

Towards NMSSM grids for LHC searches

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in collaboration with

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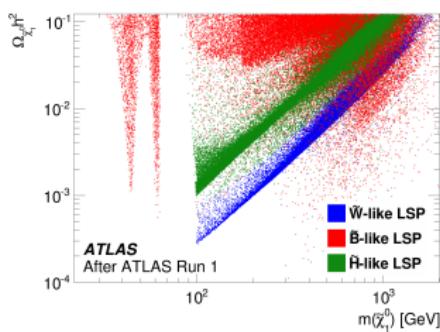
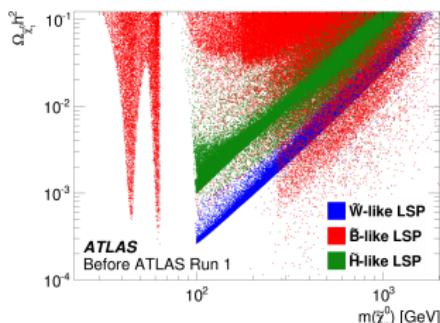
NMSSM Workshop @ LAL, November 22, 2016



Introduction: SUSY grids at run 1

ATLAS run 1 SUSY summary (JHEP 1510(2015) 134)

- randomly choose 500 000 000 pMSSM parameter configurations
- compute spectrum and observables
- discard points incompatible with experimental constraints
- evaluate whether production processes are accessible at LHC
- generate events and evaluate whether the point is excluded by ATLAS searches (45 000 fully simulated points)



- perform a full scan of the NMSSM parameter space including all of the run 2 SUSY searches
- first step: provide a (small) grid in parameter space of semi-constrained NMSSM accessible at run 2

semi-constrained Next-to-Minimal Supersymmetric Standard Model

Higgs superpotential

$$W = \lambda \hat{S} \hat{H}_u \cdot \hat{H}_d + \frac{\kappa}{3} \hat{S}^3$$

Soft Higgs terms

$$\begin{aligned} -\mathcal{L}_{\text{soft}} = & m_{H_u}^2 |H_u|^2 + m_{H_d}^2 |H_d|^2 + m_S^2 |S|^2 \\ & + \left(\lambda A_\lambda S H_u \cdot H_d + \frac{\kappa}{3} A_\kappa S^3 + \text{h. c.} \right) \end{aligned}$$

Universality conditions

- require universal soft parameters at Grand Unification scale
⇒ constrained NMSSM
- allow for non-universality in the Higgs sector: doublets and singlet
⇒ semi-constrained NMSSM

Free parameters

- couplings at SUSY scale: λ, κ
- universal soft terms at GUT scale: $m_0, M_{1/2}, A_0$
- soft Higgs trilinear couplings at GUT scale: A_λ, A_κ
- VEVs: $\tan \beta = \langle H_u \rangle / \langle H_d \rangle$ at M_Z , $\mu_{\text{eff}} = \lambda \langle S \rangle$ at SUSY scale

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Higgs boson

ATLAS and CMS discovered a "SM-like" Higgs boson with a mass of

$$M(H_S^0) = [125.09 \pm 0.24 \text{ (exp)} \pm 2.5 \text{ (theo)}] \text{ GeV}$$



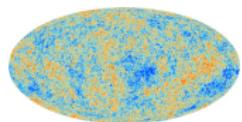
and **couplings** to SM fields searched for in the channels¹

	WW^*	ZZ^*	$\gamma\gamma$	$\tau\tau$	$b\bar{b}$	$Z\gamma$	inv	lep
ggF	✓	✓	✓	✓	✗	✓	✗	✗
VBF	✓	✓	✓	✓	✓	✓	✓	✗
VH	✓	✓	✓	✓	✗	✓	CMS	✗
ttH	✗	✓	✓	✗	CMS	✓	✗	CMS

- both H_1^0 and H_2^0 are candidates for the SM-like Higgs boson
- a light Higgs with large singlet content could have escape detection so far

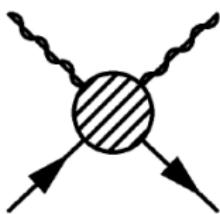
¹listed are channels considered in this analysis, with ✓ for both ATLAS and CMS results

Dark matter



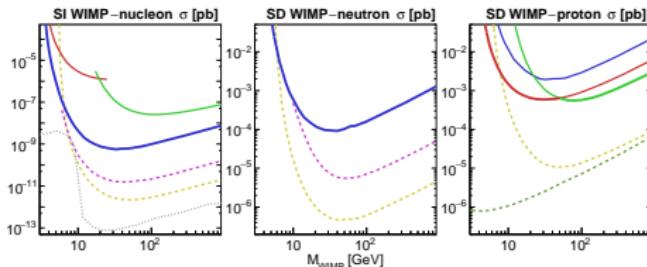
The dark matter **relic density** is estimated from CMB anisotropy measurements of the Planck satellite:

$$\Omega_{\text{DM}} h^2 = 0.1188 \pm 0.0010 \text{ (exp)} \pm 0.0119 \text{ (theo)}$$



Direct detection experiments search for recoils of dark matter off nucleons and set upper limits on the **WIMP–nucleon cross section**:

