Cosmology at the LHC?

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  - Total energy $\sim \rho R^3 =$const. $\Longrightarrow \frac{\dot{T}}{T} \sim -\frac{3}{4} \frac{c}{R} \sim 0.015T$
    $\sim 3 \cdot 10^{16} \left. \frac{\dot{T}}{T} \right|_{\mathrm{early\ Universe}}$ ($T_{\mathrm{initial}} = 500$ MeV)

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LHC will *not* recreate conditions of the early Universe!

Creating massive particles

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- Implies $\sim 10^4$ Higgs bosons are produced per year in CR events on Earth

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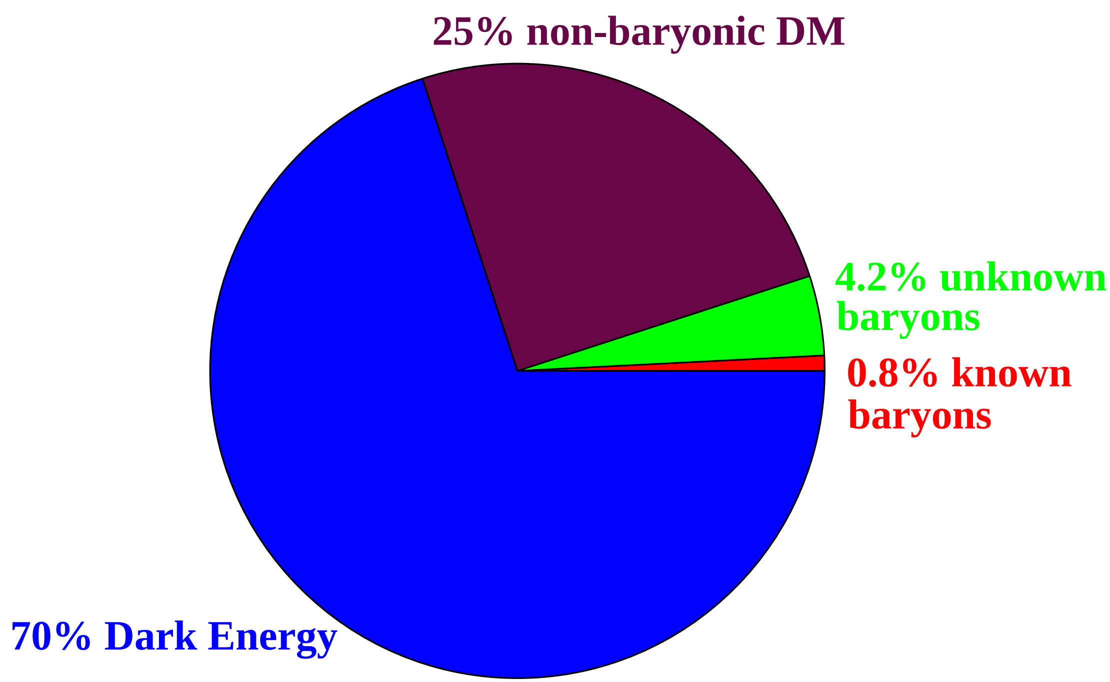
- Some of these particles may well be of relevance for cosmology
- LHC discoveries may well be of interest to cosmologists!

