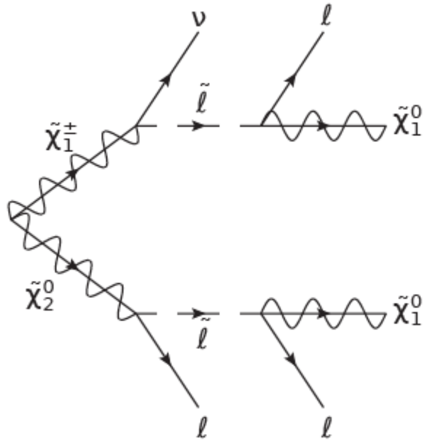
Searches for direct supersymmetric gaugino and slepton pair production in final states with leptons with the ATLAS detector



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6th Annual Workshop of the Helmholtz Alliance

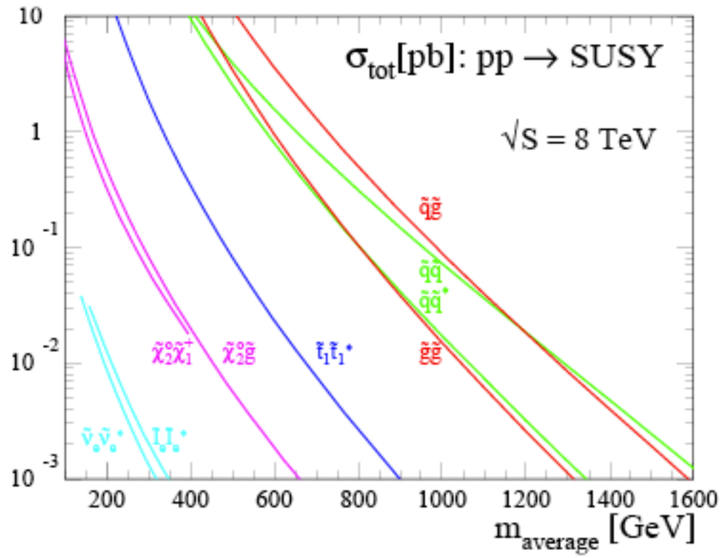
03.12.2012

Motivation

- if coloured SUSY particles ($\tilde{g}$, $\tilde{q}$) are very massive while non-coloured SUSY particles are light
- → weak gauginos (charginos $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^{\pm}$ or neutralinos $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$, $\tilde{\chi}_3^0$, $\tilde{\chi}_4^0$) and sleptons $\tilde{l}$ may dominate the SUSY production at the LHC
- limits on squark/gluino masses are being pushed higher and naturalness favours gaugino masses around 100 GeV

→search for events with missing transverse energy E_T^{miss} and leptons (electrons and muons)

Present the results for the 2 leptons analysis ($7 TeV\ 4.7\ fb^{-1}$ arXiv: 1208.2884, accepted by PLB) and
3 lepton analysis ($8 TeV\ 13 fb^{-1}$ ATLAS-CONF-2012-154)



2(3)-LEPTON SUSY SEARCHES

- Looking for events with exactly 2(3) leptons (e or μ) (+ jets) and relative missing transverse energy $E_T^{\text{miss, rel}}$

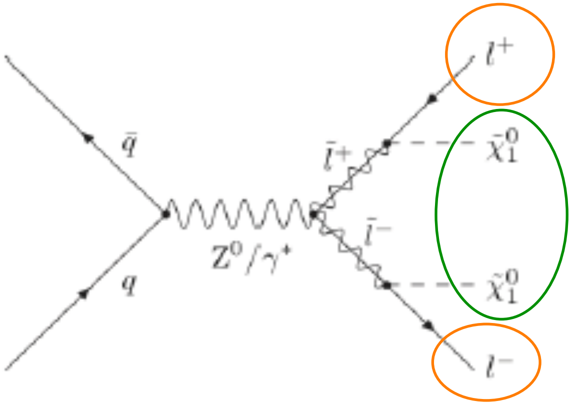
$$E_{\mathrm{T}}^{\mathrm{miss,rel}} = \begin{cases} E_{\mathrm{T}}^{\mathrm{miss}} & \text{if } \Delta\phi_{\ell,j} \geq \pi/2 \\ E_{\mathrm{T}}^{\mathrm{miss}} \times \sin\Delta\phi_{\ell,j} & \text{if } \Delta\phi_{\ell,j} < \pi/2 \end{cases}$$

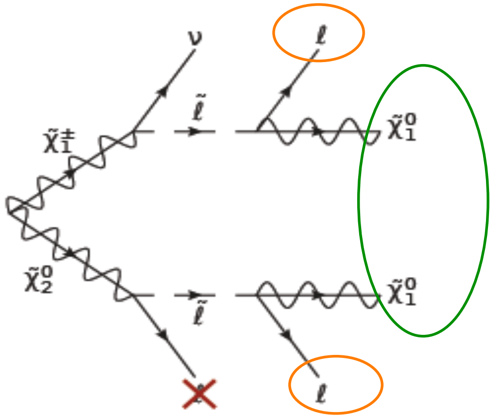
ΔΦ=azimutal angle between the direction of E_T^{miss} vector and the nearest lepton or jet

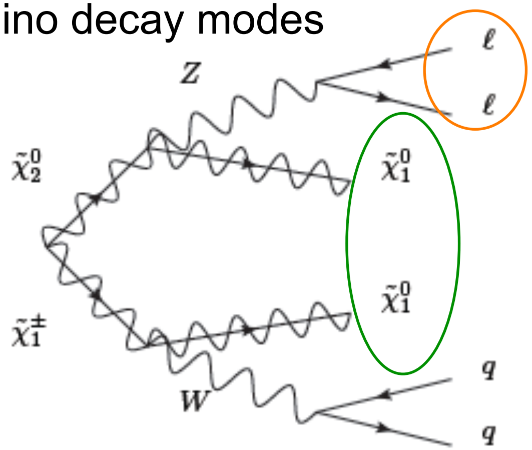
→ reduce the impact of events where an object is badly reconstructed such that it is aligned with E_T^{miss}

2-LEPTON SUSY SEARCHES

- define same charge (SS) and opposite charge (OS) signal regions depending on the SUSY process
- four SR are optimized for slepton production and different gaugino decay modes







2 lepton opposite charge
2 lepton OS with
m(l,l)>20 GeV
jet veto
Z mass veto
$E_T^{miss, rel}$ > 50 GeV
stransverse mass
m_{T2}> 90 GeV

m_{T2}

3 lepton final state
1 lepton not reconstr./out of acceptance
2lepton + OS or SS with
m(l,l)>20 GeV
jet veto
Z mass veto in OS
$E_T^{miss, rel}$ > 100 GeV

OS jveto/SS jveto

2 lepton opposite charge
2 lepton OS with
m(l,l)>20 GeV
≥ 2 jets
Z mass veto
$E_T^{miss, rel}$ > 50 GeV
bjet + top veto

