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Correlation of $B_s \to \mu^+\mu^-$ and $(g-2)_\mu$ in Minimal Supergravity

In collaboration with:

H. Dreiner and U. Nierste, `hep-ph/0108037`

We show :

1. the decay $B_s \to \mu^+\mu^-$ is a stringent test of the mSUGRA scenario with large $\tan\beta \gtrsim 35$, in particular when correlated with $(g-2)_\mu$

2. if $(g-2)_\mu$ exceeds the Standard Model prediction by $30 \cdot 10^{-10}$, $\mathcal{B}(B_s \to \mu^+\mu^-)$ is larger by a factor of 100 than in the Standard Model and well within reach of Run-II of the Tevatron.

3. Higgs masses less than 119 GeV are correlated with an enhancement of $\mathcal{B}(B_s \to \mu^+\mu^-)$ over the SM value by two orders of magnitude.

4. $\mathcal{B}(B_s \to \mu^+\mu^-)$ and $(g-2)_\mu$: a threat or discovery for SO(10) GUTS!

- Based on Davier-Höcker calculation for the Hadronic contributions to the muon $g-2$, BNL reports a 2.6σ deviation from the SM

There are four possible interpretations of this discrepancy :

- a statistical fluctuation with 0.9% probability.
- something is "wrong" with the experiment
- something is "wrong" with the theoretical analysis of the hadronic and/or the light by light contribution to the muon anomalous magnetic moment.
- the by far most exciting possibility:

there is "New Physics" BSM

$$21.5 \times 10^{-10} \lesssim \delta a_\mu^{NP} \lesssim 63.7 \times 10^{-10} \quad @90\% \text{ CL}$$

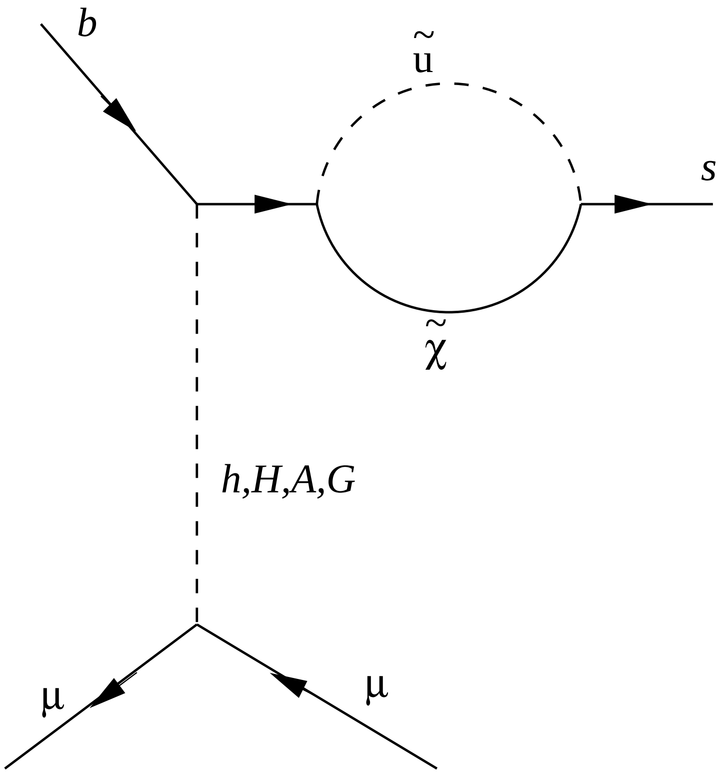
- δa_μ^{NP} is positive
- δa_μ^{NP} is of the same order of the EW contributions, $\delta a_\mu^{NP} \propto \frac{G_F m_\mu^2}{4\pi^2\sqrt{2}}$

