Colored SUSY Production at (Existing and) Future Colliders

Mike Hance
Lawrence Berkeley National Laboratory
Exploring the Physics Frontier with Circular Colliders

Introduction

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- Addresses the hierarchy problem
- Has a dark matter candidate
- Possible unification of gauge couplings

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This talk: what can SUSY simplified models tell us about colored new physics at $\sqrt{s} = 100$ TeV?

- Focus on high-mass states not accessible at the LHC
- Use simple analysis strategies, avoid assumptions on detector design, pileup sensitivity, etc
- Try to extract:
  - Mass reach for different scenarios/spectra
  - Implications for accelerator and detector design

Outline

1. ~~Introduction~~
2. The tools
3. Simplified models with jets+$E_{\mathrm{T}}^{\mathrm{miss}}$
   - Gluino/neutralino
   - Squark/neutrino
   - Gluino/squark
4. Simplified models with heavy flavor
   - Gluino/neutralino with decays to top quarks
   - Stop/neutralino
5. Summary

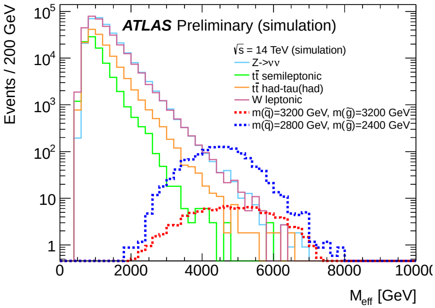
Based on....

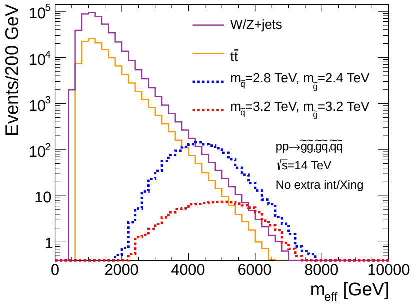
- SUSY Simplified Models at 14, 33, and 100 TeV Proton Colliders
  Cohen, Golling, Hance, Henrichs, Howe, Loyal, Padhi, Wacker (2013)
- Boosting Stop Searches with a 100 TeV Proton Collider
  Cohen, D'Agnolo, Hance, HK Lou, Wacker (2014)
- *And some new work, to be documented.*

The Tools

Samples

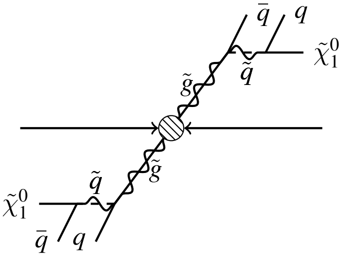
- MC samples from Snowmass 2013 production
  - Madgraph5+Pythia6
  - H_T binned to give reach out to very high energy/luminosity
  - Normalized to NLO predictions from MCFM
- DELPHES3 simulation using a hybrid ATLAS+CMS detector
- Several pileup conditions considered
  - 0, 50, 140 extra interactions/crossing
  - Most studies performed with no pileup
- Assume systematic uncertainties of 20% for background estimates
- Validation of framework against ATLAS European Strategy projections

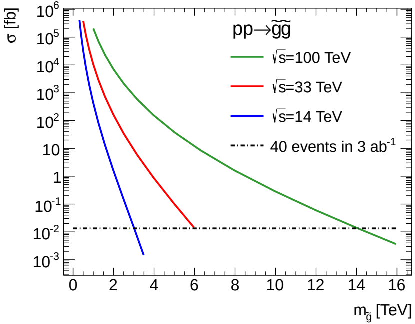




Simplified Models with Jets+$E_{\mathrm{T}}^{\mathrm{miss}}$

Gluino/Neutralino Simplified Model

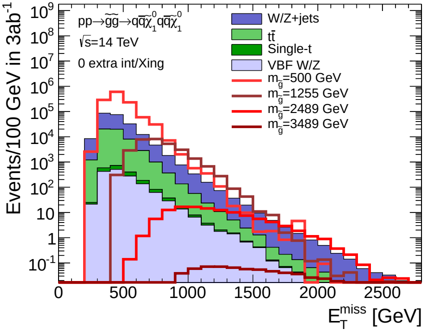


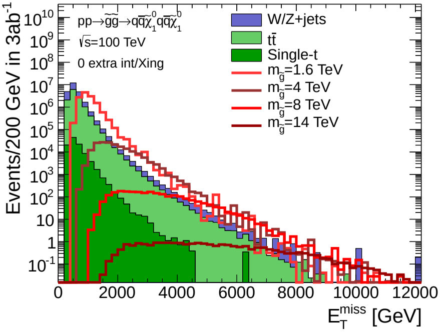


Search Strategy: Jets+E_T^{miss}

- Zero leptons ($p_T > 10$ GeV, $|\eta| < 2.6$)
- $E_T^{miss} > 100$ GeV, >4 jets ($p_T > 30$ GeV, $|\eta| < 3.5$)
- $E_T^{miss}/\sqrt{H_T^{jets}} > 15\ \text{GeV}^{1/2}$ to reduce QCD multijets (not simulated)
- $p_T^{\text{lead jet}}/H_T^{jets} < 0.4$ reduces V+jets
- Optimize simultaneous cuts on E_T^{miss} and H_T^{jets}