Biggest puzzles in particle cosmology

Composition of the Universe



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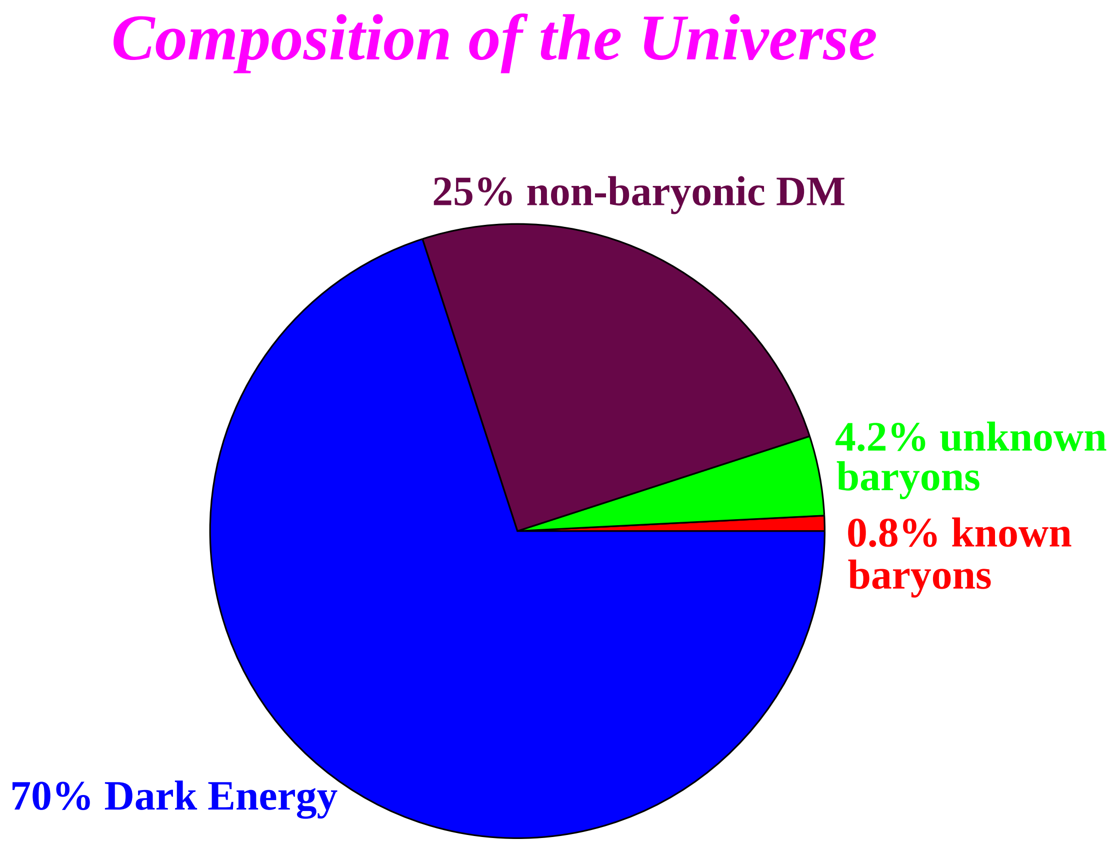

What is all the dark stuff?

2 Dark Energy and the LHC

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- In models with large extra dimension: LHC may be black hole factory; “cosmon” should be produced in bh decay

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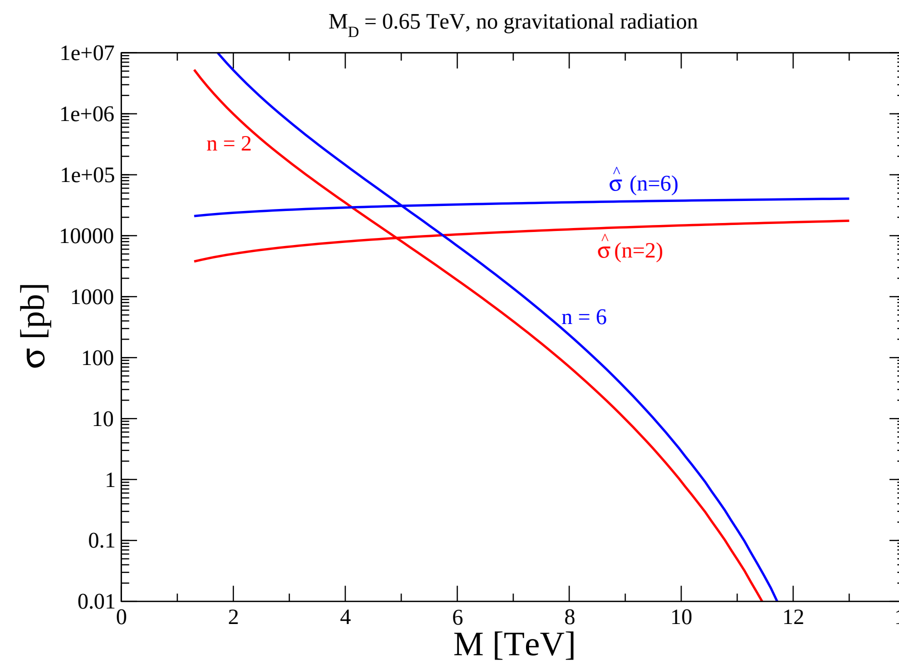

