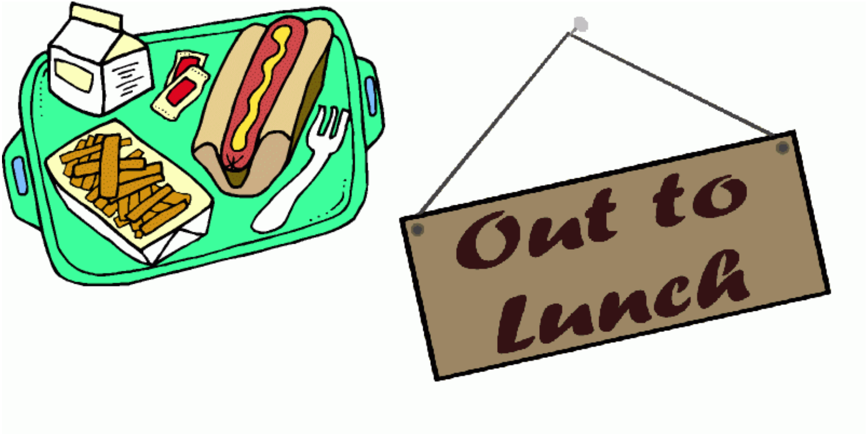

Out to
Lunch

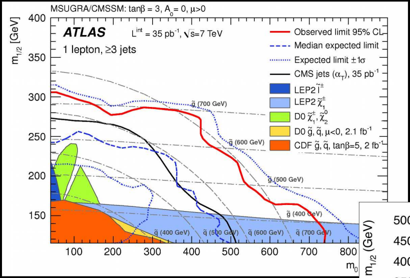
Supersymmetry Without Prejudice at 7 TeV

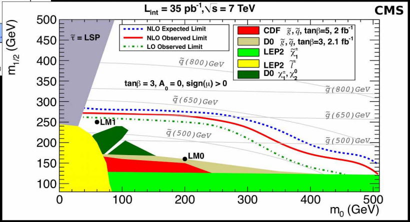
James S. (Jamie) Gainer
Argonne/ Northwestern

UC Davis LHC Lunch
February 25, 2011

In 2010 the LHC recorded $\sim 48\ \mathrm{pb}^{-1}$ at 7 TeV

Not Looking Good For SUSY?





Not Looking Good For SUSY?

- Strumia.
  The Fine-tuning price of the early LHC.
  CMSSM.
  1101.2195

- Allanach.
  Impact of CMS Multi-jets and Missing Energy Search on CMSSM Fits.
  CMSSM.
  1102.3149

- Scopel, Choi, Fornengo, Bottino.
  Impact of the recent results by the CMS and ATLAS Collaborations at the CERN Large Hadron Collider on an effective Minimal Supersymmetric extension of the Standard Model.
  9 parameter pMSSM, a particular scenario.
  1102.4033

- Buchmueller, Cavanaugh, Colling, De Roeck, Dolan, Ellis, Flacher, Heinemeyer, Isidori, Olive, Rogerson, Ronga, Weiglein.
  Implications of Initial LHC Searches for Supersymmetry.
  (CMSSM, NUHM1, VCMSSM, mSUGRA).
  1102.4585

..

- Maybe.
- But the MSSM has 105 parameters.
- Most work/ recent limits has been done in scenarios with many fewer parameters (mSUGRA, CMSSM, etc.)

- The way one often deals with the large number of parameters in the MSSM is to choose (or devise) a particular model of SUSY breaking.
- Advantages:
  - Small number of parameters: can rule out parameter space.
  - Easier to set limits.
  - Predictive.
  - May tell us something about physics at very high energies.

- Disadvantage: we may not have thought of the way SUSY is broken in nature.

- Want to understand the impact of 2010/2011 LHC running in a less-model dependent way.

- Would like to consider as general of an MSSM parameter space as possible.

In principle, it would be best to scan the entire MSSM parameter space.

However the 105 parameters of the MSSM are too many to work with.

Also many parameters are strongly limited by flavor physics and do not have a strong effect on (at least early-ish) LHC physics.

- Assume
  - **CP conservation** (removes phases)
  - **Minimal Flavor Violation** (removes off-diagonal terms in mass matrices)
  - **1st and 2nd generation sfermion masses are degenerate** (reduces number of mass parameters)
  - **1st and 2nd generation trilinear couplings negligible** (removes A_e, A_μ, A_u, A_d by setting $= 0$.)
- Hopefully we are still exploring SUSY without **TOO MUCH** prejudice.
- End up with the **pMSSM** (phenomenological MSSM).

- # 19 Parameters
- Gaugino masses: M_1, M_2, M_3
- Sfermion masses: $m_{q1,2}, m_{u1,2}, m_{d1,2}, m_{l1,2}, m_{e1,2}, m_{q3}, m_{u3}, m_{d3}, m_{l3}, m_{e3}$.
- 3rd generation trilinears: A_t, A_b, A_τ
- Higgs/ Higgsino parameters: $\mu, m_A, \tan\beta$
- **Notes:** All parameters specified $\sim$ the weak scale.

