$B_s \to \mu\mu$ and $B \to \tau\nu$ in comparison

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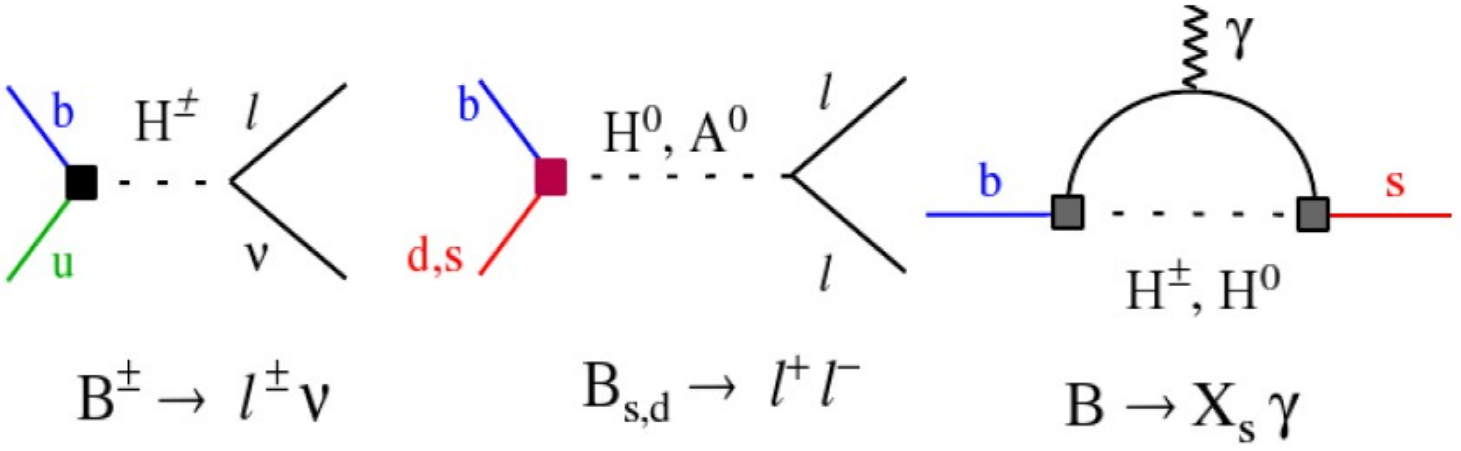
Goal of the presentation

MFV at large tanβ

Main flavor effects:



Other possible relevant effects:

$K \rightarrow \mu\nu$
mh
$H \rightarrow \tau\tau$
g-2
susy direct search

The measure of two of them will be soon improved:

1) LHCB 10 fb^{-1}: SM value with 20% error

2) SuperB 75 ab^{-1}: 5% error

Observing the SM in $B \rightarrow \mu\,\mu$ is it possible to observe deviations in $B \rightarrow \tau\,\nu$?

Which is the parameter space allowed after $B \rightarrow \mu\,\mu$ accessible throught $B \rightarrow \tau\,\nu$?

Theories and analysis

2HDM-II

- 5 physical higgs: h, H^0, A, H^{+-}
- $U(1)_{PQ}$ symmetry: Hu(d) couples only with u(d) (otherwise too large FCNC with genir couplings)

MSSM-MFV

- NHUM: m and mH free parameters
- First order in MFV → universal common soft terms
- Broken $U(1)_{PQ}$ → loop effects in B processes

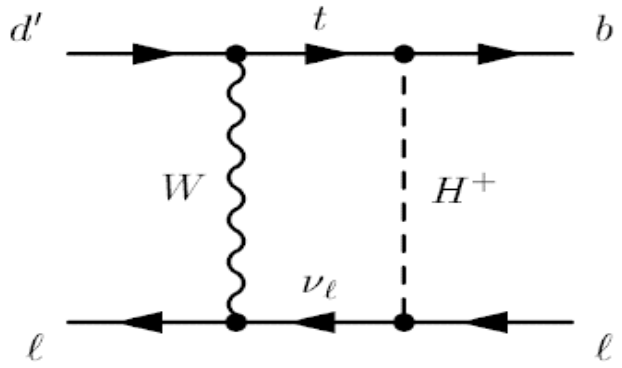
Preliminary Analysis

- Leading tanβ effects (usually dominant)
- No effects from non-universal soft terms (usually subdominant)
- Flavor constraints: $B \to \tau\nu$ (present+future), $B \to \mu\mu$ (present+future), $B \to X_s \gamma$, $K \to \mu\nu$
- Higgs constraints (only for MSSM): mh, $h \to \tau\,\tau$ (not jet)
- Addictional contraints: g-2

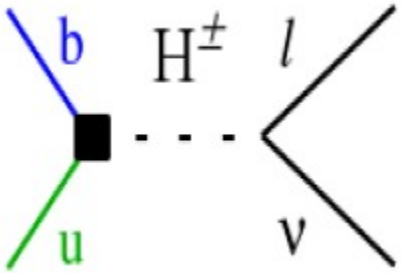
2HDM vs MSSM

2HDM-II

H^+ → new source of charged FC current at tree level



tanβ⁴

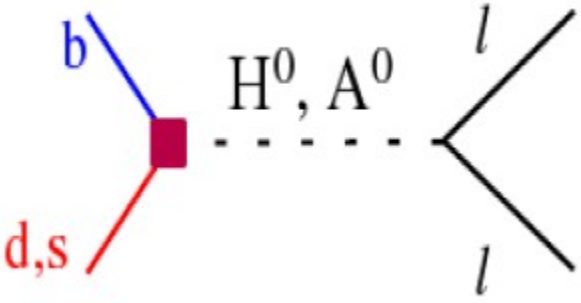


tanβ⁴

MSSM-MFV

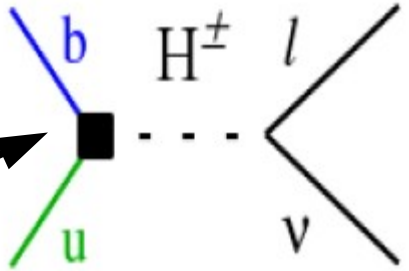
Addictional contribution from $U(1)_{PQ}$ breaking → new source of FCNC at loop level

→ proportional to susy parameters



tanβ⁶

vertex corrections



tanβ⁴

$B \to \tau\nu$

SM and experimental

- Today 2σ disagreement between SM and exp → enhancement

$$\mathcal{B}(B \to \tau\nu)^{\rm SM} = (0.79 \pm 0.07) \times 10^{-4} \ [\text{UTfit}] \ , \qquad \mathcal{B}(B \to \tau\nu)^{\rm exp} = (1.64 \pm 0.34) \times 10^{-4}$$
$$\mathcal{B}(B \to \tau\nu)^{\rm SM} = (0.76 \, {}^{+\,0.10}_{-\,0.06}) \times 10^{-4} \ [\text{CKMfit}]$$

