How low can SUSY go?

Jamie Tattersall

In collaboration with H Dreiner and M Krämer.
arXiv:1207.1613

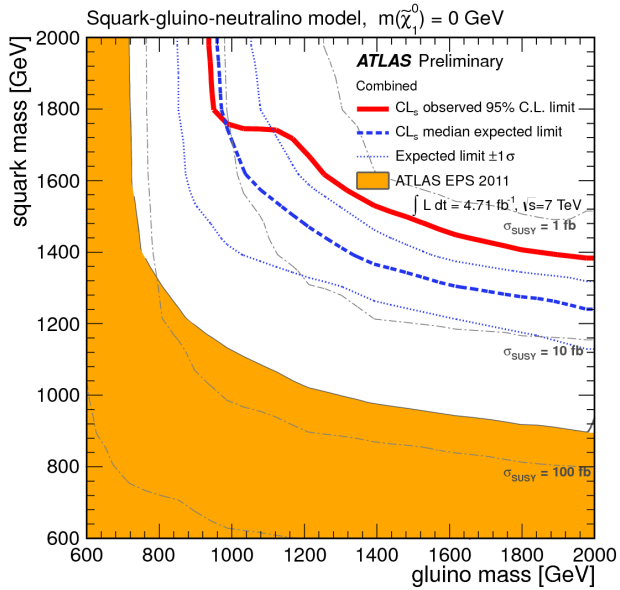
universitätbonn

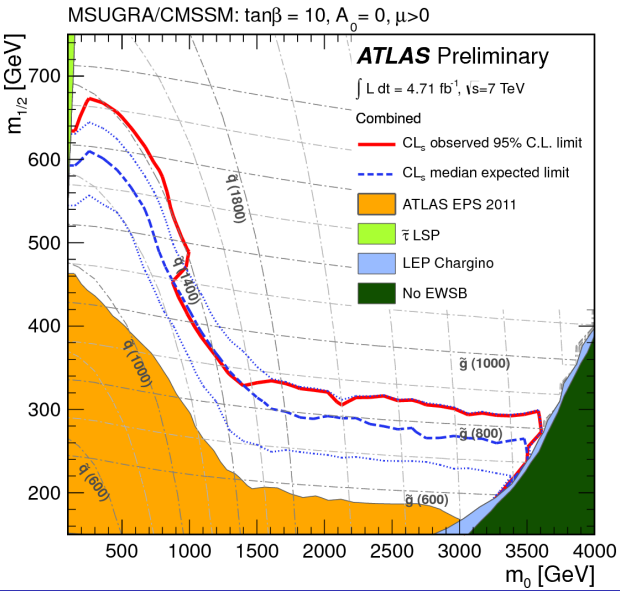
bctp Bethe Center for Theoretical Physics

Current Limits

LHC now sets very strict limits on the SUSY parameter space.

- Simplified Model ($m_{\tilde{\chi}_1^0} = 0$).
  - $m_{\tilde{q}} = m_{\tilde{g}} \gtrsim 1.5$ TeV.
  - $m_{\tilde{g}} \gtrsim 940$ GeV, ($m_{\tilde{q}} = 2$ TeV).
  - $m_{\tilde{q}} \gtrsim 1380$ GeV, ($m_{\tilde{g}} = 2$ TeV).
- mSugra ($\tan\beta = 10, A_0 = 0, \mu > 0$).
  - $m_{\tilde{q}} = m_{\tilde{g}} \gtrsim 1.4$ TeV.
- CMS gives very similar bounds (all a little weaker).
- Everything else has much weaker bounds.
  - $\tilde{t}$'s, $\tilde{b}$'s, $\tilde{\ell}$'s, $\tilde{\chi}$'s.





