A Global Fit of EW data incl. $b \to s\gamma$, a_μ and Higgs limits in the SM and CMSSM

W. de Boer[a], C. Sander

University Karlsruhe

A. Gladyshev, D. Kazakov

JINR, Dubna

HEP2001
Budapest, July, 12-19, 2001

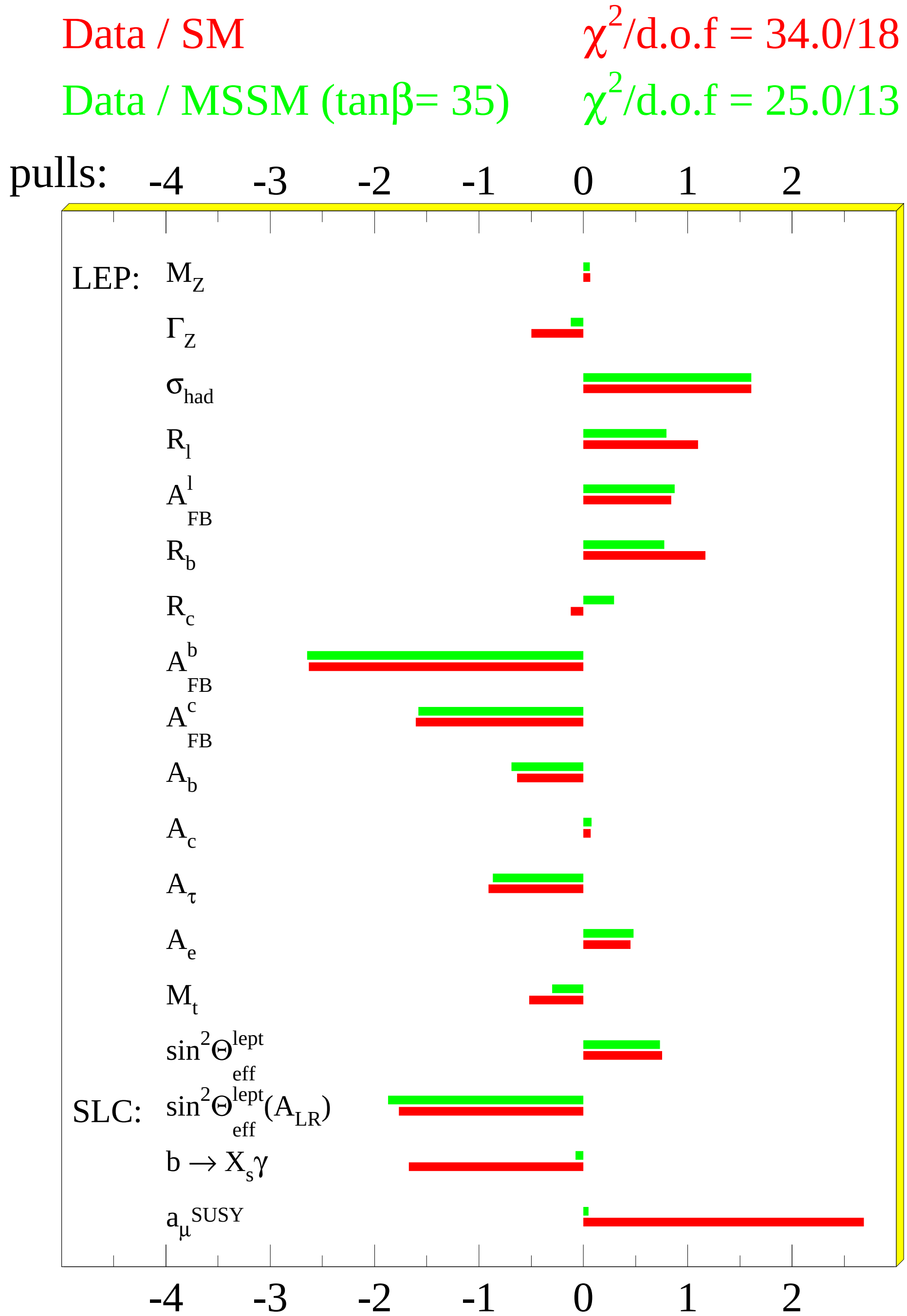
Outline

- Comparison of SM and CMSSM global fits
- g-2 constraints
- $b \to s\gamma$ in NLO
- Higgs masses

[a]Talk at: http://home.cern.ch/~deboerw

MSSM-FITTER vs SM

Fit results in SM and MSSM!! (Data 2001)
MSSM better χ^2 because of a_μ^{SUSY} and $b \to X_s\gamma$

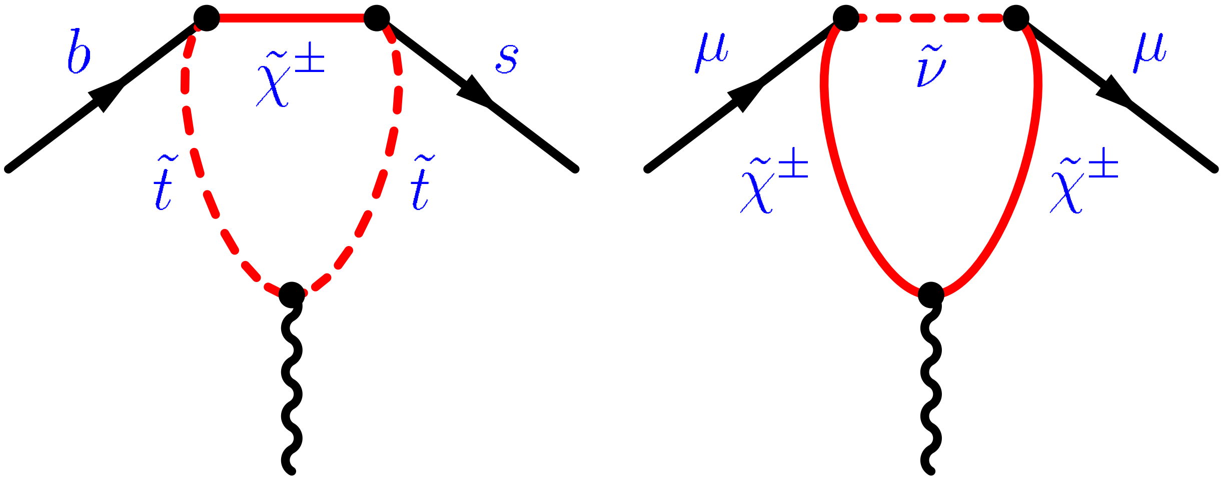


MSSM results from MSSM-Fitter (see WdB, W. Hollik et al., Z.Phys. C75(1997) 627 and hep-ph/9609209)

SM results obtained with ZFITTER6.11 (see D. Bardin et al., hep-ph/9412201)