2jets

SM BACKGROUNDS- 2 LEPTON

Main SM backgrounds

OS signal regions

"real" SM backgrounds:
top-antitop pairs, Z/γ + jets, WW

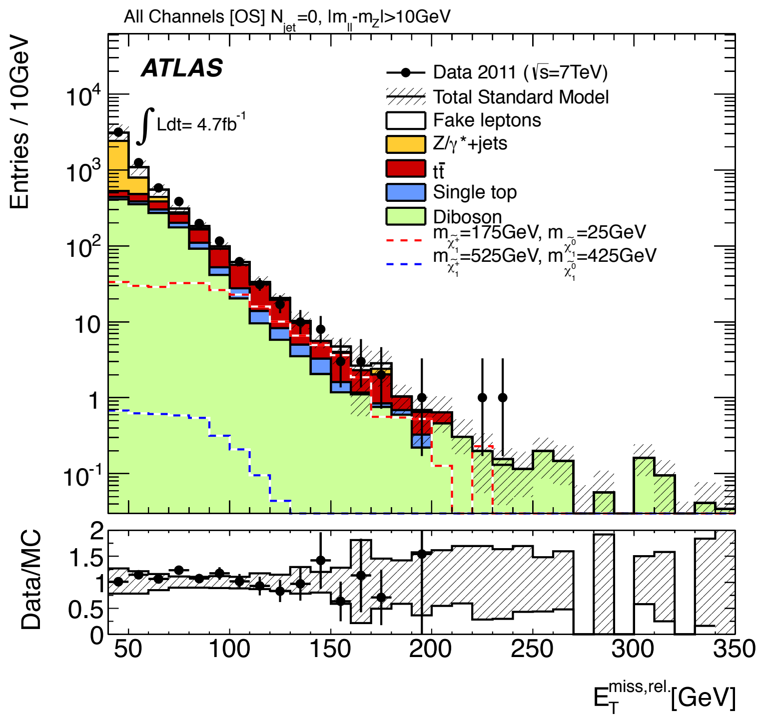
retrieved from data in dedicated control regions by normalizing MC to data and extrapolation to the SR based on MC derived transfer factors
or using MC simulation only
(WW in SR: m_{T2})

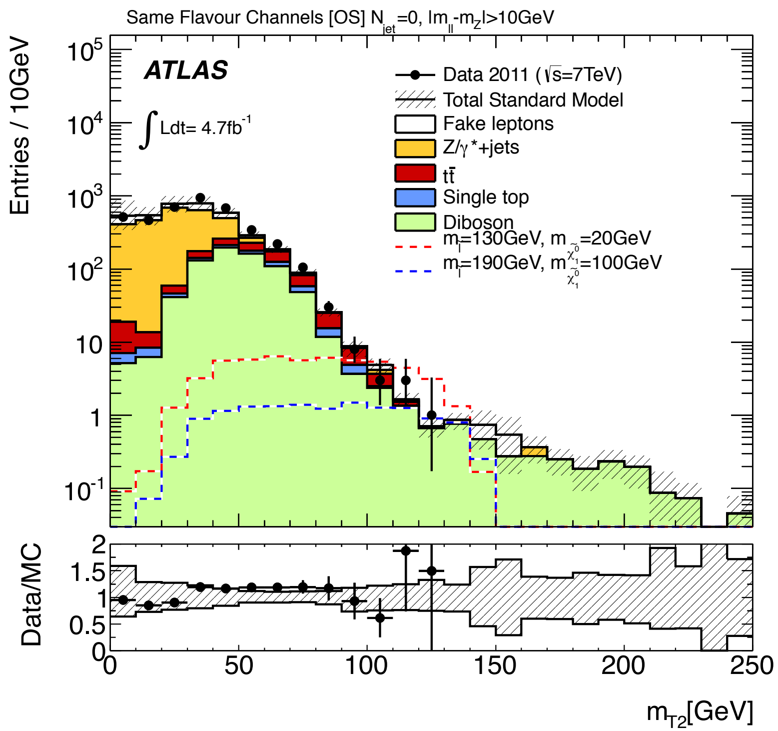
SS signal regions

"fake" (or reducible) SM backgrounds from mulit-jets /W+jets:

consists of events with non-prompt leptons originating from jets or conversion
estimated with data-driven "matrix method"
→categorize events according to lepton id criteria, use efficiency /fake rate to obtain the fake contribution in SR

RESULTS -2 Lepton 7TeV 4.7 fb^{-1}





Signal Region	Background	Data
m_{T2}	$32.8 \pm 3.2 \pm 6.3$	24
OSjveto	$161.7 \pm 6.7 \pm 30.8$	139
SSjveto	$11.0 \pm 1.5 \pm 3.9$	9
2jets	$65.5 \pm 4.0 \pm 31.8$	78

2011 Data, $\sqrt{s} = 7$ TeV
$\int \mathcal{L}\mathrm{d}t = 4.7$ fb^{-1}
arXiv:1208.2884

3-LEPTON SUSY SEARCHES

- require exactly three leptons of same-flavour opposite sign (SFOS) with m_{SFOS}> 12 GeV

$$\tilde{\chi}_2^0 \rightarrow \tilde{\ell}\bar{\ell} \rightarrow \ell\bar{\ell}\tilde{\chi}_1^0 \qquad\qquad \tilde{\chi}_2^0 \rightarrow Z\tilde{\chi}_1^0 \rightarrow \ell\bar{\ell}\tilde{\chi}_1^0$$

neutralino decay via sleptons or off-shell Z-bosons
2 SRs with similar cuts – one SR with tighter cuts to enhance sensitivity to large mass splitting

neutralino decay via on-shell Z-bosons

3 leptons opposite charge Z mass veto E_T^{miss} > 75 GeV b-jet veto		3 lepton opposite charge Z-candidate: $\lvert m_{SFOS}-m_Z\rvert$ < 10 GeV E_T^{miss} > 120 GeV any number of b-jets
no transverse mass m_T cut lepton p_T> 10 GeV	m_T> 110 GeV lepton p_T> 30 GeV	m_T> 110 GeV lepton p_T> 10 GeV
SR1a	SR1b	SR2

SM BACKGROUNDS- 3 LEPTON

- **"reducible" fake background (at least one fake lepton):**

  dominate: top-antitop pair production, Z + jets → determined with matrix method

- **"real" irreducible** backgrounds:

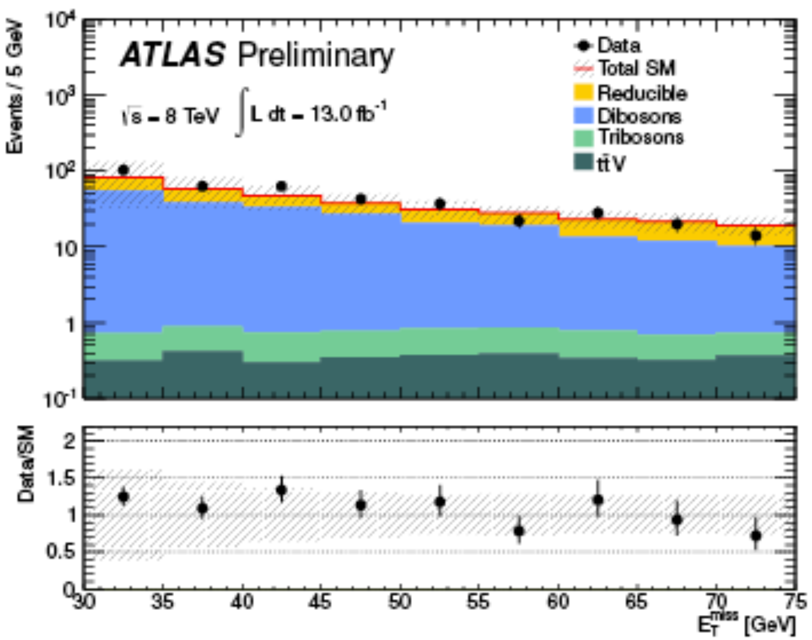
  diboson (WW, ZZ), triboson (WWW, ZZZ, ZWW) and top-antitop W/Z production

