0-lep. SUSY Searches from ATLAS and CMS

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16th March 2016
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Introduction

- Supersymmetry is one of the most favoured extensions of the Standard Model (SM) of particle physics.
- It postulates the existance of partner particles for all the SM particles.
- There have been many searches for such particles and here I will cover the latest results from ATLAS and CMS in channels without leptons.
- These are some of the most sensitive channels for many supersymmetric models as seen from the parameter scans performed after Run I [1][2].
- ATLAS has produced 3 separate results for 3 different signatures;
  1. 0-lep. + $\geq$2-6 jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ [ATLAS-CONF-2015-062]
  2. 0-lep. + $\geq$7-10 jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ [1602.06194]
  3. 0/1-lep. + $\geq$3-b-jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ [ATLAS-CONF-2015-067]
- CMS have produced 4 separate results utilizing different approaches;
  1. H_{T} and $H_{\mathrm{T}}^{\mathrm{miss}}$ search [1602.06581]
  2. M_{T2} based search [1603.04053]
  3. α_{T} based search [CMS-PAS-SUS-15-005]
  4. Razor variables based search [CMS-PAS-SUS-15-004]

Contents

- As the ATLAS and CMS analyses are similar in nature and look for similar models I will go through them in parallel;
  1. The signatures that we search for
  2. Variables used to define signal regions
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  4. Estimating the Z$\rightarrow \nu\nu$ background
  5. Estimating the Multi-jet background
  6. Estimating the background in the Razor analysis
  7. Results and Statistical interpretation
  8. Limits on models

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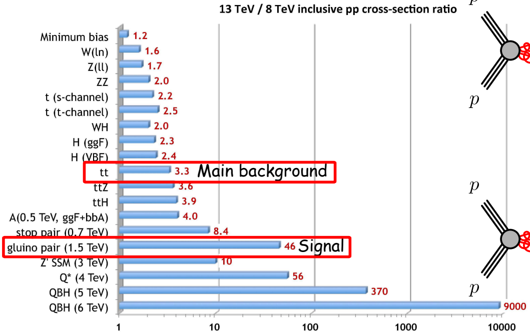
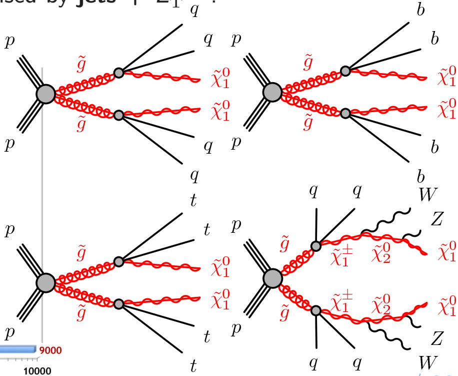
The Signatures We Search For

- The focus at the start of Run I has been searches for gluino production in R-parity conserving models due to the large x-section increase.
- The lightest supersymmetric particle is neutral and passes through the detector undetected in these models $\rightarrow E_{\mathrm{T}}^{\mathrm{miss}}$.
- The searches are all therefore characterised by **jets** + $E_{\mathrm{T}}^{\mathrm{miss}}$.





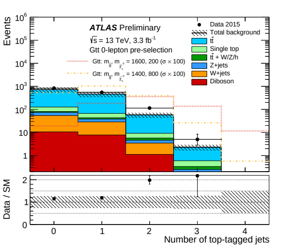
Variables used to define signal regions (ATLAS)

The ATLAS $\geq$2-6 jets and $\geq$3-b-jet analyses are both largely based around the variable;

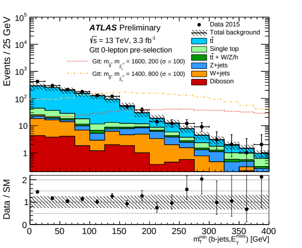
$$m_{\mathrm{eff}} = E_{\mathrm{T}}^{\mathrm{miss}} + \sum p_{\mathrm{T}}^{\mathrm{jet}}$$

and also use cuts on $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ to reduce the multi-jet background.

For $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$, $\geq$3-b-jets also cuts on the number of high mass large radius jets.



They also use $m_{\mathrm{T}}^{\mathrm{min}}(b\text{-jets}, E_{\mathrm{T}}^{\mathrm{miss}})$ which has an end-point for semi-lep. $t\bar{t}$.



The ATLAS $\geq$7-10 jet search counts the number of jets $p_{\mathrm{T}} > 50, 80$ GeV with $|\eta| < 2$, bins in the number of b-jets, and requires $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}} > 4\ \mathrm{GeV}^{1/2}$ motivated by the multijet background estimation (see later).

ATLAS Signal Regions (for reference)

The 7 $\geq$2-6 jet search signal regions:

Requirement	Signal Region						
	2jl	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
E_T^{miss} [GeV] $>$	200						
$p_T(j_1)$ [GeV] $>$	200	300	200				
$p_T(j_2)$ [GeV] $>$	200	50	200	100			
$p_T(j_3)$ [GeV] $>$	–			100			
$p_T(j_4)$ [GeV] $>$	–			100			
$p_T(j_5)$ [GeV] $>$	–				100		
$p_T(j_6)$ [GeV] $>$	–					100	
$\Delta\phi(\text{jet}_{1,2,(3)}, \boldsymbol{E}_T^{miss})_{min} >$	0.8	0.4	0.8	0.4			
$\Delta\phi(\text{jet}_{i>3}, \boldsymbol{E}_T^{miss})_{min} >$	–			0.2			
$E_T^{miss}/\sqrt{H_T}$ [GeV$^{1/2}$] $>$	15		20	–			
Aplanarity $>$	–			0.04			
$E_T^{miss}/m_{eff}(N_j) >$	–			0.2	0.25		0.2
m_{eff}(incl.) [GeV] $>$	1200	1600	2000	2200	1600	1600	2000

The 15 $\geq$7-10 jet search signal regions:

	8j50	8j50-1b	8j50-2b	9j50	9j50-1b	9j50-2b	10j50	10j50-1b	10j50-2b
n_{50}	≥ 8			≥ 9			≥ 10		
$n_{b-\text{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_T^{miss}/\sqrt{H_T}$	$> 4\,\text{GeV}^{1/2}$								

	7j80	7j80-1b	7j80-2b	8j80	8j80-1b	8j80-2b
n_{80}	≥ 7			≥ 8		
$n_{b-\text{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_T^{miss}/\sqrt{H_T}$	$> 4\,\text{GeV}^{1/2}$					

ATLAS Signal Regions (for reference)

The 3 $\tilde{g} \rightarrow b\bar{b}\tilde{\chi}_1^0$ and 3 $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$, ≥3-b-jet search signal regions (1-lepton regions are also used in this analysis):

Criteria common to all Gbb regions: ≥ 4 signal jets, ≥ 3 b-jets

	Variable	Signal region	Control region	Validation region
Criteria common to all regions of the same type	Lepton	Candidate veto	= 1 signal	Candidate veto
	$\Delta\phi^{4j}_{min}$	> 0.4	–	> 0.4
	$m^{b-jets}_{T,min}$	–	–	< 160
	m_T	–	< 150	–
Region A (Large mass splitting)	$p_T{}^{jet}$	> 90	> 90	> 90
	E_T^{miss}	> 350	> 250	> 250
	m^{4j}_{eff}	> 1600	> 1200	< 1400
Region B (Moderate mass splitting)	$p_T{}^{jet}$	> 90	> 90	> 90
	E_T^{miss}	> 450	> 300	> 300
	m^{4j}_{eff}	> 1400	> 1000	< 1400
Region C (Small mass splitting)	$p_T{}^{jet}$	> 30	> 30	> 30
	E_T^{miss}	> 500	> 400	> 400
	m^{4j}_{eff}	> 1400	> 1200	< 1400