Main SUSY contr. to $b \to X_s\gamma$ and a_μ

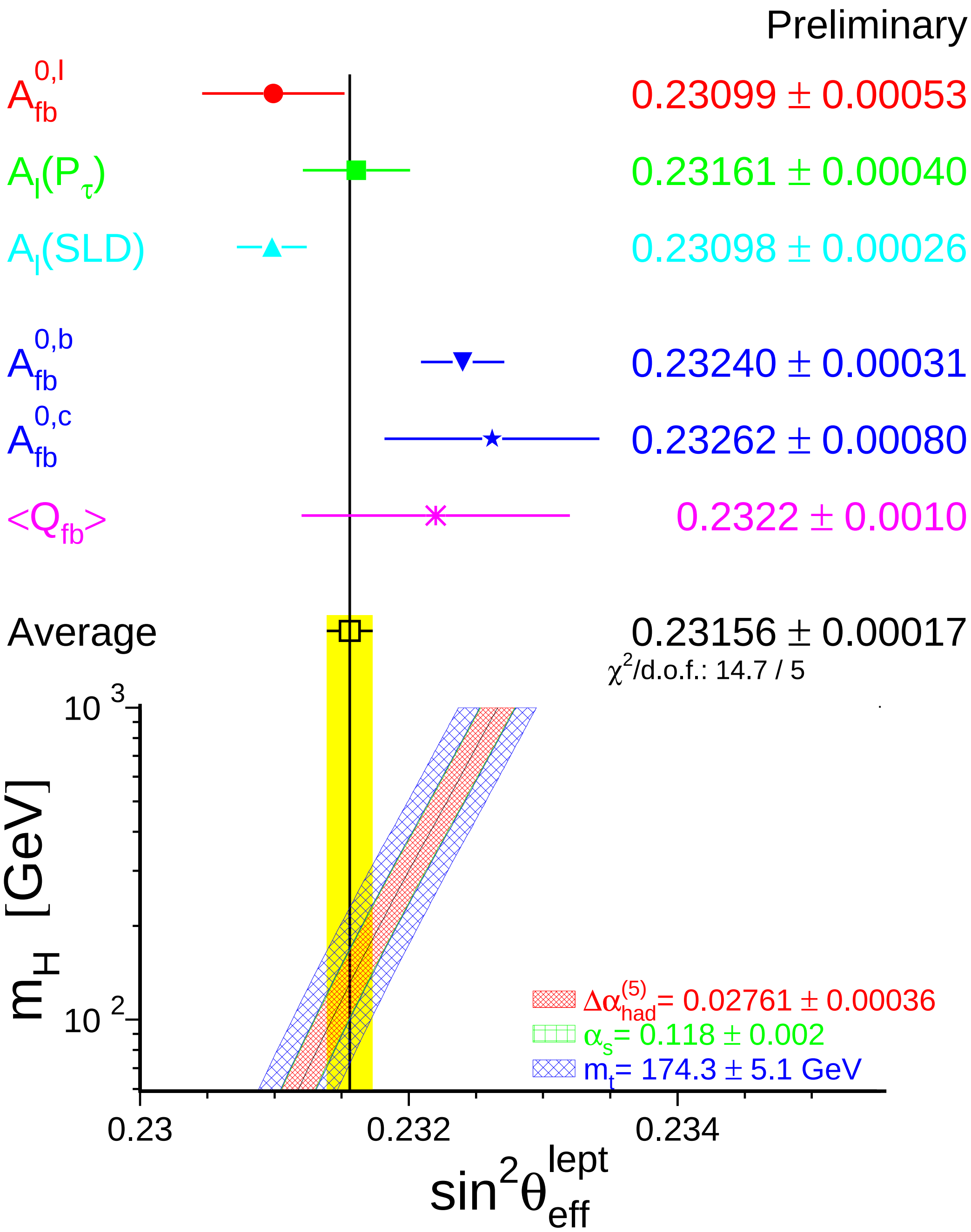
$b \to s\gamma$ muon anom. magnetic moment



Best Fitted SUSY masses $\tan\beta$=35			
Symbol	**[GeV]**	**Symbol**	**[GeV]**
$m_{\tilde{\chi}_1^\pm}$	**105**	$m_{\tilde{\chi}_1^0}$	**66**
$m_{\tilde{\chi}_2^\pm}$	**217**	$m_{\tilde{\chi}_2^0}$	**110**
$m_{\tilde{t}_1}$	**600**	$m_{\tilde{\chi}_3^0}$	**156**
$m_{\tilde{t}_2}$	**710**	$m_{\tilde{\chi}_4^0}$	**216**
$m_{\tilde{\nu}}$	**500**		

EW FIT: NO common GUT scale parameters assumed for sleptons and squarks
a_μ wants charginos close to experimental limit
Sleptons and squarks at intermediate masses, else ew precision data changed.

