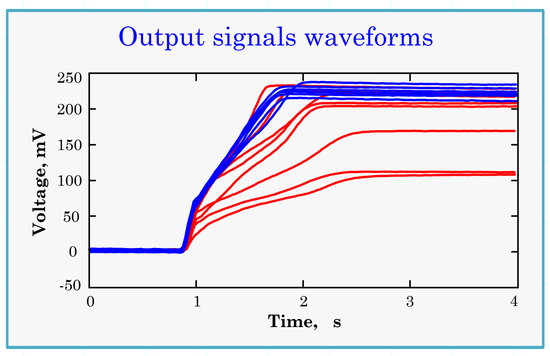
Application of infrared stimulation to improve spectrometric performance of CdZnTe large volume quasi-hemispherical detectors

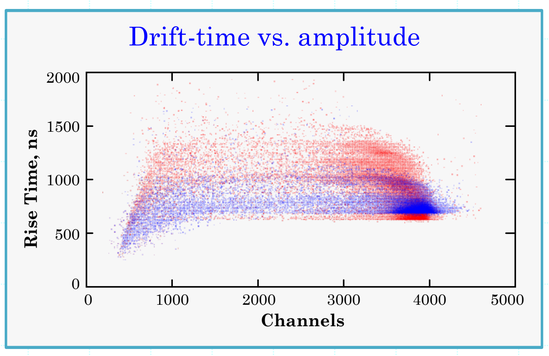
V. Ivanov, A. Loutchanski, P. Dorogov, S. Khinoverov

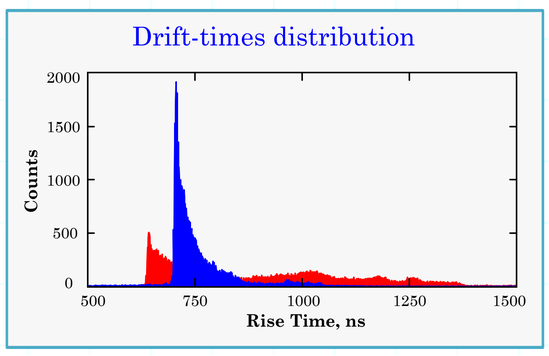
At present time various CdZnTe detectors widely and successfully used for different applications due to its favourable detection properties. For many applications detectors with volumes of a few cubic centimetres are required. To ensure complete and uniform charge collection in such detectors and thereby to achieve high spectrometric characteristics the use of high operating voltages is desirable. However application of very high operating voltages is limited due to increased noise and possible impacts of strong electric field effects in the detector.

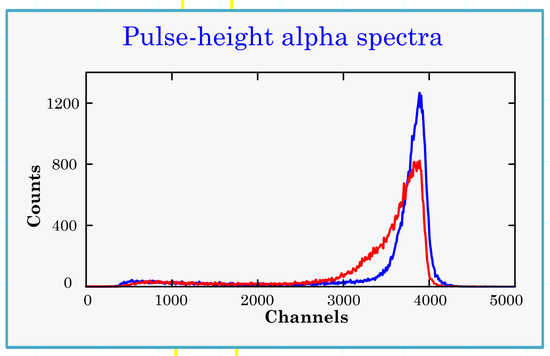
On the other hand was found that infrared (IR) illumination with a properly chosen wavelength and intensity can significantly improve spectrometric characteristics of CdZnTe quasi-hemispherical detectors [1] due to improved of uniformity of charge collection by the detector volume. Under IR Illumination good spectrometric characteristics at significantly lower operating voltages can be reached. This method allowed noticeable improves spectrometric characteristics of the CdZnTe quasi-hemispherical detectors with large volumes up to 4 cm^3.

