Implications of 125 GeV Higgs for LHC SUSY and Dark Matter searches

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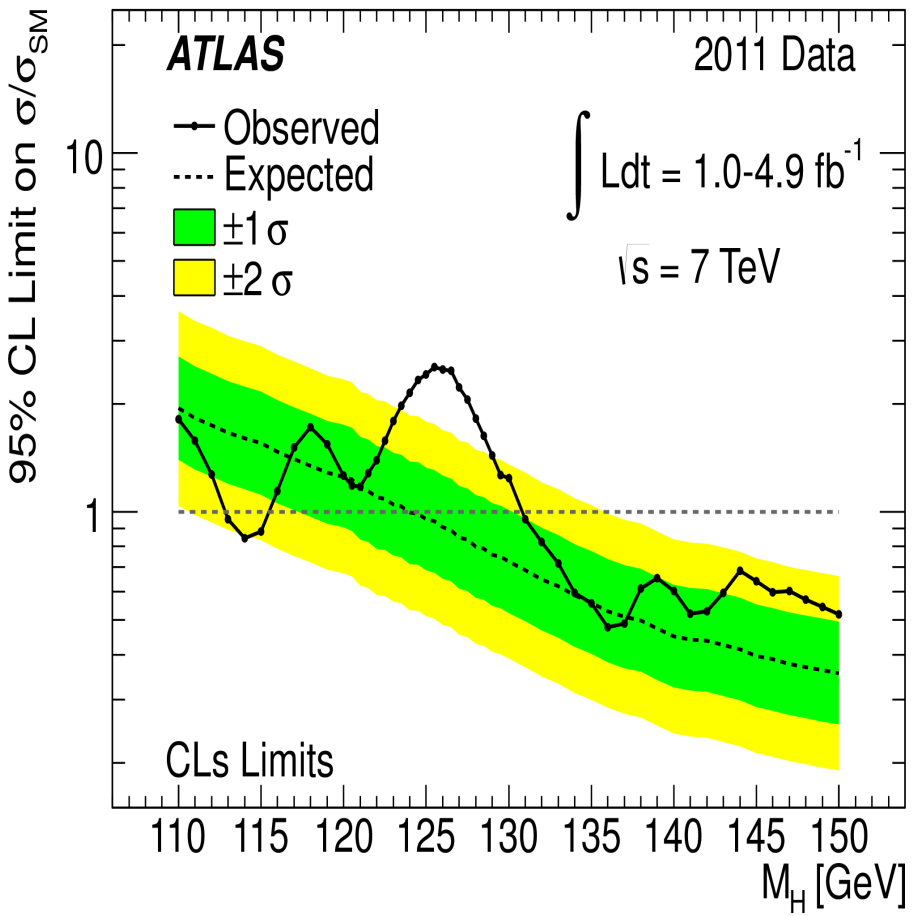
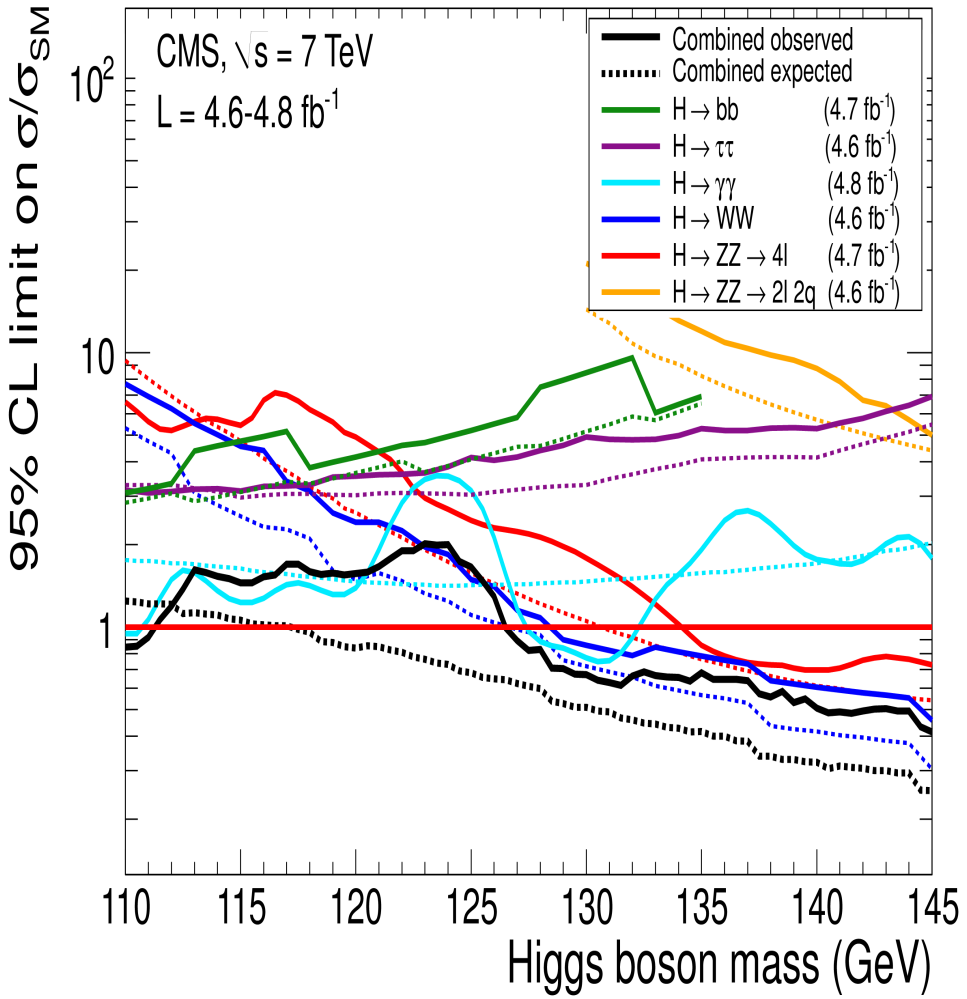
H.Baer, V.Barger, P.Huang, A.M. arXiv: 1109.3907, 1112.3017, 1202.4038

LHC Higgs Searches





Both ATLAS and CMS observed broad excess in H→WW and localized excess in H→γγ and H→ZZ→4l at ~125 GeV

Higgs in MSSM

- Two Higgs doublets ⟹ 5 Higgs bosons: $h, H, A, H^{\pm}$
- Lighter CP-even Higgs *h* is (usually) SM-like with mass

$$m_h^2 \simeq m_Z^2 \cos^2 2\beta + \frac{3m_t^4}{4\pi^2 v^2}\left(\log\left(\frac{M_{SUSY}^2}{m_t^2}\right) + \frac{X_t^2}{M_{SUSY}^2}\left(1 - \frac{X_t^2}{12M_{SUSY}^2}\right)\right)$$

$$X_t = A_t - \mu/\tan\beta$$

- *h* mass is maximized when
  - A decouples $m_A \gtrsim 250\,GeV$
  - large $\tan\beta \gtrsim 10$
  - heavy stops $m_{\tilde{t}} \sim O(TeV)$
  - large stop trilinear $A_t \simeq \sqrt{6} M_{SUSY}$

Higgs in MSSM

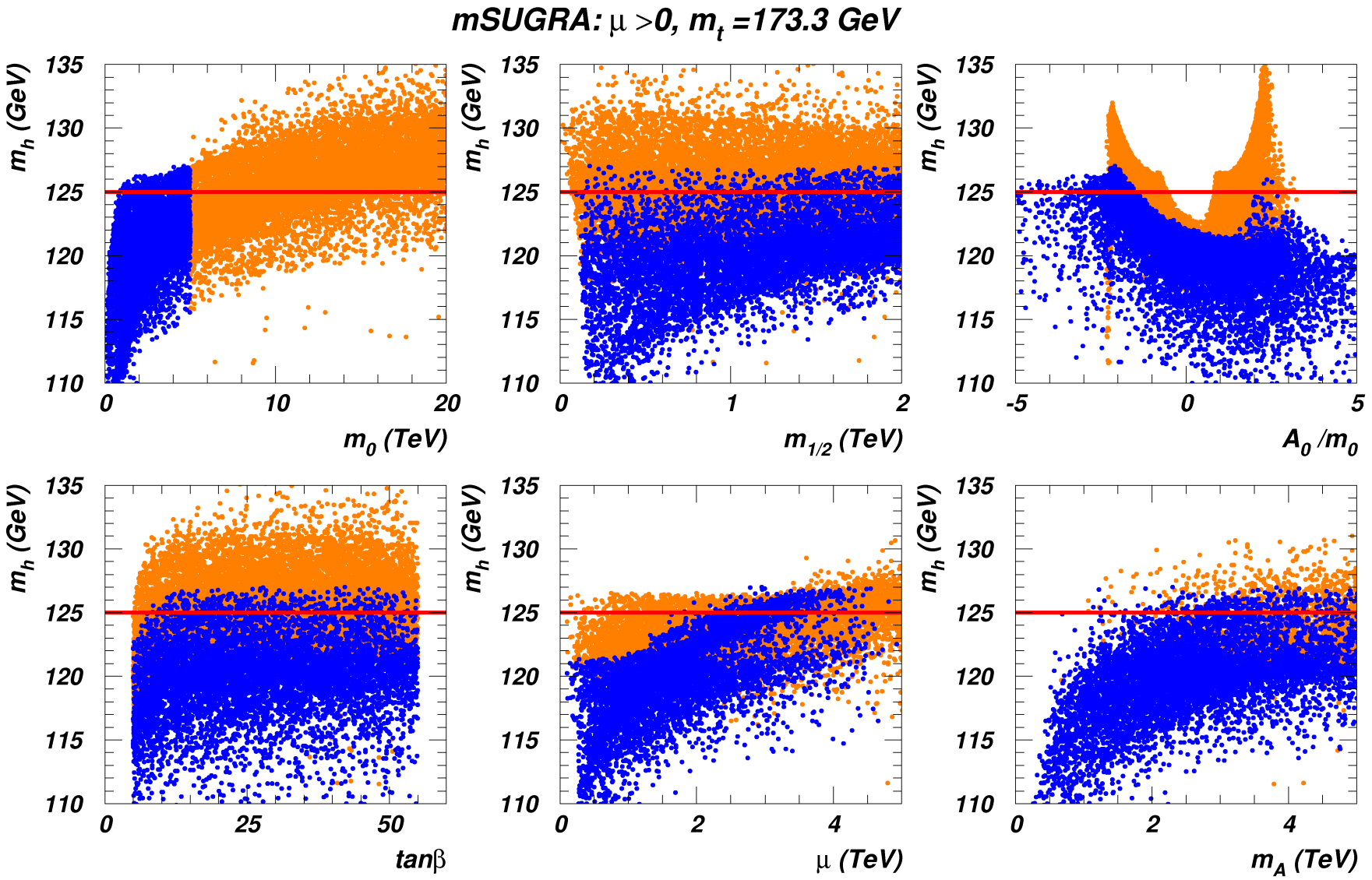
- MSSM is well motivated minimal SUSY framework currently being tested, but it has more than 100 free parameters

