

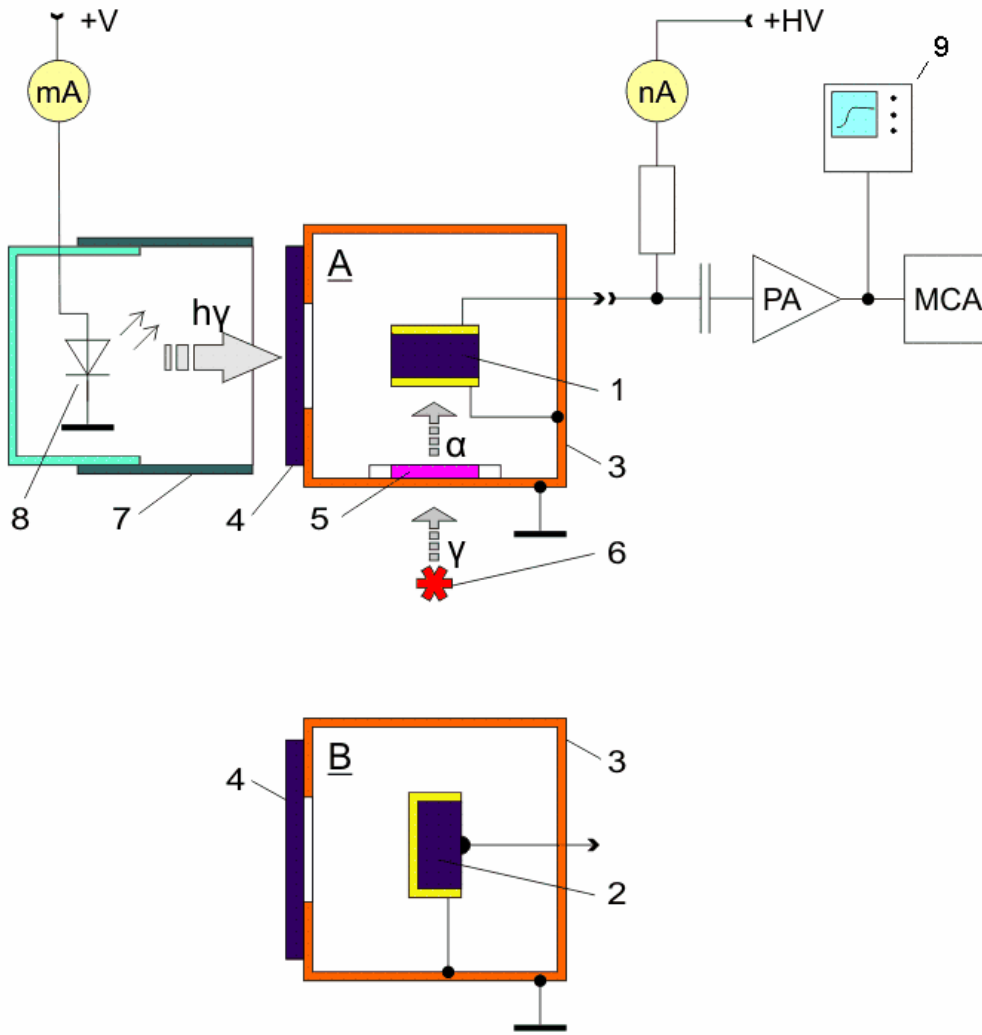
# Influence of Infrared Illumination on the Characteristics of CdZnTe Detectors

*V. Ivanov, P. Dorogov, A. Loutchanski*

# Introduction

- ✓ Infrared (IR) radiation of wavelengths above the CdZnTe band gap may deep penetrate inside the CdZnTe detector.
- ✓ This property is widely used in the infrared optical transmission measurements and infrared transmission microscopy to determine the composition of bulk and investigate the secondary phases, inclusions and other defects inside the CdZnTe crystals, as well as internal electric field distribution inside the CdZnTe radiation detectors using Pockels electro-optic effect.
- ✓ IR radiation interacts with the detector material causing a change in the equilibrium balance between the population of the trapping centers and the concentration of free carriers and thereby affects the processes of charge carriers collecting.
- ✓ In our work, we investigate the influence of IR illumination on the characteristics of CdZnTe planar and quasi-hemispherical detectors.
- ✓ We show that by selecting a wavelength and intensity of IR illumination from IR LEDs, the quasi-hemispherical detectors spectrometric characteristics can be significantly improved.

# Location of the detectors inside the measuring chambers and experimental setup for measurements



A – measuring chamber for measurements with planar detectors

B – measuring chamber for measurements with quasi-hemispherical detectors.

