Search for pair- and single-production of vector-like quarks in final states with at least one Z boson decaying into a pair of electrons or muons in pp collision data collected with the ATLAS detector at $\sqrt{s} = 13$ TeV

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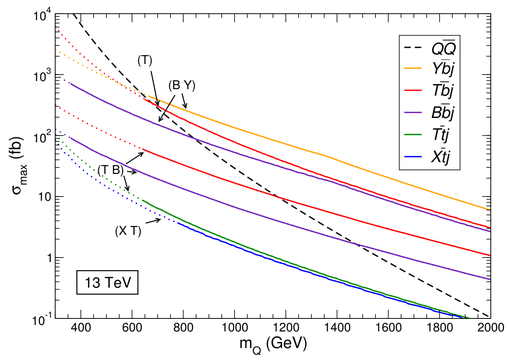
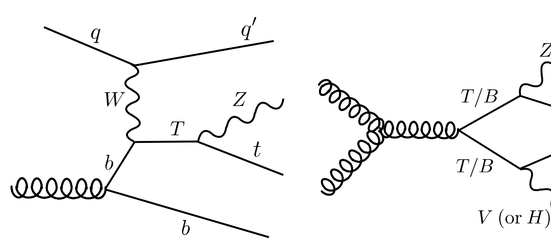
1. Motivation

- Vector-like quarks (VLQs) predicted by e.g. Composite Higgs models
  $\Rightarrow$ Solve hierarchy problem
- **Pair and single production** possible for vector-like top (T) and vector-like bottom (B) quarks
- **Same SU(2) transformation for LH and RH spinors: Allows Dirac mass term**
- Singlet, doublets, triplets ($\Rightarrow$ Different BRs)
- $q_T = \frac{2}{3}e$, $q_B = -\frac{1}{3}e$
- Assumed: **Mixing** with t, b quarks
- **Final states with $Z(\ell^+\ell^-)$**
- Assumption about decay: $W/Z/H + t/b$

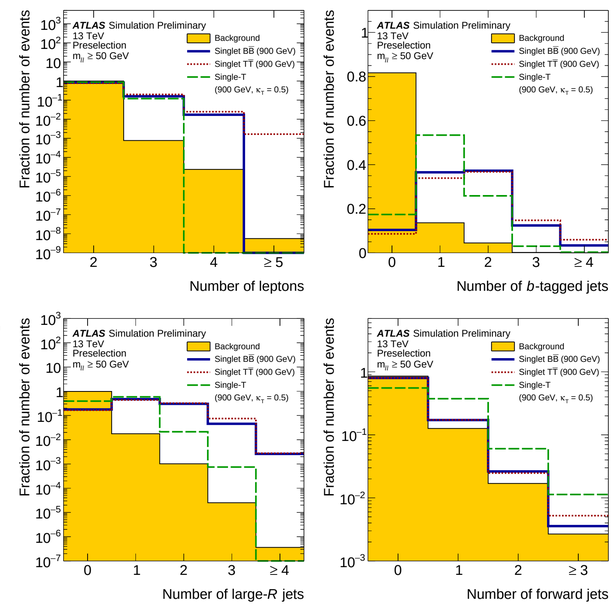


[1]



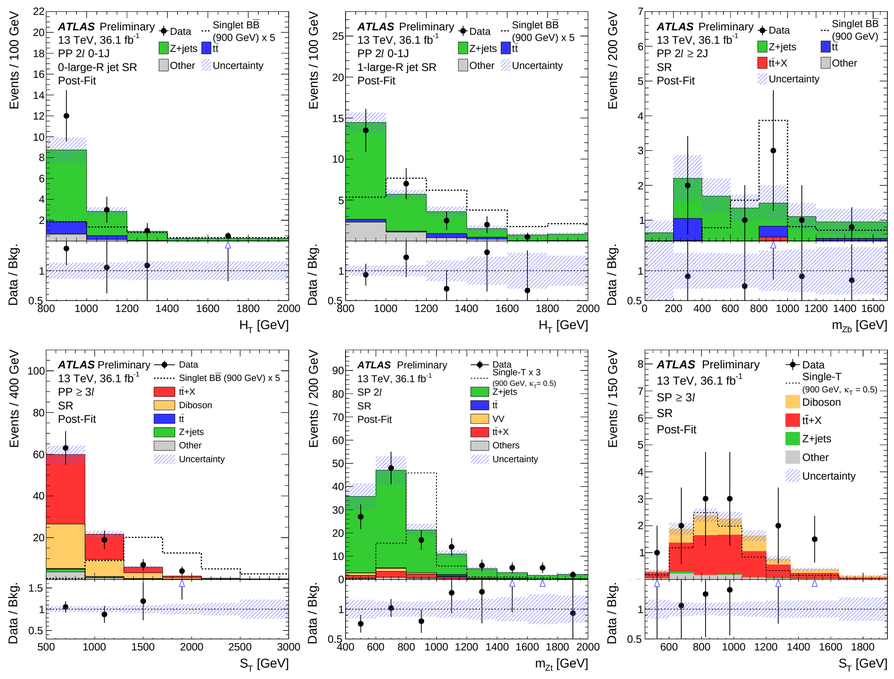
2. Analysis Strategy

- Common discriminating features:
  - # of leptons
  - # of jets/b-jets
  - High $p_{\mathrm{T}}(\ell\ell)$
  - Several high p_{T} objects
- **Pair production (PP)**:
  2ℓ with ≤ 1 large-R jet or ≥ 2 large-R jets, $\geq 3\ell$
- **Single production (SP)**: 2ℓ, $\geq 3\ell$
- Optimization of channels done individually
- Separate statistical combination for SP and PP analyses

