On the Use of a Thick Carbon Target in the 90o Compton Spectroscopy for the Measurement of Diagnostic X-rays

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Radio-diagnostic technologies are widely used in medical fields. In order to perform quality assurance and quality control of the X-ray radiographic systems, we studied the Compton spectroscopy using scatteres with various shape and size to find optimum condition of scattere in terms of efficiency and energy broadening[1, 2)]. For the purpose, simulation was made for Compton scattered photons at 90º after the secondary collimator in the experimental setup (Fig. 1, without the detector) using the MCNP4C code.

The flux of 90º scattered photons was calculated for different shapes of carbon scatterers including a cylinder with height and diameter of 2 cm, and five cylinders with the same diameter of 2 cm but cut at 15º, 30º, 45º, 60º and 75º respectively.

Figure 2 shows simulation photon spectrum at 90º for 100 keV monoenergetic photons at x-ray focal spot from a cylinder and the scatterers with cutting angle of 15º and 30º. The energy broadening is shown in Fig. 3 for primary photon energy of 100 keV. From Fig. 2 and Fig. 3, it is clear that smaller cutting angle leads to lower values of energy broadening and multiple scattering. However, from the viewpoint of fabrication and practical use, this cutting angle is not convenient. Fortunately, the energy broadening and fraction of multiple scattering are weak functions of the cutting angle; hence we adopted two carbon scatterers with cutting angle of 30º and 45º in our experiments.

Compton scattered photon spectrum of an x-ray unit (Hitachi Medico Machine) at 70 kV and 5 mA was measured in experimental set up of Fig. 1. The scattered photon spectrum was deduced by the stripping method and then the primary x-ray spectrum was calculated using Compton scattering cross section with Klein-Nishina formula[3)]. Measured and reconstructed x-ray spectra are shown in Fig. 4 and Fig. 5 from scatterers with 30º cutting angle and 45º cutting angle, respectively.

For validation of reconstructed spectra, the exposure at a distance of 50 cm was measured using an ion chamber (Radiation Monitor Controller, Model 9015, 6 cc chamber) and was compared with calculated exposure from reconstructed spectra. The measured exposure was compared with calculated exposures in table 1 at an X-ray tube voltage of 70 kV. The calculated exposure results based on the Compton spectroscopy using two scatteres, were confirmed by the results of the measured exposure. Therefore, Compton scattering measurements using thick carbon scatterers can be effectively used to evaluate the performance of radio-diagnostic systems.

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References

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Table 1. Comparison of measured exposure and calculated exposures for tube voltage of 70 kV.

Method	Exposure (mR)
Reconstructed spectrum from scatterer with 30º cutting angle	669.9
Reconstructed spectrum from scatterer with 45º cutting angle	680.3
Ionization chamber	690.0

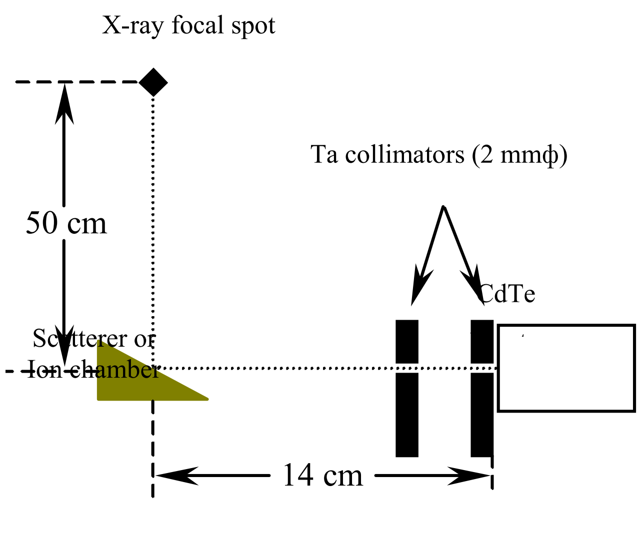

Figure 1. Experimental setup for Compton scattering measurement.

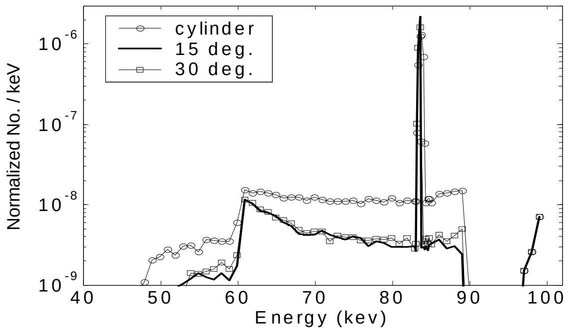

Figure 2. Calculated spectra of Compton scattered photons for primary photons of 100 keV for threeScatterers.

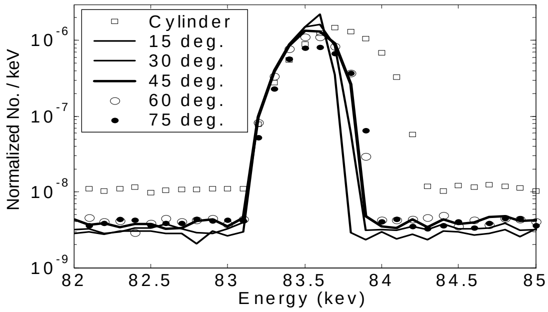

Figure 3. Energy broadening of Compton scattered photons for primary photons of 100 keV.

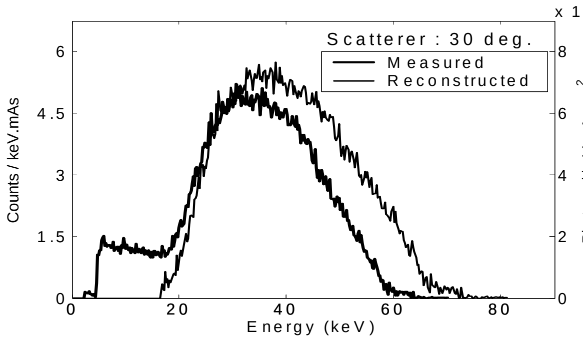

Figure 4. Measured and reconstructed spectra using a scatterer with 30º cutting angle for 70 kV tube voltage.

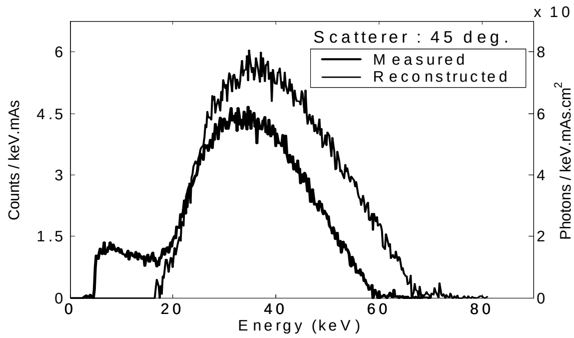

Figure 5. Measured and reconstructed spectra using a scatterer with 45º cutting angle for 70 kV tube voltage.