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A Toolkit to Study Sensitivity of the Geant4 Predictions to the Variations of the Physics Model Parameters

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Geant4 is the leading detector simulation toolkit used in high energy physics to design
detectors and to optimize calibration and reconstruction software. It employs a set of carefully validated
physics models to simulate interactions of particles with matter across a wide range of interaction energies.
These models, especially the hadronic ones, rely largely on directly measured cross-sections and phenomeno-
logical predictions with physically motivated parameters estimated by theoretical calculation or measurement.
Because these models are tuned to cover a very wide range of possible simulation tasks, they may not always
be optimized for a given process or a given material.
This raises several critical questions, e.g.:
How sensitive Geant4 predictions are to variations of the model parameters ?
What uncertainties are associated with a particular tune of one or another Geant4 physics model, or a group
of models ?
How to consistently derive guidance for Geant4 model development and improvement from a wide range of
available experimental data ?
We have designed and implemented a comprehensive, modular, user-friendly software toolkit to study and
address such questions from the users community. It allows to easily modify parameters of one or several
Geant4 physics models involved in the simulation, and to perform collective analysis of multiple variants of
the resulting physics observables of interest and their statistical comparison against a variety of correspond-
ing experimental data.
Based on modern event-processing infrastructure software, the toolkit offers a variety of attractive features,
e.g. flexible run-time configurable workflow, comprehensive bookkeeping, easy to expand collection of ana-
lytical components.
Design, implementation technology, and key functionalities of the toolkit will be presented and illustrated
with results obtained with Geant4 key hadronic models.

Keywords: Geant4 model parameters variation, systematic uncertainty in detector simulation

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