(1) Search for Supersymmetry in the 4-Lepton Final State with the ATLAS Detector

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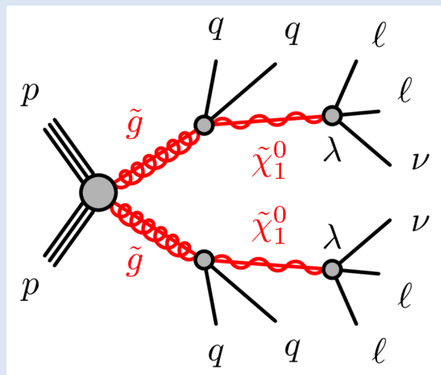
The four-lepton final state, rare in standard model processes, is an attractive channel for new physics searches at the LHC. In super-symmetry (SUSY), charged leptons may arise from cascade decays of SUSY particles to the lightest supersymmetric particle, or from R-Parity violating decays to standard model particles. This poster presents a search for supersymmetry in events with at least four charged leptons carried out using 20.3 fb^{-1} of proton-proton collision data taken with the ATLAS detector at $\sqrt{s}$ = 8 TeV during the 2012 LHC run. Up to two of the leptons may be hadronically decaying tau leptons, enhancing the sensitivity to tau-enriched scenarios.

SUSY Signal Models with 4-Lepton final states



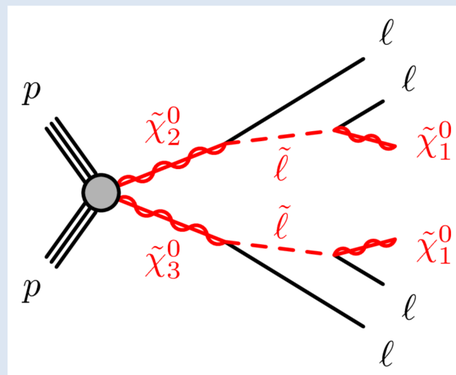
R-Parity violating (RPV) Simplified Models

RPV via the superpotential term

$$W_{LLE} = \lambda_{ijk} L_i L_j \bar{E}_k$$

Gluino, (R/L)-Slepton, Sneutrino, Chargino production investigated

Study of tau-rich (λ_{133}, λ_{233}) or tau-depleted (λ_{121}, λ_{122}) final states

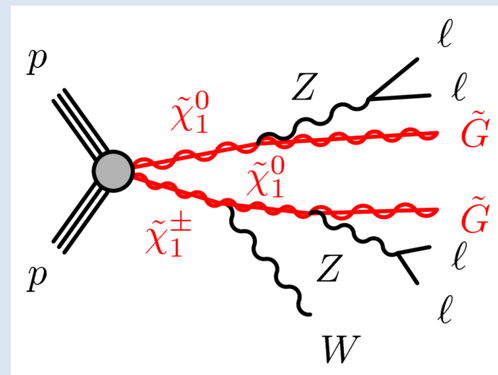


R-Parity conserving (RPC) Simplified Models

Production of $\tilde{\chi}_2^0 \tilde{\chi}_3^0$ pairs

Decay to $\tilde{\chi}_1^0$ LSP

- via intermediate sleptons ($\tilde{e}$, $\tilde{\mu}$)
- via intermediate staus
- via intermediate Z bosons



General Gauge Mediation (GGM)

Weak and strong production

Gravitino LSP, $\tilde{\chi}_1^0$ NLSP

Z Bosons from the NLSP decay $\tilde{\chi}_1^0 \to Z + \tilde{G}$

Leptons from $Z \to \ell^+\ell^-$

Analysis Strategy

Events selected using **single- and dilepton triggers (e,μ)**
At least **four charged leptons** required; at least **2 (e,μ)**

Muons:	Electrons:	Hadronic tau decays:
p_T > 10 GeV, |η| < 2.5	p_T > 10 GeV, |η| < 2.47	p_T > 20 GeV, |η| < 2.47
Track Quality	Track and Calo Quality	1 or 3 charged tracks
Isolation	Isolation	Muon veto
Small Impact Parameter	Small Impact Parameter	Electron and jet veto

Discriminating variables: **missing transverse momentum**, **effective mass**:

$$m_{eff} = \sum_{\text{Leptons}} p_T + \sum_{\text{Jets}}^{p_T > 40\text{GeV}} p_T + E_T^{miss}$$

Define **Signal Regions (SR)** to separate a possible SUSY signal in the data from the **standard model background:**

Irreducible Backgrounds:

at least four prompt charged leptons

main sources: **ZZ, $t\bar{t}$Z, tWZ, VVV, Higgs**

estimate using **MC simulation**

Dominant **uncertainty:** Theory (cross-sections, differential shapes)

Reducible Backgrounds:

fewer than four prompt charged leptons

→ at least one non-prompt / fake

main sources: **WZ, Z+jets, $t\bar{t}$**

estimate using **data-driven method**

Dominant **uncertainty:** estimation of non-prompt / fake leptons

The **final observable** is the absolute number of events observed in the signal regions.