  ⇒ intractable phenomenology

- Most studies and experimental searches assume high-scale SSB inputs: mSUGRA, NUHM, mAMSB, mGMSB, ...

- Many recent studies of Higgs signal implications: Djouadi et al; Carena, Gori, Shah, Wagner; Feng et al; Ellis, Olive et al; Nath et al; Gogoladze, Shafi, Un; ...

Random scan in mSUGRA para space



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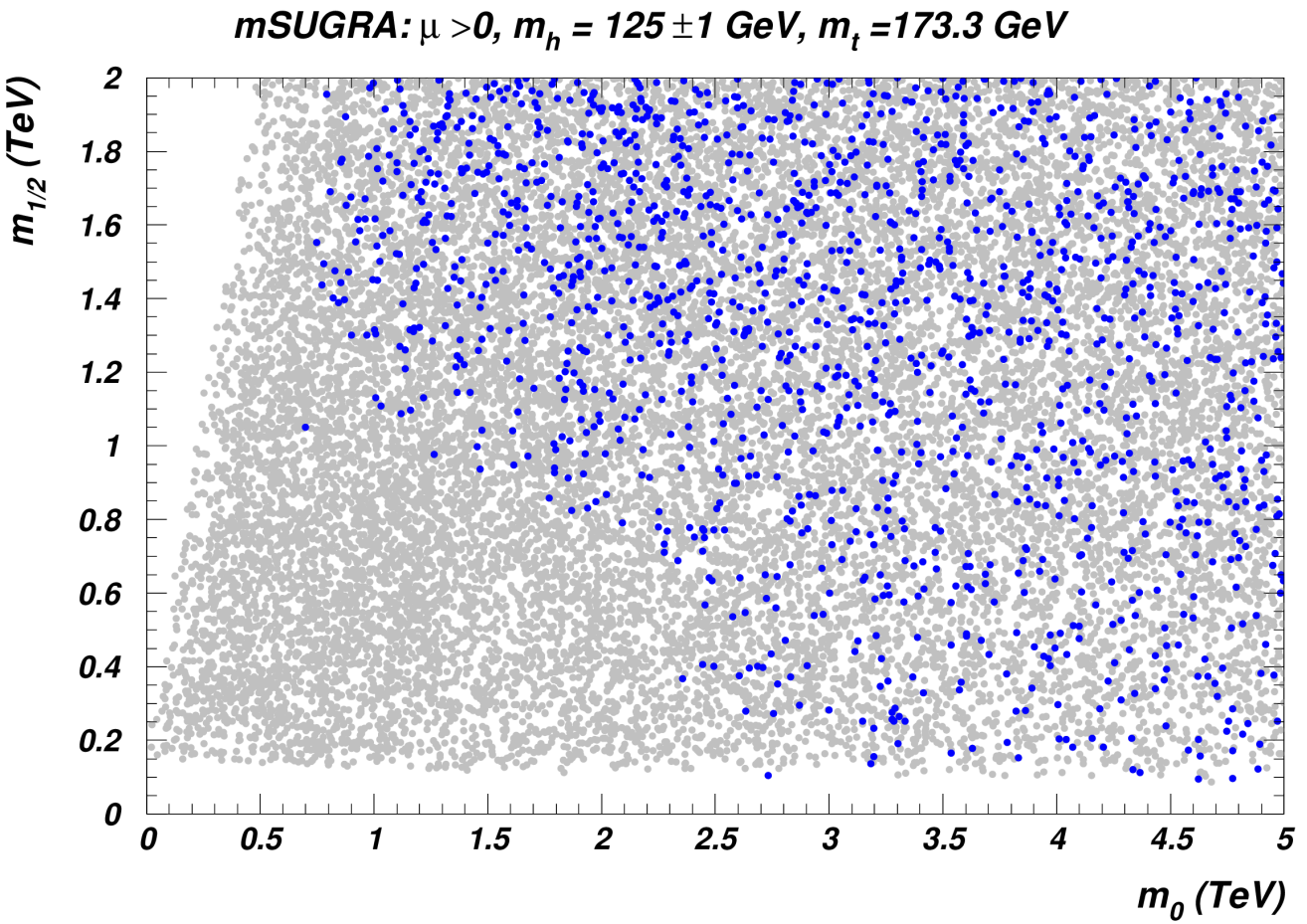


More restrictive than direct SUSY searches which mhf < 0.5 TeV

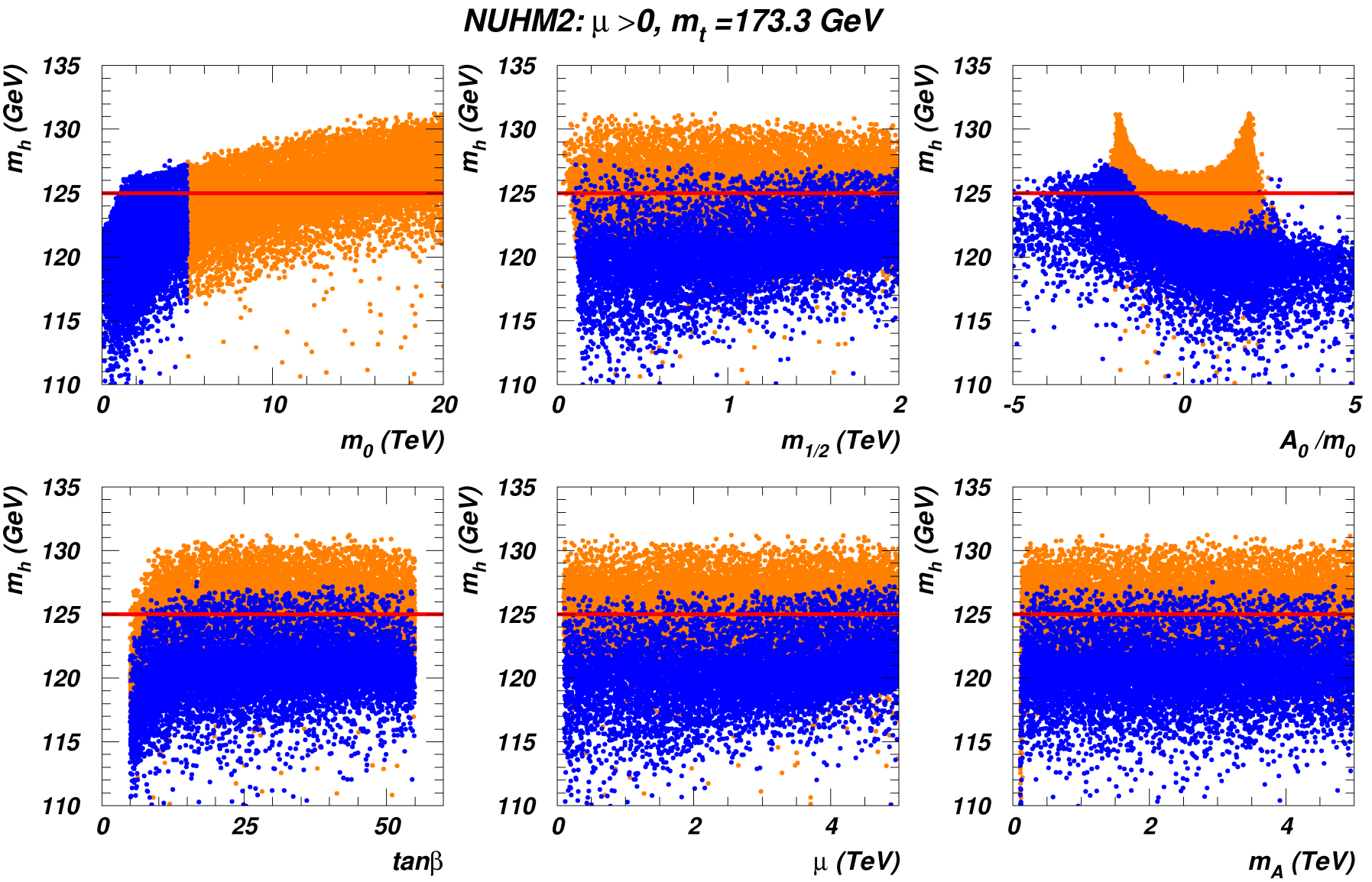
NUHM model

- Parameter space:

