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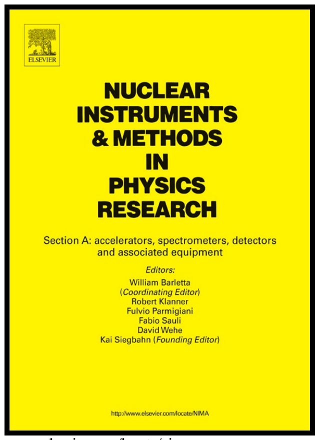

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PII: S0168-9002(17)30310-8
DOI: http://dx.doi.org/10.1016/j.nima.2017.02.087
Reference: NIMA59717

To appear in: *Nuclear Inst. and Methods in Physics Research, A*

Received date: 24 October 2016
Revised date: 15 February 2017
Accepted date: 27 February 2017

Cite this article as: J.G. Guerra, J.G. Rubiano, G. Winter, A.G. Guerra, H Alonso, M.A. Arnedo, A. Tejera, P. Martel and J.P. Bolivar, Computational Characterization of HPGe detectors usable for a wide variety of sourc geometries by using Monte Carlo simulation and a multi-objective evolutionar algorithm, *Nuclear Inst. and Methods in Physics Research, A* http://dx.doi.org/10.1016/j.nima.2017.02.087

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Computational Characterization of HPGe detectors usable for a wide variety of source geometries by using Monte Carlo simulation and a multi-objective evolutionary algorithm

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ABSTRACT

In this work, we have developed a computational methodology for characterizing HPGe detectors by implementing in parallel a multi-objective evolutionary algorithm, together with a Monte Carlo simulation code. The evolutionary algorithm is used for searching the geometrical parameters of a model of detector by minimizing the differences between the efficiencies calculated by Monte Carlo simulation and two reference sets of Full Energy Peak Efficiencies (FEPEs) corresponding to two given sample geometries, a beaker of small diameter laid over the detector window and a beaker of large capacity which wrap the detector. This methodology is a generalization of a previously published work, which was limited to beakers placed over the window of the detector with a diameter equal or smaller than the crystal diameter, so that the crystal mount cap (which surround the lateral surface of the crystal), was not considered in the detector model. The generalization has been accomplished not only by including such a mount cap in the model, but also using multi-objective optimization instead of mono-objective, with the aim of building a model sufficiently accurate for a wider variety of beakers commonly used for the measurement of environmental samples by gamma spectrometry, like for instance, Marinellis, Petris, or any other beaker with a diameter larger than the crystal diameter, for which part of the detected radiation have to pass through the mount cap. The proposed methodology has been applied to an HPGe XtRa detector, providing a model of detector which has been successfully verificated for different source-detector geometries and materials and experimentally validated using CRMs.

Keywords:
HPGe detectors, Efficiency calibration, Monte Carlo simulation, Marinelli beakers, Differential Evolution Multi-objective, Characterization Germanium Detectors.

Accepted manuscript

1. Introduction

The quantitative and qualitative analysis of gamma-emitting radionuclides content in samples is frequently performed by HPGe detectors, especially in the case of low-level activity environmental samples. The main advantage of this type of gamma detectors is its high energy resolution, which allows discriminating between emissions with close energies (a few keV). When determining the activity concentration of radionuclides in a sample by gamma spectrometry, it is indispensable to know the full energy peak efficiency (FEPE) for the corresponding gamma emission, which mainly depends on the photon energy, material and geometry of the sample, and source-detector arrangement. Therefore, it is necessary to calibrate the system in regard to the efficiency of detection. Such calibrations can be made either experimentally, by using certified reference materials, or computationally by mean of Monte Carlo

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