JOINT INSTITUTE FOR NUCLEAR RESEARCH
Veksler and Baldin laboratory of High Energy Physics

FINAL REPORT ON THE
SUMMER STUDENT PROGRAM

Study of kinetics of gallium gadolinium garnet doped aluminum and yttrium aluminum gallium gadolinium garnet doped cerium by photoelectric multiplier ETL9141B

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Abstract

The results of an investigation of the kinetics gallium gadolinium garnet doped aluminum and yttrium aluminum gallium gadolinium garnet doped cerium are present in this paper. Absorption curves of garnets were obtained and a comparative analysis was made. The study was done by the photoelectric multiplier ETL9141B and an oscilloscope TELEDYNE LECROY wavesufer 3034R operating in a single-photoelectron mode.
It is established that the relaxation time of the yttrium aluminum gallium gadolinium garnet is more smaller than that that the relaxation time of the gallium gadolinium garnet doped aluminum.
The contribution of cosmic radiation in the experiment was noted.

For create an ECAL for the NIKA supercollider (RUSSIA), it is necessary to create a construction that will capture the photons that are obtained during the interaction of particles with the construction like a shashlik (Fig. A, B) [1].

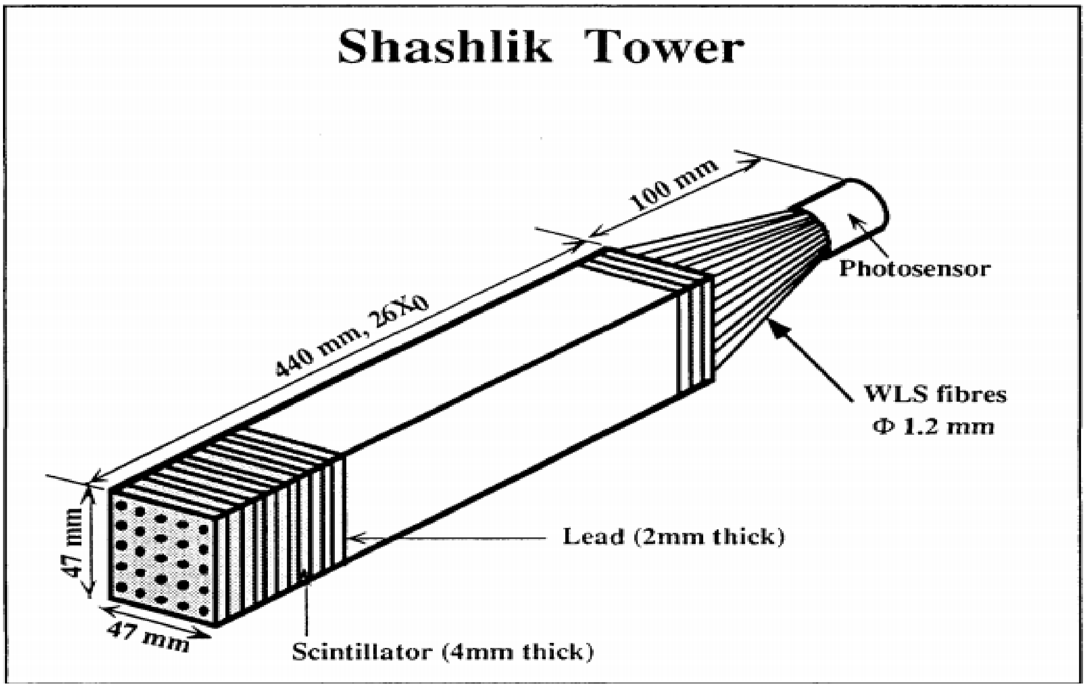


Figure A. The example mechanical design of a CMS Shashlik calorimeter prototype tower equipped with 25 aluminized WLS fibres. Side view.