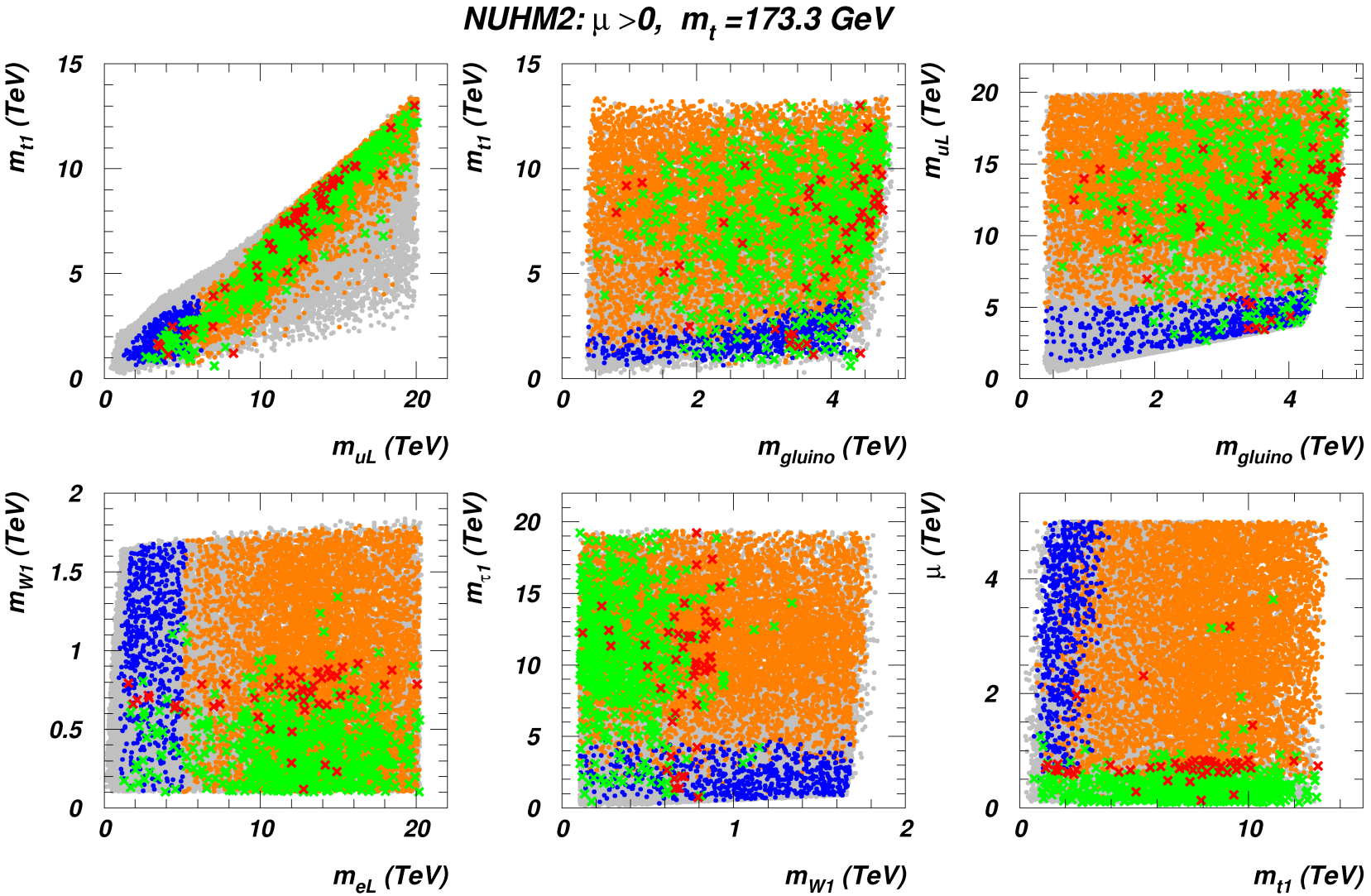
$$m_0,\ m_{H_u},\ m_{H_d},\ m_{1/2},\ \tan\beta,\ sgn(\mu)$$

- GUT-scale inputs $m^2_{H_u}, m^2_{H_d}$ can be traded for $\mu,\ m_A$
- Motivated by SU(5) and SO(10) grand-unified theories where higgses reside in separate multiplet(s)

Random scan in NUHM2 para space



NUHM2 mass spectrum at mh=125GeV



NUHM2 mass spectrum

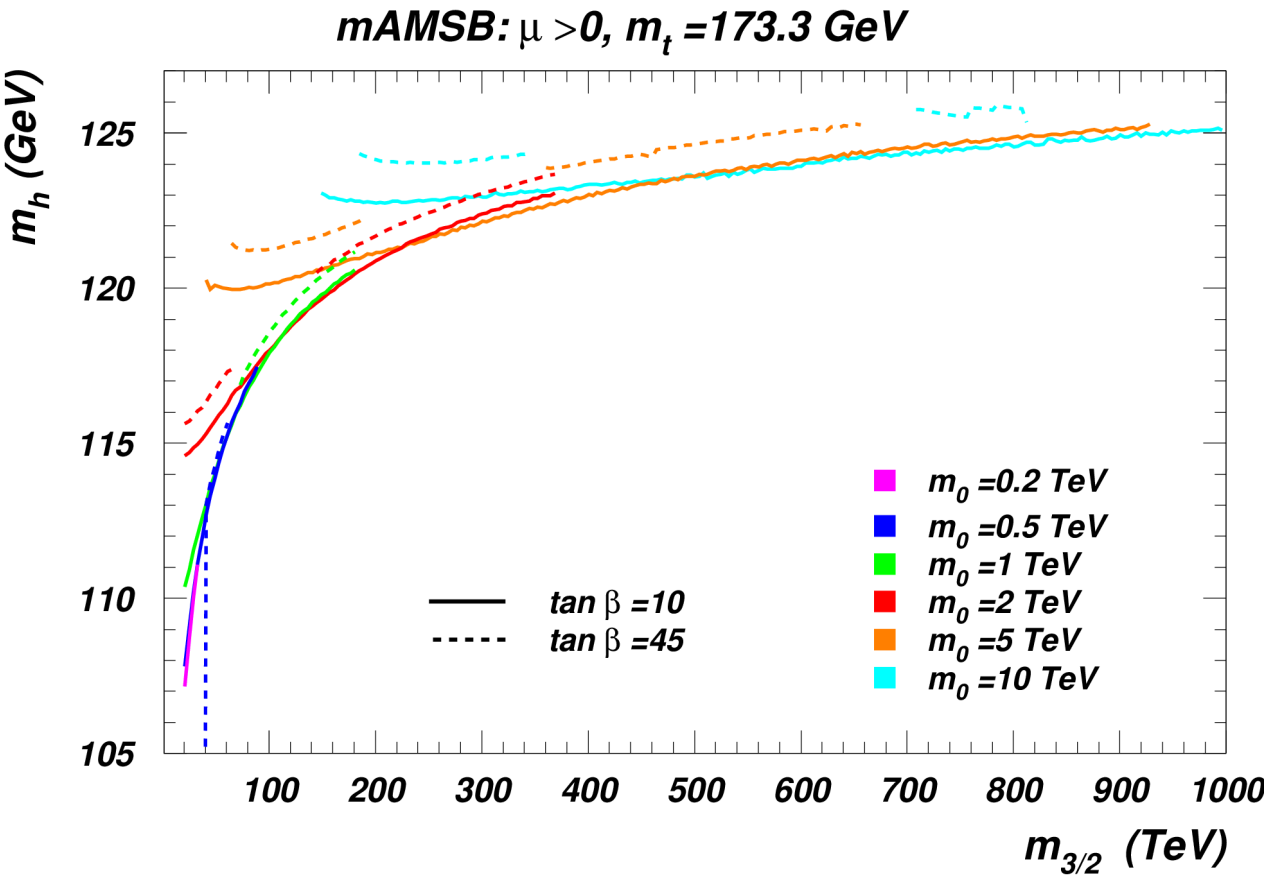
- Squarks are heavy >2 TeV, but light stop <1 TeV possible
- Possible stop pair production at LHC
- Multi-TeV squarks, few-TeV stop and sub-TeV gluino:
  gluino pair production with dominant $\tilde{g} \to t\bar{t}\widetilde{Z}_i$
  $\Rightarrow$ signal in 4t+MET
- Sleptons are >1TeV, but stau <1 TeV are allowed
- Low μ and light stops are possible $\Rightarrow$ low fine-tuning

