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Searching for Heavy Neutral Leptons at A Future Muon Collider

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As the planning stages for a high energy muon collider enter a more concrete era, an important question arises as to what new physics could be uncovered. A TeV-scale muon collider is also a vector boson fusion (VBF) factory with a very clean background, and as such it is a promising environment to look for new physics that couples to the electroweak (EW) sector. In this paper, we explore the ability of a future TeV-scale muon collider to search for Majorana and Dirac Heavy Neutral Leptons (HNLs) produced via EW bosons. Employing a model-independent, conservative approach, we present an estimation of the production and decay rate of HNLs over a mass range between 200 GeV and 9.5 TeV in two benchmark collider proposals with $\sqrt{s}$=3,10 TeV, as well as an estimation of the dominant Standard Model (SM) background. We find that exclusion limits for the mixing between the HNLs and SM neutrinos can be as low as $\mathcal{O}(10^{-6})$. Additionally, we demonstrate that a TeV-scale muon collider allows for the ability to discriminate between Majorana and Dirac type HNLs for a large range of mixing values.

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