SEARCH FOR LONG-LIVED DARK PHOTONS THROUGH LEPTON-JETS

MOTIVATION
• So far most analyses have considered new particles to decay promptly, impacting the design of the detector and the reconstruction algorithms
• A particle with a displaced vertex of only a few millimetres would leave an unusual signature that can easily distinguish from the SM background
• BSM models, as hidden/dark sectors, predicts exotic long-lived particles (LLP)

DARK PHOTON MODELS
• Dark matter particles could be part of a hidden/dark sector that interact with standard particles through subtle mixing
• The Higgs boson could work as a portal to a hidden/dark sector
• ATLAS upper limit for BSM contributions to the Higgs boson total width is 10-20% (at 95% CL)
• Dark/Hidden sector, mediated by the Higgs boson, weakly couples to the SM via

VECTORportal

H

Z

\mathcal{L} \propto \frac{1}{2} c_{\mathcal{V}} H^{\mu \nu} \mathcal{P}_{\mu \nu}

HIGGSportal

S

H

\mathcal{L} \propto \kappa |\phi_{SM}|^2 |\phi_{Zd}|^2

\epsilon = \frac{1}{M_{Zd}} \propto \frac{1}{\epsilon^2 m_{Zd}}

• Lifetime of the dark photon (Zd) varies with its mass, but mostly \( \epsilon \)
• The minimal effective SM extension of a dark/hidden sector model is given by the FRVZ benchmark, which by adding an extra $U(1)$ symmetry and scalar, introduces two dark fermions, a dark photon and a hidden scalar

SIGNAL SELECTION
• At the LHC, FRVZ dark photons would typically be produced with large boost due to their small mass, having collimated jet-like structures containing pairs of leptons and/or light hadrons (lepton-jets)
• The analysis divides signal lepton-jets (LJ) into categories based on the type of its constituent particles (top figure)
• Selection is based on dark photon jets identification and its displaced vertex signatures

§ Type 0 lepton-jets (muonic)
Main background: cosmic ray muons, which is rejected by requiring >= 2 MS tracks without ID track, no jets, and displaced vertex variables
§ Type 2 lepton-jets (hadronic)
Main background: QCD multijet, which is rejected by requiring a single collimated jet with low EM fraction
§ Other Background processes: V+jets, tt, single-top, WW, BB

RESULTS
• Upper limits on the production cross section times BF as a function of the dark photon proper decay length are derived for two and four dark photons processes in all LJ categories
• No significant excess of events compares with the background expectation is observed at 95% CL
• An additional interpretation of the kinetic mixing parameter as a function of the dark photon mass is given at 90% CL for the two dark photon process