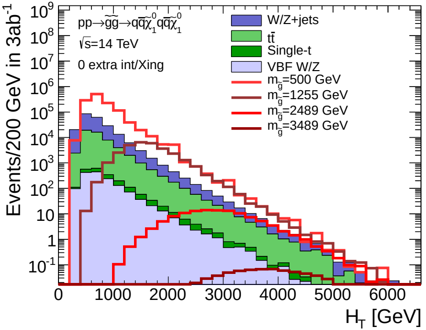
$pp \to \tilde{g}\tilde{g} \to q\bar{q}\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$

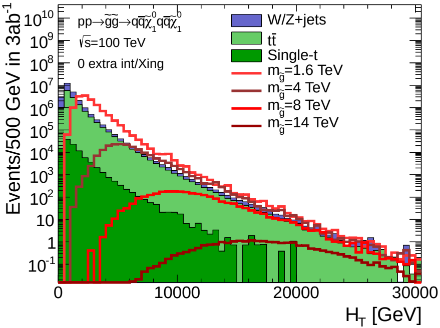




- Primary backgrounds
  - 14 TeV: 65% W/Z+jets, 35% $t\bar{t}$
  - 100 TeV: 40% W/Z+jets, 60% $t\bar{t}$
- Keep same search strategy for 14 TeV and 100 TeV
  - Allows for direct comparison
  - Sensitivity mostly comes from E_T^{miss} and H_T^{jets} cuts

$pp \to \tilde{g}\tilde{g} \to q\bar{q}\tilde{\chi}^0_1 q\bar{q}\tilde{\chi}^0_1$





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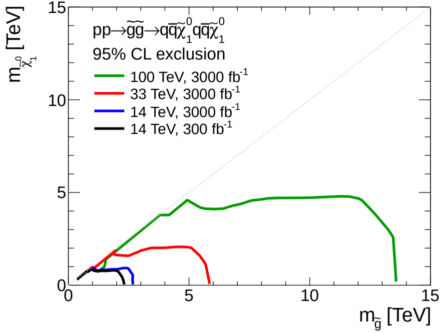
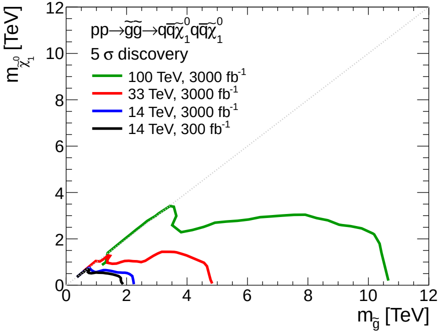
- Keep same search strategy for 14 TeV and 100 TeV
  - Allows for direct comparison
  - Sensitivity mostly comes from $E_{\mathrm{T}}^{\mathrm{miss}}$ and $H_{\mathrm{T}}^{\mathrm{jets}}$ cuts

$pp \to \tilde{g}\tilde{g} \to q\bar{q}\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$





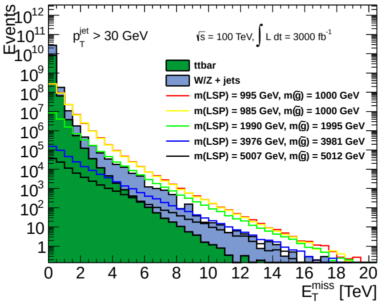
Discover gluinos with masses up to 11 TeV!

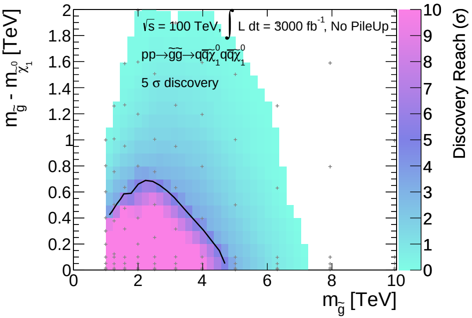
- 13.5 TeV exclusion at ∼100 events, improvements still possible
- Worse sensitivity for massive neutralinos
- Assumes 20% systematic uncertainty on backgrounds
  - 5% unc: reach ∼12 TeV for m(LSP)=0, also improves m(LSP)>0
- Assumes no pileup, checks at $\sqrt{s} = 14$ TeV show this is safe
  - Optimal $H_T^{\text{jets}} \sim m_{\tilde{g}}$, not sensitive to pileup

Compressed $pp \to \tilde{g}\tilde{g} \to q\bar{q}\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$

Two strategies to target the compressed region ($m_{\tilde{g}} \sim m_{\tilde{\chi}_1^0}$)

- **Mono-jet**: optimize $p_T^{\text{lead jet}}$, E_T^{miss} in events with ≤ 2 jets
  - Best for light gluinos and small $\Delta m = (m_{\tilde{g}} - m_{\tilde{\chi}_1^0})$
- **High-E_T^{miss}**: optimize E_T^{miss} cut
  - Best for heavy gluinos and/or large Δm
  - **Always beats mono-jet at 100 TeV** (no ≤ 2 jets requirement)





