Searches for electroweak production of supersymmetric gauginos and sleptons with the ATLAS detector

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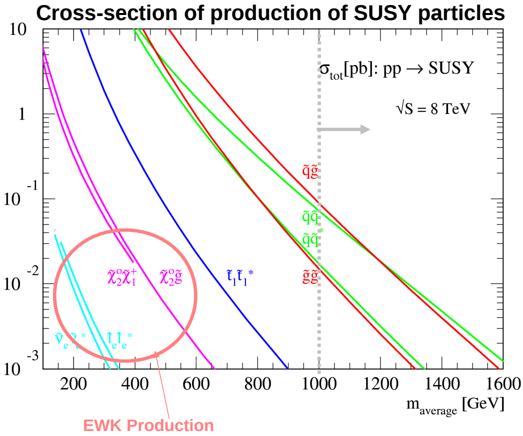
On behalf of the ATLAS Collaboration

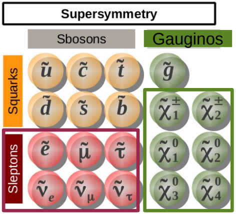
University of Sussex

ATLAS

ICNFP 2014

Introduction





Stringent limits on strong production (squarks and gluinos) with masses above 1 TeV.

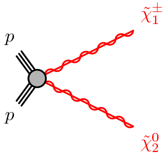
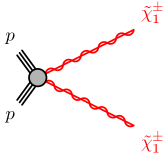
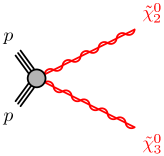
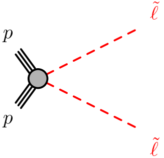
Naturalness suggests low mass sparticles

EWK production can be dominant at the LHC.

- Low cross sections
- Suppressed SM backgrounds
- Multileptonic signatures

EWK Search Strategy

Signature-based analyses characterised by lepton multiplicity (L) and missing transverse energy.

Channel				
1L+bb	via Wh			
* 2L (e, μ)	via WZ	via $\tilde{\ell}/\tilde{\nu}$, WW		with $\tilde{\ell} = \tilde{e}, \tilde{\mu}$
* 2L (τ)	via $\tilde{\tau}/\tilde{\nu}$	via $\tilde{\tau}/\tilde{\nu}$		with $\tilde{\ell} = \tilde{\tau}$
* 3L (e, μ, τ)	via $\tilde{\ell}/\tilde{\nu}$, $\tilde{\tau}$, WZ, Wh			
** 4L (e, μ, τ)			via $\tilde{\ell}$, $\tilde{\tau}$, ZZ	

This talk focuses on the R-Parity conserving scenarios.

The results presented here explore the full ATLAS 2012 dataset.

Supersymmetric Models

- Simplified Models
  - One simulated process with 100% BR
- (*) phenomenological MSSM
  - 19 free parameters $\rightarrow$ (M$_2$,μ) by making assumptions on the other parameters, i.e. m_h set to 125 GeV
- (**) General Gauge Mediation (GGM)
  - gauge-mediated SUSY breaking mechanism with gravitino as the LSP

Standard Model Background Modelling

Some SUSY processes can be SM-like.
SUSY searches rely on accurate modelling of SM background.

Standard Model Background

Irreducible

Dominant sources: normalised to data in dedicated **Control Regions**

Sub-dominant sources: estimated with MC-simulated data

Reducible

Data-driven estimation analyses dependent

All predictions are thoroughly validated using dedicated **Validation Regions**

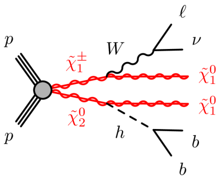
Signal Regions

$1L + bb$

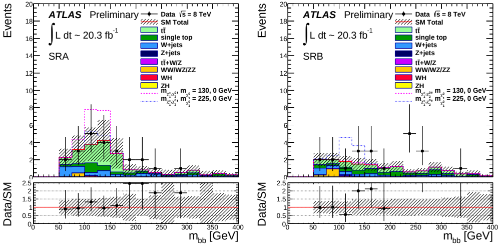
ATLAS-CONF-2013-093

$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via Wh

- $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$ wino, mass degenerate
- $\tilde{\chi}_1^0$ bino
- 100% BR to 125 GeV Higgs



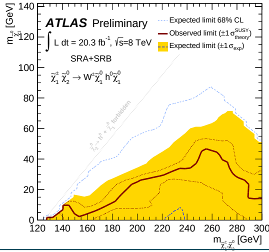
First analysis including SM higgs



No significant deviation from SM.

