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STUDY OF THE ABSOLUTE FULL ENERGY PEAK EFFICIENCY OF A Ge/Li/ DETECTOR

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BUDAPEST

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ABSTRACT

The absolut full energy peak efficiency and the dependence of the sensitivity on the source-detector geometry was determined for a CANBERRA type Ge/Li/ detector.

АННОТАЦИЯ

Определена абсолютная эффективность пика энергии и зависимость чувствительности от геометрии источника-детектора для детектора Ge/Li/ типа CANBERRA.

KIVONAT

A dolgozat ismerteti egy CANBERRA tipusu Ge/Lí/ detektor abszolut hatásfokának és a forrás-detektor geometria érzékenység-függésének meghatározását.

INTRODUCTION

The use of Ge/Li/ detectors in all fields of gamma-ray spectroscopy has been rapidly expanding because they ensure an improved energy resolution and can be used for very precise gamma-ray energy measurements.

For this reason, nowadays, the calibration of this kind of detectors for accurate measurements of gamma-ray energies and intensities is of interest.

Unlike the case of NaI/Tl/ scintillation spectrometers, where it is possible to calculate the detection efficiency with a high degree of precision, the analysis of pulse height spetra to get gamma-ray intensities is a difficult task [1].

The more reasonable method for the experimental determination of the absolute detector efficiency is the secondary calibration technique using well calibrated standard sources of monoenergetic radiation.

The purpose of this work was to determine the absolute full energy peak efficiencies for a given Ge/Li/ semiconductor detector at different source distances and solid angles. The investigated detector was a CANBERRA coaxial type Ge/Li/ with diameter 44 mm, length 43.5 mm, p-core diameter 11 mm. Its relative efficiency was 11.8%, by comparing to a 3" x 3" NaI/Tl/ detector.

The efficiency values at different source-detector geometries can be used for the determination of the absolute activity of a large sample, for instance to measure the uranium content of a long fuel pin. If the activity distribution along the fuel pin is known, the averaging can be made by simple numerical integration.

EXPERIMENTAL

The centre of the semiconductor detector cannot be determined, because it depends on the measuring conditions, therefore the source positions were measured in /r,z/ geometry as illustrated in *Fig. 1*.

The efficiencies at different /r,z/ points were determined by using a set of IAEA standard sources, containing ^{241}Am, ^{57}Co, ^{22}Na, ^{54}Mn, ^{60}Co and ^{203}Hg /OMH*/ sources. The activity error of the sources was <2%, while the error of peak area determination was <1%.

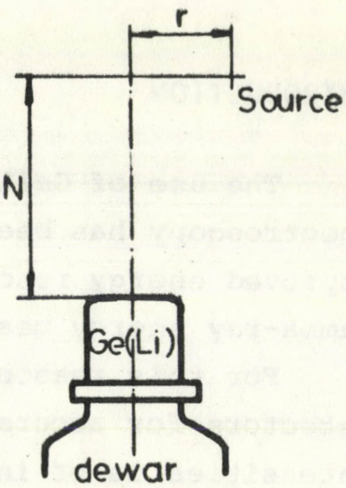

Fig1. Measuring geometry

For studying the effects of source-detector geometry conditions, the efficiency measurements for each energy were done at different source-detector distances. The heights were z = 2, 4, 6, 8 and 10 cms. The value of parameter r changed at each height from 0 to 4.5 cm.

Spectra were recorded using a 4096 channel analyzer taking only 1024 channels for each measurements. The number of events contained in each peak was obtained by using the computer program SIRIUS /2/. This program automatically searches for the peaks in the regions of interest and uses a function with semi-empirical parameters to represent the detector response in the vicinity of a peak. It performs an iterative nonlinear least-squares fit to get optimum values for the peak shape and background parameters. The output gives the energy, the width, the area and count rate of peaks and the standard deviations.

The values of the absolute full energy peak efficiency versus the energy at different heights and radial positions were fitted to the function

$$\varepsilon = A.E^{-B}. \qquad /1/$$

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*National Office for Metrology

Table 1 shows the values of the constants A and B for different heights and radial positions; E is measured in keV.

