Characterization of the UOIT Applied Radiation Laboratory

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Summary

This paper describes a preliminary characterization of the scattering process contribution along the axis of the gamma rays emitted from UOIT's G-10 gamma source at the University Of Ontario Institute Of Technology's applied radiation laboratory. Multiple data points were taken along the axis of the beam using a lanthanum bromide detector mounted on Canberra Osprey multi-channel analyzer. This paper presents some preliminary data of the measurement at different points in the room.

1. Introduction

The University of Ontario Institute of Technology (UOIT) has constructed an Energy Research Center, on an area of 9290 m^2 for research in different energy technologies [1]. The applied radiation laboratory is one of the laboratories constructed and used to host high intensity radiation sources. The laboratory is constructed with 100 cm thick high density concrete walls, engineered security barriers, and a double maze entry. As a result of the Compton scattering gamma rays the radiation field in the heavily shielded room from a 10 Ci gamma source exhibits a complex shape relative to the location in the room. Therefore its characterization is paramount for shielding and dose calculation purposes as well as other activities such as detector calibration.

If one does not consider this effect when conducting detection experiments in the laboratory, then the recorded data may be interpreted incorrectly and not take into account the radiation field characteristics in the room. In attempt to characterize the radiation field in the room, a radiation detection system consisting of a $LaBr_3$ (Ce) scintillation crystal viewed by a miniature data acquisition system has been used to measure the pulse shape spectra at different spots. The detection system has been mounted on a linear positioning system consisting of a stand on a secure track with the detector centered using a laser system for precise position. Due to the high intensity of the field at close proximity to the source, a lead filter has been used to avoid the saturation of the detection system. The reference point of minimum scattering has been taken at around 10 cm from the source.

2. Brief Facility Description

2.1 Applied Radiation Laboratory Description

The G-10 irradiator located approximately in the centre of the laboratory main room. The aperture of the irradiator is located approximately 33 cm from the middle wall. The data acquisition system was operated at various positions along the track outlined in the figure. A general view of the facility is represented in Figure 1.

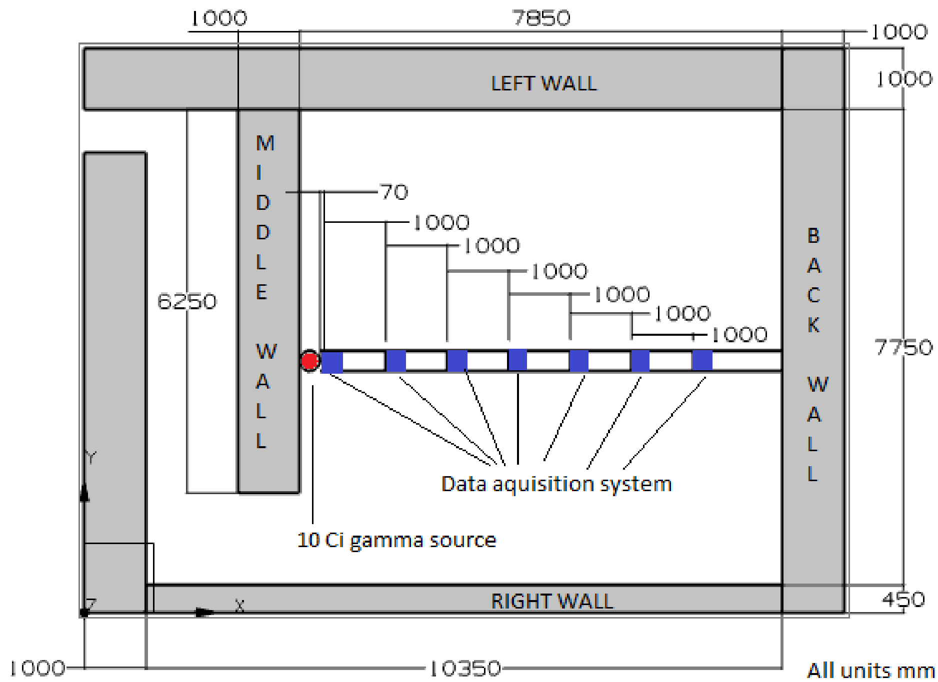

Figure 1: Applied radiation laboratory

2.2 Gamma Source

The gamma source used for the experiment was a Hopewell Designs Inc. Model G10-1-12 gamma beam irradiator with a single 10 Ci ^{137}Cs source. The source is doubly encapsulated, hermitically sealed, with a ^{134}Ce content not exceeding 5% [2]. A linear positioning system along the axis of the collimated beam consists of a secured track and platform which allows for reduced variance in the radiation detection system and provides more consistent measurements. A lead filter of 8.8 cm thick was used to prevent the saturation of the detector system at close range.

3. Experimental setup and methodology

The radiation detection system used for the experiment consists of a 1.5x1.5 inches LaBr scintillator, a digital signal processor, and gamma spectroscopy software developed by Canberra Co. The digital signal processor used was an Osprey digital tube base which is an "all in one" high voltage power supply, preamplifier, and digital multichannel analyser. The data processing and acquisition software used was Genie 2000 V3.2.1 which acquires, displays, and analyses the gamma spectroscopy data [3]. The experiment was conducted on the linear positioning system along the axis of the collimated beam. The reference point for the lowest contribution of the back scattering has been taken around 10 cm from the source, and then six experimental spots along the collimated beam have been adopted. The gamma irradiator was activated and then the measured data has been recorded and normalized for 60 seconds live time.

4. Results and Discussion

The total counts over the duration of the 60 seconds was recorded and graphed as a function of channel number vs. total counts. It is evident that the total counts received by the data acquisition system decreases as the distance to the source increases. The resultant spectra and distance vs. total counts graphs are shown in the following figure 2.

