Non-Universal Gaugino Masses and Natural Supersymmetry

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Outline

I. Little Hierarchy Problem.
II. What is Natural SUSY?
III. Results and Conclusions.

Little Hierarchy Problem

- In the MSSM, $M_Z = 91.2$ GeV is computed in terms of μ and m_{H_u} as

$$\frac{1}{2} M_Z^2 \simeq -\mu^2 - m_{H_u}^2$$

- Fine tuning required to get the right M_Z unless

$$\mu^2 \sim M_{H_u}^2 \sim M_Z^2/2$$

- Little Hierarchy Problem:

How do multi-TeV SUSY model parameters conspire to yield $M_Z = 91.2$ GeV.

What is Natural SUSY?

"Natural SUSY seeks to solve the Little Hierarchy Problem by proposing a light third generation spectrum with the first and second generation in the several to multi-TeV range"

Fine Tuning parameters

- We employ two parameters that are a measure of fine tuning at the weak and GUT scale [1].

$$\Delta_{\rm EW} \equiv \max(C_i)/(M_Z^2/2)$$

$$\Delta_{\rm HS} \equiv \max(B_i)/(M_Z^2/2)$$

- C_i and B_i parametrize each term in the following equation at the EW and HS

$$\frac{M_Z^2}{2} = \frac{(m_{H_d}^2 + \Sigma_d^d) - (m_{H_u}^2 + \Sigma_u^u)\tan^2\beta}{\tan^2\beta - 1} - \mu^2$$

[1] H. Baer *et al.* , arXiv:1210.3019 [hep-ph].

Ameliorating the LHP

- A 125 GeV Higgs requires stop quark mass to be around a TeV.
- A heavy stop quark significantly affects the values of m_{H_u} and pushes it to be order TeV thereby worsening the LHP.
- Heavy stop quark contribution to m_{H_u} can be canceled by non-Universal gaugino masses and ameliorate the little hierarchy problem.

$$m_{H_u}^2 \approx -2.67 M_3^2 + 0.2 M_2^2 - 0.091 m_0^2 - 0.1 A_{t_0}^2 - 0.22 M_3 M_2 + \ldots$$

[2] I. Gogoladze, M. U. Rehman and Q. Shafi, Phys. Rev. D **80**, 105002 (2009).

- We will show that the LHP can be largely solved by embedding the MSSM in the 4-2-2 model.

$$M_1 = \frac{2}{5} M_3 + \frac{3}{5} M_2, .$$

- We have performed random scans for the following range of the parameter space of 4-2-2:

$$\begin{aligned} 0 \leq m_0 = m_{H_u} = m_{H_d} &\leq 20\,\mathrm{TeV} \\ 0 \leq M_3 &\leq 5\,\mathrm{TeV} \\ 0 \leq M_2 &\leq 5\,\mathrm{TeV} \\ 2 \leq \tan\beta &\leq 60 \\ -3 \leq A_0/m_0 &\leq 3 \\ \mu &> 0 \end{aligned}$$

