Phenomenology of GUT-less SUSY Breaking

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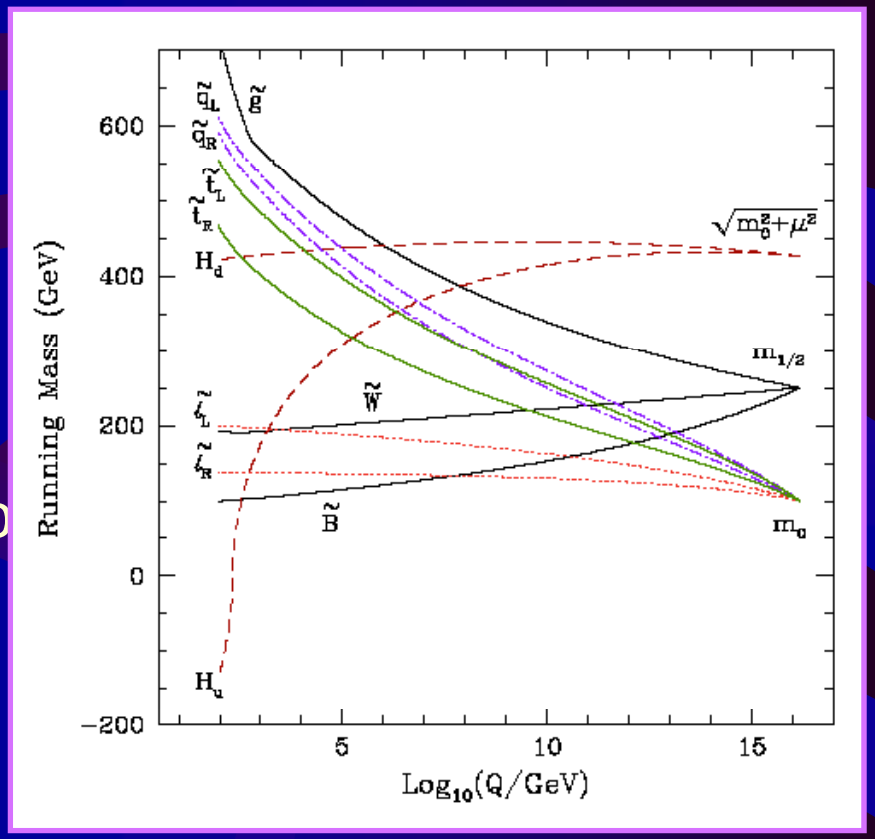
Ellis, Olive & PS, Phys. Lett. B **642** (2006) 389
Ellis, Olive & PS, JHEP **06** (2007) 079

Standard CMSSM

- Soft SUSY-breaking parameters
- GUT-scale universality
- Use RGEs to run down to weak scale



GUT-less CMSSM

- Universality at ~~GUT-scale~~ $M_{in} < M_{GUT}$
  - Constraints from colliders and cosmology:

$m_h > 114$ GeV
$m_{\chi^\pm} > 104$ GeV } LEP
$BR(b \rightarrow s\,\gamma)$ HFAG
$BR(B_s \rightarrow \mu^+\mu^-)$ CDF
$(g_\mu - 2)/2$ g-2 collab.

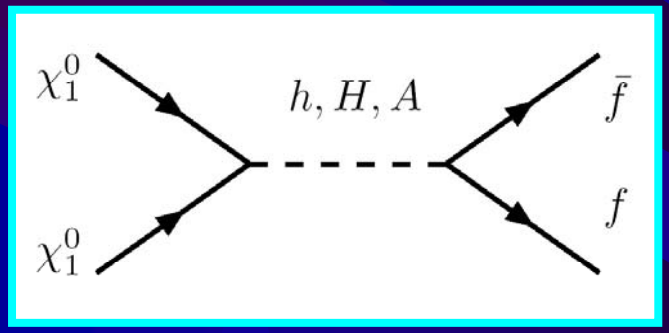
$0.09 \leq \Omega_\chi h^2 \leq 0.12$

SUSY Dark Matter

- Solve Boltzmann rate equation:

$$\frac{dn_\chi}{dt} = -3Hn_\chi - \langle \sigma v_{rel} \rangle \left[n_\chi^2 - (n_\chi^{eq})^2 \right]$$

- Special Situations:
  - s - channel poles
    - 2 $m_\chi \approx m_A$
  - thresholds
    - 2 $m_\chi \approx$ final state mass
  - Coannihilations
    - $m_\chi \approx m_{\text{other sparticle}}$



Evolution of the Soft Mass Parameters

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$$M_a(Q)$$

$$\frac{(Q)}{M_{in})} m_{1/2}$$

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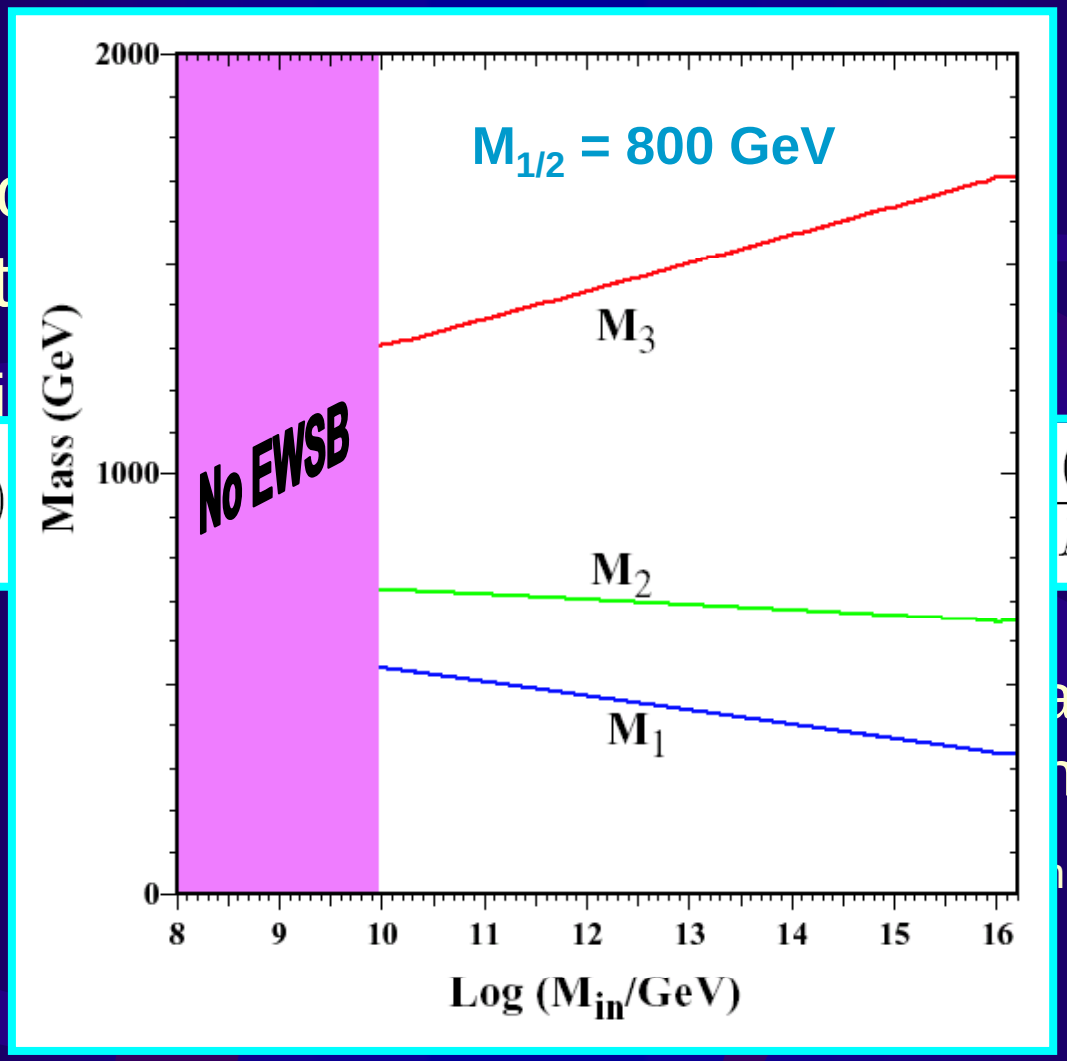