- mSUGRA

$$(\delta a_\mu)_{SUSY} \propto \tan\beta \, \frac{f(M_0)}{M_{1/2}^2}$$

invites large $\tan\beta \gtrsim 10$ and $M_{1/2} \lesssim 750$ GeV

- SUSY modifies B-meson observables if $\tan\beta$ is large [$\Rightarrow Y_b$ large]
- Especially sencitive observables : $B \to X_s\gamma, B \to l^+l^-$
  - $B \to X_s\gamma$: relies on a cancelation between $H^\pm - t$ and $\tilde{\chi} - \tilde{t}$ loops.
  - $B \to l^+l^-$: large for large $\tan\beta$, almost independent from the sign of μ



$$\mathcal{B}(B_s \to \mu^+\mu^-) \propto \frac{\tan^6\beta}{M_{1/2}^2}$$

So,

$$\mathcal{B}(B_s \to \mu^+\mu^-) \propto \frac{\tan^5\beta \quad (\delta a_\mu)_{SUSY}}{f(M_0)}$$

- Standard Model :

$$\mathcal{B}(B_s \to \mu^+\mu^-) = (3.7 \pm 1.2) \times 10^{-9} \quad \text{very} \quad \text{small!}$$

- Only an experimental bound from CDF Run I

$$\mathcal{B}(B_s \to \mu^+\mu^-) < 2.6 \times 10^{-6}, \qquad \text{at 95\% C.L.}$$

- Future experiment: CDF Run IIa and IIb

$\rightarrow$ 5×10^{-7} for 50 events with luminosity 2 fb^{-1}

$\rightarrow$ 5×10^{-7} for 250-500 events with luminosity 10-20 fb^{-1}

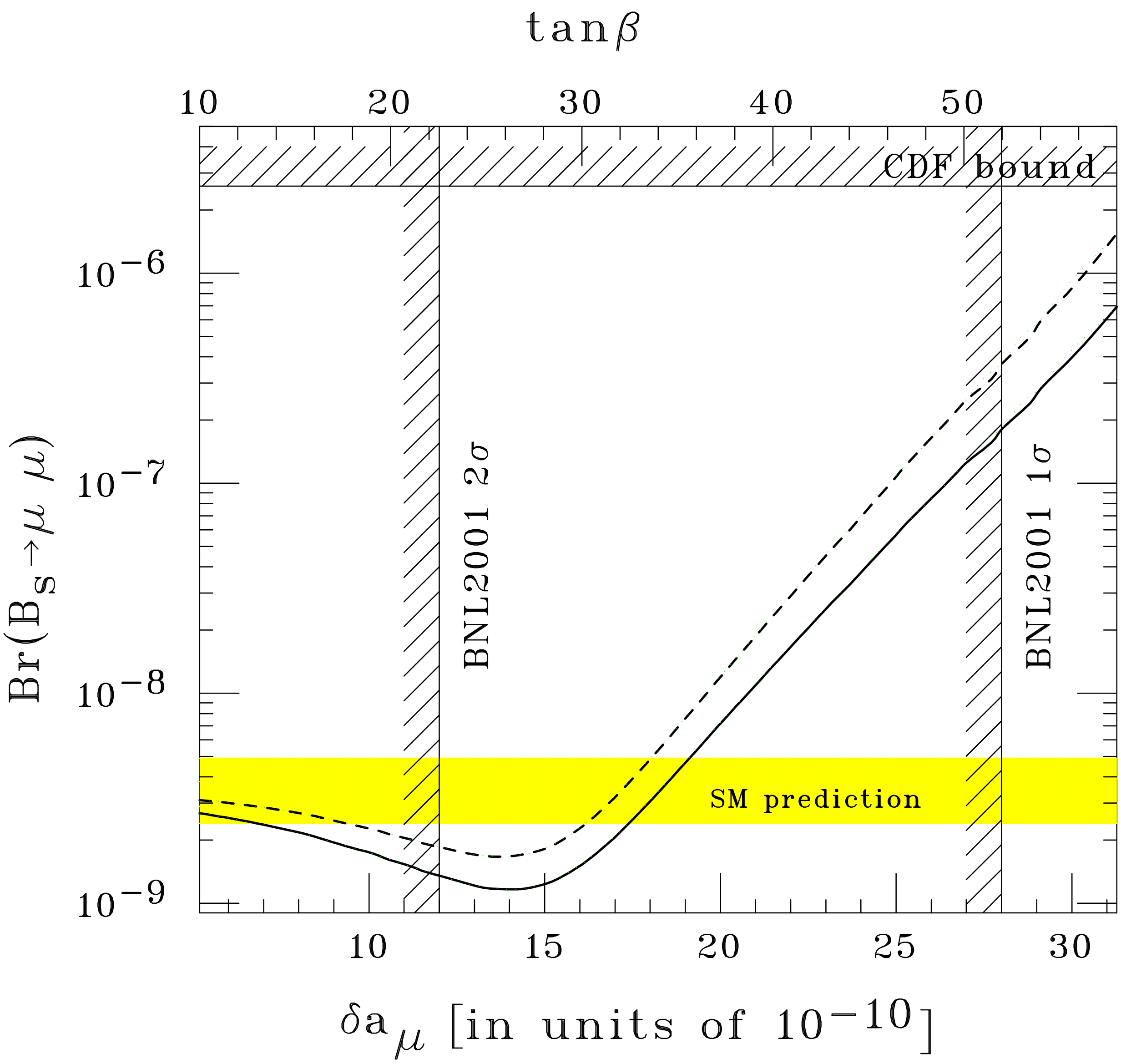
$$\mathcal{B}(B_s \to \mu^+\mu^-) = 6.0 \cdot 10^{-7} \left(\frac{|V_{ts}|}{0.040}\right)^2 \left(\frac{f_{B_s}}{230\,\text{MeV}}\right)^2 \frac{m_\mu^2}{m_{B_s}^2} \sqrt{1 - \frac{4m_\mu^2}{m_{B_s}^2}}$$

