

Searches for BSM particles decaying to 3rd generation quarks

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Heavy gauge bosons

- ▶ appears in various theories beyond the standard model
- ▶ E.g. in Sequential Standard Model (SSM), they obey lepton universality and have couplings identical to the SM W/Z boson
- ▶ other models include heavy gauge bosons e.g.:
 - ▶ non-universal $G(221)$ model (NU) with $SU(2)_l \times SU(2)_h \times U(1)$, they decay preferentially to heavy fermions
 - ▶ model with extra dimensions
 - ▶ strong dynamics
 - ▶ Composite / Little Higgs
- ▶ W'_L decay in LH fermions
- ▶ W'_R decay into RH fermions with ν_R heavier than W'_R

$$W' \rightarrow t\bar{b} \rightarrow q\bar{q}'b\bar{b}$$

CERN-EP-340

arXiv:1801.07893

- ▶ ATLAS 8 TeV, 20.3 fb⁻¹: 2.0 TeV
- ▶ CMS 13 TeV, 35.9 fb⁻¹: 3.6 TeV

Event selection

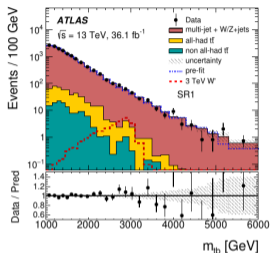
- ▶ veto e/μ
- ▶ jet $p_T > 420$ GeV
- ▶ Boosted t tagger with shower deconstruction
 - ▶ tuned to $p_T > 800$ GeV
 - ▶ 6 highest- p_T subjets of a k_T 1.0 jet fed to tagger
 - ▶ two WP used (50% and 80%)
- ▶ all b -jets $|\eta| < 1.2$

Event categories

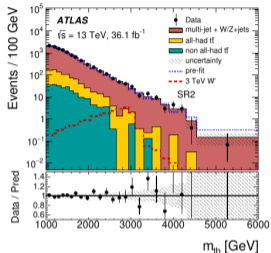
- ▶ J_t^{cand} : large jet with $\max(m_j + 0.15m_J)$ (m_j : highest p_T subjet, m_J : large jet)
- ▶ j_b^{cand} : highest p_T small jet with $\Delta R(J_t^{\text{cand}}, j_b^{\text{cand}}) > 2.0$
- ▶ Categories based on (0 or 1) b -jet in $\Delta R(J_t^{\text{cand}}, j) < 1.0$
- ▶ each category split in 6 regions
 - ▶ b tagged / not tagged j_b^{cand}
 - ▶ Tight / loose not tight / not loose J_t^{cand}
- ▶ 0 b : 1 SR, 1 VR, 4 CR ; 1 b : 2 SR, 4 CR

$W' \rightarrow t\bar{b} \rightarrow qq'\bar{b}\bar{b}$ – Results

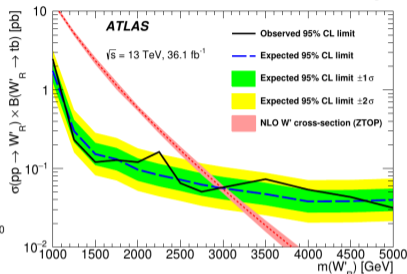
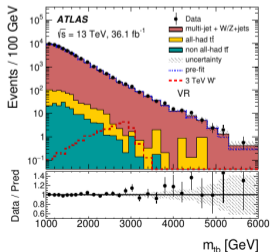
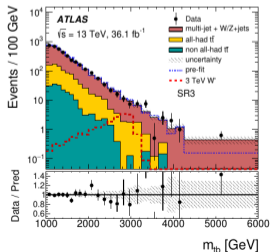
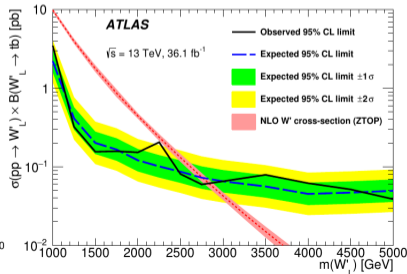
arXiv:1801.07893



