WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 10, Oct., 2023

REDUCING THE EFFECT OF BACKSCATTERING AND COMPTON EDGE ON NA-22'S SPECTRUM USING DIFFERENT MATERIALS

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Abstract

The purpose of this study is the effect of shields made of different materials on reducing back scattering and the Compton edge are calculated at the photon energies (511 ,1274) Kev emitted by a source (Na-22). Different types of shields such as (stander, lead3cm, lead 2cm, polyethylene and concrete) were studied using one of gamma-ray spectroscopy techniques, which consists of a thallium NaI (Tl)–activated sodium iodide scintillation detector with dimensions of 3"×3" and its electronic accessories and by using radioactive source (Na-22). The results we obtained indicated a decrease in the overall count rates when lead shield surrounds the detector, as the count rates decreased in all channels (almost all the energy peaks of the spectrum). Increasing the thickness of the lead shield will prevent more gamma rays from reaching the detector. This traditional method of detector shielding, consisting of a single material, is considered the best method for detector shielding. The results we obtained in the experimental part confirmed the theoretical part.

Keywords: Shielding, NaI(Tl) detector, Compton edge, Back scattering, Stander source, Gamma ray spectroscopy.

Introduction

Nuclear radiation detectors were essential tools from the outset of the utilization of radioactive sources in a variety of disciplines [1]. As nuclear technology advances there is a greater chance that they will be exposed to ionizing radiation. To absorb the radiation and lessen its intensity, a shielding is required. It is one of the protected strategies that the International Commission on Radiation Protection advises (ICRP) [2]. Background radiation originates from cosmic sources, radioactive nuclides that are created artificially or naturally, or both [3]. One of the most popular gamma spectrometry materials is NaI(Tl), and its performance is closely correlated with its detection efficiency. [4]. A main element of radiation safety programs intended to lower employee exposure to ionizing radiation is the attenuation or shielding of

ISSN: 2776-0979, Volume 4, Issue 10, Oct., 2023

gamma radiation. choosing the most suitable protective material [5]. Lead is a typical x-ray and gamma radiation shielding material. Sometimes it's important to shield with a variety of materials when working with a radionuclide that generates gamma radiation and beta particles, among other radiation kinds. Depending on the photon energy, different shielding types and levels apply. This typically reduces scattering and the overall amount of needed shielding material. [6]. The attenuation process due to these interactions depends on the geometry of the beam because the photons may be absorbed or reach the target point with their original energy if the beam is not collimated, but if it is, the photons will lose energy and either pass through the material without interaction or may be partially or completely absorbed by absorption or scattering interactions, respectively. [7]. There are twelve reactions in which the photon interacts with the material, but the photoelectric effect, Compton scattering, and pair creation are the most well-known ones. [8].Radiation shields are made from radiation-emitting materials or used to contain radioactive sources [9]. Consequently, it is to create nuclear shields made of single, heavy materials such as lead, or a compound that is lightweight and simple to from at the same time. [10]. The quantity of scattered photons will grow as the target material's thickness increases, and their intensity will depend on the materials' atomic number and thickness [11]. The photon can transfer energy through scattering by a free electron. The energy distribution is continuous up to the Compton edge, where the greatest energy delivered to an electron in Compton scattering occurs for a scattering angle of 180°. When the gamma scatters without being noticed, scatters once more, and then scatters once more until it is completely absorbed, the backscattered peak results. In actuality, the backscattered peak's energy value is equal to the photo peak's energy value less the Compton edge's energy [12].
In the present work, the experimental study of various detector shielding materials with different thicknesses to determine the Compton edge location and backscattering of gamma-ray photons using a gamma source (Na-22). We used different materials, such as lead, concrete, and polyethylene, from which shields were made in different sizes and thicknesses. Minimum Compton edge and backscatter values were obtained using a suitably shielded 3 × 3 NaI(Tl) scintillator detector while keeping the distance between the radiation source and detector constant.

2. Experimental set-up

There are two main components to the experimental part. The preparation of the nuclear shields employed in this research is included in the first part. and the second

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ISSN: 2776-0979, Volume 4, Issue 10, Oct., 2023

involves special calculations to determine the Compton edge and back scattering for Na-22 gamma ray stander source.

2.1. Construction shields

The purpose of shielding is to reduce background radiation reaching the detector. The materials used to shield the detector are lead, lead with other metal and polyethylene. We use the lead due to its high density and large atomic number. The laboratory contains one shield, which is the company's standard shield that we have. Two lead shields of different thicknesses and dimensions were manufactured to protect the detector.

