Sub-GUT mSUGRA

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Ellis, Olive & Sandick (2006,2007,2008)

Ellis, Luo, Olive & Sandick (2013)

mSUGRA

CMSSM

$$\mathcal{L}_{\text{soft}} = -\frac{1}{2}M_\alpha \lambda^\alpha \lambda^\alpha - m_{ij}^2 \phi^{*i}\phi^j$$

$$-A_e y_e H_1 L e^c - A_d y_d H_1 Q d^c - A_u y_u H_2 Q u^c - B\mu H_1 H_2$$

$m_{1/2}$ → $\mathcal{L}_{\text{soft}}$ term; m_0 → $\mathcal{L}_{\text{soft}}$ term; A_0 → trilinear terms; tanβ → $B\mu$ term; sign(μ) → $B\mu$ term

- Strict Minimal Supergravity (mSUGRA) is defined by a flat Kahler potential that leads to *minimal* kinetic terms in the supergravity Lagrangian.

1. scalar mass universality w/ $m_0 = m_{3/2}$ gravitino LSP for $m_{3/2} < m_\chi$
2. trilinear coupling (A_0) universality

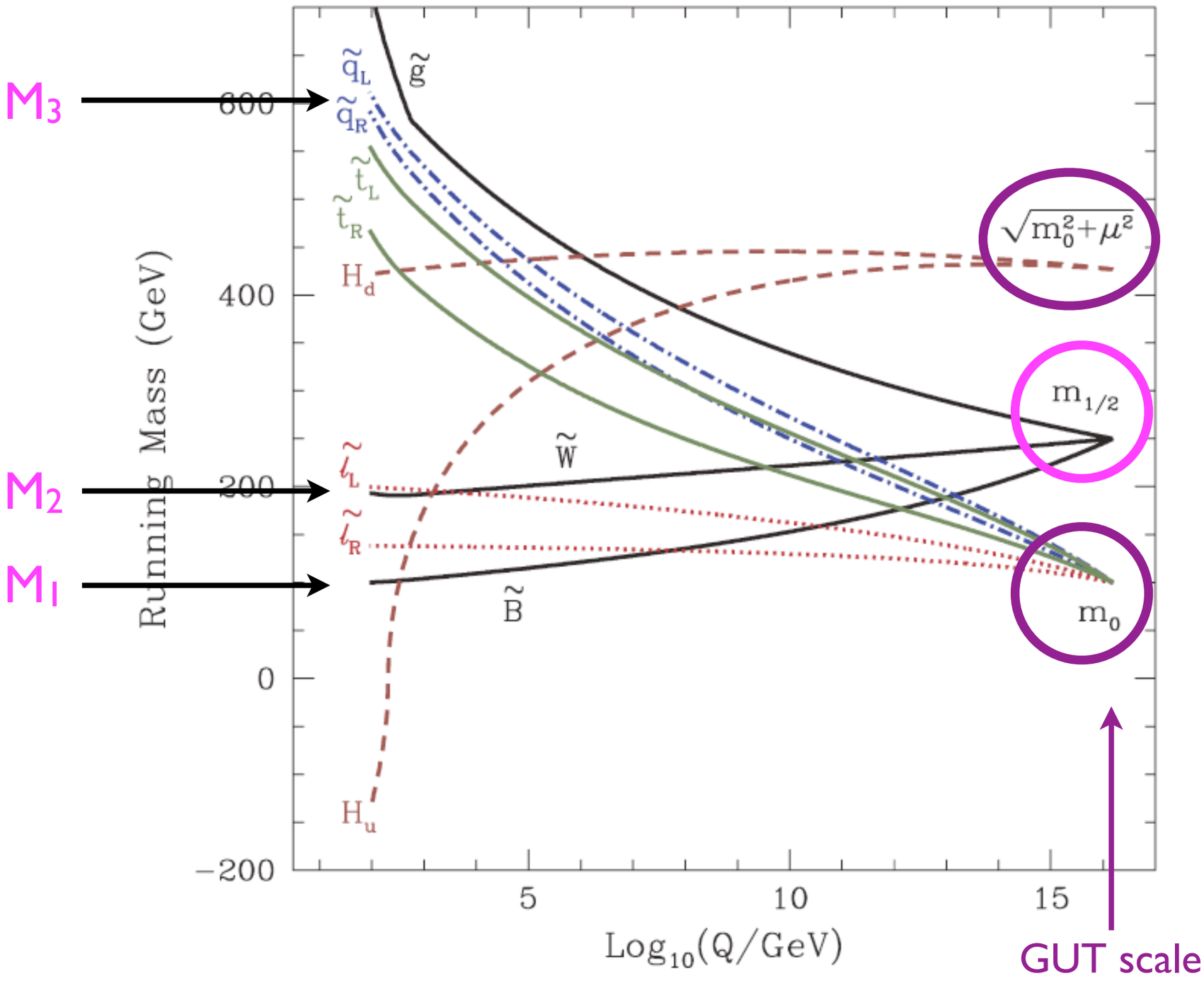
Polonyi: $A_0 = (3 - \sqrt{3})m_{3/2}$

3. $B_0 = A_0 - m_0$ calculate tanβ ⇒ {$m_{1/2}$, m_0, A_0, sign(μ)}
4. minimal gauge kinetic term ⇒ gaugino mass universality

