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Application of ISOCS system in the laboratory efficiency calibration

Dominik Grządziel*, Krzysztof Kozak, Jadwiga Mazur, Mariusz Mroczek

Institute of Nuclear Physics PAN, Radzikowskiego 152, 31-342 Kraków, Poland

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ABSTRACT

ISOCS (In Situ Counting Object System) from Canberra is applied in laboratory for creating efficiency calibrations of good quality without using radioactive standards. Besides of typical sample containers used in laboratory, ISOSC system also allows modelling containers and objects of almost any shape and elemental composition.

The study was based on gamma spectrometry with HPGe semiconductor detector with electronics and software spectrum analysis GENIE 2000 + ISOCS. Measuring set is equipped with portable shield system with set of collimators ISOCS Shield Systems Model ISOXSHLD from Canberra. This shielding system provides attenuation of gamma background radiation with average value 33 (for gamma energies from 186 keV to 2615.5 keV).

The portable shield system can be used for low-background laboratory measurements. For this purpose a measuring vessel of new geometry was constructed: the polystyrene cylinder with a height of 40 mm and a diameter of 70 mm. The efficiency calibration for this container was performed using both ISOCS system and classical calibration standard in the same geometry. In order to verify the correctness of performed calibration procedures, the measurements of radioactive standard CBSS 2 were made. The results of both calibrations were compared with the data from the standard certificate. Satisfactory agreement was achieved. Mean percentage difference between results from ISOCS calibration compared to reference values is 6% for all isotopes activities in CBSS 2 standard.

The set of collimators was used to develop efficiency calibration for in situ measurements of the soil surface. Test measurements were carried out at the area of the Institute of Nuclear Physics Polish Academy of Sciences in Kraków, Poland (IFJ PAN). Two measurement methods were compared: in situ and laboratory gamma spectroscopy. The obtained average results (from all 10 measuring points) are consistent within the range of measurement uncertainty.

1. Introduction

In situ gamma spectroscopy offers a lot of advantages over the traditional method of laboratory spectroscopy. Skipping stages of taking a representative sample, transporting sample to a laboratory and then preparing it for counting may be a huge relief of measurement process. Furthermore some samples may be difficult to collect because of their radioactivity or location (material inside pipes, tanks, etc.).

The ISOCS system allows improving and accelerating gamma spectrometric measurements carried out with the use of HPGe semiconductor detector. It enables one to generate calibration efficiency curves without using radioactive standards, which can be used during a variety of measurements. Thanks to the portable shield system with a set of collimators it is possible to quickly and accurately measure radioactivity of objects with different shapes and compositions that are sometimes located at a distance from the detector. On this basis, in situ gamma measurements of the soil layer may be performed.

The ISOCS system is used for various types of in situ gamma spectroscopy measurements, such as determination of radionulclides contamination inside building structures (Boden et al., 2013) or radioactivity of surface area (Witt, 2006). The portable shield system can be also used for background reduction in laboratory measurements.

The correctness of ISOCS efficiency calibration procedures was validated earlier (Venkataraman et al., 1999), but the aim of this study was to verify the correctness of the ISOCS system, which has been implemented for typical measurements made by the

* Corresponding author.
E-mail address: Dominik.Grzadziel@ifj.edu.pl (D. Grządziel).

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laboratory. For this purpose, the measurements of certified calibration standard CBSS 2 (in geometry NW, described below) were performed.

The ISOCS system has also been tested for in situ measurements of soil radioactivity at the area of IFJ PAN. The results from is situ method were compared to those obtained from laboratory measurements of soil samples collected in appropriate locations at measuring site.

2. Material and methods

The ISOCS product is designed to be a complete In Situ Object Counting System. It includes the MCNP-characterized germanium detector GX4020 with appropriate shielding.

Energy resolution for GX4020 detector is 2.0 keV (FWHM) at 1.3 MeV. Relative efficiency is 40%. The rest of the ISOCS set are multichannel analyzer and dedicated software for data acquisition, spectra analysis and geometry composing (GENIE 2000 + ISOCS).

The ISOCS measurement process includes the following steps (Canberra, 2002):

- specific characteristics of the detector made by the producer
- acquiring spectral data from a sample
- specifying dimensions and physical composition of a measured object
- generating an efficiency calibration file appropriate for the specific counting configuration
- using these efficiency results to analyze the acquired spectra.

The shield system is made of 5 cm thick lead fittings with built-in collimators, which form a gamma radiation beam reaching the detector. An important element of the system is a special transport trolley on which the detector and shield system are mounted (Fig. 1.).

Fig. 1. HPGe detector with shielding system on a transport trolley, during measurement of in situ soil surface.

2.1. In situ measurements of the soil surface

In situ measurements of the soil surface were made using the set of cylindrical collimators: 30° or 90°. Detector was located on the trolley at the height of 0.55 m above the ground. Depending on which collimator was used, soil diameter seen by detector was 0.31 m for 30° collimator and 1.16 m for 90° collimator. The thickness of soil surface taken into account was 0.25 m − this is a value for which massimetric efficiency of the detector is constant. The scheme of this measurement is shown in Fig. 2.

2.2. Low-background laboratory measurements

The portable shield system is a part of the whole ISOCS product. It can be also used as a low-background shielding for laboratory measurements. For this purpose a measuring vessel of new geometry NW was applied. Dimensions of the NW container have been selected in such a way that the container fits into the shielding. NW container is a cylinder with the height of 40 mm and the diameter of 70 mm. The wall thickness is 1 mm. It is made of transparent polystyrene. The germanium detector is positioned vertically during this measurement process. The shielding cover is completely closed. The NW container with a sample is located directly on the top of the detector in central position (Fig. 3.).

3. Results

3.1. Efficiency of shielding system

In the first step of this study, the ISOCS shielding system was tested. The measurements of gamma background were made in the

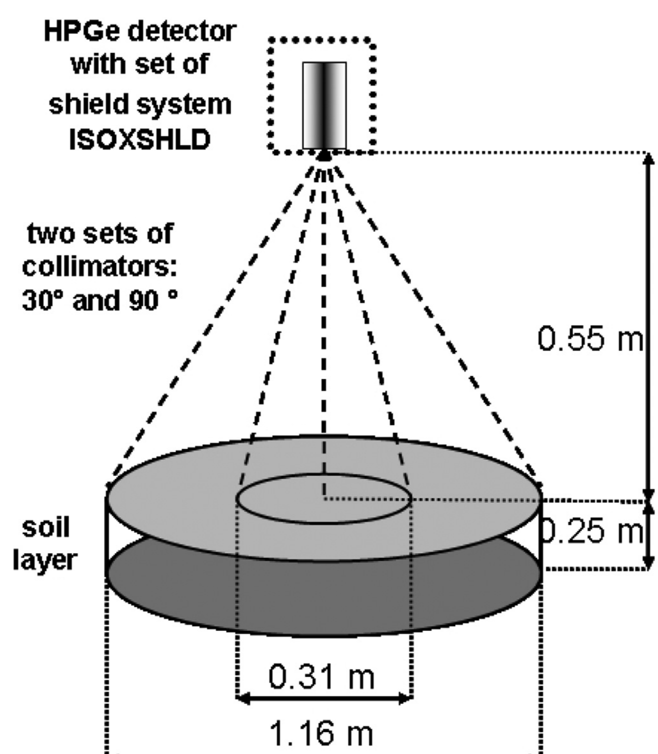

Fig. 2. Scheme of in situ measurements of soil surface.

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