Implications of first LHC results

1) Large extra dimensions (http://arxiv.org/abs/1101.4919)
2) SuperSymmetry (http://arxiv.org/abs/1101.2195)

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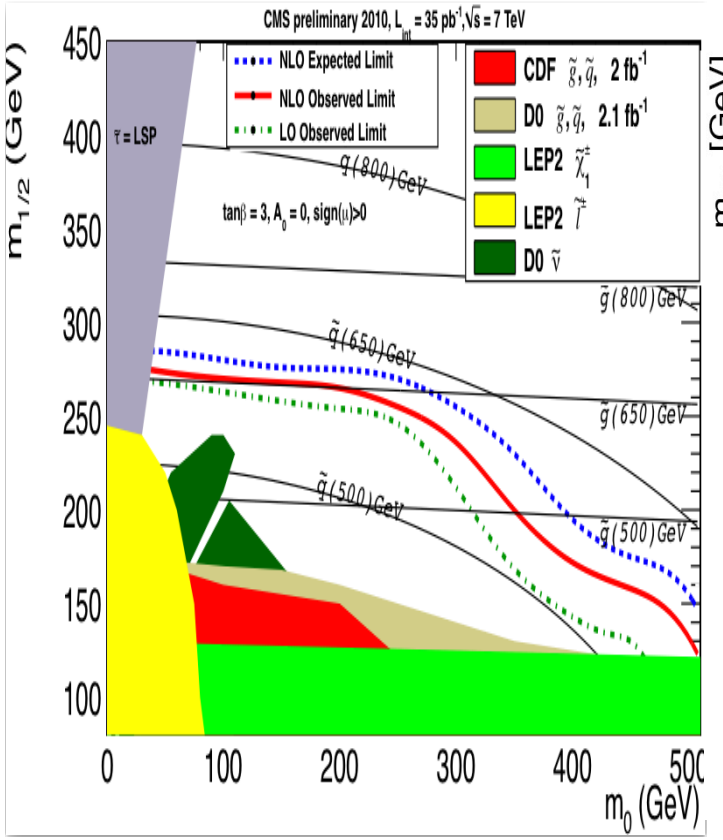
Talk at CERN, May 17, 2011

SUSY

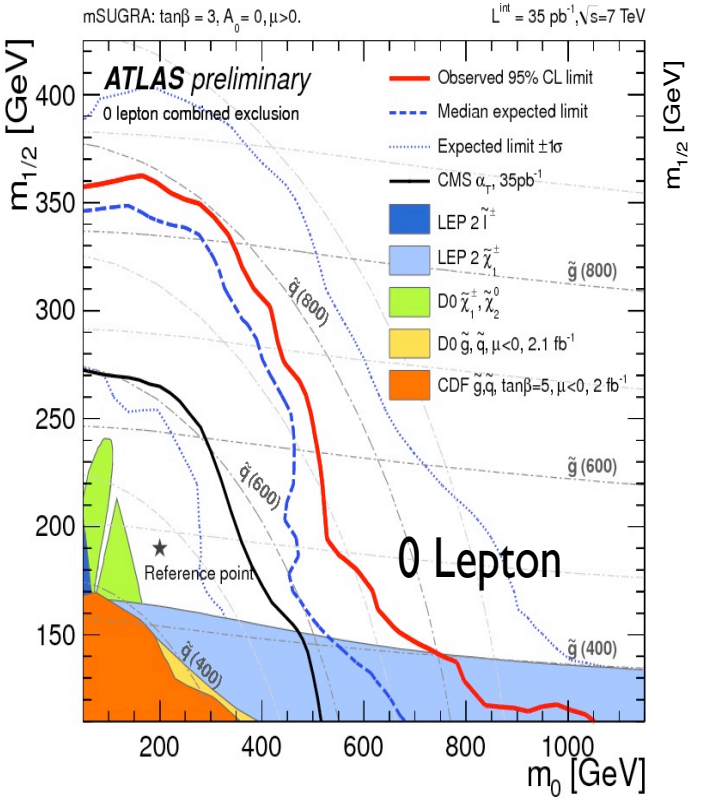
First LHC data about SUSY

Actually about CMSSM = mSuGra = ...