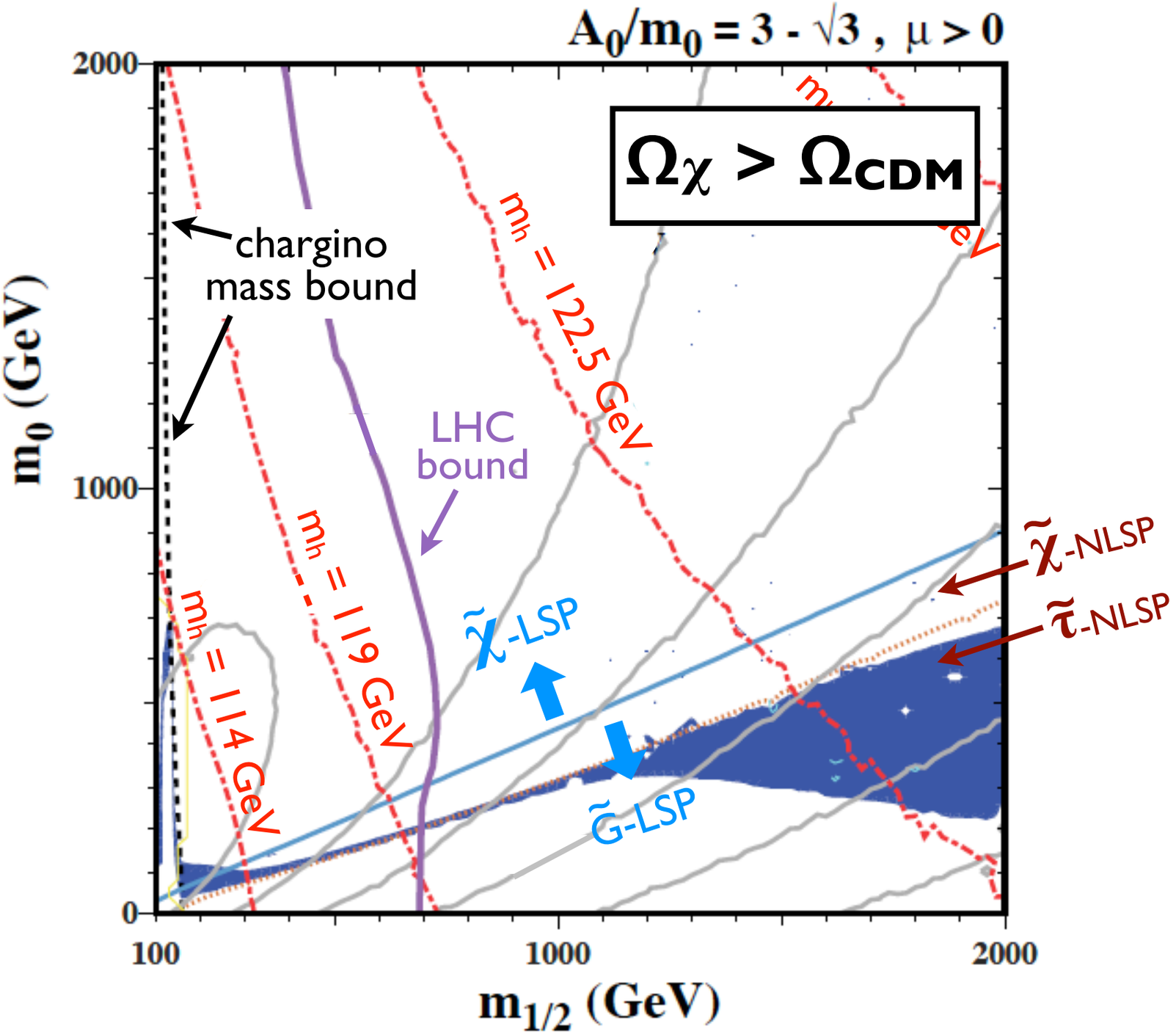
More general forms of the Kahler potential lead to the CMSSM. (Arnowitt, Chamseddine, & Nath)

Nilles, Srednicki, & Wyler (1983)
Hall, Lykken, & Weinberg (1983)

mSUGRA


M3
M2
M1
600
400
200
0
−200
Running Mass (GeV)
5
10
15
Log10(Q/GeV)
g̃
q̃L
q̃R
t̃L
t̃R
Hd
Hu
W̃
B̃
√m0²+μ²
m1/2
m0
GUT scale

Standard mSUGRA



Universality Scale

- Input universality scale, M_{in}, assumed to be M_{GUT}
- Could be larger: "superGUT"
  - SUSY breaking and mediation characterized by Planck or string scale

Polonsky & Pomarol (1994)
For recent analyses, see Ellis, Mustafayev, & Olive (2010,2011)

- Could be smaller: "subGUT/GUTless", "Mirage", or "TGM"

Ellis, Olive, & Sandick (2006, 2007, 2008)

Choi et al. (2004, 2005), Kachru et al. (2003), and others

Monaco et al. (2011)

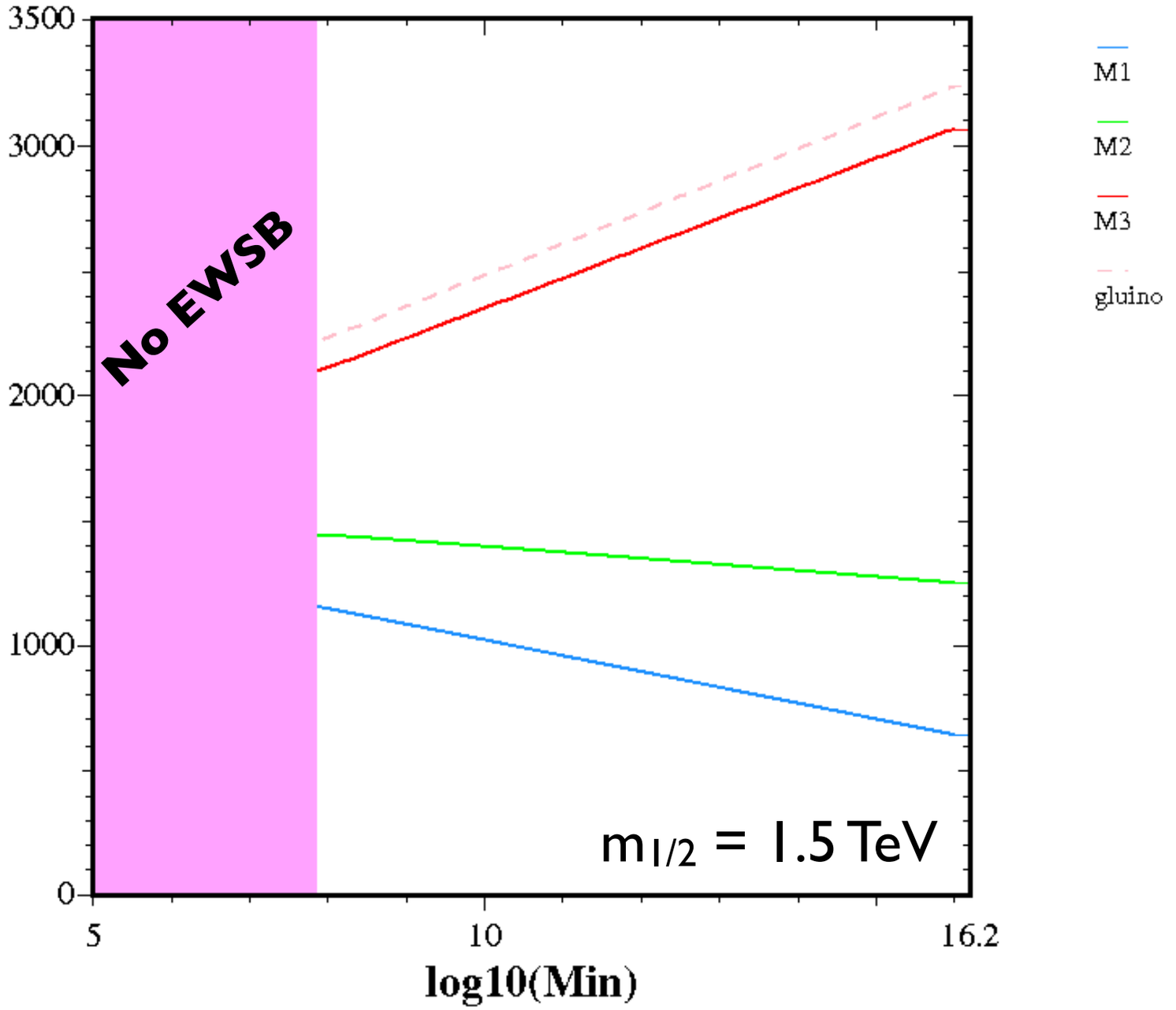
  - Lowest dynamical scale in the Polonyi/hidden sector where SUSY is broken, or scale of interactions that transmit breaking to observable sector