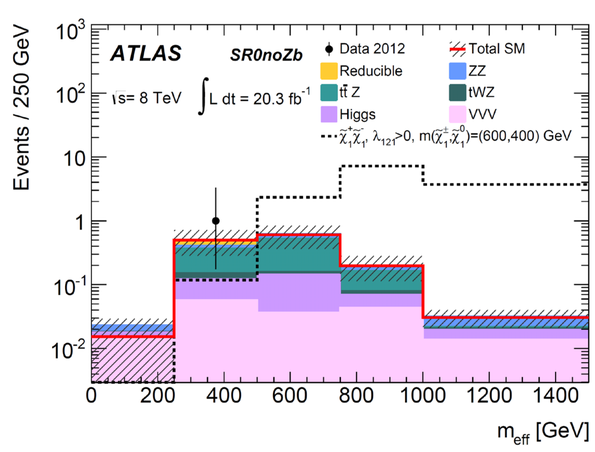
Signal Regions and Results

Z veto SR	N(ℓ)	N(τ)	E_T^{Miss}		m_{eff}	Σ SM	Data	p_0
SR0noZa	≥4	≥0	>50			1.6 ± 0.5	3	0.15
SR0noZb			>75	or	>600	1.4 ± 0.4	1	0.50
SR1noZa	3	≥1	>50			$4.6^{+1.3}_{-1.2}$	4	0.50
SR1noZb			>100	or	>400	$2.9^{+1.0}_{-0.9}$	1	0.50
SR2noZa	2	≥2	>75			$4.0^{+1.2}_{-1.3}$	7	0.13
SR2noZb			>100	or	>600	3.0 ± 1.0	6	0.10

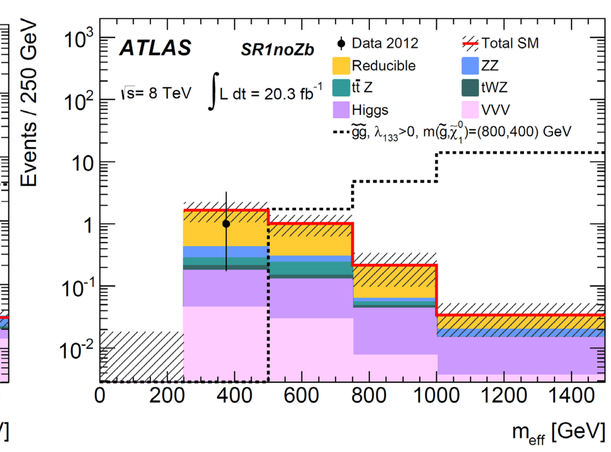
Z request SR	N(ℓ)	N(τ)	E_T^{Miss}	Σ SM	Data	p_0
SR0Z	≥4	≥0	>75	5.6 ± 1.4	7	0.29
SR1Z	3	≥1	>100	2.5 ± 0.6	3	0.34
SR2Z	2	≥2	>75	1.8 ± 0.5	1	0.50

p_0: p-value for the standard model background-only hypothesis

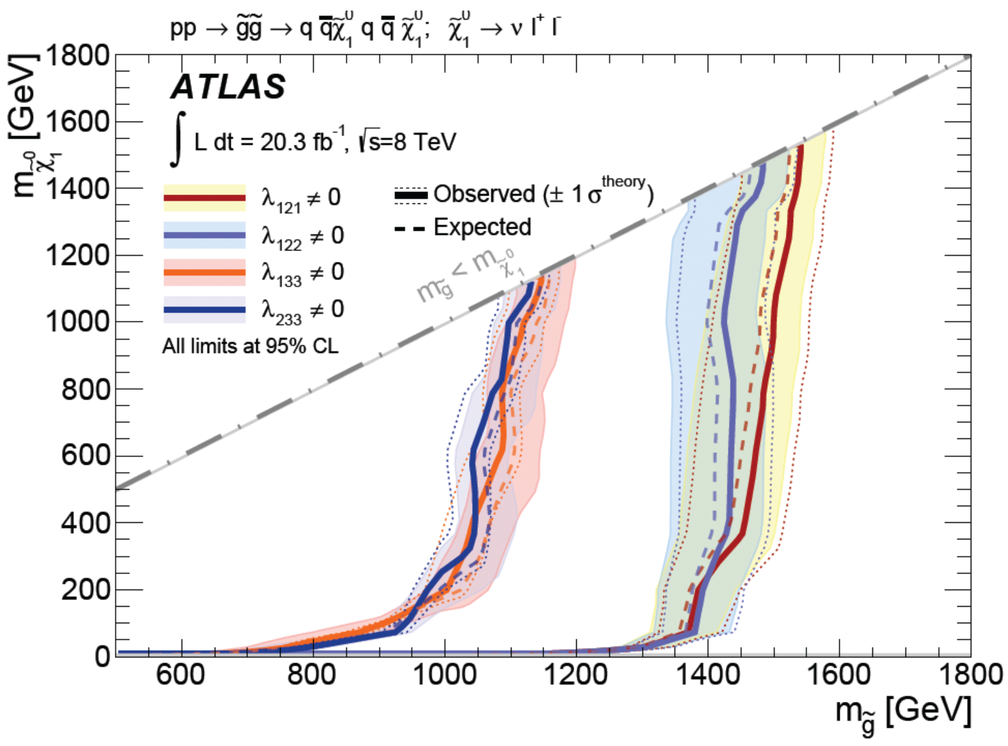
Observation on data shows good agreement with the standard model hypothesis