Criteria common to all Gtt 0-lepton regions: $p_T{}^{jet} > 30$ GeV

	Variable	Signal region	Control region	VR1L	VR0L
Criteria common to all regions of the same type	Lepton	0 signal	= 1 signal	= 1 signal	0 signal
	$\Delta\phi^{4j}_{min}$	> 0.4	–	–	> 0.4
	N^{jet}	≥ 8	≥ 7	≥ 7	≥ 8
	$m^{b-jets}_{T,min}$	> 80	–	> 80	< 80
	m_T	–	< 150	< 150	–
Region A (Large mass splitting)	E_T^{miss}	> 400	> 250	> 250	> 200
	m^{incl}_{eff}	> 1700	> 1350	> 1350	> 1400
	N^{b-jet}	≥ 3	≥ 3	≥ 3	≥ 2
	N^{top}	≥ 1	≥ 1	≥ 1	≥ 1
Region B (Moderate mass splitting)	E_T^{miss}	> 350	> 200	> 200	> 200
	m^{incl}_{eff}	> 1250	> 1000	> 1000	> 1100
	N^{b-jet}	≥ 4	≥ 4	≥ 4	≥ 3
	N^{top}	≥ 1	≥ 1	≥ 1	≥ 1
Region C (Small mass splitting)	E_T^{miss}	> 350	> 200	> 200	> 200
	m^{incl}_{eff}	> 1250	> 1000	> 1000	> 1250
	N^{b-jet}	≥ 4	≥ 4	≥ 4	≥ 3

ATLAS Signal Regions (for reference)

The 3 $\tilde{g} \rightarrow b\bar{b}\tilde{\chi}_1^0$ and 3 $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$, ≥3-b-jet search signal regions (1-lepton regions are also used in this analysis):

Criteria common to all Gtt 1-lepton regions: ≥ 1 signal lepton, $p_T{}^{jet}$ > 30 GeV					
	Variable	Signal region	Control region	VR-m_T	VR-$m_{T,min}^{b-jets}$
Criteria common to all regions of the same type	m_T	> 150	< 150	> 150	< 150
	N^{jet}	≥ 6	≥ 6	≥ 5	≥ 6
	N^{b-jet}	≥ 3	≥ 3	= 3	= 3
Region A (Large mass splitting)	E_T^{miss}	> 200	> 200	> 200	> 200
	m_{eff}^{incl}	> 1100	> 1100	> 600	> 600
	$m_{T,min}^{b-jets}$	> 160	–	< 160	> 140
	N^{top}	≥ 1	≥ 1	≥ 1	≥ 1
Region B (Moderate to small mass splitting)	E_T^{miss}	> 300	> 300	> 200	> 200
	m_{eff}^{incl}	> 900	> 900	> 600	> 600
	$m_{T,min}^{b-jets}$	> 160	–	< 160	> 160

Criteria common to all G…	
	Variable
Criteria common to all regions of the same type	Lepton
	$\Delta\phi_{min}^{4j}$
	$m_{T,min}^{b-jets}$
	m_T
Region A (Large mass splitting)	$p_T{}^{jet}$
	E_T^{miss}
	m_{eff}^{4j}
Region B (Moderate mass splitting)	$p_T{}^{jet}$
	E_T^{miss}
	m_{eff}^{4j}
Region C (Small mass splitting)	$p_T{}^{jet}$
	E_T^{miss}
	m_{eff}^{4j}

Criteria common to all Gtt 0-lepton regions: $p_T{}^{jet}$ > 30 GeV				
Variable	Signal region	Control region	VR1L	VR0L
		= 1 signal	= 1 signal	0 signal
		–	–	> 0.4
		≥ 7	≥ 7	≥ 8
		–	> 80	< 80
		< 150	< 150	–
		> 250	> 250	> 200
		> 1350	> 1350	> 1400
		≥ 3	≥ 3	≥ 2
		≥ 1	≥ 1	≥ 1
		> 200	> 200	> 200
		> 1000	> 1000	> 1100
		≥ 4	≥ 4	≥ 3
		≥ 1	≥ 1	≥ 1
		> 200	> 200	> 200
		> 1000	> 1000	> 1250
		≥ 4	≥ 4	≥ 3

Variables used to define signal regions (CMS I)

The $H_{\mathrm{T}} = \sum p_{\mathrm{T}}^{\mathrm{jet}}$ analysis has a similar strategy to the ATLAS 2-6 jet search but sets up exclusive bins in H_{T}, $H_{\mathrm{T}}^{\mathrm{miss}}$, N^{jet} (4-6, 7-8, 9+), and $N^{\mathrm{b-jet}}$ (0,1,2,3+), making a total of 72 SRs.

Razor variables.

- The objects are grouped into two hemispheres such that the sum of the masses of the hemispheres is minimised.
- Then using the 4-vector (z-component) of the hemispheres, P_i (p_z^i) we define;

$$M_R = \sqrt{(P_{j1} + P_{j2})^2 - (p_z^{j1} + p_z^{j2})^2}$$

$$M_T^R = \sqrt{\frac{E_{\mathrm{T}}^{\mathrm{miss}}(p_T^{j1} + p_T^{j2})^2 - \vec{p}_{\mathrm{T}}^{\mathrm{miss}}.(\vec{p}_T^{j1} + \vec{p}_T^{j2})^2}{2}}$$

$$R^2 = (M_T^R / M_R)^2$$

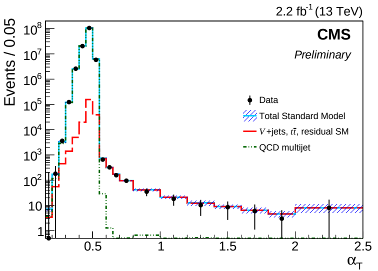
- For a SUSY event M_R is related to the mass scale of the particles, and R^2 is related to the $E_{\mathrm{T}}^{\mathrm{miss}}$ so can be used to suppress SM backgrounds.

Variables used to define signal regions (CMS II)

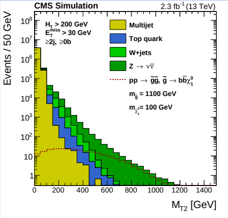
The α_{T} variable is designed to kill multi-jet background events. It is defined by;

$$\alpha_{\mathrm{T}} = E_T^{j2}/M_{\mathrm{T}}$$

where E_T^{j2} is the sub-leading jet energy and M_{T} is the transverse mass of the di-jet system. After cuts on this variable and $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ the multi-jet background is negligible.

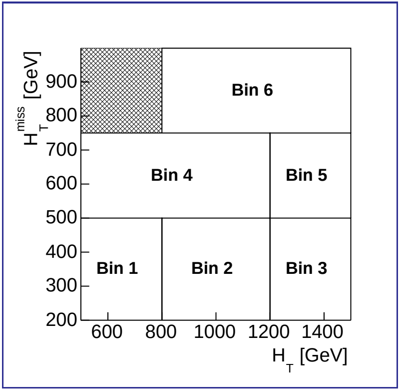


The M_{T2} variable is defined as the analogue to the transverse mass for a system of two particles decaying to a visible and invisible particle.
Experimentally it is formed by clustering the jets around the highest mass pair and using these jets and the $E_{\mathrm{T}}^{\mathrm{miss}}$. This variable provides good discrimination against the QCD and other backgrounds as well. Additionally $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ are applied in this analysis.



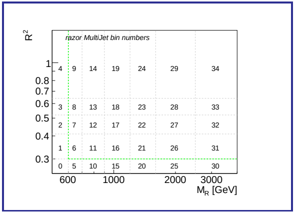
CMS Signal Regions (for reference)

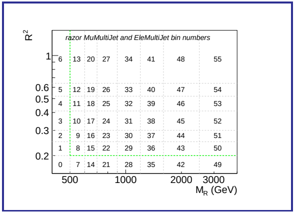
The 72 signal regions of the H_{T} based search - N^{jet} (4-6, 7-8, 9+), and $N^{\mathrm{b-jet}}$ (0,1,2,3+) for each of;



CMS Signal Regions (for reference)

Planes in the Razor variables used as signal regions. Note that both channels with and without leptons are considered.