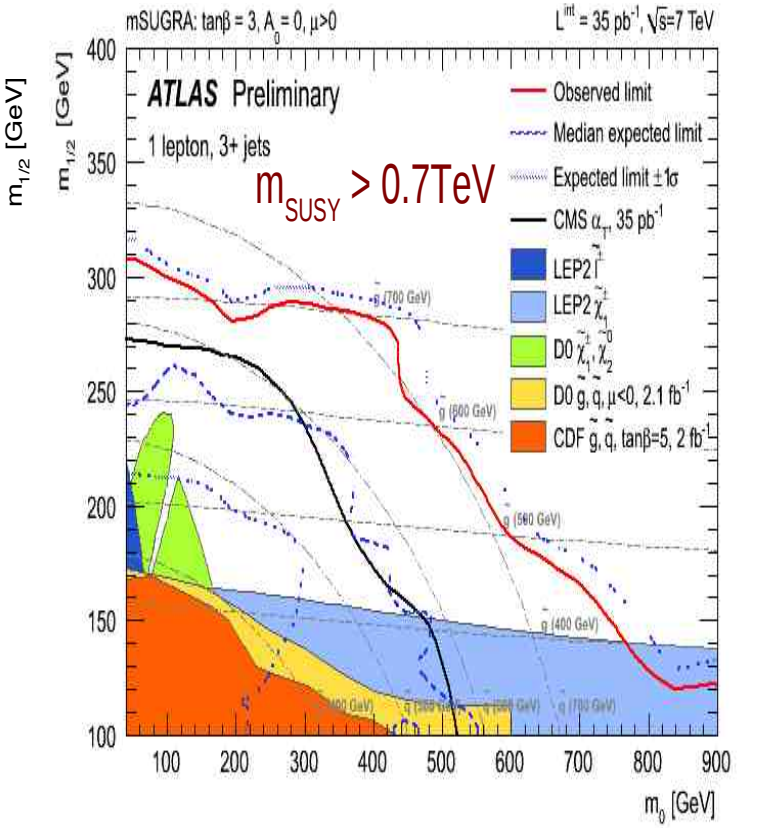
CMS, $j \not{E}_T$



ATLAS, $j \not{E}_T$

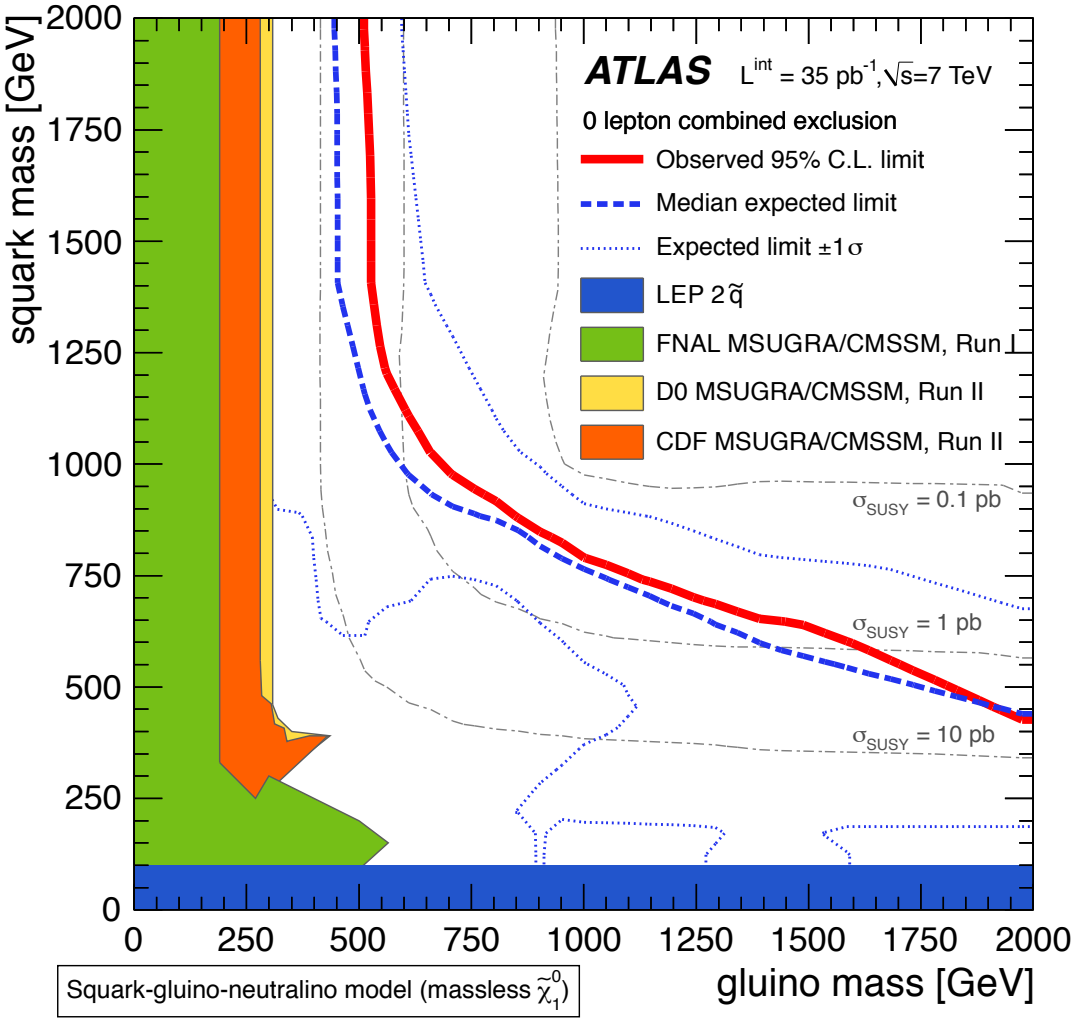


