2011 International Nuclear Atlantic Conference - INAC 2011
Belo Horizonte,MG, Brazil, October 24-28, 2011
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
***ISBN:* 978-85-99141-04-5**

COMPARISON BETWEEN THE EFFICIENCIES OBTAINED BY MONTE CARLO METHOD AND THOSE OBTAINED EXPERIMENTALLY FOR POINT SOURCES

Josenilson B. Lima and Ademar J. Potiens Jr

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
jblima@ipen.br and apotiens@ipen.br

ABSTRACT

The Radioactive Waste Characterization Laboratory of Nuclear and Energy Research Institute has as one of the goals the primary characterization of the waste through alpha, beta, and gamma spectrometry. These wastes must be properly characterized and treated to meet the acceptance criteria for final disposal. One of the main difficulties in the detectors calibration process is to obtain their counting efficiencies. A solution to this case is the use of mathematical techniques that avoid the production of calibration standards, preventing the generation of additional waste. A mathematical technique widely used is the Monte Carlo method, which simulates the radiation transport in the middle, thus obtaining the efficiencies of the detectors. The aim of this study was to compare the results obtained by Monte Carlo method simulation with the experimental results for point sources of Co-57, Co-60, Cs-137 and Am-241. Comparing the two methods we can conclude that is possible to use the Monte Carlo method for calibration of the detectors.

1. INTRODUCTION

The Radioactive Waste Characterization Laboratory of Nuclear and Energy Research Institute has as one of the goals the primary characterization of the waste through alpha, beta, and gamma spectrometry. Among the various steps that comprise the management of radioactive waste, the characterization is the step where is produced the documentation that contains information on chemistry, physics and radiological characteristics of these waste, and with such information is possible to adopt an appropriate method of treatment so that they meet the acceptance criteria for their interim storage or final disposal [1]. How this information is obtained through practical analyses using the laboratory spectrometry equipments, quality control efficiencies of such equipment becomes necessary, it gives reliability and traceability of the results obtained experimentally by the laboratory. One of the greatest difficulties in the detectors calibration process is to obtain their counting efficiencies, that are related to variables such as source geometry, energy source, distance from the source to the detector and other. A solution to this case is the use of mathematical techniques that avoid the production of calibration standards, preventing the generation of additional waste. A mathematical technique widely used is the Monte Carlo method, which simulates the radiation transport in the middle, thus obtaining the efficiencies of the detectors. This method enables simulations of complex systems in a simple, even if the principle is not necessary to know the associated kinetic equation and to perform simulations just that used random numbers [2]. Because of its simplicity Monte Carlo simulations is being investigated in different detectors configurations and point sources in general [3]. The method consists in

obtaining the efficiencies of theoretical way, positioning the source at different distances from the detector. The aim of this study was to compare the results obtained by Monte Carlo method simulation with the experimental results for point sources of Co-57, Co-60, Cs-137 e Am-241.

2. MATERIALS AND METHODS

The work began obtaining the experimental counting efficiencies, through the measurements increasing distance from source-detector observing the positions and distances shown in table 1. All analyses were performed with the counting time of 18000s, for Co-57, Co-60, Cs-137 and Am-241 point sources. The equipment used for the measurements was the Hyperpure Germanium detector (HPGe) from Canberra, model GX2518, inside a lead shielding whose walls are 10 cm thickness. The images of sources and detection system are showed in Fig. 1. The system also has an electronic setup composed of a high voltage source, an amplifier and a multiport multichannel analyzer coupled to a microcomputer. This whole system is managed by acquisition software Genie 2000 from Canberra. Mathematical modeling was done taking the dimensions off all equipment that comprises the measurement system, including point sources used. The radiation transport simulations by Monte Carlo method were performed using MCNP software installed on a Pentium 4 microcomputer.

Table 1. Source position and source-detector distances

Position	2	4	6	8	10	12
Distance (mm)	18.82	36.20	56.38	76.35	96.54	115.8

Figure 1. Detection system and point sources used in this work.

3. RESULTS AND DISCUSSION

The results obtained experimentally and through theoretical simulations using the Monte Carlo method are presented in the following. The Fig. 2 shows the comparison of the relative efficiencies obtained experimentally and through Monte Carlo simulations for the point source of Co-57 (122kev).