Gaugino Mass Evolution

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

1. Gaugino masses closer to $m_{1/2}$
2. Lighter gluino

(2-loop results)

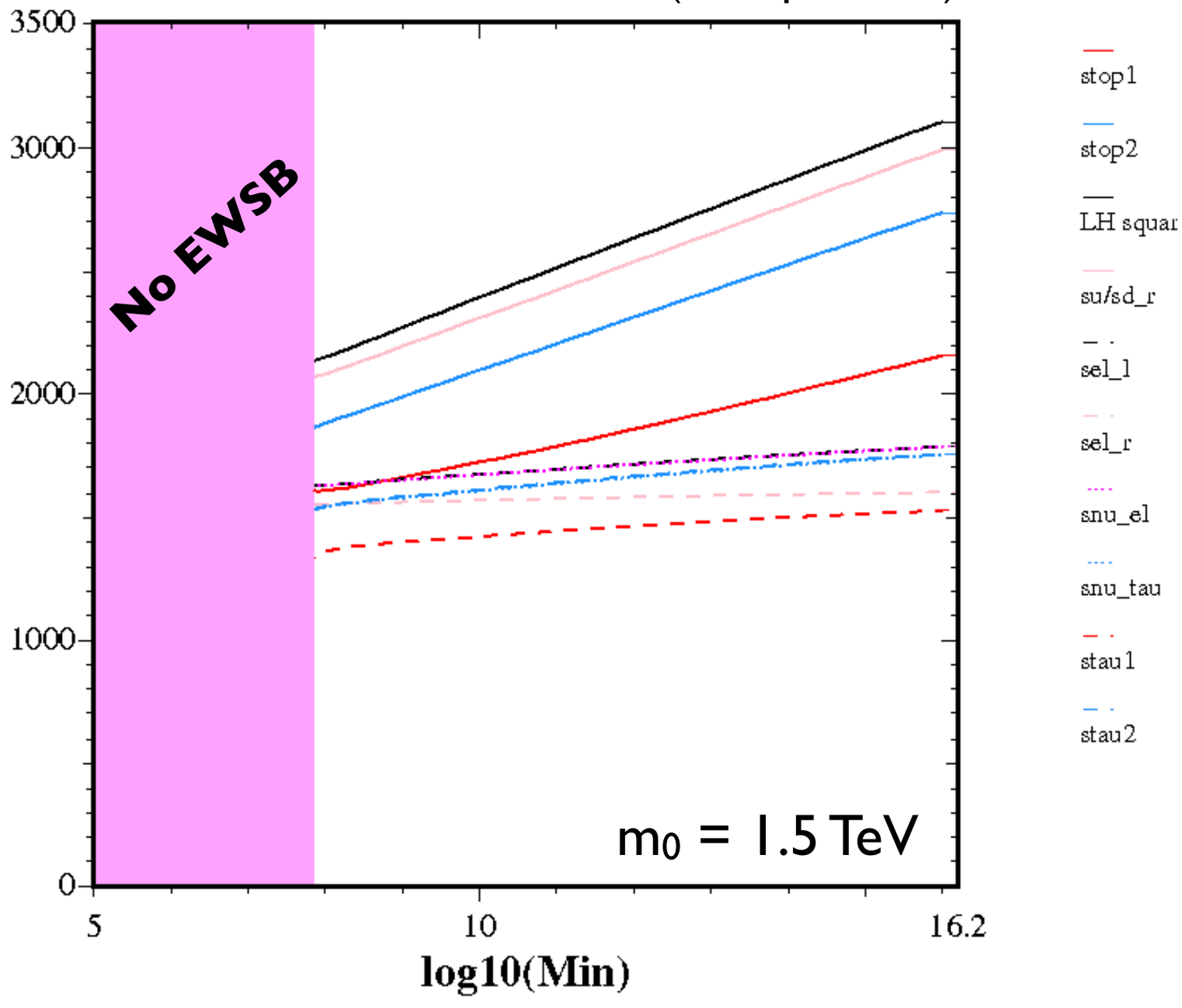


Scalar Mass Evolution

$$m^2_{0,i}(Q) = m^2_0 + C_i(Q, M_{in}) m^2_{1/2}$$

1. Scalar masses closer to m_0
2. Lighter squarks
3. Somewhat lighter sleptons

(2-loop results)