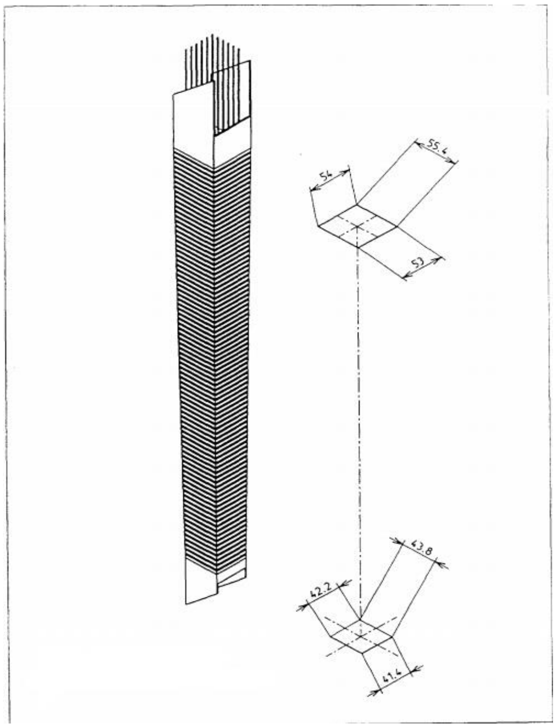


Figure B. The example shashlik tower design.View of face.

Waveguides and the construction of a shashlik should be made of a material whose density exceeds the density of lead tungstate ($PbWO_4$: the density is 8,24 g/cm^3), has a high radiation hardness and high optical clarity.

It is known that such properties are possessed by such materials as the garnets [2,3,4].
We have two samples for study: gallium gadolinium garnet doped aluminum and yttrium aluminum gallium gadolinium garnet doped cerium

Sample: $Gd_3Ga_5O_{12}$: Al (Figure 1a) (GGG/ GGG: Al)
Sample: $YGd_3Ga_5O_{12}$: Ce (Figure 1b) (YGGG/ YGGG: Ce)

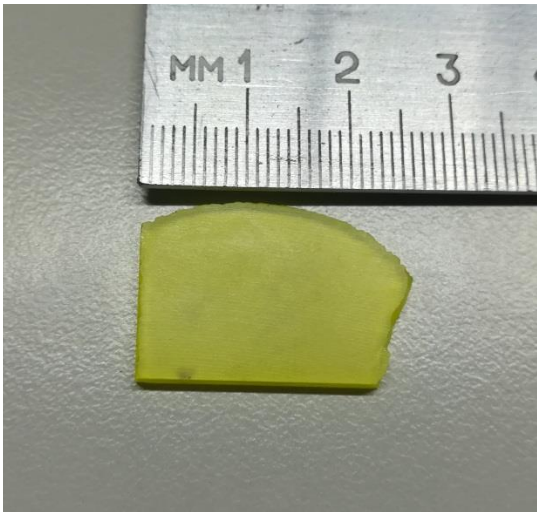


Fig. 1a. Experimental sample of single crystal $Gd_3Ga_5O_{12}$: Al. The sample was provided by Fomos-MaterialisGroupe

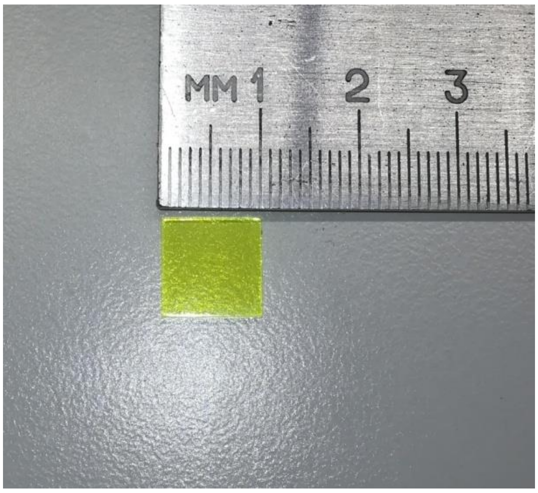


Fig. 1a. Experimental sample of single crystal $Gd_3Ga_5O_{12}$: Ce. The sample was provided by Fomos-MaterialisGroupe

the experiment was built as follows: an electronic oscilloscope TELEDYNE LECROY wavesufer 3034R registered single photoelectrons emitted from the photocathode (one-photoelectronic regime)[5].

Based on the results of the data obtained, absorption curves were plotted.

As a pulse shape analyzer, the TELEDYNE LECROY wavesufer 3034R oscilloscope was used (Figure 2a, 2b and 2c)

Fig. 2a. The photo of the photoelectronic multiplier used in the experiment. Side view.