  →using MC approach

  main background WZ/γ*

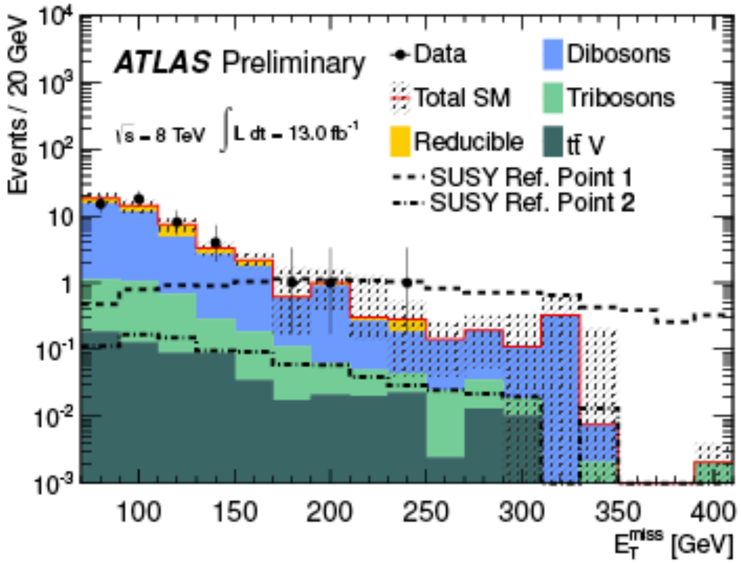
  → determined via semi-data driven approach

  → select three validation regions, fit MC to data

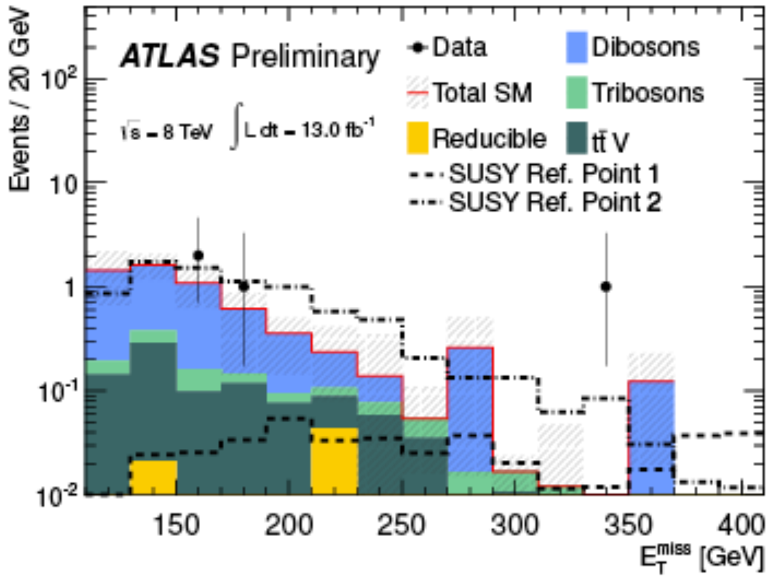


VR1

RESULTS -3 Lepton 8TeV 13 fb^{-1}



SR1a



SR2

Signal Region	Background	Data
SR1a	50 ± 8	48
SR1b	3.1 ± 1.0	4
SR2	$6.1^{+2.0}_{-1.2}$	4

2012 Data, $\sqrt{s} = 8$ TeV
$\int \mathcal{L}dt = 13$ fb^{-1}
ATLAS-COM-CONF-2012-192

SUSY Ref. Point 1: $m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^0}, m_{\tilde{\ell}_L}, m_{\tilde{\chi}_1^0} = 500, 500, 250, 0\,\mathrm{GeV}$

SUSY Ref. Point 2: $m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^0}, m_{\tilde{\chi}_1^0} = 250,\ 250,\ 0\,\mathrm{GeV}$

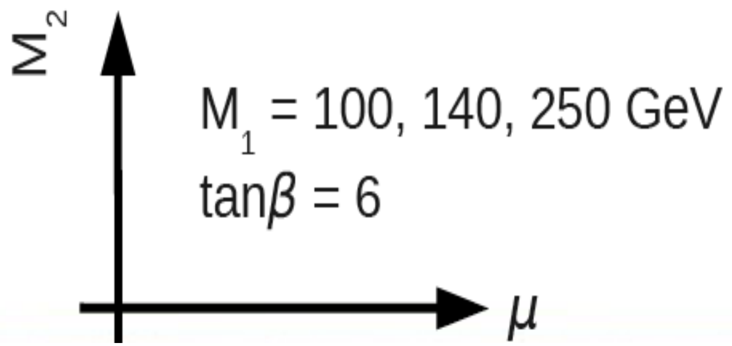
SUSY MODELS

pMSSM models

- gaugino xsection governed by the gaugino masses M_1, M_2 and higgs mass parameter tanβ and μ
- gluino/squark masses, left-handed sleptons > 2TeV
- right-handed sleptons degenerated

$$m_{\tilde{\ell}} = \frac{m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_2^0}}{2}$$

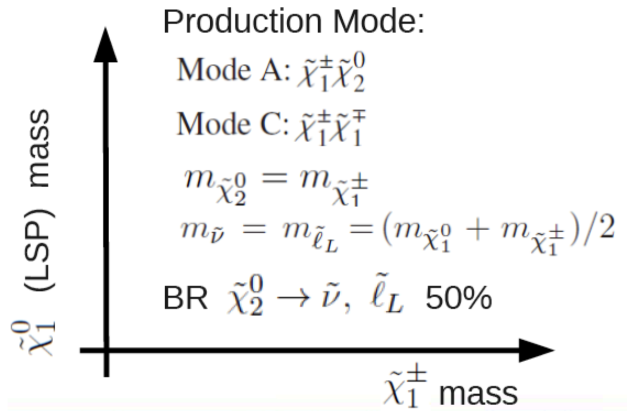
- grids are parameterized in M_1,M_2 and μ, tanβ = 6



Simplified models

- Minimal particle content necessary to produce SUSY-like events
- parameterization in SUSY particles masses; only free parameter are:

  mass of the neutralino1, sneutrino, left-handed slepton, chargino1 and neutralino2

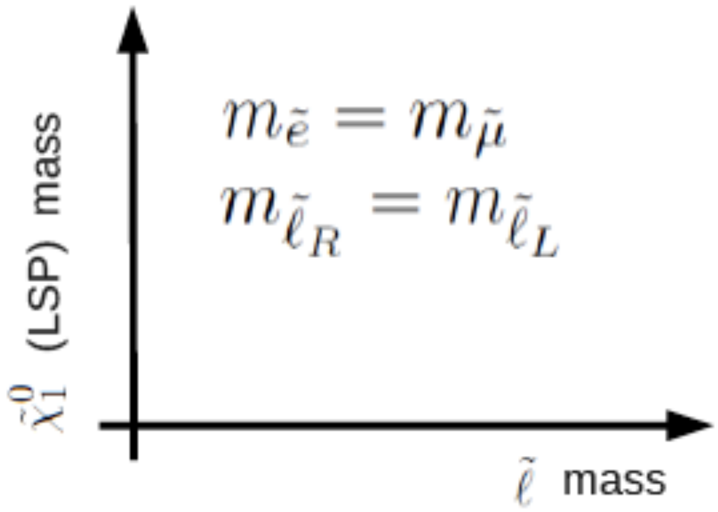


SUSY MODELS

Direct slepton models:

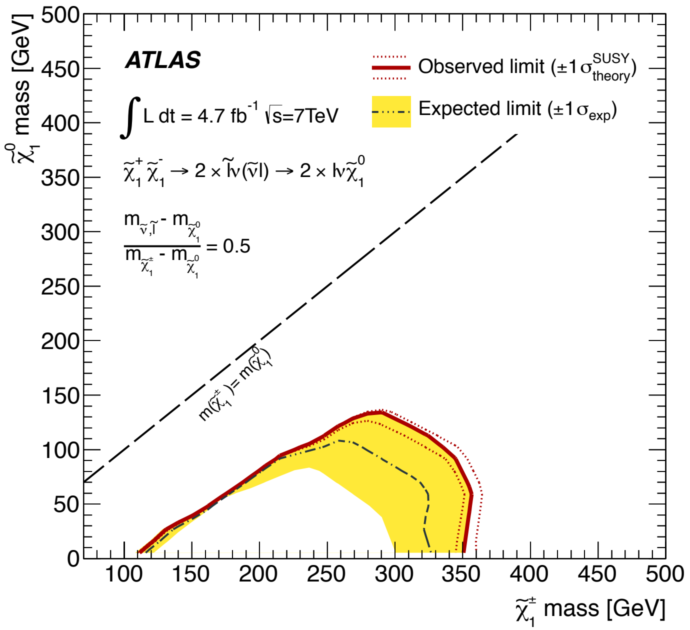
- direct production of sleptons, models based on pMSSM, but left-handed sleptons are included via: $m_{\tilde{\ell}_L} = m_{\tilde{\ell}_R}$
- masses of the gauginos – except for LSP set to 2.5 TeV
- models contain only selectrons and smuons

$$m_{\tilde{e}} = m_{\tilde{\mu}}$$

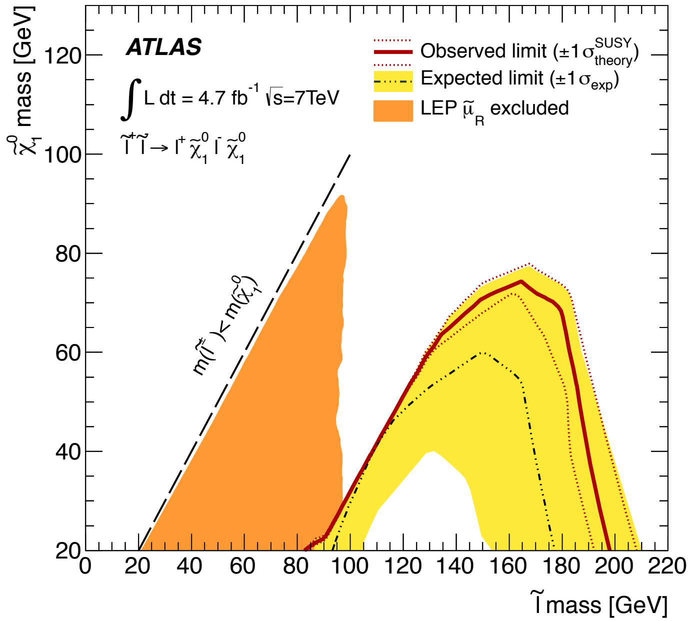


2 LEPTON EXCLUSION LIMITS

simplified model grid



slepton grid



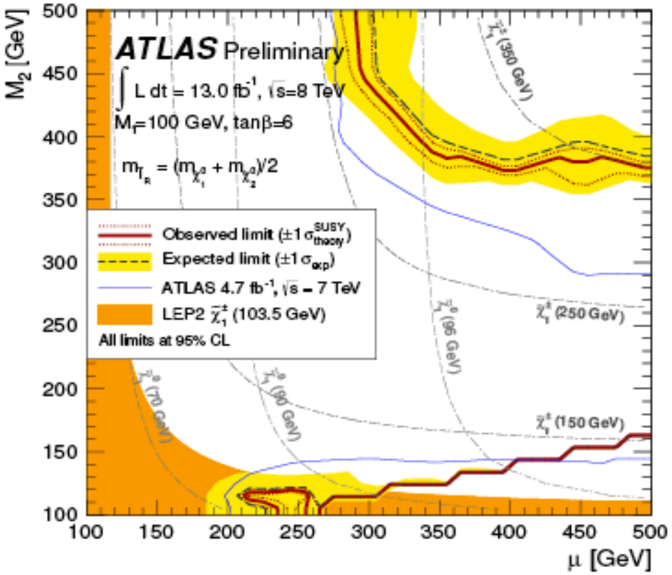
chargino masses between 110 and 330 GeV are excluded for a neutralino mass of 10 GeV
best limit with SR m_{T2}
earlier gaugino searches focused on $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ production
→new mass limit on chargino 1 mass independent of the neutralino 2 mass

limits based on m_{T2} signal region results
sensitivity decreases with m_{NLSP}-m_{LSP}
→ need considerable mass gap to the LSP

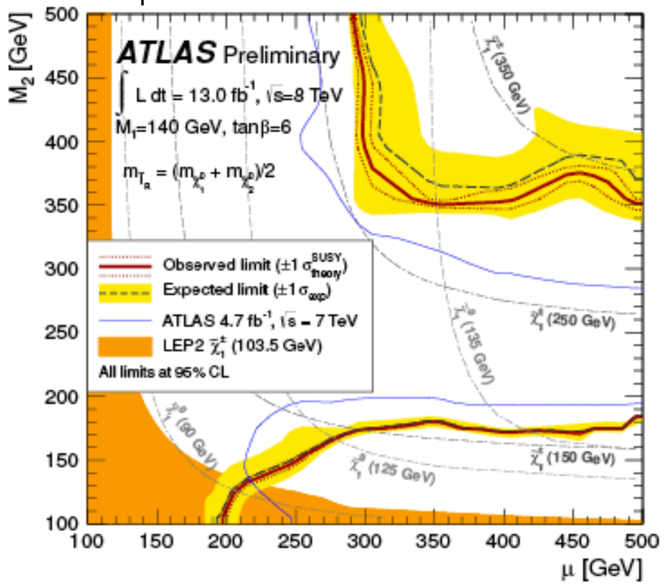
slepton masses between 90-185 GeV for 20 GeV neutralinos are excluded

