Implications of SUSY and Higgs Searches at the LHC on MSSM for a Linear Collider

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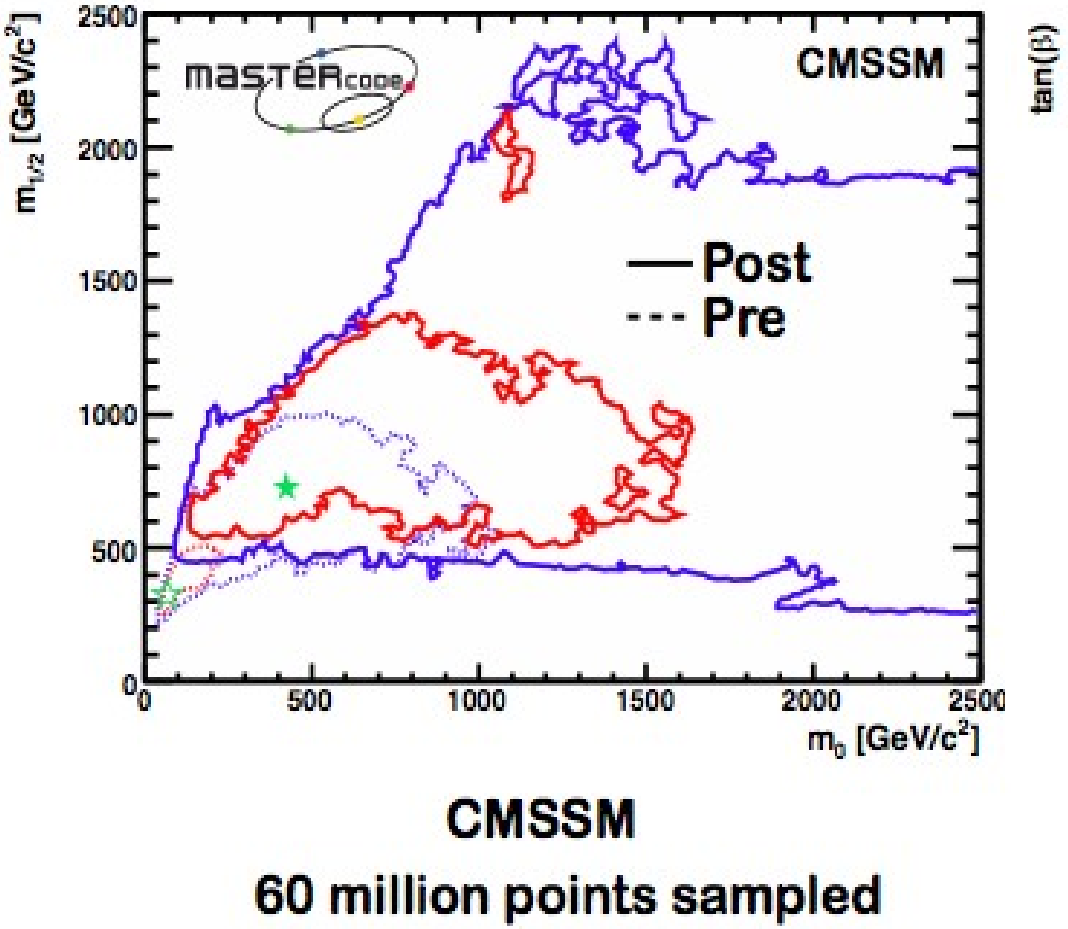
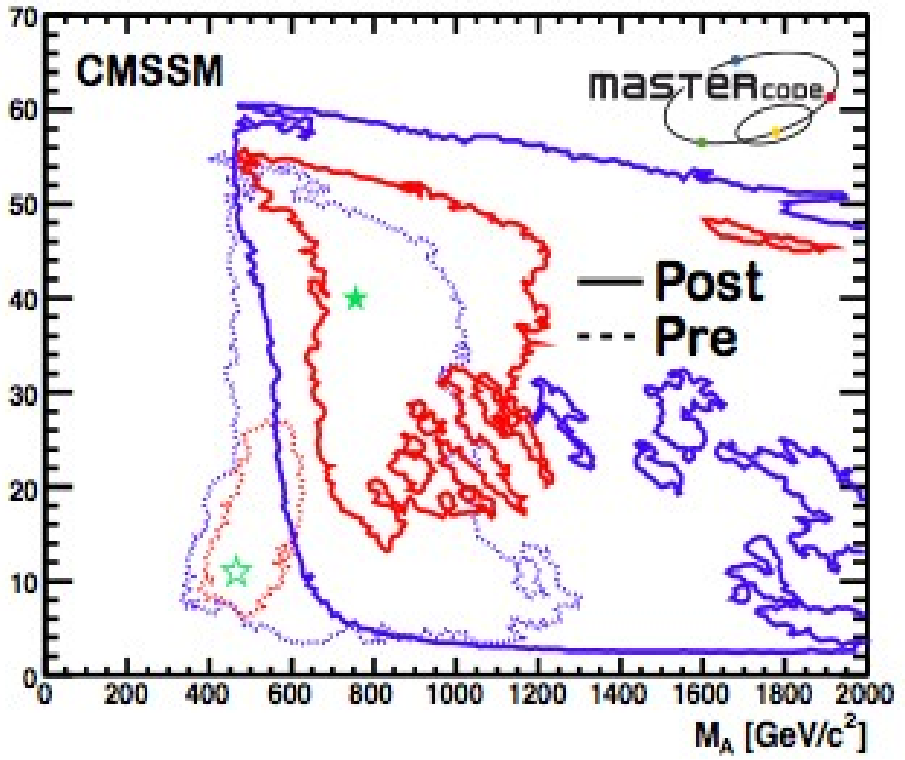
3rd Linear Collider Forum
DESY, 6-9 February, 2012

LHC Searches and the cMSSM

ATLAS+CMS (1 fb^{-1}) + Xenon-100 Data





CMSSM

60 million points sampled

Ellis, LPCC 09/2011

Preferred regions in constrained models move to larger masses and open up at the cost of worsening the fit probability.

More general MSSM models with conservative enough parameter sets most useful for studying impact of LHC data and LC perspectives:

- CP and R-parity conserving
- Neutralino LSP
- First two sfermion families degenerate

19-parameter pMSSM

Scans in pMSSM remove mass relations between sparticles typical only of constrained models

Provide understanding of interplay of flavour physics, low energy, relic dark matter, direct DM searches + LHC searches in shaping mass spectra of viable SUSY models.

Parameter	Range Standard Scan	Range Extended Scan
$\tan\beta$	[1, 60]	[1, 60]
M_A	[50, 2000]	[50, 2000]
M_1	[-2500, 2500]	[-2500, 2500]
M_2	[-2500, 2500]	[-2500, 2500]
M_3	[50, 2500]	[50, 2500]
$A_d = A_s = A_b$	[-2000, 2000]	[-10000, 10000]
$A_u = A_c = A_t$	[-2000, 2000]	[-10000, 10000]
$A_e = A_\mu = A_\tau$	[-2000, 2000]	[-10000, 10000]
μ	[-1000, 2000]	[-3000, 3000]
$M_{\tilde{e}_L} = M_{\tilde{\mu}_L}$	[50, 2500]	[50, 2500]
$M_{\tilde{e}_R} = M_{\tilde{\mu}_R}$	[50, 2500]	[50, 2500]
$M_{\tilde{\tau}_L}$	[50, 2500]	[50, 2500]
$M_{\tilde{\tau}_R}$	[50, 2500]	[50, 2500]
$M_{\tilde{q}_{1L}} = M_{\tilde{q}_{2L}}$	[50, 2500]	[50, 2500]
$M_{\tilde{q}_{3L}}$	[50, 2500]	[50, 2500]
$M_{\tilde{u}_R} = M_{\tilde{c}_R}$	[50, 2500]	[50, 2500]
$M_{\tilde{t}_R}$	[50, 2500]	[50, 2500]
$M_{\tilde{d}_R} = M_{\tilde{s}_R}$	[50, 2500]	[50, 2500]
$M_{\tilde{b}_R}$	[50, 2500]	[50, 2500]