- LUX
- PICO-60
- PICO-250L



⇒ allow up to four times higher cross sections

- require that the lightest neutralino makes up for all the DM content of the universe
- both mass and couplings of DM are heavily influenced by the neutralino composition

Further constraints

B physics:

$$\begin{aligned} \text{BR}(B \rightarrow X_s \gamma) &= [3.43 \pm 0.21 \text{ (exp)} \pm 0.35 \text{ (theo)}] \times 10^{-4} \\ \text{BR}(B_s^0 \rightarrow \mu^+ \mu^-) &= [2.80 \pm 0.07 \text{ (exp)} \pm 0.28 \text{ (theo)}] \times 10^{-9} \\ \text{BR}(B^+ \rightarrow \tau^+ \nu_\tau) &= [1.14 \pm 0.22 \text{ (exp)} \pm 0.12 \text{ (theo)}] \times 10^{-4} \\ \Delta M(B_d^0) &= [0.510 \pm 0.003 \text{ (exp)} \pm 0.051 \text{ (theo)}] \text{ ps}^{-1} \\ \Delta M(B_s^0) &= [17.757 \pm 0.021 \text{ (exp)} \pm 1.776 \text{ (theo)}] \text{ ps}^{-1} \end{aligned}$$

Z boson decays:

$$\begin{aligned} \Gamma(Z^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0) &= [-2.48 \pm 1.50 \text{ (exp)} \pm 0.05 \text{ (theo)}] \text{ keV} \\ \Gamma(Z^0 \rightarrow H_1^0 H_1^0) &= [0.9 \pm 2.3 \text{ (exp)} \pm 0.5 \text{ (theo)}] \text{ keV} \end{aligned}$$

muon magnetic moment:

$$\Delta a_\mu^{\text{SUSY}} = [288 \pm 63 \text{ (exp)} \pm 79 \text{ (theo)}] \times 10^{-11}$$

LEP results:

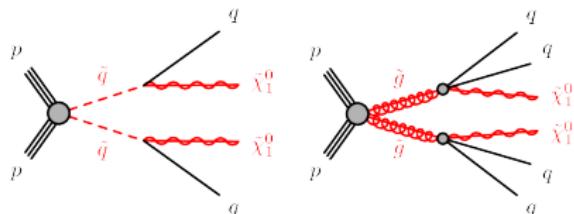
$$M(\tilde{\chi}_1^\pm) > 103.5 \text{ GeV}$$

$$M(H^\pm) > 78.6 \text{ GeV}$$

pair production cross section for light neutralinos

ATLAS' supersymmetry searches at 13 TeV

0-lepton analysis Eur. Phys. J. C 76 (2016) 392



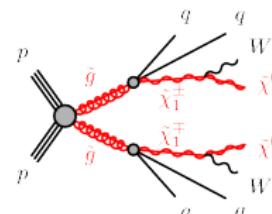
search for events with 2 to 6 jets,
missing E_T and no leptons

performed on 3.2 fb^{-1} of data collected at $\sqrt{s} = 13 \text{ TeV}$ in 2015

SR: four-jet tight (4jt)

$E_T^{\text{miss}} > 200 \text{ GeV}$	$\Delta\varphi(\vec{j}_{1\dots 3}, \vec{E}_T^{\text{miss}}) > 0.4$
$p_T(j_1) > 200 \text{ GeV}$	$\Delta\varphi(\vec{j}_{>3}, \vec{E}_T^{\text{miss}}) > 0.2$
$p_T(j_4) > 100 \text{ GeV}$	$E_T^{\text{miss}} / m_{\text{eff}}(N_j) > 0.2$
$A > 0.04$	$m_{\text{eff}}(\text{incl.}) > 2200 \text{ GeV}$

1-lepton analysis Eur. Phys. J. C 76 (2016) 565



search for events with 2 to 6 jets,
missing E_T and one isolated lepton

SR: five-jet hard-lepton (5j HL)

$E_T^{\text{miss}} > 250 \text{ GeV}$	$p_T(\ell) > 35 \text{ GeV}$
$p_T(j_1) > 225 \text{ GeV}$	$m_T > 125 \text{ GeV}$
$p_T(j_5) > 50 \text{ GeV}$	$E_T^{\text{miss}} / m_{\text{eff}}(\text{incl.}) > 0.1$
$A > 0.04$	$m_{\text{eff}}(\text{incl.}) > 1800 \text{ GeV}$

Tools

MCMC exploration

- **likelihood**: combine all experimental constraints including flat theory errors and Gaussian experimental errors to a likelihood distribution
- **SFitter**: perform a MCMC exploration of the NMSSM parameter space along this likelihood distribution
- **NMSSMTools**: compute Higgs and sparticle masses, couplings and decays in the NMSSM
- **micrOMEGAs**: compute relic density and direct detection cross sections of neutralino dark matter

MC event generation

- **MadGraph5_aMC@NLO**: compute cross section and generate hard events for $\tilde{g}\tilde{g}$, $\tilde{g}\tilde{q}$, $\tilde{q}\tilde{q}$ production
- **Pythia6**: sparticle decays and showering of hard events with the k_T -jet MLM scheme
- **Delphes**: fast simulation of ATLAS detector response
- **MadAnalysis**: apply ATLAS analyses (own implementation) to compare with upper limits from data

