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Using Machine Learning algorithms in the search for dark photons with the ATLAS detector at the LHC.

The search for new physics is one of the key goals of the ATLAS Collaboration. With the discovery of the Higgs boson in 2012, the Standard Model (SM) gained an essential ingredient towards the understanding of fundamental particles and their interactions –but it cannot yet be considered complete. The nature of Dark Matter (DM), which constitutes about 27% of the Universe, remains a major open question. Dark matter might be part of a complex “dark sector”of particles beyond the Standard Model, with its own internal symmetry structure and interactions. Among these “dark particles”, the “dark photon”(gamma;_d) is a predicted mediator particle for interactions in this new sector. If dark photons interact with Standard Model particles, they could be produced in high-energy proton-proton collisions at the LHC and be detected by the ATLAS experiment. We will explore the use of the ATLAS experiment collected data in proton-proton collisions at the LHC to explore the production of a dark photon originating from the Higgs boson portal to DM, via the decay H ⟶ Z + gamma;_d . The Z boson decays to two same-flavour, opposite-sign leptons (either e+e- or μ+ μ-) while the undetected gamma;_d produces a missing transverse energy E_T^{miss} in the detector. Hence a final state: e+e- /μ+μ- + E_T^{miss} that would give an indication to the existence of gamma;_d. However, the SM presents several physics processes with similar final state that are produced with a higher probability in pp collisions. To separate these background processes from the gamma;_d signal, Machine Learning (ML) algorithms offer a powerful tool to analyse large amount of data using multi-variables models. Algorithms such as Boosted Data Three (BDT), Deep and Graphical Neural Networks (DNN,GNN) are applied to ATLAS Monte Carlo Simulation data to investigate to most efficient one, before applying the results to collected data for signal-to-background discrimination and searches for gamma;_d.

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Primary authors: TAU, Karabo (School of Physics, University of the Witwatersrand); MAZINI, Rachid (School of Physics, University of the Witwatersrand)

Presenter: TAU, Karabo (School of Physics, University of the Witwatersrand)

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