Journal of Information Engineering and Applications
ISSN 2224-5782 (print) ISSN 2225-0506 (online)
Vol.4, No.2, 2014

Study the Effect of the Size of Crystal Detector (Scintillation) Nai(Tl) on the Energy Spectrum

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Abstract :
In this research are used two types of detectors scintillation NaI(Tl) sizes (2"x2") ,(1"x1.5")for a comparative study between them and are used source of radioactive cesium has energy (0.662 MeV) and calculating the total area of the spectrum space scattering and area of peak optical and portability energy analysis, found the size large for crystal detector leads to probability escape photons outside the crystals to be less because it can reveal again and recorded pulse with pulse recorded by the electron apostate so increase the value of portability energy analysis, and increase the volume of detectors cause increased probability for scattering Compton ,In other words the increase in the probability of interaction effect photoelectric be less than the increase in the probability of interaction scattering Compton so the Net Area under the peak at less an increase of scattering spectrum.

Introduction

The gamma ray differ from charged particles in the interaction with the material as the gamma rays great ability to breakthrough, and is the scattering of the most important interactions these rays with material to the likelihood of occurrence of high in a wide range of energies (Kindem,et.al.,2010) as a result of its uses wide in several field such as shielding, treatments and diagnostics medical further to utilize it to get information on the properties of materials and installation of molecules may occupied the attention of researchers widely (Gurendik&Tsoulfanid,2000). Vary detectors nuclear depending the type of the study and the aim to several types, Characterized detectors scintillation wide uses such as nuclear radiation detection and environmental studies, nuclear medicine and is used particularly for measuring energy gamma rays, X-rays and high-energy beta particles because it is characterized by high efficiency due to its density and atomic number for thallium and iodine (Knoll,2000). The crystal iodide sodium activator thallium NaI (TI) of materials inorganic and mechanical flashes depends on the energy levels specified by the crystal format of material relates to material flash glass tube cylindrical vacuum called tube multiplier photosynthesis that are transforming the optical signal to an electronic signal is analyzed pulse stream processed optical multiplier by electronic devices. Capacity this pulse is directly proportional to the energy rays falling on the crystal.

The aim of the present work is study a comparison of the detector (scintillation) sizes (2"x2") ,(1"x1.5") in terms of efficiency and Severability energy resolution and note the effect change voltages and amplification on the power spectrum by calculating the total area of the spectrum space scattering and area of peak optical.

The nuclear Detector system

In the present work , the nuclear detection system , Fig. (1) , type (UCS 30) (Spectrum Techniques LLC) with NaI(Tl) size of crystal (2"x2") ,(1"x1.5")cm.

Fig. (1) Detection system used

Scintillating Crystals are used to detect the energy and intensity level of γ ray. The crystals NaI is a kind of scintillation crystal with good properties. It has a very high luminescence efficiency and is available in single crystals or polycrystalline forms in a wide variety of sizes and geometries. The material exhibits no significant self absorption of the scintillation light and has good resolution ability to X-ray and γ-ray. of all available scintillators, NaI is the most extensively used material. It is widely used in nuclear medicine, well logging, environmental monitoring, high energy physics ,port as well as oil field and geographic exploration where detection is required (Knoll,2006,Salgado,et.al.,2012).

The NaI(Tl) detector consist of two pants , the NaI(Tl) crystal and the photo multiplier , the detection system consist of two amplifiers , pave and main , the job of this amplifiers is shaping the electronic signal, amplification and release the electronic noise .The electronic signals go to the multichannel analyzer and show the result as an energy spectrum as shown in Fig. (2) (Salgado,et.al.,2012).

