Calculation of efficiency of NaI(Tl) detectors using the transfer method and the MCNP-X code

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The detection systems based on NaI(Tl) detectors have high absorption efficiency in the detection of high energy gamma rays, allowing the use of low activity radiation sources, which reduces the shielding and radiation protection requirements [1]. The use of NaI(Tl) detectors for measurements implies the determination of the response efficiency curve of the detector as function of the energy of the incident photon. The Efficiency Transfer Method (MTE) that is based on the ratio of effective solid angles will be used [2]. This method saves time, resources and allows you to calculate efficiency in different positions without the need to repeat a new measurement with a new source repositioning. In order to provide data for the use of MTE, a mathematical model with a NaI(Tl) detector was developed using the MCNP-X code [3]. In this way, this work studies two different ways of obtaining the detection efficiency of radiation detectors, especially the MTE method.

Efficiency Transfer Method

It is a modern method to calculate the efficiency absolute of photopeak by correlating the effective solid angle between the source and the detector. By providing the efficiency value of a source at a point P_1, it is possible to obtain the efficiency response at a different point P_2, using the Equation 1.

$$E_1 = \frac{E_2.\Omega_2}{\Omega_1} \quad (1)$$

Where:
E_n= Efficiency with respect to position P_n,
Ω_n= Solid angle relative to source-detector system at position P_n.

Model developed by MCNP-X code

The simulation of detector in the MCNP-X code was based on data from previously published work [1]. A schematic of the source and detector is shown in Figure 1. Objects around the apparatus, such as the source holder, were not considered.

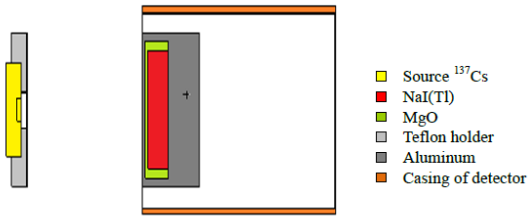

Figure 1. Mathematical model

The results obtained by the mathematical model using the MCNP-X code were compared in order to provide more data reliability to test the Efficiency Transfer Method (MTE). Table 1 shows a comparison of the data obtained with the MCNP-X code and the MTE.

Table 1. Comparisons between MCNP-X code and MTE.

	Efficiency		
DFD (cm)	MCNP-X	MTE	ERROR %
10.6	0.0384	0.0379	1.30
11.3	0.0333	0.0338	-1.32
12.0	0.0301	0.0303	-0.59

It is possible to observe that the values obtained by the MTE are very close compared to the simulated ones, this shows that the model developed in the MCNP-X code was well represented and that the MTE method is valid for this geometry. The mathematical model developed in the MCNP-X code presents good agreement when compared to the MTE with relative errors lower than 1.4%. The results indicate the possibility of applying the MTE in the calculation of photopeak absolute efficiency.

References

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