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Application of GEANT4's Importance Biasing in radiogenic background simulations

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Experiments which aim to measure extremely rare events such as the direct detection of dark matter or coherent elastic neutrino-nucleus scattering are in need of low-background environments to be able to observe a potential signal and distinguish it from the present background. Furthermore, it is crucial to understand the background composition of the measured energy spectra to explore new regions of interest with statistical methods such as a profile likelihood approach.

In order to reach these goals, such experiments are located in underground laboratories and their detectors are surrounded by several layers of shielding material to protect them from external radiation.
Typically, a shield is composed of $\mathcal{O}(10)$ cm of lead to absorb γ-rays and thick layers of polyethylene to thermalize and absorb neutrons. Consequently, the corresponding Monte Carlo simulations based on GEANT4 require a huge amount of primary particles to be propagated through the experiment's geometry to achieve sufficient statistics inside the detectors. Nevertheless, the simulated energy spectra in the detectors lack in statistics which propagates into large uncertainties in the background composition.

GEANT4 offers a mechanism called Importance Biasing which can increase the amount of detector hits by orders of magnitude for the same number of primary events. This is achieved by intentionally duplicating particles which propagate into the direction of the detectors while aborting particle tracks that travel away from the detectors.
This talk will present the challenges of implementing Importance Biasing in the GEANT4 application developed by the SuperCDMS collaboration and will discuss the achieved efficiency boost of the respective background simulations.

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