

# Search for direct top squark pair production in final states with one isolated lepton

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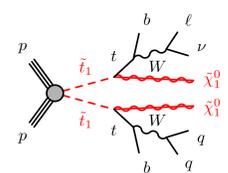
## Abstract

Motivated by natural SUSY, a search for pair production of the supersymmetric partner of the top quark (stop) in final states with one isolated lepton, jets and missing transverse momentum in  $\sqrt{s} = 8$  TeV  $pp$  collisions using  $20.3 \text{ fb}^{-1}$  of data from the ATLAS experiment, is presented. Five different decay scenarios for the stop are considered. As the data are in agreement with predictions from the Standard Model, the measurements are translated into 95% C.L. upper limits on the masses of the stop and the lightest supersymmetric particle (LSP) in various supersymmetric scenarios. The sensitivity to a limited number of pMSSM models, in which the stop can decay into heavy neutralinos and charginos, is also presented.

## Decay scenarios

$$\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$$

Stop decays into a top quark and the lightest neutralino with 100% branching ratio.

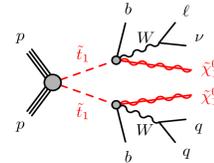


## Asymmetric

Both the  $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$  and  $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$  decay channels are open.

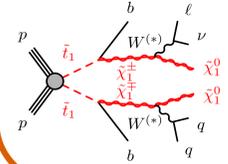
## 3-body

Stop decays into  $bW\tilde{\chi}_1^\pm$  with 100% branching ratio.



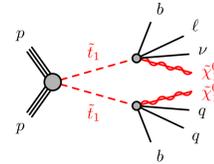
$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$$

Stop decays into a bottom quark and the lightest chargino with 100% branching ratio.



## 4-body

Stop decays into  $bf\tilde{\chi}_1^0$ .



## Signal regions

- One isolated  $\mu$  or  $e$   
 $p_T > 25$  GeV (hard)  
 $p_T > 6/7$  GeV (soft).
- $N_{\text{jet}} \geq 2-4, p_T > 25$  GeV.
- Large  $E_T^{\text{miss}}$

## Soft-lepton SRs

Leading jet not  $b$ -tagged,  $\geq 1$   $b$ -tag amongst other jets ( $\epsilon_b=70\%$ ).

Leading 2 jets  $b$ -tagged ( $\epsilon_b=60\%$ ).

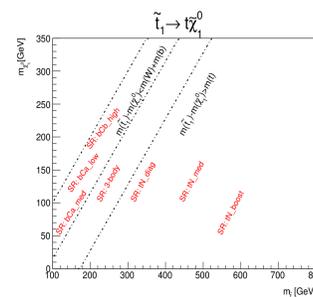
## Asymmetric SR

$\geq 1$   $b$ -tagged jets ( $\epsilon_b=70\%$ ).

$$\tilde{t}_1 \rightarrow t^{(*)}\tilde{\chi}_1^0 \text{ SRs}$$

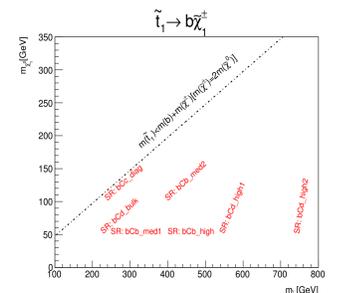
$\geq 1$   $b$ -tagged jet ( $\epsilon_b=70\%$ ).

- \* 3body : a 2D-shapefit in  $m_T$  and  $am_{T2}$ .
- \* tN\_diag : a 2D-shapefit in  $E_T^{\text{miss}}$  and  $m_T$ .
- \* tN\_boost :  $\geq 1$  large- $R$  jet (to select boosted  $t$ ).



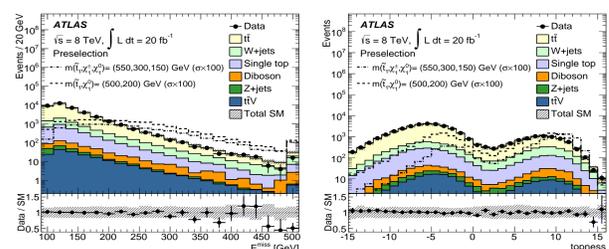
$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm \text{ SRs}$$

- \* bCc\_diag : = 0  $b$ -tagged jet ( $\epsilon_b=70\%$ ).
- $\geq 2$   $b$ -tagged jets ( $\epsilon_b=80\%$ ).
- \* bCd\_bulk : a 2D-shapefit in  $m_T$  and  $am_{T2}$ .
- \* bCb\_med2 : a 2D-shapefit in  $m_T$  and  $am_{T2}$ .



