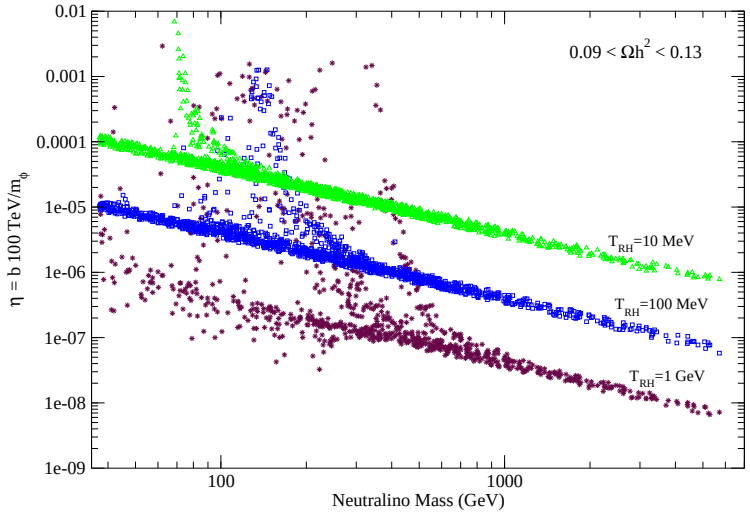
The effect of a decaying scalar field on the neutralino relic density