Fig. 2b. Photo of the detector used in the experiment. View from the ends.

Fig. 2c. Photo of the photomultiplier assembly with amplifier and high-voltage converter EMCO.

The photomultiplier consists of:

1. Divisor
2. Preamplifier on the operational amplifier AD8014
3. Discriminator for selecting the threshold AD8561
4. Power supplies of the pre-suppressor NJM7806 and NJM7906.
5. High voltage source combined with the discriminator unit (threshold range 10mV - 100mV).
6. Photoelectric amplifier ETL9141B (ETL9106SB)

The type of photomultiplier used in the experiment (Fig. 3).

Fig. 3. The Photomultiplier ETEnterprises model 9141B

The block of electronic, the divider and the power source of photomultiplier are shown in Fig. 4a and 4b.

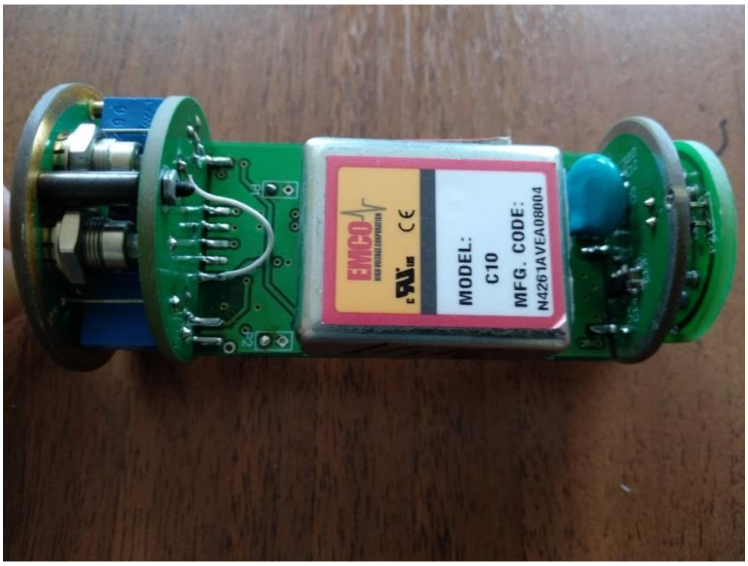


Fig. 4a. the module of electronic of the photoelectric multiplier ETEnterprises model 9106sb

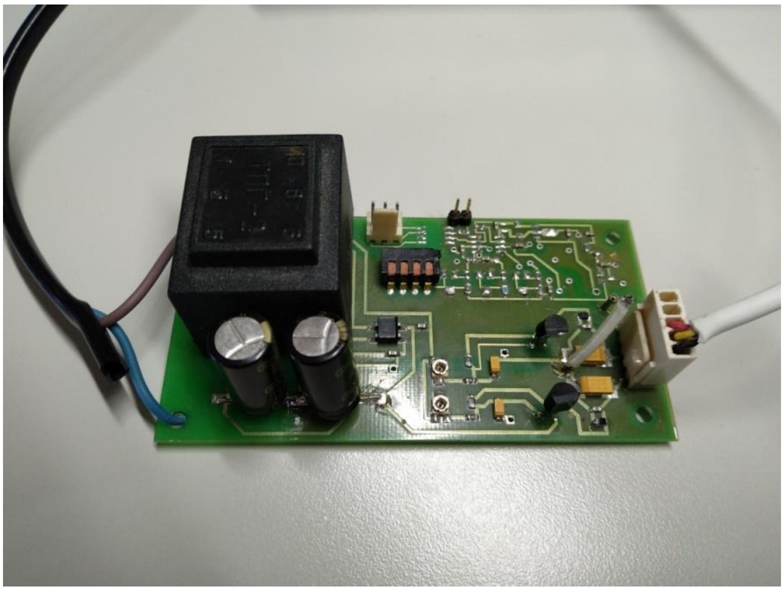


Fig. 4 b. Power supply ETEnterprises model 9106sb

To protect the photomultiplier from magnetic fields, a μ-metal screen was used. The device is inserted into tube (Fig. 5)

Fig. 5. The tube of μmetal near the photoelectric multiplier device

Our group was made:

1) Preparation of samples and assembly of a photoelectric multiplier;
2) Determination of the noise level;
3) Determination of single-photoconductor parameters;
4) Measurement of a photomultiplier connected to an oscilloscope.

