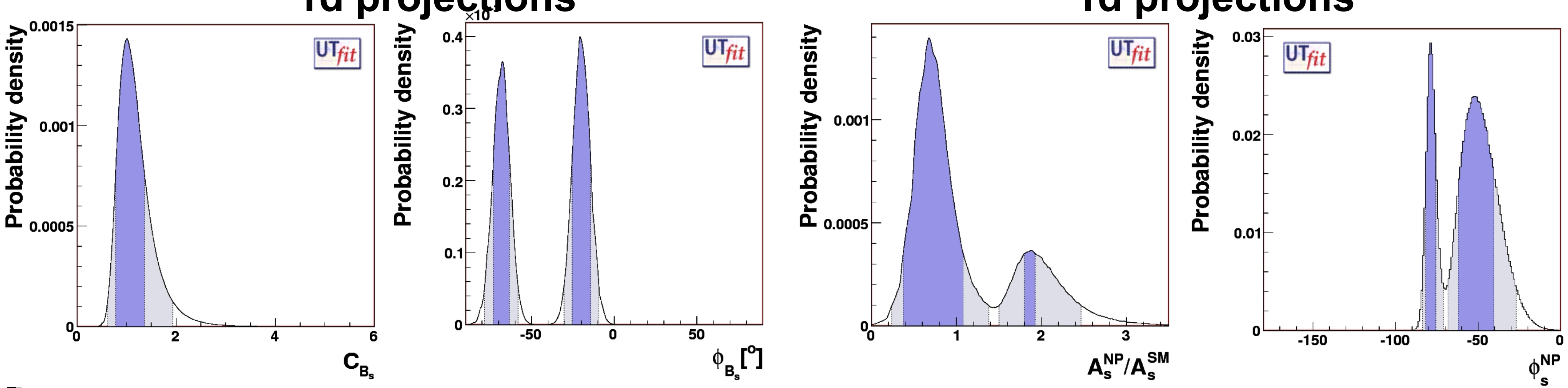
Some conclusions

- We have an evidence of discrepancy between the measurements and a clean SM prediction
- D0 and CDF are not using their entire dataset: they will hopefully update the measurements soon
- In any case, LHCb will allow to reach better precision and will provide additional measurements (e.g. $\gamma+2\beta_s$ from $B_s \rightarrow D_s K$)
- This result, if confirmed, will change our perspective for LHC: NP seen in flavour means that we don't need anymore the NP scale to be at 1000 TeV
- Challenging for theory:
  - MFV would not be an acceptable solution anymore (byproduct of previous point: mSUGRA ruled out?)
  - NP models need some (not fine tuned) mechanism to produce effects in $b \rightarrow s$ w/o inducing effects in $b \rightarrow d$ and K

