USE OF CYLINDRICAL HPGe DETECTOR CANBERRA GX 4020 IN LOW-LEVEL RADIOACTIVITY MEASUREMENTS

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INTRODUCTION

The main problem in the experimental research in low-level gamma-ray spectrometry is that low intensity processes must be detected in the presence of the other higher intensity processes. For this reason for the successful experimental research of these processes must be used the high sensitivity spectrometers. The high sensitivity spectroscopic equipment must have a good-quality passive shield, because the crucial problem in low-level counting is the problem of background and besides the passive shield good-quality detectors must be used.

FACTORS OF MERIT OF SINGLE SPECTROMETER

In our Low-level Gamma-ray Spectrometry Laboratory we studied the characteristics of the new cylindrical HPGe detector Canberra GX 4020. The detector has the crystal dimension ø 61 x 62 mm, the relative efficiency 43.2 %, the ratio peak/Compton has the value 57 and the energy resolution for 1.33 MeV peak ^{60}Co is 2.0 keV. Electronic modules NIM fy Silena were used. The measured spectra were evaluated with the program EMCAPLUS made by fy Silena. We measured the values of the factors of merit in dependence on distances detector – source.

The value of the factor of merit, F, is characteristics for low-level gamma-ray spectrometers. Spectrometer with the highest value F has the highest sensitivity (the lowest limit of detection) for detecting gamma-rays of energy E in presence of interference radiation coming from the natural background of the spectrometer and from gamma-quanta higher energy of the emitters present in the measured sample. In our measurements the value of the factors of merit of spectrometer F was estimated from the equation

$$F = \frac{\varepsilon(E)}{\sqrt{B_N(E)}}$$

where ε(E) is the peak efficiency for gamma rays of the energy E and $B_N(E)$ is the natural background of the spectrometer in the energy region E. The peak efficiency of spectrometer was estimated using point radioactive standards (^{241}Am, ^{133}Ba, ^{152}Eu, ^{22}Na, ^{137}Cs and ^{54}Mn). The standards were situated on the top of the detector, in the centre, in different distances detector – source (0, 5, 10, 15, 20 and 25 cm). The HPGe detector was located inside the simple lead shield (only 10 cm of lead) and outside this shield.

Table 1. Factors of merit of single HPGe spectrometer obtained for 661.66 keV gamma-rays of ^{137}Cs for various distances detector – source.

Distance detector-source [cm]	F [10^{-3}]	F_{Pb} [10^{-3}]
0	100.04 ± 3.02	343.70 ± 10.39
5	23.00 ± 0.49	78.80 ± 1.68
10	8.69 ± 0.18	29.80 ± 0.64
15	4.38 ± 0.09	15.00 ± 0.32
20	2.67 ± 0.06	9.20 ± 0.20
25	1.72 ± 0.03	5.92 ± 0.12

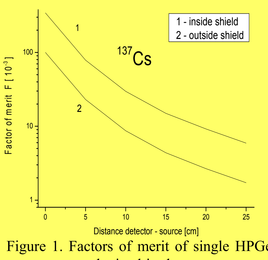

Figure 1. Factors of merit of single HPGe spectrometer obtained in the measurements of ^{137}Cs inside and outside the simple lead shield in dependence on distances detector – source.

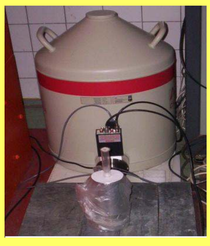

Figure 2. The HPGe detector situated outside the simple shield.

Table 2. Factors of merit of single HPGe spectrometer obtained for gamma-rays of ^{241}Am, ^{22}Na and ^{54}Mn when the detector was located in simple shield.

Distance detector-source [cm]	Factor of merit [10^{-3}]		
	^{241}Am (59.54 keV)	^{22}Na (511 keV)	^{54}Mn (834.84 keV)
0	525.1 ± 14.5	258.5 ± 7.7	326.5 ± 10.3
5	111.0 ± 2.2	60.4 ± 1.8	72.7 ± 1.7
10	36.8 ± 0.7	24.2 ± 0.7	28.8 ± 0.7
15	17.6 ± 0.4	11.7 ± 0.3	14.1 ± 0.3
20	10.0 ± 0.2	7.2 ± 0.2	8.5 ± 0.2
25	6.6 ± 0.1	4.9 ± 0.1	5.7 ± 0.1

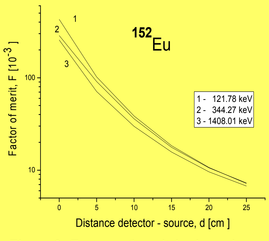

Figure 3. Factors of merit in dependence on distances detector - source obtained in the measurements with ^{152}Eu. Detector was located inside the shield.

Figure 4. The HPGe detector situated inside the simple shield.

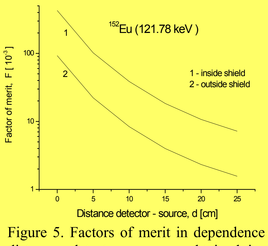

Figure 5. Factors of merit in dependence on distances detector - source obtained in the measurements with ^{152}Eu for gamma line 121.78 keV.

Figure 6. The electronic part of the measuring equipment

CONCLUSION

Experimental search of the factors of merit of single spectrometer containing the new cylindrical HPGe detector Canberra GX 4020 showed that this spectrometer is very suitable for the detection of single gamma-rays. In low-level gamma ray counting and spectrometry single HPGe spectrometers are used for estimating non-coincidence gamma rays emitted nuclei which are containing in measured samples. The single spectrometers we often use for estimating the radioactivity impurities of measured samples in which afterwards we are looking for some coincidence or anticoincidence gamma rays.

The obtained results showed that the new cylindrical HPGe detector Canberra GX 4020 will be very useful in experimental investigations in the field of low-level gamma rays counting and spectrometry.