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Intercomparision of Geant4 hadronic models in simulating the Highly-Granular Neutron Detector for the BM@N experiment

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The Geant4 toolkit is widely used in basic and applied sciences to model radiation propagation in matter [1,2]. Several hadronic models [3-5] are implemented in the Geant4 library to simulate nuclear reactions induced by different particles colliding with nuclei of various materials. The Geant-val web application [6] has been designed to validate model performance for specific tasks. Reference Physics Lists [7] (RPL) are recommended for detector simulation in particle and nuclear physics. RPLs combine models for different physical processes and particle energies because no single model applicable at all energies. Recently, simulation results for 20-200 GeV π- and e- interacting with ATLAS and CALICE calorimeters have been included [8] in the Geant-val web application.

The interactions of primary high-energy neutrons with calorimeters or other detectors are not yet included in Geant-val. In this work the modeling of the Highly-Granular Neutron Detector (HGND) [9], which was constructed for the BM@N experiment at NICA, is proposed to fill this gap. The HGND was constructed to detect neutrons with kinetic energy of 0.3-4 GeV, which are produced in nucleus-nucleus collisions, in particular, in nuclear fragmentation and electromagnetic dissociation (EMD) of 3.8A GeV 124Xe on CsI target [10]. In the BM@N setup equipped with a large magnet, forward spectator neutrons and neutrons from EMD can be separated from forward spectator protons and directed to HGND. The HGND consists of alternating layers of absorbers and scintillators. It is modeled with Geant4 v11.3 using the Bertini Cascade [3], Binary Ion Cascade [4] and INCL [5] models, implemented in the respective RPLs. Signals from the different scintillator layers are calculated using these three options and then compared. The feasibility of benchmarking Geant4 hadronic models with future HGND data is evaluated.

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