

(Neutralino Dark Matter in)
GUT-less mSUGRA

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University of Utah

work in progress with J. Ellis, F. Luo, and K.A. Olive

mSUGRA

$$\mathcal{L}_{\text{soft}} = -\frac{1}{2}M_\alpha\lambda^\alpha\lambda^\alpha - m_{ij}^2\phi^{*i}\phi^j - A_e y_e H_1 L e^c - A_d y_d H_1 Q d^c - A_u y_u H_2 Q u^c - B\mu H_1 H_2$$

- 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/ $m_0 = m_{3/2}$
 2. trilinear mass universality w/ $A_0 = \langle \frac{dg}{d\zeta} \rangle \langle \zeta \rangle + \langle g \rangle \langle \zeta \rangle^2$
 3. $B_0 = A_0 - m_0$
 4. minimal gauge kinetic term \Rightarrow gaugino mass universality

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

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

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Hall, Lykken, & Weinberg (1983)

Polonyi Model

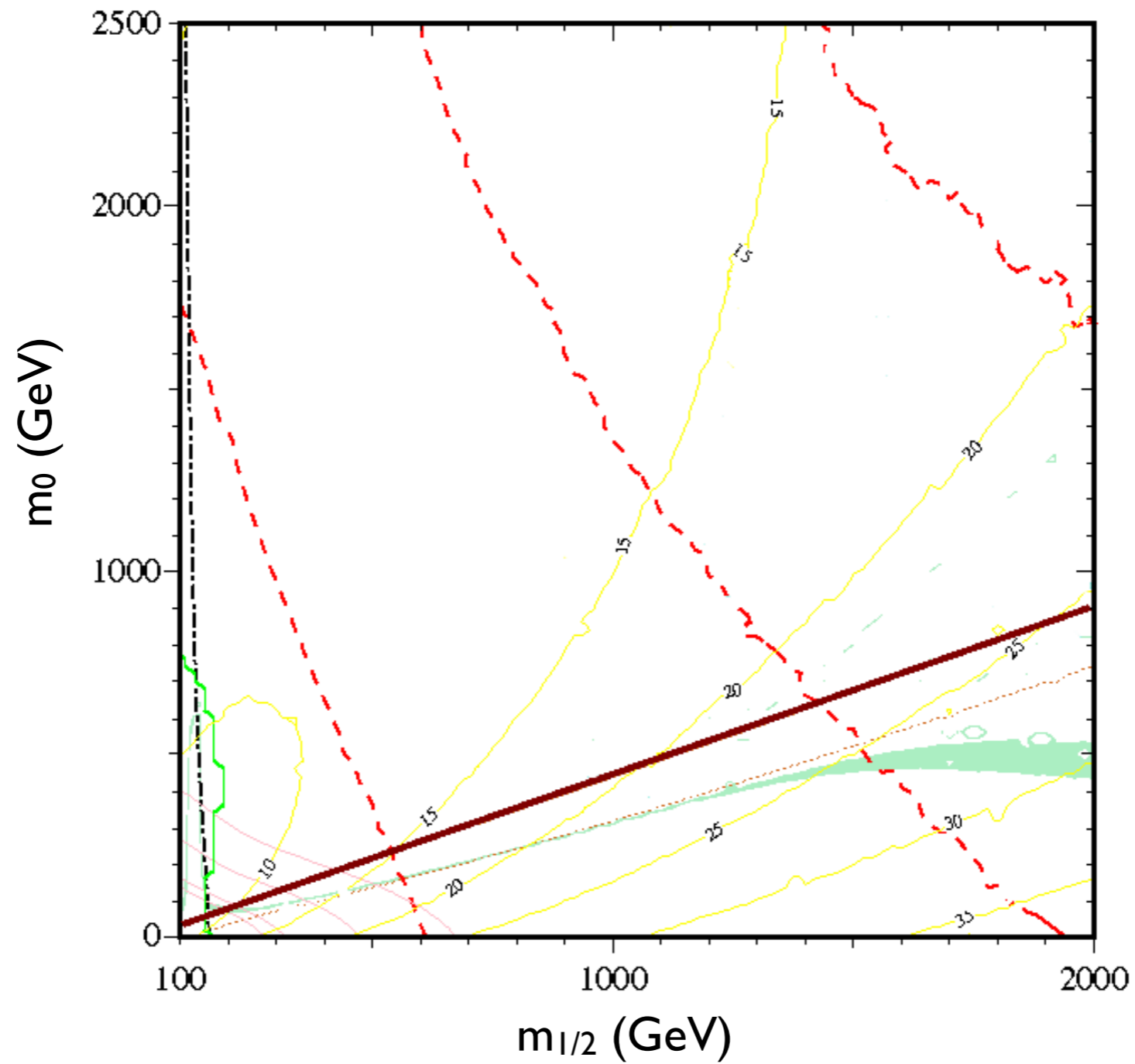
- Simplest model for local SUSY breaking

$$W = F(\phi) + g(\zeta)$$

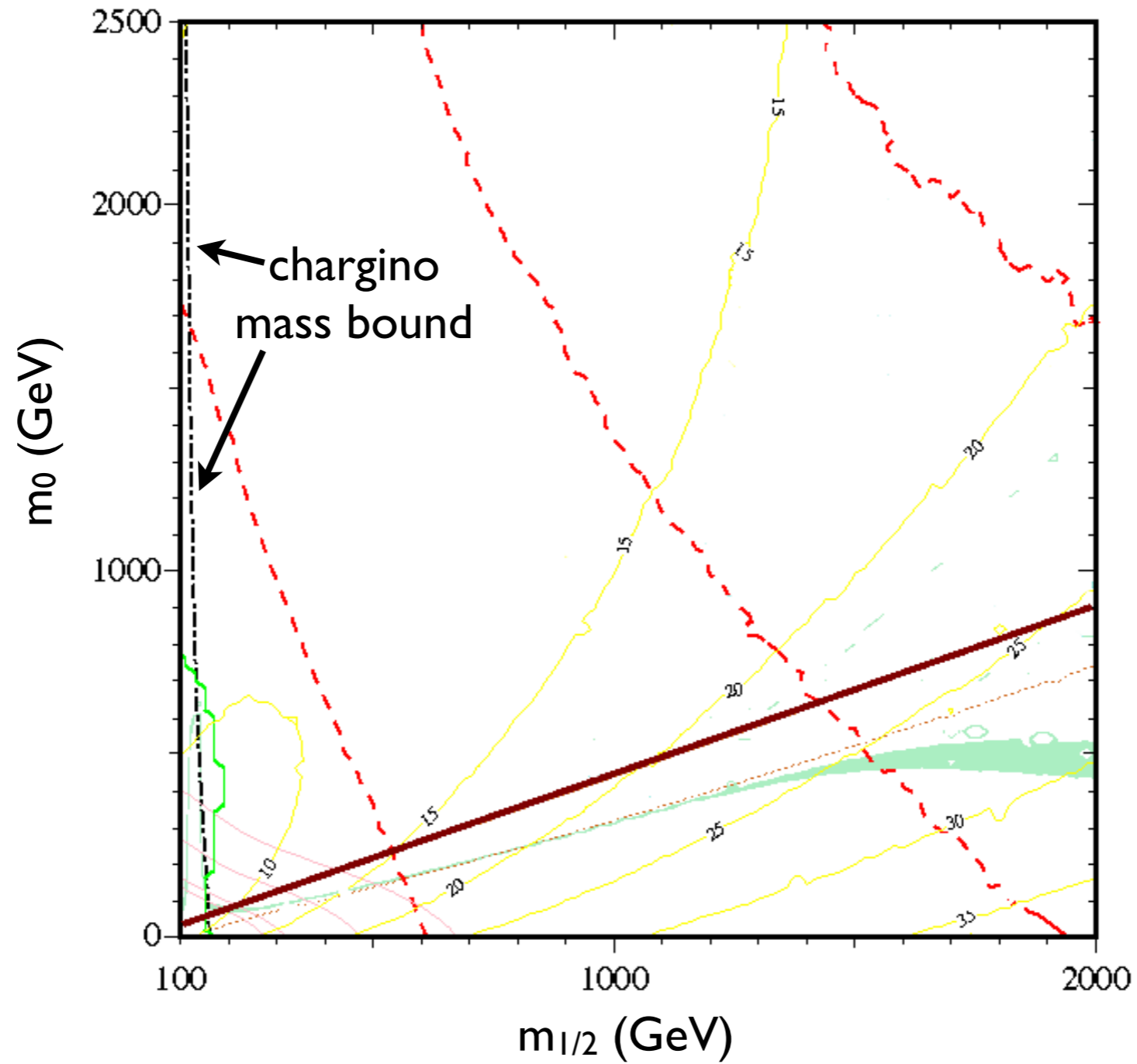
- J. Polonyi (1977): $g(\zeta) = \nu(\zeta + \beta)$
 1. $|\beta| = 2 - \sqrt{3}$
 2. $A_0 = (3 - \sqrt{3})m_{3/2}$
- $\{m_{1/2}, m_0, \text{sign}(\mu)\}$

(Not necessary to make same choice as Polonyi.)