By plotting the values of the absolute full energy peak efficiency versus the energy at 6 cm height and at radial positions 0, 2 and 4 cms, the curves in *Figure 2* were obtained.

Figures 3 and *4* show the efficiency values against the radial positions for the 122 keV gamma-ray corresponding to ^{57}Co and for the 1173 keV gamma-ray corresponding to ^{60}Co respectively, at five different heights.

Figures 5 and *6* show the full energy peak efficiency versus the source-detector distance for different energies at radial positions 0.5 and 4.5 cms, respectively.

DISCUSSION

The efficiency of the investigated Ge/Li/ detector can be calculated by using the equation

$$\varepsilon = A.E^{-B},$$

where the values of A and B at different source positions are given in *Table 1*. The accuracy of the fit is about 2%. No azimuthal distribution was found in the experimental efficiency values, therefore only the radial dependences are given.

The error caused by inaccurate position of the source was investigated at different heights in the axis of the detector. Fitting the function

$$\varepsilon(z) = \frac{a_1}{(a_2+z)^2}$$

to the measured points at energies 122 keV and 1173 keV, the heights sensitivity /the relative error/ of efficiency is

$$\frac{\Delta\varepsilon/\varepsilon}{\Delta z} = -\frac{2}{(a_2+z)}.$$

It is interesting to note, that a_2 is the distance of the virtual centre of the detector, measured from the aluminium cover of the detector. Its value was 2.1 and 3.8 cms at energies 122 keV and 1173 keV, respectively. The relative errors versus height can be found in *Table 2*.

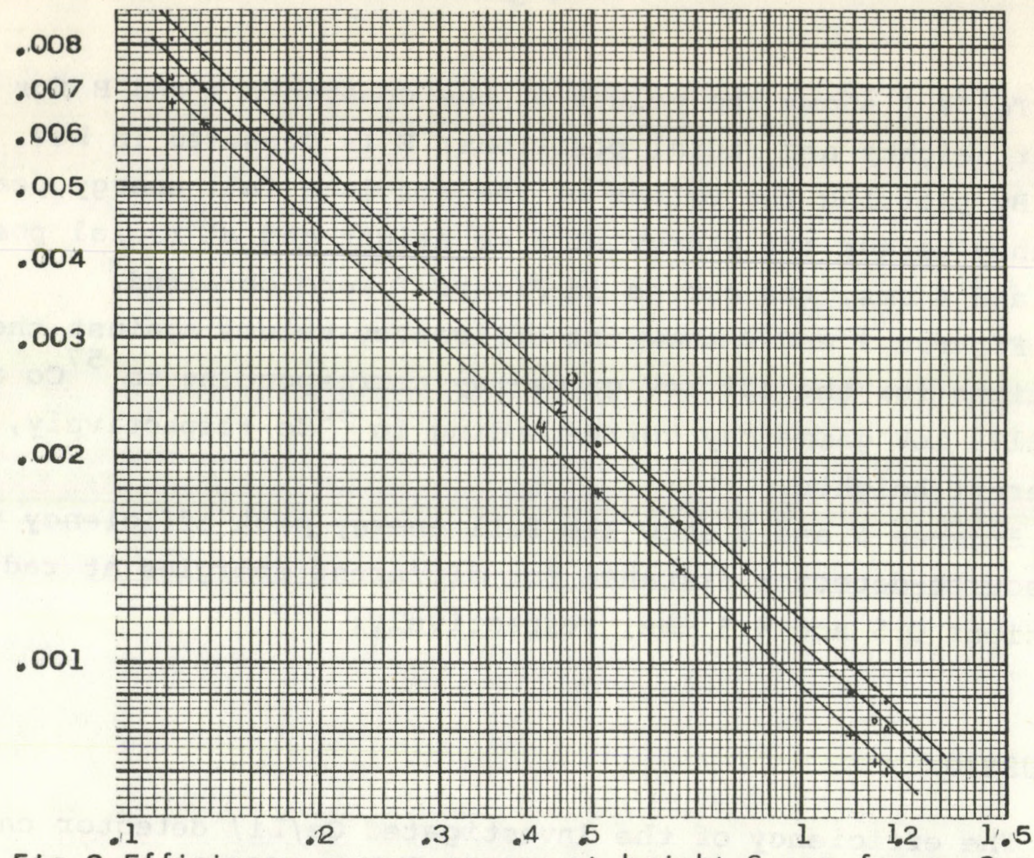

Fig.2 Efficiency versus energy at height 6 cms for o, 2 and 4 cms radial position of the source

