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

(draft)

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Letter of Interest
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One of the main goals at 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, 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, $\gamma\gamma\rightarrow\gamma\gamma$. The 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. Thus, by tagging the intact protons and reconstructing the daughters of the hard scatterers, 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, the quartic couplings $\gamma\gamma\gamma\gamma$, $\gamma\gamma W W$, $\gamma\gamma Z Z$, $\gamma\gamma \gamma Z$. The latter induce anomalous contributions on top of the SM contributions to the scattering $\gamma\gamma\rightarrow VV$, where $V = \gamma, Z, W$.

We propose to better constrain these anomalous couplings in the following final-states:

- $\gamma\gamma\rightarrow \gamma\gamma$
- $\gamma\gamma\rightarrow ZZ$
- $\gamma\gamma\rightarrow Z\gamma$
- $\gamma\gamma\rightarrow W^+W^-$

Final states where the W or Z boson are produced can be studied in either leptonic or hadronic decays. Given that the anomalous processes contribute mostly at high-mass, the W

or Z bosons of BSM interactions are likely to be produced in boosted topologies. Thus, hadronic decays of the weak bosons in large-radius jets can greatly enhance the sensitivity compared to the leptonic final states. Studies considering High Luminosity LHC (HL-LHC) need to be done to fully assess the discovery potential in this final-state.