BR($B \to \tau\nu$) & New Physics

Marco Ciuchini

INFN Roma Tre

* BR($B \to \tau\nu$) and the UT analysis
* implications for MFV models
* constraints on the 2HDM
* constraints on the MSSM at large tanβ
* conclusions

talk based on arXiv:0908.3470 (see also hep-ph/0606167)

(**UT***fit* Collaboration)

M. Bona,[1] M. Ciuchini,[2] E. Franco,[3] V. Lubicz,[2,4] G. Martinelli,[3,5] F. Parodi,[6] M. Pierini,[1]
C. Schiavi,[6] L. Silvestrini,[3] V. Sordini,[7] A. Stocchi,[8] C. Tarantino,[2,4] and V. Vagnoni[9]

[1] *CERN, CH-1211 Geneva 23, Switzerland*
[2] *INFN, Sezione di Roma Tre, I-00146 Roma, Italy*
[3] *INFN, Sezione di Roma, I-00185 Roma, Italy*
[4] *Dipartimento di Fisica, Università di Roma Tre, I-00146 Roma, Italy*
[5] *Dipartimento di Fisica, Università di Roma "La Sapienza", I-00185 Roma, Italy*
[6] *Dipartimento di Fisica, Università di Genova and INFN, I-16146 Genova, Italy*
[7] *ETH Zurich, HG Raemistrasse 101, 8092 Zurich, Switzerland*
[8] *Laboratoire de l'Accélérateur Linéaire, IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex, France*
[9] *INFN, Sezione di Bologna, I-40126 Bologna, Italy*

http://www.utfit.org (not updated yet)

The leptonic decay
$B \to \tau\nu$

Experimental status

Recent history (HFAG)

W06: $(1.09\ ^{+0.38}_{-0.31})\times10^{-4}$

W07: $(1.32 \pm 0.49)\times10^{-4}$

W09: $(1.43 \pm 0.37)\times10^{-4}$

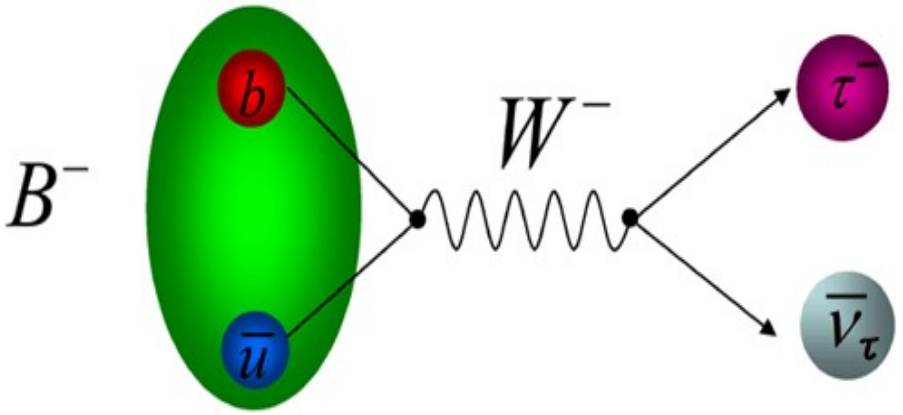
$$BR_{\rm exp} = (1.73 \pm 0.34) \times 10^{-4}$$

UT*fit* '09, T. Iijima, LP09

naïve average including the latest measurements

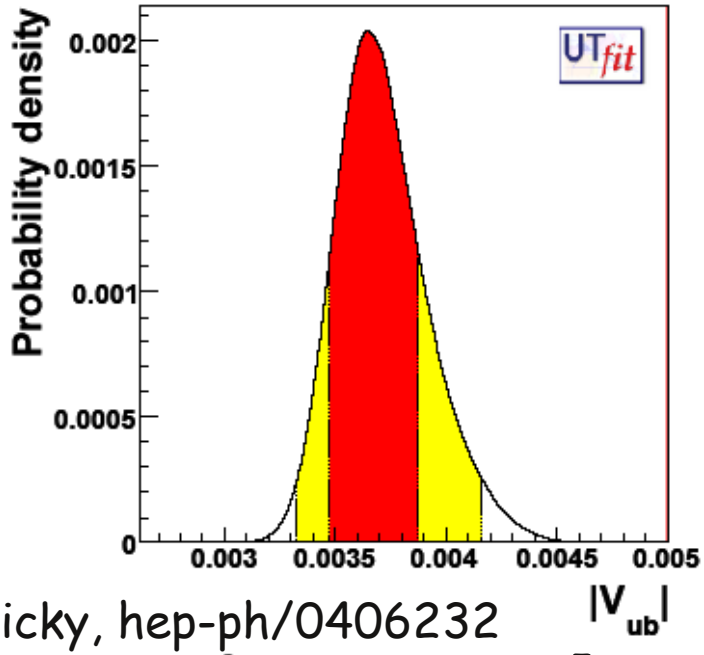
In the SM: $$BR(B \to \tau\nu) = \frac{G_F^2 m_B m_\tau^2}{8\pi}\left(1-\frac{m_\tau^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

* helicity-suppressed tree-level decay
* uncertainty driven by f_B and $|V_{ub}|$



f_B: $f_B = 200 \pm 20$ MeV Lubicz, Tarantino, arXiv:0807.4605

$|V_{ub}|$: $|V_{ub}| = (36.7 \pm 2.1) \times 10^{-4}$



inclusive: $|V_{ub}|^{\rm incl} = (40.0 \pm 1.5 \pm 4.0) \times 10^{-4}$

exclusive: $|V_{ub}|^{\rm excl} = (33.3 \pm 2.7) \times 10^{-4}$

Ball, Zwicky, hep-ph/0406232

$BR(B \to \pi \ell \nu)_{q^2 < 16\,{\rm GeV}^2} = (0.94 \pm 0.05 \pm 0.04) \times 10^{-4}$ $\left[FF(q^2 < 16\,{\rm GeV}^2) = 5.44 \pm 1.43\right]$

$BR(B \to \pi \ell \nu)_{q^2 > 16\,{\rm GeV}^2} = (0.37 \pm 0.03 \pm 0.02) \times 10^{-4}$ $\left[FF(q^2 > 16\,{\rm GeV}^2) = 2.04 \pm 0.40\right]$

Using these figures:

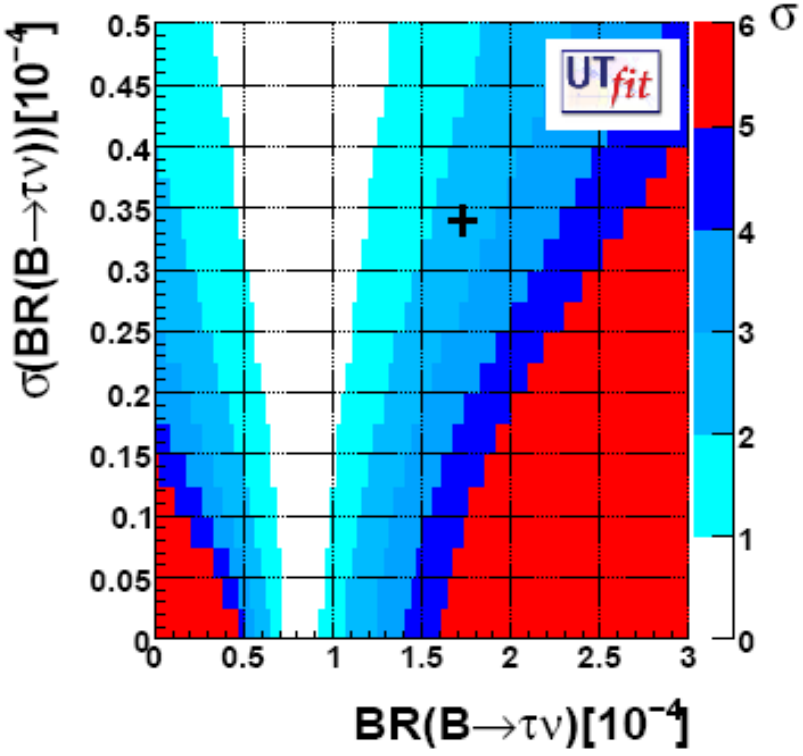
$$BR(B \to \tau\nu) = (0.98 \pm 0.24) \times 10^{-4}$$

compatible with BR_{exp} at ~1.8σ

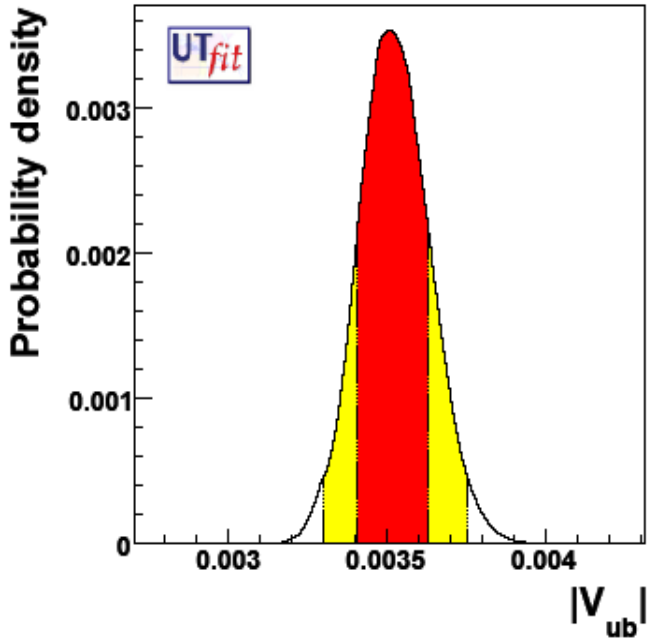
UTfit-improved predictions

* theoretical predictions of f_B and $|V_{ub}|$ can be improved with the UT analysis (SM, ...)

* theoretical prediction of $|V_{ub}|$ can be improved with the UUT analysis (MFV, ...)