MCMC exploration: Normalized χ^2 for first grid

showing all configurations with right relic density and Higgs boson mass

First grid:

$$\lambda = 0.6$$

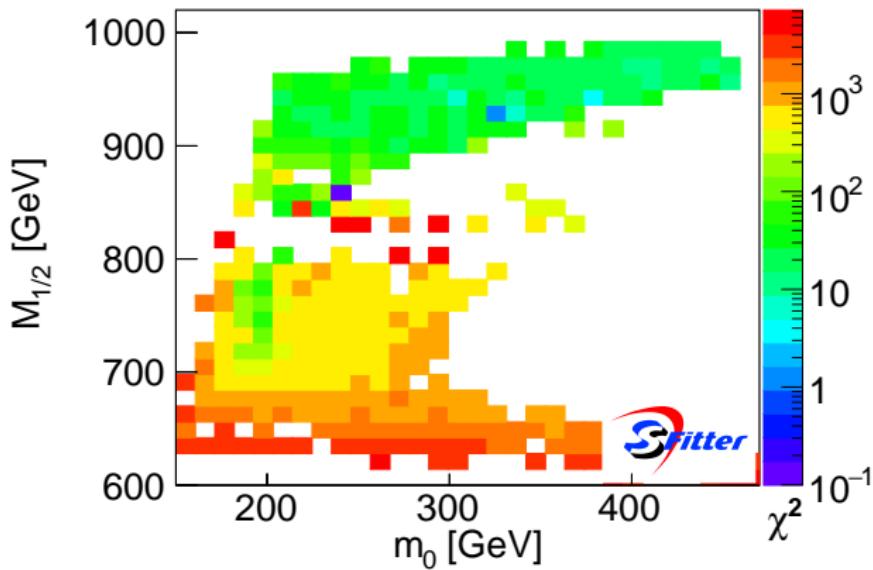
$$\kappa = 0.18$$

$$A_\lambda = 1400 \text{ GeV}$$

$$A_\kappa = 1488 \text{ GeV}$$

$$\tan \beta = 5.44$$

$$\mu_{\text{eff}} = 209 \text{ GeV}$$



- for too low m_0 , too light $\tilde{\tau}_1$ (LSP or too high Ωh^2 through coannihilations)
- for too high m_0 , too high Ωh^2
- for too high $M_{1/2}$, no 125 GeV Higgs boson
- for low $M_{1/2}$, too high direct detection cross section
- for too low A_0 , no 125 GeV Higgs boson

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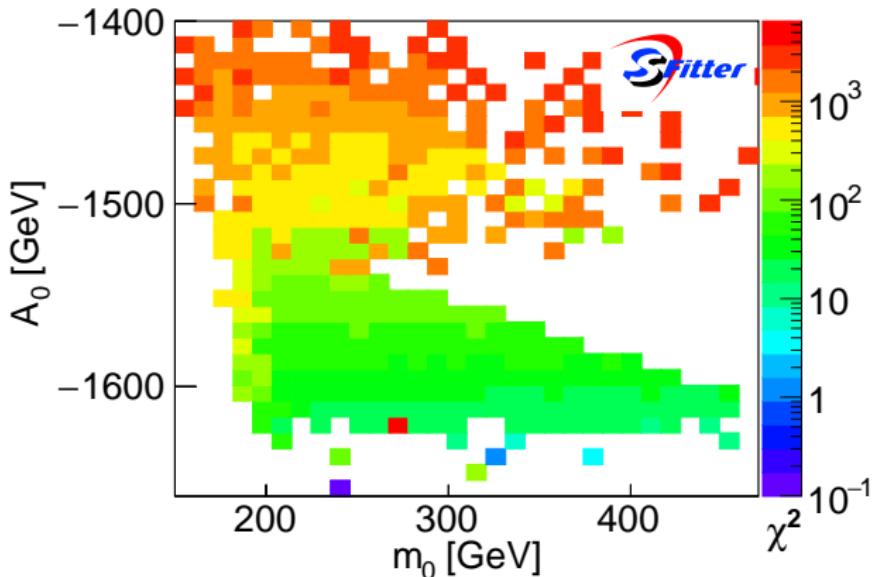
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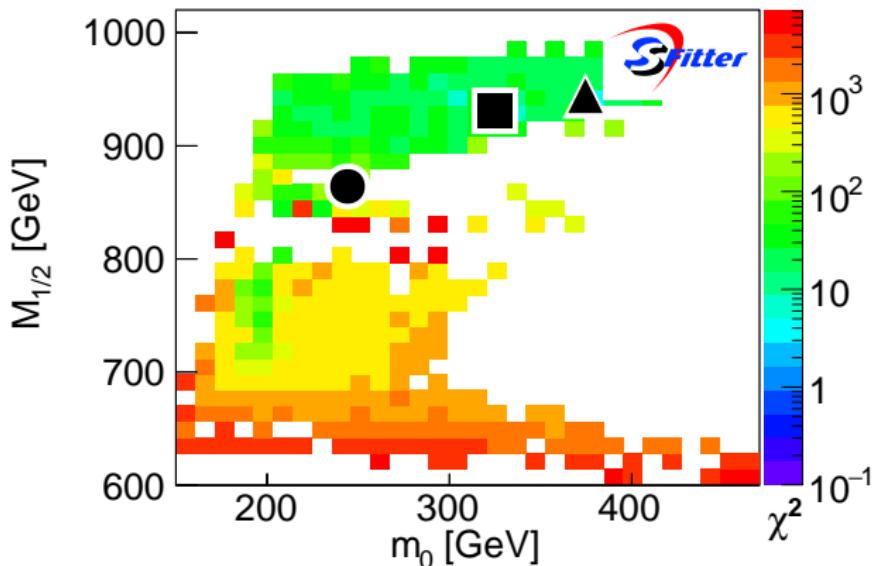
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MCMC exploration: Normalized χ^2 for second grid

showing all configurations with right relic density, Higgs boson mass and SI direct detection cross section

