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Applications of Geant4 simulation methods in studies of nuclear processes

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Geant4 is a toolkit for Monte Carlo simulations of the particle transport through matter. It has a complete set of routines for modelling particle trajectories and interactions: geometry and materials, physical processes, event generation, detector response and analysis and visualisation. It has been used in wide range of applications in high energy, nuclear and accelerator physics, as well as in studies in medical and space science.

The low-background underground laboratory at the Institute of Physics Belgrade is a facility for gamma-ray spectroscopy measurements and for measurements of the cosmic-ray muon intensity. Related to the two research objectives, studies of the cosmic-ray muon induced background in gamma-ray spectroscopy is of particular interest. In these experiments various Monte Carlo based simulations (Geant4, CORSIKA) have been extensively used.

Continuous measurements of the cosmic-ray muon intensity at the ground and the underground levels have been done since 2002, by means of plastic scintillation detectors. The detector response, interpretation of the experimental spectra and their calibration have been done and verified using Geant4 based simulation. The results of the simulations were used for calculation of the muon fluxes at the ground and the underground levels [1].

The scintillation detector in the underground laboratory can operate in coincidence with HPGe gamma-ray detector. A simulation of the coincident response of the two detectors to the cosmic-ray muons has been made in order to determine the muon contribution to the background spectrum of the HPGe detector [2]. The cosmic-ray muons contribute to the background through production of particles in detector surroundings. In low-level gamma spectroscopy, neutrons are produced in the lead shielding of an HPGe detector. The Geant4 simulation of the muon induced neutron production in lead has been developed. It can also be used for the simulation of production of nuclei in rock or soil.

The Geant4 toolkit has been widely applied in efficiency calibration of HPGe detectors in gamma-ray spectroscopy measurements. The main problem with this method is an imprecise detector description; the detector parameters initially are not well defined and certain parameters deteriorate with time. Therefore the simulation models need to be optimised in order to obtain the best possible agreement with experimental results. Several studies on uses of the Geant4 based simulations in calculation of efficiency of HPGe detectors have been performed, applied to different detector assemblies [3,4].

References

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