The shield consists of three parts, one of which is the upper part that represents the cover, the lower part that forms the base, and the last part that surrounds the detector crystal so that the detector is completely covered by the shield. We made the first shield by designing a cylindrical mold of iron an inner diameter of 15 cm, a thickness of 2 cm, a height of 15 cm, and about 35 kg of lead. As for the second shield, we designed a cylindrical mold of iron with an inner diameter of 16 cm, a thickness of 3 cm, and a height of 22 cm, the total weight was about 52 kg. Making cylindrical iron molds for the three components of the shield is the most crucial step of the shield manufacturing process. Lead is provided for this job from local markets. After being heated to remove any impurities, the lead is then poured into cylindrical molds. After that, the components underwent filtering, removal of deformities and protrusions, and dyeing until they appeared good and appropriate for use. The manufacturing of concrete the shield is done designing an iron cylindrical mold of 15cm inner diameter 3cm thickness, 16 cm height. The construction of polyethylene shield was made of polyethylene The cylindrical mold of 17cm inner diameter, 1cm thickness , 18 cm height.

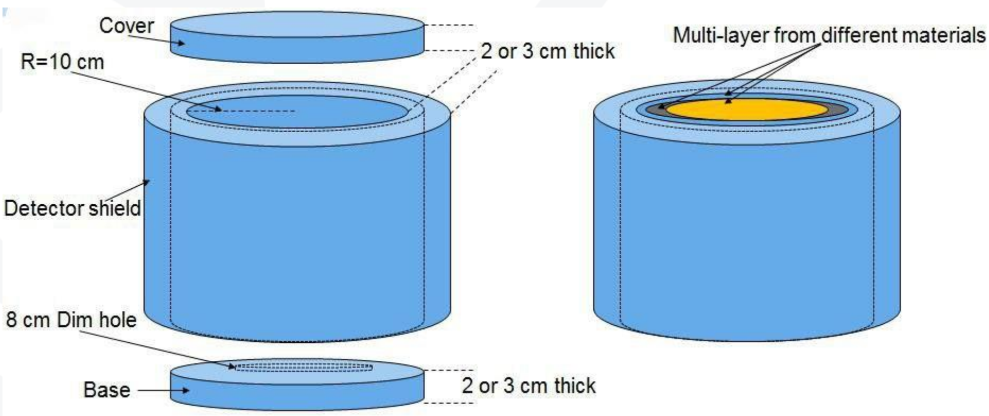

Figure 2.1 : schemes diagram of the design shields .

ISSN: 2776-0979, Volume 4, Issue 10, Oct., 2023

Table 2.1: Types of shields

Shield ID	Type of shield
Stsh	Stander Lead shield
L3sh	Lead 3cm shield
Wosh	Without shield
Cosh	Concrete shield
Posh	Polyethylene shield
L2sh	Lead 2cm shield

Figure 2.2: The measurement system used in the current study.

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2.2 NaI(Tl) Detector

In the current research, the Teledyne Isotope scintillation detector of an American origin was used, its crystal size 3"x 3". This detector mainly consists of a transparent solid inorganic scintillation crystal of sodium iodide doped with thallium (TI), and attached to this crystal a high-efficiency photomultiplier tube whose function is to the light flash into an electrical signal whose is proportional to the energy of the gamma-ray photons falling on detector. This detector is characterized by a good energy analysis ability close to (7.5%) at a power line (661.7 KeV) which is one of the energies of gamma rays emitted from the standard source of the radioactive cesium-137 (Cs137) isotope and operates at operating voltage (733 Volt).

3. Results of backscattering and Compton edge

The backscattering and Compton edge spectra are obtained by scattering the radiation with Na- source for 900 s. The shield is made of different materials and is in the shape of a cylinder with different dimensions. The spectrum of these shields used was recorded for the same time period to allow recording of events (photo peak, Compton edge and backscatter) for all shields.