(a)



(b)

 $m_{W'_{RH}} > 3 \text{ TeV}$  $m_{W'_{LH}} > 2.9 \text{ TeV}$

Vector like quarks (VLQ)

- ▶ defined as colour triplet, spin $\frac{1}{2}$ fermions
- ▶ LH / RH fermions transform equally under $SU(2)_L$
- ▶ $< (>)1$ TeV pair (single) production dominant (depending on coupling assumptions)
- ▶ Many models favor couplings to 3rd generation, but couplings to 1st and 2nd generation in general not excluded
- ▶ appear e.g. in Little / Composite Higgs models
- ▶ depending on model, VLQ are produced in $SU(2)$ singlet, doublets or triplets
- ▶ flavors B,T,X,Y with the charges $-\frac{1}{3}, \frac{2}{3}, \frac{5}{3}, -\frac{4}{3}$
- ▶ for consistency with electroweak precision fits, small mass splitting in $SU(2)$ multiplet
- ▶ flavor changing neutral and charged currents are allowed
- ▶ $B \rightarrow Wt, Zb, Hb$ $T \rightarrow Wb, Zt, Ht$ $X \rightarrow Wt$ $Y \rightarrow Wb$

Pair produced VLQ to high- p_T W bosons and b quarks in lepton+jets

CERN-EP-2017-094

arXiv:1707.03347

- ▶ old limits: ATLAS and CMS excluded masses below 740 GeV for any combination of BR
 - ▶ below 782 GeV for $BR(T \rightarrow Wb) = 1$
 - ▶ ATLAS at 13 TeV: 1160 GeV for $BR(T \rightarrow Zt) = 1$
- ▶ optimized for $T\bar{T}$ with one $T \rightarrow Wb$

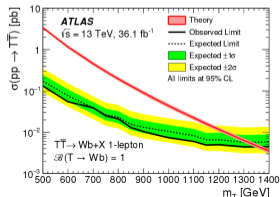
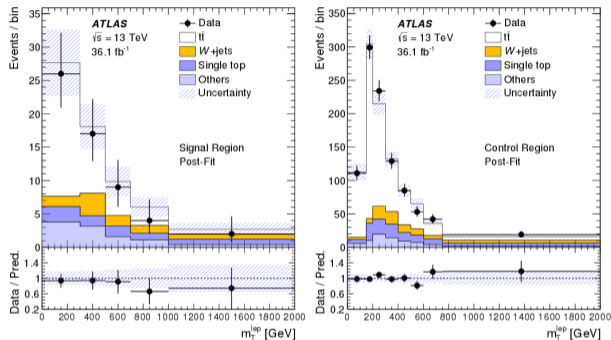
Event selection

- ▶ exactly 1 e/μ
- ▶ ≥ 3 jet, ≥ 1 b -tagged jet, ≥ 1 jet $p_T > 60$ GeV
- ▶ hadronic and leptonic VLQ reconstructed using lepton, large and small jets and E_T^{miss}
 - ▶ pairing of a W candidate with b -jet
 - ▶ choose minimum $|\Delta m| = |m_T^{\text{had}} - m_T^{\text{lep}}|$ (< 300 GeV in SR)
 - ▶ $S_T > 1800$ GeV scalar sum of E_T^{miss} , $p_T(\text{lep})$, $p_T(\text{smalljets})$
(CR: $1000 \text{ GeV} < S_T < 1800 \text{ GeV}$)

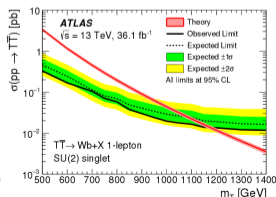
Pair produced VLQ to high- p_T W bosons and b quarks in lepton+jets