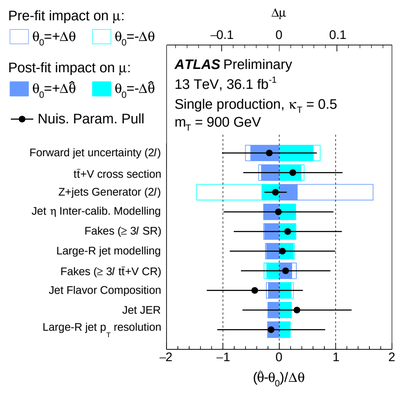


3. Data/MC Agreement

- **Main backgrounds**: Z+jets, $t\bar{t}$, $t\bar{t}+X$, VV depending on channel
- **Post-Fit distributions** for final discriminants in the signal regions for all channels:



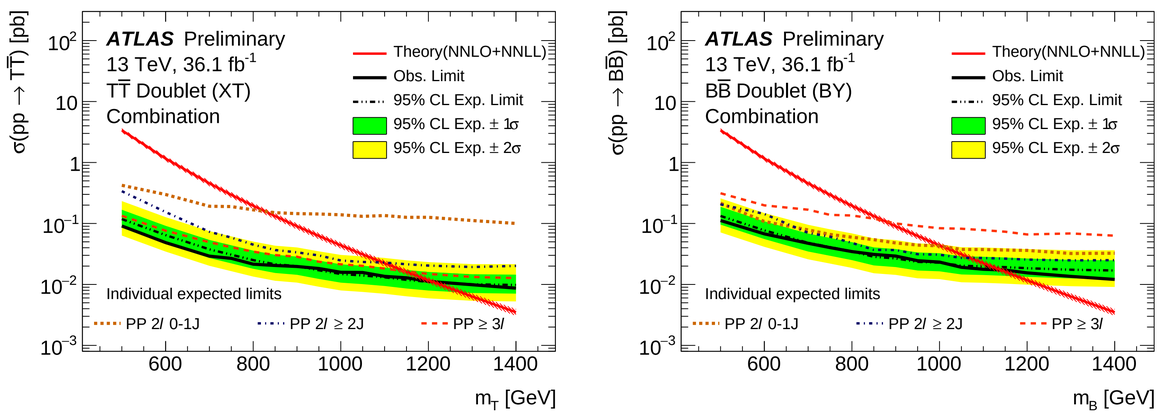
4. Statistical Analysis



- Binned profile likelihood fit with CL_s method
- No significant excess observed
- Derivation of upper 95% confidence level (CL) limits on $\sigma \times BR$ and couplings to SM quarks

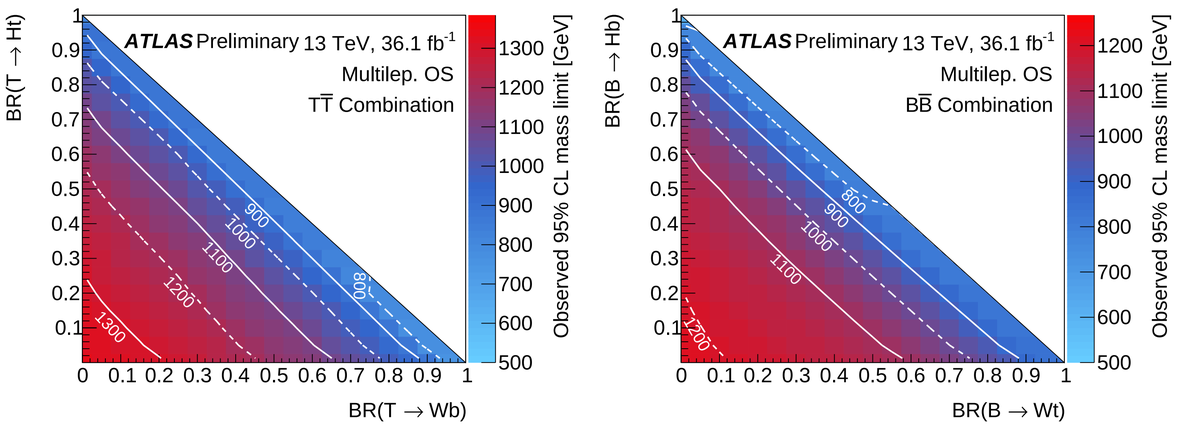
5. Pair Production Results for B and T

Expected and observed 95% CL cross-section limits as function of m_B and m_T for doublet model:



Model	2ℓ 0-1J exp.	$2\ell \geq$ 2J exp.	$\geq 3\ell$ exp.	Combination obs. (exp.)
$T\bar{T}$ doublet	820 GeV	1100 GeV	1150 GeV	1210 (1210) GeV
$B\bar{B}$ doublet	1000 GeV	1070 GeV	880 GeV	1140 (1120) GeV

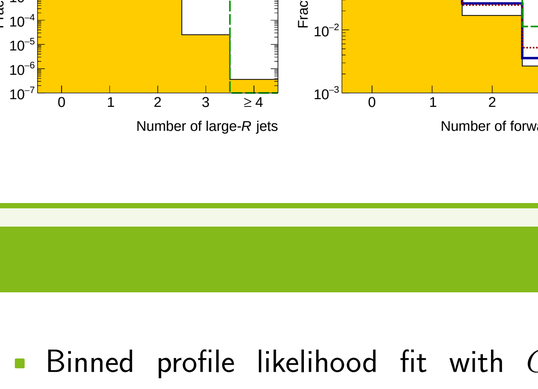
Branching ratio scan with highest sensitivity in $Q \to Zq$ corner



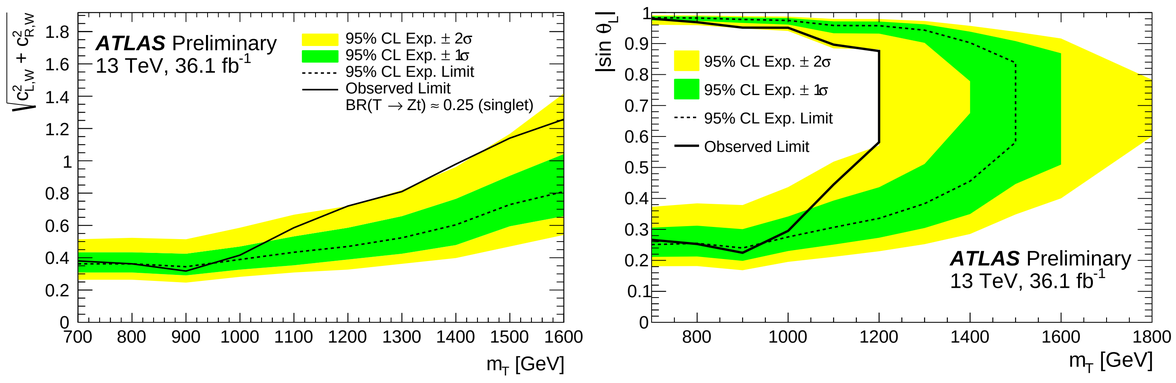
6. Single Production Results for T

Expected and observed limits on cross-section $\times$ BR as function of m_T for $\kappa_T = 0.5$ [2]:

Benchmark coupling $\kappa_T = 0.5$ corresponding to $c_W = \sqrt{c^2_{L,W} + c^2_{R,W}} = 0.45$ [3]



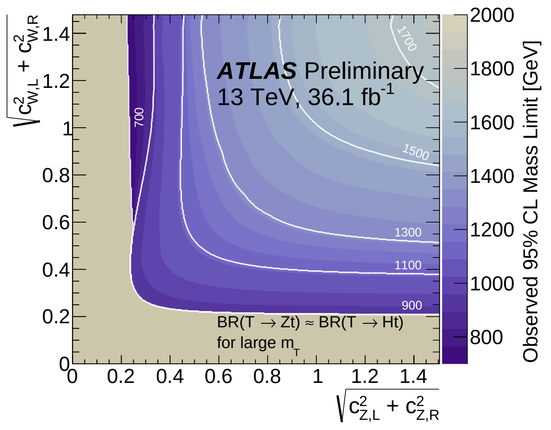
c_W and the mixing angle $|\sin(\Theta_L)|$ [1] between T and t for singlet model:



Generalized limits in coupling-mass space:

Assumption for high m_T limit:
$BR(T \to Zt) \approx BR(T \to Ht)$

Exclude T masses as function of the couplings to W, Z and H



7. Conclusions

- Search for vector-like T (in pair and single production) and B (in pair production)
- High number of high p_{T} objects $\Rightarrow$ large-R jets, top tagging
- Single and pair production channels combined
  $\Rightarrow$ Increased sensitivity

References

[1] J. A. Aguilar-Saavedra et al. *Handbook of vectorlike quarks: Mixing and single production.* *Phys. Rev.* D 88 (2013), p. 094010. arXiv: 1306.0572 [hep-ph]. [2] M. Buchkremer et al. *Model Independent Framework for Searches of Top Partners.* *Nucl. Phys.* B 876 (2013), p. 376. arXiv: 1305.4172 [hep-ph]. [3] O. Matsedonskyi, G. Panico, and A. Wulzer. *On the Interpretation of Top Partners Searches.* *JHEP* 12 (2014), p. 097. arXiv: 1409.0100 [hep-ph].