- We take conservative approach → $R_{B\tau\nu} \in [0.51, 2.51]$

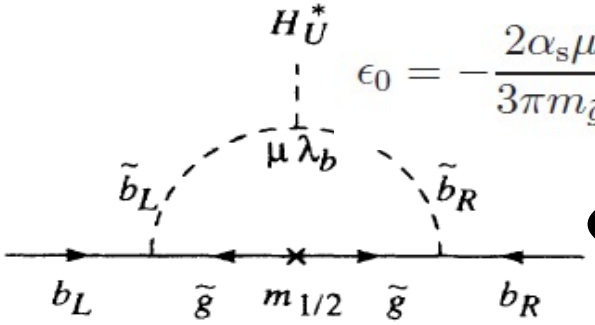
2HDM-II

$$R_{B\tau\nu} = \left[1 - \frac{m_B^2}{m_H^2} \tan^2\beta\right]^2$$

suppression

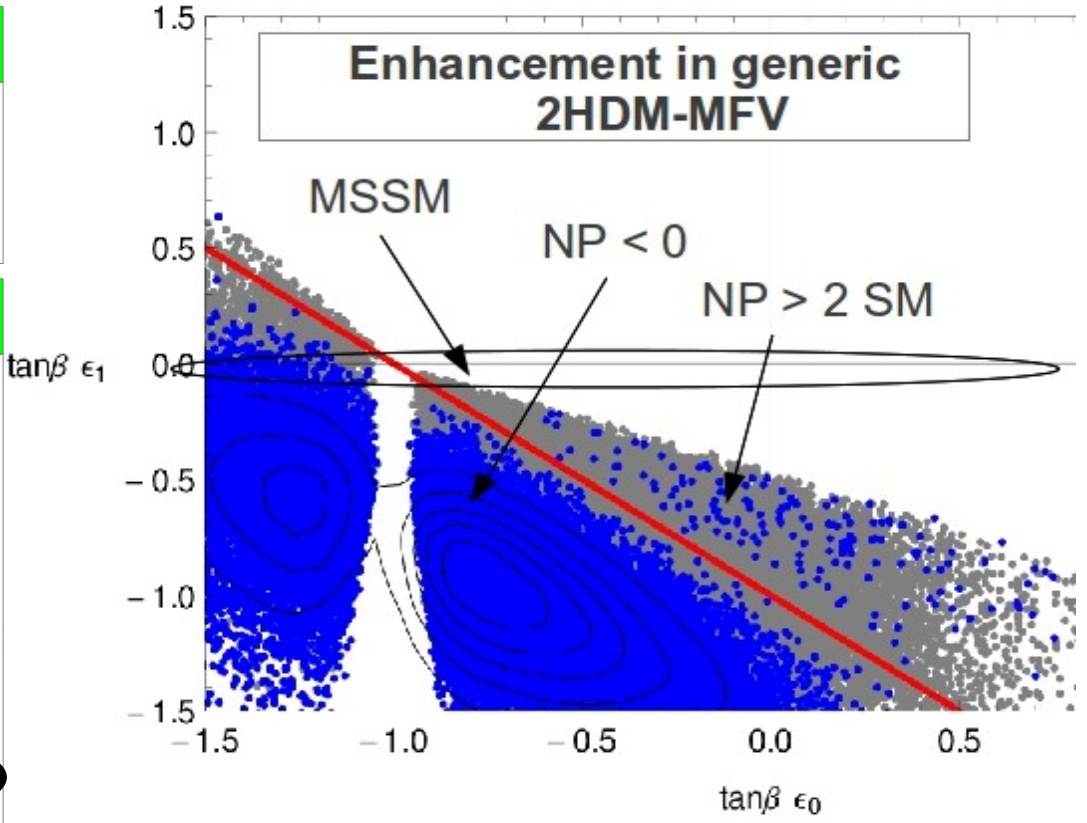
MSSM-MFV

$$R_{B\tau\nu} = \left[1 - \frac{m_B^2}{m_H^2} \frac{\tan^2\beta}{1 + \epsilon_0 \tan\beta}\right]^2$$



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

suppression?



GB, Isidori 1107.1216

$B \to \tau\nu$

Lattice improvements: Vub, fB

SuperB δBR/BR = 5%

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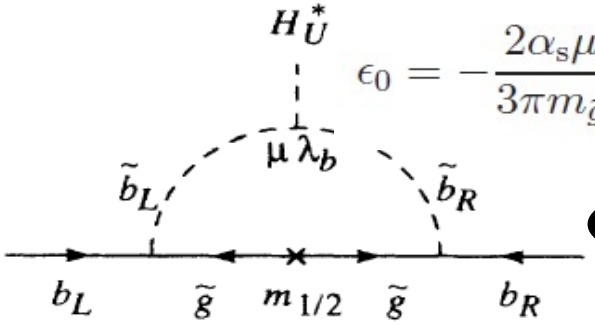

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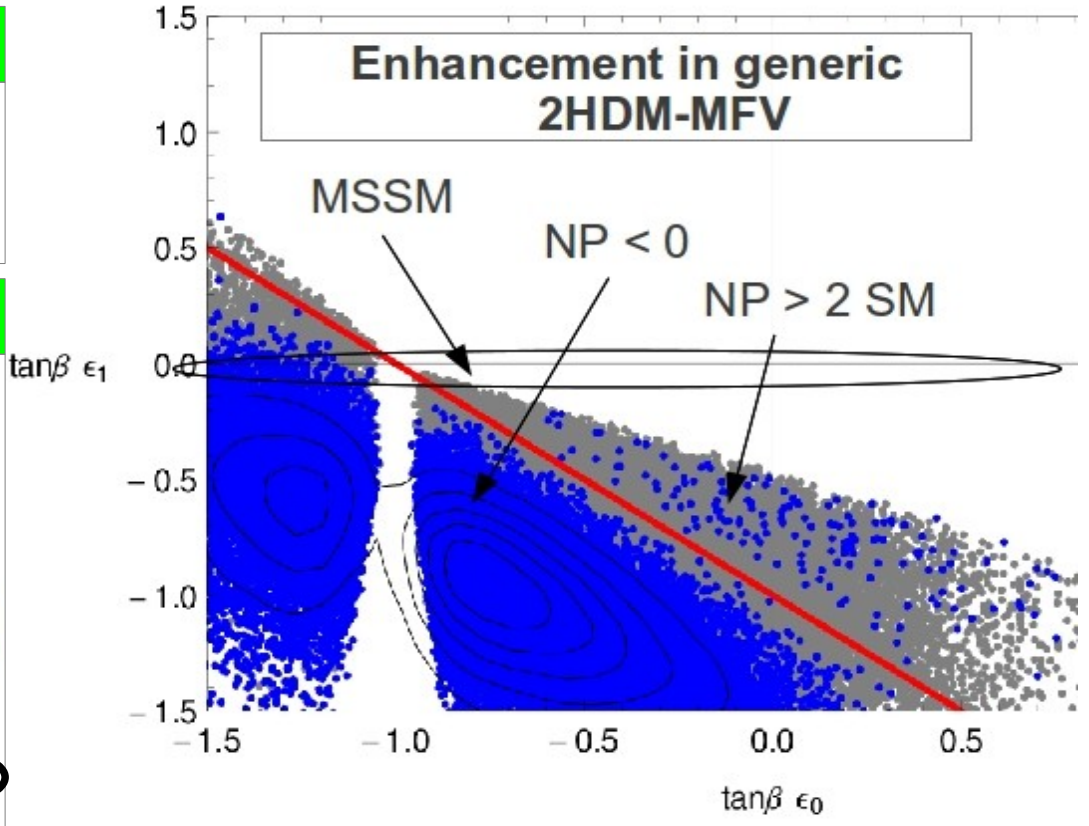


GB, Isidori 1107.1216

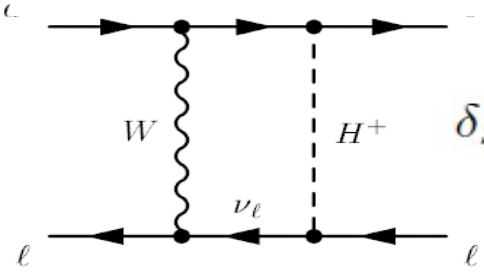
Bs → μ μ

SM and experimental

SM: $\mathcal{B}(B_s \to \mu^+\mu^-)^{\rm SM} = (3.1 \pm 0.2) \times 10^{-9}$ LHCb: $BR(B_s \to \mu\mu) < 4.5 \times 10^{-9}$

2HDM-II

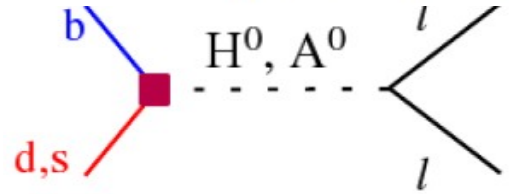
$$R_{B\mu\mu} = (1+\delta_S)^2 + \left(1 - \frac{4m_\mu^2}{M_B^2}\right)\delta_S^2$$

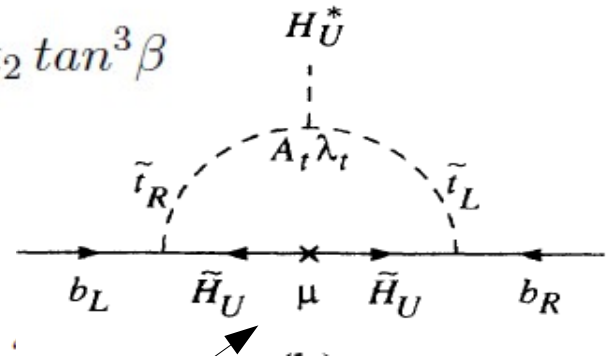


$$\delta_S = -\frac{m_B^2\, log\,(M_H^2/m_t^2)}{8\, M_W^2\, (M_H^2/m_t^2 - 1)} tan^2\beta$$

