INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The Standard Model (SM) of particle physics is well established with the discovery of the Higgs boson by the independent experiments, ATLAS and CMS at LHC in 2012. The properties of the discovered Higgs boson is very similar to the proposed one in the SM and the discovery is considered as a remarkable success of this model. In spite of this success, many experimental evidences provide hints of some fundamental issues; mainly absence of dark matter (DM), non-zero neutrino mass and hierarchy problem, which shows that the SM is not a complete theory. A possible way out of this situation is to look beyond the SM(BSM) to resolve these issues by accommodating new particles in the spectrum or extending the gauge sector of the SM. Out of many attractive proposals of BSM, models governing seesaw mechanism could explain the non-zero masses of neutrinos. Similarly, DM issue is addressed by many multi-Higgs models with or without addition of extra fermionic sector in the particle spectrum. Among the seesaw models, we consider Type III seesaw model, which is a simple extension of the SM with an additional $SU(2)_L$ fermion triplet and Minimal Left Right Symmetric Model(MLRSM) with additional Higgs fields and right-handed neutrino, and extending the gauge group by a additional $SU(2)_R$ symmetry. Alongside, we also consider inert version of the Two Higgs Doublet Model with a charged fermion singlet as partner to it. But the fate of these BSM scenarios will be decided by the observation or non-observation of these new particles at collider experiments. Our main aim in this thesis is to focus on the collider signatures of Type III seesaw model, MLRSM, and Dark Matter Models in the context of Large Hadron Collider(LHC) and Future Linear Colliders(FLC).

In the first work of the thesis, we consider the Type III seesaw model to probe the heavy fermions arising in this model at high energy electron-positron collider through their direct production and subsequent decays. We study the single production of charged as well as neutral fermions in association with leptons at 1 TeV center of mass energy and pair production of charged fermion at 2 TeV center of mass energy. Our study establishes that final states

arising from single production of heavy fermions can probe electron type mixing very well with heavy fermions. 2j + e^- + MET in the final state is the best channel providing 5-sigma sensitivity using less than 2 inverse fb luminosity. On the other hand, in the case of pair production we consider both electron and muon type mixing, taking once at a time. The final state 4b+ 2l comes out to be the best channel and can be probed with 5-sigma significance using around 50 inverse fb luminosity. Thus, clearly, the leptonic collider can fingerprint the mixing very efficiently, unlike the case of LHC. The mass reach of around 1 TeV can be achieved for the considered center of mass energy.

In the second work, we perform a collider study of the rich scalar sector of the Minimal version of the Left Right Symmetric Model. We consider the four-leptonic final state arising from the pair production of doubly charged Higgs boson and trileptonic final states arising from associated production of doubly charged Higgs boson with singly charged Higgs boson at 14 TeV LHC. A full set of signal and SM background analysis for a selected benchmark point is performed using 1000 inverse fb integrated luminosity. We generalize the study for upcoming High Luminosity - LHC and obtained required luminosity to probe four leptonic final state is around 350 inverse fb with 5sigma sensitivity. For the trileptonic case, the required luminosity with 5sigma sensitivity is quite larger, around 800-1200 inverse fb. We demonstrate the 5-sigma mass reach of doubly charged Higgs boson around 980 GeV and 960 GeV using 3000 inverse fb luminosity for four-leptonic and trileptonic final states, respectively.

In the last work, we consider Inert Higgs Doublet Model (IHDM) added with a charged partner fermions, which are considered as fermionic dark matter candidate along with scalar dark matter candidate originating from the Inert Higgs doublet. We emphasize the discovery possibility of such charged fermions arising in Multi Component Dark Matter Models at International Linear Collider(ILC) with its baseline center of mass energy of 250 GeV. The charged fermions are produced at ILC in pairs with gauge coupling and decays to tau lepton and lightest dark matter candidate. We perform a complete signal versus background study using ILCsoft. The outcome of the study is very impressive with the potential of discovering charged fermions using 50 inverse fb integrated luminosity.

Summarising, we focus on the models beyond the SM to probe the discovery potential of additional scalars and fermions at LHC and FLC.