Search for SUSY with two same-sign leptons or three leptons and jets at $\sqrt{s} = 13$ TeV with the ATLAS Detector

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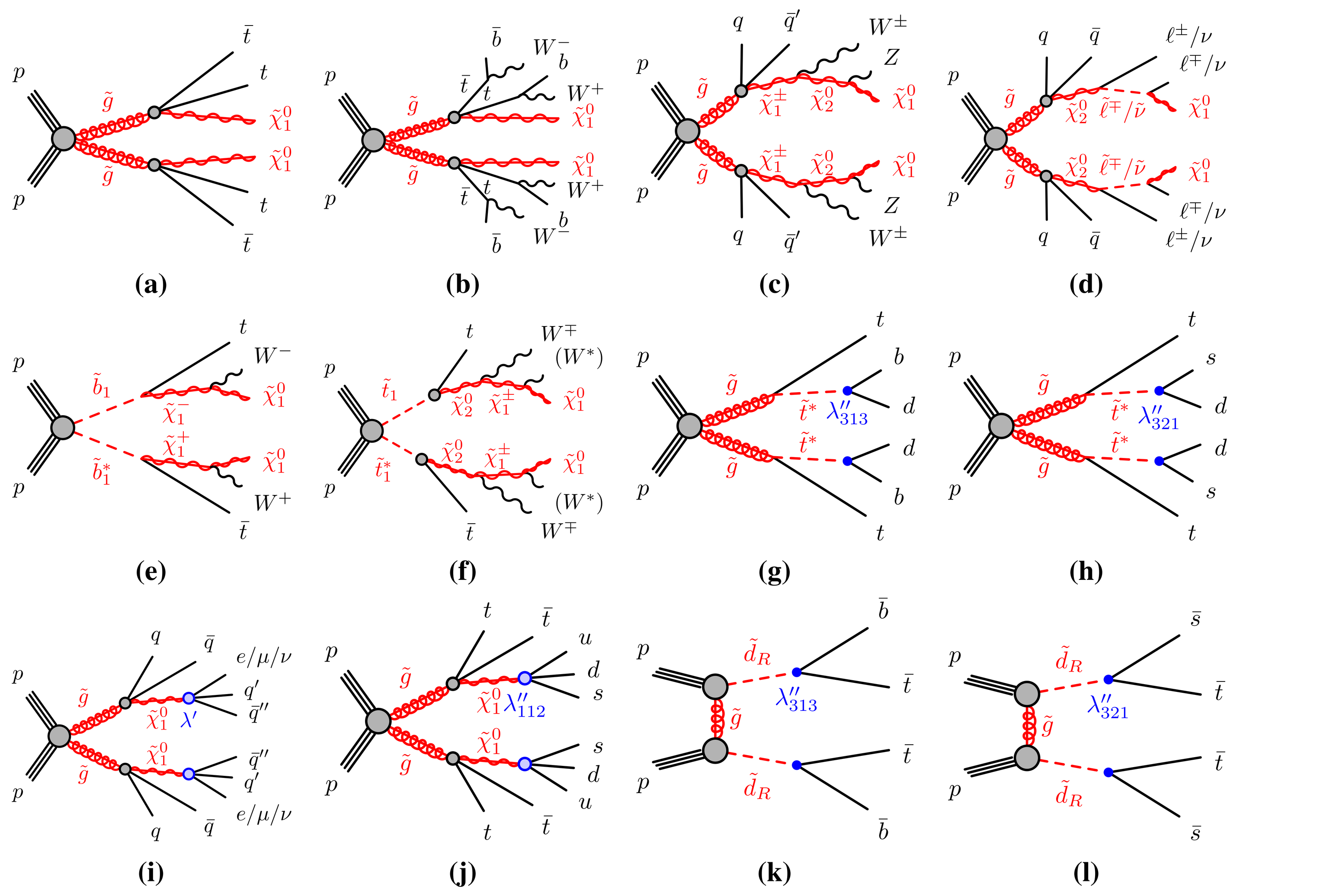
Introduction

