Searches for heavy resonances decaying to top quarks with the ATLAS detector at LHC

Farida Fassi, Badr-eddine Ngair

Mohammed V University in Rabat, Faculty of science, Morocco

Abstract:

A search for new resonances that decay into top-quark pairs is performed using data collected from proton–proton collisions at a centre-of-mass energy of 13 TeV by the ATLAS detector at the Large Hadron Collider. Events consistent with top-quark pair production are selected by requiring a single isolated charged lepton, missing transverse momentum and jet activity compatible with a hadronic top-quark decay. The invariant mass spectrum of hypothetical resonances is examined for local excesses or deficits that are inconsistent with the Standard Model prediction. No significant deviation from the prediction is found so far.

Introduction

The top quark is a constituent of matter with unique characteristics. Its mass is the largest one amongst the fundamental fermions and it is intriguingly close to the scale of the electroweak symmetry breaking (EWSB). As such. it plays a special role in many Beyond the Stander Model (BSM) theories of EWSB. In models with top condensation such as Technicolor and Topcolor the role of the SM Higgs bosons is filled by a composite particle that is a $t\bar{t}$ bound state [1]. These models predict additional heavy gauge bosons, which couple strongly to top quarks, e.g. color-singlet Z´ [2], color octets, such as colorons [3] or axigluons [4]. Further models are two Higgs doublet and Minimal Supersymmetric models, where pseudoscalar (A) and scalar (H) Higgs bosons [5] may couple strongly to top quarks. The weakness of gravity compared to other forces (hierarchy problem) has been addressed in the context of extra dimesnsion, such as the Rundall-Sundrum [6] and ADD models [7]. In many of these models gauge interactions exist whose couplings with the third generation quarks and in particular the top quark is enhanced.

This letter presents, in a way that is model-independents as possible, the experimental sensitivity in ATLAS to new resonances in the $t\bar{t}$ invariant mass distribution. The search uses the data collected from 2015 to 2018 by the ATLAS experiment in $\sqrt{s} = 13$ TeV pp collisions at LHC, which corresponds to an integrated luminosity of 139.9 fb^{-1} .

Search for $t\bar{t}$ resonances in the lepton plus jets final state

The search for new particles in the $t\bar{t}$ production is performed in the lepton+jets topology, using a single muon or electron (indicated with *l*) as a trigger. The signature is a deviation from the $t\bar{t}$ invariant mass spectrum predicted by the SM. The selection requires a single isolated *l* with $p_T > 25$ GeV, large missing transverse momentum (E_T^{misss}), and hadronic jets. At least one of the jets must be identified as a b-jet. The b-tagged track-jets are used to categorise the accepted events into several channels. Based on the hadronic activity, the event is classified as *Boosted* or *Resolved*. The reconstruction of the event is based on three types of jets, all using the anti-kt algorithm: The Small-R jets with $p_T > 25$ GeV and $|\eta| < 2.5$. The Large-R jets, with $p_T > 300$ GeV and $|\eta| < 2.0$, are reconstructed with R = 1, but also have a "trimming" process, to discard low-energy sub-jet components, which are due to event pile-up. The track-jets are reconstructed from charged tracks, with R = 0.2, $p_T > 10$ GeV and $|\eta| < 2.5$. A lepton p_T-dependent isolation cut is also used. An event passes the *Boosted* selection if meets the following criteria: A Small-R jet (*Jsel*), with no specific b-tagging is required to be near to the lepton, at $\Delta R(\text{jet-l}) < 1.5$. The Large-R jet is required to be at a large azimuthal angle from both the lepton ($\Delta\varphi_1 > 2.3$ rad) and from *Jsel* ($\Delta\varphi_2 > 1.5$ rad). Events that fail any of these *Boosted* selection requirements are classified as passing the *Resolved* selection if there are at least 4 Small-R jets with $p_T > 25$ GeV and if the χ^2 algorithm for reconstructing $t\bar{t}$ system yields a value of $\log_{10}(\chi^2) < 0.9$. Cuts on E_T^{miss} are also required: $E_T^{misss} > 20$GeV and $E_T^{misss} + m_T^W > 60$GeV. The resulting $t\bar{t}$ distributions for Z´ signal masses are shown in Figure-1.

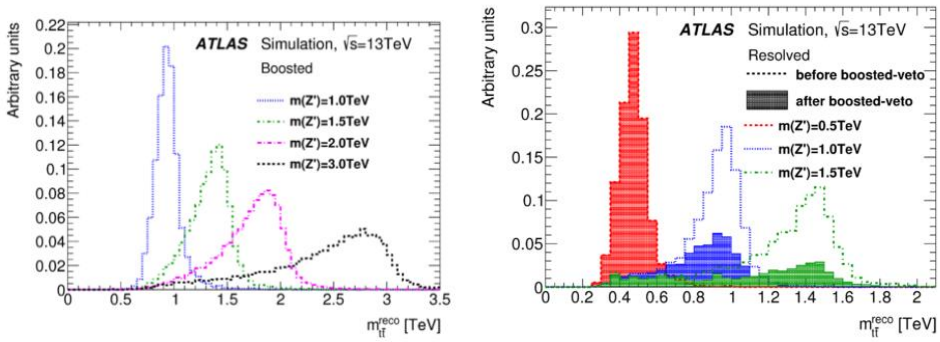

Fig-1: Reconstructed invariant masses for the resolved (left) and boosted (right) selections.

References

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