ATLAS, $j\ell \not{E}_T$



First LHC data

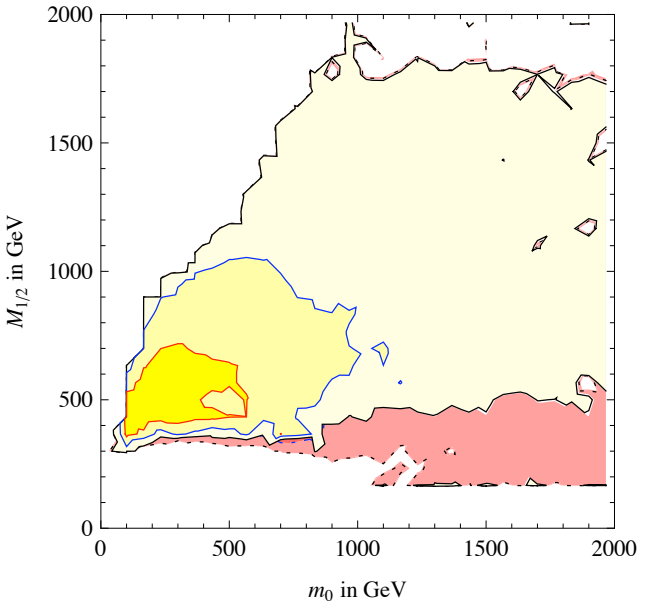
Actually are a bound on $m_{\tilde{q}}$ and M_3, up to 800 GeV