III. Results and Conclusions.

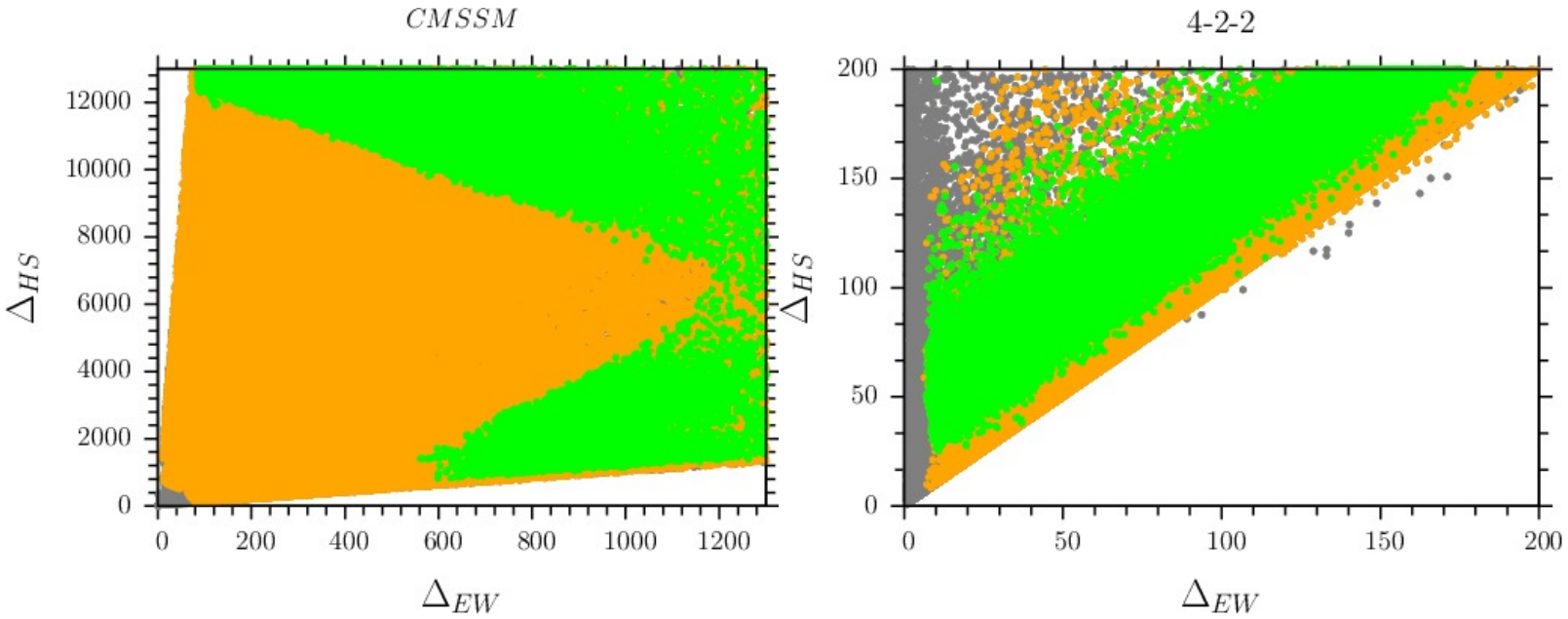