Supersymmetry (SUSY) is a well motivated extension of the Standard Model (SM) that postulates the existence of a superpartner for each SM particle. A search for strongly produced SUSY particles decaying to a pair of two isolated **same-sign leptons (SS)** or **three leptons (3L)** has been carried out using the complete data set collected by the ATLAS experiment in 2015-16 at 13 TeV ($36.5 fb^{-1}$). The analysis benefits from a low SM background and uses looser kinematic requirements compared to other beyond the SM (BSM) searches which increases its sensitivity to scenarios with small mass differences between the SUSY particles, or in which R-parity is not conserved. The results are interpreted in the context of **R-parity conserving (RPC)** or **R-parity violating (RPV)** simplified signal models

Signal Regions

The signal regions (SR) were optimized on both RPC or RPV SUSY signal scenarios using the number of (b-tagged)jets missing transverse monmentum(E_T^{miss}), $m_{eff} = E_T^{miss} + \sum p_T$(jets and leptons) and their ratio(E_T^{miss}/m_{eff}).



Signal region Name	$N_{\text{leptons}}^{\text{signal}}$	$N_{b-\text{jets}}$	N_{jets}	$p_{\text{T,jet}}$ [GeV]	$E_{\text{T}}^{\text{miss}}$ [GeV]	m_{eff} [GeV]	$E_{\text{T}}^{\text{miss}}/m_{\text{eff}}$	Other	Targeted Signal
Rpc2L2bS	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	–	Fig. 1a
Rpc2L2bH	≥ 2SS	≥ 2	≥ 6	> 25	–	> 1800	> 0.15	–	Fig. 1a, NUHM2
Rpc2Lsoft1b	≥ 2SS	≥ 1	≥ 6	> 25	> 100	–	> 0.3	20,10 $< p_T^{\ell_1}, p_T^{\ell_2} <$ 100 GeV	Fig. 1b
Rpc2Lsoft2b	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	20,10 $< p_T^{\ell_1}, p_T^{\ell_2} <$ 100 GeV	Fig. 1b
Rpc2L0bS	≥ 2SS	$= 0$	≥ 6	> 25	> 150	–	> 0.25	–	Fig. 1c
Rpc2L0bH	≥ 2SS	$= 0$	≥ 6	> 40	> 250	> 900	–	–	Fig. 1c
Rpc3L0bS	≥ 3	$= 0$	≥ 4	> 40	> 200	> 600	–	–	Fig. 1d
Rpc3L0bH	≥ 3	$= 0$	≥ 4	> 40	> 200	> 1600	–	–	Fig. 1d
Rpc3L1bS	≥ 3	≥ 1	≥ 4	> 40	> 200	> 600	–	–	
Rpc3L1bH	≥ 3	≥ 1	≥ 4	> 40	> 200	> 1600	–	–	
Rpc2L1bS	≥ 2SS	≥ 1	≥ 6	> 25	> 150	> 600	> 0.25	–	Fig. 1e
Rpc2L1bH	≥ 2SS	≥ 1	≥ 6	> 25	> 250	–	> 0.2	–	Fig. 1e
Rpc3LSS1b	$\geq \ell^\pm\ell^\pm\ell^\pm$	≥ 1	–	–	–	–	-	veto 81$< m_{e^\pm e^\pm} <$101 GeV	Fig. 1f
Rpv2L1bH	≥ 2SS	≥ 1	≥ 6	> 50	–	> 2200	–	–	Figs. 1g,1h
Rpv2L0b	$= 2$SS	$= 0$	≥ 6	> 40	–	> 1800	–	veto 81$< m_{e^\pm e^\pm} <$101 GeV	Fig. 1i
Rpv2L2bH	≥ 2SS	≥ 2	≥ 6	> 40	–	> 2000	–	veto 81$< m_{e^\pm e^\pm} <$101 GeV	Fig. 1j
Rpv2L2bS	$\geq \ell^-\ell^-$	≥ 2	≥ 3	> 50	–	> 1200	–		Fig. 1k
Rpv2L1bS	$\geq \ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1200	–	–	Fig. 1l
Rpv2L1bM	$\geq \ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1800	–	–	Fig. 1l