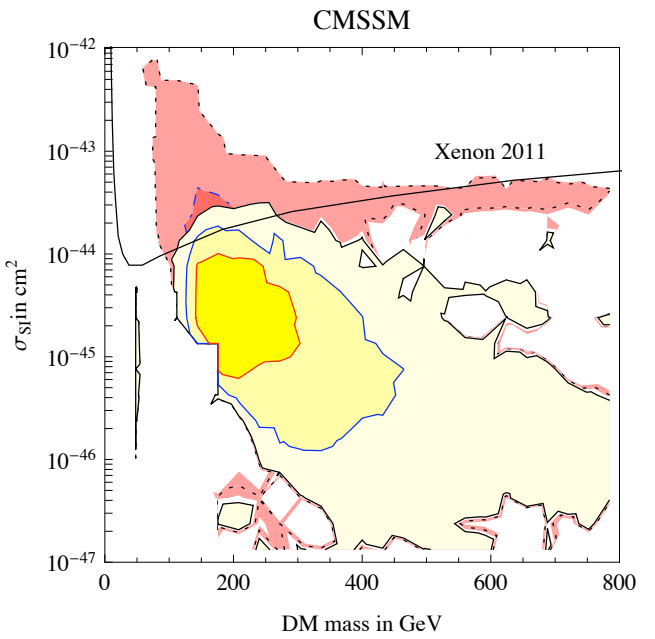


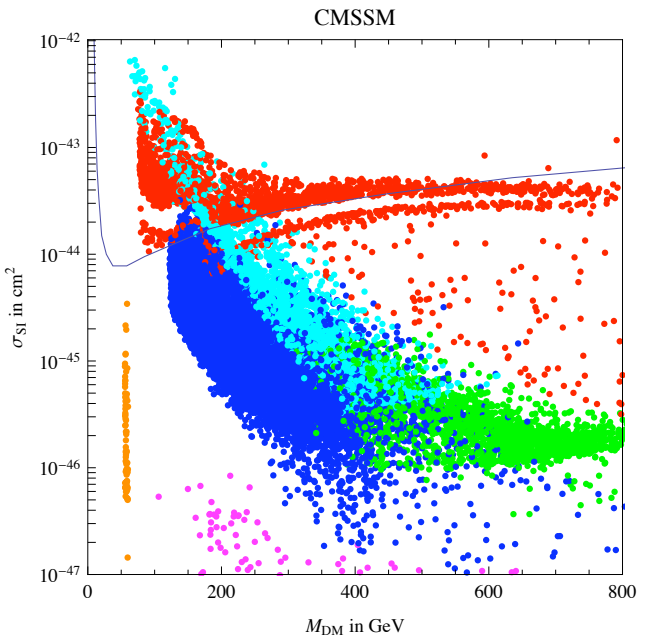
1) Implications on global fits? 2) Implications on naturalness?

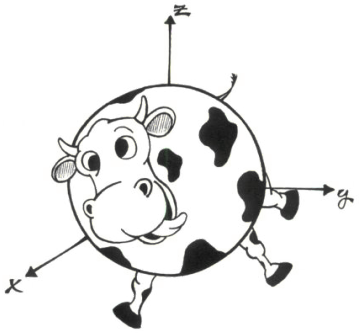
Early LHC has little impact on global fits

Global fit ($g_\mu - 2$, $\Omega_{\rm DM}$, $b \to s\gamma$, Xenon100, ...) favors heavier $m_{\rm SUSY}$.

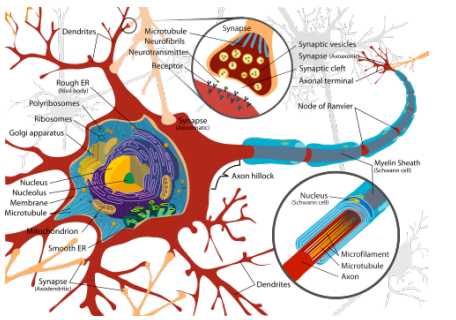








Dissection of the spherical cow: special mechanisms needed to get $\Omega_{\rm DM}$: $\tilde{\ell}$ co-annihilations, well-tempered, h resonance (test now), H, A resonance, h, H, A at large $\tan\beta$, $\tilde{t}$ co-annihilations