No high scale assumptions.

- Choose random points in an MSSM parameter space (described on the past few slides).
- Calculate observables for each parameter space point.
- Determine, using these observables, whether the model is allowed by existing theoretical, observational, and experimental constraints.
- Obtain a set of viable "models". One can then characterize these models or study e.g. their signatures at the 7 TeV LHC.

Berger, JSG, Hewett, Rizzo. 0812.0980.

Flat Priors 10^7 points

$$
\begin{aligned}
100\,\mathrm{GeV} \le m_{\tilde{f}} &\le 1\,\mathrm{TeV}\,,\\
50\,\mathrm{GeV} \le |M_{1,2}, \mu| &\le 1\,\mathrm{TeV}\,,\\
100\,\mathrm{GeV} \le M_3 &\le 1\,\mathrm{TeV}\,,\\
|A_{b,t,\tau}| &\le 1\,\mathrm{TeV}\,,\\
1 \le \tan\beta &\le 50\,,\\
43.5\,\mathrm{GeV} \le m_A &\le 1\,\mathrm{TeV}\,.
\end{aligned}
$$

Log Priors 2×10^6 points

$$
\begin{aligned}
100\,\mathrm{GeV} \le m_{\tilde{f}} &\le 3\,\mathrm{TeV}\,,\\
10\,\mathrm{GeV} \le |M_{1,2}, \mu| &\le 3\,\mathrm{TeV}\,,\\
100\,\mathrm{GeV} \le M_3 &\le 3\,\mathrm{TeV}\,,\\
10\,\mathrm{GeV} \le |A_{b,t,\tau}| &\le 3\,\mathrm{TeV}\,,\\
1 \le \tan\beta &\le 60\,,\\
43.5\,\mathrm{GeV} \le m_A &\le 3\,\mathrm{TeV}\,.
\end{aligned}
$$

We take SM parameters as given.

For each parameter point, we calculate the SUSY spectrum using **SuSpect** (as interfaced by **micrOMEGAs** for convenience in calculating other observables).

We then applied the constraints...

- LSP is lightest neutralino.
- No tachyons, CCB vacua.
- Higgs potential bounded from below.
- LSP thermal relic density satisfies WMAP limit,
  but we **DO NOT** demand that the LSP be the dominant component of the dark matter
  (e.g. axions could be dominant dark matter species).
- Contribution to invisible width of the Z less than 2 MeV (LEP).

Demanded

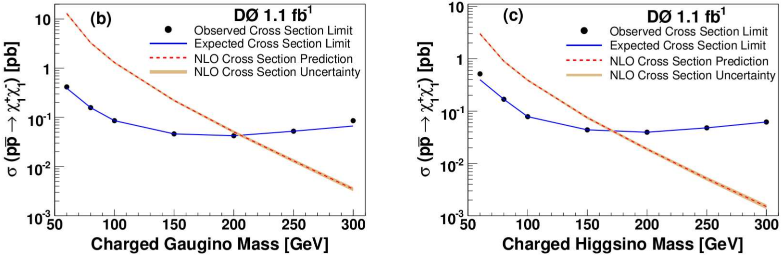
- $\Delta\rho$
- $b \to s\gamma$
- $B \to \mu\mu$
- $g - 2$
- $B \to \tau\nu$

be in range allowed by experiments. (Most of these were calculated with micrOMEGAs).

Also implemented direct search constraints from LEP and Tevatron:

- LEP charged particles. Constraint on charged particle mass as a function of LSP mass. (Light charged particles with soft decay products may evade LEP limits. Stronger limits on “detector stable” particles.)
- LEP Higgs. Constraints on ZZh coupling versus branching ratios to $b\bar{b}$, $\tau^+\tau^-$ for each Higgs. Constraints strongest for light CP even Higgs.
- Tevatron Higgs. Constraint on M_A versus $\tan\beta$.

We implement D0 constraints on charginos that are stable on detector length scales, interpolating between limits on Wino and Higgsino type charginos.



0809.4472[hep-ex]

- We also implement Tevatron constraints obtained from limits on trilepton and jet plus missing energy events.
- Use PYTHIA/PGS to simulate $\sim 2.1\ \text{fb}^{-1}$ of data.
- Use Prospino to calculate K-factors.
- Use SUSY-HIT for the decay table.
- Trilepton constraints: CDF (arXiv:0808.2446 [hep-ex]).
- Jet plus missing energy constraints: D0 (arXiv:0712.3805 [hep- ex]).
- Validate procedure by comparing signal rate obtained using our procedure with than obtained for benchmark models by CDF, D0.
- Models ruled out if non-observance (or ~ 1 event) of process at Tevatron rules out the model at 95% confidence level.

Finally, we use micrOMEGAs to calculate the spin-independent and spin-dependent WIMP-proton and WIMP-neutron cross sections and implement bounds on WIMP-nucleon cross section.

Stronger constraint is from the spin-independent cross section.