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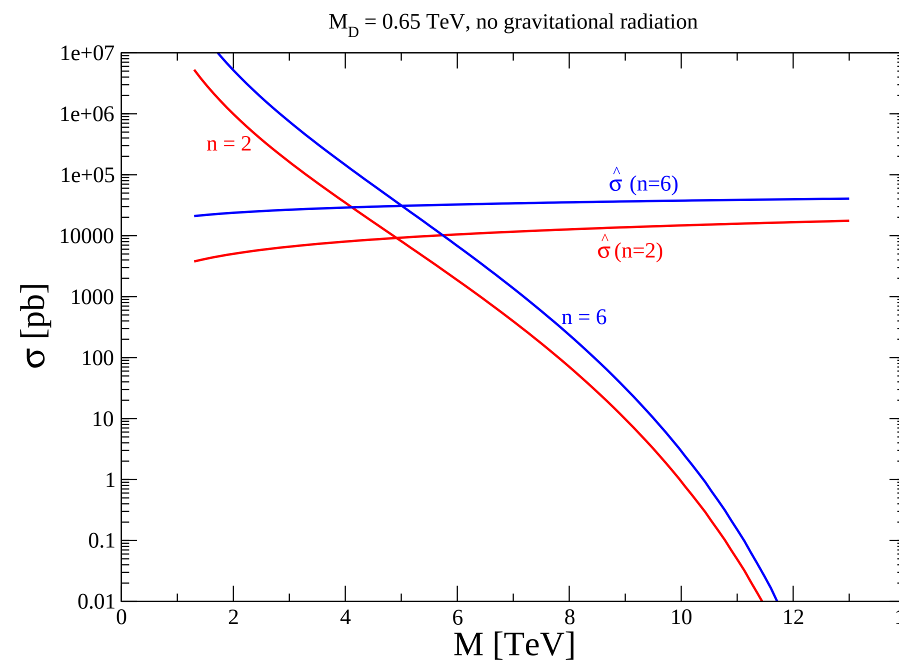

- Hence: Neither understand final stage of bh decay, nor total bh production cross section!

On the other hand . . .

Finding superparticles makes understanding small cosmological constant 10^{60} times easier!

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- Cosmic Microwave Background anisotropies (WMAP) imply $\Omega_{\rm DM} h^2 = 0.105^{+0.007}_{-0.013}$ **Spergel et al., astro–ph/0603449**

Density of thermal DM

Decoupling of DM particle χ defined by:

$$n_\chi(T_f)\langle v\sigma(\chi\chi \to \mathrm{any})\rangle = H(T_f)$$

n_χ: χ number density $\propto \mathrm{e}^{-m_\chi/T}$

v: Relative velocity

$\langle \dots \rangle$: Thermal average

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Gives average relic mass density

$$\Omega_\chi \propto \frac{1}{\langle v\sigma(\chi\chi \to \mathrm{any})\rangle}$$

Yields roughly right result for weak cross section!

Assumptions

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- Such particles exist for best–motivated χ candidates: SUSY, Little Higgs, (universal extra dimension)

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Conditions for successful DM candidate:

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$$\chi = \tilde{\chi}_1^0$$

(or in hidden sector)

$\tilde{\chi}_1^0$ relic density

To predict thermal $\tilde{\chi}_1^0$ relic density: have to know

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Neutralino mass matrix in the MSSM:

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Are produced both directly and in $\tilde{q}$, $\tilde{g}$ decays at the LHC!

