LHCC Poster Session – CERN, 22 February 2017

Prospects of a search for $t\bar{t}$ resonances at the High Luminosity LHC with an upgraded ATLAS Detector

A study of the expected mass reach of a search for new high-mass resonances decaying to a top quark pair using a simulation of the upgraded ATLAS experiment and using an integrated luminosity of 3000 fb^{-1} from the High Luminosity LHC has been made. The simulation of the upgraded ATLAS experiment under HL-LHC conditions, including pileup, was done using parameterised estimates of the performance. Expected upper limits are set on the cross section of a $t\bar{t}$ resonance in a benchmark model for several signal masses and show that particles with masses up to 4 TeV can be seen.

Motivation

- Many BSM theories predict new particles with masses in the TeV scale that decay to $t\bar{t}$.
- Topcolour models, Randall–Sundrum extra dimensional models, two-Higgs-doublet models.
- Benchmark analysis for evaluating physics prospects at the HL-LHC.
- This study estimates the impact of the increased statistics, collision energy and upgraded detector on the sensitivity of the search.

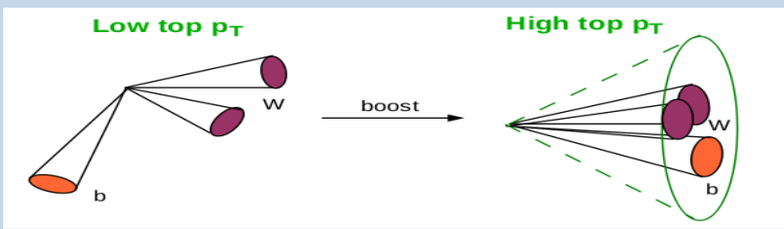
Analysis Strategy

Overview

- Searching for a localised excess or deficit in the $t\bar{t}$ mass spectrum compared with Standard Model prediction.
- Performed on $t\bar{t}$ events selected from Monte Carlo simulations of p-p collisions with $\sqrt{s}$ = 14 TeV, over a total luminosity of 3000 fb^{-1} .
- Semi-leptonic decay channel ($t\bar{t} \rightarrow WbWb \rightarrow qq'blvb$).
- Search method is model independent, but a Z' boson in a Topcolour model is used for limit setting.
- Standard Model backgrounds included were $t\bar{t}$, W+jets, Z +jets and single top.
- Expected $t\bar{t}$ mass spectrum prepared under the signal-plus-background and under the background-only hypotheses.
- Expected upper cross section section limits set for several signal masses.

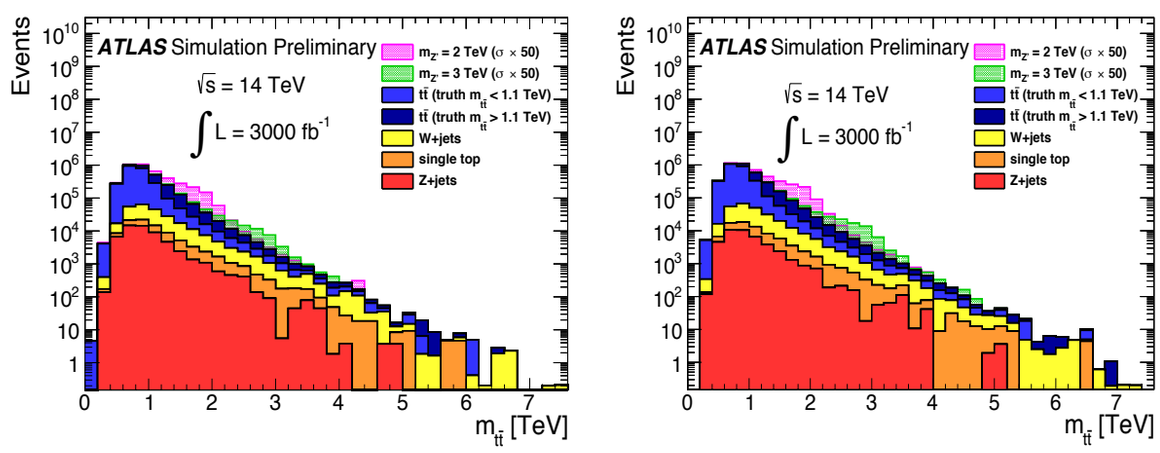
Event selection and mass reconstruction

- Require events with a high p_T lepton, large $E_{T,miss}$, and either one large-R jet or multiple small-R jets.
- $t\bar{t}$ pairs produced with a large range of pT ⇒ two channels based on decay topology to optimise reconstruction.



resolved channel boosted channel

- Different mass reconstruction methods for boosted and resolved events.
- Two channels depending on whether the single lepton is an electron or a muon.
- Four orthogonal channels recombined for limit setting.