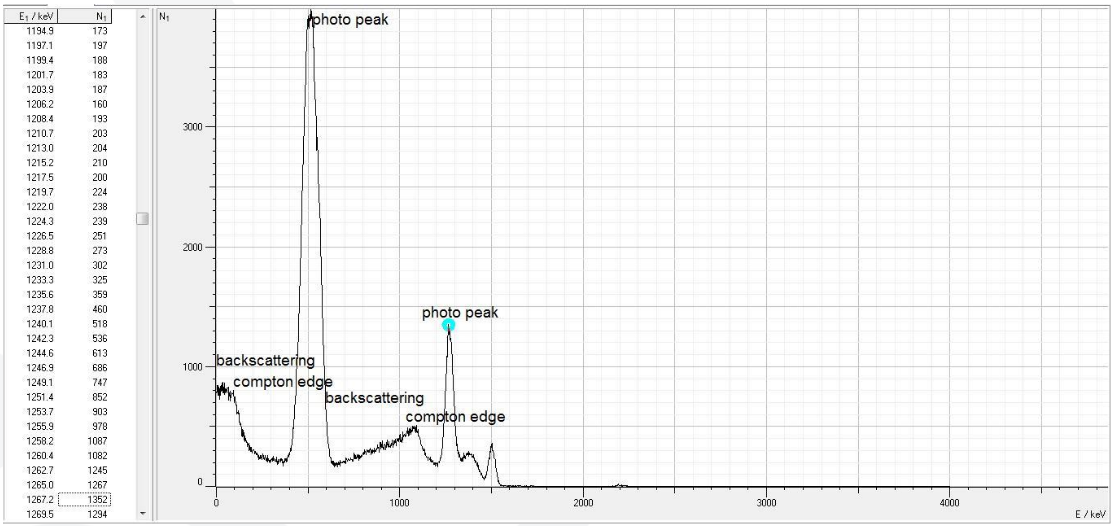

Figure 3.1:Na-22 spectrum measured using NaI(Tl) detector for stander shield.

It shows the photo peak, backscatter and Compton edge. This spectrum is stored in a file in the computer and the radioactive isotope Na-22 has two energies, one (511 keV) and the other (1274 keV). Characteristics found in the spectrum include: pulse height, which is the Compton edge, and backscatter. The Compton interaction is a purely kinetic collision between a gamma-ray photon and a free electron in a detector crystal. Through this process, the incident photon loses part of its energy to the electron. The numbers of scattered photons depend on the target's atomic number and the thickness of target used in the experiment .Based on the experimental work and the

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ISSN: 2776-0979, Volume 4, Issue 10, Oct., 2023

equipment used (detector and calibration sources), it was concluded that the Compton edge and backscatter values were obtained.

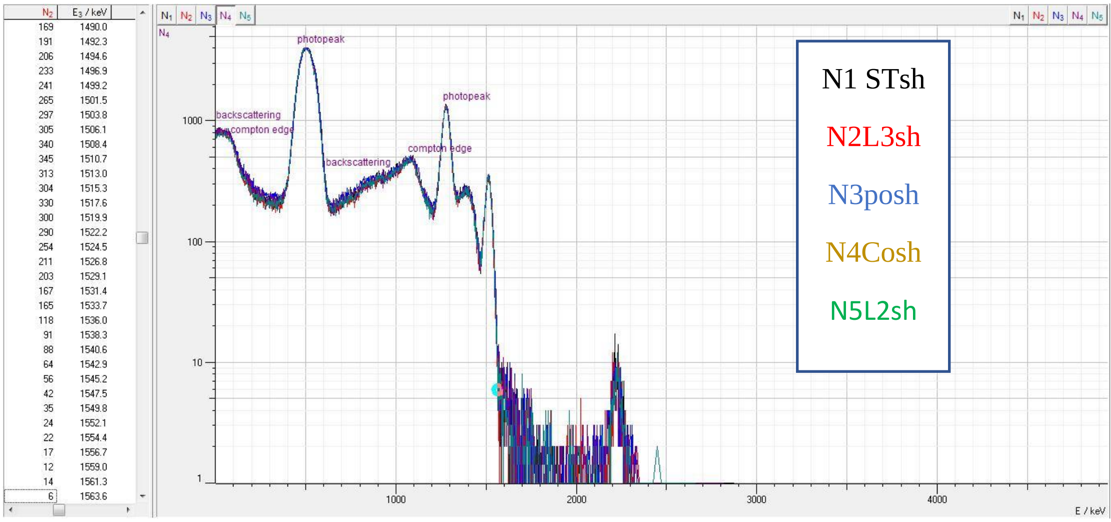

Figure 3.3:Na-22 spectrum measured using NaI (Tl) detector for many shield.

Table 3.1: Calculation experimental of the back scattering and Compton edge of the standard source of Na-22 for the scintillation detector type3″ × 3″.

