Background Gamma Radiation Surveying in the Indian Peninsula with a Portable USB Spectrometer

Jithin B.P.[1] and O.S.K.S. Sastri[1*]
[1] *Department of Physics and Astronomical Sciences, Central University of Himachal, HP 176215 , INDIA*

Introduction

Isotopic analysis of radioactive Monazite sand from the beaches of Kanyakumari was carried out using a handheld, USB powered 'plug and play' gamma spectrometer which we have developed[1]. We were able to identify the dominant decay chain to be ^{232}Th, and have also correlated other spectral features. The recorded spectrum also has excellent value from a teaching perspective due to the complex, multi-layered nature of the associated spectrum, and is a much safer alternative to enriched sources.

A comparison study of the energy efficiency of our $10mm * 10mm * 8mm$ scintillator was also carried out against a lab grade 3" x 3" NaI scintillator available at IREL (India) Ltd, Manavalakurichi, India in order to establish its usability for surveying purposes. The results indicated good performances up to 1.5MeV, but reduced efficiency at higher energies due to the smaller scintillator volume. This can be compensated with longer acquisition times. Analysis was carried out with our cross-platform software-CNspec[2].

Data Collection from Monazite Sand

Monazite , a type of weakly radioactive sand found in the beaches of south India which is composed of ^{232}Th and trace amounts of Natural Uranium, has safe levels of radiation and is easily available[3][4]. The activity of a 1g sample was measured as approximately 300 Bq of ^{232}Th and 30Bq of nat/U in secular equilibrium with daughters with a commercial detector. The corresponding energy yield is calculated and shown in Table I. Its low activity requires long acquisition times to get a spectrum, and data from our instrument(Figure 1) was collected over a period of 14 hours.

Nuclide	E(MeV)	Yield fraction	Emission Rate
^{228}Ac	0.129	0.024	7.8
^{228}Ac	0.209	0.0389	12.64
^{212}Pb	0.238	0.43	139.75
^{228}Ac	0.338	0.11	35.75
^{208}Tl	0.583	0.3	97.5
^{212}Bi	0.727	0.0658	21.39
^{228}Ac	0.911	0.258	83.85#
^{228}Ac	0.964	0.0499	16.22#
^{228}Ac	0.969	0.158	51.35#
^{208}Tl	2.614	0.35	113.75

TABLE I: Calculated yield fractions and emission rates for 1gm Monazite sand. Cells with relatively higher yield fractions have been identified in our spectrum shown in Figure 1. # Appears as broad peak at 930keV

Calibration and Efficiency Comparison

The instrument was calibrated with a ^{60}Co source whose 1.33MeV photopeak was fitted to obtain a channel number centroid of 397.55, and FWHM of 5.9%. The Monazite sample is a 15mm dia planchette containing 1 gm of Monazite sand packed using Araldite. Centroids of peaks were located with a Gaussian+Lorentzian curve fitting algorithm, and all major yield gamma sources were reliably identified as shown in Table II.

Normalized efficiency figures for the same

*Electronic address: sastri.osks@gmail.com

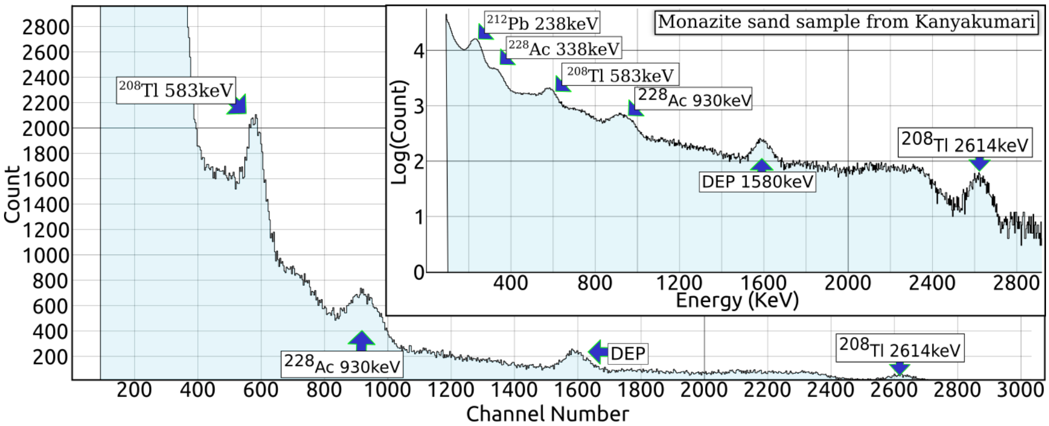

FIG. 1: 14 hour spectrum from 1g Monazite sand. Inset shows log plot of the same. Peaks were well matched with the decay chain of ^{232}Th

1gm Monazite with 3"x3" Scintillator				
Total	238 keV	583 keV	930 keV	2614 keV
970787	287079	138376	103526	2761
1	0.29571	0.1425	0.1066	0.00288
Monazite with 10mmx10mm scintillator				
Total	238 keV	583 keV	930 keV	2614 keV
12,33,420	347729	72616	22685	2097
1	0.282	0.06	0.0183	0.0017

TABLE II: The total counts as well as normalized counts from a 1gm Monazite sample were recorded with a 3"x3" NaI scintillator, as well as our instrument. The results confirm usability for isotopic analysis, but efficiency reduces at higher energies due to the lower interaction volume. A double escape peak can be seen centered around 1580keV with a relative efficiency of 0.008

sample were obtained from a 3" x 3" NaI scintillator based system at IREL (INDIA) Ltd to check the relative efficiency of our smaller volume scintillator, and draw usability related conclusions as shown in Table II.

Peaks belonging to the decay chain of ^{232}Th were identified in the spectrum. A shoulder peak was also observed at 338keV due to limited resolution. The instrument shows good promise as a surveying tool for isotope identification in addition to dosimetry due to its compactness and $< 250mA$ current consumption, and we are now preparing larger volume scintillators to increase efficiency. Data acquisition has also been tested on a Raspberry Pi SBC to develop a fully portable system.

Acknowledgements

We thank Dr. K Sreekumar and Dr. R Rajagopal from IREL (India) Ltd for the efficiency comparison data from their spectrometer, and for valuable suggestions concerning applications.

References

[1] B.P., Jithin et al. Indigenously developed gamma spectrometer , DAE Symp.Nucl.Phys. 63 (2018) 1072-1073
[2] CNSpec: Python based software for analysis of spectroscopic data. `https://github.com/csparkresearch/cnspec`
[3] Christa et al. , Radiation dose in the high background radiation area in Kerala, India. , Radiat Prot Dosimetry. 2012 Mar;148(4):482-6. doi: 10.1093/rpd/ncr198
[4] Nambi et al.,Natural background radiation and population dose distribution in India ,BARC: `https://www.aerb.gov.in/images/PDF/image/20084715.pdf`