The 30 α_T signal regions:

Baseline selection:	
Jets selection	Select jets satisfying $p_T > 40$ GeV and $\lvert\eta\rvert < 3$
Forward jet veto	Veto events containing jet satisfying $p_T > 40$ GeV and $\lvert\eta\rvert > 3$
Lepton/photon vetoes	$p_T > 10, 10, 25$ GeV for leptons, isolated tracks, photons (respectively) and $\lvert\eta\rvert < 2.5$
Lead jet acceptance	$p_T > 100$ GeV and $\lvert\eta\rvert < 2.5$
Second jet acceptance	$p_T > 100$ GeV (symmetric), $40 < p_T < 100$ GeV (asymmetric), $p_T < 40$ GeV (monojet)
Energy sums	$H_T > 200$ GeV and $H_T^{miss} > 130$ GeV
E_T^{miss} cleaning	Various filters related to beam and instrumental effects
(n_{jet},nb) categorisation and H_T binning:	
n_{jet} binning	1 (monojet), 2, 3, 4, $\geq$5 (both symmetric and asymmetric)
n_b binning	0, 1, 2, ≥ 3 ($n_b \leq n_{jet}$)
H_T (GeV) binning	200, 250, 300, 350, 400, 500, 600, >800 GeV (bins can be merged depending on n_{jet}, n_b)
Signal region:	
QCD suppression	$\alpha_T > 0.65$ to $\alpha_T > 0.52$ (H_T-dependent, for the region $H_T < 800$ GeV)
QCD suppression	$\Delta\phi^*_{min} > 0.5$
QCD suppression	$H_T^{miss} / E_T^{miss} < 1.25$

CMS Signal Regions (for reference)

The 162 signal regions of the M_{T2} based search

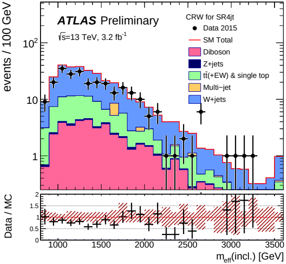
- 5 bins in H_T: [200,450], [450, 575], [575, 1000], [1000, 1500], [1500,∞]
  These bins are also referred to as very low H_T, low H_T, medium H_T, high H_T, and extreme H_T regions.
- 11 bins in $\mathrm{N_j}$ and $\mathrm{N_b}$: 2–3j 0b, 2–3j 1b, 2–3j 2b, 4–6j 0b, 4–6j 1b, 4–6j 2b, ≥7j 0b, ≥7j 1b, ≥7j 2b, 2–6j ≥3b, ≥7j ≥3b

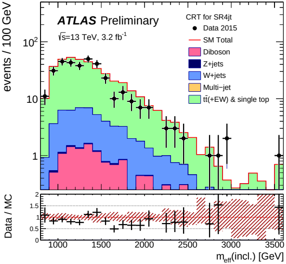
Each bin defined by the H_T, $\mathrm{N_j}$, $\mathrm{N_b}$ requirements above is referred to as a *topological region* and we further divide each topological region in bins of M_{T2}.

- 3 bins in M_{T2} at Very Low H_{T}: [200,300], [300,400], [400,∞]
- 4 bins in M_{T2} at Low H_{T}: [200,300], [300,400], [400,500], [500,∞]
- 5 bins in M_{T2} at Medium H_{T}: [200,300], [300,400], [400,600], [600,800], [800,∞]
- 5 bins in M_{T2} at High H_{T}: [200,400], [400,600], [600,800], [800, 1000], [1000,∞]
- 5 bins in M_{T2} at Extreme H_{T}: [200,400], [400,600], [600,800], [800,1000], [1000,∞]

Estimating the W and $t\bar{t}$ backgrounds (ATLAS)

- Backgrounds from W+jets and $t\bar{t}$ enter the search regions either when either the electron or muon is missed (out of acceptance or reconstruction efficiency), or through a hadronic τ decay.
- This background is determined in all three searches by forming **control regions** requiring an isolated electron of muon.
- W+jets and $t\bar{t}$ are separated by requiring or vetoing a b-tagged jet.
- These have slightly relaxed kinematic cuts compared to the signal region.
- The final prediction then comes from taking the ratio between the regions from Monte-Carlo in the combined fit of signal and control regions.





Estimating the W and $t\bar{t}$ backgrounds (CMS)

- CMS determine the backgrounds from missed leptons and $\tau_{\rm had}$ separately

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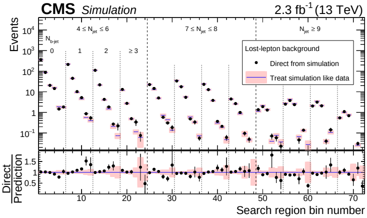
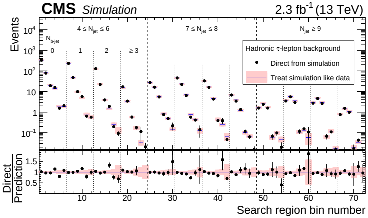
- The missed lepton background is determined using a CR requiring a e or μ and each event is then assigned to the signal regions assuming the lepton has been lost with the appropriate probability of it having been lost.
- These probabilities include the dependance on acceptance, reconstruction and isolation ϵ and are functions of $H_{\rm T}$, $H_{\rm T}^{\rm miss}$, $N^{\rm jet}$, $p_{\rm T}^{\rm lep}$,etc.

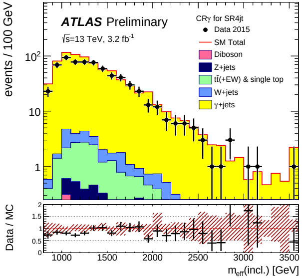
- The $\tau_{\rm had}$ background is determined from a control region requiring a μ.
- The muons are then smeared by a response function and the events entered into the SRs. Closure of both of these methods is tested in MC.

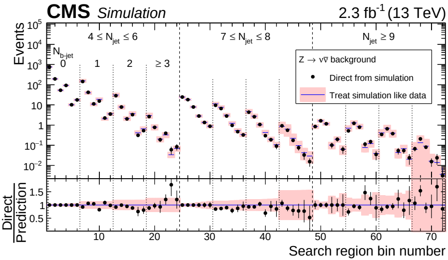




Estimating the Z$\to\nu\nu$ background (ATLAS+CMS)

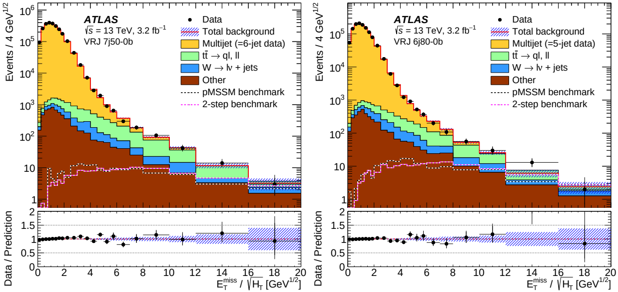
- Both estimate the Z$\to\nu\nu$ background using a similar strategy.
- Events with similar kinematic properties to the signal region but with a high p_{T} photon instead of $E_{\mathrm{T}}^{\mathrm{miss}}$ are selected.
- This process is similar to Z production other than the up/down quark couplings and the boson mass.
- Overall normalisation is taken from $Z \to ll$ events.
- Below is the agreement in the γ control region from ATLAS and the closure of this method in MC from CMS.





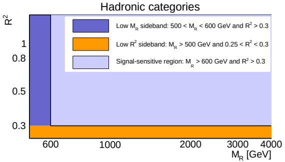
Estimating the Multi-jet background (ATLAS)

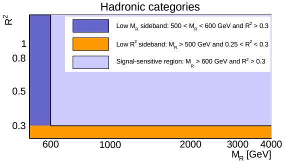
- The ATLAS ≥2-6 jet and ≥3-b-jet cut so hard on $E_{\mathrm{T}}^{\mathrm{miss}}$ and the other variables eg.$\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ that this background is negligible ($<$ 0.5%).
- The ≥7-10 jet search cuts softly on $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ such that this remains a major background component.
- This background is estimated by using a template taken from low jet multiplicity data of the $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ distribution.
- The assumption is then that this distribution is invariant under changes in multiplicity which is shown to work at multiplicities lower than the SRs.



Razor Search Background Estimation (CMS)

- The CMS Razor search uses a very different approach to the others.
- An empirical shape with 4 parameters is used across the R^2, M_R plane.
- Regions of low R^2 or M_R are used to constrain the background fit parameters in each binned number of b-jets.
- The fit is tested in Monte-Carlo and is found to describe the distribution across the plane well.
- A potential issue could occur if the fraction of the different backgrounds was different in Monte-Carlo and data such that these are varied by $\pm 30\%$ and the fit is seen to still be able to describe the distribution.
- The fit is also tested in the presence of a signal to check that it wouldn't be unduely biased.



