

# Search for top squarks with ATLAS at $\sqrt{s} = 13\text{TeV}$ in fully hadronic and semi-leptonic final states

ICHEP, Seoul, 2018, July 6<sup>th</sup>

Philipp Mogg

UNI  
FREIBURG

The top squark plays an important role in addressing the hierarchy problem of particle physics using supersymmetry (SUSY). Searches for it are mostly conducted in *simplified models*, where in the most prominent scenario the top squark decays exclusively into  $t\tilde{\chi}_1^0$ , as depicted in fig. 1. The rest of the SUSY spectrum is assumed to be decoupled and does not contribute.

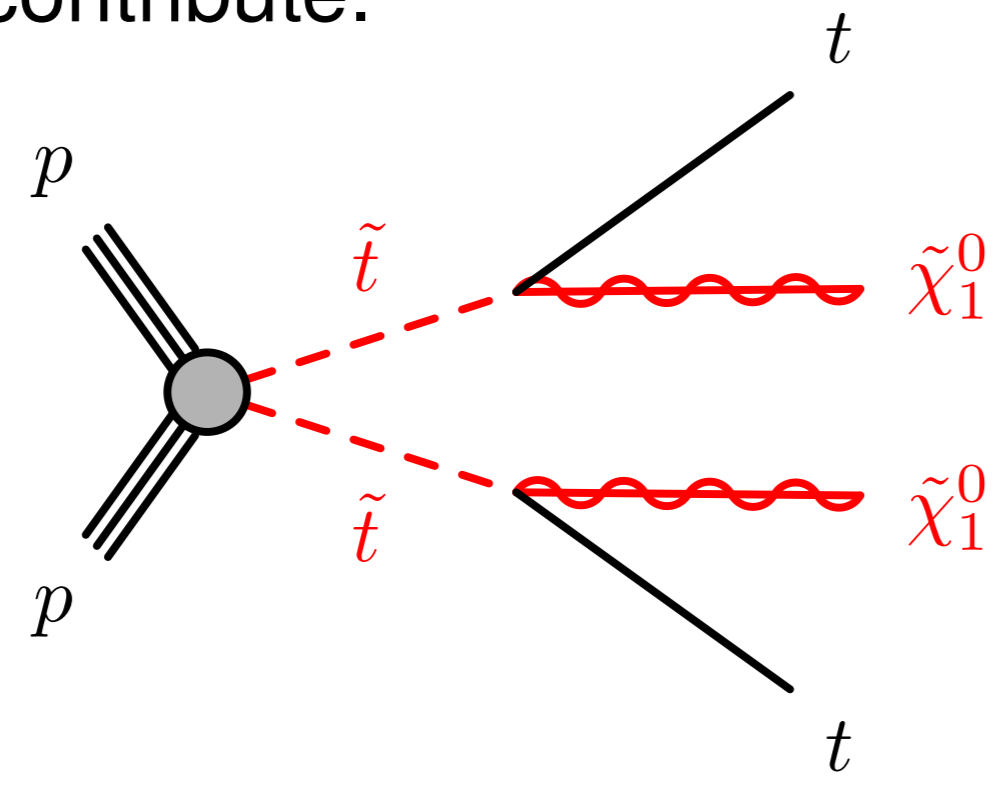


Figure 1: Quasi-Feynman diagram of top-squark pair production and the subsequent decay  $\tilde{t} \rightarrow t\tilde{\chi}_1^0$ .

The final state is characterised by the decay products of the top quarks. Searches in the 0- and 1-lepton final states allow for high sensitivity in large regions of the parameter space. Results are interpreted as constraints on SUSY models in various signal grids, including full pMSSM models. In fig. 2, the current 95%-CL exclusion limits of various analyses using data recorded by ATLAS during LHC Run 2 are shown.