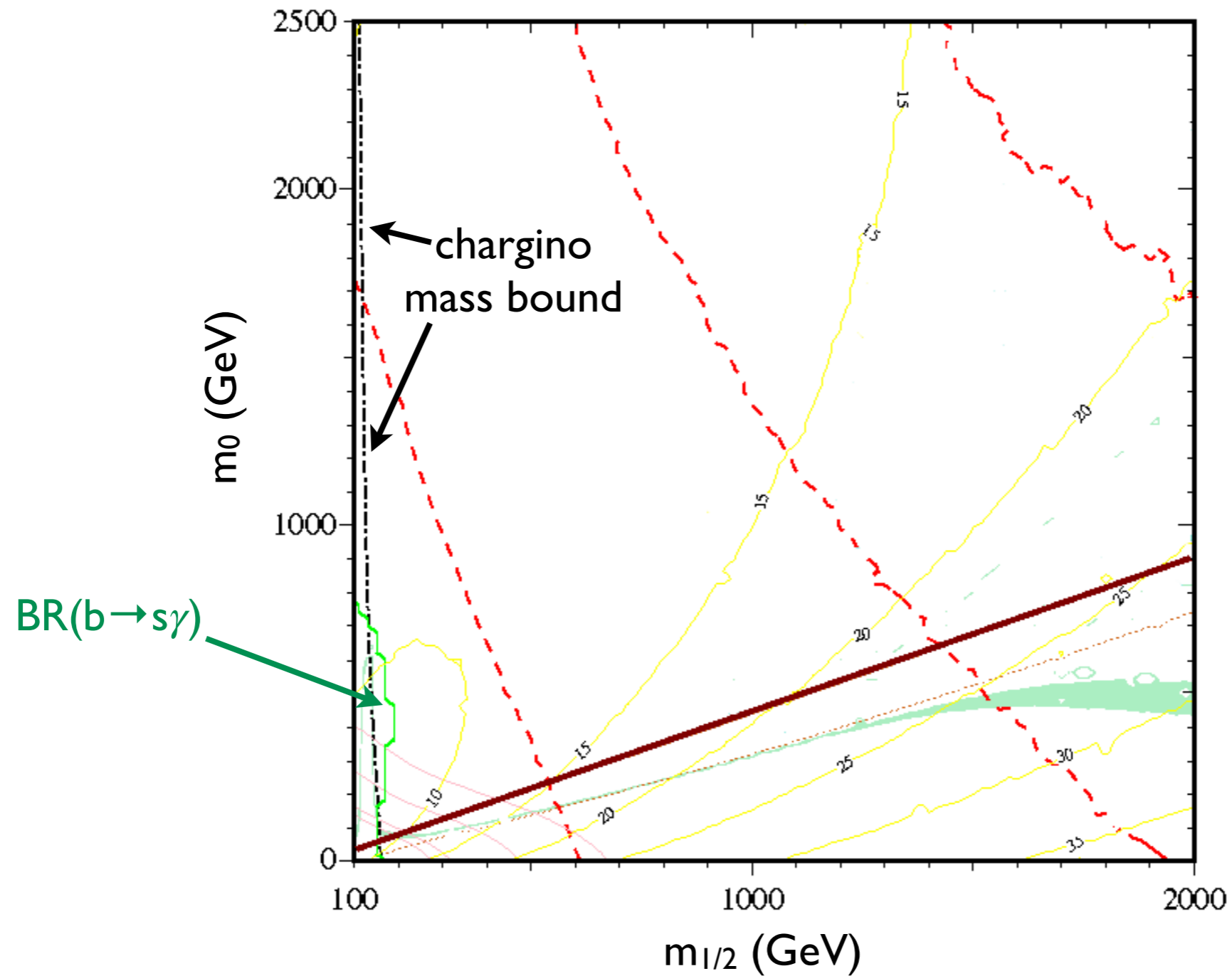
Standard Polonyi



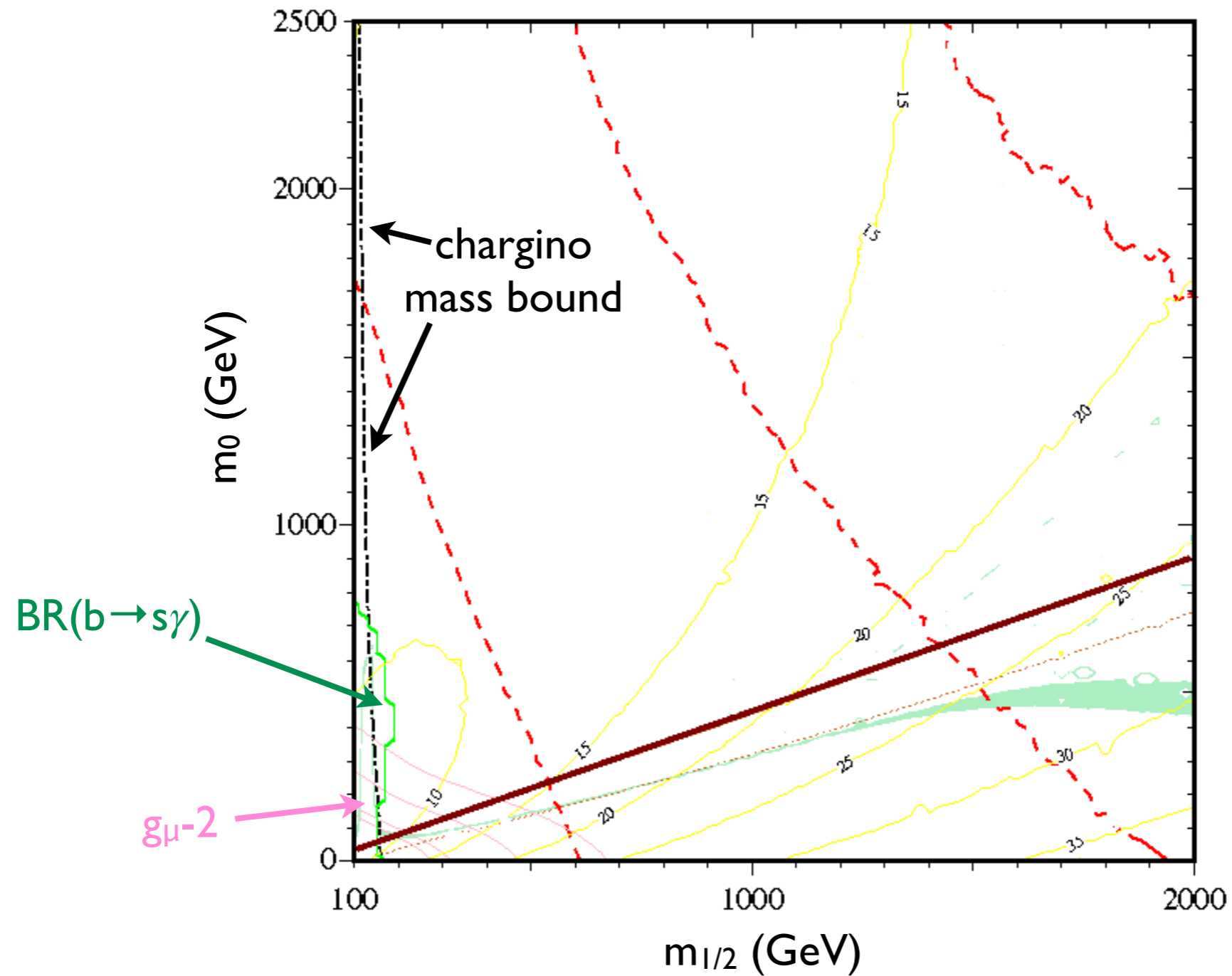
Standard Polonyi



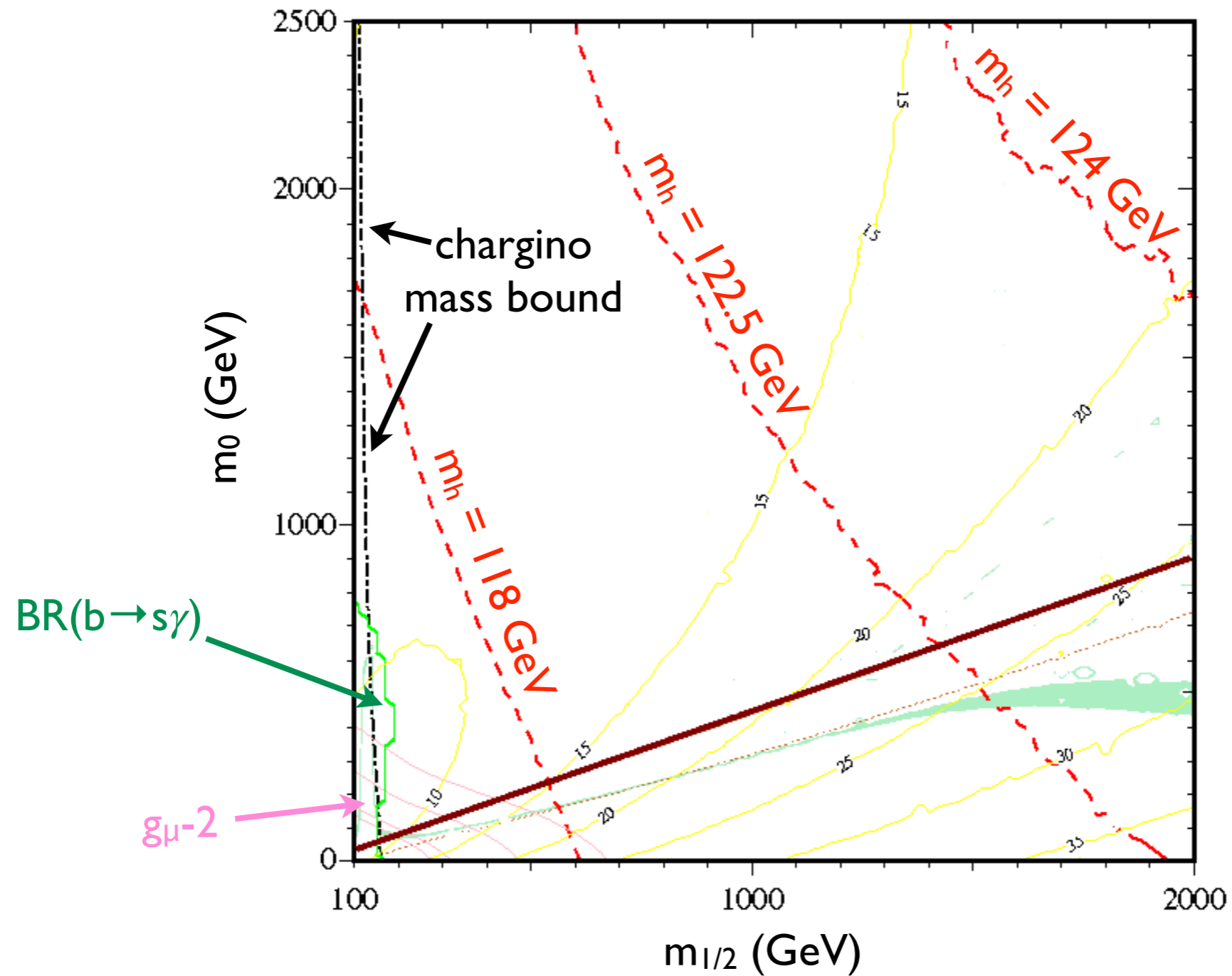
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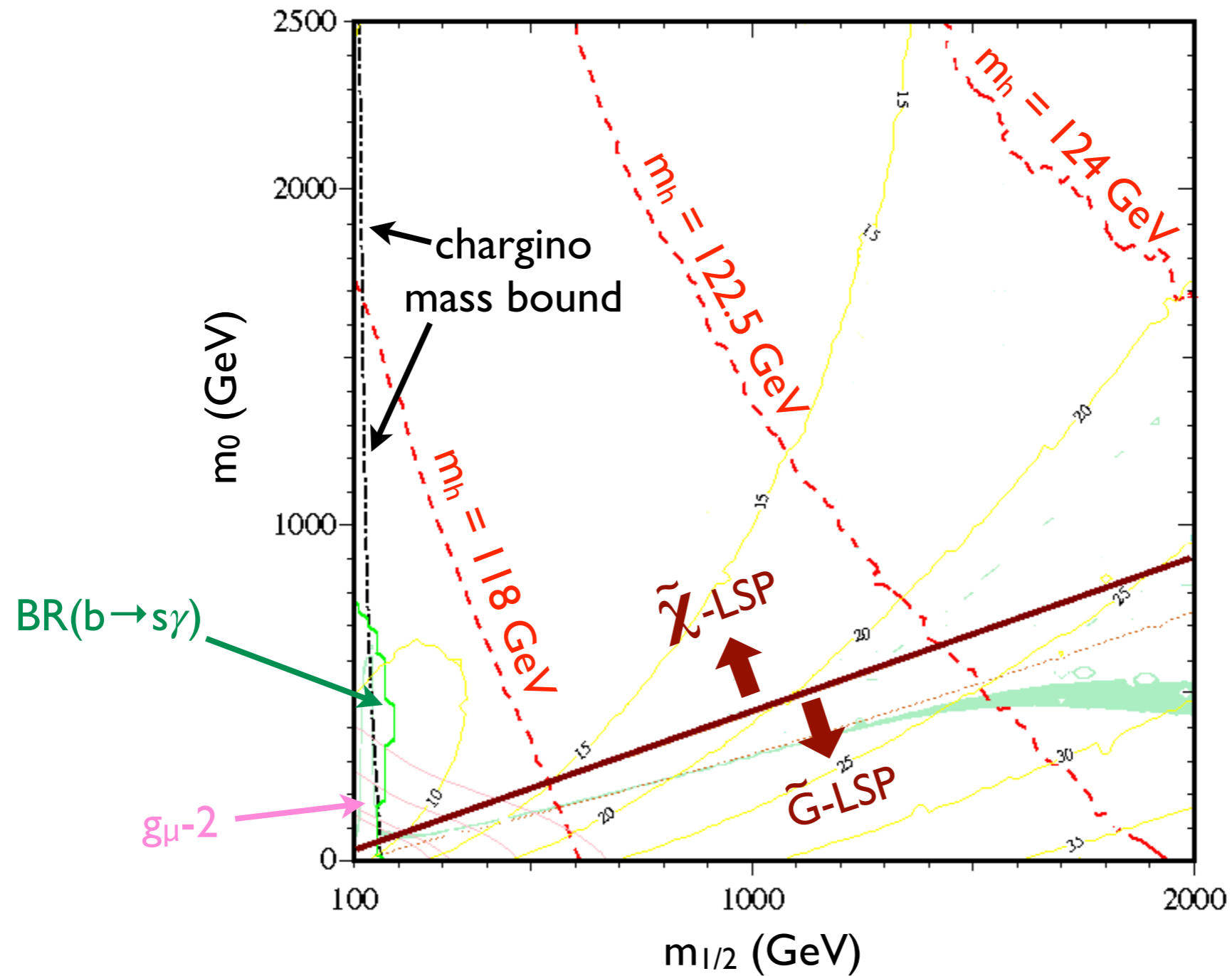
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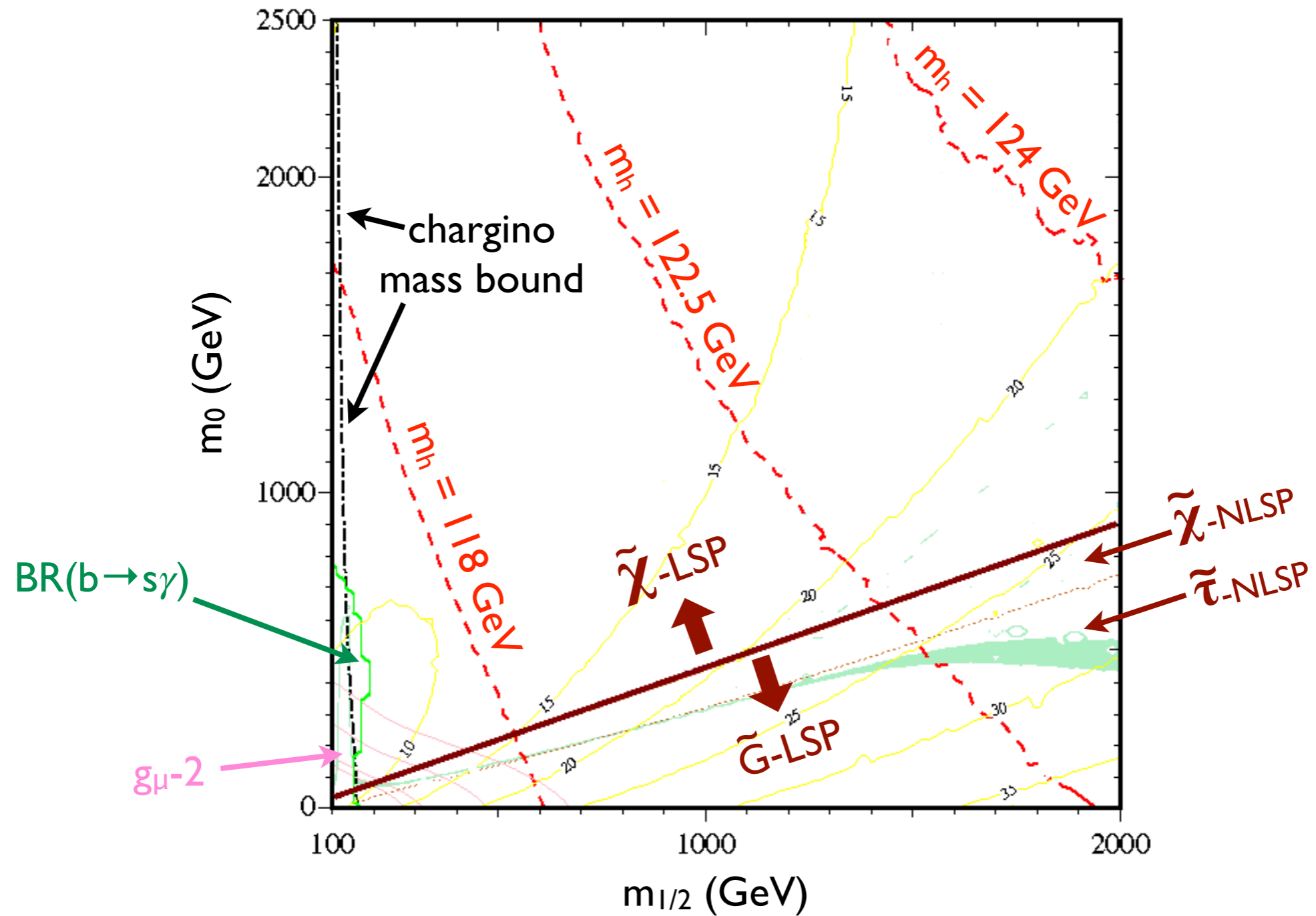
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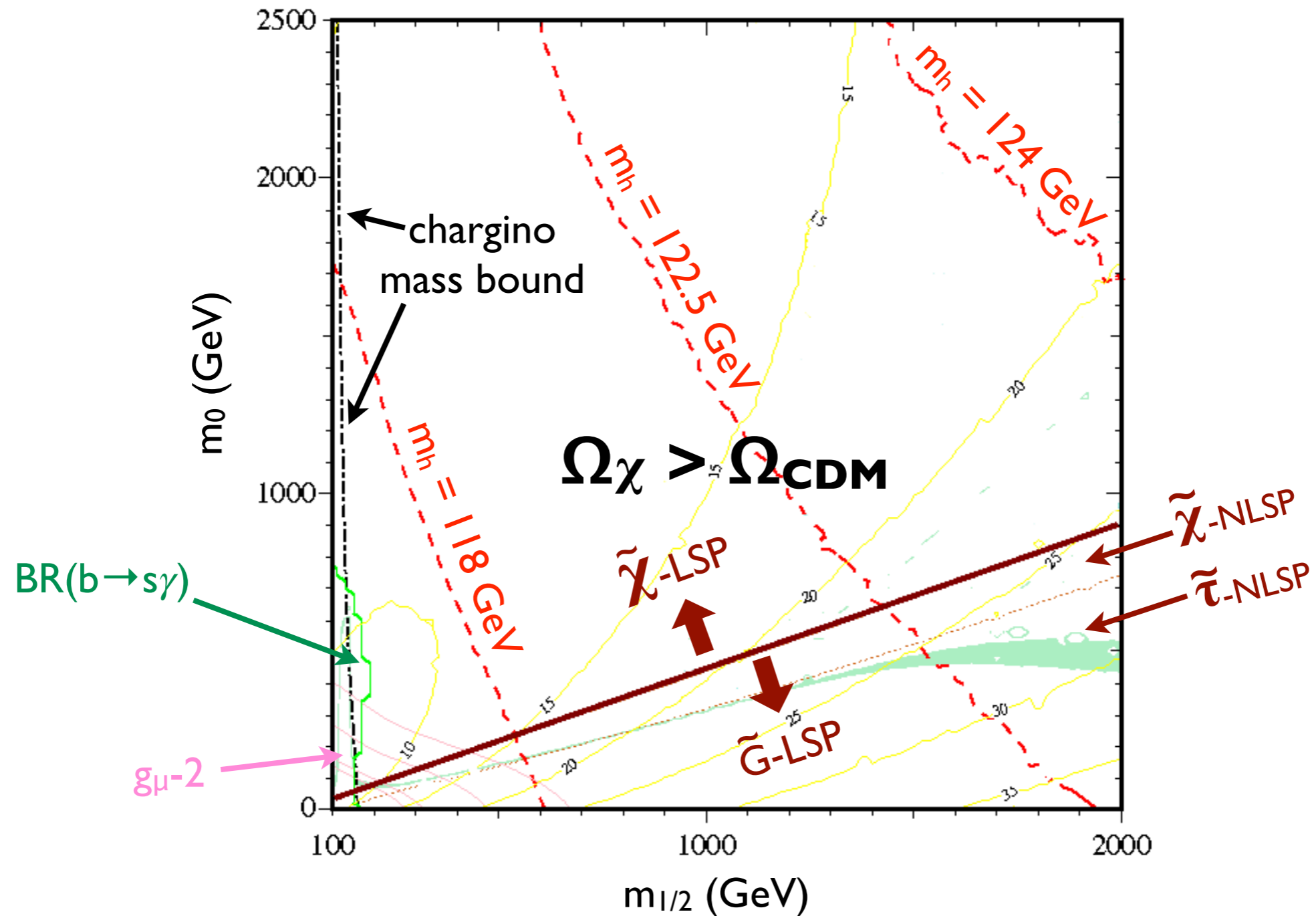
Standard Polonyi



Standard Polonyi



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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” or “Mirage”

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

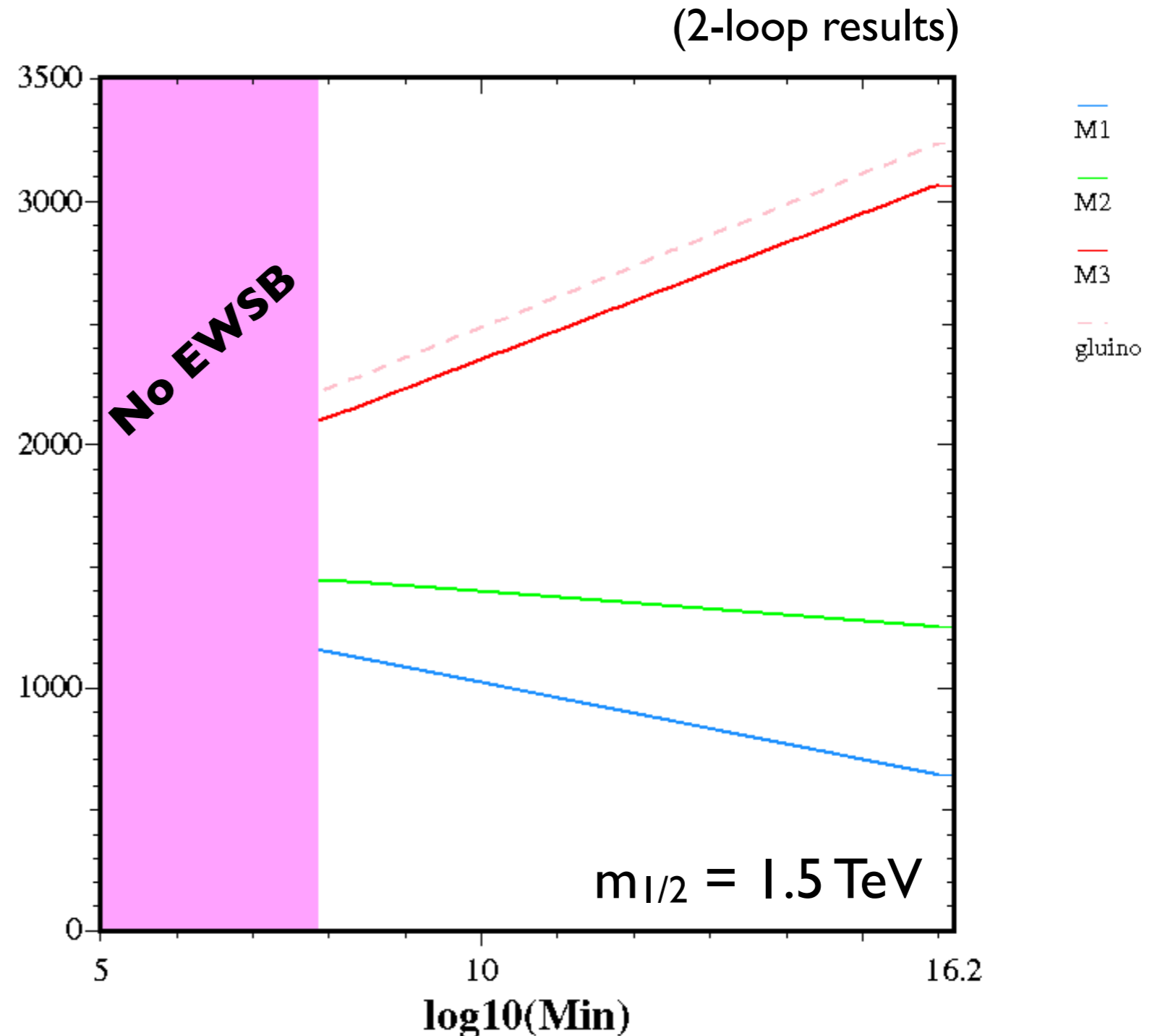
Choi et al. (2004, 2005),
Kachru et al. (2003),
and others

