

Search for new physics with top quarks at the ATLAS experiment

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Summary. — With the proton-proton collision data collected during 2015 and 2016 at the centre-of-mass energy of 13 TeV, the ATLAS experiment is exceeding the sensitivity reached with the analysis of the 7 and 8 TeV data during LHC Run 1 for many New Physics scenarios involving top quarks and their heavy partners. In this contribution, some of the latest ATLAS results in searching for top-pair resonances, top and bottom vector-like quarks and four-top-quark events are shortly reviewed.

1. – Introduction

The top quark, given its high mass with respect to the other quarks and leptons in the Standard Model (SM), is expected to play a special role in searching for physics Beyond the Standard Model (BSM). In particular, new heavy particles predicted by different models couple preferentially to top quarks.

This is the case of the so called “vector-like quarks” (VLQ), which provide the simplest coloured fermions still allowed by experimental data [1]. Predicted to appear at the TeV-scale by many classes of models, due to the large top-quark Yukawa coupling y_t and their consequent sizable mixing with the 3rd generation of quarks, their decay into final states including top quarks is favoured.

Another class of hypothetical new heavy particles decaying to top quarks comes from the extension of the Higgs sector with additional Higgs bosons, for instance within the so-called two-Higgs-doublet models (2HDM) [2], which predict two additional heavy neutral states, H and A . Given the outcome of the recent LHC Higgs boson property measurements and of $H/A \rightarrow \tau\tau$ searches, the only realistically accessible decay channel is $H/A \rightarrow t\bar{t}$, strongly motivating searches for high-mass $t\bar{t}$ resonances at the LHC. Moreover, strong interference effects between $H/A \rightarrow t\bar{t}$ signal and SM $t\bar{t}$ background [3] motivate dedicated searches for associated production $b\bar{b}H/A$ and $t\bar{t}H/A$, processes which would give rise to rarer $b\bar{b}t\bar{t}$ and $t\bar{t}t\bar{t}$ final states and, therefore, a smaller effect from interference, $t\bar{t}t\bar{t}$ in particular.

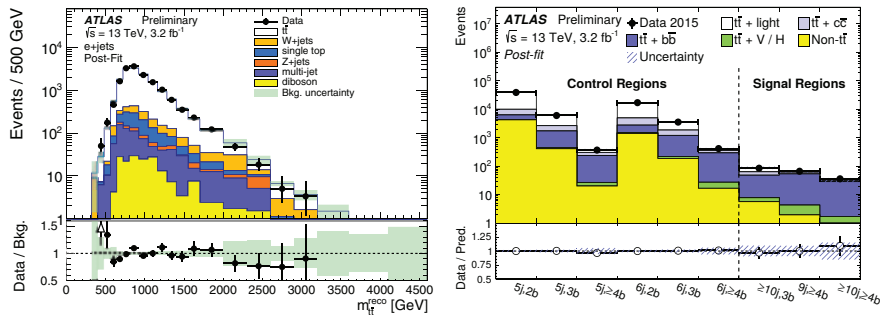


Fig. 1. – Comparison of data and prediction (left) in each bin of the $m_{t\bar{t}}$ distribution for one of the channels analysed in [4] and (right) in each of the event categories analysed in [6].

2. – Experimental results

The ATLAS experiment is putting significant efforts in searching for signs of new physics in final states with top quarks. The Run 2 searches in this sense take advantage of the many precise measurements performed during LHC Run 1 in the context of top-quark physics, both in terms of the understanding of the SM processes involving top quarks and of new and improved techniques for identifying jets originated from b quarks (b -tagging) and from hadronically decaying top quarks produced at high transverse momenta (boosted-top-tagging).

The analysis reported in [4] is based on the reconstruction of the $m_{t\bar{t}}$ spectrum in the ℓ +jets channel, to look for localised deviations from the SM prediction. Events are selected and reconstructed with boosted-top-tagging techniques.

Different analysis strategies are carried on in other searches which target a large variety of signals producing final states with smaller SM background. This is the case of [5], where events with a pair of same-sign-charged leptons in association with b -tagged jets are selected and splitted in several categories to maximise the sensitivity to BSM signals (including $t\bar{t}t\bar{t}$ and VLQ production) and the separation from the SM background, mainly from $t\bar{t} + W/Z$ production and events with non-prompt or mis-identified leptons.

Similar strategies are used in the analyses reported in [6] and [7], where events with a low number of charged leptons (one or zero) but high jet and b -tagged jet multiplicities are selected, and the presence of boosted-top-quark and Higgs-boson candidates, large effective mass and/or missing transverse energy is exploited. Events are classified in several categories including categories with a large contribution from the background (dominated by $t\bar{t}b\bar{b}$ production) which are used to calibrate *in situ* systematic uncertainties on its prediction.

Figure 1 shows the comparisons of data and the prediction for two of the reported analyses. None of these searches observed significant excess over the SM expectations, and each of them extended significantly the Run 1 exclusion limits on different BSM models.

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