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Validation of Geant4 Hadronic Physics Models at Intermediate Energies

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Geant4 provides a number of physics models at intermediate energies (corresponding to incident momenta in the range 1-20 GeV/c). Recently, these models have been validated with existing data from a number of experiments: (a) inclusive proton and neutron production with a variety of beams (piˆ-, piˆ+, p) at different energies between 1 and 9 GeV/c on a number of nuclear targets (from beryllium to uranium); (2) inclusive pion/kaon/proton production from 14.6 GeV/c proton beams on nuclear targets (from beryllium to gold); (3) inclusive pion production from pion beams between 3-13 GeV/c on a number of nuclear targets (from beryllium to lead). The results of simulation/data comparison for different Geant4 models are discussed in the context of validating the models and determining their usage in physics lists for high energy application. Due to the increasing number of validations becoming available, and the requirement that they be done at regular intervals corresponding to the Geant4 release schedule, automated methods of validation are being developed. These will also be discussed.

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Summary

Geant4 provides several models for hadronic processes each having its validity range in term of beam type or incident energy. For example, there are theory driven string models or parametrized model which are valid at high energies (for beam momenta above few ten's of GeV/c). At low energies there are cascade models or parametrized models to complement the high energy models. It is essential to find out the range of applicability of these models by examining them against available data.

Validation of physics models is an integral part of commissioning the model within Geant4 toolkit and has been performed from the very early days. This work is done either within the Geant4 collaboration using published data or by users with a complete description of their detector setup. The earlier studies were done with thin and thick target data. Comparisons with thin target data is rather crucial because it directly compares the models against data without the effect of other processes like particle propagation or electromagnetic physics effects.

This work includes three sources of data. The first set of data comes from an ITEP experiment which has carried out an extensive set of measurements on inclusive neutron and proton production in hadron-nucleus collision at energies between 1 and 9 GeV/c. The experiment measured Lorentz invariant double differential cross section as a function of kinetic energy of the final state particle at fixed angles in the laboratory frame.

The second set of data come from the BNL E802 experiment where measurements are made with proton beam at 14.6 GeV/c. Published data exist on inclusive production of charged pions, kaons and proton for a variety of nuclear targets ranging from beryllium to gold. The measured quantities are Lorentz invariant cross sections as a function of transverse mass in bins of rapidity.

The third set of data come from the HARP collaboration which measured inclusive pion production in pion-nucleus collision with beam momenta between 3 and 12.9 GeV/c. They measure inclusive momentum spectra of produced particles in certain solid angles.

These data are compared with the results from simulation for different Geant4 models and the comparison is used to validate the models and to determine their usage in physics lists for high energy application. Due to the increasing number of validations becoming available, and the requirement that they be done at regular intervals corresponding to the Geant4 release schedule, automated methods of validation are being developed. These will also be discussed.

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