$\tilde{\chi}_1^0$ annihilation in the MSSM

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- Parameters in Higgs and squark sector are also needed to predict $\tilde{\chi}_1^0$ detection rate, i.e. $\sigma(\tilde{\chi}_1^0 N \to \tilde{\chi}_1^0 N)$

Impact on particle physics (mSUGRA)

w./ A. Djouadi, J.-L. Kneur, hep-ph/0602001

Parameter space is constrained by:

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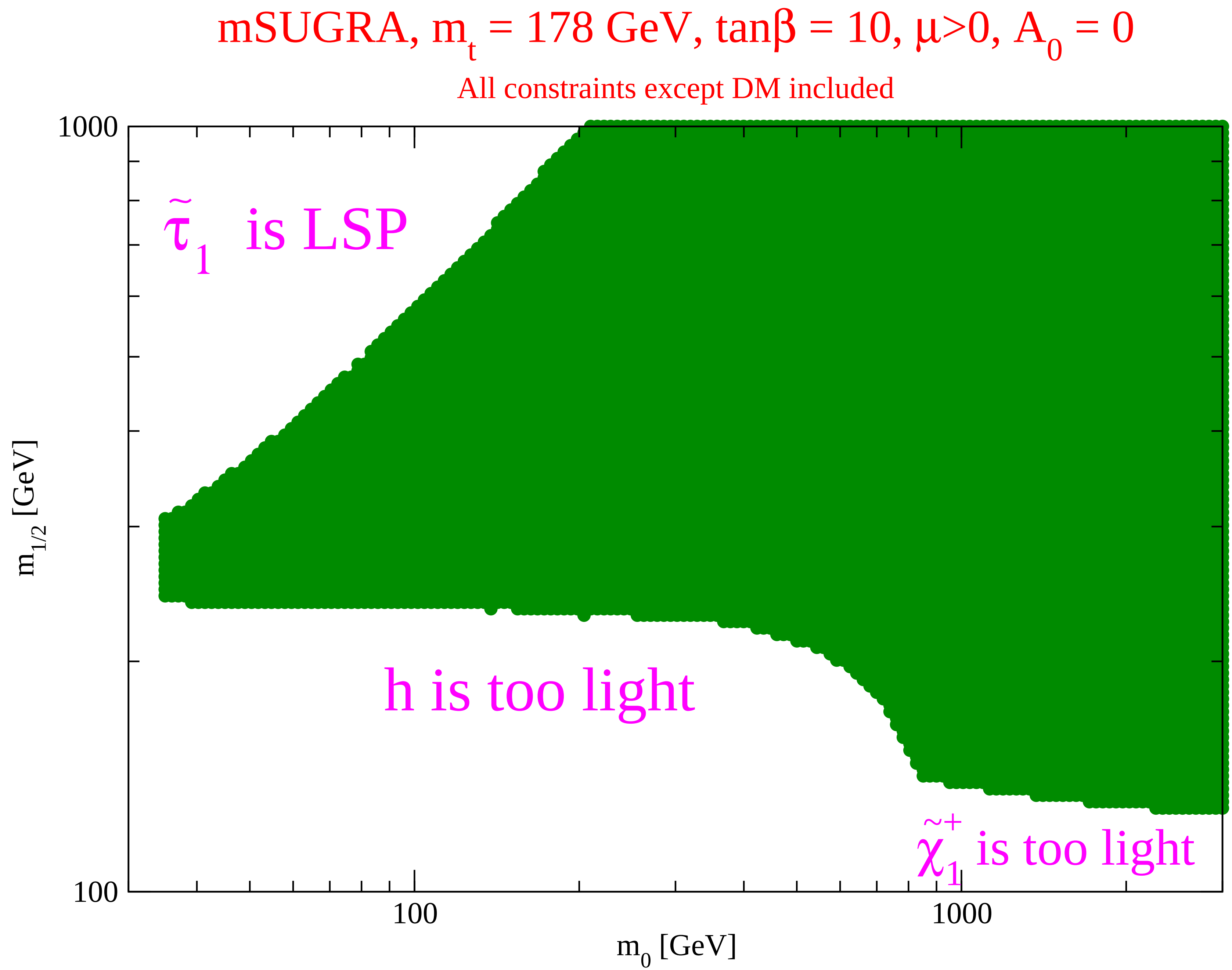

mSUGRA, m_t = 178 GeV, tanβ = 10, μ>0, A_0 = 0
All constraints except DM included
$\tilde{\tau}_1$ is LSP
h is too light
$\tilde{\chi}_1^+$ is too light
1000
100
100
1000
$m_{1/2}$ [GeV]
m_0 [GeV]

