

The Effect of Collimator Diameters on Buildup Factor by using Gamma – Gamma Coincidence System

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Abstract
In this work buildup factor of aluminum and copper samples was studied for different thickness using a gamma _ gamma coincidence technique and by use two collimator 10 and 7 mm, buildup factor was calculated for thickness ranged between (0 - 9.6) cm of aluminum and (0 - 4.0) cm of copper using Na - 22 source with activity of (1 micro Curie) with single energy (0.511 MeV) and by using (3 "× 3") sodium iodide detector NaI (TI). The results showed that buildup factor was more accuracy when we used small diameter because this will decrease the scattering ray which make our calculations more acute for buildup factor which is very important in shielding process for gamma ray.
Keywords: Buildup factor, Gamma ray, Shield, Coincidence.

1. Introduction

The gamma-ray spectroscopy and the measurement of nuclear life times provide excellent tools for obtaining information on nuclear structure. Gamma spectroscopy also provides excellent detailed information in the energy spectrum of incident gamma-rays. This information can be used to not only quantify but also identify any gamma emitters within a material. In addition gamma spectroscopy can be a valuable tool for understanding the internal structure of atomic nuclei. Lifetime measurements of quadric pole transitions can also provide information on nuclear deformation [1, 2].

Sodium (Na^{22}) is an excellent source for a simple gamma-gamma coincidence experiment. From the decay scheme it can be seen that 99.95% of the time of Na-22 decay occurs by positron emission and electron capture through the 1.274 MeV. Ninety percent of these decay events occur with positron emission, which then annihilate and produce a pair of 0.511 MeV gamma rays that can be seen in the gamma spectrum (figure 1) which shows a typical gamma spectrum for Na-22 that was obtained with a NaI (Tl) detector [3].

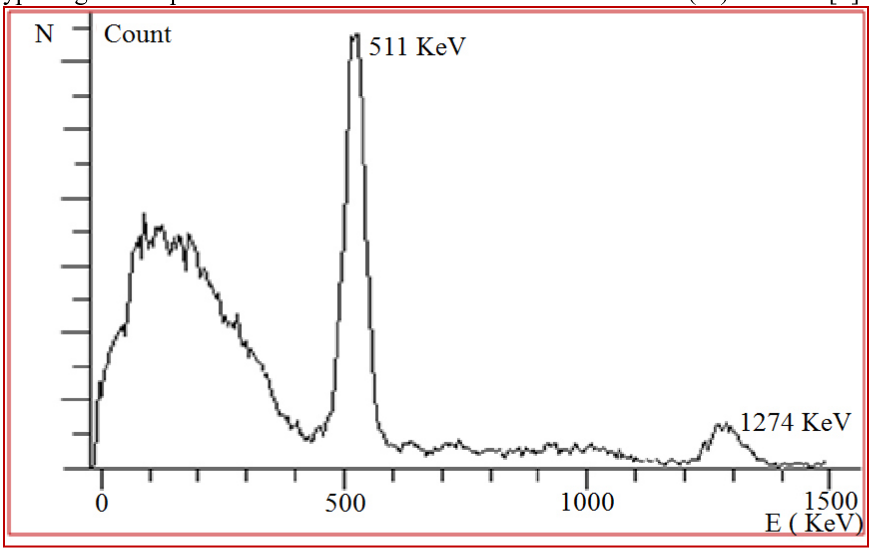

Figure 1: Typical gamma spectrum for Na-22 source that was obtained with NaI (Tl) detector [3].

The 0.511 MeV peak will usually be quite a bit more intense than the 1.274 MeV peak, primarily because of the detector efficiency differences at the two energy levels and the annihilation process. The Na-22 source is usually covered with a thin absorber such as a thin (1/16in.) piece of metal or plastic. Positrons from the source will lose energy in the absorber and will be annihilated in the absorber. The NaI (Tl) detectors will see an approximate point source of radiation. When the positrons are annihilated, two 0.511 MeV gammas will leave the source with an angular separation of 180°. Experimentally the pair of gamma rays are detected and measured with one detector that is fixed and another detector that can rotate about the source [3]. We replaced collimator diameter from 10 mm to 7 mm, and we conclusion that the buildup factor in collimator 7 mm was more than acute [3].