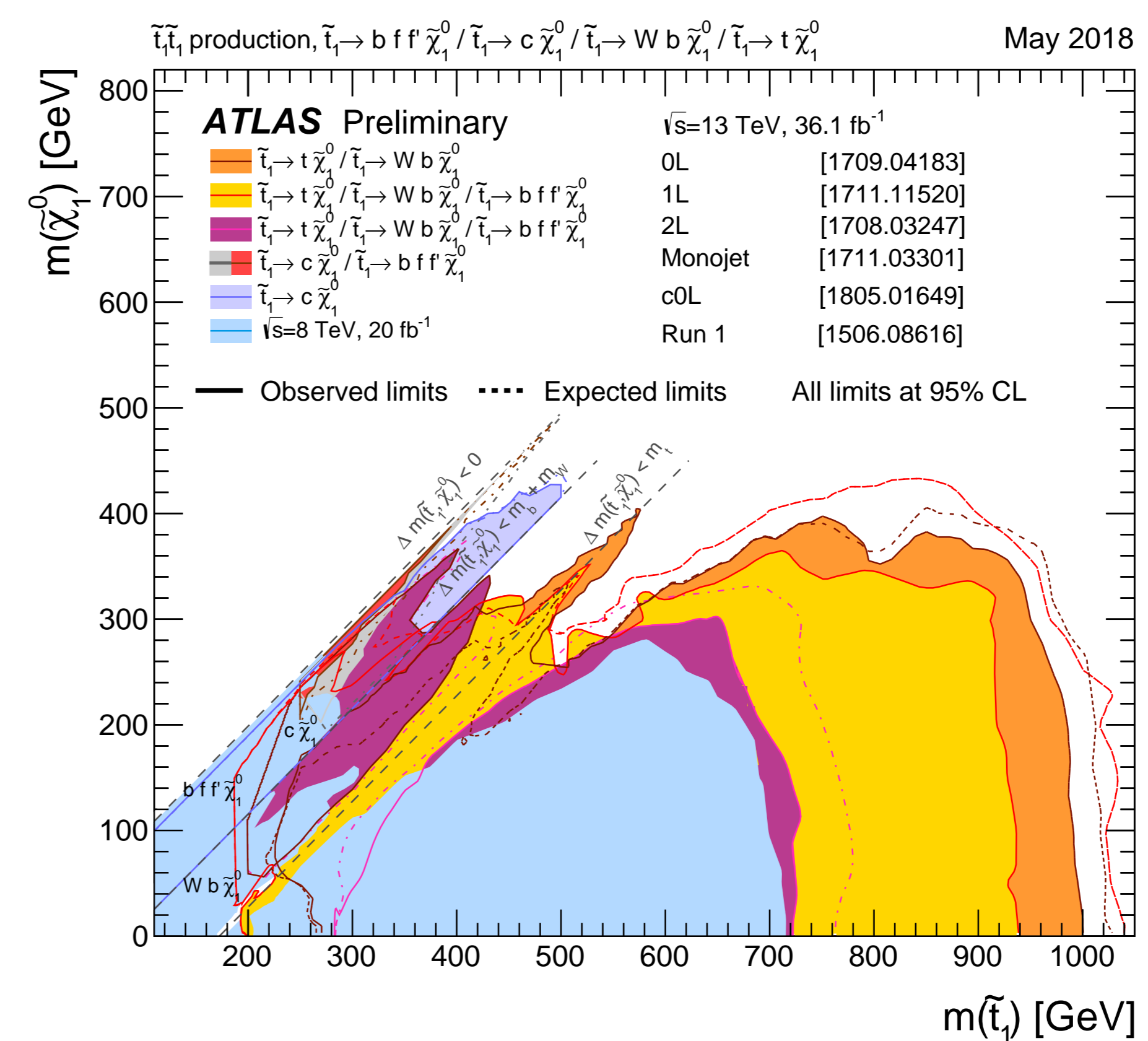


Figure 2: Summary of ATLAS searches for the top-squark in various final states using LHC Run 2 data.

## 0-lepton Final States

### Signal Selection

- Final state:  $\geq 4$  jets including  $\geq 2$   $b$ -tags from top-decays, substantial  $E_T^{\text{miss}}$  due to neutralinos.
- Main backgrounds:  $Z, t\bar{t}$  (semi-leptonic),  $t\bar{t} + Z/W$ ,  $W$ , single top and multi-jet production.
- Top-candidate reconstruction by re-applying the anti- $k_T$  algorithm.