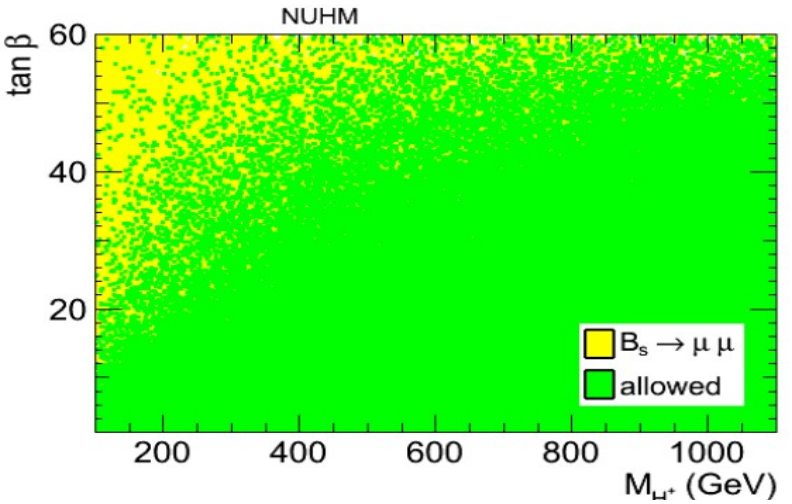
MSSM-MFV

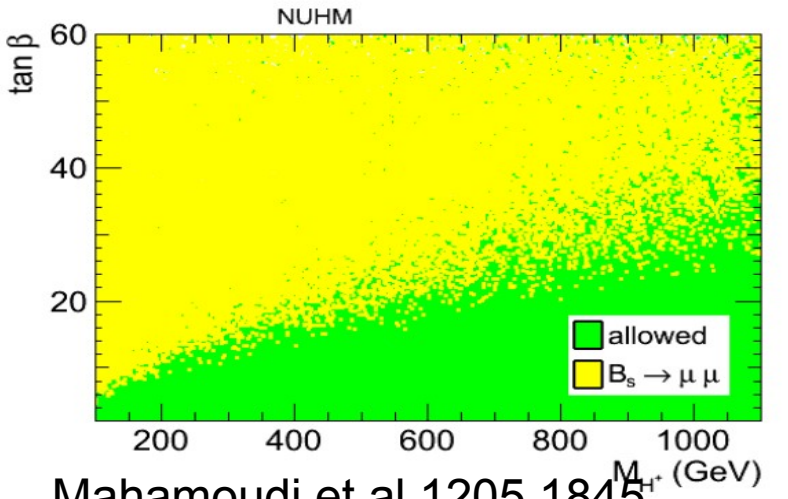
$$\delta_S = \frac{\pi sin^2\theta_W M_B^2}{\alpha M_H^2\,(1+\epsilon_0 tan\beta)^2}\epsilon_2\, tan^3\beta$$





$$\epsilon_2 = \frac{1}{16\pi^2}\frac{\mu A}{m_{\tilde{q}_L}^2} H_2\left(\frac{\mu^2}{m_{\tilde{q}_L}^2}, \frac{m_{\tilde{u}_R}^2}{m_{\tilde{q}_L}^2}\right)$$





Mahamoudi et al 1205.1845

Bs → μ μ

LHCB (10 fb^{-1}): δBR/BR = 20%

SM and experimental

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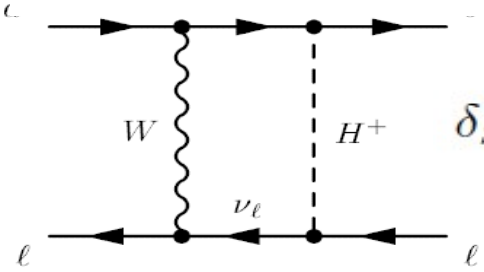

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MSSM-MFV

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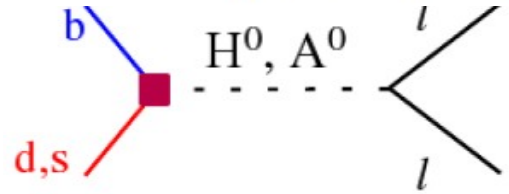

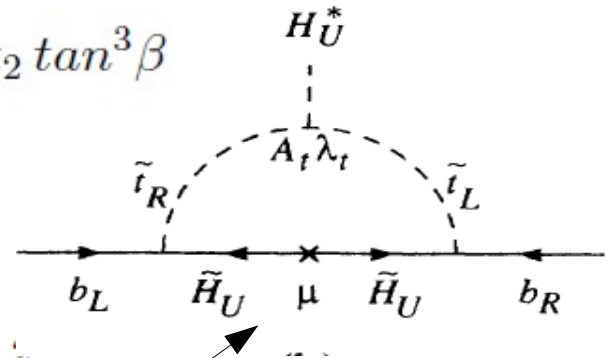

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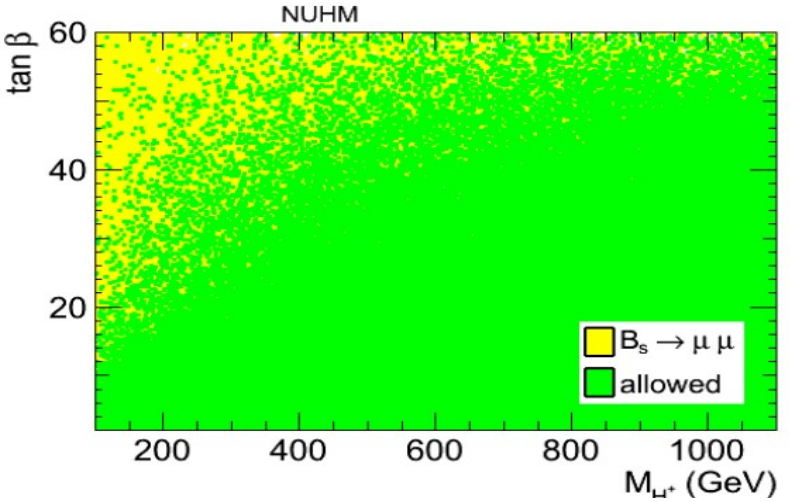
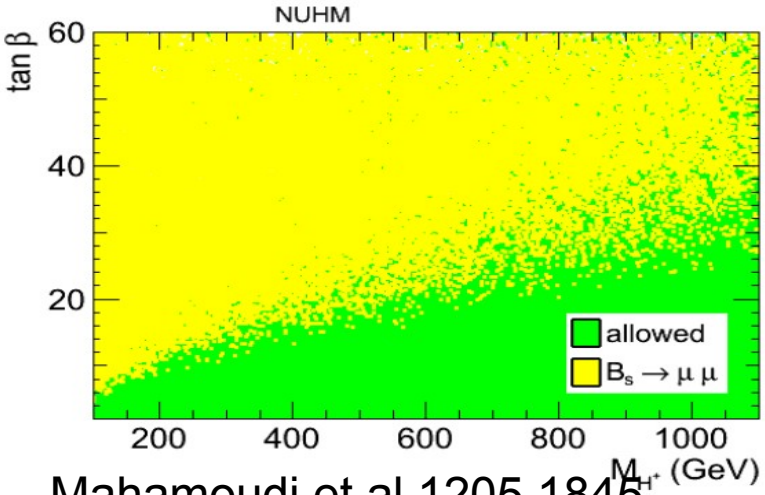
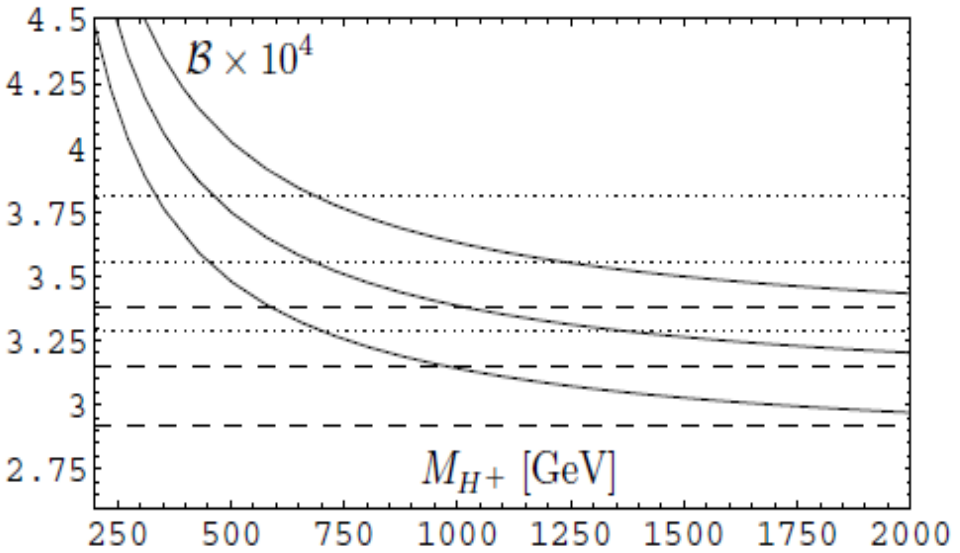