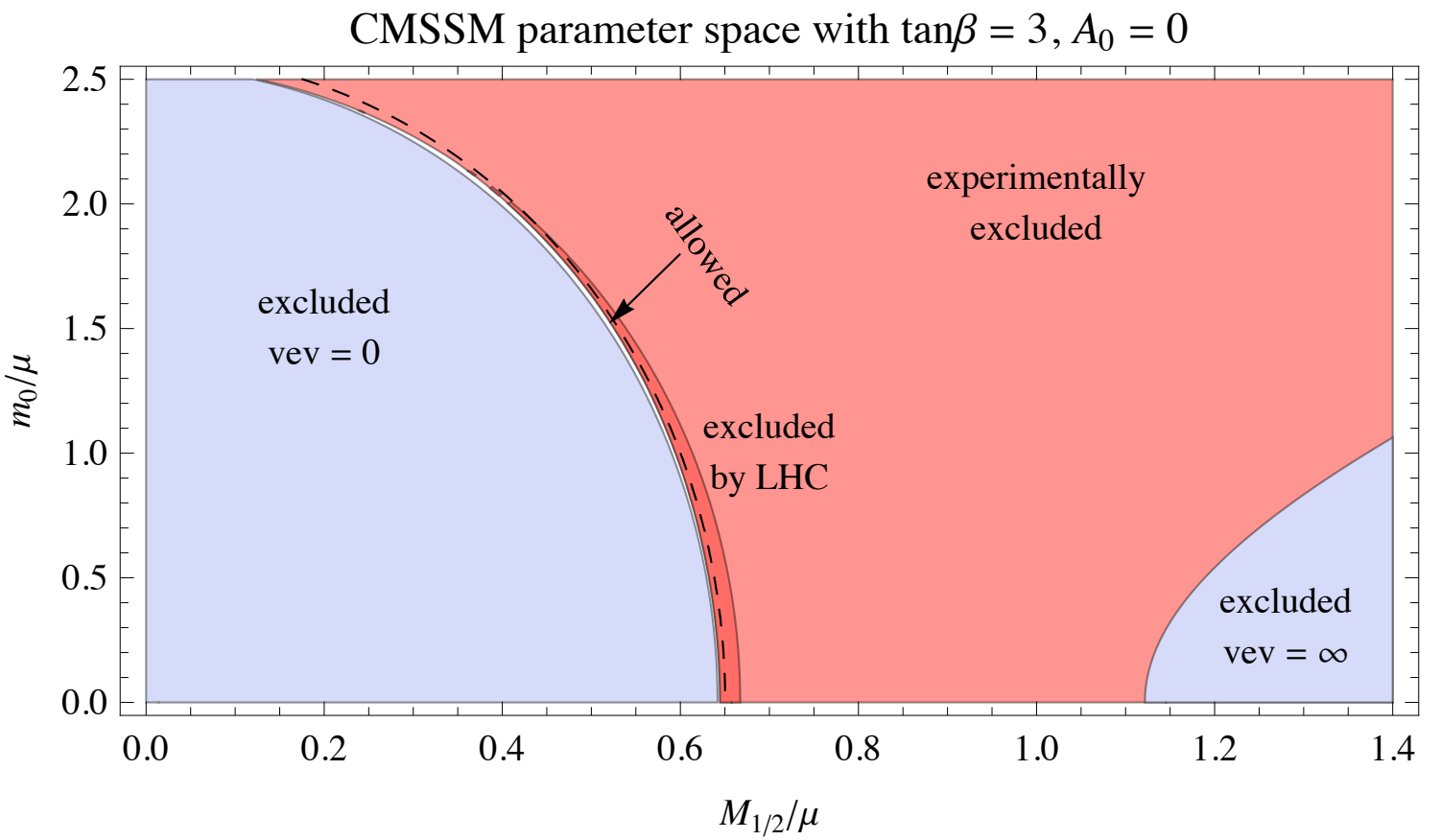
So far naturalness ignored; in the rest focus on it

