Feasibility study on probing the Seesaw Mechanism with full detector simulation for 250 GeV ILC

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Several new physics models have been proposed to solve problems with the Standard Model (SM). For instance, the SM does not explain why the neutrinos have tiny nonzero masses. We consider the so-called minimal B-L model, which is a well-motivated simple extension of the SM by promoting the global symmetry, known as Baryon minus Lepton number in the SM, to the local symmetry. In the model, three right-handed neutrinos (RHNs) are required to make this local (gauge) symmetry anomaly-free. With the RHNs, the small neutrino masses can be explained by the seesaw mechanism. The RHN pair production through the B-L gauge boson (Z) can result in a "smoking-gun" signature: the final state with same-sign di-leptons plus four jets is arisen from the Majorana nature of RHNs. In addition, some of RHNs couple very weakly to the SM particles and thus are long-lived, which leads to a clear signature as a displaced vertex. The decay length measurement could be cross-checked with the neutrino oscillation data and neutrino-less double beta-decay limits. The Z' gauge boson has been searched at the LHC Run-2 and its production cross section is already severely constrained. Prospects of discovering the Majorana RHN at the future LHC experiments can be found, for example, [1–6]. A theoretical work related to our ILC study has been done by A. Das et. al [7]. The authors found a possibility that even after a null Z' boson search result at the HL-LHC, the 250 GeV ILC can search for the

RHN pair production and explore the origin of the Majorana neutrino mass generation. From the viewpoint of the experimental side, isolated lepton finding, charge identification and displaced vertex finding play key roles for this analysis. Since the number of signal events is expected to be very small, we should clarify the feasibility with realistic detector simulation and event reconstruction. We are planning to use the software framework developed by LCC Software and Computing Working Group.

References

[1] Z. Kang, P. Ko and J. Li, "New Avenues to Heavy Right-handedNeutrinos with Pair Production at Hadronic Colliders", Phys.Rev. D93, no. 7, 075037 (2016) [arXiv:1512.08373 [hep-ph]].

[2] P. Cox, C. Han and T. T. Yanagida, "LHC Search for Right-handed Neutrinos in Z' Models", JHEP1801, 037 (2018) [arXiv:1707.04532 [hep-ph]].

[3] E. Accomando, L. Delle Rose, S. Moretti, E. Olaiya and C. H. Shepherd-Themistocleous, "Extra Higgs boson and Z' as portals to signatures of heavy neutrinos at the LHC", JHEP1802, 109 (2018) [arXiv:1708.03650 [hep-ph]].

[4] A. Das, N. Okada and D. Raut, "Enhanced pair production ofheavy Majorana neutrinos at the LHC, Phys. Rev. D97, no.11, 115023 (2018) [arXiv:1710.03377 [hep-ph]].

[5] A. Das, N. Okada and D. Raut, "Heavy Majorana neutrino pair productions at the LHC in minimal U(1) extendedStandard Model", Eur. Phys. J. C78, no. 9, 696 (2018)[arXiv:1711.09896 [hep-ph]].

[6] S. Jana, N. Okada and D. Raut, "Displaced vertex signature of type-I seesaw model", Phys. Rev. D98, no. 3, 035023 (2018)[arXiv:1804.06828 [hep-ph]]

[7] A. Das, N. Okada, S. Okada, and D. Raut, "Probing the seesaw mechanism at the 250 GeV ILC", [arXiv:1812.11931 [hep-ph]].