THE ENERGY AND FWHM CALIBRATION OF A GAMMA SPECTROMETRIC SYSTEM WITH A HPGe DETECTOR ON THE BASIS OF THE BACKGROUND SPECTRUM

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The paper presents the energy and FWHM calibration of a gamma spectrometric system with a HPGe detector on the basis of the environmental spectrum.

Key words: HPGe Gamma Ray Detector, photon detector, gamma spectrometry.

1. INTRODUCTION

In some cases, when a movement of the amplitude of the spectrum, large enough to alter the automatic analysis of the peaks is detected, the energetic calibration and the resolution of the system must be remade. This paper presents such a situation and the energy and FWHM calibration of a gamma spectrometric system with a HPGe detector in the absence of other certified sources of standard.

2. MATERIALS AND METHODS

For this purpose we used a spectrometric gamma system (ORTEC) with the following components and characteristics: germanium detector GeHP model GEM3OP4 PopTop - 3"×3" with a diameter of 59.1 mm and a length of 54,1 mm, multichannel module analyzer DigiDART MCA, interface module DIMPOSGE, interface for the filling of the probe model PMB276, vertical cryostat, Dewar recipient with a volume of 30 liters, transfer 50 liter Dewar system, specialized software package, Maestro-32, and Gamma Vision 32 v-6. The energetic work interval of the spectrometric system with a HPGe detector is 50 keV – 3000 keV and the installation parameters are: for the HPGe (from the ORTEC certificate, parameters obtained with a time constant of 6 μs) relative efficiency 30 % at 1332 keV (^{60}Co); resolution 1,85 keV at 1332 keV (^{60}Co); 0,85 keV la 122 keV (^{57}Co). The work parameters are: HV= (+) = +4400V; Gain Range = 2.2 (Coarse

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Gain: X4, Fine Gain: 0.55); Offset = OFF; LLD = 100; ULD: 16383; Conversion Gain: 16384; SHAPING = 6 μs; PUR=OFF; POLARITY Entry signal=positive [1].

3. RESULTS AND DISCUSSIONS

According to existent and applied laboratory procedures, we obtained a background on a very large time interval. We used the table with radionuclids and energies coming from the radiation background present in Table 1 and a library of radionuclids that are present in the radion background normally, with the gamma lines knows as energy, [2, 3].

As it is known, the calibration of a spectrometric gamma system evolves three main aspects:

(i) The energy as a function of the number of the channel;

(ii) FWHM as a function of the number of the channel;

(iii) The efficiency as a function of the energy correlated with the acquisition geometry pf the radiation spectrum.

Adiacent to the (iii), in the case of applied geometries the correlation with the coincidental standard (TCC) can be made additionally, if the used software has this ability. The energy as a function of the number of the channel and the FWHM as a function of the number of the channel do not interfere with the initial calibration in efficiency of the measuring system, [4].

The movement in energy of the system is seen as a displacement of the amplification. Only at high energies the movement of the peaks was observed. Thus we were able to use the points from the calibration curves from low energies and we replaced the points from high energies with those from the background spectrum.

The standardization in energy of the system was made in the energetic domain of interest: 50 keV ÷ 3000 keV, taking into account the energetic lines of the ^{40}K and ^{208}Tl of 1460 keV, 2614 keV, respectively, [1].

The work parameters of the system and their settings were: HV(+) = 4400 V; Gain = 2.2 (4 × 0.55); Rise time: 6; Flat Top: Width = 0.8, Tilt = - 0.0396; PZC = regal intern; Formation time constant = 6 μs; ADC Conversion Gain = 16384; Digital offset = Automatic; Zero = 0; LLD= 100; ULD = 16383, [4].