Evolution of the Soft Mass Parameters

- First
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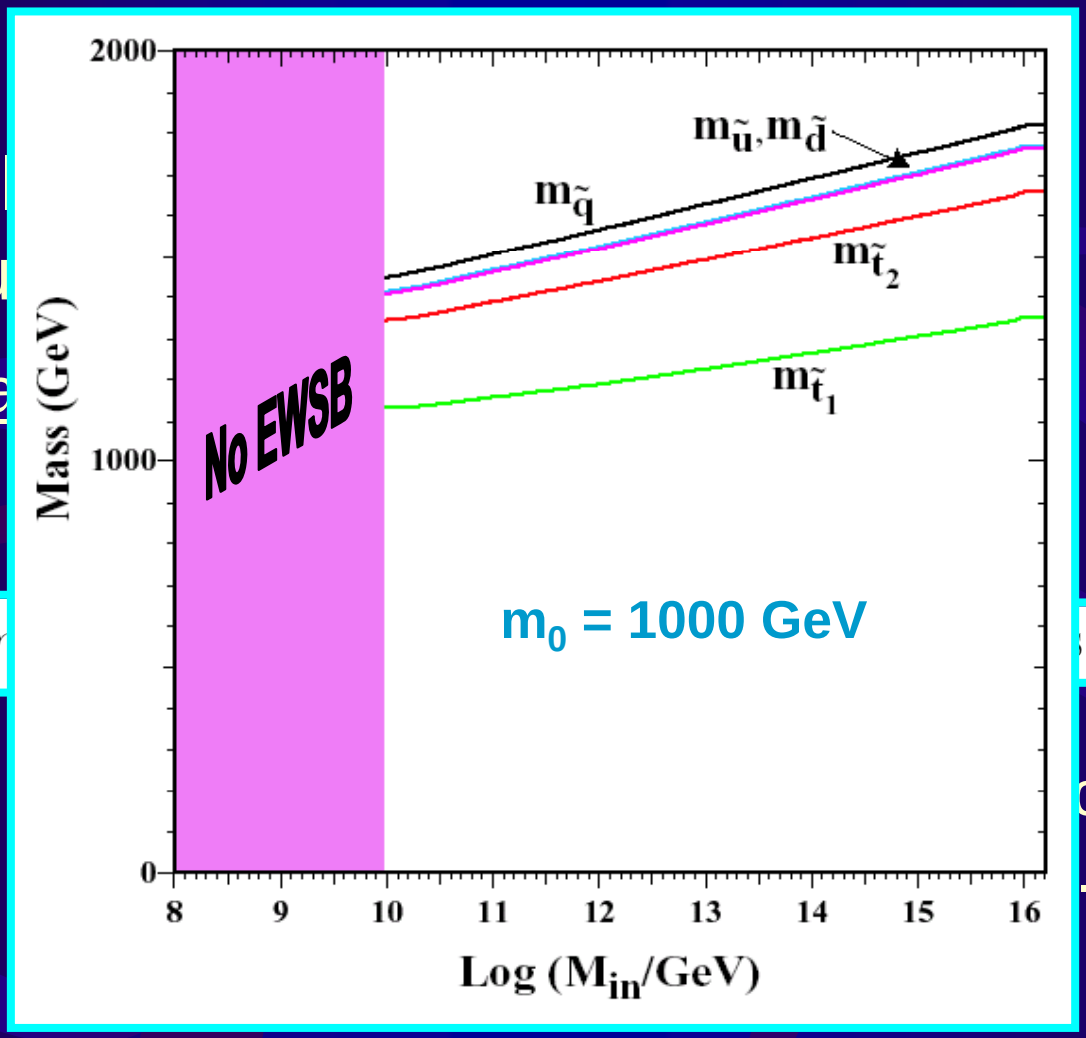
  Scala



$M_{in} \rightarrow Q$

cale

Evolution of the Soft Mass Parameters

- Higgs mass parameter, μ (tree level):

$$\mu^2 = \frac{m_1^2 - m_2^2 \tan^2\beta}{\tan^2\beta - 1} - \frac{M_Z^2}{2}$$

As $M_{in} \rightarrow$ low scale Q, expect low scale scalar masses to be closer to m_0.

μ^2 becomes generically smaller as M_{in} is lowered.