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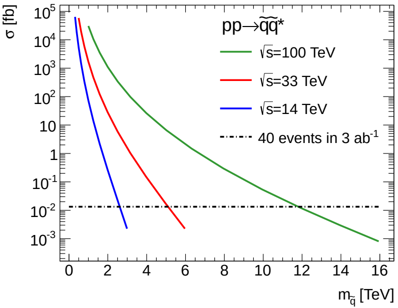
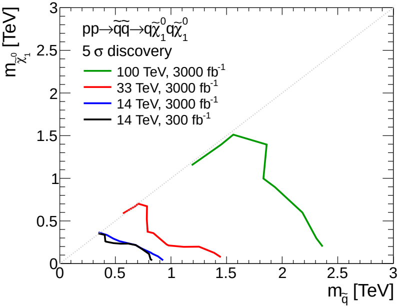
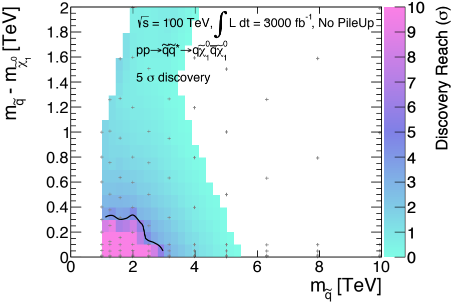




Same jets+E_T^{miss} strategy

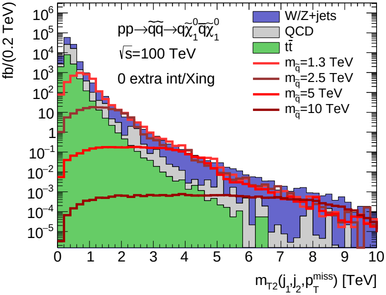
- Jets+E_T^{miss} optimized for >2 jets in cascade
- Significant gain near diagonal with dedicated search
  - Discover to 2.5 TeV
- But we can do better....



$pp \to \tilde{q}\tilde{q}^* \to q\tilde{\chi}_1^0\bar{q}\tilde{\chi}_1^0$ – Updates

Jets+E_T^{miss} strategy not optimal for dijet+E_T^{miss} topology

- Use CMS approach from LHC8 (PAS-SUS-13-019):
  - Bin in H_T^{jets}
  - Optimize cuts on m_{T2} (leading jets + p_T^{miss})



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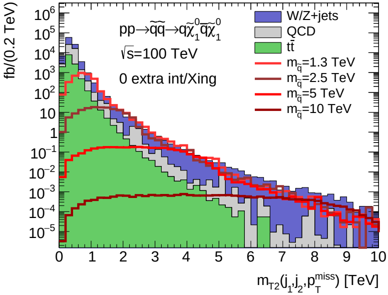
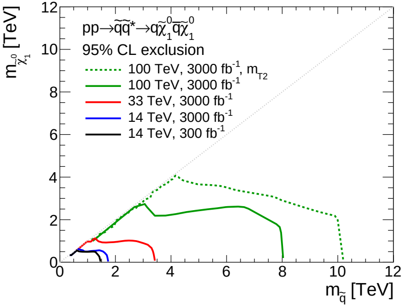
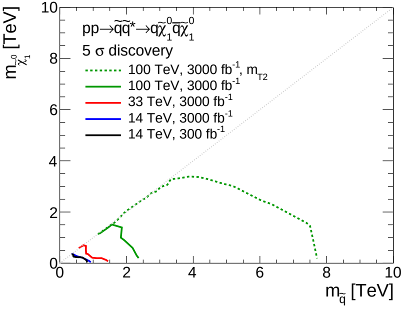
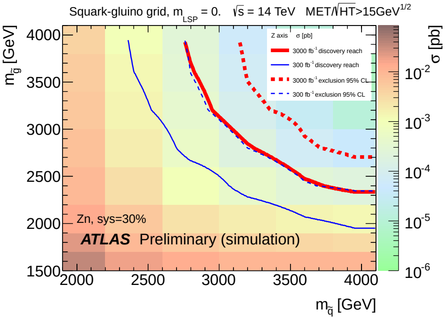


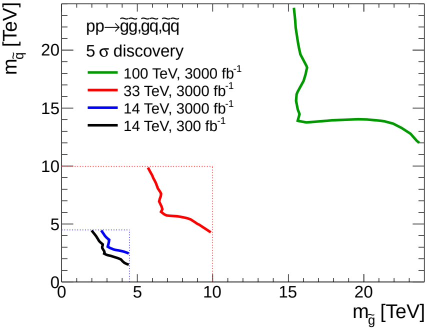




$pp \to \tilde{g}\tilde{g}, \tilde{g}\tilde{q}, \tilde{q}\tilde{q}$

Assume massless LSP, vary $m_{\tilde{g}}$ and $m_{\tilde{q}}$:





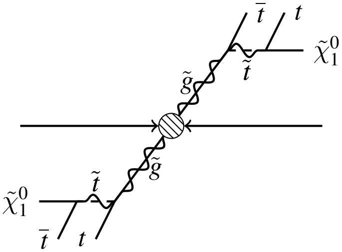
Multijets+$E_{\mathrm{T}}^{\mathrm{miss}}$ gives good sensitivity, but richer topologies are also likely:

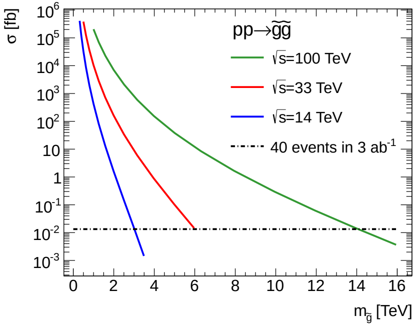
- Naturalness suggests $m_{\tilde{t}} < m_{\tilde{q}}$, so decays via off-shell $\tilde{t}$ are more likely than light-flavor squarks

So... what if $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$?