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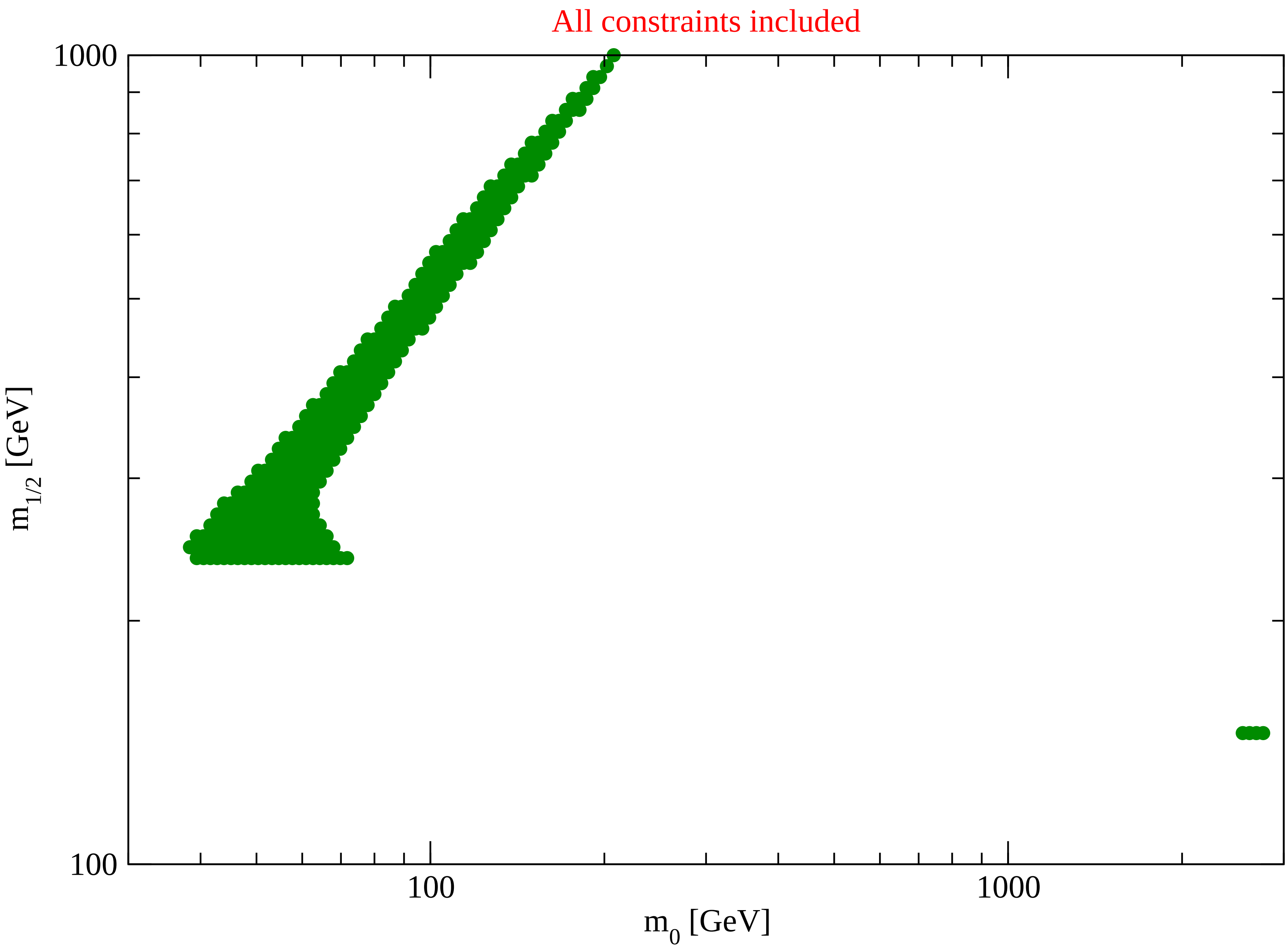

