Searches for dark photon with the ATLAS detector at the LHC
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ABSTRACT

Many extensions to the Standard Model introduce a hidden or dark sector to provide candidates for dark matter in the universe and explanation to astrophysical observations such as the positron excess observed in the cosmic radiation flux. This hidden sector could rise from an additional U(1) gauge symmetry. The gauge boson of the dark sector would be either a massless or a massive dark photon that can either kinetically mix with the SM photon, or couple to the Higgs sector via some mediators. If dark photons decay back to the SM with a significant branching ratio, we could observe measurable deviations in some particular Higgs decay channels or new exotic signatures that would be accessible at LHC energies.

COLLIDER SEARCH STRATEGY

• Lepton-Jet(LJ) : collimated jet-like structure containing pair(s) of muons and/or electrons (and/or light hadrons)
• Non-collimated: sufficiently far apart for standard reconstruction

MODELS FOR DARK PHOTON SEARCHES

Vector Portal: Add a U(1)' whose massive "dark" gauge boson (A'/Z'_D/γ_D) mixes kinetically with SM photon.

\[ \mathcal{L} = -\frac{1}{4}g_1'^2 A'_\mu \partial^\mu A'_\nu + \frac{1}{4}g_2^2 Z_D^\mu \partial^\mu Z_D^\nu + \frac{1}{2}g_f^2 H^\mu \partial^\mu H^\nu + \frac{1}{4}g'_2^2 \gamma_D^\mu \partial^\mu \gamma_D^\nu \]

Higgs Portal: Add dark scalar singlet (φ/γ) that spontaneously breaks U(1) and mixes with SM Higgs:

\[ V_{\phi}(H) = -\frac{1}{2}m^2_H H^2 + \lambda H^2 (\phi^2 + \gamma^2) + \lambda' H^2 \phi^2 + \lambda'' H^2 \gamma^2 \]

Hidden Valley: Sector of dark particles, interacting amongst themselves, weakly coupled to SM through loops of TeV-scale particles or marginal operators : SUSY

Notation: γ_D: low-mass dark photon, A': agnostic, κ: kinetic mixing parameter Z, Z_D

DARK PHOTON SEARCHES WITH THE ATLAS DETECTOR

ATLAS searches for dark photon in different physics processes with masses ranging from 0 massless γ_D to 60 GeV Z_D. Two main categories have been considered:

High mass searches: \( H \rightarrow \gamma_D Z_D \rightarrow 2l \gamma \) to 60 GeV Z_D

• sensitive to κ and κ
• good acceptence at low Z_D mass (1/2-3/lepton trigger) but low σ

DISPLACED LEPTON_JETS : Partial Run 2 data 36.1 fb⁻¹

• DLJs channels, main backgrounds, triggers:

μDPJ–μDPJ channel
Cosmic-ray muons background
≥ 2 MS tracks without ID tracks, ≥ 1 jet

• Results and Interpretation:

Engaging: 3.2σ
Local significance: 1.2σ
X = Z_D |α (pseudoscalar boson)

μDPJ–hDPJ channel
QCD multi-jet background
1 jet with low EM fraction

90% CL exclusion region for H → 2γ + X as a function of the γ_D mass and of the kinetic mixing parameter κ.

Excluded regions with decay branching fraction of the Higgs boson into γ_D of 10% from the run-1 ATLAS displaced prompt dark-photon jets searches.

arXiv:1802.03388v2
arXiv:1909.01246v1