- 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

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

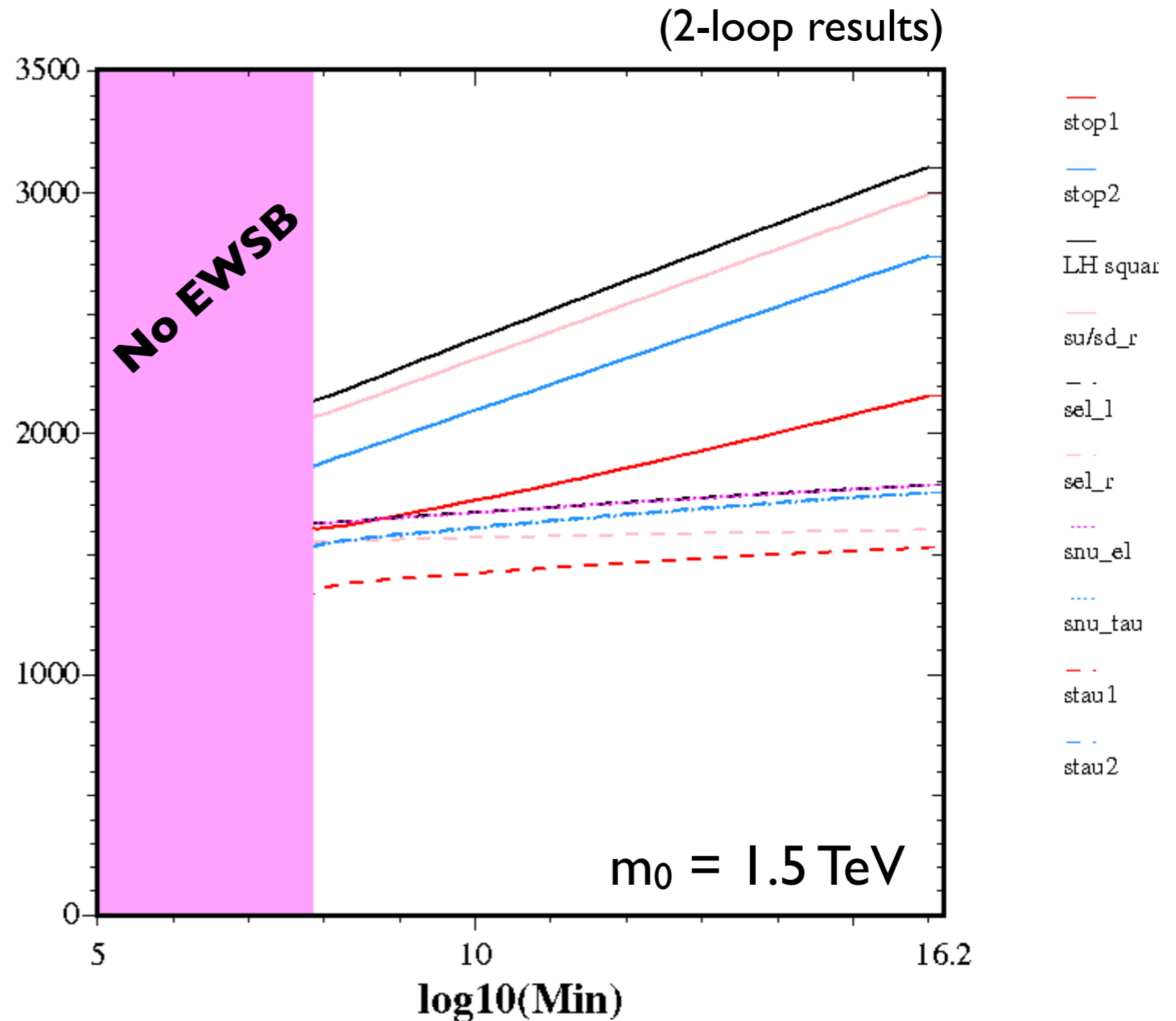
1. Gaugino masses closer to $m_{1/2}$
2. Lighter gluino



Scalar Mass Evolution

$$m_{0,i}^2(Q) = m_0^2 + C_i(Q, M_{in})m_{1/2}^2$$

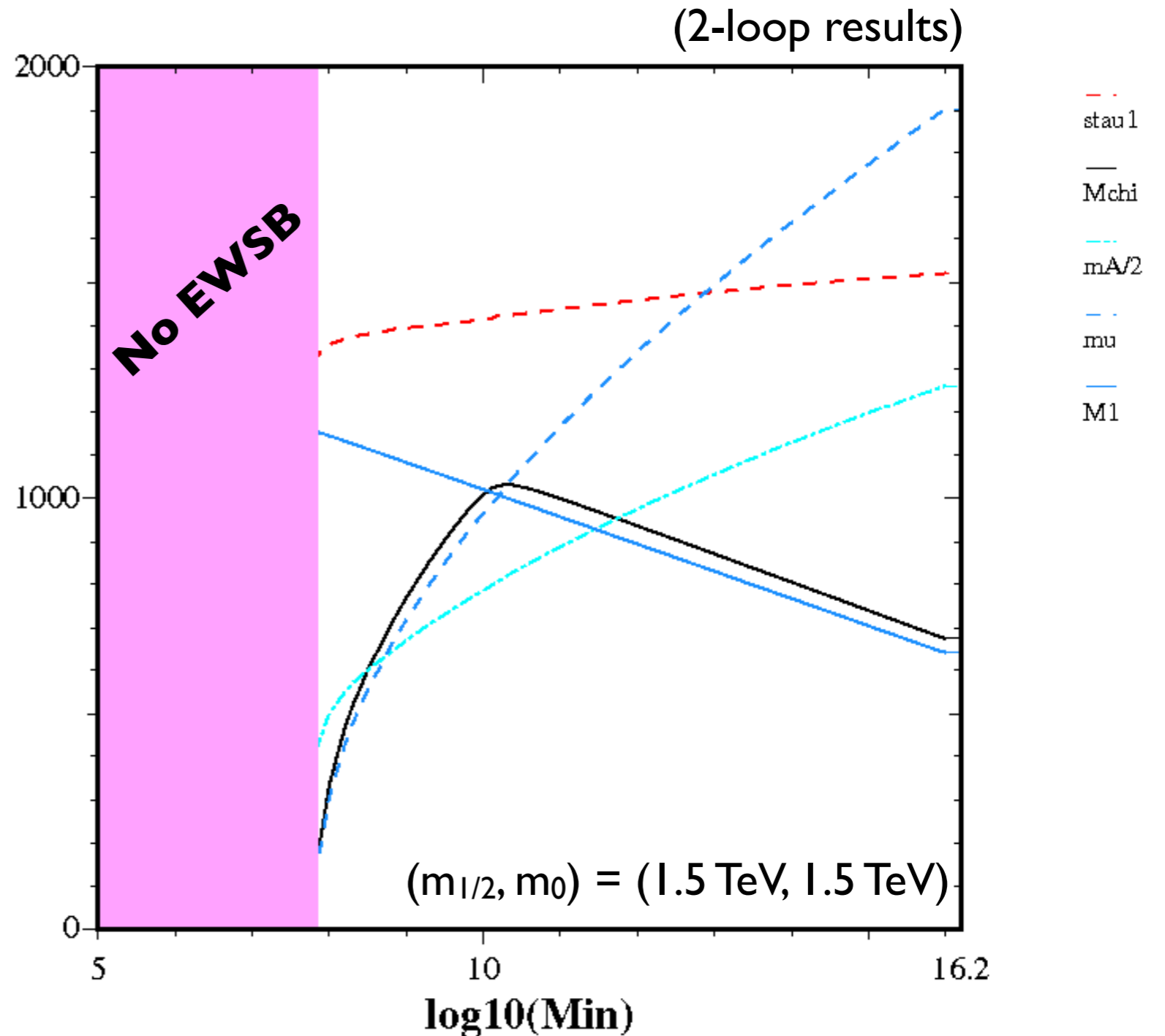
1. Scalar masses closer to m_0
2. Lighter squarks
3. Somewhat lighter sleptons



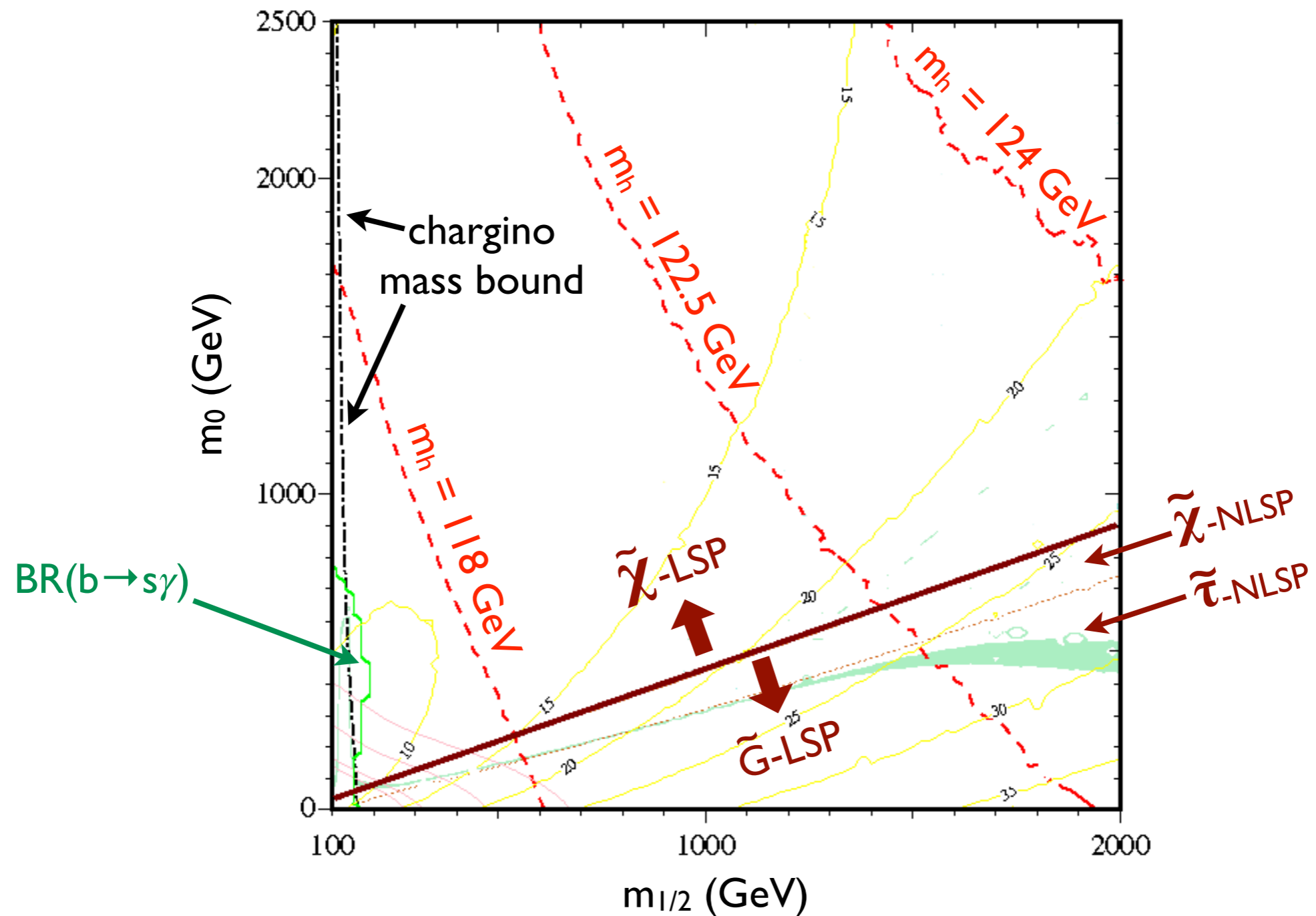
Mass Evolution

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

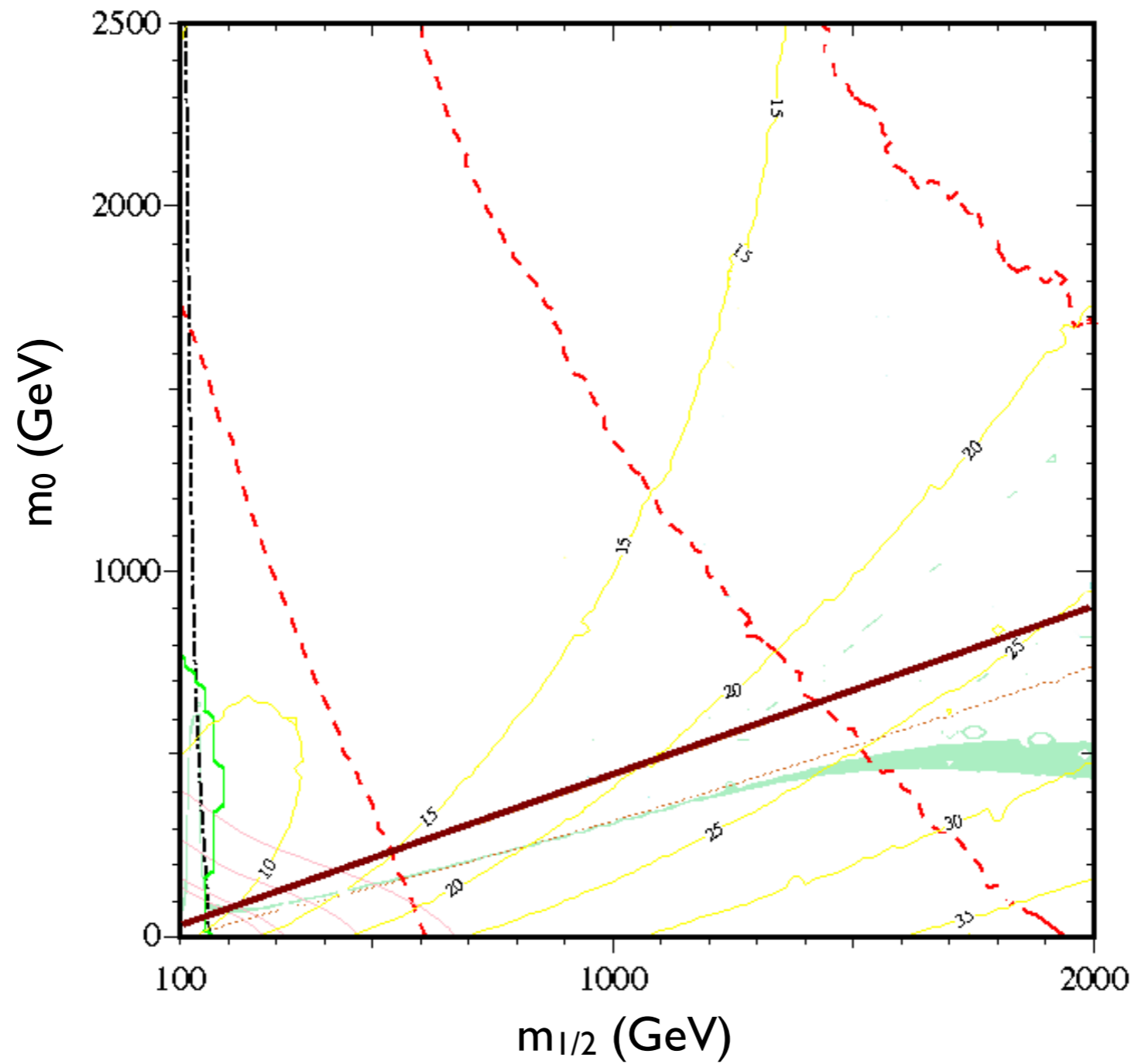
1. μ much smaller
2. neutralino LSP becomes Higgsino-like at low M_{in}
3. m_A decreases with M_{in} - appearance of rapid annihilation funnel



