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COMPARISON OF LABORATORY BACKGROUND "SPECTRUM SHAPE" RELATIONS OBTAINED BY USING HpGe AND NaI (Tl) DETECTORS

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Abstract:

The laboratory background (BG) were measured by using HpGe and 3" x 3" NaI(Tl) detectors and used to obtain the BG "spectrum shape" relations for the energy range (121.8 -1408) keV calibrated by using the Eu-152 standard source. The «spectrum shape» relations for both detectors are obtained by fitting the count rates data at the corresponding Eu-152 source energies by using a MATLAB program. The relations were of similar exponential terms except the coefficients values. The experimental count rate factor BG (NaI)/BG (Ge) were obtained at the corresponding energies. This factor values may be used to extract one detector count data from that of the other detector being known at the specified measurement conditions. According to these results and those of other investigators the efficiency information may also be obtained.

Key words: HpGe, NaI(Tl), background "spectrum shape" , ɤ-ray

مقارنة علاقتي «شكل طيف»الخلفية الأشعاعية للمختبر الحاصلتين من استخدام كاشفي HpGe و NaI (Tl)

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الخلاصة:

قيس طيفا الخلفية الأشعاعية للمختبر بأشتخدام كاشفي HpGe و3x3 " NaI(Tl) " واستخدم الطيفان للحصول على علاقتي " شكل طيف " الخلفية الأشعاعية لمدى الطاقة (1408 – 121.8) keV المدرج باستخدام المصدر القياسي Eu-152 . ان علاقتي "شكل الطيف" لكلا الكاشفين تم الحصول عليهما بمطابقة بيانات معدلات العد عند طاقات المصدر Eu-152 المقابلة باستخدام برنامج MATLAB . العلاقتان كانتا بحدود اسية متشابهة ماعدا قيم المعاملات. ان عامل معدل العد التجريبي BG (NaI) / BG ((Ge) تم الحصول عليه عند قيم الطاقات المقابلة. ان قيم هذا العامل يمكن استخدامها لأستخلاص معلومات العد لأحد الكاشفين من تلك المعلومة للكاشف الآخر عند شروط القياس المحددة. وطبقاً لهذه النتائج ونتائج باحثين آخرين فان معلومات الكفاءة يمكن الحصول عليها ايضاً.

كلمات مفتاحية: كاشف HpGe ، كاشف NaI (Tl) ، " شكل طيف " الخلفية الأشعاعية، أشعة كاما.

1. Introduction:

In radiation measurements the laboratory background (BG) is what the detector registers in the absence or removal of the specified radioactive source. In gamma ray measurements the BG may be of natural or artificial origin, and is preferred to be as low as possible.

The BG radiation accompanies the radiation emitted by the source being measured. Generally it complicates the source spectrum and should be treated carefully in measurements and calculation. If both the source and BG spectra interfere and have the same energy line, a difficulty will appear in obtaining the correct information of the measured source [1, 2].

BG can be reduced or even removed from γ-ray spectra through using suitable geometry and measurement techniques. The coincidence method can highly eliminate BG [3,4]. One another efficient technique is the spectrum stripping that eliminates the BG nearly to any desired degree. But one should be cautious here particularly when making quantitative measurements (say efficiency),as results may differ (even little) before and after stripping [5].

On the other hand the BG spectrum may be helpful. With assuming the BG count rate with respect to energy as unchanged, one may obtain a relation between the BG "spectrum shape» and the detector efficiency. Recently the authors [6] had investigated and compared the relations of efficiency curve of HpGe detector and the BG "spectrum shape". Further investigation [7] followed that with applying the comparison using NaI(TI) detector. In the present work we compare between the BG" spectra shape"recorded by both HpGe and NaI(TI) detectors.

2. Theoretical part:

There are four radioactive series and most of the radioactive elements found in nature belong to one of these series. These series are thorium, neptunium, uranium and actinium. For neptunium series, the half-life of the parent Np-237 which is $2.25 * 10^6$ y is very short in comparison with universe age (~ 10^{10} y), so the nuclides of this series do not exist in nature now, but could be obtained experimentally by bombarding heavy nuclides with neutrons[8].

The laboratory BG is mainly a result of the decays of natural radioactive series to their daughter nuclides at certain energies [Bi-214 (609keV), Pb-214(352keV), Ac-228(911keV)] in addition to the K-40(1460keV) and the artificial Cs-137 (661keV) nuclide.