UTfit, arXiv:0908.3470

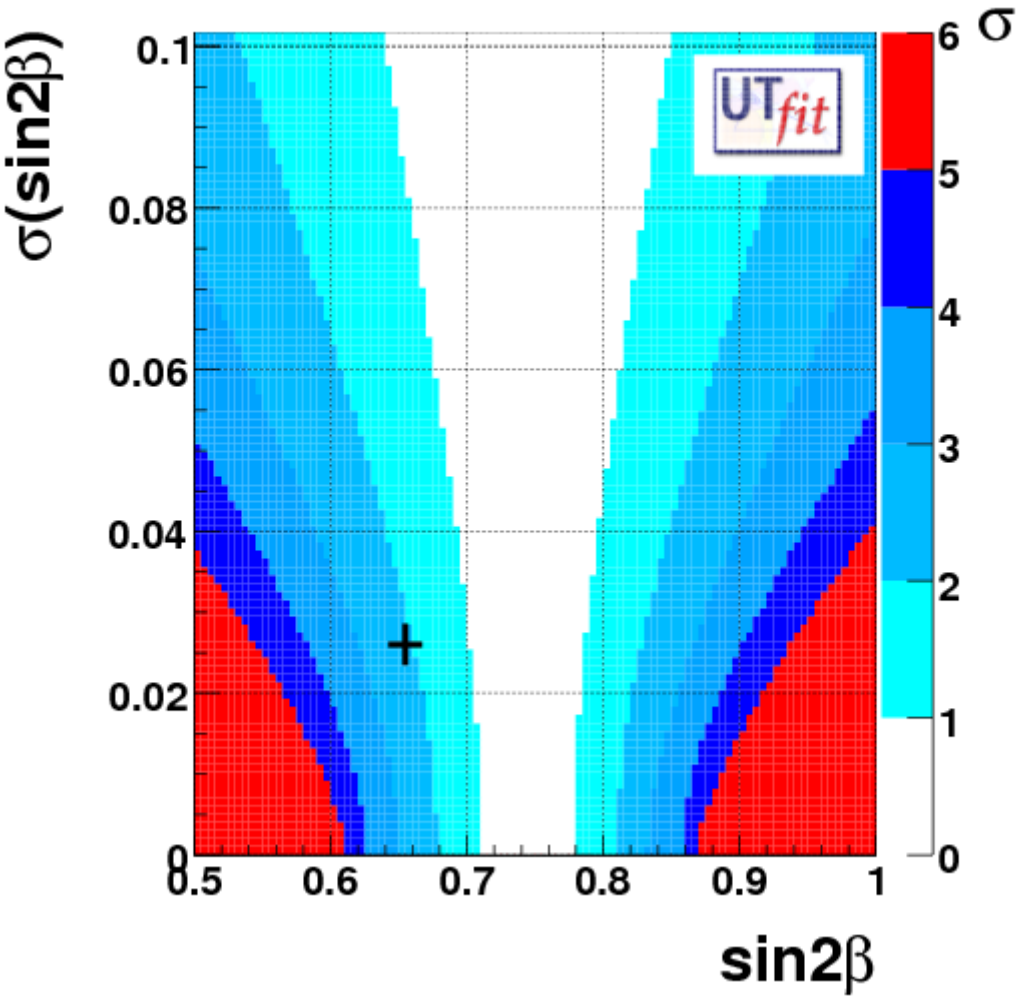


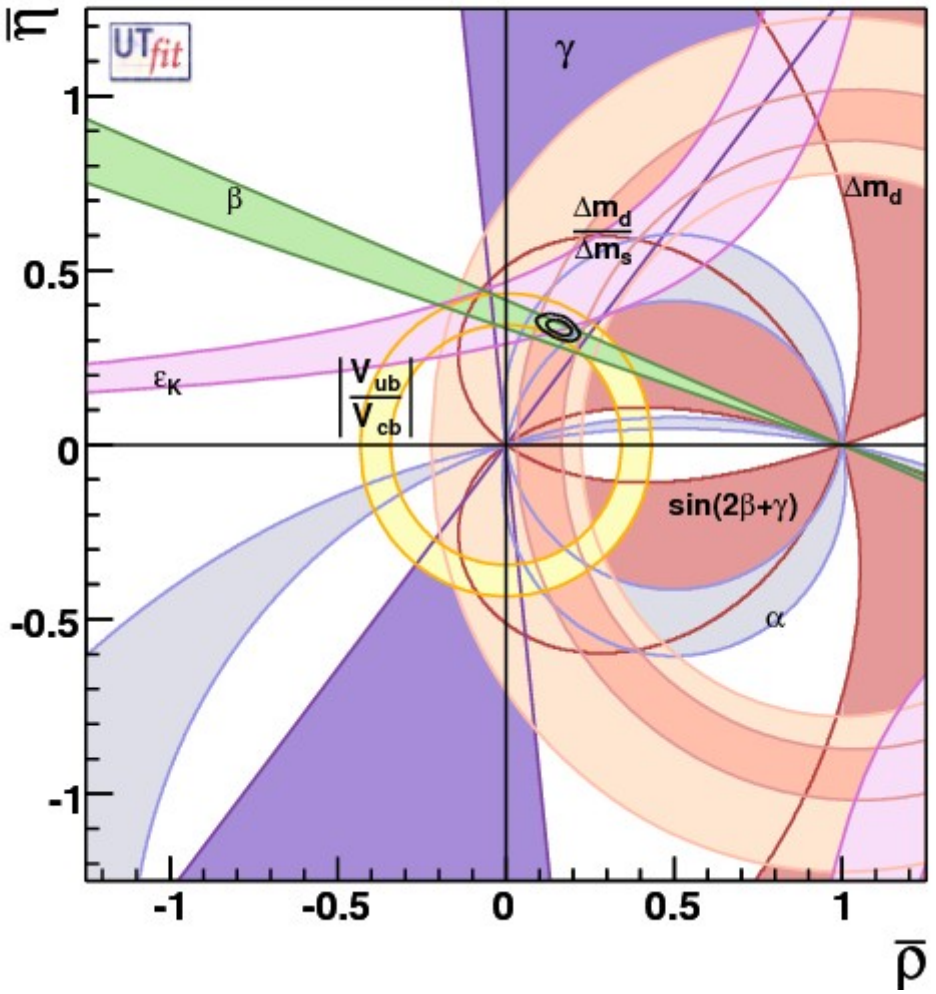
scenario	$\lvert V_{ub}\rvert \times 10^4$	f_B (MeV)	$\overline{BR} \times 10^4$	pull
UT	35.2 ± 1.1	196 ± 11	0.84 ± 0.11	2.5σ
UUT	35.0 ± 1.2	200 ± 20	0.87 ± 0.20	2.2σ
no-fit	36.7 ± 2.1	200 ± 20	0.98 ± 0.24	1.8σ

sin2β "tension"

$\sin 2\beta^{\text{UTfit}} = 0.744 \pm 0.035$

$\sin 2\beta^{J/\psi K} = 0.655 \pm 0.026$



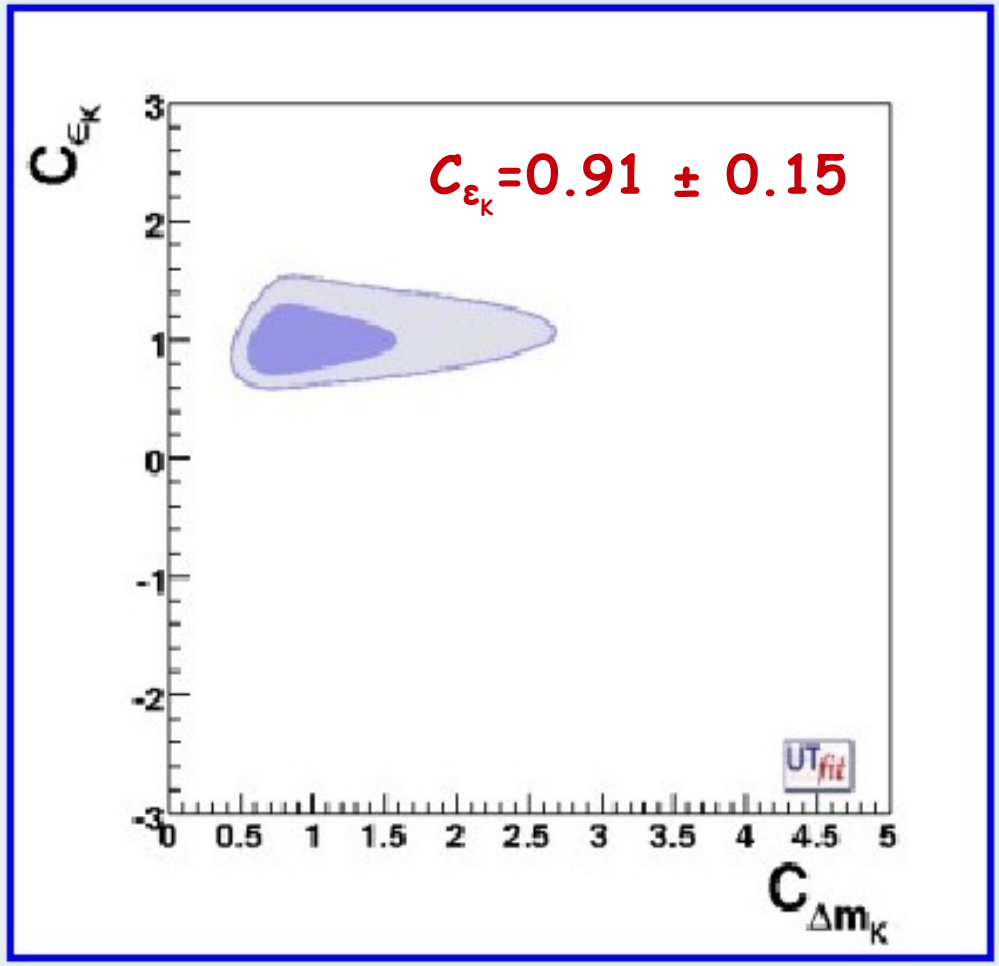


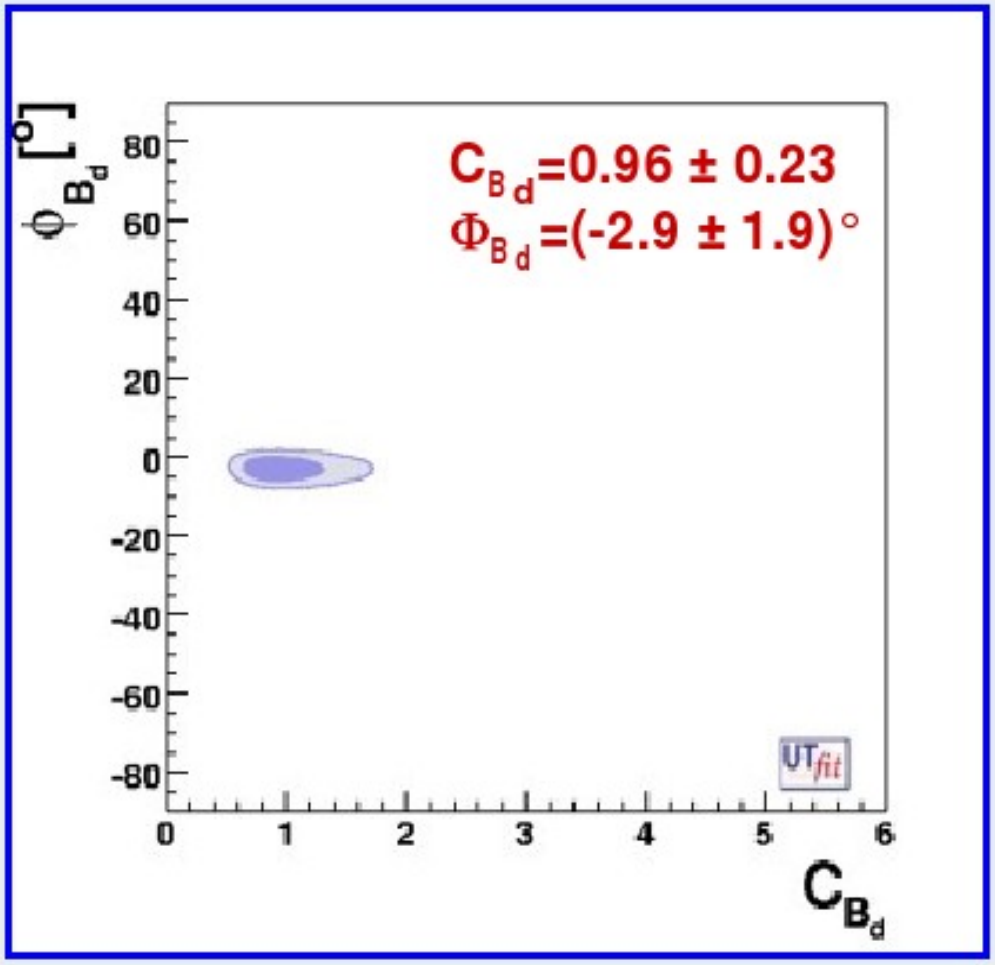
good old $|V_{ub}|$-sin2β "tension" revived by Buras-Guadagnoli corrections to ε_K (theoretical prediction down by 8%)