Summary of $\sin^2 \Theta_W^{eff}$

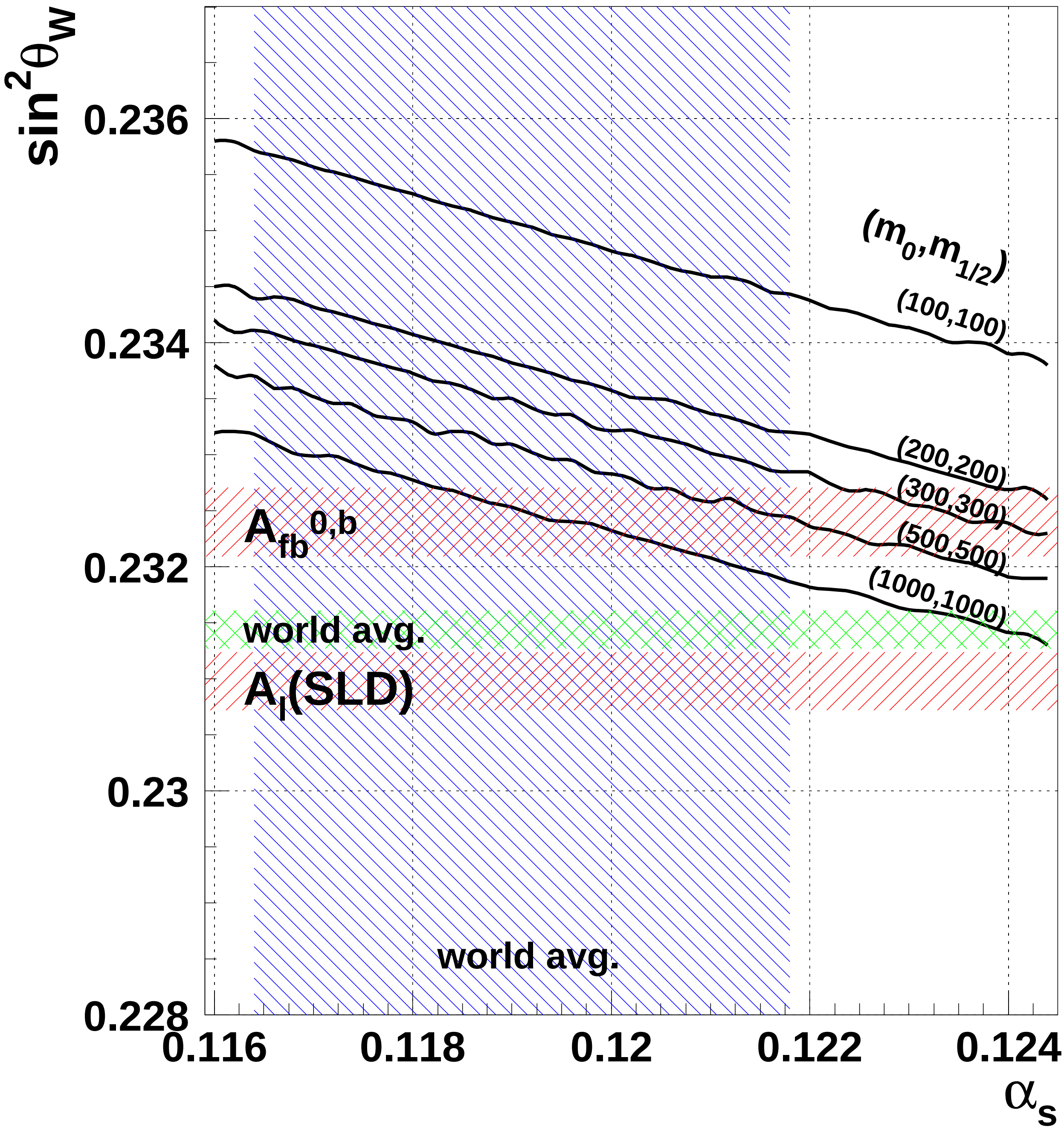


Most sensitive $\sin^2 \theta_W^{eff}$ values more than 3σ apart!!
Averaged value independent of Higgs constraint in the fit!!!

Higgs mass = F(M_t,α, $\sin^2 \theta_W$)

Requiring $m_h > 113.5$ increases M_t from fit by 1.1 GeV and reduces α a little, but errors on $\sin^2 \theta_W$ so small compared with error on M_t, that couplings are not changed by Higgs constraint.

Which CC needed for unification?



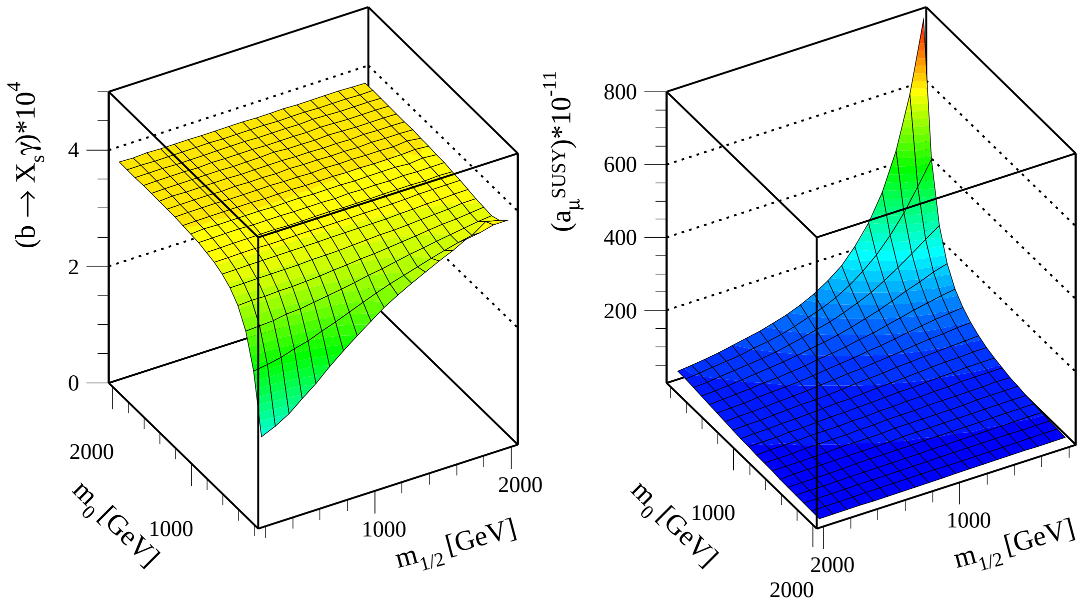
Most precise α_s values (calc. up to $\mathcal{O}(\alpha_s^3)$):

α_s from $R_l = 0.1231 \pm 0.0037^{+0.0033}_{-0.0000}$ (Higgs)

α_s from $\sigma_{tot} = 0.1159 \pm 0.0041^{+0.0026}_{-0.0000}$(Higgs)

(σ_{tot} dominated by theoretical error on luminosity!!)

$\mathrm{Br}(\mathrm{b} \to \mathrm{X_s}\gamma)$ and a_μ^{SUSY}



- New measurements:

  CLEO (F. Blanc, Moriond, 2001 and hep-ex/9908022):
  $\mathbf{BR(b \to s\gamma) = (2.85 \pm 0.35_{stat} \pm 0.22 sys) \cdot 10^{-4}}$
  ALEPH (PL B429 (1998) 169):
  $\mathbf{BR(b \to s\gamma) = (3.11 \pm 0.80_{stat} \pm 0.72_{sys}) \cdot 10^{-4}}$
  BELLE (hep-ex/0103042, Phys. Lett. B511 (2001) 151:
  $\mathbf{BR(b \to s\gamma) = (3.36 \pm 0.53_{stat} \pm 0.42_{sys}\ ^{+0.50}_{-0.54}\ (model)) \cdot 10^{-4}}$

  Weighted Average:

  $$Br(b \to X_s\gamma) = 2.96 \pm 0.35 \cdot 10^{-4}$$

- $m_c/m_b = 0.29$ for pole masses.

  Should one use running mass for charm quark in loop:

  $$m_c(\mu)/m_b = 0.22\ ??$$

  (Gambino and Misiak, hep-ph/0104034)

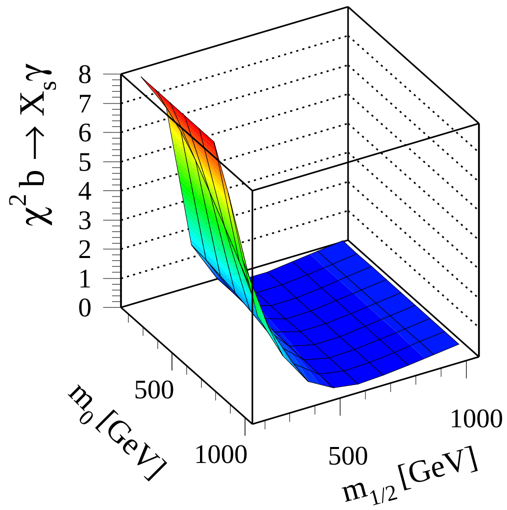
  Increases SM prediction for $\mathrm{Br}(\mathrm{b} \to \mathrm{X_s}\gamma)$ by $\mathcal{O}(10\%)$

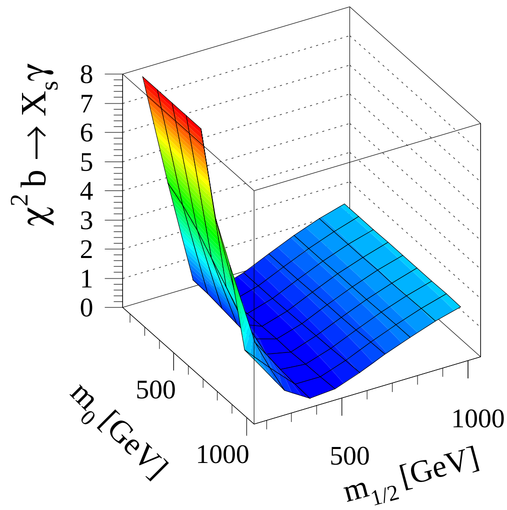
$$Br(b \to X_s\gamma) = (3.73 \pm 0.3) \cdot 10^{-4}$$ **in the SM.**

Data now 1.7σ below SM prediction?