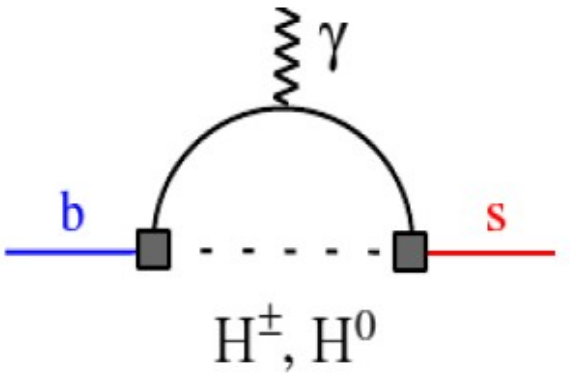
Mahamoudi et al 1205.1845

Other flavor constraints

B → Xs γ



2HDM → lower bound on $mH^+ > 290$ GeV
Misiak et al ('06)



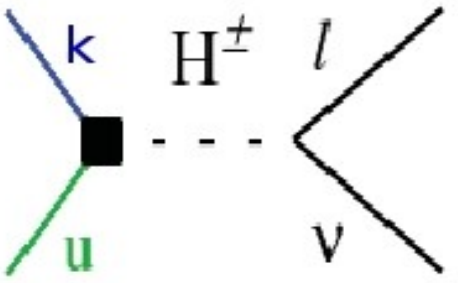
$$\delta C_7 \in (-0.14, 0.06)$$

Hurth et al ('08)

K → μ ν

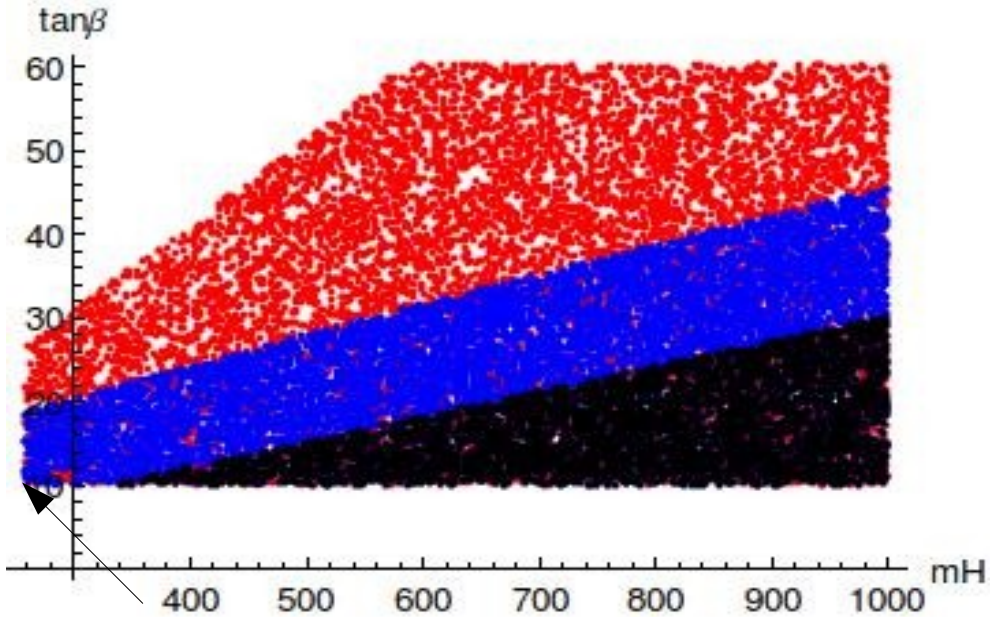
$$R_{K\mu\nu} = \left[1 - \frac{m_K^2}{m_H^2} \frac{\tan^2\beta}{1 + \epsilon_0 \tan\beta}\right]^2$$

$$R_{K\mu\nu} \in (0.98, 1.02)$$



Red: pres LHCb
Blue: LHCb 10 fb^{-1}
Black: SuperB 75 ab^{-1}

Plots 2HDM



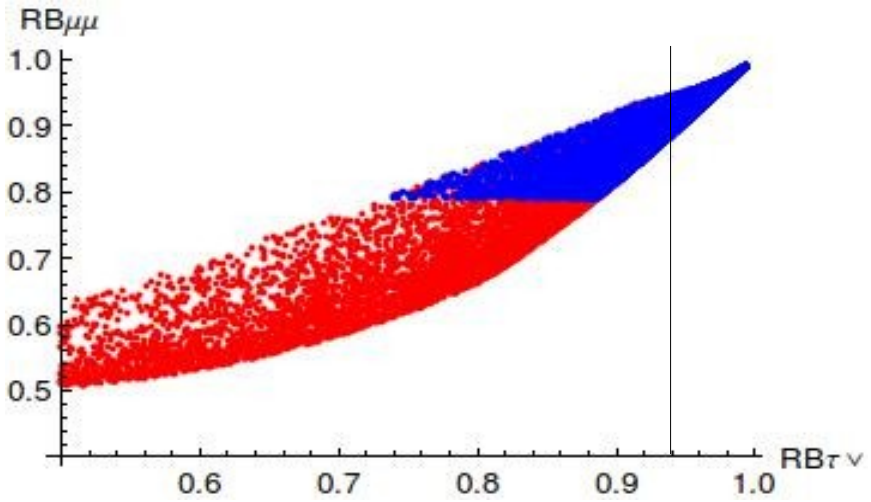
B → τ ν

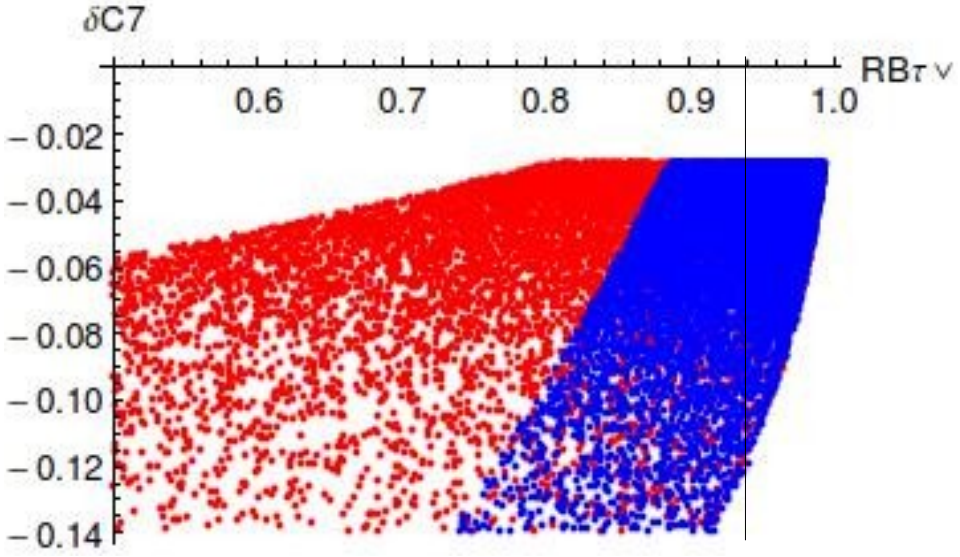
- **2σ bound:** $R_{B\tau\nu} \in [0.51, 2.51]$
- **Only suppression: NP > 2 SM excluded by K → μν and B → Xs γ**

$$R_{B\tau\nu} = \left[1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right]^2$$

- **Possible large effects: after LHCb 10 fb^{-1} even at 20 %**

lower bound from B → Xs γ





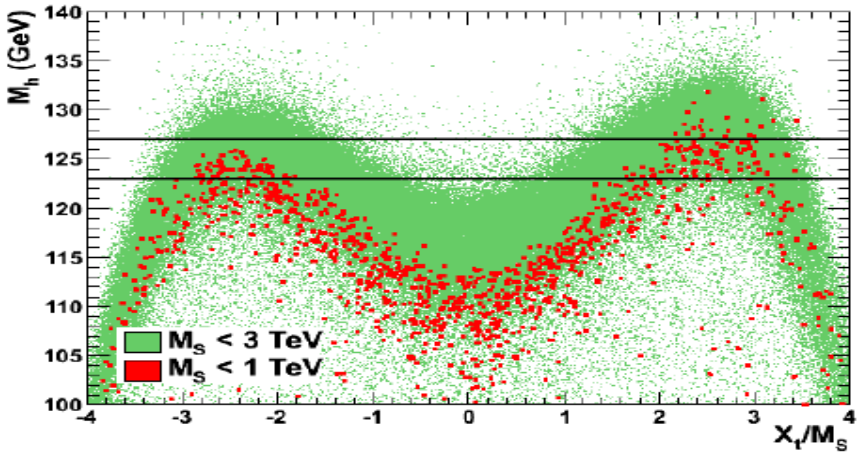
Addictional constraints in MSSM

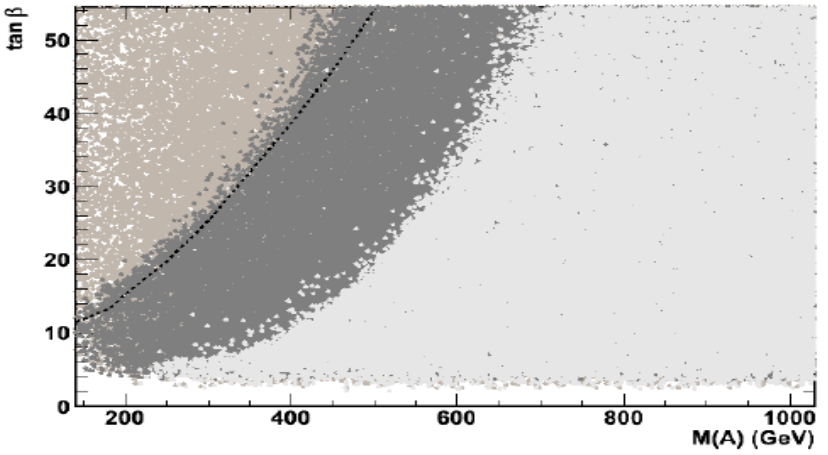
Higgs sector

- **Light higgs mass → 123<mh<127**
  - Large A term (and squark mass)
- **In MSSM at large tanβ enhanced higgs coupling to b and τ + heavy higgs contributions**
  - Model dependent analysis in mh^{max} → not jet included in our analysis