Mass Evolution with M_{in}

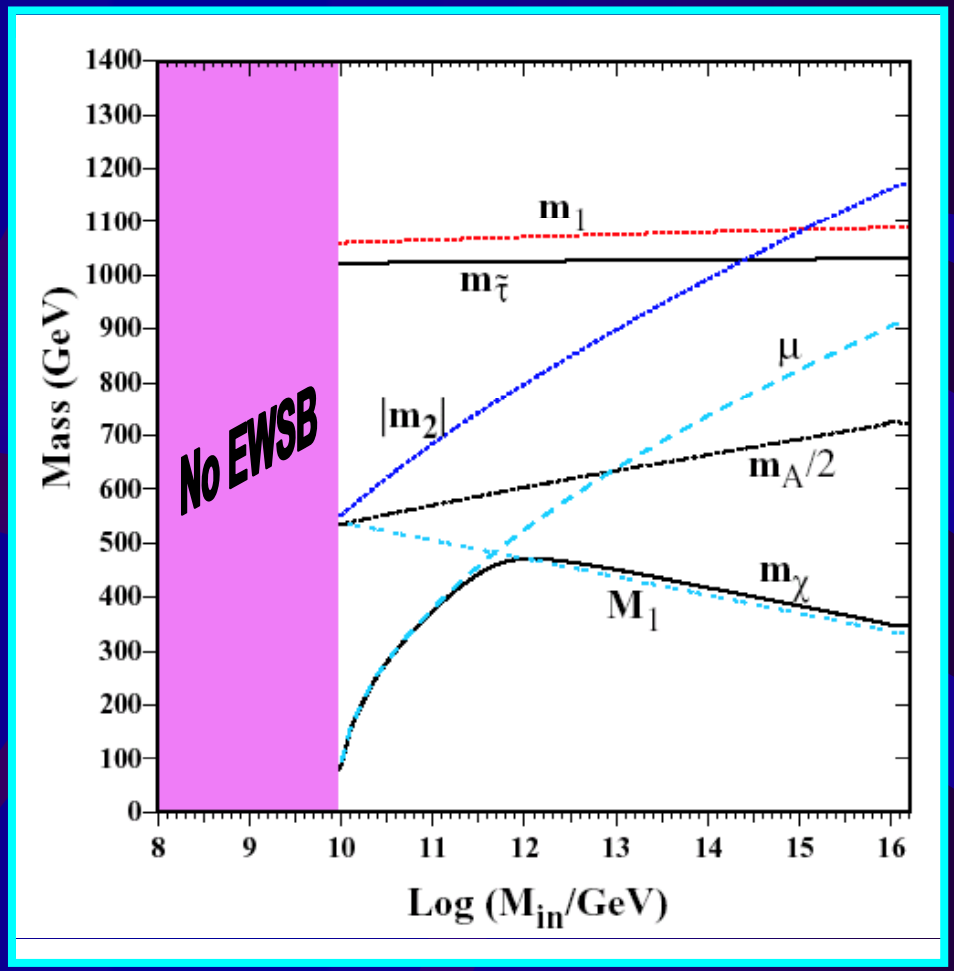
$m_{1/2}$ = 800 GeV

m_0= 1000 GeV

A_0 = 0

tan(β) = 10

μ > 0



Neutralinos and Charginos

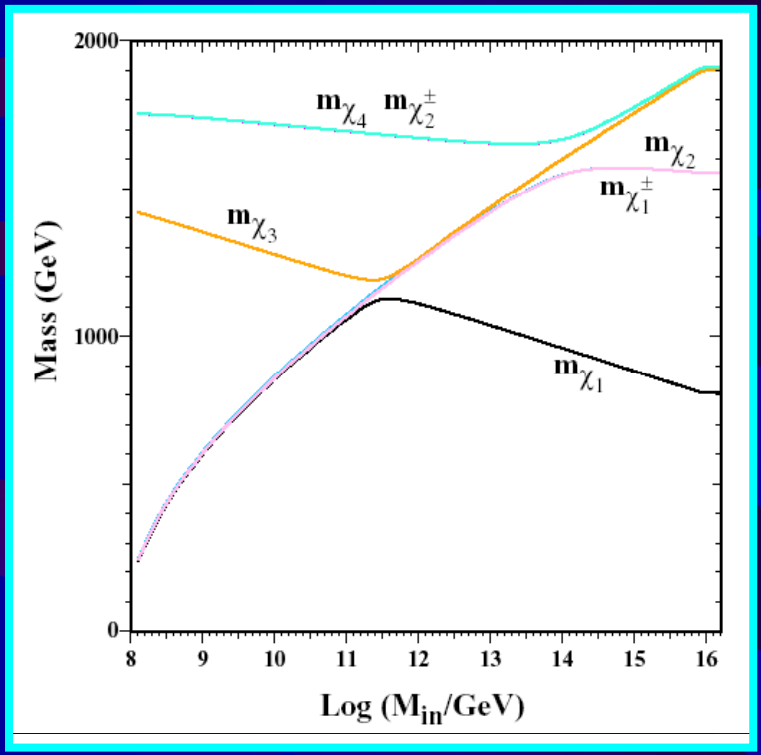
$m_{1/2}$ = 1800 GeV

m_0= 1000 GeV

A_0 = 0

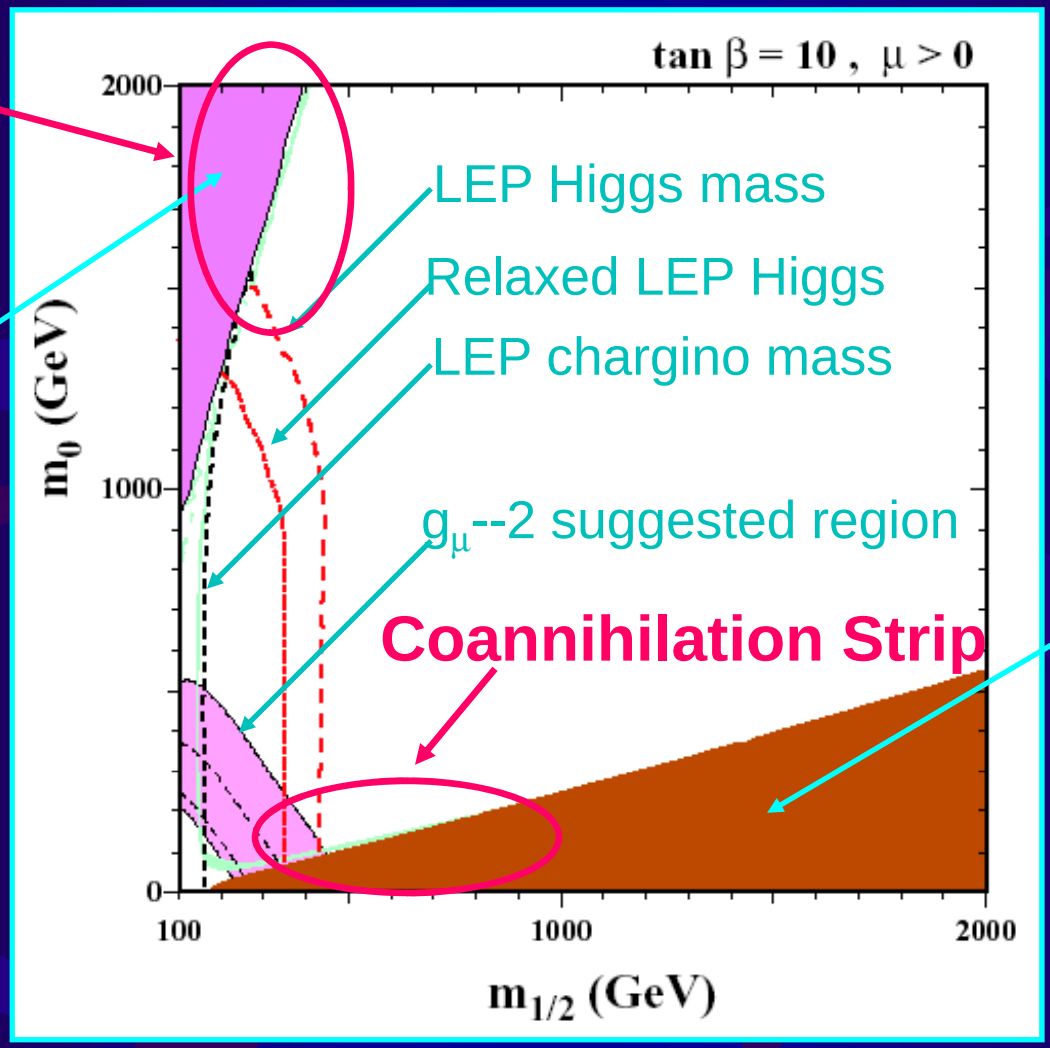
tan(β) = 10

μ > 0

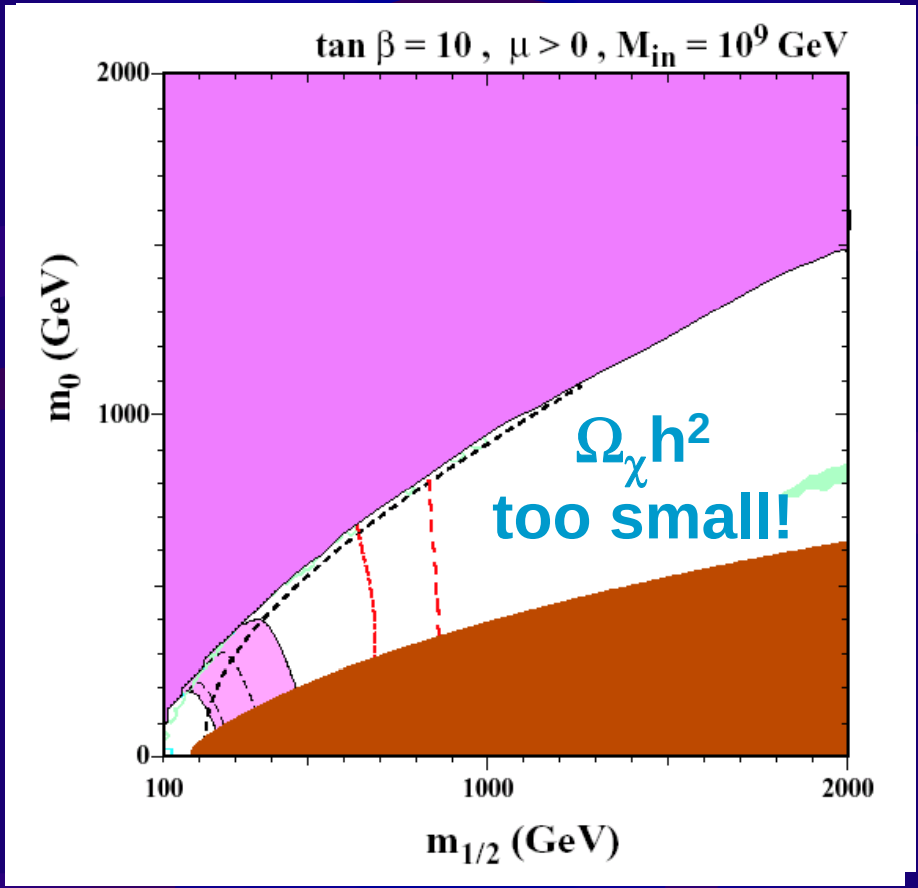


Must properly include coannihilations involving all three lightest neutralinos!

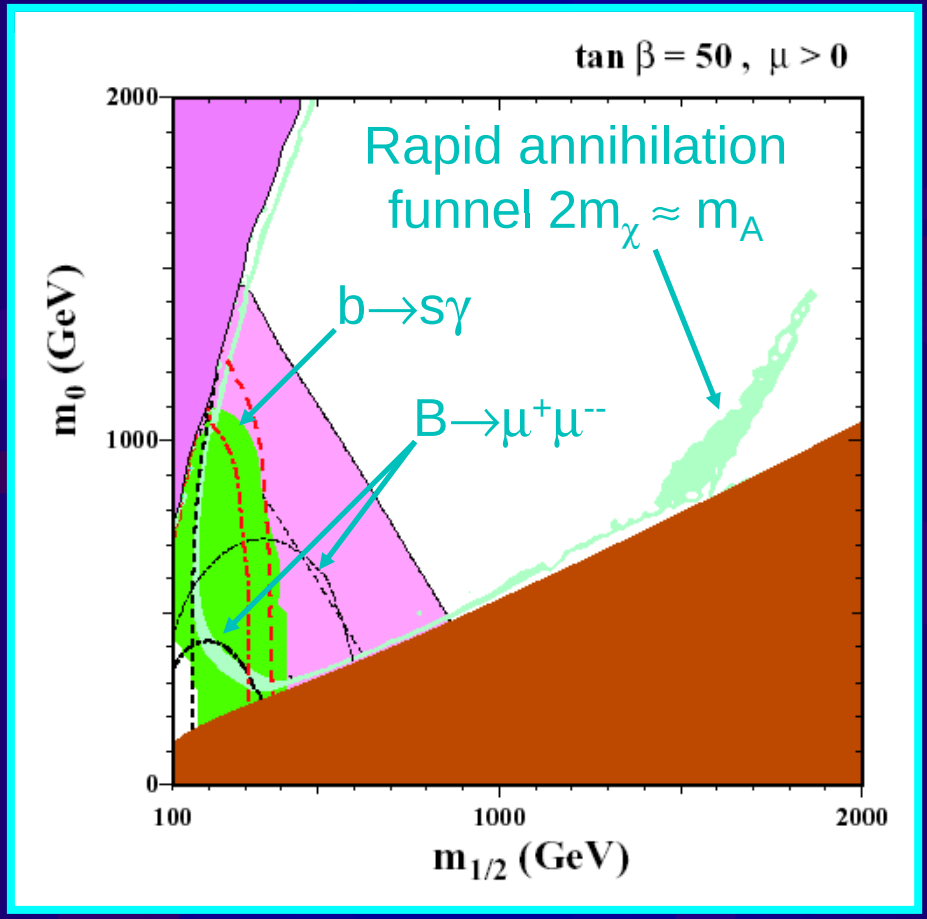
Standard CMSSM



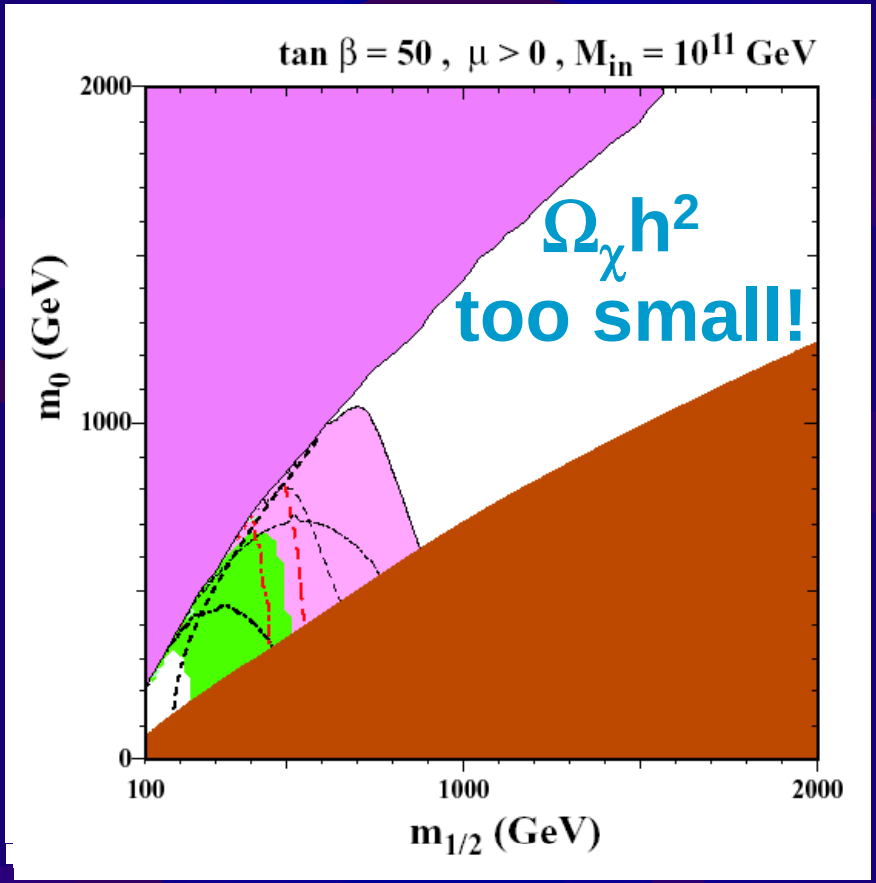
Lowering M_{in} - tan(β) = 10



Large tan(β)

