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Highlights of the HL-LHC physics projections by ATLAS and CMS

The ATLAS and CMS experiments are unique drivers of our fundamental understanding of nature at the energy frontier. In this contribution to the update of the European Strategy for Particle Physics, we update the physics reach of these experiments at the High-Luminosity LHC (HL-LHC) in a few key areas where they will dominate the state-of-the-art for decades to come. With a collected luminosity of 3ab^{-1} of physics quality data per experiment, ATLAS and CMS can achieve:

-The observation of the $H \to \mu^+\mu^-$ and $H \to Z\gamma$ rare processes and the determination of the corresponding couplings with a precision of 3 and 7%, respectively;
-The measurement of the other main Higgs boson couplings to fermions and vector bosons (including loop-induced and Standard Model (SM) suppressed couplings to the photon and the gluons) with a precision between 1.6 and 3.6%, assuming only known Higgs boson interactions;
-A sensitivity to the charm Yukawa coupling of 1.5 times the SM value at 95% Confidence Level (CL);
-The observation of the SM di-Higgs-boson production with a significance exceeding 7σ;
-The measurement of the Higgs boson trilinear self-coupling λ_3 with a precision better than 30%;
-Sensitivity to fully exclude at 95% CL generic, high-scale new physics models enabling a strong first-order electroweak phase transition in the early universe;
-The observation of the longitudinally polarised vector boson scattering $W_L W_L$ process, which constitutes an independent check of the spontaneous electroweak symmetry breaking mechanism, and the measurement of its cross section with better than 20% precision;
-The measurement of extremely rare processes, such as simultaneous four-top-quark production, with a precision of 6%;
-Constraints on anomalous interactions between the top quark and the Z boson, probing new physics at energy scales up to 2 TeV.

Several results are limited by theoretical uncertainties, highlighting the need for further progress in high-precision theoretical calculations aligned with the demands of the HL-LHC.

We interpret these HL-LHC projections in the following contexts:

-A generic BSM model for baryogenesis featuring an additional heavy neutral scalar;
-The constraints on various BSM scalar potentials, highlighting the power of future HL-LHC measurements in establishing the shape of the electroweak vacuum;
-Our capability to use the top quark and Higgs boson mass constraints in unveiling the nature of the electroweak vacuum and the stability of the universe.

This document serves two purposes:

-Updating the physics goals of HL-LHC, in line with the phenomenological studies made in the last five years on the impact of future collider proposals;
-Providing a more realistic assessment of the HL-LHC physics reach, as input to the discussion on the choice of a future collider at CERN.

Authors: PIERINI, Maurizio (CERN); FERRARI, Pamela (Nikhef National institute for subatomic physics (NL)); LOWETTE, Steven (Vrije Universiteit Brussel (BE))