Abstract

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Genetic Algorithm Optimization of Tin-Copper Graded Shielding for Improved Plutonium Safeguards Measurements

International nuclear safeguards, which are used to control special nuclear material such as plutonium, are quintessential to global security and safety. Recently, more interest has been shown in detection systems based on organic scintillators for safeguards applications as opposed to the current state-of-the-art He-3 based systems. The advantages of using organic scintillators over the current state-of-the-art include shorter measurement times and sensitivity to both neutrons and photons. The problem faced when using organic scintillators for plutonium safeguards measurements is data throughput limitations. Organic scintillators experience data throughput limitations due to the buildup of Am-241 in plutonium samples. This isotope emits 60-keV gamma rays with high specific activity. In this work, a genetic algorithm is used to design graded shielding made of tin and copper that preferentially shields low-energy gamma rays from Am-241, while simultaneously allowing higher-energy, fission photons to pass through. The genetic algorithm optimization conservatively takes two days to run, while simulating every possibly shielding configuration would take years. The genetic algorithm was run for different levels of 60-keV gamma-ray attenuation, and one of the designs was fabricated. The shielding was placed in front of an array of 12 cylindrical, 5.08 cm by 5.08 cm diameter trans-stilbene organic scintillation detectors for a measurement of approximately 4.5 kg of alpha-phase, weapons-grade plutonium, an AmLi source, and a Cf-252 source. The shield was successfully able to attenuate low-energy, non-fission gamma rays, which significantly improved the organic scintillator performance.