1 – planar detector

2 – quasi-hemispherical detector

3 – measuring chambers

4 – CdZnTe window

5 – alpha-particles source

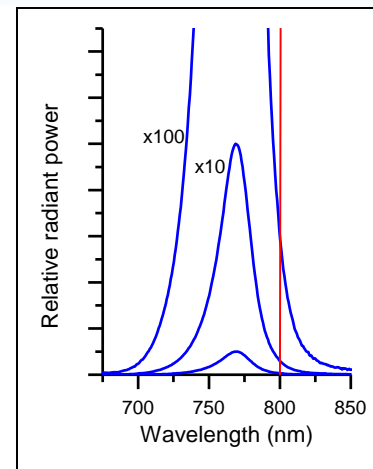
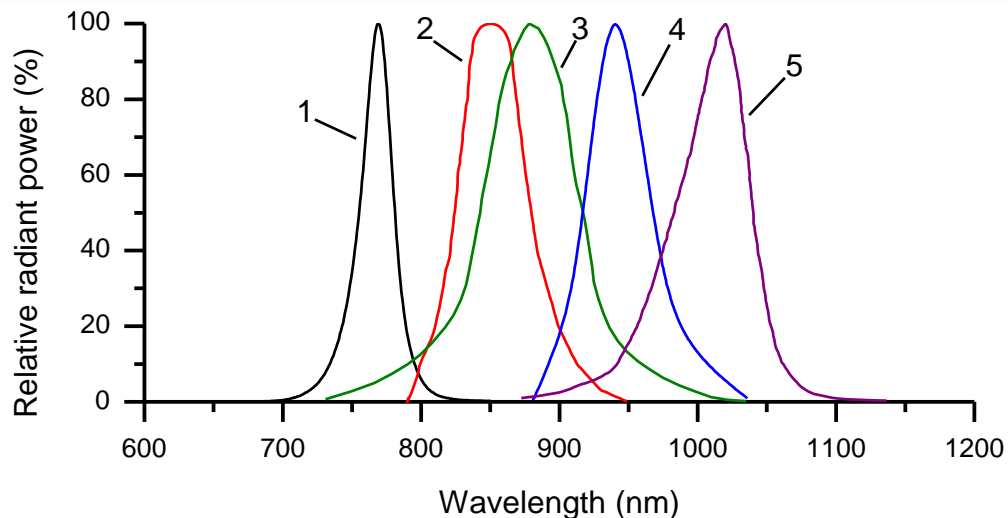
6 – gamma-radiation source

7 – adjustable LED's holder

8 – IR LED

9 – Digital oscilloscope

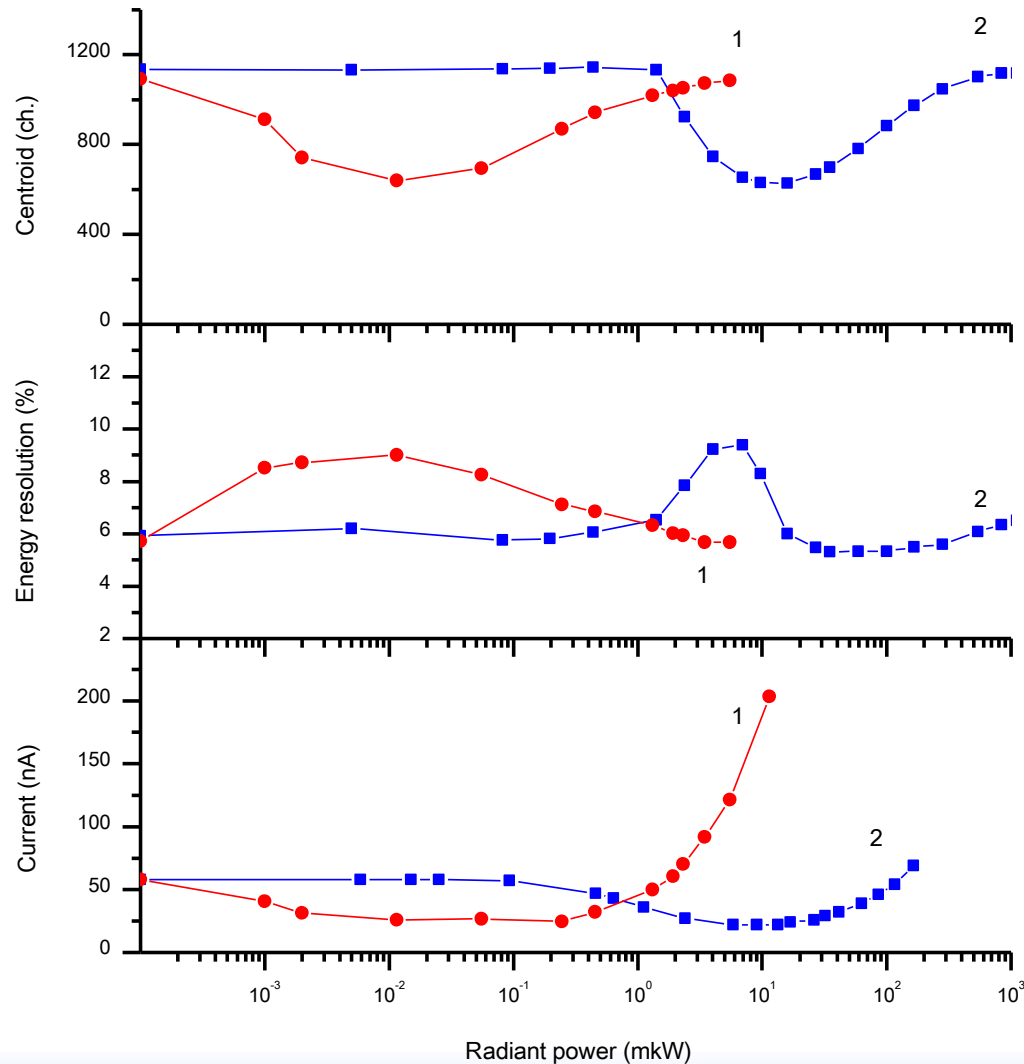
# Characteristics of IR LEDs used at measurements