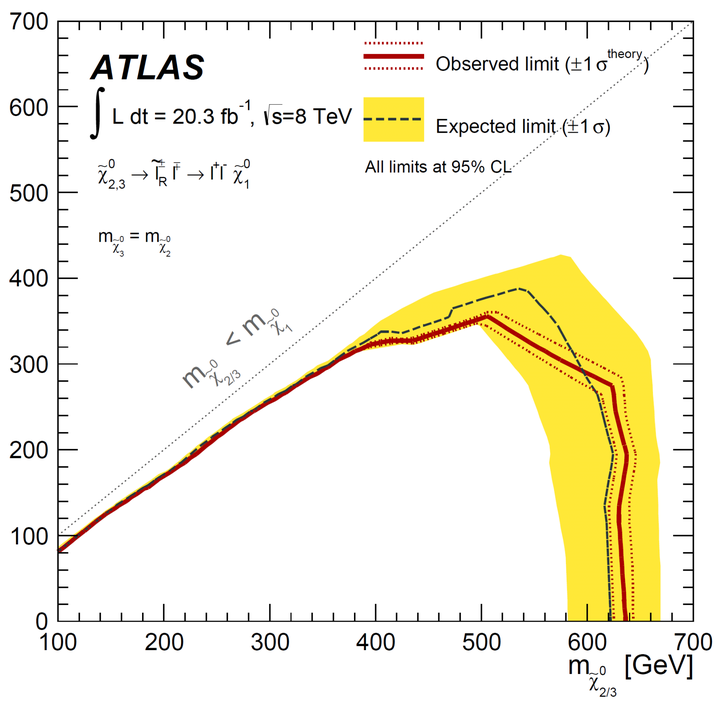
Effective mass distribution in the SR0noZb signal region.



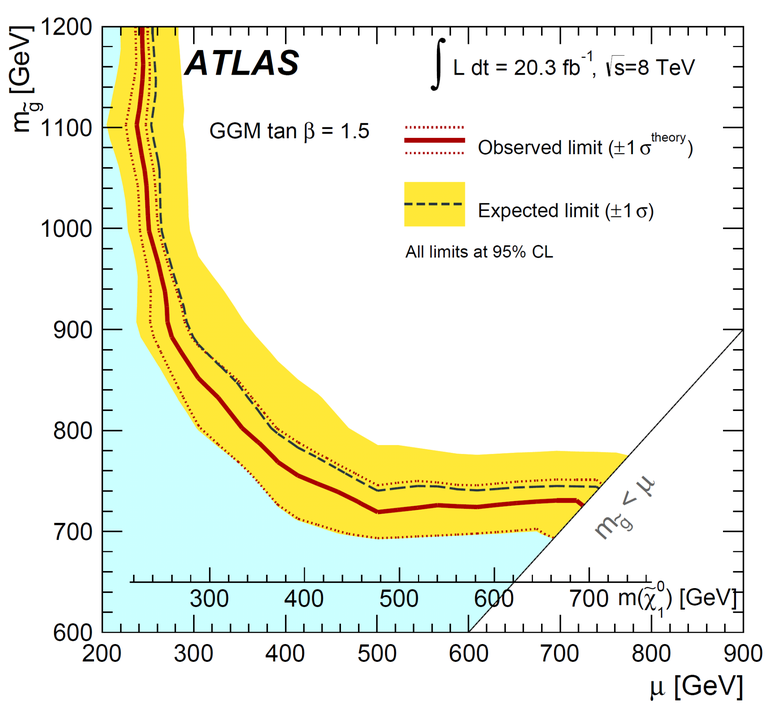
Effective mass distribution in the SR1noZb signal region.



Exclusion limits (95% CL) for the RPV Gluino production simplified model. Four different RPV couplings are investigated. Gluino masses of less than 1400 (950) GeV are excluded for tau-poor(tau-rich) decays, if $m(\tilde{\chi}_1^0) > 0.2\, m(\tilde{g})$.



Exclusion limits (95% CL) for the RPC neutralino pair production simplified model with decays via sleptons. Masses of the heavy neutralinos of less than 620 GeV are excluded for a massless LSP.



Exclusion limits (95% CL) for the GGM model. 200 < μ < 230 is excluded for any Gluino mass. Gluino masses below 720 GeV are excluded independently of the μ parameter.

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ATLAS EXPERIMENT