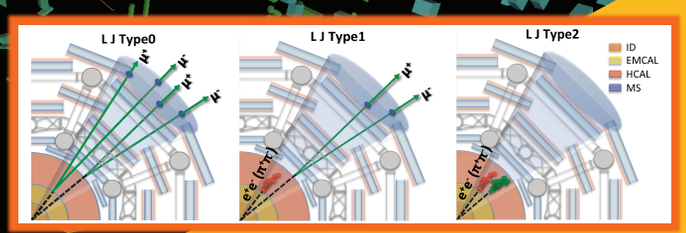
SEARCH FOR LONG-LIVED DARK PHOTONS THROUGH LEPTON-JETS

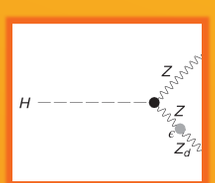
MOTIVATION

- 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)



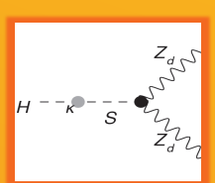
DARK PHOTON MODELS

- 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:



Vector portal

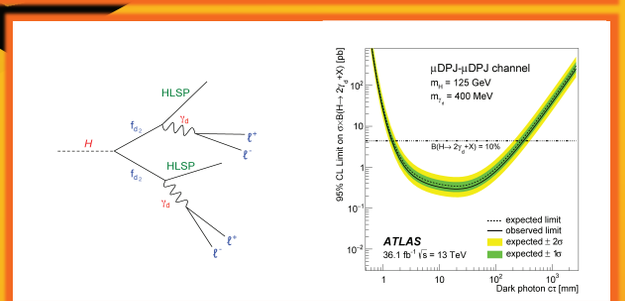
$$\mathcal{L} \propto \frac{1}{2}\epsilon\gamma_d^{\mu\nu}B_{\mu\nu}$$

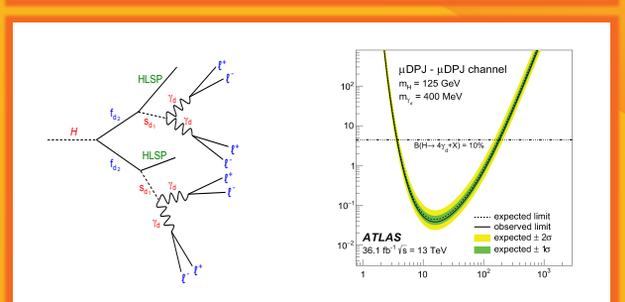


Higgs portal

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

- Lifetime of the dark photon (Zd) varies with its mass, but mostly ϵ $\quad c\tau = \frac{1}{\Gamma_{Z_D}^{tot}} \propto \frac{1}{\epsilon^2 m_{Z_D}}$
- 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

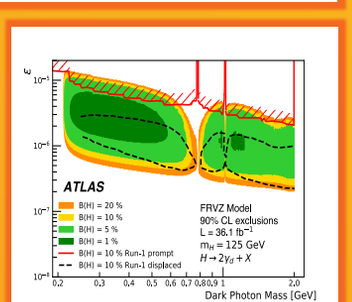
- At the LHC, FRVZ dark photons would typically be produced with large boost due to their small mass, having collimated jet-like structures containing pairs of leptons and/or light hadrons (lepton-jets)
- The analysis divides signal lepton-jets (LJ) into categories based on the type of its constituent 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, VV, BIB

RESULTS



- Upper limits on the production cross section times BF as a function of the dark photon proper decay lenght 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 fuction of the dark photon mass is given at 90% CL for the two dark photon process

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ATLAS EXPERIMENT