Higgs in mAMSB

- Parameter space:

  $m_0,\ m_{3/2},\ \tan\beta,\ sgn(\mu)$

- 125 GeV Higgs possible for $m_{3/2} \gtrsim 500\,TeV$ with heavy spectrum: sleptons > 1.5 TeV, squarks > 7 TeV, gluino > 9 TeV

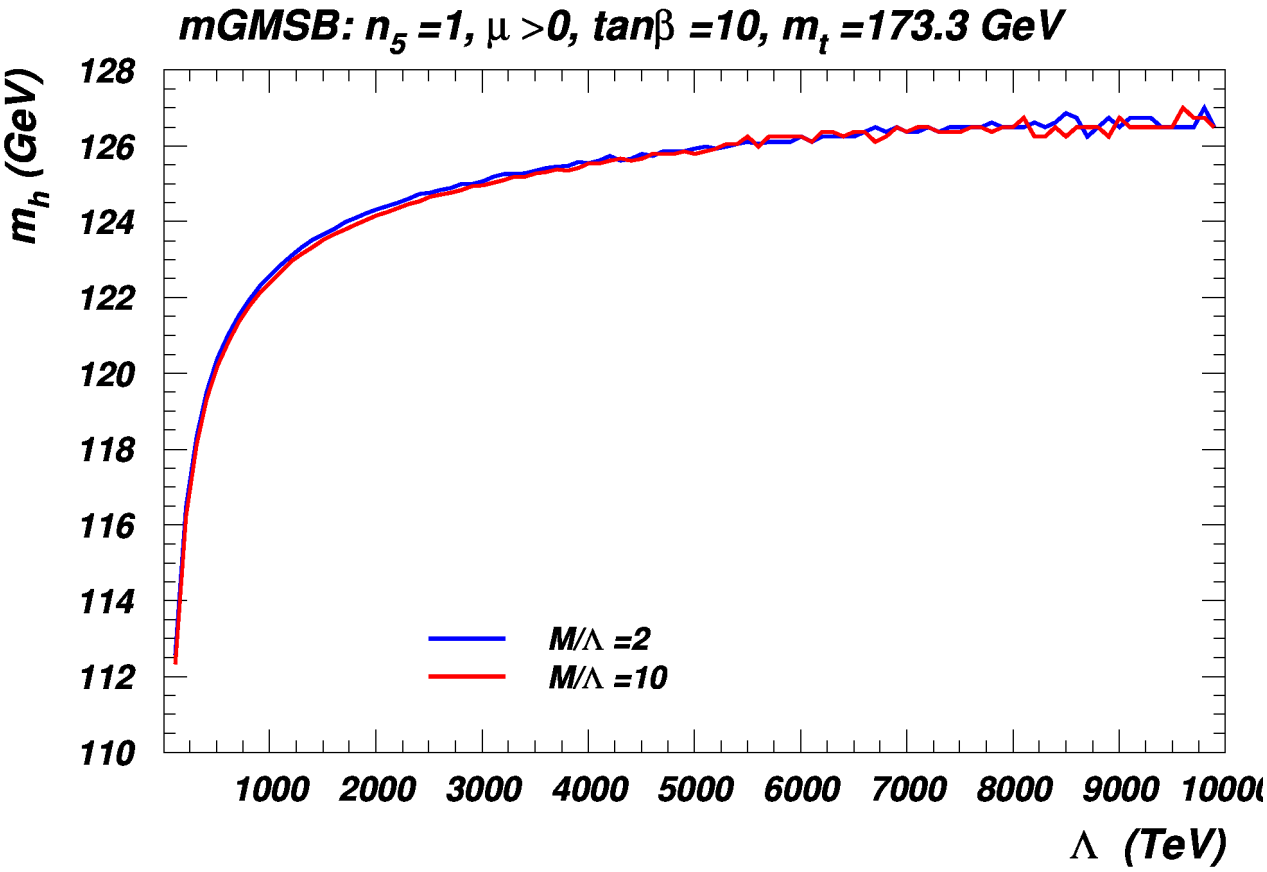


Higgs in mGMSB

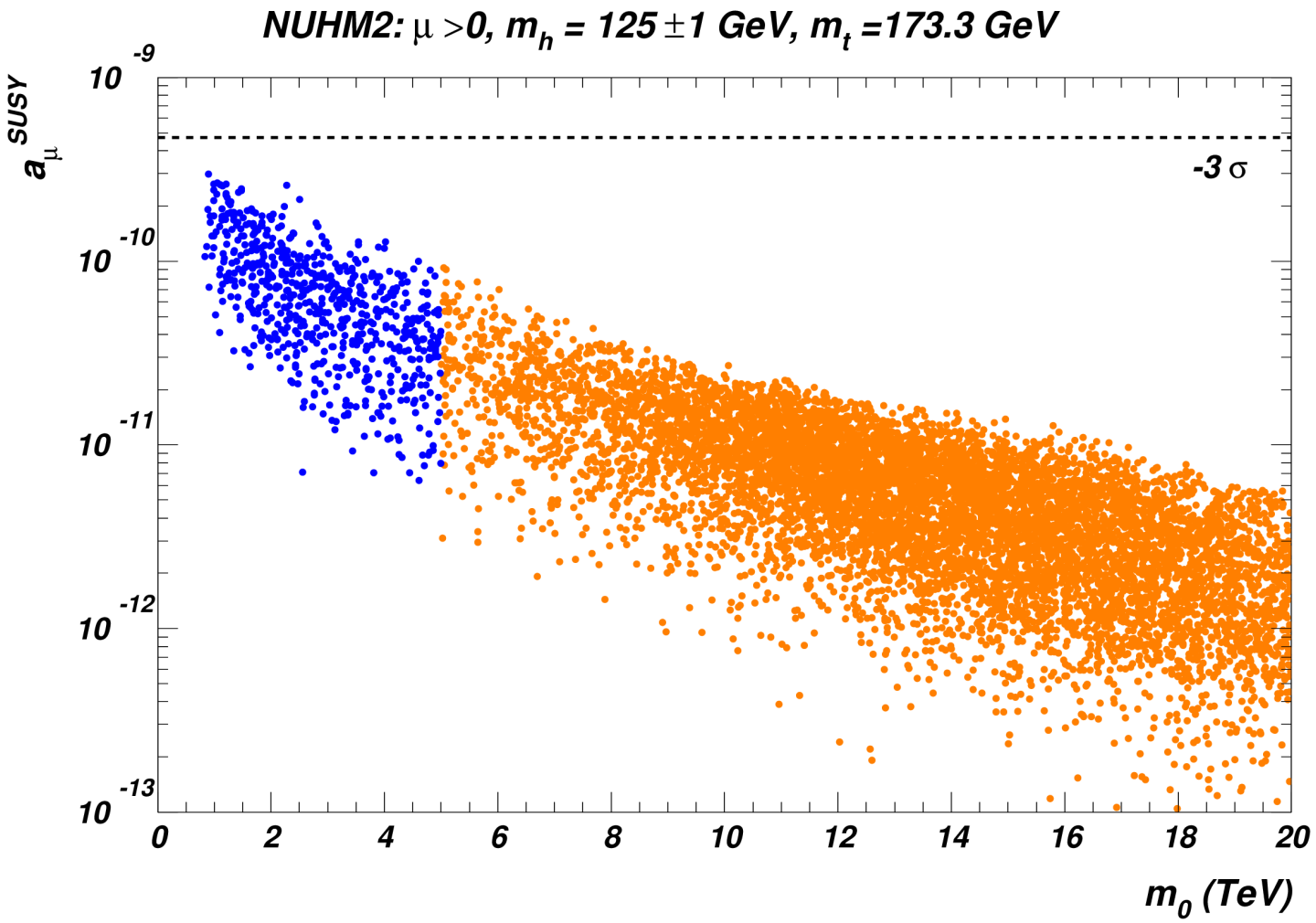
- Parameter space:
  $\Lambda,\ M,\ n_5,\ \tan\beta,\ sgn(\mu)$

- 125 GeV Higgs possible for $\Lambda \gtrsim 3000\,TeV$ with very heavy spectrum > 4.5 TeV