Flavour Physics and Other Constraints

$$2.16 \times 10^{-4} < \mathrm{BR}(B \to X_s\gamma) < 4.93 \times 10^{-4}$$

$$\longrightarrow \quad \mathrm{BR}(B_s \to \mu^+\mu^-) < 1.08 \times 10^{-8}$$

$$0.56 < \frac{\mathrm{BR}(B \to \tau\nu)}{\mathrm{BR}_{SM}(B \to \tau\nu)} < 2.70\,,$$

$$4.7 \times 10^{-2} < \mathrm{BR}(D_s \to \tau\nu) < 6.1 \times 10^{-2}\,,$$

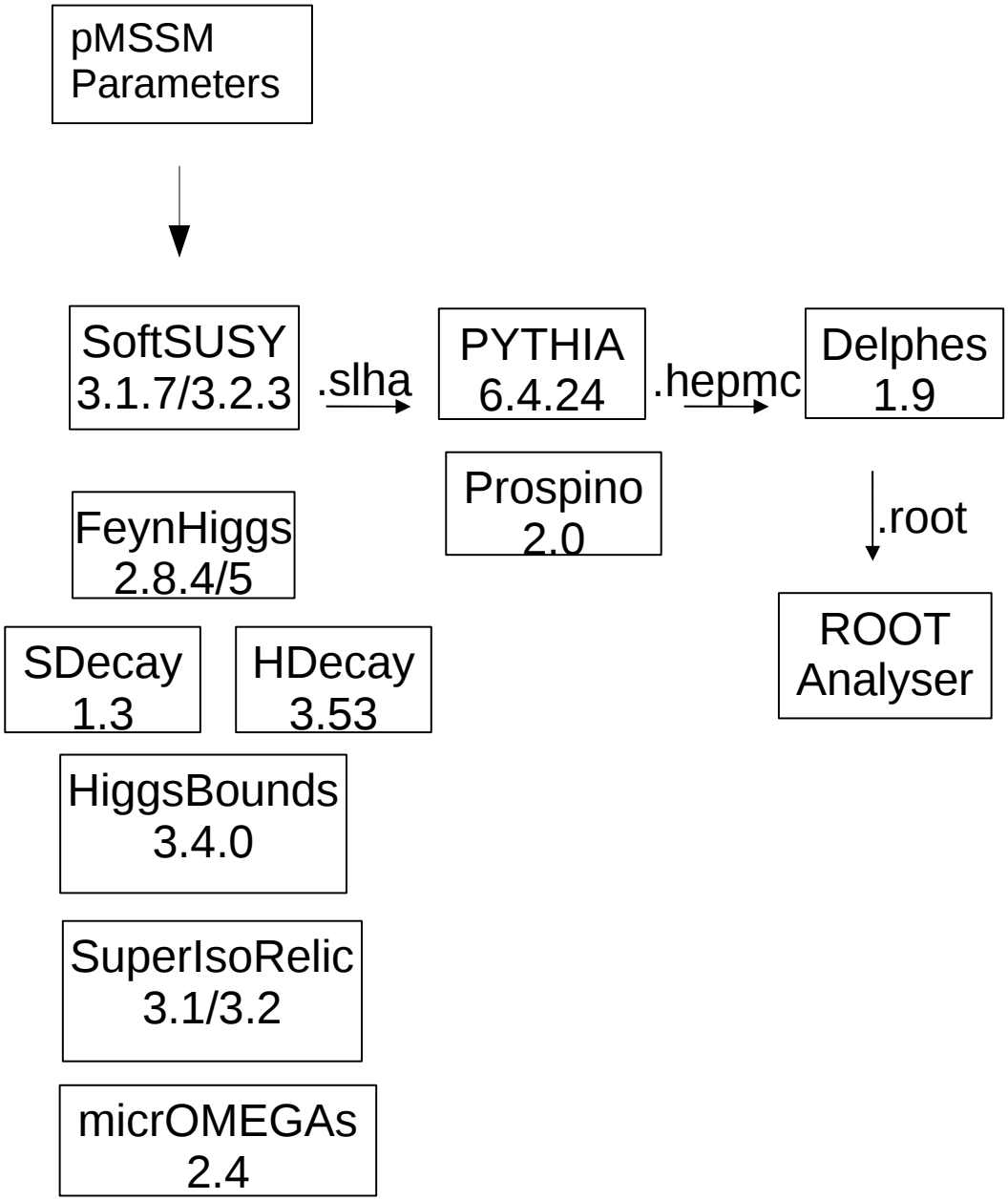
$$2.9 \times 10^{-3} < \mathrm{BR}(B \to D^0\tau\nu) < 14.2 \times 10^{-3}\,,$$

$$0.985 < \mathrm{R}_{\ell 23}(K \to \mu\nu) < 1.013\,.$$

$$-2.4 \times 10^{-9} < \delta a_\mu < 4.5 \times 10^{-9}$$

$$10^{-4} < \Omega_{DM} h^2 < 0.135$$

Software Chain

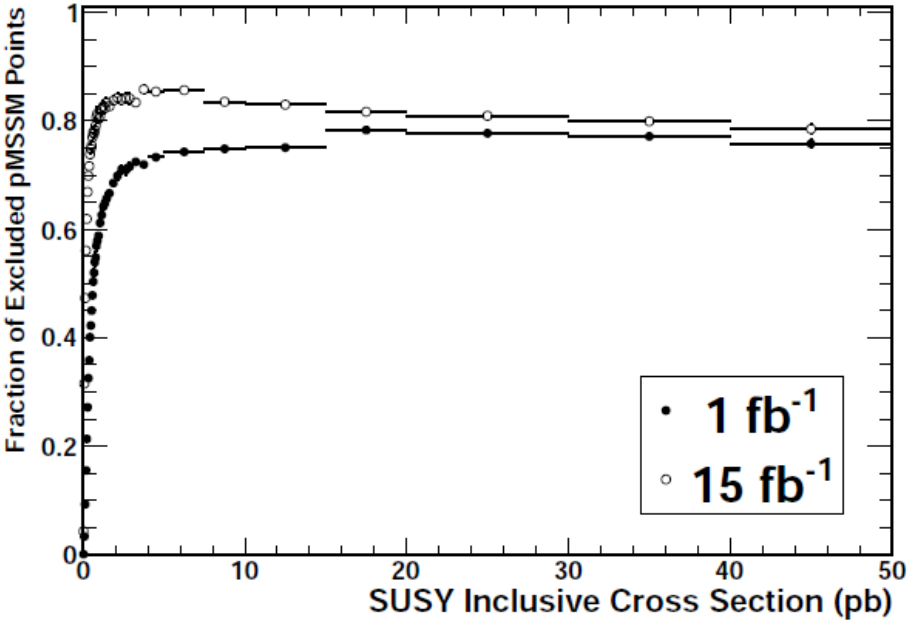


pMSSM flat scan including heavy flavour, g-2 and relic DM constraint+CMS searches (had α_T, 2l OS, 2l SS): 25M points

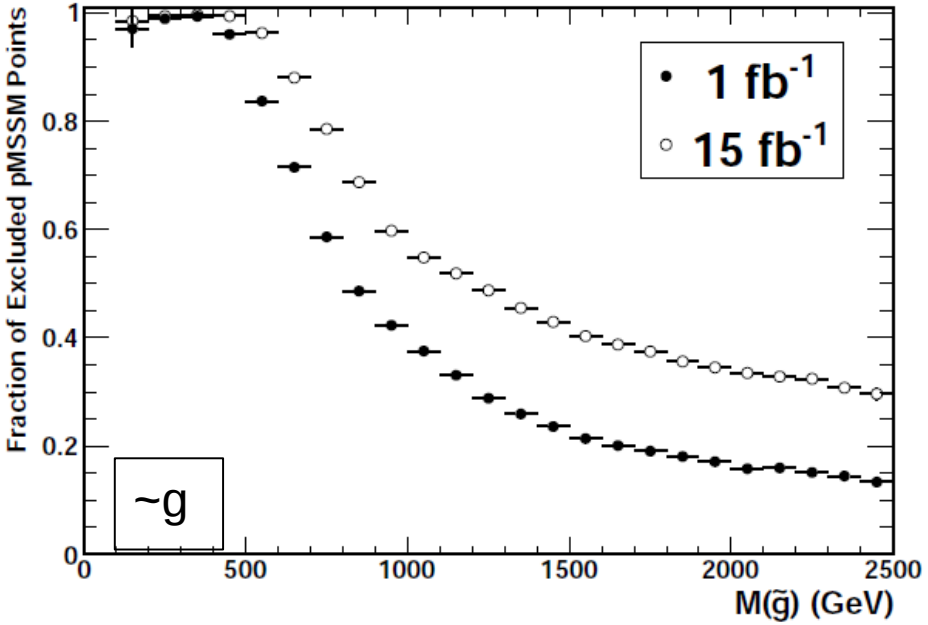
Present results in terms fraction of points compatible with non-LHC constraints and excluded by LHC searches (use 1 fb^{-1} and projection for 15 fb^{-1}):

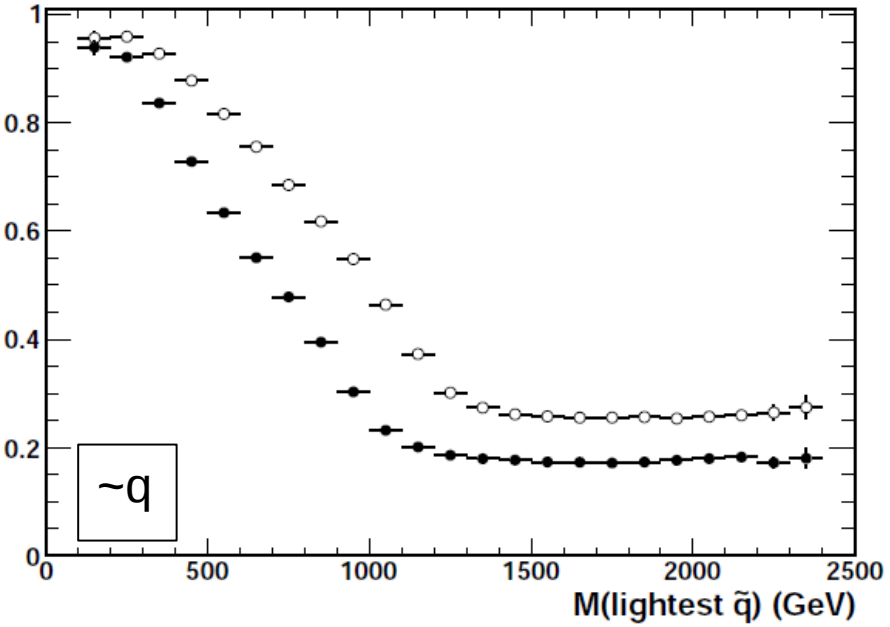
A Arbey, MB, N Mahmoudi, EPJ C72 (2012)

