Modeling and diagnostics of uranium gamma activation after passage through 10 cm of iron

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A comprehensive numerical approach to the remote detection of fissile materials concealed behind massive metallic shielding using laser-driven gamma radiation is presented. In the first stage, Particle-In-Cell (PIC) simulations are employed to model electron acceleration from solid targets irradiated by an ultra-short laser pulse (20 fs, 2 J). The resulting electron energy and angular distributions are used as input for GEANT4 simulations of bremsstrahlung generation in a converter, demonstrating a high conversion efficiency into gamma quanta with energies above 7.5 MeV.

The propagation of the high-energy gamma flux through 7–10 cm thick iron shielding and its interaction with a uranium-containing sample are subsequently investigated. Photoneuclear reactions, including (,n), (,2n), and (,f), are modeled, leading to the emission of fast and delayed neutrons as well as the formation of neutron-deficient unstable nuclei.

It is shown that under high gamma fluence conditions a measurable induced radioactivity is produced, giving rise to characteristic gamma lines persisting for minutes to hours after the laser pulse. This delayed emission enables spectral measurements in a time-separated (“slow”) regime with reduced prompt background. A combined analysis of energy-dependent signatures and time windows (prompt, neutron-induced, and activation-related components) demonstrates the feasibility of a laser-driven gamma activation method for selective identification of the composition and burial depth of shielded fissile materials.