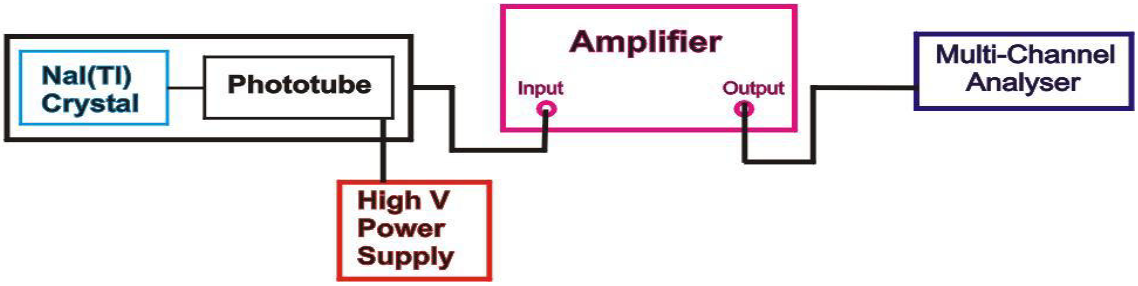


Fig. (2) Parts of the system detect

The Detection system calibration

Two calibration were done for the gamma ray nuclear detection system , the first for the detection efficiency and the second is the energy , by using a standrad radioactive sources putted in a container of 0.25 L volume .

The calculate efficiency (ξ) is given by [6]

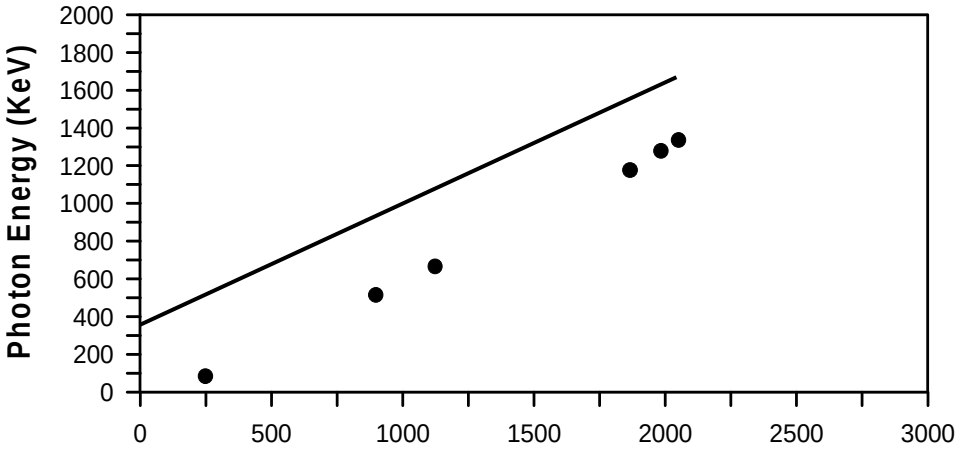
$$\xi = = \frac{N/T}{A\ .I\gamma} \qquad \text{..... (1)}$$

N: count rate under photo peak position .

T : time measurement .

A : activity of radioactive sources using of calibration .

I_γ : relative intensity of each energy source of the energies of the radioactive



Peak Position (ch.no)

Fig. (3) calibration system energy

And the energy resolution (E.R) is given by , fig. (3) , by using Cs-137 source (Sabharwal,et.al.,2008).

$$ER(\%) = \frac{F.H.W.M}{Ch} \times 100\,\% \qquad (2)$$

F.W.H.M : Full width at high maximum .

Ch .no : photo peak position .

Results and Discussion

To find out the effect of crystal size detector (scintillation) on the resulting spectrum was calculated the total area of the spectrum (T.A) , a scattering area (Sc.A) and Photo peak (Ph.P) and N, G refer to the Net and Gross respectively.

1- Study the effect of voltage on the energy spectrum

To investigate the effect of voltages on the energy spectrum show table (1) accounts process for both detector NaI(Tl) and source radioactive cesium-137 which sends a photon his energy (0.662 MeV), effectiveness radiological (1μCi) and half-life (30.07 year), with the installation of the time on (200) sec and the distance between the radioactive source and detector NaI(Tl) (15) cm at amplification on (2) by changing the voltage (V) (500-700) volt.

