EPS Conference on High Energy Physics, Venice - 10. July 2017

SUSY searches at $\sqrt{s}$ = 13 TeV with two same-sign leptons or three leptons, jets and E_T^{miss} with the ATLAS detector

Background estimation and latest analysis results

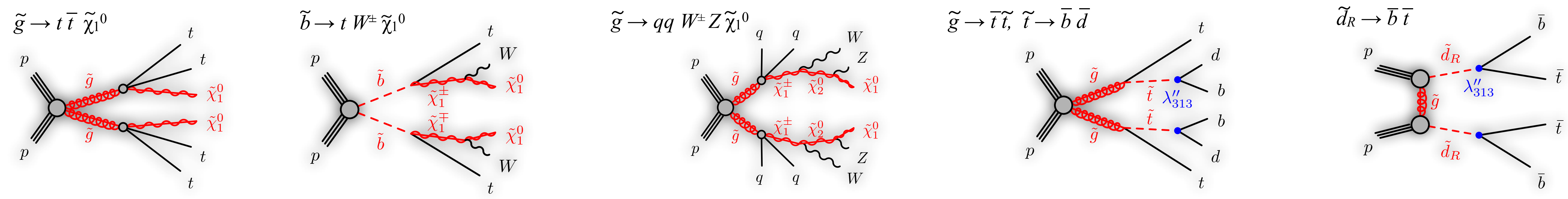
On which SUSY signature do we focus?

Motivation

- Strong production of SUSY particles: Gluino $\tilde{g}$ and squark $\tilde{q}$
- Gluinos are Majorana particles: allow same-sign lepton pair production.
- Rare processes in Standard Model: very low background.

Signal scenario

- Same-sign (SS) lepton pair or at least three leptons (3L) with jets and/or b-jets.
- Large E_T^{miss}, m_{eff} ($\sum p_T$(lep)+$\sum p_T$(jets)+ E_T^{miss}) for RPC SUSY models. Low E_T^{miss} (but high m_{eff}) for RPV scenarios.



Event selection and background estimation

Event selection

- 19 different signal regions (SR) are defined which are optimised for specific RPC and RPV SUSY benchmark scenarios.
- Same-sign or three lepton requirement (p_T > 10 GeV). Additional cuts on signal jets (p_T > 25 GeV), b-jets (p_T > 20 GeV, 70% OP), E_T^{miss} and m_{eff} are applied.
- The number of electrons with mis-identified charge is reduced by using a classifier based on a boosted decision tree (BDT) for the electron selection.

Signal region Name	$N_{leptons}^{signal}$	N_{b-jets}	N_{jets}	$p_{T,jet}$ [GeV]	E_T^{miss} [GeV]	m_{eff} [GeV]	E_T^{miss}/m_{eff}	Other	Targeted Signal
Rpc2L2bS	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	–	$\tilde{g}\tilde{g} \to t\bar{t}t\bar{t}\tilde{\chi}_1^0\tilde{\chi}_1^0$
Rpc2L2bH	≥ 2SS	≥ 2	≥ 6	> 25	–	> 1800	> 0.15	–	
Rpc2Lsoft1b	≥ 2SS	≥ 1	≥ 6	> 25	> 100	–	> 0.3	20,10 < $p_T^{\ell_1}, p_T^{\ell_2}$ < 100 GeV	
Rpc2Lsoft2b	≥ 2SS	≥ 2	≥ 6	> 25	> 200	> 600	> 0.25	20,10 < $p_T^{\ell_1}, p_T^{\ell_2}$ < 100 GeV	
Rpc2L0bS	≥ 2SS	= 0	≥ 6	> 25	> 150	–	> 0.25	–	$\tilde{g}\tilde{g}$ with $\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$
Rpc2L0bH	≥ 2SS	= 0	≥ 6	> 40	> 250	> 900	–	–	
Rpc3L0bS	≥ 3	= 0	≥ 4	> 40	> 200	> 600	–	–	$\tilde{g}\tilde{g}$ with $\tilde{g} \to q\bar{q}(\ell\ell/\ell\nu)\tilde{\chi}_1^0$
Rpc3L0bH	≥ 3	= 0	≥ 4	> 40	> 200	> 1600	–	–	
Rpc3L1bS	≥ 3	≥ 1	≥ 4	> 40	> 200	> 600	–	–	
Rpc3L1bH	≥ 3	≥ 1	≥ 4	> 40	> 200	> 1600	–	–	
Rpc2L1bS	≥ 2SS	≥ 1	≥ 6	> 25	> 150	> 600	> 0.25	–	$\tilde{b}_1\tilde{b}_1^* \to t\bar{t}\tilde{\chi}_1^+\tilde{\chi}_1^-$
Rpc2L1bH	≥ 2SS	≥ 1	≥ 6	> 25	> 250	–	> 0.2	–	
Rpc3LSS1b	≥ $\ell^\pm\ell^\pm\ell^\pm$	≥ 1	–	–	–	–	-	veto 81< $m_{e^\pm e^\pm}$ <101 GeV	$\tilde{t} \to tW^{\pm}(W*)\tilde{\chi}_1^0$
Rpv2L1bH	≥ 2SS	≥ 1	≥ 6	> 50	–	> 2200	–	–	$\tilde{g}\tilde{g}, \tilde{g} \to tds/tdb$
Rpv2L0b	= 2SS	= 0	≥ 6	> 40	–	> 1800	–	veto 81< $m_{e^\pm e^\pm}$ <101 GeV	$\tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}_1^0(\to lqq)$
Rpv2L2bH	≥ 2SS	≥ 2	≥ 6	> 40	–	> 2000	–	veto 81< $m_{e^\pm e^\pm}$ <101 GeV	$\tilde{g}\tilde{g}, \tilde{g} \to t\bar{t}\tilde{\chi}_1^0(\to qqq)$
Rpv2L2bS	≥ $\ell^-\ell^-$	≥ 2	≥ 3	> 50	–	> 1200	–	–	$\tilde{d}_R\tilde{d}_R/\tilde{d}_R^*\tilde{d}_R^*, \tilde{d}_R \to tb$
Rpv2L1bS	≥ $\ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1200	–	–	$\tilde{d}_R\tilde{d}_R/\tilde{d}_R^*\tilde{d}_R^*, \tilde{d}_R \to ts$
Rpv2L1bM	≥ $\ell^-\ell^-$	≥ 1	≥ 4	> 50	–	> 1800	–	–	