Simplified Models with Heavy Flavor

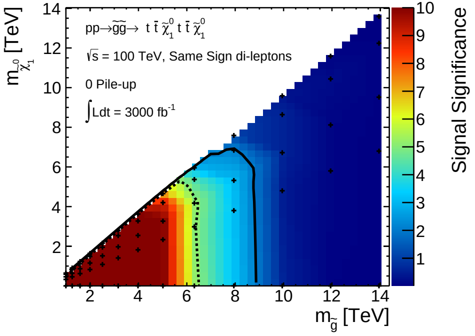
$pp \rightarrow \tilde{g}\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0 t\bar{t}\tilde{\chi}_1^0$

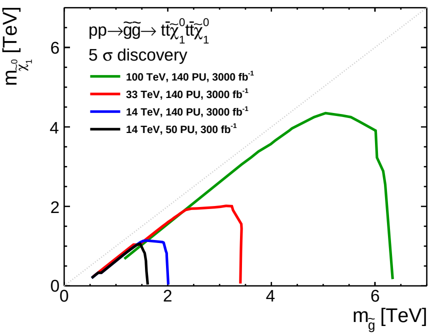




Search Strategy: same-sign dileptons

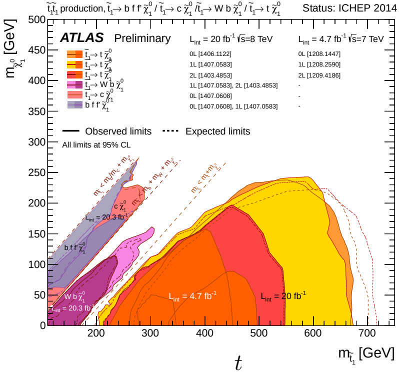
- Preselection: Z-veto, ≥ 2 b-tags, $H_T^{\text{jets}} > 80$ GeV, $E_T^{\text{miss}} > 50$ GeV
- 8 signal regions
  - Variables: symmetric M_{T2}, $p_T^{\text{lead lepton}}$, E_T^{miss}, N_{jets}, $N_{b-\text{jets}}$, m_{eff}, H_T^{jets}
  - Tight cuts on several variables for light $\tilde{g}$ and $\tilde{\chi}_1^0$
  - Targeted SRs for heavy $\tilde{g}$ and compressed spectra
- Dominant backgrounds from $t\bar{t}$, diboson, tW

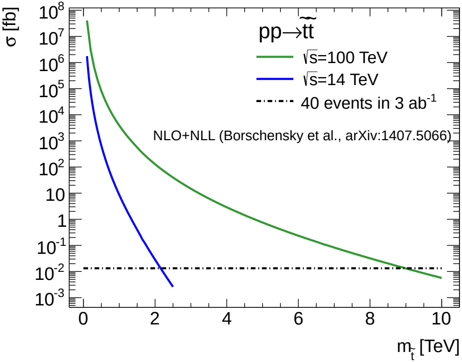


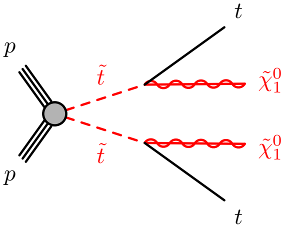


- Multi-SR approach: good reach for high masses and compressed spectra
- Room for future work:
  - All-hadronic channels
  - Lepton isolation tuning
  - Substructure, top-tagging, etc

Direct Stop Search







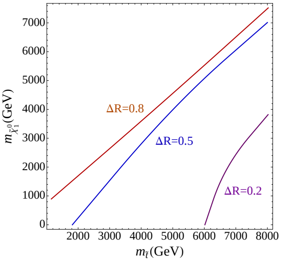
"Natural" SUSY needs a light $\tilde{t}$ to regulate the Higgs

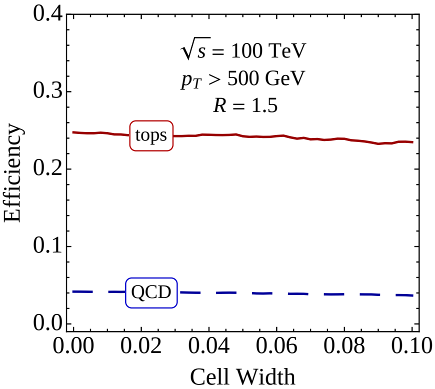
- Rich phenomenology
  - Multiple analysis strategies
- Major focus for LHC

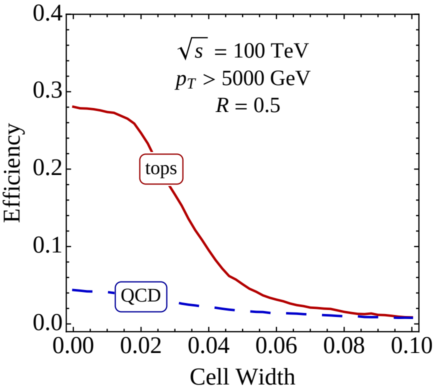
Obvious gain at high-mass for $\sqrt{s}$ =100 TeV – can we exploit it?