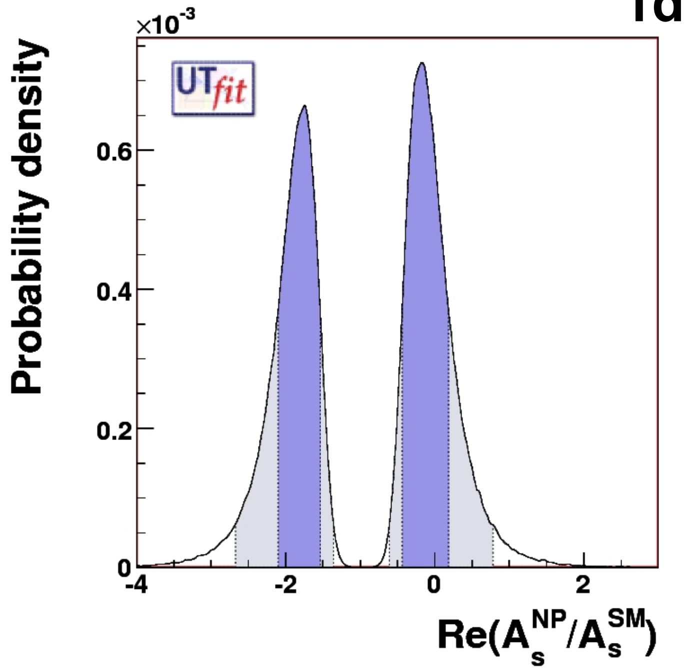
Back-up slides

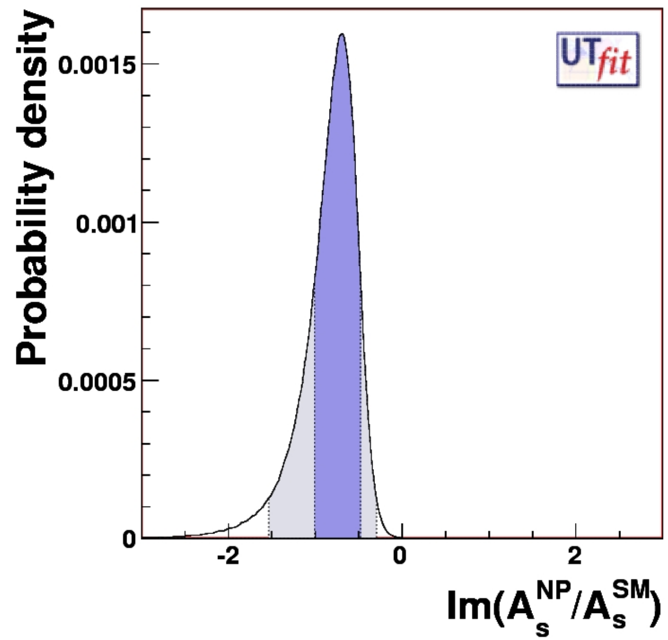


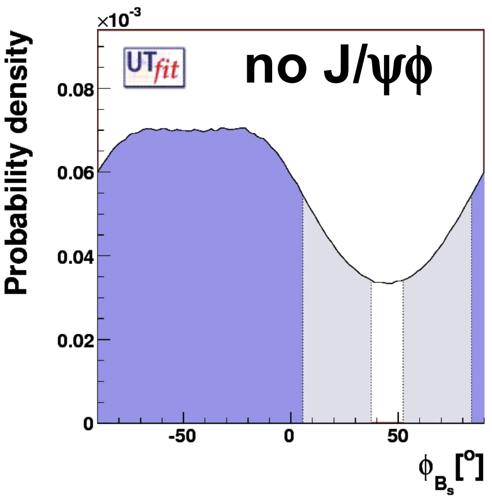
1d projections 1d projections

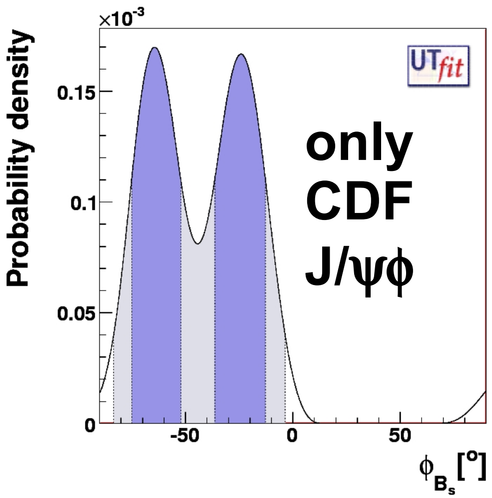


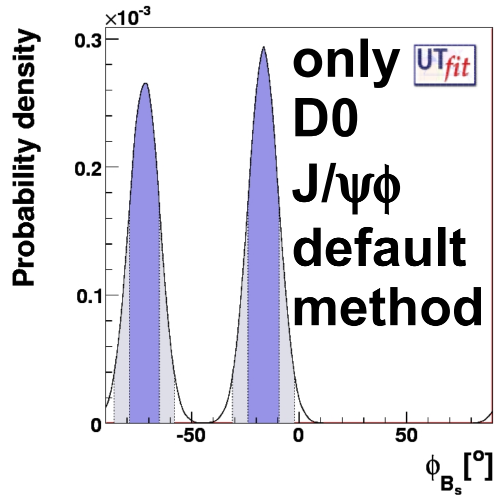
1d projections

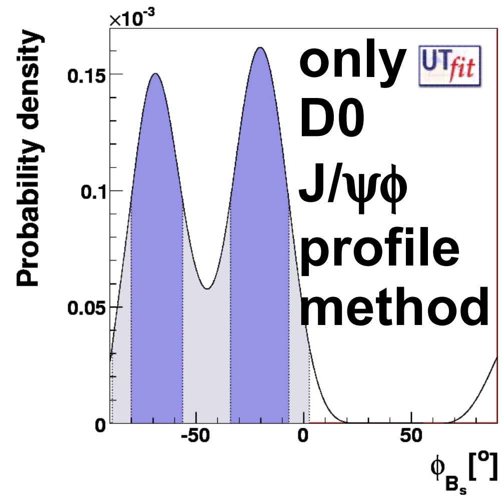




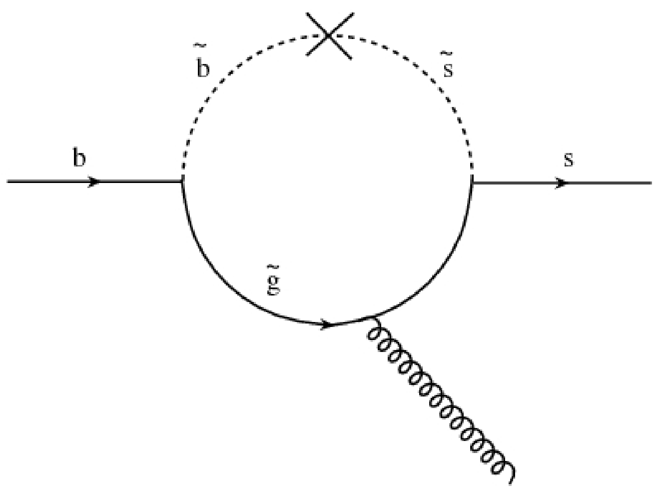


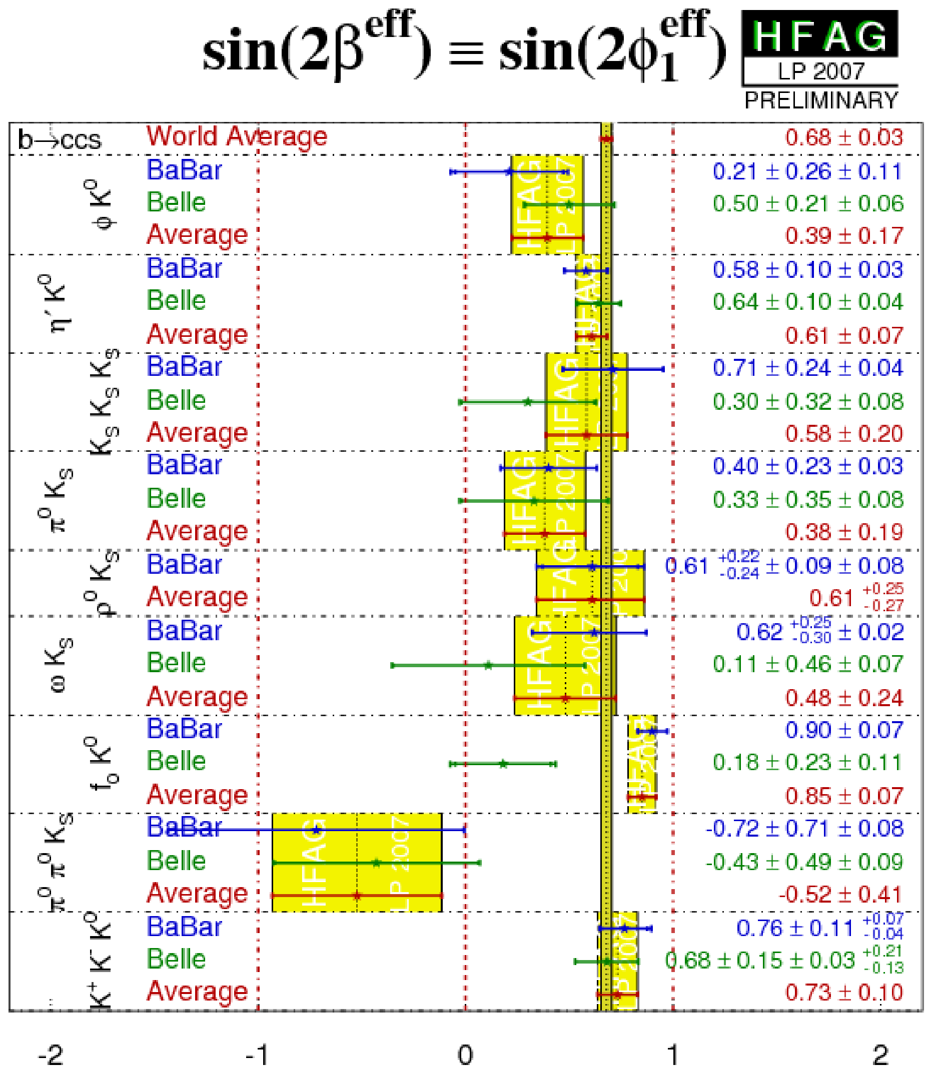






Experimental situation (II)





- **Extra sources of FCNC: investigation looking at b ↔ s penguin decays**
- **Some "hints" seen on sin2β in penguin decays**
- **Difficult interpretation due to theoretical issues (but SM hadron corrections are expected to induce positive shifts)**

$\phi_s=2\beta_s$ vs $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$ (I)

- Angular analysis of decays as a function of proper time and b-tagging
- Similar to B_d measurement in $B_d \to J/\psi K^*$
- Additional sensitivity from the $\Delta\Gamma_s$ terms (negligible for B_d)

$$\frac{d^4\Gamma}{dt\,d\cos\theta\,d\varphi\,d\cos\psi} \propto$$
$$2\cos^2\psi(1-\sin^2\theta\cos^2\varphi)|A_0(t)|^2$$
$$+\sin^2\psi(1-\sin^2\theta\sin^2\varphi)|A_\|(t)|^2$$
$$+\sin^2\psi\sin^2\theta|A_\perp(t)|^2$$
$$+(1/\sqrt{2})\sin 2\psi\sin^2\theta\sin 2\varphi\mathrm{Re}(A_0^*(t)A_\|(t))$$
$$+\quad(1/\sqrt{2})\sin 2\psi\sin 2\theta\cos\varphi\mathrm{Im}(A_0^*(t)A_\perp(t))$$
$$-\quad\sin^2\psi\sin 2\theta\sin\varphi\mathrm{Im}(A_\|^*(t)A_\perp(t)).$$

Dunietz, Fleisher and Nierste Phys.Rev.D63:114015,2001

Ambiguities for
$\phi_s \to \pi-\phi_s$,
$\Delta\Gamma_s \to -\Delta\Gamma_s$,
$\cos(\delta_1-\delta_2) \to -\cos(\delta_1-\delta_2)$

- θ and φ determine the direction of the μ^+ from J/ψ decay
- ψ is the angle between the decay planes of J/ψ and ϕ