3 LEPTON EXCLUSION LIMITS

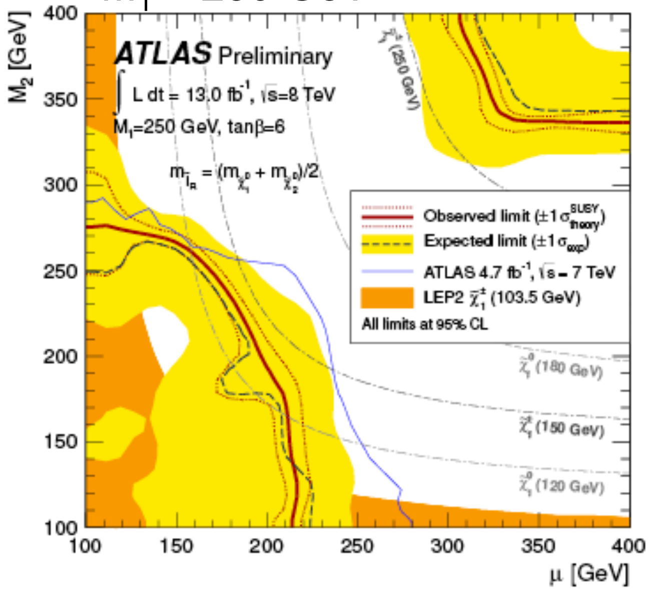
M_1 = 100 GeV



M_1 = 140 GeV



M_1 = 250 GeV

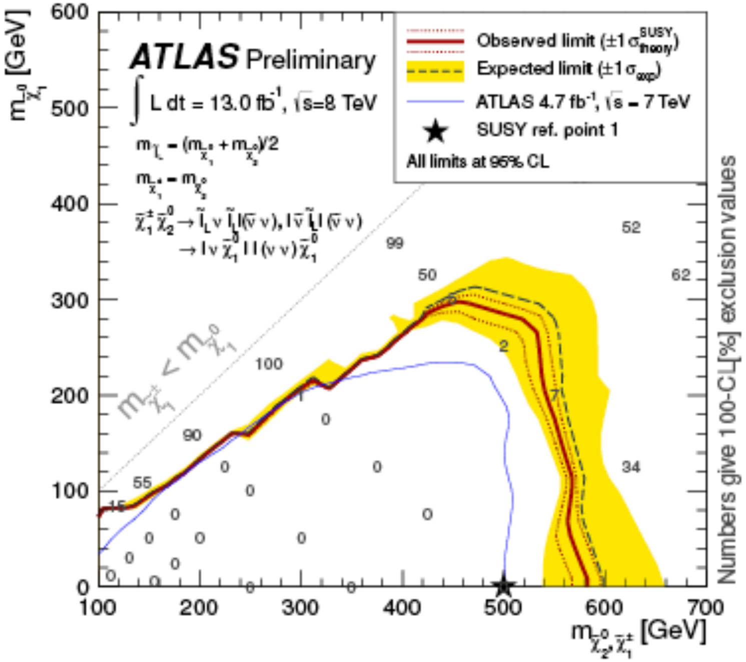


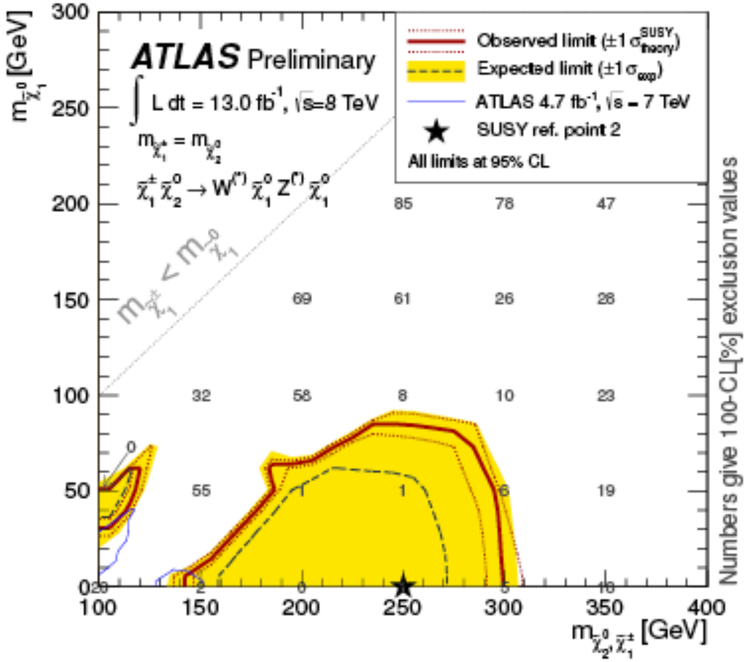
- 95% exclusion limits for chargino-neutralino production in the pMSSM grids for

  M_1= 100, 140 and 250 GeV and light sleptons
- limits are optimized using in each grid point the CL values from the most sensitive SR

3 LEPTON EXCLUSION LIMITS

95% CL limit contours for chargino and neutralino production in the simplified model scenario with intermediate slepton decay and intermediate gauge boson decay





degenerated chargino1 and neutralino 2 masses are excluded up to 580 GeV for large mass differences from the neutralino1

degenerated chargino1 and neutralino 2 masses up to 300 GeV are excluded for large mass differences from the neutralino1

SUMMARY

- dedicated searches for slepton/gaugino production in final states with 2/3 leptons have been performed with the ATLAS detector
- searches are complementary and optimized independently
- good agreement between ATLAS data and standard model prediction is observed, no significant excess was found
- ATLAS limits for slepton and chargino/neutralino production are set using full 2011 data (2-lepton search) and 13 fb^{-1} 2012 data (3-lepton search)

BACKUP

m_{T2}

- The stransverse mass m_{T2} is defined for pair produced particles that each decay to two particles, out of which one goes undetected.
- If the undetected particles are massless, the two-lepton m_{T2} distribution (for $\tilde{\ell}$ pair production) has an endpoint given by

$$m_{\mathrm{T2}}^2 = m_{\tilde{\ell}}^2 - m_{\tilde{\chi}_1^0}^2 + \frac{m_{\tilde{\ell}}^2 - m_{\tilde{\chi}_1^0}^2}{2m_{\tilde{\ell}}} \left(\sqrt{\left(\frac{m_{\tilde{\ell}}^2 + m_{\tilde{\chi}_1^0}^2}{2m_{\tilde{\ell}}}\right)^2 - m_{\tilde{\chi}_1^0}^2} - \frac{m_{\tilde{\ell}}^2 + m_{\tilde{\chi}_1^0}^2}{2m_{\tilde{\ell}}} \right)$$

- It can be shown that this equation simplifies to $\approx m_{\tilde{\ell}} - m_{\tilde{\chi}_1^0}$.
- In particular, m_{T2} is a powerful tool rejecting *WW* background, since the *WW* m_{T2} distribution will end at the W mass.
- *J.Phys. G29 (2003) 2343-2363, Phys.Lett. B463 (1999) 99-103.*

BACKUP

m_{CT}

- The m_{CT} variable is defined for two pair-produced particles δ decaying to an invisible particle α and visible decay products χ_i.

$$m_{CT}(\chi_1, \chi_2) = \left[E_t^2(\chi_1) + E_t^2(\chi_2)\right]^{1/2} - \left[p_T^2(\chi_1) + p_T^2(\chi_2)\right]^{1/2}$$

- The m_{CT} variable can be constructed using combinations of leptons and jets. If $m_{\chi_1} = m_{\chi_2} = m_\chi$ in the above equation, then there is an endpoint given by

$$m_{CT}\left[m^2(\chi)\right] < m_{CT}^{max}\left[m^2(\chi)\right] = \frac{m^2(\chi)}{m(\delta)} + \frac{m^2(\delta) - m^2(\alpha)}{m(\delta)}$$

- The $t\bar{t}$ system should fulfill this inequality for (δ, α) pairs of (W, ν), (t, W) and (t, ν).
- Each dilepton event in SR-2jets is checked against this inequality, and events consistent with $t\bar{t}$ kinematics are removed.