- See Q.Shafi et al arXiv: 1204.2856 for more details



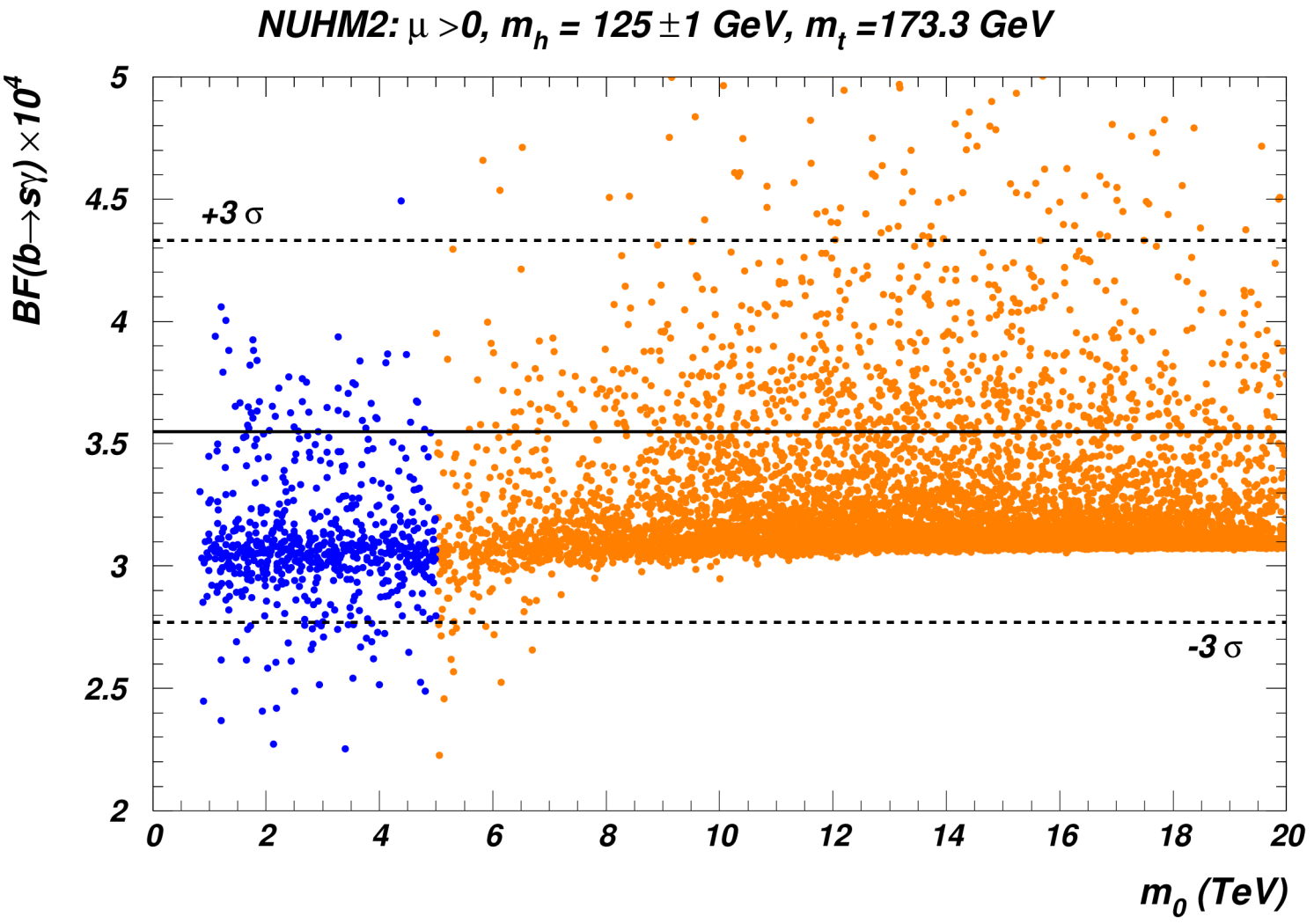
Muon magnetic moment



- m0 < 5 TeV
- m0 < 20 TeV

Muon magnetic moment is inconsitent with Higgs signal

$b \to s\gamma$



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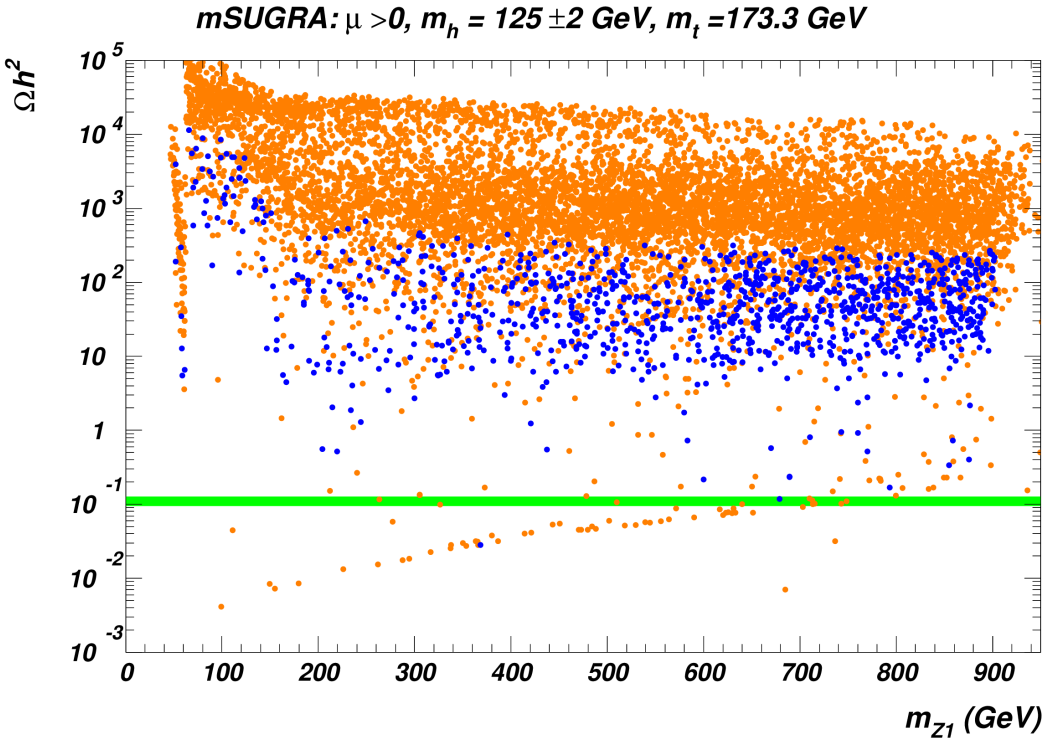
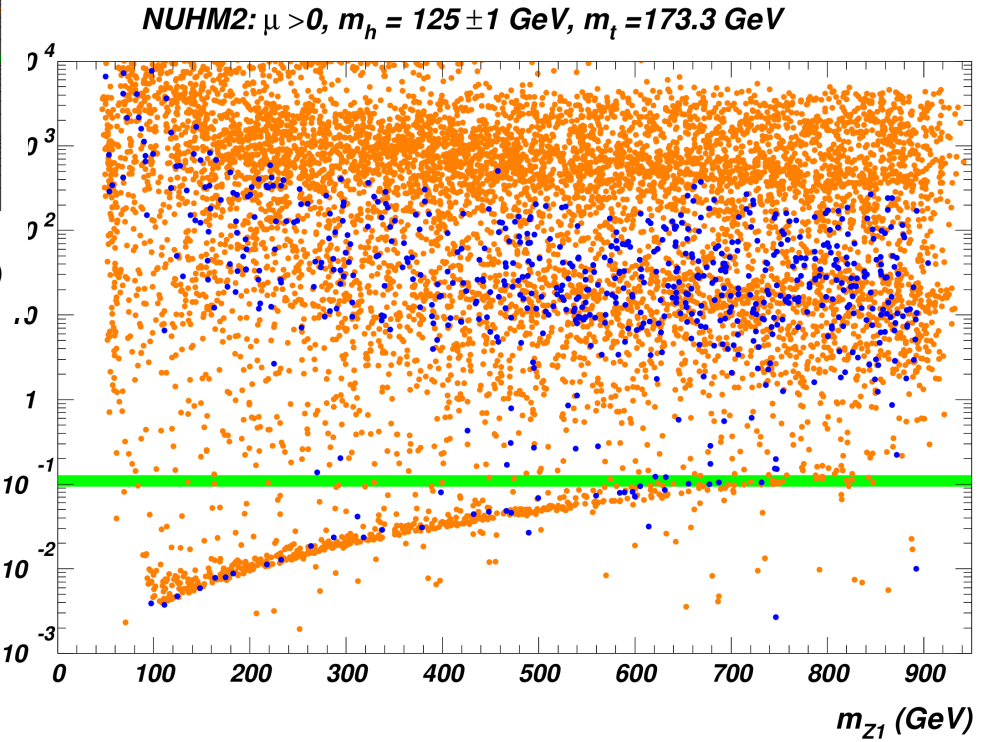
Neutralino Dark Matter density



$$\widetilde{Z_1} = N_1\widetilde{B} + N_2\widetilde{W} + N_3\widetilde{H}_u + N_4\widetilde{H}_d$$