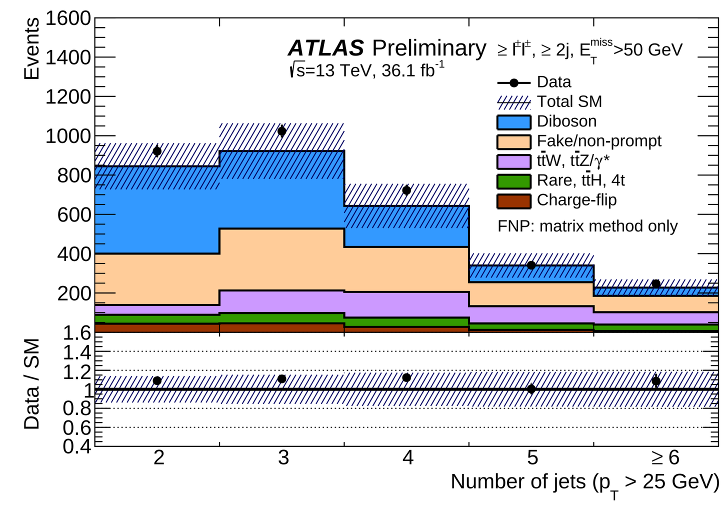
Background Estimation

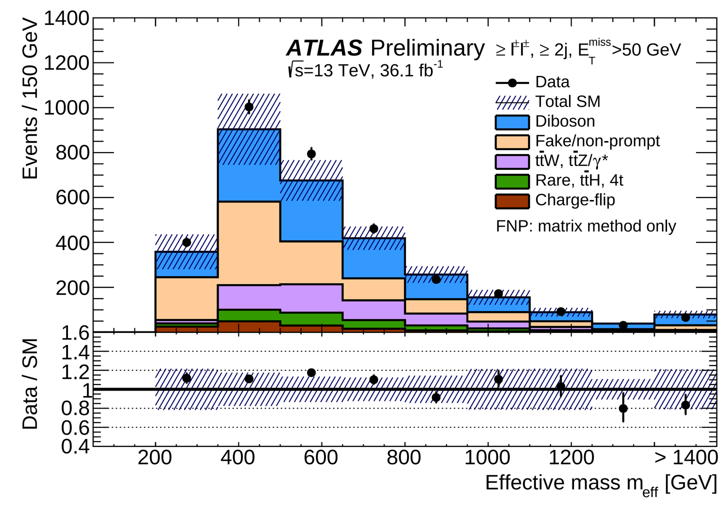
Two main sources of SM background:

irreducible: Prompt SS/3L sources estimated with pure MC. Since diboson and $t\bar{t}V$ events are the main backgrounds in the signal regions, dedicated validation regions (VR) with an enhanced contribution from these processes, and small signal contamination, are defined to verify the background predictions from the simulation.

reducible: Fake or non-prompt (FNP) leptons and mis-measured electron charge (charge-flip) estimated using data-driven methods.

- Charge-flip mainly from $t\bar{t}$: use charge-flip rates measured in $Z/\gamma^* \to ee$ data sample to re-weight data events in VRs or SRs but with an opposite sign lepton pair requirement.
- FNP leptons mainly from hadron decays estimated by the combination of matrix-method and MC template