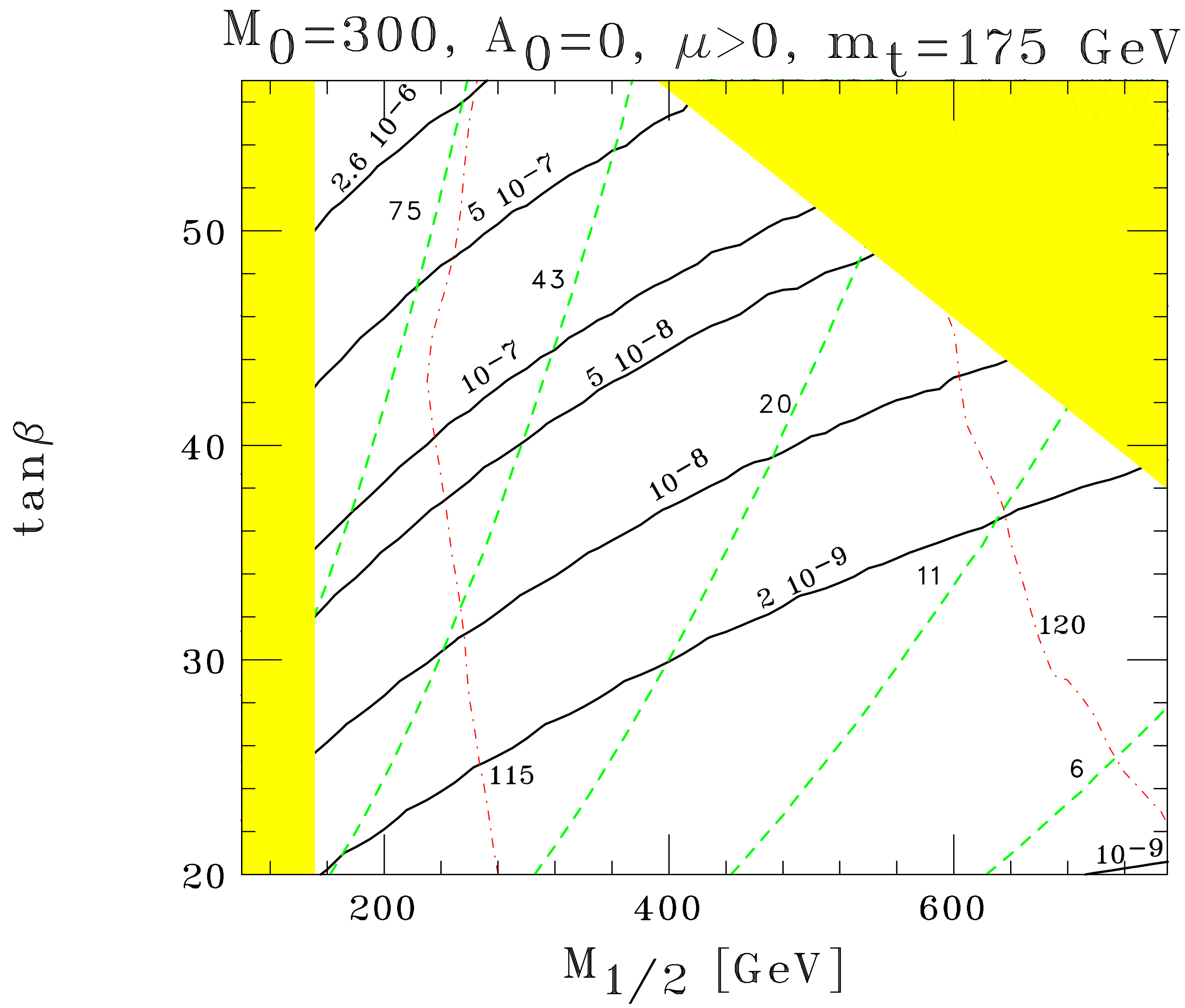
$$\left\{\left(1 - \frac{4m_\mu^2}{M_{B_s}^2}\right) \left|\frac{m_{B_s}^2 C_S}{m_\mu}\right|^2 + \left|\frac{m_{B_s}^2 C_P}{m_\mu} - 2C_A\right|^2\right\}.$$