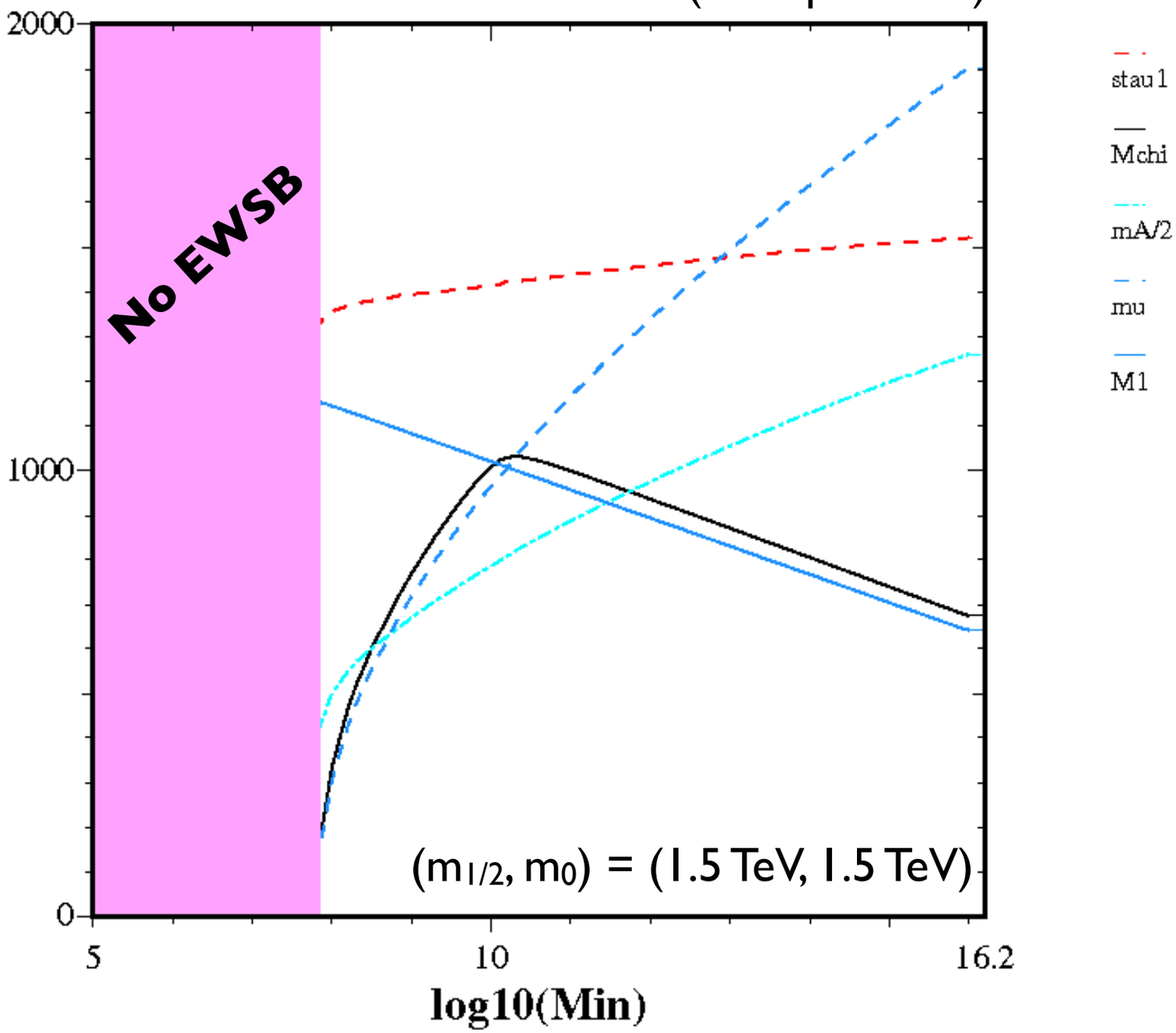


Mass Evolution

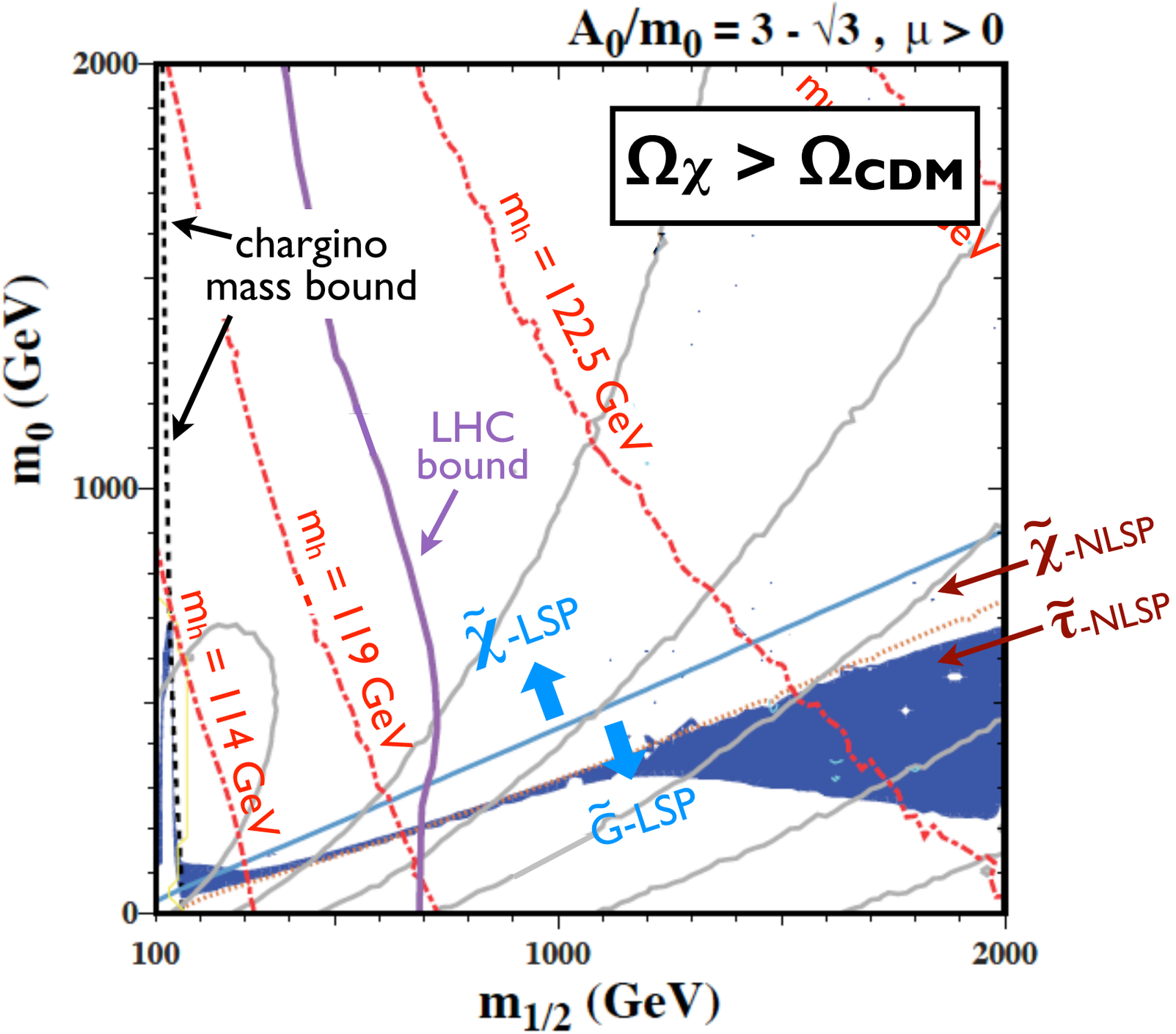
$$\mu^2 = \frac{m_1^2 - m_2^2 \tan^2\beta}{\tan^2\beta - 1} - \frac{M_Z^2}{2}$$

1. μ much smaller
2. neutralino LSP becomes Higgsino-like at low M_{in}
3. m_A decreases with M_{in} → appearance of rapid annihilation funnel