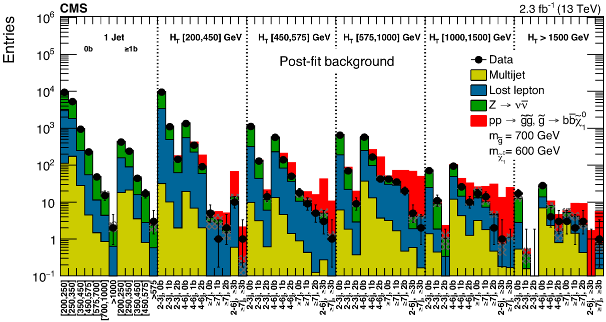


Results and Statistical interpretation (ATLAS)

- For each of the individual search channel a simultaneous fit of the signal region and relevant control regions is performed.
- These fits are not overconstrained as the number of control regions correspond to the number of free background components (eg. $t\bar{t}$, W, Z, etc.)
- No significant deviation from the Standard Model is found in these fits.
- To set limits the fits are performed in the presence of signal (to account for control region signal contamination).
- The limit contour then comes from the region with the best expected limit for each point in the plane.
- This simple setup is designed for easy **discovery** with relatively little "look-elsewhere" effect.
- Upper limits on the number of BSM events present in each signal region are given for re-interpretation.
- For the $\geq$3-b-jet search results from the 0 and 1 lepton channels present in the analysis are combined.

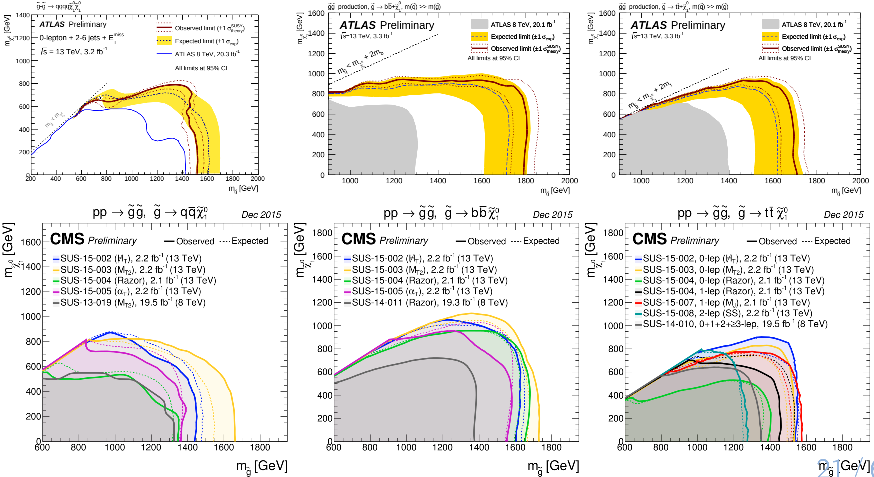
Results and Statistical interpretation (CMS)

- Each of the CMS analyses has a large number of signal regions.
- No significant deviation is found across the phase space such that limits are set.
- They use a fit to all regions in the presence of each signal point to determine if it can be excluded.
- This utilizes the **full shape information** of the signal distributions to enhance their sensitivity.



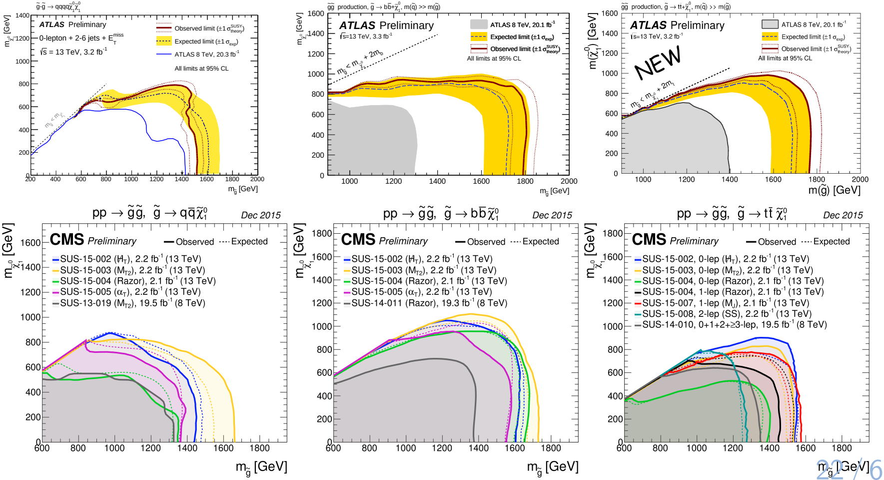
Limits on models I

- Both ATLAS and CMS set limits on the same models; $\tilde{g} \rightarrow \tilde{\chi}_1^0 + q\bar{q}/b\bar{b}/t\bar{t}$



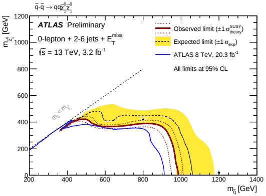
Limits on models I

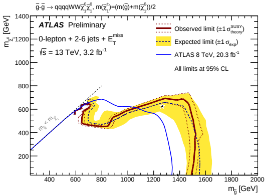
- Both ATLAS and CMS set limits on the same models; $\tilde{g} \rightarrow \tilde{\chi}_1^0 + q\bar{q}/b\bar{b}/t\bar{t}$

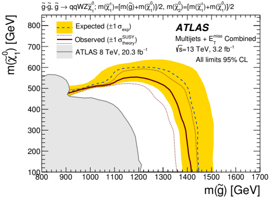


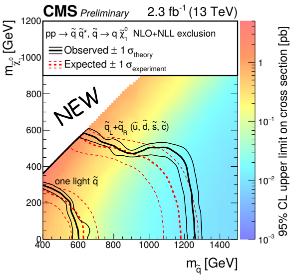
Limits on models II

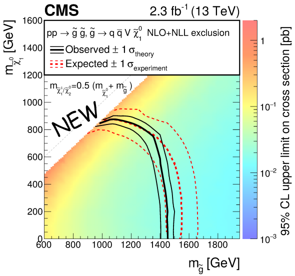
- Additionally both collaborations have looked at additional models;

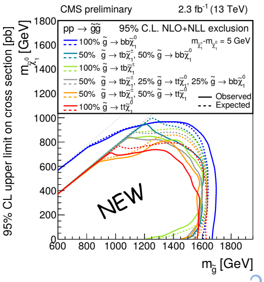












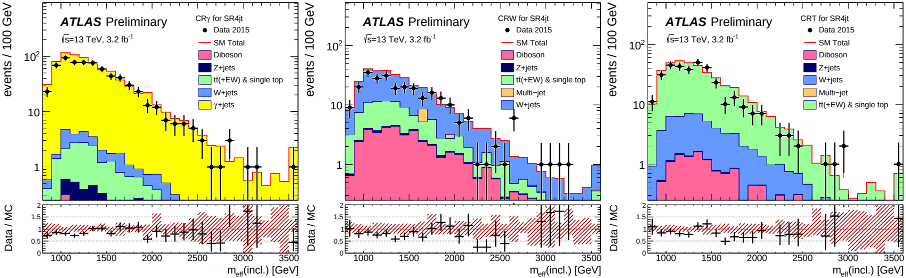
Conclusions

- There has been a significant effort to find the $\tilde{g}$ in the 2015 13 TeV data by both ATLAS and CMS.
- Unfortunately no evidence for such particles has been found.
- Limits have been set in various models (more than I have been able to show today).
- Much more documentation of these searches appears on the ATLAS and CMS public webpages.
- The upcoming 2016 data will offer new opportunities for the discovery of Supersymmetry!
- Fingers crossed nature is kind to us and the Supersymmetry is just around the corner...

