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Search for $t\bar{t}$ resonances in semileptonic final states at $\sqrt{s} = 8\,\text{TeV}$ with the CMS detector

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Summary. — We present a search for heavy resonances decaying to a top quark-antiquark pair with the Compact Muon Solenoid (CMS) detector in pp collisions at $\sqrt{s} = 8\,\text{TeV}$. The analysis is performed in the semileptonic channel and corresponds to the combination of two dedicated searches, one designed for the reconstruction of top decays with well-separated decay products, the other optimized to probe the production of two high-p_T top quarks, whose decay can potentially lead to the presence of merged jets and non-isolated leptons at the reconstruction level. No excess is observed in data with respect to the background expectation and 95% CL limits are set on the production cross section of resonances in the mass range from $500\,\text{GeV}/c^2$ to $3\,\text{TeV}/c^2$ for several benchmark models.

PACS 14.65.Ha – Top quarks.

Numerous extensions of the Standard Model (SM) predict the existence of new particles with enhanced couplings to third-generation quarks and, in particular, to top quarks because of their large mass.

A search for heavy resonances decaying to a top quark-antiquark pair with the Compact Muon Solenoid (CMS) detector is presented [1]. The dataset considered corresponds to an integrated luminosity of $19.6\,\text{fb}^{-1}$ recorded in pp collisions at $\sqrt{s} = 8\,\text{TeV}$. The analysis is performed in the semileptonic channel and it is the combination of two dedicated searches: one is optimized to probe the production of a $t\bar{t}$ pair with well-separated decay products (threshold analysis), while the other is designed to reconstruct the decay of two high-p_T top quarks, which is characterized by the presence of non-isolated leptons and merged jets at the reconstruction level (boosted analysis).

The threshold analysis selects events with exactly one isolated lepton (electron or muon), missing transverse energy (MET) and at least four jets, whereas the boosted analysis only requires the presence of one lepton without any isolation requirement, MET and at least two high-p_T jets. In both analyses, the final event sample is split based on the number of b-tagged jets in order to enhance the sensitivity. A χ^2-hypothesis test is performed to reconstruct the kinematics of the $t\bar{t}$ pair in both kinematic regimes. For the boosted analysis, SM backgrounds are modelled using MC simulation and the total

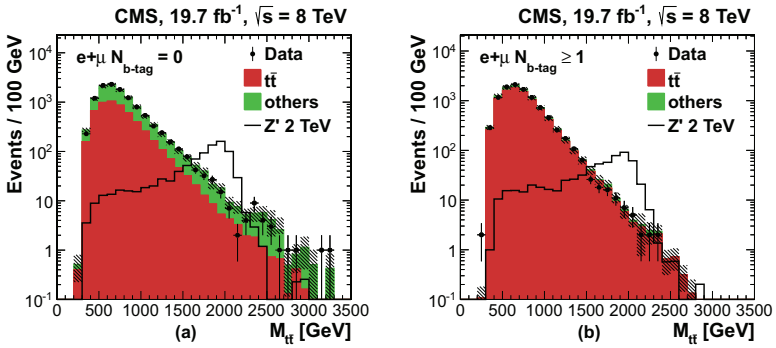

Fig. 1. – Invariant mass of the reconstructed $t\bar{t}$ system for the boosted analysis in the 0 b-tag (a) and 1 b-tag categories (b) [2]. The signal template is normalized to a cross section of 1 pb.

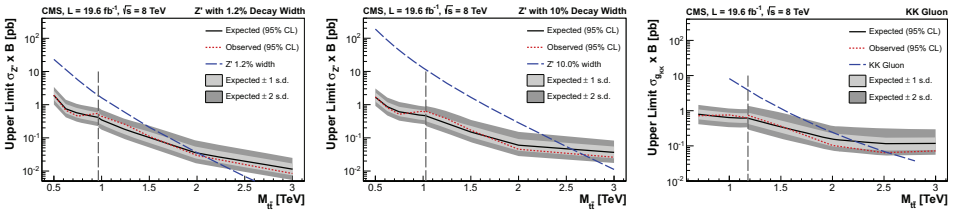

Fig. 2. – 95% CL upper limits on $\sigma \times$ BR for a resonance decaying to $t\bar{t}$, as a function of the resonance mass. Limits are shown for the three benchmark models considered in the analysis. The vertical dashed line marks the transition between the threshold and boosted analysis [1].

background yield is normalized to data using a binned maximum-likelihood fit of the $M_{t\bar{t}}$ distributions (fig. 1). In the threshold analysis, the background prediction of the $M_{t\bar{t}}$ spectrum is parameterized with an analytic function.

Several sources of systematic uncertainties are considered in the analysis, in particular for lepton identification and trigger efficiency, jet energy scale and resolution, b-tagging (and mistagging) efficiency, cross sections of SM backgrounds and choice of renormalization and matching scale for $t\bar{t}$ and W/Z + jets production.

No excess is observed in data with respect to the expected background, thus exclusion limits are set on the production cross section times branching ratio (BR) for a resonance decaying to a $t\bar{t}$ pair, as a function of the resonance mass. A bayesian statistical method is used to extract 95% CL upper limits on $\sigma \times$ BR using as template the $M_{t\bar{t}}$ distribution. The results of the two analyses are combined based on their expected sensitivity, with the boosted analysis giving better performance in the $M_{t\bar{t}} > 1\,\text{TeV}/c^2$ region. Exclusion limits for the three benchmark models considered are shown in fig. 2: Z' gauge bosons with relative width of 1.2% (10%) are excluded at 95% CL for masses below 2.10 (2.68) TeV/c^2; Kaluza-Klein excitations of a gluon in the Randall-Sundrum model are excluded for masses below 2.54 TeV/c^2.

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[2] CMS Collaboration, *Phys. Rev. Lett.*, **111** (2013) 211804 (arXiv:1309.2030); *ibid*, **112** (2014) 119903(E).