Table (1) Shows the accounts process for the source of radioactive cesium -137 at Amplification (2) for both detectors NaI(Tl) 1"x1.5",(2"x2")

	2Amp								
	Detector 1"x1.5"								
Cs-137	V	T.A		Sc.A		Ph.P		F.W.H.M	C	E.R
		G	N	G	N	G	N			
	500	25857	23485	19372	18035	5709	4859	40	527	7.59
	550	30477	25178	24556	22379	5769	4835	88	1343	6.552
	600	31527	27378	25921	22712	5782	4864	109	2920	3.733
	620	32207	28840	26559	26018	5789	4820	112	3824	2.929
	Detector 2"x2"									
	V	T.A		Sc.A		Ph.P		F.W.H.M	C	E.R
		G	N	G	N	G	N			
	500	1114	993	—	—	—	—	—	—	—
	550	9508	9148	—	—	—	—	—	—	—
	600	14413	13939	4670	3641	7541	6188	12	123	9.756
	650	22230	21750	2279	10990	7776	6213	18	210	8.571
	700	30370	29363	20424	18019	8059	6745	27	333	8.108

Seen from table (1) that increased voltages lead to increasing every(T.A) and (Sc.A) as in Figure (4), which shows the relationship between voltage and the total area of both detector by using source cesium-137 at amplification (2), and notes in detector 2"x2" be the spectrum does not appear at first clearly but gradually begins to emerge while the energy resolution decreases with increasing voltage for both detector as shown in Figure (5).

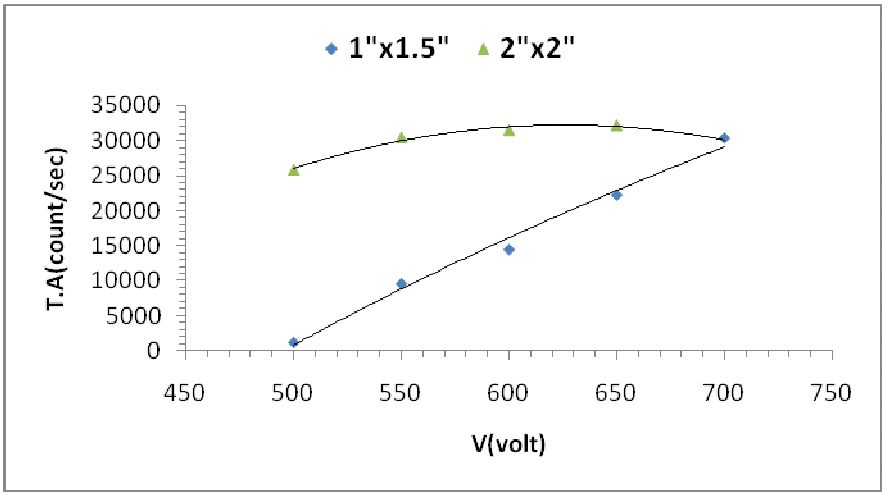


Fig. (4) The relationship between the voltage and the total area of the spectrum at Amplification (2) for both the detectors (1"x1.5") ,(2"x2") using the source of Cesium-137

We note from Figure (4) that the relationship between voltage and the total area of the spectrum is positive relationship was found that voltages in detector 1"x1.5" start of 500 V and stand at 620 V while in detector 2"x2" start of 500V and ends at 700V.