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PHENO 06

The dark matter constraint severely restricts the parameter space of susy models

Higgsino-like neutralino

$m_\chi \sim 1$ TeV

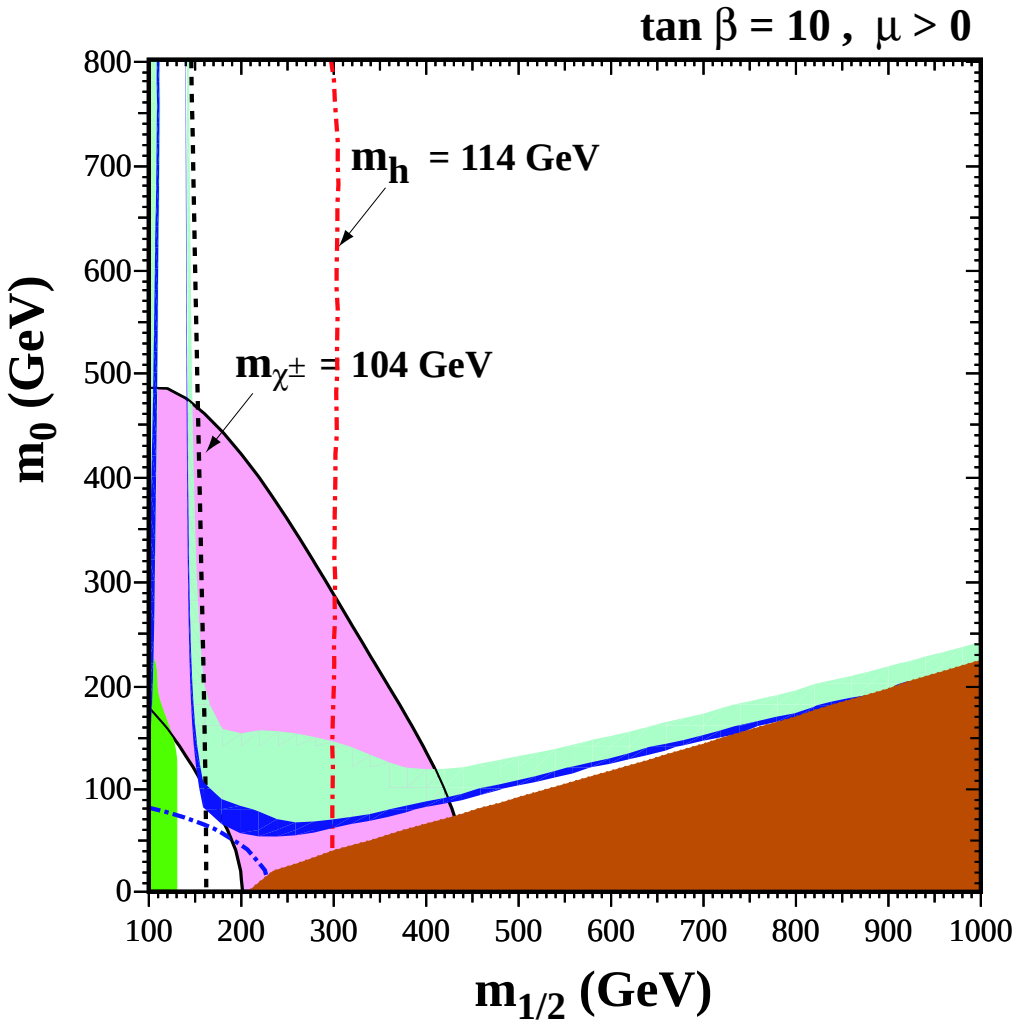
Wino-like neutralino

$m_\chi \sim 2$ TeV

Bino-like neutralino

coannihilations

resonances



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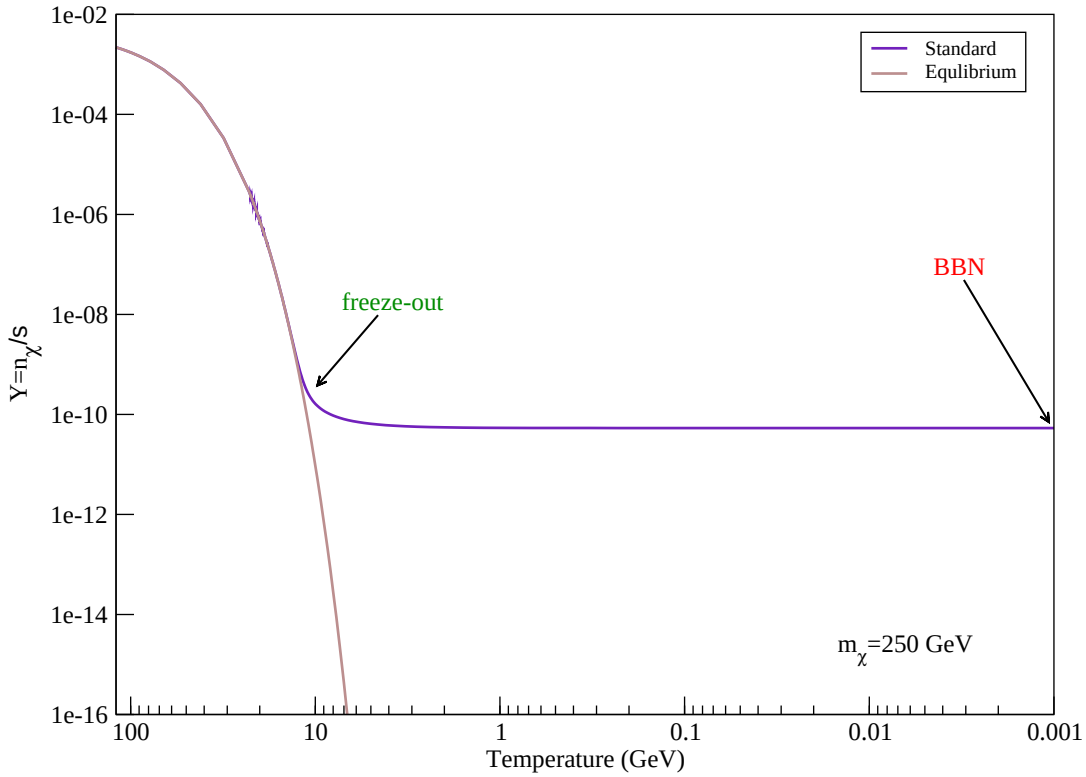
The calculation of Ω_χ assumes that the Universe was radiation dominated

At high T the neutralinos are in equilibrium

Ω_χ is determined at freeze-out

There is no evidence of a RD era before BBN



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We assume that the Universe was initially dominated by a scalar field

The Universe might not be RD at freeze-out ($H \propto T^4$)

The entropy increases due to the ϕ decay

χ's are produced non-thermally in ϕ decays

$$\frac{d\rho_\phi}{dt} = -3H\rho_\phi - \Gamma_\phi \rho_\phi$$

$$\frac{ds}{dt} = -3Hs + \frac{\Gamma_\phi \rho_\phi}{T}$$

$$\frac{dn}{dt} = -3Hn - \langle\sigma v\rangle (n^2 - n_{eq}^2) + \frac{b}{m_\phi}\Gamma_\phi \rho_\phi$$