Results

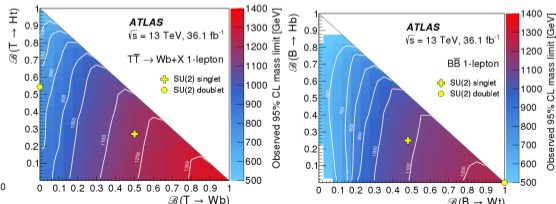
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Searches for BSM particles decaying to 3rd generation quarks



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Pair produced $T\bar{T}$ VLQ to $1l$, jets, E_T^{miss}

CERN-EP-2017-075

arXiv:1705.10751

- ▶ optimized for $T\bar{T}$ with $T \rightarrow Z(\rightarrow \nu\nu)t + X$

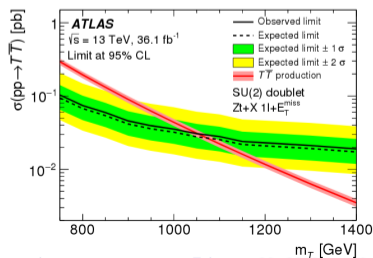
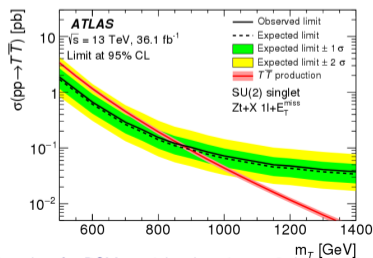
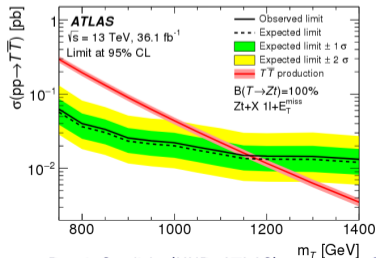
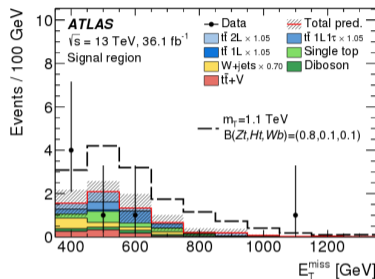
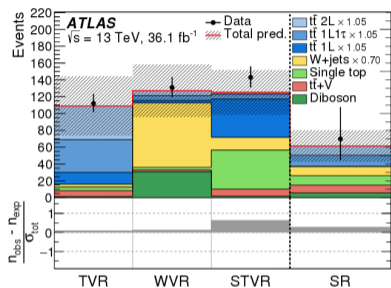
Event selection

- ▶ exactly 1 e/μ
- ▶ ≥ 4 jets, ≥ 1 b -jet
- ▶ $am_{T_2} > 175$ GeV (100 GeV in the CR): a transverse mass
 - ▶ combination of lepton and either one of the highest b -tag weighted jets
 - ▶ reduces dileptonic $t\bar{t}$ decays
- ▶ $m_{T_2}^\tau > 80$ GeV: a transverse mass, only applicable if a hadronic τ candidate is found
 - ▶ using the τ candidate as the signal lepton
 - ▶ reduces $t\bar{t}$ events with one e/μ and a hadronically decaying τ
- ▶ $H_{T,\text{sig}}^{\text{miss}} = \frac{H_T^{\text{miss}} - 100 \text{ GeV}}{\sigma_{H_T^{\text{miss}}}} > 12$ (no cut in CR), reduces effect of mis-reconstructed E_T^{miss}

Pair produced $T\bar{T}$ VLQ to $1l$, jets, E_T^{miss} – Results

CERN-EP-2017-075

arXiv:1705.10751



Conclusion

- ▶ New ATLAS results presented for searches for heavy vector bosons and vector-like quarks predominantly coupling to 3rd generation quarks
- ▶ no significant deviations from standard model observed
- ▶ mass and coupling limits pushed further thanks to increased center-of mass-energy and luminosity