

# Search for supersymmetry in final states with two same-sign or three leptons and jets using $36 \text{ fb}^{-1}$ of $\sqrt{s} = 13 \text{ TeV}$ $pp$ collision data with the ATLAS detector,

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## 1 Validation

Processes:

- **Rpc2L2bS**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{\chi}_1^0$$

$m_g = 1500 \text{ GeV}$ ,  $m_{\tilde{\chi}_1^0} = 800 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	98000	10000
Expected for $36 \text{ fb}^{-1}$	510	510
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$19.96 \pm 0.35$	22.1
Trigger	$19.17 \pm 0.35$	–
$\geq 2$ $b$ -jets ( $p_T > 20 \text{ GeV}$ )	$16.10 \pm 0.32$	17.5
$\geq 6$ jets ( $p_T > 25 \text{ GeV}$ )	$13.11 \pm 0.28$	14.3
$E_T^{\text{miss}} > 200 \text{ GeV}$	$10.17 \pm 0.26$	10.8
$m_{\text{eff}} > 0.6 \text{ TeV}$	$10.17 \pm 0.26$	10.8
$E_T^{\text{miss}} > 0.25 \cdot m_{\text{eff}}$	$5.94 \pm 0.20$	6.3

- **Rpc2L2bH**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{\chi}_1^0$$

$m_g = 1700 \text{ GeV}$ ,  $m_{\tilde{\chi}_1^0} = 200 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	98000	10000
Expected for $36 \text{ fb}^{-1}$	170	170
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$7.32 \pm 0.13$	7.6
Trigger	$7.19 \pm 0.13$	–
$\geq 2$ $b$ -jets ( $p_T > 20 \text{ GeV}$ )	$5.81 \pm 0.11$	6.1
$\geq 6$ jets ( $p_T > 40 \text{ GeV}$ )	$4.92 \pm 0.11$	5.1
$m_{\text{eff}} > 1.8 \text{ TeV}$	$3.93 \pm 0.09$	3.8
$E_T^{\text{miss}} > 0.15 \cdot m_{\text{eff}}$	$3.12 \pm 0.08$	2.9

- **Rpc2Lsoft1b**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow tWb\tilde{\chi}_1^0$$

$m_g = 1200 \text{ GeV}$ ,  $m_{\tilde{\chi}_1^0} = 940 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	50000	10000
Expected for $36 \text{ fb}^{-1}$	3100	3100
$\geq 2$ SS leptons ( $100 > p_T > 20, 10 \text{ GeV}$ )	$101.9 \pm 2.7$	123
Trigger	$89.3 \pm 2.5$	–
$\geq 2$ $b$ -jets ( $p_T > 20 \text{ GeV}$ )	$75.1 \pm 2.3$	99.6
$\geq 6$ jets ( $p_T > 25 \text{ GeV}$ )	$31.5 \pm 1.5$	43.8
$E_T^{\text{miss}} > 100 \text{ GeV}$	$23.0 \pm 1.3$	29.4
$E_T^{\text{miss}} > 0.3 \cdot m_{\text{eff}}$	$6.5 \pm 0.7$	6.9

- **Rpc2Lsoft2b**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow tWb\tilde{\chi}_1^0$$

$m_g = 1200 \text{ GeV}$ ,  $m_{\tilde{\chi}_1^0} = 900 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	50000	20000
Expected for $36 \text{ fb}^{-1}$	3100	3100
$\geq 2$ SS leptons ( $100 > p_T > 20, 10 \text{ GeV}$ )	$91.8 \pm 2.6$	125
Trigger	$79.7 \pm 2.4$	–
$\geq 2$ $b$ -jets ( $p_T > 20 \text{ GeV}$ )	$41.3 \pm 1.7$	66.8
$\geq 6$ jets ( $p_T > 25 \text{ GeV}$ )	$21.4 \pm 1.2$	38.9
$E_T^{\text{miss}} > 200 \text{ GeV}$	$8.7 \pm 0.7$	12.1
$m_{\text{eff}} > 0.6 \text{ TeV}$	$8.7 \pm 0.7$	11.9
$E_T^{\text{miss}} > 0.25 \cdot m_{\text{eff}}$	$6.7 \pm 0.6$	8.1