$$H^2 = \frac{8\pi}{3M_P^2}(\rho_\phi + \rho_{SM} + \rho_\chi)$$

$$\Gamma_\phi = \sqrt{\frac{4\pi^3 g(T_{RH})}{45}}\frac{T_{RH}^2}{M_P}$$

$$\eta = b\left(\frac{100\ \text{TeV}}{m_\phi}\right)$$

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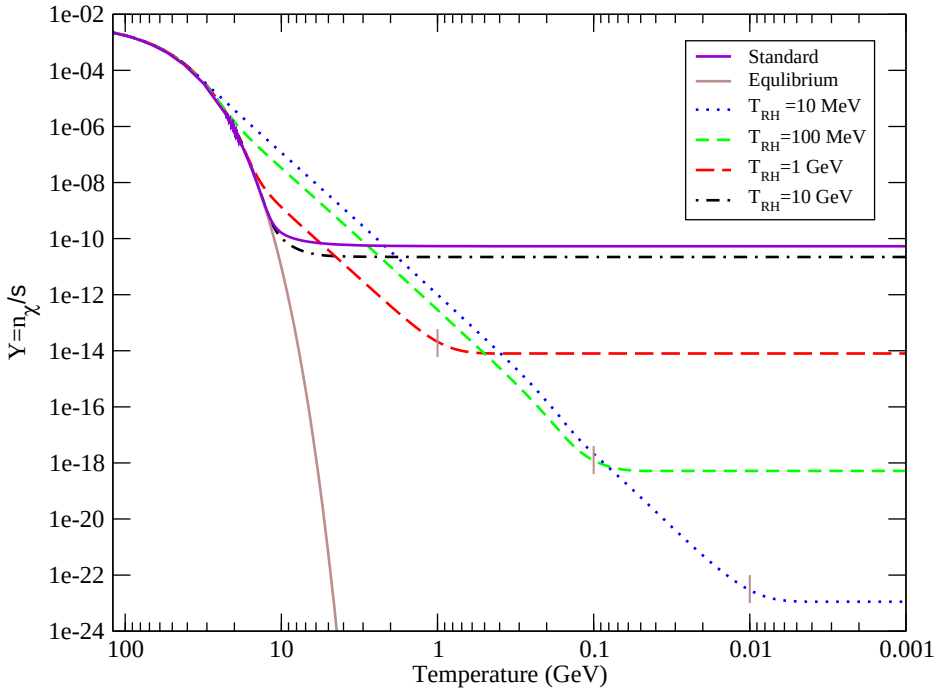
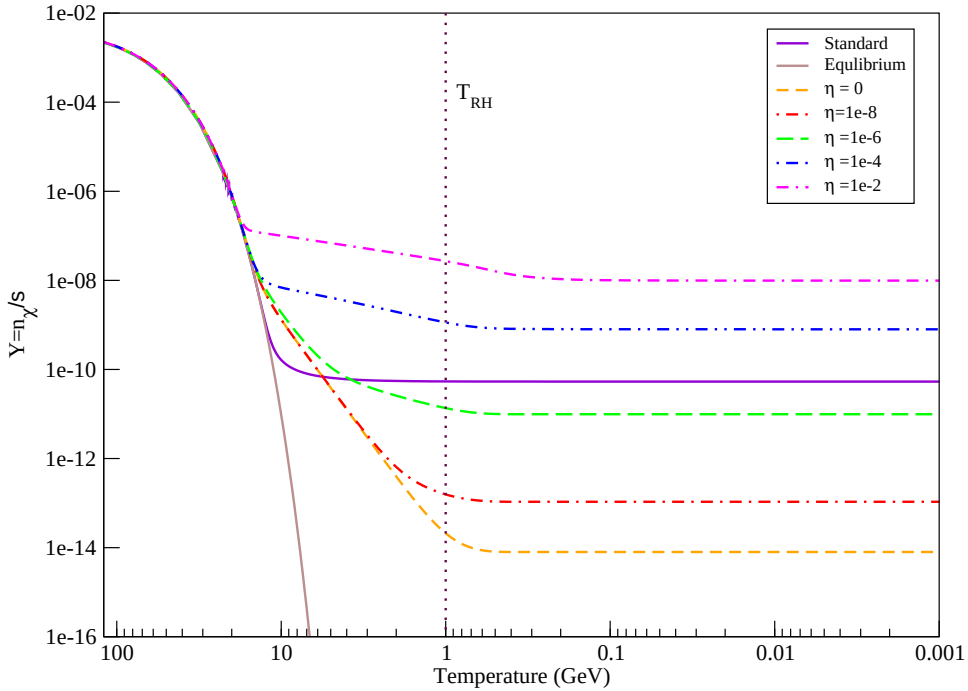
The evolution of the neutralino abundance $Y = n/s$ depends on both T_{RH} and η

$\eta = 0$



$T_{RH} = 1$ GeV



Ω_χ increases with T_{RH} for $\eta = 0$

Ω_χ increases with η for T_{RH} fixed

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Some models with $\Omega_\chi^{std} \neq \Omega_{DM}$ can be saved by adjusting T_{RH} and η

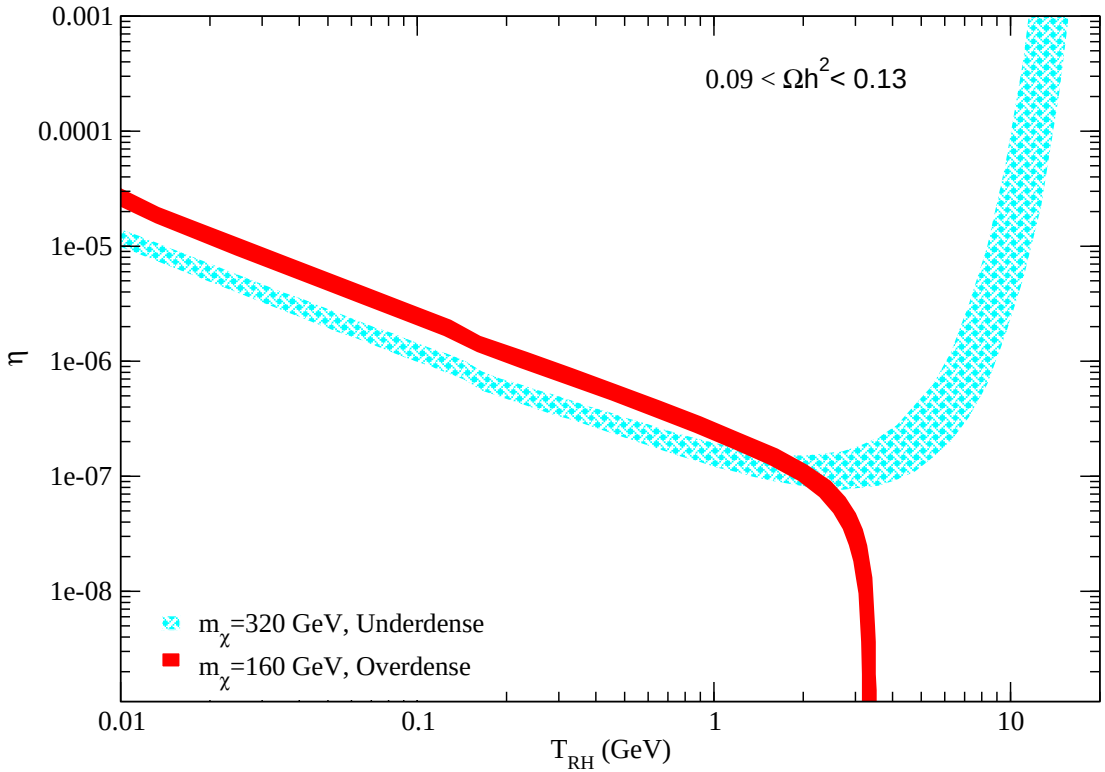
m_χ is the only relevant quantity at small T_{RH}