The term means Free Path which is a rate of distance for radiation in material before the interaction with it, and Symbolizes by (m.f.p.). The use of this term is appropriate in the study of the transmission of photons in the material and study of buildup factor [4]. Generally produces accumulation of two types of gamma ray patterns of interaction with the material by Compton and pair production phenomenon , the measurements of buildup factor correspond by calculates of the intensity of gamma ray it transition in material using net peak area (NET) and the following equation buildup factor [1] :

$$\text{Buildup Factor} = \frac{\dfrac{NET\ WITHOUT\ COLLIMATED}{I_0}}{\dfrac{NET\ WITH\ COLLIMATED}{I_0}} \qquad \text{……………..} (1)$$

Where I_o is the incident ray intensity.
The coincidence circuits give some simple pulse output when two pulses inter to circuit separated at time equal to (2τ) which it's name resolving time , but it does not giving output pulse when one pulse inter to him through that time (resolving time) , and resolving time of coincidence circuit it detected of overlapping of two pulses and every one of pulse have duration equal to ($2\tau_0$) , because timing coincidence detecting if that one of pulses in range of Period of time (± τ) [5] . We have used coincidence circuit fast - slow, with two scintillation detectors of sodium Iodide NaI (TI) that to study coincidence of gamma radiation that produced from beta annihilation (positron) which it is emitting from sodium source (Na-22) to study buildup factor for aluminum.

2. Materials and Methods

In this work gamma – gamma coincidence spectrum (fast – slow) was used the electronic units mostly it produced by ortec company and two detectors 3" x 3" that produced by bicorn company. Also we used sodium source (Na-22) with low activity (lower than 1μCi) which product by AMERSHAM Company British. we hold the measurements by status the two detectors by versus angles ($\theta = 180^0$) and source (Na-22) which placed between two detectors , then we used multi thickness of aluminum and copper sheets with dimensions (10 x 10) cm^2 , that covered the face of detector . The total spectrum where we recorded when there is no sheets between the two detectors , then the coincidence spectrum recorded where we put aluminum and copper sheets , we do this produce for different thickness (1.2 - 9.6) cm of aluminum and (0 – 4.0) cm of copper . The total spectrum recorded for air when the beam of radiation it collimated and none collimated. The same produce we do for the coincidence spectrum. All spectrums were recorded and net area was measured then using eq. (1) buildup factor for direct and coincidence spectrum were calculated than we replaced collimator from 10 mm to 7 mm [6]. And we recorded direct and coincidence spectrum in air and two collimators.

Table 1
Buildup factor of aluminum of two spectrums direct and coincidence with collimator 10 mm.

Thickness (cm)	Buildup factor for C.S.	Buildup factor for D.S.
1.2	1.001	0.953
2.4	0.957	0.903
3.6	1.019	0.955
4.8	1.119	0.943
6.0	1.062	0.850
7.2	1.155	0.910
8.4	1.090	0.748
9.6	1.011	0.985

Table 2
Buildup factor of copper of two spectrums direct and coincidence with collimator 10 mm.

Thickness (cm)	Buildup factor for C.S.	Buildup factor for D.S.
0.5	1.076	1.024
1.0	1.100	0.993
1.5	1.159	0.947
2.0	1.180	0.979
2.5	1.105	0.908
3.0	1.143	1.074
3.5	1.139	0.865
4.0	1.157	1.079

Table 3
Buildup factor of aluminum of two spectrums direct and coincidence with collimator 7 mm.

Thickness (cm)	Buildup factor for C.S.	Buildup factor for D.S.
1.2	1.004	0.809
2.4	1.006	0.799
3.6	1.029	0.748
4.8	1.135	0.832
6.0	1.020	0.884
7.2	1.036	0.971
8.4	1.023	0.967
9.6	1.194	0.958

Table 4
Buildup factor of copper of two spectrums direct and coincidence with collimator 7 mm.

Thickness (cm)	Buildup factor for C.S.	Buildup factor for D.S.
0.5	1.110	1.103
1.0	1.078	1.160
1.5	1.081	1.262
2.0	1.099	1.504
2.5	1.180	2.089
3.0	1.069	2.069

The next scheme represent gamma – gamma coincidence system that we used in work.