$\mathrm{Br}(\mathrm{b} \to \mathrm{X_s}\gamma)$ and a_μ^{SUSY}

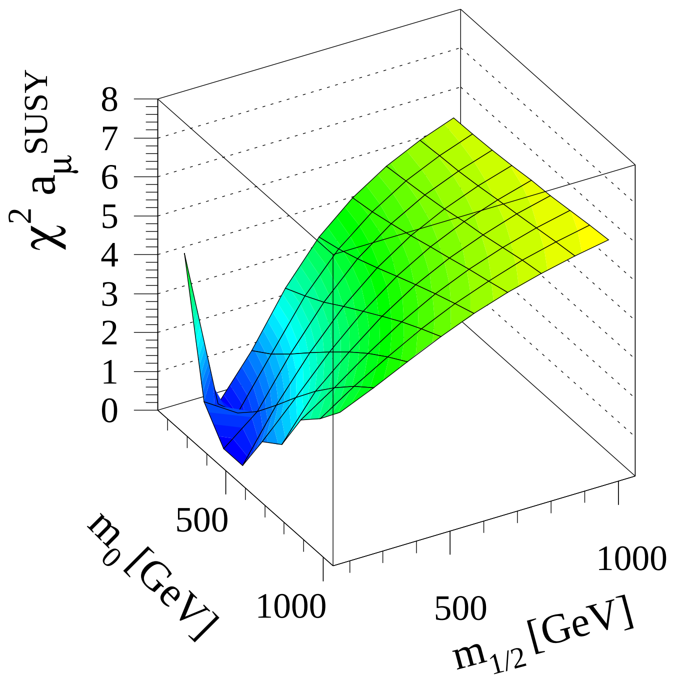
Old **New**





"Old" $\mathrm{b} \to \mathrm{X_s}\gamma$ with $m_c/m_b = 0.29$ wants heavy sparticles

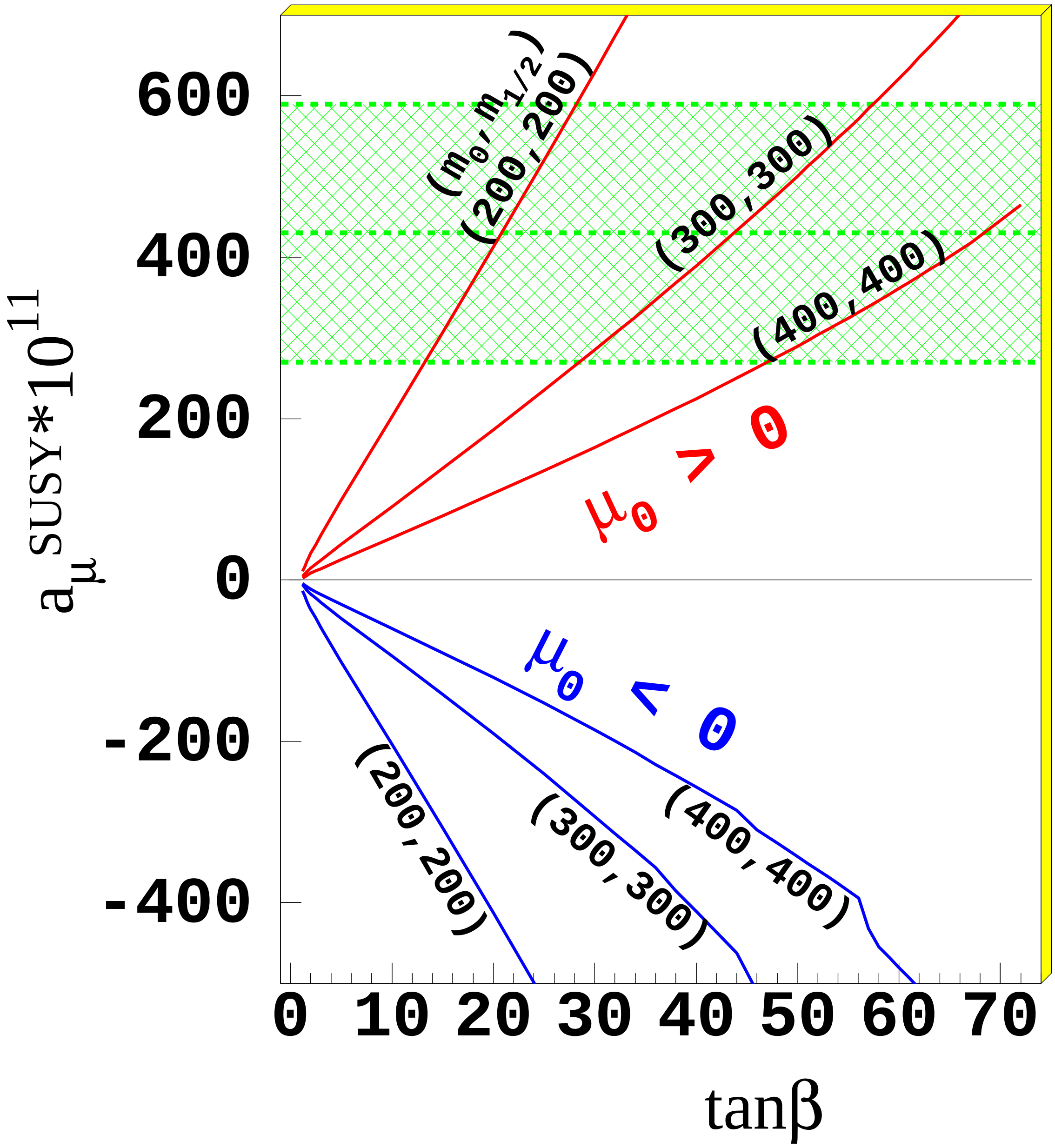
"new" $m_c/m_b = 0.22$ with current c-quark mass wants intermediate sparticles



