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Dark photon production in pion-proton collisions: bremsstrahlung vs Drell–Yan mechanisms

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The study investigates the production of dark photons in pion-proton collisions through two mechanisms: inelastic pion bremsstrahlung and Drell–Yan-like process in the mass range 0.4–3.5 GeV.

The factorization method, previously applied to proton bremsstrahlung processes, is adapted for pion beams to overcome the limitations of chiral perturbation theory at high energies. The splitting function for pion bremsstrahlung is derived, linking the dark photon production cross section to the inclusive inelastic pion-proton scattering cross section.

For the Drell–Yan process, both leading- and next-to-leading-order contributions within perturbative QCD are considered.

The results show that pion bremsstrahlung dominates dark photon production for masses 0.4–1.3 GeV, while the Drell–Yan process becomes dominant in the 1.3–3.5 GeV range. Mean energies of produced dark photons are estimated for pion momenta relevant to T2K, DUNE, and SHiP experiments.

These findings provide crucial inputs for dark photon searches in fixed-target experiments, particularly NA64h at CERN SPS.

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