Contribution ID: **524** Type: **Parallel**

Beautiful Majorana Higgses at Colliders

Wednesday 9 July 2025 17:15 (15 minutes)

We investigate a novel collider signature within the minimal Left-Right Symmetric Model, featuring a Higgs sector composed of a bi-doublet and two triplets. Our study focuses on a region of the parameter space where the $SU(2)_R$ charged gauge boson W_R lies in the multi-TeV regime (3-100 TeV) and the additional Higgs states play a significant role. In this scenario, a heavy neutral Higgs boson Δ with a dominant $SU(2)_R$ triplet component can be produced in association with either a Standard Model Higgs boson or a massive weak boson. The subsequent decay of the heavy Higgs into Majorana neutrinos N results in displaced lepton signatures, providing a striking manifestation of lepton number violation. Additionally, we explore how the production of b-jets in these processes can enhance hadron-collider sensitivity to such signals. A particularly compelling channel, $pp \to b\bar{b}NN$, offers the exciting possibility of simultaneously probing the spontaneous mass origin of both Dirac fermions and Majorana states. Based on an optimised event selection strategy and state-of-the-art Monte Carlo simulations, we outline the expected reach at the HL-LHC and future colliders. Our findings demonstrate that this channel probes a region of parameter space where the neutral Higgs triplet and heavy neutrino masses are relatively light (m_Δ
$lesssim$250 GeV, m_N
$lesssim$80 GeV), indirectly constraining the W_R boson to the deep multi-TeV domain, with sensitivity extending up to 70-80 TeV, effectively turning the LHC into a precision machine.

Secondary track

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Session Classification: T09

Track Classification: T09 - Beyond the Standard Model