Search for phenomena beyond the Standard Model in events with large b-jet multiplicity using the ATLAS detector at the LHC

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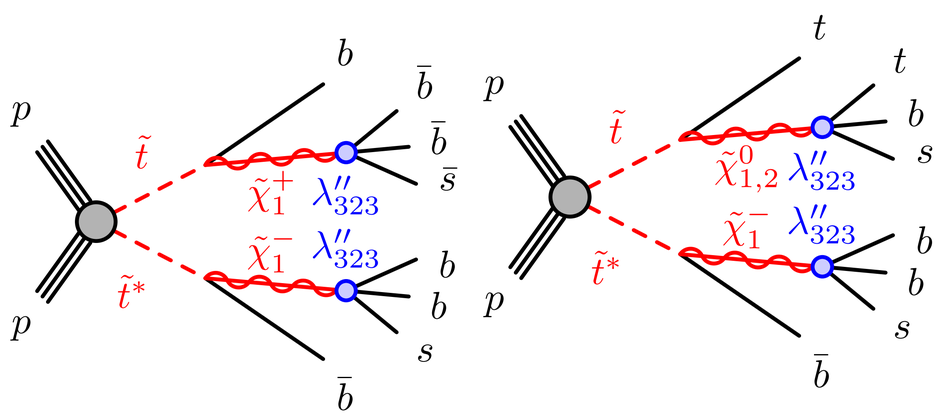
Introduction

Events with a large number of high-p_{T} b-jets are rarely produced by Standard Model (SM) processes in pp collisions at the LHC. An excess of events with such topology can be a signal of phenomena beyond the SM (BSM). Event topologies with large b-tagged multiplicities, small momentum imbalance and no leptons have not been covered by present searches at the LHC. The result presented are obtained from 139 fb^{-1} of ATLAS data at $\sqrt{s} = 13$ TeV.

RPV decay of top squark pair production

$\tilde{t} \to b\chi_1^+(\chi_1^+ \to \bar{b}\bar{b}\bar{s})$ $\quad$ $\tilde{t} \to b\chi_1^+(\chi_1^+ \to \bar{b}\bar{b}\bar{s})$ BR $= 0.5$
$\tilde{t} \to t\chi_{1,2}^0(\chi_{1,2}^0 \to tbs)$ BR $= 0.5$

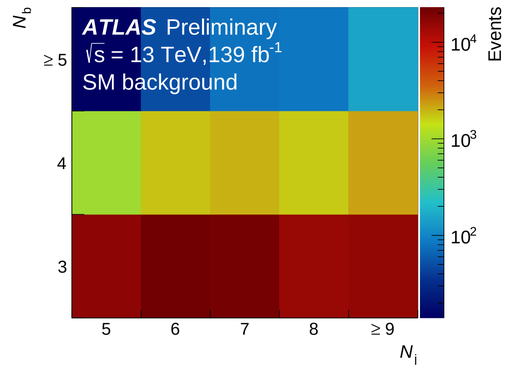


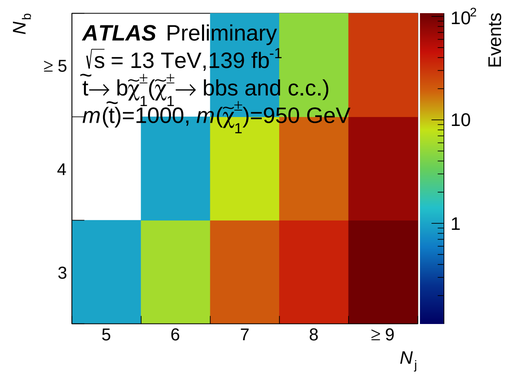
Saturate BR in
$m_{\tilde{t}} - m_{\tilde{\chi}_1^+} < m_{\mathrm{top}}$

Dominant in
$m_{\tilde{t}} - m_{\tilde{\chi}_1^+,\chi_{1,2}^0} > m_{\mathrm{top}}$