Soft sector

- **M_S > 800 GeV**
- **M_g > 600 GeV**
- **M_{Xc} > 94 GeV**





Arbey et al
1112.3028
1112.3032

Muon g-2

- **3-4σ disagreement with the SM**
  - → separate plots

$$\Delta a_\mu = a_\mu^{\mathrm{exp}} - a_\mu^{\mathrm{SM}} = (25.5 \pm 8.0) \times 10^{-10}$$

$$\Delta A_\mu = \frac{\alpha_2}{4\pi} m_\mu^2 tan\beta \frac{\mu M_2}{m_S^4} f_4(x_2, x_\mu)$$

Red: pres LHCb
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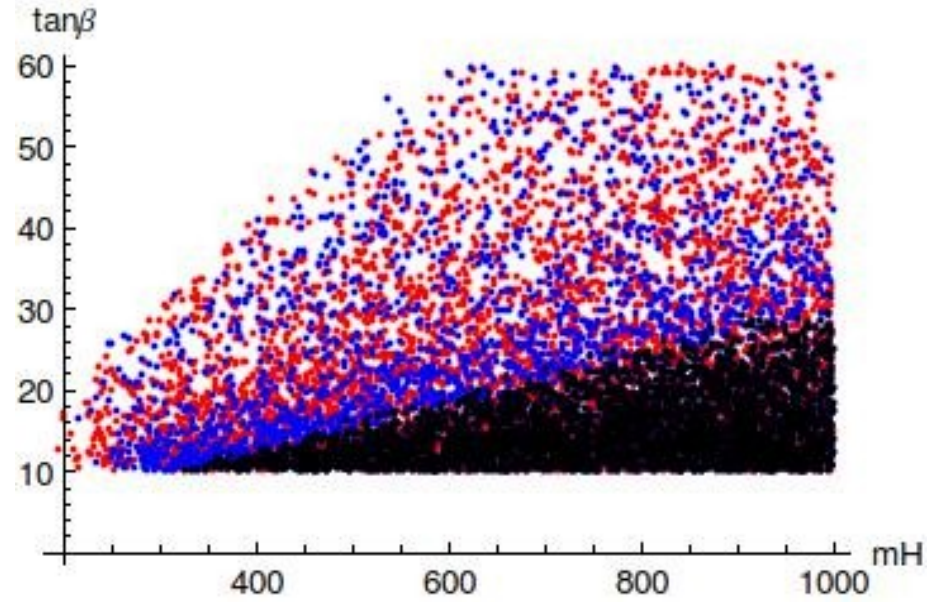
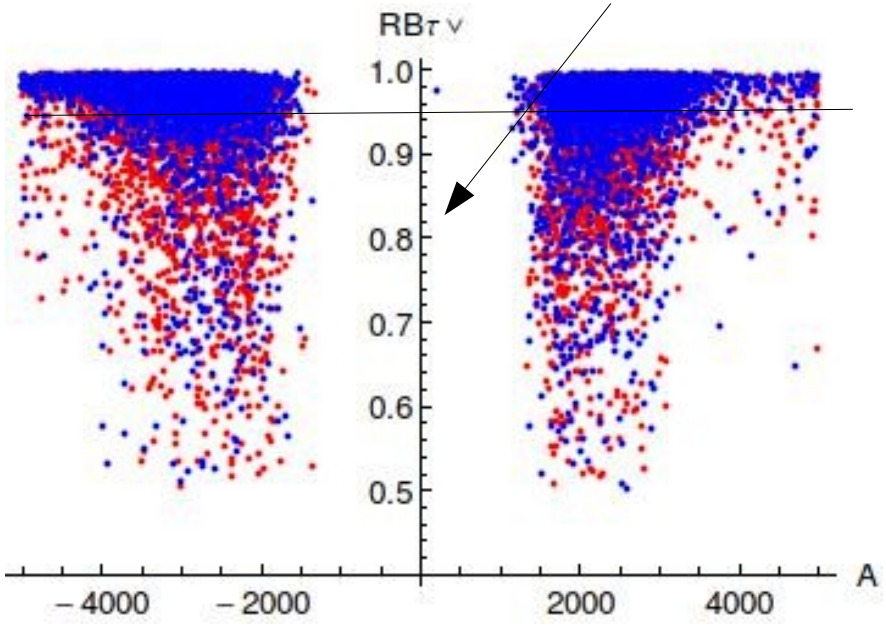
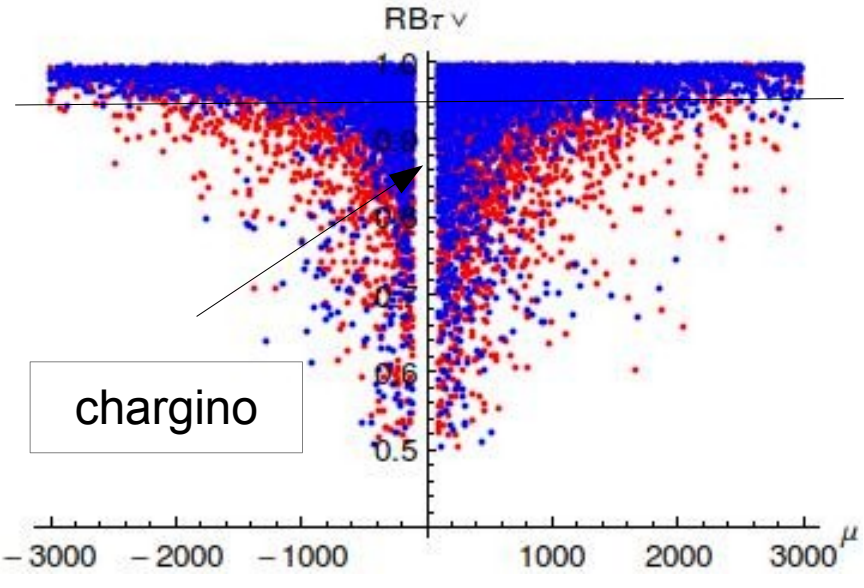
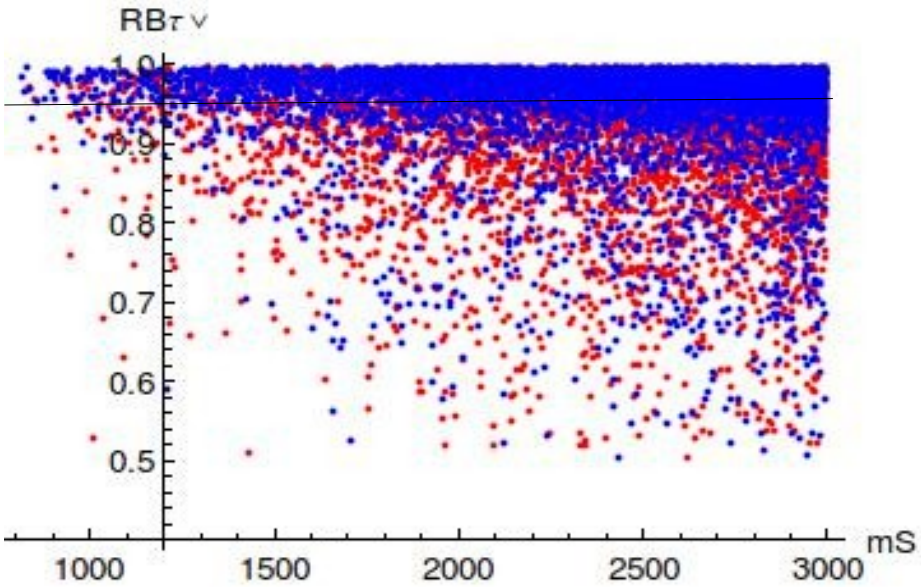
Black: SuperB 75 ab^{-1}