Table 1

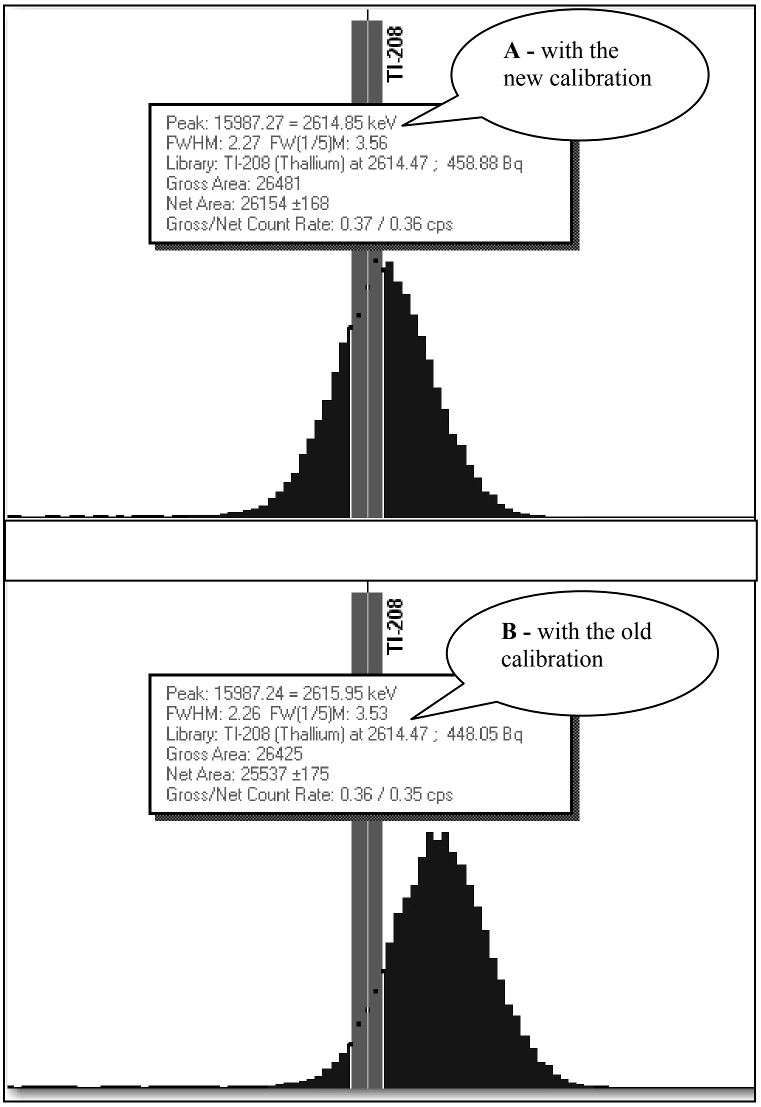
Radionuclids with energies deriving from the radiation background

Energy nuclide [keV]	**YIELD (Percent)**	**Nuclide**	**Half**	**Life**	**Energy spectrum [keV]**
74.81	9.60%	Pb-212	10.64	Hrs,	74.81
74.81	6.33%	Pb-214	26.8	Min,	

Table 1 (continued)

77.11	17.50%	Pb-212	10.64	Hrs,	77.11
77.11	10.70%	Pb-214	26.8	Min,	
238.63	43.10%	Pb-212	10.64	Hrs,	238.63
351.99	37.10%	Pb-214	26.8	Min,	351.99
463	4.64%	Ac-228	6.131	Hrs,	463
510.72	22.50%	Tl-208	186	Sec,	510.72
583.14	86%	Tl-208	186	Sec,	583.14
609.32	46.09%	Bi-214	19.9	Min,	609.32
727.17	11.80%	Bi-212	60.55	Min,	727.17
768.36	4.89%	Bi-214	19.9	Min,	768.36
911.07	29%	Ac-228	6.131	Hrs,	911.07
964.6	5.45%	Ac-228	6.131	Hrs,	964.6
968.9	17.46%	Ac-228	6.131	Hrs,	968.9
1120.28	15.04%	Bi-214	19.9	Min,	1120.28
1238.11	5.92%	Bi-214	19.9	Min,	1238.11
1377.65	4.02%	Bi-214	19.9	Min,	1377.65
1509.19	2.19%	Bi-214	19.9	Min,	1509.19
1592.47	100%	Tl-208	186	Sec,	1592.47
1620.56	2.75%	Bi-212	60.55	Min,	1620.56
1661.28	1.15%	Bi-214	19.9	Min,	1661.28
1729.6	3.05%	Bi-214	19.9	Min,	1729.6
1764.51	15.92%	Bi-214	19.9	Min,	1764.51
1847.44	2.12%	Bi-214	19.9	Min,	1847.44
2204.12	4.99%	Bi-214	19.9	Min,	2204.12
2447.71	1.55%	Bi-214	19.9	Min,	2447.71

For the recalibration of the system, the in energy calibration was reopened together with a library containing the peaks that appear in the background spectrum. We identified the swarms in the background spectrum, we introduced the energies of the corresponding peaks and also the new calibration points. We started with the peak of 2614,47 keV of the ^{208}Tl. We eliminated several points from the old in energy calibration, especially those with high energies and with a high deviation from the new fitting curve. Finally, the new calibration is saved and it is used in spectra and in the acquisition program. This calibration is valid for the ORTEC, Gamma Vision software with the help of which we developed Figures 1, 2, 3 and 4, [5].



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Peak: 15987.27 = 2614.85 keV
FWHM: 2.27  FW(1/5)M: 3.56
Library: Tl-208 (Thallium) at 2614.47 ;  458.88 Bq
Gross Area: 26481
Net Area: 26154 ±168
Gross/Net Count Rate: 0.37 / 0.36 cps
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Peak: 15987.24 = 2615.95 keV
FWHM: 2.26  FW(1/5)M: 3.53
Library: Tl-208 (Thallium) at 2614.47 ;  448.05 Bq
Gross Area: 26425
Net Area: 25537 ±175
Gross/Net Count Rate: 0.36 / 0.35 cps
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Fig. 1 – The effect of the 2614.47 keV of the ^{208}Tl recalibration of the spectrometric system on the peak, A-new calibration, B-old calibration.