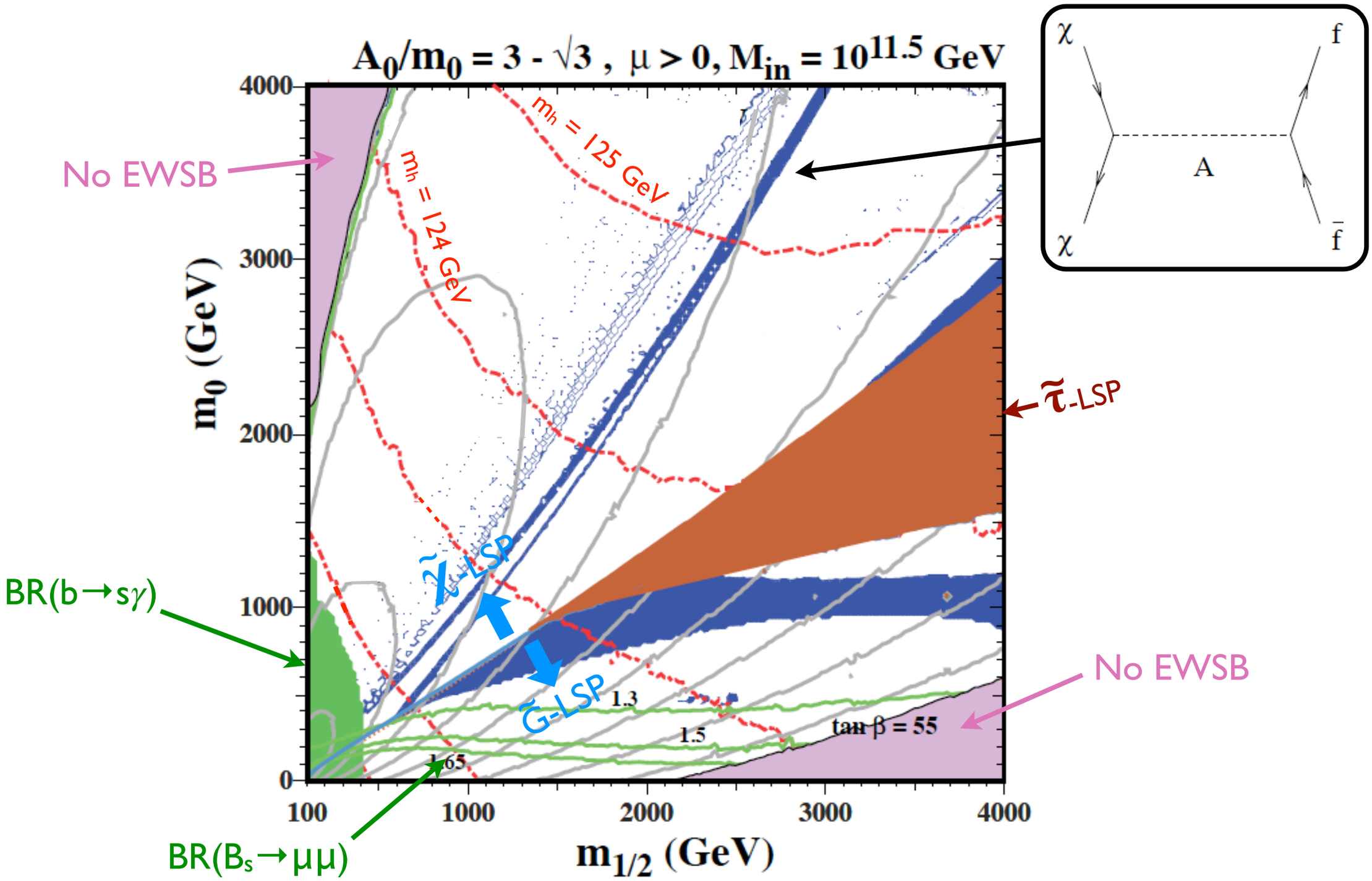
(2-loop results)



