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Revealing the Origin of Neutrino Masses through Displaced Shower Searches in the CMS Muon System

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We study the potential to probe the origin of neutrino masses, by searching for long-lived right-handed neutrinos (RHNs) N in the $B - L$ model and in the RHN-extended Standard Model (SM) Effective Field Theory (EFT). Despite the small active-sterile mixing $|V_{\ell N}|^2$, RHNs are produced abundantly via SM and exotic Higgs production, as long as the Higgs mixing or EFT operator coefficient is sufficiently large. We reinterpret a search for displaced showers in the CMS muon system and we find that it is sensitive to parameter space at and below the seesaw floor, $|V_{\ell N}|^2 \approx 10^{-12}$ ($\ell = e, \tau$) for $m_N \approx 40$ GeV. With existing data constraining such well-motivated scenarios of neutrino mass generation, we determine the projected sensitivity at the HL-LHC, motivating dedicated searches for long-lived RHNs with decay lengths ≈ 10 m.

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