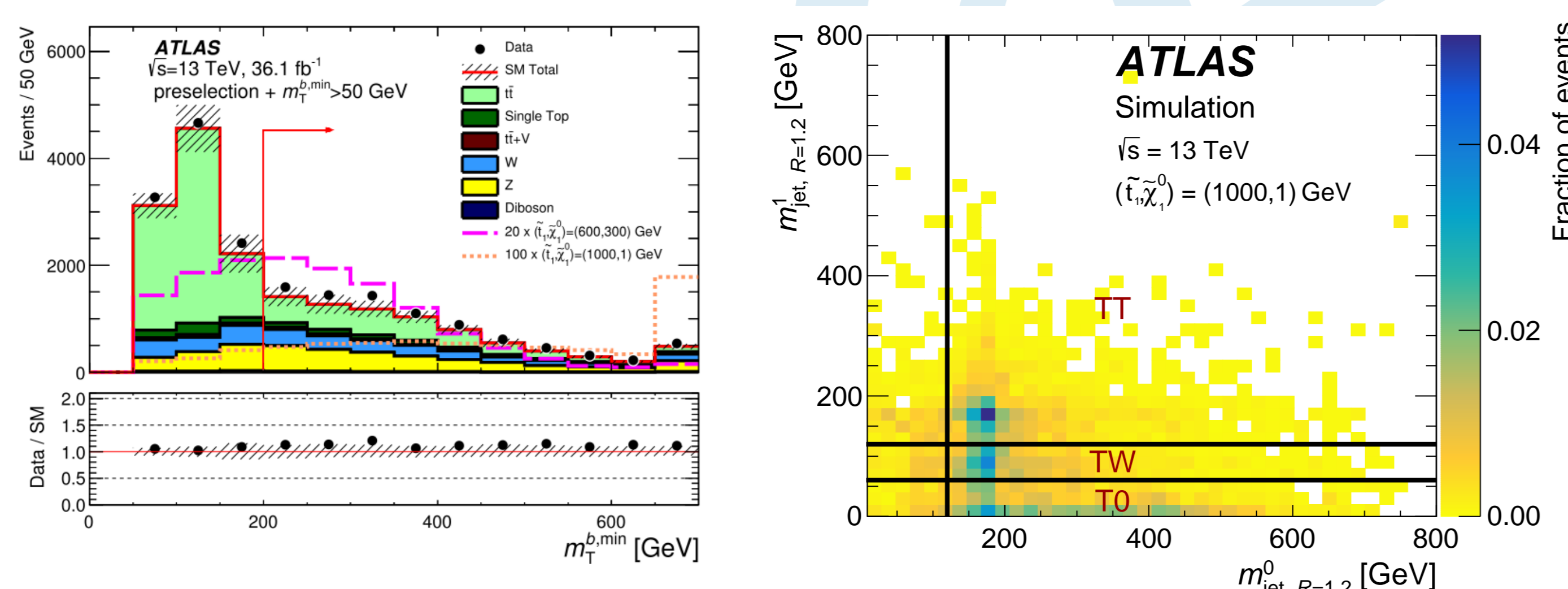


Figure 3:  $m_T(b_{\min}[\Delta\phi], E_T^{\text{miss}})$  (left), used for background rejection, mass of the  $p_T$  leading and sub-leading  $R = 1.2$  reclustered jet (right), used for top reconstruction.

- Signal Region A and B:** 3-bin regions based on reconstructed tops, optimized for high (1000 GeV) and medium (300 GeV)  $\Delta M(\tilde{t}, \tilde{\chi}_1^0)$ , respectively.
- Signal Region C:** 5-bin region in  $R_{\text{ISR}}$ , using the *recursive jigsaw* reconstruction technique for  $\Delta M(\tilde{t}, \tilde{\chi}_1^0) \simeq M_t$ .
- Signal Region D:** Two cut-and-count signal regions without top reconstruction for  $\tilde{t} \rightarrow b\tilde{\chi}_1^\pm$ , optimized for high (600 GeV) and medium (350 GeV)  $\Delta M(\tilde{t}, \tilde{\chi}_1^0)$ , respectively, assuming  $M_{\tilde{\chi}_1^\pm} = 2M_{\tilde{\chi}_1^0}$ .

### Estimation of Standard Model Backgrounds

- 1-lepton control regions for  $W$ , single top,  $t\bar{t}$ .
- $Z$ -background estimated in 2-lepton control region.
- Multi-jet background estimated via *jet smearing* method.
- $t\bar{t} + Z/W$  via  $\gamma$ +jets.

