Monte Carlo and least squares methods applied in unfolding of X-ray spectra measured with cadmium telluride detectors

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A cadmium telluride (CdTe) detector was used to measure x-ray spectra commonly employed in medical diagnostics. Corrections were applied to the measured data in order to obtain the energy spectra of the source. Calculations with the Geant4 Monte Carlo toolkit [1] were carried out to simulate the energy deposition in the CdTe detector. Position and energy values of each event were used to take into account effects of trapping of charge carriers, which are not negligible in CdTe. The efficiency of charge collection was approximated by the Hecht equation [2] in the active zone of the CdTe crystal, and a continuous function was used to produce drop of efficiency near the metallic contacts and borders. The mean free path of the charge carriers and the parameters used to model the efficiency in the borders were chosen as the ones which best fit spectra of ^{241}Am, ^{133}Ba and ^{152}Eu calibration sources. Statistical fluctuations weighted by the Fano factor and electronic noise were included to simulate the measured energy resolution. The response function of the detector, $R(E,E_0)$, was simulated in steps of 0.2 keV for use in the reconstruction of the source spectrum. The unfolding of the experimental spectrum was performed by using the least squares method. This procedure was employed also in data acquired with rise time discrimination of pulses, which almost eliminates the effects of incomplete charge collection [3]. The rise time discrimination effect is approximated by a cut in the depth of the detector active zone [4] plus a factor which takes into account the pulse amplitude. The reconstruction of the spectra of the calibration sources was successful and the same procedure was used in spectra obtained with x-ray tubes used in diagnostics.

References

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