

Same-sign dimuon probe of charged lepton flavor violation at electron–photon colliders

Observation of charged lepton flavor violation would constitute unambiguous evidence for physics beyond the Standard Model (SM). We identify a previously unexplored same-sign dimuon signature in electron–photon collisions, $\gamma e^- \rightarrow e^+ \mu^- \mu^-$, mediated by an axionlike particle (ALP) with flavor-violating e – μ couplings. The absence of irreducible SM backgrounds and the on-shell production of the ALP render this channel intrinsically clean and highly sensitive, with only small residual backgrounds arising from detector effects. Such collisions can be realized via laser Compton backscattering at e^+e^- colliders including BEPC-II with the BESIII detector, STCF, CEPC, and ILC. We find that STCF, CEPC, and ILC can probe couplings one to two orders of magnitude below existing bounds. This combination of resonant production, vanishing irreducible background, and same-sign topology would be difficult to achieve in conventional e^+e^- or hadron-collider environments, establishing electron–photon collisions as a uniquely powerful probe of charged lepton flavor violation.

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