$t\bar{t}$ invariant mass spectrum in the boosted electron and boosted muon channels. Most signal events are boosted, so this channel dominates the limit setting. Signal samples at $m_{Z'}$ = 2 TeV and m_Z = 3 TeV are shown.

Detector Effects

Results of studies on the performance of the upgraded phase-II ATLAS detector assuming instantaneous luminosities of up to 7.5×10^{34} $cm^{-2}s^{-1}$ were used to derive functions that provide parameterised estimates of detector performance for different objects [1]. The functions are p_T and η dependent, and are applied to truth quantities to emulate energy resolution, efficiencies and fake rates.

Leptons: Identification efficiencies, energy smearing and fake rates for jets faking electrons.

Small-R jets: Flavour tagging efficiencies and fake rates, track confirmation efficiencies and energy smearing.

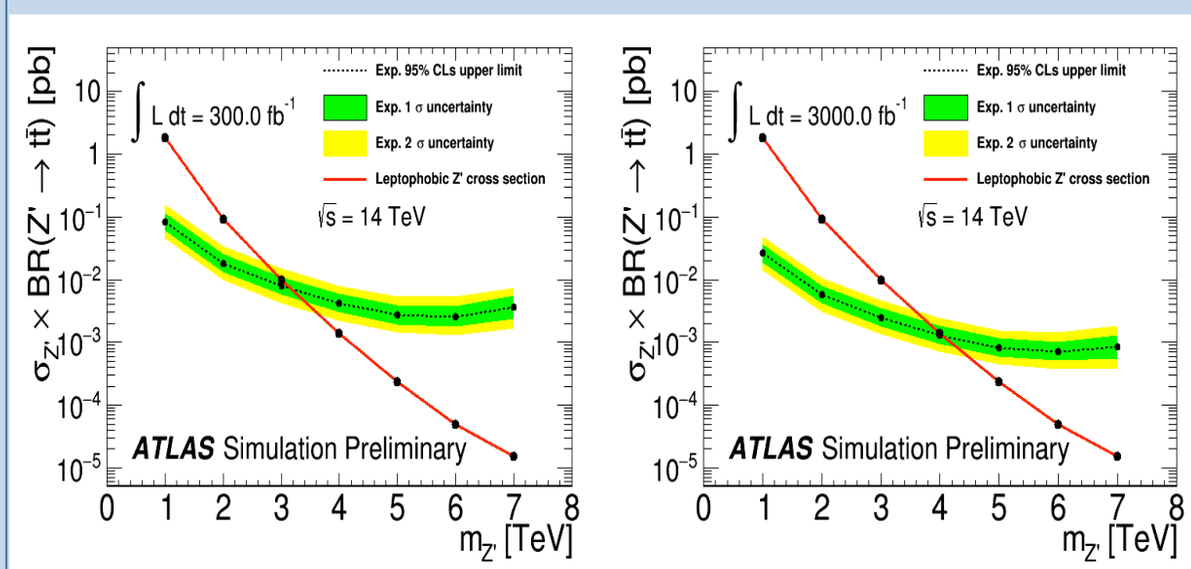
Large-R jets: Energy smearing (not based on upgrade study).

$E_{T,miss}$: Missing p_x and p_y smeared before $E_{T,miss}$ is calculated.

Pileup jets: Small-R jets are included from a pileup library built assuming an average of 200 proton-proton interactions per bunch crossing.

Results

- A statistical analysis [2] determines the expected upper limits that can be set on the signal cross section in the absence of signal.



- Expected limits are compared to the theoretical signal cross section for several signal masses to estimate the mass reach of the search.

We can expect to exclude this resonance for:

- ➢ $m_{Z'}$ < 3 TeV after Run 3
- ➢ $m_{Z'}$ < 4 TeV after the HL-LHC

The strongest mass limit on this resonance currently set by ATLAS is **2.1 TeV**, with 20.3 fb^{-1} [3].

References: [1] CERN-LHCC-2015-020 (2015), [2] CERN-OPEN-2012-016, [3] arXiv: 1505.07018 [hep-ex] (submitted to JHEP)

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ATLAS EXPERIMENT