

The Radioactivity of Shielding Design of a Gamma-Ray Spectroscopy



Ali Hassan Ahmed

*Dept. of Physics, College of Science, University of Salahaddin
Arbeel, Kurdistan Region, Iraq*

ABSTRACT

Radioactivity of Lead shielding blocks and the Marinelli beaker used with a computerize Gamma-Ray spectroscopy were studied. More than twenty Lines were identified and ascribed to radionuclides of Uranium, Thorium and Actinium natural decay serieses, as well as the 1461 keV γ -line due to natural ^{40}K radio nuclide was clearly observed. For these γ -lines, both quantitative and qualitative measurements were done; among them, four common lines were determined. Because of the low intensity of other γ -lines they were ascribed qualitatively. Furthermore, several fluorescence lines were observed. A good agreement with standard results of N.D.S. and other studies is obtained.

Keywords: Gamma-Ray Spectra copy, NBG Radioactivity.

Introduction

The use of modern high-resolution spectrometers has permitted the use of complex γ -ray spectra in many fields of investigation. The information contained in these spectra consists of positions and net areas of peaks due to γ -ray emission. The determination of these quantities requires an accurate estimation of the spectral background. In order to reduce the low energy γ -lines and mainly to prevent the cosmic ray and its variations, radiation

accidents, and nuclear testing to affect the measurements, conveniently a shielding design, such as shown in Fig.(1), used in the γ -ray spectroscopy of sample spectra. In these analysis the net sample spectra is obtained by stripping the shielding design spectrum (due to shielding material itself, trapped air, and high intensity natural background lines reduced by the shielding) from the collected sample spectra.

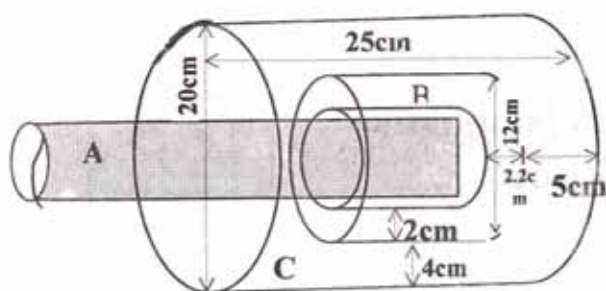


Figure (1): The counting geometry :

- A : Detector,
- B : Marinelli beaker[1]
- C : Lead shielding blocks

In this study, the γ -ray spectrum of shielding design was analyzed, and consequently the radioactive nuclides were identified, hence the contribution of such a design [2] becomes clear and known precisely. Therefore, this work serves as a basic knowledge in accurate analysis of any other sample spectra.

Experimental Setup

The gamma-ray spectrometer consisted of a closed coaxial HPGe crystal [3] with an active volume 63 c.c of model (III2-10200-S) supplied by ORTEC Company. The energy resolution given by the manufacturer is nominally 2.1 keV at an E_γ of 1.332 MeV. Amplified pulses (2 μ s) were digitized by a 2020 CANBERRA analog / digital converter and registered by a MCA of type (series 85 CANBERRA)[4]. The spectral data were printed with a proprinter of type C(5514-2) from IBM Company.

The γ -ray spectrum has been calibrated using the standard sources (^{226}Ra , ^{133}Ba ,

^{137}Cs , ^{60}Co , and ^{22}Na). The gain of the system is adjusted so that the full spectrum will cover the energy range of interest in measurements of natural radioactivity. Relative efficiency calibration was performed by means of ^{226}Ra source using the relative intensities of Alexandarove[5].

Results and Discussion

Figure (2 - a, b, and c) presents the gamma - spectrum of the shielding design. Throughout the spectrum a continuum background has been observed, which originates from Compton interaction and small-angle scattering of γ -ray photons.

Tables (1 to 5) show a list of the γ -lines with their relative intensities, that belong to the natural decay serieses as the following:

- 1- Six lines (609, 665, 768, 1120, 1764, and 2204 keV) due to ^{214}Po and three lines (242, 252, and 352 keV) due to ^{214}Bi , where ^{214}Po and ^{214}Bi are members of U-decay series.
- 2- Six lines (209, 270, 328, 338, 911, and 968 keV) due to ^{228}Th , three lines (511, 583, and 2615 keV) due to ^{208}Pb , and two lines (238 and 300 keV) due to ^{212}Bi , where these radionuclides are members in the Th-decay series.
- 3- The 186 keV line due to ^{231}Th , which is a member of Actinium - decay series.

The relative intensity data obtained for these natural decay-series radio nuclides are generally in good agreement with those reported previously, [6-18]. The few discrepancies observed have not been due to failure of the background calculation, but the low intensity of these γ -lines will be the only reason.