$\phi_s = 2\beta_s$ vs $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$ (II)

$$|A_{0,\parallel}(t)|^2 = |A_{0,\parallel}(0)|^2 \left[\mathcal{T}_+ \pm e^{-\overline{\Gamma}t} \sin\phi_s \sin(\Delta M_s t)\right],$$

$$|A_\perp(t)|^2 = |A_\perp(0)|^2 \left[\mathcal{T}_- \mp e^{-\overline{\Gamma}t} \sin\phi_s \sin(\Delta M_s t)\right],$$

Dunietz, Fleisher and Nierste

Phys.Rev.D63:114015,2001

$$\mathrm{Re}(A_0^*(t)A_\parallel(t)) = |A_0(0)||A_\parallel(0)|\cos(\delta_2 - \delta_1) \times \left[\mathcal{T}_+ \pm e^{-\overline{\Gamma}t} \sin\phi_s \sin(\Delta M_s t)\right],$$

$$\mathrm{Im}(A_0^*(t)A_\perp(t)) = |A_0(0)||A_\perp(0)|| \times [e^{-\overline{\Gamma}t}(\pm\sin\delta_2\cos(\Delta M_s t) \mp \cos\delta_2 \sin(\Delta M_s t)\cos\phi_s) - (1/2)(e^{-\Gamma_H t} - e^{-\Gamma_L t})\sin\phi_s\cos\delta_2],$$

Ambiguity for

$\phi_s \to \pi - \phi_s$,

$\Delta\Gamma_s \to -\Delta\Gamma_s$,

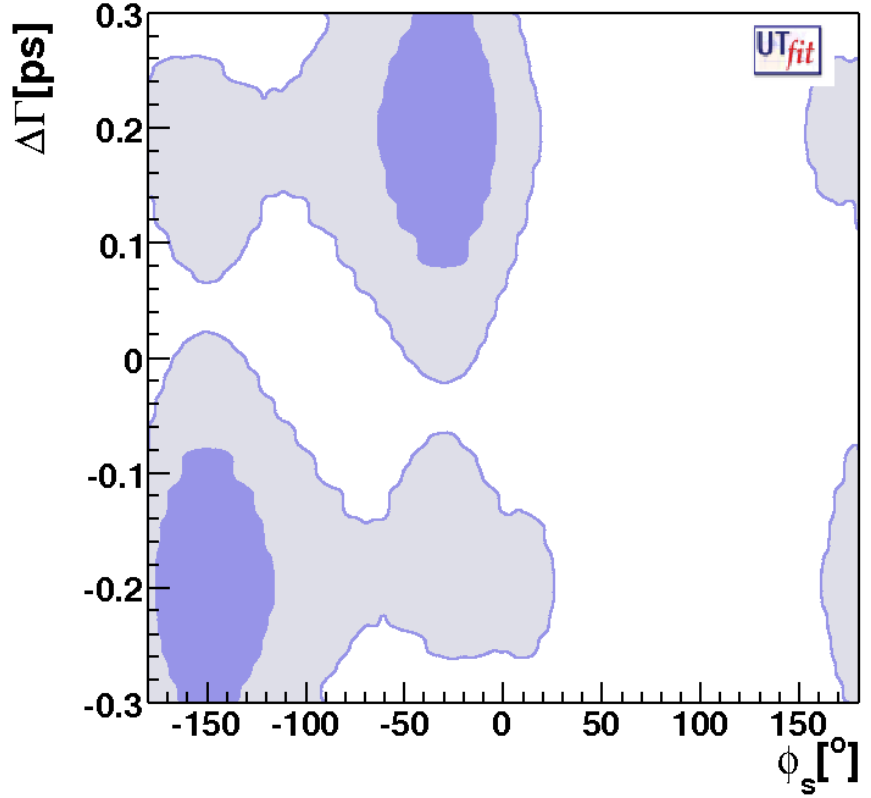
$\cos(\delta_1 - \delta_2) \to -\cos(\delta_1 - \delta_2)$

$$\mathrm{Im}(A_\parallel^*(t)A_\perp(t)) = |A_\parallel(0)||A_\perp(0)| \times [e^{-\overline{\Gamma}t}(\pm\sin\delta_1\cos(\Delta M_s t) \mp \cos\delta_1 \sin(\Delta M_s t)\cos\phi_s) - (1/2)(e^{-\Gamma_H t} - e^{-\Gamma_L t})\sin\phi_s\cos\delta_1],$$

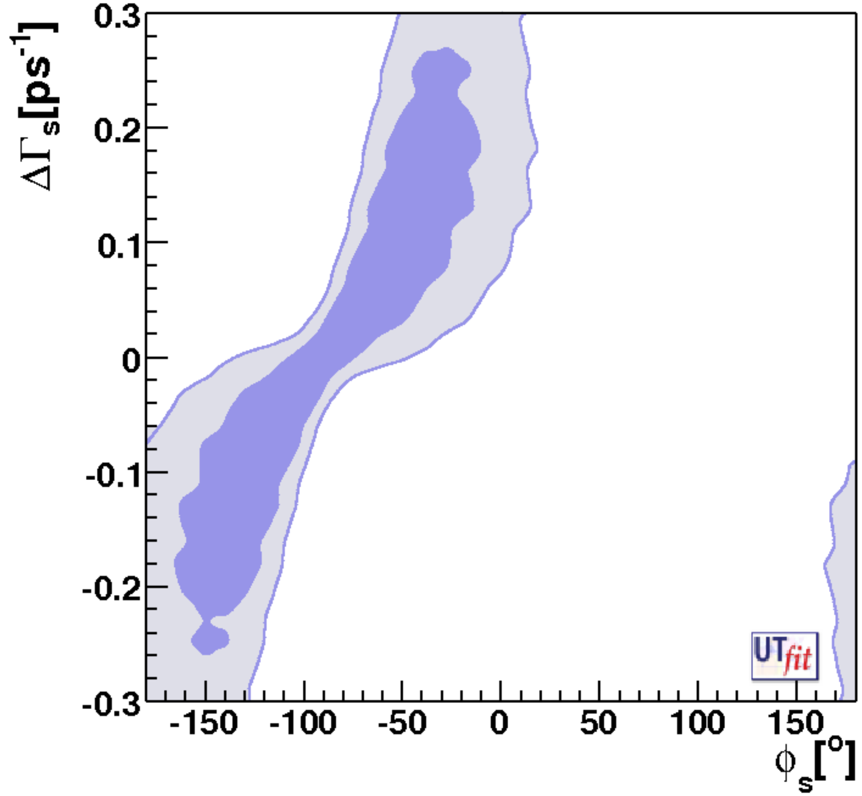
where $\mathcal{T}_\pm = (1/2)\left[(1 \pm \cos\phi_s)e^{-\Gamma_L t} + (1 \mp \cos\phi_s)e^{-\Gamma_H t}\right].$

More than two measurements

$\Delta\Gamma$ vs β_s region selected by the D0 constraint



$\Delta\Gamma$ vs β_s region selected by UTfit analysis with D0 constraint



- Someone call it statistics prior:
  we call it physics a-priori knowledge
- We are not performing a simple average of experimental results (we are not HFAG)

