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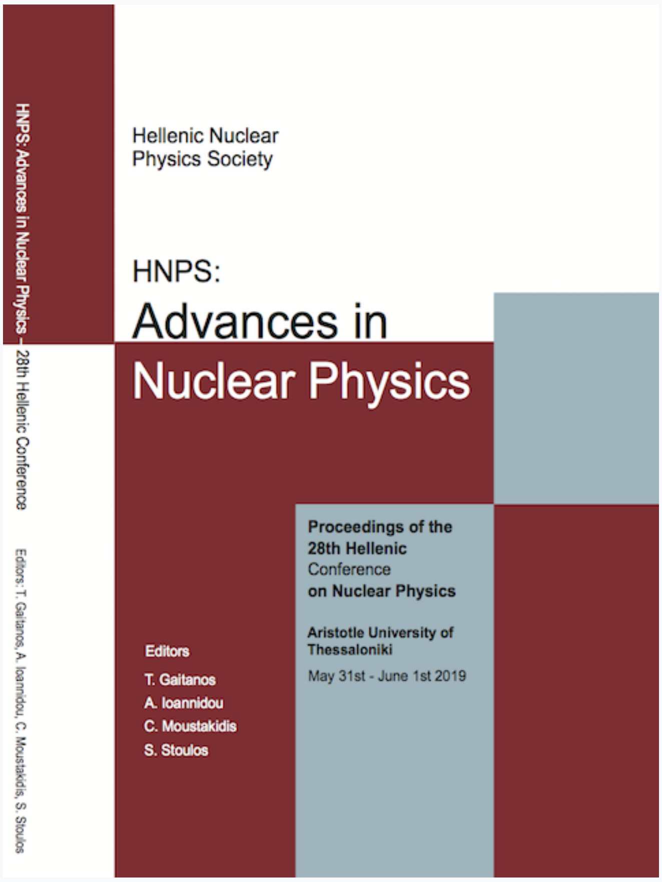

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D. Mavrikis, A. Markopoulos, A. Ioannidou, A. Savidou

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Radiological Characterization of Contaminated Pipes of Different Dimensions and Densities

Dimitrios Mavrikis[1,2], Angelos Markopoulos[2], Alexandra Ioannidou[1], Anastasia Savidou[2]

[1] *Aristotle University of Thessaloniki, Physics Department, Nuclear Physics and Elementary Particle Physics Division, Nuclear Physics Lab*
[2] *National Centre for Scientific Research "Demokritos", Institute of Nuclear & Radiological Sciences & Technology, Energy and Safety, Radioactive Materials Management Laboratory*

Abstract The present work concerns a preliminary study for development of a technique for radiological characterization and segregation of raw historical radioactive waste in different management routes. The efficiency of a 3x3 NaI (Tl) detector for a contaminated cylindrical pipe - detector configuration was evaluated by Monte Carlo simulations performed by using the MCNP code. The efficiency for detector source configuration as well as the measurement bias due to possible inhomogeneity in the distribution of the activity were examined for cylindrical pipes of different densities and dimensions. Cylinders of three different densities made by Pb, Fe, Al were examined. All studied cylinders keep the same ratio between length, diameter and thickness, although the absolute values are different, in order to study the difference in efficiencies of similar geometric objects.

Keywords: MCNP-X, detector efficiency, radiological characterization, radioactive waste

INTRODUCTION

The raw radioactive waste includes activated or contaminated items of several geometries, materials and activities. The accurate determination of each item specific activities is essential for segregation of the raw waste in different management routes [1] as well as for characterization and clearance [2].

EXPERIMENTAL DETAILS

Monte Carlo simulations for cylindrical pipes and 3x3 NaI (Tl) detector configuration (Fig.1.) were carried out using the MCNPX code [4].

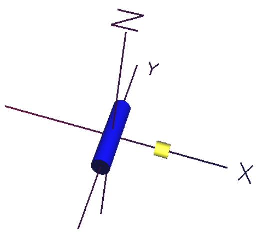

Figure 1 *MCNP visualization*

Three activity distributions at the internal surface of the pipe were modelled: i) homogeneous activity distribution ii) over a ring at the one edge iii) over a ring at the middle (Fig.2.).The non-homogeneous activity distributions represent the worst envisaged cases of inhomogeneity. The models were validated against experimental measurements [3].The measurements bias due to possible inhomogeneity in the distribution of the activity was examined for cylindrical pipes of different density and dimensions. Although in a first approximation the selected four cylindrical pipes have different dimensions, the ratio length/diameter/thickness remains the same in all cases (Table 1). More specifically, in Table 1 the ratio in case A of 100/21.6/0.9 is equal with the ratio in case B 75/16.2/0.675, as well equal with the ratio in case C of 50/10.8/0.45 and equal with the ratio of case D of 25/5.4/0.225. The purpose of the selected values with similar ratios was to study the difference in efficiencies of similar geometric objects.

