Calibration of the High and Low Resolution Gamma-Ray Spectrometers

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1. INTRODUCTION

-Many laboratories from Romania are accredited according to the standard EN ISO/IEC 17025:2005 “General requirements for the competence of testing and calibration laboratories”.
-For the laboratories involved in the measurement and certification of the radioactive content of various samples collected from the environment and food chain, or industrial products, the most frequently used analysis method is the gamma-ray spectrometry method with high resolution HPGe and low resolution NaI(Tl) or equivalent detectors.
-The Radionuclide Metrology Laboratory (RML) from IFIN-HH, Primary Activity Standard Laboratory, assures the continuity of the whole metrological traceability chain of activity measurement and is accredited by the national accreditation body RENAR as a Calibration and Testing Laboratory according to the EN ISO/IEC 17025:2005. The RML has recently elaborated two working procedures specific for the calibration of the gamma-ray spectrometry systems, with emphasis on the corrections to be applied by the testing laboratories.

2. THE GAMMA-RAY SPECTROMETRY METHOD

-In accredited laboratories, the gamma-ray spectrometry method is used to perform both qualitative and quantitative radioactivity analysis for all types of samples. A typical gamma-ray spectrometry system is composed of: a detector (semiconductor, such as HPGe, or scintillator, for example NaI(Tl) or plastic scintillator) with a shielding – mainly lead, to reduce the gamma-ray background; high voltage power supply; electronics for signal processing (preamplifier, amplifier, multichannel analyzer); computer and dedicated software.
-High quality calibrations in energy, resolution (FWHM) and efficiency are essential.
-Other important aspects: careful choice of the detector (type, geometry, window) and the radioactive standard sources used for calibration;
-sample geometry, matrix, position relative to the detector;
-passive or active detector shielding;
-various corrections: background, dead time, geometry (sample different from the standard), deconvolution of overlapped spectrum peaks, true coincidence summing (TCS).

3. CALIBRATIONS

Fig. 1. The energy calibration of a NaI(Tl) detector (linear function), using standard sources of gamma-rays emitters ^{134}Cs (604.69 keV and 795.84 keV) and ^{137}Cs (661.66 keV).

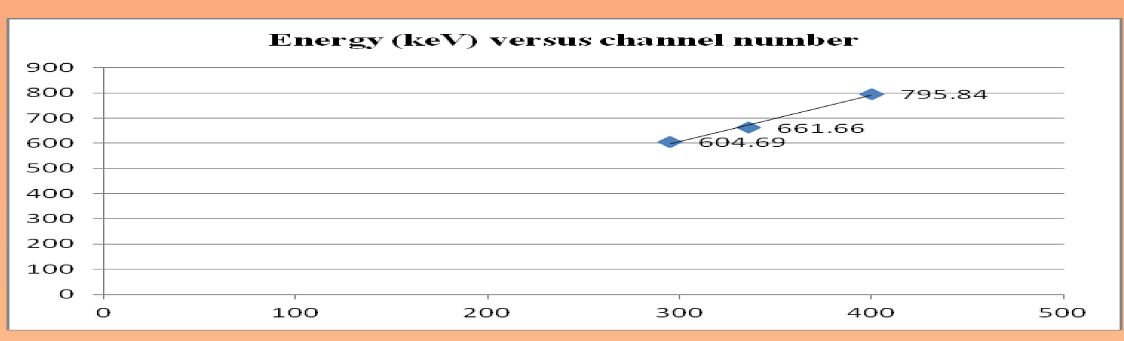


Table 1. Comparison of the experimental FWHM values between two detectors of HPGe and NaI(Tl) type