Main experimental limits for our LSP mass range are from XENON10 and CDMS (for lower LSP masses, the limits would be from CRESST and DAMA).

- We allowed for factor of 4 uncertainty in cross section.
- This is due to uncertainties in nuclear form factors, strange content of the proton, etc.
- Cross section scaled to LSP fraction of DM $(\Omega h^2)_{LSP}/(\Omega h^2)_{WMAP}$.

Q: Are There New Possibilities* in this Set of Models?

*Mass heirarchies, etc. that do not show up in more constrained SUSY scenarios.

A: Yes!

Brief Summary of SUSY Scan Results

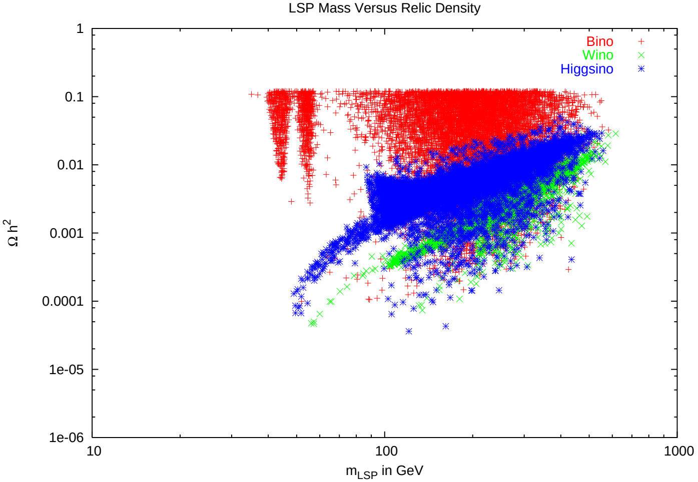
Focusing on results most relevant for LHC

- We find that $\sim$ 68,000 models out of the 10,000,000 flat prior points chosen satisfy all existing constraints.
- For logarithmic priors, $\sim$ 2000 models out of 2,000,000 satisfy all constraints.

LSP Type	Definition	Fraction of Models
Bino	$\|Z_{11}\|^2 > 0.90$	0.156
Wino	$\|Z_{12}\|^2 > 0.90$	0.186
Higgsino	$\|Z_{13}\|^2 + \|Z_{14}\|^2 > 0.90$	0.393
All other models		0.265

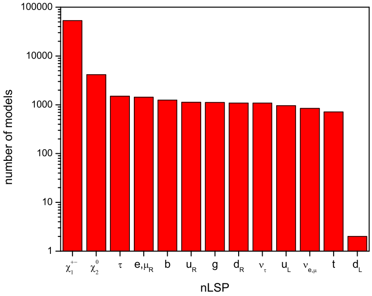
The majority of models in our pMSSM sample have LSPs which are relatively pure gaugino/Higgsino eigenstates.

Many models with Wino LSP (less often considered) or Higgsino LSP (even less often considered).



Higgsino and Wino LSPs prevalent because **relic density** allowed to be less than WMAP value.

NLSP Properties



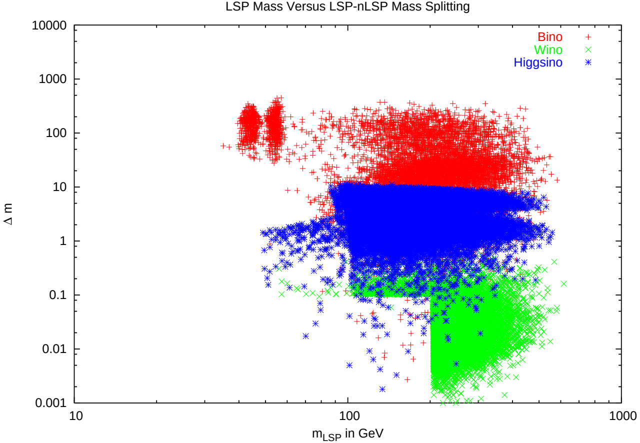
NLSP distribution by sparticle

Large number of models with chargino NLSP due to Wino, Higgino LSPs.

Large number of models with neutralino NLSP due to Higgsino LSPs.

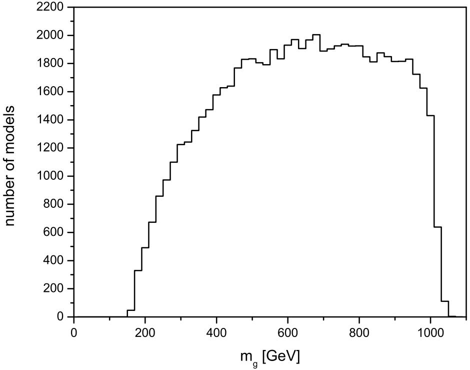
Any other sparticle which can be the NLSP is in $\sim$ 1000 models.