MSSM – no g-2









Red: pres
Blue: LH
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B → τ ν

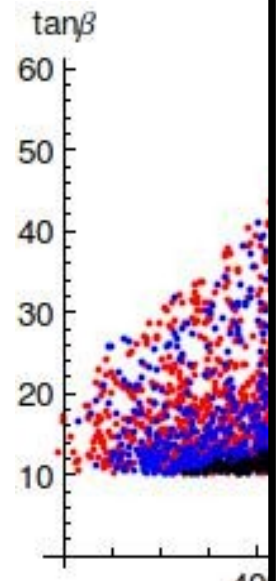
- **Only suppression**

$$R_{B\tau\nu} = \left[1 - \frac{m_B^2}{m_H^2}\frac{\tan^2\beta}{1+\epsilon_0\tan\beta}\right]^2$$

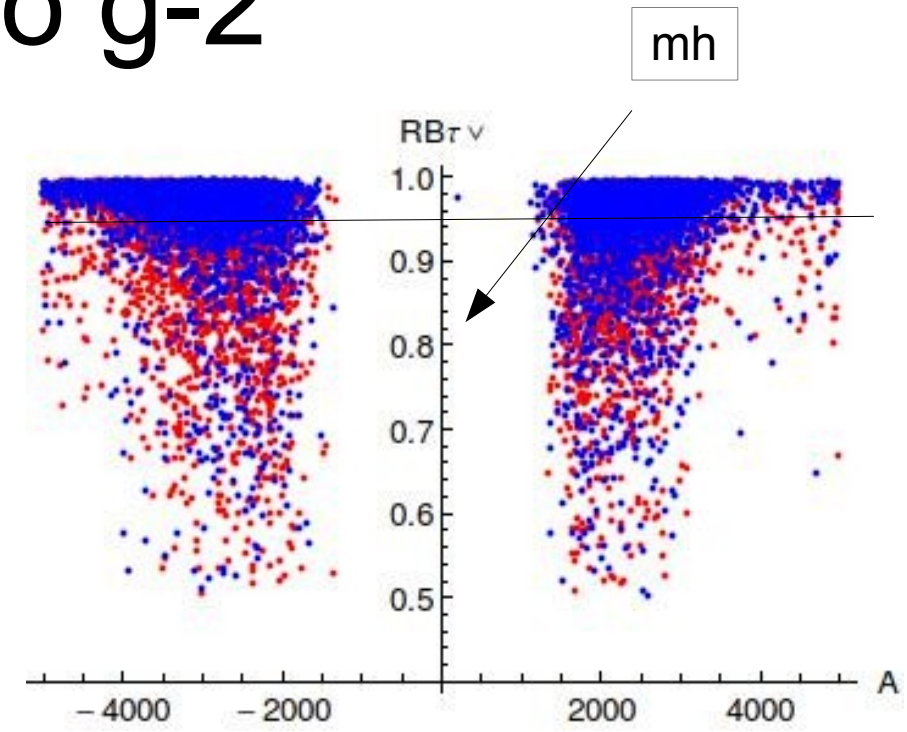
- **Interesting regions after B → μμ**
  - **A small → mh tension**
  - **M small (→ chargino bound)**
  - **Heavy squarks → 2hdm-like**

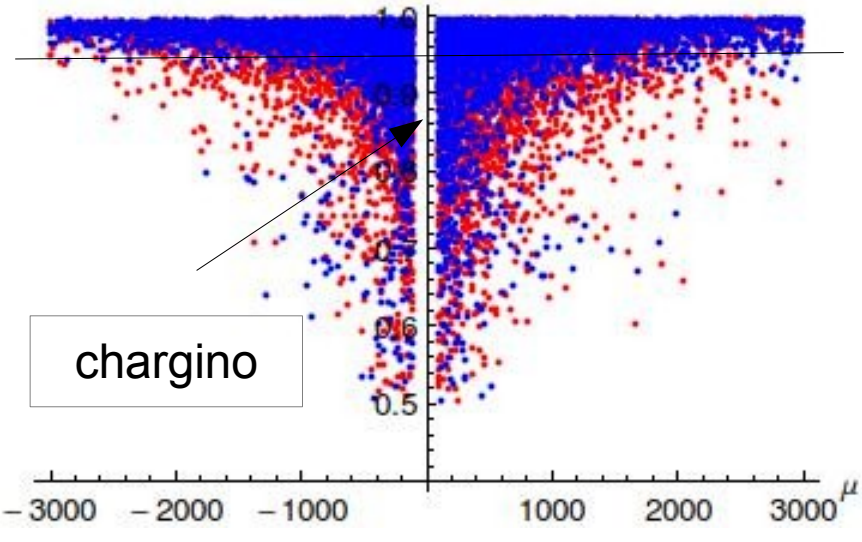
$$\delta S \propto \epsilon_2 = \frac{1}{16\pi^2}\frac{\mu A}{m^2_{\tilde{q}_L}} H_2\left(\frac{\mu^2}{m^2_{\tilde{q}_L}}, \frac{m^2_{\tilde{u}_R}}{m^2_{\tilde{q}_L}}\right)$$

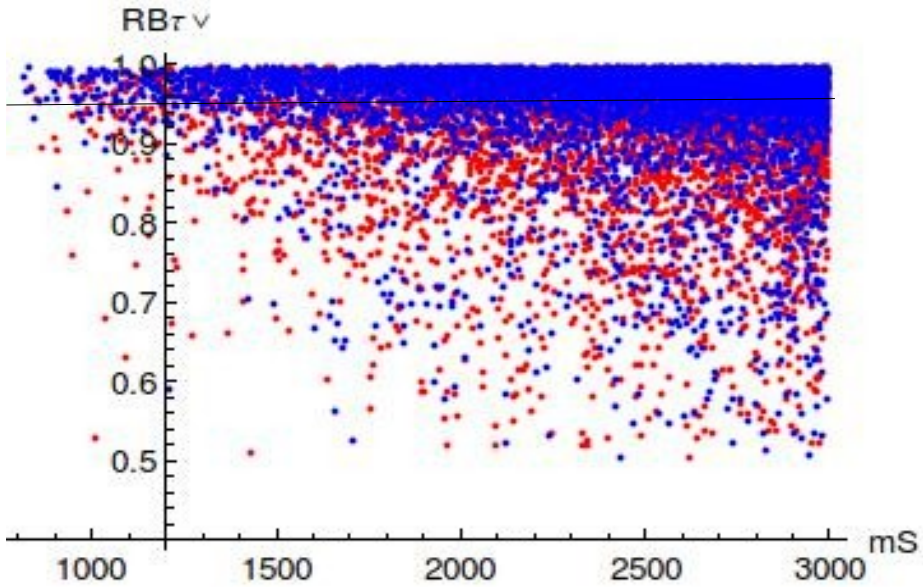
- **Possible large effects: after LHCb 10 fb^{-1} even > 20**