If $\Omega_\chi^{std} > \Omega_{DM}$

T_{RH} can not be large

If $\Omega_\chi^{std} < \Omega_{DM}$

η can not be small



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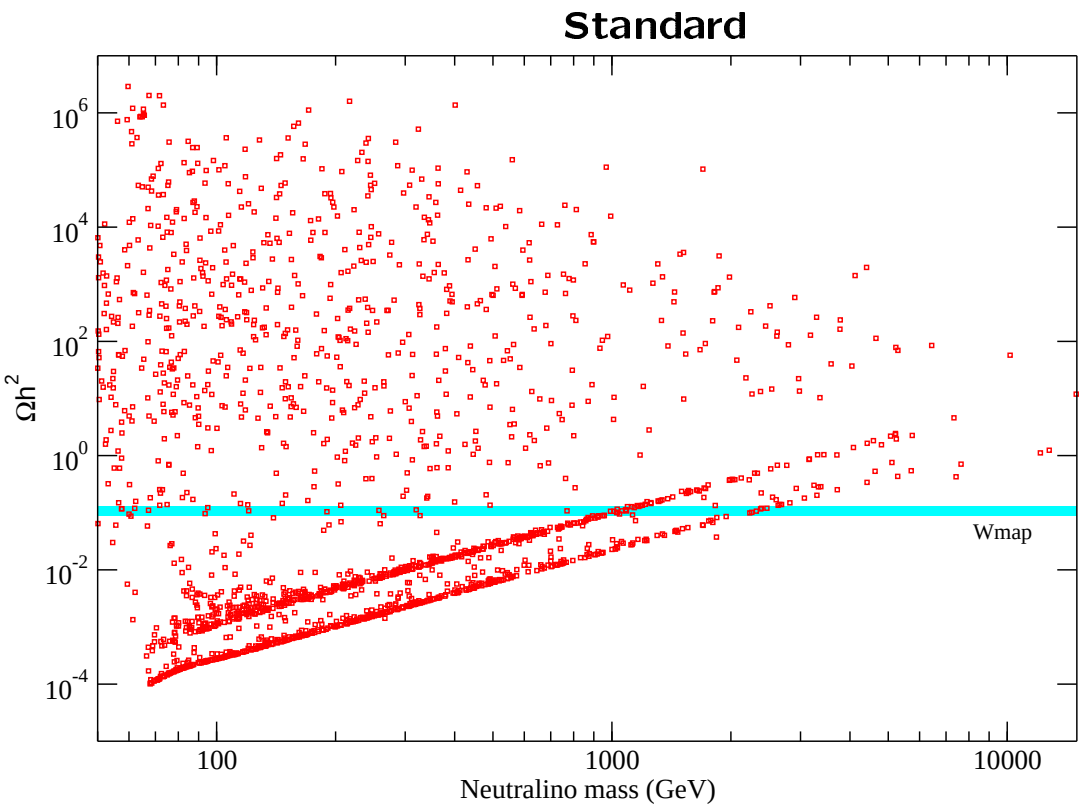
We study the neutralino relic density in generic supersymmetric models

$$10\ \mathrm{GeV} < M_i, \mu, m_A < 50\ \mathrm{TeV}$$
$$10\ \mathrm{GeV} < m_0 < 200\ \mathrm{TeV}$$
$$-3m_0 < A_t,\ A_b < 3m_0$$
$$1 < \tan\beta < 60$$

χ can be bino-, wino-, or higgsino-like

The neutralino mass is arbitrary



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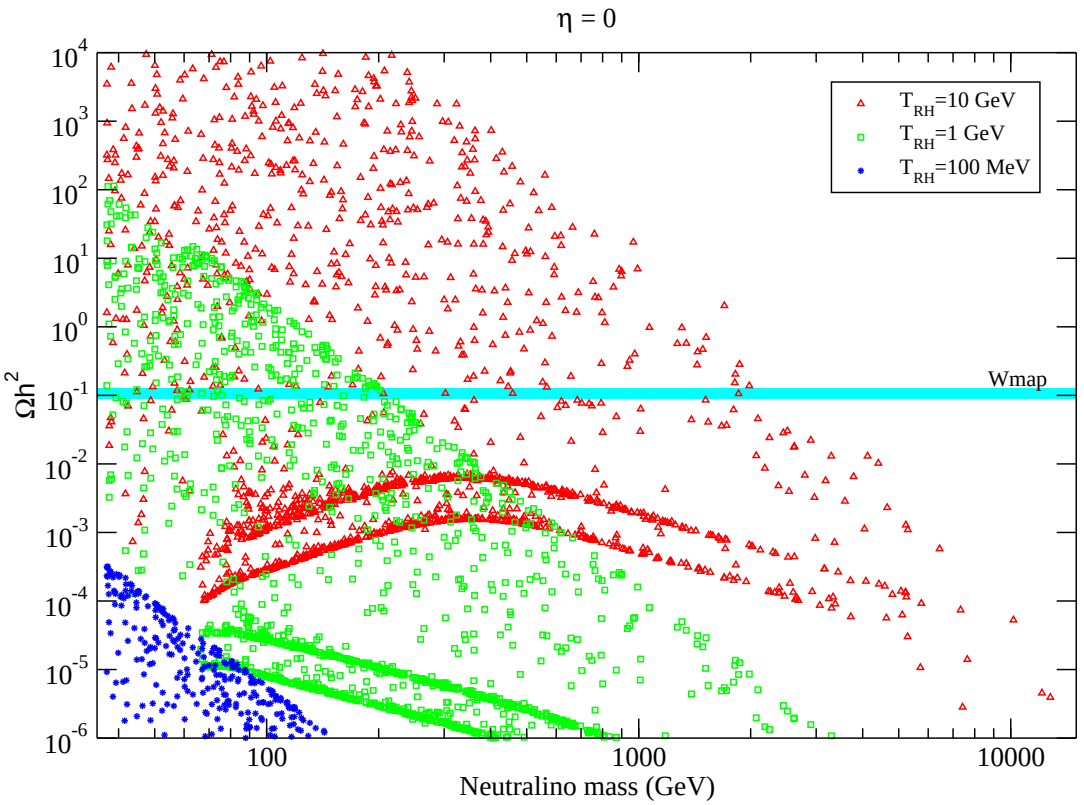
If neutralinos are produced thermally ($\eta = 0$) T_{RH} should be larger than 100 MeV

