The Measurement of Efficiency and Resolution for CdZnTe and NaI(Tl) detectors

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1. Introduction

Nuclear radiation detectors become the most fundamental equipment for radioactive sources in variety of different fields such as industry, energy, health physics and environmental application. Nuclear radiation is hazard for human health. The detection efficiency of detector is a measure of the percentage of radiation that a given detector detects from the total emitted from the source. The energy resolution of radiation detector is the ability to differentiate slightly different energy gamma rays [1]. Gamma ray spectroscopy is used for measurement of efficiency and resolution using different energy radiation. Cadmium Zinc Telluride (CdZnTe) semiconductor detector is preferably used for X-ray and gamma ray detection due to good energy resolution and compact size of detector at room temperature. In the present work, efficiencies and energy resolutions were measured for CZT and NaI(Tl) detectors.

2.Experiment

The experiments were performed for CZT and NaI(Tl) detector using gamma rays spectroscopy method. Radioactive sources ^{133}Ba,^{137}Cs, ^{60}Co and ^{22}Na were used to measure the energy resolution and efficiency of detectors. BICRON 2''X2'' NaI(Tl) scintillation detector and Kitec 24mmX33mm CdZnTe large volume spectrometric hemispherical semiconductor detectors were used for efficiency and resolution measurement. A positive bias voltages were applied to NaI(Tl) and CZT detector 700 V and 1200 V respectively. ORION 64 K multichannel analyser (MCA) used for digital signal processing and for spectrum analyse used InterWinner 7.0 software. The data were taken for live time 7200 sec for each detector. Sources put 1 cm and 5 cm apart from front surface of CZT and NaI(Tl) detectors respectively.

Table 1 Detail of radioactive sources [2]

S.No	Sources	Energy (keV)	Half-Life In years	Activity(A0) Micro ci
1	Cs-137	661.66	30	3.5
2	Na-22	511	2.6	3.5
3	Co-60	1273.23 1173.23	5.3	3.0
4	Ba-133	1332.41 356	7.5	2.5

3.Results and Discussion

1. *Energy Resolution of detector*

The energy resolution of a detector system is obtained from the peak full width at one-half of the maximum height (FWHM) of a single peak using the following equation

$$R = (\mathrm{FWHM}/Eo)\times 100$$

Here R is energy resolution and Eo is the related energy.

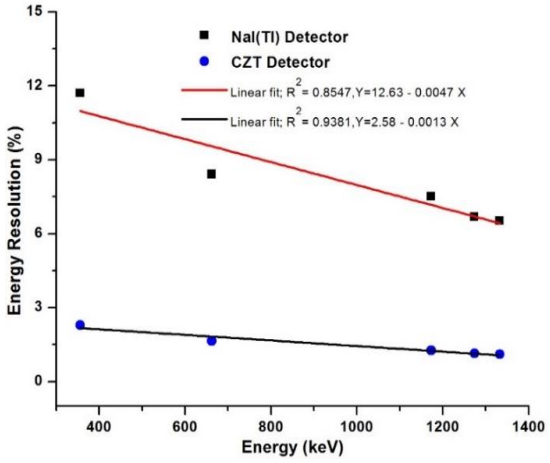

Figure 1: Variation of energy resolution with energy for NaI(Tl) and CZT detectors

2.Efficiency of detector

Absolute Efficiency

The ratio of the number of counts produced by the detector to the number of gamma rays emitted by the source (in all directions).

Intrinsic Efficiency

The intrinsic efficiency of a detector is defined in terms of the number of photons in a collimated beam incident on its entrance window, except number of photons emitted by the source.

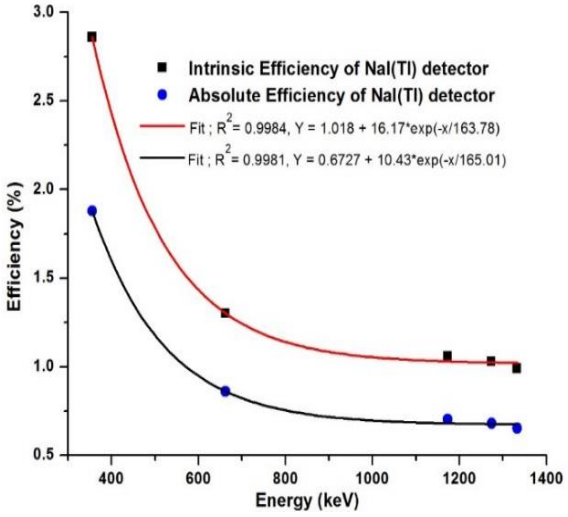

Figure 2: Variation of Intrinsic and absolute efficiency of NaI(Tl) detector with gamma ray energies

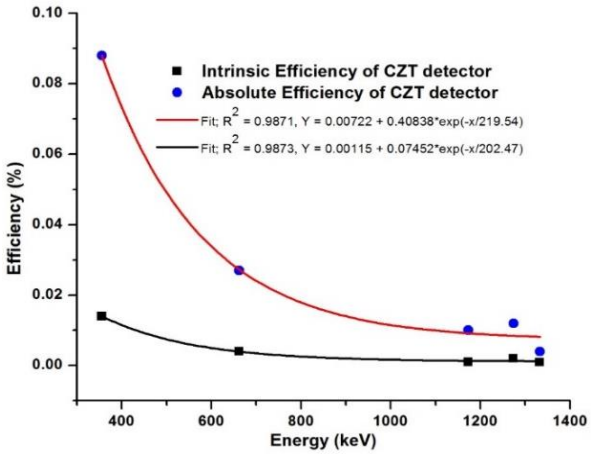

Figure 2: Variation of Intrinsic and absolute efficiency of CZT detectors with gamma ray energy

4.Conclusion

In this work, we have studied the resolution and efficiency of CZT and NaI(Tl) detectors. Energy resolution varies between 2.22% to 1% for CZT detector and 11.7% to 6.5% for NaI(Tl) detector in the energy range of 355.86 keV to 1332.41 keV. The absolute efficiency varies from 0.004 to 0.08 and 0.65% to 1.88% for CZT and NaI(Tl) respectively, & intrinsic efficiency varies 0.0009 to 0.014 % and 0.99 to 2.86 % for CZT and NaI(Tl) detectors respectively. Results shows that NaI(Tl) have high efficiency and lower resolution compare to CZT detector. Scintillation detector can use for natural radioactivity any geographical area in country.

5.References

[1] G.F. Knoll, Radiation Detection and Measurement, Third Ed., John Wiley & Sons Ltd, ISBN: 0-471-07338-5, USA, (2008)
[2] https://www.nndc.bnl.gov/