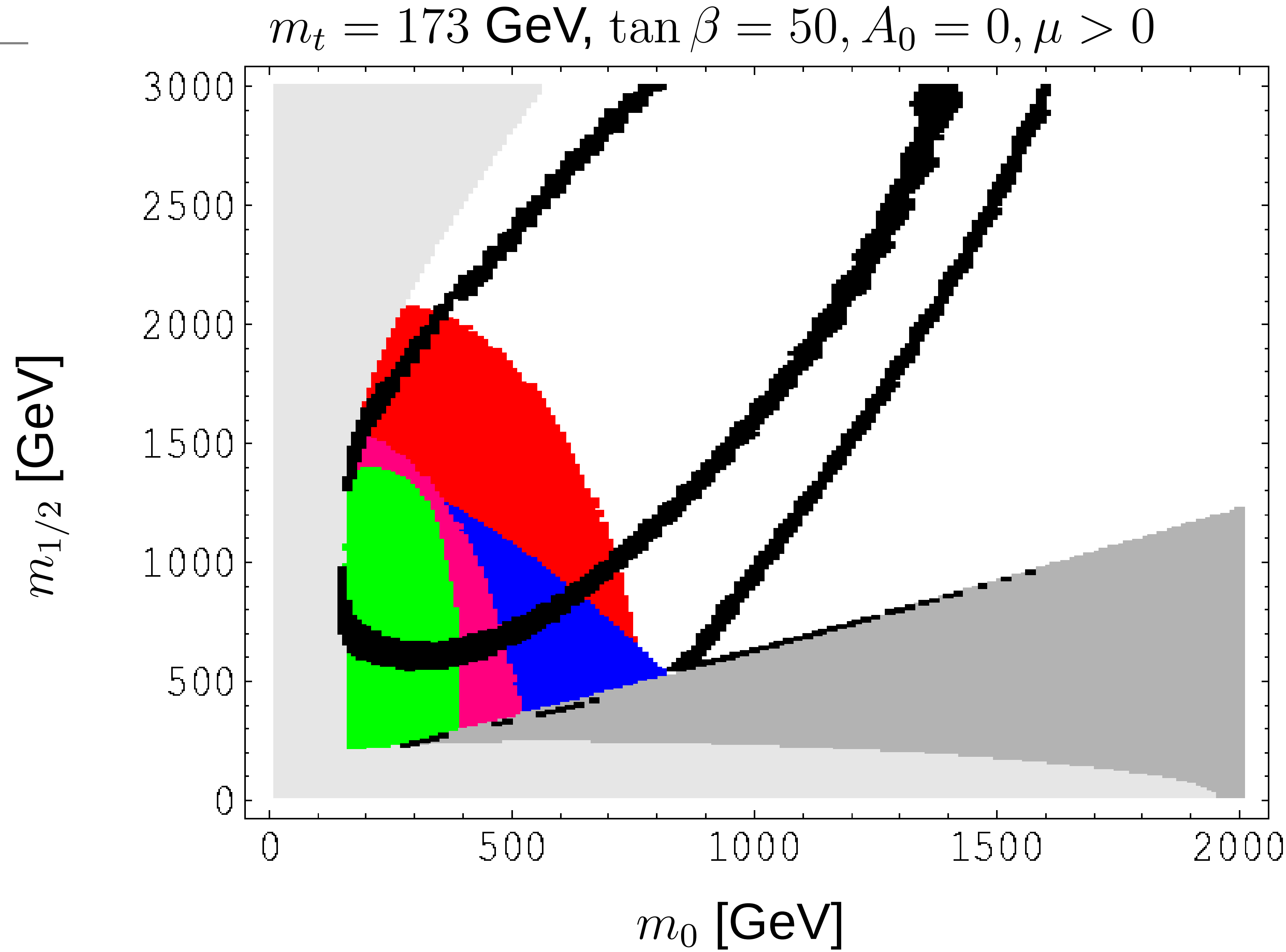
$m_t = 173$ GeV, $\tan\beta = 50, A_0 = 0, \mu > 0$
3000
2500
2000
1500
1000
500
0
$m_{1/2}$ [GeV]
0
500
1000
1500
2000
m_0 [GeV]

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Finetuning arguments *do* guarantee LHC signal, if SUSY is to stabilize the hierarchy.

Predicting $\Omega_{\tilde{\chi}_1^0} h^2$ from LHC data

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