We find that the total area of the spectrum increases with increasing voltage for both detector, but the rate of increase using detector (1"x1.5") be greater than detector (2"x2"), because the increased volume of detector means increasing the number of electrons reaching the anode multiplier photosynthesis and then increase capacity pulse leaving the detector which makes the necessary voltages for detector (2"x2") is greater than the voltage required for the detector (1"x1.5") using the same amplification (A-Taie,2001), as well as increased voltage leads to change Location Photo peak and exit it channel axis so the detector (1"x1.5") not spectrum appears when you increase the voltage more than 620 V, while the spectrum is a clear in detector (2"X2") because of the large crystal size compared to the size of detector (1"X1.5") this result is consistent with the findings of the (Al-Araji,1998) when he studied the effect of crystal size detector NaI (TI) sizes (3"X3") and (1"X1.5") on the energy spectrum and found that the size difference detector leads to increased capacity pulse emerging from detector (3"X3") and that appear with a capacity greater than the detector (1"X1.5") which leads to offset for its peaks where increasing both T.A and Sc.A only E.R decreasing voltages increase (Sidhu,2000).

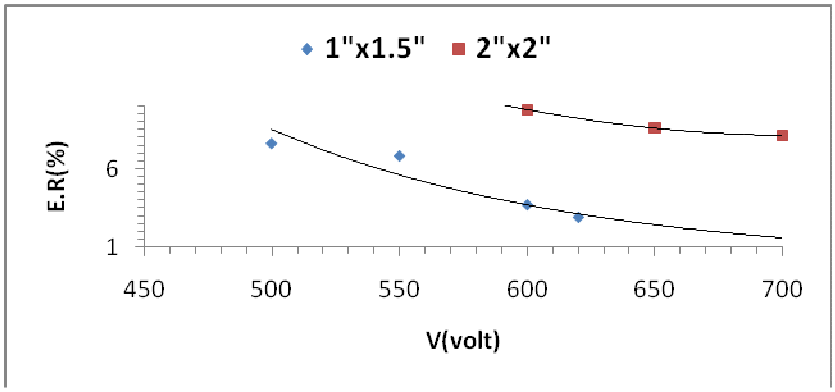


Fig. (5) The relationship between the voltage and energy resolution at Amplification (2) for both detectors (1"x1.5"),(2"x2") using a source of Cesium-137

Seen from Figure (5) that the relationship between voltage and portability energy analysis is an inverse relationship in other words with increasing voltage increases (FWHM) which leads to the decrease in energy resolution and thus an event improvement in discrimination and separation of peaks, where the detector (1"x1.5") less than it is in the detector(2"x2") which leads to increased efficiency of detector (2"x2"), this he found (Al-hawamdeh,2010), who studied effect mixing radioactive sources on the spectra nuclear using NaI (Tl) and effect voltages on the spectrum energy and his found that the T.A and Sc.A increasing with increase voltages as well as increase the photo peak leading to an offsets peak from location to the location of the top of the channel axis while viability analysis energy decreases due to the increased width of the channel (Al-Araji,1998).

2- Study the effect of amplification on the energy spectrum

To see the effect of amplification on the energy spectrum show table (2) accounts process for both detector NaI(Tl) by using source radioactive cesium-137 with the installation of the time on (200) sec and the distance between the radioactive source and detector NaI(Tl) (15) cm at voltage on (500 volt) by changing the amplification (1-64) (Amp).

Table (2) Shows the accounts process for the of source radioactive Cesium -137 at voltage on (500 volt) for both detectors NaI(Tl) 1"x1.5",(2"x2")

Cs-137	500 volt									
	Detector1"x1.5"									
	Am	T.A		Sc.A		Ph.P		F.W.H.M	C	E.R
		G	N	G	N	G	N			
	1	18271	16590	11817	10286	5424	4136	23	260	8.846
	2	25857	23485	19483	18210	5411	3924	40	526	7.605
	4	29833	27348	23443	22038	5491	4364	58	1022	5.68
	8	31914	28066	26047	24302	5846	4674	91	1960	4.643
	16	32648	31304	26700	25724	5979	5236	139	3750	3.707
	Detector 2"x2"									
	Am	T.A		Sc.A		Ph.P		F.W.H.M	C	E.R
		G	N	G	N	G	N			
	1	72	50	—	—	—	—	—	—	—
	2	1114	993	—	—	—	—	—	—	—
	4	10100	9935	—	—	—	—	—	—	—
	8	18366	17935	8266	7162	7795	5464	15	163	9.202
	16	30752	29601	20704	18513	8012	6127	30	338	8.876
	32	41414	38778	31622	28834	7915	5968	52	658	7.903

We note at table (2) that increasing every(T.A) , (Sc.A)and (Ph.P) with increased amplification as in Figure (6), while possibility analysis of energy less as in Figure (7), and also noted that in the detector 1"x1.5" does not appear spectrum at amplification (32) while being clear in the detector "2x2".