Analysis Design

- Event Selection:
1 leptons (e, μ), 2 b-tagged jets compatible with $m_h = 125$ GeV
- 2 signal regions optimised for low(high) $\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0)$
- Dominating SM backgrounds:
$t\bar{t}$, W+jets targeted with $m_{\mathrm{CT}} \approx \sqrt{2p^{b_1}p^{b_1 2}(1 + cos\Delta\phi_{b_1 b_2})}$
(mass of pair produced particles with semi-invisible decay)



2L (e, μ)

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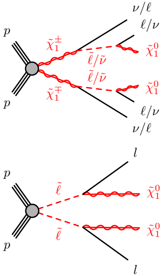
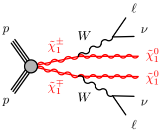
SR-m_{T2}



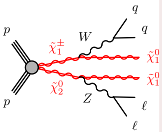
Simplified models

- $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ wino, mass degenerate
- $\tilde{\chi}_1^0$ bino

SR-WW



SR-Z+jets



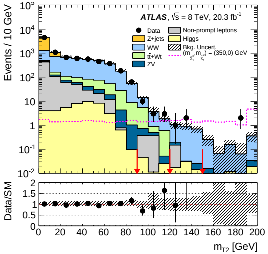
$m_{\mathrm{T2}} =$
$min_{\mathbf{q}_{\mathrm{T}}}[max(m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 1}, \mathbf{q}_{\mathrm{T}})), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}}))]$

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

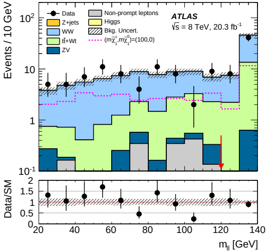
Analysis Design

- Divided by lepton flavour: DF, SF
- Event Selection: 2 leptons (e, μ) + high $E_{\mathrm{T}}^{\mathrm{miss}}$ (+ jets)
- 7 signal regions optimised for different models
- Top and diboson SM background processes dominate
- Optimisation done exploiting s-transverse mass (m_{T2}) with a kinematic end-point at the W mass and $E_{\mathrm{T}}^{\mathrm{miss,rel}}$

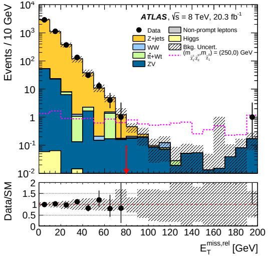
SR-m_{T2}



SR-WW



SR-Z+jets



2L (e, μ)

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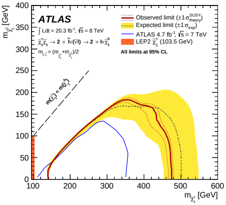
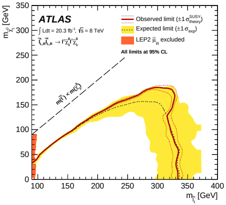
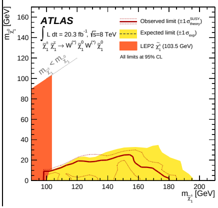
$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm}$ decay via $\tilde{\ell}/\tilde{\nu}$



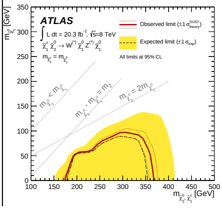
$\tilde{\ell}$-pair production



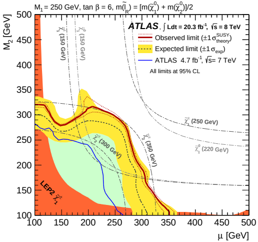
$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm}$ decay via WW