OIS 330 770  
770 nm

Item	IR LED Type (Producer)	Continuous forward current, mA	Typical forward voltage, V	Typical radiant intensity,	Peak wavelength, nm	Spectral bandwidth, nm
1	OIS 330 770 OSA (Opto Light GmbH)	30	1.7	6	770	25
2	HIR204/H0 (Everlight Electronics Co., Ltd.)	20-50	1.45 (20 mA)	8.9 (20 mA)	850	45
3	OP298B (Optek Technology Inc.)	≤100	≤2.0		890	80
4	IR204 (Everlight Electronics Co., Ltd.)	20-100	1.2 (20 mA)	5.6 (20 mA)	940	45
5	ELD-1060-525 (Roithner LaserTechnik GmbH)	≤100	1.05 (20 mA)	1 (20 mA)	1020	50

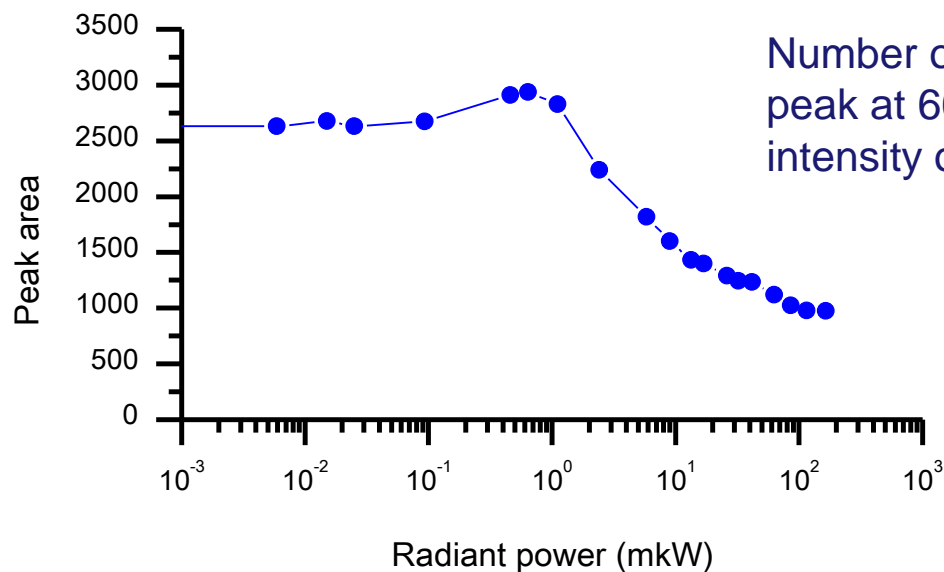
# Alpha-peak centroid, energy resolution and leakage current on intensity of IR illumination measured with planar detector



1 – illumination by IR LED HIR204 (850 nm)

2 – illumination by IR LED IR204 (940 nm)