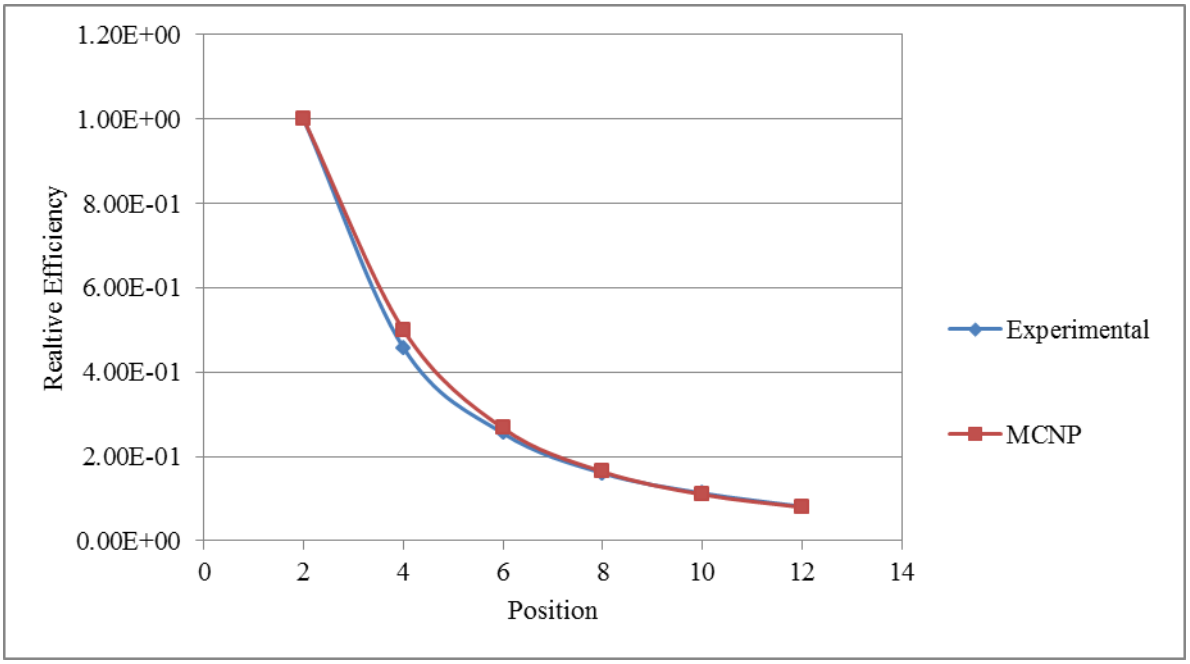

Figure 2. Comparison of the efficiencies obtained experimentally and by MCNP simulations for the point source Co-57 (122 kev).

The table 2 presents the position, distance from source to detector and percent differences between experimental and simulated efficiencies for point source of Co-57 (122 kev).

Table 2. Percent differences between experimental and simulated efficiencies for Co-57 (122 kev) point source

Position	Distance (mm)	Percent difference (%)
2	18.82	0
4	36.20	8.43
6	56.38	4.48
8	76.35	2.06
10	96.54	2.86
12	115.8	2.52

The Fig. 3 shows the comparison of the relative efficiencies obtained experimentally and through Monte Carlo simulations for the point source of Co-57 (136kev).