- **Rpc2L0bS**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}'WZ\tilde{\chi}_1^0$$

$m_g = 1200 \text{ GeV}$ ,  $(m_{\tilde{\chi}_1^\pm} - 150) = (m_{\tilde{\chi}_2^0} - 75) = m_{\tilde{\chi}_1^0} = 900 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	50000	20000
Expected for $36 \text{ fb}^{-1}$	3100	3100
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$64 \pm 4$	71
Trigger	$58.6 \pm 3.3$	–
no $b$ -jet ( $p_T > 20 \text{ GeV}$ )	$46.3 \pm 3.0$	51.4
$\geq 6$ jets ( $p_T > 25 \text{ GeV}$ )	$26.6 \pm 2.4$	29.6
$E_T^{\text{miss}} > 150 \text{ GeV}$	$16.3 \pm 2.0$	16.3
$E_T^{\text{miss}} > 0.25 \cdot m_{\text{eff}}$	$9.0 \pm 1.3$	9.5

- **Rpc2L0bH**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}'WZ\tilde{\chi}_1^0$$

$m_g = 1600 \text{ GeV}$ ,  $(m_{\tilde{\chi}_1^\pm} - 750) = (m_{\tilde{\chi}_2^0} - 375) = m_{\tilde{\chi}_1^0} = 100 \text{ GeV}$ , squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	20000	5000
Expected for $36 \text{ fb}^{-1}$	290	290
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$12.8 \pm 0.5$	15.3
Trigger	$12.5 \pm 0.5$	–
no $b$ -jet ( $p_T > 20 \text{ GeV}$ )	$8.5 \pm 0.4$	9.4
$\geq 6$ jets ( $p_T > 40 \text{ GeV}$ )	$7.1 \pm 0.4$	7.1
$E_T^{\text{miss}} > 250 \text{ GeV}$	$5.1 \pm 0.3$	3.7
$m_{\text{eff}} > 0.9 \text{ TeV}$	$5.1 \pm 0.3$	3.7

- **Rpc3L0bS**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}'(\tilde{\ell}\ell/\tilde{\nu}\nu)$$

$$m_{\tilde{g}} = 1400 \text{ GeV}, (m_{\tilde{\chi}_2^0} - 150) = (m_{\tilde{\ell},\tilde{\nu}} - 75) = m_{\tilde{\chi}_1^0} = 1100 \text{ GeV}, \text{ squarks decoupled}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	20000	10000
Expected for 36 fb <sup>-1</sup>	910	910
≥ 3 leptons ( $p_T > 20, 20, 10$ GeV)	76.9 ± 2.1	91.5
Trigger	76.0 ± 2.0	–
no $b$ -jet ( $p_T > 20$ GeV)	67.5 ± 1.9	55
≥ 4 jets ( $p_T > 40$ GeV)	31.6 ± 1.3	26.4
$E_T^{\text{miss}} > 200$ GeV	17.1 ± 1.0	13.0
$m_{\text{eff}} > 0.6$ TeV	17.1 ± 1.0	13.0

- **Rpc3L0bH**

$$pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}'(\tilde{\ell}\ell/\tilde{\nu}\nu)$$

$$m_{\tilde{g}} = 1800 \text{ GeV}, (m_{\tilde{\chi}_2^0} - 850) = (m_{\tilde{\ell},\tilde{\nu}} - 375) = m_{\tilde{\chi}_1^0} = 100 \text{ GeV}, \text{ squarks decoupled}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	20000	5000
Expected for 36 fb <sup>-1</sup>	100	100
≥ 3 leptons ( $p_T > 20, 20, 10$ GeV)	10.0 ± 0.3	13.7
Trigger	9.9 ± 0.3	–
no $b$ -jet ( $p_T > 20$ GeV)	8.4 ± 0.2	8.2
≥ 4 jets ( $p_T > 40$ GeV)	7.8 ± 0.2	7.6
$E_T^{\text{miss}} > 200$ GeV	6.6 ± 0.2	6.2
$m_{\text{eff}} > 1.6$ TeV	6.6 ± 0.2	6.2