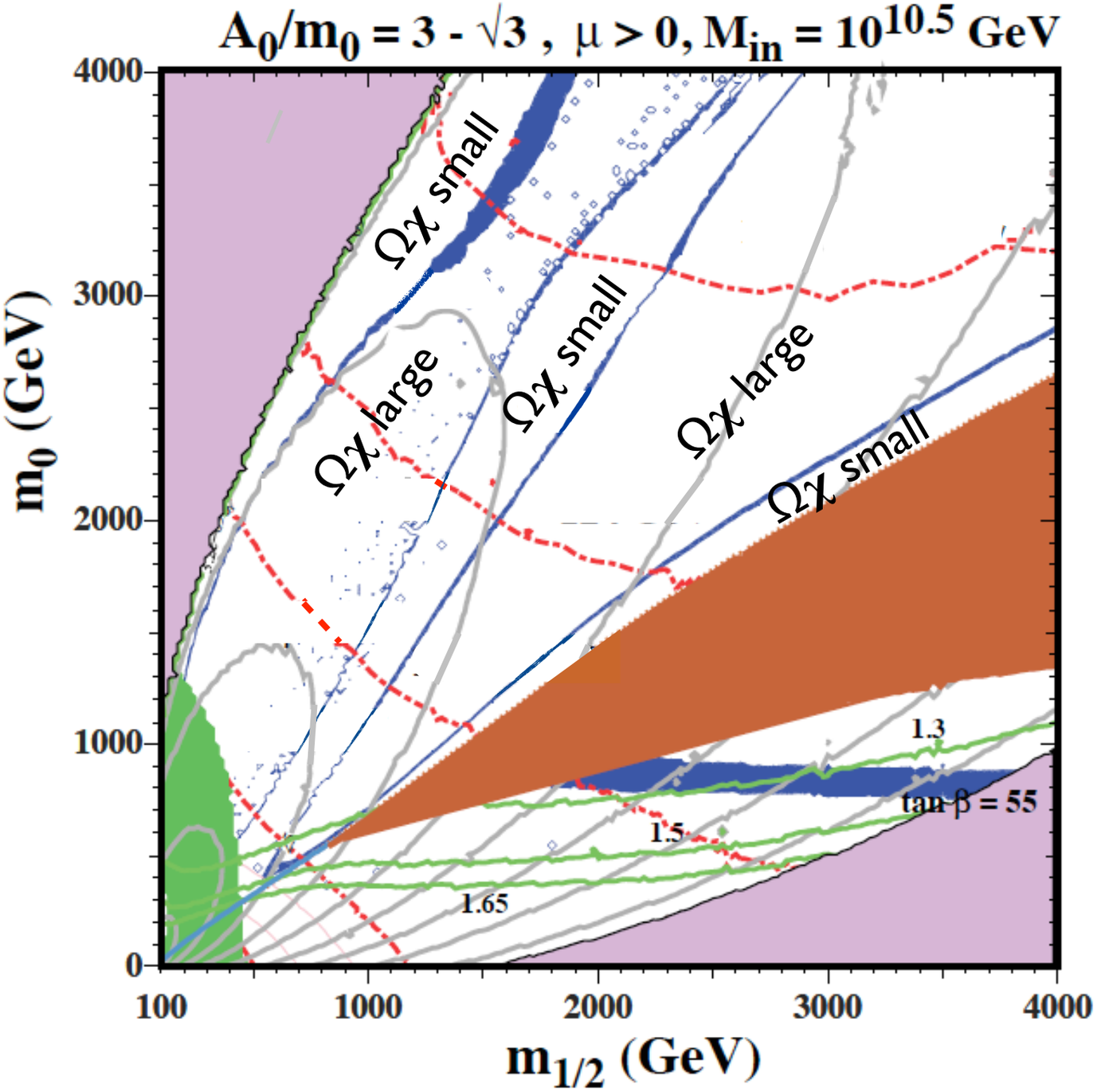
sub-GUT mSUGRA



sub-GUT mSUGRA



sub-GUT mSUGRA



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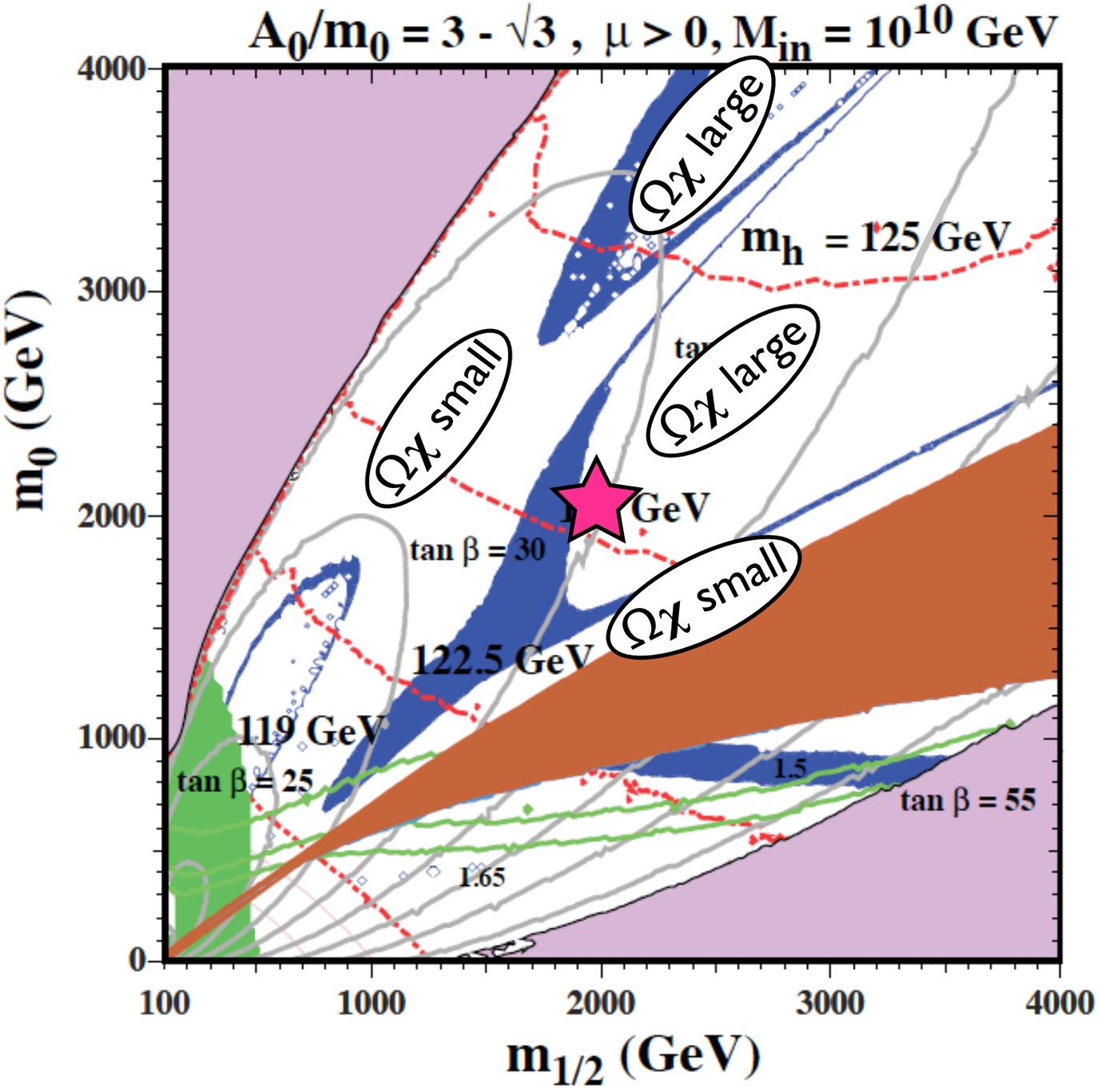
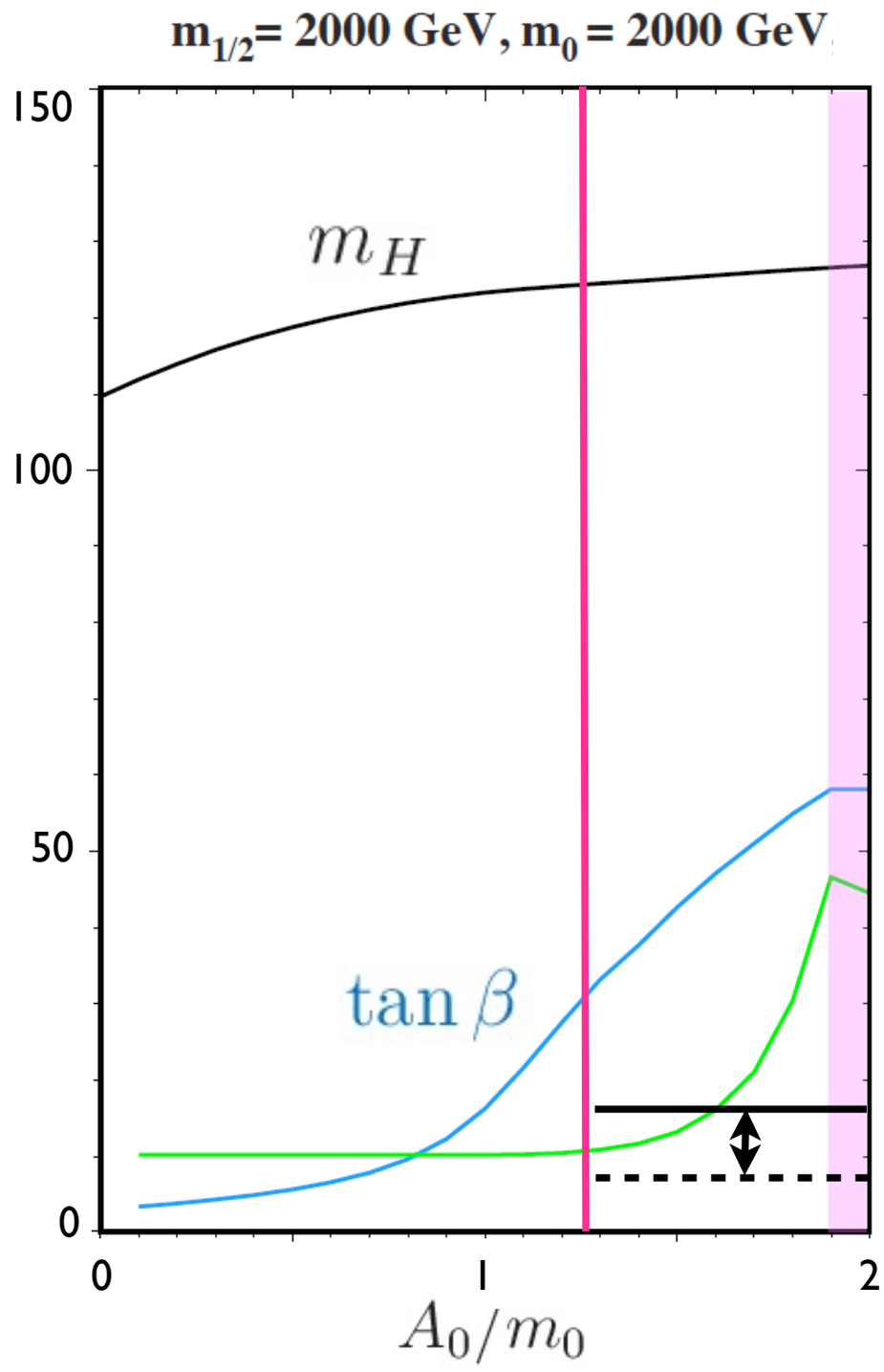