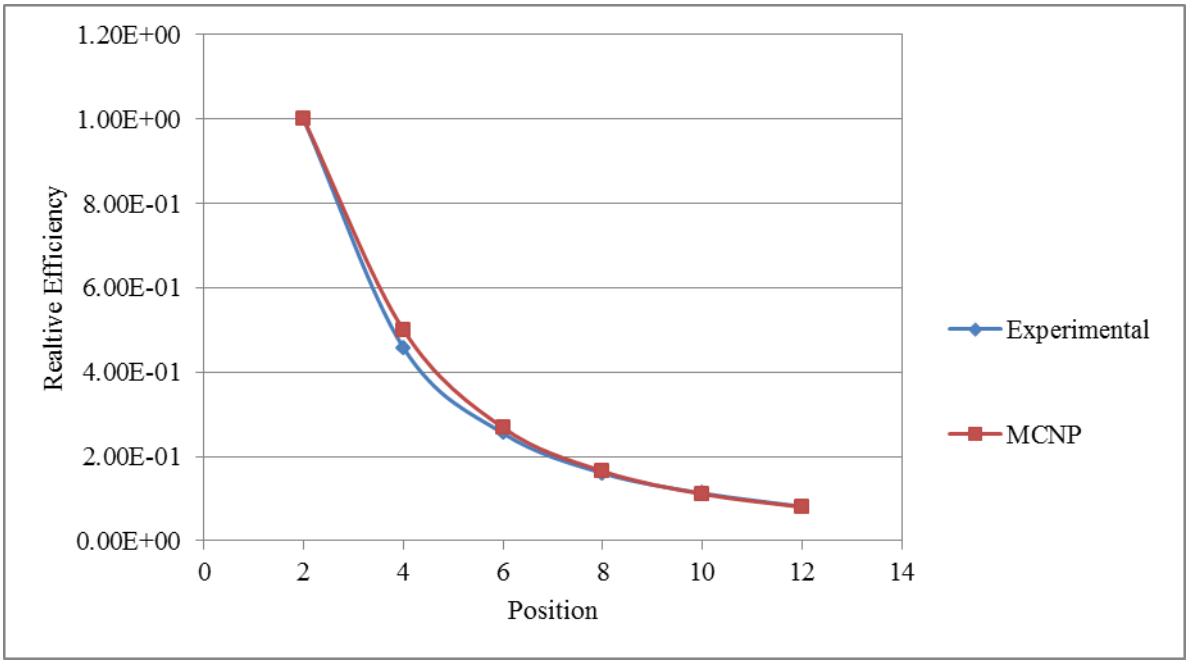

Figure 3. Comparison of the efficiencies obtained experimentally and by MCNP simulations for the point source Co-57 (136 kev).

The table 3 presents the position, distance from source to detector and percent differences between experimental and simulated efficiencies for point source of Co-57 (136kev).

Table 3. Percent differences between experimental and simulated efficiencies for Co-57 (136 kev) point source

Position	Distance (mm)	Percent difference
2	18.82	0
4	36.20	8.44
6	56.38	4.93
8	76.35	2.84
10	96.54	1.78
12	115.8	1.55

The Fig. 4 shows the comparison of the relative efficiencies obtained experimentally and through Monte Carlo simulations for the point source of Co-60.