no g-2







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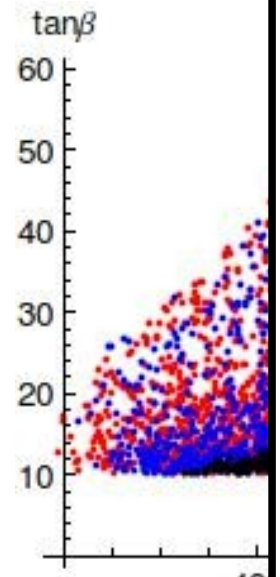
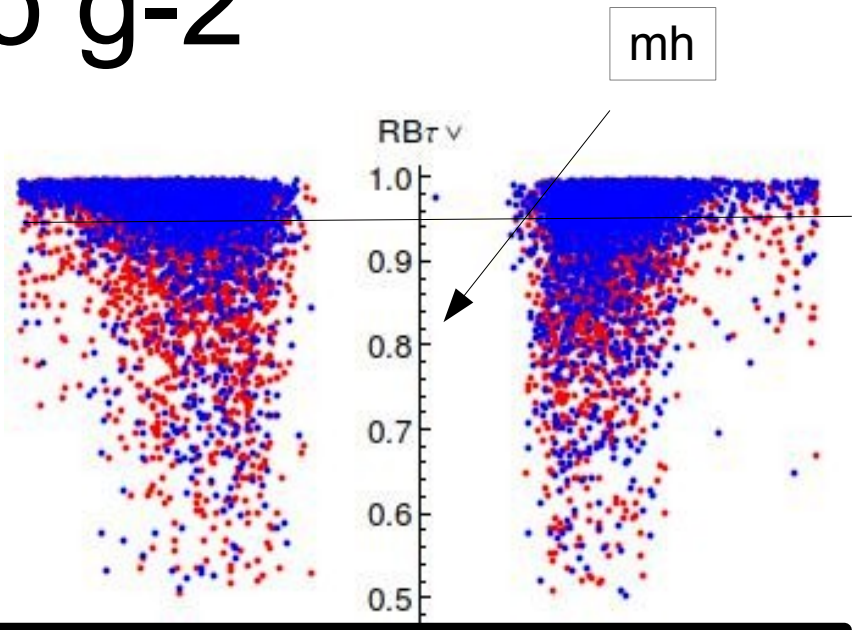
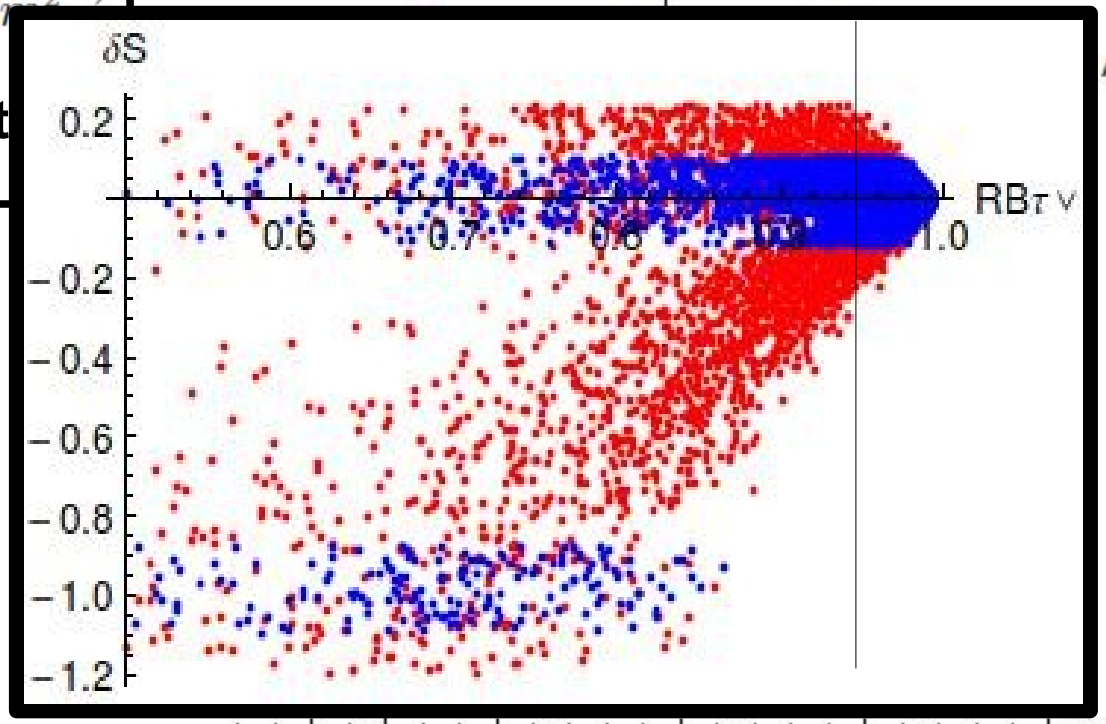
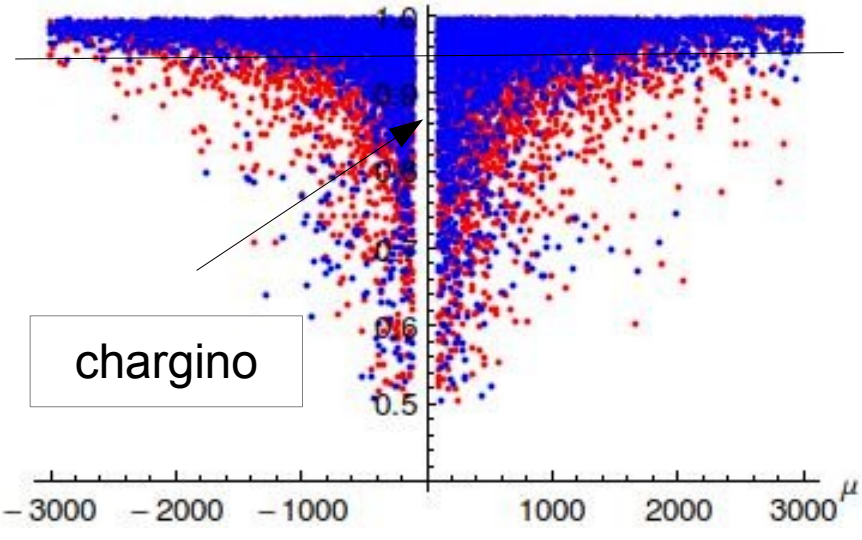
- **Possible large effects: aft**
  LHCb 10 fb^{-1} even > 20

