

Heavy Neutral Lepton Searches at the Electron-Ion Collider

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We consider the model of heavy neutral leptons (HNLs) as an example to explore the potential of new physics searches at the Electron-Ion Collider (EIC). We propose two broad categories of search strategies depending on the HNL lifetime: direct searches for the prompt decay of HNLs with a short lifetime and displaced vertex searches for long-lived ones. After identifying the most promising signals and the corresponding backgrounds, we perform a detailed simulation to estimate the sensitivity of the EIC to HNLs, accounting for detector thresholds, resolutions, and geometric acceptance. We derive projections for the EIC reach to the HNL squared mixing angle as a function of the HNL mass under the electron flavor mixing dominance hypothesis. Our findings indicate that the EIC can provide comparable sensitivity to the existing constraints for the prompt searches, while the displaced vertex searches can cover substantial new ground for HNLs in the 1-10 GeV mass range. Our proposed strategies are generally applicable to other new physics scenarios as well and motivate additional phenomenological exploration and dedicated future searches at the EIC.

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