Reinterpreting of ATLAS limits using PGS for compressed SUSY in 4.7 fb^{-1} at 7 TeV

Stephen P. Martin

Northern Illinois University

w/ Tom LeCompte, 1105.4304, 1111.6897, and 2012 unpublished

User feedback

Fast simulators for the LHC

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ATLAS and CMS can't rule out every model that is a favorite of some theorist, so we sometimes have to do it ourselves, by reinterpreting similar analyses.

At some level, don't care about the details of the detector simulation. We only care that the Acceptance $\times$ efficiency for a signal region comes out right.

My experience is very limited; only used PGS. Used leptons and taus only to veto, did not use photons. Did not use b-tagging in the project I'll talk about today.

What happens if the superpartner mass spectrum is more compressed than mSUGRA?

Less visible energy: smaller jet p_T's, $m_{\rm eff}$ or H_T, and $E_T^{\rm miss}$.
Signal looks more like QCD, $t\bar{t}$, W+jets, and Z+jets backgrounds.

SUSY may be lurking at masses smaller than the CMSSM exclusions.

We studied models that generalize mSUGRA by including a "compression factor", c. At the TeV scale:

$$M_1 = \left(\frac{1+5c}{6}\right) M_{\tilde{g}}, \qquad\qquad M_2 = \left(\frac{1+2c}{3}\right) M_{\tilde{g}},$$

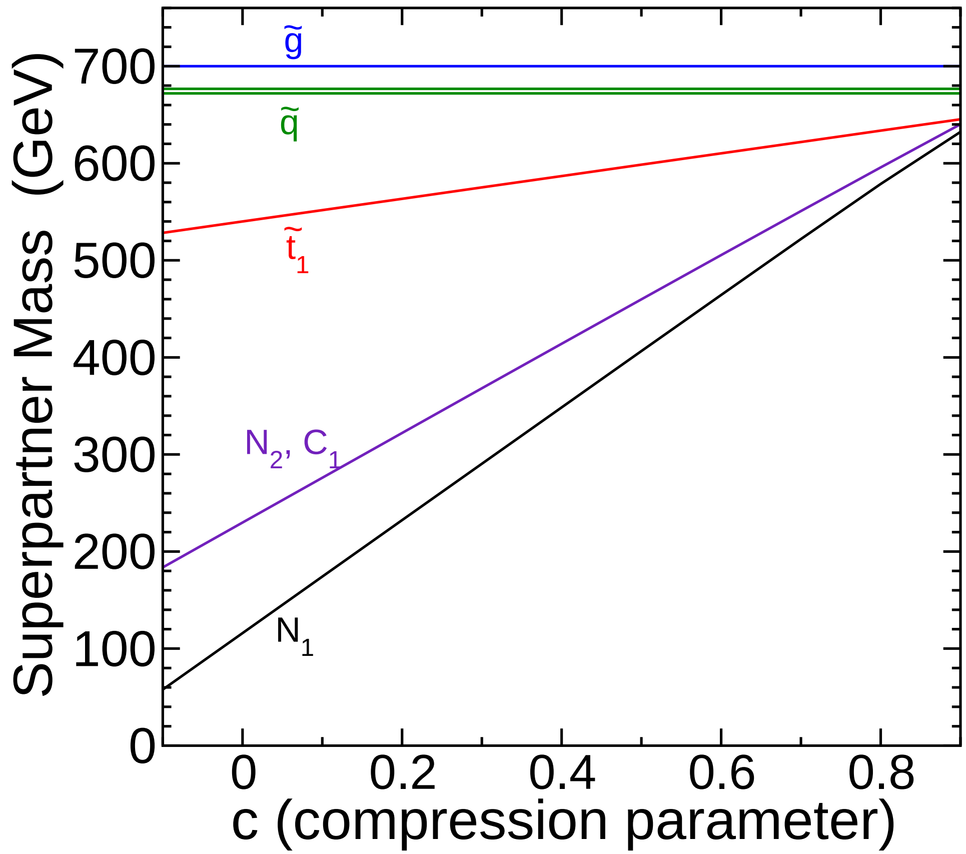
$c = 0$ corresponds to mSUGRA=CMSSM.

$c = 1$ is total compression (gauginos degenerate).