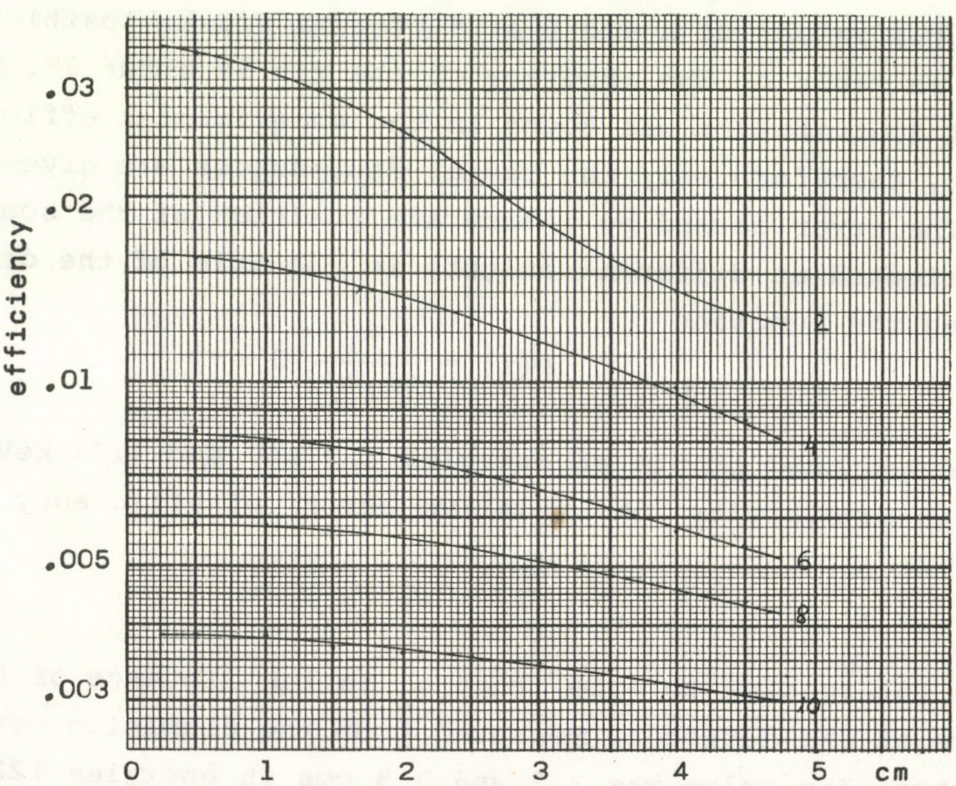

Fig.3 Efficiency versus radial positions at five different heights for E=122 keV/ ^{57}Co/