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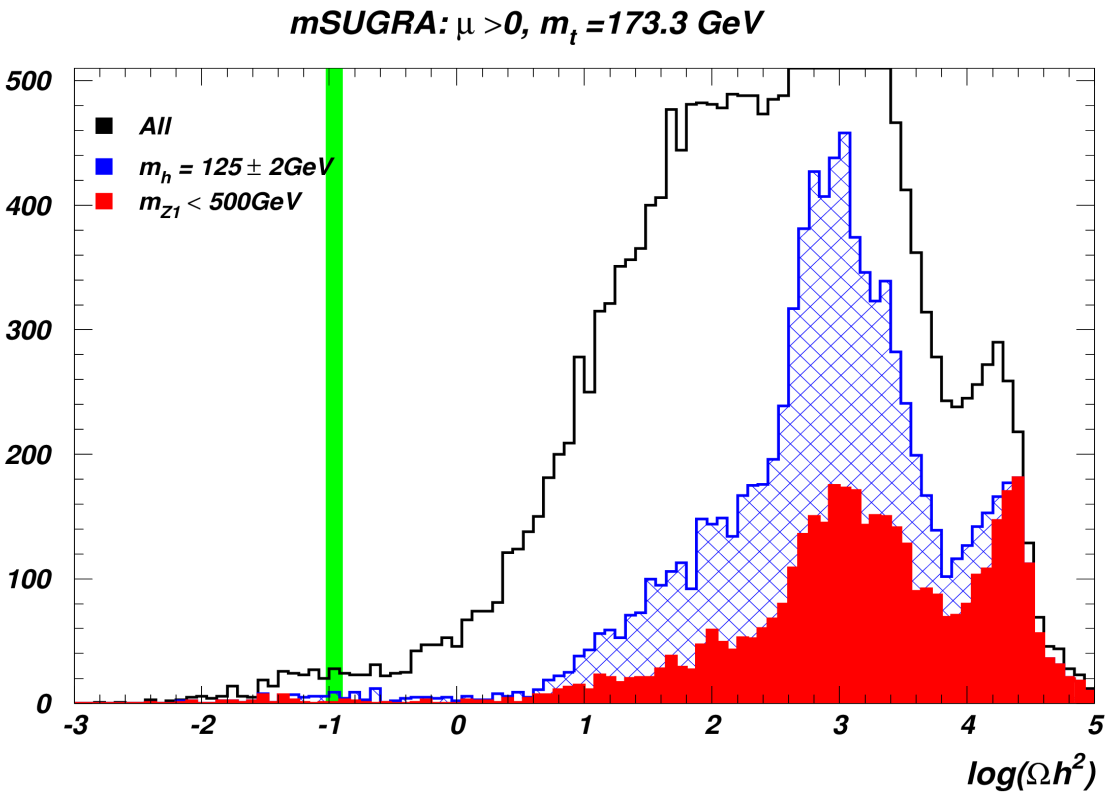
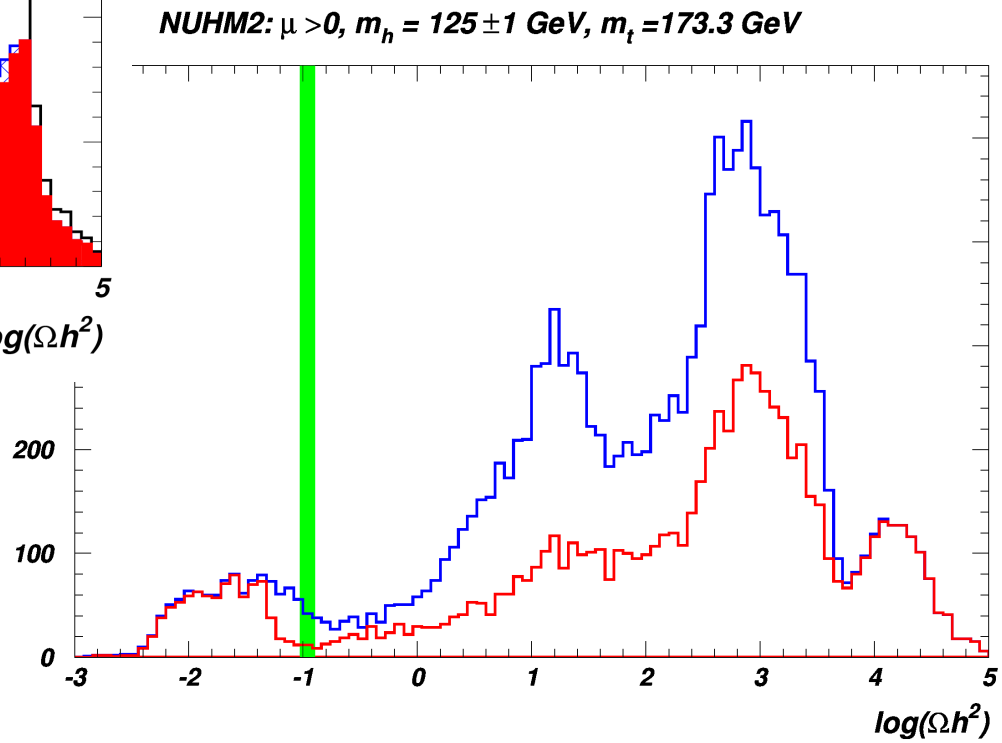
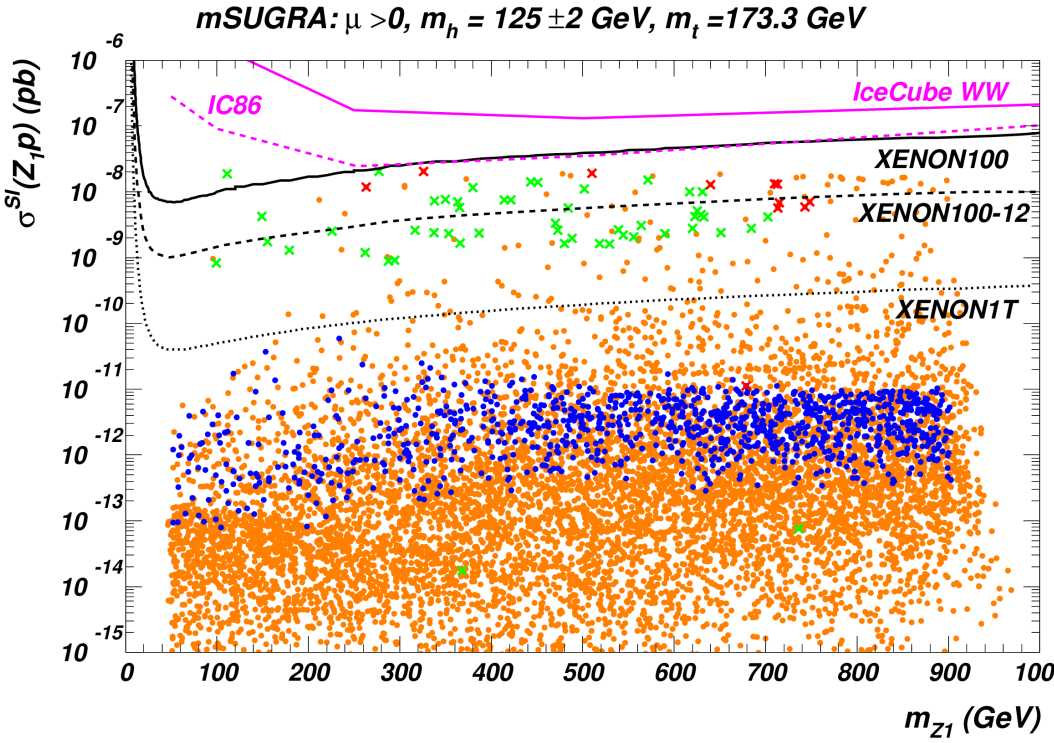
Neutralino RD in mSUGRA and NUHM2