Second grid:

$$\lambda = 0.545$$

$$\kappa = 0.253$$

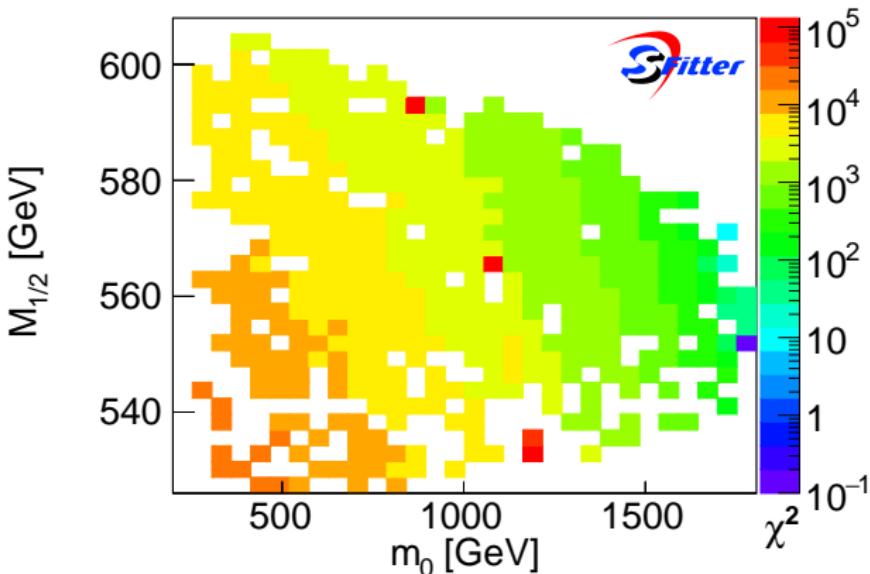
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$$\tan \beta = 2.4$$

$$\mu_{\text{eff}} = 120 \text{ GeV}$$

Ellwanger & Hugonie, Adv.
High Energy Physics 2012
(2012) 625389



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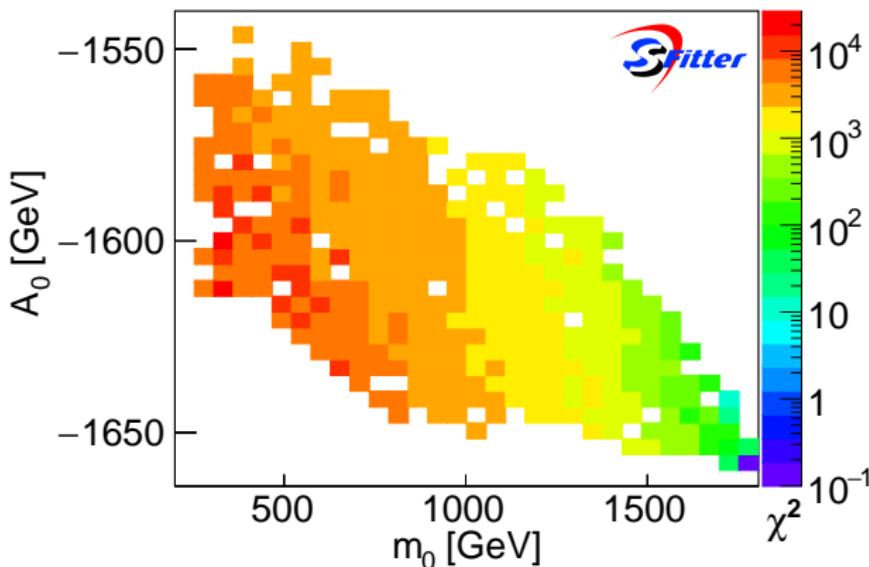
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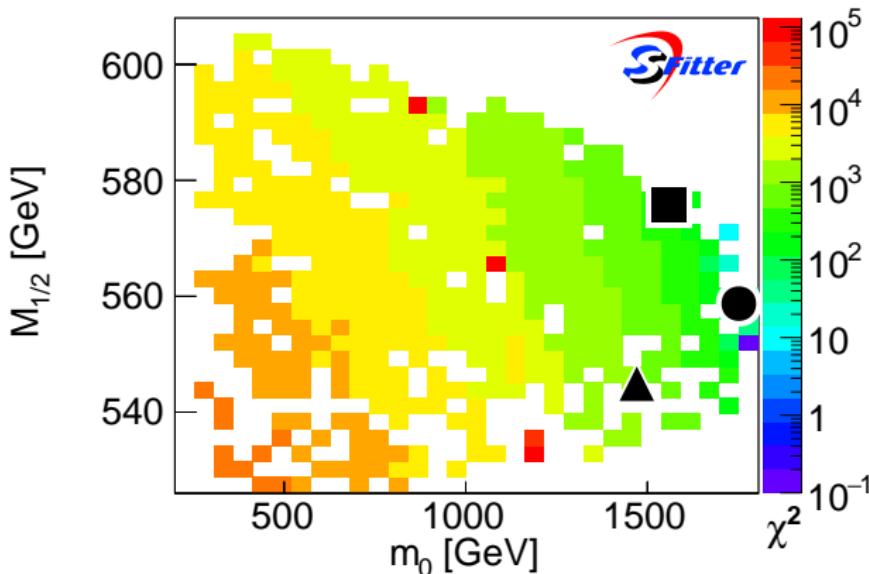
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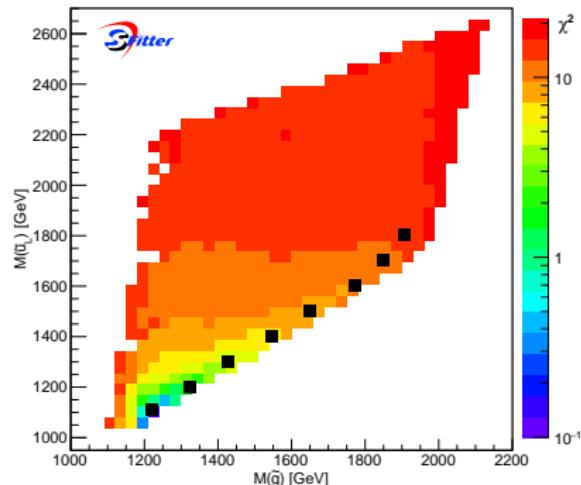
Event generation for benchmark configurations