BACKUP

MATRIX METHOD

- Define a set of tight and loose object selection criteria.
- Determine the *real efficiency* r, i.e the probability for a real, prompt lepton to pass the tight selection. This is done using real data.
- Determine the *fake rate* f, i.e the probability for a fake, non-prompt lepton to pass the tight selection. This is done using MC truth.
- Let N_{TT} denote the number of events with two tight leptons, N_{TL} the number of events with one tight and one loose lepton and so on.
- Let N_{RR} denote the number of events with two real leptons, N_{RF} the number of events with one real and one fake lepton and so on.
- The number of events with at least one fake lepton is found by inverting the matrix below. For 3-Lepton, the method is applicable under the assumption that the leading lepton is always real.

$$\begin{pmatrix} N_{TT} \\ N_{TL} \\ N_{LT} \\ N_{LL} \end{pmatrix} = \begin{bmatrix} r_1 r_2 & r_1 f_2 & f_1 r_2 & f_1 f_2 \\ r_1(1-r_2) & r_1(1-f_2) & f_1(1-r_2) & f_1(1-f_2) \\ (1-r_1)r_2 & (1-r_1)f_2 & (1-f_1)r_2 & (1-f_1)f_2 \\ (1-r_1)(1-r_2) & (1-r_1)(1-f_2) & (1-f_1)(1-r_2) & (1-f_1)(1-f_2) \end{bmatrix} \cdot \begin{pmatrix} N_{RR} \\ N_{RF} \\ N_{FR} \\ N_{FF} \end{pmatrix}$$

BACKUP

SYSTEMATIC UNCERTAINTIES

- The following sources of systematic uncertainty are considered (where applicable).

- Luminosity
- Cross section
- Jet Energy Scale
- Jet Energy Resolution
- Trigger Reweighting
- b-tag Efficiency
- Generator
- Parton Shower
- PDF

- Electron Efficiency
- Electron Energy Resolution
- Electron Energy Scale
- Muon Efficiency
- Muon Energy Resolution
- Muon Energy Scale
- Muon MS Momentum
- Muon ID Momentum

BACKUP

Exactly 2 leptons +

SR-	m_{T2}	OSjveto	SSjveto	2jets
charge	OS	OS	SS	OS
flavour	any	any		SF
m_{ll}	Z-veto	Z-veto	-	Z-veto
signal jets	$= 0$	$= 0$		≥ 2
signal b-jets	-	-		$= 0$
$E_T^{miss,rel.}$	> 40	> 100		> 50
other	$m_{T2} > 90$	-		m_{CT}-veto

Syst. uncert. in %

SR-	m_{T2}	OSjveto	2jets	SSjveto
Total statistical	9	4	6	13
Total systematic	19	19	49	35
Jet systematics	9	8	5	3
Lepton systematics	14	1	5	1
b-tagging efficiency	1	1	14	0
MC modelling	7	17	45	4
Fake leptons	5	5	4	35

BACKUP

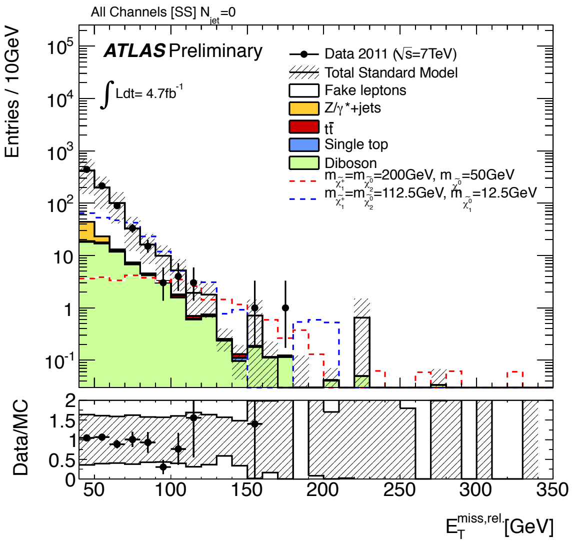
SR-m_{T2}					
	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all	SF
Z+X	$3.2 \pm 1.1 \pm 1.7$	$0.3 \pm 0.1 \pm 0.2$	$3.6 \pm 1.3 \pm 1.7$	$7.1 \pm 1.7 \pm 2.1$	$6.8 \pm 1.7 \pm 2.1$
WW	$2.3 \pm 0.3 \pm 0.4$	$4.8 \pm 0.4 \pm 0.7$	$3.5 \pm 0.3 \pm 0.5$	$10.6 \pm 0.6 \pm 1.5$	$5.8 \pm 0.4 \pm 0.9$
$t\bar{t}$, single top	$2.6 \pm 1.2 \pm 1.3$	$6.2 \pm 1.6 \pm 2.9$	$4.1 \pm 1.3 \pm 1.6$	$12.9 \pm 2.4 \pm 4.6$	$6.8 \pm 1.8 \pm 2.3$
Fake leptons	$1.0 \pm 0.6 \pm 0.6$	$1.1 \pm 0.6 \pm 0.8$	$-0.02 \pm 0.01 \pm 0.05$	$2.2 \pm 0.9 \pm 1.4$	$1.0 \pm 0.6 \pm 0.6$
Total	$9.2 \pm 1.8 \pm 2.5$	$12.4 \pm 1.7 \pm 3.1$	$11.2 \pm 1.9 \pm 3.0$	$32.8 \pm 3.2 \pm 6.3$	$20.4 \pm 2.6 \pm 3.9$
Data	7	9	8	24	15
$\sigma_{vis}^{obs(exp)}$ (fb)	1.6 (1.9)	1.7 (2.2)	1.7 (2.1)	2.6 (3.8)	2.0 (2.7)

SR-OSjveto				
	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Z+X	$4.5 \pm 1.2 \pm 1.2$	$3.0 \pm 0.9 \pm 0.5$	$4.7 \pm 1.1 \pm 1.2$	$12.2 \pm 1.8 \pm 1.8$
WW	$8.8 \pm 1.8 \pm 4.4$	$20.9 \pm 2.6 \pm 6.2$	$13.3 \pm 1.9 \pm 3.5$	$43.0 \pm 3.7 \pm 12.2$
$t\bar{t}$, single top	$21.1 \pm 2.3 \pm 4.2$	$47.7 \pm 3.4 \pm 20.5$	$27.5 \pm 2.5 \pm 9.0$	$96.2 \pm 4.8 \pm 29.5$
Fake leptons	$2.9 \pm 1.2 \pm 1.2$	$6.9 \pm 1.8 \pm 2.6$	$0.4 \pm 0.6 \pm 0.3$	$10.3 \pm 2.2 \pm 4.1$
Total	$37.2 \pm 3.3 \pm 6.4$	$78.5 \pm 4.7 \pm 20.9$	$45.9 \pm 3.4 \pm 9.4$	$161.7 \pm 6.7 \pm 30.8$
Data	33	66	40	139
$\sigma_{vis}^{obs(exp)}$ (fb)	3.5 (4.0)	8.1 (9.6)	4.3 (5.1)	11.4 (14.1)