Type of shield	Photo peak(kev)	Compton edge(kev) experimental	Backscattering(kev) experimental
Stsh	511 1274	322 1035	124 595
L3sh	499.5 1276.3	224 1054.69	116 624
Wosh	504.1 1274	338.06 1017.85	205 570
Cosh	504.1 1278.6	287 1104.32	184 588
Posh	494.9 1278.6	295 1085.5	194 927
L2sh	485.7 1278.3	278 1083.3	117 775.3

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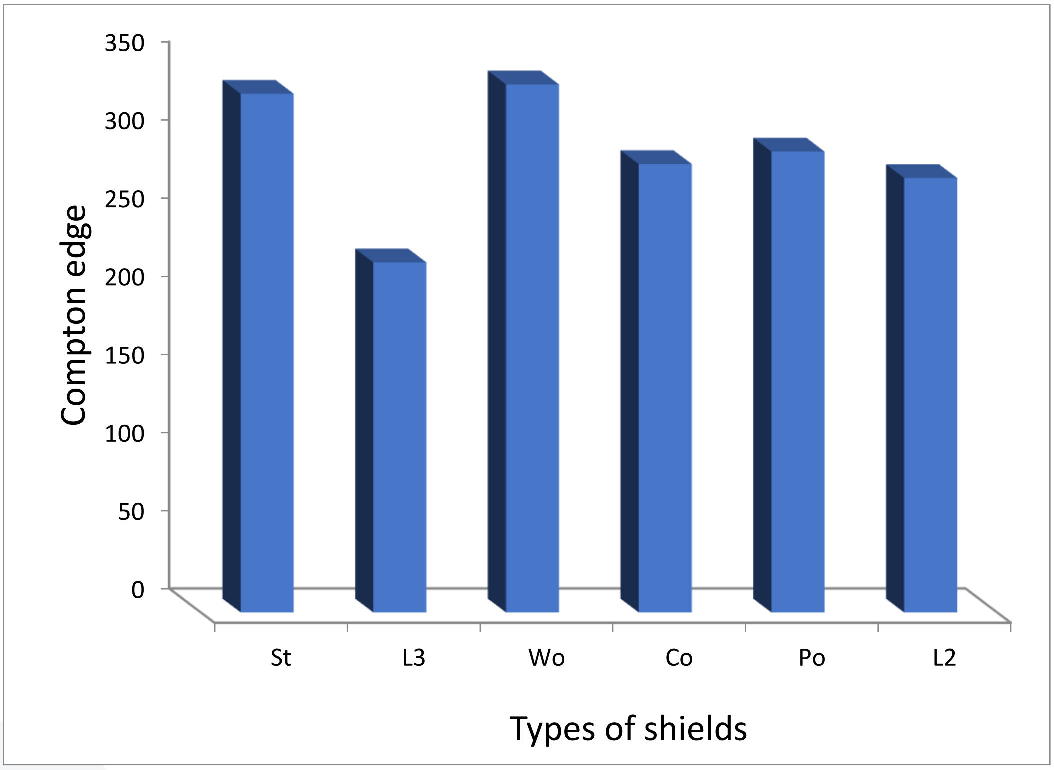

Figure 3.4: Experimental of the compton edge is function of types of shielding for stander source of Na-22 at 511 Kev.

