INVESTIGATION OF LIMIT OF DETECTION USING STANDARD RADIOACTIVE SOURCES WITH A 2”x2” $LaBr_3$:Ce DETECTOR

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BACKGROUND AND MOTIVATION

When radiation sources are measured, the presence of background radiation will unavoidably contribute to the number of counts for each peak in spectra. It is therefore important to ensure that background corrections are performed by subtracting counts originating from background radiation from total peak counts. The aim of this study was to determine the limit of detection of standard radioactive sources using a 2”x2” $LaBr_3$:Ce detector considering this ambient background radiation. Additional to this the following were also investigated:

- Change in radiation intensity measured as a function of increasing distance from the detector (change in solid angle between the points of the radiation sources and the active detector volume).
- Calculation of the limit of detection correlating the solid angle to radiation source activity.

Why use a 2”x2” $LaBr_3$:Ce detector? More than two-fold better peak resolution compared to other conventional detectors, good photon detection efficiency and the size and mass of the detector allows mobile applications.

EXPERIMENTAL

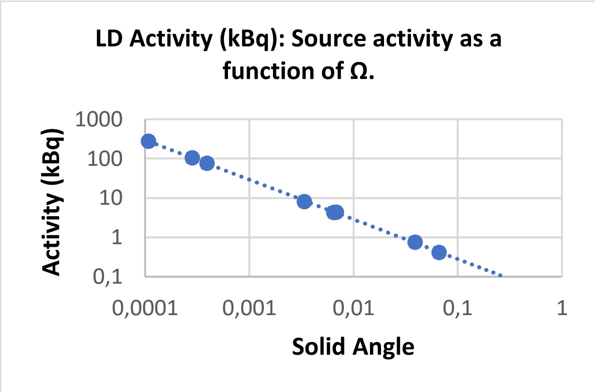
All radiation sources and background measurements were done using a 2”X2” $LaBr_3$:Ce detector. The detector was energy calibrated using three standard sources: ^{22}Na (375 (19) kBq, ^{60}Co (47 (7) kBq) and ^{152}Eu (166 (13) kBq). Measurements were performed over 10 minutes. It is known that the $LaBr_3$:Ce detector contains the naturally occurring radioactive ^{138}La isotope that leads to intrinsic activity. This leads to a gamma-ray energy peak at 789 keV following β-decay, and a peak at 1436 keV. Two standard sources, ^{22}Na and ^{60}Co, were measured at various distances from the detector. These distances were correlated with a solid angle value (Ω) where $\Omega = A/r^2$. The symbol A represents the detector surface area, and r represents the point-source distance between the detector and radiation source being measured.

RESULTS AND DISCUSSSION

The results obtained during the measurement phase were used to determine a first order response between source activity and solid angle. It can be assumed that the number of counts measured is directly proportional to the source activity, and the solid angle. These linear correlations are summarised in the figures below. Using the linear response equations, it is possible to calculate the number of peak counts at specific activities. This allows for the calculation of a limit of detection in terms of activity at a specific solid angle. Using the linear response equations, it is possible to calculate the number of peak counts at specific activities. This allows for the calculation of a limit of detection in terms of activity at a specific solid angle as shown in the table below.

Limits of detection expressed as activity (kBq) at specific solid angles.

Distance (mm)	Solid angle (Ω)	511 keV LD Activity	1274 keV LD Activity
228	0,03899	0.761 (0,87)	0.761 (0,87)
545	0,006824	4.35 (2.1)	4.35 (2.1)
2275	0,0003916	75.7 (8.7)	75.7 (8.7)
2675	0,0002832	104.7 (10.2)	104.7 (10.2)
4330	0,0001081	274.3 (16.6)	274.3 (16.6)
mm	Ω	1173 keV LD Activity	1333 keV LD Activity
175	0,06618	0,415 (0,64)	0,420 (0,65)
560	0,006463	4,25 (2,1)	4,30 (2,1)
775	0,003375	8,14 (2,85	8,32 (2,9)



When measurements are done in terrestrial environments it is most likely that the main source of radiation will be NORM’s, hence the predominant source of background radiation. The intensity of this radiation is also regional-dependent as it will differ from one location to another. This emphasise the importance of being able to estimate a limit of detection in terms of source activity, as well as optimising measurement time should there be some other source of radiation present, other than NORM’s. By using two different radiation sources during this research, it is also evident that the activity limit of detection is source-independent.