Top-tagging at 100 TeV?

- Tops are **very** boosted
- Efficiency depends on detector granularity
- Requires lots of assumptions about calorimeters, trackers, etc
- **What's possible with a simpler approach?**





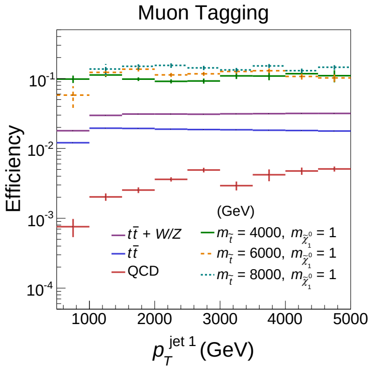


Search Strategy

- Two anti-k_t jets ($R = 0.5$), $p_T > 1$ TeV (500 GeV for compressed)
- Veto events with isolated leptons with $p_T > 35$ GeV
  - **Require** ≥ 2 leptons for compressed
- $\min\Delta\phi(E_T^{\text{miss}}, J/\ell) > 1.0$
- Three SRs: $E_T^{\text{miss}} > 3.0, 3.5, 4.0$ TeV (2 TeV for compressed)

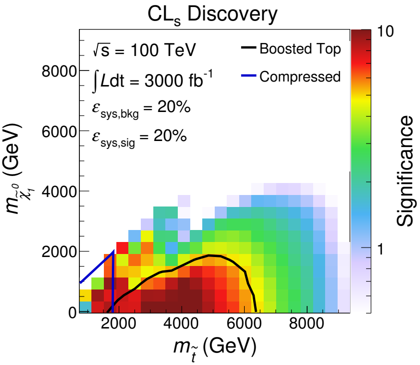
Additional requirement: muon-in-jet

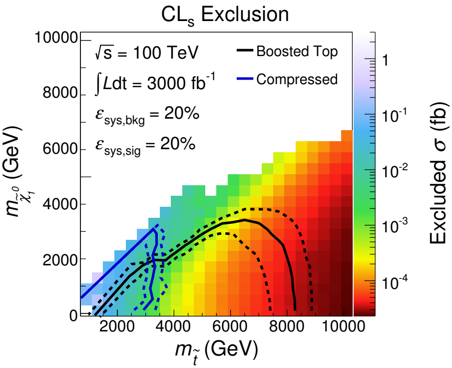
- ≥ 1 muon with $p_T > 200$ GeV
- **Must be in $\Delta R < 0.5$ of leading jets**
- Similar to early b-tagging algorithms at the Tevatron
- Generated QCD sample to check muons from b-decays
  - Negligible after other requirements (E_T^{miss})



$pp \to \tilde{t}\tilde{t}^* \to t\tilde{\chi}_1^0\bar{t}\tilde{\chi}_1^0$ Results

arXiv:1406.4512



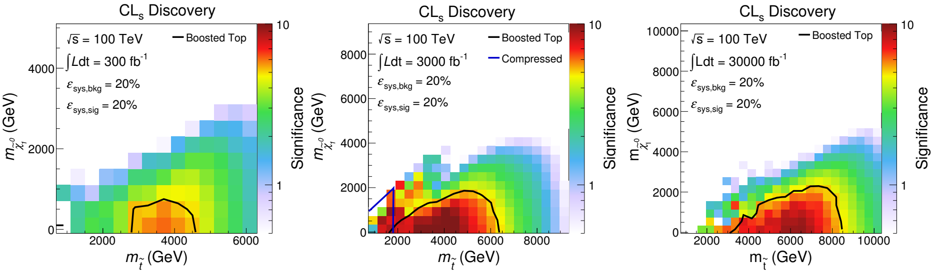


Discovery reach up to 6.5 TeV!

- Provides full access to "natural" $\tilde{t}$ masses in MSSM
  - Strong sensitivity to GMSB, AMSB, etc.
- Room for additional improvement for compressed scenarios
- Also room for detector-specific strategies:
  - Boosted top-tagging, *b*-tagging, searches with isolated leptons, etc

Will 3 ab^{-1} be enough at 100 TeV?

- Scale E_T^{miss} cuts for higher masses, going from 0.3 ab^{-1} to 30 ab^{-1}



- Comparable gain in reach from additional factor of 10:
  - Still not saturating gains from higher $\sqrt{s}$ with 3 ab^{-1}!
- Implications for detector design, running conditions, analysis strategies
- Also accelerator design: Optimal choice of $\sqrt{s}$ vs $\int \mathcal{L}dt$ and $\mathcal{L}_{inst}$?

