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Geant4 Detector Simulations for Future HEP Experiments

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The experimental programs planned for the next decade are driving developments in the simulation domain; they include the High Luminosity LHC project (HL-LHC), neutrino experiments, and studies towards future facilities such as Linear Colliders (ILC/CLIC) and Future Circular Colliders (FCC). The next-generation detectors being planned for long-term future programs will have increased granularity. Detector simulation plays a crucial role in their design and conception. In order to achieve the desired precision in physics measurements, whilst avoiding that the simulation dominates the systematic uncertainties, more accurate simulations and larger Monte Carlo samples will be needed. This presents major challenges both for the development of more accurate models of physics interactions and for the performance of the software used to implement them. In this paper, we will discuss the status of the most widely used detector simulation toolkit, Geant4, in the context of detector R&D for present and future facilities. We highlight, in particular, the need to review some of the physics models'assumptions, approximations and limitations in order to increase precision, and to extend the validity of models up to FCC-hh energies (100 TeV). Results will be shown of recent major improvements in the multiple scattering model of electrons and positrons and a more accurate theoretical description of the Landau-Pomeranchuk-Migdal effect, which plays a significant role at high energies. We will outline the ambitious plans that are foreseen for the further theoretical review of major processes that are a high priority for future HEP experiments.

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