MCNP6 code in source-detector solid angle calculation

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Nuclear techniques based on the attenuation of gamma radiation are used in the industry to calculate flow rate, determine fluid density, predict inorganic scale in oil pipelines, evaluate industrial mixers, among other applications. In order to use these nuclear techniques is necessary to perform studies of important parameters of radioactive source and radiation detectors, which are part of the measurement geometry, such as detection efficiency and solid angle. The aim of this report is to calculate the solid angle subtended by a hypothetical detector using the MCNP6 code [1]. The results of the simulations were compared with reference results found in the literature using relative error (RE%). These cases were simulated using a ^{137}Cs (662 keV) point isotropic source (4-π) and an upright circular cylinder. The detector has 10 mm of radius and 20 mm of length. The source is placed in six different positions (S_0, S_1, S_2, S_3, S_4 and S_5) as follows Figure 1 [2].

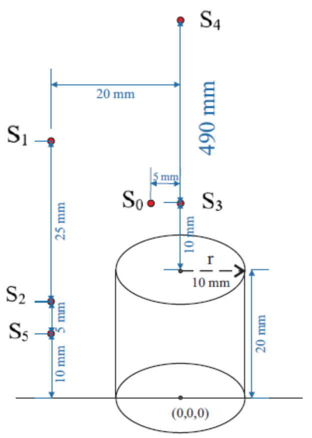

Figure 1. Different positions of the point isotropic source

The solid angle (Ω) values of source positions in the collinear axis of the detector (S_3 and S_4) were compared to Equation 1, where d is the distance source-detector and R is radius of the detector, as follows Table 1.

$$\Omega = 2\pi\left(1 - \frac{d}{\sqrt{d^2 + R^2}}\right)$$

Equation 1

Table 1 - Values of solid angle calculated by MCNP6 code and by Equation 1

Position	Ω MCNP6	Ω Equation 1	RE (%)
S_3	1.8395	1.8403	0.0436
*S_4	0.0012	0.0012	0

*S_4 difference in Ω was beyond fourth decimal place.

The values of the solid angles calculated by means of the MCNP6 and compared to the literature are in Table 2. Column Ω_1 represents the values of MCNP6 tally card F1 and column Ω_2 are the values obtained by Masket et al. (1956) [3]. It is important to note that in positions S_0, S_3 and S_4 the detector was set to a disk shape.

Table 2 - Solid angle calculations using MCNP6 code and results found in the literature

Position	Ω_1	Ω_2	RE (%)
S_0	1.6366	1.6371	0.0305
S_1	0.3792	0.3791	0.0264
S_2	1.2624	1.2624	0
S_3	1.8395	1.8403	0.0435
*S_4	0.0012	0.0012	0
S_5	1.3901	1.3899	0.0144

*S_4 and S_2 difference in Ω was beyond fourth decimal place.

These results indicate that the proposed methodology is able to calculate the solid angle in agreement with the values found in the literature. More information can be found in DAM et al., (2019) [2].

References

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