Alpha particle (5.5 MeV) response of planar CdZnTe detector (Au/CdZnTe/Au) of size 10x10x5 (thickness) mm^3 without (red colour) and with illumination (blue colour) with IR light with wavelength of 940 nm



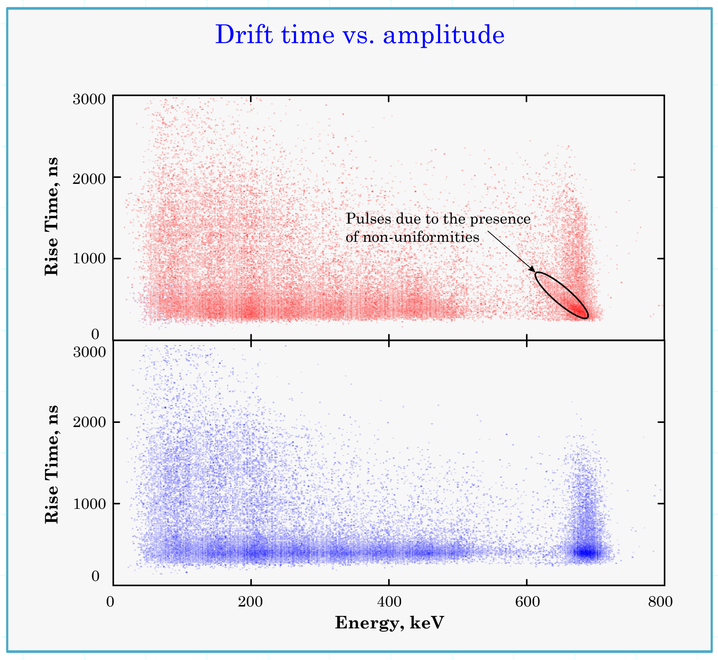


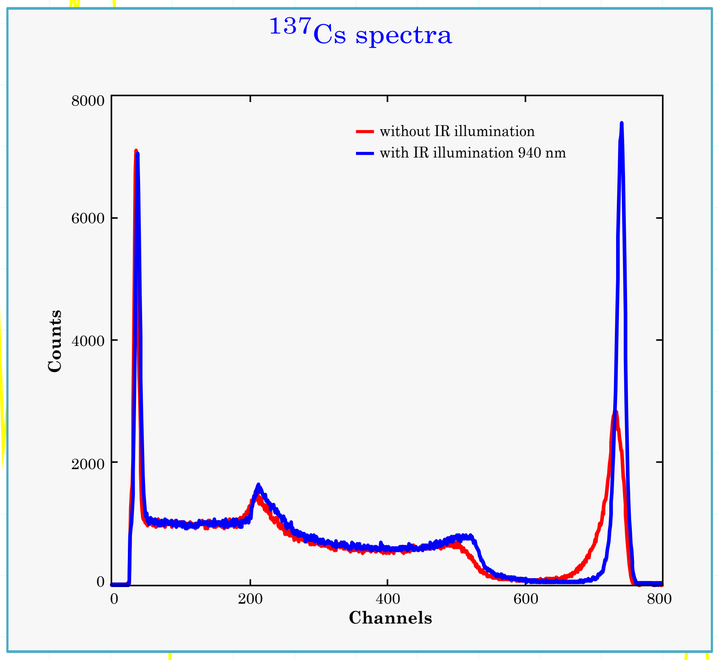


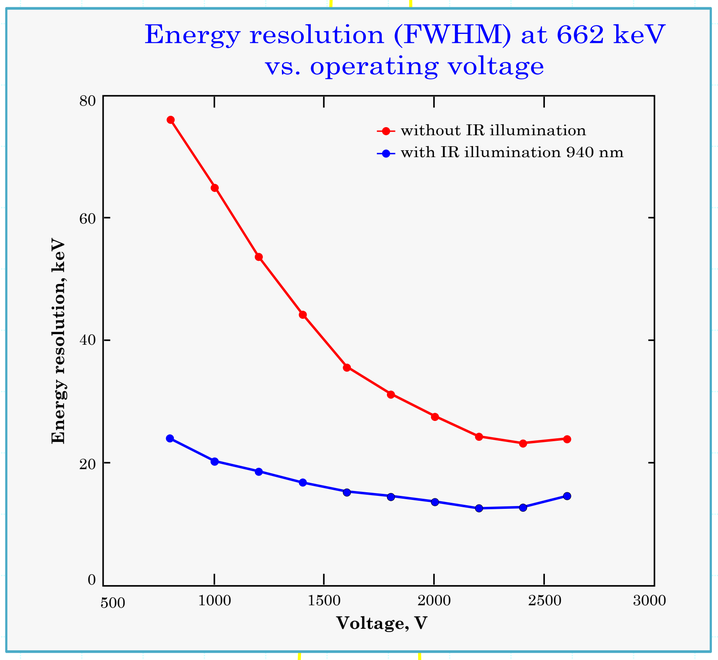


Without IR illumination a great difference in the output signals waveforms, highly non-linear and great variation signals rise times and a wide pulse-height alpha spectrum distribution was obtained. This may be a result of impact of various non-uniformities in the detector. IR light with a wavelength below the fundamental absorption edge penetrates deeply into the detector and influences charge carriers trapping and detrapping processes, thus affecting a charge carrier's collection. Application of a low intensity IR illumination with wavelength of 940 nm significantly reduces the drift-time variation and improves the uniformity of charge collection in an uniform planar detector.

Gamma radiation (^{137}Cs) response of quasi-hemispherical CdZnTe detector of size 20x20x10 mm^3 without (red color) and with illumination (blue colour) with IR light with wavelength of 940 nm







The IR illumination allows improving uniformity of charge collection and obtaining good energy resolution at a rather low operating voltage. Energy resolution of 24.2 keV (3.7%) at 662 keV measured without IR illumination was improved up to 12.5 keV (1.9%) with IR illumination at operation voltage of 2200 V.

