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Bridging the Higgs Portal to the Dark Sector: From FCCee to LHC

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Dark showers arising from the Higgs coupling to a strongly confined dark sector present a unique avenue for exploring new physics signatures. Within the FCC-ee framework, this model is being studied, highlighting the production of semi-visible jets (SVJs) enriched with photons and leptons. These signatures, featuring displaced decays and complex jet structures, demand tailored reconstruction techniques and novel targeted analyses.
We aim to adapt this model for the LHC, leveraging vector boson fusion production of the Higgs, which couples to dark quarks and subsequently hadronizes into dark mesons. Standard jet identification at the LHC may fail to capture such photon-enriched and lepton-enriched SVJs, necessitating the development of new algorithms relying on jet substructure.
Key challenges include understanding how Standard Model (SM) analyses, such as those targeting the Higgs-to-b-quark decay channel, overlap with or constrain these novel signatures. While $H \to bb$ acts as a background, assessing the sensitivity of SM analyses to dark sector scenarios or highlighting their limitations in identifying photon- and lepton-enriched SVJs is central to our exploration.
This work will focus on developing new analysis strategies tailored to the LHC environment, where existing detector capabilities and triggers may already offer opportunities to probe this signature. By uncovering an unexplored parameter space, particularly in the low-mass regime around the Higgs scale, we aim to refine the methods for identifying dark sector signatures and enhance sensitivity to new physics within Higgs portal frameworks.

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