LHC Limits and inclusive NLO SUSY Cross Section

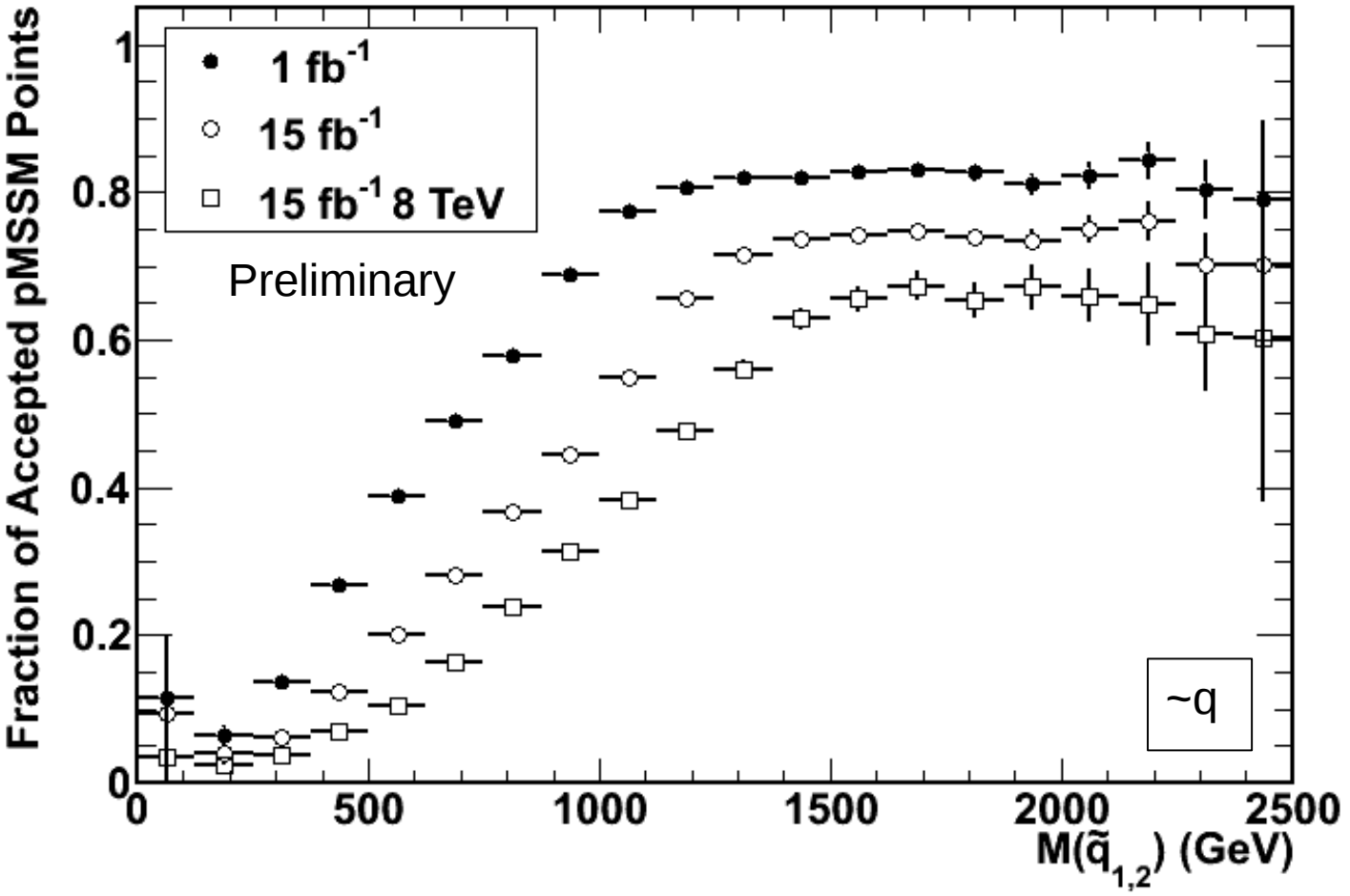


LHC Limits and the Spectra of Strongly-interacting SUSY Particles



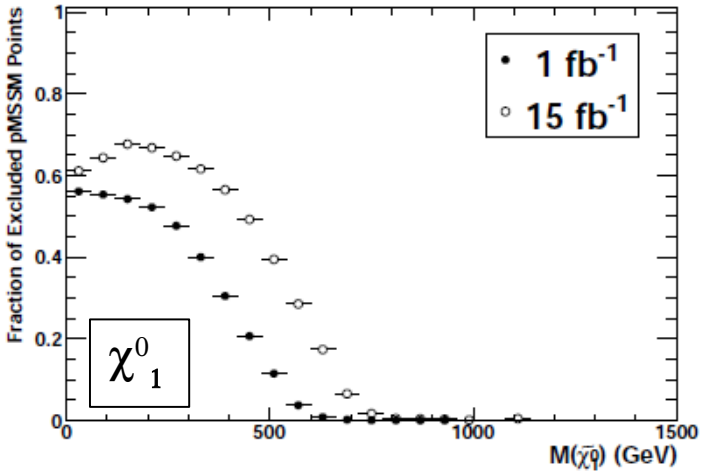


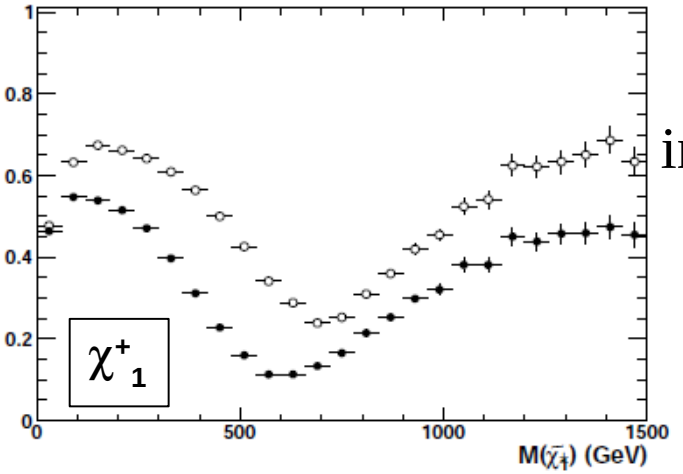
LHC Limits and the Spectra of Strongly-interacting SUSY Particles
Preliminary comparison of 7 and 8 TeV