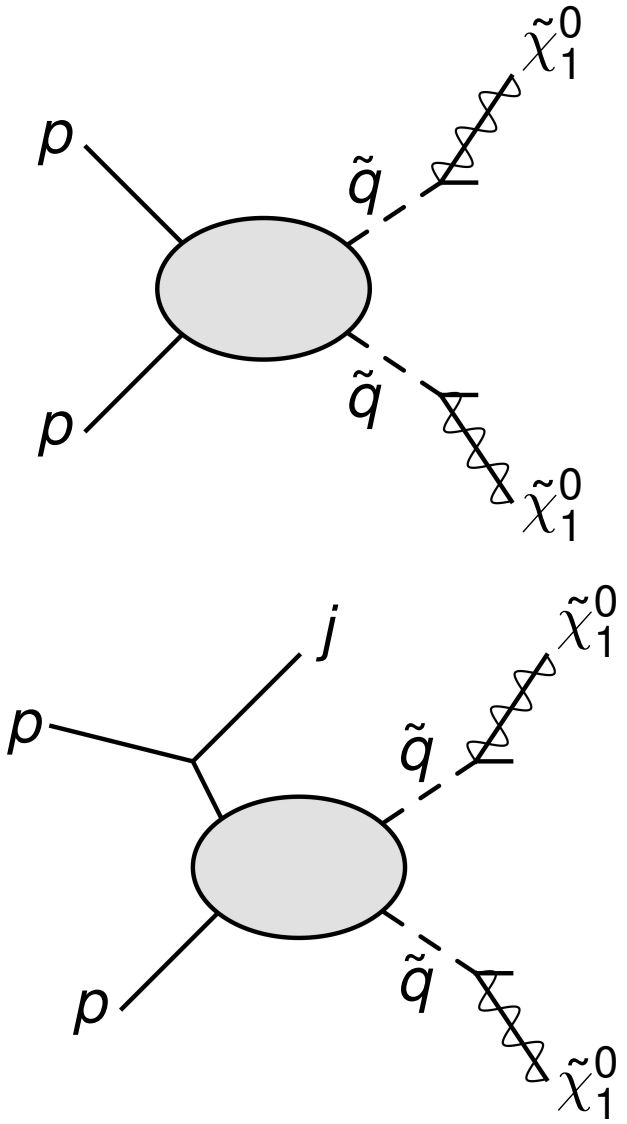
Events containing only MET

If the spectrum is compressed all momentum is carried by the LSP.

- Hard event is invisible.
- Possibility to use ISR to recoil against LSP.
- Hard ISR jets are common.

Process, $m_{\tilde{q}_i}$ = 500 GeV $p_T(j) > 100$ GeV	Xsec (fb)
$pp \to \tilde{q}\tilde{q}$	24
$pp \to \tilde{q}\tilde{q}\, j$	6.6
$pp \to \tilde{q}\tilde{q}\, j\, j$	1.1

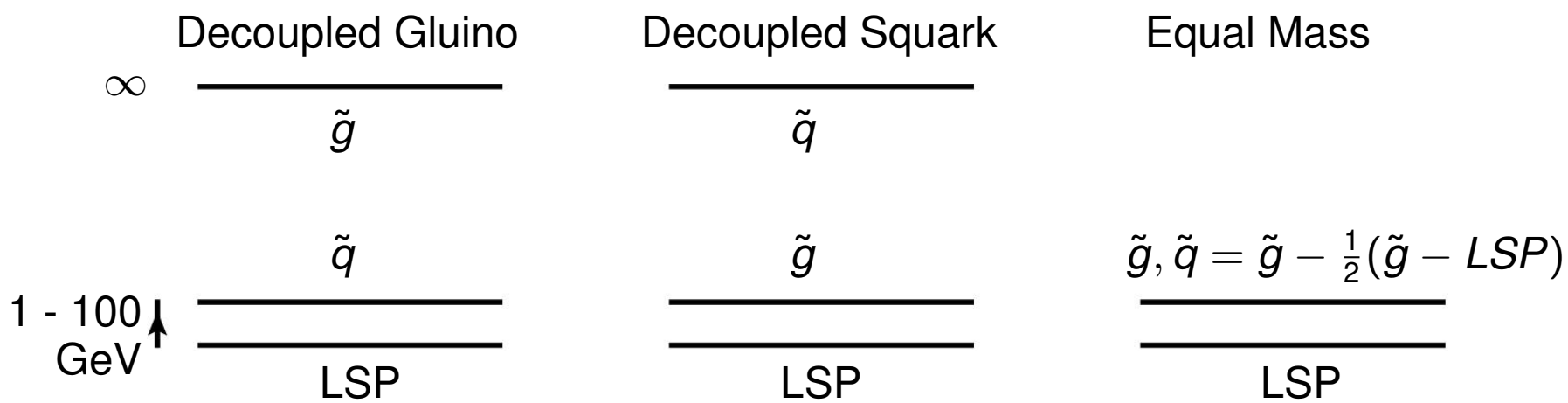
- I will concentrate on this possibility here.