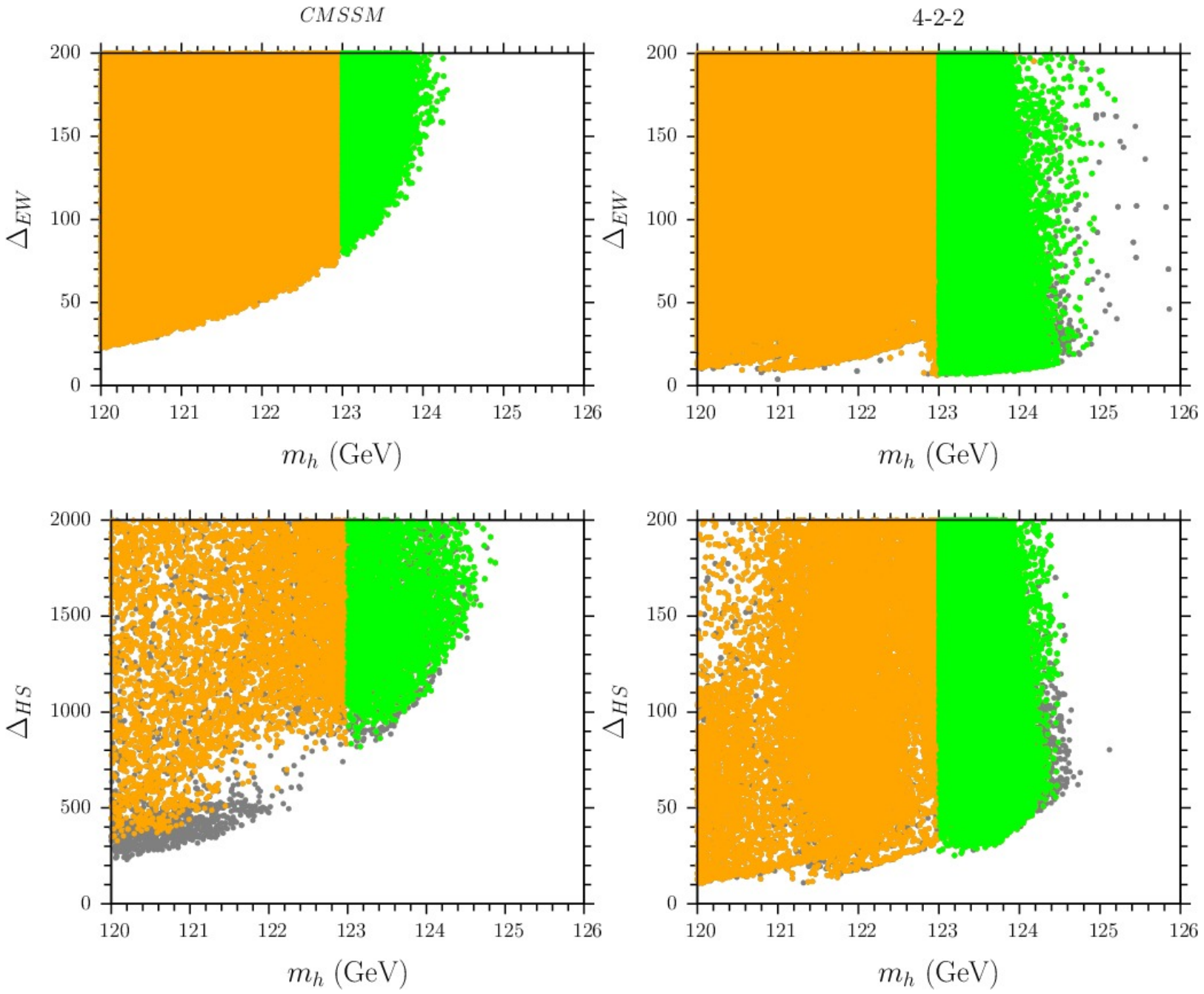


