# INVESTIGATION OF THE INFLUENCE OF INFRARED ILLUMINATION ON THE PULSE SHAPES OF OUTPUT SIGNALS IN CdZnTe DETECTORS

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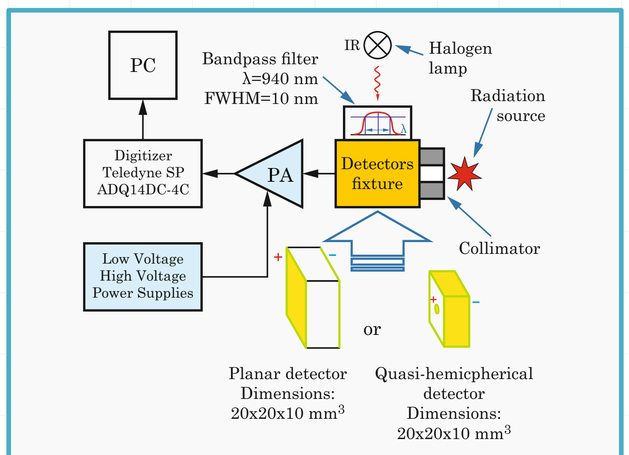
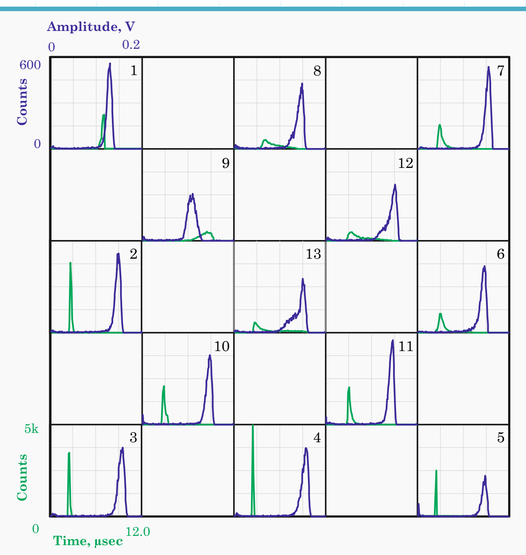
Spectrometric characteristics of CZT detectors are greatly affected by the material inhomogeneity and the formation of space charges (polarization effects) in the sensitive volume of the detector. They change the distribution of electric field in the detector. Registration of alpha particles and analysis of shapes of output signals of the charge-sensitive preamplifier allow one to evaluate the uniformity of charge collection and distribution of the electric field in the detector, as well as to determine the influence of IR illumination on them.

Signals from the preamplifier output are directly fed to the input of a digitizer without preprocessing. This eliminates a possible influence of the shaping circuit on amplitudes of the output signals. The digitized signals are transferred to a PC for further processing. During the measurements, an alpha-particle source $^{239}$Pu (5.6 MeV) was located at about 1 mm from the detector surface in a measuring fixture. The diameter of a collimator was about 2 mm. A planar CZT detector (REDLEN Technologies) with an area of 20×20 mm$^2$ and a thickness of 10 mm and a quasi-hemispherical detector with dimensions of 15×15×7.5 mm$^3$ were used in the investigation. In all measurements, gamma irradiation was carried out from the side of the cathode. An incandescent halogen bulb with a bandpass filter of wavelength of 940 nm was used as a light source for the IR illumination. The width of the resulting spectral line (FWHM) was 10 nm.




Schematic of the measuring setup.

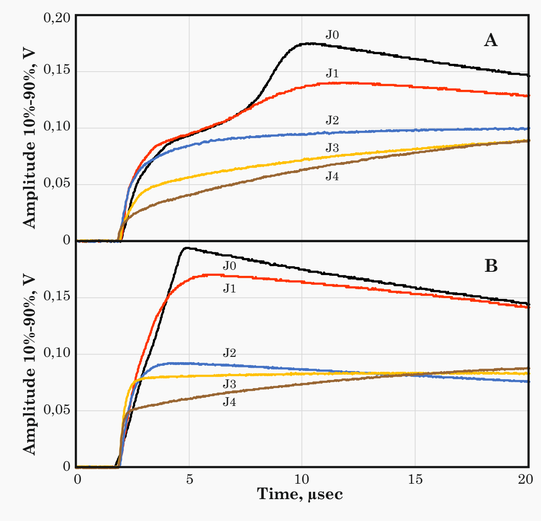
The use of a digitizer allowed to obtain simultaneously the amplitude spectrum and the distribution of rise times of the output signals for evaluation of the distribution of the electric field and its uniformity.




Shapes of the recorded amplitude and time spectra at the registration of alpha particles depending on the irradiated area on the surface of the planar detector.

