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Electroweak Restoration at the LHC and Beyond: The Vh Channel

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The LHC is exploring electroweak (EW) physics at the scale EW symmetry is broken. As the LHC and new high energy colliders push our understanding of the Standard Model to ever-higher energies, it will be possible to probe not only the breaking of but also the restoration of EW symmetry. We propose to observe EW restoration in double EW boson production via the convergence of the Goldstone boson equivalence theorem. This convergence is most easily measured in the vector boson plus Higgs production, Vh, which is dominated by the longitudinal polarizations. We define EW restoration by carefully taking the limit of zero Higgs vacuum expectation value (vev). EW restoration is then measured through the ratio of the p_T^h distributions between Vh production in the Standard Model and Goldstone boson plus Higgs production in the zero vev theory, where p_T^h is the Higgs transverse momentum. As EW symmetry is restored, this ratio converges to one at high energy. We present a method to extract this ratio from collider data. With a full signal and background analysis, we demonstrate that the 14 TeV HL-LHC can confirm that this ratio converges to one to 40% precision while at the 27 TeV HE-LHC the precision will be 6%. We also investigate statistical tests to quantify the convergence at high energies. Our analysis provides a roadmap for how to stress test the Goldstone boson equivalence theorem and our understanding of spontaneously broken symmetries, in addition to confirming the restoration of EW symmetry.

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