The noise level when measuring the pulse on an oscilloscope was not more than +/- 1mV (Fig. 6)

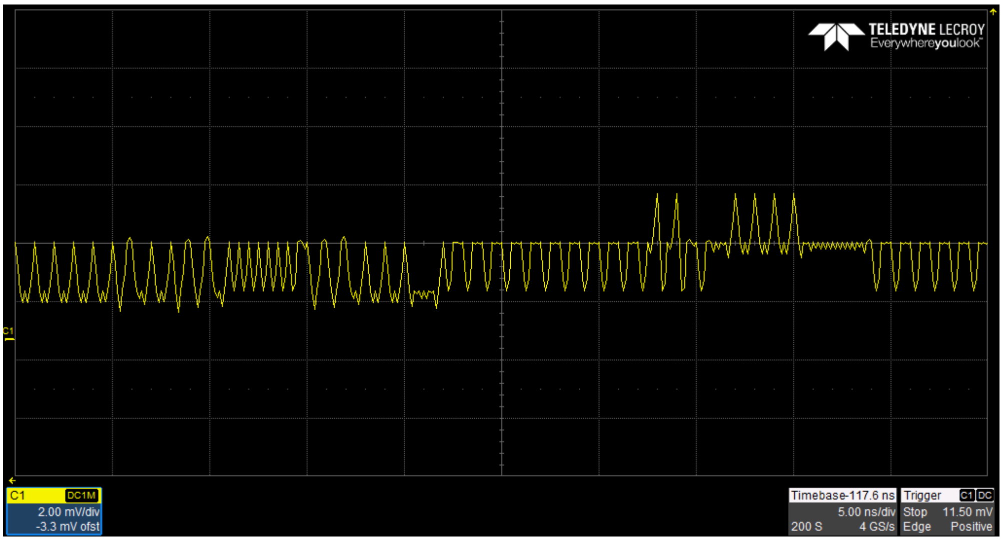
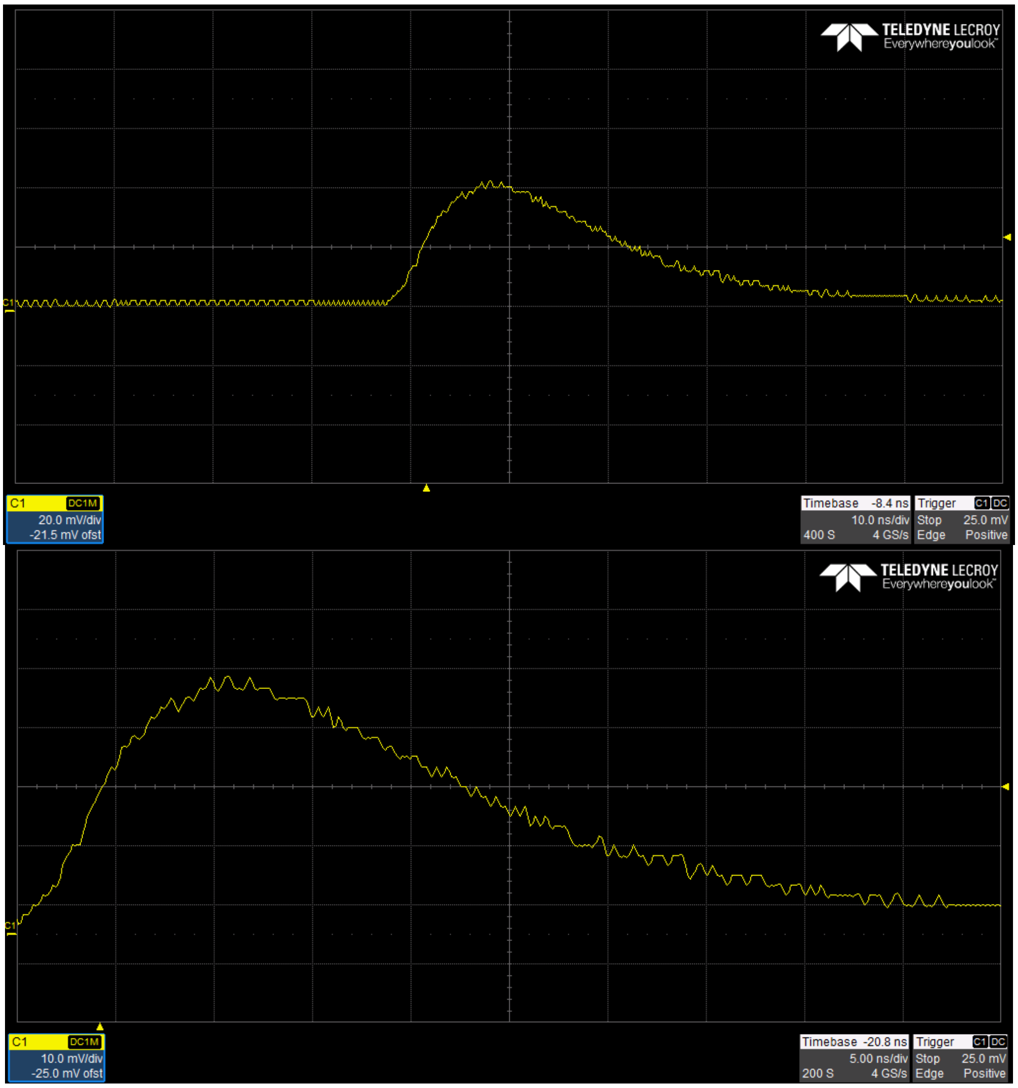