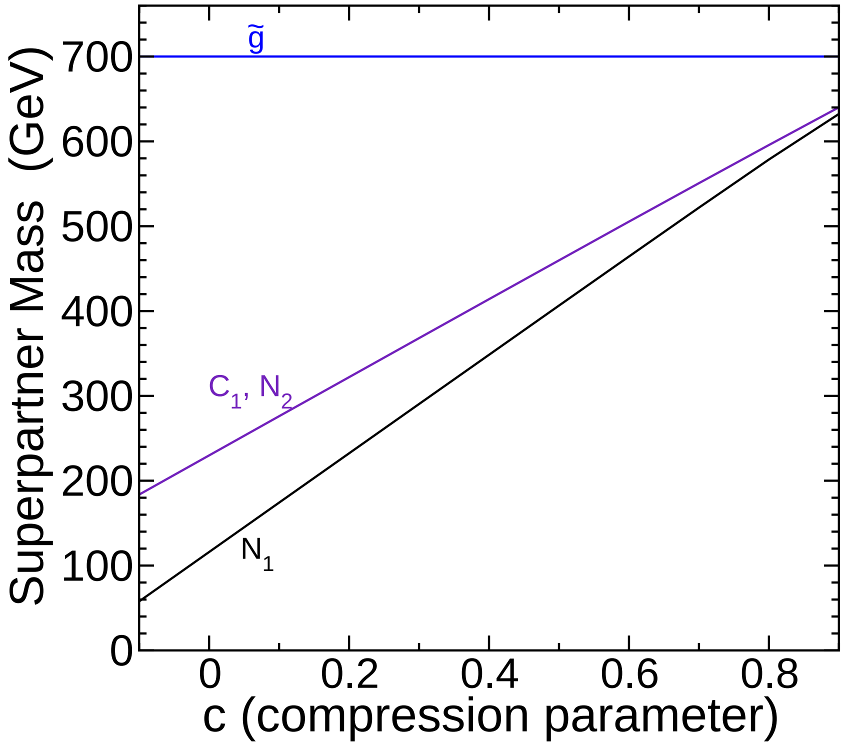
Also take $\tan\beta = 10$, and $\mu > 0$.

Variable input parameters: $M_{\tilde{g}}$ (overall superpartner mass scale) and c (compression factor).

Masses of important superpartners, as a function of c, for $M_{\tilde{g}} = 700$ GeV:



We also considered variations, including Heavy Squark Compressed Models:



Take $M_{\tilde{Q}} \gg M_{\tilde{g}}$ (Motivated by $M_h = 125$ GeV!)

$\tilde{g} \to jjjj + E_T^{\rm miss}$ dominates.

ATLAS-CONF-2012-033 based on 4.7 fb^{-1}

11 distinct Signal Regions. Demand $E_T^{\rm miss} > 160$ GeV, $p_T(j_1) > 130$ GeV, $p_T(j_{2,3,4}) > 60$ GeV, $p_T(j_{5,6}) > 40$ GeV when required.

	A (2j)	A$'$(2j)	B (3j)	C (4j)	D (5j)	E (6j)
$N_{\rm jets} \geq$	2	2	3	4	5	6
$m_{\rm eff}$(incl) [GeV] $>$	$1900,$ 1400	1200	1900	$1500,$ $1200,$ 900	1500	$1400,$ $1200,$ 900
$E_T^{\rm miss}/m_{\rm eff}(N_{\rm jets}) >$	0.3	0.4	0.25	0.25	0.2	0.15
4.7 fb^{-1} limit (fb)	0.62, 5.3	6.2	0.65	3.5, 3.7, 12	2.2	2.6, 2.5, 18

Our method:

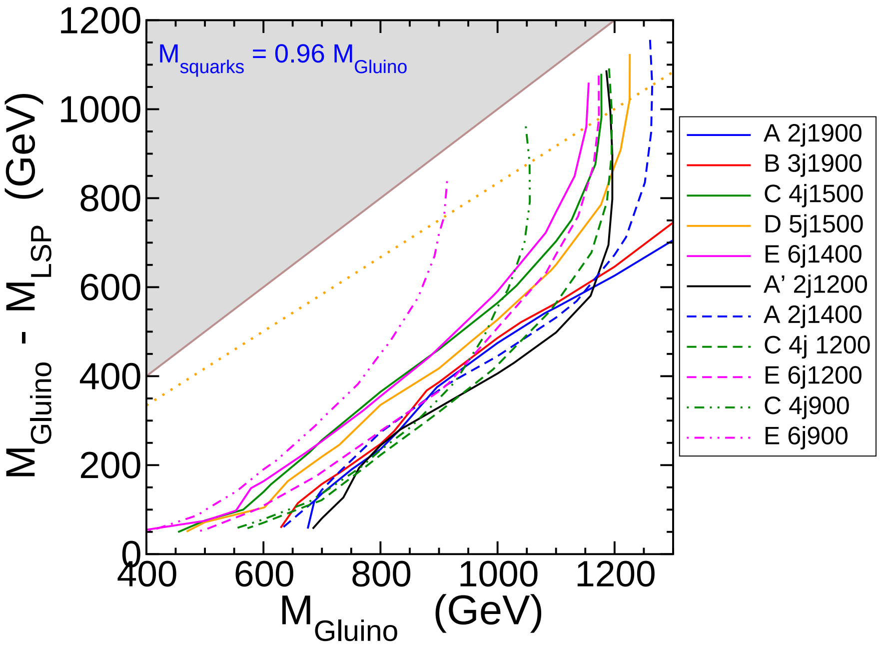
- Don't try to simulate the backgrounds: just used ATLAS results.
- For SUSY events, used the golden path:

  Madgraph $\longrightarrow$ Madevent $\longrightarrow$ Pythia $\longrightarrow$ PGS4
- Validate with MSUGRA/CMSSM models on public ATLAS grid.

