A search for tt bar resonances in 2011 ATLAS data at $sqrts = 7$ TeV

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A search for $t\bar{t}$ resonances in 2011 ATLAS data at $\sqrt{s} = 7$ TeV [1]

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1 $t\bar{t}$ resonance motivation

Due to its large mass, top quark has specific properties. It strongly interacts with Higgs sector and may play a specific role in electroweak symmetry breaking. Some new phenomena connected to electroweak symmetry breaking should couple preferentially with top quark. Top sector is then a laboratory to search for new physics. This study searches for narrow and wide $t\bar{t}$ resonances through two models:

- Coloured gluon from Randall Sundrum model g_{KK}, predicting wide $t\bar{t}$ resonance
- Colourless Z' boson from Topcolor model, predicting narrow $t\bar{t}$ resonance

2 Selection of the $t\bar{t}$ events

The study is done on $t\bar{t}$ events decaying into one lepton plus jets, this channel being the best compromise between a clear signature and a reduced background for first data analyses. The dataset used for this study is about 200 pb^{-1}, with a systematic uncertainty of 9 pb^{-1}, recorded in 2011.

The object reconstruction is based on top pair signature requiring transverse momenta to be greater than 20 GeV for muon and jet candidates (25 GeV for electron candidates). A b-tagging algorithm is used. It has a working point corresponding to a tagging efficiency of 50 % of the jets coming from b quarks. The missing transverse energy, E_T^{Miss}, is then reconstructed as the vector sum of calorimeter cells associated to each object, with a dedicated correction factor. The first step to search for New Physics signal is to enhance the event sample in $t\bar{t}$ events, basing the event selection on semileptonic signature. We ask for single lepton trigger and exactly one isolated lepton reconstructed in the event. This one must match the triggered lepton. Cuts on timing and object tranverse momenta are applied to reduce pileup and instrumental backgrounds. More than 4 jets must have been reconstructed and additionnal cuts on E_T^{Miss} and leptonic W transverse momentum are applied to reduce QCD physical backgrounds.

The control of the physical backgrounds is an important point of searching for New Physics signal. The QCD background is estimated from data, its shape and integral being under high uncertainties in simulation. Using a multi jet data sample, we require exactly one jet with high electromagnetic fraction, faking the lepton candidate to model QCD distributions from data. The QCD normalisation is estimated from a discriminant parameter between QCD and all other samples, here E_T^{Miss}. The samples are fitted to data and the QCD fraction is then estimated for both channels. Figure 1 shows the distributions of charged lepton and leading jet transverse momentum. It illustrates the comparison done on different kinematical distributions.

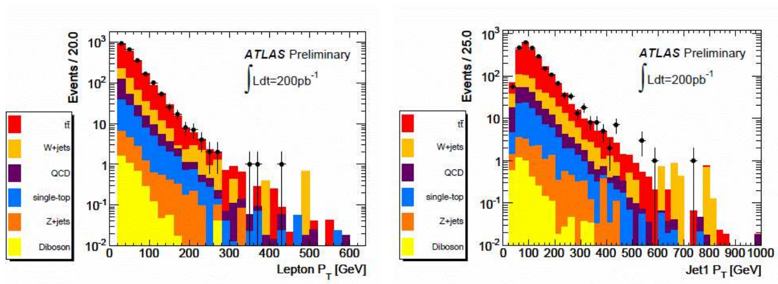

Figure 1: Tranverse momentum distributions for charged lepton (left) and leading jet (right) after event selection.

3 Reconstruction of the $t\bar{t}$ events

The dominant source of non-gaussian tails in $t\bar{t}$ mass resolution spectrum is the misuse of ISR jets to recontruct the top pair. To reduce this, a ΔR_{min} algorithm is used. It is an exclusion procedure which considers the four leading jets with $p_T > 20$ GeV and excludes a jet if its angular distance to the closest jet or lepton satisfies the criteria:

$$\Delta R_{min} > 2.5 - 0.015 \times m_j$$

where m_j is the jet mass. This exclusion procedure is stopped if only three jets remain in the sample.