The little hierarchy problem

Fix $\tan\beta = 3$ and $A_0 = 0$; the overall SUSY mass scale is fixed by

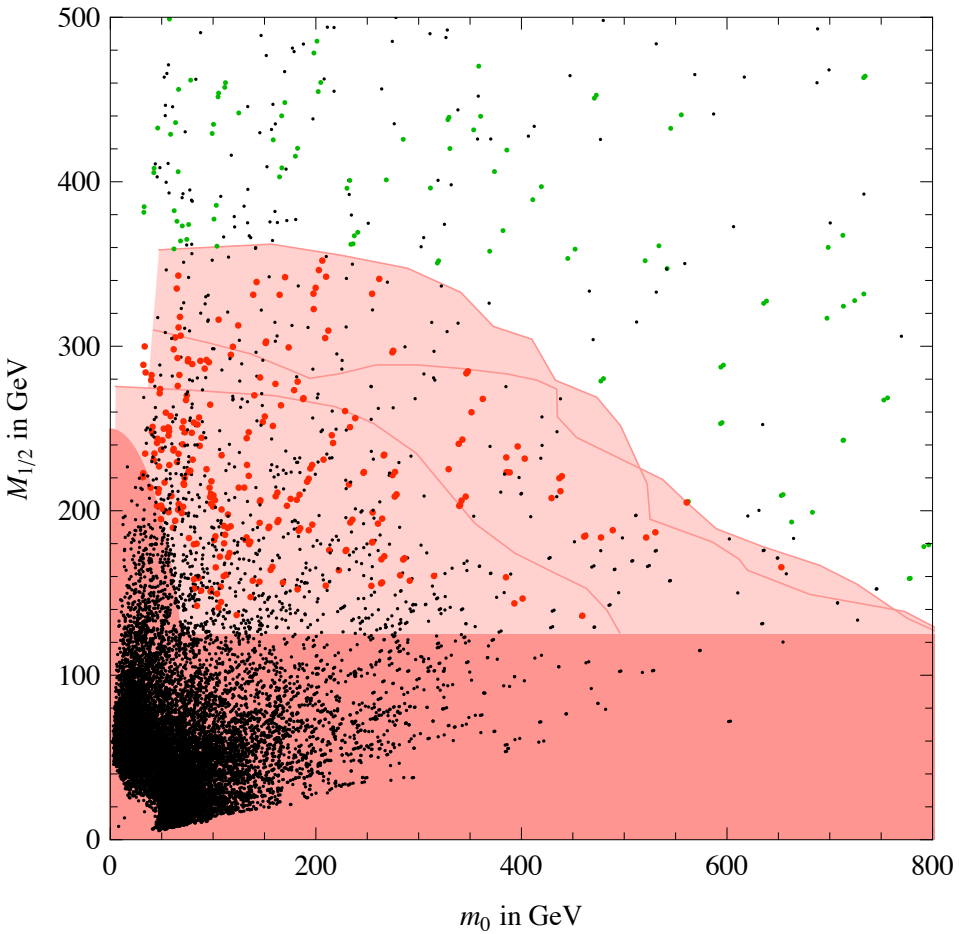
$$M_Z^2 \approx 0.2 m_0^2 + 0.7 M_3^2 - 2\mu^2 = (91\,\text{GeV})^2 \times 50 (\frac{M_3}{780\,\text{GeV}})^2 + \cdots$$

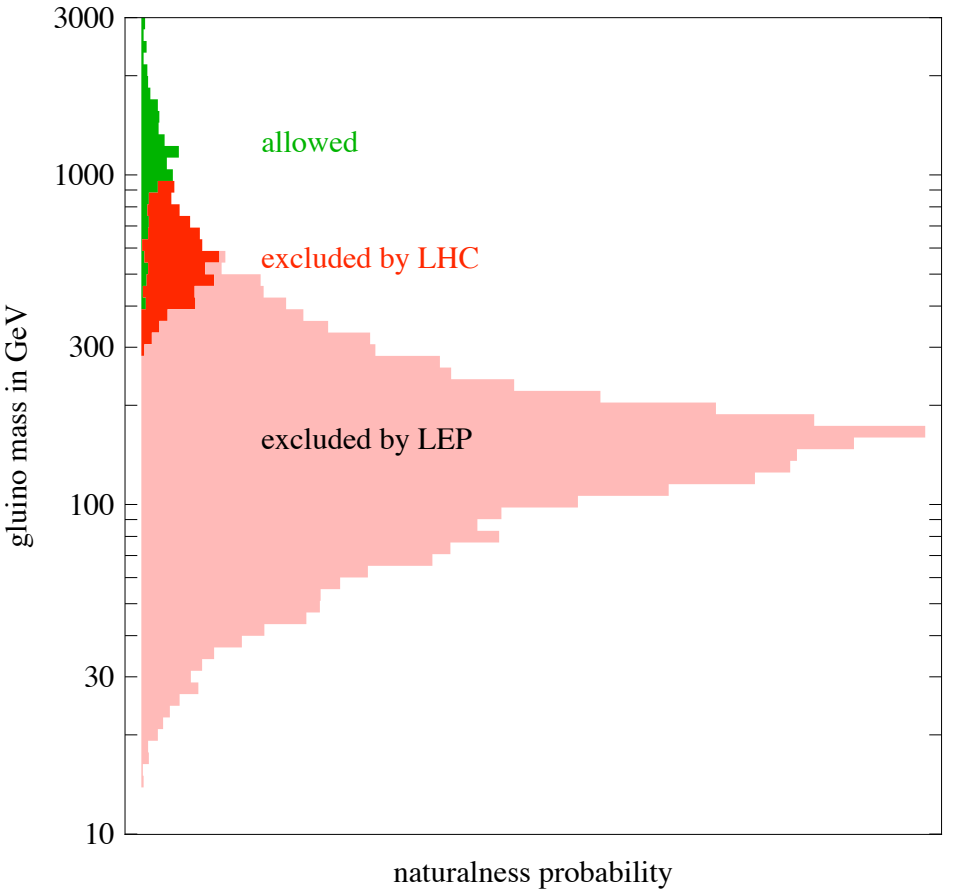
Plot this in the plane of the adimensional free parameters $(M_{1/2}, m_0)/\mu$:



Bayesian MonteCarlo technique

Scan over all adimensional parameters (m_0/μ, B_0/m_0,..., λ_t) compatible with measured m_t. Compute $\tan\beta$ and $m_{\rm SUSY}$ from $V_{\rm MSSM}$. Normally $m_{\rm SUSY} \sim M_Z$; rare accidents can make it bigger. All possible fine-tunings are included without using any explicit FT parameter Δ. E.g. focus point is fine-tuning of λ_t.





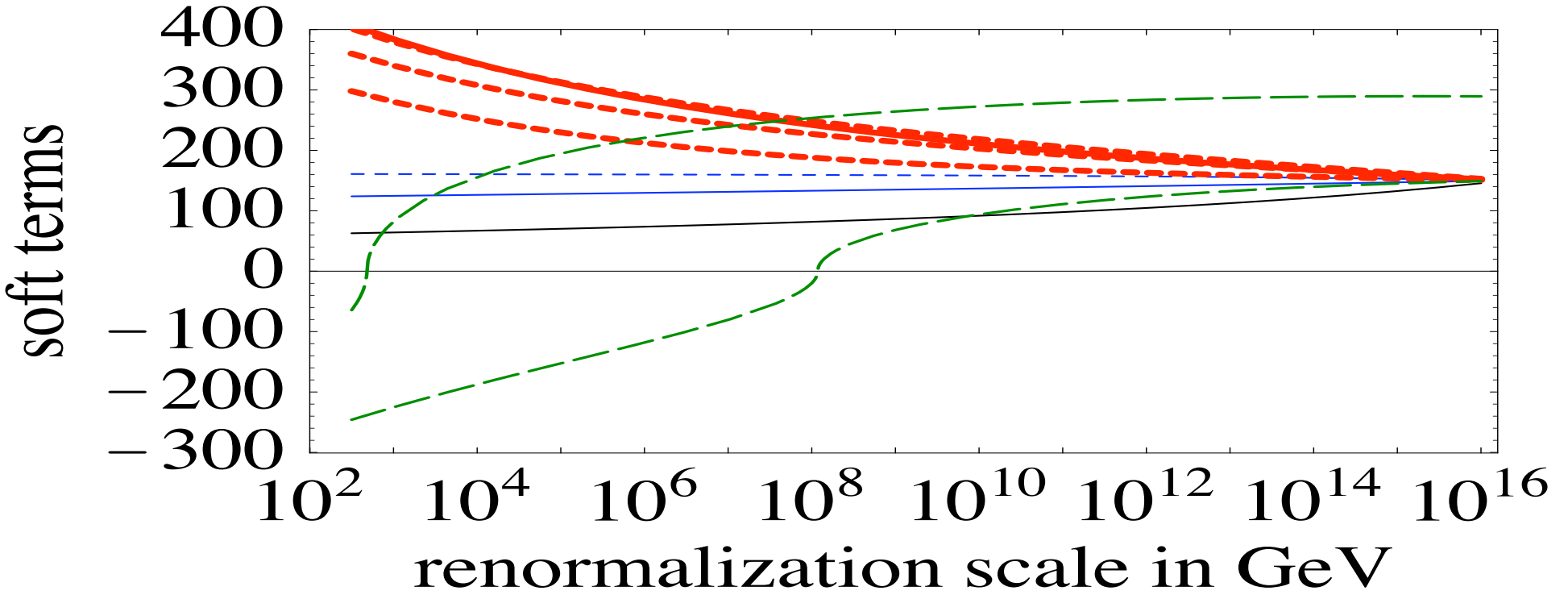
Black dot = excluded spectrum. Red = excluded by LHC. Green = allowed

Fraction of alive CMSSM $\approx 1/\Delta$

(the theoretical uncertainty in m_h is about 3 GeV;
the CMSSM prediction for m_h can be circumvented
NMSSM, NRO [hep-ph/9906266...], $h \to$ light scalars...)