Figure: Plots in the $\Delta_{HS} - \Delta_{EW}$ planes for CMSSM and 4-2-2 cases. Gray points are consistent with REWSB and neutralino to be LSP. The orange points form a subset of the gray ones and satisfy all the constraints. Green points belong to the subset of orange points and satisfy the Higgs mass range $123\,\mathrm{GeV} \leq m_h \leq 127\,\mathrm{GeV}$.


CMSSM
4-2-2
Δ_{EW}
Δ_{HS}
m_h (GeV)
0
50
100
150
200
500
1000
1500
2000
120
121
122
123
124
125
126

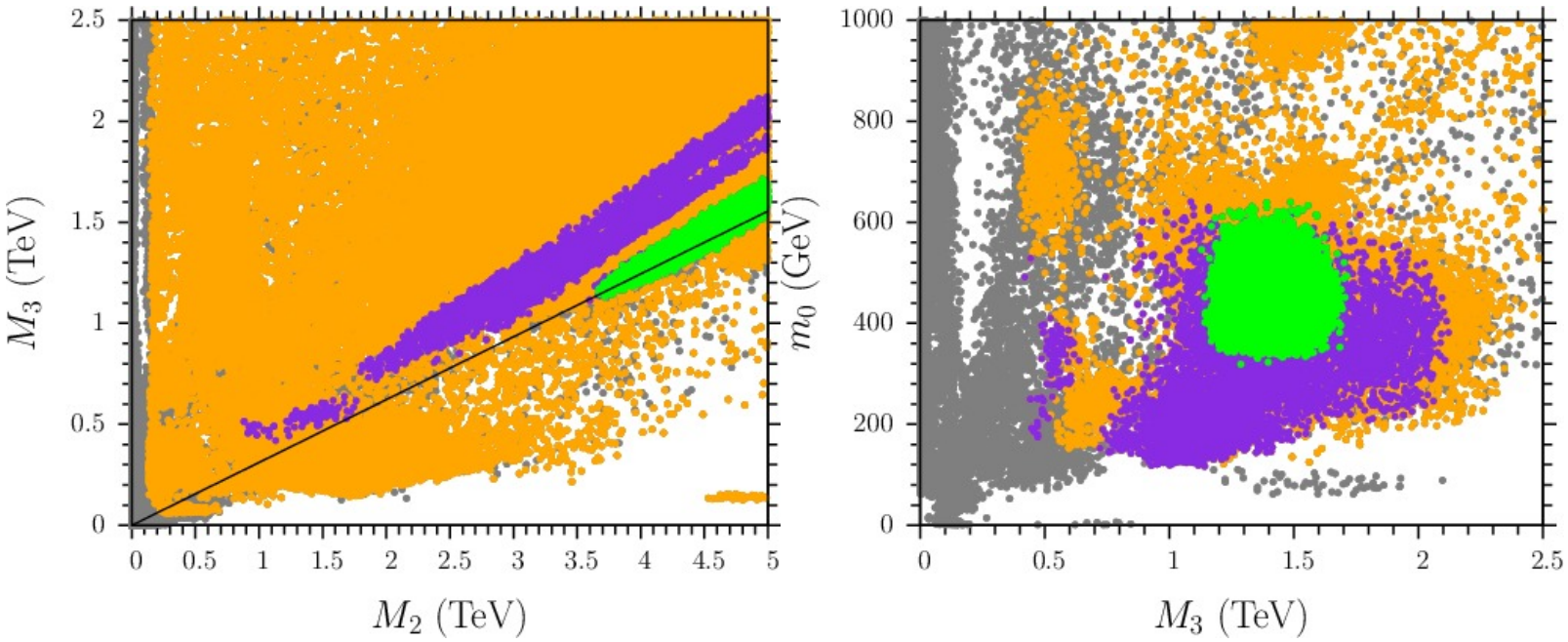
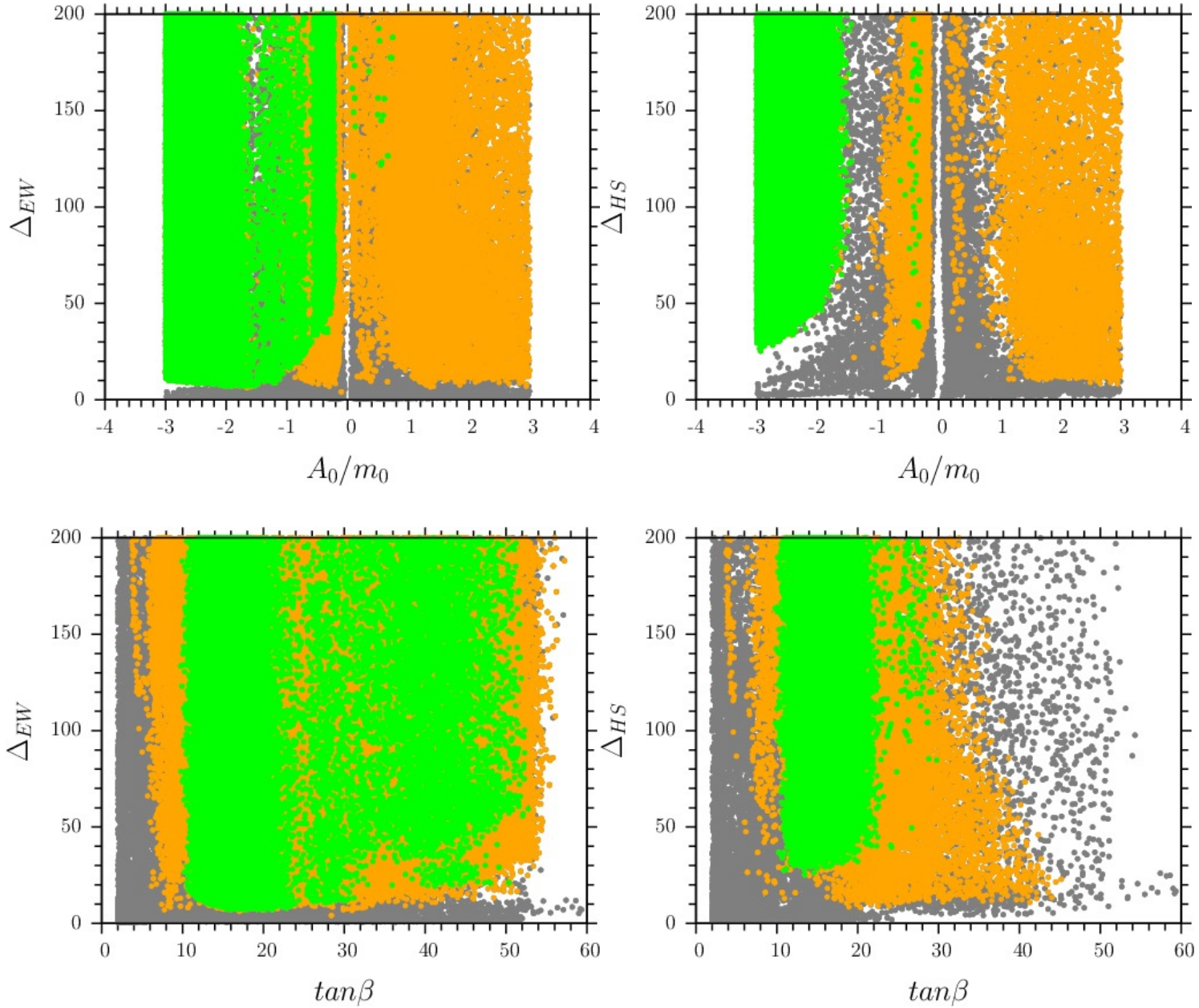