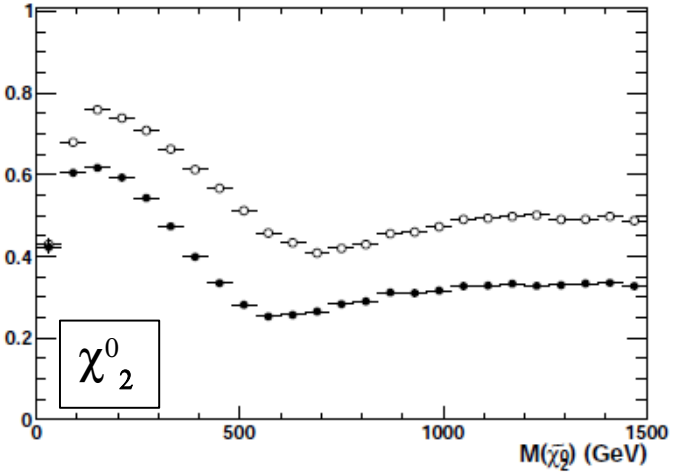


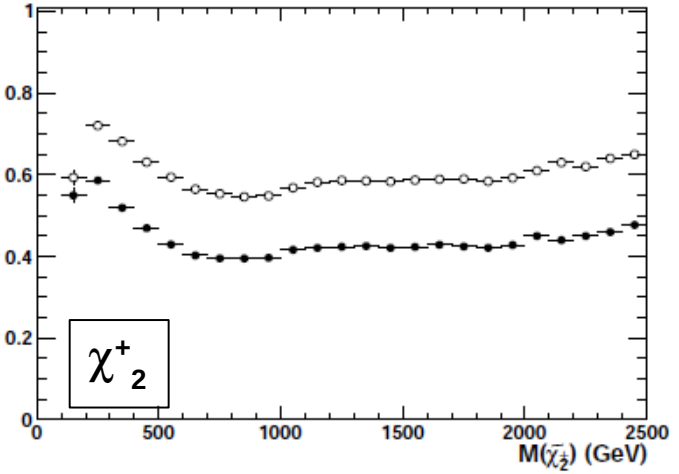
Arbey, MB, Mahmoudi,
to appear

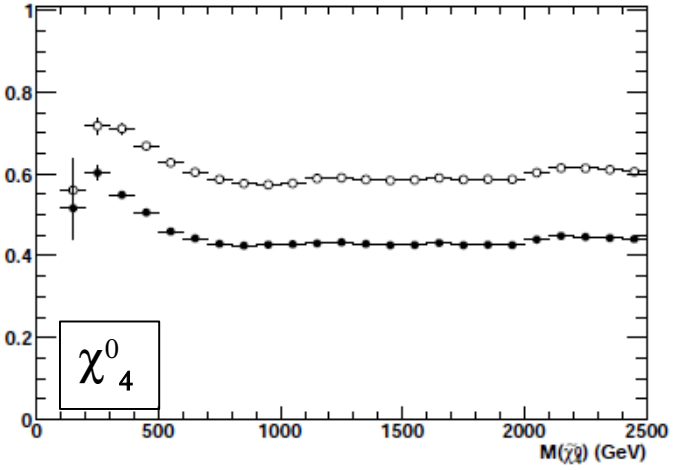
LHC Limits and the Spectra of Weakly interacting SUSY Particles

