



# Search for new physics involving top quarks at ATLAS.

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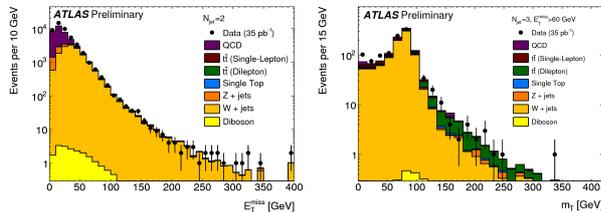


## Introduction

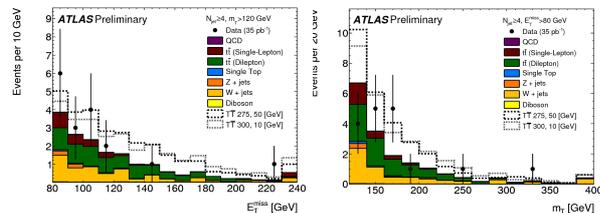
The top quark, discovered at the Fermilab Tevatron collider in 1995, is the heaviest elementary particle observed to date. Its unique large mass of about 173 GeV makes it an excellent probe for new physics beyond the Standard Model (SM). With 35 pb<sup>-1</sup> pp collisions at a center-of-mass energy of  $\sqrt{s} = 7$  TeV collected by the ATLAS detector during 2010, searches for, anomalous  $E_T^{\text{miss}}$  in  $t\bar{t}$  events[1] and  $t\bar{t}$  resonances[2] were performed. The former was recently updated[3] with 200 pb<sup>-1</sup> data collected this year. Some of results from the analyses are presented.

## Search for anomalous $E_T^{\text{miss}}$ in $t\bar{t}$ events (35 pb<sup>-1</sup>)

The search for a pair-produced exotic top partner  $T$ , decaying to a top quark and a stable neutral scalar  $A_0$ , was performed in the lepton+jets final state, which contains a single lepton (electron or muon), four or more jets and  $E_T^{\text{miss}}$  (missing transverse energy). The final state is identical to  $t\bar{t}$ , but with large  $E_T^{\text{miss}}$ . The cuts,  $E_T^{\text{miss}} > 80$  GeV and transverse mass  $m_T > 120$  GeV, were optimized and applied together with a dilepton veto to maximize the ability to exclude the new physics model.



$E_T^{\text{miss}}$  and  $m_T$  distributions in data and stacked simulation in two control samples, 2-jet and 3-jet events. The QCD background shape was taken from data and was known to be poorly modeled at small  $E_T^{\text{miss}}$  and  $m_T$ .



$E_T^{\text{miss}}$  and  $m_T$  distributions in the signal region. The dotted lines show the expected distributions for two of the excluded signal mass points stacked on the backgrounds.

### Systematic uncertainties

Source	Relative Error
Dilepton $t\bar{t}$ , Single Top, Dibosons, Z+jets	
Cross Section	15%
Dilepton Veto	15%
Jet Energy Scale & Resolution	11%
Luminosity	3.4%
Lepton ID	3%
Monte Carlo Statistics	1%
<b>Total</b>	<b>25% (2.1 events)</b>
Single Lepton Backgrounds	
Spread in $S(m_T)$	15%
Normalization	10%
$b$ -Tag Veto	3%
QCD Shape	1%
<b>Total</b>	<b>18% (1.6 events)</b>
QCD	
Normalization in Control Regions	100%
Muon Statistics	0.6 events
<b>Total</b>	<b>0.6 events</b>

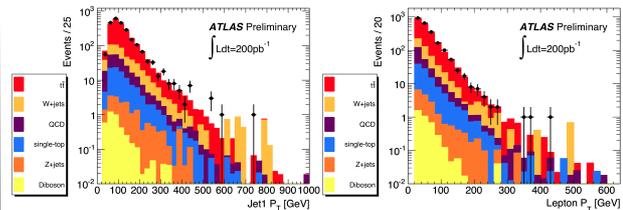
After the final selection, 17 events were observed from the combined electron and muon channels, while 17.2 background events were expected. No excess was observed. Through the study of event yield distribution from pseudo-experiments for signal and background-only hypotheses, with signal and background systematic uncertainties included (as listed in the table above), the model of pair-produced quark-like objects decaying to a top quark and a heavy neutral particle was excluded at 95% confidence level (CL) for the mass points:

$$m(T) = 300 \text{ GeV with } m(A_0) < 10 \text{ GeV}$$

$$m(T) = 275 \text{ GeV with } m(A_0) < 50 \text{ GeV}$$

## Search for $t\bar{t}$ resonances in lepton+jets (200 pb<sup>-1</sup>)

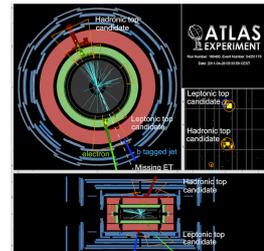
The search for resonances in the reconstructed  $t\bar{t}$  mass spectrum was performed in the lepton+jets final state, which consists of a single lepton (electron or muon), four jets and a neutrino. In the construction of  $t\bar{t}$  mass, the neutrino's longitudinal momentum ( $p_z$ ) was determined by imposing the  $W$ -boson mass constraint. To reduce the effects of initial- and final-state radiation of the jets directly related to a top quark decay product, which resulted in the long non-Gaussian tails in the mass resolution, the  $dR_{\text{min}}$  algorithm was employed, which excluded a jet if its angular distance to the lepton or closest jets satisfying  $\Delta R_{\text{min}} > 2.5 - 0.015 \times M$ . The  $m_{\bar{t}t}$  was then constructed from the lepton, the neutrino and the leading four jets, or three jets if only three remained.



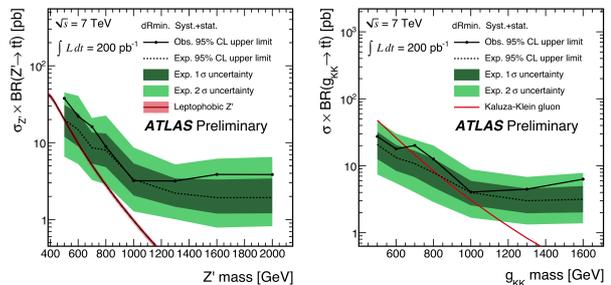
Leading jet (left) and charged lepton (right)  $p_T$  distributions after all cuts (electron and muon channels combined, statistical uncertainties only).

### Systematic uncertainties

Source	Uncertainties
Background Normalization	
$t\bar{t}$	+7.0/-9.6%
Single Top	10%
W+jets	35%
Diboson	5%
QCD(e)	30%
QCD( $\mu$ )	50%
$b$ -Tagging	11% (in the event yields)
Jet Energy Scale	9%
Lepton Trigger & Reconstruction	$\leq 1.5\%$
ISR/FSR	7%
Integrated Luminosity	4.5%



A high-mass event  $m_T = 1602$  GeV



Expected (dashed line) and observed (black points) upper limits on  $\sigma \times BR(Z' \rightarrow t\bar{t})$  (left) and  $\sigma \times BR(g_{KK} \rightarrow t\bar{t})$  (right). The dark and light green bands show the range in which the limit is expected to lie in 68% and 95% of experiments, respectively, and the red lines correspond to the predicted signal cross sections.

In the search for top quark pair resonances in the lepton+jets final state, no evidence for a resonance was found. Using the reconstructed  $t\bar{t}$  mass spectrum, limits were set on the production cross section times branching ratio to  $t\bar{t}$  for narrow  $Z'$  models. The observed limits at 95% CL range from 38 pb at  $m_{Z'} = 500$  GeV to 3.2 pb at  $m_{Z'} = 1300$  GeV. In Randall-Sundrum models, Kaluza-Klein gluons with masses below 650 GeV were excluded at 95% CL.

## References

- "Search for Anomalous Missing  $E_T$  in  $t\bar{t}$  Events", ATL-CONF-2011-036
- "A Search for New High-Mass Phenomena Producing Top Quarks with the ATLAS Experiment", ATL-CONF-2011-070
- "A Search for  $t\bar{t}$  Resonance in the Lepton Plus Jets Channel using 200 pb<sup>-1</sup> of pp Collisions at  $\sqrt{s} = 7$  TeV", ATL-CONF-2011-091