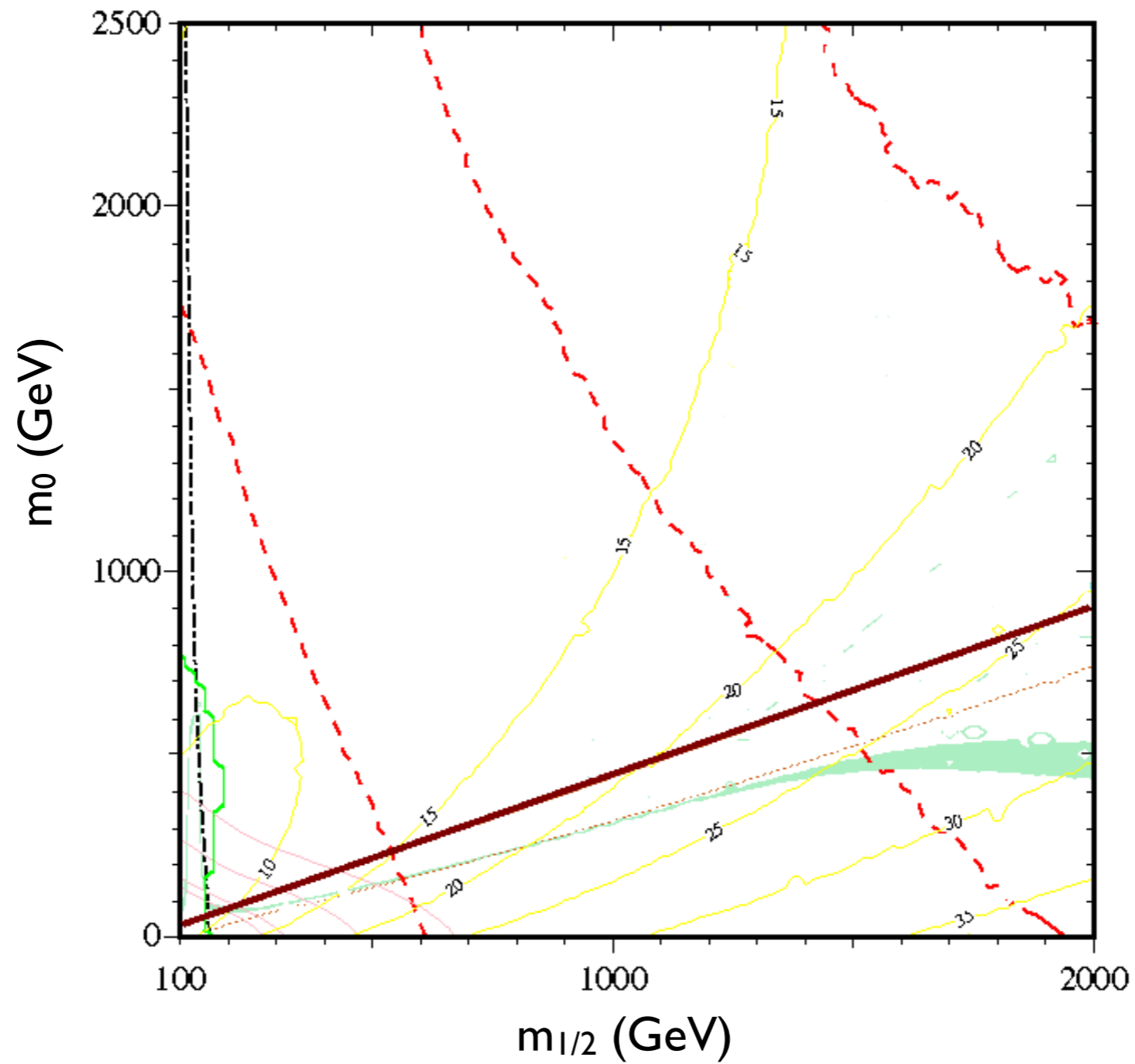
GUT-less Polonyi



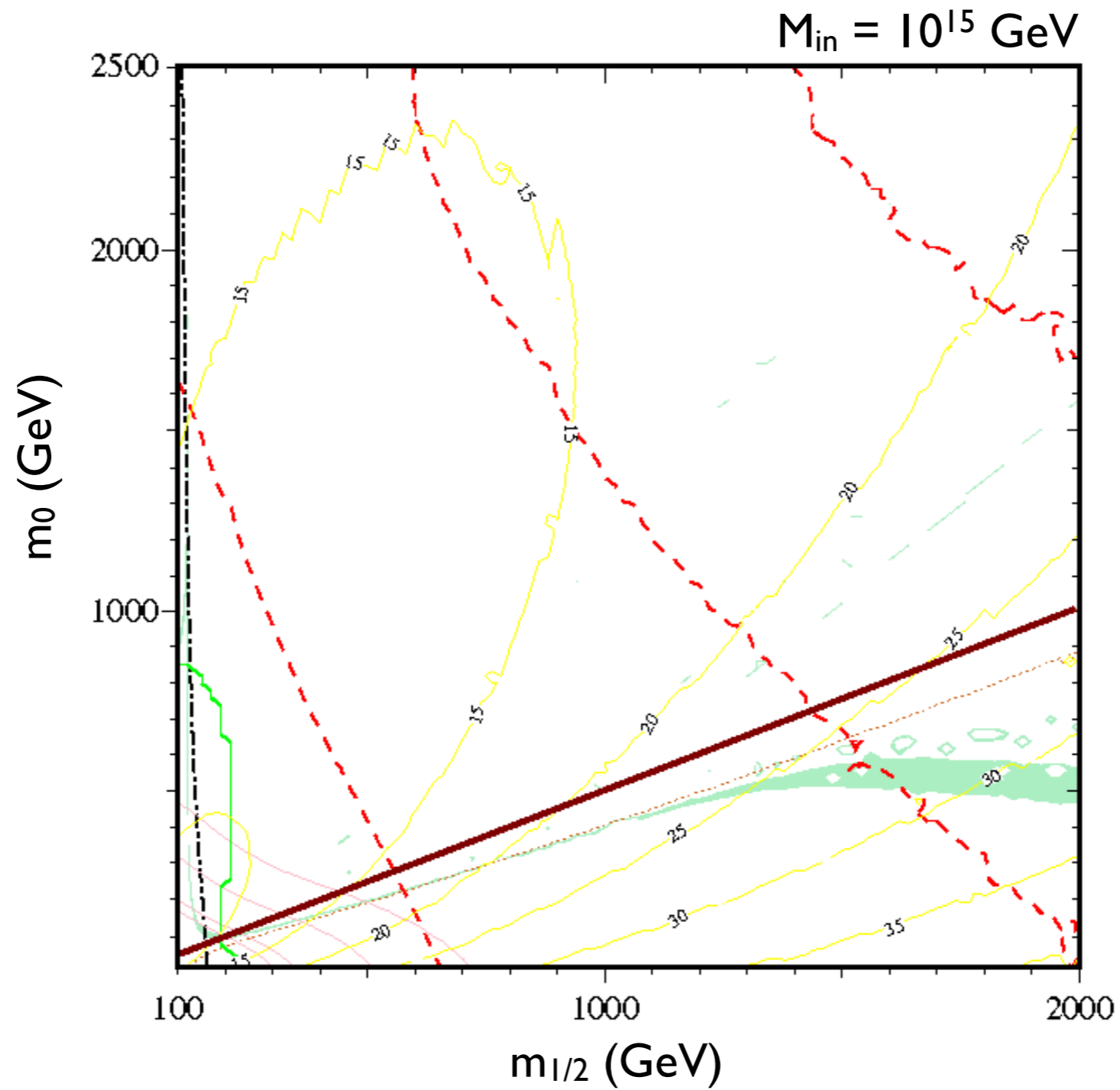
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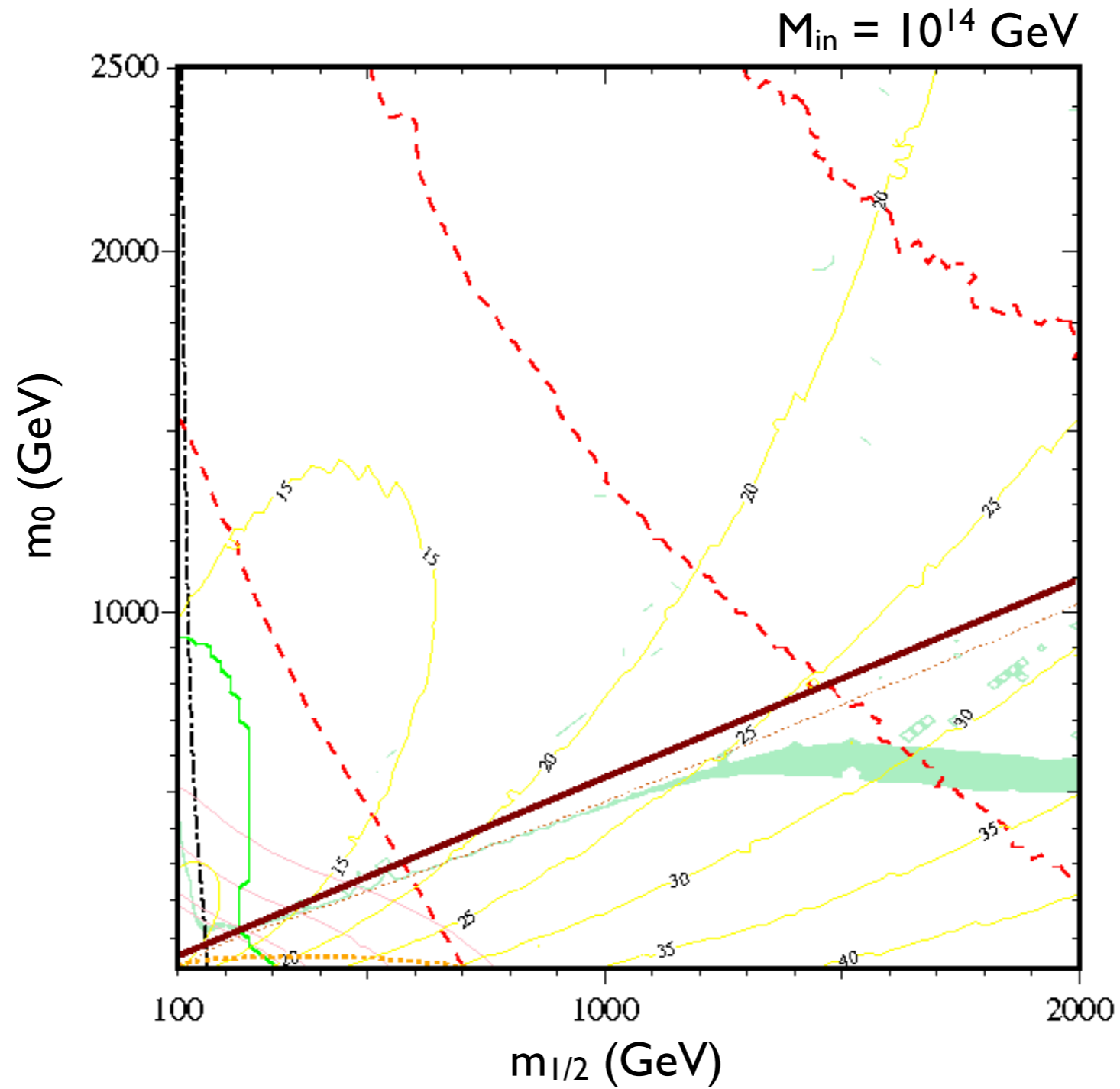
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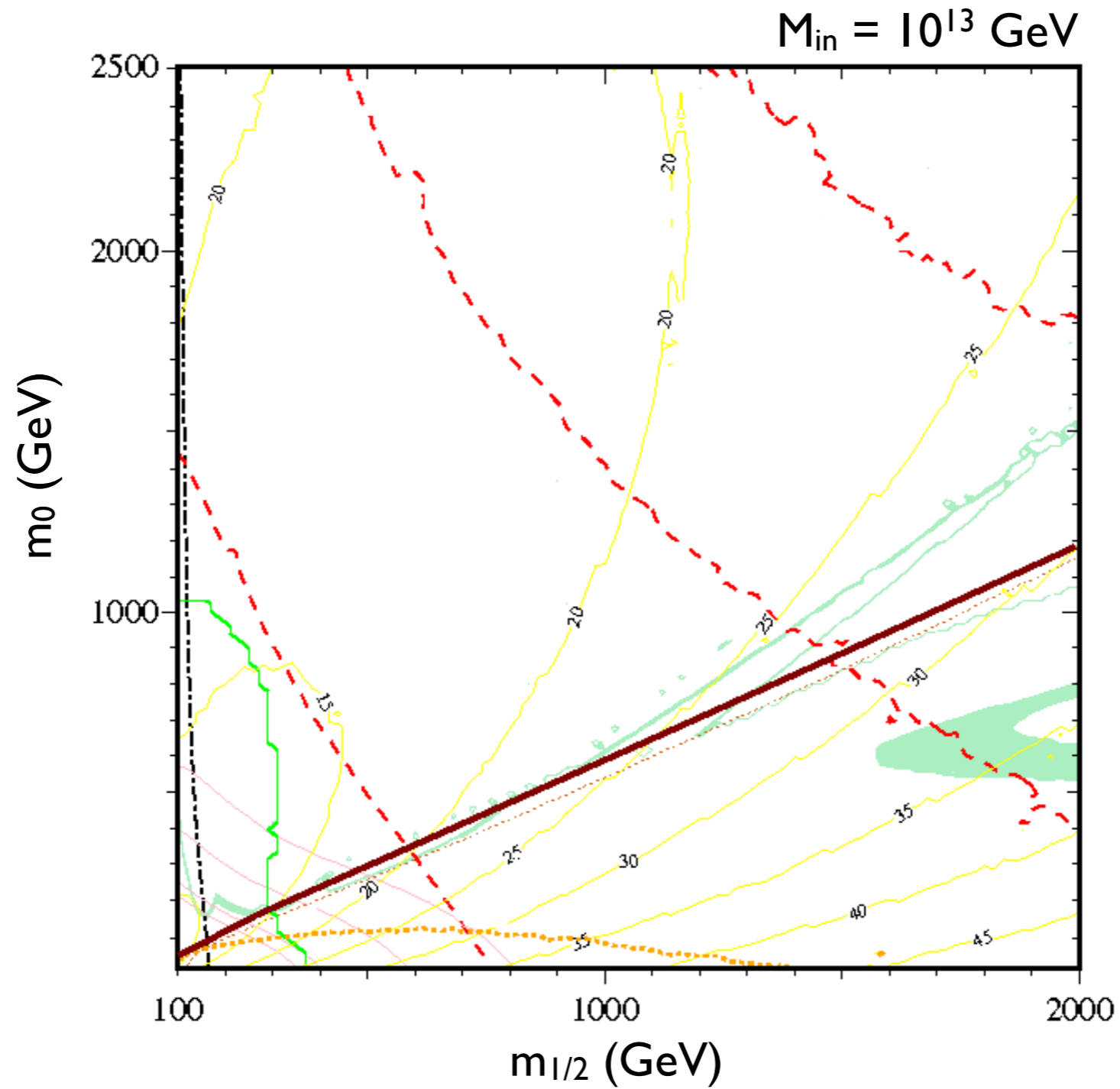
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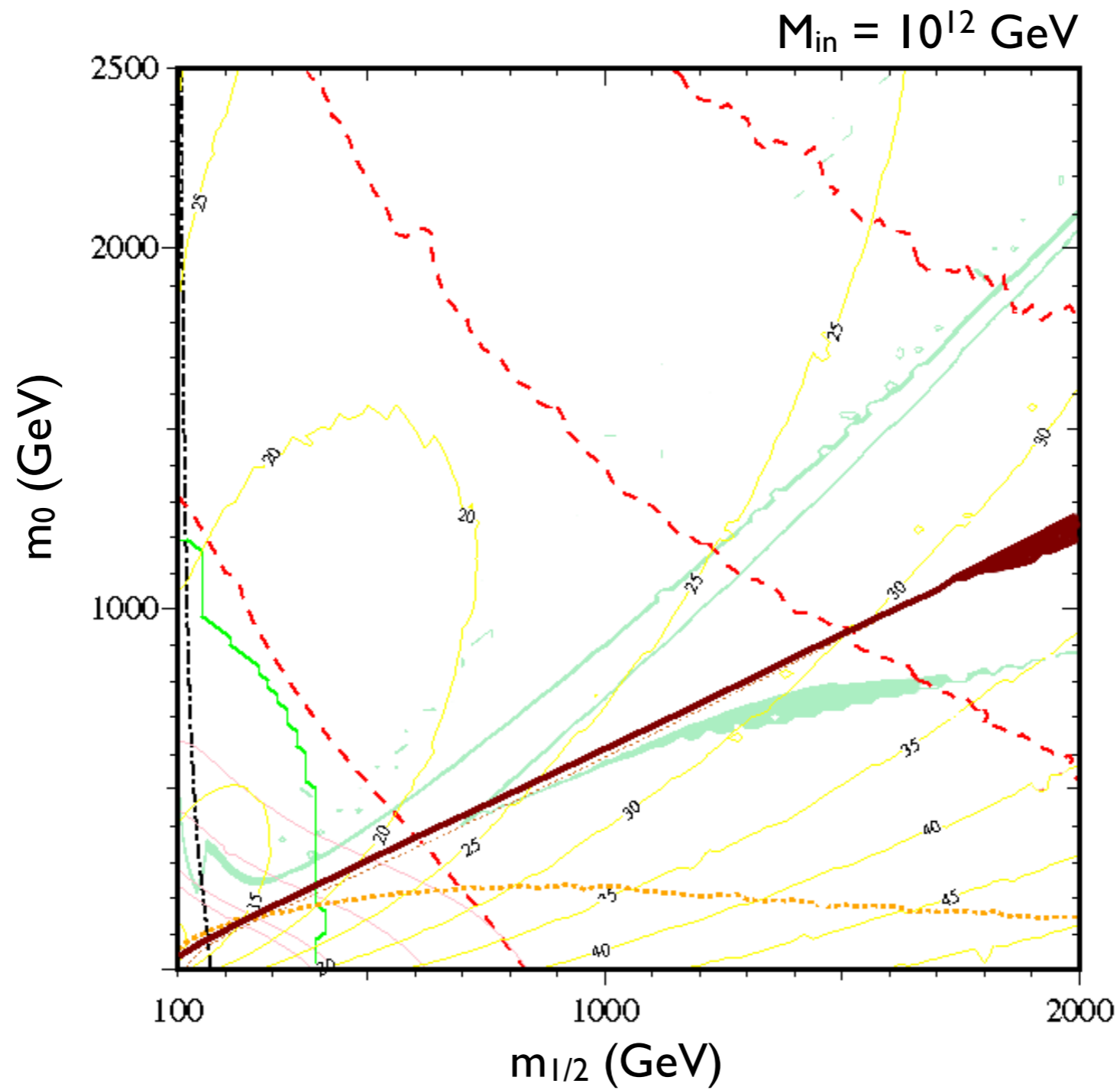
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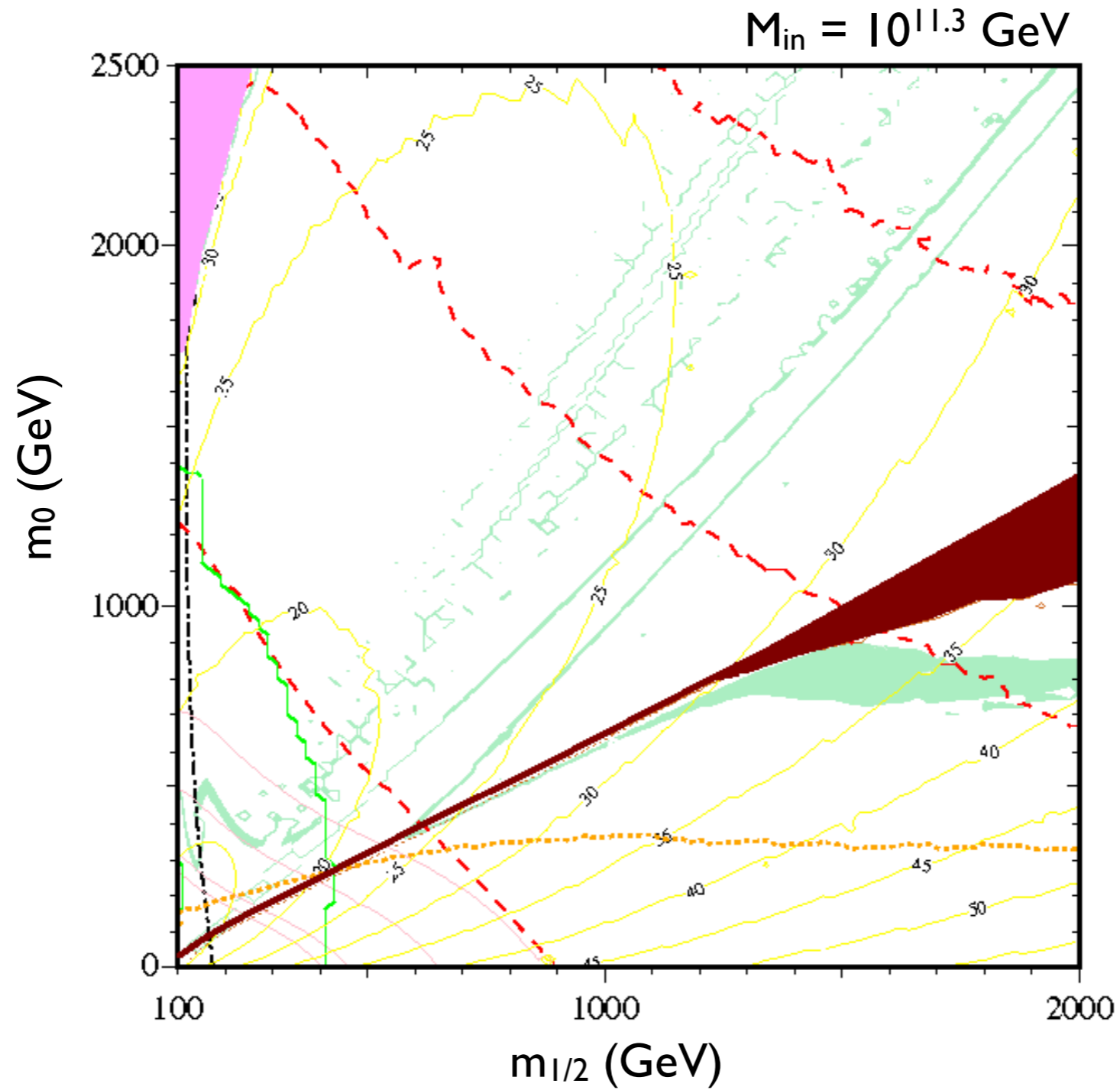