- Validation regions (VR) designed to verify the background estimation for SM processes leading to a SS/3L signature, like *ttW, ttZ, W±W±, WZ+jet*. Good agreement between data and prediction in all VR.
- To check the data-driven background estimations, several variables are compared with the predicted background after SR-like selections.

Background estimation

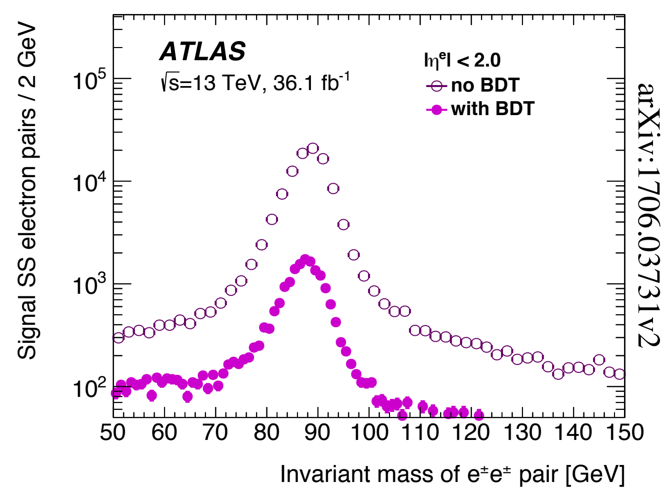
- Different sources for Standard Model processes contaminating the signal regions: Prompt SS/3L production, fake/non-prompt leptons and electrons with mis-identified charge (charge-flip).

(I) Prompt SS or 3L background is estimated with simulated Monte Carlo events.

(II) For charge-flip electrons (negligible for muons), the charge-flip rate is measured with a likelihood fit in a $Z/\gamma^* \to e^+e^-$ sample. The yields of this background in the signal regions are obtained by applying the measured rate to data regions similar to signal regions but with OS leptons.

(III) Fake-leptons are estimated from data with a matrix-method: If the ratio of signal leptons to loose leptons $\varepsilon_{1,2}$, $\zeta_{1,2}$ is known separately for prompt/fake leptons, the number of events with at least one fake lepton can be predicted with a matrix Λ.

Using weighted average with CR-corrected MC yields in the SR (MC template method) for the final fake prediction.



