Abstract

In modern astroparticle physics and cosmology, the nature of Dark Matter is one of the central problems. Particle Dark Matter in form of WIMPs is favoured among many proposed candidates. The EDELWEISS direct Dark Matter search uses Germanium bolometers to detect these particles by nuclear recoils. Here, the use of two signal channels on an event-by-event basis, namely the heat and ionisation signal, enables the detectors to discriminate between electron and nuclear recoils. This technique leaves neutrons in the underground laboratory as the main background for the experiment. Besides (α,n) reactions of natural radioactivity, neutrons are produced in electromagnetic and hadronic showers induced by cosmic ray muons in the surrounding rock and shielding material of the Germanium crystals. To reach high sensitivities, the EDELWEISS-II experiment, as well as other direct Dark Matter searches, has to efficiently suppress this neutron background.
The present work is devoted to study the muon-induced neutron flux in the underground laboratory LSM and the interaction rate within the Germanium crystals by using the Monte Carlo simulation toolkit *Geant4*. To ensure reliable results, the implemented physics in the toolkit regarding neutron production is tested in a benchmark geometry and results are compared to experimental data and other simulation codes. Also, the specific energy and angular distribution of the muon flux in the underground laboratory as a consequence of the asymmetric mountain overburden is implemented. A good agreement of the simulated muon flux is shown in a comparison to preliminary experimental data obtained with the EDELWEISS-II muon veto system. Furthermore, within a detailed geometry of the experimental setup, the muon-induced background rate of nuclear recoils in the bolometers is simulated. Coincidences of recoil events in the Germanium with an energy deposit of the muon-induced shower in the plastic scintillators of the veto system are studied to determine the veto efficiency. Finally, the remaining background rate of muon-induced bolometer hits after applying the veto condition is approximately $\Gamma_{\mathrm{bg}} \lesssim 10^{-5}\mathrm{kg}^{-1}\mathrm{d}^{-1}$. The muon detection efficiency in the simulations of the EDELWEISS-II veto system corresponds to $(99.94 \pm 0.01\ ^{+0.06}_{-0.1})\%$. This translates to a potential reduction of the muon-induced background in the order of $R \approx \mathcal{O}(10^3)$. As a result of this work, the sensitivity of the EDELWEISS-II experiment is in principle not limited by muon-induced background down to a WIMP-nucleon cross section in the range of 10^{-10}pb.