Semileptonic Asymmetry A_{SL}

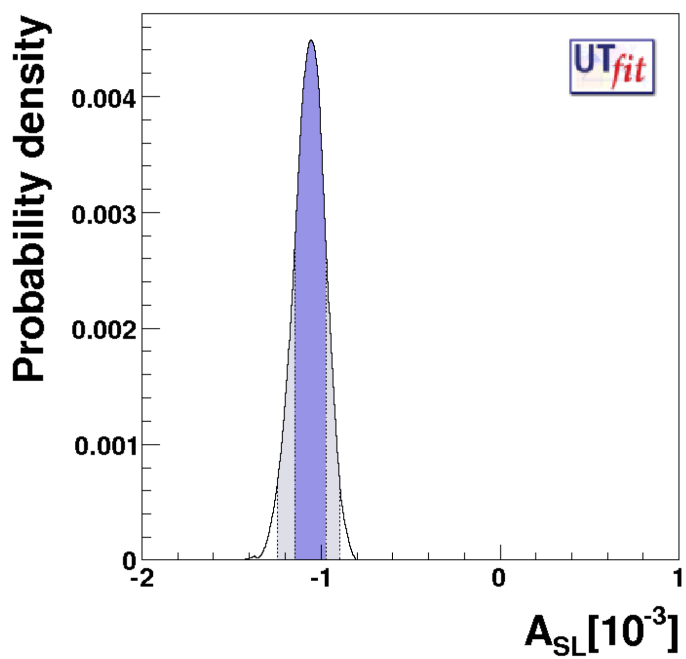
$$A_{\rm SL} \equiv \frac{\Gamma(\bar{B}^0 \to \ell^+ X) - \Gamma(B^0 \to \ell^- X)}{\Gamma(\bar{B}^0 \to \ell^+ X) + \Gamma(B^0 \to \ell^- X)}$$

$$= -\mathrm{Re}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\sin 2\phi_{B_d}}{C_{B_d}} + \mathrm{Im}\left(\frac{\Gamma_{12}}{M_{12}}\right)^{\rm SM} \frac{\cos 2\phi_{B_d}}{C_{B_d}}$$

SM prediction $(-1.06\pm0.09)10^{-3}$

Direct measurement $(-0.3\pm5.0)10^{-3}$

Laplace, Ligeti, Nir and Perez Phys.Rev.D 65:094040,2002



Similar constraint available both Bs decays

$\Delta\Gamma$ for B_d and B_s

$$\frac{\Delta\Gamma_q}{\Delta m_q} = -2\frac{\kappa}{C_{B_q}}\left\{\cos(2\phi_{B_q})\left(n_1+\frac{n_6B_2+n_{11}}{B_1}\right)-\frac{\cos(\phi_q^{SM}+2\phi_{B_q})}{R_t^q}\left(n_2+\frac{n_7B_2+n_{12}}{B_1}\right)+\frac{\cos(2(\phi_q^{SM}+\phi_{B_q}))}{R_t^{q^2}}\right.$$

$$\left.\left(n_3+\frac{n_8B_2+n_{13}}{B_1}\right)+\cos(\phi_q^{Pen}+2\phi_{B_q})\,C_q^{Pen}\left(n_4+n_9\frac{B_2}{B_1}\right)-\cos(\phi_q^{SM}+\phi_q^{Pen}+2\phi_{B_q})\frac{C_q^{Pen}}{R_t^q}\left(n_5+n_{10}\frac{B_2}{B_1}\right)\right\}$$

- The constraint on B_d is not effective (experimental error~ 10 times the precision from the rest of the fit)

	SM	SM+NP	exp
$10^3\,\Delta\Gamma_d/\Gamma_d$	2.8 ± 2.7	2.0 ± 1.8	9 ± 37
$\Delta\Gamma_s/\Gamma_s$	0.10 ± 0.06	0.00 ± 0.08	0.25 ± 0.09

- The experimental measurement of $\Delta\Gamma_s$ actually measures $\Delta\Gamma_s\cos(\beta_s+\phi_{Bs})$ (Dunietz et al., hep-ph/0012219)
- NP can only decrease the experimental result wrt the SM value
- Experimental WA > SM expectation (NP suppressed)

NLO calculation of the matrix element of B meson mixing

Ciuchini et al. JHEP 0308:031,2003.

Same Sign dilepton charge asymmetry

Ratio of B_d and B_s production at Tevatron

Semileptonic asymmetries of Bd and Bs mesons

$$A_{CH} = \frac{1}{4}\left(A^d_{\rm SL} + \frac{f_s \chi_{s0}}{f_d \chi_{d0}} A^s_{\rm SL}\right)$$

$$\overset{(-)}{\chi_q} = \frac{\frac{\Delta\Gamma_q}{\Gamma_q}^2 + 4\frac{\Delta m_q}{\Gamma_q}^2}{\frac{\Delta\Gamma_q}{\Gamma_q}^2 (\overset{(-)}{z_q} - 1) + 4(2\overset{(-)}{z_q} + \frac{\Delta m_q}{\Gamma_q}^2 (1 + \overset{(-)}{z_q}))}$$

With $z = |q/p|^2$ and $\bar{z} = |p/q|^2$

From NLO calculation of the B meson mixing

τ_{Bs} in Flavor Specific final states

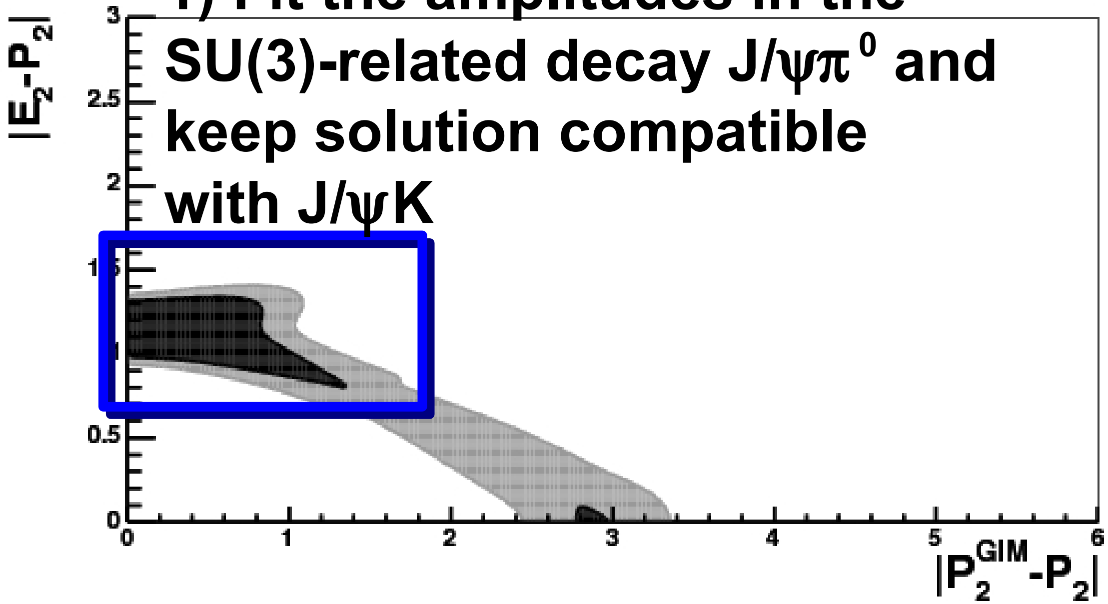
- B_s and $\overline{B}_s$ lifetime difference induced by $\Delta\Gamma_s$
- Experimental fit done with a single exponential rather than two exponentials
- The "average" lifetime is a function of the width and width difference