	A1	A2	A3	B1	B2	B3
m_0 [GeV]	244.126	325.223	374.596	1751.26	1557.50	1470.56
$M_{1/2}$ [GeV]	864.158	931.364	944.247	558.720	575.842	544.903
A_0 [GeV]	-1652.06	-1641.61	-1637.38	-1656.11	-1622.02	-1639.32
$M(H_2^0)$ [GeV]	127.3	127.8	127.8	122.5	122.3	122.9
$M(\tilde{\chi}_1^0)$ [GeV]	108.8	109.6	109.7	76.4	77.0	75.4
$M(\tilde{g})$ [GeV]	1915	2055	2084	1370	1397	1327
$M(\tilde{u}_L)$ [GeV]	1744	1878	1911	2052	1919	1817
$M(\tilde{t}_1)$ [GeV]	674.7	816.9	848.5	676.8	643.7	568.9
$\sigma(pp \rightarrow jj)$ [fb]	20.12 ± 0.04	10.69 ± 0.03	9.20 ± 0.02	36.46 ± 0.08	40.75 ± 0.09	64.72 ± 0.12
$N_{\text{exp}}(4\text{jlxHL})$	2.45 ± 0.17	1.54 ± 0.10	1.39 ± 0.09	6.7 ± 0.5	7.9 ± 0.6	10.1 ± 0.7

- most sensitive search channel: signal region "four-jet low-x hard lepton" of the 1-lepton analysis
- compare to ATLAS model-independent upper limit of $N_{\text{obs}}(4\text{jlxHL}) \leq 3.9$
- ⇒ A1, A2, A3 not excluded, but expect sensitivity of future data
- ⇒ B1, B2, B3 already excluded by present ATLAS results
- other analyses like \tilde{t} searches might be more sensitive

Third grid

MCMC exploration



$$\tan \beta = 8.2 \quad A_\lambda = 1860.07 \text{ GeV}$$

$$\lambda = 0.3314 \quad A_\kappa = 314.14 \text{ GeV}$$

$$\kappa = 0.1195 \quad \mu_{\text{eff}} = 177.05 \text{ GeV}$$

- right dark matter relic density
- obey direct detection exclusion limits
- have SM-like H_2^0

Event generation

	$M(\tilde{g})$ [TeV]	$M(\tilde{q})$ [TeV]	$N(4\text{jt})$ 0-lepton	$N(5\text{j HL})$ 1-lepton
1	1.27	1.14	38.2	16.4
2	1.32	1.17	33.5	12.8
3	1.42	1.27	23.1	9.5
4	1.54	1.37	17.4	5.3
5	1.64	1.47	11.7	4.1
6	1.76	1.57	7.8	2.8
7	1.84	1.67	5.3	1.6
8	1.90	1.77	3.6	1.0
ATLAS upper limit			< 8.7	< 2.8

- H_1^0 : mass between 60 GeV and 72 GeV, $\sim 86\%$ singlet content
- χ_1^0 : mass between 108 GeV and 113 GeV, singlino–Higgsino
- \tilde{t}_1 : mass between 0.7 TeV and 1.3 TeV

Conclusions

- I found grids in semi-constrained NMSSM parameter space compatible with experimental constraints and accessible at LHC run 2.
- Such grids can be a good framework for the interpretation of future LHC SUSY searches like the ATLAS 0/1-lepton analyses.
- Complementary, future results of dark matter direct detection experiments will further probe the grids.
- More work needs to be done to identify parameter space regions with all the desired properties.