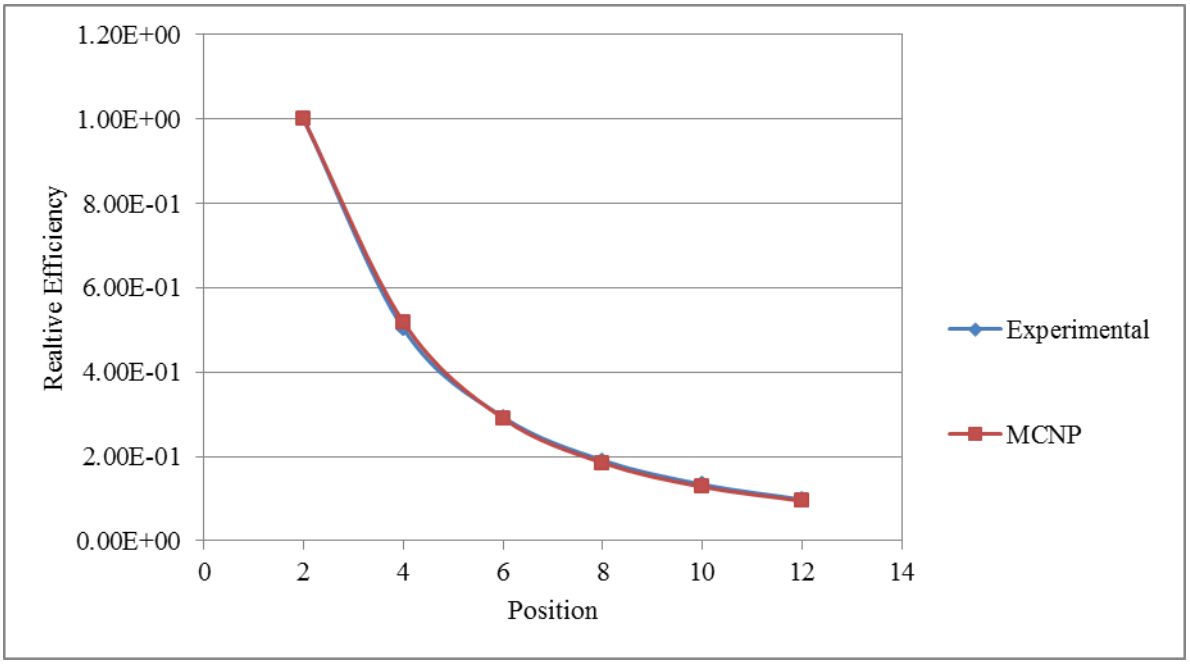

Figure 4. Comparison of the efficiencies obtained experimentally and by MCNP simulations for the point source Co-60.

The table 4 presents the position, distance from source to detector and percent differences between experimental and simulated efficiencies for point source of Co-60.

Table 4. Percent differences between experimental and simulated efficiencies for Co-60 point source

Position	Distance (mm)	Percent difference
2	18.82	0
4	36.20	2.98E-02
6	56.38	9.99E-03
8	76.35	3.16E-02
10	96.54	4.49E-02
12	115.8	3.31E-02

The Fig. 5 shows the comparison of the relative efficiencies obtained experimentally and through Monte Carlo simulations for the point source of Cs-137.

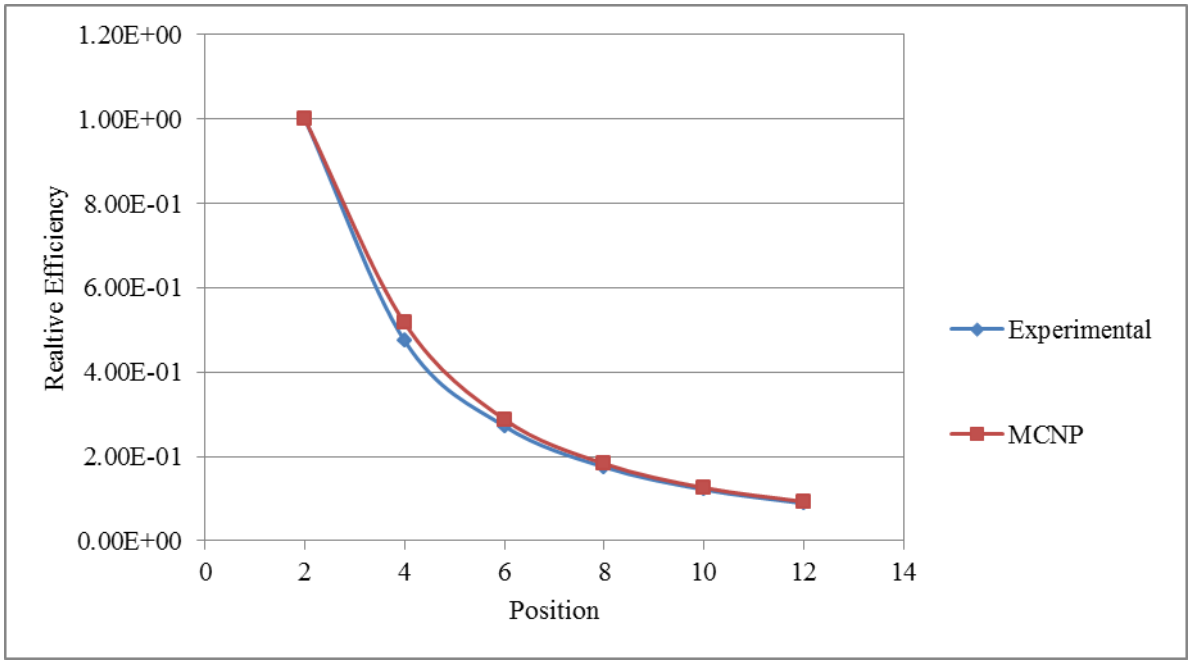

Figure 5. Comparison of the efficiencies obtained experimentally and by MCNP simulations for the point source Cs-137.

The table 5 presents the position, distance from source to detector and percent differences between experimental and simulated efficiencies for point source of Cs-137.

Table 5. Percent differences between experimental and simulated efficiencies for Cs-137 point source

Position	Distance (mm)	Percent difference
2	18.82	0
4	36.20	5.01E-01
6	56.38	5.30E-01
8	76.35	5.51E-01
10	96.54	5.52E-01
12	115.8	5.44E-01

The Fig. 6 shows the comparison of the relative efficiencies obtained experimentally and through Monte Carlo simulations for the point source of Am-241.