τ_{Bs} in Flavor Specific final states

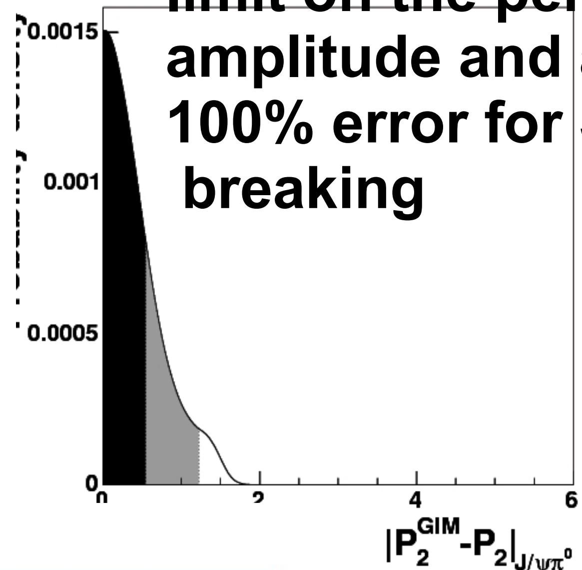
$$\tau_{B_s}^{FS} = \frac{1}{\Gamma_s} \frac{1 - \left(\frac{\Delta\Gamma_s}{2\Gamma_s}\right)^2}{1 + \left(\frac{\Delta\Gamma_s}{2\Gamma_s}\right)^2}$$

Theory error on sin2β

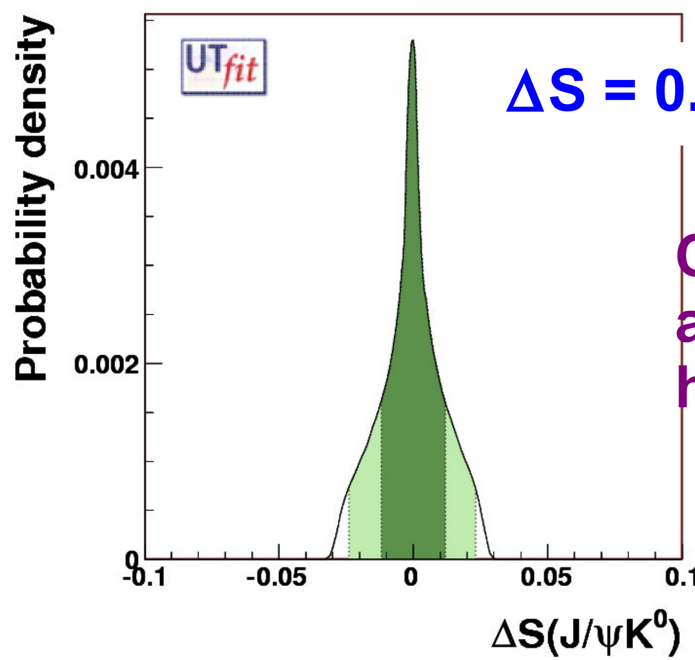
1) Fit the amplitudes in the SU(3)-related decay $J/\psi\pi^0$ and keep solution compatible with $J/\psi K$



2) Obtain the upper limit on the penguin amplitude and add 100% error for SU(3) breaking



3) Fit the amplitudes in $J/\psi K^0$ imposing the upper bound on the CKM suppressed amplitude and extract the error on sin2β



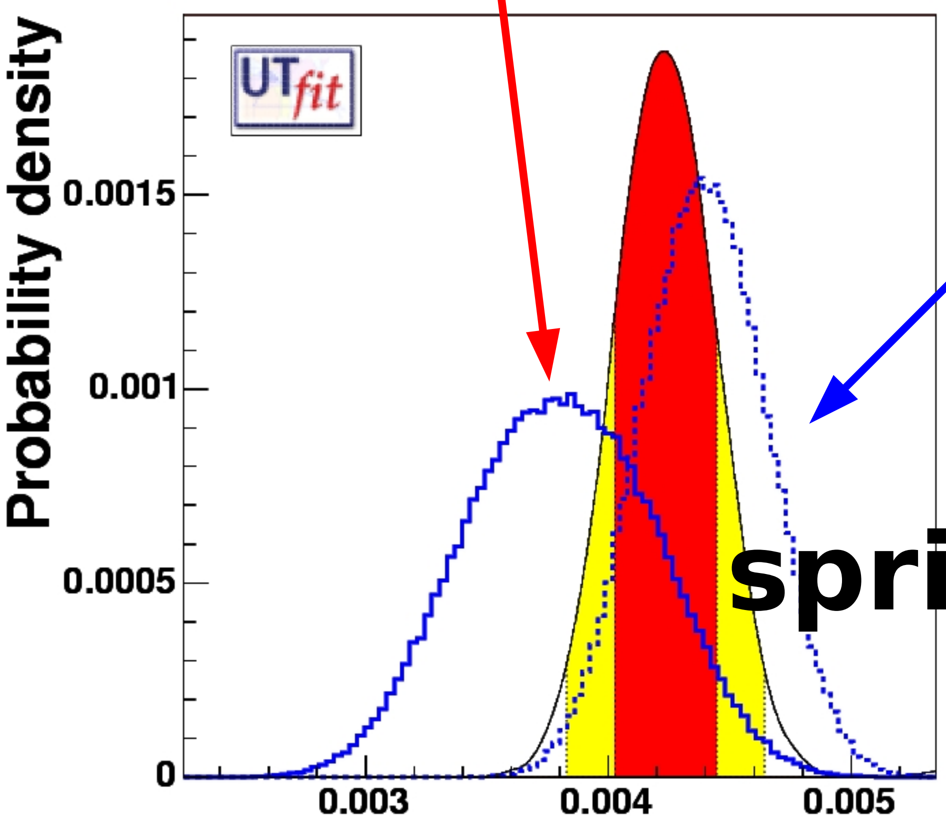
$\Delta S = 0.000 \pm 0.012$

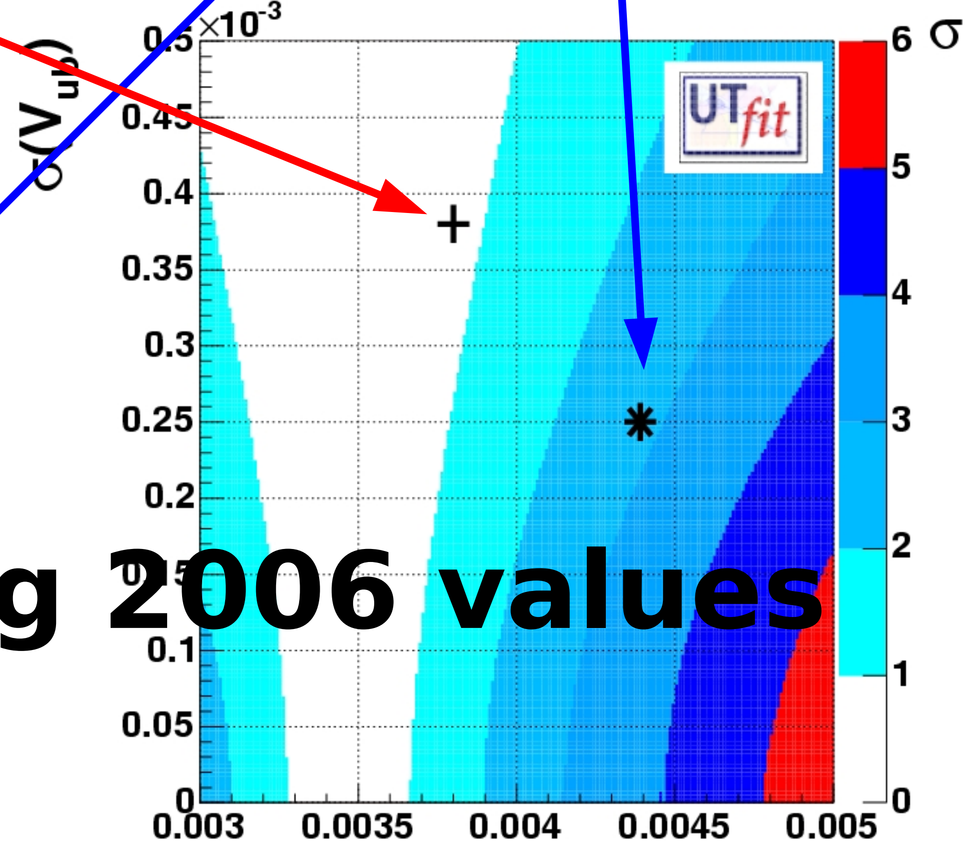
Ciuchini, Pierini and Silvestrini hep-ph/0507290 from quenched LQCD

