

# Experimental quantification of Geant4 PhysicsList recommendations: methods and results

Tullio Basaglia<sup>1</sup>, Min Cheol Han<sup>2</sup>, Gabriela Hoff<sup>3</sup>, Chan Hyeong Kim<sup>2</sup>, Sung Hun Kim<sup>2</sup>, Maria Grazia Pia<sup>4</sup>, Paolo Saracco<sup>4</sup>  
<sup>1</sup>CERN, Geneva, Switzerland, <sup>2</sup>Hanyang University, Seoul, Korea, <sup>3</sup>CAPES, Brasilia, Brazil, <sup>4</sup>INFN Sezione di Genova, Italy

The Geant4 *physics\_lists* package encompasses predefined selections of physics processes and models to be used in simulation applications. Limited documentation is available in the literature about Geant4 pre-packaged *PhysicsLists* and their validation. The grounds for their assembly and the appraisal of their performance are mostly related to LHC experiments; assessments of their validity in other application environments are sparse. Quantitative estimates of the validity of the Geant4 physics models used in pre-packaged *PhysicsLists* and *PhysicsConstructors* are scarce in the literature. Comparisons of physics modeling components and simulated observables with experimental data often rest on qualitative appraisal, lacking objective quantification based on statistical methods.

Our scientific research contributes to this domain through a **rigorous validation strategy of Geant4 physics** and **extensive documentation of its results** in peer reviewed journals.

## Validation methods

Due to their intrinsic nature – an assembly of physics processes and models, Geant4 *PhysicsLists* can only be assessed over **specific use cases**, which in turn involve **specific observables** (*while individual physics models can be validated against experimental data independently from any specific application scenario*). Therefore it is essential to **document quantitatively their performance over a large number of experimental use cases**. Comparison with measured observables is quantified by statistical methods.

The body of knowledge deriving from this extensive validation effort provides **guidance to the experimental community** regarding the use of Geant4 pre-packaged *PhysicsLists* and *PhysicsConstructors*. Methods of **uncertainty quantification**, which allow the calculation of the uncertainty of simulated observables based on the uncertainty of model parameters, can be applied to predict simulation accuracy. This is a field of **ongoing active research**.

## Validation strategy

- Validation of the physics “ingredients” of Geant4 *PhysicsLists* and *PhysicsConstructors*: cross sections, secondary particle spectra, angular distributions etc.
- Validation of *PhysicsConstructors* and *PhysicsLists* over a wide variety of experimental scenarios

## 0.5 picometer makes a difference!

