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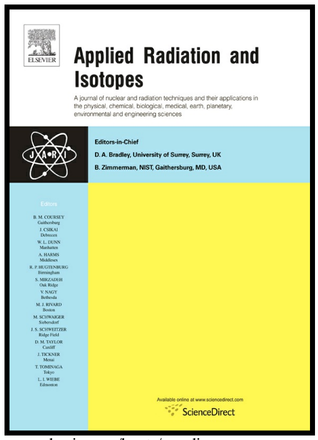

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Octavian Sima, Aurelian Luca, Maria Sahagia

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MONTE CARLO SIMULATION OF AIR SAMPLING METHODS FOR THE MEASUREMENT OF RADON DECAY PRODUCTS

Octavian Sima[a*], Aurelian Luca[b], Maria Sahagia[b]

[a]Physics Department, University of Bucharest, Bucharest-Magurele, RO-077125, Romania
[b]National Institute of R&D for Physics and Nuclear Engineering-Horia Hulubei (IFIN-HH), Bucharest-Magurele, RO-077125, Romania

ABSTRACT

A stochastic model of the processes involved in the measurement of the activity of the ^{222}Rn decay products was developed. The distributions of the relevant factors, including air sampling and radionuclide collection, are propagated using Monte Carlo simulation to the final distribution of the measurement results. The uncertainties of the ^{222}Rn decay products concentrations in the air are realistically evaluated.

Keywords: ^{222}Rn decay products; air sampling; Monte Carlo simulation; propagation of distributions; uncertainty

1. Introduction

In view of the significant contribution of radon (^{222}Rn) and its short-lived decay products (^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po) to the natural radiation dose, as well as to the occupational dose in specific working places, the metrology of radon is an important issue. In Romania this problem was addressed in the first step by the development of a radon standard (Sahagia et al., 2008; Sahagia et al, 2010) and by the establishment of the traceability chain for ^{222}Rn measurements (Sahagia et al., 2011) from the top, primary standardization of ^{222}Rn by an absolute method using liquid scintillation (Cassette et al., 2006), up to the end user level. The second step is the development of a radon chamber, which is an important project of the Metrology Laboratory (Sahagia et al., 2016) of the National Institute of R&D for Physics and Nuclear Engineering – Horia Hulubei (IFIN-HH), Bucharest, Romania. The radon chamber will provide a certified radon concentration atmosphere at a given temperature and pressure, to be used for the calibration of the field radon measurement equipment for various end users.

The contribution of the short-lived radon decay products to the dose is much higher than the contribution of the radon itself. It is therefore desirable to assess decay product activities in air directly rather than infer them from ^{222}Rn measurements. Indeed, due to the plate-out processes, the activity of the decay products in air is not in equilibrium with the activity of the radon gas. In this context, in the present work we study the so-called active methods for the assessment of the radon decay products, with emphasis on the evaluation of the uncertainties. In these methods a volume of air is sampled through a filter, retaining the decay products with a given efficiency. The measurement of the activity collected on the filter can then be used for the evaluation of the activity of these nuclides in the air. In the spirit of the recommendation described in Supplement 1 of the "Guide to the expression of uncertainty in measurement," or GUM (JCGM 101:2008), in this work the uncertainty of the final results is obtained by the propagation of distributions using Monte Carlo simulation. Thus the distribution of the nuclei in air, the stochastic processes of nuclei retention on the filter, of