arXiv:0805.3887

No 2σ deviation found in the fit of ΔF=2 NP parameters: the effect is diluted

$$\mathrm{Im}\,M_{12}^{K} = C_{\varepsilon_K}\,\mathrm{Im}\,M_{12}^{K,SM}, \qquad M_{12}^{B_d} = C_{B_d} e^{2i\phi_{B_d}} M_{12}^{B_d,SM}$$





sin2β & B $\to \tau\nu$

2006

$BR(B \to \tau\nu) > BR_{exp}$

$|V_{ub}|$ ↘

$|\Delta BR_{\tau\nu}|$ ↘

$|\Delta \sin 2\beta|$ ↘

A small value of $|V_{ub}|$, which was preferred by the UT fit, smoothed all the "tensions"

UTfit, hep-ph/0606167

2009

$BR(B \to \tau\nu) < BR_{exp}$

$|V_{ub}|$ ↘

$|\Delta BR_{\tau\nu}|$ ↗

$|\Delta \sin 2\beta|$ ↘

No simultaneous $|V_{ub}|$ explanation for the $BR(B \to \tau\nu)$ and sin2β "tensions"

$B \to \tau\nu$ in MFV models

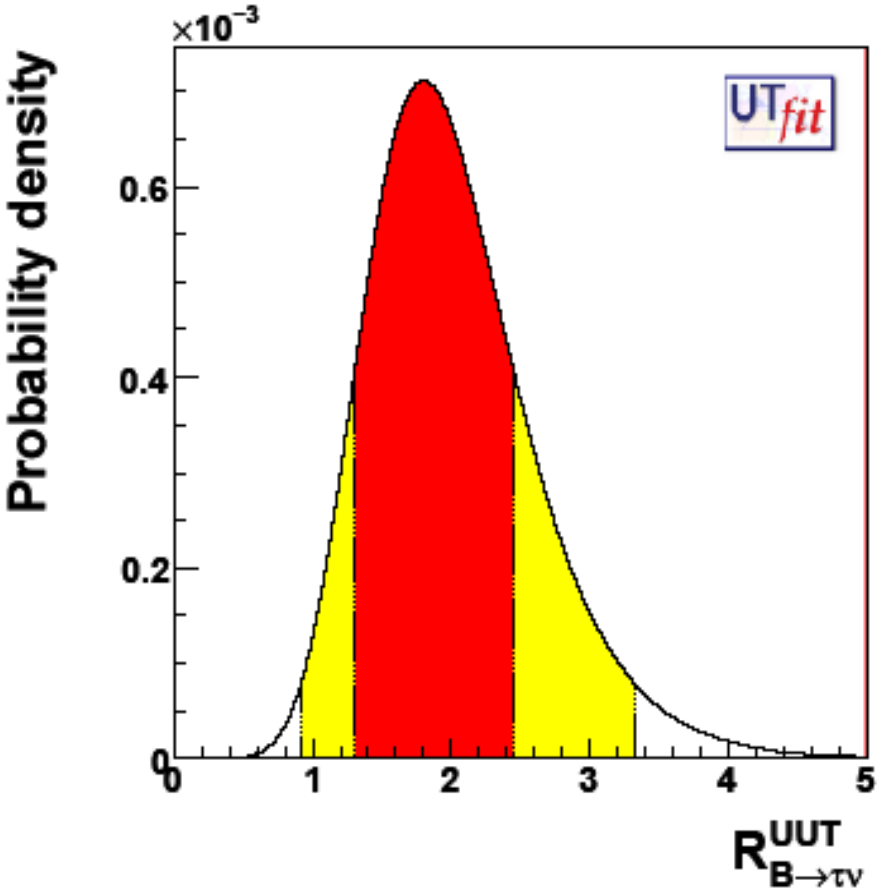
The prediction of the SM $\overline{BR}$ can still be improved with the UUT analysis (UT without $\Delta m_{d/s}$ and ε_K)

The result is better given as:

$$R_{\mathrm{UUT}}^{\mathrm{exp}} = 1.9 \pm 0.6$$

where $R^{exp}_{UT} = BR_{exp} / \overline{BR}_{UT}$

to be compared with the $|V_{ub}|$- and f_B-independent th. calculation of R_{UT} in specific MFV models

