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Geant4 simulation of optical photon transport in monolithic crystal scintillator with readout by silicon photomultiplier array.

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GEANT4-based Monte Carlo simulation has been performed for a cylindrical shape single-crystal scintillators in order to evaluate the possibility of using position sensitive response of the silicon photomultiplier (SiPM) array to perform gamma sources localization with the target on pulsed fast neutron analysis (PFNA). PFNA utilized microsecond wide fast neutron pulses produced by electronic neutron generator to initiate fast neutron inelastic scattering reactions on nuclei. Characteristic combination of prompt γ-rays from nitrogen, carbon and oxygen nuclei excitations is an evidence of presence explosive materials. Since the fluorescence decay time of widely used and relatively cheap NaI, BGO and CsI scintillators can reach 300-1000 ns, pulse pile-ups become serious problem that cause resolution degradation, spectral distortion and peak position shift. In this case the choice is to use fast LaBr3(Ce) scintillator with <30 ns decay time. But this scintillator is 10-20 times more expensive and has relatively high intrinsic radiation background. To address these issues cylindrical shape monolithic scintillators directly coupled SiPMs arrays for double side readout were simulated using Geant4 optical transport. According to preliminary simulation results high energy gamma rays in the range 4-7 MeV undergo multiple Compton scattering inside the simulated 2”×2” cylindrical crystal several percent of such events form the scattering and absorption clusters spatially separated. Calculating center of gravity of this clusters allow to apply Compton imaging method to localize gamma source. Additionally, cluster analysis allow to separate gamma scattering events from alpha particle absorption events which are the main source of intrinsic background of LaBr3(Ce) scintillator thus improving its detection sensitivity. Besides, in case of two gamma quanta hitting the crystal simultaneously cluster analysis can recognize such events and reject pile-up pulses. This will allow to use relatively slow NaI(Tl) and BGO scintillators for imaging gamma sources for the PFNA application.

Collaboration

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