NaI(Tl) detector's model using the MCNP-X code

C.M. Salgado[1], L.E.B. Brandão[1]
e-mail: otero@ien.gov.br, brandao@ien.gov.br

[1] *DIRA, IEN*

Keywords: MCNP-X code; NaI (Tl) detector; Gamma spectrometry.

In this study, the Monte Carlo method was used to calculate the photon detection efficiency and energy resolution curves of a planar a 1¾ "x ¼" NaI(Tl) scintillator detector exposed to gamma rays in energy ranging from 20 keV to 662 keV [1]. The detector was modeled with the MCNP-X code. The methodology consists of the mathematical modeling of the detector and simulation by the Monte Carlo method. The detector's model was based on information from the picture detector using the gammagraphy technique. As shown in Fig. 1, it was possible to estimate the detector's dimensions used in this work with precision. Both the detector's crystal dimension and the surrounding materials dimension, which reduce the incidence of photons, must be considered and well characterized. The crystal dimensions must be as accurate as possible, so as to avoid great errors while determining the photon detection efficiency of the detector.

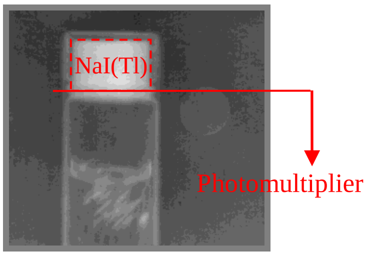

Figure 1. NaI(Tl) detector gammagraphy.

Both material information and the detector's dimension are used for calculations using the mathematical code. These are important information which allows the simulation to present values which may represent the reality of the experiment. The MgO powder density was 2.0 g.cm^{-3}. The photomultiplier on the back of the crystal was treated as 30 mm thick aluminum disk. Fig. 2 represents the NaI(Tl) detector's model showing the different regions, material and surfaces (planes and cylinders) considered in the detector's modeling. This information is necessary for the calculations using the code. The aluminum disk at the base of the detector represents all the materials after the crystal, such as the photomultiplier. To improve the response obtained by simulation of detectors in the code it is necessary to use a special treatment for distributions of pulse height (PHD), in which the energy peak behaves as a Gaussian function broadening.

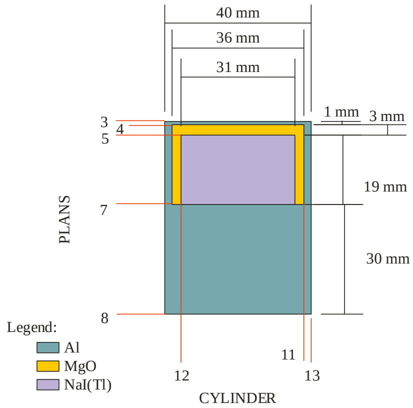

Figure 2. Schematic representation of the NaI(Tl) detector considered in simulation.

The effect of the energy resolution on the PHD, obtained by code by the detector under the energy of 662 keV (simulated only to the bare NaI(Tl) hypothetical crystal) is shown in Fig. 3.

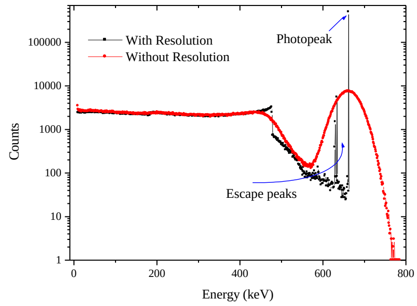

Figure 3. PHD by the MCNP-X code for bare NaI(Tl) crystal considering the effect of energy resolution.

The mathematic code presents the PHD as results, after running the detector's simulation. So that it is necessary to inform, for the mathematical code, the parameters of the real energy resolution of the detector obtained by experimental measurements. The modeling of a detector by means of the code correctly validated with experimental measurements is an important step in the practical implementation.

References

[1] SALGADO, C. M. et al. Validation of a NaI(Tl) detector's model developed with MCNP-X code. **Progress in Nuclear Energy**, Oxford, v. 59, p. 19-25, 2012.