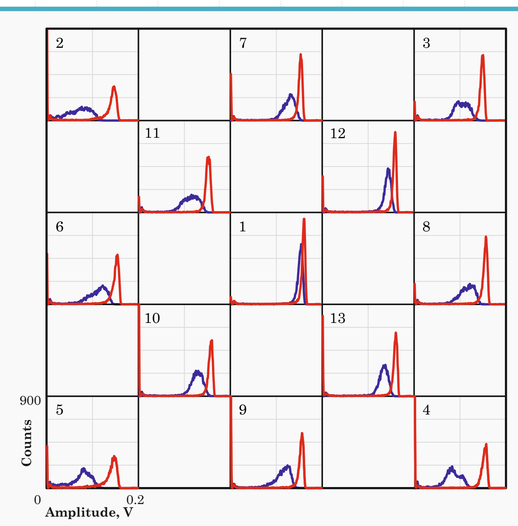
Spectra recorded demonstrated a significant difference during scanning of the surface of the planar detector. From regions 1 and 9, the rise time of pulses is much longer and the amplitude is noticeably smaller than those from other regions.

Close to linearly rising front of the output pulse from region 5 without IR illumination indicates the presence of a uniform distribution of the electric field in this region of the detector. The shape of the output pulses from region 9 without IR illumination has a complex shape. The signal rises rapidly at first, then, — slows down and rises rapidly again. This shape of the output signal may indicate a highly nonuniform electric field in this region of the detector. The electric field has an increased field strength near the cathode and anode. IR illumination has only a marginal positive effect on the performance of a planar detector at low illumination levels and degrades it significantly at high illumination levels. In general, IR illumination affects the duration and shape of the rising edge of the output signals. This is owing to a small change in the electric field strength near the cathode at low illumination levels and a strong increase in the electric field strength near the cathode and a drop in the field strength in the rest of the detector at a strong illumination level.

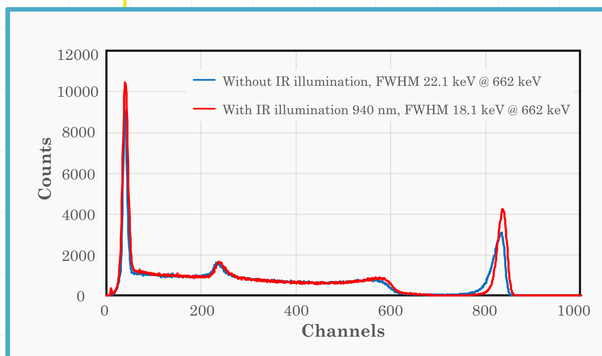



Output pulses shapes from region 9 (A) and 5 (B) measured without (J0) and with IR illumination at different illumination levels (J1<J2<J3<J4).

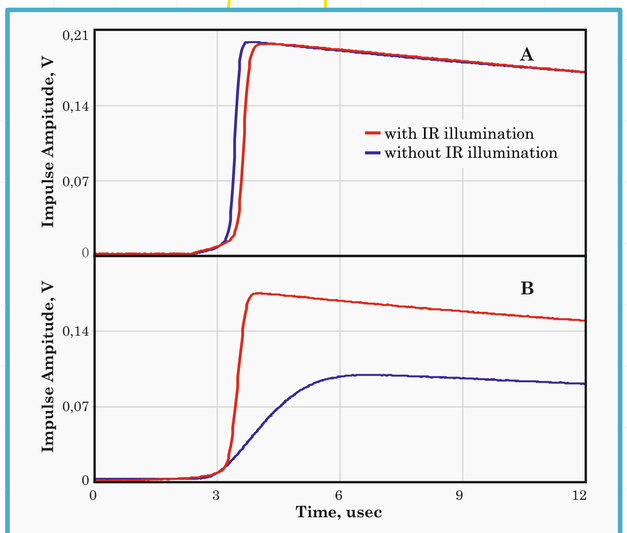
A significant deterioration in the characteristics of the detector (amplitude reduction, deterioration in energy resolution, and increase in collection time) is observed when collecting a charge from the peripheral regions (primarily corners) of a quasi-hemispherical detector. IR illumination greatly improves the charge collection from these areas.




Shapes of the recorded amplitude spectra at the registration of alpha particles depending on the irradiated area on the surface of the quasi-hemispherical detector without (–) and with (–) IR illumination 940 nm.




Spectra $^{137}$Cs recorded with a quasi-hemispherical CZT detector of 15 x 15 x 7.5 mm$^3$ without and with IR illumination.




Shapes of the output signals with and without IR illumination when collecting a charge from the central region 1 (A) and from the corner region 2 (B) of the quasi-hemispherical detector.

The output pulses rise time is significantly reduced. This is due to an increase in the electric field in the peripheral regions of the detector, which is confirmed by a significant decrease in the collection time from these regions.

An increase in the electric field strength in the peripheral regions of the detector is owing to the redistribution of the space charge in the detector under the influence of IR radiation. IR illumination also allows significantly improve the spectrometric characteristics of the quasi-hemispherical detector when registering gamma radiation.

## MAIN RESULTS

- The investigation of the shapes of the output pulses of the CZT detectors during the registration of alpha particles makes it possible to evaluate the uniformity of the charges collection and the distribution of the electric field in the detectors.
- IR illumination significantly affects the shape of the output pulses of the detectors due to a change in the distribution of the electric field in the detector caused by the redistribution of space charges;
- IR illumination has the great positive effect on charge collection in quasihemispherical detectors.

## ACKNOWLEDGMENT

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