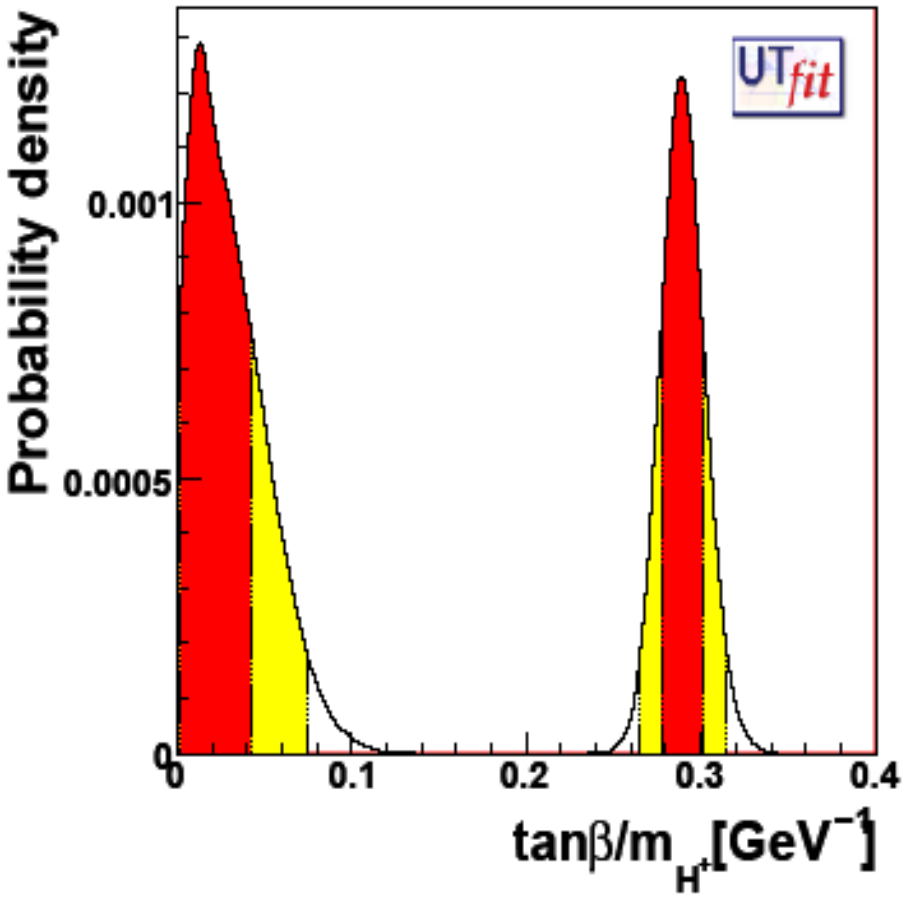


Two Higgs Doublet Model II

$$R_{2\mathrm{HDM}} = \left(1 - \tan^2\beta \frac{m_B^2}{m_{H^+}^2}\right)^2 \quad \rightarrow \text{bounds on } \tan\beta/m_{H^+}$$

Two regions selected:

1. small $\tan\beta/m_{H^+}$: R < 1 but acceptable within errors
2. "fine-tuned" region for $\tan\beta/m_{H^+} \sim 0.3$: positive correction, $R \sim R_{exp}$ can be obtained



Additional constraints:

1. BR($B \to X_s \gamma$)

$m_{H+} > 295$ GeV

Misiak et al., hep-ph/0609232

2. semileptonic decays

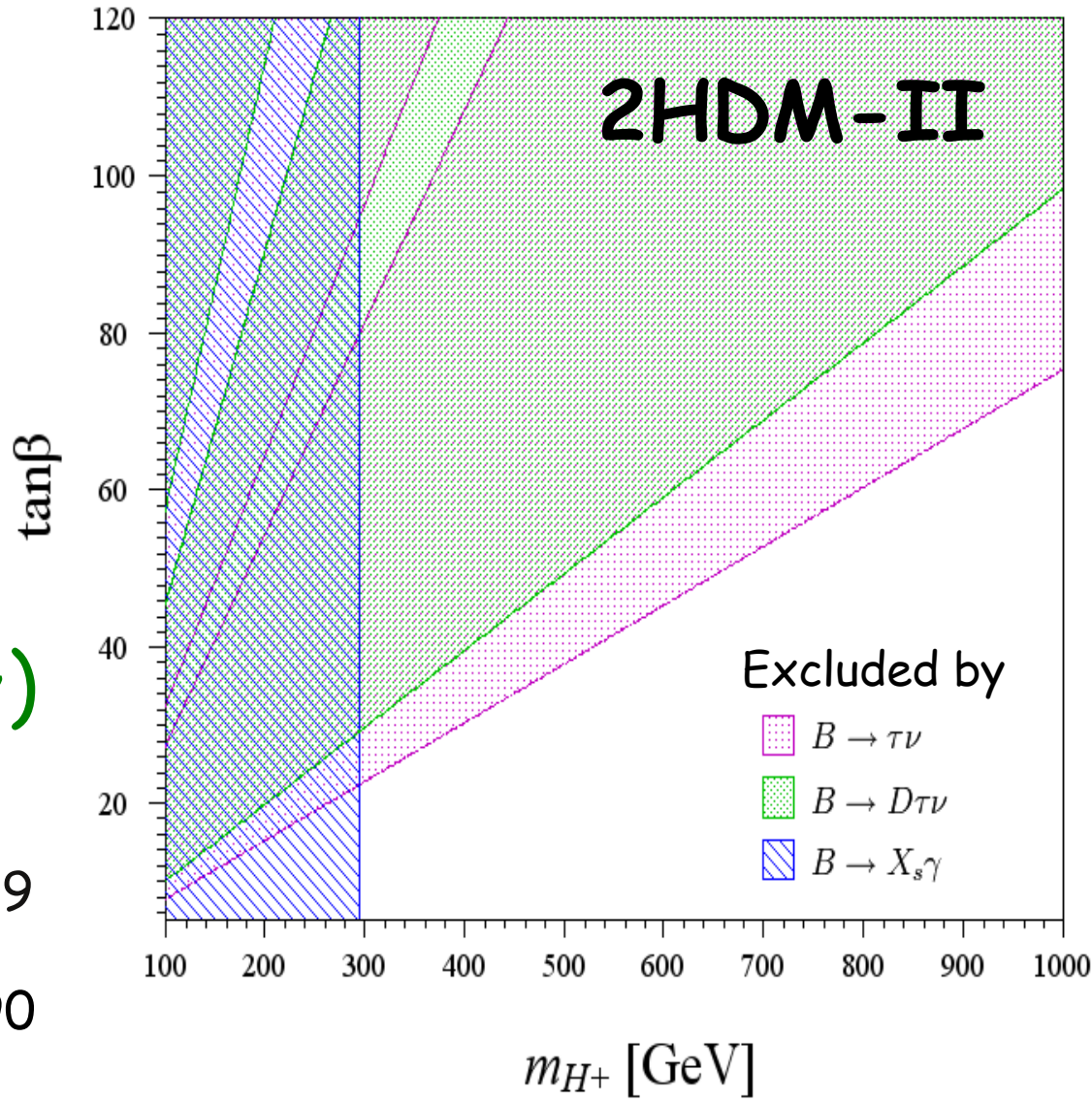
BR($B \to D\tau\nu$)/BR($B \to D\ell\nu$)

measurement: (49±10)%

T. Iijima, LP09

calculation from

Kamenik, Mescia, arXiv:0802.3790



Combined result: "fine-tuned" region excluded and

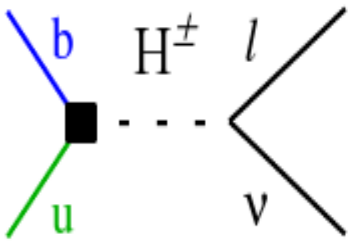
$$\tan\beta < 7.5 \frac{m_{H+}}{100\,\text{GeV}}$$

MFV-MSSM at large tanβ

Isidori, Paradisi, hep-ph/0605012

* MFV MSSM with TeV sparticles
* large tanβ

All flavour effects in:

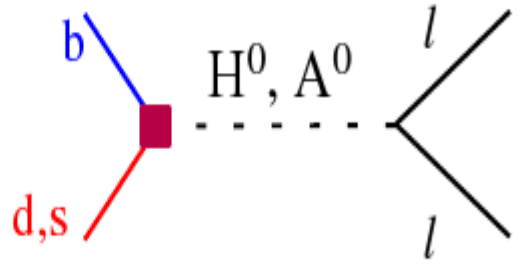


$B^{\pm} \to l^{\pm}\nu$

$\propto \tan^4\beta$

~(10-50)%

suppression

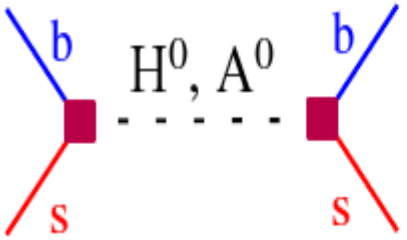


$B_{s,d} \to l^+ l^-$

$\propto \tan^6\beta$

up to 100 ×

enhancement

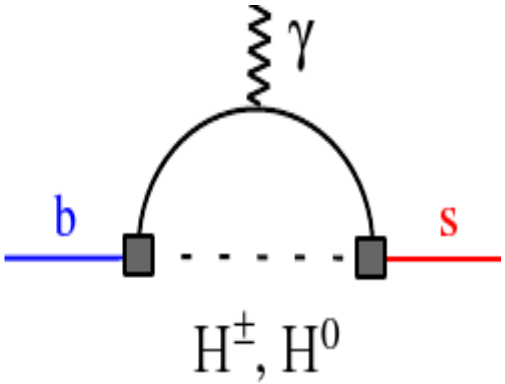


ΔM_{B_s}

$\propto m_s \tan^2\beta$

~(0-20)%

suppression



$B \to X_s \gamma$

$\propto \tan^2\beta,$
$\tan^3\beta$

~(0-50)%

enhancement

for M_H=0.5 TeV & tanβ=50

Additional constraints:

* $BR(B_s \to \mu\mu) < 5.8 \times 10^{-8}$ @95% C.L.
* $\Delta m_s = (17.77 \pm 0.12)\ ps^{-1}$

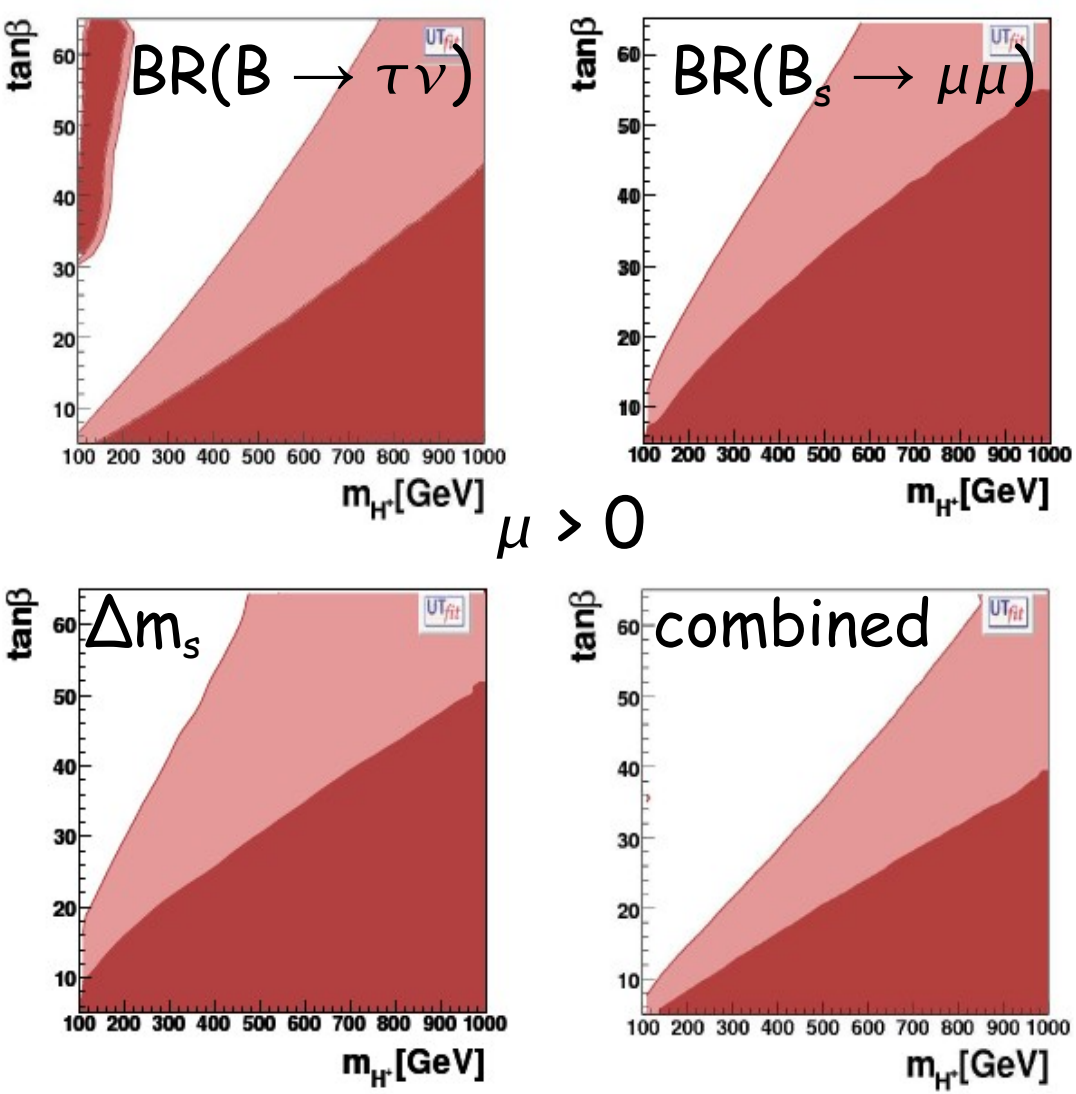
* additional constraints exclude the "fine-tuned" region at very large tanβ

* bound similar to 2HDM

$$\tan\beta < 7.3 m_{H^+}/(100\ \text{GeV})$$

In addition:

$BR(B_s \to \mu\mu) < 19 \times 10^{-9}$ (5xSM) @95% prob.



The case $\mu < 0$ is similar…

$$R_{B\tau\nu} = \left[1 - \left(\frac{m_B^2}{m_{H^\pm}^2}\right) \frac{\tan^2\beta}{(1+\epsilon_0 \tan\beta)}\right]^2$$

$$\epsilon_0 = -\frac{2\alpha_s \mu}{3\pi M_{\tilde{g}}} H_2\left(\frac{M_{\tilde{q}_L}^2}{M_{\tilde{g}}^2}, \frac{M_{\tilde{d}_R}^2}{M_{\tilde{g}}^2}\right)$$

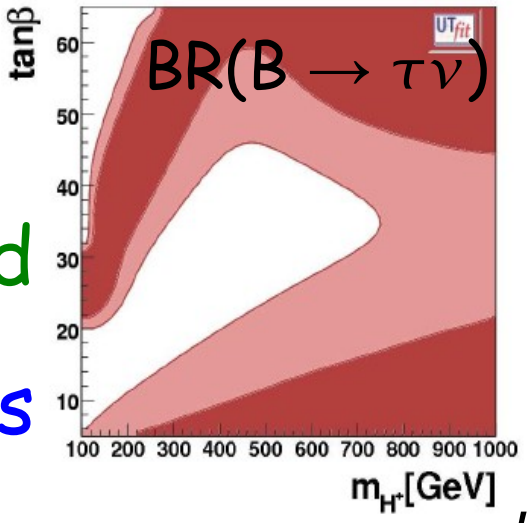
* for $\mu < 0$ the region of positive interference at very large tanβ is enlarged

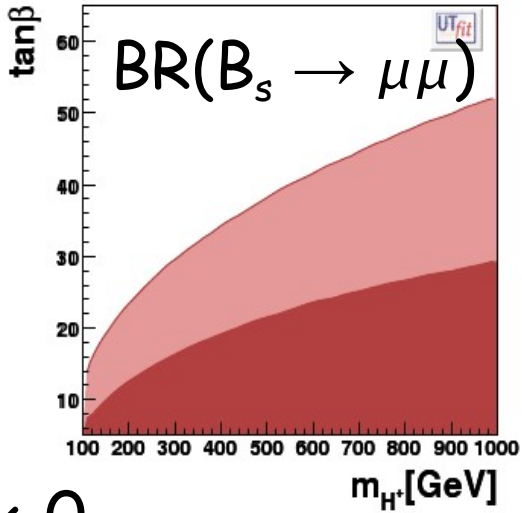
* yet the combined bound is stronger than for $\mu < 0$

tanβ < 38 @95% prob.