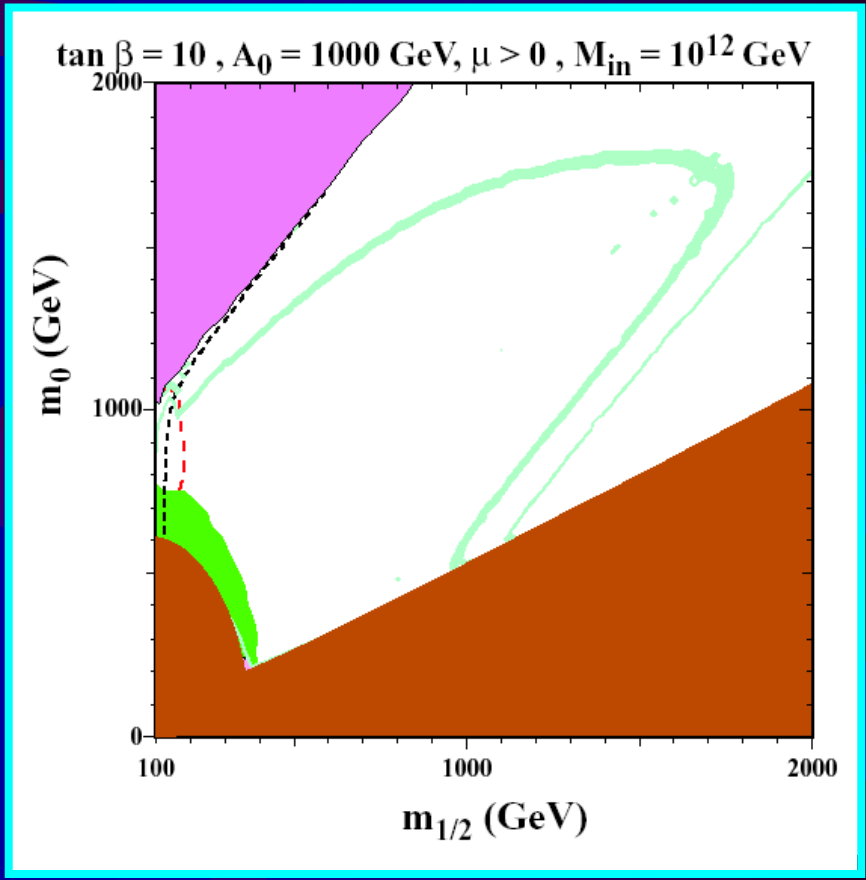

tan β = 50 , μ > 0
Rapid annihilation
funnel 2m$_\chi$ ≈ m$_A$
b→sγ
B→μ$^+$μ$^-$
m$_0$ (GeV)
2000
1000
0
100
1000
2000
m$_{1/2}$ (GeV)

Lowering M_{in} - tan(β) = 50



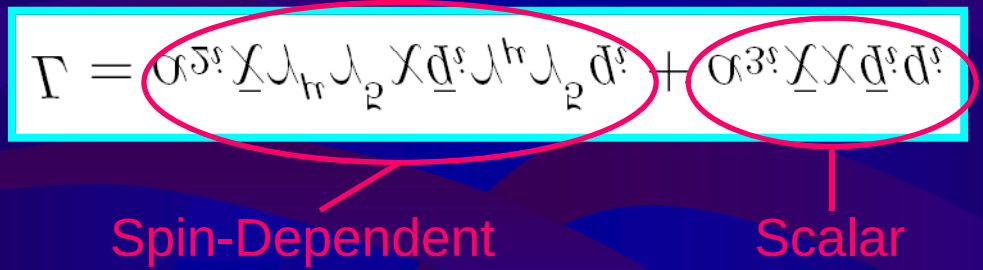
$A_0 \neq 0$

- $A_0 > 0 \Rightarrow$ larger weak-scale trilinear couplings, A_i
- Large loop corrections to μ depend on A_i, so μ is generically larger over the plane than when $A_0 = 0$.
- Also see stop-LSP excluded region



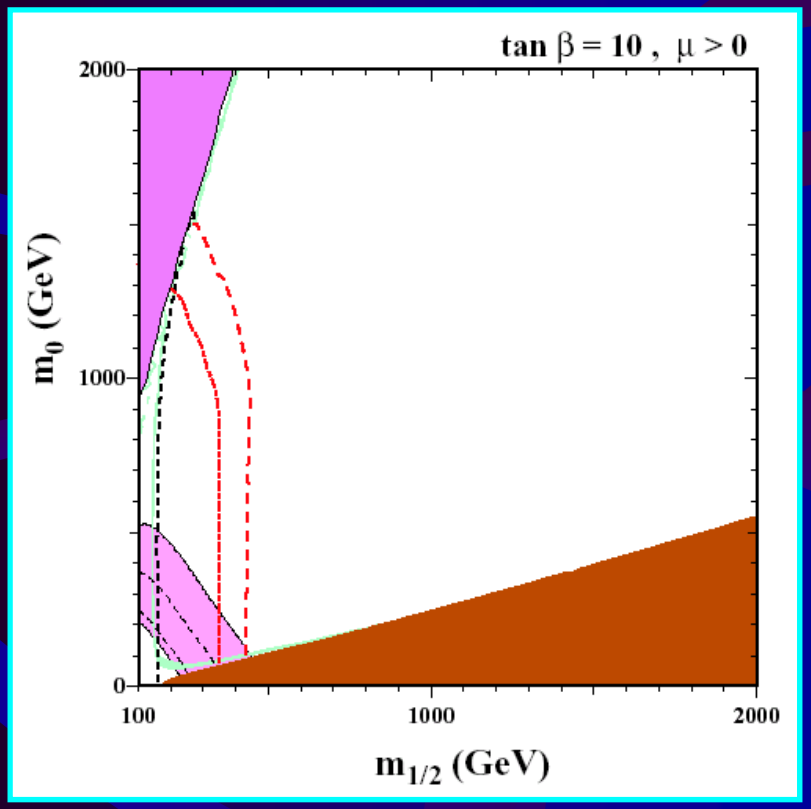
Direct Detection: Neutralino-Nucleon Cross Sections

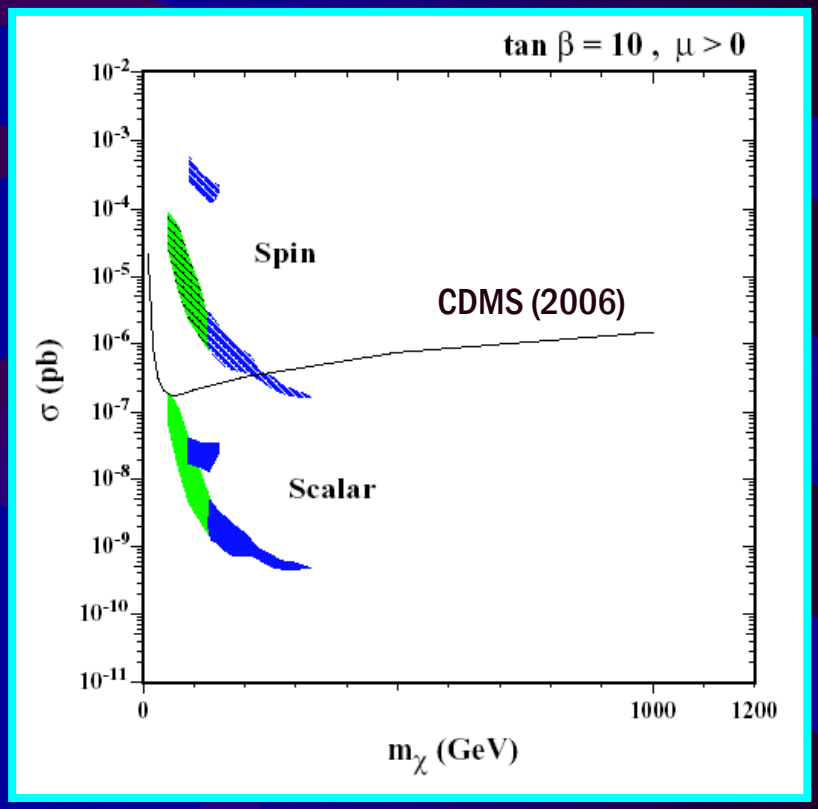
- Interaction Lagrangian (neglecting velocity dep. terms):



- Plot all cross sections *not forbidden* by constraints
  - If $\Omega_\chi^{calc} < \Omega_{CDM}^{WMAP}$, scale by $\Omega_\chi^{calc}/\Omega_{CDM}^{WMAP}$