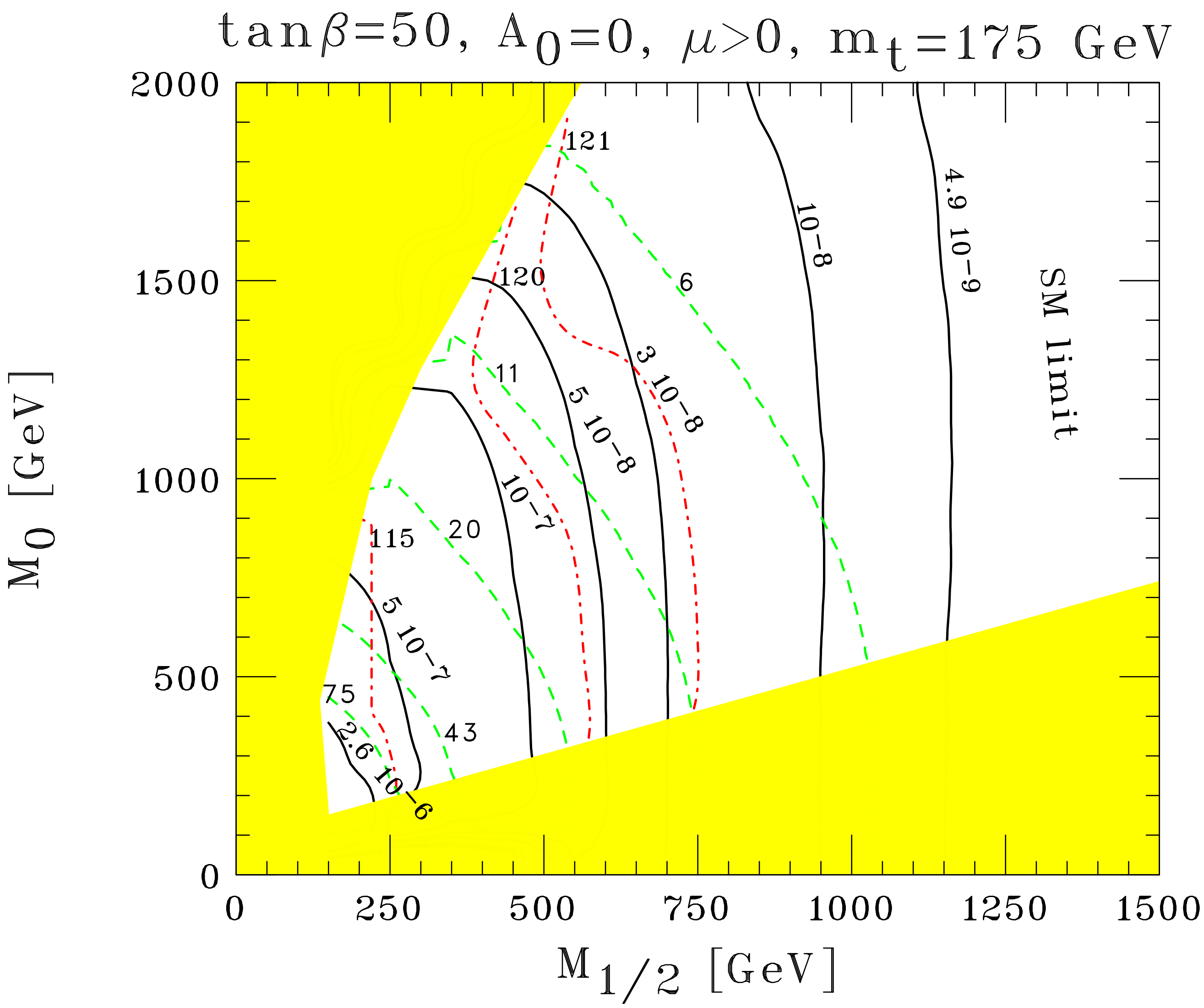
$$C_P^{self-SUSY}, C_S^{self-SUSY} \propto \tan^3\beta$$