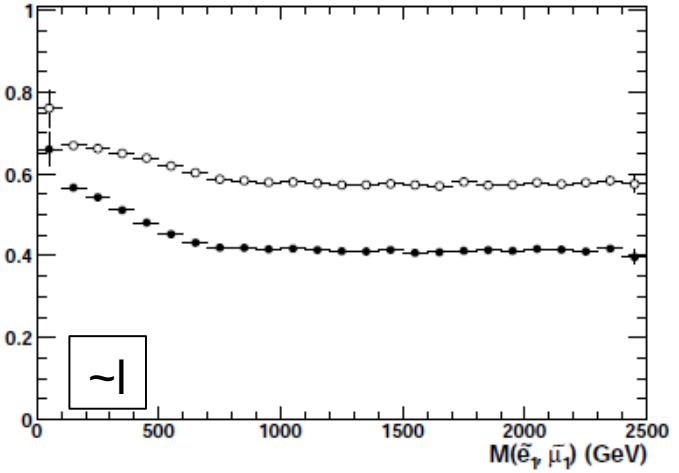






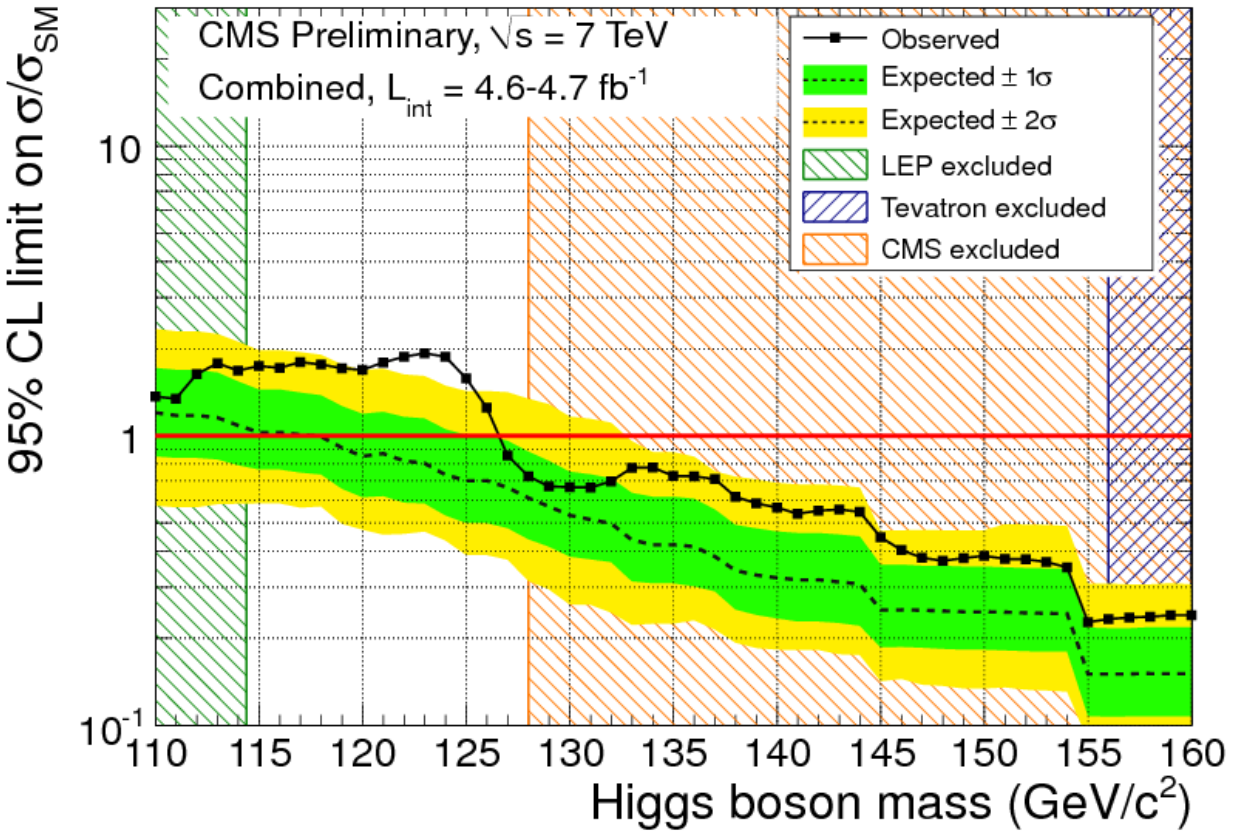






Arbey, MB, Mahmoudi,
Eur Phys J C 72 (2012) 1847

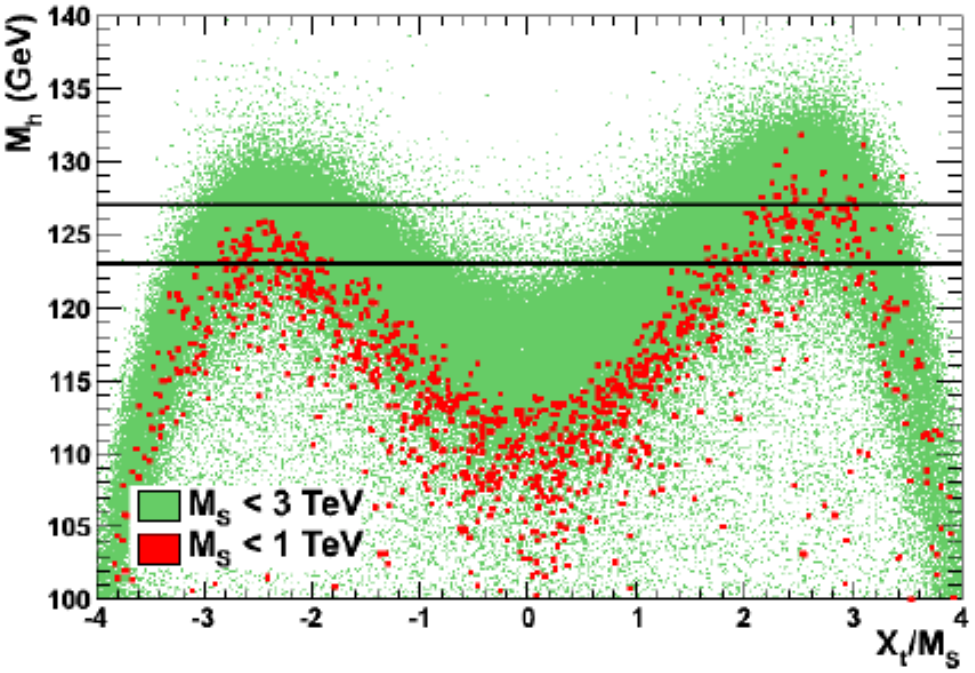
Test SUSY through the Higgs Sector

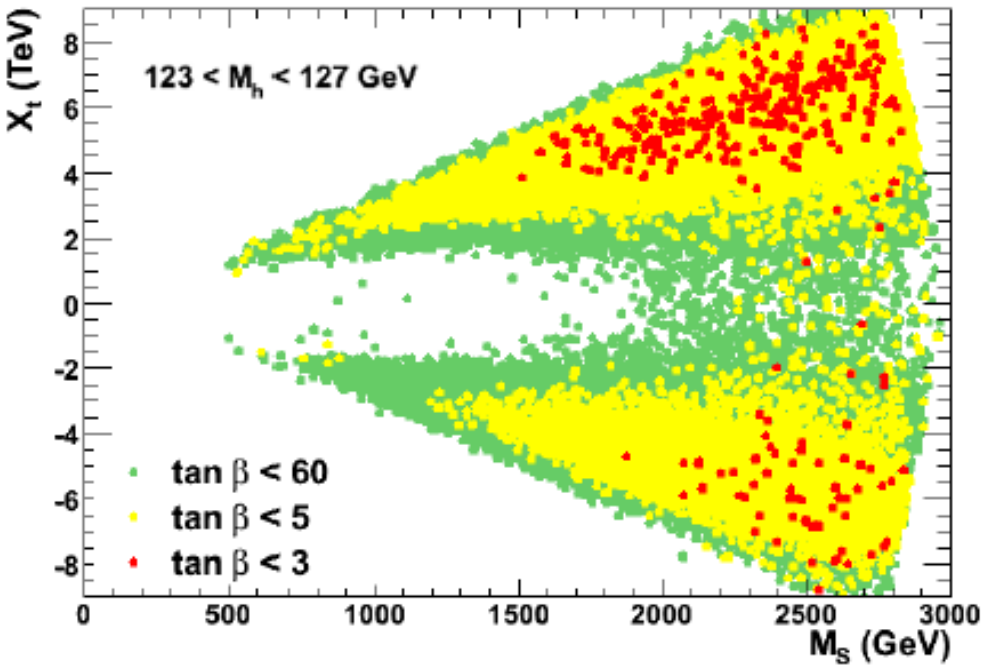


Constraints from M_h determination

$$123 < M_h < 127 \text{ GeV}$$

pMSSM





$$1 \leq \tan\beta \leq 60\,,\ 50 \text{ GeV} \leq M_A \leq 3 \text{ TeV}\,,\ -9 \text{ TeV} \leq A_f \leq 9 \text{ TeV}\,,$$
$$50 \text{ GeV} \leq m_{\tilde{f}_L}, m_{\tilde{f}_R}, M_3 \leq 3 \text{ TeV}\,,\ 50 \text{ GeV} \leq M_1, M_2, |\mu| \leq 1.5 \text{ TeV}.$$

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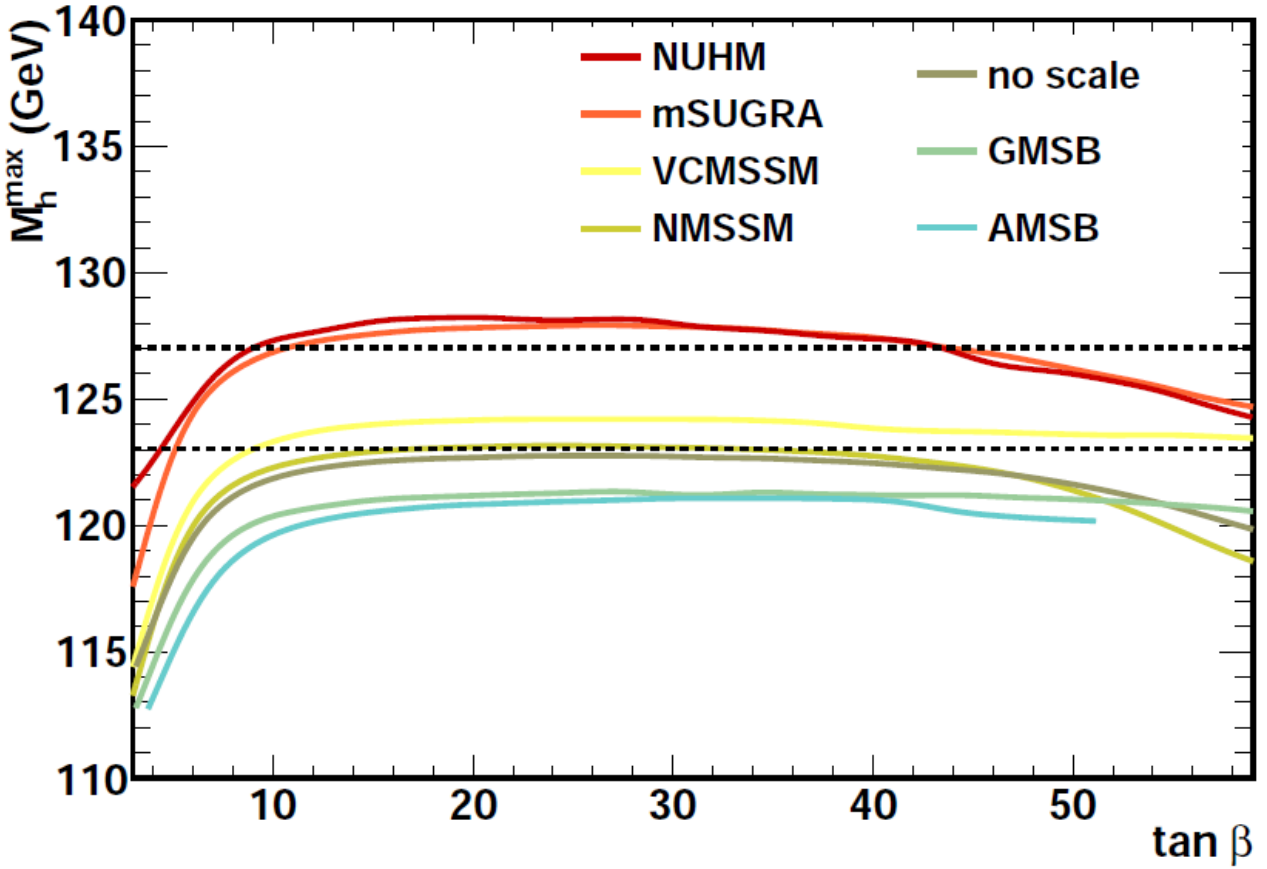
Constrained Models



mSUGRA: $50\ \text{GeV} \leq m_0 \leq 3\ \text{TeV}$, $50\ \text{GeV} \leq m_{1/2} \leq 3\ \text{TeV}$, $|A_0| \leq 9\ \text{TeV}$;
GMSB: $10\ \text{TeV} \leq \Lambda \leq 1000\ \text{TeV}$, $1 \leq M_{\text{mess}}/\Lambda \leq 10^{11}$, $N_{\text{mess}} = 1$;
AMSB: $1\ \text{TeV} \leq m_{3/2} \leq 100\ \text{TeV}$, $50\ \text{GeV} \leq m_0 \leq 3\ \text{TeV}$.