The ɤ-ray BG spectrum also is a result of the three main interaction processes, i.e. photoelectric, Compton and pair production. The first two dominate the spectra registered .The Compton distributions of low and high energies of nuclides accumulate upon each other resulting in the decreasing behavior of the final BG registered spectrum.

3. Experimental part:

The measurements were carried out using the gamma-ray spectrometry system at department of physics-college of education for pure science- university of Baghdad. Two types of measurements were performed with using HpGe and Na I(TI) detectors. For HpGe system, the detector was of 20% relative efficiency and 3keV energy resolution. The detector is connected to a personal computer MCA card (ICS-PCI)-SPECTECH Company that controls the spectra accumulation and makes the data analysis.

A one liter Marinelli beaker standard source were used in making the energy calibration. The standard contains the Eu-152 radioactive material mixed with soil with overall activity of about 1000 Bq which is suitable for the measurements of natural radioactivity. The spectrum of the standard was accumulated for 3600 sec. and is shown in Fig. (1).The laboratory background (BG) spectrum was also measured for the same time period and is shown in Fig.(2).

For the other type of measurements a 3" X 3" NaI (Tl) detector were used and connected to the same MCA card system mentioned above. Energy calibration were made using a one liter water beaker standard source containing the Eu-152 material with activity of about 10000 Bq. The spectrum of this standard is shown in Fig. (3), and the laboratory BG spectrum was measured for 7200 sec. and is shown in Fig. (4).

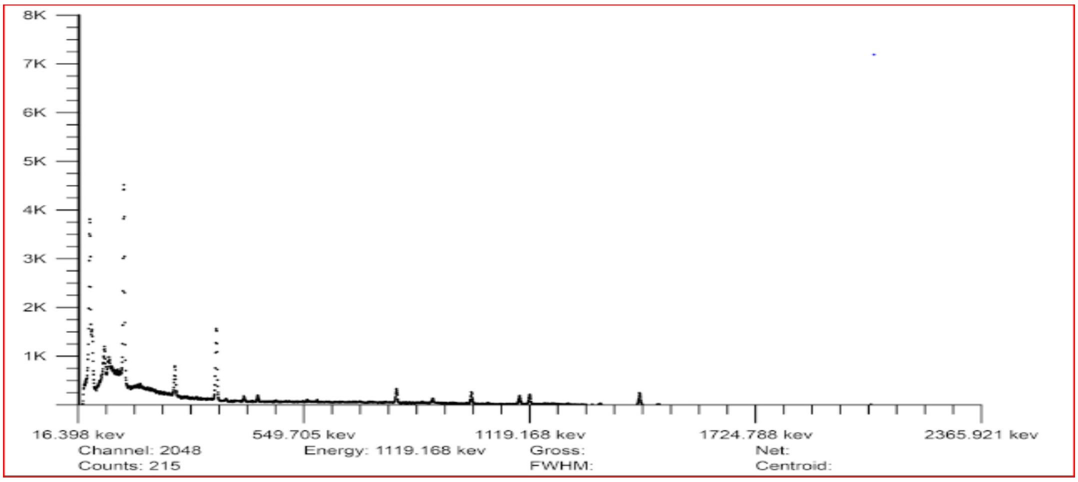

Fig. (1): Eu-152 source spectrum measured by HpGe detector.