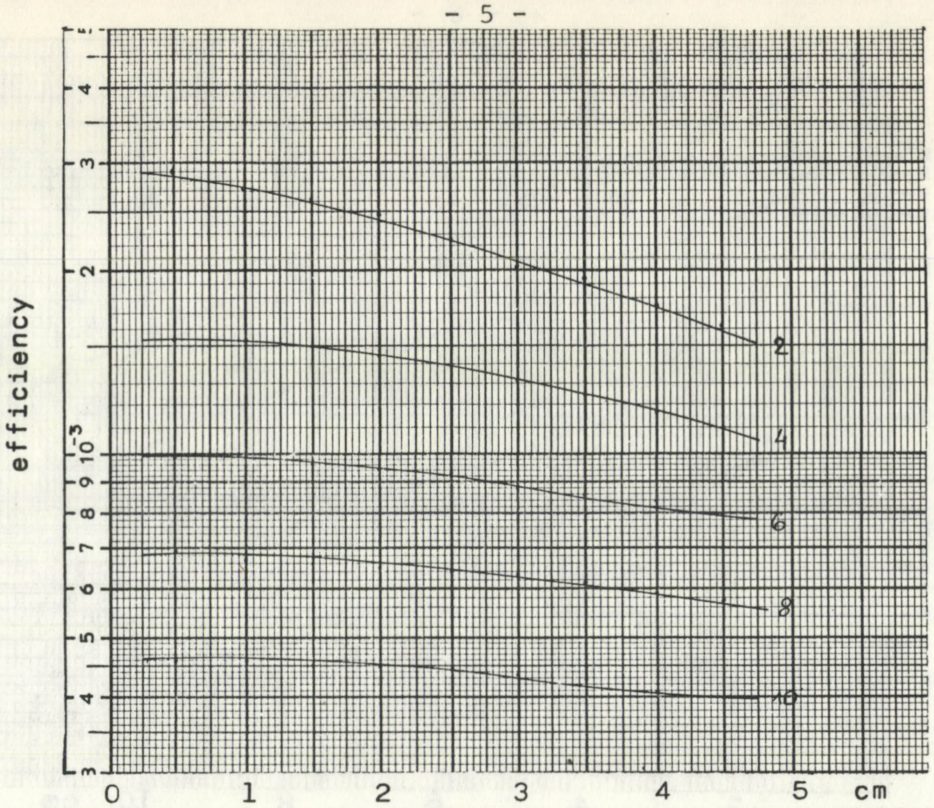

Fig.4 Efficiency versus radial positions at five different heights, for E=1173 keV / ^{60}Co/