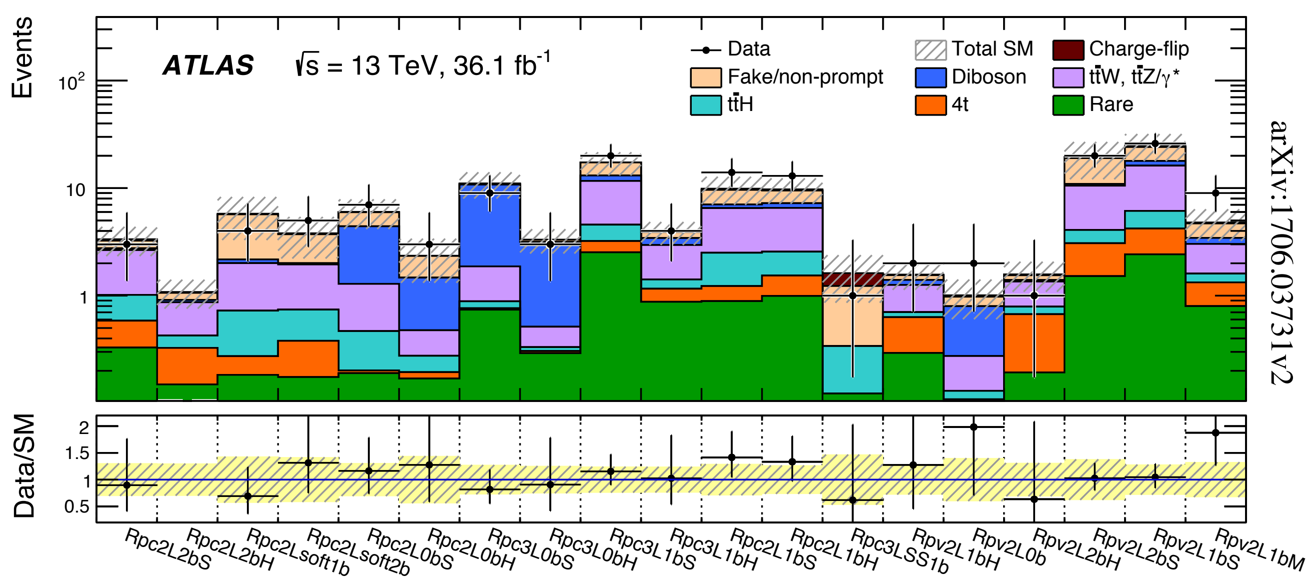
$$\begin{pmatrix} N_{SS} \\ N_{SL} \\ N_{LS} \\ N_{LL} \end{pmatrix} = \Lambda \cdot \begin{pmatrix} N_{PP} \\ N_{PF} \\ N_{FP} \\ N_{FF} \end{pmatrix}$$

S = Signal lepton
L = Loose lepton
P = Prompt lepton
F = Fake lepton

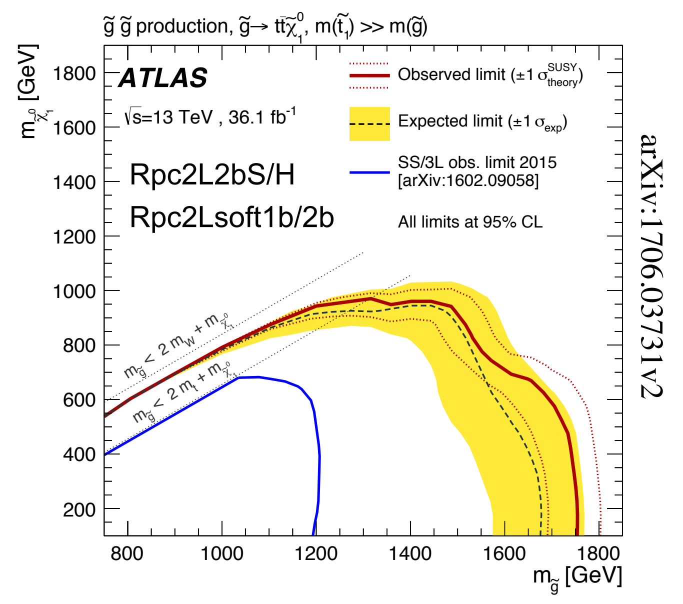
$$\Lambda = \begin{pmatrix} \varepsilon_1\varepsilon_2 & \varepsilon_1\zeta_2 & \zeta_1\varepsilon_2 & \zeta_1\zeta_2 \\ \varepsilon_1(1-\varepsilon_2) & \varepsilon_1(1-\zeta_2) & \zeta_1(1-\varepsilon_2) & \zeta_1(1-\zeta_2) \\ (1-\varepsilon_1)\varepsilon_2 & (1-\varepsilon_1)\zeta_2 & (1-\zeta_1)\varepsilon_2 & (1-\zeta_1)\zeta_2 \\ (1-\varepsilon_1)(1-\varepsilon_2) & (1-\varepsilon_1)(1-\zeta_2) & (1-\zeta_1)(1-\varepsilon_2) & (1-\zeta_1)(1-\zeta_2) \end{pmatrix}$$