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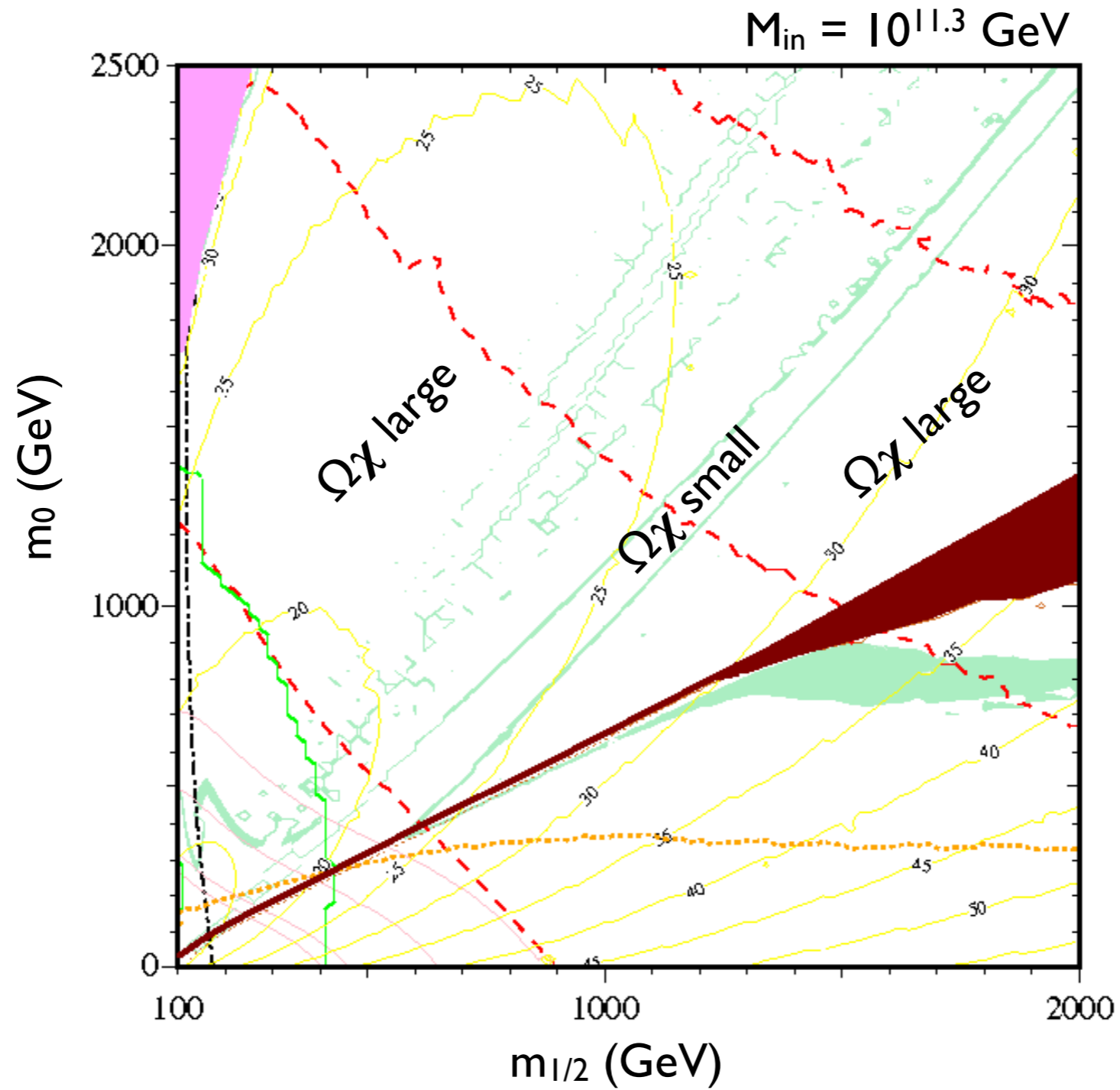
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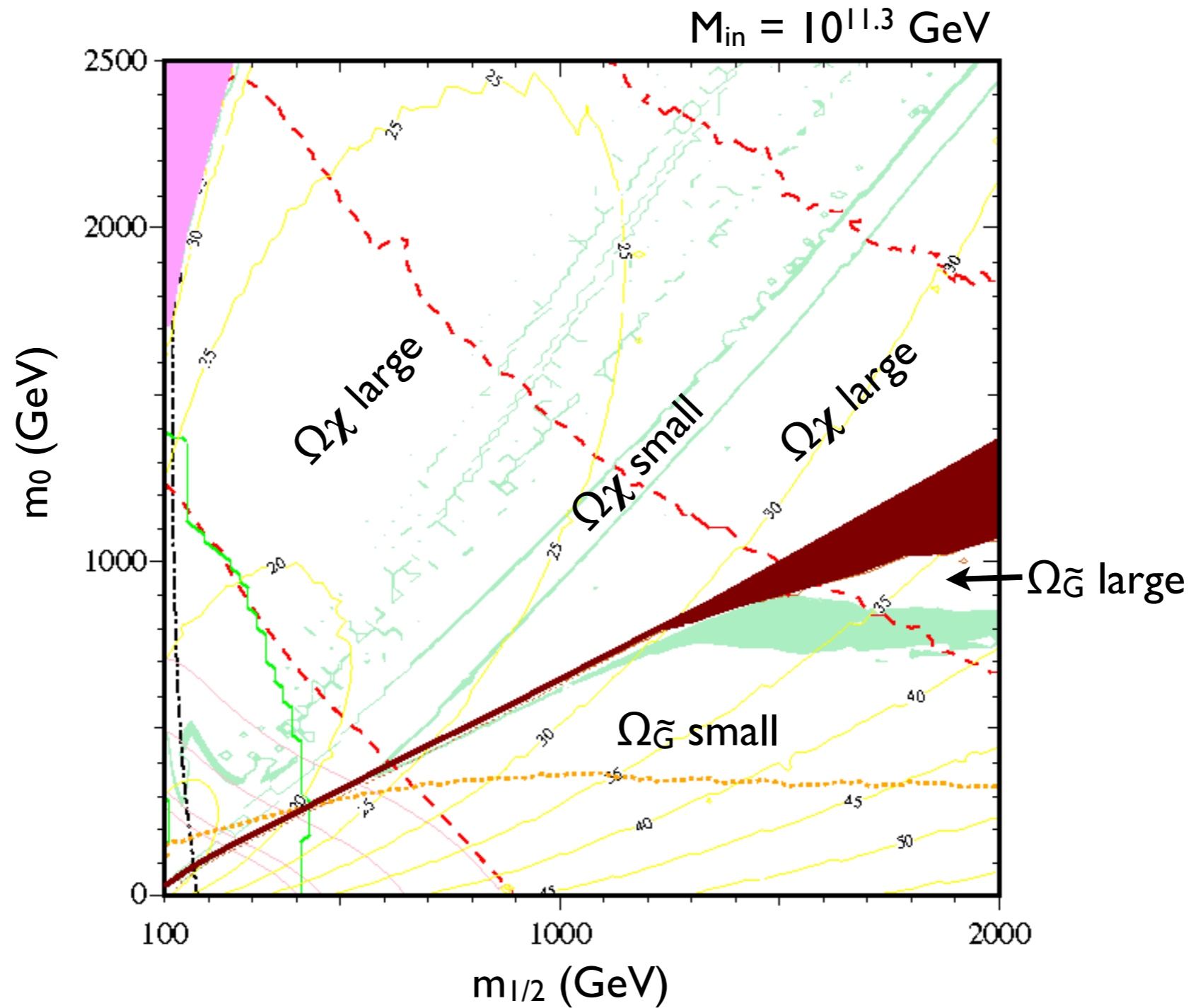
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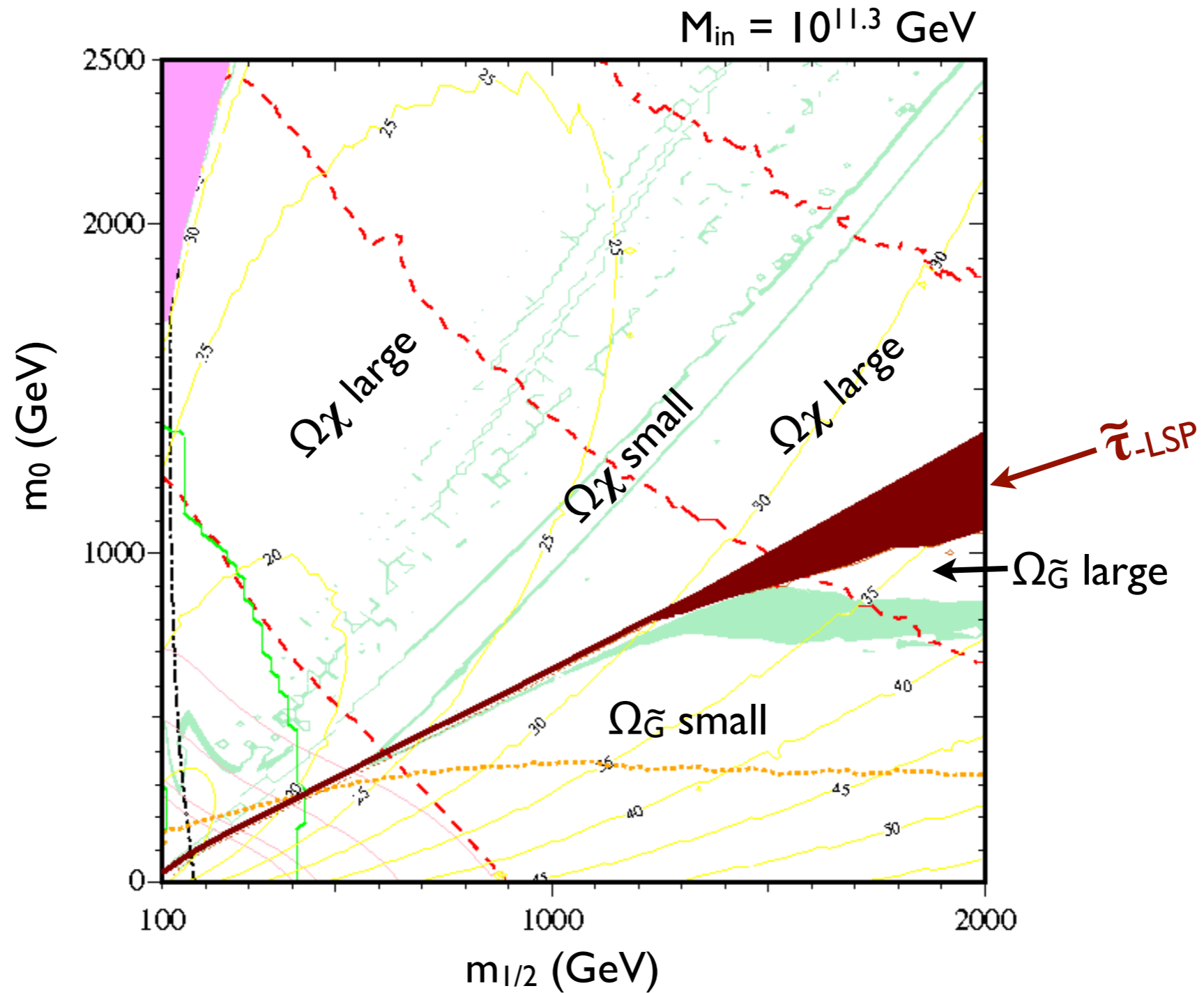
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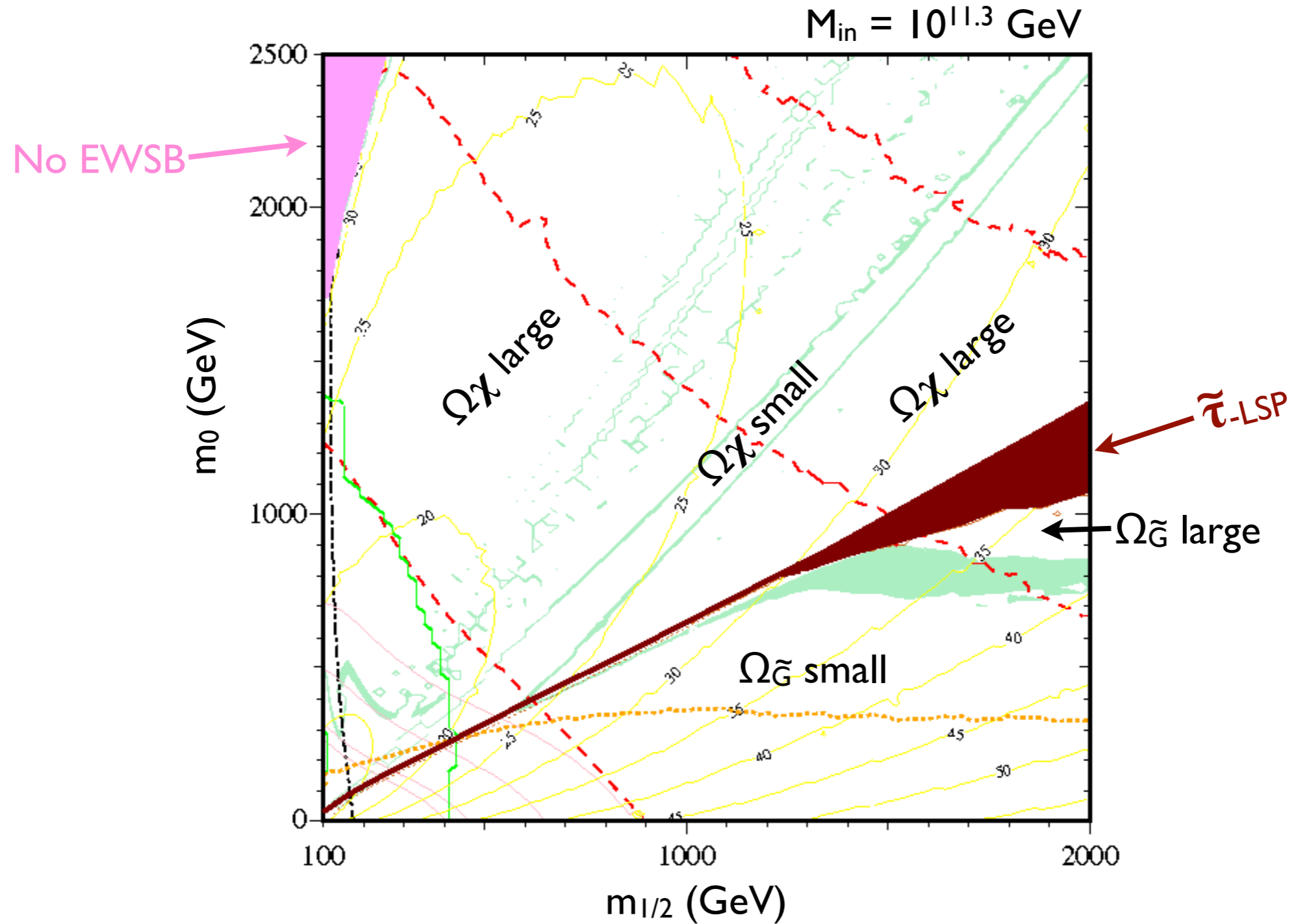
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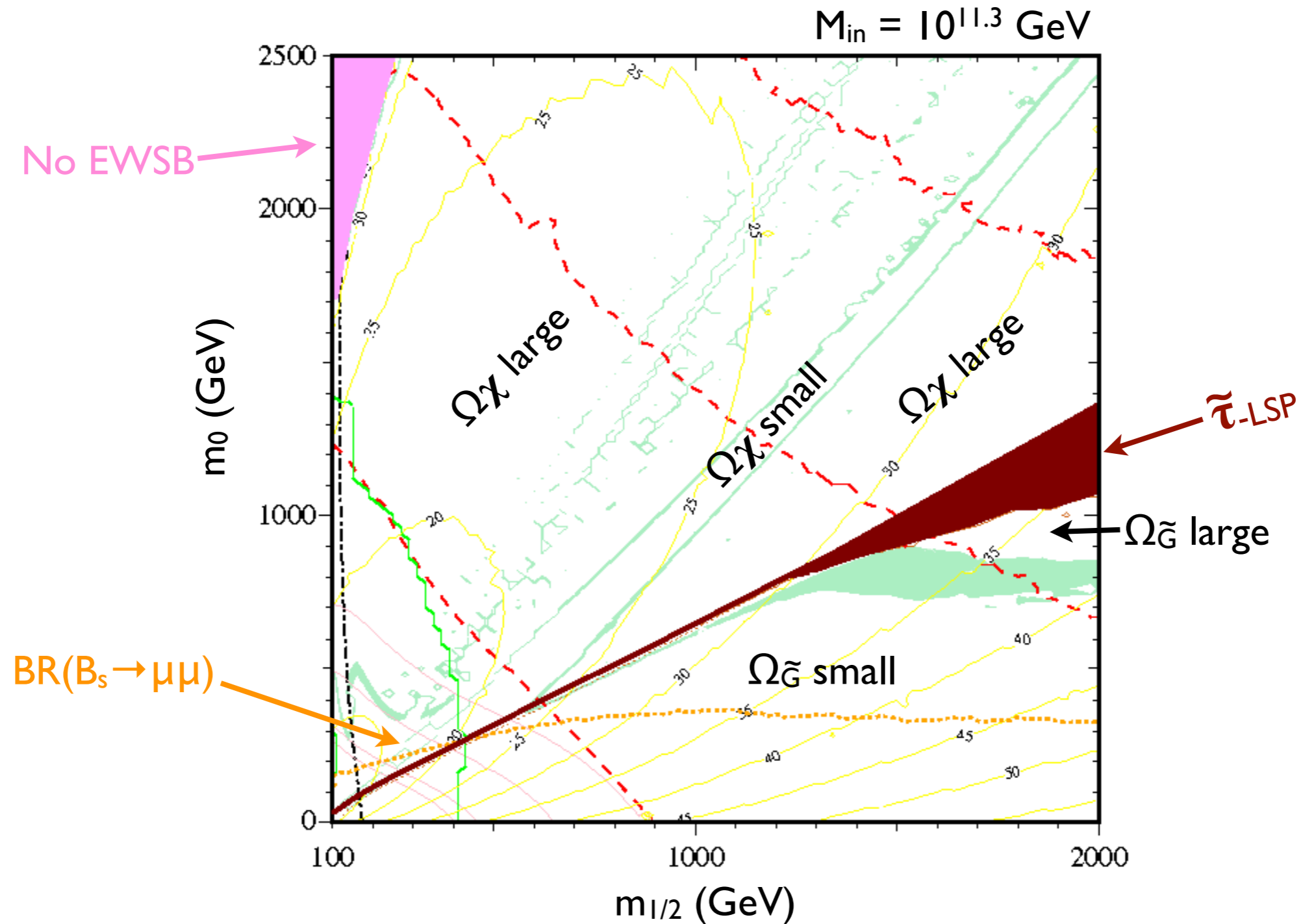