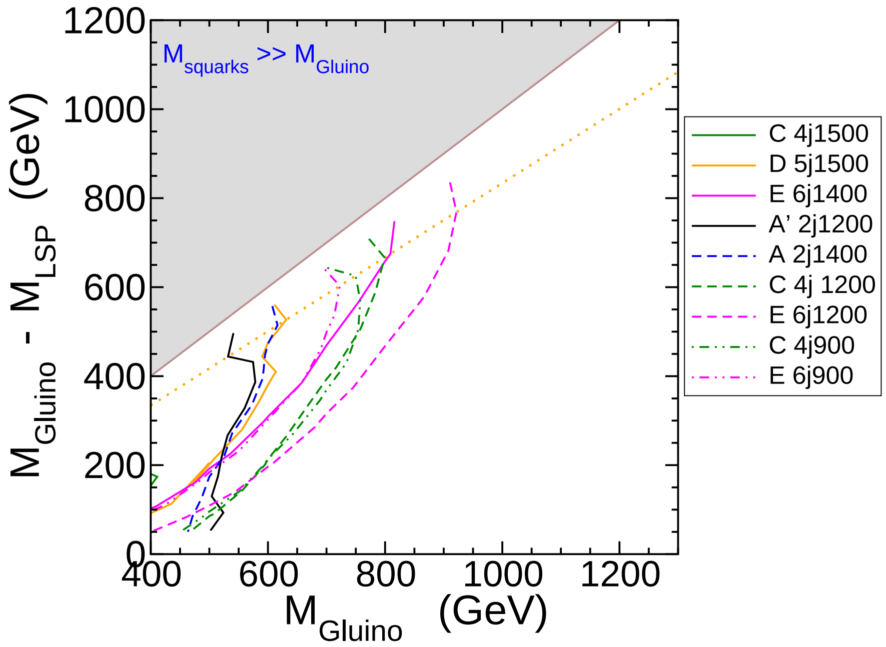
  Usually obtained agreement in acceptance $\times$ efficiency to better than 20%.
- Hope that agreement will be maintained in compressed regions.
- Estimate exclusions from ATLAS limits in each Signal Region

Estimates of exclusion curves, based on ATLAS Signal Region exclusions, but using PGS:

Normal models



Heavy Squark models



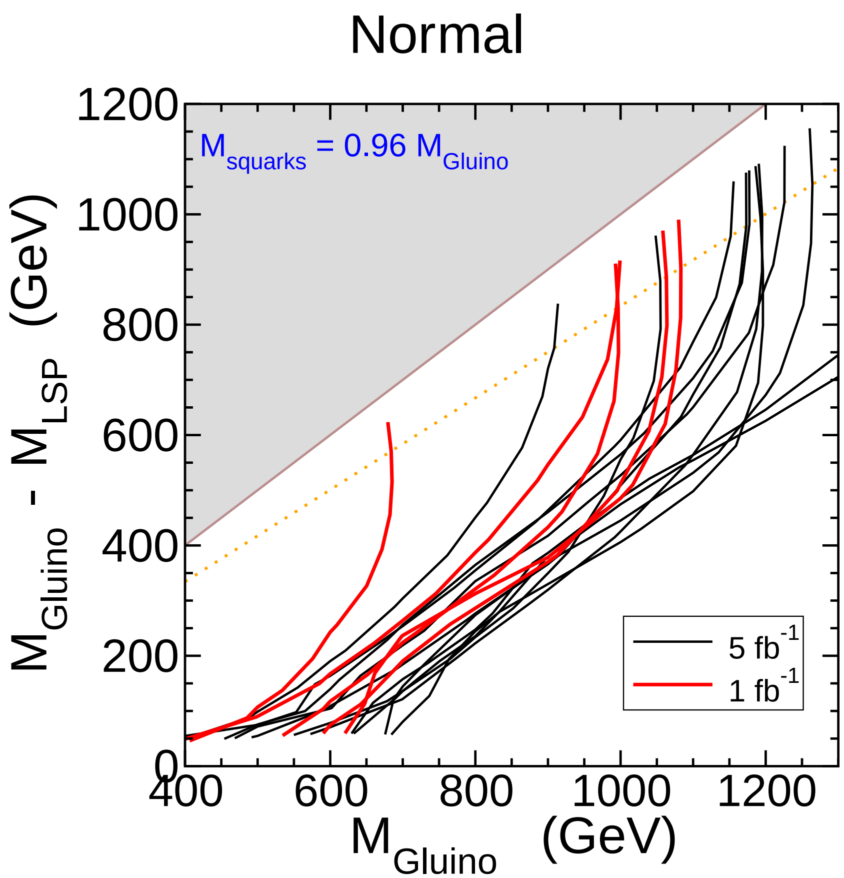
Note: not ATLAS plots! Made using public ATLAS results.