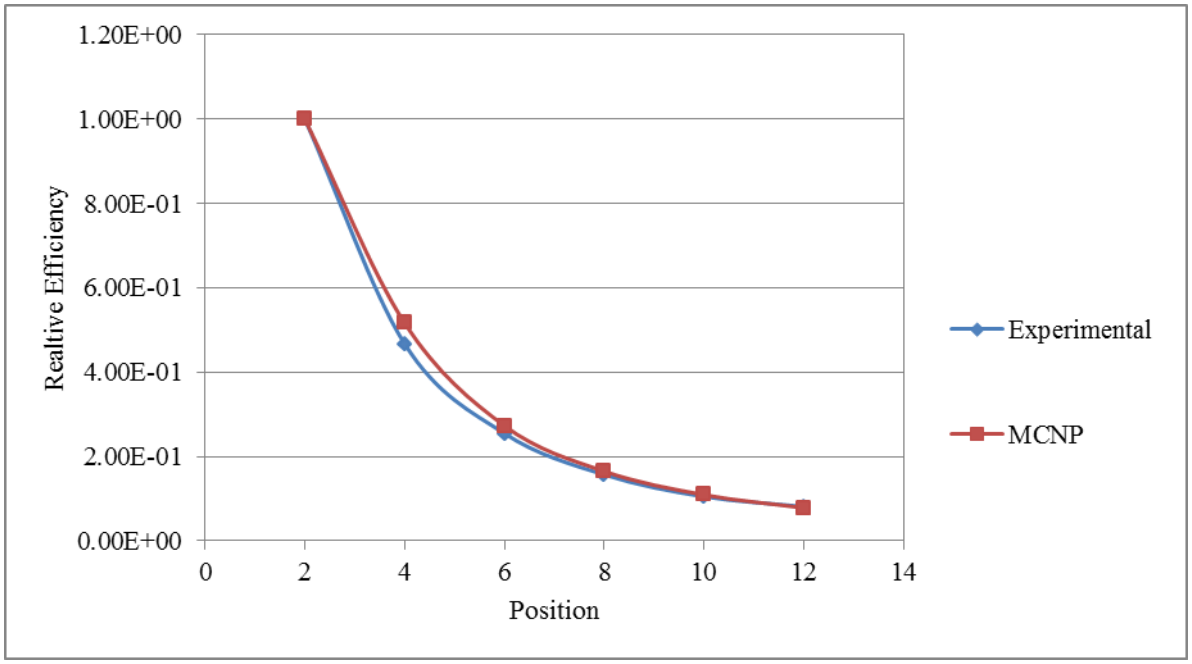

Figure 6. Comparison of the efficiencies obtained experimentally and by MCNP simulations for the point source Am-241.

The table 6 presents the position, distance from source to detector and percent differences between experimental and simulated efficiencies for Am-241point source.

Table 6. Percent differences between experimental and simulated efficiencies for Am-241 point source

Position	Distance (mm)	Percent difference
2	18.82	0
4	36.20	-9.55E-02
6	56.38	-6.61E-02
8	76.35	-4.83E-02
10	96.54	-3.84E-02
12	115.8	3.74E-02

4. CONCLUSIONS

Based on the presented results and comparing the two methods can conclude that is possible to use the Monte Carlo method for efficiency detector calibration, avoiding the production of calibration standards and preventing the generation of additional radioactive waste.

REFERENCES

[1] COMISSÃO NACIONAL DE ENERGIA NUCLEAR. *Critérios de aceitação para deposição de rejeitos radioativos de baixo e médio nível de radiação.* Rio de Janeiro: CNEN-NN-6.09. (2002).

[2] J.B.M. Novo, L.C. Dias. "Simulação Monte Carlo de mecanismo de transferência de energia de excitação eletrônica: modelo de Perrin para a supressão estática da luminescência," *Química nova*, **Volume 34,** pp. 707-709 (2011).

[3] J.D. Allyson, D.C.W. Sanderson "Monte Carlo Simulation of Environmental Airborne Gamma-spectrometry," *Journal of Environmental Radioactivity*, **Volume 38**, pp.259-282 (1998).