Summary

Summary

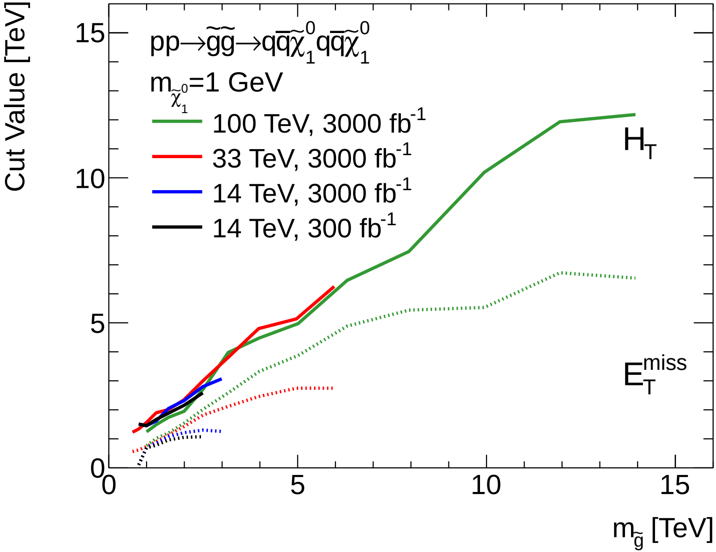
Assuming a massless LSP

Model	Limit [TeV]	Discovery Reach [TeV]	
	8 TeV	14 TeV	100 TeV
	20 fb^{-1}	3000 fb^{-1}	3000 fb^{-1}
$pp \to \tilde{g}\tilde{g} \to q\bar{q}\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$	1.4 (ATLAS)	2.3	**11**
$pp \to \tilde{g}\tilde{g} \to t\bar{t}\tilde{\chi}_1^0 t\bar{t}\tilde{\chi}_1^0$	1.4 (ATLAS)	2.0	**6.0**
$pp \to \tilde{q}\tilde{q}^* \to q\tilde{\chi}_1^0 \bar{q}\tilde{\chi}_1^0$	1.0 (CMS)	1.0	**7.8**
$pp \to \tilde{t}\tilde{t}^* \to t\tilde{\chi}_1^0 \bar{t}\tilde{\chi}_1^0$	0.7 (CMS)	1.2[a]	**6.5**

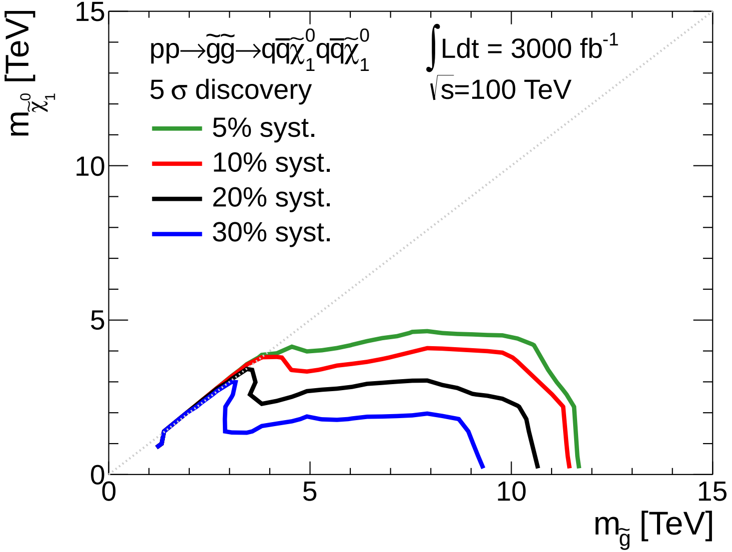
[a] ATLAS projection

Bonus Slides

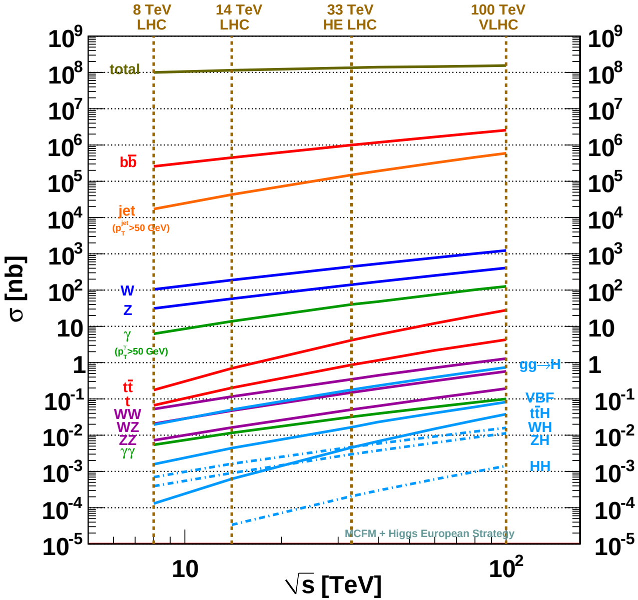
Optimal cuts for gluino/neutralino search