Ω_χ steeply decreases with T_{RH}

Winos and higgsinos have a too small relic density

For $T_{RH} = 1\,\mathrm{GeV}$ only light binos are viable



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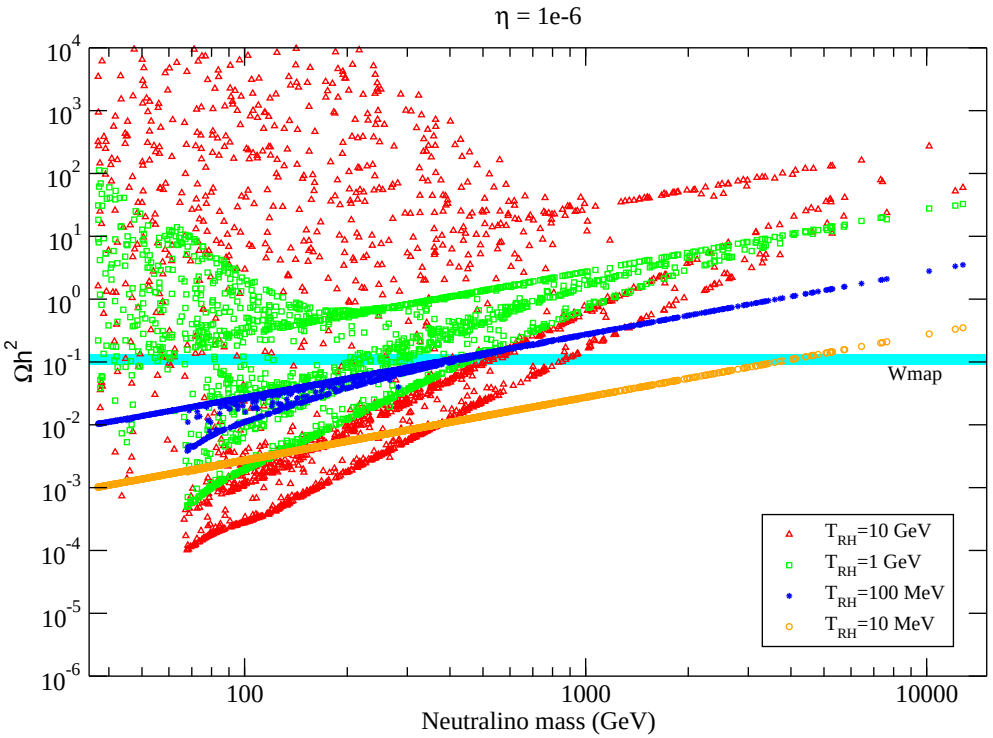
Reheating temperatures between 10 GeV and 10 MeV are allowed for $\eta = 10^{-6}$

$\eta \neq 0$ has a huge impact on Ω_χ

Neutralino production is non-thermal at low T_{RH}

Light winos and higgsinos are viable



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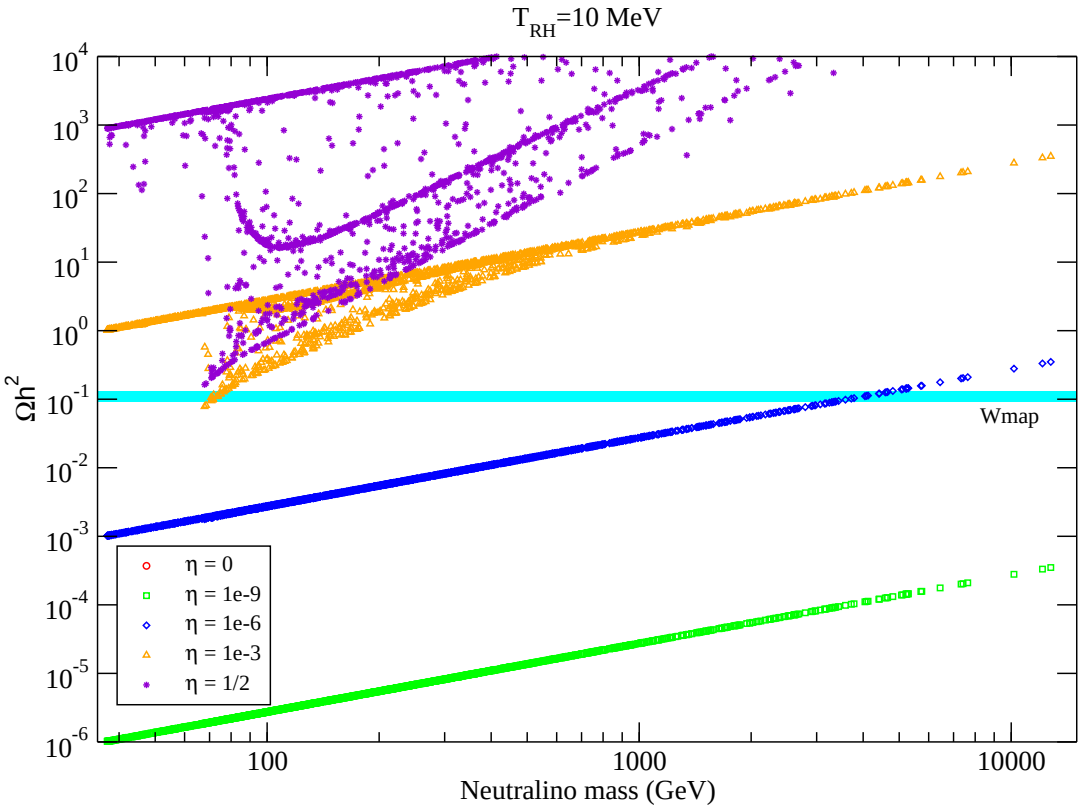
At $T_{RH} = 10$ MeV neutralino production is dominantly non-thermal