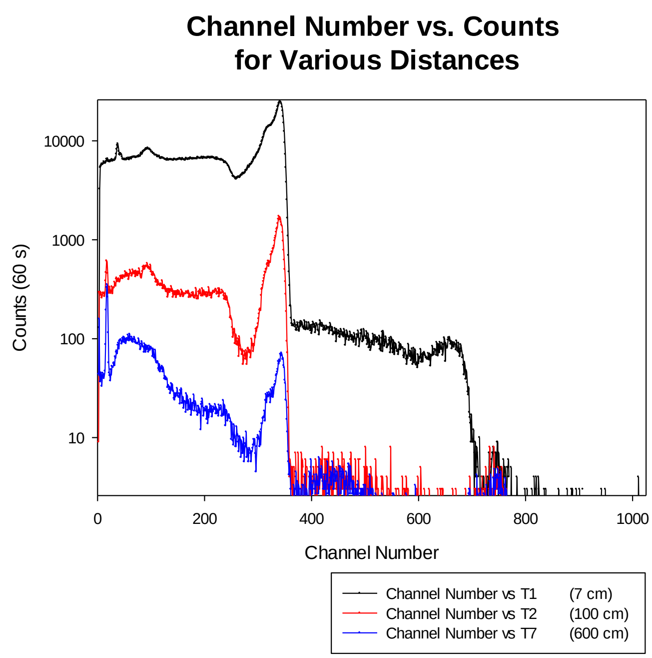

Figure 2: Spectra at various distances

Due to the position of the source inside the lead shielding, the backscattering contribution from the middle wall is negligible. When the detector is placed near the source, the contribution by the Compton scattered gammas should be at a minimum compared to other position where the detector is far away from the source. The contribution of the Compton scattered gammas can be determined by subtracting the actual count by the theoretical count from the source. This is tabulated in Table 1.

Distance to source	Actual Count for 60 s	Theoretical Count for 60 s	Compton Scattering Contribution Count for 60 s
7	2744817	2595898	148919
100	132245	12720	119525
200	50126	3180	46946
300	29794	1413	28381
400	21890	795	21095
500	18550	509	18041
600	16141	353	15788

Table 1: Actual and theoretical counts and Compton scattering contribution

As the distance between the detector and the source increases, the number of potential gamma rays interacting directly with the detector from the source decreases due to geometrical factor and the inverse square law. However, the contribution of the scattered gammas from the walls and floors at further distances becomes increasingly significant. This can be observed by plotting Table 1 and observing that the actual count does not decrease at the same rate as the theoretical count.

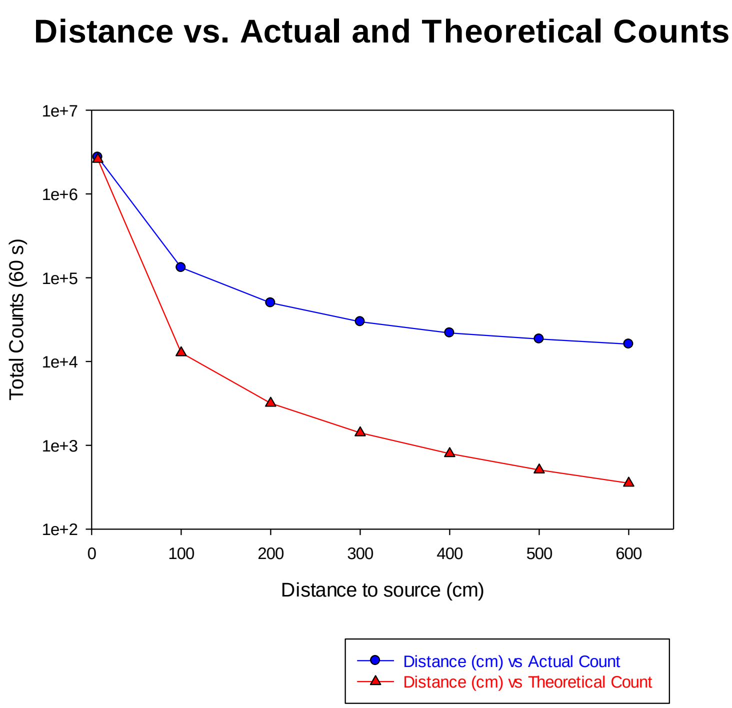

Figure 3: Comparison of recorded counts and theoretical counts

5. Concluding Remarks

More data collection points are required between 7 cm and 100 cm in order to obtain a better relationship between the distance from the source and the total number of counts recorded to confirm the inverse square relationship. The background radiation in the laboratory should also be recorded and subtracted from the spectrums to remove any environmental contribution which may be present.

The next steps for the experiment are to further characterize the room by further analysing the contribution of the Compton scattered gamma from the walls. This can be done by determining the distance on the walls relating to a scattering angle of 10 degrees and collecting multiple data points along the walls. This will detect the first scattered gamma from the source so that the highest scattered gamma energy is known relative to the scattering angle.

6. References

[1] The University of Ontario Institute of Technology, "Energy systems and nuclear science Research Center (ERC) backgrounder." Retrieved January 14, 2013, from http://www.uoit.ca: https://shared.uoit.ca/shared/uoit/documents/buildings/UOIT_ERC_backgrounder.pdf

[2] Hopewell Designs Inc., "Model G10 gamma beam irradiator." Retrieved January 27, 2013, from http://www.hopewelldesigns.com/G10GBIBrochure.pdf

[3] Canberra, "LABR-1.5x1.5-$LaBr_3$(Ce) Scintillation Detector." Retrieved November 1, 2012, from http://www.canberra.com/products/detectors/pdf/LABR-SS-C38657.pdf