Direct Detection: Neutralino-Nucleon Cross Sections





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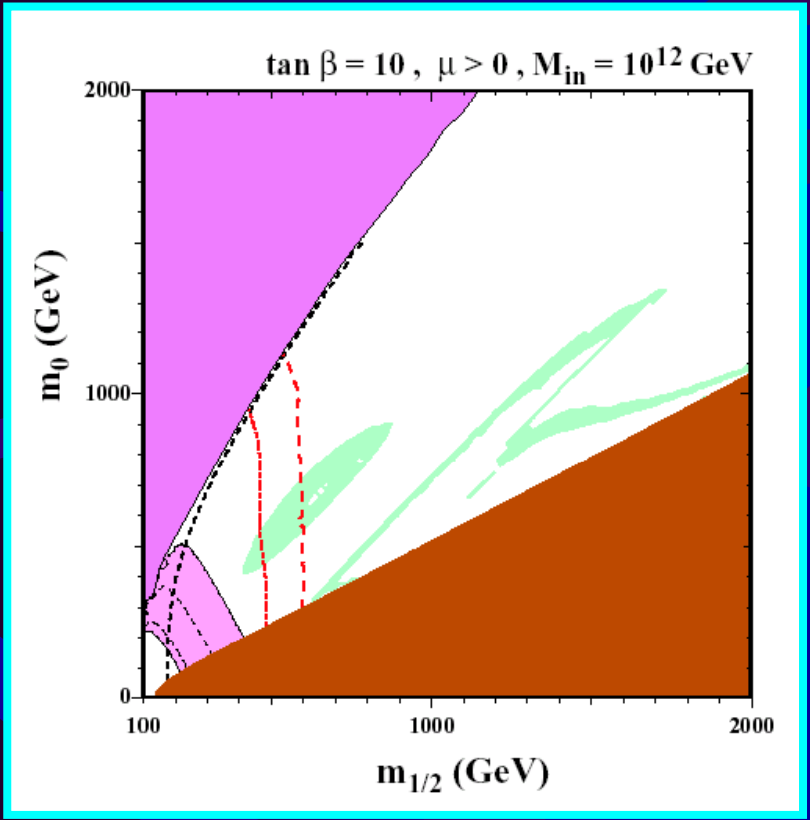
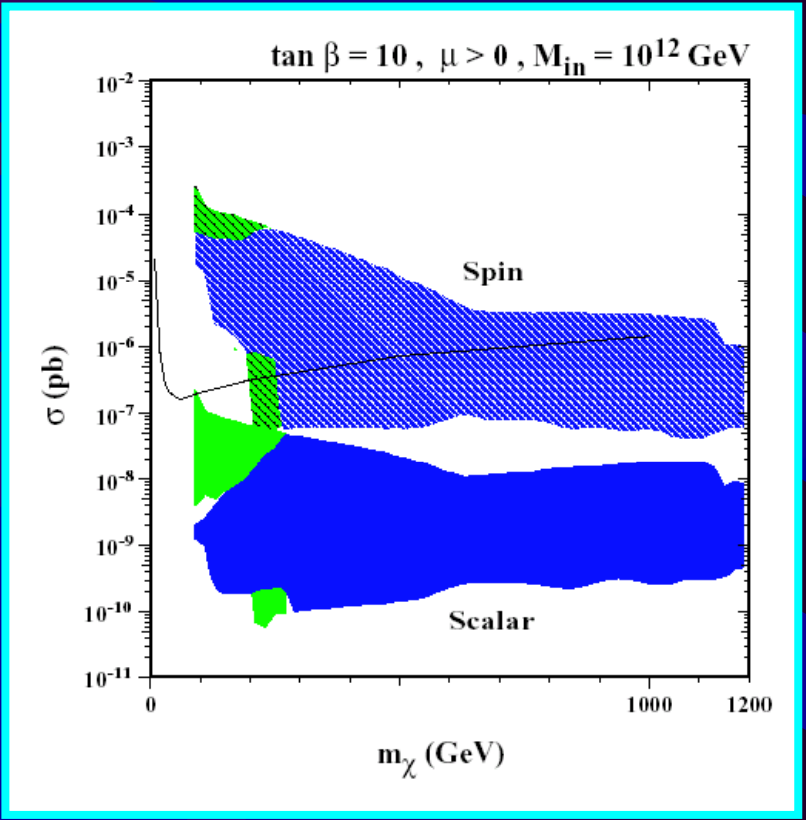


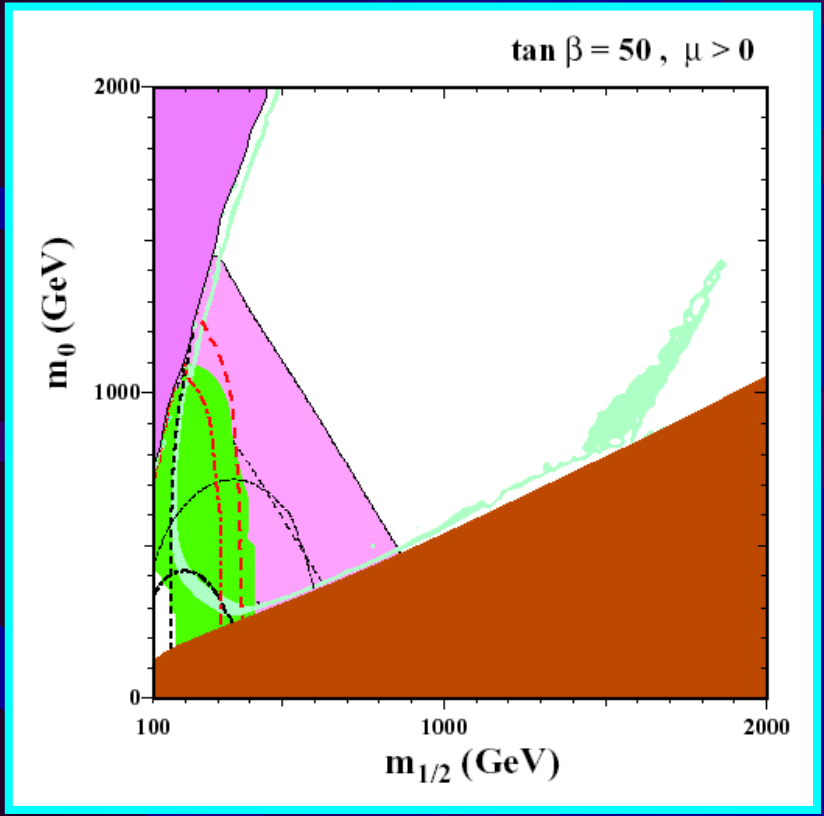


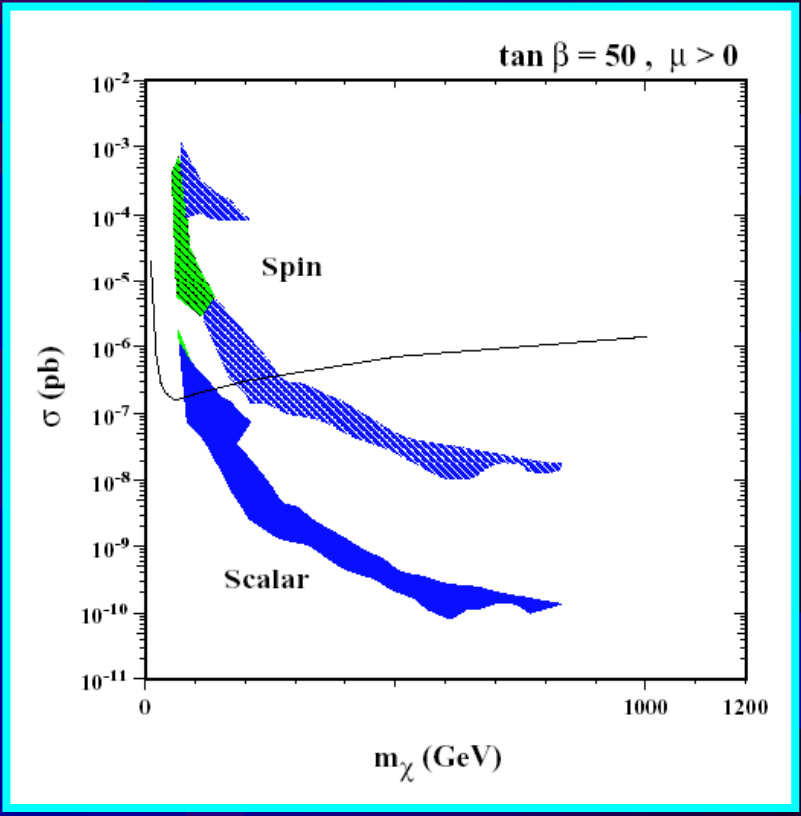
Conclusions

- Intermediate scale unification results in:
  - Rapid annihilation funnel even at low tan(β)
  - Merging of funnel and focus point
- Below some critical M_{in} (dependent on tan(β) and other factors), all of nearly all of the ($m_{1/2}$, m_0) plane is disfavored because the relic density of neutralinos is too low to fully account for the relic density of cold dark matter.