V_{ub}

exclusive value:
semileptonic BRs from HFAG
form factor (courtesy of V. Lubicz)
$V_{ub} = (3.80 \pm 0.27 \pm 0.47)\ 10^{-3}$

inclusive value: from HFAG
$V_{ub} = (4.38 \pm 0.19 \pm 0.27)\ 10^{-3}$





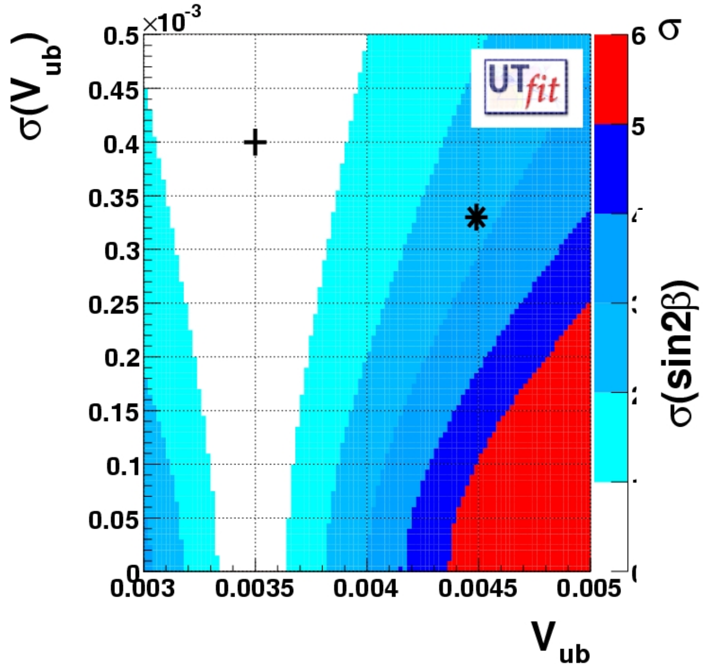
spring 2006 values

mediating:
$V_{ub} = (4.20 \pm 0.20)\ 10^{-3}$

from all the other inputs:
$V_{ub} = (3.48 \pm 0.20)\ 10^{-3}$

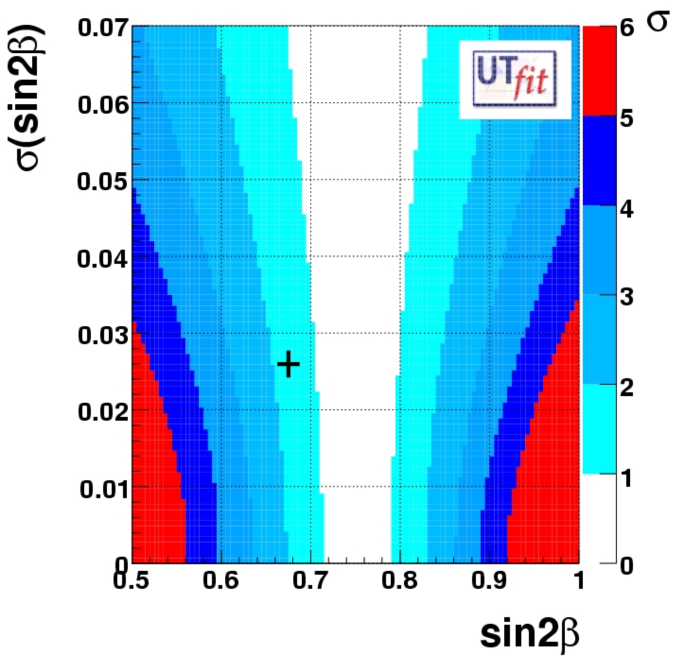
V_{ub}(II)