Direct Detection of Neutralino DM



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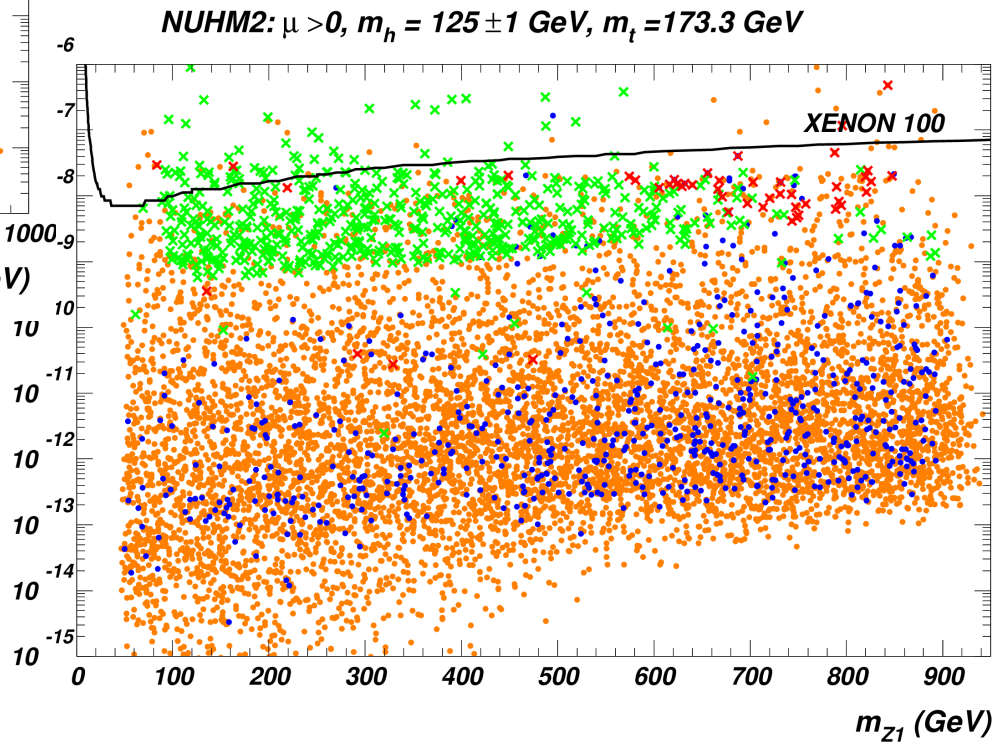
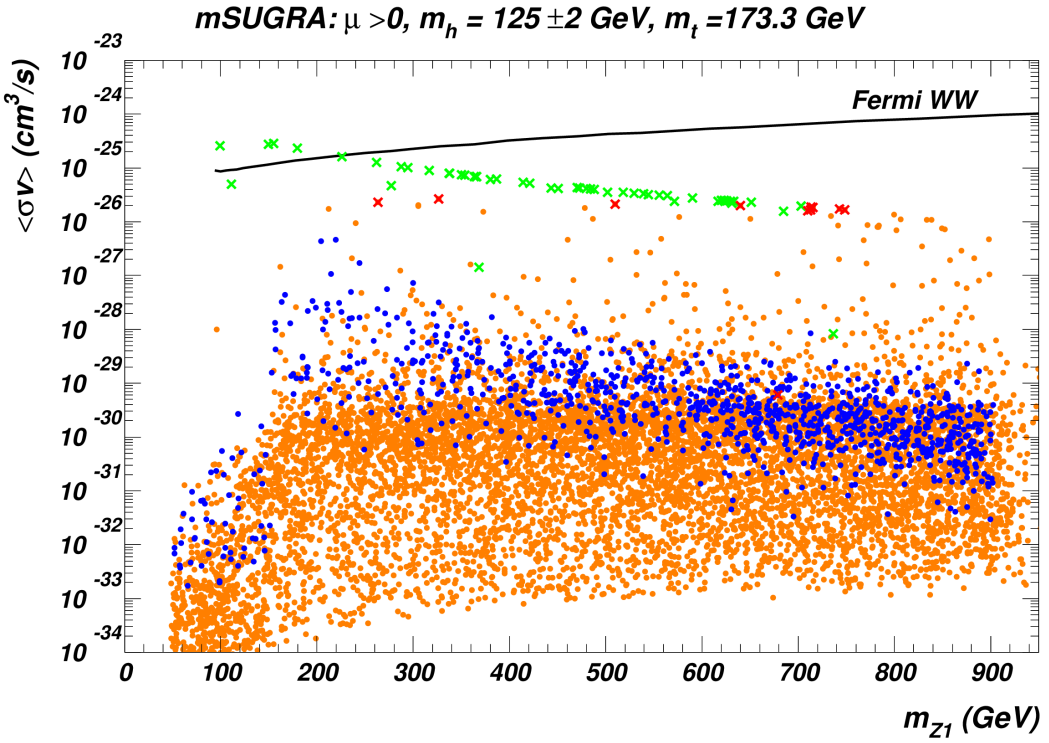
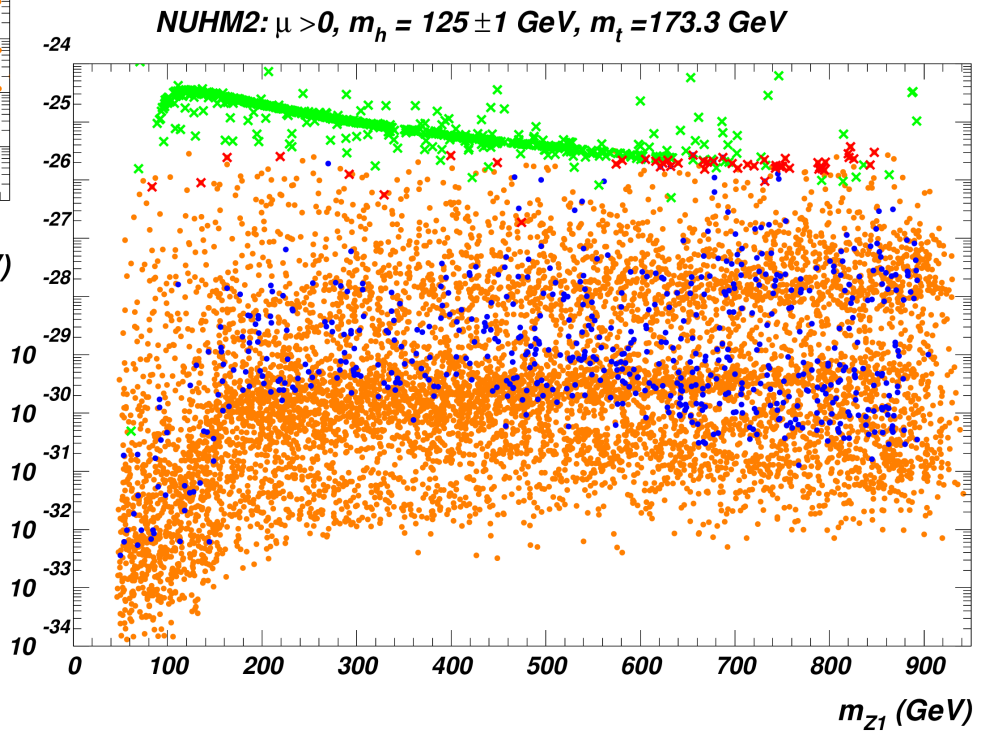