# Planar detector spectrometric characteristics measurements at 662 keV and 59.6 keV depending on illumination intensity

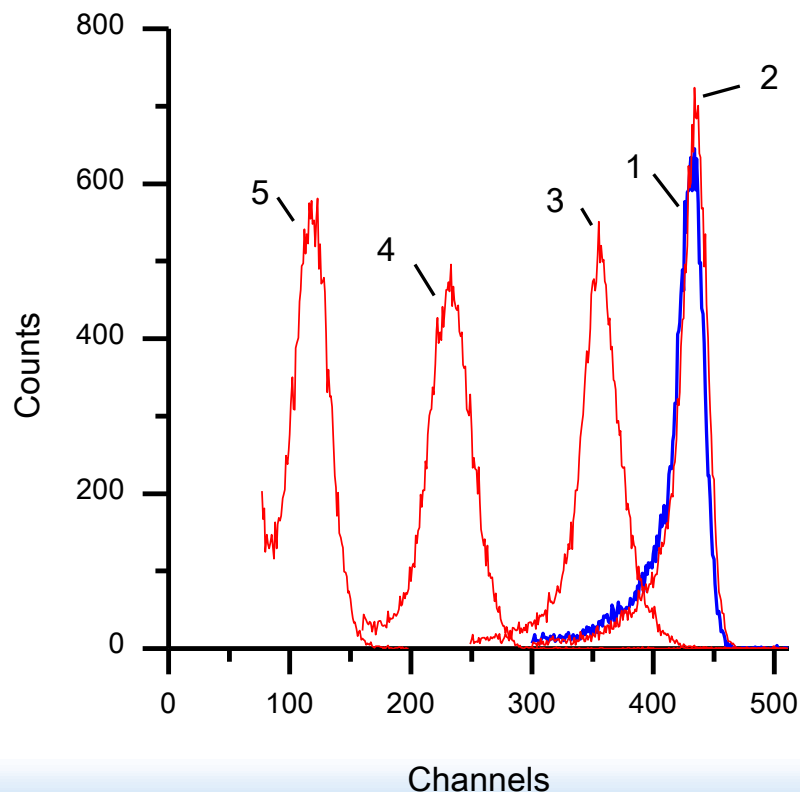


Number of pulses in the total absorption peak at 662 keV depending on illumination intensity of the IR LED IR204

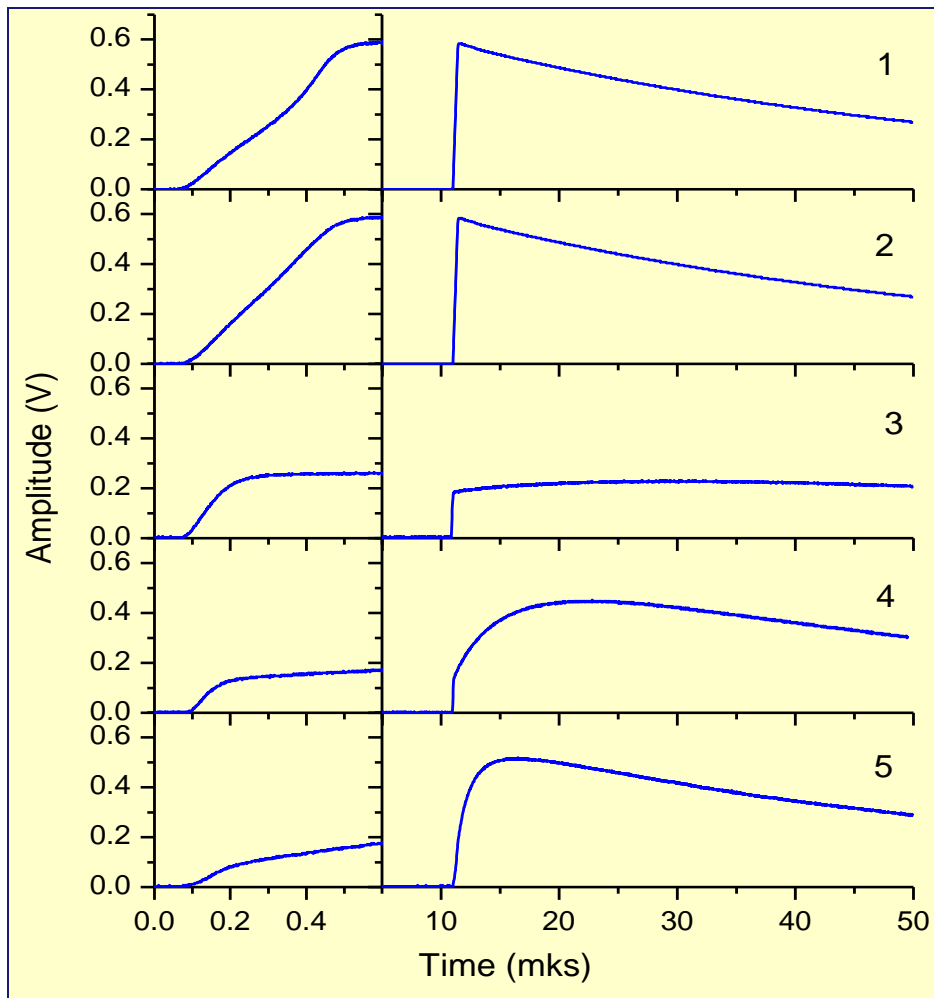
Am-241 spectra measured at different illumination level of the LED IR204

Radiant power:

- 1 – without illumination;
- 2 – illumination of 0.5 mkW
- 3 – illumination of 2.3 mkW
- 4 – illumination of 7.3 mkW
- 5 – illumination of 53.0 mkW



# Output signals waveforms at alpha-particle registration



Planar detector thickness – 5 mm

Operating voltage – 800 V

Illumination by LED IR204 (940 nm)

Radiant power:

1 – without illumination;

