Study of the homogeneity of a NaI(Tl) detector

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This report presents a methodology that aims to evaluate the homogeneity of a NaI(Tl) scintillation detector using the Grubbs test to validated the crystal homogeneity. The Grubbs test is designed to verify the presence of extreme values in sample observations [1]. According to previous research, a detection efficiency study was performed for a detector with real dimensions and it was found that the values obtained were not compatible with the values simulated using Monte Carlo method [2]. In order to improve these results, a source-support-detector system was developed to stablish an adequate measurement geometry. Five positions in the frontal face of the detector were predetermined, as shown in Figure 1.

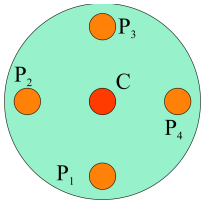

Figure 1. Distribution of predetermined points on the face of the detector

A spectrum for each predetermined point of the frontal area of the crystal were obtained with the pulse height distributions, which were recorded from each measurement of ^{137}Cs source. In order to obtain good statistical parameters, a proper measurement time was stablished and three counts were performed using this source for each predetermined point. Photopeak area was chosen to make this calculation. The counts average of all points was equal to 18048.53, with a standard deviation of 1489.10, and this information was used to perform Grubbs test with a significance level of 0.5% to perform the test with five measurements. The critical table value is equal to 1.764. The test result can be seen in Table 1.

Table 1 - Result achieved for points P1, P2, P3, P4 and Center

Point	Photopeak Area	Z	Status 0.005
P1	17390.67	0.05956	ok
P2	17502	1.05428	ok
P3	17410.67	0.23826	ok
P4	17232.67	1.3521	ok
Center	20706.67	1.78506	outlier

The center point is an outlier for a significance interval of up to 10%, which can be explained by escape probability of light photons, that is, for an effective test the compared points must be equidistant from the center of the crystal. Compared with other measurements, the center of the crystal has the highest photopeak counts, as it was possible to observe experimentally, showing the region that has the highest photon absorption during radiation interaction with the crystal. This is because scattered photons are more likely to escape at the edges of the crystal. Through the Grubbs test, it was possible to consider that the measurements made at points P1, P2, P3, P4 are within the confidence interval of 0.5% for the critical values of each point. With this, it was also possible to consider, statistically through the Grubbs test, that the NaI(Tl) crystal is homogeneous. It is important to highlight that this study aims to evaluate damages and ageing effects in detectors currently in use. More details and information of this study can be found in RAMOS et al., (2019) [3]. Next steps of this study will be the design and development of a new holder system that allows measurements laterally to the detector. In addition, it is necessary to use other sources with different energies and to increase the number of investigated regions to make new measurements.

References

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