Probing anomalous quartic gauge couplings with proton tagging at the CERN Large Hadron Collider

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One of the main goals of the CERN LHC and future colliders is the discovery of physics beyond the standard model (BSM) of particle physics. Direct and indirect searches in standard pp inelastic collisions have proven to be very powerful for a wide spectra of extensions of the SM. However, extensions that lead to slight modifications of electroweak gauge boson scattering are quite hard to test in standard searches based on hard collisions of quarks and gluons in pp collisions. In particular, for this Snowmass process contribution, we are interested in collisions where quasi-real photons are emitted coherently off each proton. Just like in quark and gluon interactions, these quasi-real photons can interact with each other to produce a number of final states of interest. For instance, one may be able to probe reactions such as the high-mass scattering of light-by-light, $\gamma\gamma \to \gamma\gamma$, which is induced at loop-level in the SM at α_{em}^4 accuracy in the SM, and a process that could receive contributions from heavy electrically charged particles not present in the SM. The colliding protons might remain intact after the aforementioned coherent photon exchange. In this case, the scattered protons can be directly detected with so-called Roman Pot (RP) detectors installed very far down the beamline relative to the interaction point (about 200 meters). The ATLAS and CMS experiments are equipped with such a set of RP detectors, known as ATLAS Forward Proton (AFP) [1] and CMS Precision Proton Spectrometer (PPS) [2], respectively. Thus, by tagging the intact protons and reconstructing the decay products of the particles created in the photon-photon collision,

one can reconstruct completely the final-state in photon-induced interactions in pp collisions.

In this Letter of Intent, we are interested mostly in studying possible ways of improving the discovery potential of anomalous quartic gauge couplings between photons, W and Z bosons. Namely, our focus is on pure gauge quartic couplings $\gamma\gamma\gamma\gamma$, $\gamma\gamma WW$, $\gamma\gamma ZZ$, $\gamma\gamma\gamma Z$. The latter induce anomalous contributions on top of the SM contributions to the scattering $\gamma\gamma \to VV$, where $V = \gamma, Z, W$. These couplings have been studied before in Refs. [3, 4, 6, 5, 7] under standard pileup conditions of the LHC Run-2, and with a heavy focus on so-called "golden" channels, where the weak gauge bosons decay into leptons only. For the Snowmass process, we would like to do an extension of previous efforts to include event reconstruction effects expected at the High Lumonisity LHC (more pileup protons at the RPs, more tracks in the central detector) and also improving sensitivities by considering hadronic decays of weak gauge bosons in boosted topologies, which may be present as large-radius jets. A close collaboration between experimentalists and phenomenologists will be devoted to these studies. A separate Letter of Intent on diffractive top quark pair production addresses also possible contributions to the $\gamma\gamma \to t\bar{t}$ process in terms of effective field theory operators, which is submitted separately.

References

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