## Data and expected Background

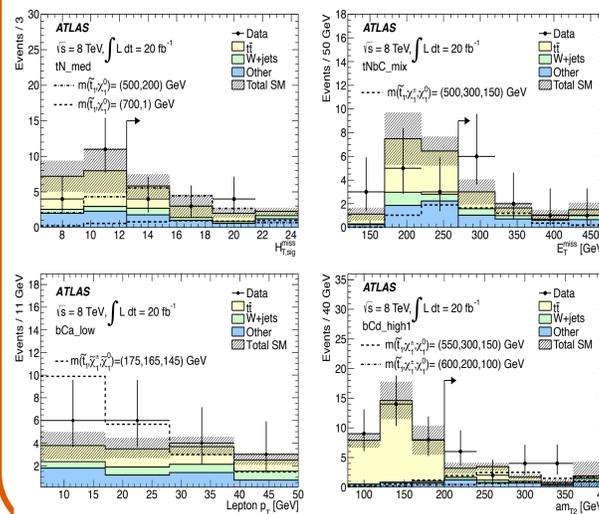
The dominant backgrounds are dileptonic decaying  $t\bar{t}$  events and  $W$ -jets events where the  $W$  boson decays leptonically.



Discriminating variables e.g  $topness$  used to suppress dileptonic  $t\bar{t}$  background.

## Results and model-independent exclusion limits

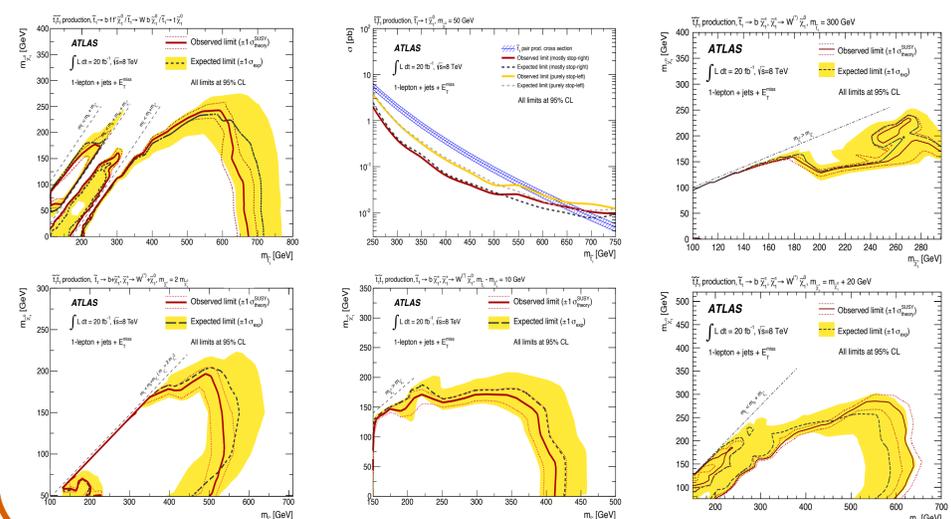
Simultaneous fit to all CRs and one SR or all shape-fit bins.  
Observed data consistent with SM background expectation.