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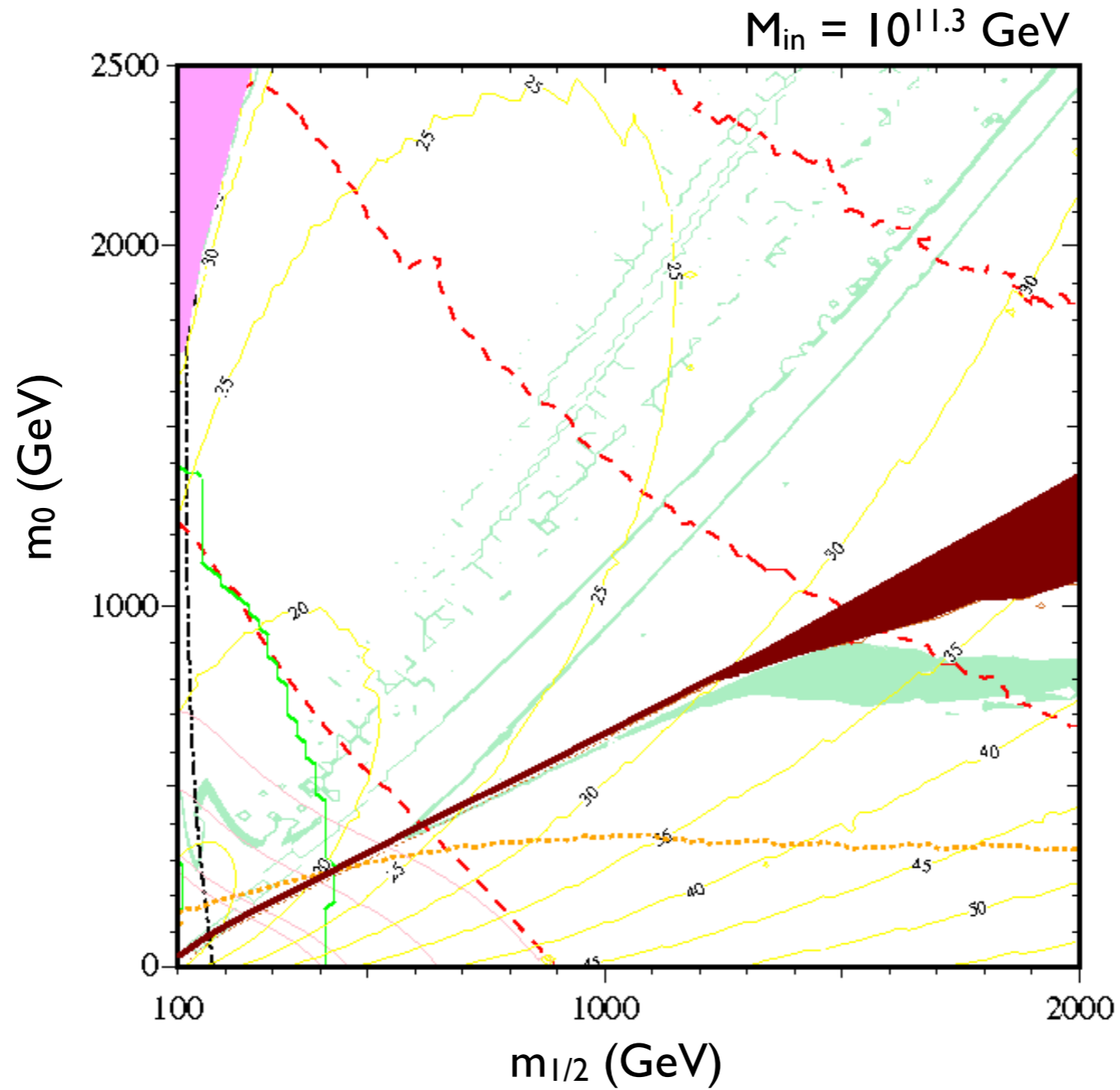
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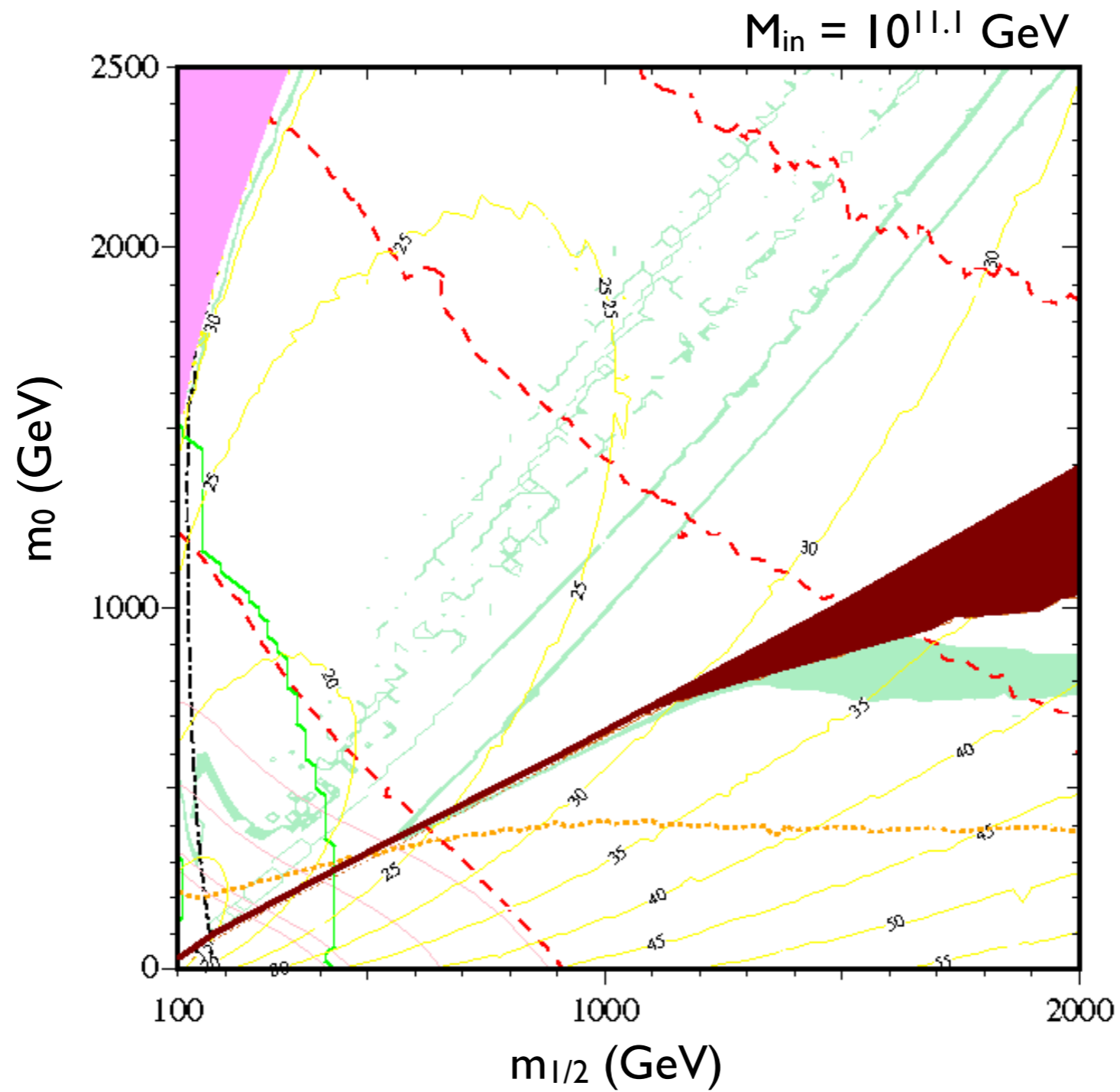
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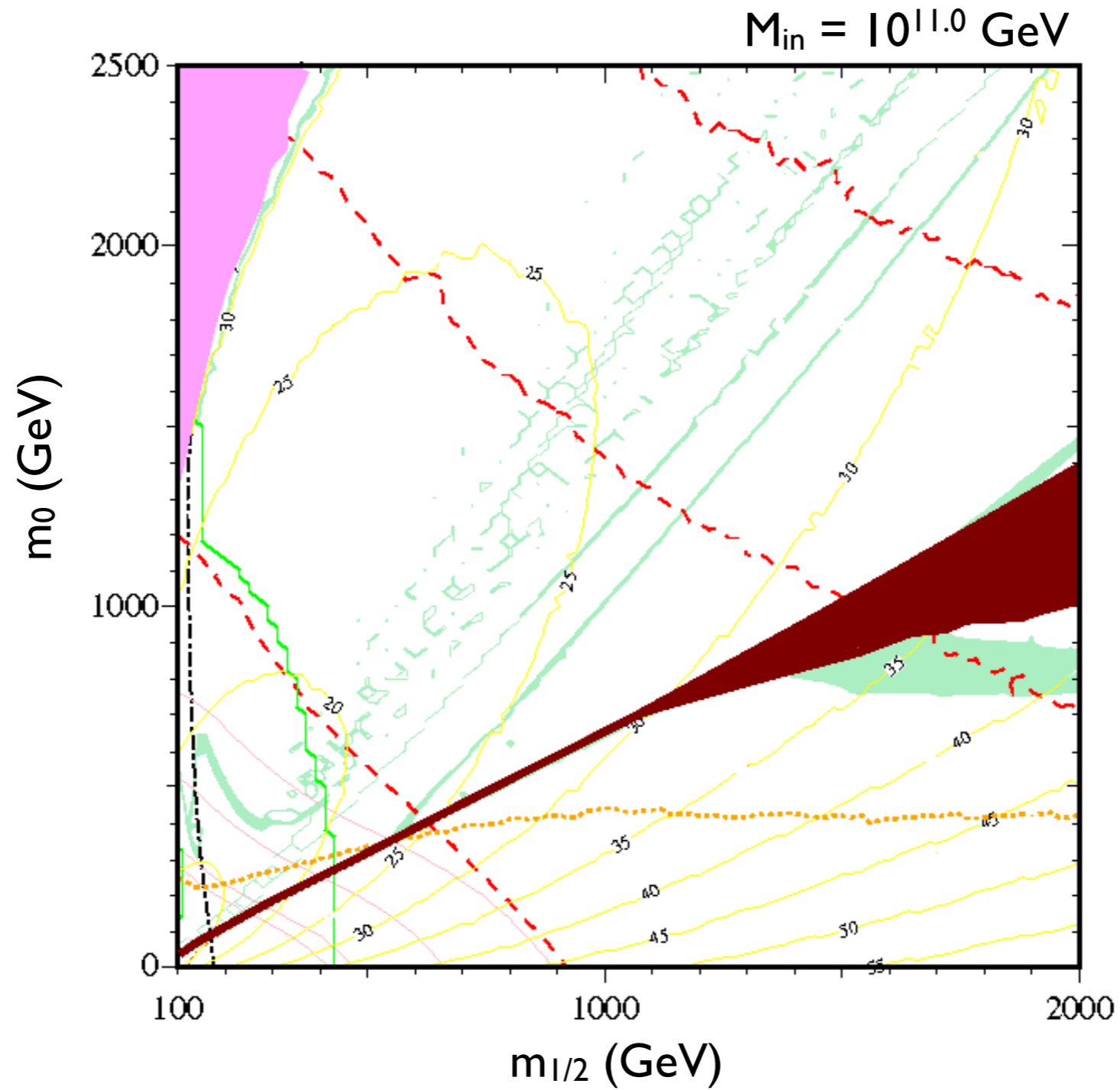
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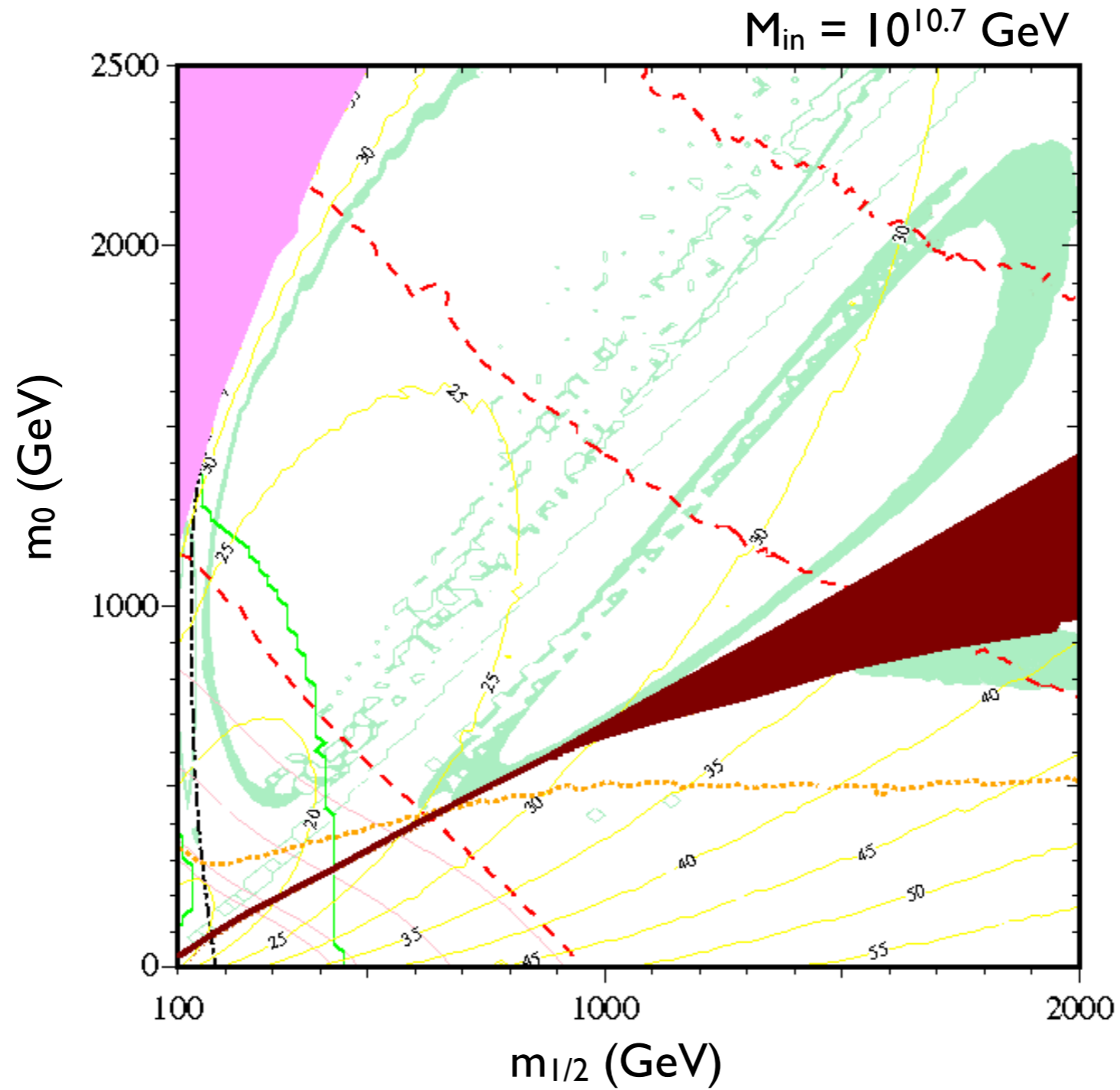
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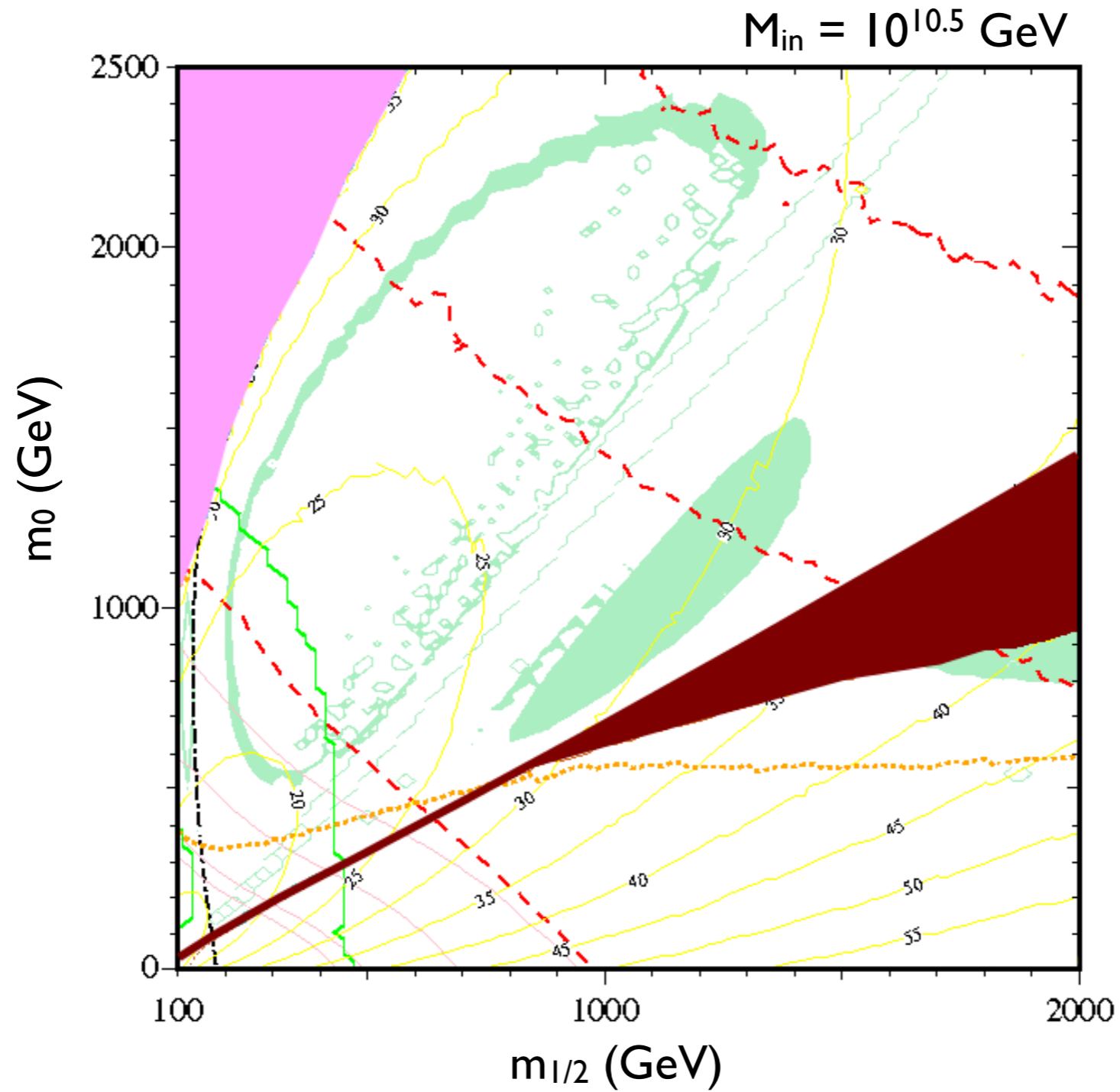
