Effect of detector collimation on the measured multiple scattered gamma-rays in $3'' \times 3''$ NaI (Tl) detector

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Introduction

Compton scattering is observed when photons interact with the matter in the energy range of 0.1 to 10 MeV. This is an inelastic scattering where photon collides with the unbound electron of the atom. Due to the finite dimension of the target, photon suffers scattering many times, which leads to multiple scattering. The quantification of multiple scattering of photons is helpful in assessment of Compton profiles, radiation shielding, assigning effective atomic number to composite materials and industrial tomography.

Singh et al [1] carried out experiments to study effect of collimator size and target thickness contributions on multiple scattering, concluded that saturation thickness cannot be altered by collimator size. The effect of collimator size and absorber thickness on gamma-ray attenuation measurements of sandy and clayey soils was investigated and was concluded that collimator size is found essential [2].

The present paper describes the experimental study of different detector collimation sizes and sample thickness on multiple backscattered photons using ^{137}Cs gamma source of strength 5.8 mCi. The iron scatterer is used and the backscattered photons are detected by a properly shielded 76 mm $\times$ 76 mm NaI (Tl) scintillation detector located at 135° to the incident beam.

Method of Measurements

Fig. 1 shows the schematic diagram of the experimental set-up for measurement of backscattered γ-rays. The entire experimental set-up was placed at a height of 340 mm on a stable platform. The platform was placed in the center of the laboratory in order to minimize scattering from the walls. The source-detector assembly is arranged in such a way that the centers of source collimator and gamma-ray detector are aligned with the center of scatterer. The experimental data were accumulated on a PC based gamma NaI (Tl) scintillation spectrometer with a fully integrated dMCA. The Microsoft Windows-XP based spectroscopic application software *winTMCA32* acted as a user interface for system set-up and display. A software program using *winTMCA32* was written for the present experimental set-up in order to evaluate parameters such as multiple scattering events and single scattering events.

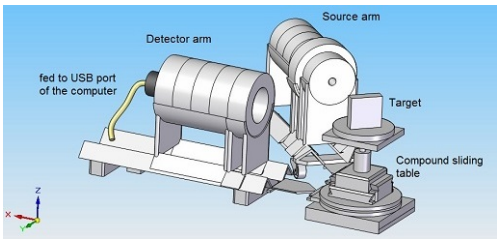

FIG. 1: Experimental setup

Using the number of counts at peak position and FWHM of the detector, the number of photons of the Gaussian distribution for each energy was calculated. The total number of photons at desired energy range is obtained by numerical integration. This results in an analytically estimated single scattered spectrum as registered by the detector [3, 4].

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Results and conclusions

Backscattered spectrum is obtained by irradiating iron samples of thicknesses 5mm to 50 mm for 1000 seconds. Subtraction of single scattered spectrum from noise subtracted spectrum in the region of interest (ROI) energy range results in only multiple scattered photons. Experiments were carried out for 6 collimators of different diameters to the scintillation detector. When the scatterer thickness is very small the increase in the intensity of multiple scattered photons with increasing collimator size is lesser because the probability for multiple scattering is practically small. As the scatterer thickness increases, the intensity of multiply scattered photons increases to a higher value with increase in detector collimator size as compared to thin targets Fig. 2.

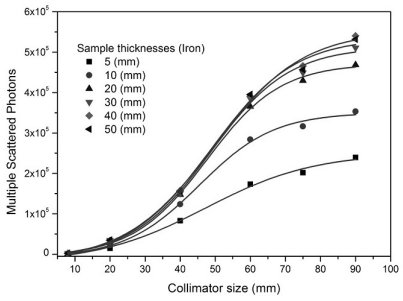

FIG. 2: Multiple scattered photons Vs collimator size.

The value of saturation thickness for iron is 31 mm and it is observed that the saturation thickness for materials is not altered by the variation in detector collimator size (Fig. 3). In Compton profiles and cross-section measurements only the single scattered photons are desired and the multiple scattered photons act as background noise to the original signal. The ratio of number of single scattered events to number of multiple scattered events known as signal-to-noise ratio is plotted as a function of target thickness for different collimators (Fig. 4). If multiple scattering backgrounds are to be avoided, a high signal-to-noise ratio is must, which can be obtained by using very thin targets.

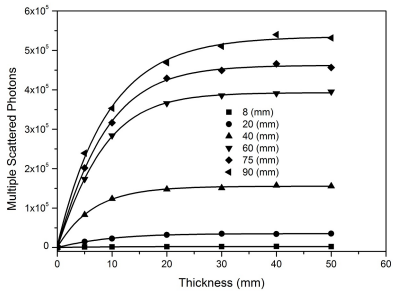

FIG. 3: Multiple scattered photons Vs target thickness.

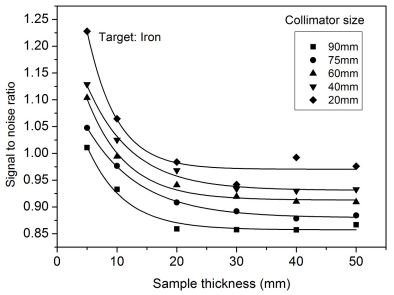

FIG. 4: Signal-to-noise ratio for iron.

Acknowledgements

Mr Kiran K U is grateful to UGC for awarding him a fellowship under its Faculty Development Programme.

References

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