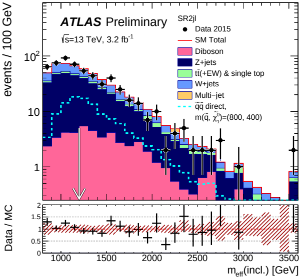
Back-Up

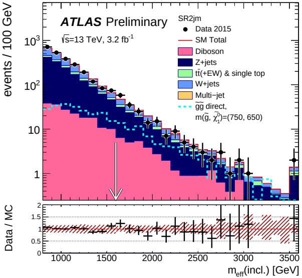
ATLAS $\geq$2-6 jet + $E_{\mathrm{T}}^{\mathrm{miss}}$ Search

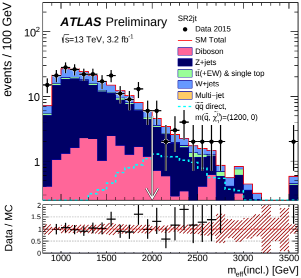
The Control Regions



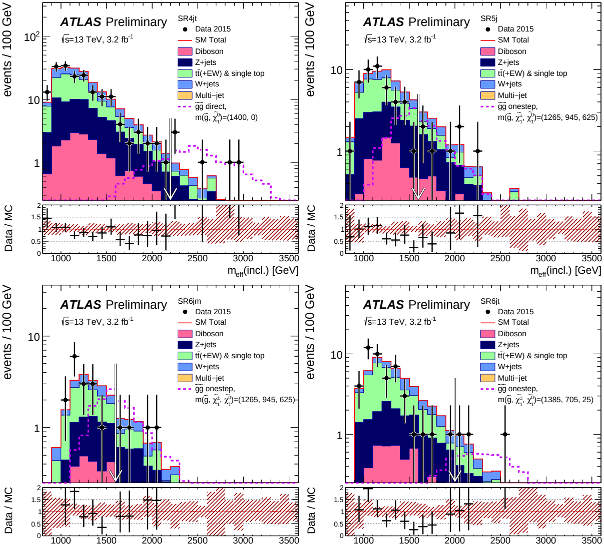
The Signal Regions



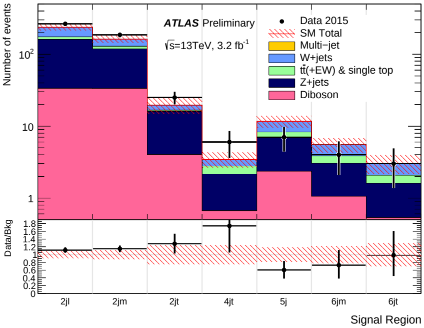




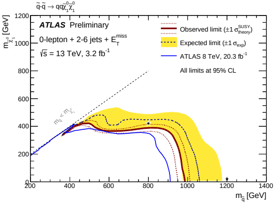
The Signal Regions

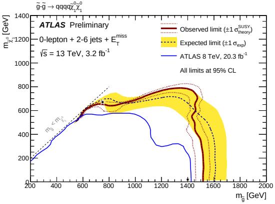


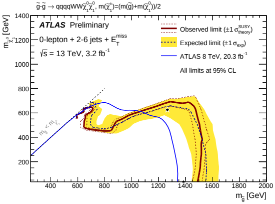
The Signal Regions



The Limit Plots







ATLAS ≥7-10 jet + $E_{\mathrm{T}}^{\mathrm{miss}}$ Search

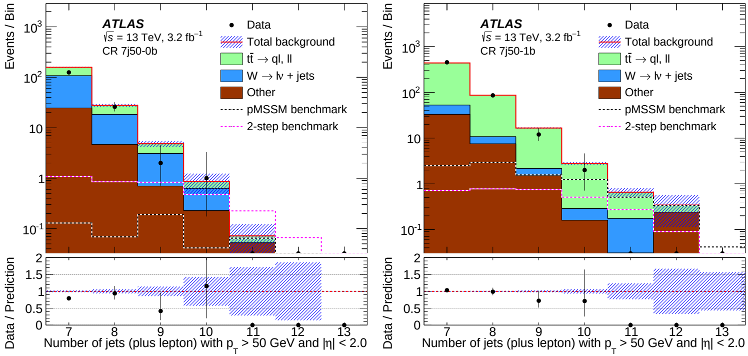
The Signal and Control Regions

	8j50	8j50-1b	8j50-2b	9j50	9j50-1b	9j50-2b	10j50	10j50-1b	10j50-2b
n_{50}	≥ 8			≥ 9			≥ 10		
$n_{b-\mathrm{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 4\,\mathrm{GeV}^{1/2}$								

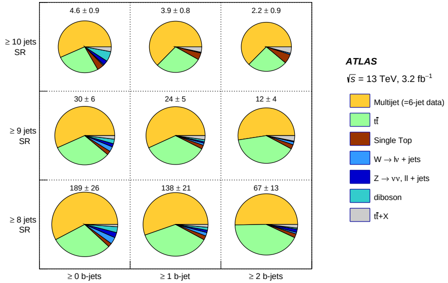
	7j80	7j80-1b	7j80-2b	8j80	8j80-1b	8j80-2b
n_{80}	≥ 7			≥ 8		
$n_{b-\mathrm{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 4\,\mathrm{GeV}^{1/2}$					

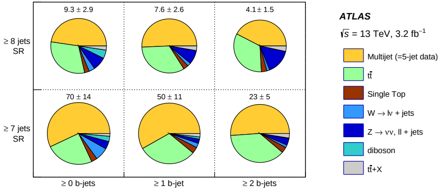
SR name	nj50 or nj50-1b or nj50-2b		nj80 or nj80-1b or nj80-2b	
CR name	CR$(n-1)$j50-0b	CR$(n-1)$j50-1b	CR$(n-1)$j80-0b	CR$(n-1)$j80-1b
p_{T}^{ℓ} ($\ell \in \{e\,\mu\}$)	> 20 GeV			
m_{T}	< 120 GeV			
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 3\,\mathrm{GeV}^{1/2}$			
n_{50}^{CR}	$\geq n_{50}-1$		—	
n_{80}^{CR}	—		$\geq n_{80}-1$	
$n_{b-\mathrm{jet}}$	0	≥ 1	0	≥ 1

Control Region Distributions

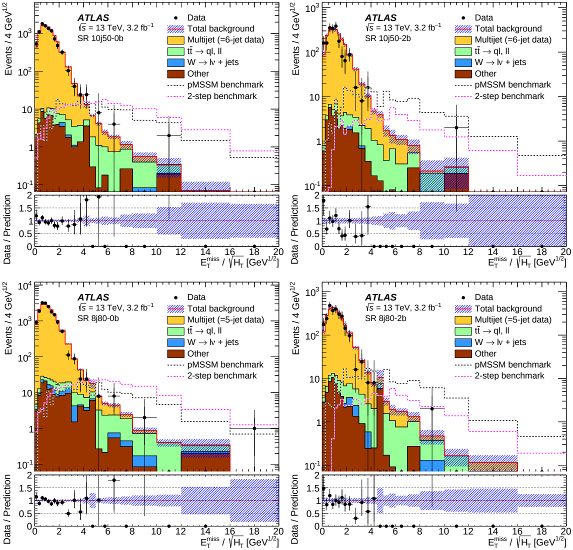


Signal Region Backgrounds





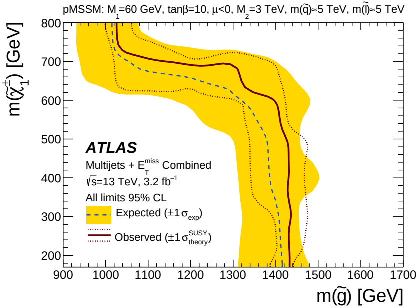
Signal Region Distributions

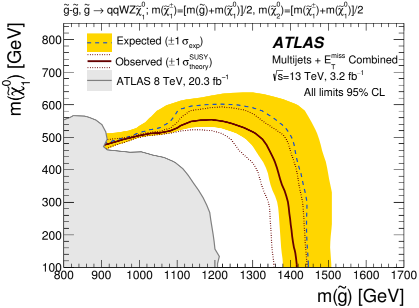


Signal Region Table

Signal region	Fitted background			Obs events
	Multijet	Leptonic	Total	
8j50	109.3 ± 6.9	80 ± 25	189 ± 26	157
8j50-1b	76.7 ± 2.7	62 ± 21	138 ± 21	97
8j50-2b	33.8 ± 2.1	33 ± 13	67 ± 13	39
9j50	16.8 ± 1.3	12.8 ± 5.4	29.6 ± 5.6	29
9j50-1b	13.5 ± 2.0	10.2 ± 4.9	23.8 ± 5.3	21
9j50-2b	6.4 ± 1.6	5.8 ± 3.3	12.1 ± 3.6	9
10j50	2.61 ± 0.61	1.99 ± 0.62	4.60 ± 0.87	6
10j50-1b	2.42 ± 0.62	1.44 ± 0.49	3.86 ± 0.79	3
10j50-2b	1.40 ± 0.87	0.83 ± 0.37	2.23 ± 0.94	1
7j80	40.0 ± 5.3	30 ± 13	70 ± 14	70
7j80-1b	29.1 ± 3.4	20.8 ± 10	50 ± 11	42
7j80-2b	11.5 ± 1.6	11.0 ± 5.0	22.5 ± 5.2	19
8j80	4.5 ± 1.9	4.9 ± 2.2	9.3 ± 2.9	8
8j80-1b	3.9 ± 1.5	3.8 ± 2.1	7.6 ± 2.6	4
8j80-2b	1.72 ± 0.93	2.3 ± 1.1	4.1 ± 1.5	2