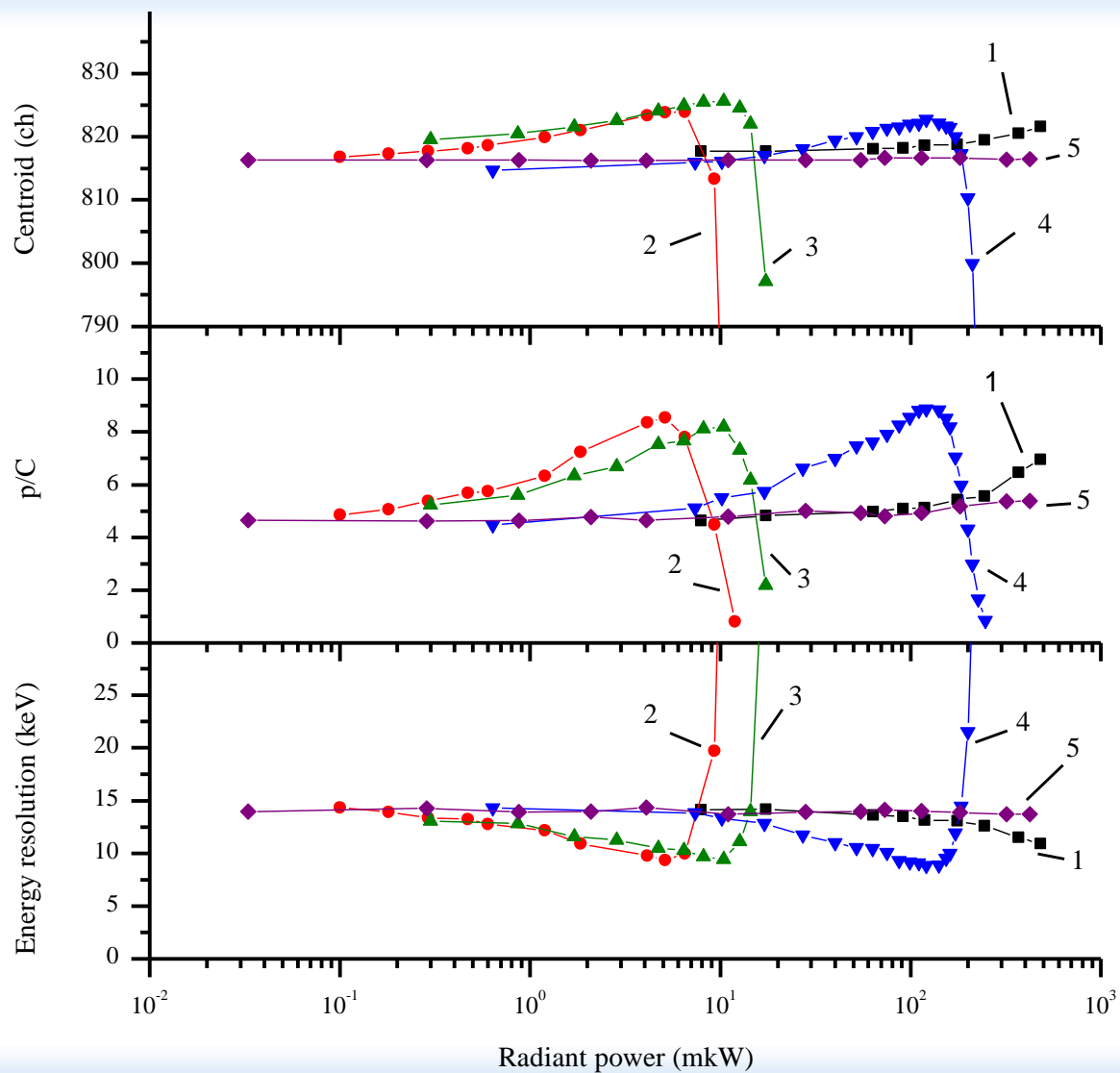
2 – illumination of 0.02 mW

3 – illumination of 19 mW

4 – illumination of 224 mW

5 – illumination of 1000 mW

# Peak centroid, energy resolution (FWHM), peak-to-Compton ratio at 662 keV on intensity of IR illumination



Quasi-hemispherical detector of 10x10x5 mm<sup>3</sup>

Operating voltage – 1000 V

Illumination by IR LED:

1 – OIS 330 770 (770 nm)

2 – HIR203/H0 (850 nm)