$a_\mu^{SUSY} = 425 \cdot 10^{-11}$ wants light sparticles

Anom. magn. moment a_μ^{SUSY} vs $\tan\beta$

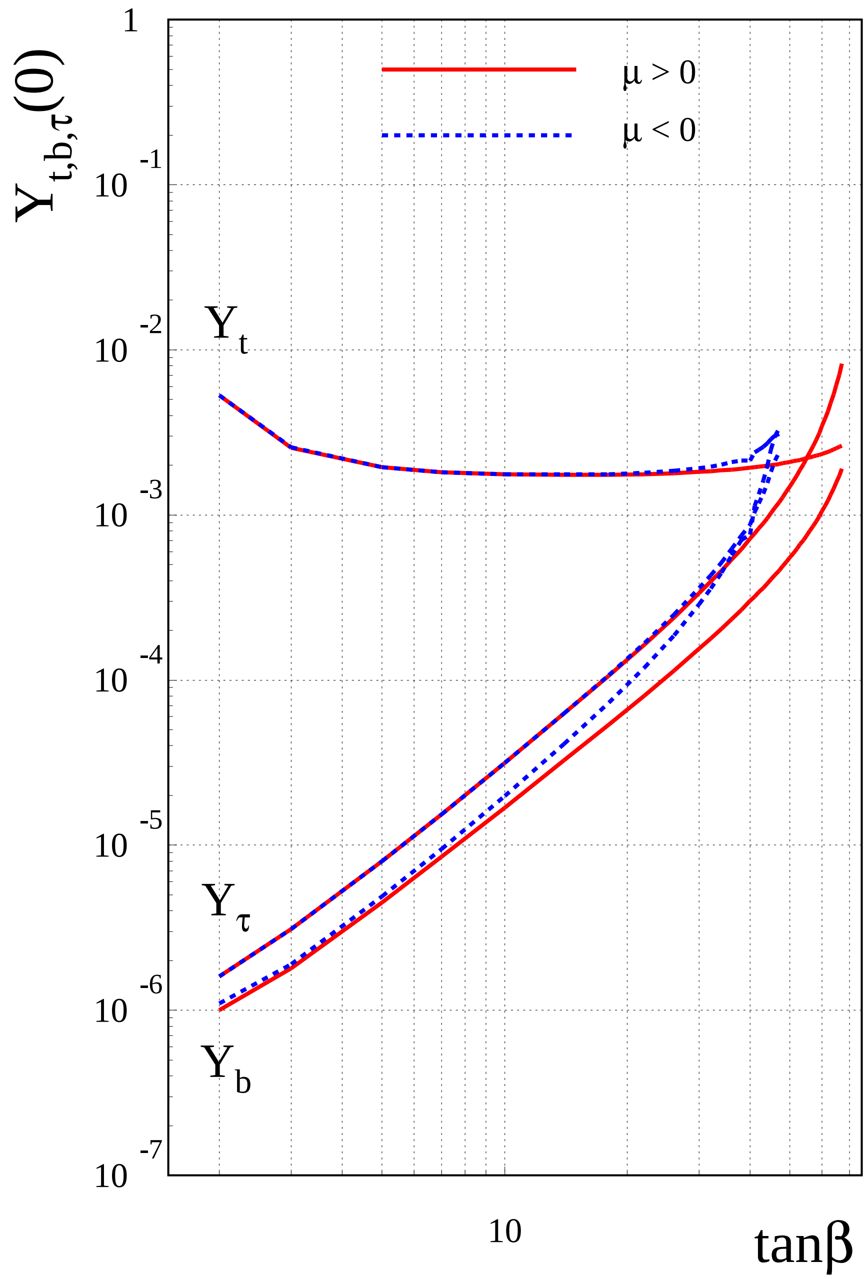
SUSY contributes via chargino-sneutrino or neutralino-smuon loops



- $a_\mu^{SUSY} \propto \tan\beta$ (Czarnecki, Marciano, Nath, ..)
- $\mu < 0$ excluded
- GUT scale mass parameters required to be in 100-500 GeV range

Yukawa Couplings vs. $\tan\beta$

Determine Yukawa's at GUT scale from $\mathbf{m_t}$, $\mathbf{m_b}$ and $\mathbf{m_\tau}$ by running RGE! Result insensitive to $m_0, m_{1/2}$.



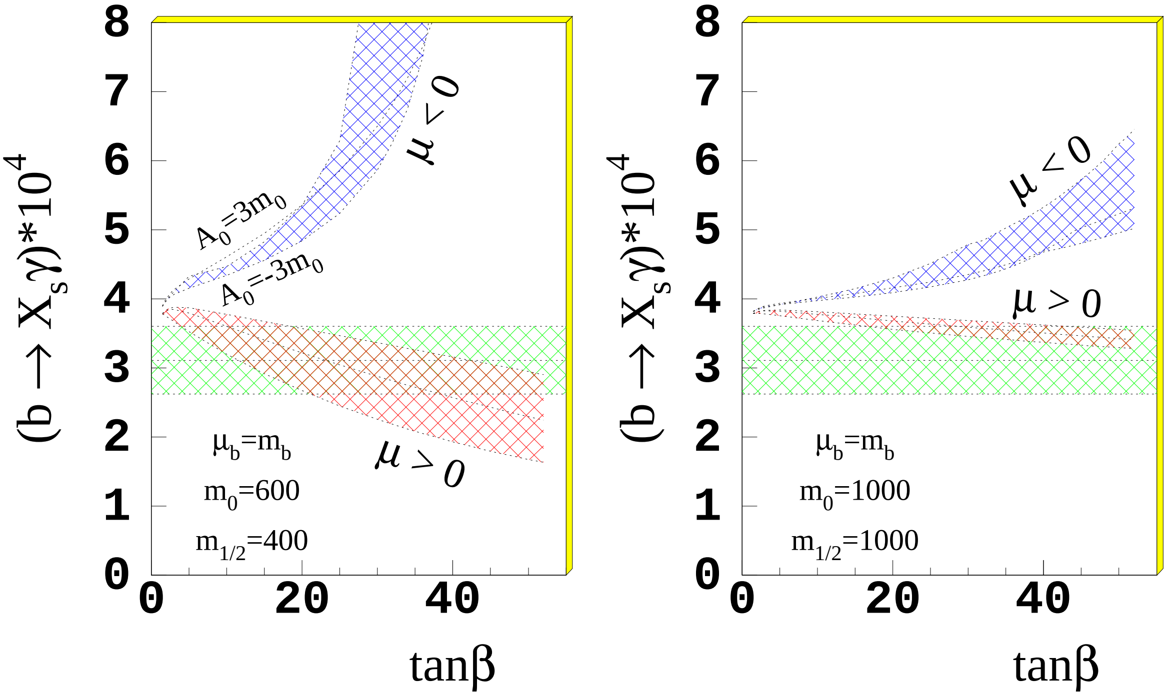
$$m_t^2 = (4\pi v)^2\, Y_t\, \frac{\tan\beta^2}{1+\tan\beta^2}\quad m_{b(\tau)}^2 = (4\pi v)^2\, Y_{b(\tau)}\, \frac{1}{1+\tan\beta^2}$$

