IL NUOVO CIMENTO **43 C** (2020) 79
DOI 10.1393/ncc/i2020-20079-2

Colloquia: IFAE 2019

Search for Dark Photons decaying to Lepton-Jets with the ATLAS detector at the LHC

I. Longarini

Sapienza Università di Roma and INFN Roma - Roma, Italy

received 8 June 2020

Summary. — Several new physics models predict the existence of neutral particles with macroscopic lifetimes decaying into pairs of light leptons and hadrons with a jet-like structure (Lepton-Jets). This search uses data corresponding to an integrated luminosity of 36.1 fb^{-1} collected in proton-proton collisions at $\sqrt{s} = 13$ TeV recorded in 2015–2016 with the ATLAS detector at the Large Hadron Collider (LHC). The current results and the experimental challenges of these searches with the ATLAS detector are presented.

1. – Introduction

Several extensions of the Standard Model (SM) predict the existence of a dark sector which is not directly coupled to the SM [1]. Following a minimalist approach, this study considers the existence of an hidden $U(1)$ gauge symmetry with a corresponding massive boson, the Dark Photon, γ_d.

The Dark Photon can be produced through the decay of the Higgs boson in association with light particles belonging to the dark sector, and it can decay via kinetic mixing to a pair of SM fermions. This study aims to identify pairs of γ_d from data collected in proton-proton collision by the ATLAS experiment during 2015 and 2016, corresponding to an integrated luminosity of 36.1 fb^{-1}, exploring values of the coupling constant of kinetic mixing $\epsilon < 10^{-5}$ and Dark Photon masses m_{γ_d} between 200 MeV and 2 GeV [2]. In this mass range, γ_d produced at the interaction point would travel until the outermost region of the ATLAS detector and decay into a pair of highly collimated electrons, muons or pions. In ATLAS, such decays are identified through the reconstruction of Displaced Lepton-Jets (dLJ).

Two classes of these objects are defined depending on the corresponding experimental signature: *Muonic dLJ*, where two collimated muons are reconstructed in the ATLAS muon spectrometer, without combined tracks in the inner detector, and *Hadronic dLJ*, where a jet is reconstructed with most of the energy deposited in the hadronic calorimeter, with no corresponding tracks from the inner detector. The main sources of irreducible background for dLJ are: cosmic muons and QCD multi-jet events, respectively.

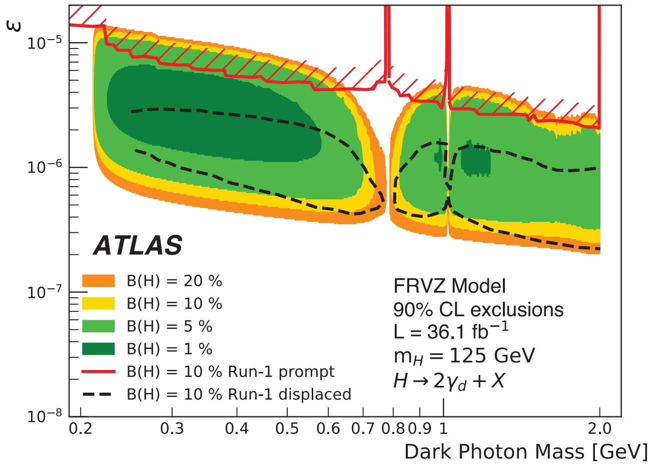

Fig. 1. – The 90% CL exclusion regions for the decay $H \to 2\gamma_d + X$ as a function of the γ_d mass and of the parameter ϵ. These limits are obtained with decay branching fractions of the Higgs boson into γ_d between 1% and 20%, and Higgs boson production cross sections via gluon-gluon fusion. Excluded regions from the Run-1 ATLAS displaced [3] and prompt [4] searches.

2. – Analysis strategy

In order to collect events which have a topology corresponding to a very displaced decay, dedicated high-level triggers are used. Further quality cuts are applied on jets, muons and electrons. In each event two back-to-back dLJ are requested, then cuts based on Boosted Decision Tree (BDT), used for classification of signal dLJ from background ones are applied. A final selection of events in the signal region and background estimation is made using data driven methods.

3. – Results and future plans

The number of events found in the signal region is compatible with the expected SM background. Events in which a pair of muonic dLJ are reconstructed allow a 95% CL exclusion in the variables m_{γ_d} and ϵ, as shown in fig. 1.

The analysis of data collected during the whole period 2015–2018 by ATLAS is ongoing. Significant improvements in the event selection are expected by the introduction of Deep Learning based classifiers, which are going to process the topology of calorimetric energy deposits of jets using convolutional neural networks. This will provide a better signal efficiency at given background rejection than the BDT currently in use and improve the selection in the hadronic dLJ channel.

REFERENCES

[1] Falkowsky A. *et al.*, *JHEP*, **05** (2010) 077.
[2] ATLAS Collaboration, *Eur. Phys. J. C*, **80** (2020) 450.
[3] ATLAS Collaboration, *JHEP*, **11** (2014) 088.
[4] ATLAS Collaboration, *JHEP*, **02** (2016) 062.