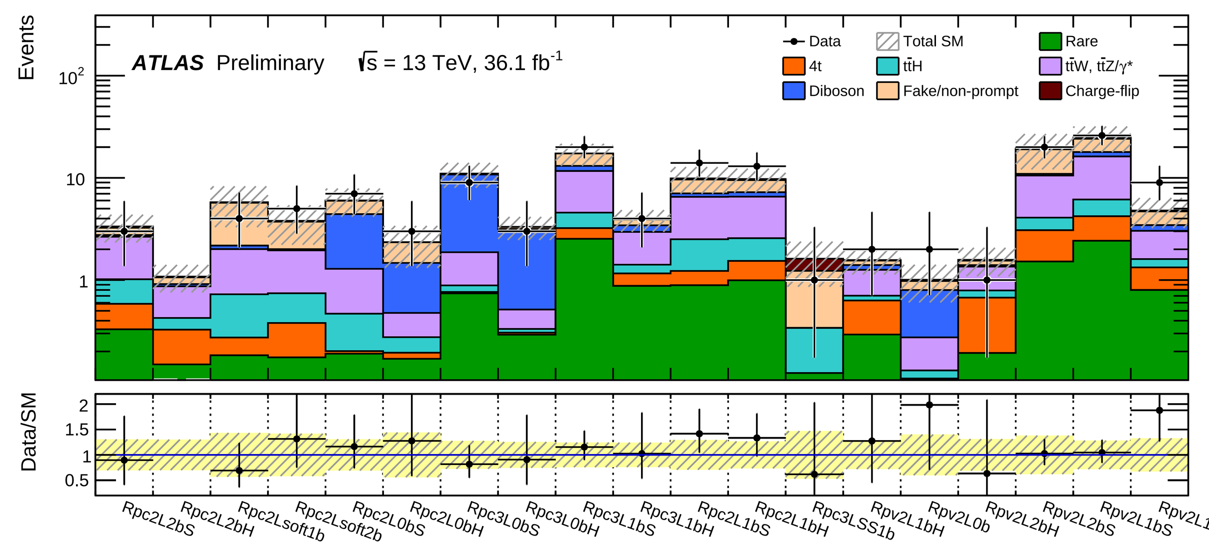


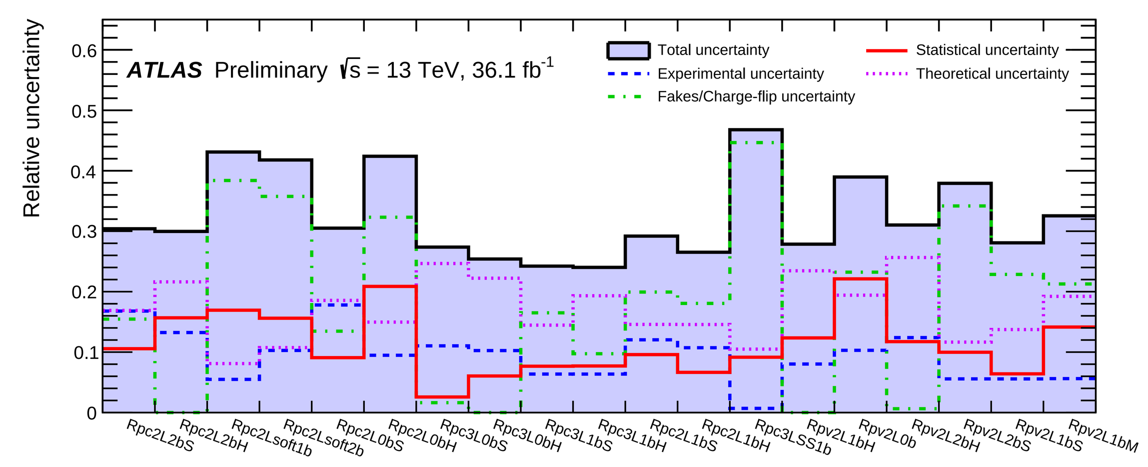


Good overall agreement between data and expected background

Results

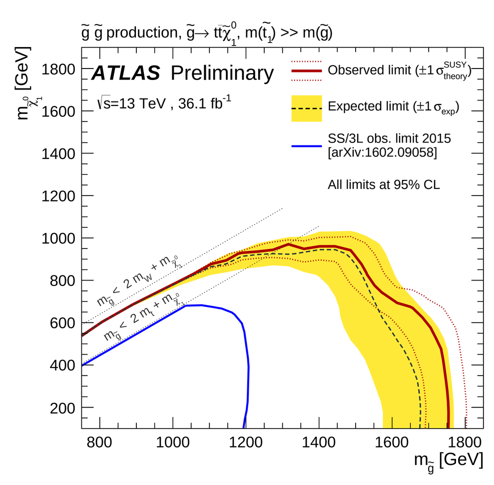
The observed data, the expected SM background and the systematic uncertainty in all SRs are concluded in the plot



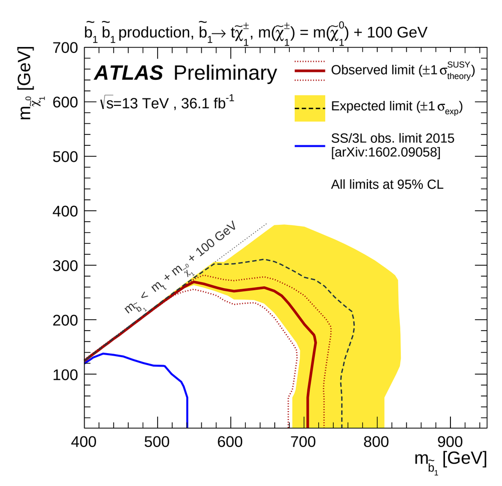


Upper limits on particle masses are derived at 95% confidence level:

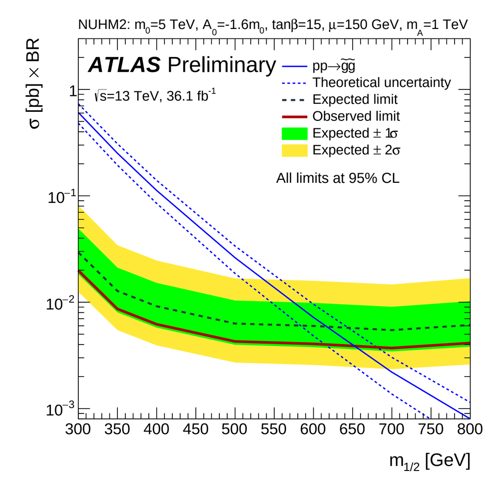
- In the $\tilde{g}\tilde{g}$ simplified RPC models considered, gluinos with masses up to 1.85 TeV are excluded in scenarios with a light $\tilde{\chi}_1^0$.
- RPC models with bottom squark masses below 700 GeV are als o excluded in a $\tilde{b}_1\tilde{b}_1^*$ simplified model with $\tilde{b}_1 \to tW^-\tilde{\chi}_1^0$ and a light $\tilde{\chi}_1^0$.
- In RPV scenarios, masses of right-handed down squarks are probed up to $m_{\tilde{d}_R} \approx 500$ GeV.
- All models with gluino masses below 1.2 TeV are excluded, extending greatly the previous published limits.



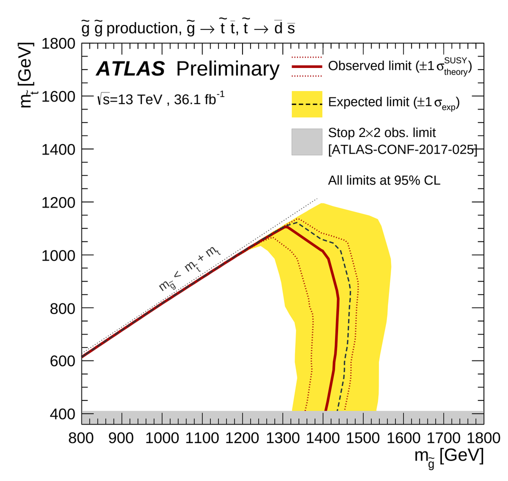
(m) Rpc2L2bS/H, Rpc2Lsoft1b/2b



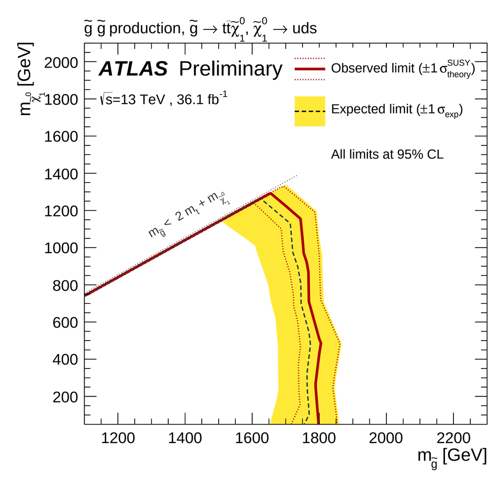
(n) Rpc2L1bS, Rpc2L1bH



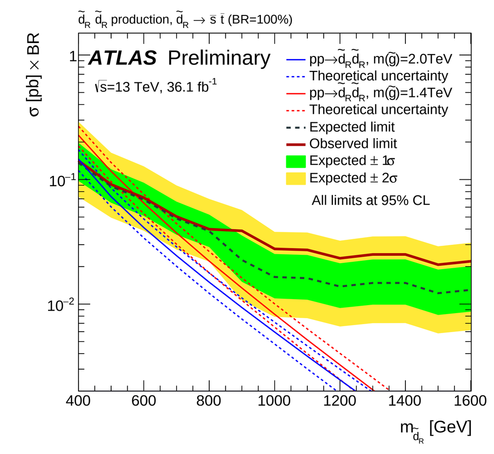
(o) NUHM2



(p) Rpv2L1bH



(q) Rpv2L2bH



(r) Rpv2L1bS, Rpv2L1bM

Conclusion

With no significant excess over the SM expectation observed, results are interpreted using SUSY simplified models featuring RPC and RPV scenarios. The analysis improves the sensitivity to BSM processes with respect to previous analyses.

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