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A Triplet Track Trigger Case Study for FCC-hh: Enhancing the Measurement of Di-Higgs Production and Higgs Self-Coupling

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The Triple Track Trigger (TTT) concept is proposed for the FCC-hh detector to exploit the full potential of the unprecedented energy ($\sqrt{s} = 100\,\mathrm{TeV}$) and high luminosity ($30 \times 10^{-34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$) proton-proton (*pp*) collisions at FCC-hh. The primary objective of the TTT is to trigger physics at the electroweak scale in real time by significantly suppressing signals from the low energetic *pp* collisions at a *pileup* rate of $\sim\mathcal{O}(1000)$, assuming $25\,\mathrm{ns}$ bunch crossing.

The TTT concept is based on a highly scalable state-of-the-art monolithic pixel sensor technology comprising three closely stacked and highly granular pixel barrel layers at large radii ($\sim$1 m). An extension of the TTT to the endcap region increases the geometrical acceptance to a pseudorapidity of 2.5. A simple and fast algorithm, which can be implemented in hardware processors at the first trigger level, enables online reconstruction of all TTT tracks at $40\,\mathrm{MHz}$. Additionally, TTT enables the reconstruction of pileup-suppressed track-jets to trigger physics signals of interest by reconstructing the primary collision vertex with high efficiency.

This presentation focuses on a case study demonstrating the ability of the TTT to trigger the rare physics process of HH $\rightarrow 4b$ \[arXiv:2401.16046\]. Based on a Geant4 simulation of the FCC-hh detector including the TTT, both the tracking and the trigger performances have been studied. A comparison of the TTT with a calorimeter trigger, illustrates TTT's superiority to select HH $\rightarrow 4b$ events with an order of magnitude lower trigger threshold. Due to the lower trigger threshold, a substantial gain in sensitivity for measuring the Higgs self-coupling is expected. Last but not the least, a potential hardware implementation of the concept is outlined.

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