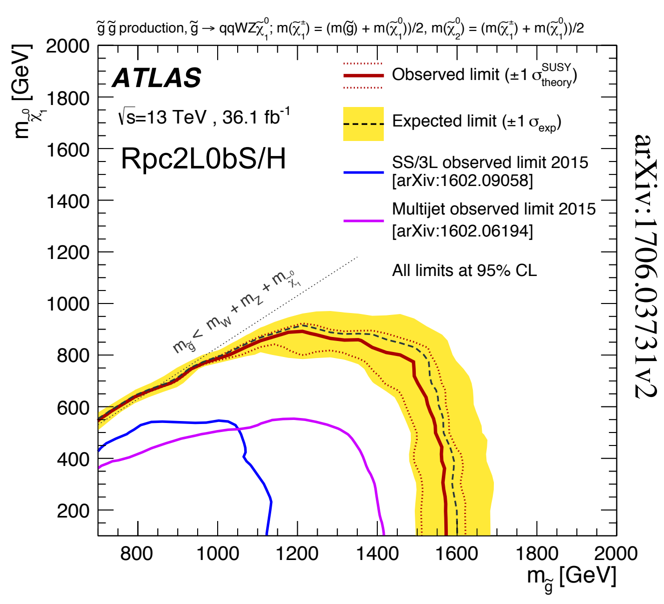
Results and statistical interpretations

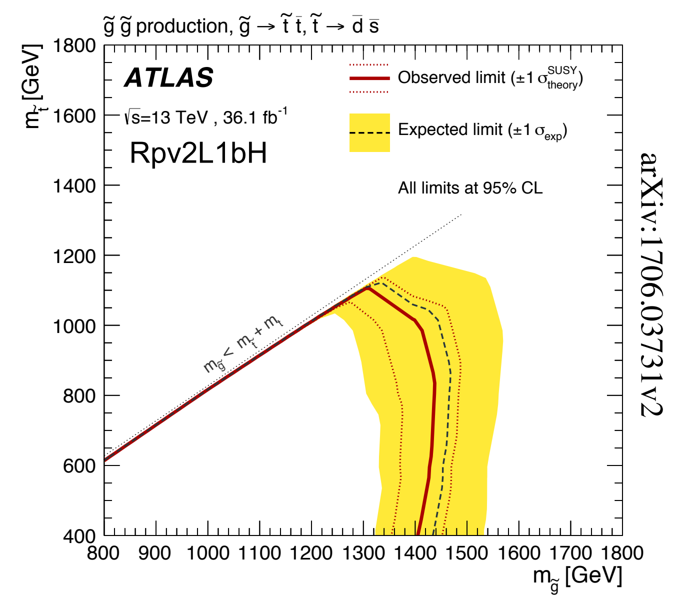
- The yields for 2015+2016 data (36.1 fb⁻¹) and the different sources of Standard Model background in the signal regions are presented.
- No significant excess over the background is observed in any of the 19 signal regions.
- The total uncertainties amount to 24 - 46% (depending on the SR).

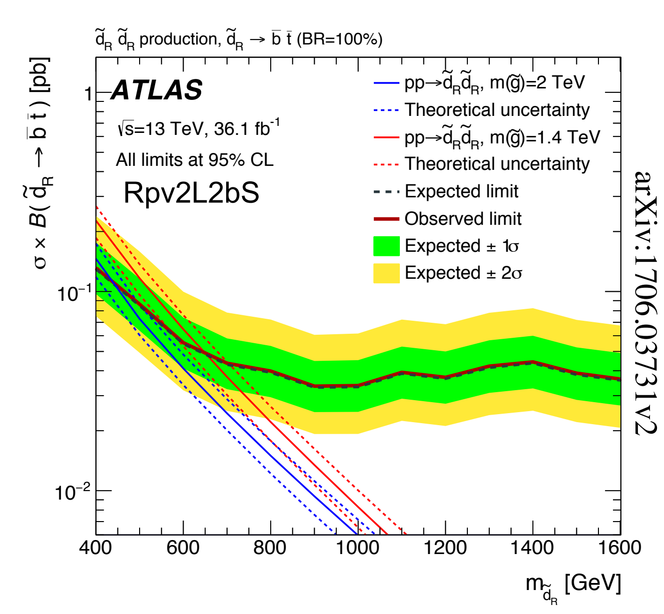


- Exclusion limits on SUSY contributions to the signal regions are computed, in particular in the context of the benchmark scenarios shown above.
- Results are also used to derive limits for other BSM scenarios (e.g. NUHM2).
- The limits can be compared to previous results of ATLAS searches. In the models considered, $m_{\tilde{g}}$ < 1.6 - 1.8 TeV and $m_{\tilde{\chi}_1^0}$ < 850 - 950 GeV can be excluded at 95% CL.









Peter Tornambè and the SS/3L+jets analysis team