Simplified Models - worst case for LHC

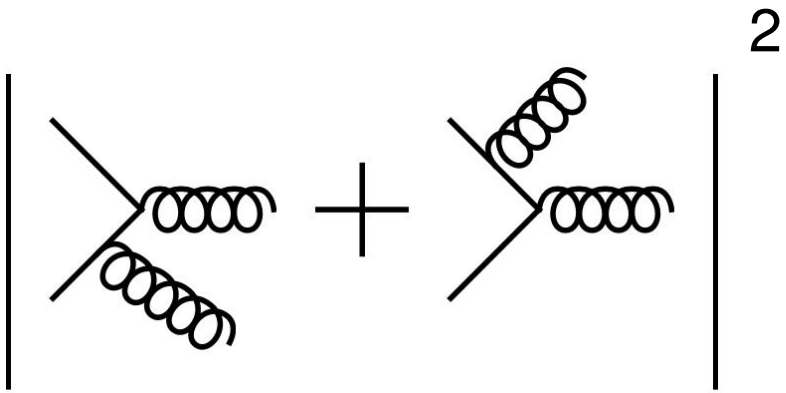
We take simplified models to capture the extremes.

- Squarks degenerate with LSP ($\Delta m = 1 - 100$ GeV). Gluino heavy.
- Gluino degenerate with LSP ($\Delta m = 1 - 100$ GeV). Squarks heavy.
- Gluino and squark degenerate with LSP ($\Delta m = 1 - 100$ GeV).
- We ignore third generation.



Matrix Element vs Parton Shower

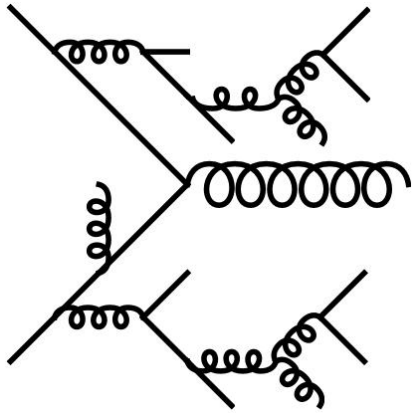
Matrix Element



- Pros:
  - Exact to fixed order.
  - Include interference effects.
- Cons:
  - Perturbation breaks down due to large logs.
  - Computationally expensive.

Valid when partons are hard and well separated.

Parton Shower



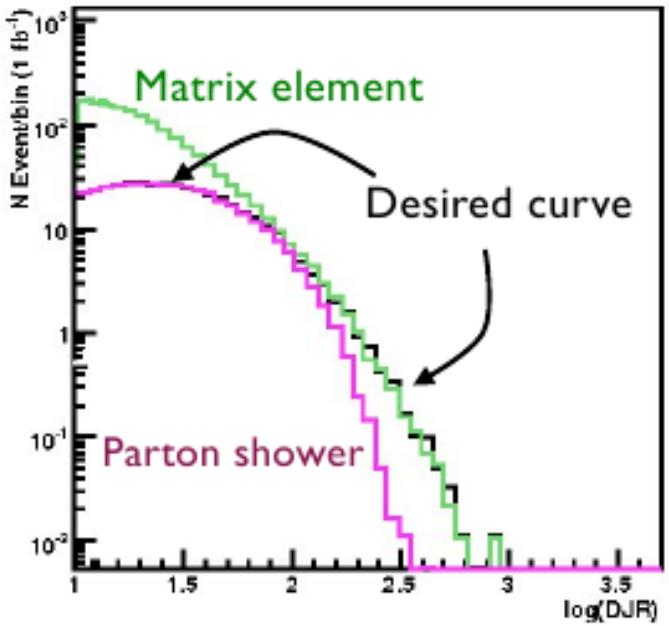
- Pros:
  - Resum logs.
  - Produce high multiplicity event.
- Cons:
  - Only an approximation to ME.
  - No interference effects.