Among the γ -lines, four lines of energies 186, 242, 270, and 511 keV were found to be common and for each line, two nuclides contribution have been identified:

1. The 186 keV γ -line:

^{231}Th from α -decay of ^{235}U and ^{222}Rn from α -decay of ^{226}Ra decays through this γ -line at energies of 185.7 and 185.99 keV respectively. Ibrahim et.al.[19] and Ahmed [20] referred it to the parent nuclide ^{226}Ra , while Roy et.al.[21] and Roy et.al. [22] referred it to the parent ^{235}U . Although, Abdullah [6], Ahmed[17] and Evance et.al. [23] ascribed it to both ^{231}Th and ^{222}Rn nuclides.

2. The 242 keV γ -line:

^{214}Bi from β -decay of ^{214}Pb and ^{219}Rn from α -decay of ^{224}Ra decays through

this γ -line at energies of 241.9 and 241 keV respectively. Ahmed [20] and Ibrahim et.al.[19] referred it to the parent nuclide ^{214}Pb , although Abdullah [6] and Ahmed [17] referred it to both ^{214}Bi and ^{219}Rn , while Evance et.al.[23] ascribed it to the parent nuclides ^{214}Pb and ^{224}Ra .

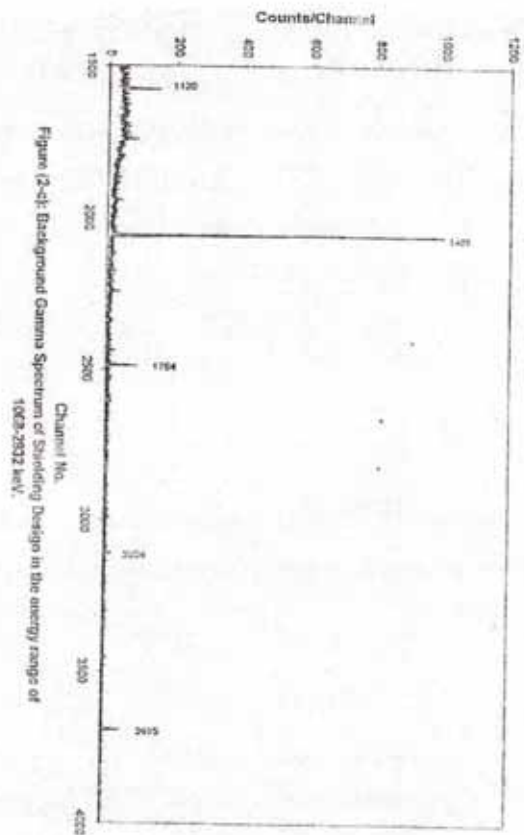
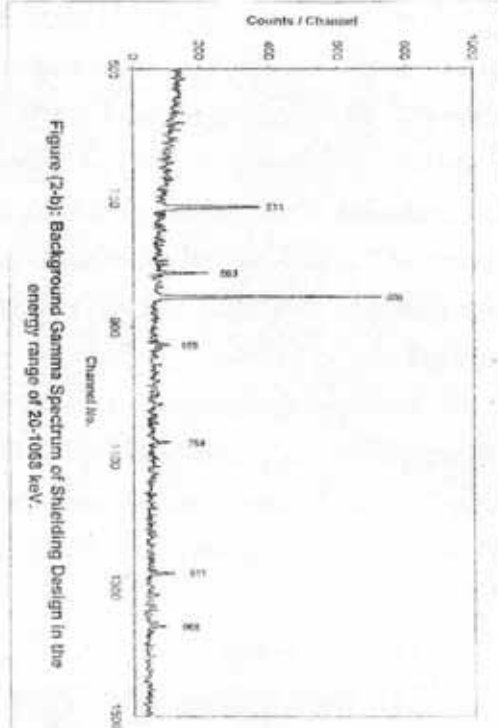
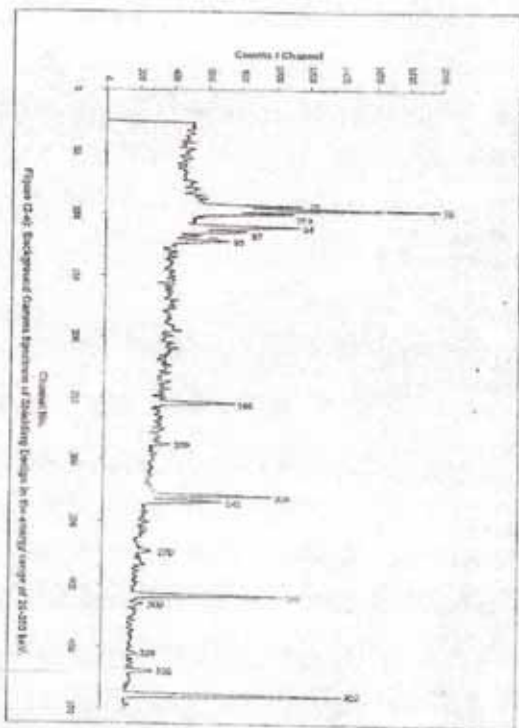
3. The 270 keV γ -line :

^{228}Th from β -decay of ^{228}Ac and ^{219}Rn from α -decay of ^{223}Ra decays through this γ -line at energies of 270.3 and 269.4 keV respectively. Ibrahim et.al. [19] and Ahmed [20] referred it to the parent nuclide ^{228}Ac . Although, Abdullah [6] and Ahmed [17] ascribed it to ^{228}Th only.

