Experimental quantification of Geant4 PhysicsList recommendations: methods and results
S. H. Kim, M. G. Pia, M. C. Han, G. Hoff, C. H. Kim, P. Saracco

Geant4 recommends a set of PhysicsLists and related classes (Builders, PhysicsConstructors) to its user community to facilitate the use of Geant4 functionality despite its intrinsic physics complexity. Relative limited documentation is available in the literature regarding Geant4 physics configuration tools, especially concerning the quantification of their accuracy, their computational performance and the stability of their results.

We present the results of a comprehensive experimental quantification project concerning recommendations related to multiple scattering, which are implemented in the "constructors" package of Geant4 PhysicsLists. We show how these findings affect the simulation of energy deposition, both regarding the absolute value of the energy deposited in a volume and its spatial pattern, as well as other observables specifically pertinent to the treatment of multiple scattering.

In-depth analysis was carried out to quantify not only the behaviour of the recommended PhysicsConstructor classes of Geant4 physics_list package, but also of individual settings embedded in them, and their contribution to the overall simulation outcome. We report an extensive assessment of the accuracy, of the computational performance and of alternative settings of the physics configuration options subject to evaluation: all these aspects are quantified with respect to a wide collection of experimental test cases with rigorous statistical methods. This analysis is documented over several Geant4 versions to quantify the stability of the results.

The results of this project provide objective guidelines for the improvement of Geant4 physics models, of their recommended use and of experimental applications of Geant4. We discuss how the method developed for this assessment could be extended to other Constructors, Builders and complete PhysicsLists released within the Geant4 Toolkit.