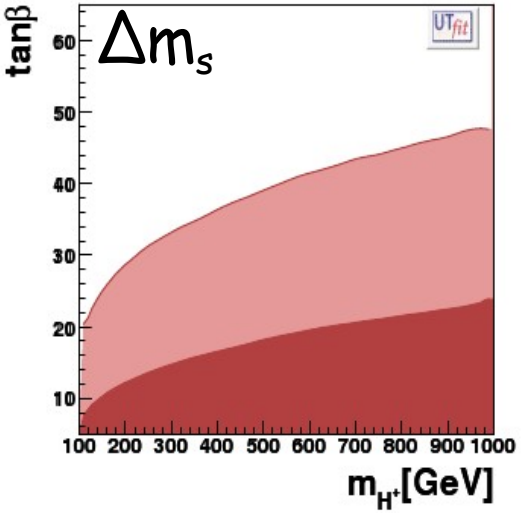
In this case:

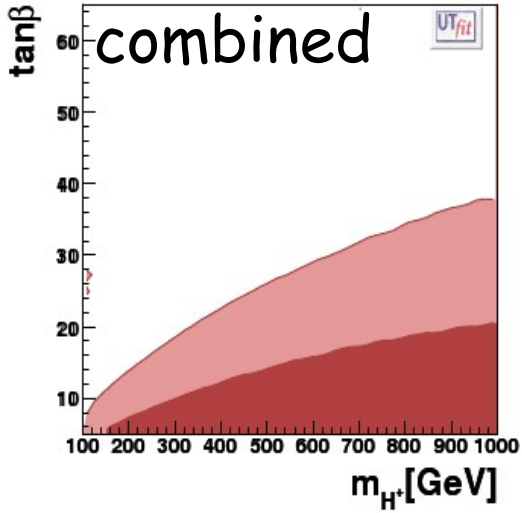
BR($B_s \to \mu\mu$) < 12x10^{-9} (3xSM) @95% prob.





$\mu < 0$





Conclusions

The prediction of $\overline{BR}(B \to \tau\nu)$ can be improved using the UT analysis: deviation is 2.5σ for SM-like $\Delta F=2$ transitions, 2.2σ for MFV and 1.8σ otherwise

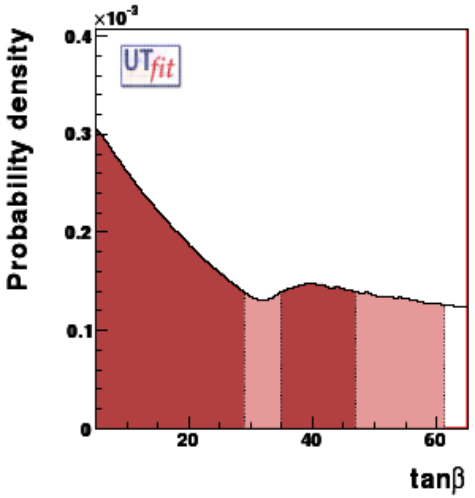
The $BR(B \to \tau\nu)$ and $\sin 2\beta$ "tensions" cannot be simultaneously eased changing the value of $|V_{ub}|$

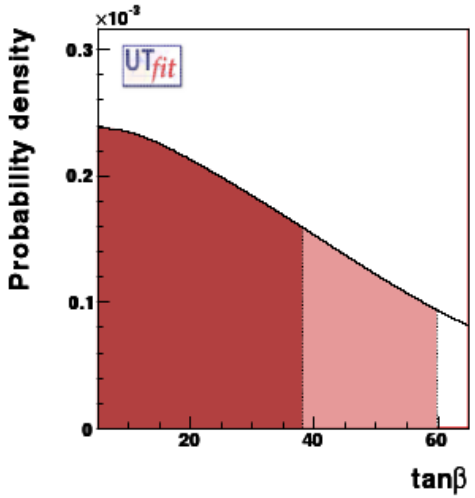
NP models predicting a suppression of $BR(B \to \tau\nu)$ are disfavoured by present data

Very large values of $\tan\beta$ for sub-TeV Higgs masses are excluded in 2HDM-II and MFV-MSSM

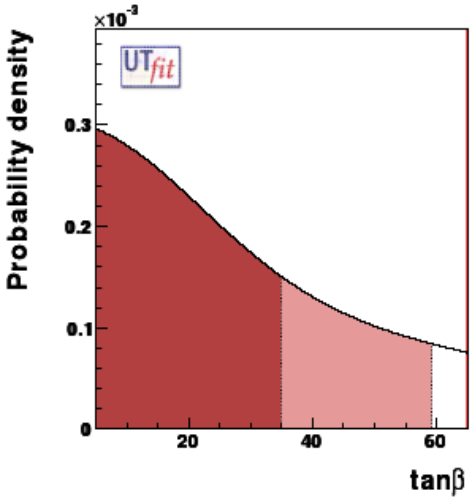
MFV-MSSM $BR(B_s \to \mu^+\mu^-) < 19 \times 10^{-9}$ @95% prob.