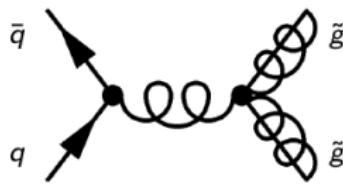
Monte Carlo Markov Chain: Metropolis–Hastings algorithm

- 1 randomly choose parameter configuration $\{p_1\}$
- 2 compute likelihood value \mathcal{L}_1 of $\{p_1\}$
- 3 take random step to new configuration $\{p_2\}$
- 4 compute likelihood value \mathcal{L}_2 of $\{p_2\}$
- 5
$$\begin{cases} \text{if } \mathcal{L}_2/\mathcal{L}_1 \geq 1, & \text{accept } \{p_2\}, \\ \text{if } \mathcal{L}_2/\mathcal{L}_1 < 1, & \text{draw a random number } x \in [0; 1] \text{ and} \\ & \begin{cases} \text{if } x \geq \mathcal{L}_2/\mathcal{L}_1, & \text{discard } \{p_2\}, \\ \text{if } x < \mathcal{L}_2/\mathcal{L}_1, & \text{accept } \{p_2\}, \end{cases} \end{cases}$$

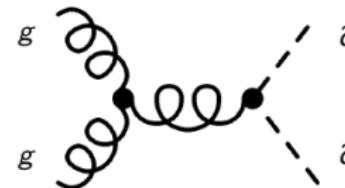
and start again with step 3

Squark and gluino production

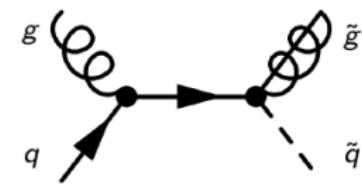
gluino pair production



squark pair production



associated production



	A1	A2	A3	B1	B2	B3
$\sigma(pp \rightarrow \tilde{g}\tilde{g}) [\text{fb}]$	0.42	0.18	0.15	16.79	13.86	21.99
$\sigma(pp \rightarrow \tilde{g}\tilde{q}) [\text{fb}]$	6.92	3.42	2.92	16.53	21.17	33.66
$\sigma(pp \rightarrow \tilde{q}\tilde{q}) [\text{fb}]$	12.78	7.09	6.13	3.14	5.72	9.07
$\sigma(pp \rightarrow \tilde{j}\tilde{j}) [\text{fb}]$	20.12 ± 0.04	10.69 ± 0.03	9.20 ± 0.02	36.46 ± 0.08	40.75 ± 0.09	64.72 ± 0.12
$N(\text{events})$	9991	9984	9985	9987	9990	9988

0-lepton analysis

Signal Region	2jl	2jm	2jt	4jt	5j	6jm	6jt
$E_T^{\text{miss}} [\text{GeV}] >$	200	200	200	200	200	200	200
$p_T(\text{jet 1}) [\text{GeV}] >$	200	300	200	200	200	200	200
$p_T(\text{jet 2}) [\text{GeV}] >$	200	50	200	100	100	100	100
$p_T(\text{jet 3}) [\text{GeV}] >$	–	–	–	100	100	100	100
$p_T(\text{jet 4}) [\text{GeV}] >$	–	–	–	100	100	100	100
$p_T(\text{jet 5}) [\text{GeV}] >$	–	–	–	–	100	100	100
$p_T(\text{jet 6}) [\text{GeV}] >$	–	–	–	–	–	100	100
$\Delta\varphi(\vec{\text{jet}}_{1\dots 3}, \vec{E}_T^{\text{miss}}) >$	0.8	0.4	0.8	0.4	0.4	0.4	0.4
$\Delta\varphi(\vec{\text{jet}}_{>3}, \vec{E}_T^{\text{miss}}) >$	–	–	–	0.2	0.2	0.2	0.2
$E_T^{\text{miss}} / \sqrt{H_T} [\text{GeV}^{1/2}] >$	15	15	20	–	–	–	–
$A >$	–	–	–	0.04	0.04	0.04	0.04
$E_T^{\text{miss}} / m_{\text{eff}}(N_j) >$	–	–	–	0.2	0.25	0.25	0.2
$m_{\text{eff}}(\text{incl.}) [\text{GeV}] >$	1200	1600	2000	2200	1600	1600	2000

1-lepton analysis

Signal Region	soft lepton		hard lepton			
	2j	5j	4jh	4jl	5j	6j
$p_T(\text{lepton}) [\text{GeV}]$	< 35, > 7(8)		> 35			
$p_T(\text{jet 1}) [\text{GeV}] >$	180	200	325	325	225	125
$p_T(\text{jet 2}) [\text{GeV}] >$	30	200	30	150	50	30
$p_T(\text{jet 3}) [\text{GeV}] >$	–	200	30	150	50	30
$p_T(\text{jet 4}) [\text{GeV}] >$	–	30	30	150	50	30
$p_T(\text{jet 5}) [\text{GeV}] >$	–	30	–	–	50	30
$p_T(\text{jet 6}) [\text{GeV}] >$	–	–	–	–	–	30
$E_T^{\text{miss}} [\text{GeV}] >$	530	375	200	200	250	250
$m_T [\text{GeV}] >$	100	–	425	125	275	225
$E_T^{\text{miss}} / m_{\text{eff}}(\text{incl.}) >$	0.38	–	0.3	–	0.1	0.2
$H_T [\text{GeV}] >$	–	1100	–	–	–	–
$m_{\text{eff}}(\text{incl.}) [\text{GeV}] >$	–	–	1800	2000	1800	1000
$A >$	–	0.02	–	0.04	0.04	0.04