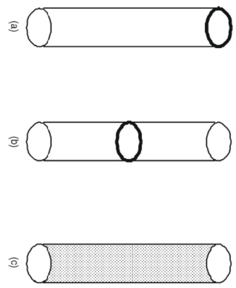

Figure 2 *Modeled activity distributions*
a) Ring at the edge, b) ring at the middle, c) homogeneous distribution

The detector was modeled as a cylinder of sodium iodine of 8.09 cm in diameter and 8.09 cm in length. The detector was positioned at a distance of 30 cm from the geometrical center of the pipe (Fig.1.). Firstly, the model included a homogeneous distributed surface source on the internal surface of the pipes. Examined pipes dimensions are presented in Table.1 and represent similar cylinders. Also 3 different density materials of pipes (Pb, Fe, Al) were simulated. Runs were performed for 662 keV photons representing the γ-ray line of Cs-137. To obtain the energy distribution of pulses created with in the detector volume, the MCNP pulse height tally (F8) was used. Relative error of less than 3% was achieved in all predicted detector efficiencies.

Table. 1. *Dimensions of similar cylinders*

	Length (cm)	diameter (cm)	Thickness (cm)
A	100	21,6	0,9
B	75	16,2	0,675
C	50	10,8	0,45
D	25	5,4	0,225

Simulations were also performed to examine the effect of inhomogeneous activity distribution on the internal surface of the pipes (Fig. 2.).

RESULTS AND DISCUSSION

From Fig.3 it is evident that for all dimension cases, the efficiency is higher for the element with the lower density (Al) and lower for the element with the higher density (Pb).

Furthermore, as we can see in Fig.3 the efficiency is higher when the total contamination is located on the ring at middle of the pipe. Since the detector has been placed facing the geometric center of the studied cylindrical geometries, this was an expected result.

Finally, in smaller dimensions in absolute values, the efficiency for different contamination distributions tends to converge around the same value.

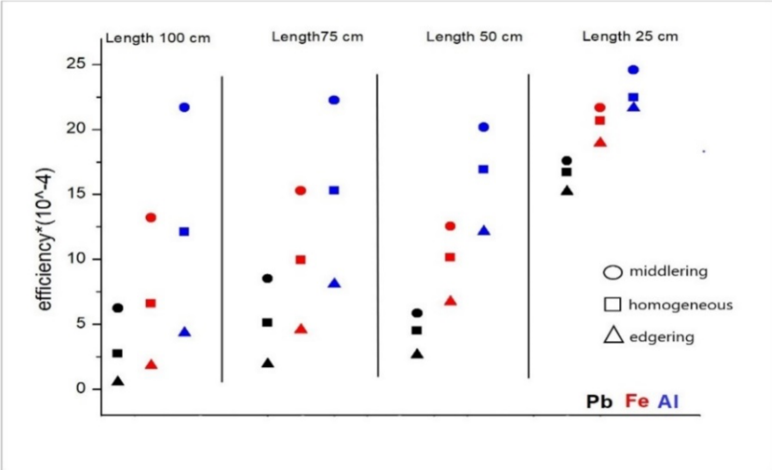

Figure 3 *Predicted efficiencies for Pb, Fe and Al pipes of different dimensions*

The Bias was predicted using the following formula **Bias** $= \frac{Ae - Aa}{Aa}$ where *Ae* is the evaluated activity for homogeneous distribution and *Aa* is the actual activity because of activity inhomogeneity. In Fig.4. Bias seems to tend to zero by reducing the length of the pipe. For 100 cm and 75 cm pipes the Bias is large and cannot be accepted for measuring. Nevertheless, the Bias which concerns 50 cm pipe made of Fe is 33% and for 25 cm pipe is 8%.

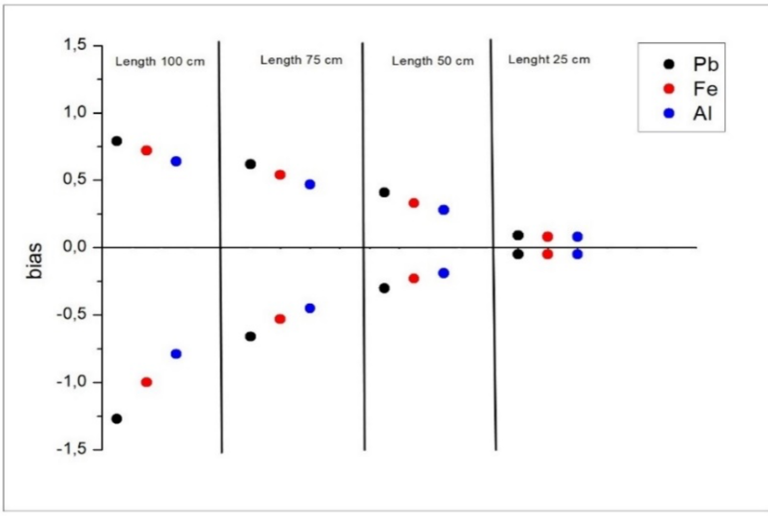

Figure 4 *Bias for Pb, Fe and Al pipes of different dimensions*

CONCLUSIONS

In the present study, the efficiency for detector - source configuration was predicted for several dimensions of similar cylinders and material densities. The effect of inhomogeneous activity distribution was examined and the bias was evaluated. The studied cylinders were similar keeping the same ratio of length/diameter/thickness. However, when the pipe dimension decreases, in absolute values the bias tends to zero. Finally the calculated efficiency values are higher for cylindrical pipes of low densities and the Bias is lower

In the future, the study will be extended to the simulation of other source geometries, of more source dimensions and materials as well as to several detector-source distances.

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