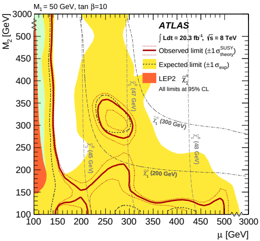


$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$ decay via WZ



pMSSM





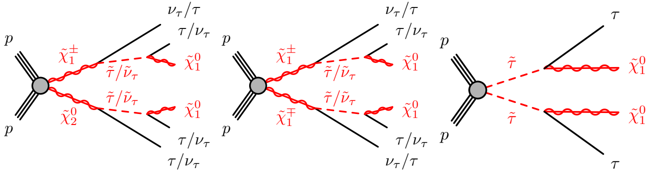
- No significant deviation from SM
- Interpretation in 8 supersymmetric models
- Overall improvements on the exclusion limits wrt 7 TeV results
- Combination of 2Lepton and 3Lepton analysis shows further improvements (more on this later)

2L (τ)

arXiv:1407.0350

First search for EWK production including hadronic tau decay from the LHC.

$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via $\tilde{\tau}/\tilde{\nu}$ $\quad$ $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm}$ decay via $\tilde{\tau}/\tilde{\nu}$ $\quad$ Direct $\tilde{\tau}$-pair production



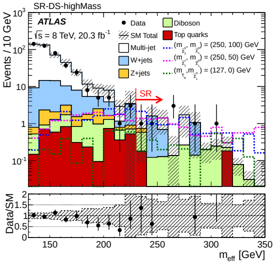
Simplified models

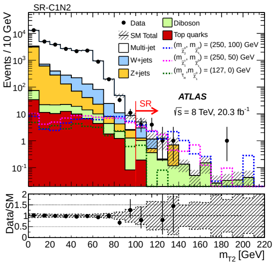
- $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$ wino, mass degenerate
- $\tilde{\chi}_1^0$ bino

Overall very good agreement between data and expectation

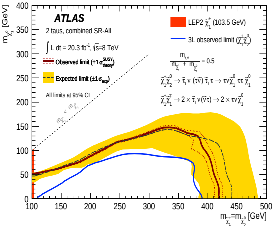
Analysis Design

- Event Selection: 2 OS τ_{had}
- 4 signal regions optimised for different models (two of them targeting the stau simplified model)
- W+jets and multi-jets SM background processes dominate
- Optimisation done exploiting m_{T2}

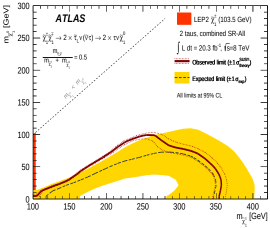




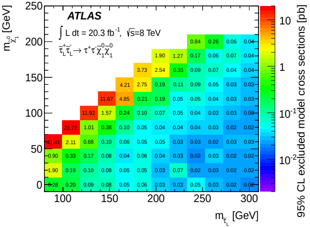
$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 / \tilde{\chi}_1^\pm \tilde{\chi}_1^\pm$ decay via $\tilde{\tau}/\tilde{\nu}$



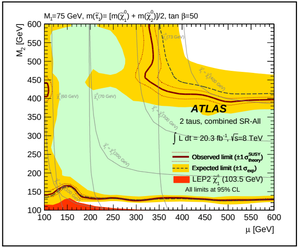
$\tilde{\chi}_1^\pm \tilde{\chi}_1^\pm$ decay via $\tilde{\tau}/\tilde{\nu}$



Direct $\tilde{\tau}$-pair production



pMSSM



- No significant deviation from SM
- Interpretation in 4 supersymmetric models.
- No exclusion for direct $\tilde{\tau}$-pair production, upper limits on the production cross section are set

3L (e, μ, τ)

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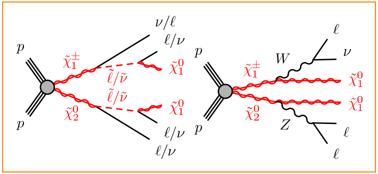
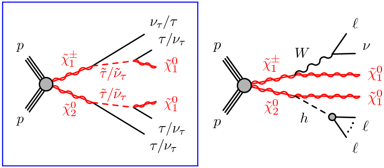