Impact of Systematics



Background Cross Sections



$pp \to \tilde{g}\tilde{g} \to t\bar{t}\tilde{\chi}_1^0 t\bar{t}\tilde{\chi}_1^0$ signal regions: 14 TeV

signal region	BSM masses	cuts	backgrounds	
SR1	$m_{\tilde{g}} = 997\text{GeV}$; $m_{\tilde{\chi}_1^0} = 1\text{GeV}$	$E_T^{miss} \gtrsim 250\text{GeV}$; $N_{jets} > 5$; $N_b > 2$	$t\bar{t}$	0.025
			di-boson	0.37
			total	0.40
SR2	$m_{\tilde{g}} = 997\text{GeV}$; $m_{\tilde{\chi}_1^0} = 641\text{GeV}$	$E_T^{miss} \gtrsim 250\text{GeV}$; $H_T \gtrsim 700\text{GeV}$; $m_{eff} \gtrsim 1000\text{GeV}$; $N_{jets} > 5$; $N_b > 2$	$t\bar{t}$	0.025
			di-boson	0.37
			total	0.40
SR3	$m_{\tilde{g}} = 1580\text{GeV}$; $m_{\tilde{\chi}_1^0} = 1\text{GeV}$	$E_T^{miss} \gtrsim 300\text{GeV}$; $H_T \gtrsim 800\text{GeV}$; $m_{eff} \gtrsim 1500\text{GeV}$; $N_{jets} > 5$; $N_b > 2$	$t\bar{t}$	0.020
			di-boson	0.0064
			total	0.031
SR4	$m_{\tilde{g}} = 1580\text{GeV}$; $m_{\tilde{\chi}_1^0} = 1224\text{GeV}$	$E_T^{miss} \gtrsim 600\text{GeV}$; $m_{eff} \gtrsim 1500\text{GeV}$; $N_{jets} > 5$; $N_b > 2$	di-boson	0.0064
			tri-boson	0.0003
			total	0.0067
SR5	$m_{\tilde{g}} = 2489\text{GeV}$; $m_{\tilde{\chi}_1^0} = 1\text{GeV}$	$H_T \gtrsim 2000\text{TeV}$; $m_{eff} \gtrsim 2500\text{GeV}$; $N_{jets} > 7$	$t\bar{t}$	0.0072
			di-boson	0.013
			total	0.022
SR6	$m_{\tilde{g}} = 2489\text{GeV}$; $m_{\tilde{\chi}_1^0} = 2133\text{GeV}$	$N_{jets} > 7$; $N_b > 2$	tW	0.96
			di-boson	0.77
			total	2.1
SR7	$m_{\tilde{g}} = 3489\text{GeV}$; $m_{\tilde{\chi}_1^0} = 1\text{GeV}$	sym-$M_{T2} \gtrsim 400\text{GeV}$; $N_{jets} > 7$	$t\bar{t}$	0.021
			total	0.021
SR8	$m_{\tilde{g}} = 3489\text{GeV}$; $m_{\tilde{\chi}_1^0} = 3133\text{GeV}$	$N_{jets} > 7$	$t\bar{t}$	0.39
			di-boson	1.1
			total	1.8

$pp \to \tilde{g}\tilde{g} \to t\bar{t}\tilde{\chi}^0_1 t\bar{t}\tilde{\chi}^0_1$ signal regions: 100 TeV

signal region	BSM masses	cuts	backgrounds	
SR1	$m_{\tilde{g}} = 997\text{GeV}$ $m_{\tilde{\chi}^0_1} = 1\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 100\text{GeV}$; $m_{\mathrm{eff}} > 1000\text{GeV}$ $H_{\mathrm{T}} \gtrsim 500\text{GeV}$; sym-$M_{T2} \gtrsim 40\text{GeV}$ $N_{\mathrm{jets}} > 5$; $N_b > 2$	$t\bar{t}$ di-boson total	19 0.17 19.2
SR2	$m_{\tilde{g}} = 997\text{GeV}$ $m_{\tilde{\chi}^0_1} = 641\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 50\text{GeV}$; $H_{\mathrm{T}} \gtrsim 400\text{GeV}$ $m_{\mathrm{eff}} \gtrsim 700\text{GeV}$ $N_{\mathrm{jets}} > 5$; $N_b > 2$	$t\bar{t}$ di-boson total	460 9.2 470
SR3	$m_{\tilde{g}} = 1989\text{GeV}$ $m_{\tilde{\chi}^0_1} = 1\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 500\text{GeV}$; $H_{\mathrm{T}} \gtrsim 1500\text{GeV}$ $m_{\mathrm{eff}} \gtrsim 2200\text{GeV}$; sym-$M_{T2} \gtrsim 200\text{GeV}$ $N_{\mathrm{jets}} > 7$; $N_b > 2$	$t\bar{t}$ tri-boson total	0.081 0.0062 0.087
SR4	$m_{\tilde{g}} = 1989\text{GeV}$ $m_{\tilde{\chi}^0_1} = 1633\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 600\text{GeV}$; $m_{\mathrm{eff}} \gtrsim 3000\text{GeV}$ $N_{\mathrm{jets}} > 7$; $N_b > 2$	$t\bar{t}$ tj total	0.20 0.035 0.26
SR5	$m_{\tilde{g}} = 3152\text{GeV}$ $m_{\tilde{\chi}^0_1} = 1\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 1000\text{GeV}$; $m_{\mathrm{eff}} \gtrsim 2000\text{GeV}$ sym-$M_{T2} \gtrsim 300\text{GeV}$ $N_{\mathrm{jets}} > 7$; $N_b > 2$	tri-boson total	0.0062 0.0062
SR6	$m_{\tilde{g}} = 3152\text{GeV}$ $m_{\tilde{\chi}^0_1} = 2796\text{GeV}$	$N_{\mathrm{jets}} > 7$; $N_b > 3$	$t\bar{t}$ tj total	2.9 0.12 3.0
SR7	$m_{\tilde{g}} = 4968\text{GeV}$ $m_{\tilde{\chi}^0_1} = 1\text{GeV}$	$E_{\mathrm{T}}^{\mathrm{miss}} \gtrsim 100\text{GeV}$; $H_{\mathrm{T}} \gtrsim 800\text{GeV}$ $m_{\mathrm{eff}} \gtrsim 1500\text{GeV}$ $N_{\mathrm{jets}} > 7$; $N_b > 1$	$t\bar{t}$ di-boson total	390 0.75 400
SR8	$m_{\tilde{g}} = 4968\text{GeV}$ $m_{\tilde{\chi}^0_1} = 4612\text{GeV}$	$m_{\mathrm{eff}} \gtrsim 400\text{GeV}$; $H_{\mathrm{T}} \gtrsim 150\text{GeV}$ sym-$M_{T2} \gtrsim 100\text{GeV}$ $N_{\mathrm{jets}} > 7$; $N_b > 2$	$t\bar{t}$ tj total	1.6 0.12 1.8