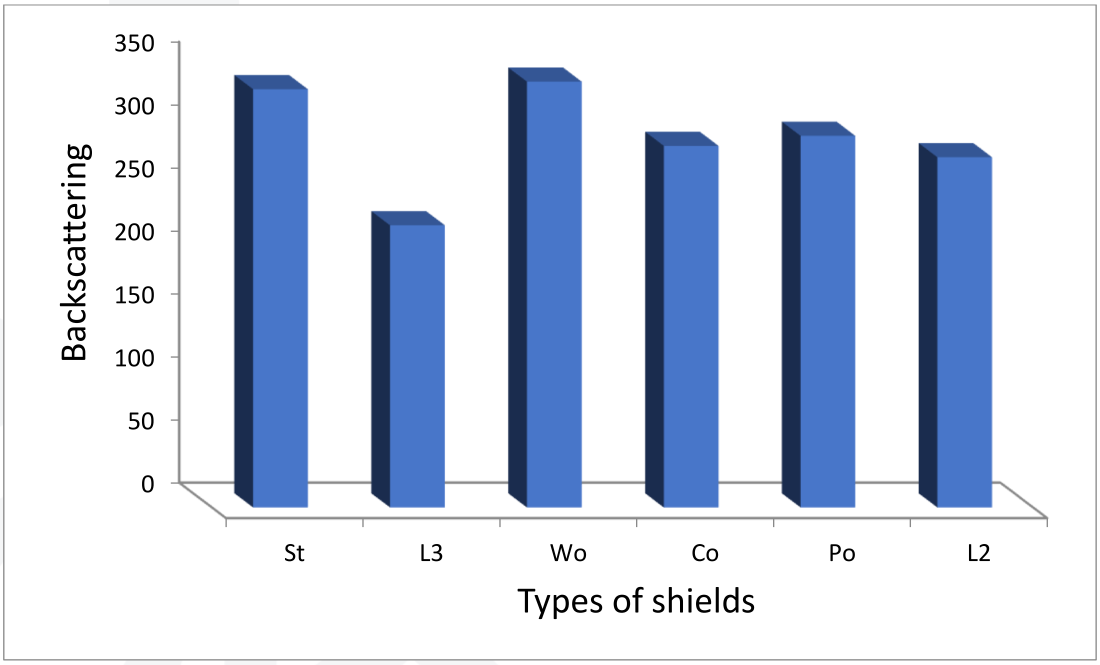

Figure 3.5: Experimental of the backscattering is function of types of shielding for stander source of Na-22 at 511 Kev.

Table 3.2: Calculation theoretically of the backscattering and Compton edge of the standard source of Na-22 for the scintillation detector type3″ × 3″.

Type of shield	Photo peak(kev)	Compton edge(kev) theoretical	Backscattering(kev) theoretical
Stsh	514 1274	344 1061.18	170 212.82
L3sh	504.1 1276.3	334.56 1063.42	169.44 212.88
Wosh	504.1 1274	334.54 1061.18	169.56 212.82
Cosh	504.1 1274	334.54 1061.18	169.56 212.82
Posh	513 1278.6	350 1065.65	163 212.95
L2sh	504.1 1278.3	334.54 1065.65	169.56 212.65

4. Conclusion

The results explained that the designed and manufactured shields of all kinds have good consistency in the energy spectrum of the source Na-22, as the effect of both backgscattering and the Compton edge of the annihilation photons whose energy 511Kev was reduced, as well as the energy of 1274kev resulting from the radioactive source used. As for increasing the thickness of the shielding material, such as lead, the number of single-energy photons coming from outside of the shielding decreases and will prevent a large number of gamma rays from reaching the detector. We note that the backscattering and Compton edge in lead shield (L3cm) is the lowest value, and then it is followed by lead shield (L2cm). We obtained practical values almost identical to theoretical values.

References

[1] I. Akkurt, K. Gunoglu, S.S. Arda, Detection Efficiency of NaI(Tl) Detector in 511 - 1332 keV Energy Range, Sci. Technol. Nucl. Install. 2014 (2014) 6-11.

[2] Waly E S A and Bourham M A 2015 Comparative study of different concrete composition as gamma-ray shielding material Ann. of Nucl. Energy 85 p 306-310.

[3] Klucke, H., Beete, J., The Optimizaton of an Anticompton Spec trom e ter for the Anal y sis of Bi o -log i cal Sam ples, Pro ceed ings, 3th In ter na tional Con -fer ence Low Radioactivities '85, Bratislava, 1987, pp. 149-154

[4] Kim Y, Park S and Seo Y 2015, Enhanced x-ray Shielding Ability of polymer-Nonleaded metal composites by multilayer structuring industrial and wng. Chem. Reaserch 54 (22) pp. 5968-5973

[5] Daniel R. Mc Alister, Ph.D, University Lane Lisle, Gamma Ray Attenuation Properties of Common Shielding Materials, 2013.
[6] J. Hans man, Design and construction of a shield for the 900 _ 900 NaI (Tl) well type detector, Nucl. Technol. Radiat. Prot. 29 (2014) 165-169.
[7] J F Krocher, R E Browman, Effects of Radiation on Materials and Components, Reinhold (Eds.), New York (1984).
[8] Muzahim Mohammed Abdullah, The measurement and the calculation of the linear attenuation and mass coefficient X-ray and Beta -rays using cement slabs, Journal of Basra Research 4 (2014).
[9] B K R Altalib, Studying the shielding properties against radiation of Some composite materials reinforced by lead, M.Sc. Thesis, College of Science for Women, Baghdad University (2009).
[10] K H Beckurts and K Wirtz, Neutron Physics, Neutron Physics, Springer – varlag, New York (1964).
[11] Majid SA, Balamesh A. Imaging corrosion under insulation by gamma ray backscattering method. Middle East Non Sharma destructive Testing Conference & Exhibition. Bahrain, Manama; 2005.
[12] Wei-Kan, et Backscattering Spectrometry, Academic Press Inc.,1978.