In Fig. 1, it can be observed the effect of the recalibration of of 2614,47 keV of the ^{208}Tl on the peak which was in the right part of the spectrum, (B) and the movement due to the deviation of the amplification from the theoretic position drawn by marker. In the (A) graph it can be observed the spectrum position after the energetic recalibration using the points from the background spectrum.

For this we used markers introduced on the spectrum by the ORTEC Gamma Vision32 software, [5]. We chose this peak, from the right corner of the spectrum at high energies because this is where the effect is visible and we zoomed in only on this one. (B) graph bears the old calibration and the (A) graph the remade one.

The calibration curve is described by the second degree function:

$$\text{Energy [keV]} = a_0 + a_1\times(\text{Channel}) + a_2\times(\text{Channel})^2,$$

Where the a_i coefficints have the values: = - 0.1018, $a_1 = 0.163419$, $a_2 = 1.7389\times10^{-9}$. The integral nonlinearity is < 0.023% in the interval of 6 keV - 2360 keV, the differential nonlinearity is < ±0.1%. Thus the calibration curve is given by the expression: [6, 7].

Energy [keV]= $0.1018+0.163419\times(\text{Channel})+1.7389\times10^{-9}\times(\text{Channel})^2$; and it is presented in Figure 2.

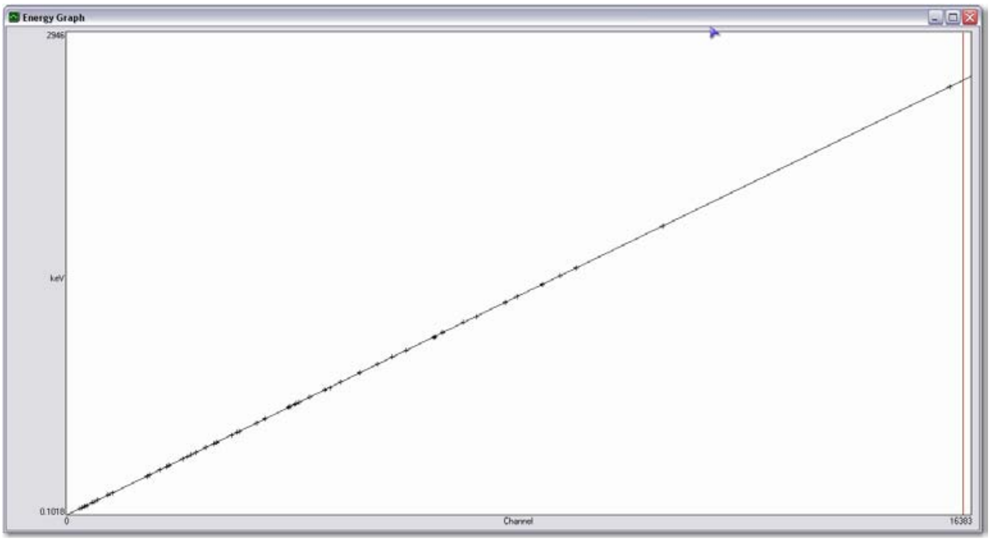

Fig. 2 – The calibration curve of the system.

The calibration in resolution curve is also described by a function of the second degree:

$$\text{FWHM [keV]} = a_0 + a_1\times(\text{Channel}) + a_2\times(\text{Channel})^2,$$

Where the a_i coefficients have the values: $a_0 = 4.4484$, $a_1 = 0.000782$, $a_2 = -1.50488\times10^{-8}$.

The calibration in FWHM curve is given by the expression:

$\mathrm{FWHM[keV]}=4.4484+0.000782\times(\mathrm{Channel})-1.50488\mathrm{e}{-008}\times(\mathrm{Channel})^2$, and it is shown in Figure 3, [6, 8].