ATLAS results

Signal Region	$\langle\epsilon\sigma\rangle_{\text{obs}}^{95}$ [fb]	S_{obs}^{95}
0-lepton		
2-jet loose	16	44
2-jet medium	15	48
2-jet tight	5.2	17
4-jet tight	2.7	8.7
5-jet	1.7	5.4
6-jet medium	1.7	5.4
6-jet tight	1.6	5.0

Signal Region	$\langle\epsilon\sigma\rangle_{\text{obs}}^{95}$ [pb]	S_{obs}^{95}
soft-lepton		
2-jet	1.33	4.3
5-jet	2.87	9.2
hard-lepton		
4-jet low-x	1.23	3.9
4-jet high-x	0.87	2.8
5-jet	0.87	2.8
6-jet	3.90	12.5

95 % C. L. upper limits on the visible cross section and on the number of signal events for the 0-lepton and 1-lepton channels of the ATLAS analysis with 3.2 fb^{-1} of 13 TeV data.

Predicted number of events

		zero-lepton signal regions		hard-lepton signal regions	
		4-jet tight	5-jet	4-jet low- x	5-jet
A1	ϵ [%]	4.10 ± 0.20	1.22 ± 0.11	3.80 ± 0.19	2.20 ± 0.15
	$\epsilon\sigma$ [fb]	0.83 ± 0.04	0.246 ± 0.022	0.77 ± 0.04	0.44 ± 0.03
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	2.64 ± 0.18	0.79 ± 0.08	2.45 ± 0.17	1.42 ± 0.12
A2	ϵ [%]	4.74 ± 0.21	1.54 ± 0.12	4.51 ± 0.21	2.41 ± 0.15
	$\epsilon\sigma$ [fb]	0.506 ± 0.023	0.165 ± 0.013	0.482 ± 0.022	0.258 ± 0.016
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	1.62 ± 0.11	0.53 ± 0.05	1.54 ± 0.10	0.83 ± 0.07
A3	ϵ [%]	5.51 ± 0.23	1.86 ± 0.14	4.73 ± 0.21	2.49 ± 0.16
	$\epsilon\sigma$ [fb]	0.507 ± 0.021	0.171 ± 0.012	0.435 ± 0.020	0.229 ± 0.014
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	1.62 ± 0.11	0.55 ± 0.05	1.39 ± 0.09	0.73 ± 0.06
B1	ϵ [%]	6.73 ± 0.25	3.15 ± 0.17	5.74 ± 0.23	3.87 ± 0.19
	$\epsilon\sigma$ [fb]	2.45 ± 0.10	1.15 ± 0.07	2.09 ± 0.09	1.41 ± 0.07
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	7.9 ± 0.5	3.68 ± 0.27	6.7 ± 0.5	4.5 ± 0.4
B2	ϵ [%]	6.90 ± 0.25	3.00 ± 0.17	6.09 ± 0.24	4.00 ± 0.20
	$\epsilon\sigma$ [fb]	2.81 ± 0.11	1.22 ± 0.07	2.48 ± 0.10	1.63 ± 0.08
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	9.0 ± 0.6	3.9 ± 0.3	7.9 ± 0.6	5.2 ± 0.4
B3	ϵ [%]	5.67 ± 0.23	2.53 ± 0.16	4.86 ± 0.22	3.47 ± 0.18
	$\epsilon\sigma$ [fb]	3.67 ± 0.15	1.64 ± 0.11	3.14 ± 0.14	2.25 ± 0.12
	$\epsilon\sigma \cdot 3.2 \text{ fb}^{-1}$	11.7 ± 0.8	5.3 ± 0.5	10.1 ± 0.7	7.2 ± 0.6
$\langle \epsilon\sigma \rangle_{\text{obs}}^{95}$ [fb]		2.7	1.7	1.23	0.57
S_{obs}^{95}		8.7	5.4	3.9	2.8

Benchmark configurations: Higgs sector

	A1	A2	A3	B1	B2	B3
$M(H_1^0)$ [GeV]	115.3	118.0	118.5	94.6	96.9	94.9
S_{11}^2 [%]	2.6	2.9	3.0	13.7	13.7	14.0
S_{12}^2 [%]	20.5	28.2	29.6	7.8	7.4	8.4
S_{13}^2 [%]	76.9	68.9	67.4	78.5	79.0	77.7
$M(H_2^0)$ [GeV]	127.3	127.8	127.8	122.5	122.3	122.9
S_{21}^2 [%]	1.4	1.1	1.0	8.2	8.3	7.8
S_{22}^2 [%]	76.2	68.6	67.1	76.2	76.7	75.8
S_{23}^2 [%]	22.4	30.4	31.9	15.6	15.0	16.4
$M(H_3^0)$ [GeV]	1170	1170	1169	327.9	326.2	328.9
$M(A_1^0)$ [GeV]	129.8	120.7	118.9	137.0	132.7	135.9
$M(A_2^0)$ [GeV]	1169	1169	1168	320.0	318.1	320.8
$M(H^\pm)$ [GeV]	1164	1164	1163	314.0	312.1	314.7