Event selection

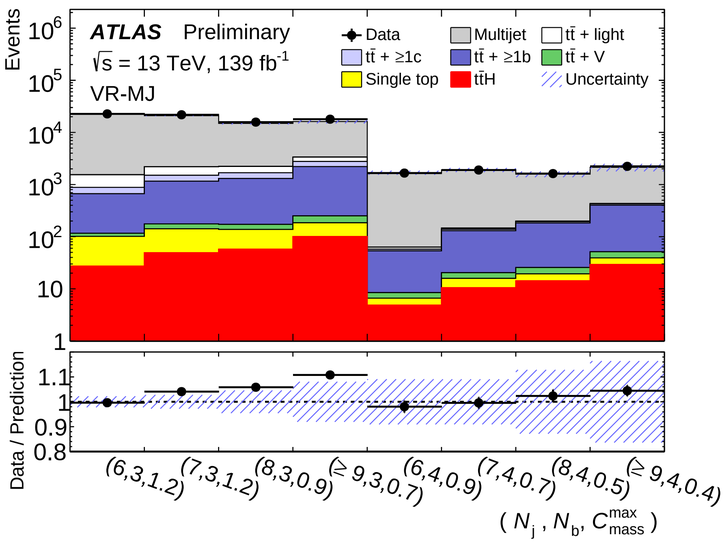
- ≥4 jets with $p_T \geq 120$ (140) GeV
  - ▷ additional jets must have $p_{\mathrm{T}} \geq 25$ GeV, $|\eta| < 2.5$
- ≥ 2 b-tagged jets at 60% efficiency
- Prompt leptons with $p_{\mathrm{T}} \geq 10$ GeV are vetoed
- Background composition:
  - ▷ MC: $t\bar{t}$, $t\bar{t}V$, $t\bar{t}H$ and single-top
  - ▷ Data-driven: multijet ($\mathrm{TRF_{MJ}}$ method)
- Strategy of this analysis:
  - ▷ Exploit difference in jet multiplicity (N_j) and b-tagged jet multiplicity (N_b) between signal and backgrounds
  - ▷ Events with $N_j \geq 6$ and $N_b \geq 4$ are categorized into 8 signal regions for model-dependent hypothesis test

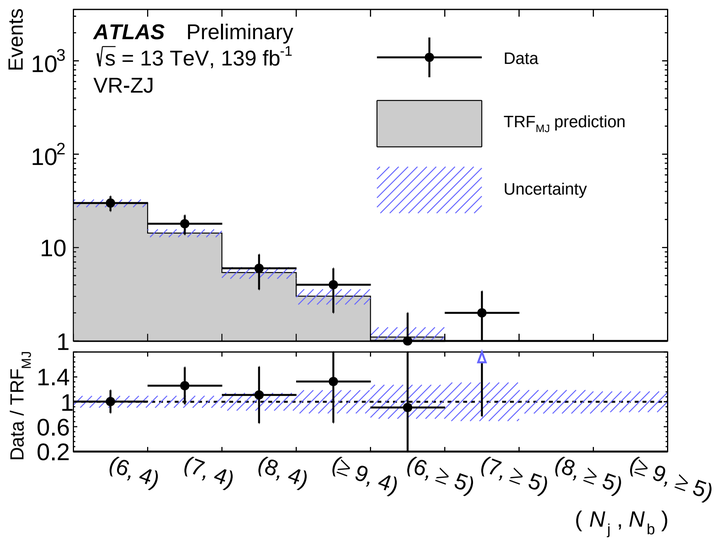




$\mathrm{TRF_{MJ}}$ data-driven method for multijet estimation

- $\mathrm{TRF_{MJ}}$ is based on probability of tagging a jet produced in multijet events
- Validation in data events
  - ▷ multijet after requiring upper value on $C_{\mathrm{mass}} = H_{\mathrm{T}}/M_{\mathrm{jets}}$ (VR-MJ)
  - ▷ 2 lepton plus jets, m_{ll} >60 GeV (VR-ZJ)





Systematic uncertainties

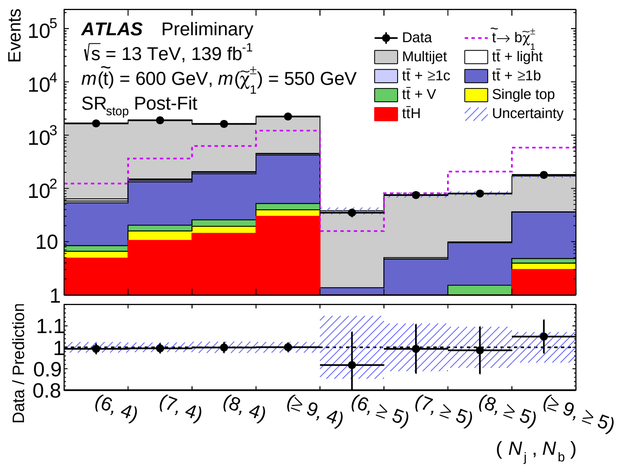
- Instrumental systematics:
  - ▷ Luminosity, pileup modelling, jet vertex tagger, jet energy scale, jet energy resolution, flavour tagging on all MC
- Theory systematics:
  - ▷ Cross section uncertainties of MC backgrounds
  - ▷ Conservative 50% uncertainties on $t\bar{t}+ \geq 1c$ and $t\bar{t}+ \geq 1b$ cross section
  - ▷ Radiation uncertainty in $t\bar{t}H$, $t\bar{t}$
  - ▷ Generator uncertainty $t\bar{t}H$, $t\bar{t}$, single-top
  - ▷ Parton shower uncertainty $t\bar{t}H$, $t\bar{t}$, single-top, $\tilde{t}\tilde{t}^*$
- $\mathrm{TRF_{MJ}}$ uncertainty
  - ▷ Derived from MC dijet events