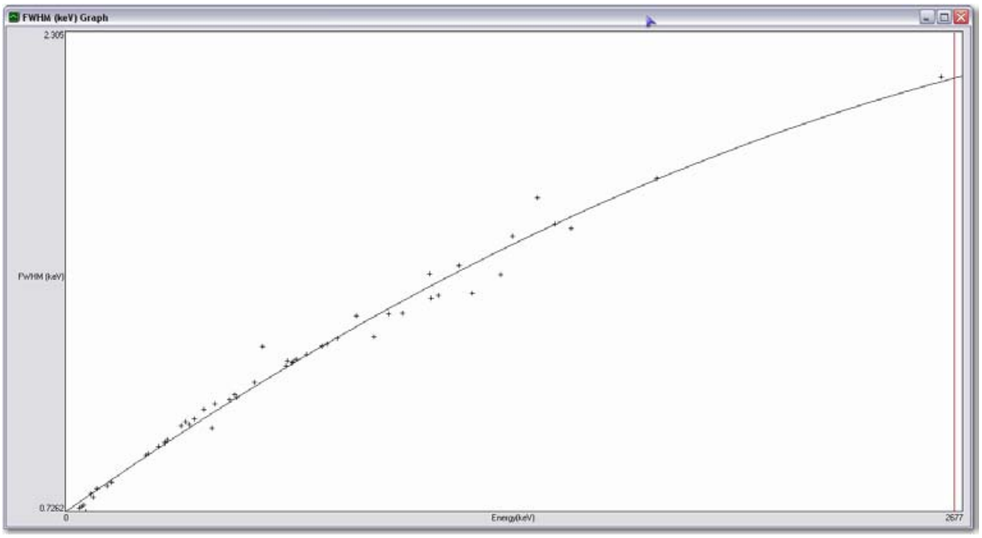

Fig. 3 – The calibration in resolution curve of the system.

In Figure 4 is presented background spectrum of the system for the long time acquisition.

4. CONCLUSIONS

In conclusion, if on a spectrometric system appeares a derangement of amplification, at high energies it is not compulsory to forsake the spectrum and it's time of acquisition. In this case we can look for the most recent background, acquired on the large time frame and observe if the same deviation appeares in the background spectrum. A recalibration in energy and resolution can be made in a very short time. Thus, the process of calibration in energy and resolution is a process that comes after the acquisition of a spectrum from a sample, not necesarily previously. Fot this purpose it is higly important to acquire each week a background spectrum on a long time interval.

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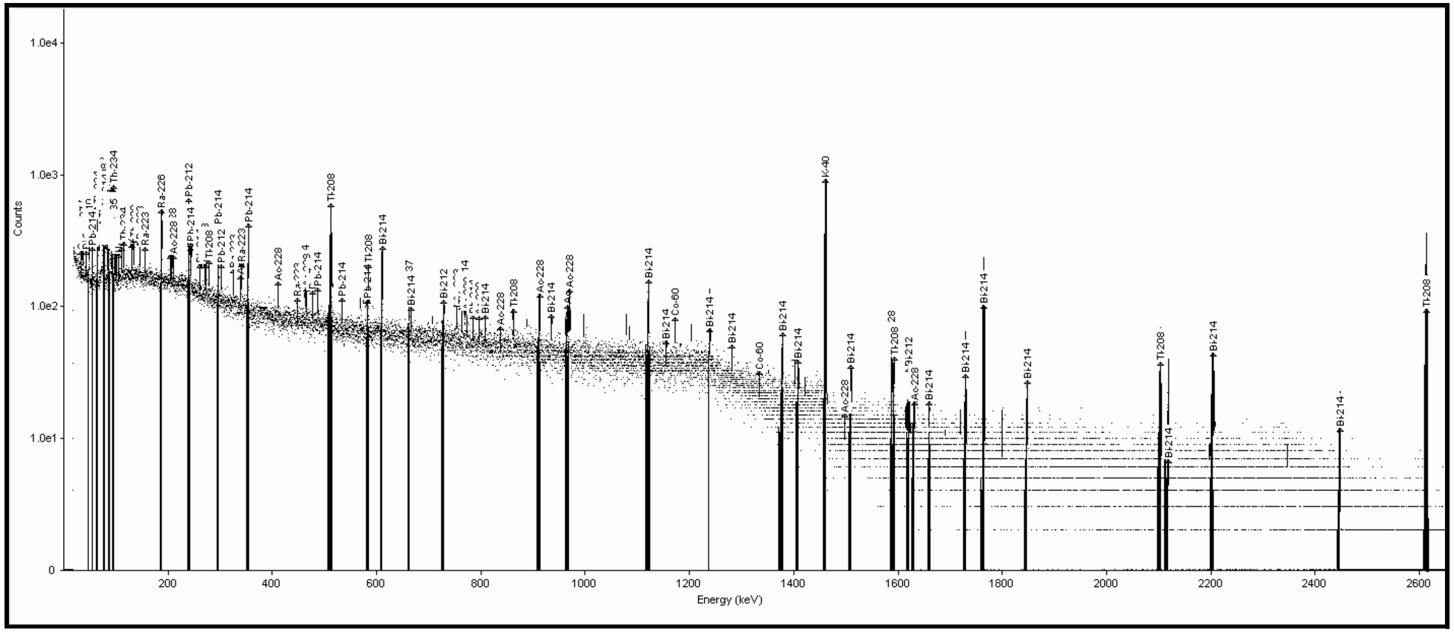

Fig. 4 – Background spectrum of the system.

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