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Monte Carlo simulations of background characteristics of Ge detectors operating in the Gran Sasso underground laboratory

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Content

If a low-background Ge spectrometer would be constructed from selected radioactivity-free materials, the dominating background component in surface or shallow underground laboratories should be due to cosmic rays. This is due to the fact that the flux of soft component cosmic-ray particles (electrons, positrons, gamma-rays) can be considerably decreased by their absorption in materials with high atomic number, e.g. lead, iron or copper. On the other hand, the flux of hard component cosmic-ray particles (muons) can be decreased only by installation of detectors deep underground, or a partial decrease can be achieved by installation of an anticosmic shielding. The typical background of Ge detectors is consisting therefore of cosmic-ray induced component, a radioactive contamination of construction parts of the detector and a contamination of materials found in the laboratory. It has been expected therefore, that in a deep underground laboratory (a several thousands of meters of water equivalent, w.e.), the influence of cosmic rays on the detector background should be negligible, and the dominating component would be a radioactive contamination of construction materials. The aim of our work has been a developing of a computing code that would allow an evaluation of background components of low-level Ge gamma-spectrometers, even in the designing stage, before their construction and installation in a deep underground laboratory. The simulation code is based on the GEANT 4 package developed at CERN. The idea was then to compare background gamma-ray spectra measured in a deep underground laboratory with predicted ones obtained from Monte Carlo simulations. Monte Carlo simulations of background components of low-level Ge gamma-ray spectrometers operating in a deep (about 1400 m of rock, providing about 3400 m w.e.) Gran Sasso underground laboratory was carried out. The experimental results showed that the total background of the HPGe detectors has been by about two orders of magnitude higher than the Monte Carlo predictions when only cosmic-ray induced background has been included in the comparison. The higher measured background should be due to radioactive contamination of the construction parts surrounding the Ge crystal, as well as due to presence of radon and its decay products in the laboratory. The contamination levels of the primordial radionuclides surrounding the Ge detector were required to be set in the Monte Carlo model at 1 mBq/kg for 40K, 0.1 mBq/kg for 232Th and 0.1 mBq/kg for 238U to get an agreement with the measured gamma-ray spectra.

About the Presenter

P. P. Povinec
Department of Nuclear Physics and Biophysics, Faculty of Mathematics, Physics and Informatics, Comenius University, 84248 Bratislava, Slovakia

Primary author(s) : Dr. BREIER, Robert (Comenius University in Bratislava)

Co-author(s) : Dr. LAUBENSTEIN, Matthias (Laboratori Nazionali del Gran Sasso, Assergi, Italy); Prof. POVINEC, Pavel (Comenius University in Bratislava)

Presenter(s) : Prof. POVINEC, Pavel (Comenius University in Bratislava)

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