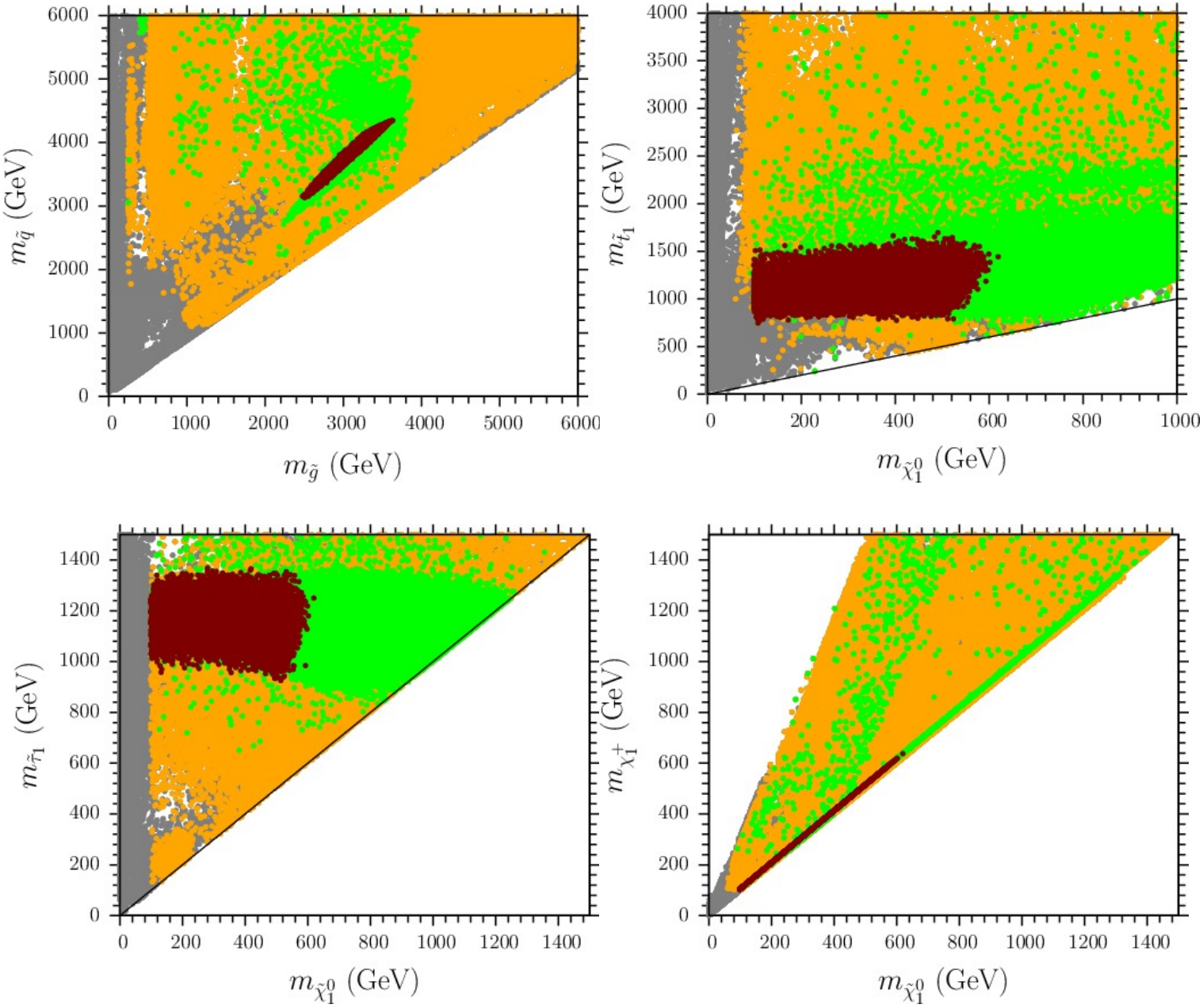
Figure: Purple points are subset of orange points with $\Delta_{EW} \leq 100$ and $\Delta_{HS} \leq 100$. Green points belong to a subset of purple points with the Higgs mass range $123\,\mathrm{GeV} \leq m_h \leq 127\,\mathrm{GeV}$.

$$m_{H_u}^2 \approx -2.67M_3^2 + 0.2M_2^2 - 0.091m_0^2 - 0.1A_{t_0}^2 - 0.22M_3M_2 + \ldots$$

$$m_{Q_t}^2 \approx 5.41M_3^2 + 0.392M_2^2 + 0.64m_0^2 + 0.115M_3A_{t_0} - 0.072M_3M_2 + \ldots$$



[3] I. Gogoladze, Q. Shafi and C. S. Un, JHEP **1208**, 028 (2012).



[4] N. Arkani-Hamed *et al.* , Nucl. Phys. B **741**, 108 (2006).

Conclusions

- By imposing conditions for natural SUSY ($\Delta_{EW} < 100$ and $\Delta_{HS} < 100$) and requiring 123 GeV $< m_h <$ 127 GeV, we obtain a distinctive particle spectra characterized by relatively light third generation sfermions.

- We found the following range of sparticle masses third generation stops and staus

$$700\mathrm{GeV} < \mathrm{m}_{\tilde{\mathrm{t}}_1} < 1500\,\mathrm{GeV}$$
$$900\mathrm{GeV} < \mathrm{m}_{\tilde{\tau}_1} < 1300\mathrm{GeV}$$

Thanks