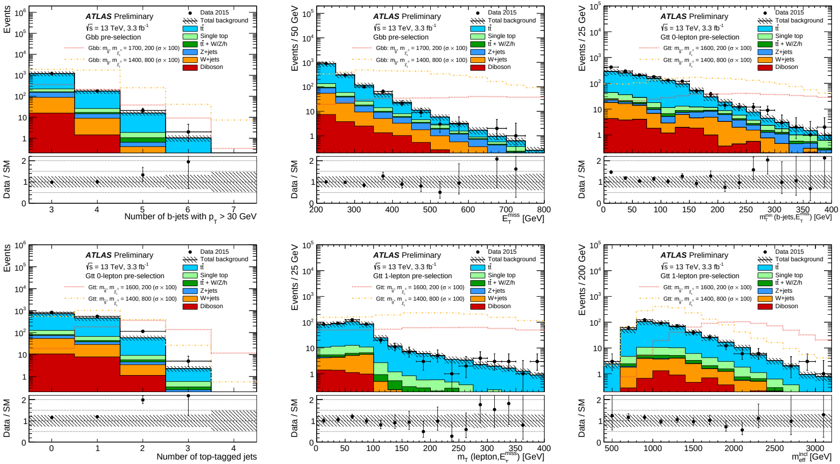
Limit Plots


pMSSM: M1=60 GeV, tanβ=10, μ<0, M2=3 TeV, m(q̃)≈5 TeV, m(l̃)≈5 TeV
ATLAS
Multijets + E_T^miss Combined
√s=13 TeV, 3.2 fb⁻¹
All limits 95% CL
Expected (±1 σexp)
Observed (±1 σ^SUSY_theory)
m(χ̃±1) [GeV]
m(g̃) [GeV]

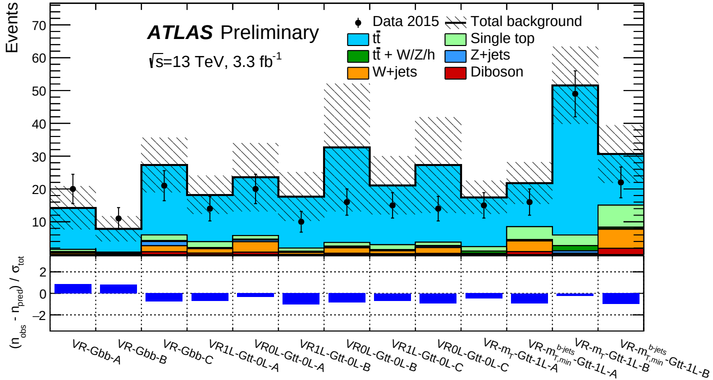

g̃-g̃, g̃ → qqWZχ̃⁰1; m(χ̃±1)=[m(g̃)+m(χ̃⁰1)]/2, m(χ̃⁰2)=[m(χ̃±1)+m(χ̃⁰1)]/2
Expected (±1 σexp)
Observed (±1 σ^SUSY_theory)
ATLAS 8 TeV, 20.3 fb⁻¹
ATLAS
Multijets + E_T^miss Combined
√s=13 TeV, 3.2 fb⁻¹
All limits 95% CL
m(χ̃⁰1) [GeV]
m(g̃) [GeV]

ATLAS $\geq$3 b-jet + $E_{\mathrm{T}}^{\mathrm{miss}}$ Search

Control Region Distributions

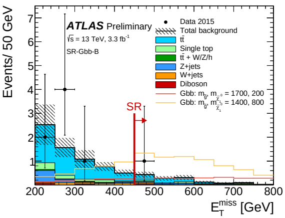


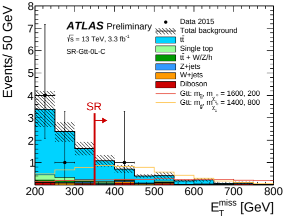
Signal Regions

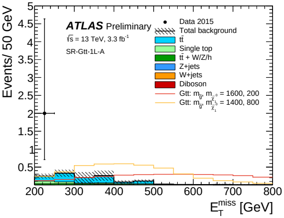


Chris Young, CERN

Signal Region Distributions

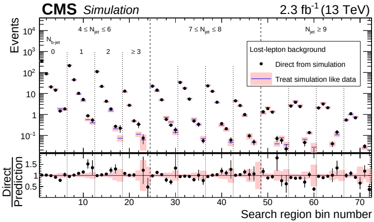


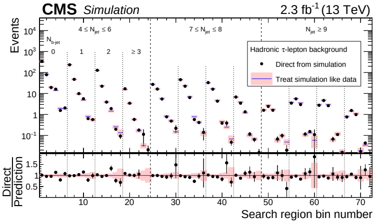


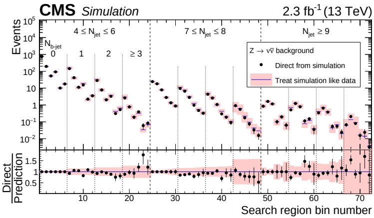


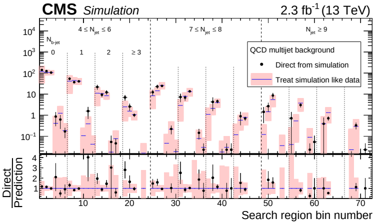
CMS H_T and $H_\mathrm{T}^\mathrm{miss}$ Search