$\mathrm{TRF_{MJ}}$ uncertainty		N_{b} 4	N_{b} ≥5
N_{j}	6	9%	27%
	7	9%	30%
	8	13%	18%
	≥9	16%	14%

Results: model-independent interpretation

- Profile-likelihood fit is performed for hypothesis testing
  - ▷ $\mathrm{TRF_{MJ}}$ non-closures are uncorrelated across N_j and N_b
  - ▷ MC systematic uncertainties correlated across N_j and N_b
- No significant excess observed

Background-only fit

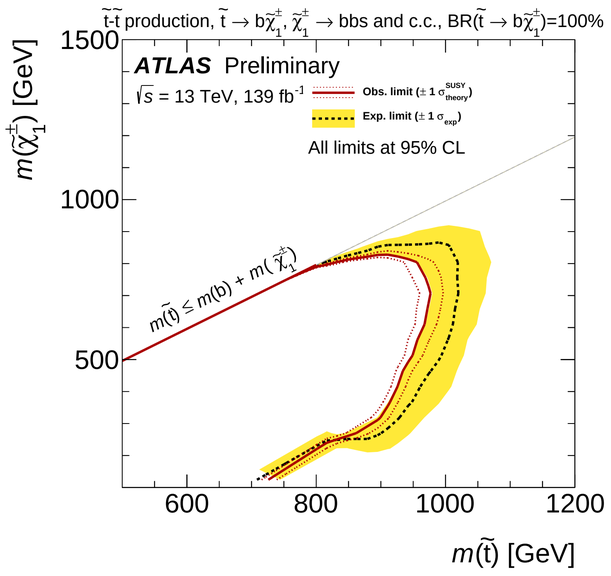


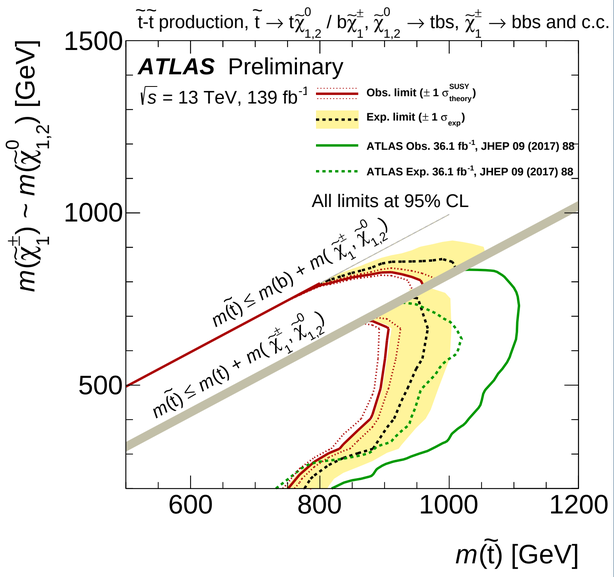
- Model-independent limits on the contribution of new phenomena to the signal-region yields are calculated

Signal region	$\sigma_{\mathrm{obs}}^{95}$ [fb]	N_{obs}^{95}	N_{exp}^{95}	p_0 (Z)
$N_{\mathrm{j}} \geq 8$, $N_{\mathrm{b}} \geq 5$	0.76	105	85^{+30}_{-24}	0.24 (0.7)
$N_{\mathrm{j}} \geq 9$, $N_{\mathrm{b}} \geq 5$	0.54	75	52^{+20}_{-15}	0.11 (1.2)

Results: model-dependent interpretation

95% CLs exclusion limits are computed





$m_{\tilde{t}} < 950$ GeV can be excluded in the chosen model

Reference: ATLAS-CONF-2020-016