## Results

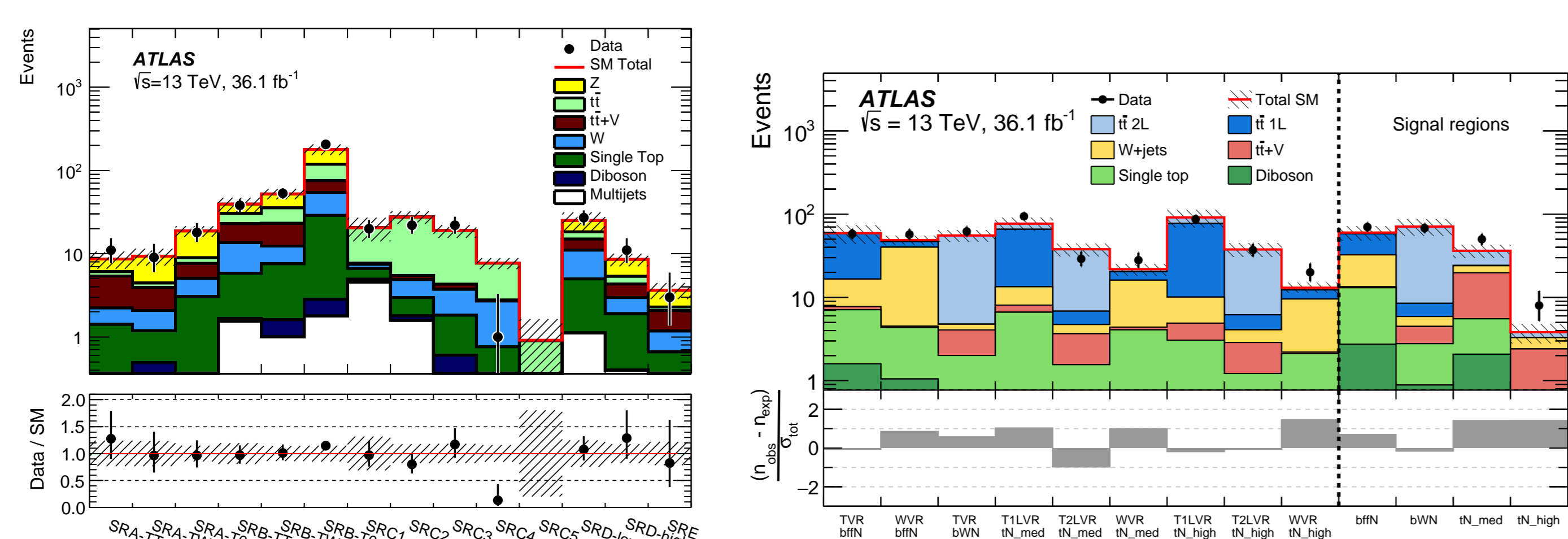


Figure 4: Summary of signal regions after simultaneous fit of control regions in 0-lepton final state (left) and a sub-set of signal and validation regions in 1-lepton final state (right). No significant excess over SM background was observed.

## 1-lepton Final States

### Signal Selection

- Final state:  $\geq 2$  jets including  $\geq 1$   $b$ -tag, 1 muon or electron,  $E_T^{\text{miss}}$  due to neutralinos and one or more neutrinos.
- Lepton with *tight* selection criteria required in regions with lower  $E_T^{\text{miss}}$ .
- Main backgrounds:  $t\bar{t}$  (semi- & di-leptonic),  $W$ , single top and  $t\bar{t} + Z/W$ .
- Hadronic top-candidate reconstruction by *recursive reclustering* in boosted regions,  $\chi^2$  method in less boosted regions.
- Leptonic top-candidate from the lepton and the remaining  $b$ -jet.