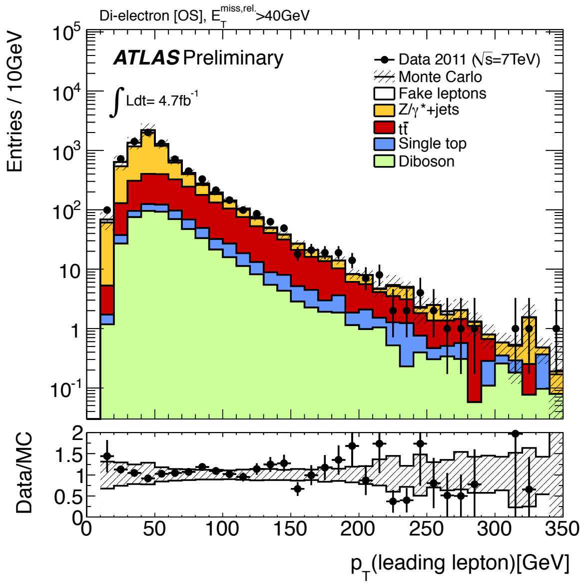
SR-2jets				
	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	SF
Z+X	$3.8 \pm 1.3 \pm 2.7$	—	$5.8 \pm 1.6 \pm 3.9$	$9.6 \pm 2.0 \pm 5.1$
WW	$6.4 \pm 0.5 \pm 4.3$	—	$8.4 \pm 0.6 \pm 5.7$	$14.8 \pm 0.7 \pm 9.9$
$t\bar{t}$, single top	$14.8 \pm 1.9 \pm 9.2$	—	$22.1 \pm 2.1 \pm 20.7$	$36.9 \pm 2.9 \pm 29.6$
Fake leptons	$2.5 \pm 1.2 \pm 1.5$	—	$1.7 \pm 1.3 \pm 0.8$	$4.2 \pm 1.8 \pm 2.3$
Total	$27.5 \pm 2.6 \pm 10.6$	—	$37.9 \pm 3.0 \pm 21.0$	$65.5 \pm 4.0 \pm 31.8$
Data	39	—	39	78
$\sigma_{vis}^{obs(exp)}$ (fb)	7.1 (5.1)	—	9.7 (9.6)	15.6 (13.9)

SR-SSjveto				
	e^+e^-	$e^\pm\mu^\pm$	$\mu^+\mu^-$	all
Charge flip	$0.49 \pm 0.03 \pm 0.17$	$0.34 \pm 0.02 \pm 0.11$	—	$0.83 \pm 0.04 \pm 0.18$
Dibosons	$0.62 \pm 0.13 \pm 0.18$	$1.93 \pm 0.23 \pm 0.36$	$0.94 \pm 0.16 \pm 0.26$	$3.50 \pm 0.31 \pm 0.54$
Fake leptons	$3.2 \pm 0.9 \pm 1.7$	$2.9 \pm 0.9 \pm 1.9$	$0.6 \pm 0.6 \pm 0.3$	$6.6 \pm 1.4 \pm 3.8$
Total	$4.3 \pm 0.9 \pm 1.7$	$5.1 \pm 1.0 \pm 1.9$	$1.5 \pm 0.6 \pm 0.4$	$11.0 \pm 1.5 \pm 3.9$
Data	1	5	3	9
$\sigma_{vis}^{obs(exp)}$ (fb)	0.8 (1.2)	1.5 (1.5)	1.3 (0.8)	2.0 (2.3)

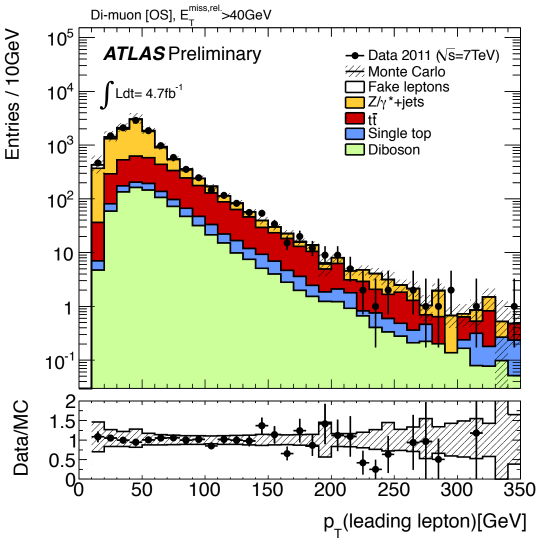
BACKUP



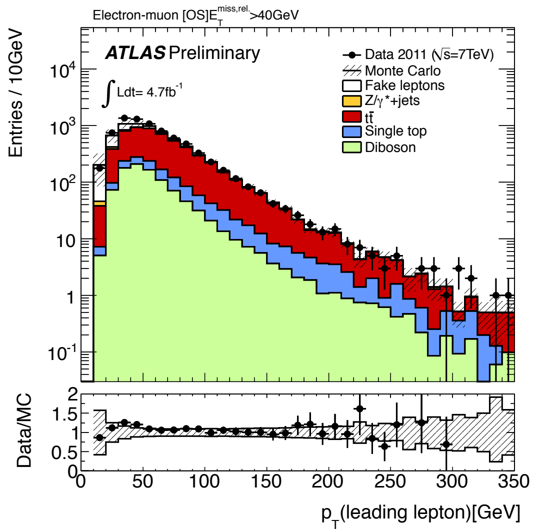
All Channels [SS] N_jet=0
ATLAS Preliminary
∫Ldt= 4.7fb⁻¹
Data 2011 (√s=7TeV)
Total Standard Model
Fake leptons
Z/γ*+jets
tt̄
Single top
Diboson
Entries / 10GeV
Data/MC
E_T^miss,rel [GeV]



Di-electron [OS], E_T^miss,rel>40GeV
ATLAS Preliminary
∫Ldt= 4.7fb⁻¹
Data 2011 (√s=7TeV)
Monte Carlo
Fake leptons
Z/γ*+jets
tt̄
Single top
Diboson
Entries / 10GeV
Data/MC
p_T(leading lepton)[GeV]



Di-muon [OS], E_T^miss,rel>40GeV
ATLAS Preliminary
∫Ldt= 4.7fb⁻¹
Data 2011 (√s=7TeV)
Monte Carlo
Fake leptons
Z/γ*+jets
tt̄
Single top
Diboson
Entries / 10GeV
Data/MC
p_T(leading lepton)[GeV]



Electron-muon [OS]E_T^miss,rel>40GeV
ATLAS Preliminary
∫Ldt= 4.7fb⁻¹
Data 2011 (√s=7TeV)
Monte Carlo
Fake leptons
Z/γ*+jets
tt̄
Single top
Diboson
Entries / 10GeV
Data/MC
p_T(leading lepton)[GeV]

BACKUP

Selection	SR1a	SR1b	SR2
Targeted $\tilde{\chi}_2^0$ decay	$\tilde{l}^{(*)}$ or Z^*		on-shell Z
$\lvert m_{\mathrm{SFOS}} - m_Z \rvert$	> 10 GeV		< 10 GeV
Number of b-jets	0		any
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 75 GeV		> 120 GeV
m_{T}	any	> 110 GeV	> 110 GeV
p_{T} of leptons	> 10 GeV	> 30 GeV	> 10 GeV

Selection	VR1	VR2	VR3
$\lvert m_{\mathrm{SFOS}} - m_Z \rvert$	> 10 GeV	SFOS veto	< 10 GeV
$E_{\mathrm{T}}^{\mathrm{miss}}$ min	30 GeV	50 GeV	30 GeV
$E_{\mathrm{T}}^{\mathrm{miss}}$ max	75 GeV	–	50 GeV