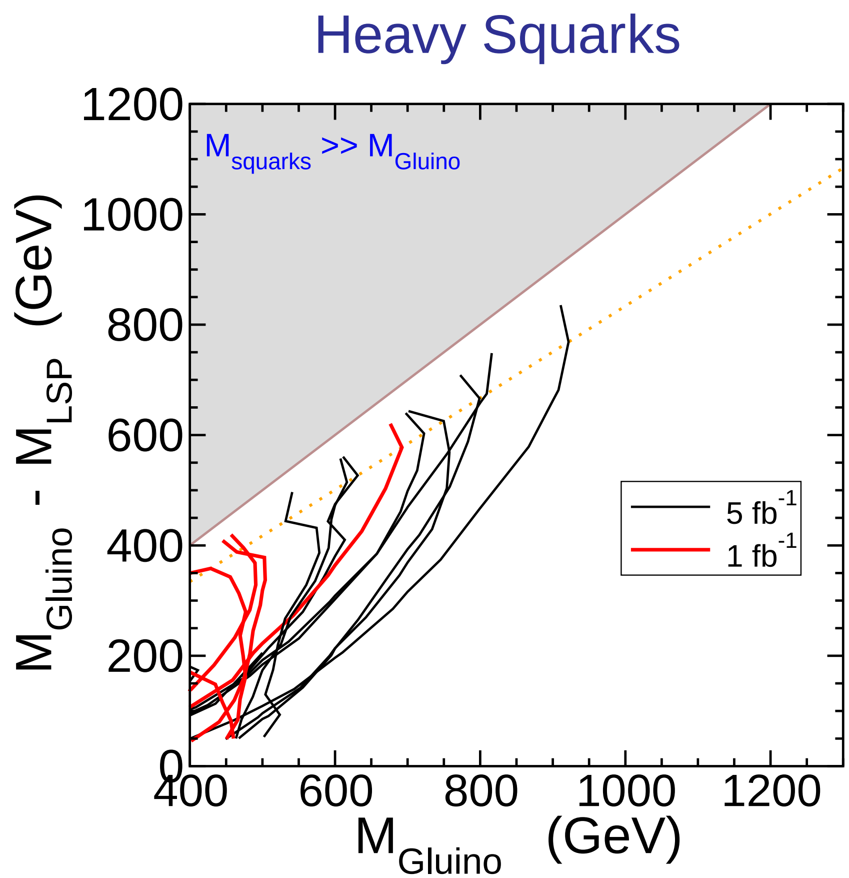
ATLAS will very soon present results for the same models. Not quite public yet.

My personal reaction: PGS does very well, compared to the “truth”, as defined by ATLAS GEANT-based detector simulation.
For $c \lesssim 0.5$, for example, agreement usually extremely good.

The most significant discrepancies occur for **highly** compressed spectra, where jets are very soft and efficiencies are very low.

Comparison of 4.7 fb^{-1} signal region exclusions with old 1 fb^{-1} results:





Improvement is not as dramatic for high compression.

Naive comments by a lazy theorist user:

- I've only used PGS, so. . .
- Ability to validate results for MSUGRA/CMSSM model grid points that ATLAS provided publicly was **crucial**!
- The automated MadEvent $\rightarrow$ Pythia $\rightarrow$ Detector Simulator $\rightarrow$ LHCO is really good for lazy theorists like me. A nice additional feature might be to incorporate parton-level "truth" directly within the single file output of the detector simulator on an event-by-event basis.
- Parameterized b tagging (adjustable p_T dependence) would be useful. (DELPHES already has this?)

- As vanilla BSM searches find nothing (MSUGRA, we're looking at you), more interest in non-standard detector objects. (CHAMPs, displaced decays)
- Detector parameter cards for ATLAS and CMS would be extremely helpful, whether official or unofficial. (Not a very original idea, I know.)
- Is official sanction really necessary?
- In lieu of official detector cards, ATLAS and CMS could just provide "usual suspect" BSM backgrounds. Provide a large sample of Pythia events together with the resulting GEANT responses in some useful form, for, say:
  - $t\bar{t}+$ jets
  - $W+$ jets, $Z+$ jets
  - $WZ+$ jets
  - Single top

  Backgrounds are the tricky part anyway. Fast simulators could then be tuned for agreement.