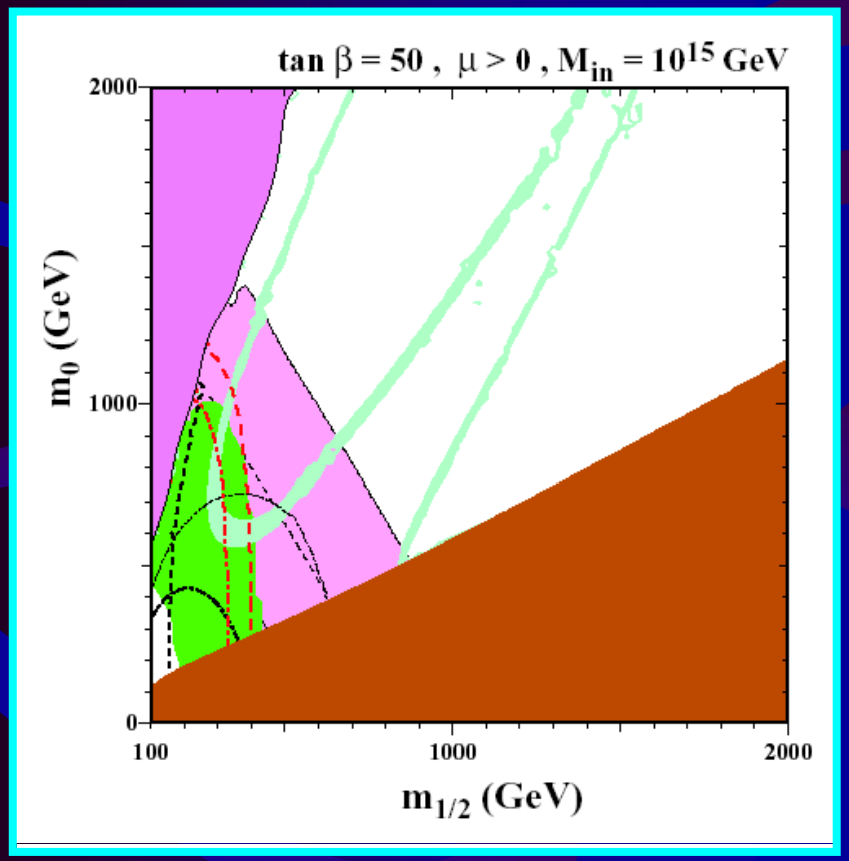
Extra Slides

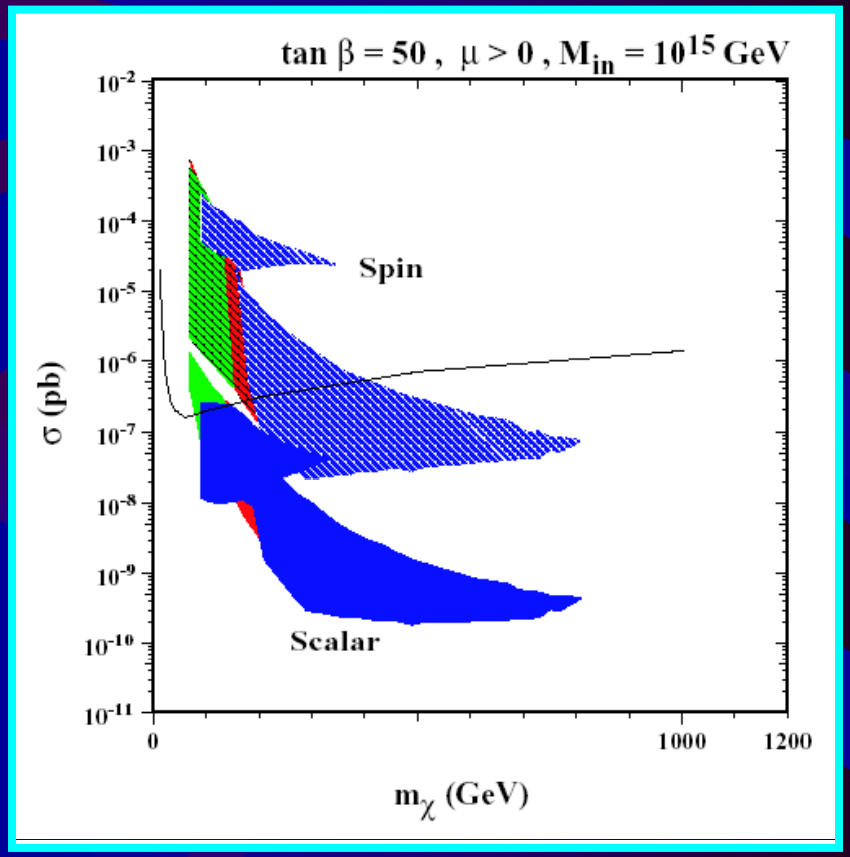
Neutralino-Nucleon Cross Sections





Neutralino-Nucleon Cross Sections





Sparticle Masses

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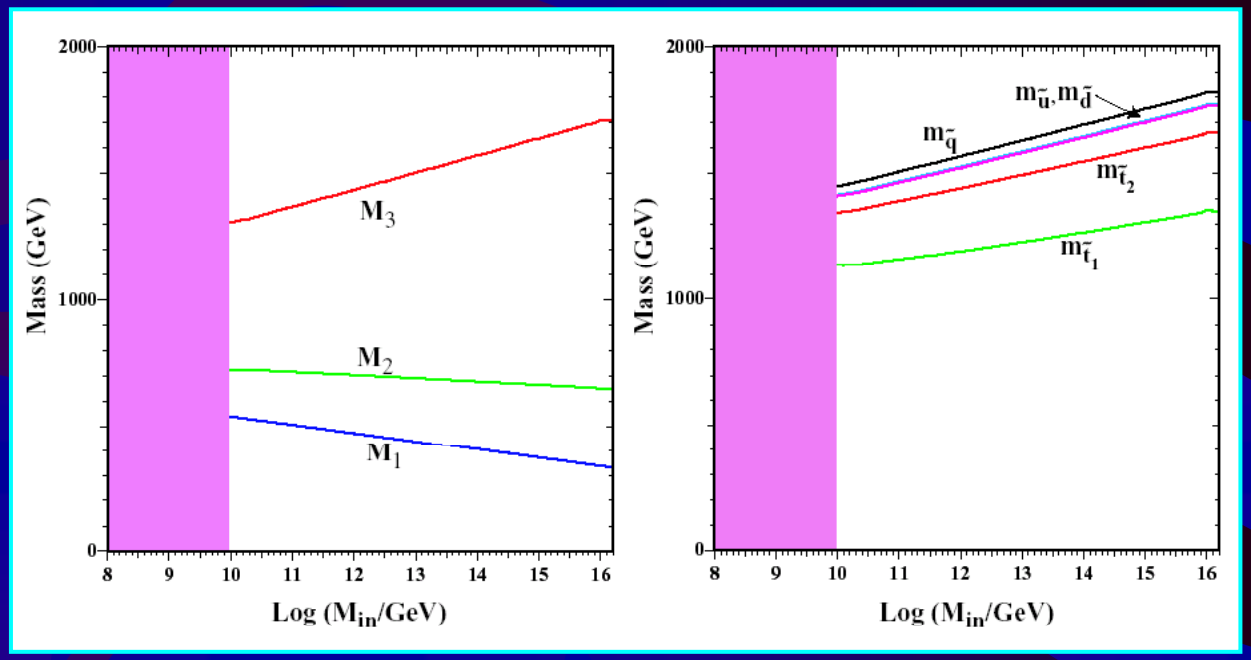
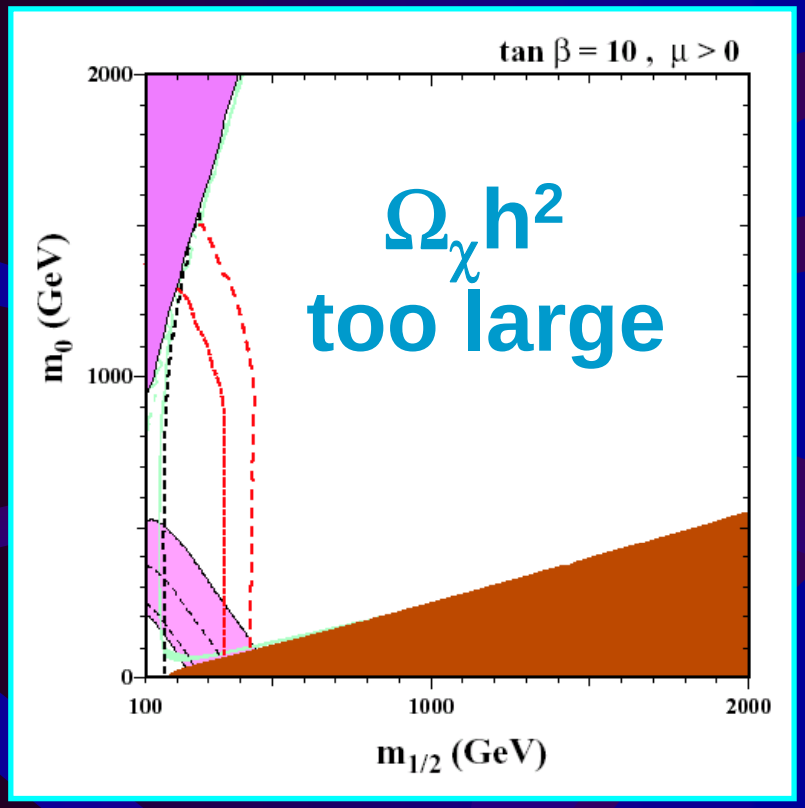
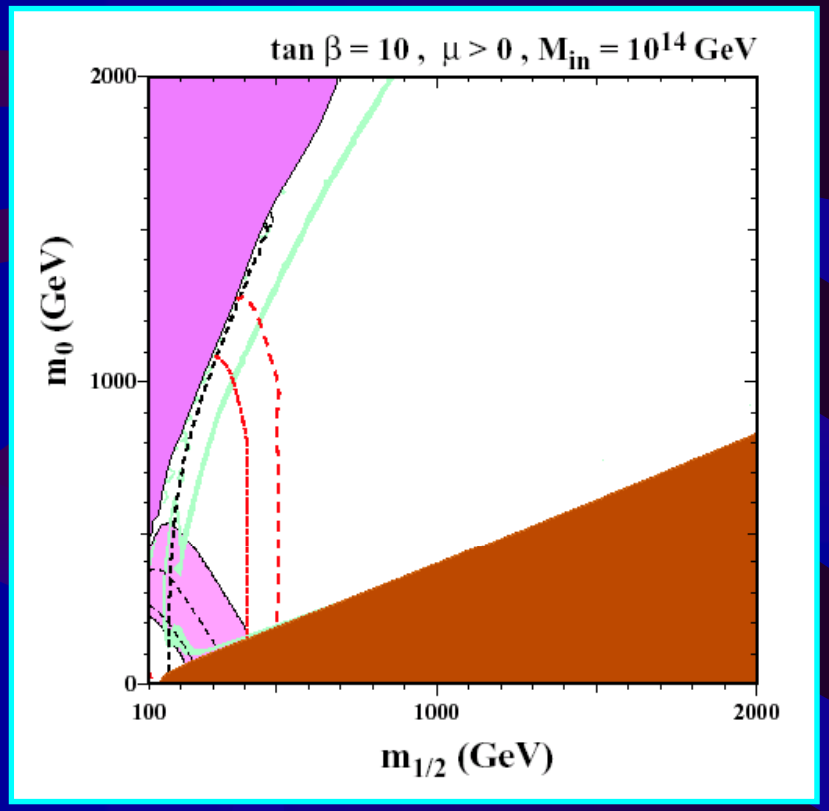