First ATLAS SUSY paper including SM Higgs

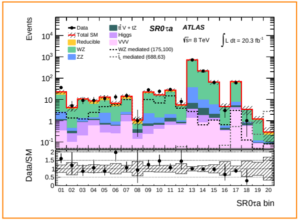
Analysis Design

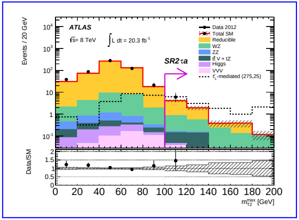
- Different lepton flavour and charge combinations explored
- Event Selection:
3 Leptons (e, μ, τ_{had}) + high $E_{\mathrm{T}}^{\mathrm{miss}}$ + no b-tagged jets
- 1 binned signal region optimised for two previously explored simplified models
- 4 signal regions optimised for two newly explored simplified models, 3 of them targeting the Higgs decay
- WZ, W+jets, VVV and ttbar SM background processes dominate.
- Optimisation done exploiting binning in $m_{\ell\ell}$, $E_{\mathrm{T}}^{\mathrm{miss}}$ and m_{T} and, s-transverse mass m_{T2}

Overall very good agreement between data and expectation

Simplified Models

- $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ wino, mass degenerate
- $\tilde{\chi}_1^0$ bino
- 100% BR to 125 GeV Higgs





3L (e, μ, τ)

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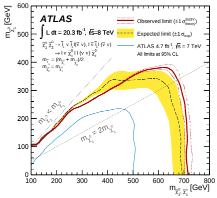
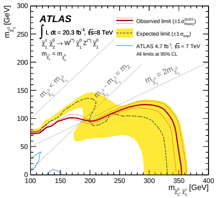
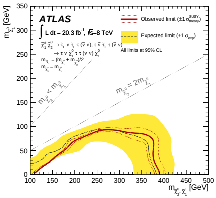
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via $\tilde{\ell}/\tilde{\nu}$



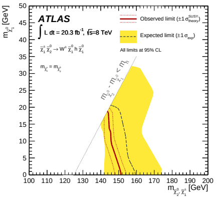
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via WZ



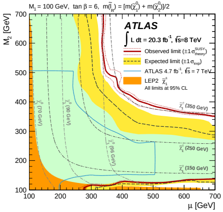
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via $\tilde{\tau}/\tilde{\nu}$

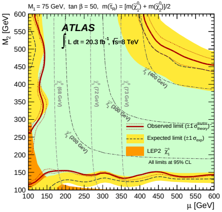


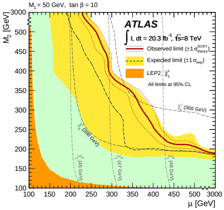
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via Wh



pMSSM







- No significant deviation from SM
- Interpretation in **9** supersymmetric models
- Overall improvements on the exclusion limits wrt 7 TeV results
- Combination of 2Lepton and 3Lepton analysis shows further improvements (more on this later)

2L+3L Combination Results

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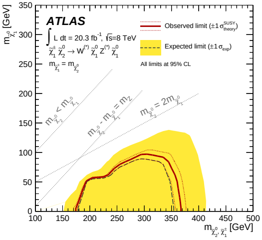
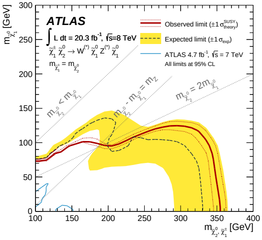
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ decay via WZ

2L



+

3L



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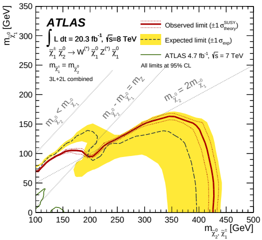
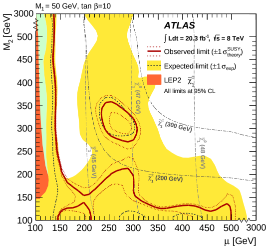
2L+3L



pMSSM no sleptons

2L



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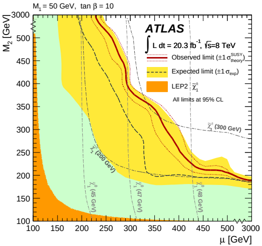
3L



