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Search for Higgs Pair Production Decaying into 2 Photons and 2 b Quarks at the High-Luminosity LHC

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The Standard Model (SM) is currently the most predictive framework for describing interactions among the fundamental constituents of matter. It includes 19 free parameters, which are measured experimentally, notably with the ATLAS detector at the Large Hadron Collider (LHC) at CERN. These parameters encompass particle masses, phases, and coupling values. One of these couplings, the Higgs boson self-coupling, stands out due to its unique nature: only a scalar can possess a self-coupling and it is a key parameter in shaping the Higgs potential, explaining the origin of particle masses. This coupling is involved in the simultaneous production of two Higgs bosons via a virtual Higgs boson, a rare process with a cross-section 1,000 times smaller than that of single Higgs boson production. This process presents a detection challenge, as the two Higgs bosons decay into various types of particles with different probabilities. A particularly sensitive signature for this measurement is the decay of a pair of Higgs bosons into two b-quarks and two photons ($HH \rightarrow b\bar{b}\gamma\gamma$). Although currently limited by the amount of collected data, this analysis has provided the best existing constraint on this value. An upgrade to the LHC, called the High Luminosity LHC (HL-LHC), aims to increase the data produced by a factor of 20 compared to the current measurement. A sensitivity projection study for this coupling measurement allows us to determine the expected constraint at the end of the HL-LHC program.

This presentation aims to introduce the challenge of detecting events with this unique signature and to show the expected results for the high-luminosity program. Precisely knowing the value of this coupling is crucial, either to strengthen the predictive power of the SM and constrain the shape of the Higgs potential, which has a direct impact on the stability of our universe, or to open the door to new physics.

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