Guaginos

Squarks

Lowering M_{in}





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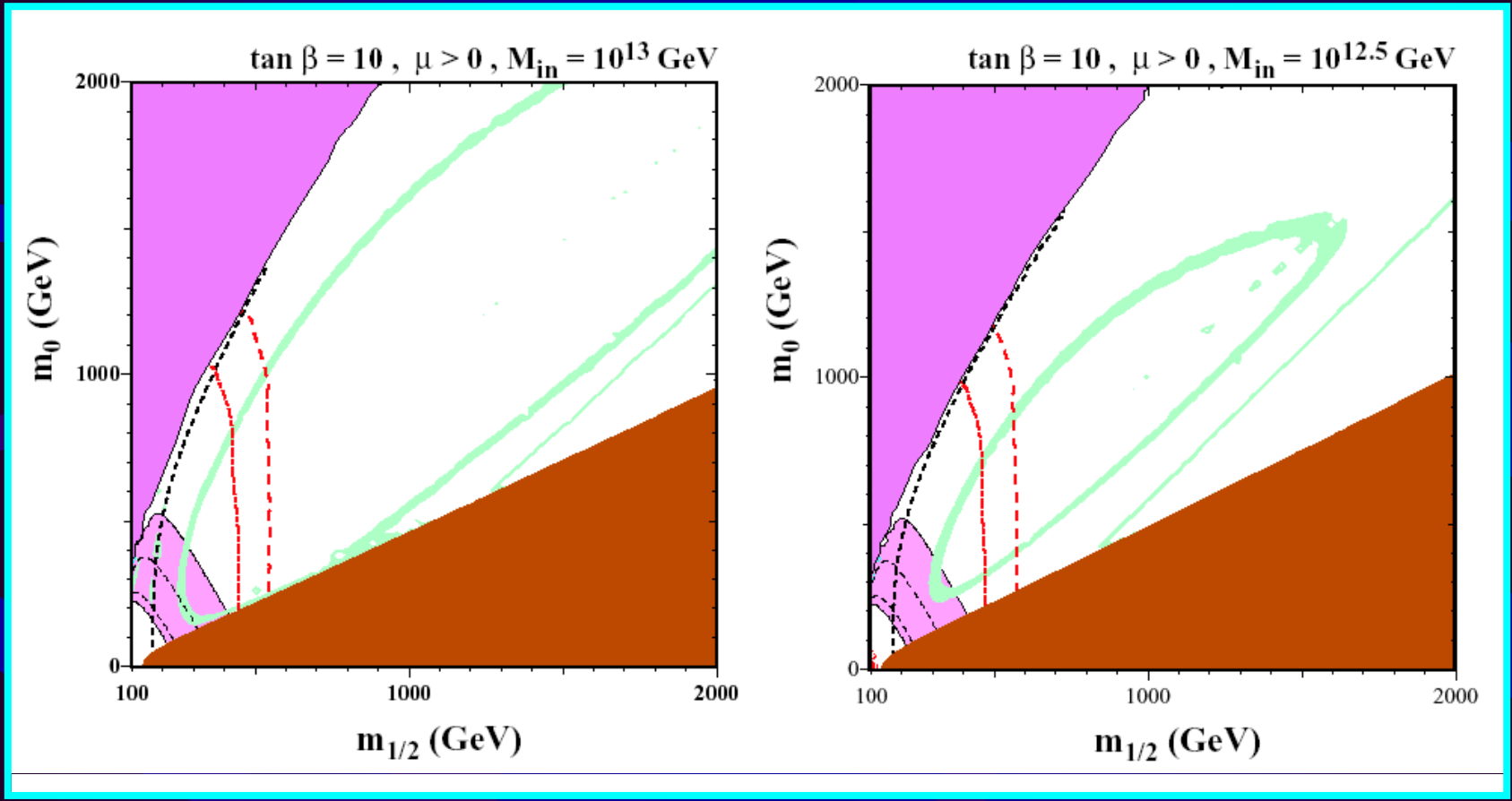

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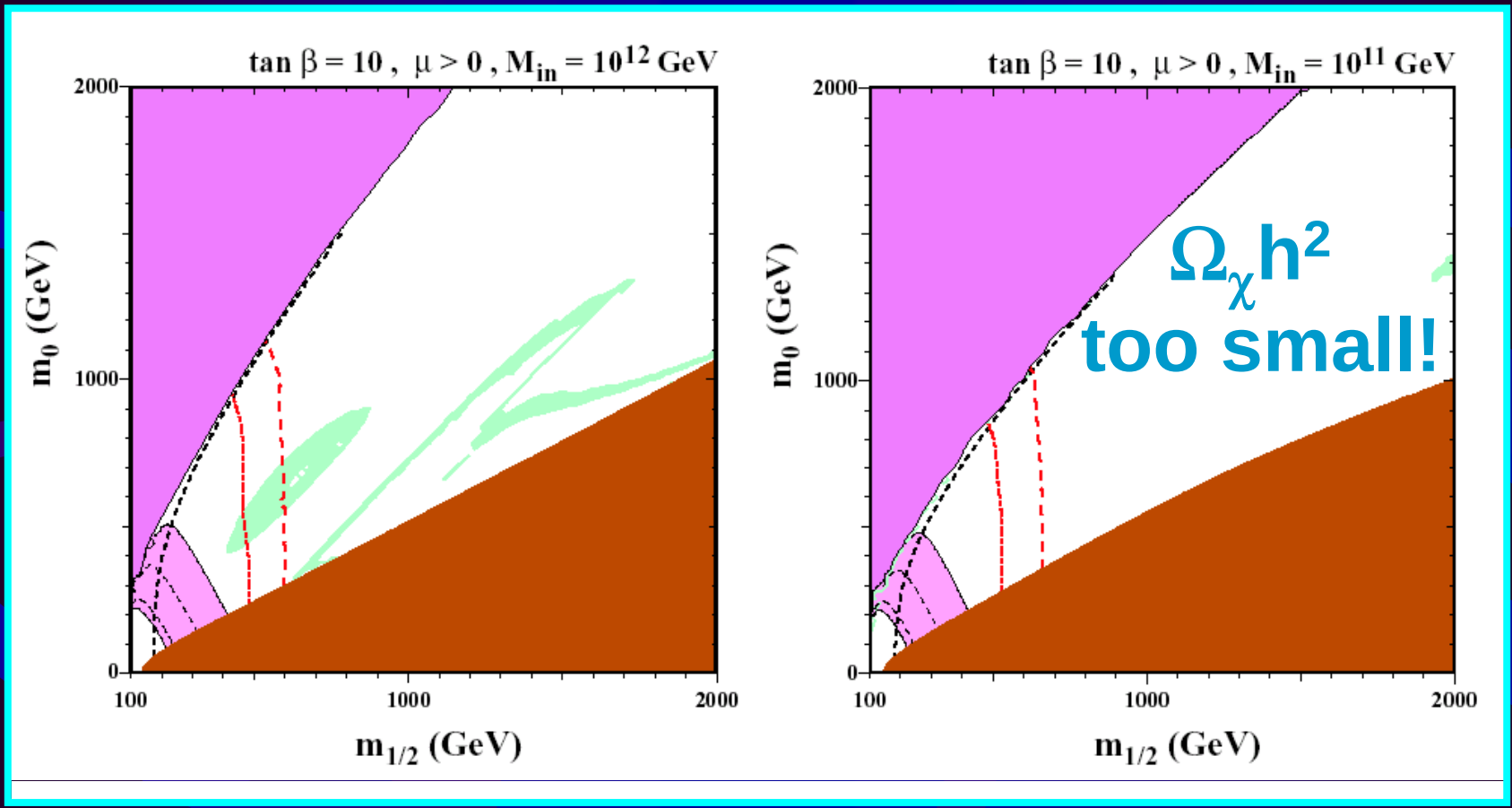
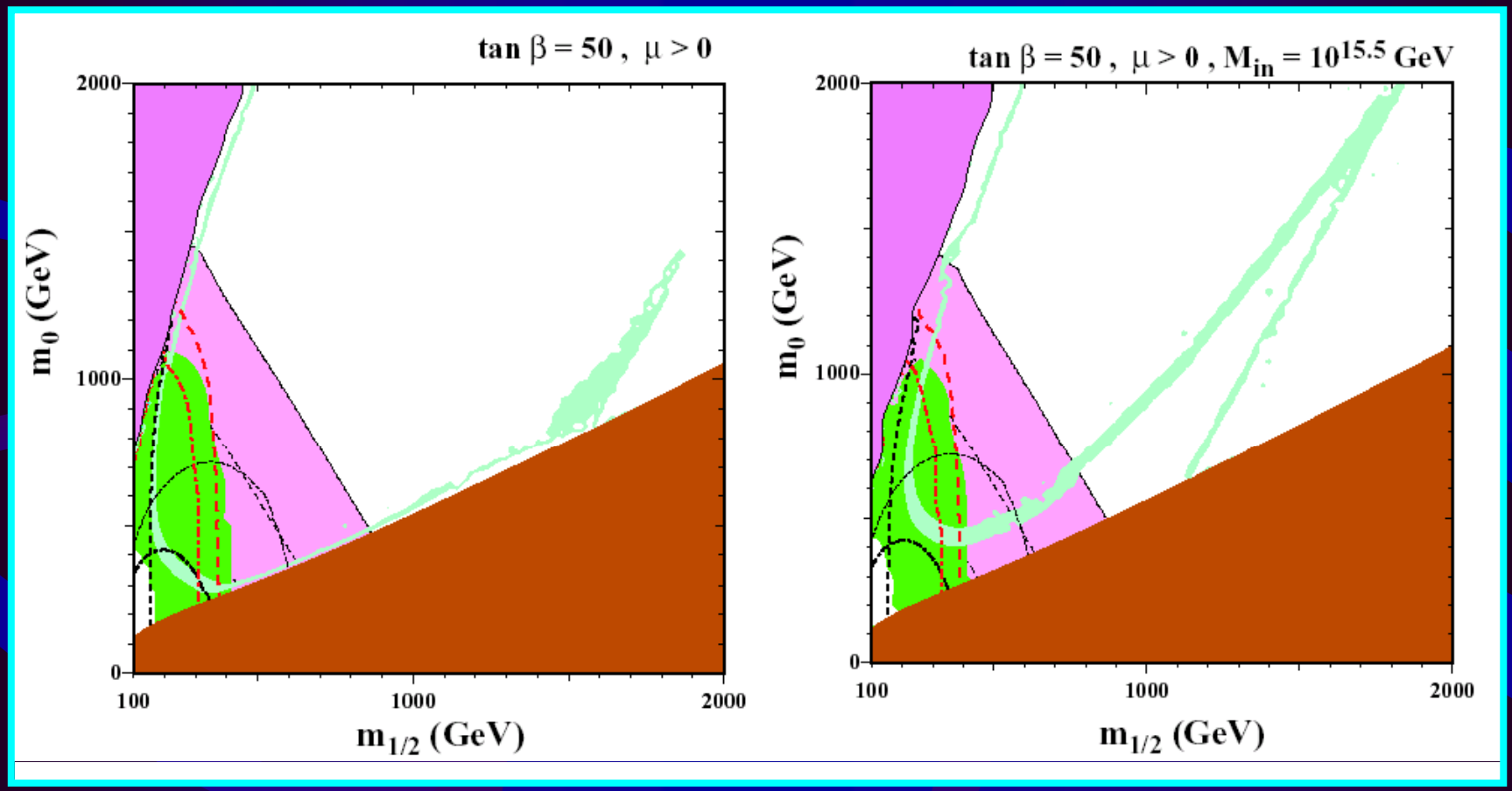