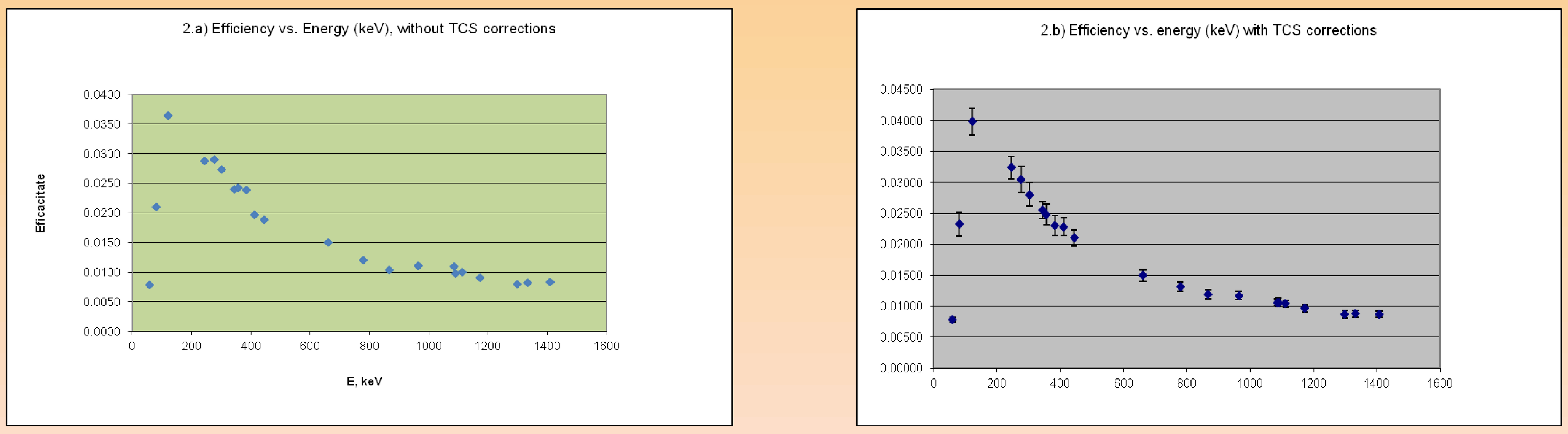
Radionuclide	Energy (keV)	FWHM (keV)	
		HPGe detector	NaI(Tl) detector
^{57}Co	122.06	1.42	16
^{137}Cs	661.66	1.84	47
^{60}Co	1332.49	2.15	69

The efficiency calibration consists in determining a polynomial function describing the Full Energy Peak (FEP) detection efficiency versus the γ-rays energy, E_γ. Radioactive standard sources with gamma-ray emissions covering a wide energy range (containing radionuclides such as ^{152}Eu, or mixtures of several radionuclides) are needed. The FEP efficiency is computed as:

$$\varepsilon = \frac{(A - A_F)\cdot F_D}{t \cdot I \cdot \Lambda \cdot F_C \cdot F_T}$$

A and A_F are the net areas of the considered peak from the gamma-ray spectrum of the standard, respectively of the installation background spectrum; *t* is the measurement time, the same for standard and background; F_C, F_T and F_D are the multiplicative coefficients for coincidence summing corrections, efficiency transfer corrections and for the decay during the reference time and the time of the sample measurement start (important for short half-life radionuclides); *I* is the emission probability of the considered gamma-rays; Λ is the activity of the standard (Becquerel units).

Fig. 2. Experimental efficiency calibration (HPGe detector, volume standard sources - soil matrix, placed on top the detector), without (a) and with (b) true coincidence summing (TCS) corrections.



4. CONCLUSIONS

-Two working procedures were elaborated and implemented in the calibration of high and low resolution γ-ray spectrometry installations.

-All the necessary calibration corrections and the customers feedback were analyzed and applied to improve the quality of the radioactivity measurements performed by the laboratories belonging to the public networks for environmental monitoring, food chain and health.

REFERENCES : A. Luca et al., „Recent participations of the Radionuclide Metrology Laboratory from IFIN-HH to proficiency tests and inter-laboratory comparisons”, Proceedings of the 3rd International Proficiency Testing Conference (PTCONF 2011), Iasi, Romania, September 28-30, 2011, ISSN 2066-737X, 120-127;; G. Gilmore, „Practical Gamma-ray Spectrometry”, John Wiley & Sons, Ltd., Chichester, England, 2008; A. Luca et al., „Conclusions from the participation at proficiency tests for gamma-ray spectrometry measurements”, Rom. J. Phys. 55 (2010), 724-732; M. Sahagia, L. Grigorescu.” Water equivalent solid standard sources”. Nucl. Instr. and Meth. A 312 (1992) 236-239; GESPECOR version 4.2. Manual, CID Media GmbH 2007, Germany.