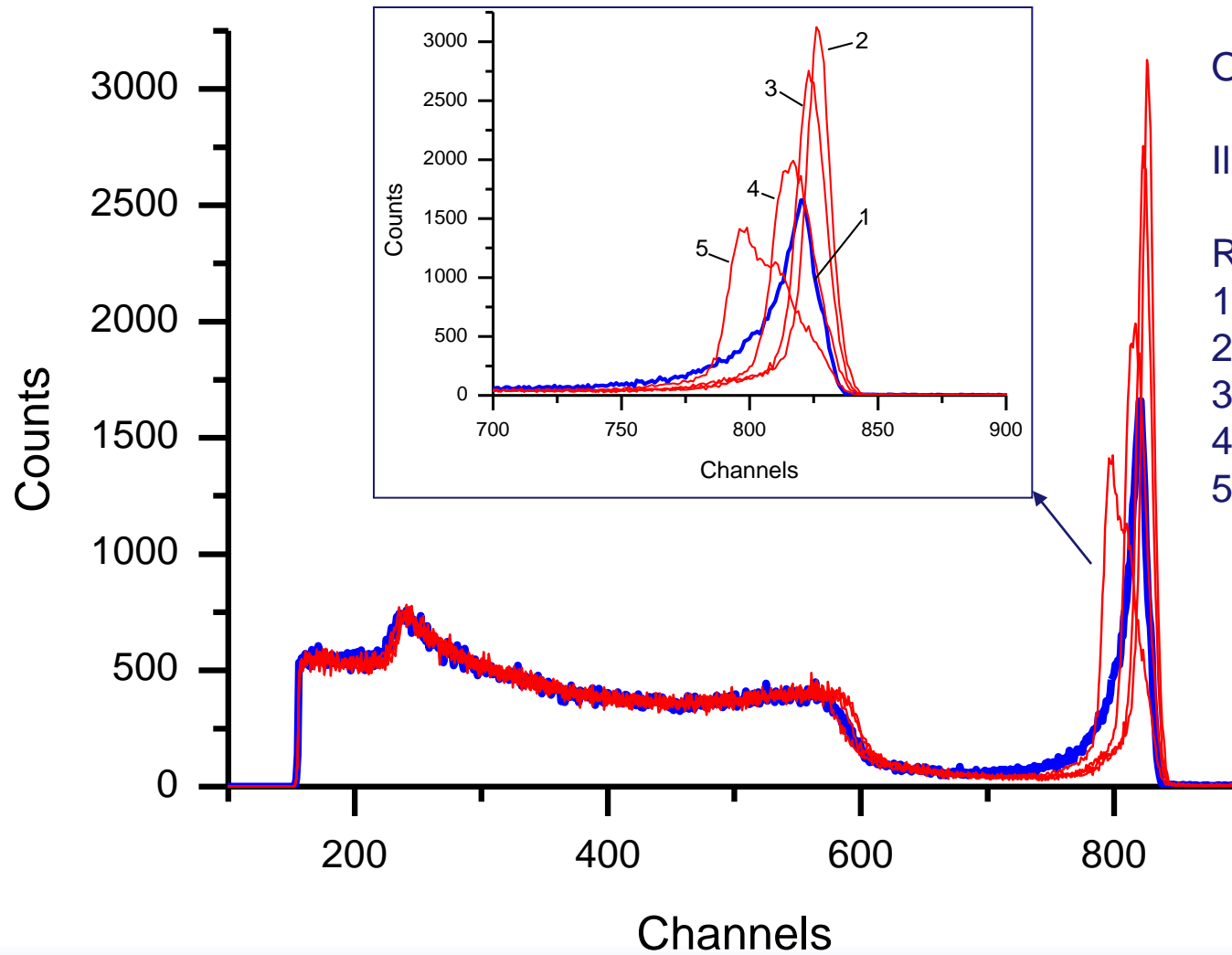
3 – OP298B (890 nm)

4 – IR204 (940 nm)

5 – ELD-1020-535 (1020 nm)



# Spectra of Cs-137 measured with quasi-hemispherical detector of 10x10x5 mm<sup>3</sup> at different illumination intensity



Operating voltage – 1000V

Illumination by IR LED IR 204

Radiant power:

1 – without illumination

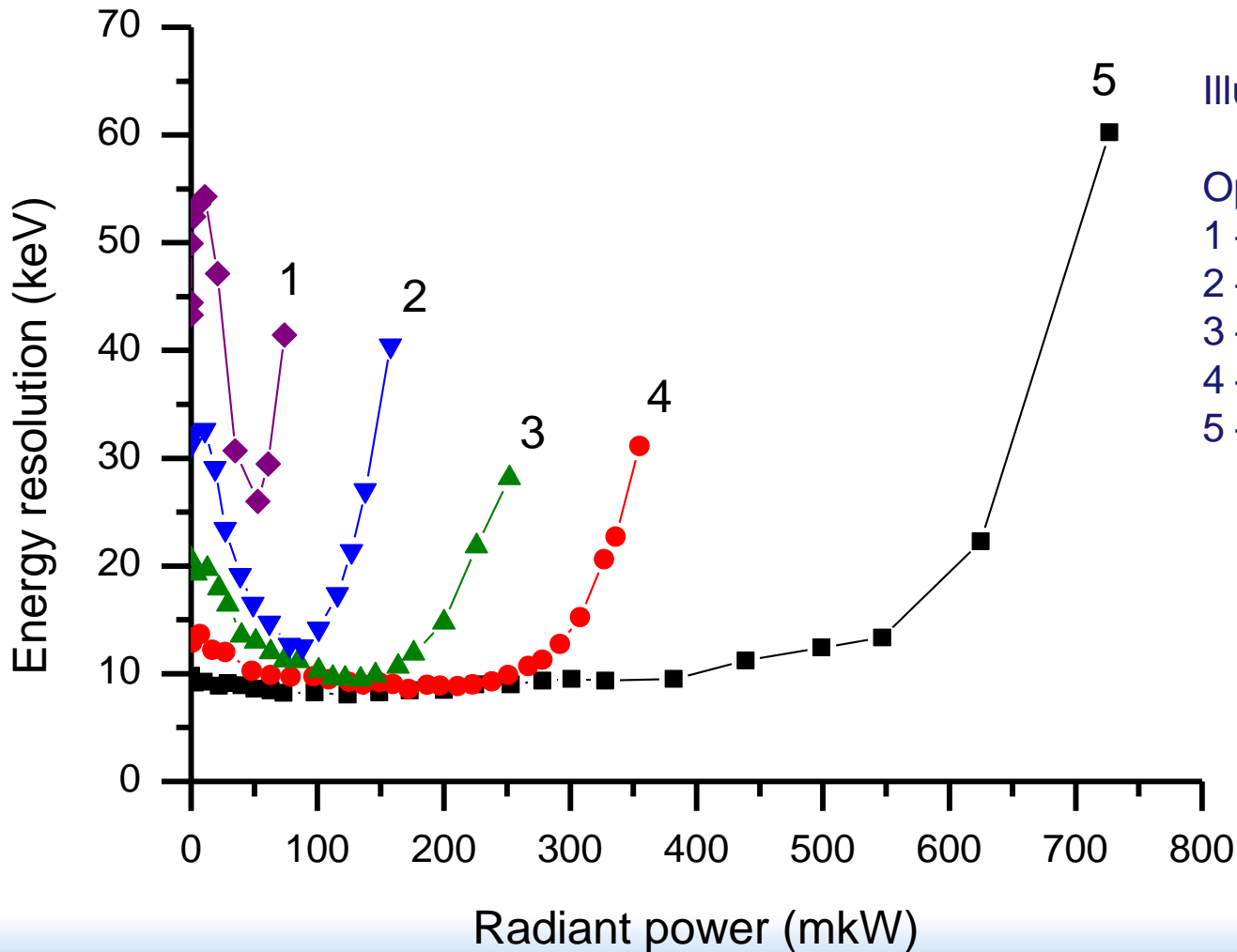
2 – 20 mW

3 – 200 mW

4 – 300 mW

5 – 340 mW

# Dependence of energy resolution at 662 keV measured with quasi-hemispherical detector of 10x10x5 mm<sup>3</sup> on IR illumination intensity at different operating voltages



Illumination by IR LED IR 204

Operating voltage:

1 – 300 V

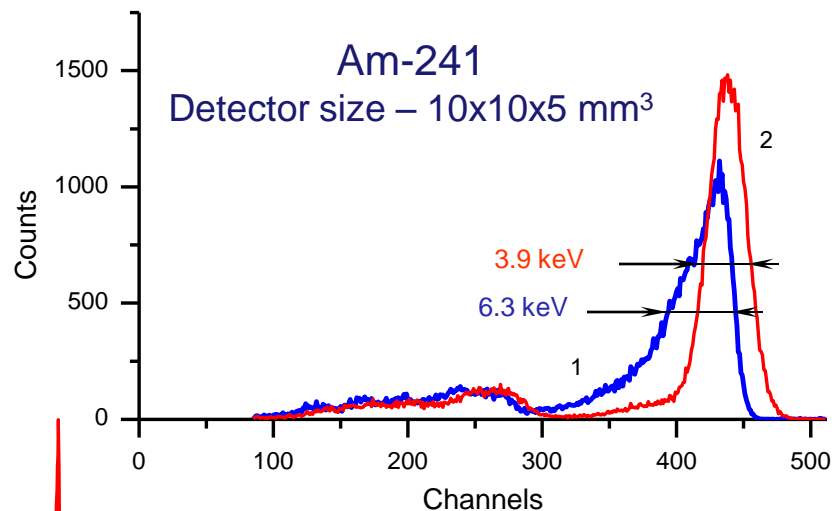
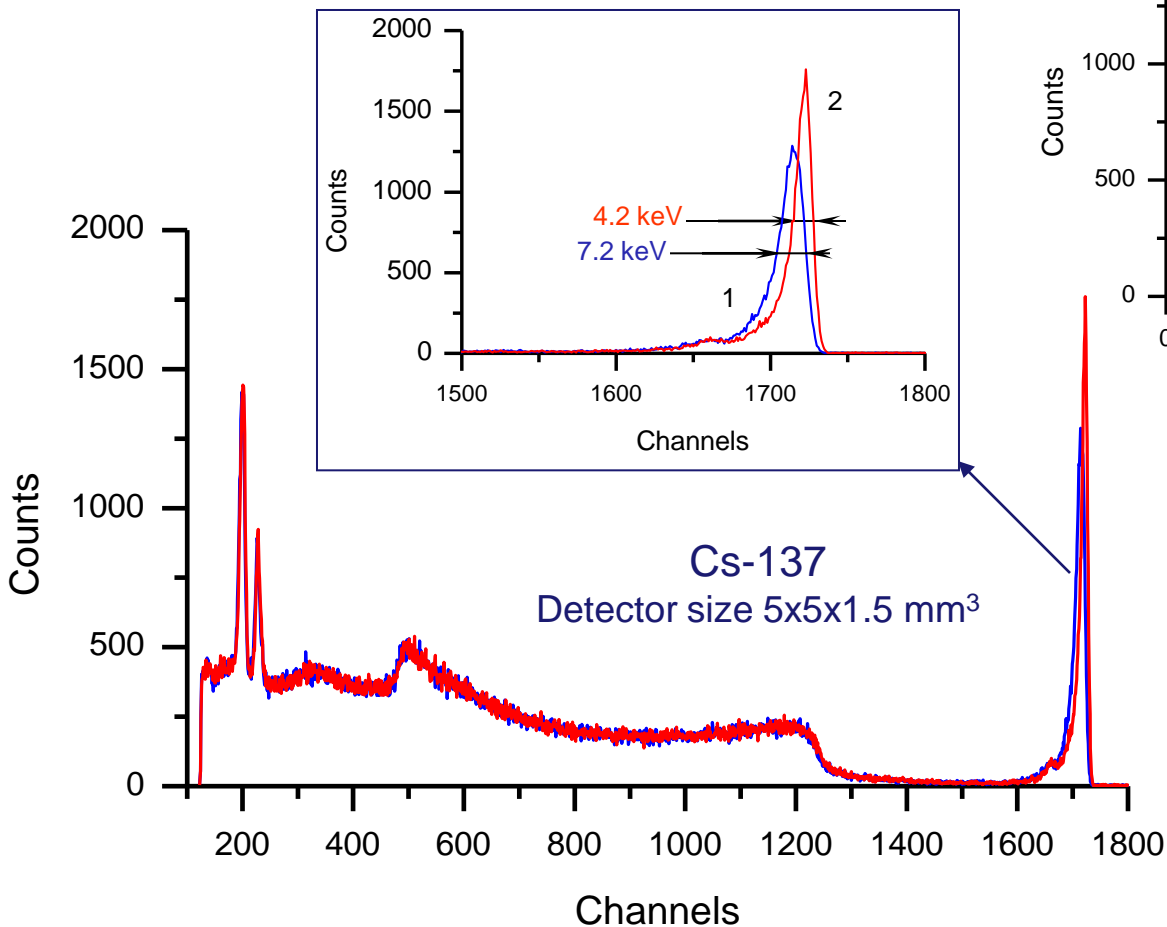
2 – 500 V