Closure Tests

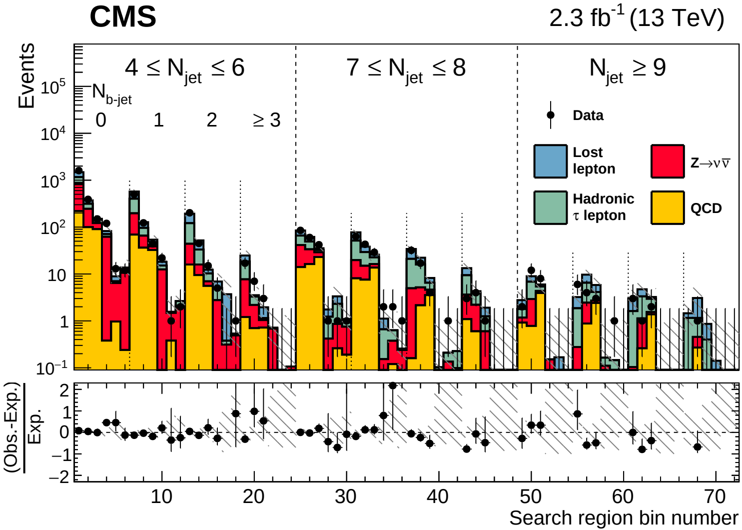




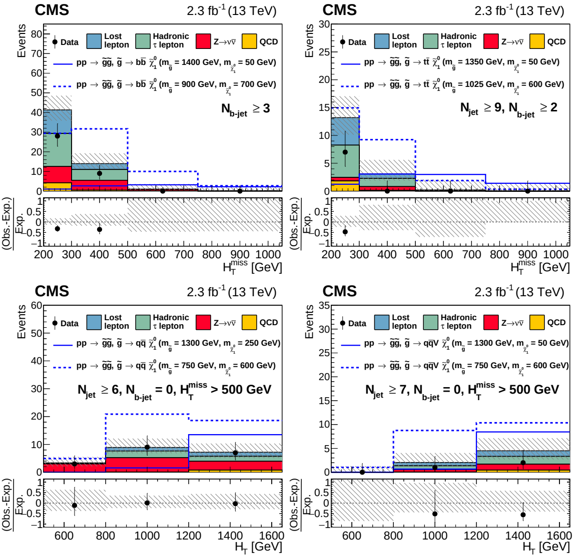




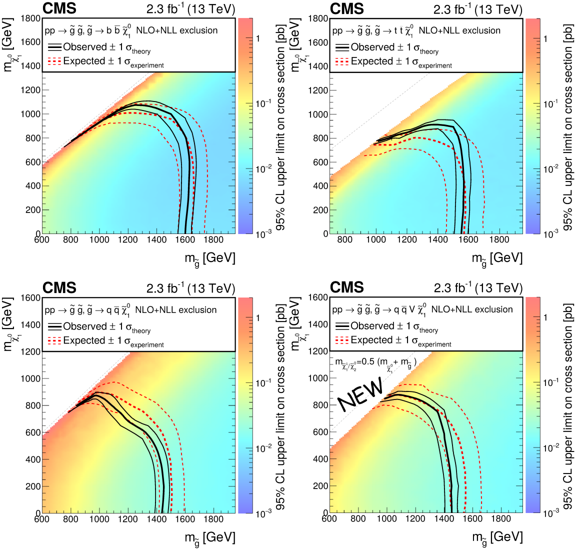
Signal Regions



Signal Region Distributions

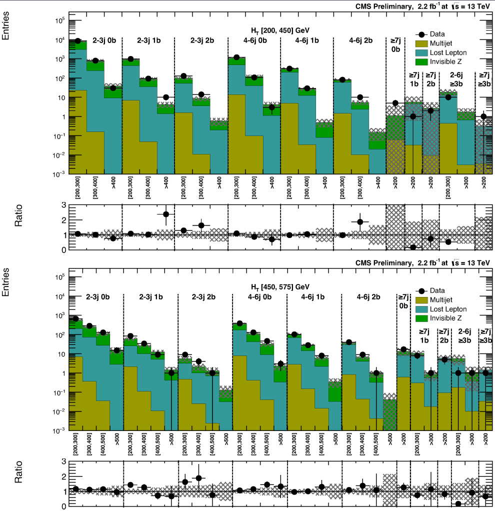


Limit Plots

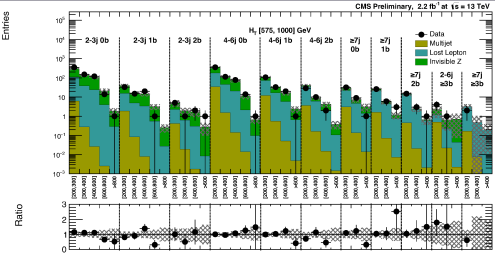

CMS
2.3 fb^{-1} (13 TeV)
pp → $\tilde{g}\,\tilde{g}$, $\tilde{g} \to b\,\bar{b}\,\tilde{\chi}^0_1$ NLO+NLL exclusion
pp → $\tilde{g}\,\tilde{g}$, $\tilde{g} \to t\,\bar{t}\,\tilde{\chi}^0_1$ NLO+NLL exclusion
pp → $\tilde{g}\,\tilde{g}$, $\tilde{g} \to q\,\bar{q}\,\tilde{\chi}^0_1$ NLO+NLL exclusion
pp → $\tilde{g}\,\tilde{g}$, $\tilde{g} \to q\,\bar{q}\,V\,\tilde{\chi}^0_1$ NLO+NLL exclusion
Observed ± 1 σ_{theory}
Expected ± 1 $\sigma_{experiment}$
$m_{\tilde{\chi}^\pm_1/\tilde{\chi}^0_2}$=0.5 ($m_{\tilde{\chi}^0_1}$ + $m_{\tilde{g}}$)
NEW
$m_{\tilde{\chi}^0_1}$ [GeV]
$m_{\tilde{g}}$ [GeV]
95% CL upper limit on cross section [pb]

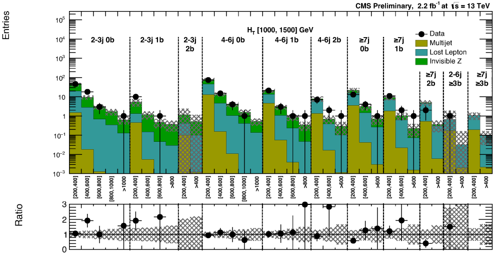
CMS M_{T2} based Search

Signal Regions

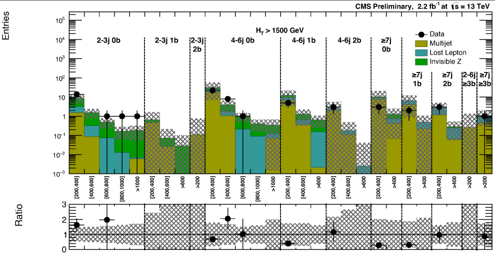


Signal Regions

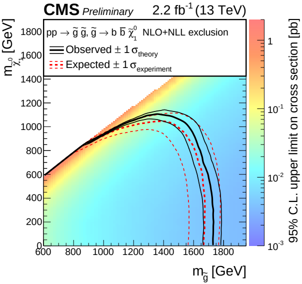


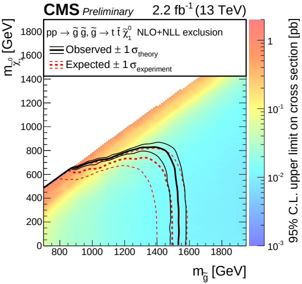


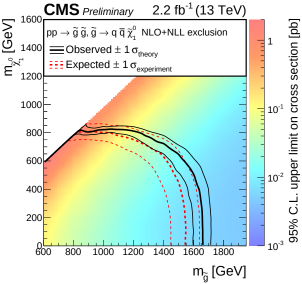
Signal Regions



Limit Plots

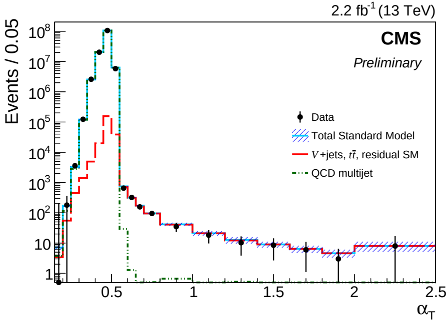

CMS Preliminary
2.2 fb-1 (13 TeV)
pp → g̃ g̃, g̃ → b b̄ χ̃01 NLO+NLL exclusion
Observed ± 1 σtheory
Expected ± 1 σexperiment
mχ̃01 [GeV]
mg̃ [GeV]
95% C.L. upper limit on cross section [pb]

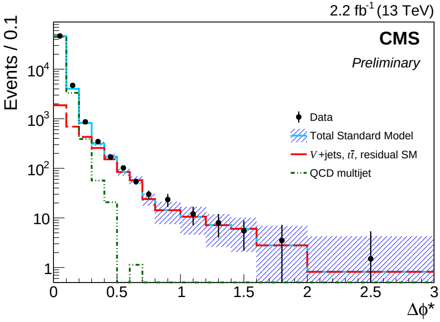

CMS Preliminary
2.2 fb-1 (13 TeV)
pp → g̃ g̃, g̃ → t t̄ χ̃01 NLO+NLL exclusion
Observed ± 1 σtheory
Expected ± 1 σexperiment
mχ̃01 [GeV]
mg̃ [GeV]
95% C.L. upper limit on cross section [pb]


CMS Preliminary
2.2 fb-1 (13 TeV)
pp → g̃ g̃, g̃ → q q̄ χ̃01 NLO+NLL exclusion
Observed ± 1 σtheory
Expected ± 1 σexperiment
mχ̃01 [GeV]
mg̃ [GeV]
95% C.L. upper limit on cross section [pb]