C_A is tha SM contribution from $t-W$ penguins $t-W-\nu$ box.

mSUGRA point: $M_{1/2} = 450, M_0 = 350, A_0 = 0, \mu > 0, m_t = 175$ GeV




M0=300, A0=0, μ>0, mt=175 GeV
2.6 10−6
75
5 10−7
43
10−7
5 10−8
20
10−8
2 10−9
11
115
120
6
10−9
50
40
30
20
200
400
600
M1/2 [GeV]
tanβ



tanβ=50, A0=0, μ>0, mt=175 GeV
M0 [GeV]
M1/2 [GeV]
0
500
1000
1500
2000
0
250
500
750
1000
1250
1500
121
120
115
75
6
11
20
43
3 10−8
5 10−8
10−7
5 10−7
2.6 10−6
10−8
4.9 10−9
SM limit

- Large $\tan\beta$ is well motivated in SO(10)

- In order to avoid various constraints [mainly proton decay, $b \to s\gamma$, $g-2$ and REWSB] it requires : breaking of universality for the Higgs masses, and $M_{1/2} << M_0$.

Example [after a fit] : $M_A = 110$ GeV, $\tan\beta \simeq 50$, $A_t \gtrsim , 1$ TeV, $m_{\tilde{t}} < 1$ TeV, $m_{\tilde{\chi}} < 250$ GeV implies :

$$\mathcal{B}(B_s \to \mu^+\mu^-) \gtrsim 10^{-5} \quad \text{already excluded by CDF}$$

A way out $\to$ relax Yukawa unification up to 5-10% and you are just around the corner of the $B_s \to \mu^+\mu^-$ to be discovered at CDF Run IIa !!

Conclusions

$\surd$ Striking correlation between the muon anomalous magnetic moment a_μ and the branching ratio $\mathcal{B}(B_s \to \mu^+\mu^-)$ in mSUGRA scenarios.

$\surd$ If the reported excess in a_μ is caused by mSUGRA corrections with large $\tan\beta$, one faces more than an order of magnitude enhancement of $\mathcal{B}(B_s \to \mu^+\mu^-)$ over its SM value.

$\surd$ Well within reach of Run-II of the Tevatron.

$\surd$ The two combined measurements significantly constrain the mSUGRA parameters, allowing a determination of $\tan\beta$ and $M_{1/2}$.

$\surd$ A measurement of $\mathcal{B}(B_s \to \mu^+\mu^-)$ will further constrain the mass of the lightest Higgs boson.

$\surd$ SO(10) SUSY explanations of the measured a_μ are barely compatible with the present upper bound on $\mathcal{B}(B_s \to \mu^+\mu^-)$.