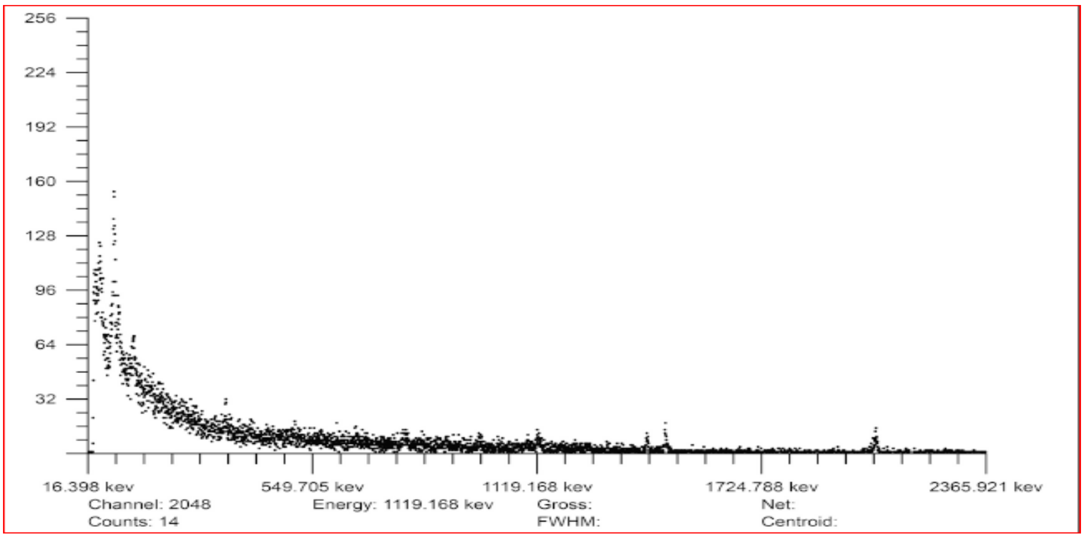

Fig. (2): Laboratory BG spectrum measured by HpGe detector.

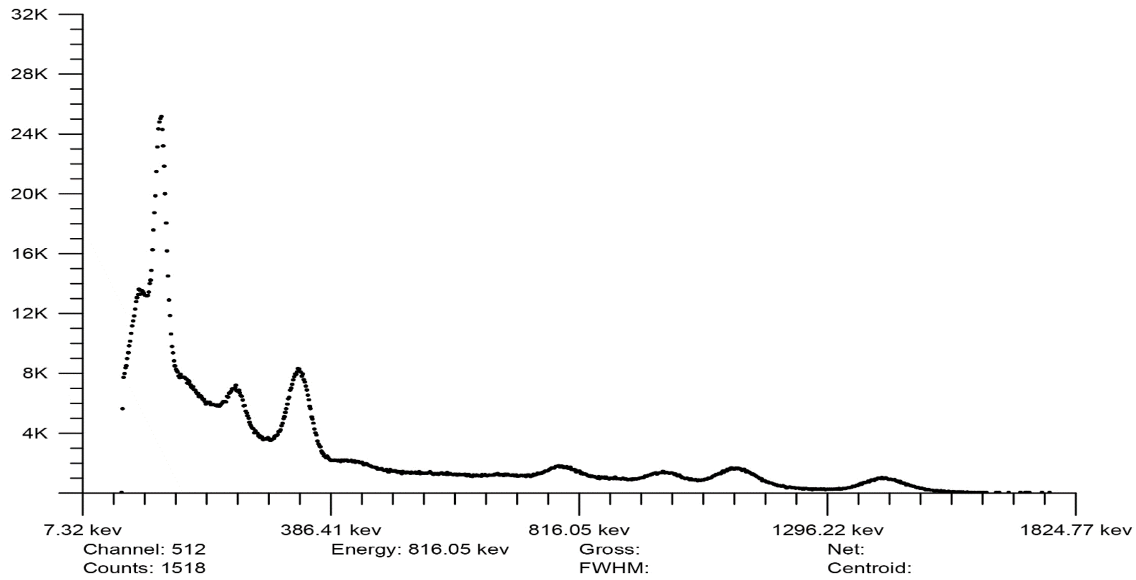

Fig. (3): Spectrum of the one liter water beaker standard (Eu-152) measured by NaI(TI) detector.

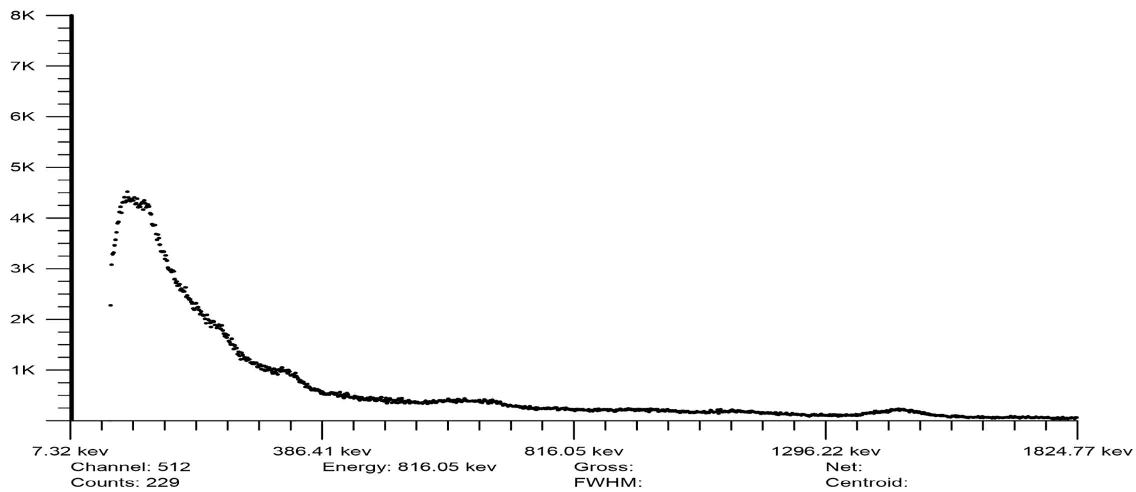

Fig. (4): Laboratory BG spectrum measured by NaI (TI) detector.