Lowering M_{in} - Large tan(β)



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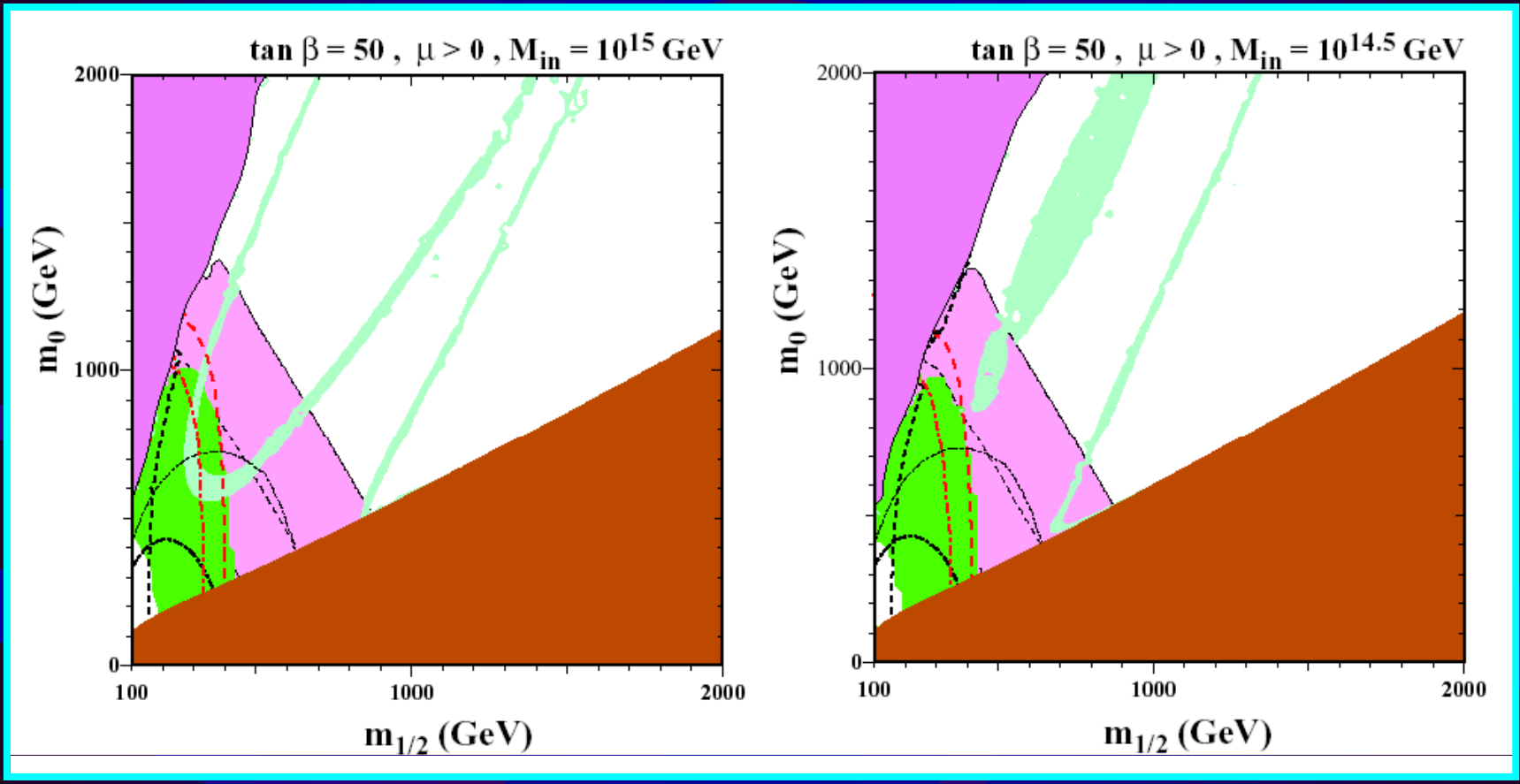

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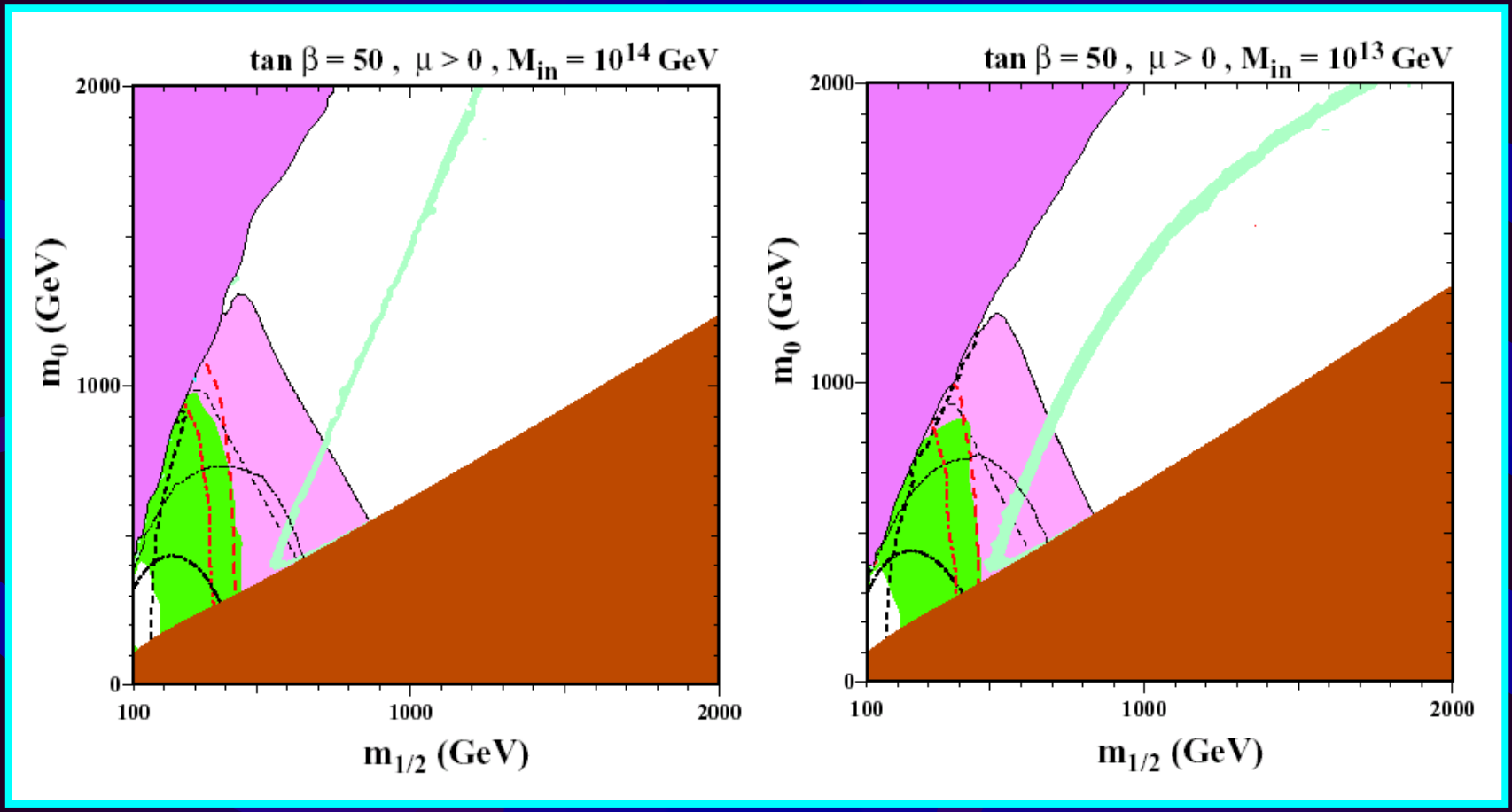

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