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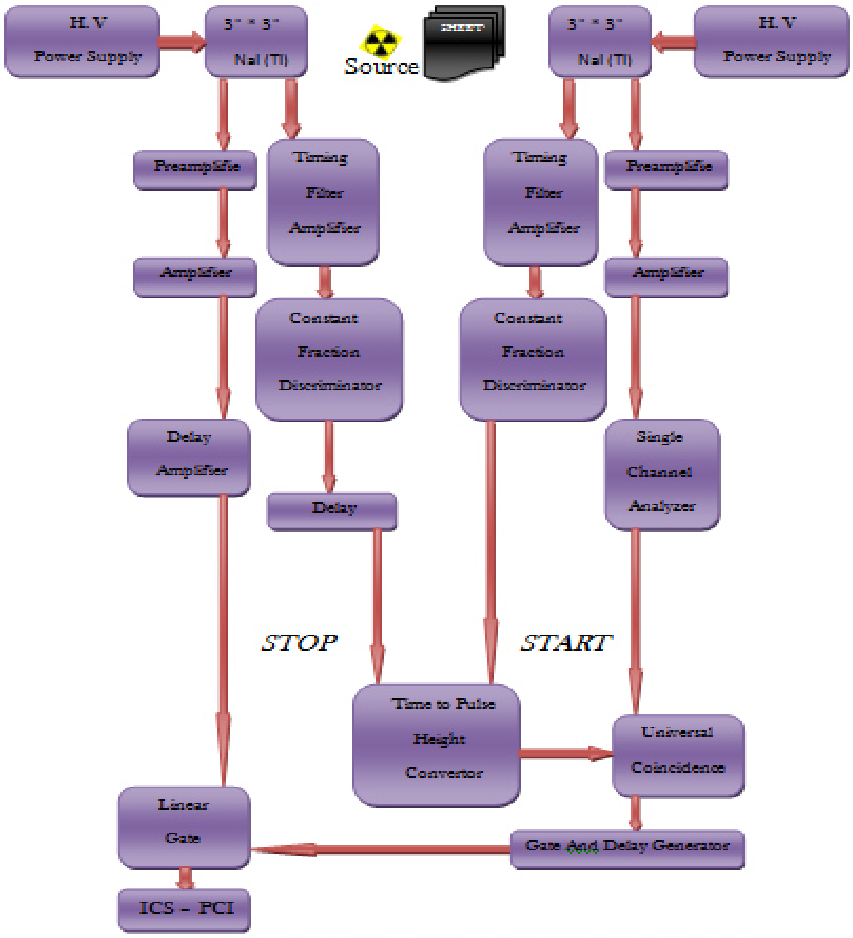

Scheme 1 Gamma - Gamma coincidence system

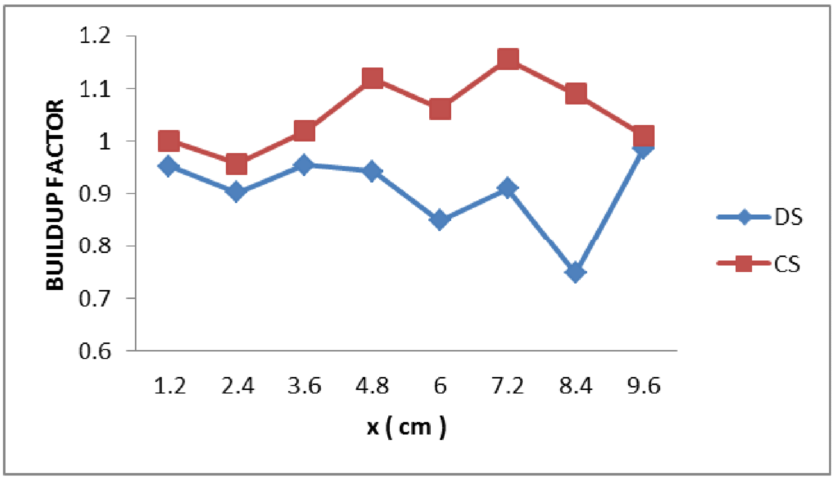

Figure 2 Buildup factor of direct and coincidence spectrum of aluminum in collimator 10 mm.

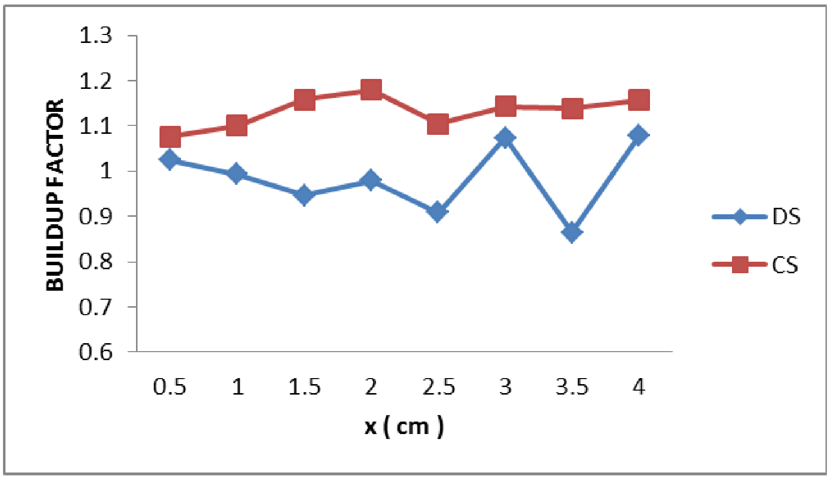

Figure 3 Buildup factor of direct and coincidence spectrum of copper in collimator 10 mm.

