Search for flavor-changing neutral currents in top quark decays at ATLAS

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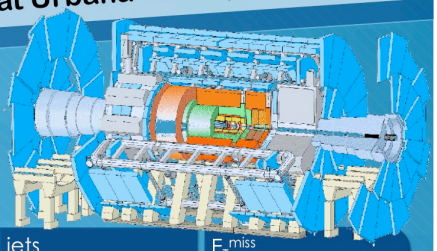
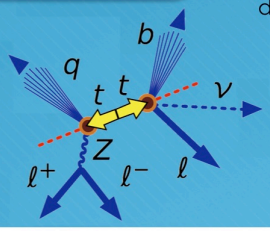
If anomalous top-quark couplings exist, this would affect production and/or decay processes at hadron colliders, such as the LHC. A rare top-quark decay is that which occurs via flavor-changing neutral current. These decays are highly suppressed in the SM, consequently observation of such a decay would be suggestive of new physics.



This search is done in $\sqrt{s}$=7 TeV pp-collisions data taken by ATLAS in 2011, with a total integrated luminosity of 0.70 fb^{-1}.

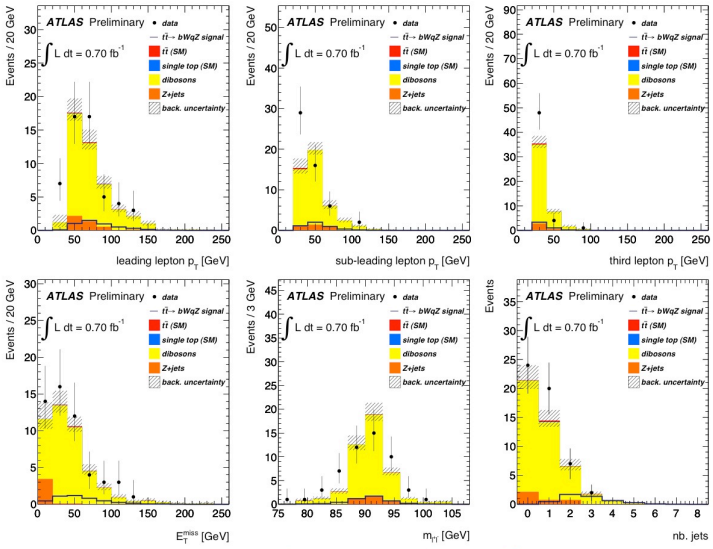
We look for t-tbar pairs with one top quark decaying through FCNC (t→qZ) and the other through the SM dominant mode (t→bW). Only the leptonic decays of the W and Z bosons are considered signal.



muons	electrons	jets	E_T^{miss}
Tracks segments from muon spectrometer matched to tracks from the inner detector, and refitted. p_T > 20 GeV, $\|\eta\|$ < 2.5	Isolated EM calorimeter cluster. p_T > 20 GeV, $\|\eta\|$ < 2.47	Anti-k$_t$ algorithm (R=0.4), corrected for pile-up effects p_T > 20 GeV, $\|\eta\|$ < 2.5	Vector sum of calorimeter cell energy depositions, corrected for identified objects

event pre-selection

3 leptons. Leading lepton: p_T > 25 GeV. One Z candidate (e^+e^-, $\mu^+\mu^-$).
$|m_Z - 91.2\ \text{GeV}| < 15\ \text{GeV}$



event reconstruction

We apply energy conservation to reconstruct the kinematics of the top quarks. The neutrino's momentum is found by minimizing:

$$\chi^2 = \frac{\left(m^{\text{reco}}_{j_a l_a l_b} - m_t\right)^2}{\sigma_t^2} + \frac{\left(m^{\text{reco}}_{j_b l_c \nu} - m_t\right)^2}{\sigma_t^2} + \frac{\left(m^{\text{reco}}_{l_c \nu} - m_W\right)^2}{\sigma_W^2} + \frac{\left(m^{\text{reco}}_{l_a l_b} - m_Z\right)^2}{\sigma_Z^2}$$

final selection

Two or more jets. Leading jet with p_T > 30 GeV.
$E_T^{miss} \geq 20$ GeV. $|m_W - 80.4\ \text{GeV}| < 30$ GeV.
$|m_{top} - 172.5\ \text{GeV}| < 40$ GeV.

background evaluation

main background source: ZZ, WZ
3 charged leptons in the final state
Simulated With MC

other : WW, Z+jets, t-tbar, W+jets, QCD
At least one jet is reconstructed as a lepton (fake)
Data-driven (DD) method

DD fake lepton(s)

1 fake lepton: estimated by loosening cuts in one lepton, and comparing to the reference analysis.
2 or 3 fake leptons: yields extrapolated from number of observed events with three leptons with the same charge.

pre-selection: Z + jets

DD method, using a single control region:
$E_T^{miss} < 20$ GeV and $|91.2\ \text{GeV} - m_{ll}^{reco}| < 15$ GeV

$$\left[N^{\text{data}}_{Z+\text{jets}}\right]_{\text{signal region}} = \left[\frac{N^{\text{data}} - N^{\text{MC}}_{\text{other bkg}}}{N^{\text{MC}}_{Z+\text{jets}}}\right]_{\text{control region}} \times \left[N^{\text{MC}}_{Z+\text{jets}}\right]_{\text{signal region}}$$

ZZ and WZ	2.4 ± 0.3
1+2+3 fake leptons (DD)	$0.0^{+1.8}_{-0.0}$
Expected background	$2.4^{+1.8}_{-0.3}$
Data	2
Signal efficiency	$(0.209 \pm 0.004)\%$

limit evaluation

Good agreement between data and background yields was observed.
No evidence for the t→qZ decay was found.
95% CL upper limits on the number of signal events were derived using the CL(s) method.

The limits are evaluated using pseudo experiments of the expected signal and background samples, and converted into upper limits using the approximate NNLO calculation for the t-tbar cross section.

	observed	(-1σ)	expected	$(+1\sigma)$
without systematics	1.06 %	0.78 %	1.22 %	1.94 %
with systematics	1.13 %	0.83 %	1.30 %	2.09 %

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conclusions

An **observed** limit at 95% CL on the t→qZ FCNC top quark decay branching fraction was set to

$$\text{BR}(t \to qZ) < 1.1\%$$

assuming BR(t→bW) + BR(t→qZ) = 1
The observed limit is 0.3σ below the expected limit of 1.3%.

Other experiments at the LEP, HERA and Tevatron accelerators have set experimental limits on the branching fraction of this FCNC top quark decay:

	LEP	HERA	Tevatron	ATLAS@LHC
$\text{BR}(t \to qZ)$	7.8 %	49 % (tuZ)	3.2 %	**1.1 %**

The limit presented here is the best direct measurement available.