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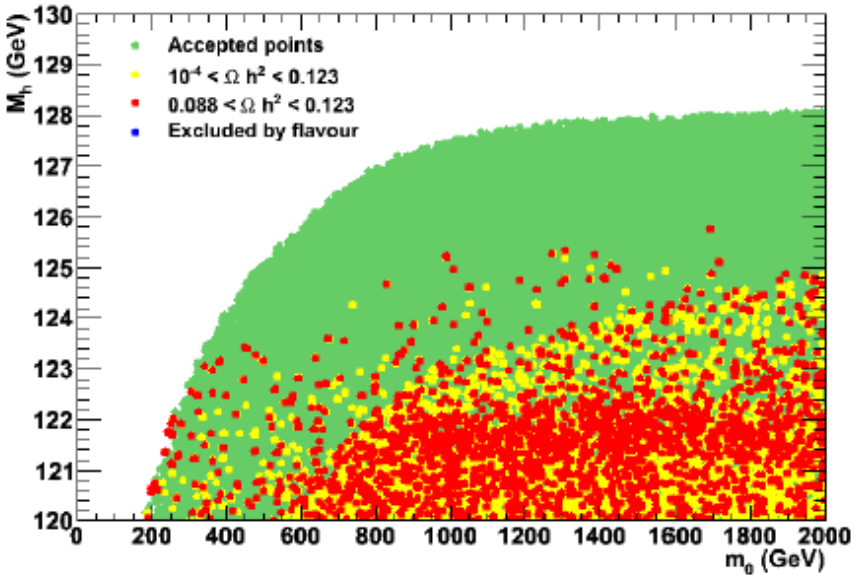
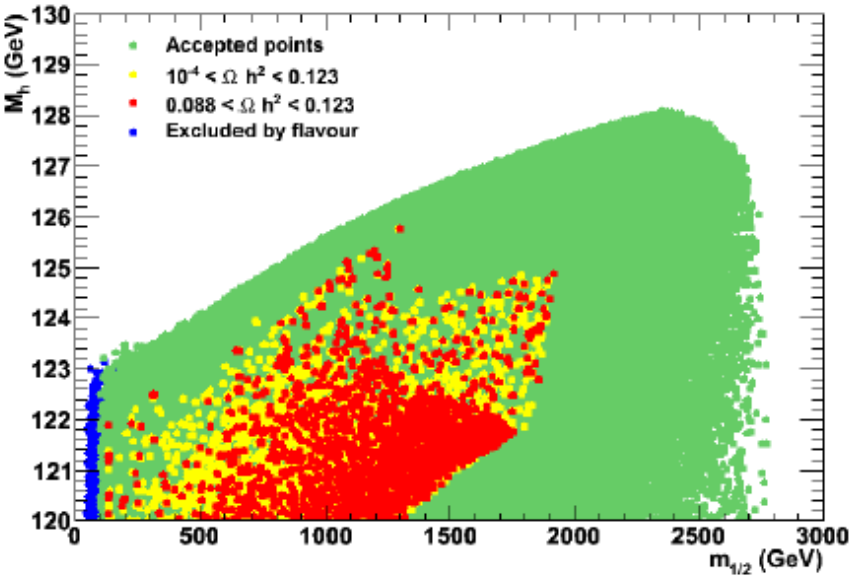
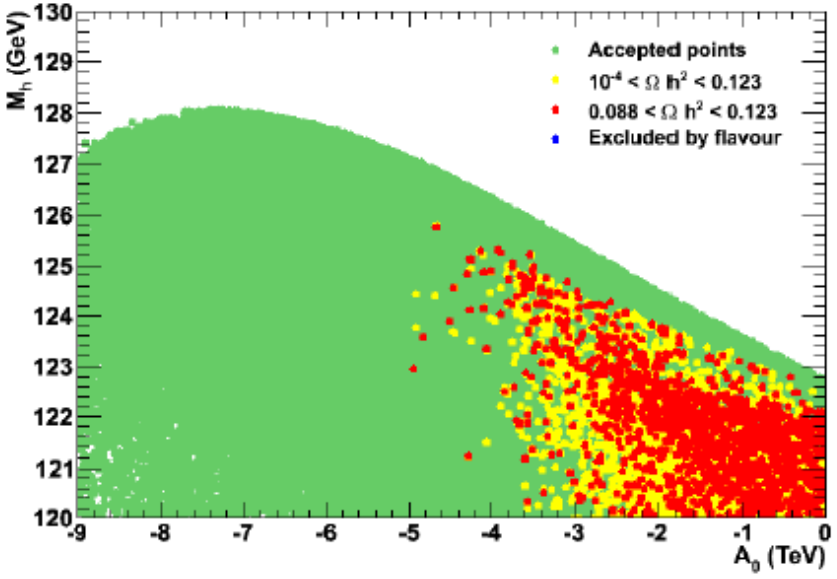
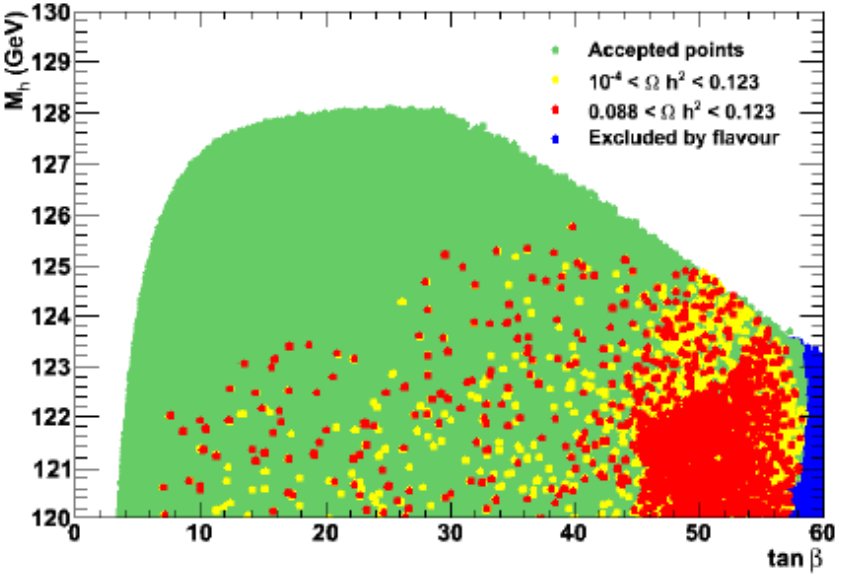
cMSSM









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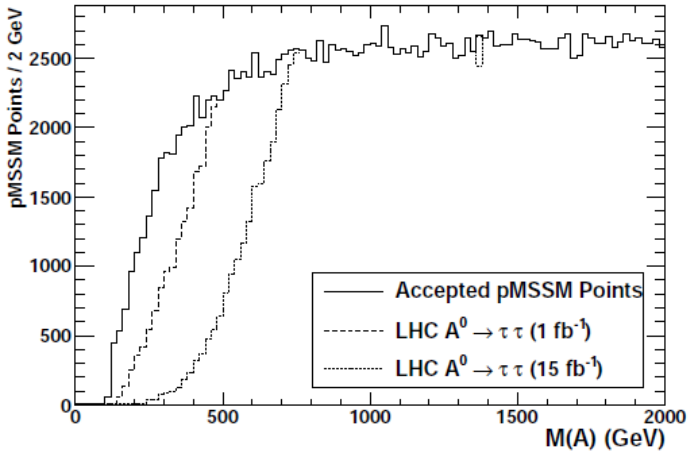
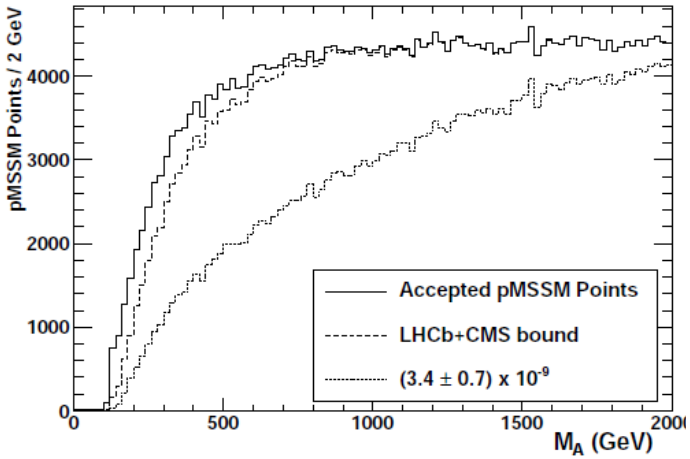
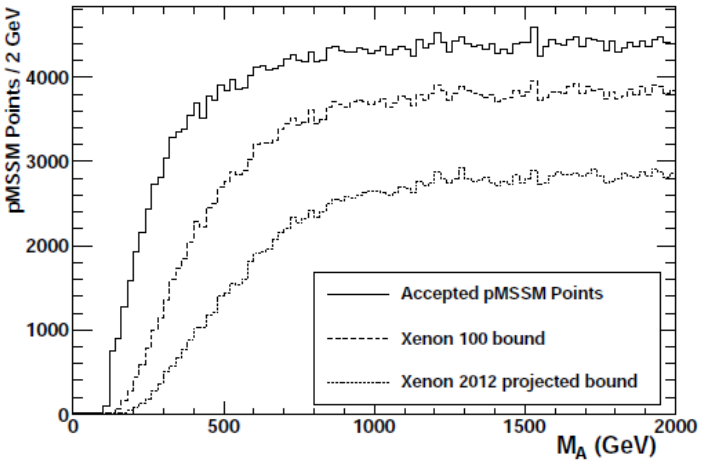
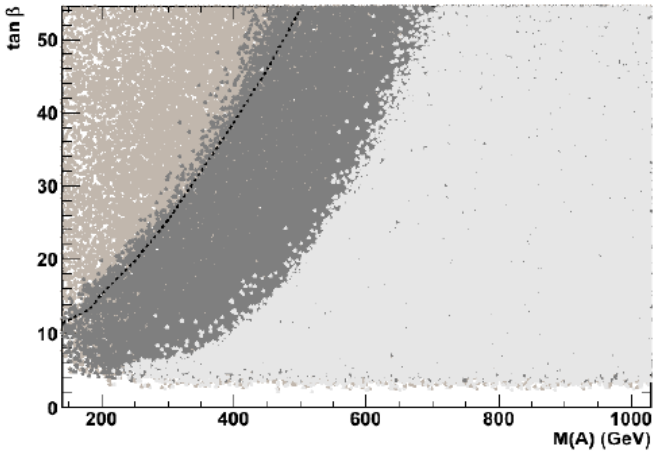
Bounds from $A \to \tau\tau$, $B^0_s \to \mu\mu$ and DM Direct Searches