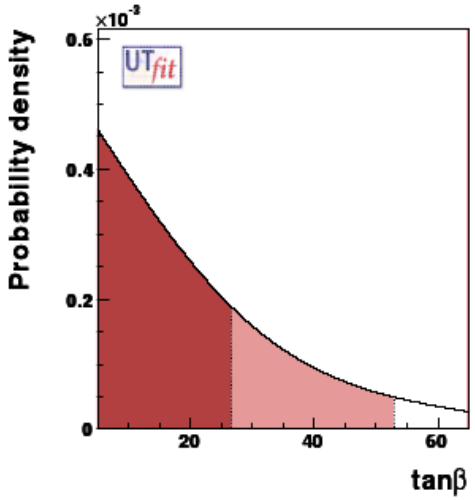
Backup slides

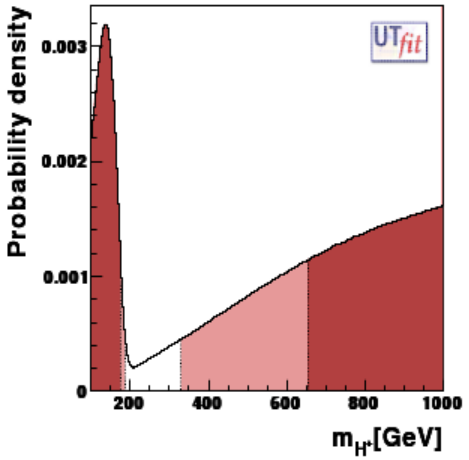


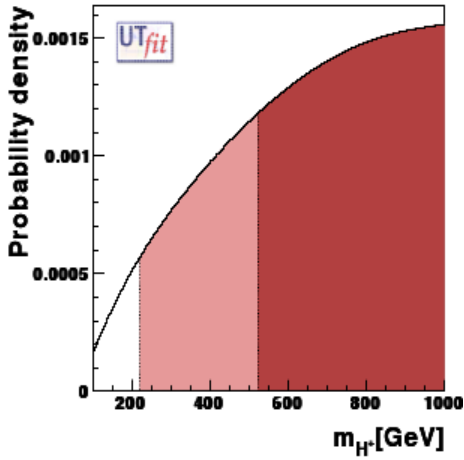


$\mu > 0$







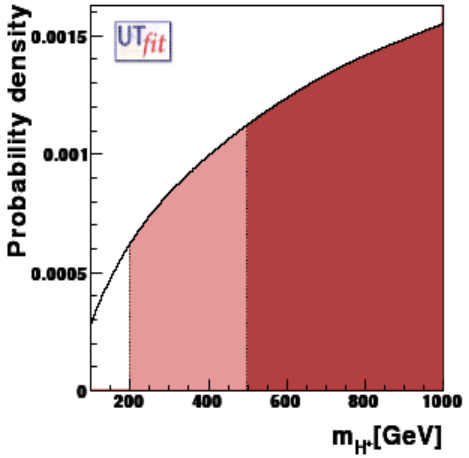


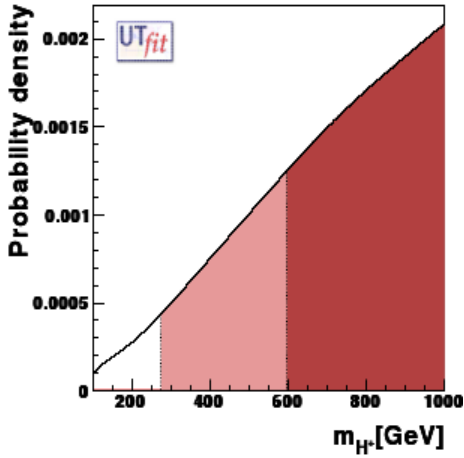
$$\mu = [-950, -450] \cup [450, 950] \text{ GeV}$$

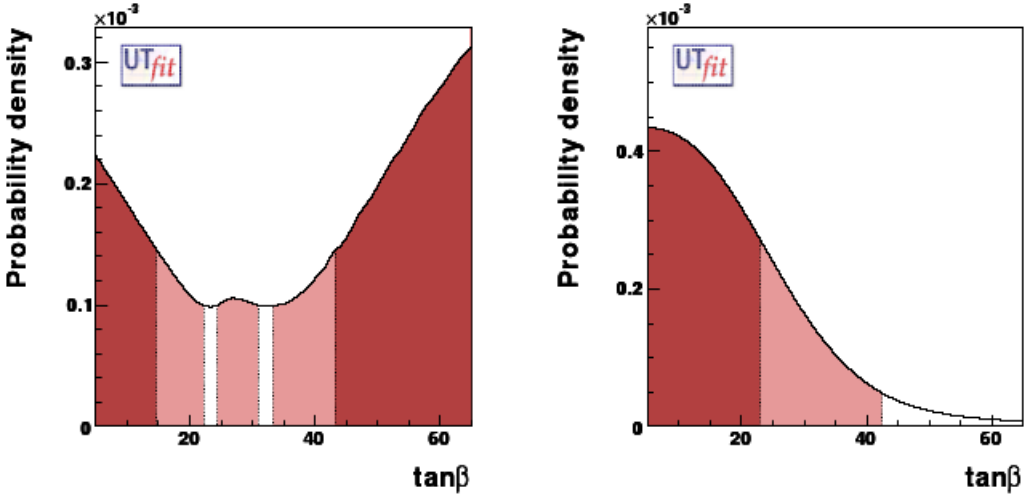
$$\tan\beta = [5, 65], \; m_{H^+} = [100, 1000] \text{ GeV}$$

$$m_{\tilde{q}} = [400, 1000] \text{ GeV}, \; m_{\tilde{g}} = [400, 1000] \text{ GeV}$$

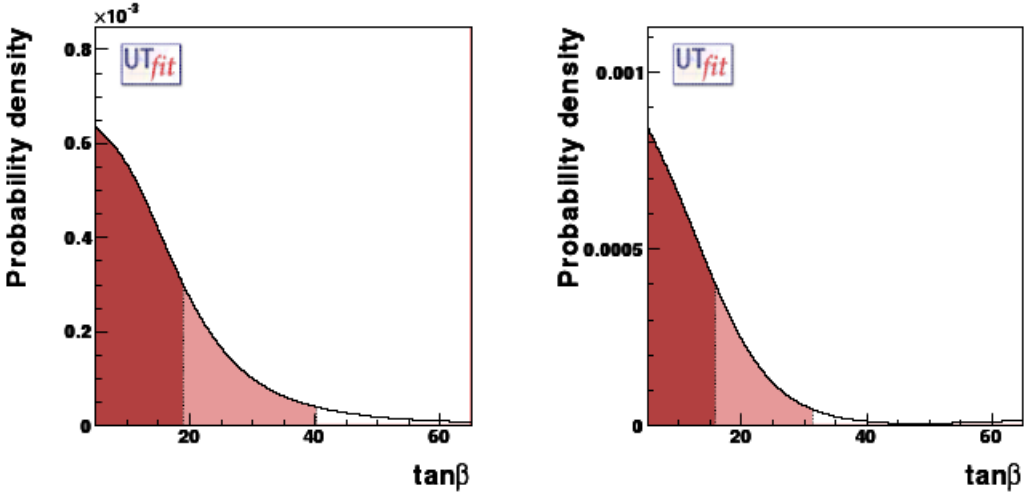
$$A_u = [-3, 3] \text{ TeV}$$

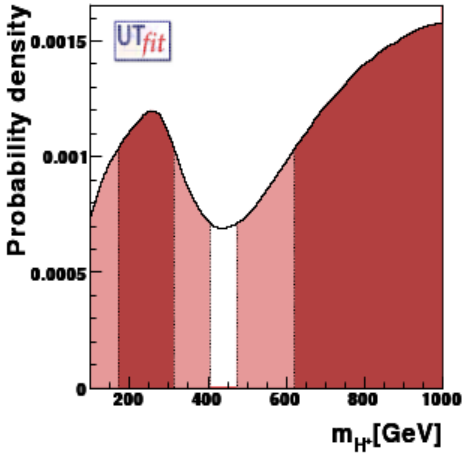


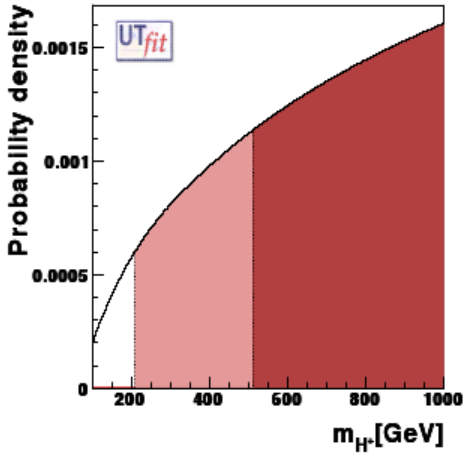




$\mu < 0$







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