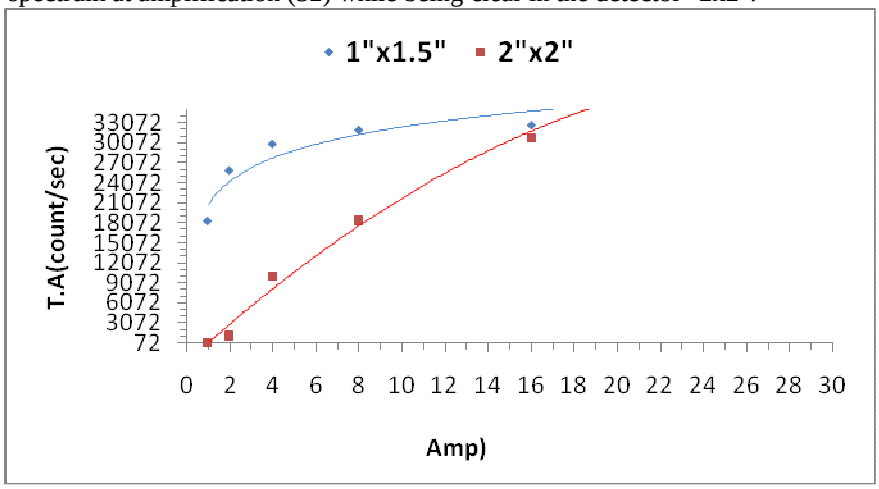


Fig. (6) The relationship between amplification and the total area of the spectrum at voltage (500 volt) for both detectors (1"x1.5"),(2"x2") using a source of Cesium-137

From Figure (6) the relationship between the amplification and the total area of the spectrum using the source cesium-137 is a direct correlation to both detectors NaI(Tl) where the rate of increase using detector (1"x1.5") bigger it when using detector (2"x2") because of effect gain amplified which corresponds to the effect voltages where changing the location photo peak change gain and remain the area under the peak fixed although distributed over a larger area in the case of increase profitability (Al-hawamdeh,2010), which leads to lower count rate at the site of the peak, and this is consistent with the findings of the (A-Dahan,2002) show where area under the spectrum for detector (2"x2") is larger detector (1"x1.5") and this means that the number of photons that interact with the detector (2"x2") is greater than the number of photons that interact with the detector (1"x1.5") (A-Dahan,2002).

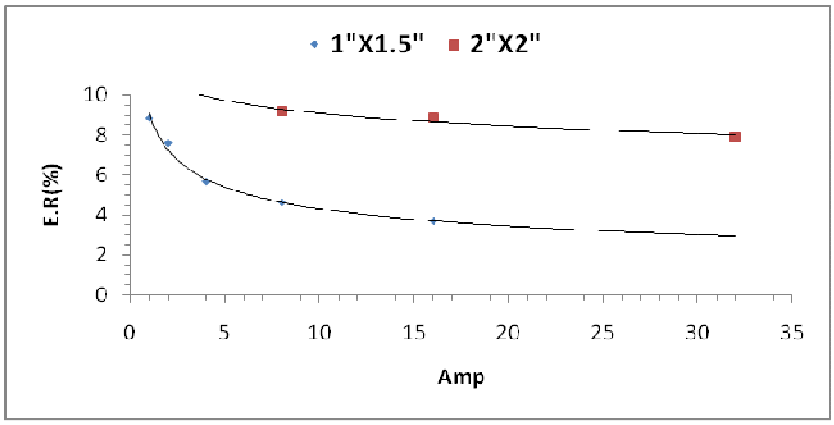


Fig. (7) The relationship between amplification and energy resolution at voltage (500 volt) for both detectors (1"x1.5"),(2"x2") using a source of Cesium-137

From Figure (7) that the relationship between the amplification and energy analysis capability is an counterproductive because of increasing the display of photo peak which lead to the decrease of energy analysis capability.

