Search for gluinos and squarks in final states with one lepton, jets and $E_{\mathrm{T}}^{\mathrm{miss}}$ at $\sqrt{s} = 8$ TeV

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Abstract

This poster presents a search for gluinos and squarks in final states with four hard jets, missing transverse momentum and one isolated electron or muon. This search uses 5.8 fb^{-1} of data from proton-proton collisions at $\sqrt{s} = 8$ TeV collected by the ATLAS experiment at the LHC. No excess over the Standard Model expectation is observed. Limits on the visible cross section of new physics are set. The results are interpreted within the minimal supergravity model.

Signature

Assuming R-parity conservation:

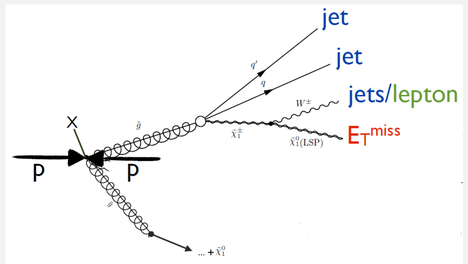
→ Pair production of gluinos and squarks

→ Decay directly or via a cascade to the lightest supersymmetric particle (LSP)

↑

stable, neutral and weakly interacting

→ Final states with jets, leptons and missing transverse momentum ($E_{\mathrm{T}}^{\mathrm{miss}}$)



A supersymmetric decay chain

Signal region

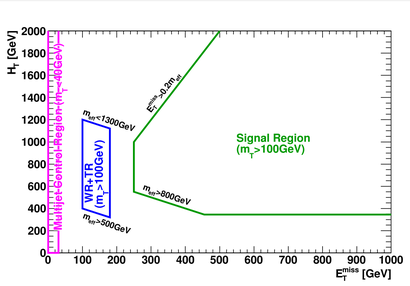
Select events with one isolated electron or muon, at least four jets, large m_{T}, large $E_{\mathrm{T}}^{\mathrm{miss}}$ and large $m_{\mathrm{eff}}^{\mathrm{inc}}$

	signal region
N_{lep}	1
p_{T}^{l} (GeV)	> 25
$p_{\mathrm{T}}^{l_2}$ (GeV)	< 10
N_{jet}	≥ 4
$p_{\mathrm{T}}^{\mathrm{jet}}$ (GeV)	$> 80, 80, 80, 80$
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	> 250
m_{T} (GeV)	> 100
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{meff}}$	> 0.2
$m_{\mathrm{eff}}^{\mathrm{inc}}$ (GeV)	> 800

$m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{l} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos(\Delta\phi(\vec{l}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}})))}$

$m_{\mathrm{eff}}^{\mathrm{inc}} = p_{\mathrm{T}}^{l} + \sum_{i=1}^{N_{\mathrm{jet}}} p_{\mathrm{T},i} + E_{\mathrm{T}}^{\mathrm{miss}}$

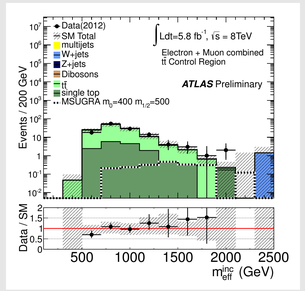
$H_{\mathrm{T}} = m_{\mathrm{eff}}^{\mathrm{inc}} - E_{\mathrm{T}}^{\mathrm{miss}}$

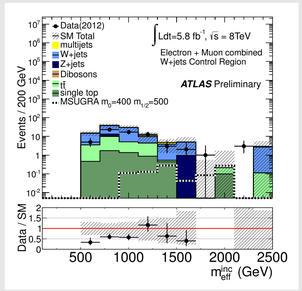


Background estimations and simultaneous fit

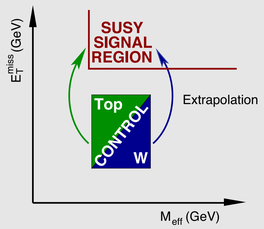
Main backgrounds in signal region: $t\bar{t}$, W+jets; other backgrounds considered: Z+jets, QCD multijet, single top, dibosons

$t\bar{t}$ and W+jets background estimation via a semi-data-driven approach





	W+jets control region	$t\bar{t}$ control region
N_{lep}	1	1
p_{T}^{l} (GeV)	> 25	> 25
$p_{\mathrm{T}}^{l_2}$ (GeV)	< 10	< 10
N_{jet}	≥ 4	≥ 4
$p_{\mathrm{T}}^{\mathrm{jet}}$ (GeV)	$> 80, 80, 80, 80$	$> 80, 80, 80, 80$
$N_{b\text{-tag}}$	0	≥ 1
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	$\in[100, 180]$	$\in[100, 180]$
m_{T} (GeV)	>100	>100
$m_{\mathrm{eff}}^{\mathrm{inc}}$ (GeV)	$\in[500,1300]$	$\in[500,1300]$



- Isolate each of the main backgrounds ($t\bar{t}$ and W+jets) in a control region
- Normalize the Monte Carlo prediction to data in all control regions simultaneously using a binned fit
- Extrapolate in $E_{\mathrm{T}}^{\mathrm{miss}}$ to the signal region:

$$N_{pred_j}^{\mathrm{SR}} = (N_{data}^{\mathrm{CR}_i} - N_{other\ bkg}^{\mathrm{CR}_i}) \times \frac{N_{pred}(MC^j, \mathrm{SR})}{N_{pred}(MC^j, \mathrm{CR}_i)} = (N_{data}^{\mathrm{CR}_i} - N_{other\ bkg}^{\mathrm{CR}_i}) \times C_{\mathrm{CR}_i \to \mathrm{SR}}^{j}$$