new from latest HFAG:
$V_{ub} = (4.09 \pm 0.25)\ 10^{-3}$

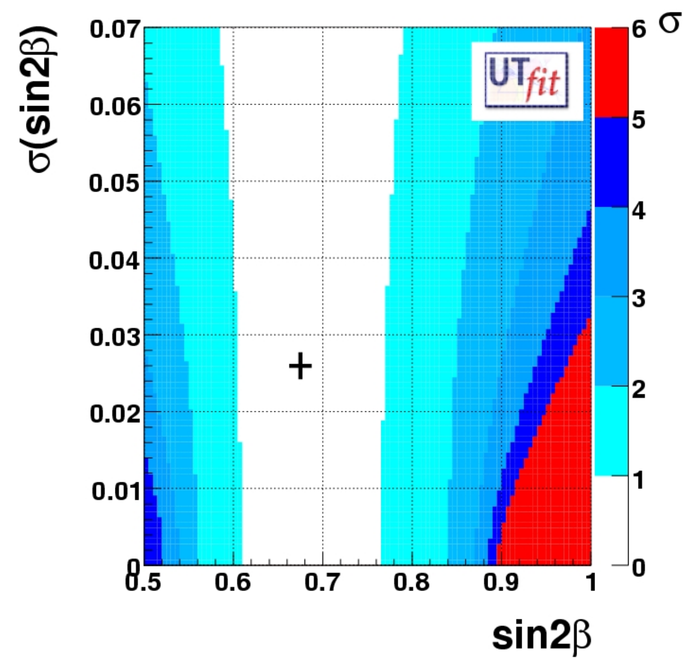


sin2β = 0.752 ± 0.038
from indirect determination

with Vub

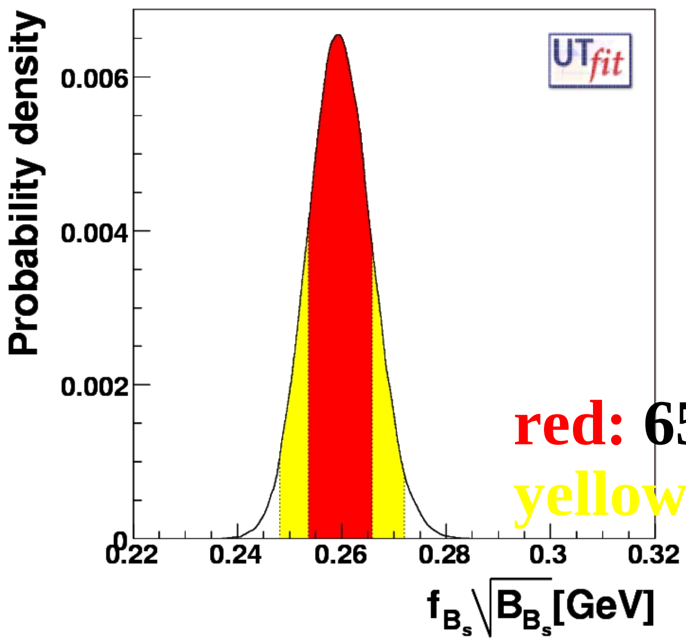


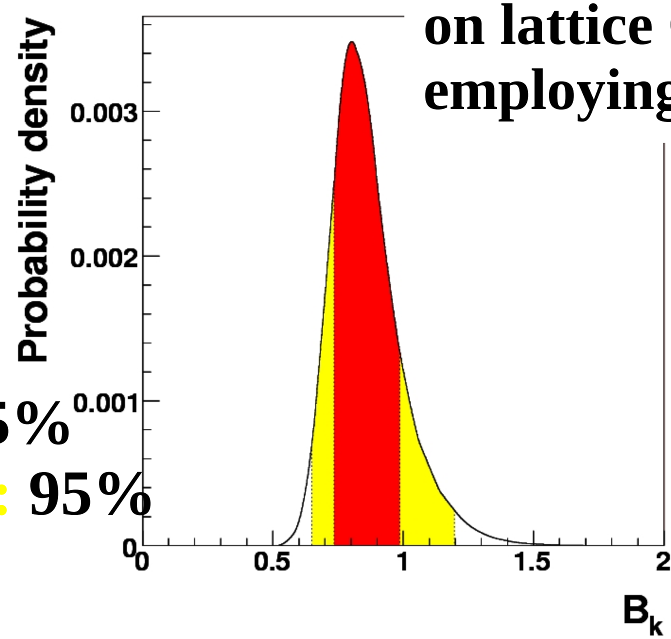
without Vub



LQCD predictions

It is possible to obtain predictions on lattice QCD parameters employing all the other inputs