Conclusions

1- The large size of the crystal detector leads to increased capacity pulse emerging from detector (2"x2") which appear with a capacity greater than the detector (1"x1.5") leading to an offset for their peaks where increasing both (T.A) and (Sc.A).
2- present study showed that the energy resolution less to increase the number of channels and voltage relationship exponential decreasing they are in detector (1"x1.5") less than it is in detector (2"x2").while increasing photo peak Location to increase the number of channels and the voltage, linear relationship.
3- At increase the size of crystal, the Photo peak increases too, because the number of photons entering the crystal detector (2"x2") be the largest and photo peak higher than at detector (1"x1.5").
4- Increase the amplification means increasing the number of pulses generated inside the detector and thus increasing (T.A), (Sc.A) and (Ph.P) due to increased capacity pulse that led to the widening spectrum and creep photo peak position and thus exit the peak from the axis of the channel, while increasing amplification lead to increased (FWHM) in other words increase width photo peak that leads to decreases portability energy analysis (E.R) (Mirela and Gheorghe,2011).
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References

1- Joel Kindem, Chuanyong Bai, and Richard Conwell, "CsI(Tl)/PIN Solid state Detectors for Combined High Resolution SPECT and CT Imaging", IEEE Journal, PP.1987-1990 ,2010.
2- M.Gurendik &N.Tsoulfanid,Nucl.Sci.Teach.,Vol.131,P.332,2000.
3- G.,Knoll," Radiation Detection and Measurement " , John Willey & Sons , New York , Third edition ,2000.
4- G., Knoll, " Nuclear and Particle Physics " , John Wiley, USA,2006.
5- C.M,Salgado,L.E.B, Brandao , C.M.N.A, Pereira, and C.C, Conti, "Validation of a NaI(Tl) detector's model developed with MCNP-X code" ,Elsevier Journal, Vol.59, PP. 19-25, 2012.
6- A.D. Sabharwal, M.Singh, B.Singh and B.S.Sandhu,"Response Function of NaI(Tl) Detectors and multi backscattering of Gamma Rays in Alumium",Vol.66,No.10,2008.
7- Fadhil Ismail Sharrad A-Taie,"A Study the Effect of Different Magnetic Fields on the Scintillation Detector NaI(Tl)", M .Sc, University of Babylon, College of Science,2001.
8- Adnan Hammoud Mohammed Al-Araji,"Study of NaI(Tl) Scintillation Detector Pulse and Photo Sensitive Pulse Height Analyzer-Desiging", M .Sc, University of Babylon, College of Science,1998.
9- G.S.Sidhu,J.Radiol.Pro.,Vol.20,P.53,2000.
10- Hussein Ahmed Ali Al-hawamedh, "A study of the Effect of Mixing Radiation Sources on the Nuclear Spectra Using the Scintillation Detector NaI(Tl).
11- Nawras Mohammad Shaheed A-Dahan," The Effect of the Scattered photons from the Surrounding on the Energy Spectrum of the Scintillation Detector NaI(Tl) ", M.Sc, University of Babylon, College of science,2002.
12- Mirela Angela Saizu and Gheorghe Cata-danll,"Lanthanum Bromide Scintillation Detector for Gamma Spectrometry Applied in Internal Radioactive Contamination Measurements" ,U.P.B.Sci.Bull., Series A,Vol.73, Iss.4, 2011.