Comparison of the Sensitivities to Dimension-eight Operators for Anomalous Neutral Triple Gauge Couplings Through pp→γγγ Process at HL/HE-LHC and FCC-hh

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ABSTRACT
We study the effects of dimension-eight operators giving rise to anomalous neutral triple gauge boson interactions in Zγγ and ZγZ vertices through the γγγ production at HL/HE-LHC and FCC-hh. The analysis is performed using transverse momentum of photon in the final state including a realistic detector effects for the future hadron colliders. The sensitivity to CP-conserving $C_{1,a}$ and CP-violating $C_{3,a}$ couplings are obtained at 95% C.L. The results are compared to the current experimental limits from ATLAS results.

THEORETICAL FRAMEWORK
The Lagrangian in the framework of an effective field theory for neutral Triple Gauge Couplings (nTGC) imposing local U(1)$_a$ and Lorentz symmetry can be written as [1]

$$\mathcal{L}_{nTGC} = \mathcal{L}^{SM} + \sum \mathcal{O}_i \mathcal{O}^*_i$$

where $i$ run over the label of the four operators which are expressed as

\begin{align*}
\mathcal{O}_{1W} &= i\ell_i^\dagger B_{\mu
u} W^\mu W^\nu \{D_\mu, D_\nu\} H \\
\mathcal{O}_{1V} &= i\ell_i^\dagger B_{\mu
u} W^\mu W^\nu \{D_\mu, D_\nu\} H \\
\mathcal{O}_{2W} &= i\ell_i^\dagger B_{\mu
u} W^\mu W^\nu \{D_\mu, D_\nu\} H \\
\mathcal{O}_{2V} &= i\ell_i^\dagger B_{\mu
u} W^\mu W^\nu \{D_\mu, D_\nu\} H
\end{align*}

The coefficients of these four dimension-eight operators describing anomalous Neutral Triple Gauge Couplings (nTGC) are CP-conserving $C_{1,a}$ and CP-violating $C_{3,a}$, $C_{1V}$, $C_{3V}$, respectively. They are related to dimension-six operators aNTGC as described in Ref. [1].

RESULTS AND DISCUSSION
The current limits on dimension-eight aNTGC couplings $C_{1,a}$ and $C_{3,a}$ from ATLAS collaboration [Ref.[6]] compared with our expected limits at 95% C.L. for HL-LHC with $E_{T} = 3$ ab$^{-1}$, HE-LHC with $E_{T} = 15$ ab$^{-1}$ and FCC-hh with $E_{T} = 3$ ab$^{-1}$.

<table>
<thead>
<tr>
<th>Couplings (TeV$^{-4}$)</th>
<th>ATLAS</th>
<th>HL-LHC</th>
<th>HE-LHC</th>
<th>FCC-hh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{1,a}/\Lambda^4$</td>
<td>-1.1, +1.1</td>
<td>-0.27, +0.36</td>
<td>-0.12, +0.12</td>
<td>-0.084, +0.084</td>
</tr>
<tr>
<td>$C_{3,a}/\Lambda^4$</td>
<td>-0.24, +0.24</td>
<td>-0.20, +0.20</td>
<td>-0.085, +0.085</td>
<td>-0.072, 0.072</td>
</tr>
</tbody>
</table>

FCC-hh provides one order of magnitude better limits than latest LHC results (Ref.[6]) on dimension-eight aNTGC couplings $C_{1,a}$ and $C_{3,a}$. 

REFERENCES

ACKNOWLEDGEMENTS
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ANALYSIS AND SIMULATION DETAILS

CROSS SECTIONS

Event generation by MadGraph5_aMC@NLO [2]
signal and all background process

Parton Shower and Hadronization by PYTHIA 8 [3]

Fast Simulation by Delphes 3.4.1 [4] with FCC-hh.tcl
and CMS_phase1_140PU_conf4.tcl

All events are analyzed by ExRootAnalysis [5] utility