LSP mass versus NLSP-LSP Mass Splitting



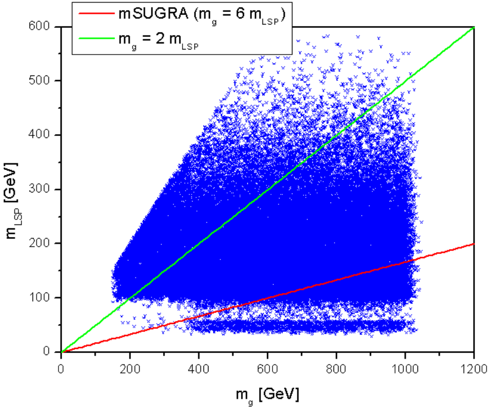
Mass Splittings are often small.

Gluino Mass Distribution



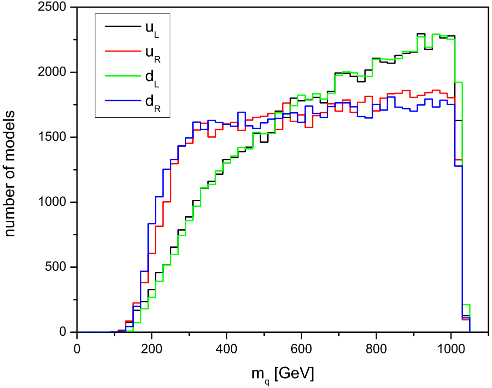
Gluino mass distribution: gluinos can be light!
(PDG bound 308 GeV, assumes gaugino mass unification.)

Gluino Mass Distribution



LSP mass versus gluino mass: not mSUGRA anymore!
This helps explain why relatively light gluinos are actually allowed by all existing constraints.

Squark Masses



Squark mass distribution: squarks can be light.

PDG bound (degenerate squarks, particular value of μ and tan β) is 379 GeV.)

They can evade Tevatron constraints due to soft decay products.

New Mass Hierarchies

- Feldman, Liu, and Nath find $\sim$ 22 mass hierarchies for the 4 lightest sparticles, non-SM Higgses in mSUGRA. (0707.1873, 0802.4085, 0711.4591).
- In our flat prior case, we have 1109 such hierarchies; 269 in the log prior case.
- Suggests our model set contains many new possibilities for LHC physics.

Linear Priors		Log Priors	
Mass Pattern	% of Models	Mass Pattern	% of Models
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\chi}_3^0$	9.82	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\chi}_3^0$	18.59
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\ell}_R$	5.39	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\nu}_\tau$	7.72
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\tau}_1$	5.31	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\ell}_R$	6.67
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\nu}_\tau$	5.02	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\tau}_1$	6.64
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{b}_1$	4.89	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{d}_R$	5.18
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{d}_R$	4.49	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\nu}_\ell$	4.50
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{u}_R$	3.82	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{b}_1$	3.76
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{g}$	2.96	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{g}$	3.73
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\nu}_\ell$	2.67	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{u}_R$	2.74
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{u}_L$	2.35	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\nu}_\tau < \tilde{\tau}_1$	2.27
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\nu}_\tau < \tilde{\tau}_1$	2.19	$\tilde{\chi}_1^0 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_3^0$	2.24
$\tilde{\chi}_1^0 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_3^0$	2.15	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\ell}_R < \tilde{\chi}_2^0$	1.42
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < A$	2.00	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{u}_L$	1.32
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{t}_1$	1.40	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0$	1.22
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\nu}_\ell < \tilde{\ell}_L$	1.37	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\tau}_1 < \tilde{\chi}_2^0$	1.19
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\tau}_1 < \tilde{\chi}_2^0$	1.35	$\tilde{\chi}_1^0 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm < \tilde{\nu}_\tau$	1.15
$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\ell}_R < \tilde{\chi}_2^0$	1.32	$\tilde{\chi}_1^0 < \tilde{\ell}_R < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0$	1.05

- Our model set contains many models with Wino, Higgsino LSPs.
- This leads to many chargino, neutralino NLSPs.
- There are a reasonable number of models with any allowed NLSP.
- Gluinos and squarks may be lighter than in mSUGRA.
- Many possibilities for mass ordering of particles.

Q: What Do These Models Tell Us About Early LHC SUSY Discoveries or Exclusions?

- To understand how well existing SUSY searches would do for the models in our model set, we simulated each model at 7 TeV.
- Then applied inclusive SUSY analyses from ATL-PHYS-PUB-2010-010.
- Conley, JSG, Hewett, Le, Rizzo. 1103.1697
- The 10 analyes are $\{2, 3, 4\}$ jets $\times\{0, 1, 2$ opposite sign $\}$ leptons, and SSDL + 2 jets.