Similar energy resolution of 2% at 662 keV with the same detector without IR illumination could be obtained at much higher operating voltages of 4-5 kV. In this case the electric field strength near the positive electrode would be about 60-75 kV/cm. Such high electric fields can cause breakdown or other strong field effects in the detector.

IR Illumination was realized by using IR LED and applied to improve spectrometric characteristics of the quasi-hemispherical CdZnTe detectors of different volumes.

CdZnTe quasi-hemispherical detectors spectrometric characteristics without and with illumination with IR light with wavelength of 940 nm measured at room temperature

No.	Detector size, mm^3	Operating voltage, V	Energy resolution (FWHM) at 662 keV, keV		Peak-to-Compton ratio	
			Without illumination	With illumination	Without illumination	With illumination
1	10x10x5	1000	15.4	7.8	4.8	9.4
2	15x15x7.5	1500	10.0	7.2	7.5	13.3
3	20x20x10	2200	24.2	12.5	4.8	13.1

MAIN RESULTS

- Method of spectrometric characteristics improvement of the CdZnTe quasi-hemispherical detectors of volumes up to 4 cm^3 based on the use of IR illumination has been successfully applied;
- Significant improvements of spectrometric characteristic within a wide gamma-energy range at operation voltage did not exceed 2200 V under influence of the low intensity IR stimulation using wavelength of 940 nm were obtained.

REFERENCE

[1] V. Ivanov, P. Dorogov, A. Loutchansky, L. Grigorjeva, D. Millers, "Improving the Performance of Quasi-Hemispherical CdZnTe Detectors Using Infrared Stimulation", IEEE Trans. Nucl. Sci., vol. 59, no. 5. pp. 2375-2382, 2012.

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AND ASSOCIATED ELECTRONICS

ZRF RITEC SIA
23 Aizkraukles St. office 407, Riga, LV-1006, Latvia
Tel./Fax: +371-67543304, E-mail: ritec@ritec.lv

Ritec