4. The 511 keV γ -line:

^{208}Pb from β -decay of ^{208}Tl decays through this line, and the annihilation radiation is the other source of this line. Abdullah [6], Ahmed [17], Ibrahim et.al.[19] and Ahmed [20] ascribed it to the above two sources.

For each radionuclide one line was taken as a 100% intensity: for ^{214}Po , ^{214}Bi , ^{228}Th , ^{208}Pb , and ^{212}Bi radionuclides, the 609 , 352 , 911 , and 2615 keV γ -lines, respectively, were selected as the 100% intensity γ - lines, see tables (1-5).



Table(1): Relative intensities of γ -lines of Po-214 from β -decay of Bi-214.

Energy (keV)	Present Work	N.D.S vol. 21 (1977) [8]	Westmeier (1981) [25]	Al-dargazelli (1987) [26]	Abdullah (1992) [6]	Ahmed (1992) [7]
609	100±0.39	100	100±0.00	100.0±3.25	100±1.04	100±0.90
665	3.24±0.51	3.39	3.390±0.05	2.04±1.50	3.89±0.624	3.385±0.44
768	9.516±1.1	10.593	10.58±0.09	11.18±2.13	10.61±0.86	10.12±0.59
1120	31.919±0.93	32.593	32.60±0.30	29.01±2.27	33.96±1.862	31.27±0.86
1764	36.096±1.2	34.541	34.45±0.30	-----	35.32±1.29	34.71±0.89
2204	9.95±0.87	10.832	-----	-----	12.7±1.347	10.96±0.52

Table (2): Relative intensities of γ -lines of Bi-214 from β -decay of Pb-214

Energy (keV)	Present Work	N.D.S vol. 21 (1977) [9]	Westmeier (1981) [25]	Burgess & Richard (1983) [27]	Abdullah (1992) [6]	Ahmed (1992) [17]
242	21.225±0.64	20.123	-----	-----	20.33±0.51	20.04±0.37
295	53.378±1.65	51.724	51.74±0.30	50.79±0.03	51.53±1.07	52.5±0.68
352	100±1.32	100	100±0.40	100±0.05	100±1.20	100±0.70

Table (3): Relative intensities of γ - lines of Th-228 from β - decay of Ac-228.

Energy (keV)	Present Work	N.D.S vol. 17 (1976) [7]	Table of isotopes (1978) [28]	Sundasivan (1982) [29]	Abdullah (1992) [6]	Ahmed (1992) [17]
209	16.25±3.41	15.7	15.92	15.35±0.2	13.19±1.52	13.97±2.79
270	12.63±2.12	13	13.33	12.99±0.2	15.49±1.34	13.86±1.4
328	11.51±1.50	11.6	11.48	11.41±0.2	11.55±1.4	12.15±2.5
338	45.59±3.8	41.4	44.07	42.12±0.5	39.51±1.97	49.83±4.2
911	100±6.42	100	100	100±1.3	100±2.7	100±5.4
968	57.43±5.64	60.2	60.37	59.44±0.8	61.33±2.66	60.86±4.9

Table (4): Relative intensities of γ - lines of Pb-208 from β -decay of Tl-208.

Energy (keV)	Present Work	N.D.S vol. 47 (1986) [16]	Abdullah (1992) [6]	Ahmed (1992) [17]
511	20.96±1.78	22.4	22.91±1.4	22.85±1.85
583	84.2±4.9	85.2	83.65±3.25	83.50±4.54
2615	100±6.14	100	100±2.9	100±3.89

Table (5): Relative intensities of γ - lines of Bi-212 from β - decay of Pb-212.

Energy (keV)	Present Work	N.D.S vol. 27 (1979) [10]	Table of isotopes (1978) [28]	Sundasivan (1982) [29]	Abdullah (1992) [6]	Ahmed (1992) [17]
238	100±2.16	100.00	100.00	100±2.00	100.00±1.0	100±1.22
300	8.16±1.34	7.66	7.674	6.74±0.2	8.03±0.62	8.015±0.72

Table (6) presents several lines including low intensity γ -lines, overlapping lines in the low energy region and fluorescence lines.