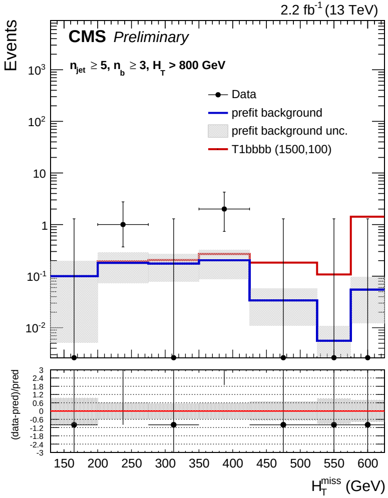
CMS α_{T} based Search

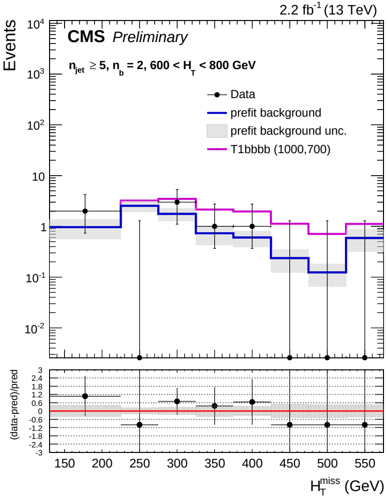
Variables Used



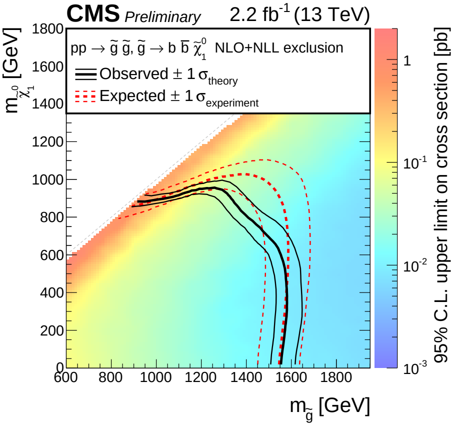


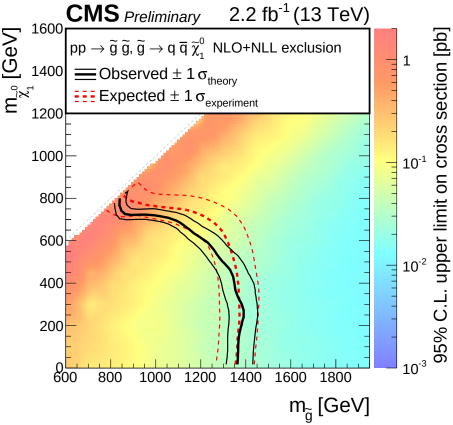
Signal Region Distributions





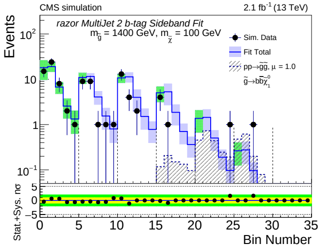
Limit Plots

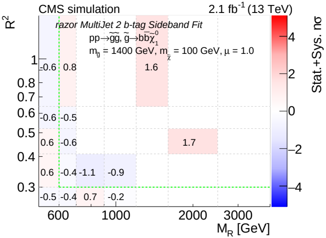

CMS Preliminary
2.2 fb^{-1} (13 TeV)
pp → $\tilde{g}\tilde{g}$, $\tilde{g}$ → b $\bar{b}$ $\tilde{\chi}_1^0$ NLO+NLL exclusion
Observed ± 1 σ_{theory}
Expected ± 1 $\sigma_{experiment}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{g}}$ [GeV]
95% C.L. upper limit on cross section [pb]

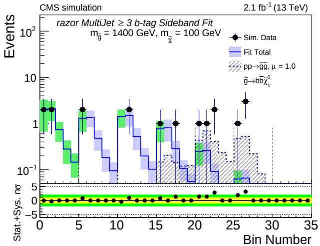

CMS Preliminary
2.2 fb^{-1} (13 TeV)
pp → $\tilde{g}\tilde{g}$, $\tilde{g}$ → q $\bar{q}$ $\tilde{\chi}_1^0$ NLO+NLL exclusion
Observed ± 1 σ_{theory}
Expected ± 1 $\sigma_{experiment}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{g}}$ [GeV]
95% C.L. upper limit on cross section [pb]

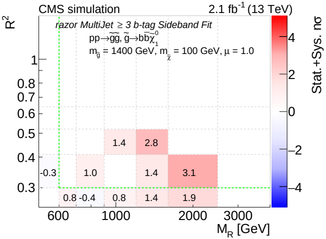
CMS Razor variables based Search

Signal Injection Study

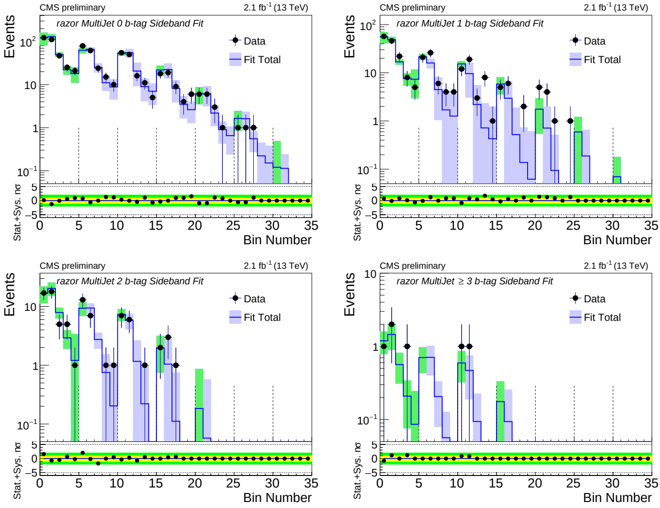




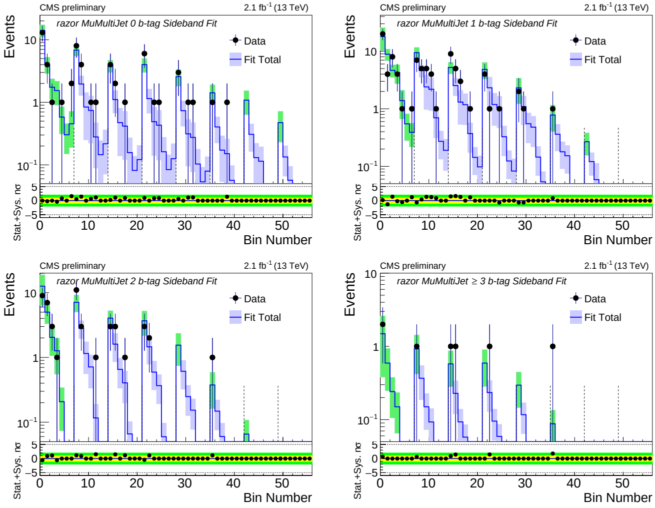




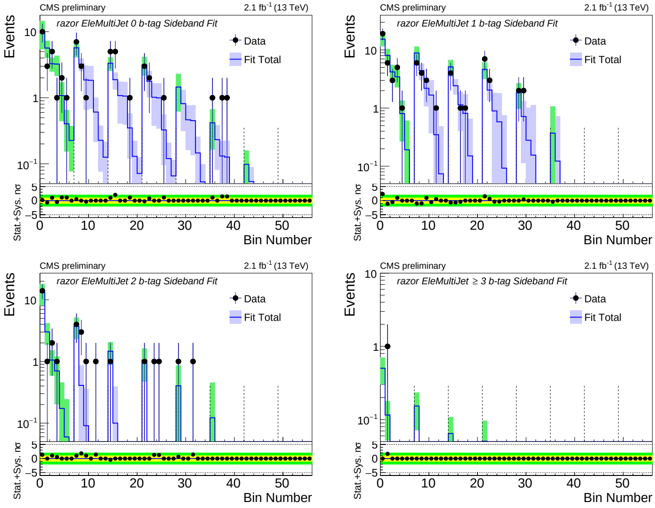
0-lepton Signal Regions



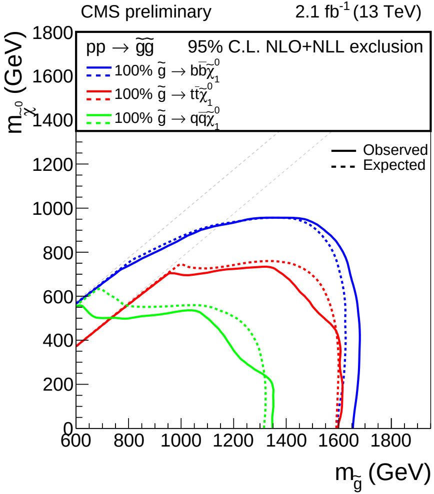
Muon Signal Regions



Electron Signal Regions



Limit Plots


CMS preliminary
2.1 fb-1 (13 TeV)
pp → g̃g̃
95% C.L. NLO+NLL exclusion
100% g̃ → bb̄χ̃01
100% g̃ → tt̄χ̃01
100% g̃ → qq̄χ̃01
Observed
Expected
mχ̃01 (GeV)
mg̃ (GeV)
0
200
400
600
800
1000
1200
1400
1600
1800
600
800
1000
1200
1400
1600
1800

ATLAS Early Run II Projections