$\Omega_\chi \propto \eta m_\chi$ for small η

χ annihilations become relevant at large η

η between 10^{-6} and 10^{-3} is required



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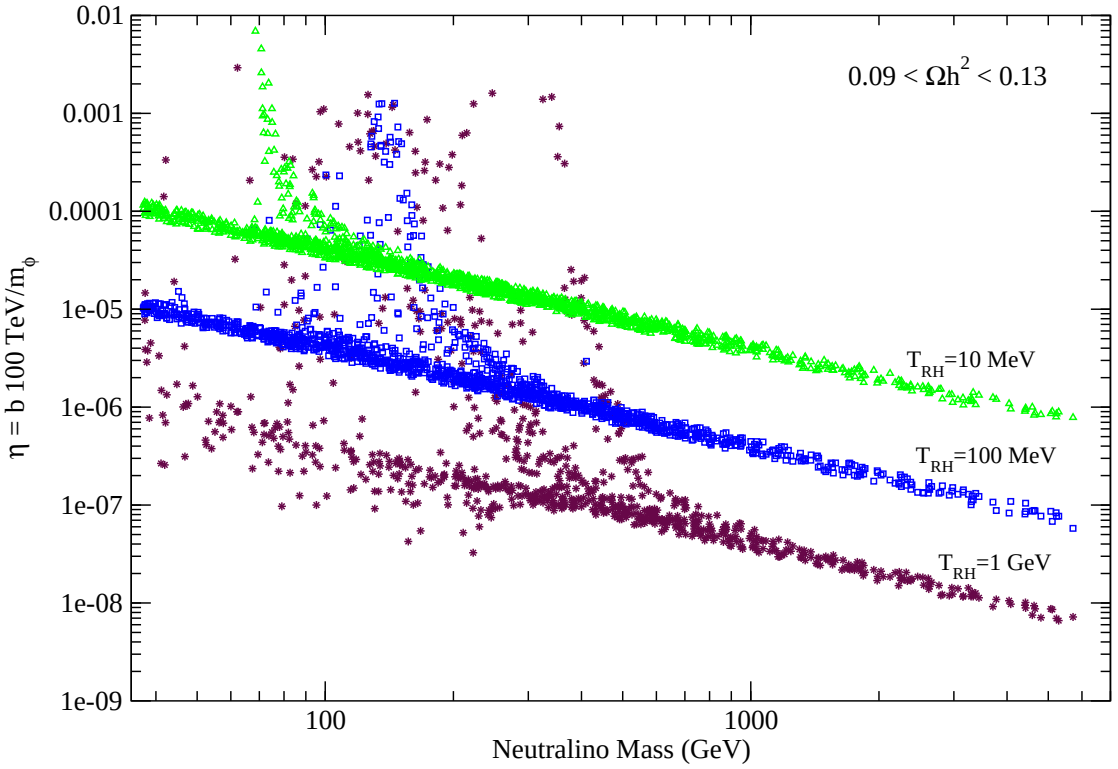
It is always possible to choose T_{RH} and η such that $\Omega_\chi = \Omega_{DM}$