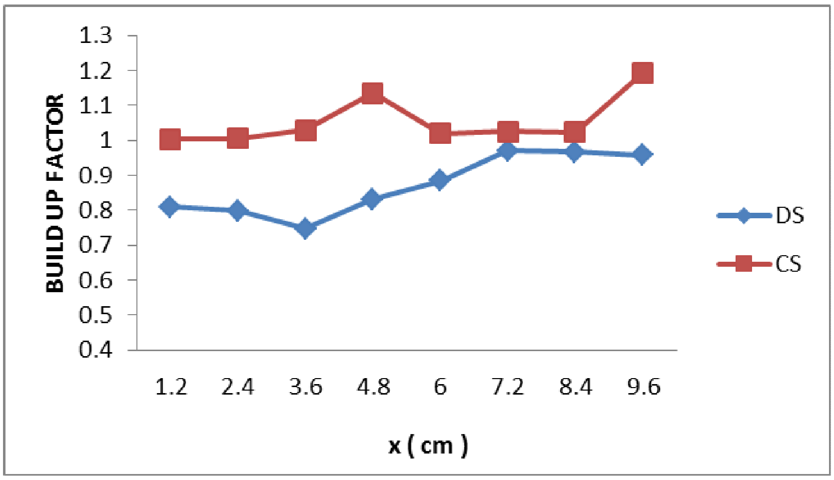

Figure 4 Buildup factor of direct and coincidence spectrum of aluminum in collimator 7 mm.

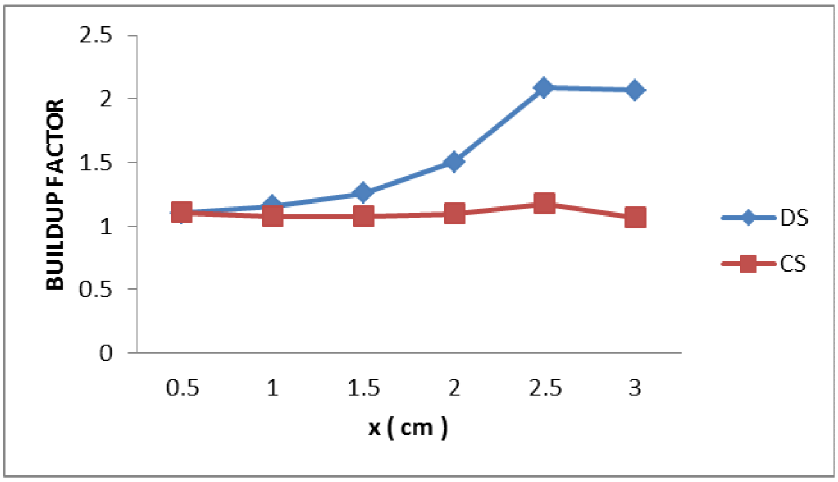

Figure 5 Buildup factor of direct and coincidence spectrum of copper in collimator 7 mm.

3. Results and Discussion

The increase of thickness of aluminum and copper as shield will increase the attenuation of intensity of gamma rays transition, which presented as net peak area (NPA) which gives the buildup factor by using equation 1. Tables (1, 2, 3, and 4) represent the buildup factor in general increasing with increase of thickness of aluminum and copper. Figures (2, 3, 4, and 5) show the buildup factor for direct and coincidence spectrum for aluminum and copper, when we use collimator diameter of 10 mm and 7 mm respectively. The buildup factor by coincidence spectrum was best and more acute than direct spectrum for both aluminum and copper, and the buildup factor of aluminum was more than copper which have good agreements with published experimental data international journal [6].

4. Conclusion

We conclude that the decrease of collimator diameter will decrease the scattering ray that will increase the accuracy of buildup factor calculations. Buildup factor of aluminum was best than copper because atomic number of aluminum is (Z = 13) and atomic number of copper is (Z = 29) , that will decrease the scattering ray , so we can use small collimator to decrease the scattering ray which that we conclude from figures (2 , 3 , 4 , and 5) that decreasing collimator diameter will decrease.

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