3 – 700 V

4 – 1000 V

5 – 1500 V

# Spectra of Am-241 and Cs-137 measured with quasi-hemispherical detectors without and with IR illumination



1 – without IR illumination  
2 – with IR illumination

# Spectrometric characteristics of different CdZnTe quasi-hemispherical detectors measured without and with IR illumination

No.	Detector size, mm	Energy resolution (FWHM) at 662 keV, keV		Peak-to-Compton ratio at 662 keV		Energy resolution (FWHM) at 59.5 keV, keV	
		Without IR illumination	With IR illumination	Without IR illumination	With IR illumination	Without IR illumination	With IR illumination
1	10x10x5	20.6	9.6	3	7.6		
2	10x10x5	9.8	8.1	7.1	10	6.3	3.8
4	7x7x3.5	27.1	16.2	2.5	4.2		
4	7x7x3.5	27.2	13.2	2.5	4.9		
5	7x7x3.5	6.4	5.1	9.4	12.6	5.4	2.8
6	5x5x2.5	18.8	14.1	3	4.2		
7	5x5x2.5	13	11.7	4.3	4.9		
8	5x5x2.5	24.5	10.8	1.8	5.4		
9	5x5x2.5	9.1	5	5.8	8.7		
10	5x5x2.5	7.2	4.7	7.4	10		
11	3x3x1.5	6.9	5.5	5.4	6.3		

# Conclusions

- ✓ The use of IR illumination with wavelengths close to the wavelength of the CdZnTe absorption edge (about 800-820 nm) can significantly improve spectrometric characteristics of quasi-hemispherical detectors.
- ✓ For the illumination practical realization the usual commercially available IR LEDs can be used.
- ✓ The positive effect is achieved at low levels of illumination, usually not more than 10 mW at the measuring point. In this case, the LED direct current is usually less than 1 mA.
- ✓ Improvement is obtained in a wide gamma-energy range without efficiency decreasing.
- ✓ Degree of improvement depends on a quality of used initial CdZnTe crystal and detectors.
- ✓ Improvements of spectrometric capabilities are obtained without increasing of detectors operation voltages. Perfect energy resolution may be obtained even at low operation voltages.
- ✓ Decreasing of CdZnTe planar detectors leakage currents under certain intensity of IR illumination was obtained.
- ✓ To further optimization of this approach and better understanding of the processes occurring in the detectors under the influence of IR radiation further investigations of the spectral response of optical transmittance and spectrometric characteristics under illumination with light within wavelength region of 600 – 1100 nm will be performed. CdZnTe detectors performance characteristics with infrared illumination, their ability to work in a wide range of operating temperatures will also be investigated and presented in the future.

Thank You !