

Nuclear Science and Technology Division

Nuclear Materials Identification by Photon Interrogation

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Introduction

The detection of shielded highly enriched uranium poses serious technical challenges that are being addressed by numerous researchers. The spontaneous fission rate in uranium is, in fact, very small and active methods are often necessary to induce fission in the material, thus generating secondary neutrons and gamma rays that can be detected. Numerous methods have been proposed that make use of neutrons or photons as sources for the interrogation of containers that might conceal highly enriched uranium. For example, methodologies have been proposed that make use of 14 MeV DT neutron sources to interrogate shipping containers and detectors to measure the delayed neutrons from the induced fission.

Problem being addressed

The present study concerns the use of high energy photons to interrogate shipping containers. A possible scenario could be, for example, the interrogation of sea land containers arriving at a port of entry. High energy photons interact with the materials in the container via photoatomic collisions such as Compton scattering and pair production and via the less common photonuclear collisions. The latter are predominantly γ , n and γ , 2n for regular materials, and include γ , fission for the actinides. In the actinides, the photofission cross sections are of the order of 500 mb at photon energies in the 10-15 MeV energy range. Photofission, like neutron-induced fission, generates a multiplicity of neutrons and gamma rays which can be used to devise measurements that are sensitive to actinides.

We are devising a method that relies on the use of organic scintillators to detect fast neutrons and gamma rays from the photofission events. Figure 1 shows an example of the time-dependent coincidence function measured by two organic scintillators when a fission source (in this case, a Pu-240 spontaneous fission source) is placed between them. The signature was obtained using the MCNP-PoliMi code [1]. The signature is composed of four contributions corresponding to the two particle type — neutrons and photons. Two photons reaching the detectors arrive at time lag zero because their speed is the same. Neutrons arrive at the detectors with different speeds and, therefore, register a pulse at different time lags.

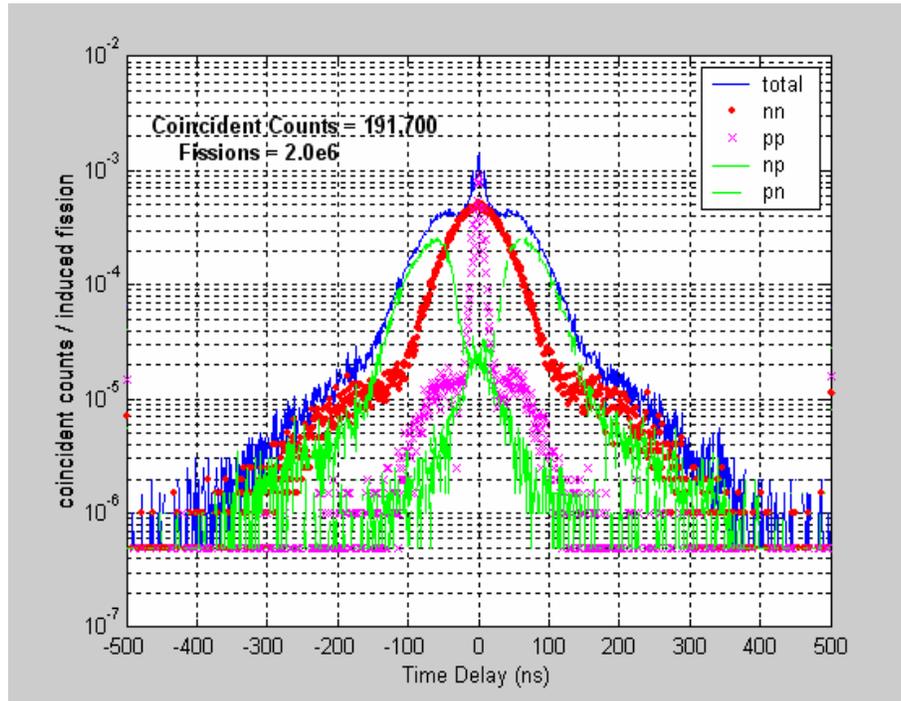


Fig. 1. Time-dependent coincidence function measured by two organic scintillators when a fission source is placed between them.

The design and analysis of correlation measurements, as shown in Fig. 1, rely on the use of Monte Carlo codes to simulate the interaction of neutrons and photons with the material under investigation. Currently, there is no Monte Carlo code available to simulate measurements based on photonuclear interactions with the accuracy needed to correctly model correlation measurements.

Proposed solution

In the present paper, we present preliminary results from a modification of the Monte Carlo codes MCNPX [2] and MCNP-PoliMi. We show how these two codes can be used to simulate measurements based on photonuclear interrogation. The modified codes are able to track photonuclear events and their progeny. An application of the use of this code in the interrogation of luggage using a 20 MeV LINAC source is described.

References

1. S. A. Pozzi, E. Padovani, M. Marseguerra, "MCNP-PoliMi: A Monte Carlo Code for Correlation Measurements," Nuclear Instruments and Methods in Physics Research A, 513/3 pp. 550-558, 2003.
2. J. S. Hendricks and G. W. McKinney, MCNPX Version 2.4.J, LA-UR-02-2127, Los Alamos National Laboratory, 2002.