The Pb and Th X-rays arise from the fluorescence of the lead in the shielding material and of the Th in the trapped air around the detector, while the Bi X-rays arise from the decay of [24].

Table (6) : Some low intensity γ -lines and X-ray lines.

Energy (keV)	Source	Series
72.8	$K_{\alpha 2}$ Pb	-----
75	$K_{\alpha 1}$ Pb	-----
77.3	$K_{\alpha 1}$ Bi	-----
84	1. ^{223}Ra from β -decay of ^{228}Th	Thorium Actinium
87	1. $K_{\beta 1}$ Bi 2. $K_{\beta 2}$ Pb	-----
90	1. ^{231}Pa from β -decay of ^{231}Th	Actinium
93	^{234}Pa from β -decay of ^{234}Th	Uranium

In addition the 1461 keV γ - line of ^{40}K was clearly observed throughout the spectrum.

Conclusions

While the present shielding design can greatly reduce the effect of natural radioactive background, it can be a cause of a source-induced background. So, this work reveals the efficiency of this design in reducing the natural background and establishes detail knowledge about its contribution to any sample spectra analysis.

A significant contribution of the natural decay series radionuclides (^{214}Po , ^{214}Bi , ^{228}Th , ^{208}Pb , and ^{212}Bi), ^{40}K natural radionuclide and X-ray fluorescence due to this shielding design were recorded, analyzed and identified.

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چالاکى تيشکاوهرى قه لغانى قورقوشمى
به کارهيزاو له گهل شه بهنگ بينى تيشكى گامى
Ray -Spectroscopy

على حسن احمد - م. ياريددهدر

به شى فيزيا - زانکوی سه لاهه دين - هه وليتر - کوردستانى عيراق
پوخته

له م توپژينه وه يه دا چالاکى تيشکاوهرى تاييه ت به قه لغانى قورقوشمى و بيکهرى مارينللى که ده وهرى
دوزه ره وهى جه رمانيو مى زور خاوينيان داوه و له گهل شيکه ره وهى شه بهنگى گامى کز مپيوته ريدا به کار ده هينرين.
زياتر له بيست هيللى گامى ناسرانه وه که نه گه پينه وه بق ناووکه کانى زنجيره سروشتى به تيشکاوهره کانى يورانسيوم و
پوريوم و نه کتينيوم، چوار له م هيلانه برىتى بوون له هيللى هاويه ش (زياتر له يه ک ناووک به شدارى هه يه له دروست
بوونيدا) وه ناووک به شدار بووه کان ديارى کران. هه ردوو لايه نى پيوانه کردنى چه نديتى و چو نيتى بق هه مو نه م
هيله گاميانه نه نجام درا. هه روه ها خه تى ۱۴۶۱ ک.ا.ف که له ناووکى پوتاسيومى -۴۰ سه ره لده دا به ناشکرايى بينرا.
هه ندى هيللى گامى تر ته نها پيوانه کردنى چو نيتيان بق کرا له به ر لاوازي تونديه کانيان. زياتر له مانه ش هه ندى هيللى
فلورسنت ده ست نيشان کران. له هه مو باره کاندا ريکه وتننکى باش له گهل نه نجامه پيوانه يه کانى ناو N.D.S. وه
نه نجامى توپژينه وه کانى تر به دى کرا.

النشاط الاشعاعي للدرع الرصاصي مطياف اشعة كاما المصمم مع

Ray -Spectroscopy

على حسن احمد - م. مساعد

قسم الفيزياء - جامعة صلاح الدين - اربيل - اقليم كردستان - العراق

الخلاصة

أجريت دراسة النشاط الأشعاعي للدرع الرصاصي و بيكر مارينللى المحيطان بكاشف الجرمانيوم النقي و
المستعملان في مطياف أشعة كاما الحاسوبي. تم تشخيص أكثر من عشرين خطأ كاميا منتمين الى نويات السلاسل
الأشعاعية الطبيعية: يورانيوم، ثوريوم، وأكتينيوم، وكذلك تم ملاحظة الخط ۱۴۶۱ ك.ا.ف الناتج من نواة البوتاسيوم -
۴۰ بوضوح. أجريت المعالجة الكمية و الوصفية لجميع هذه الخطوط الكامية، وتم تحديد أربعة خطوط مشتركة من بين
هذه الخطوط. نظرا للشدة الضعيفة للخطوط الكامية الأخرى فقد أجريت لها المعالجة الوصفية فقط. بالإضافة الى ذلك
تم ملاحظة عدد من خطوط الفلورة. في جميع الحالات وجدت تطابق جيد مع النتائج القياسية الموجودة في N.D.S.

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په سه ندى کرا له ۲۰۰۰/ ۸/۲۱ دا