Jets

Number of jets	≥ 2	≥ 3	≥ 3
Leading jet p_T (GeV)	> 180	> 100	> 100
Other jets p_T (GeV)	> 50	> 40	> 40
min. $\Delta\phi(\mathrm{jet}_i, E_T^{\mathrm{miss}})$	$0.2, 0.2$	$0.2, 0.2, 0.2$	$0.2, 0.2, 0$
$E_T^{\mathrm{miss}} > f \times M_{\mathrm{eff}}$	$f = 0.3$	$f = 0.25$	$f = 0.2$

Transverse sphericity (S_T) > 0.2


- Crack Veto: events with electrons with $1.37 < |\eta| < 1.52$.
- Zero Leptons: no leptons with $p_T > 20$ GeV.
- 1 Lepton: 1 lepton with $p_T > 20$ GeV. No other leptons with $p_T > 10$ GeV.
- OSDL: Exactly two leptons with $p_T > 10$ GeV (with opposite charge!)
- $E_T^{\mathrm{miss}} > 80$ GeV

- Two leptons with $p_T > 20$ GeV and same charge and $m_{\ell\ell} > 5$ GeV.
- No additional lepton with $p_T > 10$ GeV.
- Two jets with transverse momenta $p_T > 80$ GeV.
- Missing transverse energy $E_T^{\mathrm{miss}} > 80$ GeV.
- Transverse mass computed with the leading lepton, $M_T > 80$ GeV.

For each model (of $\sim 70,000$!):

- Generate SUSY spectrum with SuSpect and decay table with SUSY-HIT (modified to take first and second generation fermion masses into account).
- Generate K-factors with Prospino
- Generate at least 10 and at most 10^4 events for each of 85 processes (e.g. $pp \rightarrow \tilde{g}\tilde{g}$ with PYTHIA and ATLAS-tuned PGS.
- Pass PGS events for each process through ATLAS analyses.
- Take analysis results for each process, weight by K factor, and combine into results for model.

Comparison to ATLAS SUSY analyses

We use ATLAS analyses primarily so that we can use their backgrounds rather than calculating our own.

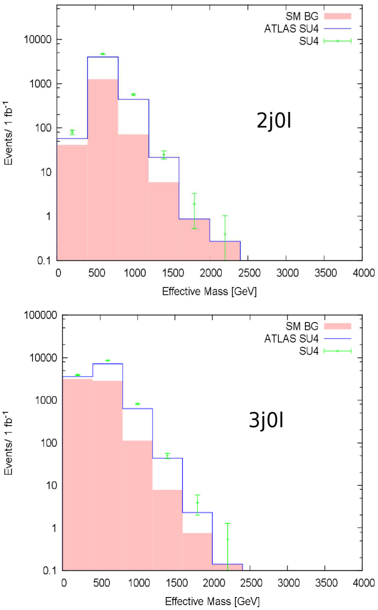
However, we couldn't generate signal events in exactly the same method as ATLAS.

	ATLAS	**Us**
Spectrum & decays	ISASUGRA	SUSY-HIT[1]
Event generation, hadronization, and showering	HERWIG	PYTHIA
K-factors	Prospino	Prospino[2]
Detector simulation	full GEANT	PGS4 LHC tune
Backgrounds	Generated large set of SM processes	Obtained from ATLAS

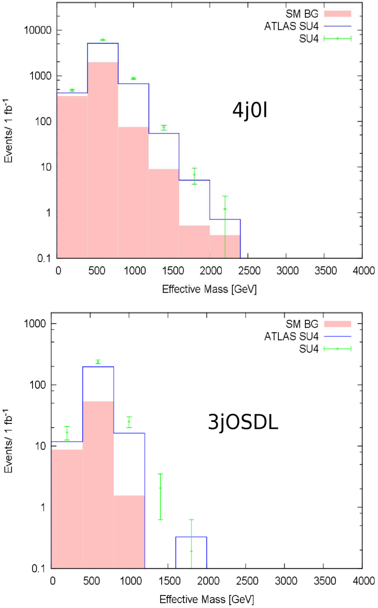
[1] several bugs/ features fixed
[2] one bug fixed

- Using ATLAS backgrounds makes life easier.
- However it makes it very important to verify signal generation procedure.
- Should agree with ATLAS.
- ATLAS used a set of mSUGRA models as benchmarks in the analyses they presented.
- One of these was SU4 (great name!).
- In the next few slides I will show ATLAS results for these analyses for this benchmark models together with our results for the same benchmark model for our analyses.

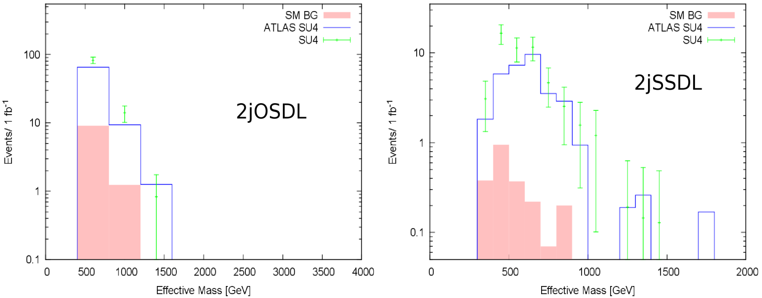
Verification of Signal Generation Procedure



