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The challenges of the HL-LHC for the Full and Fast Simulation of the CMS Experiment

Monte Carlo Simulation data for the CMS experiment are produced using two different software chains. Full Simulation, is a precise tool based on Geant4 detector simulation. The other tool, Fast Simulation, provides a faster but still reliable tool and is based on parametric particle-material interactions. Full Simulation for the LHC Run-3 has shown significant computing performance improvements compared to LHC Run-2. The challenging CMS detector upgrade plan for HL (High Luminosity)-LHC requires extra efforts due to the increased luminosity and a new and more complex detector geometry. Full Simulation plans to meet the requirements for HL-LHC, which includes continues migration to newer versions of Geant4 as well as further physics improvements. In Fast Simulation, a more efficient treatment of the generator particles during their propagation through the detectors was achieved. The increasing use of machine learning (ML) techniques in simulation leads to an enhanced description of physics processes and detector responses, which reduces the needed for computing capacity. This contribution reports the current Full and Fast Simulation performance innovations and developments to fulfill the significant higher Monte Carlo Simulation demands for HL-LHC. ML software tools already in use and new developments for Full and Fast Simulation and other promising simulation tools such as FlashSim are introduced.

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