- **Rpc2L1bS**

$$pp \rightarrow \tilde{b}_1\tilde{b}_1^*, \tilde{b}_1 \rightarrow t(\tilde{\chi}_1^- \rightarrow tW^- \tilde{\chi}_1^0)$$

$$m_{\tilde{b}_1} = 600 \text{ GeV}, m_{\tilde{\chi}_1^\pm} = 350, m_{\tilde{\chi}_1^0} = 250 \text{ GeV}, \text{ squarks decoupled}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	10000	10000
Expected for 36 fb <sup>-1</sup>	6300	6300
≥ 2 SS leptons ( $p_T > 20$ GeV)	221 ± 4	273
Trigger	201 ± 4	–
≥ 1 $b$ -jets ( $p_T > 20$ GeV)	173 ± 4	221
≥ 6 jets ( $p_T > 25$ GeV)	66.3 ± 2.2	91.8
$E_T^{\text{miss}} > 150$ GeV	36.5 ± 1.7	41.9
$m_{\text{eff}} > 0.6$ TeV	36.1 ± 1.7	41.0
$E_T^{\text{miss}} > 0.25 \cdot m_{\text{eff}}$	15.1 ± 1.1	19.3

- **Rpc2L1bH**

$$pp \rightarrow \tilde{b}_1\tilde{b}_1^*, \tilde{b}_1 \rightarrow t(\tilde{\chi}_1^-)$$

$$m_{\tilde{b}_1} = 750 \text{ GeV}, m_{\tilde{\chi}_1^\pm} = 200, m_{\tilde{\chi}_1^0} = 100 \text{ GeV}, \text{ squarks decoupled}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	10000	10000
Expected for 36 fb <sup>-1</sup>	1600	1600
≥ 2 SS leptons ( $p_T > 20$ GeV)	71.1 ± 1.2	80.9
Trigger	66.4 ± 1.2	–
≥ 1 $b$ -jets ( $p_T > 20$ GeV)	56.6 ± 1.1	68.4
≥ 6 jets ( $p_T > 25$ GeV)	27.7 ± 0.7	33.0
$E_T^{\text{miss}} > 250$ GeV	12.5 ± 0.5	12.9
$E_T^{\text{miss}} > 0.25 \cdot m_{\text{eff}}$	9.5 ± 0.4	11.4

- **Rpc3LSS1b**

$$pp \rightarrow \tilde{t}_1 \tilde{t}_1^*, \tilde{t}_1 \rightarrow t \tilde{\chi}_2^0 \rightarrow t W^\pm \tilde{\chi}_1^\mp$$

$m_{\tilde{t}_1} = 700$  GeV,  $m_{\tilde{\chi}_2^0} = 525$  GeV,  $m_{\tilde{\chi}_1^\pm} \approx m_{\tilde{\chi}_1^0} = 425$  GeV, squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	10000	10000
Expected for 36 fb <sup>-1</sup>	1600	1600
≥ 3 SS leptons ( $p_T > 20, 20, 10$ GeV), $Z \rightarrow e^\pm e^\pm$ veto	4.6 ± 0.5	4.0
Trigger	4.5 ± 0.5	–
≥ 1 $b$ -jets ( $p_T > 20$ GeV)	3.6 ± 0.4	3.2

- **Rpv2L1bH**

$$pp \rightarrow \tilde{g} \tilde{g}, \tilde{g} \rightarrow \tilde{t}_1 \tilde{t}_1^*, \tilde{t}_1 \rightarrow \bar{d} \bar{s}$$