Indirect Detection of Neutralino DM



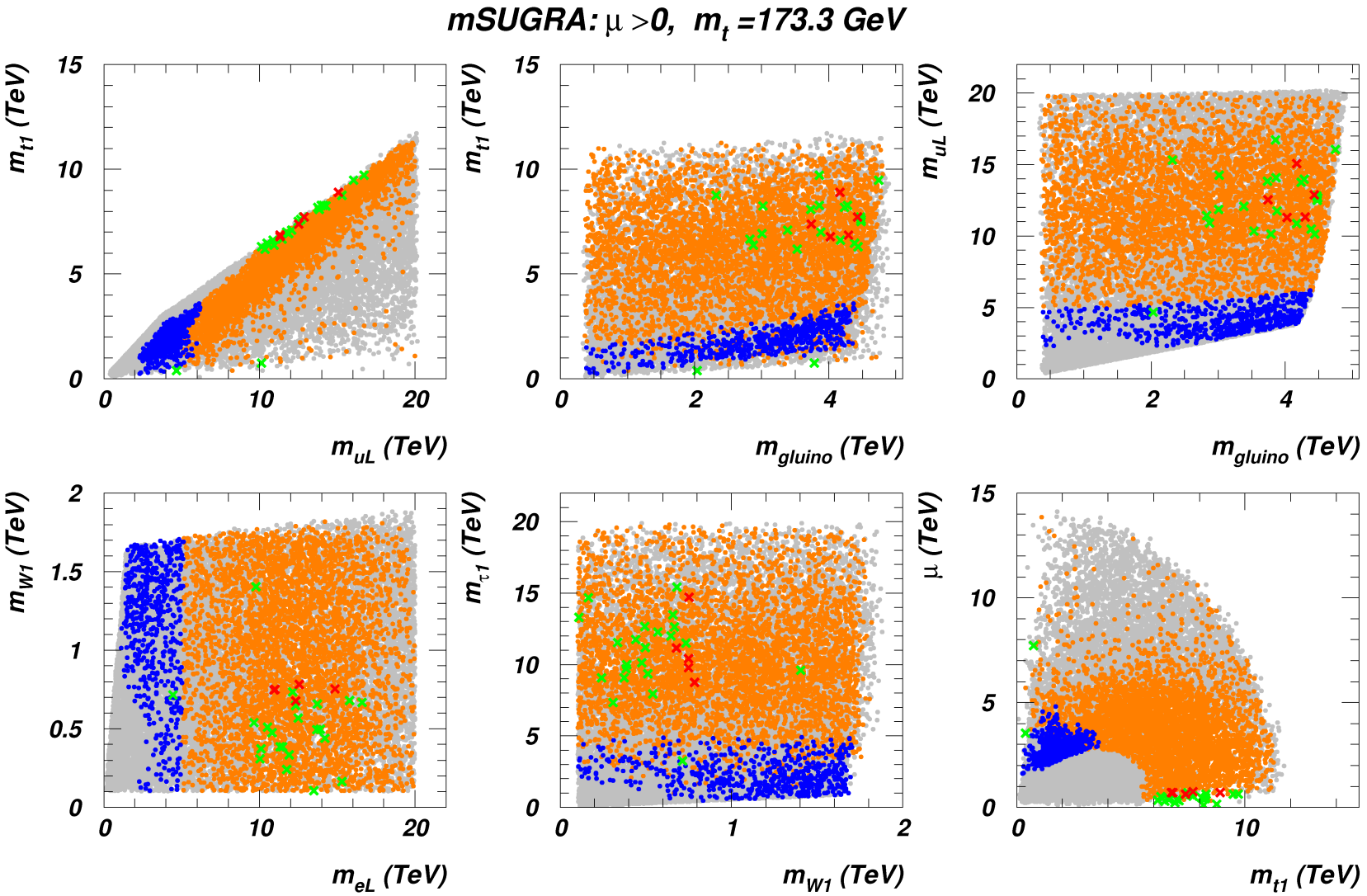
- m0 < 5 TeV
- m0 < 20 TeV



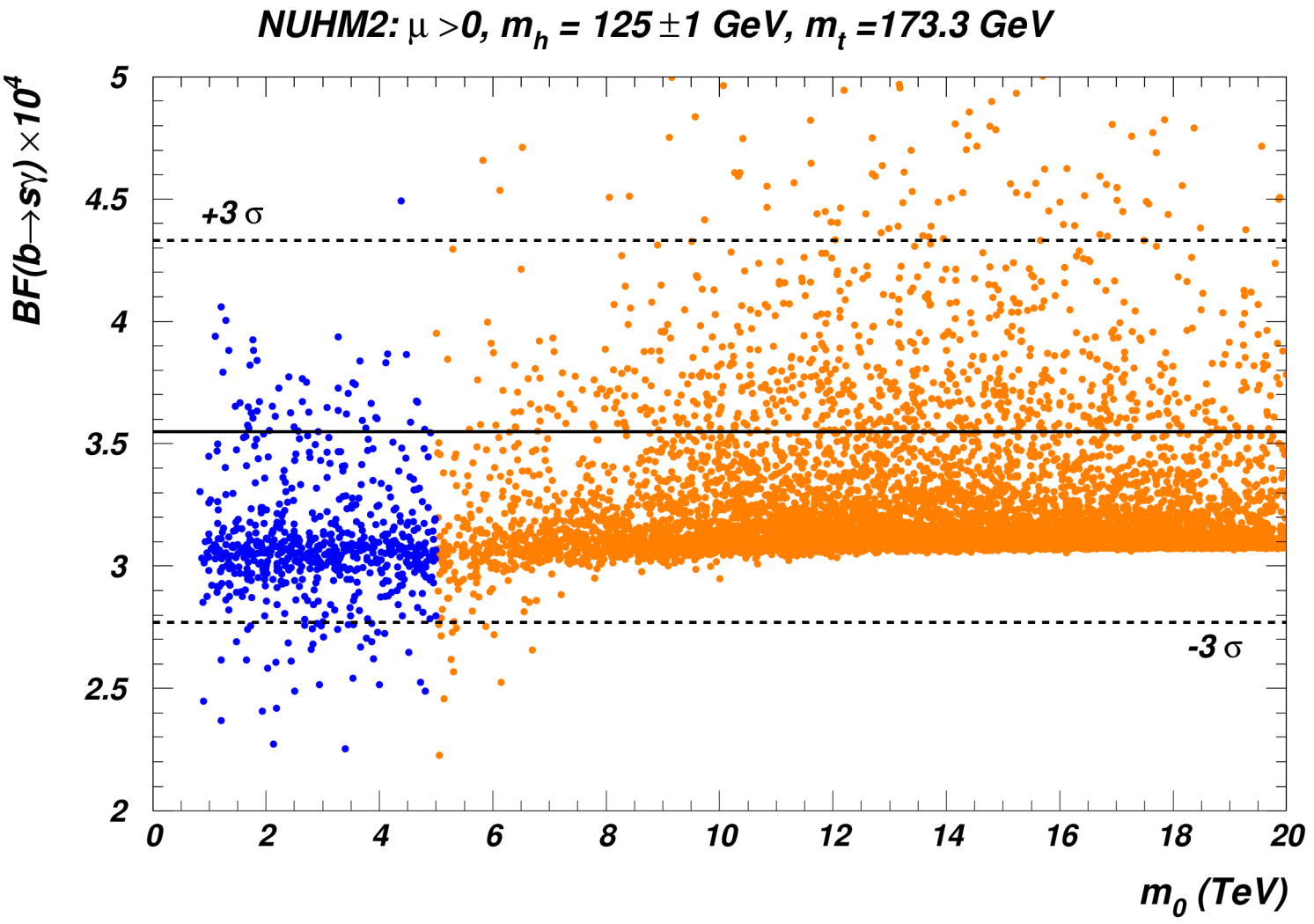
Conclusions

- In mSUGRA 125 GeV Higgs requires large A0 and m0 > 0.8 TeV. The entire low mhf and low m0 region is ruled out. Squarks and sleptons are >2TeV, but stop can be <1 TeV.
- In NUHM2 m0 > 0.8 TeV is required, but small A0 is allowed for m0>5TeV. Unlike mSUGRA, entire ranges of μ and m_A are allowed.
- In mAMSB and mGMBS, 125 GeV Higgs leads to very heavy spectrum.
- 125 GeV Higgs is inconsistent with muon g-2 anomaly
- $BF(b \to s\gamma)$ and $BF(B_s \to \mu\mu)$ are consistent with mh=125 GeV
- “effective SUSY” spectrum expected, leading to dominantly gluino pair production at LHC
- In mSUGRA at mh=125GeV stau and stop coannih. and A-funnel are nearly ruled out. Remaining HB/FP is more fine-tuned than before, but can be completely probed by next round of Dark Matter experiments.

mSUGRA spectrum at mh=125GeV



$b \to s\gamma$



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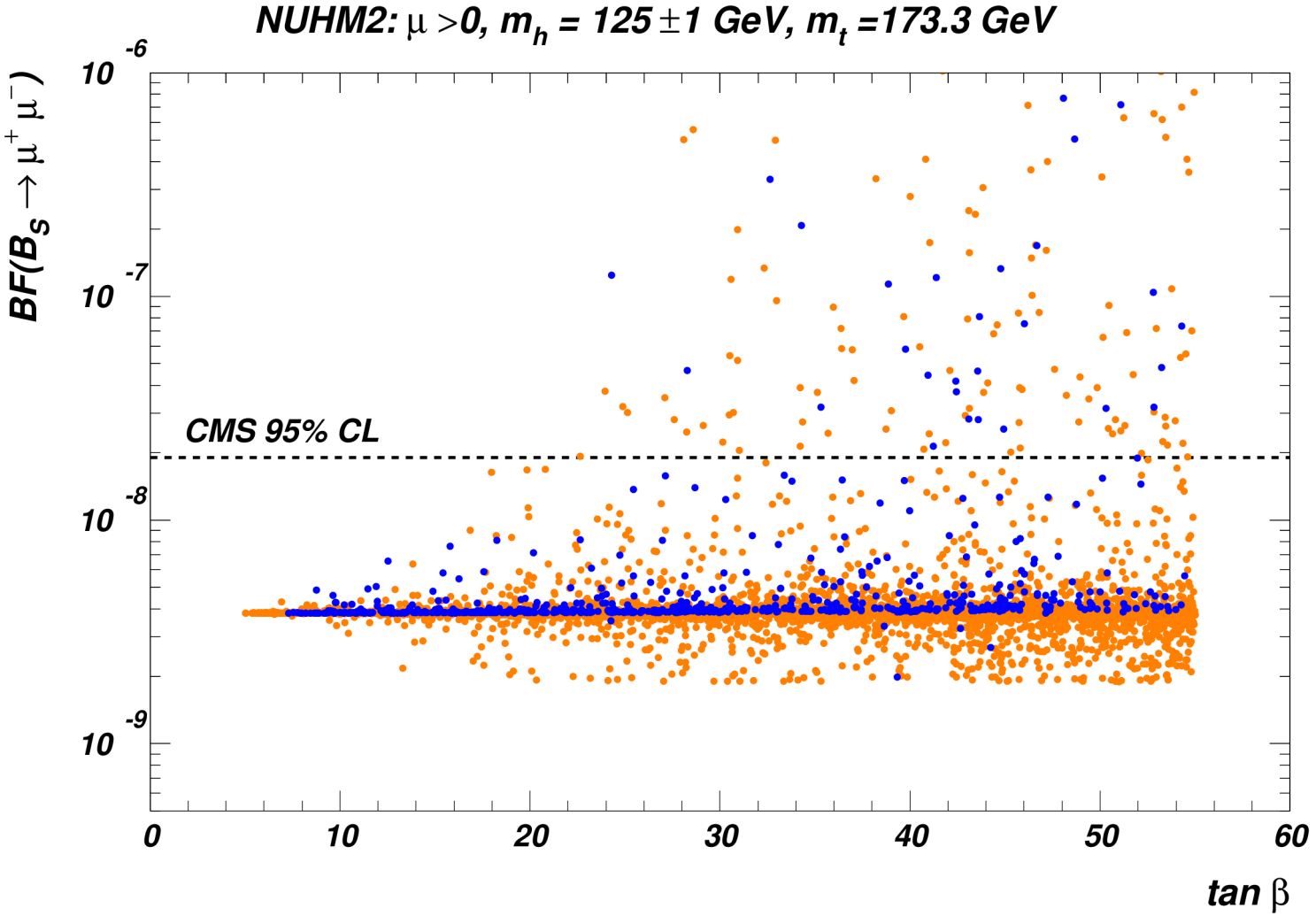
$B_S \to \mu^+\mu^-$



- m0 < 5 TeV
- m0 < 20 TeV