4. Results and Discussion:

For both the laboratory BG spectra measured by using HpGe and Na I(TI) detectors and shown in Figs. (2) and (4) respectively, the count rates at the locations corresponding to Eu-152 source energies, are determined and expressed in counts/sec. unit energy. as presented in Table (1). The count rates are higher for NaI (TI) than those of HpGe detector. This is a main result of the difference in their efficiencies, and is also expressed in Table (1) by the count factor BG (NaI) / BG (Ge). Although this factor may seem "high» and the Na I (TI) measurements are somewhat affected by a nearby experimental facilities, the subject is of comparative nature and needs more confirmation.

To obtain the mathematical formula that expresses the «spectrum shape» of BG , a MATLAB program were used to fit the experimental count rates. The BG spectrum shape relations after fitting are shown in Figs. (5) and (6)· The curve relations for both BG spectra are of same terms except the coefficients values. The general curve relation were as:

BG (count/sec. unit energy) =
a * exp (b*E) + c * exp (d*E) **(1)**

where E is gamma-ray energy and a, b, c and d are coefficients.

Table (1): Laboratory BG (Counts/sec. unit energy) recorded by HpGe and Na I(TI) detectors at Eu-152 source energies with comparison factor.

Eγ (keV)	121.8	244	344	411	443	778	867	964	1112	1408
BG(Ge)	0.0180	0.0061	0.0034	0.0023	0.0029	0.0020	0.0009	0.0008	0.0009	0.0011
BG(NaI)	0.5822	0.2302	0.1338	0.0681	0.0672	0.0359	0.0305	0.0305	0.0308	0.0247
BG (NaI) / BG (Ge)	32.3444	37.75	39.375	29.6413	23.1724	17.975	33.9442	38.1875	34.25	22.4545

To ease the comparison between the two BG “spectrum shape» curves shown in Figs.(5) and (6), the BG (NaI) / BG (Ge) factor at 121.8keV were multiplied by the BG(Ge) at all the remaining energies. The resultant «new» BG values recorded by HpGe detector after fitting are shown in Fig. (7). Here also the mathematical relation is similar to eq. (1) except the coefficients values.

The BG (NaI) / BG (Ge) factor values in Table (1) may be used to obtain the count rate of one detector if unknown with respect to the other, and obtain the BG “shape‟ relation which in turn may lead to extract the efficiency [6 , 7] at the specified measurement conditions. The results obtained in this work are still thought as preliminary, and the subject needs more investigation in different laboratories and with using different systems. It is also required to make long measuring time runs together with using data treatment methods available in modern MCA’s.

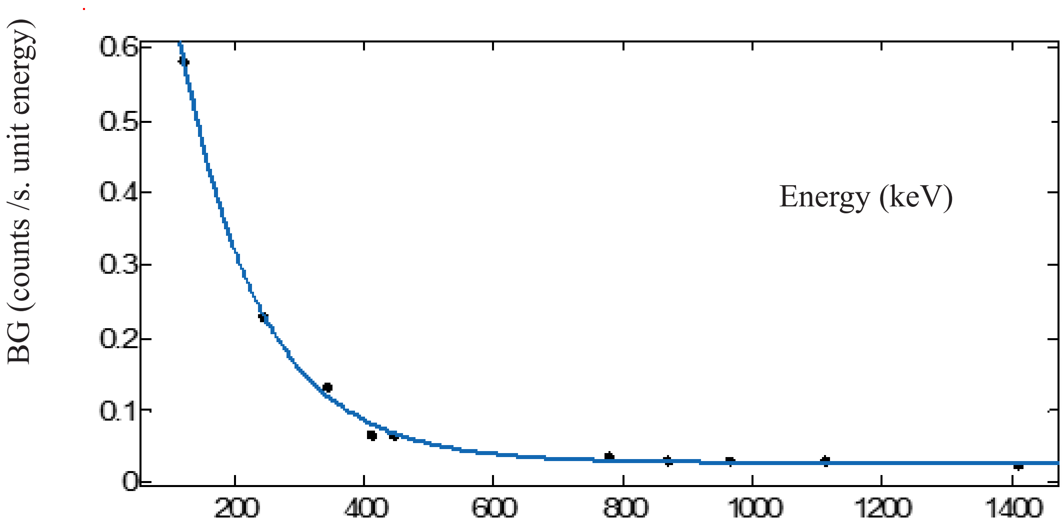

Fig. (5): The BG (NaI) data of Table (1) fitted by using MATLAB program.

