Quasi-monoenergetic Photon Field of 200keV using a Radioactive Source with Back-Scatter Layout

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At present, Cs-137 is used as a standard in the calibration of radiation detectors and dosimeters because it is a monoenergetic source (662 keV) and has a long half-life of 30.07 years. Calibration of detector response depends strongly on the energy of the source. Many available stable calibration sources have high energies (above 300 keV), to achieve accurate readings during calibration. Then a stable source with energy of ~200 keV is desirable. However, there are currently no sources that fulfill these energy requirements. According to the Compton scattering equation, Compton scattering of gamma rays with energies from 3 MeV to a few hundred keV produces backscattered radiation with energies of 170–220 keV for angles between 120 and 180°. With Cs 137, a backscattered source energy of ~200 keV can be obtained by indirect measurement. We aimed to use this backscattered radiation as a source to calibrate our detectors, using a range of detector positions.

Vertical and horizontal arrangements of source and detector were tested with 1-cm3 CZT detector (KROMEK GR1), and the vertical geometry proved advantageous because of the backscattered radiation had a uniform distribution from the scattering target. By considering the backscatter radiation field uniformity by from experimental data and calculation (EGS5 code), the optimal backscatter arrangement is when detector to Pb distances of 20 cm with a source to floor distance of 20 cm to obtain backscatter peak at 189 keV FWHM 4.6%(8.7 keV, 14.4ch) and dose rate of 5.39μSv/hr was obtained under the layout. The detector demonstrated a weak dose rate dependence on its vertical position. Monte Carlo simulations were carried out to understand the pulse height spectrum of the backscattered radiation, to enhance the backscattered peak and reduce other scattering components. The calculation reproduce the measurements in the energy range from 50 keV to 140 keV well, but slightly overestimates the measurements around the 170 keV. Further simulations revealed that the aluminum detector housing and the detector itself caused a peak at 107 keV in the output spectrum. Calculations on different scattering materials (carbon, iron, copper and tin) revealed that scattering decreased with increasing atomic number. Iron was determined to be the optimum scattering material because it provided a well-defined backscatter peak, low intensity background scattering components, and gave a only a small reduction in the dose rate measurements. The method outlined is advantageous as it could be used to obtain a suitable backscatter doses without the requirement of a high-intensity and high-energy source.