	Systematic uncertainties
Luminosity	4.5 %
SM $t\bar{t}$ norm.	(+7.0 -9.6) %
Single top norm.	10 %
W+jets norm.	35 %
Dibosons norm.	5 %
QCD norm.	e: 30 % μ: 50 %
Lepton trigger and reco. eff.	$<$ 1.5 %

Table 1: Dominant systematic uncertainties.

The reconstruction of the top pair is then done using the lepton, jets and reconstructed neutrino. The reconstruction takes at least three jets, this allows for one jet to be out of acceptance or merged with another jet. Figure 2 shows the reconstructed $t\bar{t}$ mass in data and simulation, electron and muon channels being added. All events out of the histogram range have been added to the last bin. Excesses were checked with `BumpHunter` tool [2] but no significant excess was found between data and simulation. This result allows to set limits on Z' and g_{KK} masses.

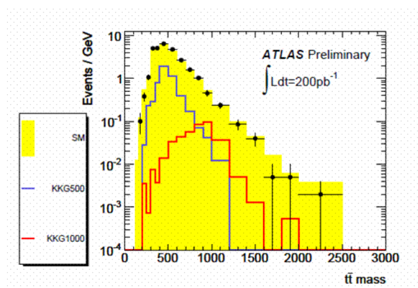

Figure 2: Reconstructed $t\bar{t}$ mass in logarithmic scale using ΔR_{min}algorithm. Electron and muon channels are added.

4 Limit setting on $t\bar{t}$ resonances

Table 1 presents the dominant systematic uncertainties of this analysis. The dominant shape uncertainties arise from b-tagging efficiency (11 %), jet energy scale (9 %) and modeling of ISR/FSR (7 %). Other uncertainties on simulation modeling exist but have a substantially smaller impact.

The $t\bar{t}$ resonance mass limit is set using Bayesian limit setting [3]. Figure 3 shows the evolution of the $t\bar{t}$ resonance cross-section times its branching ratio as a function of its mass hypothesis. For narrow $t\bar{t}$ resonances, such as Z' boson in Topcolor model, observation on 200 pb^{-1} can't exclude mass range but is already able to probe cross-sections in the few picobarn rage close to 1 TeV. For large $t\bar{t}$ resonances, such as g_{KK} from Randall-Sundrum model, the observation excludes masses lower than 650 GeV at 95 % Confidence Level.

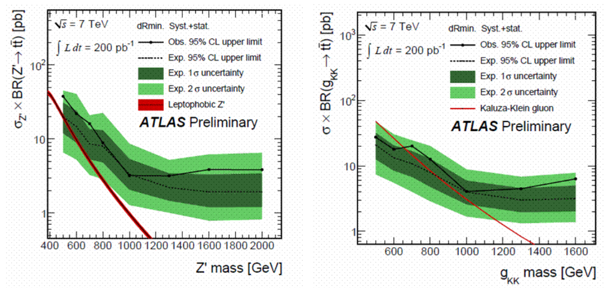

Figure 3: $t\bar{t}$ resonance cross-section times its branching ratio as a function of its mass hypothesis, for Z' bosons on the left and g_{KK} on the right.

5 Conclusion

This analysis has been optimized to search for $t\bar{t}$ resonances in the lepton+jets final state for two models, Z' boson from Topcolor model (narrow resonance) and g_{KK} from Randall-Sundrum model (large resonance). Using 200 pb^{-1} of data, no evidence for a resonance was found but limits are set on cross-sections times branching ratio for Z' resonances and g_{KK} with masses lower than 650 GeV are excluded.

References

[1] ATLAS Collaboration, ATLAS-CONF-2011-087, *A search for $t\bar{t}$ resonances in the lepton plus jets channel in 200 pb^{-1} of pp collisions at $\sqrt{s}$ = 7 TeV.*

[2] G. Choudalakis, `arXiv:1101.0390 [physics.data-an]`, *One hypothesis testing, trials factor, hypertests and the BumpHunter.*

[3] D0 Collaboration, FERMILAB-TM-2104, *A Recipe for the construction of confidence limits.*