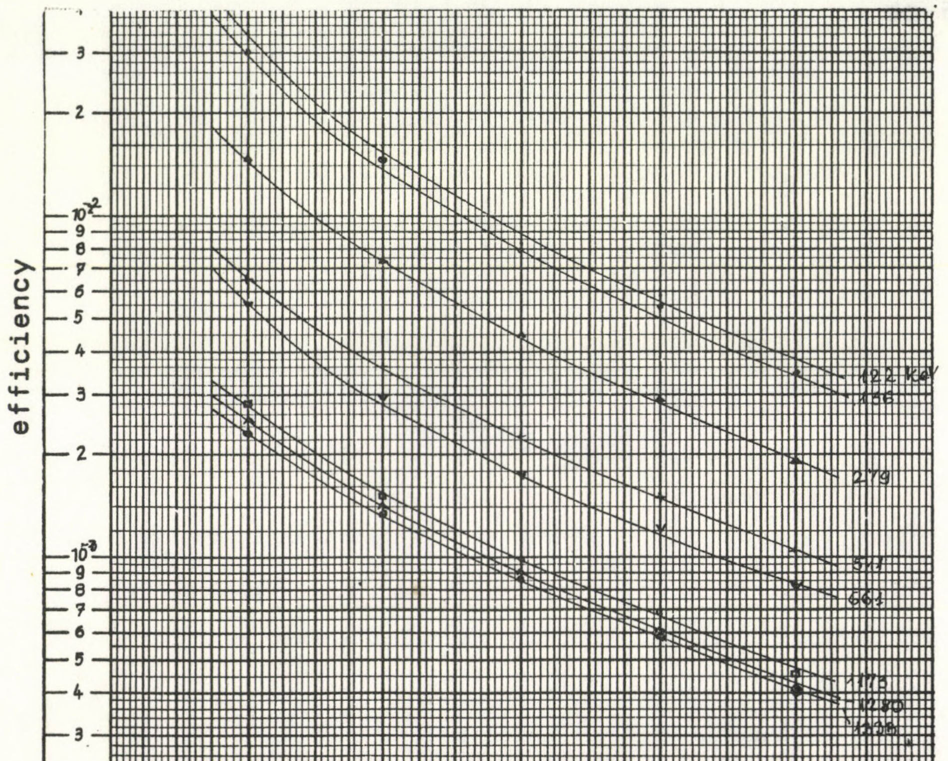

Fig.5 Absolute full energy peak efficiency vs height at r=.5 cm

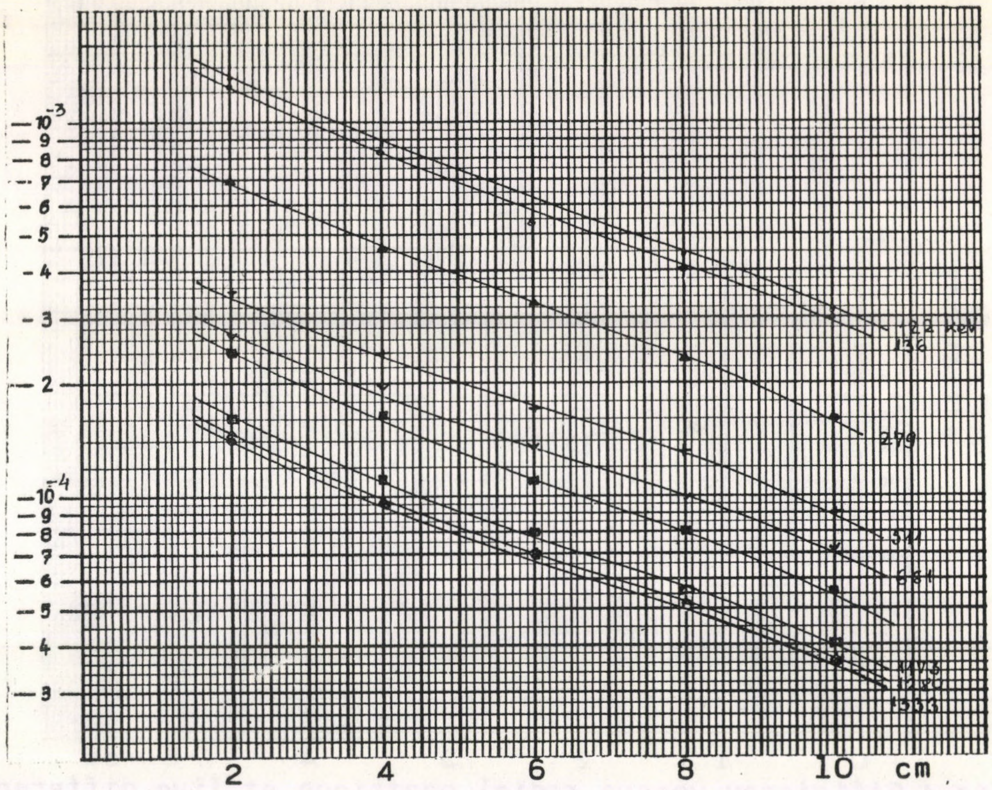

Fig.6 Absolute full energy peak efficiency vs height at r=4.5 cm

Table 1

Values of A and B in efficiency function $\varepsilon = AE^{-B}$, where E is meansured in keV

Height /cms/	Radial Position /cms/	B	A
2	0.5	1.11	7.12
2	1.5	1.09	5.74
2	2.5	1.01	3
2	3.5	0.954	1.70
2	4.5	0.942	1.27
4	0.5	1.03	2.30
4	1.5	1.02	2.08
4	2.5	0.976	1.40
4	3.5	0.964	1.16
4	4.5	0.939	0.845
6	0	0.944	0.808
6	2	0.934	0.693
6	4	0.952	0.667
8	0	0.964	0.618
8	3	0.935	0.465
10	0	0.936	0.351
10	4	0.911	0.268

Table 2

Height sensitivity of officiency

	$\frac{\Delta\varepsilon/\varepsilon}{\Delta z}$ (cm^{-1})				
Z /cm/ \ E /keV/	2	4	6	8	10
122	-0.488	-0.328	-0.245	-0.198	-0.165
1173	-0.345	-0.256	-0.204	-0.169	-0.145

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