$m_{\tilde{g}} = 1400$  GeV,  $m_{\tilde{t}_1} = 800$  GeV, squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	18000	10000
Expected for 36 fb <sup>-1</sup>	910	910
≥ 2 SS leptons ( $p_T > 20$ GeV)	9.3 ± 0.7	9.1
Trigger	8.5 ± 0.7	–
≥ 1 $b$ -jets ( $p_T > 20$ GeV)	7.6 ± 0.7	7.7
≥ 6 jets ( $p_T > 50$ GeV)	6.5 ± 0.6	6.6
$m_{\text{eff}} > 2.2$ TeV	5.4 ± 0.6	4.9

- **Rpv2L0b**

$$pp \rightarrow \tilde{g} \tilde{g}, \tilde{g} \rightarrow qq \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow q \bar{q}' \ell$$

$m_{\tilde{g}} = 1800$  GeV,  $m_{\tilde{\chi}_1^0} = 500$  GeV, squarks decoupled

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	10000	5000
Expected for 36 fb <sup>-1</sup>	100	100
≥ 2 SS leptons ( $p_T > 20$ GeV) $Z \rightarrow e^\pm e^\pm$ veto	6.4 ± 0.3	7.7
Trigger	5.6 ± 0.3	–
no $b$ -jet ( $p_T > 20$ GeV)	4.6 ± 0.2	6.3
≥ 6 jets ( $p_T > 40$ GeV)	4.5 ± 0.2	6.3
$m_{\text{eff}} > 2$ TeV	4.5 ± 0.2	6.3

- **Rpv2L2bS**

$$pp \rightarrow \tilde{d}_R \tilde{d}_R, \tilde{d}_R \rightarrow \bar{t} \bar{b}$$

$m_{\tilde{g}} = 2000$  GeV,  $m_{\tilde{d}_R} = 600$  GeV

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	20000	15000
Expected for $36 \text{ fb}^{-1}$	1500	1500
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$31.2 \pm 1.7$	38.8
Trigger	$28.2 \pm 1.6$	–
$\geq 2$ $b$ -jets ( $p_T > 20 \text{ GeV}$ )	$23.2 \pm 1.5$	30.9
$\geq 3$ jets ( $p_T > 50 \text{ GeV}$ )	$21.9 \pm 1.5$	29.2
$m_{\text{eff}} > 1.2 \text{ TeV}$	$13.0 \pm 1.0$	14.6

- **Rpv2L1bS**

$$pp \rightarrow \tilde{d}_R \tilde{d}_R, \tilde{d}_R \rightarrow \bar{t} \bar{s}$$

$$m_g = 2000 \text{ GeV}, m_{\tilde{d}_R} = 600 \text{ GeV}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	20000	15000
Expected for $36 \text{ fb}^{-1}$	1500	1500
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$29.5 \pm 1.8$	34.3
Trigger	$26.2 \pm 1.7$	–
$\geq 1$ $b$ -jet ( $p_T > 20 \text{ GeV}$ )	$22.8 \pm 1.6$	28.3
$\geq 4$ jets ( $p_T > 50 \text{ GeV}$ )	$17.1 \pm 1.5$	20.3
$m_{\text{eff}} > 1.2 \text{ TeV}$	$11.0 \pm 1.2$	11.5

- **Rpv2L1bM**

$$pp \rightarrow \tilde{d}_R \tilde{d}_R, \tilde{d}_R \rightarrow \bar{t} \bar{s}$$

$$m_g = 2000 \text{ GeV}, m_{\tilde{d}_R} = 1000 \text{ GeV}$$

Events generated with MG5\_aMC 2.6.1 interfaced to Pythia8 with up to two extra partons (CKKW-L).

	ATLAS	CM
MC events generated	18000	5000
Expected for $36 \text{ fb}^{-1}$	220	220
$\geq 2$ SS leptons ( $p_T > 20 \text{ GeV}$ )	$4.6 \pm 0.3$	5.8
Trigger	$4.2 \pm 0.3$	–
$\geq 1$ $b$ -jet ( $p_T > 20 \text{ GeV}$ )	$3.5 \pm 0.3$	4.7
$\geq 4$ jets ( $p_T > 50 \text{ GeV}$ )	$3.2 \pm 0.3$	3.9
$m_{\text{eff}} > 1.8 \text{ TeV}$	$2.5 \pm 0.2$	2.4