Verification of Signal Generation Procedure



Verification of Signal Generation Procedure



- Following the procedure used in ATLAS studies
- We first total all background and signal events above an optimized (steps of 400 GeV $M_{\rm eff}$ cut).
- Then compute the probability p that the number of observed "signal" events can be produced by a background fluctuation.
- Systematic error on the background is Gaussian and statistical error is described by Poisson statistics

$$p = A \int_0^\infty db\, G(b; N_b; \delta N_b) \sum_{i=N_{\rm data}}^{\infty} \frac{e^{-b} b^i}{i!} \,, \qquad (1)$$

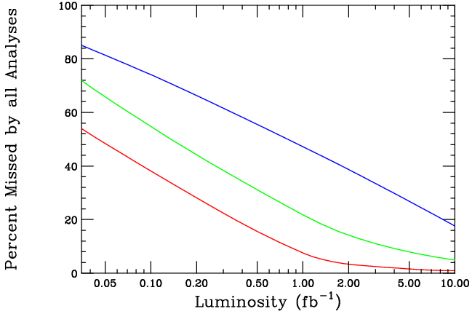
- N_b is the number of background events
- δN_b is the associated systematic error
- $N_{\rm data} = N_b + N_{\rm signal}$ is the total number of events above the $M_{\rm eff}$ cut.
- G is a Gaussian distribution
- A is a normalization factor.

Significance is then given by

$$Z_n = \sqrt{2}{\rm erf}^{-1}(1 - 2p) \,. \qquad (2)$$

The value of δN_b, the systematic error on the background that one assumes, has a large impact on whether models are discovered at 5 σ.

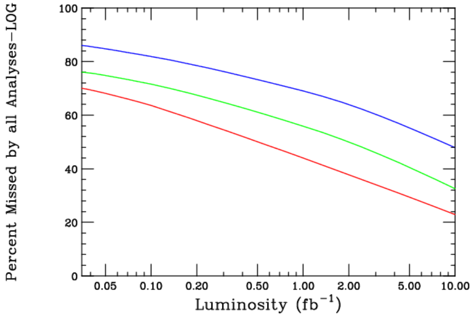
Results: Models Not Discovered



..

- Fraction of flat prior models which are completely missed after combining all of the ATLAS E_T^{miss} analyses.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

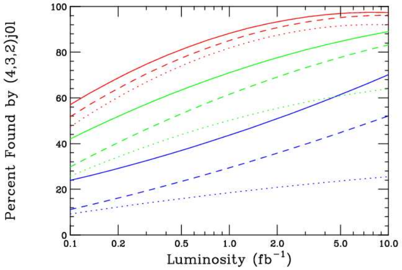
Results: Models Not Discovered



..

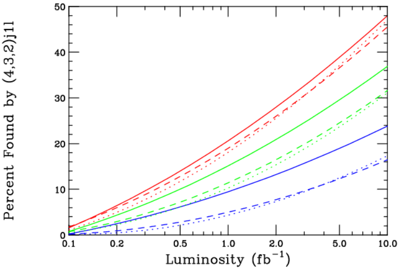
- Fraction of log prior models which are completely missed after combining all of the ATLAS E_T^{miss} analyses.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: Jets, No Leptons (flat priors)



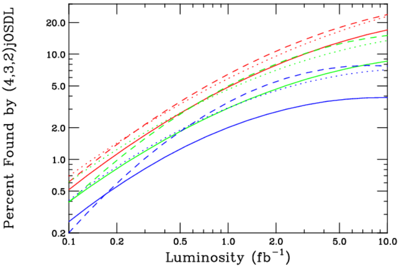
- Fraction of flat prior models found with $S \geq 5$ in the nj0l analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: Jets, 1 Lepton (flat priors)



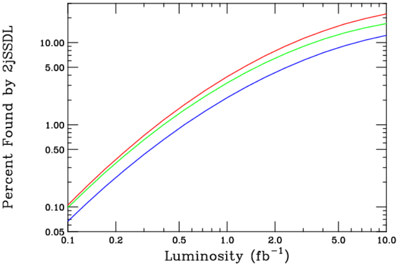
- Fraction of flat prior models found with $S \geq 5$ in the nj1l analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: OSDL (flat priors)



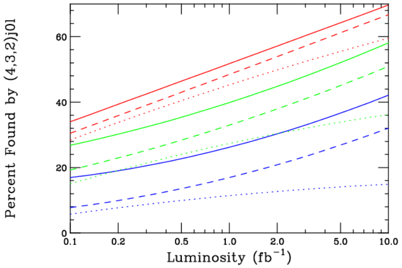
- Fraction of flat prior models found with $S \geq 5$ in the njOSDL analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: SSDL (flat priors)



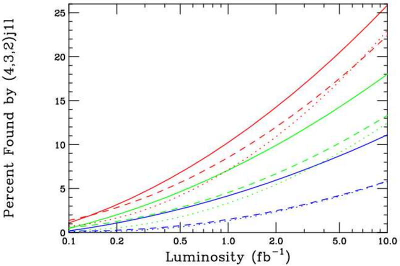
- Fraction of flat prior models found with $S \geq 5$ in the 2jSSDL analyses as a function of the integrated luminosity.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: Jets, No Lepton, (log prior)