no g-2



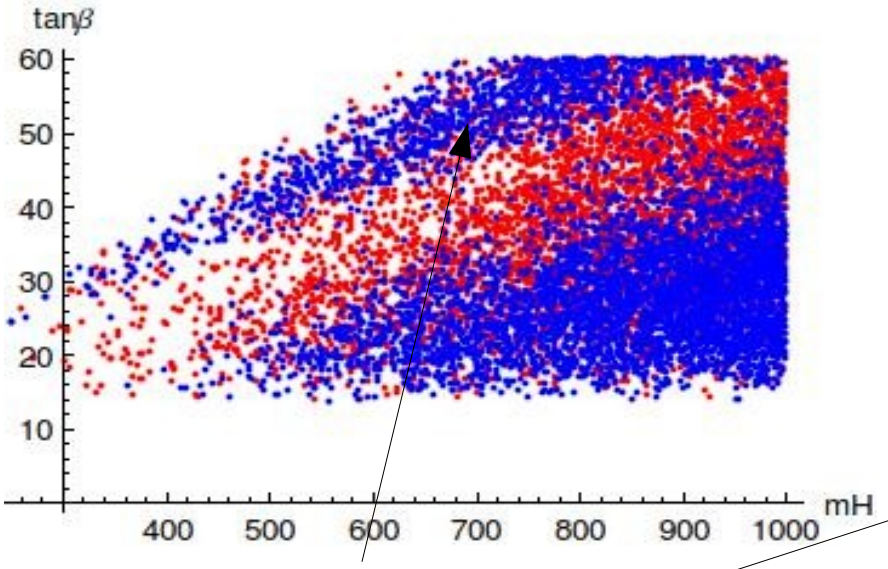


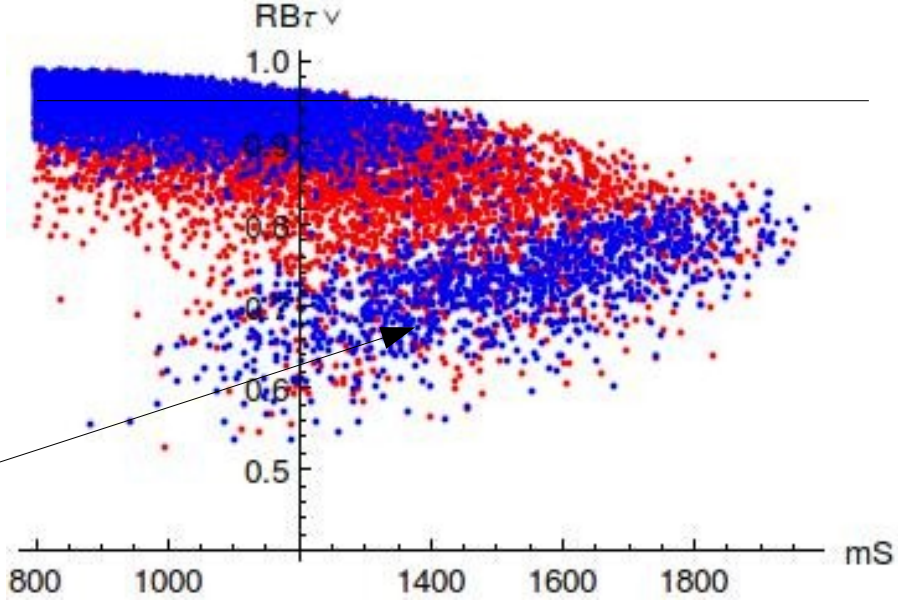




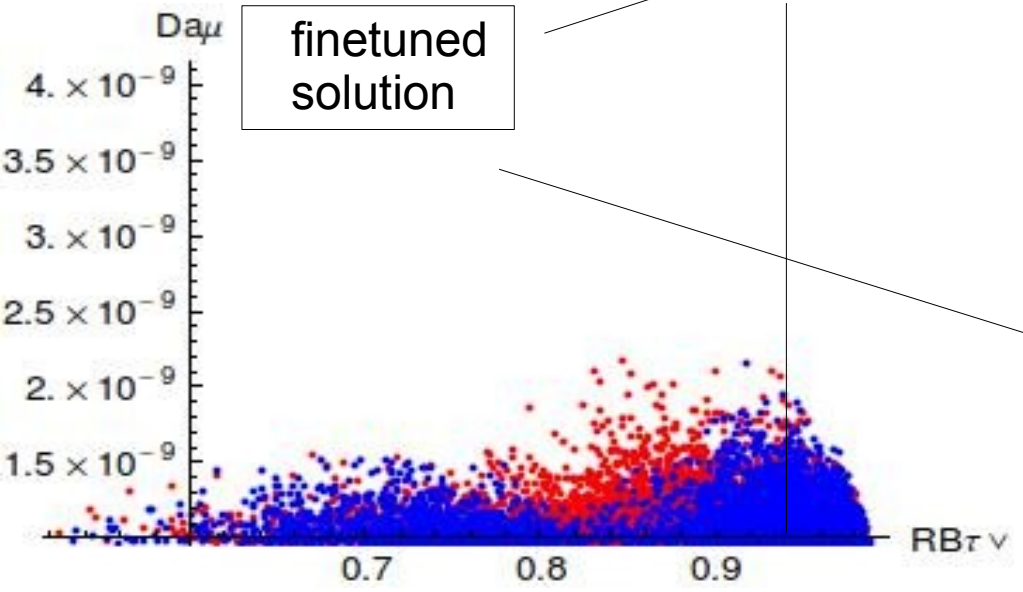
Red: pres LHCb
Blue: LHCb 10 fb^{-1}
Black: SuperB 75 ab^{-1}

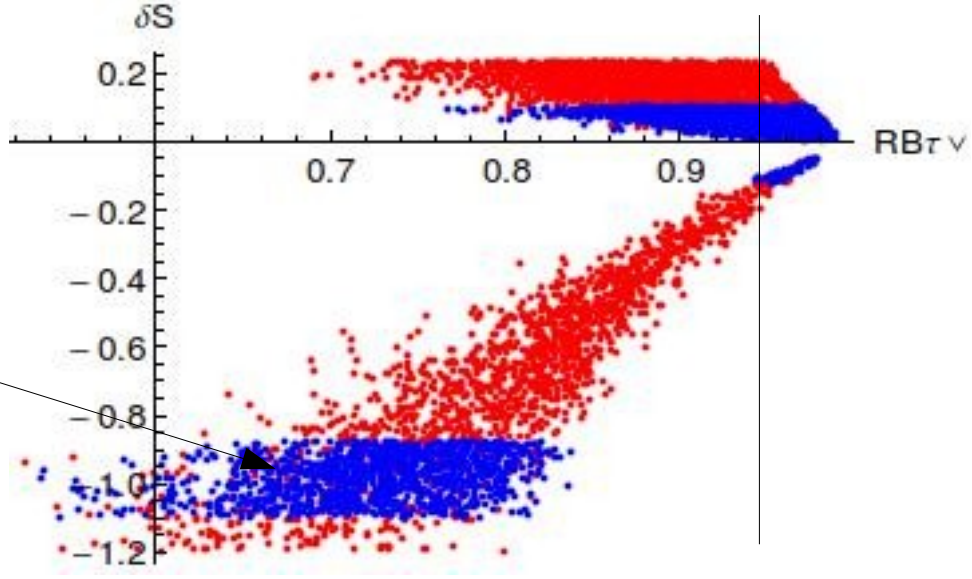
MSSM – with g-2





finetuned solution





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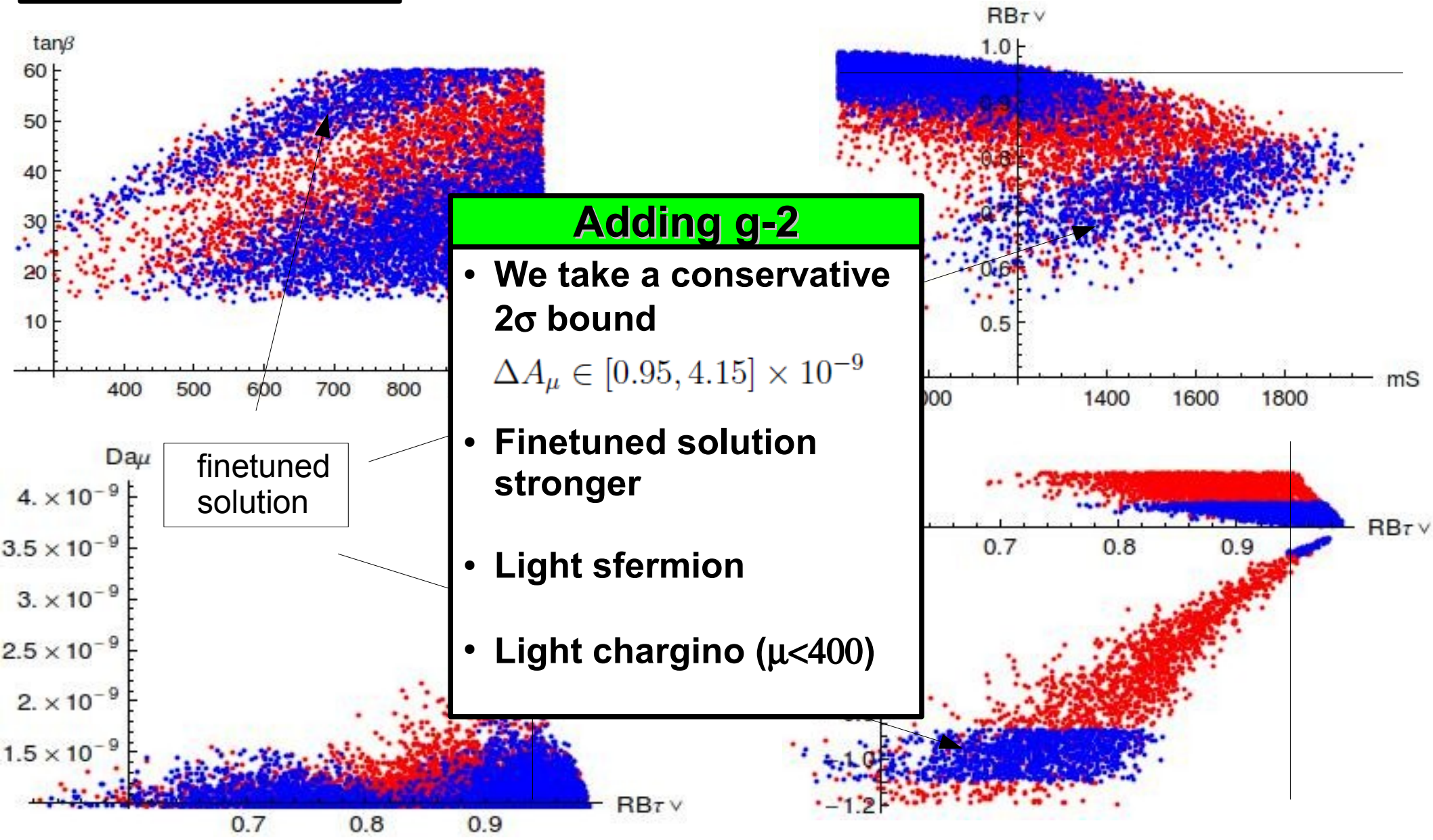

Adding g-2

- **We take a conservative 2σ bound**

$$\Delta A_\mu \in [0.95, 4.15] \times 10^{-9}$$

- **Finetuned solution stronger**
- **Light sfermion**
- **Light chargino (μ<400)**

Possible improvements

"subleading" contributions

We are looking for regions where the usually domanint tanβ enahanced effect are small

other susy contributions from beyond leading MFV usually subleading

general models (eg pMSSM)

running effects in constrained models

- Third families splitting
- Off-diagonal squarks

→ possible cancellations with tanβ enhanced contributions

Other models

Different Higgs bounds → no large A needed (eg NMSSM)

Enahncement in B → τν

Conclusions

Future prospects

- **A SM measurement of $B \to \mu\mu$ at LHCb will stronlgy constrain the large $\tan\beta$ region**
- **$B \to \tau\nu$ at SuperB will further investigate the large $\tan\beta$ region**

2HDM-II

- **detectable deviations can be found in $B \to \tau\nu$ ($B \to \mu\mu$ is loop process μ $\tan\beta^4$ while $B \to \tau\nu$ is tree level μ $\tan\beta^4$)**
- **but only a suppression is possible**

MSSM-MFV

- **$B \to \mu\mu$ can be more enhanced than in 2HDM (loop process μ $\tan\beta^6$)**
- **detectable deviations in $B \to \tau\nu$ is possible, for**
  - **μ small → chargino bound**
  - **A small → mh measurement**
  - **M_s large → 2HDM-like**
- **again only a suppression is possible**