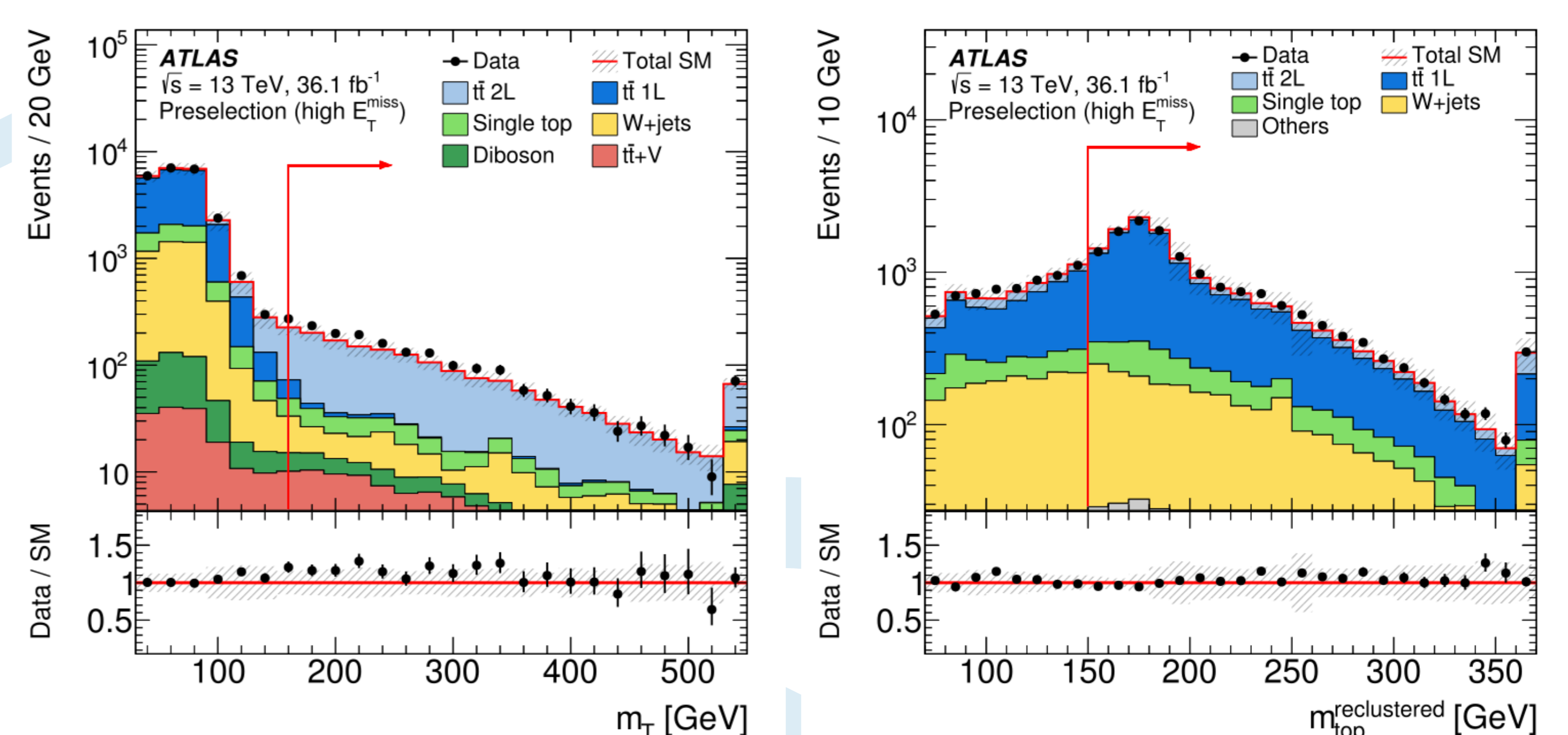


Figure 5:  $m_T$  (left), used for background rejection, mass of the hadronic top candidate from *recursive reclustering* method (right).

- Cut-and-count signal region **tN\_high** for  $\Delta M(\tilde{t}, \tilde{\chi}_1^0) = 1000\text{GeV}$ , 5-bin-region in  $E_T^{\text{miss}}$  **tN\_med** for  $\Delta M(\tilde{t}, \tilde{\chi}_1^0) = 300\text{GeV}$ .
- 3 signal regions, **tN\_diag\_low**, **tN\_diag\_med**, **tN\_diag\_high** for  $\Delta M(\tilde{t}, \tilde{\chi}_1^0) \simeq M_t$ , using BDT cut-and-count or shape-fit.
- 2 regions without tops, **bWN** and **bffN**, targeting scenarios with  $\Delta M(\tilde{t}, \tilde{\chi}_1^0) < M_t$  and  $< M_W$ , using shape-fits in  $am_{T2}$  and  $(p_T^l/E_T^{\text{miss}})$ .
- 6 additional signal regions, targeting different Wino NLSP and Higgsino LSP scenarios, partially without  $b$ -tagging, using cut-and-count and shape-fit in  $(p_T^l/E_T^{\text{miss}})$ .

### Estimation of Standard Model Backgrounds

- Control regions with hadronic  $t$ - or  $W$ -veto for di-leptonic  $t\bar{t}$ , single-top and  $W$ .
- Inverted cuts to enrich control regions in certain backgrounds.
- Low BDT-score control regions for BDT signal regions.
- Multi-jet background estimated via *fake factor* method, found to be negligible.

Published in *The ATLAS collaboration, Aaboud, M., Aad, G. et al. J. High Energ. Phys. (2017) 2017: 85.* and published on arXiv (1711.11520) and submitted to JHEP.