η between 10^{-2} and 10^{-8} is needed

The required T_{RH} and η are not unique

The susy spectrum is unconstrained



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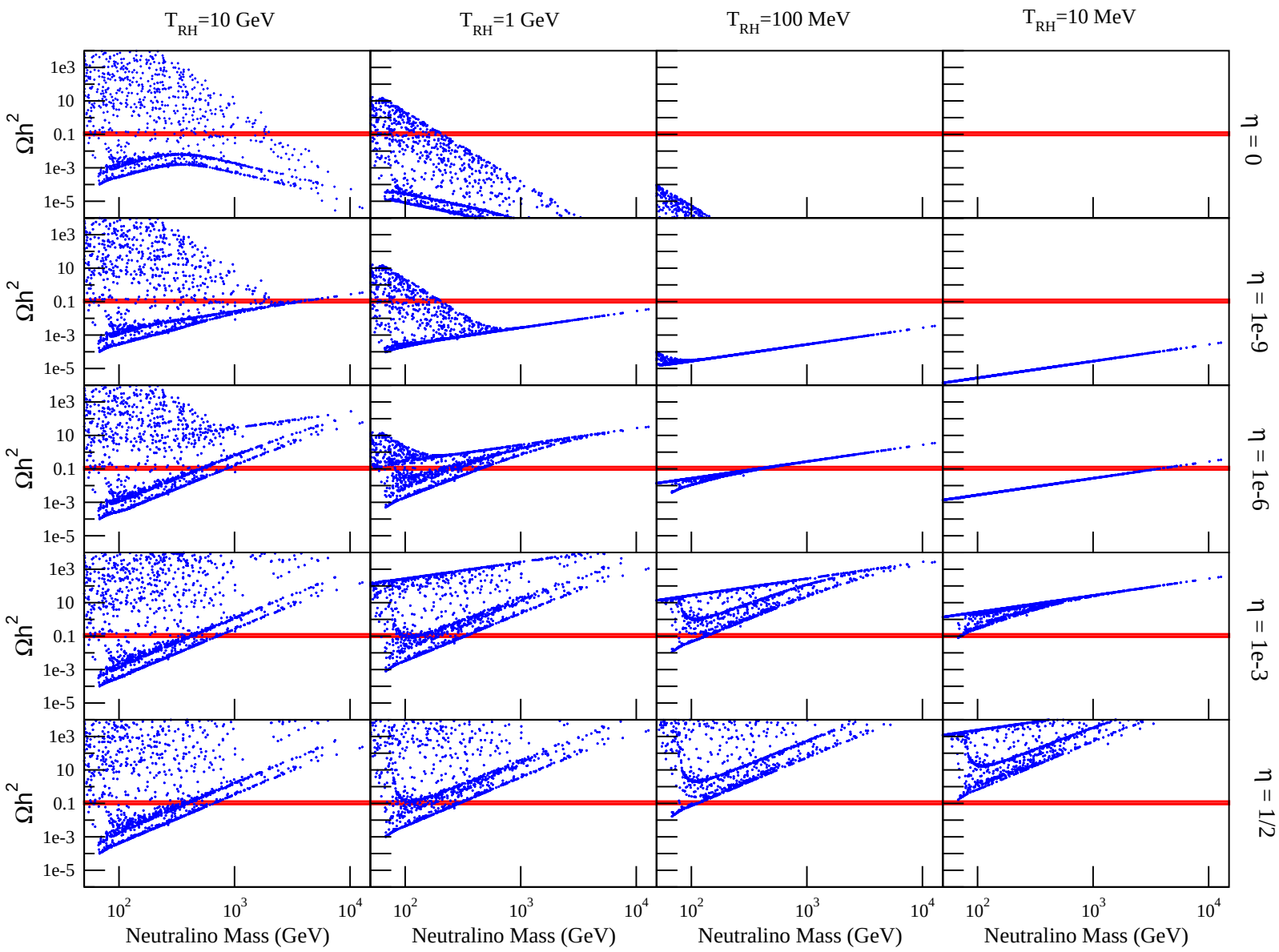
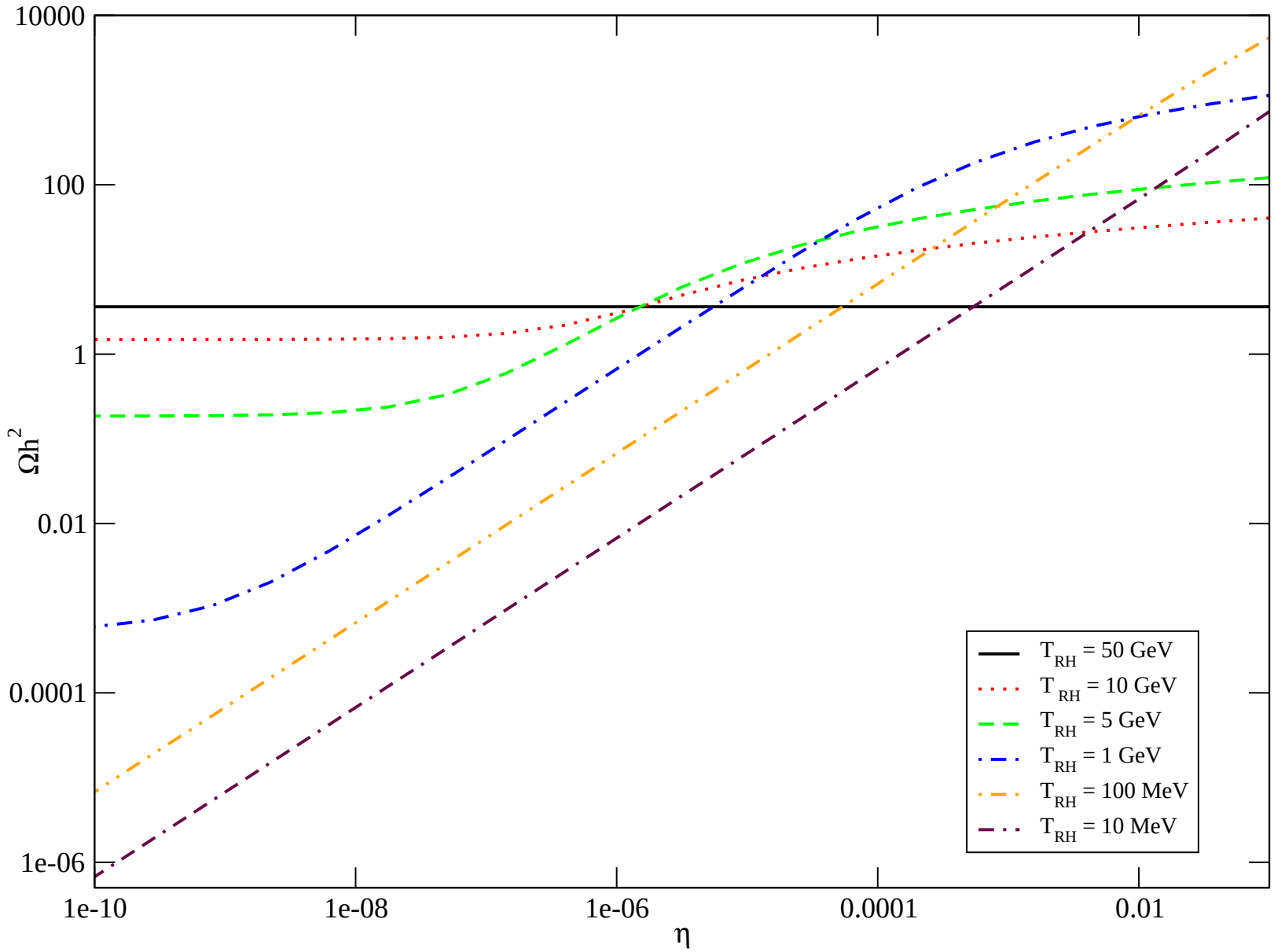
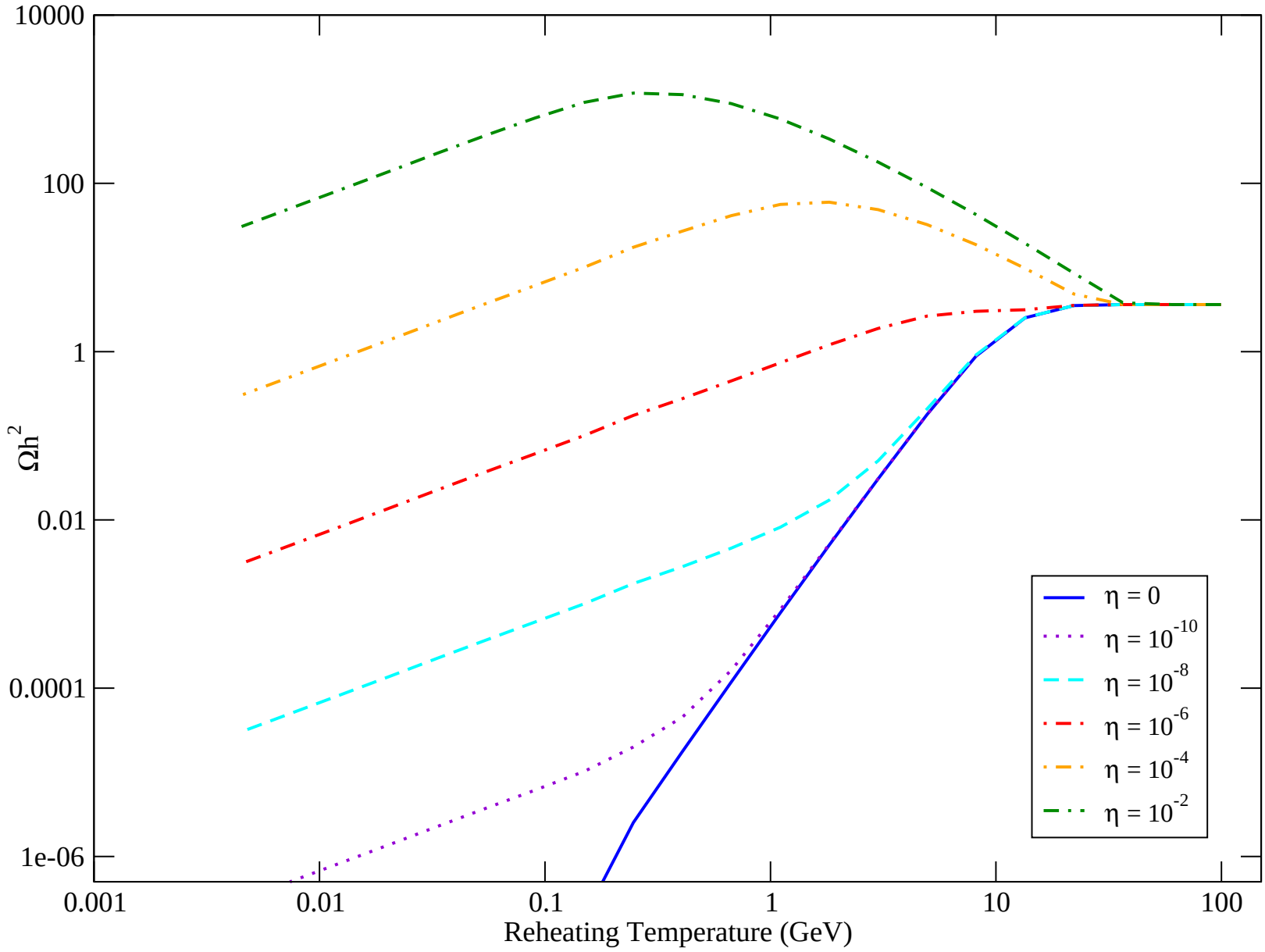

T_RH=10 GeV
T_RH=1 GeV
T_RH=100 MeV
T_RH=10 MeV
η = 0
η = 1e-9
η = 1e-6
η = 1e-3
η = 1/2
Ωh^2
1e3
10
0.1
1e-3
1e-5
10^2
10^3
10^4
Neutralino Mass (GeV)


10000
100
1
0.01
0.0001
1e-06
Ωh2
1e-10
1e-08
1e-06
0.0001
0.01
η
T RH = 50 GeV
T RH = 10 GeV
T RH = 5 GeV
T RH = 1 GeV
T RH = 100 MeV
T RH = 10 MeV


10000
100
1
0.01
0.0001
1e-06
Ωh^2
0.001
0.01
0.1
1
10
100
Reheating Temperature (GeV)
η = 0
η = 10^-10
η = 10^-8
η = 10^-6
η = 10^-4
η = 10^-2