Benchmark configurations: Dark matter sector

	A1	A2	A3	B1	B2	B3
$M(\tilde{\chi}_1^0)$ [GeV]	108.8	109.6	109.7	76.4	77.0	75.4
N_{11}^2 [%]	0.9	0.7	0.7	4.8	4.5	5.2
N_{12}^2 [%]	0.6	0.5	0.5	3.0	2.8	3.2
$N_{13}^2 + N_{14}^2$ [%]	33.4	33.1	33.0	71.9	72.1	71.7
N_{15}^2 [%]	65.1	65.7	65.8	20.3	20.6	19.9
$M(\tilde{\chi}_2^0)$ [GeV]	235.3	236.1	236.2	153.1	153.0	152.9
$M(\tilde{\chi}_3^0)$ [GeV]	235.9	237.0	237.3	161.3	161.6	160.9
$M(\tilde{\chi}_4^0)$ [GeV]	375.2	403.6	409.1	249.7	256.1	243.3
$M(\tilde{\chi}_5^0)$ [GeV]	708.6	762.9	773.8	480.4	491.9	467.7
$M(\tilde{\chi}_1^\pm)$ [GeV]	205.6	206.7	206.9	107.9	108.3	107.1
$M(\tilde{\chi}_2^\pm)$ [GeV]	708.5	762.9	773.7	480.1	491.2	467.4
$\Omega(\tilde{\chi}_1^0)h^2$	0.105 09	0.105 34	0.105 19	0.105 35	0.106 00	0.107 51
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow W^+ W^-$ [%]	35	34	34	10	15	6
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow Z^0 Z^0$ [%]	16	16	16	–	–	–
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow Z^0 H_1^0$ [%]	15	12	11	–	–	–
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow Z^0 H_2^0$ [%]	18	22	22	–	–	–
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow q\bar{q}$ [%]	10	10	10	64	60	68
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow \ell^+ \ell^-$ [%]	–	–	–	10	10	10
$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \leftrightarrow \nu\bar{\nu}$ [%]	3	3	3	15	15	15

Benchmark configurations: Other sparticles

	A1	A2	A3	B1	B2	B3
$M(\tilde{g})$ [GeV]	1915	2055	2084	1370	1397	1327
$M(\tilde{d}_L)$ [GeV]	1746	1880	1912	2053	1920	1818
$M(\tilde{d}_R)$ [GeV]	1665	1793	1824	2019	1884	1783
$M(\tilde{u}_L)$ [GeV]	1744	1878	1911	2052	1919	1817
$M(\tilde{u}_R)$ [GeV]	1709	1841	1873	2098	1957	1854
$M(\tilde{b}_1)$ [GeV]	1354	1480	1509	1503	1416	1332
$M(\tilde{b}_2)$ [GeV]	1654	1781	1813	2014	1880	1778
$M(\tilde{t}_1)$ [GeV]	674.7	816.9	848.5	676.8	643.7	568.9
$M(\tilde{t}_2)$ [GeV]	1388	1511	1539	1516	1431	1348
$M(\tilde{e}_L)$ [GeV]	664.4	740.5	771.8	1826	1639	1549
$M(\tilde{e}_R)$ [GeV]	200.1	285.9	337.5	1668	1479	1395
$M(\tilde{\nu}_{eL})$ [GeV]	660.1	736.7	768.1	1825	1638	1547
$M(\tilde{\tau}_1)$ [GeV]	168.4	264.1	319.1	1666	1478	1394
$M(\tilde{\tau}_2)$ [GeV]	660.1	736.6	768.0	1825	1638	1548
$M(\tilde{\nu}_{\tau L})$ [GeV]	655.7	732.7	764.2	1824	1637	1547

Benchmark configurations: Constraints

	A1	A2	A3	B1	B2	B3
$\sigma^{\text{SI}} [\text{zb}]$	1.0001	0.9719	0.9921	0.0744	0.1640	0.2107
$\sigma_p^{\text{SD}} [\text{fb}]$	1.9588	1.9711	1.9729	2.7873*	2.8782*	2.6986*
$\sigma_n^{\text{SD}} [\text{fb}]$	1.4977*	1.5071*	1.5085*	2.1307*	2.2002*	2.0627*
$\text{BR}(B \rightarrow X_s \gamma) [10^{-4}]$	2.9200	3.3117	3.2985	4.2633*	4.2436*	4.1884
$\text{BR}(B_s^0 \rightarrow \mu^+ \mu^-) [10^{-9}]$	3.4699*	3.4759*	3.4771*	2.0832*	2.0744*	2.0577*
$\text{BR}(B^+ \rightarrow \tau^+ \nu_\tau) [10^{-4}]$	1.0688	1.0688	1.0688	1.0667	1.0667	1.0667
$\Delta M(B_d) [\text{ps}^{-1}]$	0.53746	0.53459	0.53411	0.57423*	0.57602*	0.58009*
$\Delta M(B_s) [\text{ps}^{-1}]$	19.084	18.982	18.965	20.390*	20.453*	20.598*
$\Delta a_\mu^{\text{SUSY}} [10^{-10}]$	1.4469*	1.3866*	1.3770*	0.2182*	0.2543*	0.2686*