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Testing Naturalness

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Solutions to the electroweak hierarchy problem typically introduce a new symmetry to stabilize the quadratic ultraviolet sensitivity in the self-energy of the Higgs boson. The new symmetry is either broken softly or collectively, as for example in supersymmetric and little Higgs theories. At low energies such theories contain naturalness partners of the Standard Model fields which are responsible for canceling the quadratic divergence in the squared Higgs mass. Post the discovery of any partner-like particles, we propose to test the aforementioned cancellation by measuring relevant Higgs couplings. Using the fermionic top partners in little Higgs theories as an illustration, we construct a simplified model for naturalness and initiate a study on testing naturalness. After electroweak symmetry breaking, naturalness in the top sector requires a_T = - ?_tˆ2 at leading order, where ?_t and a_T are the Higgs couplings to a pair of top quarks and top partners, respectively. Using a multivariate method of Boosted Decision Tree to tag boosted particles in the Standard Model, we show that, with a luminosity of 30 abˆ{-1} at a 100 TeV pp-collider, naturalness could be tested with a precision of 10 % for a top partner mass up to 2.5 TeV.

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