ATLAS SUSY Searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: ICHEP 2014

ATLAS Preliminary

$\sqrt{s}$ = 7, 8 TeV

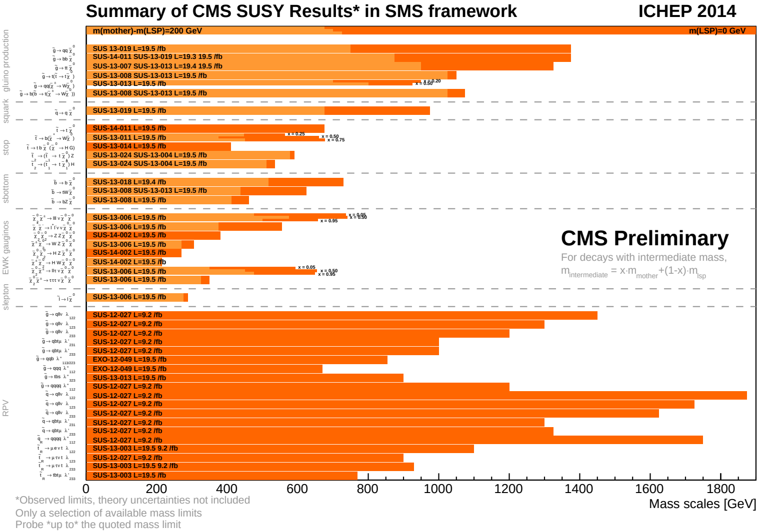
	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int \mathcal{L}\,dt\,[fb^{-1}]$		Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q},\tilde{g}$	1.7 TeV	$m(\tilde{q})$=$m(\tilde{g})$	1405.7875
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	850 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.33 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1405.7875
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)$=0.5($m(\tilde{\chi}_1^0)$+$m(\tilde{g})$)	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$	1.6 TeV	$\tan\beta$ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$	1.28 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2014-001
	GGM (wino NLSP)	1 e,μ + γ	-	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	m(NLSP)>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{G})$>10^{-4} eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.25 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	1407.0600
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	1407.0600
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$	275-440 GeV	$m(\tilde{\chi}_1^\pm)$=2 $m(\tilde{\chi}_1^0)$	1404.2500
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-210 GeV	$m(\tilde{\chi}_1^0)$ =$m(\tilde{t}_1)$-$m(W)$-50 GeV, $m(\tilde{t}_1)$<<$m(\tilde{\chi}_1^\pm)$	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$	215-530 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20	$\tilde{t}_1$	210-640 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1407.0583
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{t}_1$	260-640 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1406.1122
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-240 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1 + Z$	3 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$	290-600 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-465 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1407.0350
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	700 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	420 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e,μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$	285 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
	$\tilde{\chi}_2^0\tilde{\chi}_3^0$, $\tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$	620 GeV	$m(\tilde{\chi}_2^0)$=$m(\tilde{\chi}_3^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_2^0)$+$m(\tilde{\chi}_1^0)$)	1405.5086
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	1310.6584
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}$, $\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e+\mu$	2 e,μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e(\mu)+\tau$	1 e,μ + τ	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q},\tilde{g}$	1.35 TeV	$m(\tilde{q})$=$m(\tilde{g})$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	750 GeV	$m(\tilde{\chi}_1^0)$>0.2×$m(\tilde{\chi}_1^\pm)$, $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV	$m(\tilde{\chi}_1^0)$>0.2×$m(\tilde{\chi}_1^\pm)$, $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$	850 GeV		1404.250
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e,μ (SS)	2 b	Yes	14.3	sgluon	350-800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

Mass scale [TeV] (10^{-1} … 1)

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

CMS SUSY Searches



Light Squark Limits