Region	Obs.	Exp. bkg.	$\sigma_{\text{vis}}$ [fb]	Obs.	Exp.
tN_med	12	$13.0 \pm 2.2$	0.4	0.5	0.5
tN_high	5	$4.97 \pm 0.96$	0.3	0.3	0.3
tN_boost	5	$3.3 \pm 0.7$	0.3	0.3	0.3
bCa_low	11	$6.5 \pm 1.4$	0.61	0.92	0.92
bCa_med	20	$17 \pm 4$	0.72	0.68	0.68
bCb_med1	41	$32 \pm 5$	1.17	0.88	0.88
bCb_high	7	$9.8 \pm 1.6$	0.32	0.22	0.22
bCc_diag	493	$470 \pm 50$	5.4	4.7	4.7
bCd_high1	16	$11.0 \pm 1.5$	0.7	0.4	0.4
bCd_high2	5	$4.4 \pm 0.8$	0.3	0.3	0.3
tNbC_mix	10	$7.2 \pm 1.0$	0.5	0.3	0.3
tN_diag					
$125 < E_T^{\text{miss}} < 150 \text{ GeV}, 120 < m_T < 140 \text{ GeV}$	117	$136 \pm 22$	2.1	2.7	2.7
$125 < E_T^{\text{miss}} < 150 \text{ GeV}, m_T > 140 \text{ GeV}$	163	$152 \pm 20$	2.7	2.4	2.4
$E_T^{\text{miss}} > 150 \text{ GeV}, 120 < m_T < 140 \text{ GeV}$	101	$98 \pm 13$	1.8	1.7	1.7
$E_T^{\text{miss}} > 150 \text{ GeV}, m_T > 140 \text{ GeV}$	217	$236 \pm 29$	2.9	3.5	3.5
bCb_med2					
$175 < am_{T2} < 250 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	10	$12 \pm 2$	0.4	0.4	0.4
$175 < am_{T2} < 250 \text{ GeV}, m_T > 120 \text{ GeV}$	10	$7.4 \pm 1.4$	0.5	0.4	0.4
$am_{T2} > 250 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	16	$21 \pm 4$	0.5	0.6	0.6
$am_{T2} > 250 \text{ GeV}, m_T > 120 \text{ GeV}$	9	$9.1 \pm 1.6$	0.4	0.4	0.4
bCd_bulk					
$175 < am_{T2} < 250 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	144	$133 \pm 22$	1.8	1.7	1.7
$175 < am_{T2} < 250 \text{ GeV}, m_T > 120 \text{ GeV}$	78	$73 \pm 8$	2.9	3.5	3.5
$am_{T2} > 250 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	61	$66 \pm 6$	0.9	1.0	1.0
$am_{T2} > 250 \text{ GeV}, m_T > 120 \text{ GeV}$	29	$26.5 \pm 2.6$	0.7	0.6	0.6
3body					
$80 < am_{T2} < 90 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	12	$16.9 \pm 2.8$	0.4	0.5	0.5
$80 < am_{T2} < 90 \text{ GeV}, m_T > 120 \text{ GeV}$	8	$8.4 \pm 2.2$	0.4	0.4	0.4
$90 < am_{T2} < 100 \text{ GeV}, 90 < m_T < 120 \text{ GeV}$	29	$35 \pm 4$	0.6	0.7	0.7
$90 < am_{T2} < 100 \text{ GeV}, m_T > 120 \text{ GeV}$	22	$29 \pm 5$	2.7	2.4	2.4

## Model-dependent exclusion limits

The results are translated into 95% CL upper limits on  $\tilde{t}_1$  and  $\tilde{\chi}_1^0$  masses.



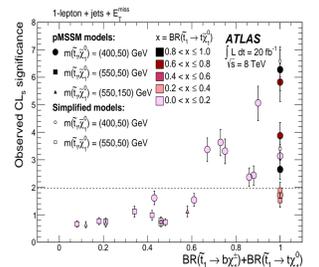
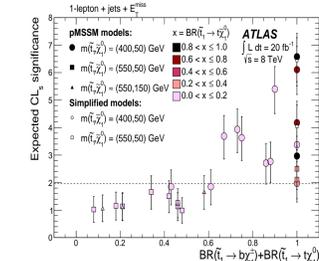
## Phenomenological MSSM sensitivity

Three sets of models:

- 14 models with  $m_{\tilde{t}_1} \sim 400$  GeV,  $m_{\tilde{\chi}_1^0} \sim 50$  GeV
- 10 models with  $m_{\tilde{t}_1} \sim 550$  GeV,  $m_{\tilde{\chi}_1^0} \sim 50$  GeV
- 3 models with  $m_{\tilde{t}_1} \sim 550$  GeV,  $m_{\tilde{\chi}_1^0} \sim 150$  GeV

Study sensitivity dependence on other parameters than  $m_{\tilde{t}_1}$  and  $m_{\tilde{\chi}_1^0}$ .

The sensitivity is based on the  $CL_s$  significance.



Conclusion:

- The sensitivity is reduced if stop decays into  $\tilde{\chi}_{2,3}^0$  or  $\tilde{\chi}_2^\pm$  (longer decay chains).