BACKUP

Selection	SR1a	SR1b	SR2
$t\bar{t}$+V	0.62 ± 0.28	0.13 ± 0.07	0.9 ± 0.4
triboson	3.0 ± 3.0	0.7 ± 0.7	0.34 ± 0.34
ZZ	2.0 ± 0.7	0.30 ± 0.23	0.10 ± 0.10
WZ (normalised)	34 ± 4	1.2 ± 0.6	4.7 ± 0.8
Reducible Bkg.	10 ± 6	0.8 ± 0.4	$0.012^{+1.6}_{-0.012}$
Total Bkg.	50 ± 8	3.1 ± 1.0	$6.1^{+2.0}_{-1.2}$
Data	48	4	4
SUSY Ref. Point 1	13.9 ± 1.0	11.4 ± 0.9	0.5 ± 0.1
SUSY Ref. Point 2	0.9 ± 0.1	0.3 ± 0.1	8.0 ± 0.6
Visible σ (exp)	< 1.5 fb	< 0.4 fb	< 0.5 fb
Visible σ (obs)	< 1.3 fb	< 0.5 fb	< 0.4 fb

BACKUP

Selection	VR1	VR2	VR3
$t\bar{t}$+V	3.1 ± 1.2	2.5 ± 0.8	3.9 ± 1.9
triboson	4 ± 4	2.1 ± 2.1	0.7 ± 0.7
ZZ	64 ± 17	0.41 ± 0.23	49 ± 4
WZ (normalised)	161 ± 19	4.5 ± 0.7	385 ± 50
Reducible Bkg.	121 ± 50	27 ± 13	185 ± 70
Total Bkg.	353 ± 60	36 ± 14	624 ± 90
Data	391	36	692
SUSY Ref. Point 1	1.2 ± 0.1	0.2 ± 0.0	0.0 ± 0.0
SUSY Ref. Point 2	0.3 ± 0.1	0.1 ± 0.0	1.5 ± 0.2

BACKUP

Selection	SR1a	SR1b	SR2
$t\bar{t}$+V	0.62 ± 0.28	0.13 ± 0.07	0.9 ± 0.4
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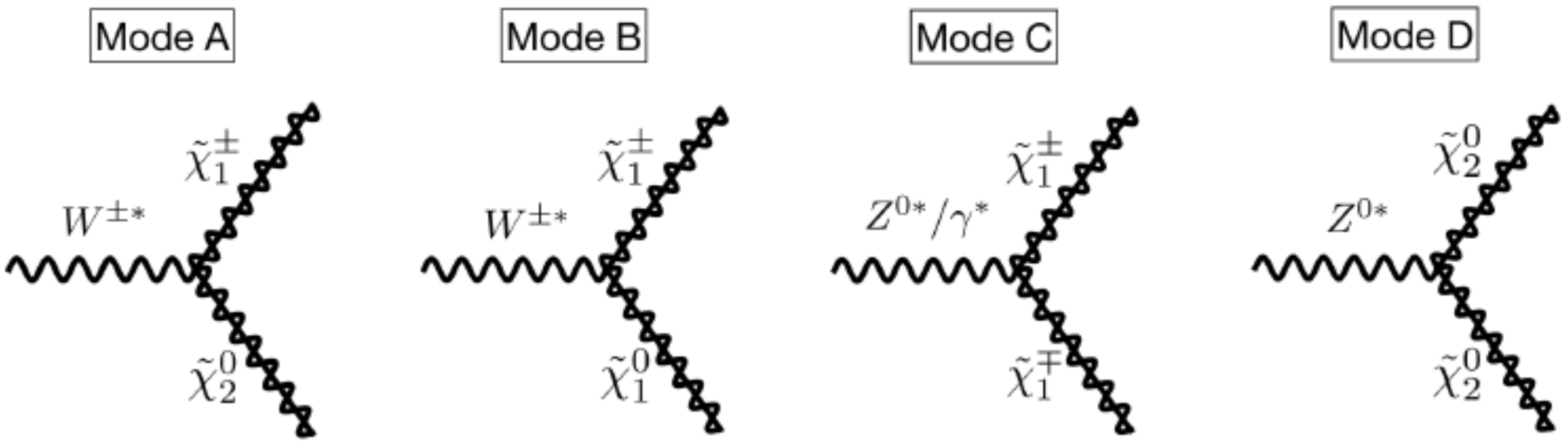
Visible σ (exp)	< 1.5 fb	< 0.4 fb	< 0.5 fb
Visible σ (obs)	< 1.3 fb	< 0.5 fb	< 0.4 fb

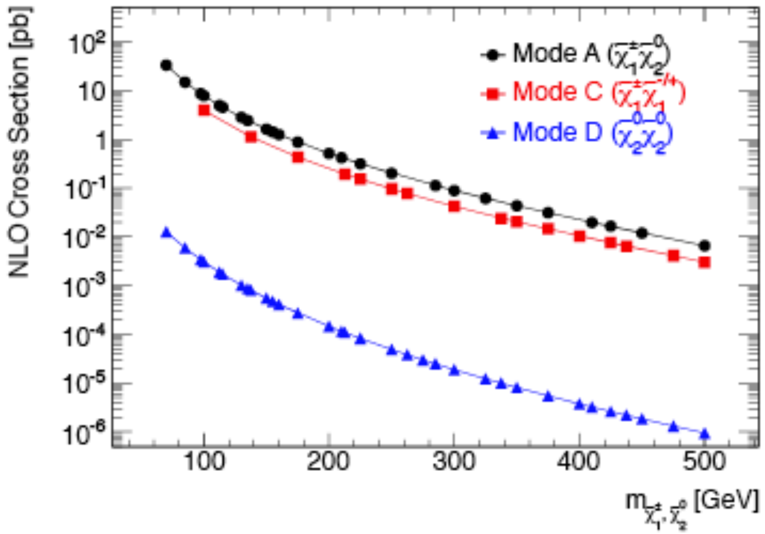
"SUSY Ref. Point 1" with intermediate sleptons, ($m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^0}, m_{\tilde{\ell}_L}, m_{\tilde{\chi}_1^0} = 500,\ 500,\ 250,\ 0\,\mathrm{GeV}$)

"SUSY Ref. Point 2" with no intermediate sleptons, ($m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^0}, m_{\tilde{\chi}_1^0} = 250,\ 250,\ 0\,\mathrm{GeV}$)

BACKUP

GAUGINO PRODUCTION





- only Mode A and C are considered in the simplified models, because they have the highest cross section

BACKUP

MSSM: minimal supersymmetric standard model

SFOS: same flavor opposite sign pair (e.g. electron positron pair)

E_T^{miss}: missing energy in the transverse (i.e. perpendicular to beam axis) plain.

M_T: transverse mass. Invariant mass in the transverse plain formed by E_T^{miss} and the lepton that does not belong to the SFOS pair that forms the best Z-candidate (mass)

tanβ: ratio of vacuum expectation values of the two Higgs doublets

μ: Higgs mass parameter

m_{T2}: related to transverse mass. End-point of WW expected at 90 GeV.
J.Phys. G29 (2003) 2343-2363, Phys.Lett. B463 (1999) 99-103

m_{CT}: top-tagging, calc. from selected jets and leptons:

$$m_{CT}^2(v_1, v_2) = [E_T(v_1) + E_T(v_2)]^2 - [\mathbf{p}_T(v_1) - \mathbf{p}_T(v_2)]^2 ,$$

$$E_T^{\mathrm{miss,rel.}} = \begin{cases} E_T^{\mathrm{miss}} & \text{if } \Delta\phi_{\ell,j} \geq \pi/2 \\ E_T^{\mathrm{miss}} \times \sin\Delta\phi_{\ell,j} & \text{if } \Delta\phi_{\ell,j} < \pi/2 \end{cases}$$