Further backgrounds

- **QCD multijet background:** estimated by a fully data-driven matrix method in which a control sample with relaxed isolation criteria for the lepton is used
- Other minor backgrounds as **single top events and diboson events** are taken from Monte Carlo simulation

Simultaneous fit to the control regions

The simultaneous fit is based on a profile likelihood method:

- Simultaneous fit to data in $t\bar{t}$ and W+jets control regions for electron or muon final states (in total four regions)
- Fit performed in four bins of $m_{\mathrm{eff}}^{\mathrm{inc}}$, ranging from 500 GeV to 1300 GeV
- Two free normalization parameters (W/Z+jets and $t\bar{t}$ background)
- All other backgrounds, including the QCD multijet backgound, are allowed to vary within their uncertainties

	$t\bar{t}$ control region		W+jets control region	
	Electron	Muon	Electron	Muon
Observed events	64	51	25	33
Fitted background events	64.2 ± 6.3	50.2 ± 5.4	26.6 ± 4.5	32.3 ± 5.1
Fitted $t\bar{t}$ events	54.1 ± 6.7	44.5 ± 5.6	7.8 ± 2.0	9.4 ± 2.1
Fitted W/Z+jets events	1.3 ± 1.2	0.0 ± 1.8	14.9 ± 4.3	19.6 ± 5.2
Fitted other background events	8.3 ± 1.9	5.1 ± 1.9	1.3 ± 0.7	2.7 ± 0.7
Fitted multijet events	0.5 ± 1.5	0.5 ± 0.7	2.6 ± 3.0	0.6 ± 0.8
MC expected SM events	66.5	51.6	48.3	48.1
MC expected $t\bar{t}$ events	55.1	44.7	9.5	9.0
MC expected W/Z+jets events	2.6	0.0	33.6	35.5
MC expected other background events	8.4	6.4	1.7	2.7
Data-driven multijet events	0.4	0.5	3.5	0.9

Table: Results of the fit in the W+jets and $t\bar{t}$ control regions (systematic uncertainties are included as nuisance parameters in the fit)

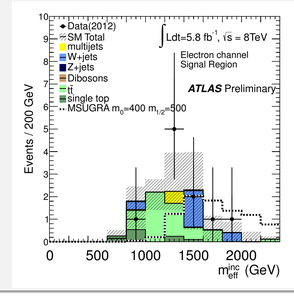
The fit results are cross checked in validation regions located between the control and the signal regions.

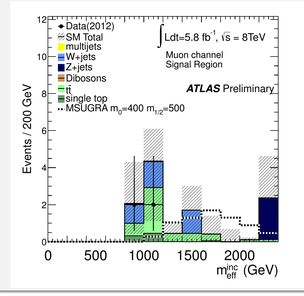
Results in the signal region

Total fitted background in the electron channel: **9.0 ± 2.8** events, while 10 events are observed.
Total fitted background in the muon channel: **7.7 ± 3.2** events, while 4 events are observed.

→ **consistent with Standard Model expectations**

	Signal region	
	Electron	Muon
Observed events	10	4
Fitted background events	9.0 ± 2.8	7.7 ± 3.2
Fitted $t\bar{t}$ events	6.0 ± 2.2	2.6 ± 1.9
Fitted W/Z+jets events	1.5 ± 0.7	4.2 ± 2.3
Fitted other background events	1.0 ± 0.7	0.9 ± 0.3
Fitted multijet events	0.4 ± 0.6	0.0 ± 0.0
MC expected SM events	9.5	11.5
MC expected $t\bar{t}$ events	5.7	4.6
MC expected W/Z+jets events	2.4	6.0
MC expected other background events	1.0	0.8
Data-driven multijet events	0.4	0.0





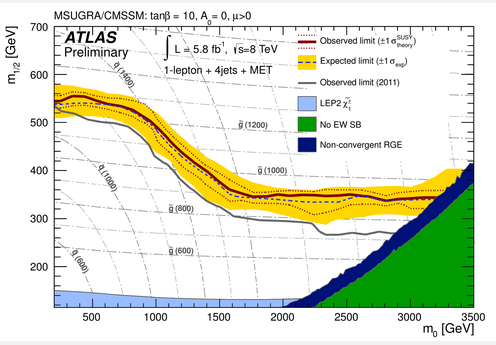
Interpretation

Two interpretations:

- In the mSUGRA model ($\tan\beta = 10$, $A_0 = 0$, $\mu > 0$):

→ squark and gluino masses of 1.24 TeV excluded (for equal squark and gluino masses)

- Model independent upper limit on the visible cross section



	$\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$ [fb]	S_{obs}^{95}	S_{exp}^{95}	CL_B
Electron	1.69	9.9	$9.3^{+3.3}_{-2.6}$	0.59
Muon	1.09	6.4	$8.3^{+3.4}_{-2.3}$	0.19

Table: 95% CL upper limits on the visible cross-section ($\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$) and on the observed ($S_{\mathrm{obs}}^{95}$) and expected ($S_{\mathrm{exp}}^{95}$) number of signal events. The last column indicates the CL_B value, i.e. the confidence level observed for the background-only hypothesis.

The ATLAS Collaboration, *Search for supersymmetry at $\sqrt{s}$=8 TeV in final states with jets, missing transverse momentum and one isolated lepton*, ATLAS-CONF-2012-104 (2012), `https://cdsweb.cern.ch/record/1472673`.