Triple Unification at $\tan\beta \approx 45$ for $\mu < 0$ only

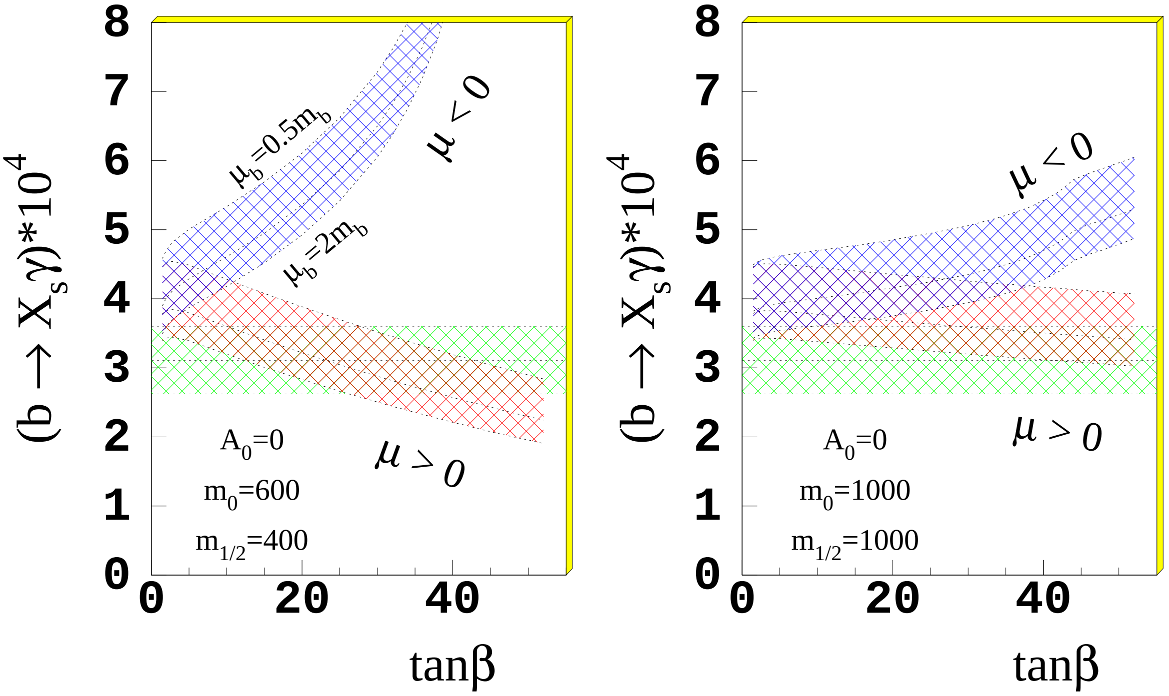
$\tan\beta < 4.3$ excluded by Higgs limit!

$\mathbf{Br(b \to s\gamma)}$ vs $\tan\beta$

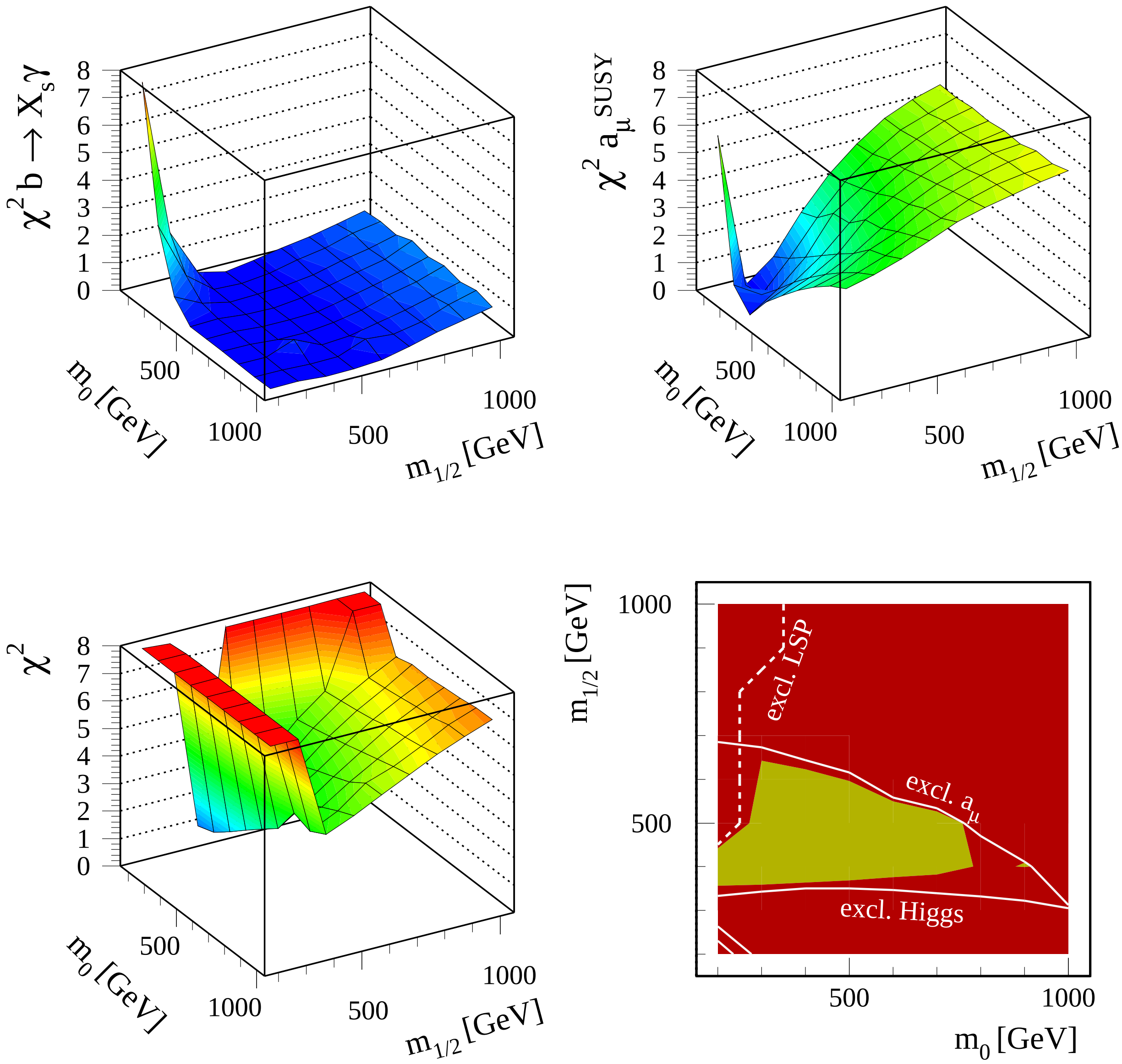
Dependence on A_0 through stop mixing (large for $m_{stop} = \mathcal{O}(m_t)$) for $\mu_b = m_b$