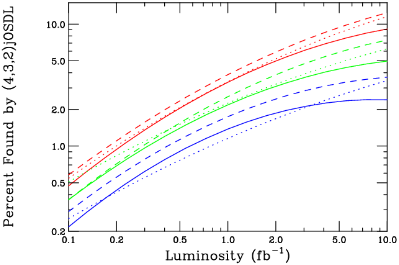
- Fraction of log prior models found with $S \geq 5$ in the nj0l analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: Jets, One Lepton, (log prior)

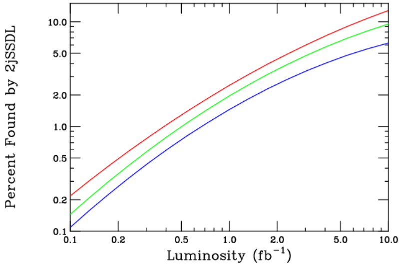


- Fraction of log prior models found with $S \geq 5$ in the nj1l analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

Results: OSDL (log prior)



- Fraction of log prior models found with $S \geq 5$ in the njOSDL analyses as a function of the integrated luminosity.
- The solid(dashed, dotted) curves in each case correspond to n=4(3,2), respectively.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.



- Fraction of log prior models found with $S \geq 5$ in the 2jSSDL analyses as a function of the integrated luminosity.
- The red(green, blue) curves correspond to background systematic uncertainties of 20(50, 100)%, respectively.

- A similar analysis for the 14 TeV LHC.
- Conley, JSG, Hewett, Le, Rizzo. 1009.2539.
- Does not take $7-8$ TeV data into account.

- Four or more jets, no leptons.
- Three or more jets, no leptons.
- Two or more jets, no leptons.
- Four or more jets, one lepton.
- Three or more jets, one lepton.
- Two or more jets, one lepton.
- Four jets, opposite sign dileptons.
- Four jets, same sign dileptons.
- Trileptons, one jet.
- Trileptons.
- Tau, 4 jets, no leptons.
- Four jets, at least two of which are b-tagged.

14 TeV Results

Analysis	50% error $1\ fb^{-1}$	50% error $10\ fb^{-1}$	20% error $1\ fb^{-1}$	20% error $10\ fb^{-1}$
4j0l	88.331	88.578	98.912	99.014
2j0l	87.616	87.774	98.75	98.802
1l4j	41.731	44.885	56.849	63.045
1l3j	64.058	70.907	69.725	81.111
1l2j	62.942	68.419	70.646	80.641
OSDL	6.0958	6.6796	15.262	18.659
SSDL	14.774	25.518	18.501	32.887
3lj	13.549	17.361	19.293	28.97
3lm	2.7406	2.9135	4.8844	5.8284
tau	83.51	86.505	96.928	98.695
b	73.983	76.939	91.672	94.867

Number of analyses	Flat, 1 fb^{-1}	Flat, 10 fb^{-1}	Log, 1 fb^{-1}	Log, 10 fb^{-1}
0	0.56754	0.36796	31.823	27.024
1	1.3458	0.98841	6.2704	6.5374
2	3.396	2.5141	8.9525	10.072
3	13.175	10.635	11.816	11.098
4	22.014	18.455	16.491	16.344
5	9.5512	10.3	5.6905	6.6135
6	15.227	16.929	6.0529	7.1456
7	20.081	17.697	6.7416	6.1954
8	7.6394	11.75	3.0083	4.371
9	3.9205	6.3569	1.5223	2.6226
10	2.0825	2.7943	1.0511	1.1783
11	1.0013	1.2116	0.57992	0.79818

The percentage of models that are observable in *n* analyses, for each model set, for 1 and 10 fb^{-1} luminosity assuming a 50% background uncertainty.

Detector-stable sparticles would provide a striking signature of SUSY!

The analyses described above for 7 and 14 TeV do not look for detector-stable sparticles.

So we note how many models have detector-stable sparticles and try to quantify the discovery prospects.

Sparticle	10^{-15} GeV	10^{-16} GeV	10^{-17} GeV	10^{-18} GeV	10^{-19} GeV
$\tilde{\chi}_1^{\pm}$	9853	9728	8642	7683	6658
$\tilde{\tau}_1$	179	179	179	179	179
$\tilde{t}_1$	67	66	66	65	65
$\tilde{c}_R$	49	49	49	49	49
$\tilde{\chi}_2^0$	78	40	19	11	4
$\tilde{\mu}_R$	17	17	17	17	17
$\tilde{b}_1$	12	12	11	9	9
$\tilde{c}_L$	8	8	8	8	8
$\tilde{s}_R$	8	8	8	8	8
$\tilde{g}$	17	10	5	2	0

- The number of models in our pMSSM model set in which the specified sparticle has a width less than the value given at the head of each column.
- This gives some idea of the effect of the specific choice of $\Gamma_{\text{stable}} = 10^{-17}$ GeV.