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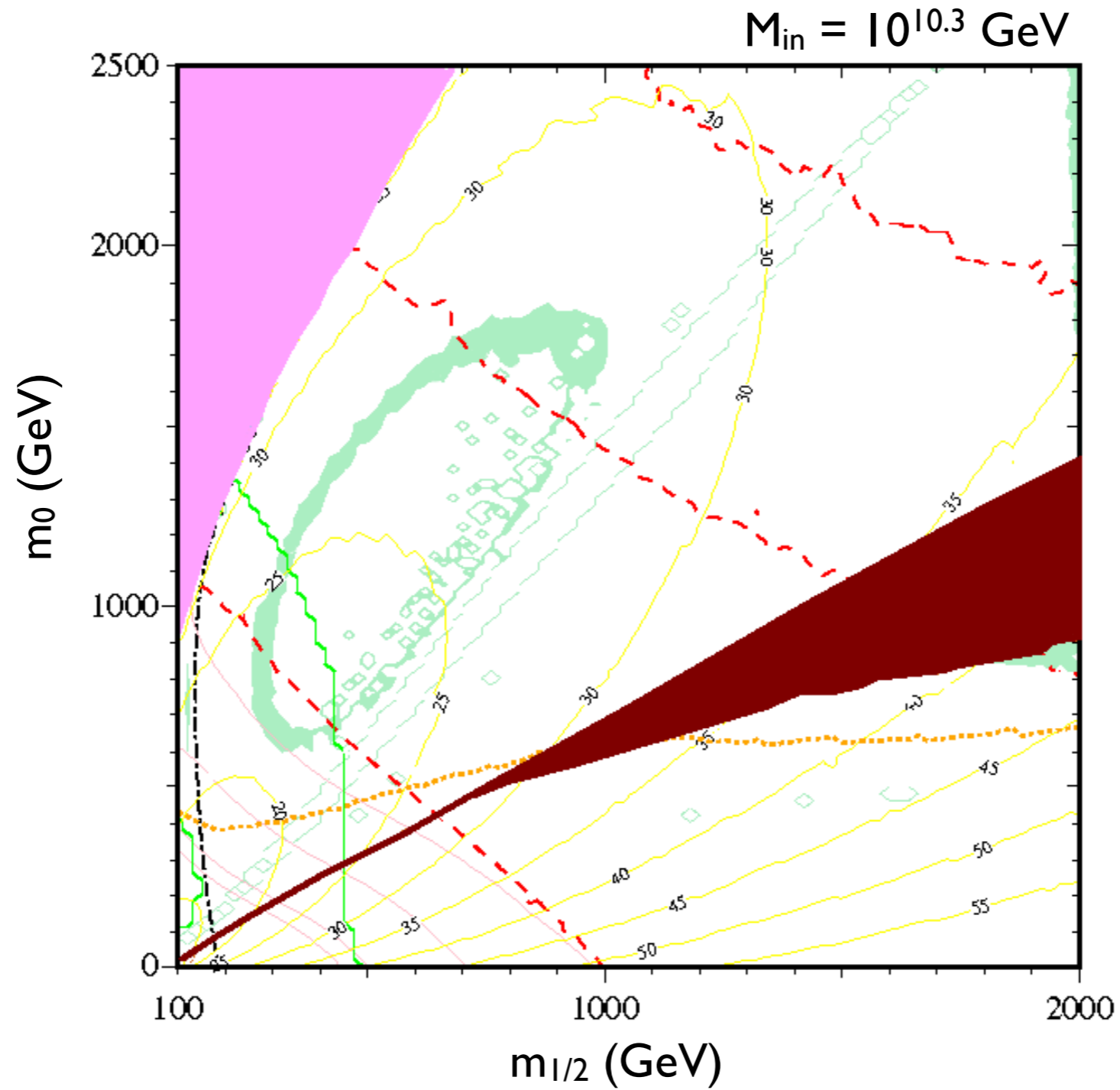
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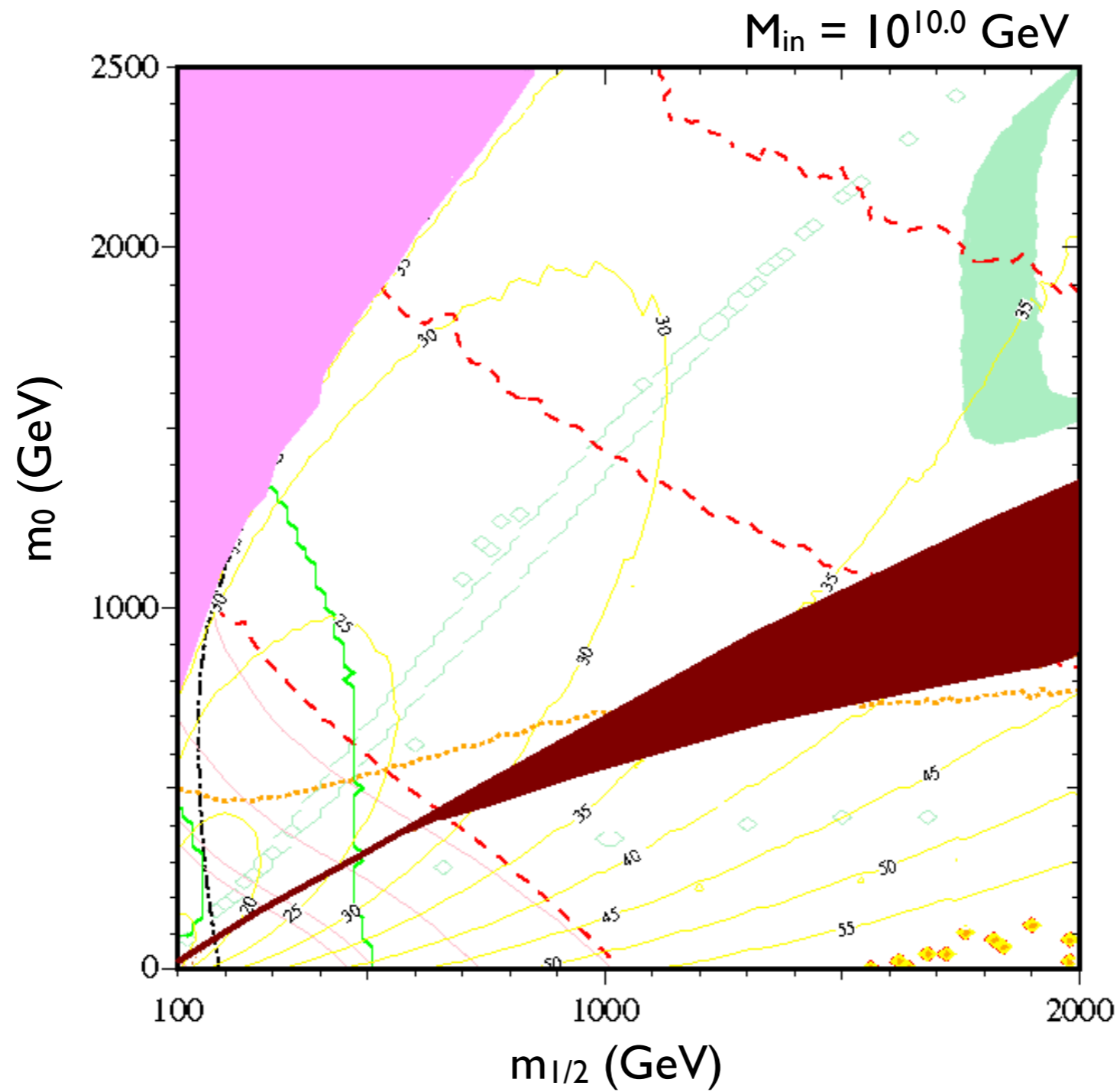
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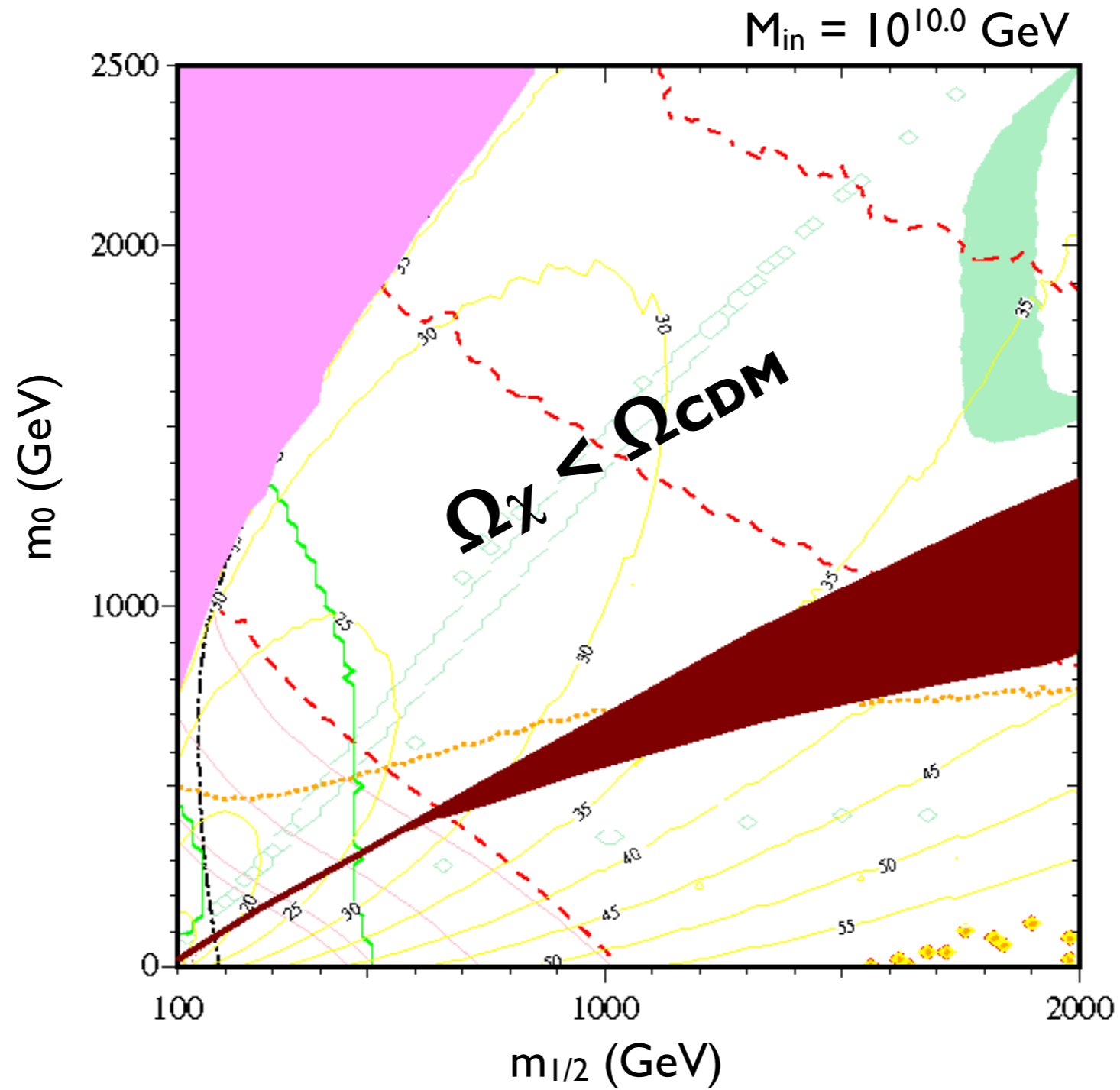
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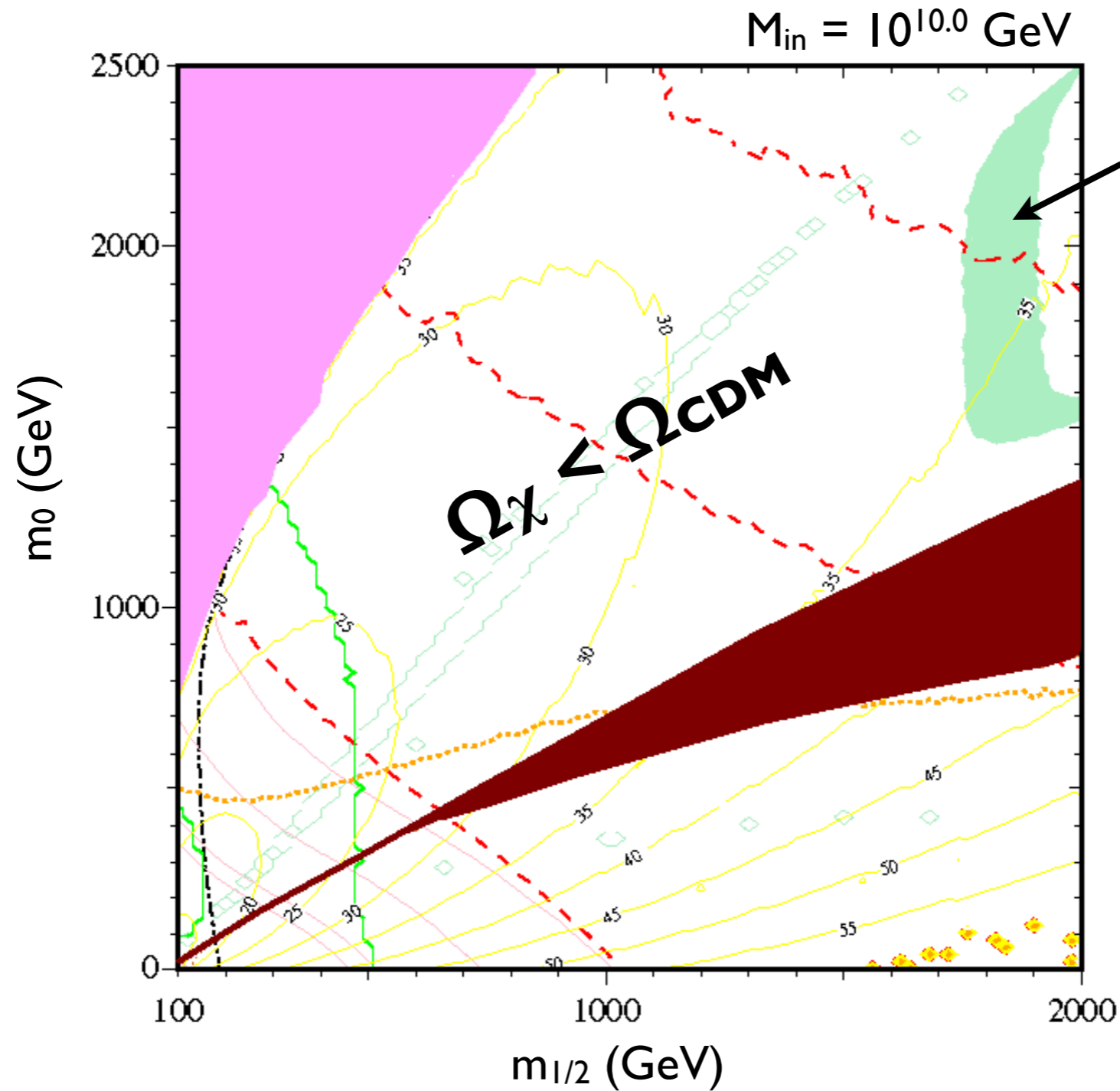
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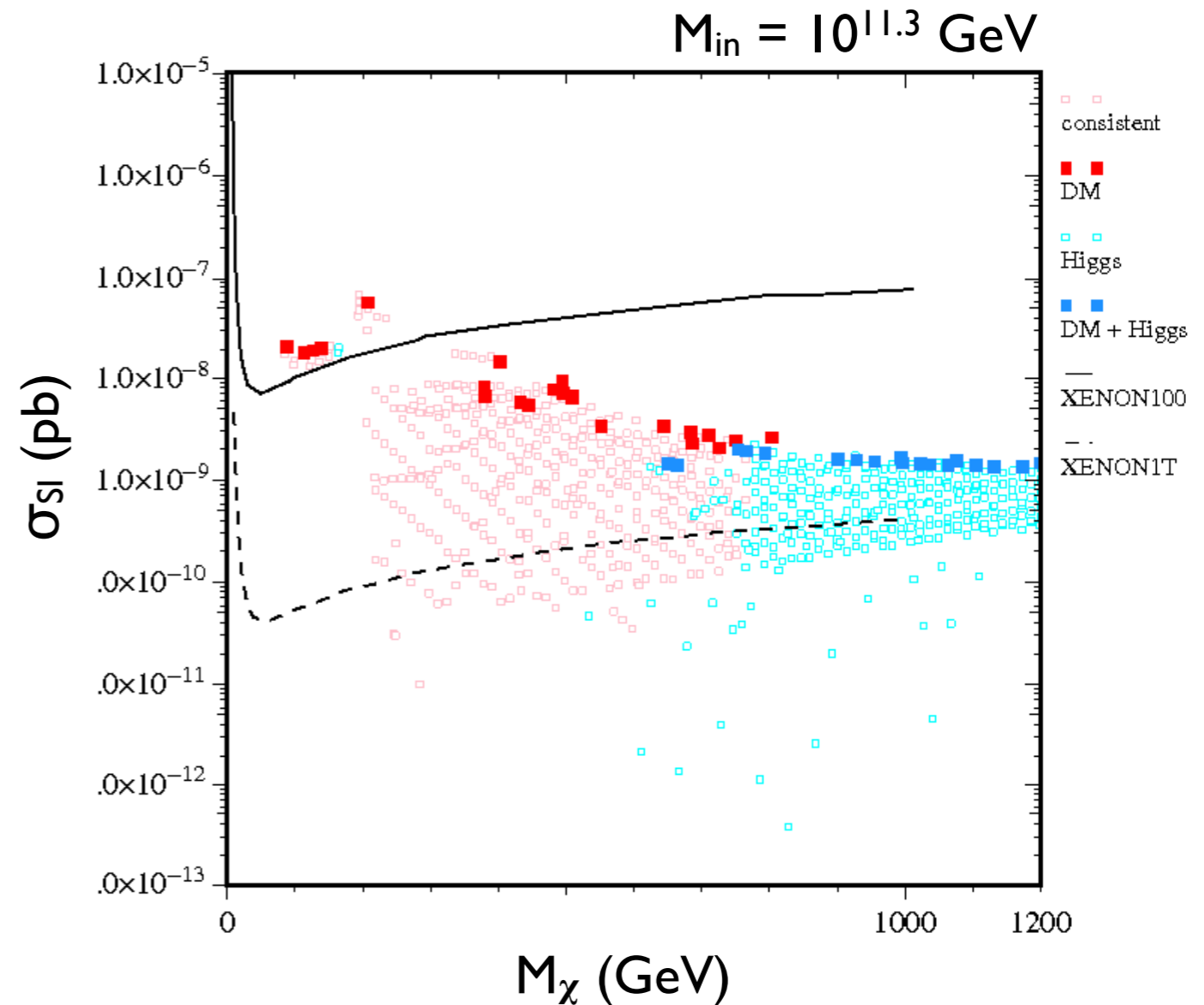
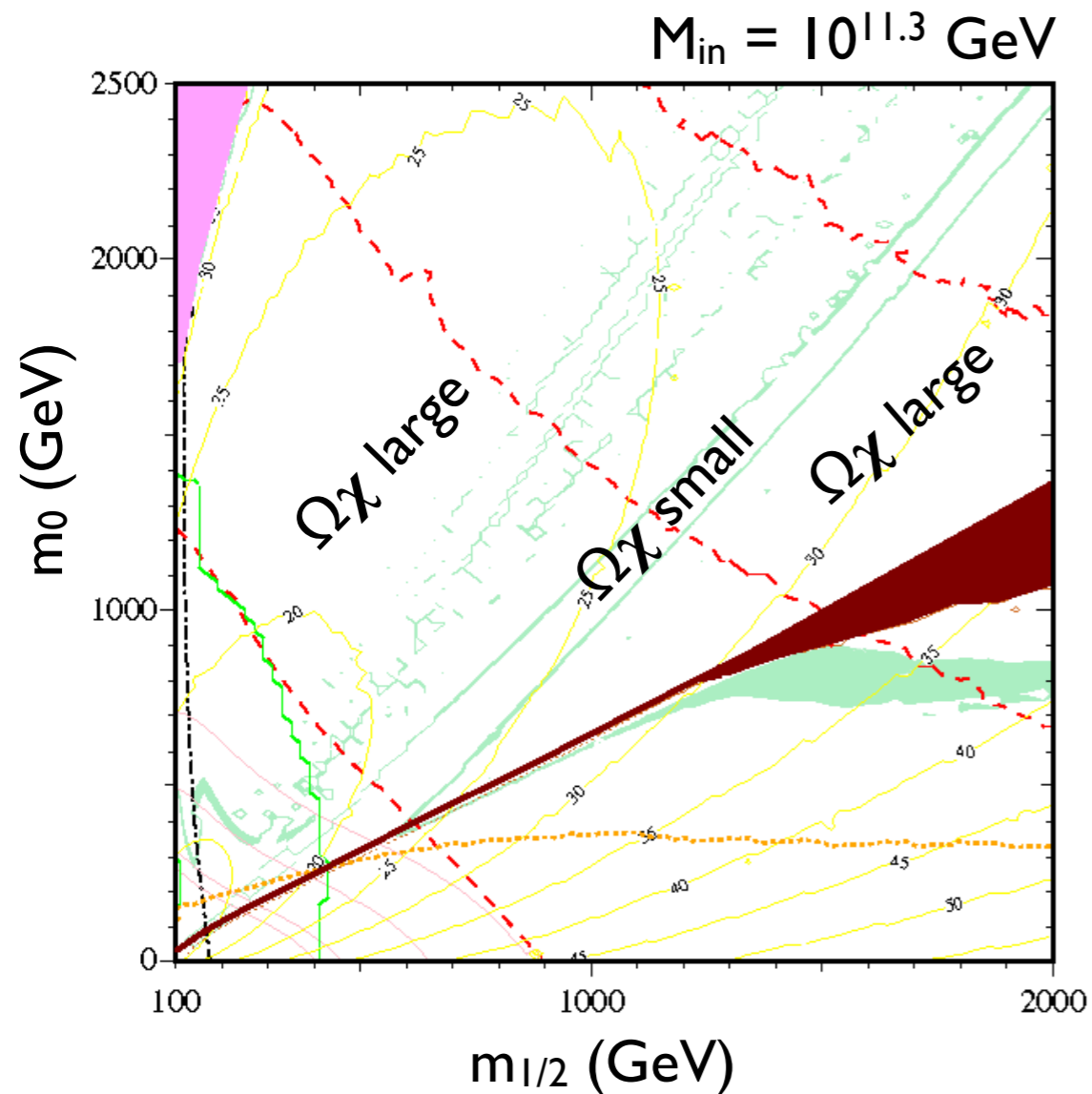