Dependence on renorm. scale μ_b for $A_0 = 0$



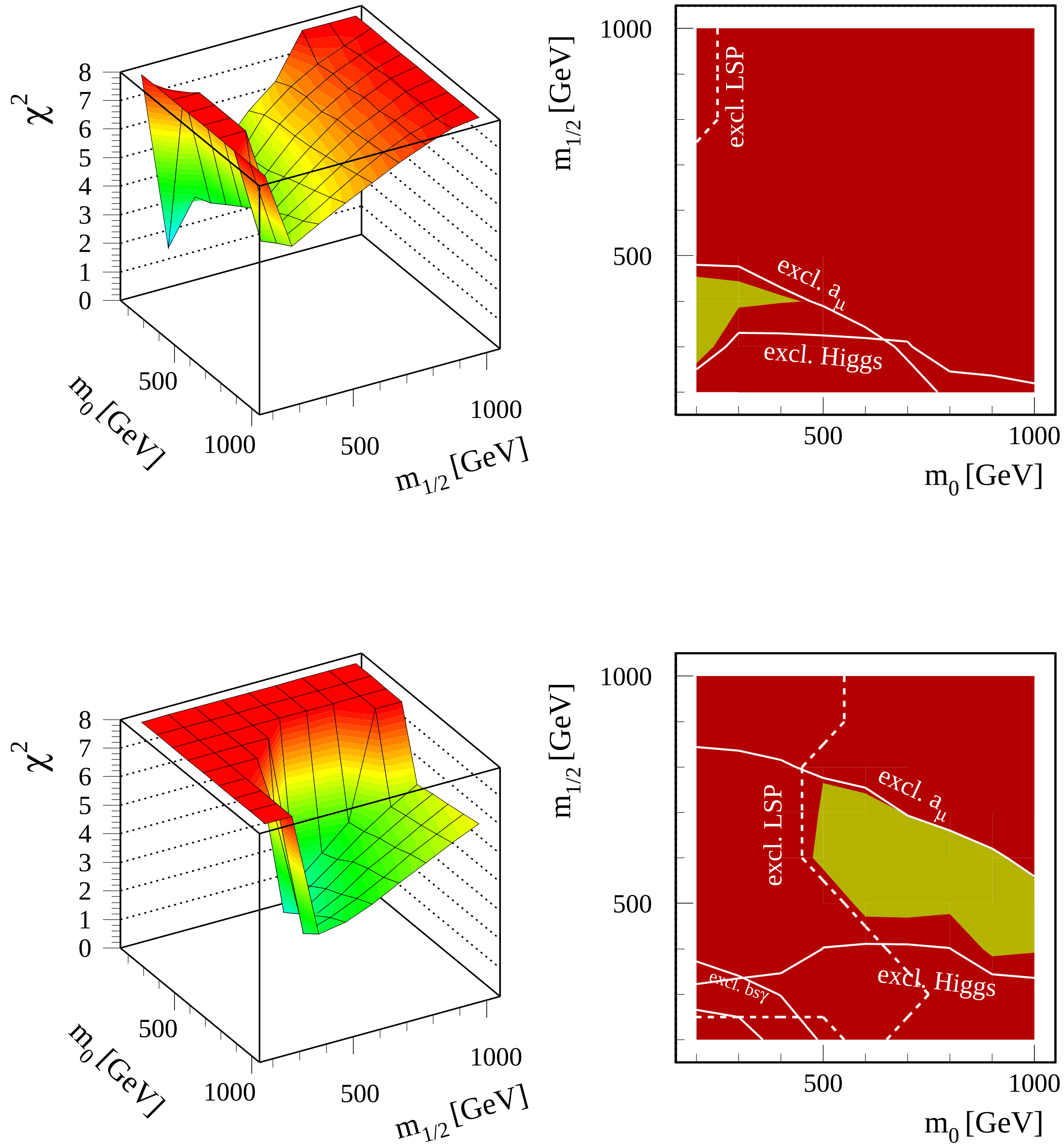
Allowed Parameter Regions for $\tan\beta = 35$



Constraints:

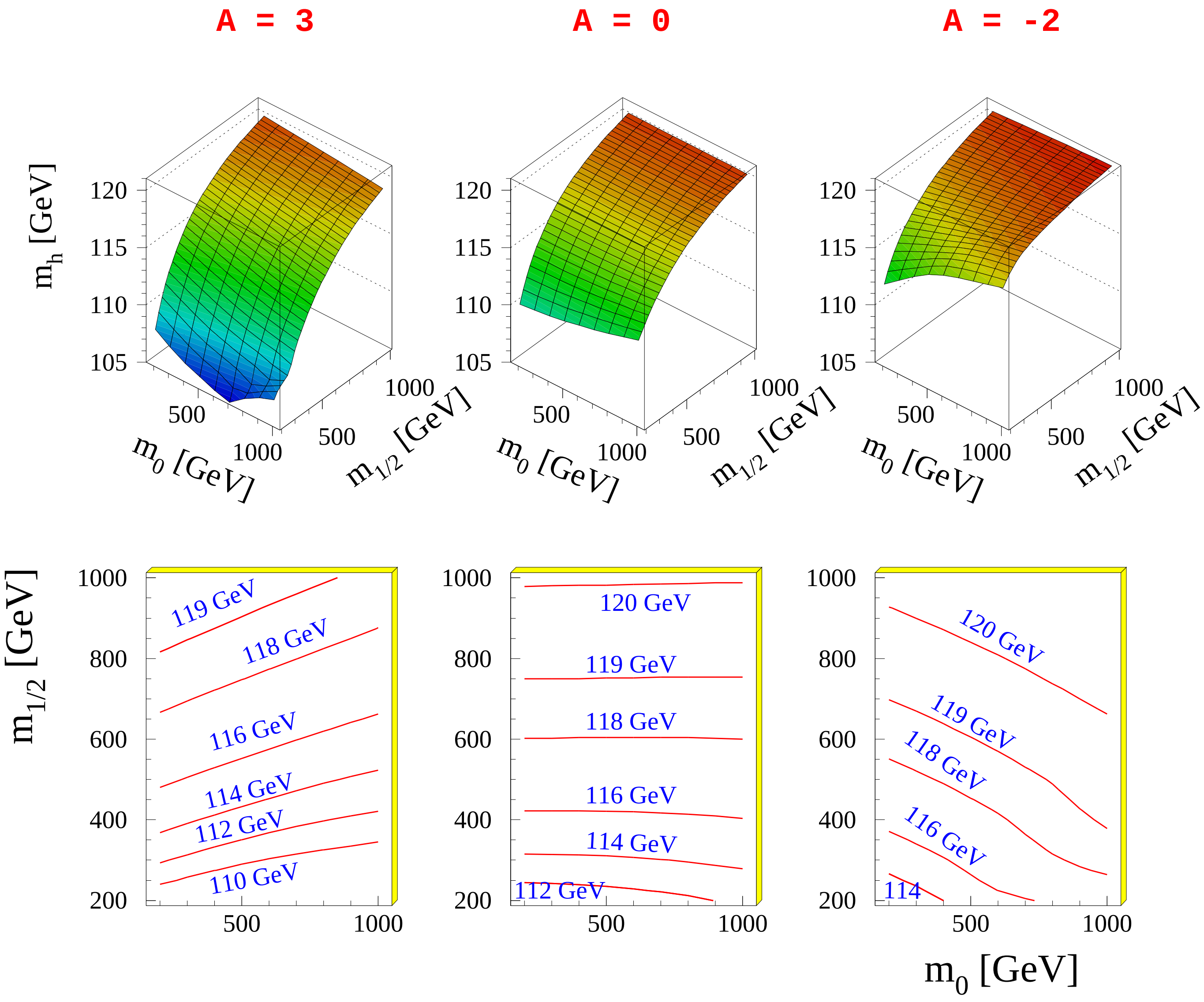
- **Gauge Unification and EWSB**
- **NO Yukawa Unification**
- **A_0 free (Fit prefers $A_0 > 0$)**
- **Renorm. scale $\mu_b = m_b$, $m_c(\mu)/m_b = 0.22$**