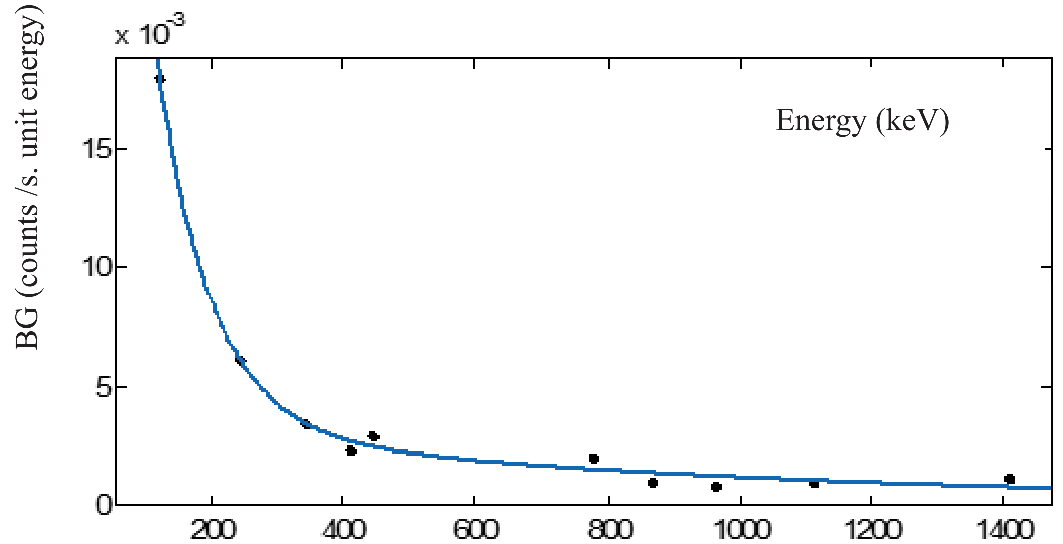

Fig. (6): The BG (Ge) data of Table (1) fitted by using MATLAB program.

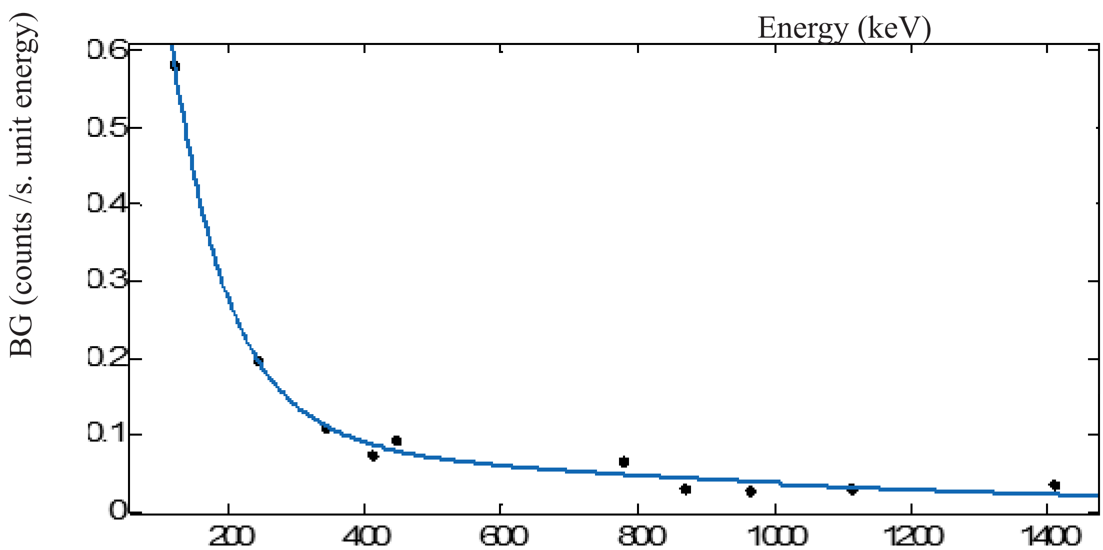

Fig. (7): The BG (Ge) data of Table (1) multiplied by the 32.3444 factor and fitted by using MATLAB program.

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