Valid when partons are soft and/or collinear.

Matching the matrix element to the parton shower

We must match the Matrix Element prediction to the parton shower.

- Reweight inclusive samples (no double counting).
- Smooth distributions between areas of validity.
- Small dependence on matching scale.
- Small dependence on parton shower.
- Should converge as we include higher multiplicities.

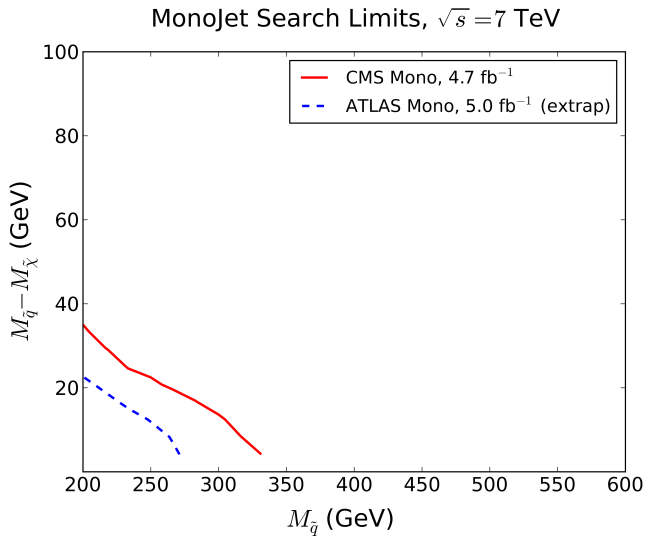


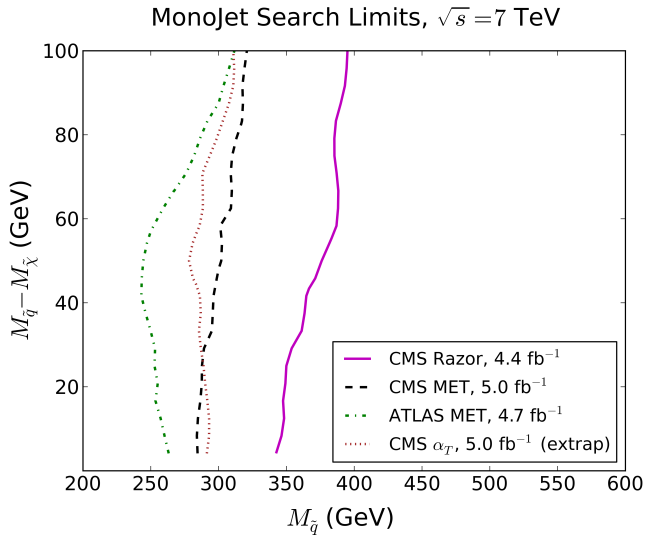
(Maltoni)

Results

Squark limit with decoupled gluino.

- $m_{\tilde{q}} \gtrsim 340$ GeV, significantly lower!
- CMS Razor sets the best limit.
  - Limit does not improve rapidly with splitting.
- Monojet searches are competitive for 'extreme' compression.
  - Extra hadronic activity quickly hurts the monojet searches.
  - Maybe remove 2nd and 3rd Jet vetoes or set these higher.





Summary

- Compressing the mass spectrum makes SUSY much harder to look for.
- ISR becomes vital to see any signal.
- Matching the matrix element to the parton shower to required to accurately model the ISR.
- Squark masses $\gtrsim$ 340 GeV.
- Gluino mass $\gtrsim$ 500 GeV.
- Equal squark and gluino masses $\gtrsim$ 650 GeV