Allowed Parameter Regions for $\tan\beta = 20, 50$



Large allowed region obtained for $\tan\beta \approx 40 \pm 10$
LSP required to be neutral.
In region "excl. LSP" Stau=LSP.

Higgs Contours (high $\tan\beta$ scenario)

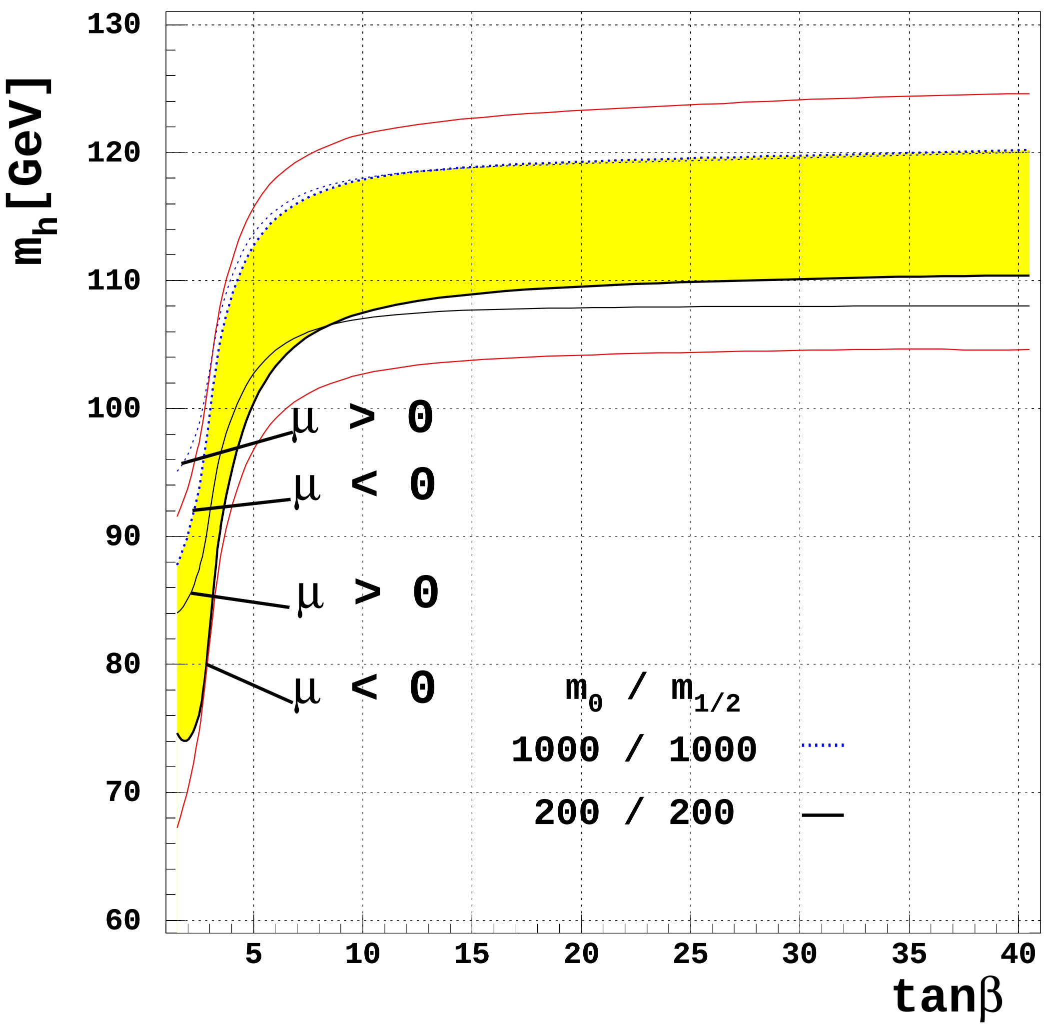


For $A_t = -2m_0 \rightarrow$ hardly limit from $m_H > 114$ GeV

However, $b \rightarrow X_s\gamma$ prefers $A_t = 3m_0$

Then lower limits on SUSY from Higgs constraint

Higgs mass vs $\tan\beta$



RGE improv. two loop by M. Carena, M. Quirós and C. Wagner

$\tan\beta \leq 4.3$ excluded by Higgs limit of 114 GeV!

Yellow band in Figure:

$m_t = 175$ GeV: $110 < m_h < 120$ GeV

For $m_t = 175 \pm 5$ GeV: $105 < m_h < 125$ GeV

or $m_h = 115 \pm 3$ (stopmasses) ± 2 (theory) ± 5 top mass GeV.

($\sigma_{stop} = interval/\sqrt{12}$)

Summary

- **Gauge Unification:**

  Fit prefers upper values of $\sin^2\theta_W$ and α_s

- **Implication from $a_\mu^{SUSY} > 0$ deviation from SM requires sign of Higgs mixing parameter to be:**
  $\mu > 0$ and $\tan\beta$ has to be large
  Large allowed parameter region for $\tan\beta \approx 40 \pm 10$

- $\mathrm{Br(b \to X_s\gamma)}$ **data consistent with a_μ^{SUSY}:**

  both require $\mu > 0$and prefer large $\tan\beta$

  and positive a_μ^{SUSY} yields negative deviation for

  $\mathrm{Br(b \to s\gamma)}$ **from SM, which is the case if the current**

  mass for m_c is used

- **No exact $b - \tau$ Yukawa unification possible for $\mu > 0$!**

- **For high $\tan\beta$: $\mathbf{105 < m_h < 125\ GeV}$**
  $m_h = 115 \pm 3\,(stop)\ \pm 2\,(theory)\ \pm 5\,(top)\ \mathrm{GeV}.$

- **If we take present data and CMSSM model seriously:**
  - **Lower limit on $m_{1/2} \approx 300$ GeV**

    This implies $m_\chi^\pm > 240$ GeV and $m_\chi^0 > 120$ GeV
  - **Upper limit on $m_{1/2} \approx 600(800)$ GeV, given by a_μ^{SUSY}. This implies $m_\chi^\pm < 480(640)$ GeV and $m_\chi^0 < 240(320)$ GeV for $\tan\beta = 35(50)$.**