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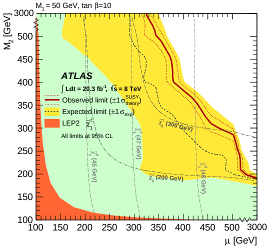
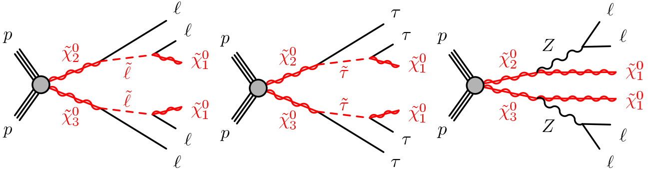
2L+3L



4L (e, μ, τ)

arXiv:1405.5086



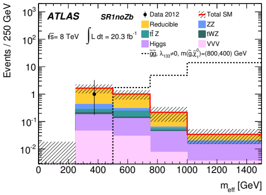
RPC Simplified models

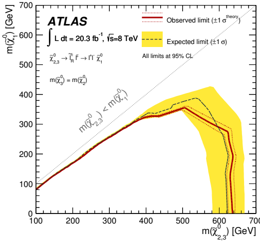
- $\tilde{\chi}_2^0, \tilde{\chi}_3^0$ higgsino, mass degenerate NLSPs
- $\tilde{\chi}_1^0$ bino, stable LSP

Analysis Features

- Explores a wide variety of SUSY models: RPC GGM models (shown on next slide), RPV (not presented here) and RPC simplified models
- Event Selection: 4 Leptons (e, μ, τ), Z-request/veto and high $E_{\mathrm{T}}^{\mathrm{miss}}$
- 9 signal regions optimised for different models (3 of them targeting RPV models) based on lepton/tau multiplicity
- ZZ/γ^{*}, ttZ and WZ SM background processes dominate
- Optimisation done exploiting effective mass m_{eff} and $E_{\mathrm{T}}^{\mathrm{miss}}$

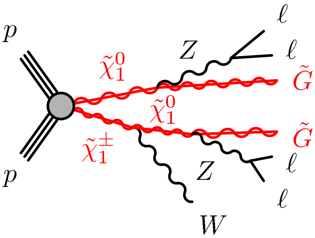
No significant deviation from SM





4L (e, μ, τ)

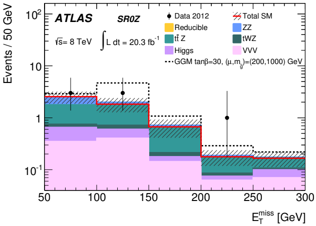
arXiv:1405.5086

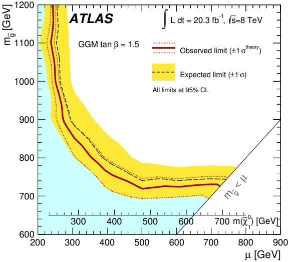


RPC GGM models

- $\tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_1^\pm$ higgsino
- Gravitino as the LSP, $\tilde{\chi}_1^0$ NLSP

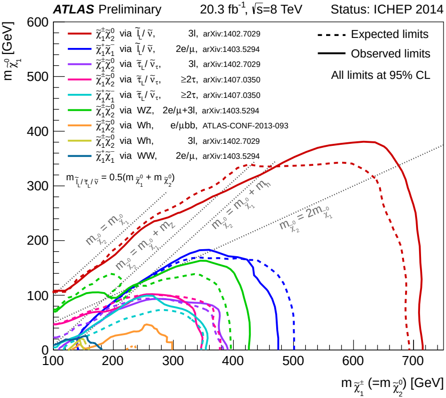
No significant deviation from SM





Summary

- The SUSY search for electroweak production of gauginos and sleptons using the full 8 TeV data delivered by the LHC during RunI was presented
- New and improved sensitivity for a wide variety of SUSY scenarios
- No significant deviation from SM observed
- Very stringent exclusion limits are set on masses of SUSY particles



Stay tuned for Run II

Backup

Auxiliary material