sub-GUT mSUGRA



At large tanβ,

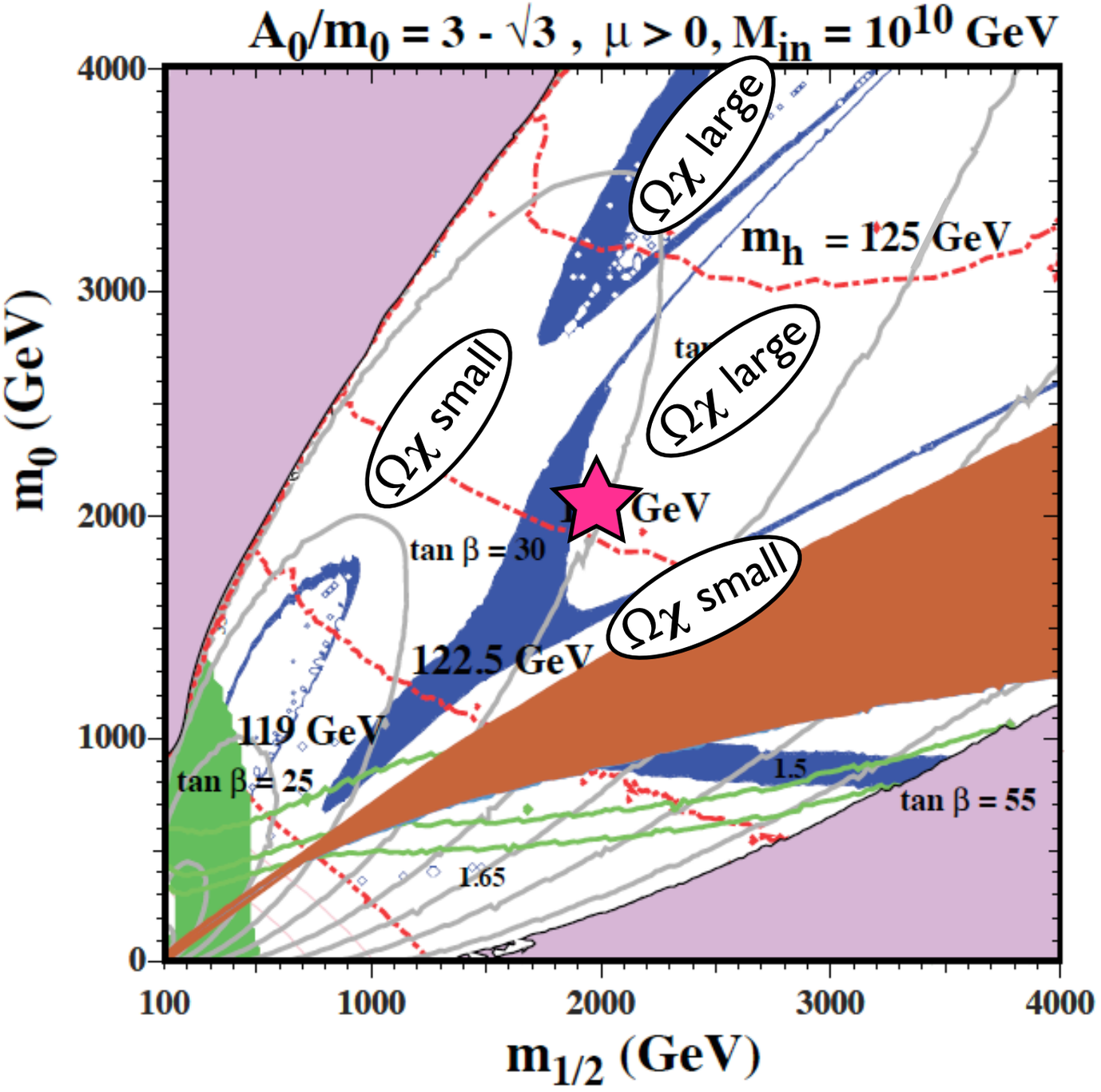
$$\mathrm{BR}(B_s \to \mu^+\mu^-) \sim \tan\beta^6$$

A_0 { large enough: $m_H \approx 126$ GeV
small enough: $BR(B_s \to \mu^+\mu^-) \lesssim 1.5$ SM value