$M_Z \ll m_{\text{SUSY}} \Rightarrow$ late SU(2) breaking

The scale Q_0 at which RGE running makes $m_h^2(Q) < 0$ must be close to m_{SUSY}



SUSY little Higgs as pseudo-Goldstone of some symmetry broken at Q_0?

The sliding $m_{\rm SUSY}$ model

Assume that $m_{\rm SUSY}$ is a free parameter determined by minimizing $V_{\rm MSSM}$ (!)

$$\min V_{\rm MSSM} \sim \begin{cases} 0 & m_{\rm SUSY} > Q_0 \\ -m_{\rm SUSY}^4 & m_{\rm SUSY} < Q_0 \end{cases}$$

Prediction [hep-ph/0005203, BS]: $m_{\rm SUSY} \lesssim Q_0$ and a loop factor above M_Z:

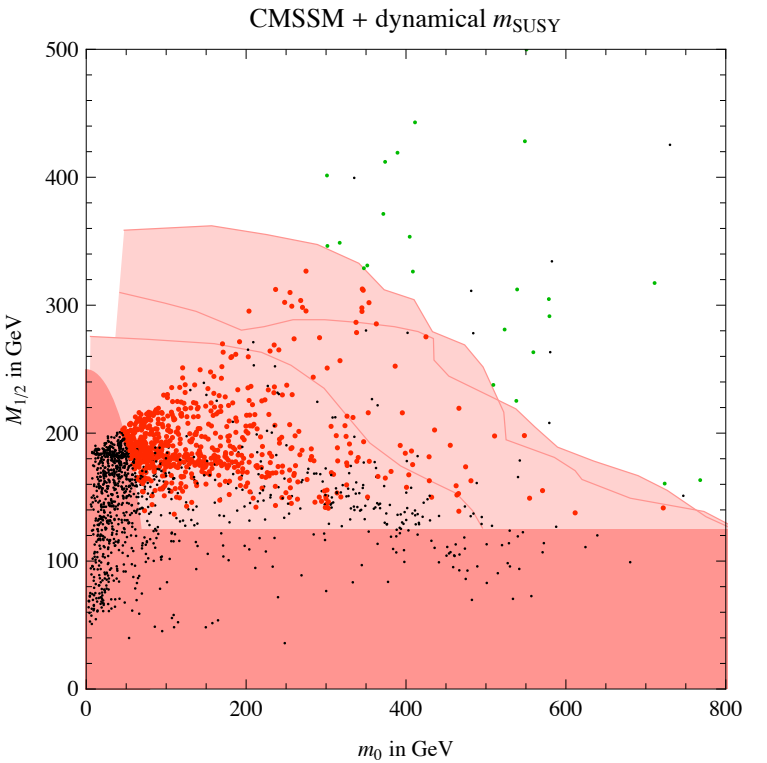
$$\frac{d\mu_{\rm u}^2}{d\ln\mu}\sin^2\beta + \frac{d\mu_{\rm d}^2}{d\ln\mu}\cos^2\beta - 2\frac{d\mu_{\rm ud}^2}{d\ln\mu}\sin\beta\cos\beta = M_Z^2\cos^2 2\beta \overset{\text{one loop}}{\longrightarrow} m_h^2$$

RGE loop factors are big: roughly this means

$$m_{\tilde t} \approx 4\pi M_Z/\sqrt{12} \approx 400\,\text{GeV}$$

Predicted: dashed line in the CMSSM plot.
Allowed: from 50% to 2% with LHC.

PS: BS hypothesis may be BS: $V \neq V_{\rm MSSM}$.
Alternative interpretation in terms of anthropic pressure ($Q_0 \ll m_{\rm SUSY}$): more rare than SM?



What does it mean?

We have significant hints for SUSY.

We have significant hints against SUSY.

At some point somebody will understand what is the logic.