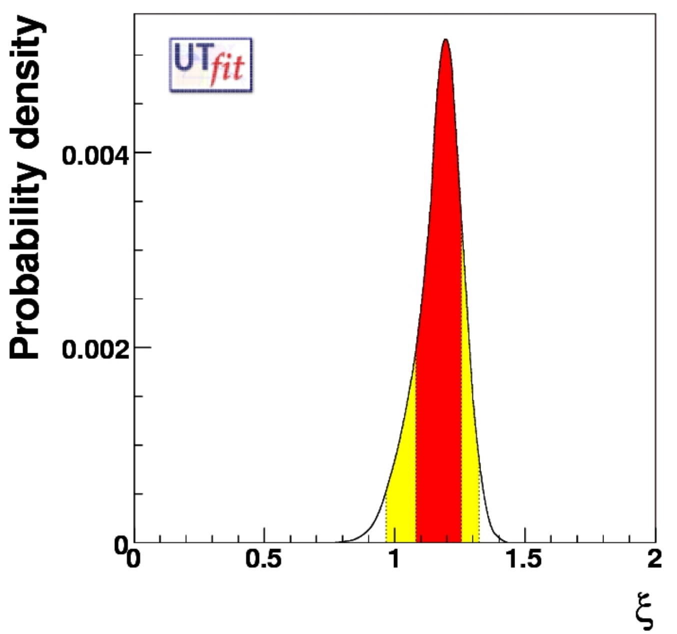




red: 65%
yellow: 95%

$f_{B_s}\sqrt{B_{B_s}} = 259 \pm 6$

$f_{B_s}\sqrt{B_{B_s}} = 276 \pm 38$ LQCD



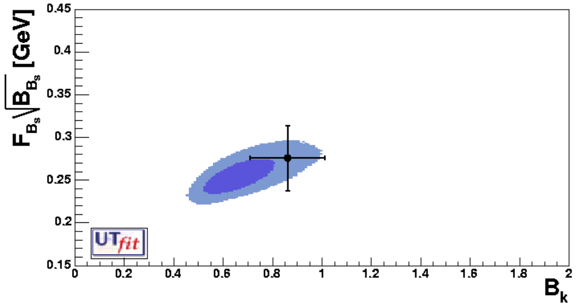
$B_K = 0.86 \pm 0.13$

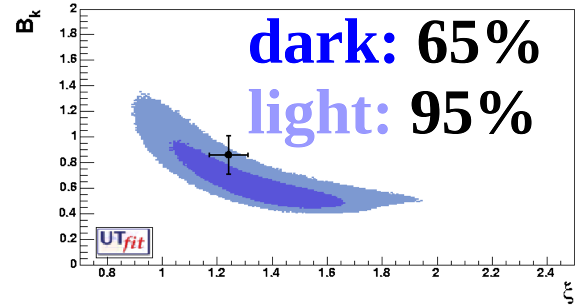
$B_K = 0.79 \pm 0.04 \pm 0.09$ LQCD

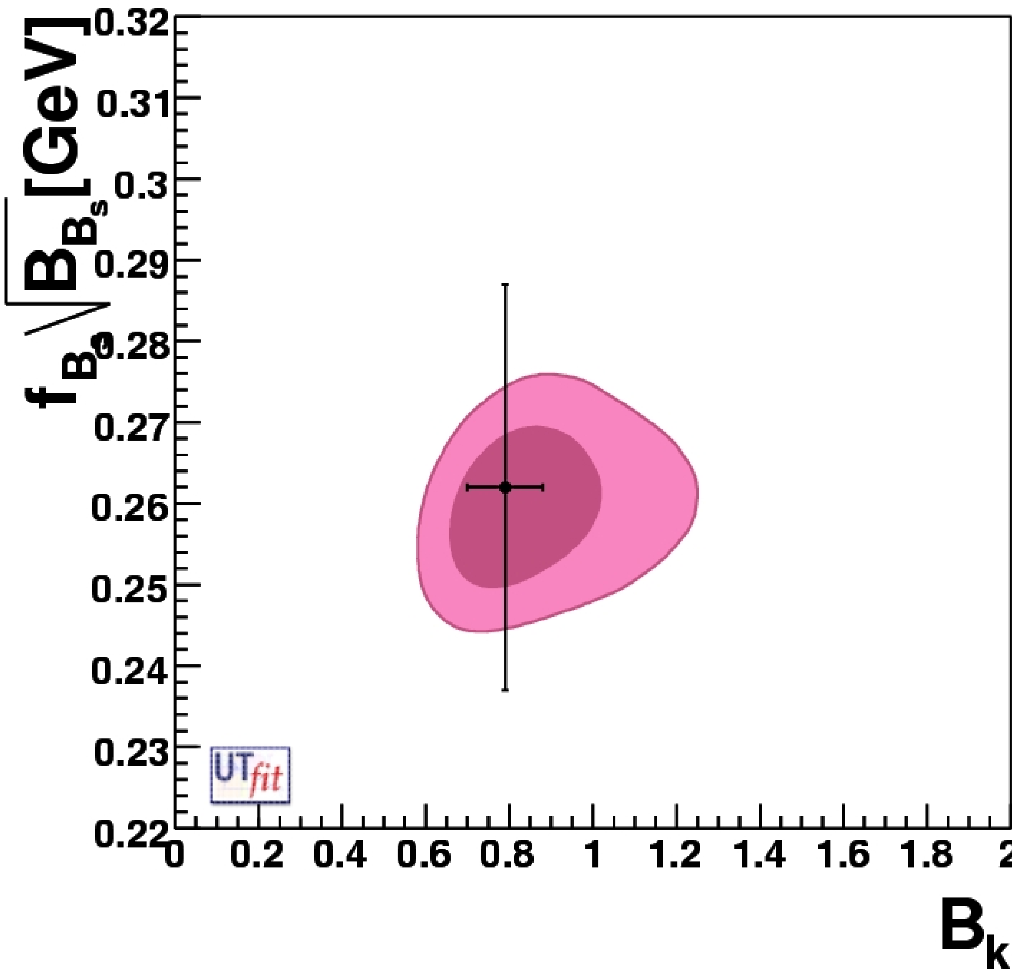
$\xi = 1.17 \pm 0.08$

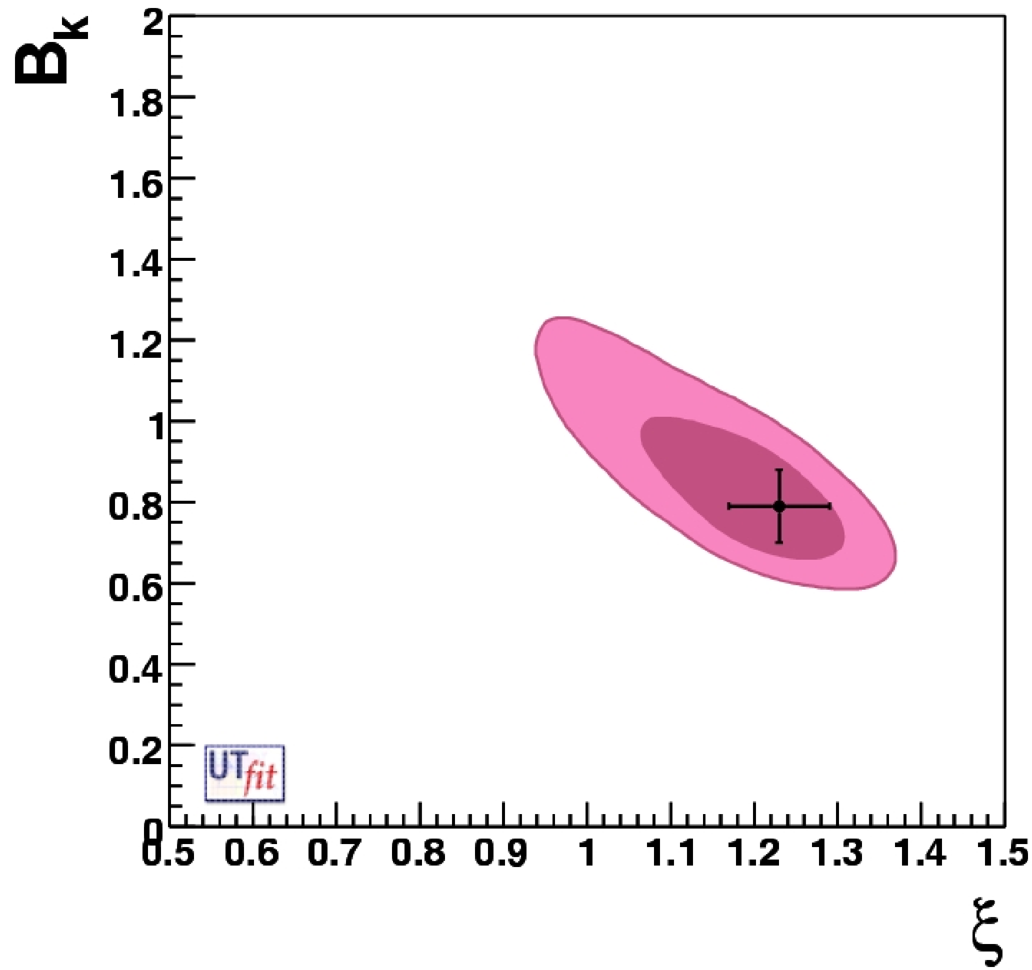
$\xi = 1.24 \pm 0.04 \pm 0.06$ LQCD

LQCD predictions (II)

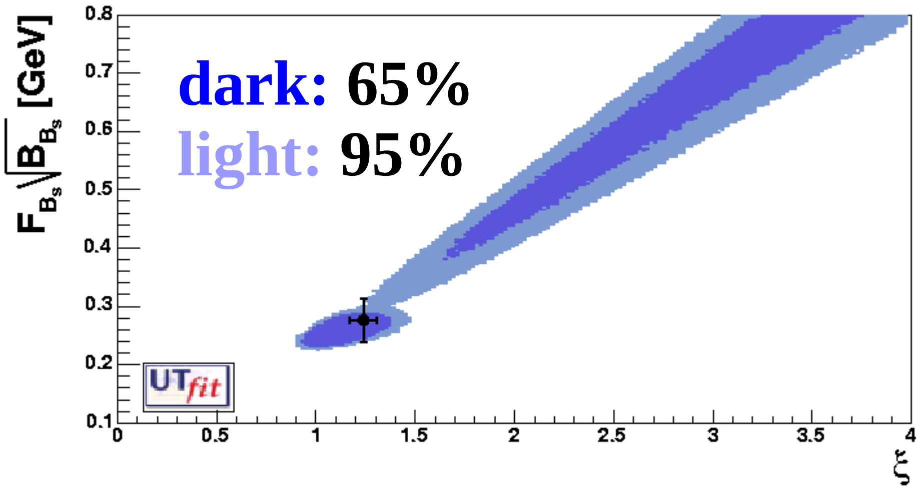


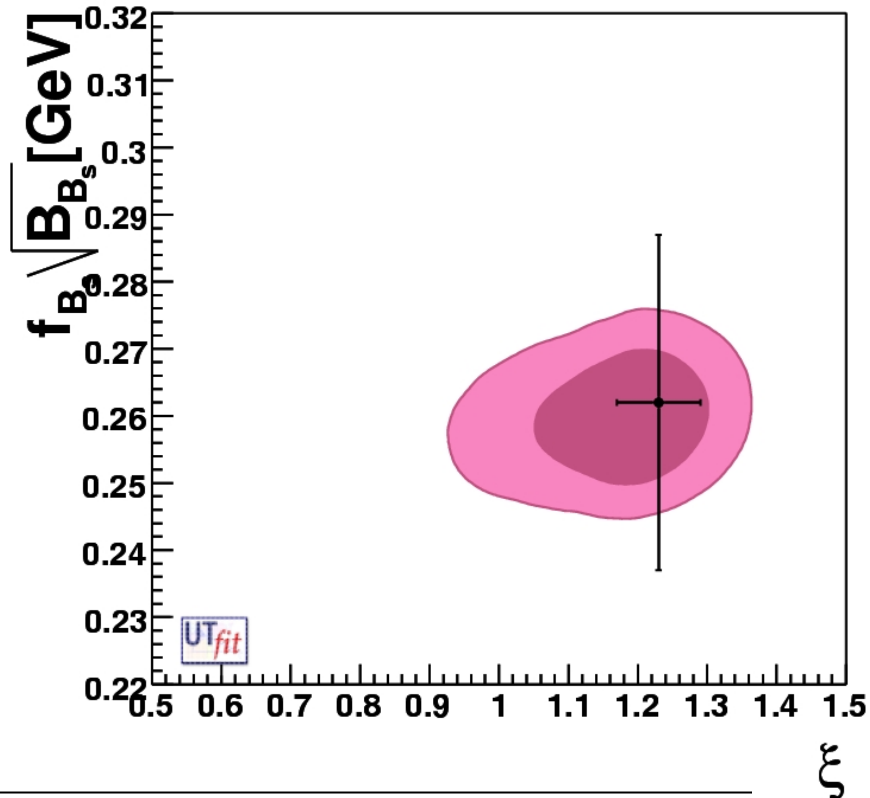






LQCD predictions (II)





Parameter	All	All[no semilep]	Lattice
$\hat{B}_K$	0.91 ± 0.18	0.86 ± 0.13	$0.79 \pm 0.04 \pm 0.09$
$f_{B_s}\,\hat{B}_{B_s}^{1/2}$ (MeV)	258 ± 6	259 ± 6	262 ± 35
ξ	1.11 ± 0.11	1.17 ± 0.08	1.23 ± 0.06