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Search for Dark Matter in events with a hight-p_T photon and high missing transverse momentum in ATLAS

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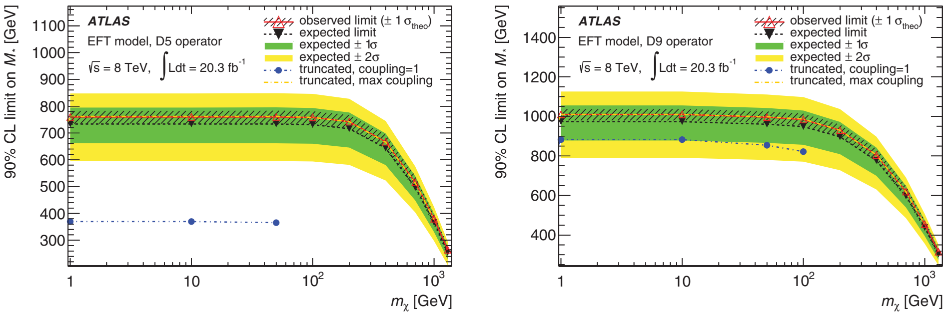
Summary. — We present the results of a search for new particles in events with a high-p_T photon and high missing transverse momentum with the ATLAS experiment at the LHC. The analysis is performed on the data collected by ATLAS at a centre of mass energy of 8 TeV and corresponding to a total integrated luminosity of 20.3 fb^{-1}. No excess has been found with respect to the Standard Model expectation. A model-independent upper limit on the fiducial cross section for the production of events with a photon and large missing transverse momentum is set. Exclusion limits on the direct pair production of dark matter candidates are presented.

1. – Motivation

Events with a high-p_T photon and a high missing transverse momentum ($\gamma + E_T^{miss}$) make a signature with a low level of background and are therefore a good and sensitive channel for the search of new physics. Among the theories that predict $\gamma + E_T^{miss}$ final states we study the direct production of Dark Matter (DM) in the form of WIMPs (Weakly Interacting Massive Particles). If WIMPs interact with Standard Model (SM) particles through a heavy mediator, a pair of WIMPs can be produced by the annihilation of two quarks or gluons in a pp collision. WIMPs would then manifest themselves as a missing momentum in the transverse plane. In order to detect such events, a high-p_T object, such as a photon, is necessary to tag the event.

2. – Analysis and methods

The analysis has been performed on the full dataset recorded by the ATLAS experiment at a centre-of-mass energy of 8 TeV. It is a "cut & count" analysis, *i.e.* a series of selection cuts is applied in order to obtain a good significance of the signal over the background, and then the number of predicted events is compared to the observed number in data.



(a) (b)

Fig. 1. – Limits at 90% CL on the EFT suppression scale M_* as a function of the WIMP mass m_χ for a spin-independent (a) and spin-dependent (b) type of interaction.

The selection of the signal region include a trigger cut, necessary for discriminating interesting physics events, cleaning cuts at event level in order to suppress the instrumental backgrounds due to detector noise as well as cosmic and beam halo backgrounds, cuts on the leading photon p_T in the event and on the E_T^{miss}; events are also required to have no hadronic jet or at most one jet well distanciated from the E_T^{miss} in order to suppress the QCD background; vetoes on the presence of electrons and muons are also applied in order to suppress events with W or Z bosons with charged leptons in the final state.

The residual dominant background after the selection is the $Z(\rightarrow \nu\nu)+\gamma$ process; secondary contributions come from the production of W/Z in association with photons, when the boson decays to leptons, if the leptons are not identified, and from the production

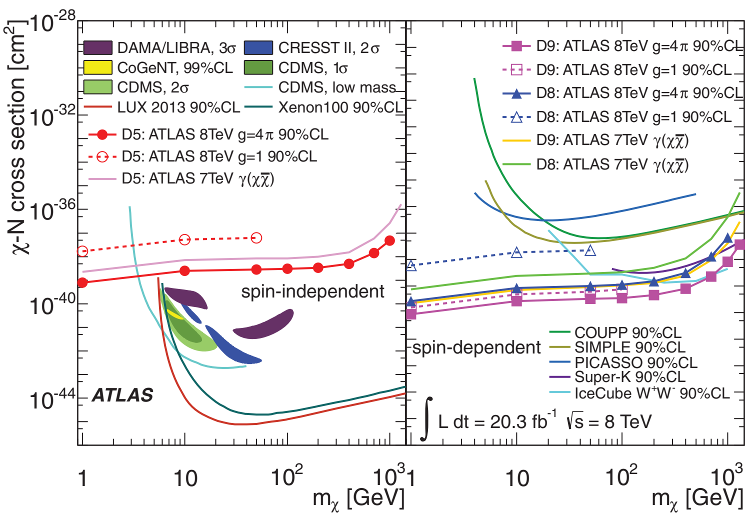


Fig. 2. – Upper limits at 90% CL on the WIMP–nucleon scattering cross section as a function of m_χ for spin-independent (left) and spin-dependent (right) interactions. The results obtained from ATLAS with 7 TeV data for the same channel are shown for comparison. Also shown are results from various dark matter search experiments.

of W/Z in association with jets, when the lepton or the jet are misidentified as photons. The background estimation procedure is based on the definition of multiple control regions enriched in a specific source of background that needs to be estimated. For the $W/Z + \gamma$ process, control regions enriched in electrons and muons are defined in which the contribution of the leptons is removed from the E_T^{miss} such that the E_T^{miss} spectrum is similar in the signal and control regions. The ratio between data and Monte Carlo (MC) in the control regions is used to normalize the contribution of the $W/Z + \gamma$ in the signal region. Entirely data-driven techniques are used in order to estimate the contribution of electrons and jets identified as photons. The first contribution is estimated with a "tag&probe" method, while the second thanks to an "ABCD" method.

The full background estimation in the signal region is obtained after simultaneously fitting the MC yields of the various processes to the data yields in the control regions. The estimate includes both statistical and systematic uncertainties due to experimental and theoretical sources. The procedure is validated in a low-E_T^{miss} validation region, optimized such that the composition of the backgrounds is similar to the one in the signal region and that the contamination of signal events is minimal.

3. – Results

The number of observed events in the signal region is found in agreement with the prediction and the result is thus interpreted in terms of a model-independent limit on the visible cross section which is found to improve the limit set in the previous publication by ATLAS [2].

Exclusion limits on the production of dark matter in the context of effective field theories (EFT) [3] are set as a function of the mass of the suppression scale of the theory M_*, as shown in fig. 1. Such limits are then translated into limits on the WIMP-nucleon scattering cross section as a function of the WIMP mass, as shown in fig. 2, which compares directly the result of this search with those from the experiments of direct and indirect detection of DM. Both spin-independent and spin-dependent interactions are separately considered.

REFERENCES

[1] ATLAS Collaboration, *Phys. Rev. D*, **91** (2015) 12008.
[2] ATLAS Collaboration, *Phys. Rev. Lett.*, **110** (2013) 011802.
[3] Goodman J. *et al.*, *Phys. Rev. Lett.*, **82** (2010) 116010.