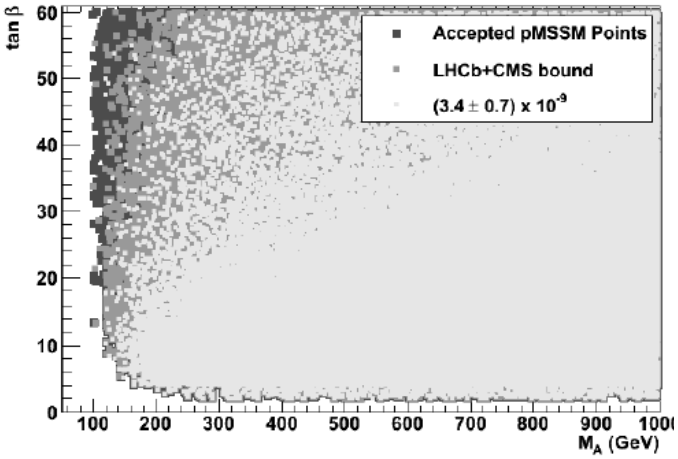
pMSSM

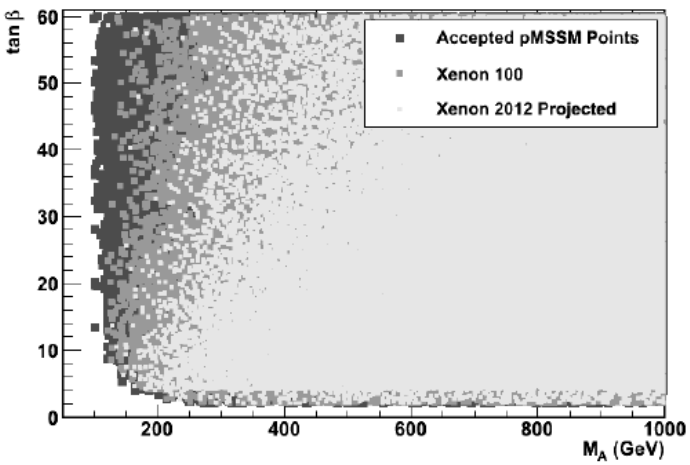




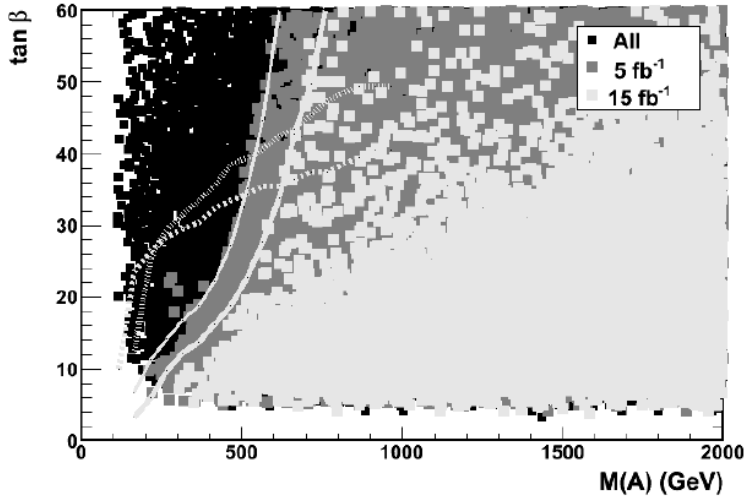


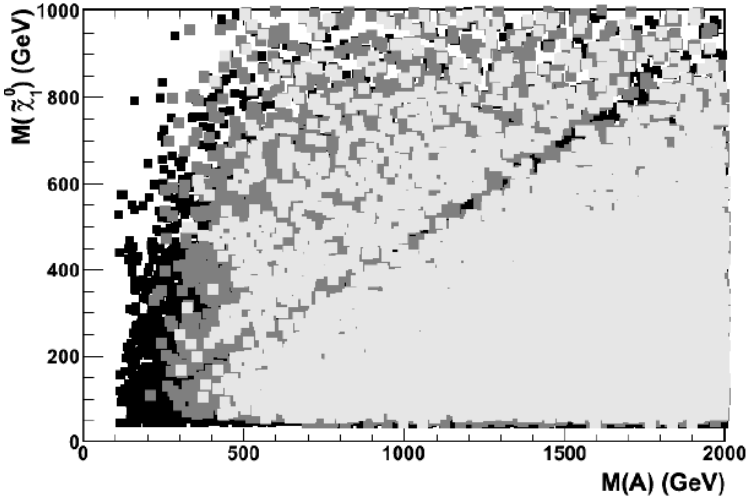


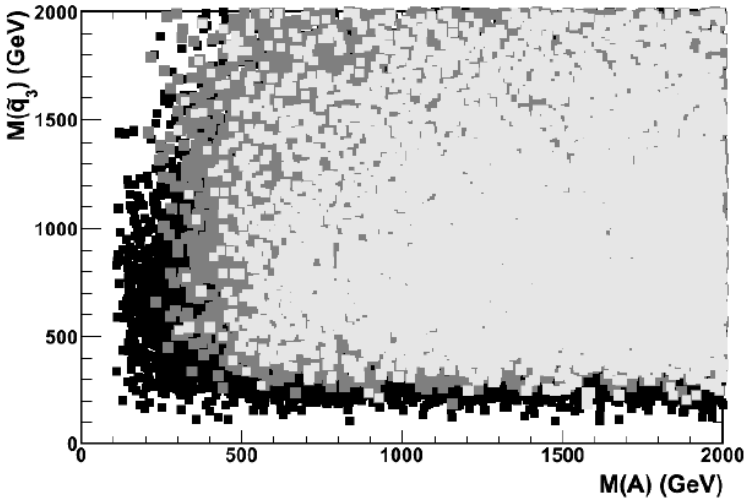




Arbey, MB, Mahmoudi,
arXiv:1112.3032





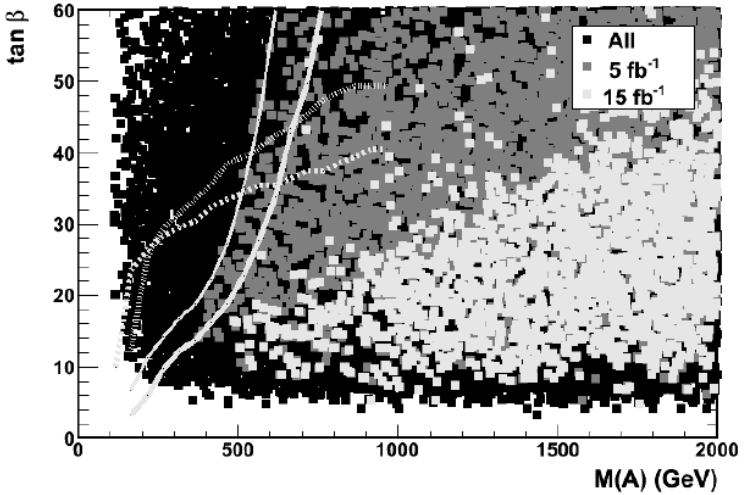


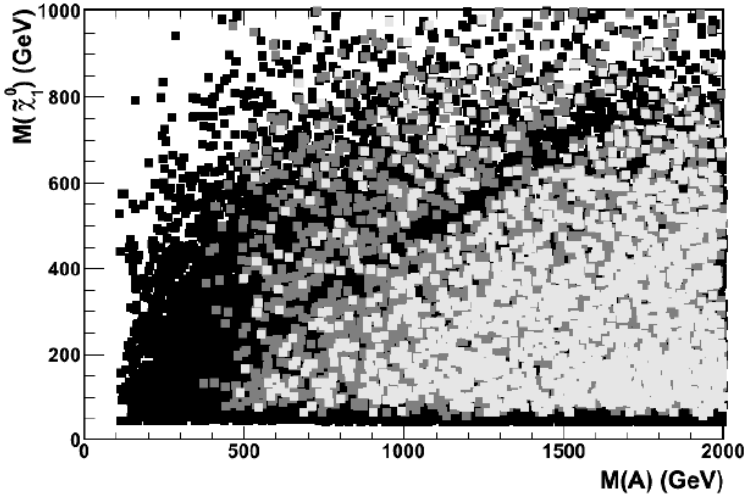
40M generated pMSSM points:
apply constraints from LHC searches.
$B_s \rightarrow \mu\mu$ and DM search at XENON

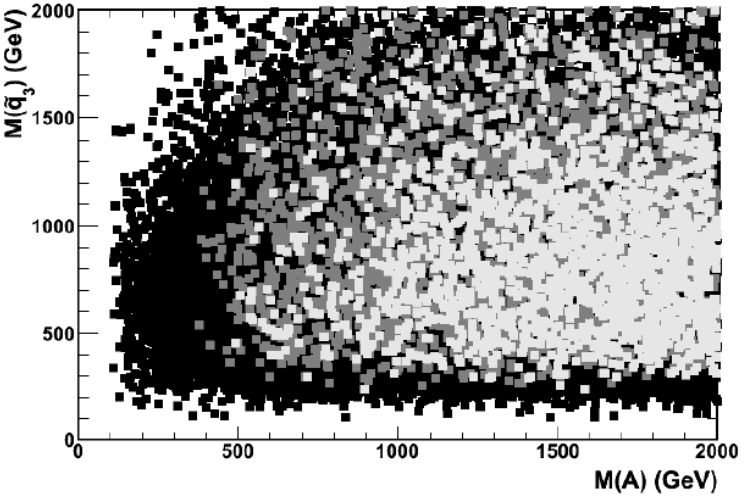
Mass constraint:

$$123 < M_h < 127 \text{ GeV}$$

Arbey, MB, Mahmoudi,
arXiv:1112.3032

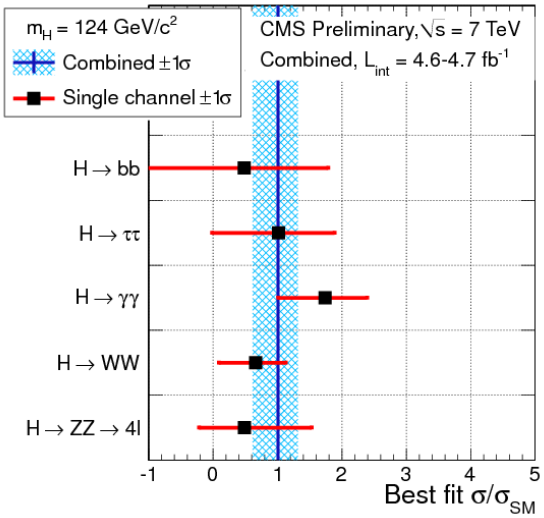


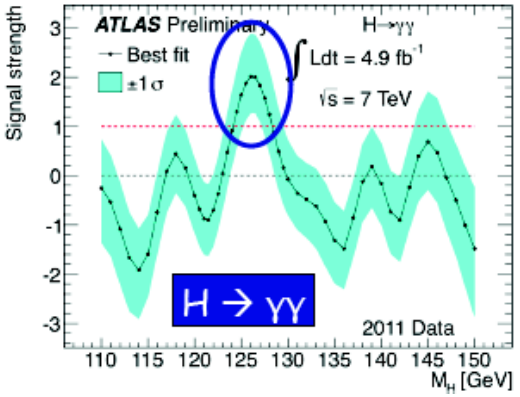


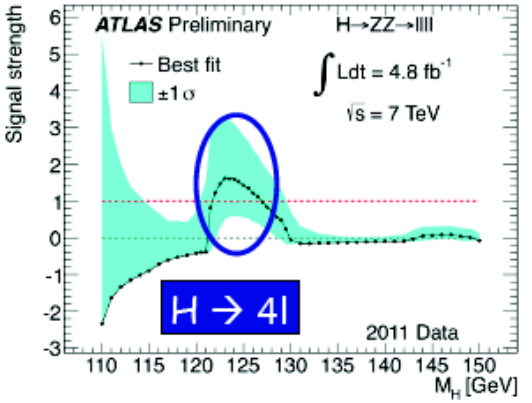


$$123 < M_h < 127 \text{ GeV}$$

+ constraint on rates:







$$1 \leq \sigma \times \mathrm{BR}(h^0 \rightarrow \gamma\gamma) < 3$$

$$0.3 < \sigma \times \mathrm{BR}(h^0 \rightarrow W^+W^-/Z^0Z^0) < 2.5$$

Arbey, MB, Mahmoudi,
arXiv:1112.3032

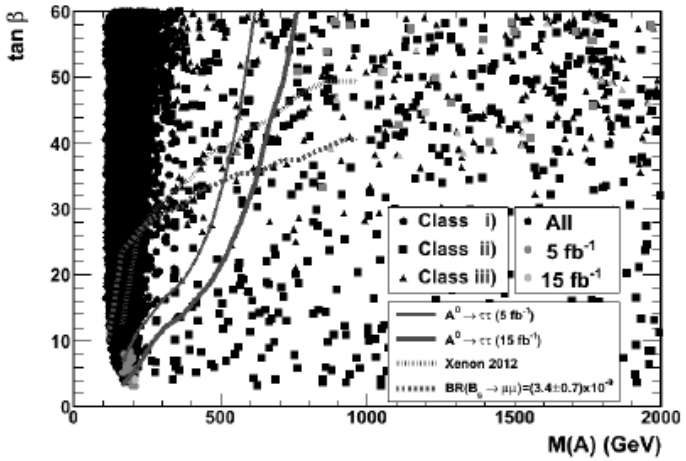
Constraints from no Higgs observation

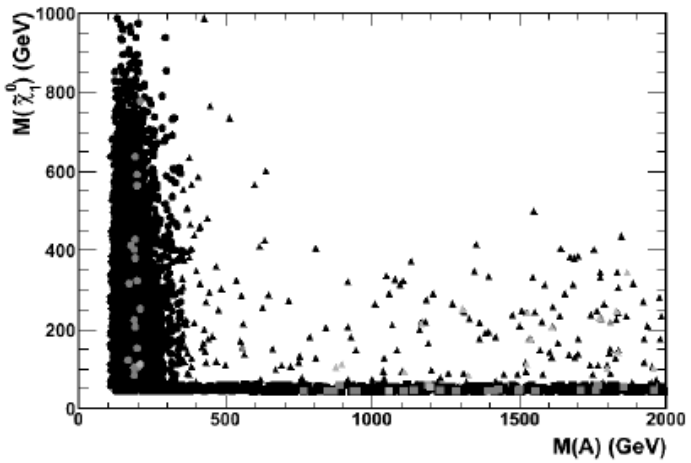
Three Scenarios with significant h^0 rate suppression at LHC:

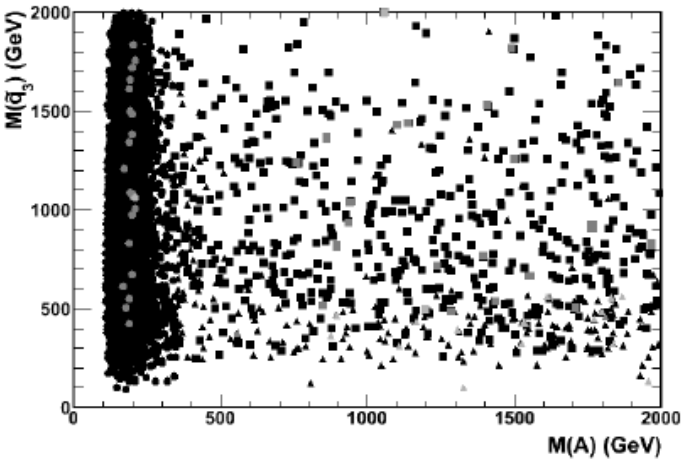
i) non decoupling at $M_A < 250$ GeV

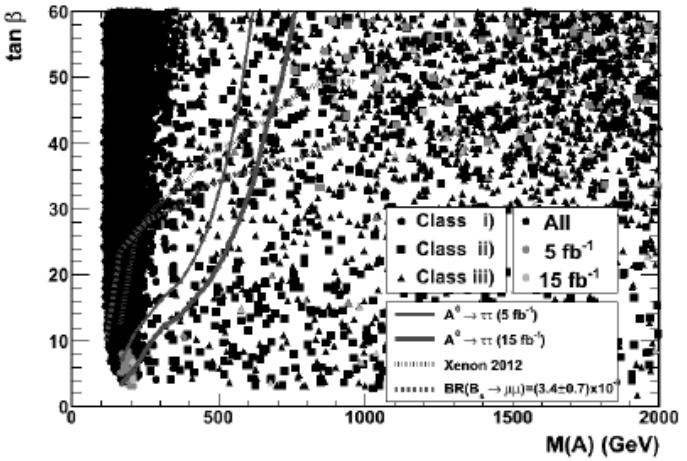
ii) invisible Higgs with $M_{\tilde{\chi}_1^0} < M_{h^0}$ and small $|\mu|$

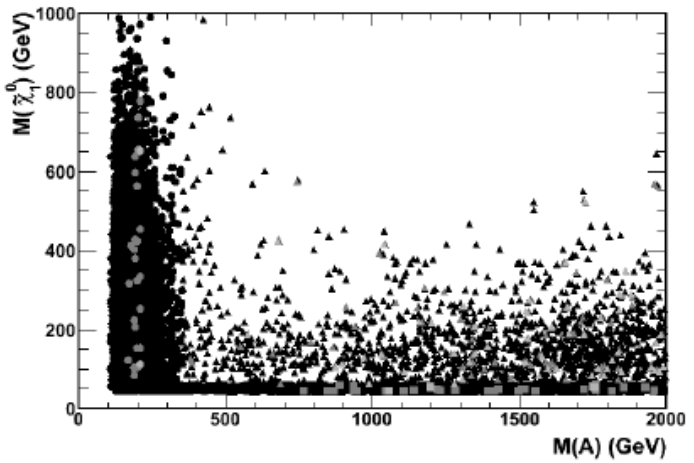
iii) light $\tilde{t}_1, \tilde{b}_1$ squarks

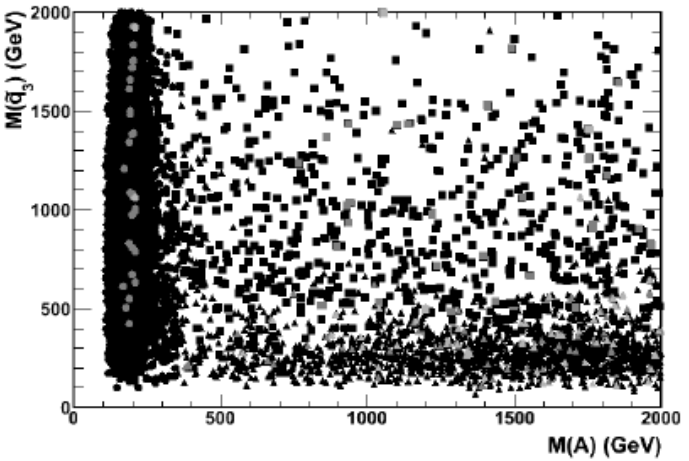












σ xBR($h^0 \rightarrow \gamma\gamma$) < 3 SM

σ xBR($h^0 \rightarrow$ WW/ZZ) < 3 SM

Arbey, MB, Mahmoudi, arXiv:1112.3032