Detector Stable Particle Prospects- 7 TeV

Sparticle	In Model Set	LHC Reach 100 pb^{-1}	LHC Reach 1 fb^{-1}
$\tilde{\chi}_1^+$	8642	8623	3471
$\tilde{\tau}_1$	179	179	174
$\tilde{t}_1$	66	20	9
$\tilde{c}_R$	49	10	4
$\tilde{\mu}_R$	17	17	17
$\tilde{b}_1$	11	0	0
$\tilde{c}_L$	8	0	0
$\tilde{s}_R$	8	3	0
$\tilde{g}$	5	0	0

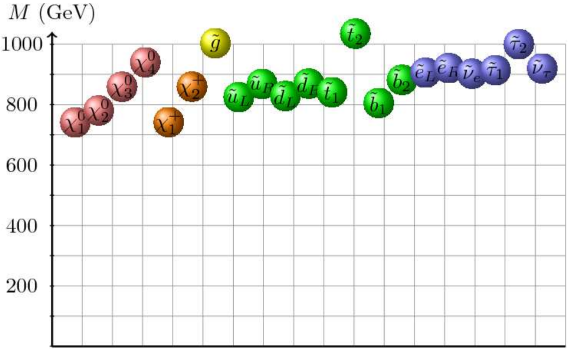
- The number of stable particles of various types present in our pMSSM model set and the number that would not have been discovered with 0.1 and 1 fb^{-1} at 7 TeV, following **Raklev (0908.0315)**.
- Note that the LHC will be more efficient at discovering or excluding stable squarks, gluinos, or charginos than sleptons.

Sparticle	In Model Set	LHC Reach 1 fb^{-1}	LHC Reach 10 fb^{-1}
$\tilde{\chi}_1^+$	8642	560	72
$\tilde{\tau}_1$	179	179	179
$\tilde{t}_1$	66	4	0
$\tilde{c}_R$	49	0	0
$\tilde{\mu}_R$	17	16	16
$\tilde{b}_1$	11	0	0
$\tilde{c}_L$	8	0	0
$\tilde{s}_R$	8	0	0
$\tilde{g}$	5	0	0

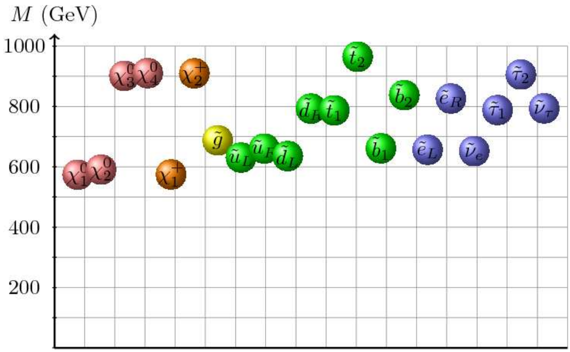
- The number of stable particles of various types present in our pMSSM model set and the number that would not have been discovered with 1 and 10 fb^{-1} at 14 TeV, following **Raklev (0908.0315)**.
- Note that the LHC will be more efficient at discovering or excluding stable squarks, gluinos, or charginos than sleptons.

- Very few flat prior models are missed even at 1 fb($^{-1}$) (11).
- Some of these are invisible because of detector-stable charginos.
- If these are the end of the decay chain; insufficient missing energy.
- But these would still be seen in early running.
- On the next three slides I will show models not seen in any analysis at 1 fb^{-1} (and sometimes with more luminosity).

Example 1: 17158

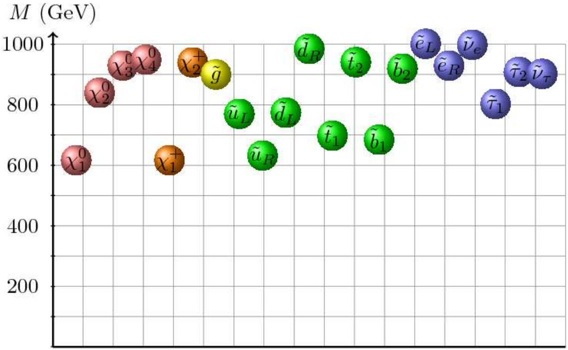


Best channel is τ at $\sim 2\sigma$ for EW backgrounds known to 20% at 10 fb^{-1}. 4 jets $\sim 1.5\sigma$.



Shows up in tau and almost in 2 jets for EW backgrounds known to 20% at 10 fb^{-1}.

Example 3: 7105



Almost shows up (significance between 3 and 4.5) for EW backgrounds known to 20% at 10 fb^{-1} in three analyses.

Conclusions

- We have investigated the reach of the 7 (and 14!) TeV at LHC by considering a set of models in a more general MSSM parameter space.
- Flat prior models with all sparticles lighter than a TeV are often seen in the first few fb^{-1} at 7 TeV and virtually always in the first few fb^{-1} at 14 TeV.
- Log prior models have more compressed spectra (and in some case higher sparticle masses) and are hence significantly harder to discover. Still most would be discovered in early LHC running.
- Suggests it's hard for light SUSY to hide much longer.
- If it does, it is probably due to a compressed mass spectrum.