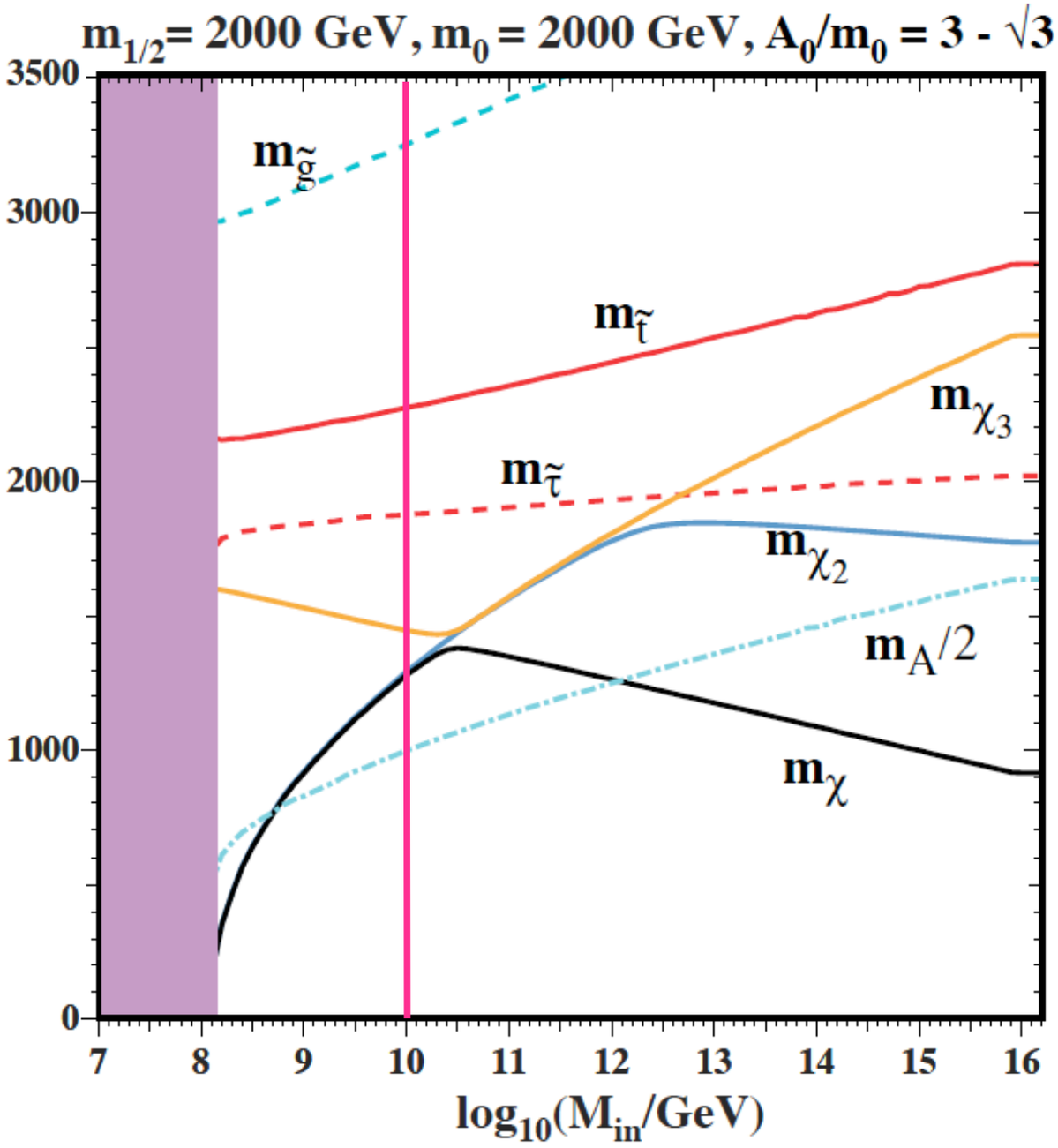
$$\frac{\mathrm{BR}(B_s \to \mu^+\mu^-)}{\mathrm{BR}(B_s \to \mu^+\mu^-)_{\mathrm{SM}}} \times 10$$

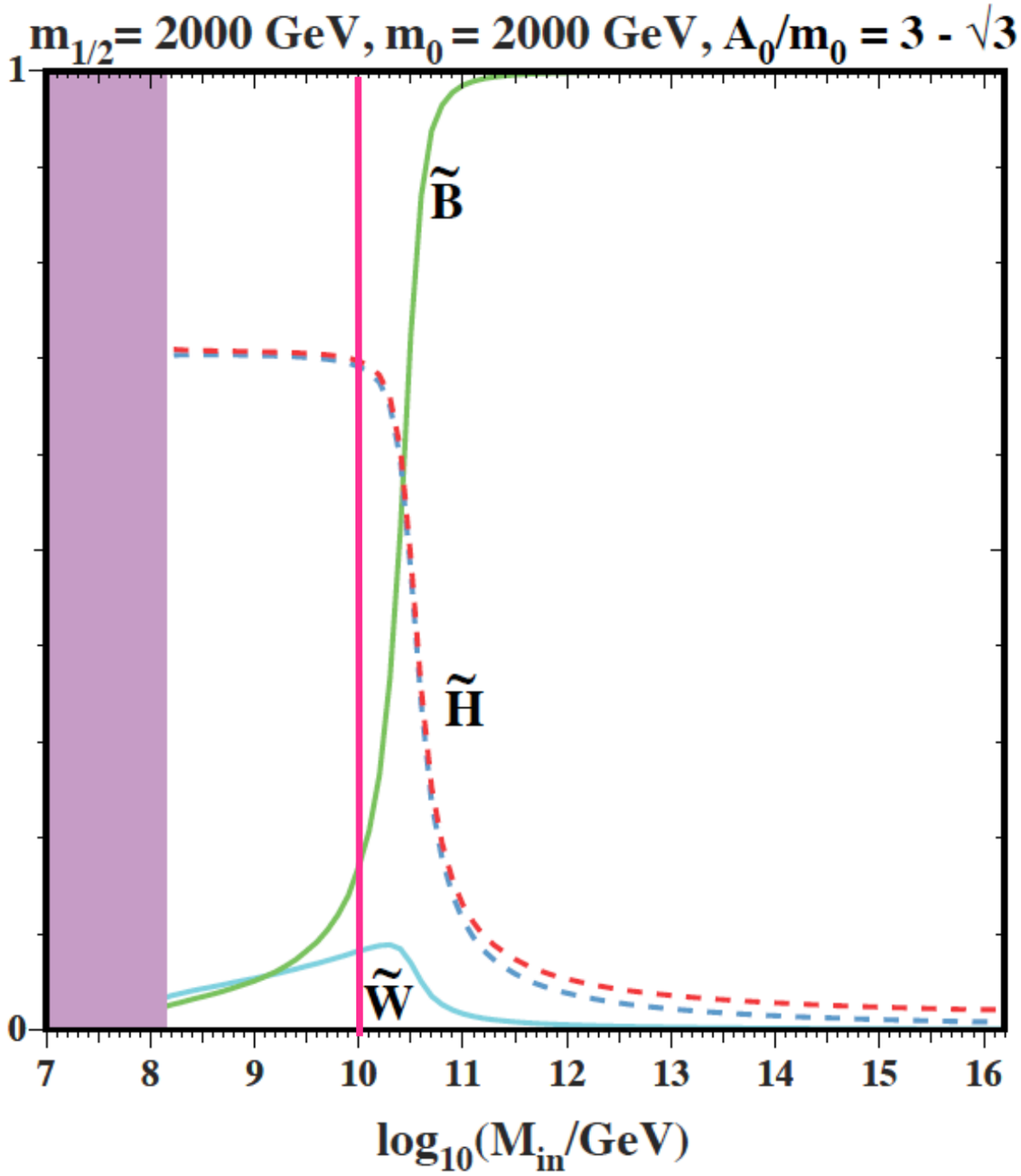
95% CL

sub-GUT mSUGRA



sub-GUT mSUGRA





Summary

- sub-GUT mSUGRA

  ➡ $\{m_{1/2}, m_0, A_0, \text{sign}(\mu)\} + M_{in}$

- Viable parameter space near Polonyi value:

$$A_0 \approx (3 - \sqrt{3}) m_{3/2}$$

  - Neutralino (or gravitino) dark matter, somewhat compressed spectrum, moderate tanβ, consistent with B-physics constraints, $m_h \approx 125$ GeV

  - Good prospects for direct detection of neutralino dark matter - currently under investigation

- For more, see 1212.4476 / EPJC (2013) **73** 2403

Extra Slides

sub-GUT CMSSM