

Search for associated production of dark matter and top quarks with the ATLAS detector

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Summary. — With the increase of the integrated luminosity recorded by LHC, the research of possible dark-matter candidates assumes more and more importance. In simplified dark-matter production models, dark matter is produced from the decay of a mediator, coupled both to standard model particles and dark matter. For scalar and pseudoscalar mediators, the associate production of dark matter and two top quarks gives an excellent sensitivity on a wide range of model parameters, mainly thanks to the high top quark Yukawa coupling. In particular the analyses are focused on the top quark decays in zero, one and two leptons. In this contribution, updates concerning the most recent ATLAS results based on 13 fb^{-1} of 13 TeV LHC data are given.

1. – Introduction

One of the best dark-matter (DM) candidate is a weakly interacting massive particle (WIMP). These particles escape the detectors and lead to a momentum imbalance in the transverse plane. Three searches [1-3] for associated production of top quark pairs with dark matter are presented, with final states characterized by the two top quarks decaying respectively in zero, one, two leptons. The searches address a simplified model where dark-matter production is mediated by a spin-zero particle, scalar or pseudoscalar. The model has four parameters: mediator and DM particle masses, DM-mediator (g_χ) and SM-mediator couplings (g_q). The assumption $g_\chi = g_q = g$ is made. In the analyses the main background processes are estimated deploying control regions (CRs), having low signal contamination, probing an event topology similar to the signal regions (SRs) while being orthogonal.

2. – Analyses description

2.1. 0-lepton final-state analysis. – This analysis [4] concerns a final state which has at least four jets, two of which b -tagged and missing transverse energy. Good background rejection is obtained cutting on the transverse mass calculated from the E_T^{miss} and the closest b -tag jet to the E_T^{miss} and on the $H_{T,\text{sig}}^{\text{miss}}$ calculated from H_T^{miss} defined as the scalar sum of the p_T of signal jets and leptons. The main SM background processes are

$Z \rightarrow \nu\nu$, $t\bar{t}$ production where the lepton from the W decay is either not identified or reconstructed as a jet. Other contributions come from $W \rightarrow \ell\nu$, single top and $t\bar{t} + Z$. $Z \rightarrow \nu\nu$ is estimated from $Z \rightarrow ll$ requiring the two leptons invariant mass to be close to the Z boson, while $t\bar{t}$ CR requires one lepton and a minimum angular distance between jets and E_T^{miss} . The number of events observed in the data in the SRs is in agreement with the SM predictions within the estimated uncertainties. A scalar or pseudoscalar mediator of mass below 300 GeV is excluded for a coupling $g = 3.5$ and a dark-matter mass below 20 GeV at 95% CL.

2.2. 1-lepton final-state analysis. – The analysis [5] targets a final state having one lepton, four jets, one of which b -tagged, and missing transverse energy. The main discriminating variables are the transverse mass m_T , calculated between the lepton and the E_T^{miss} , the asymmetric transverse mass am_T , a generalization of the transverse mass when two particles are not directly detected, the $\Delta\phi$ distance between E_T^{miss} and jets, and the $E_T^{\text{miss}}/\sqrt{H_T}$, based on the negative vector sum of all hadronic and leptonic activity in the event. Dominant background processes include $t\bar{t}$, single top, Wt , $t\bar{t}Z \rightarrow \nu\nu$ and $W + \text{jets}$. In top and W CRs different m_T and am_T selections are operated, additionally loosening or removing other kinematic requirements to increase the event yield. Single top CR requires also at least two b -tag jets with a minimal ΔR distance. Data and Monte Carlo simulation are compared in SR: no significant excess is found, scalar and pseudoscalar mediators below 320 (350) GeV assuming 1 GeV dark-matter particle are excluded at 95% CL.

2.3. 2-lepton final-state analysis. – The analysis [6] targets a process having two leptons, at least one b -tagged jet and transverse missing energy in the final state. Same-flavour leptons compatible with Z are vetoed, and an additional cut on the angle between the E_T^{miss} and the opposite of the vector sum of all the hadronic activity is required. The most important discriminating variable is the m_{T2} , built from the two leptons and E_T^{miss} . This variable has an end point at the W mass for events where two W bosons decay leptonically and E_T^{miss} originates from the neutrinos. The main SM background contributions come from $t\bar{t}$ and $t\bar{t}Z$. For these two processes two CRs have been implemented, loosening the m_{T2} and dropping the E_T^{miss} requirements in the first case, while increasing the lepton multiplicity for the second one. Also in this case comparison between data and SM Monte Carlo prediction does not provide significant excess. In particular lower limits on the mediator mass between 300 and 350 GeV are set for a coupling of $g = 3.5$. For the pseudoscalar case dark-matter candidate masses below 80 GeV are excluded at 95% CL when $m(a) < 2m(\chi)$.

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