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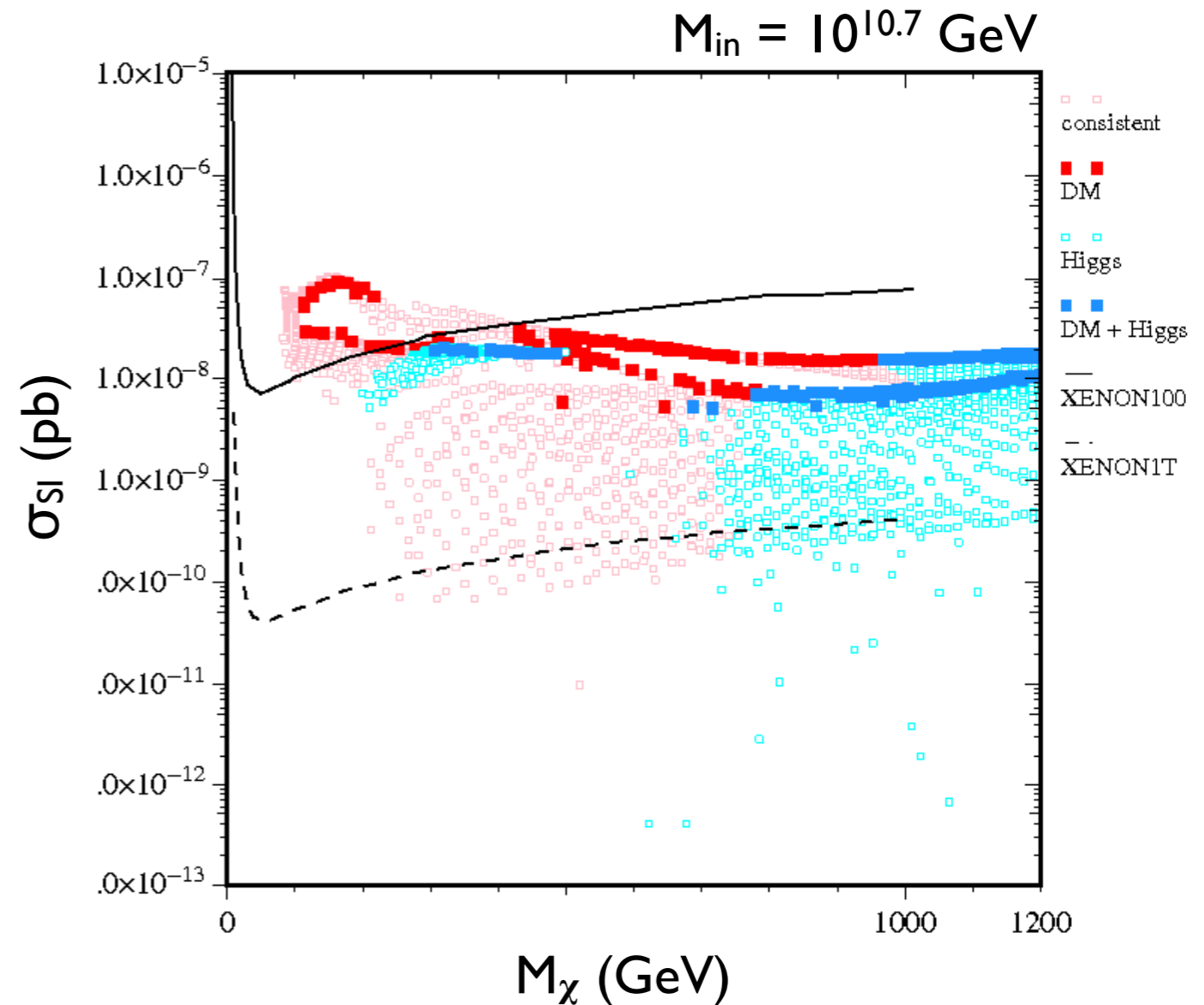
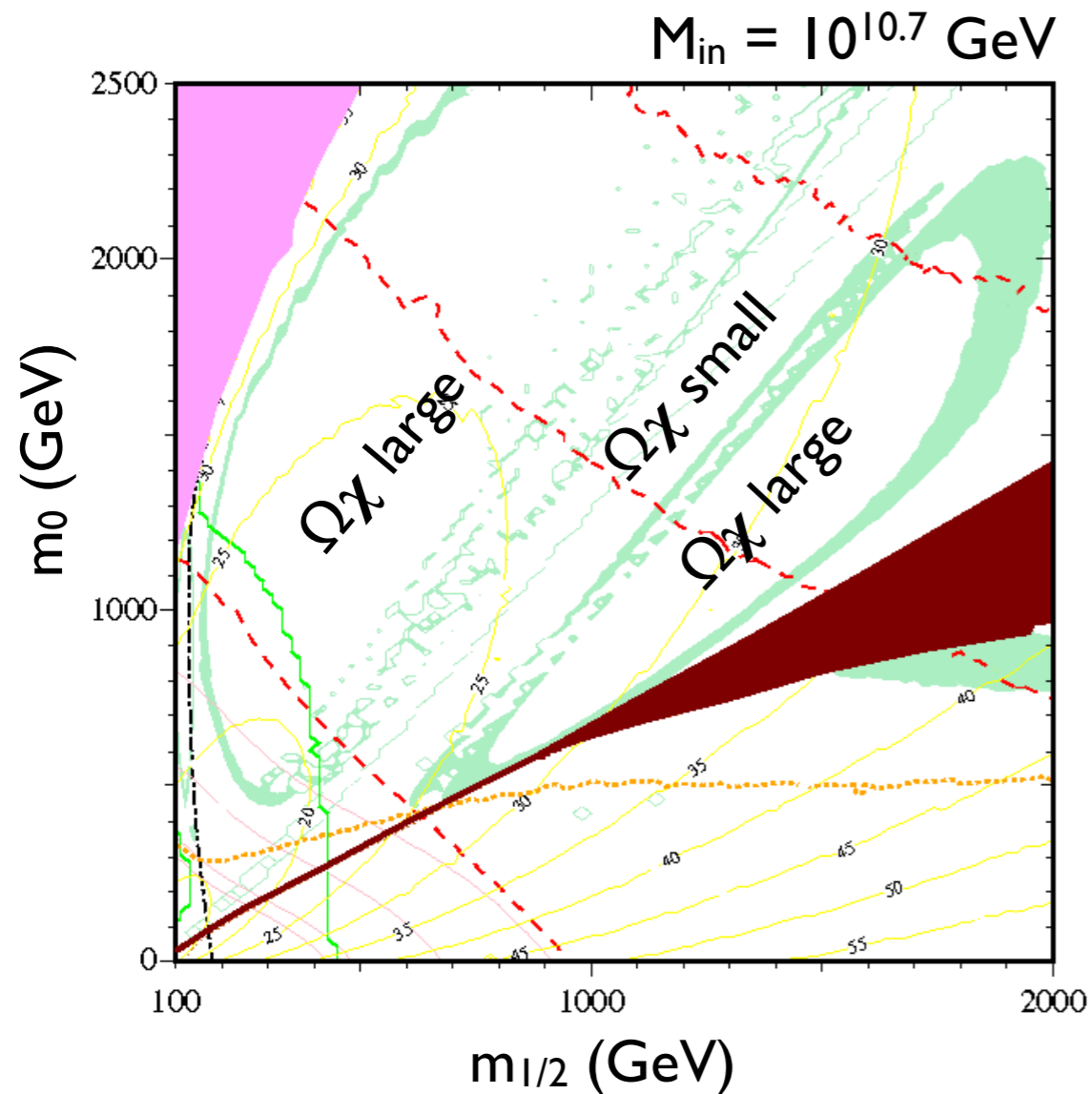


interesting things
still happening at
large $(m_{1/2}, m_0)$

Direct Detection Prospects



Direct Detection Prospects



Summary

- GUT-less mSUGRA

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

- Viable Polonyi Model

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

- Neutralino (or gravitino) dark matter, somewhat compressed spectrum, consistent with B-physics constraints, moderate $\tan\beta$, $m_h \approx 125$ GeV
- Good prospects for direct detection of neutralino dark matter - but still need collider confirmation
- Other GUT-less supergravity models to be investigated

Extra Slides