Fig. 6. Noise level during measurements (without sample)

the oscilloscope TELEDYNELECROY wavesufer 3034R was used in the experiment.
The duration of the leading edge of the pulse to the maximum point is approximately 10 ns. And the relaxation time is ~ 22ns. The total pulse duration is approximately ~ 35 ns. Constants of integration time of the preamplifier are:
For the leading edge ~ 5ns
For the trailing edge ~ 7ns.
The shape of the signal from the single-photon pulse presented in the picture is determined by the integration constants of the built-in preamplifier. The contribution of the photomultiplier is negligible.(Fig. 6 a - c)



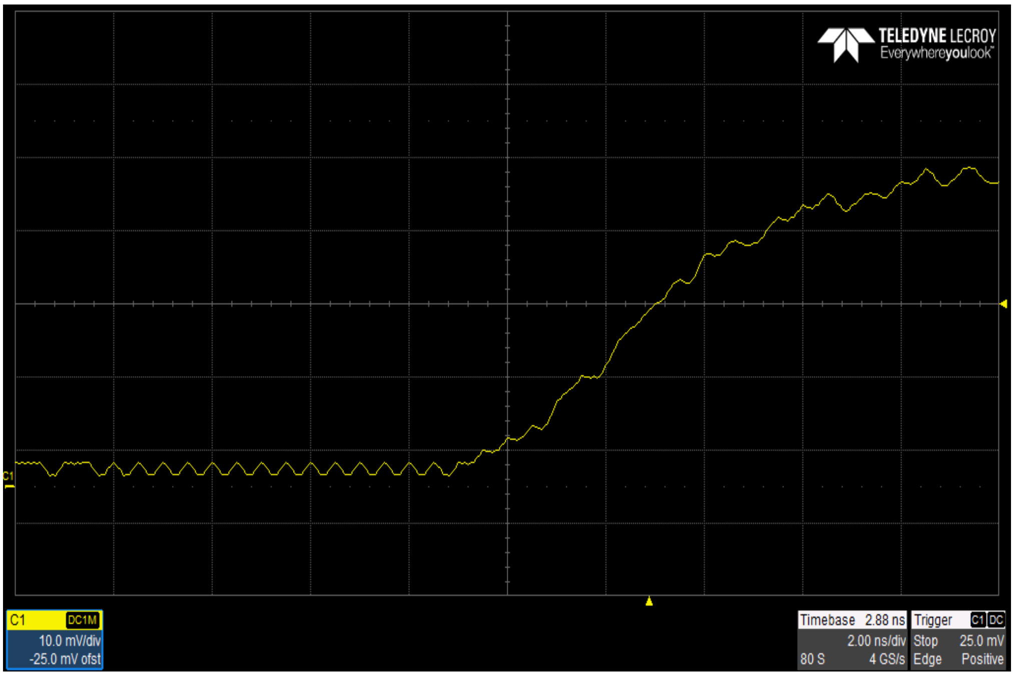
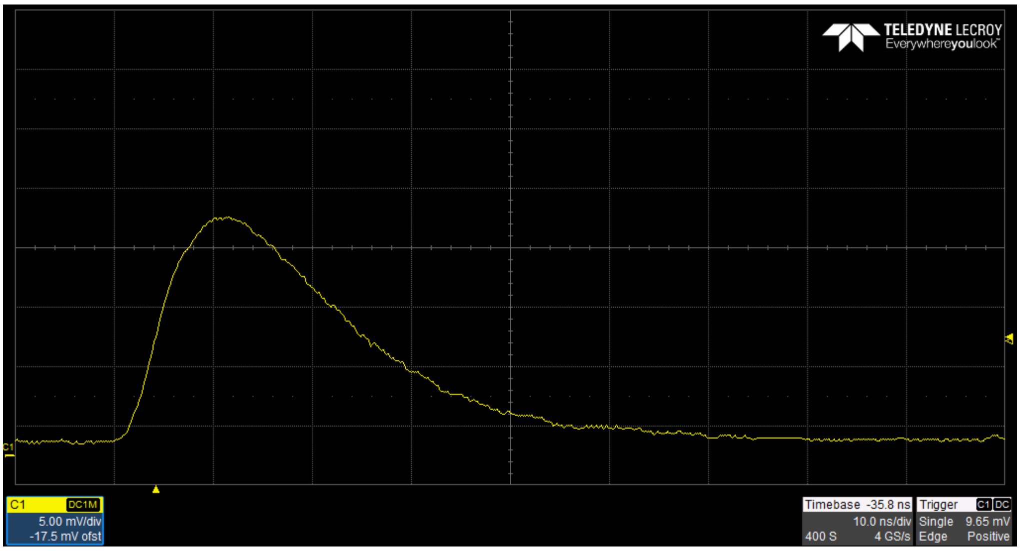


Fig. 6 a-c. 2 ns for one division

The amplitude and shape of the pulses with a photomultiplier, without a GAGG crystal, are presentedon fig. 7 a – b.



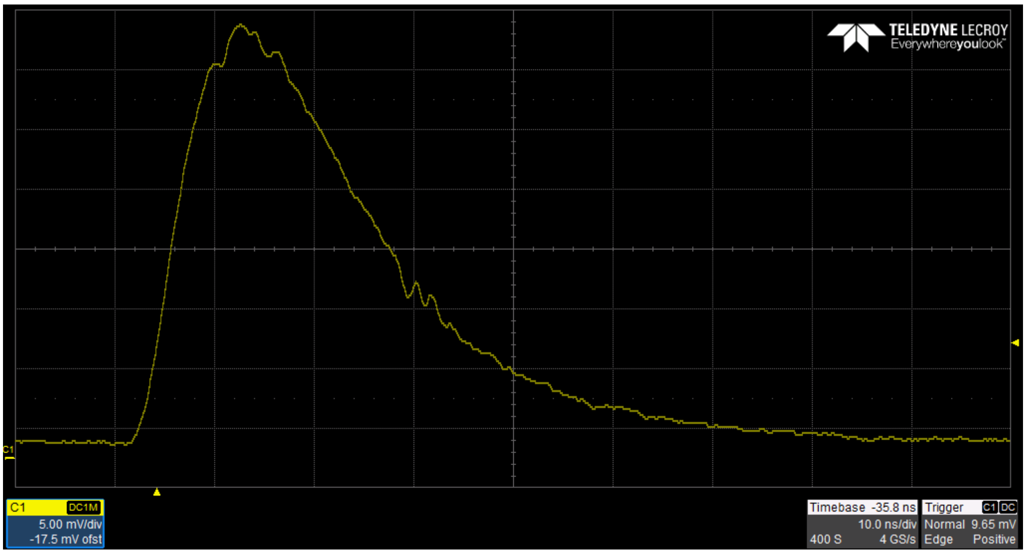
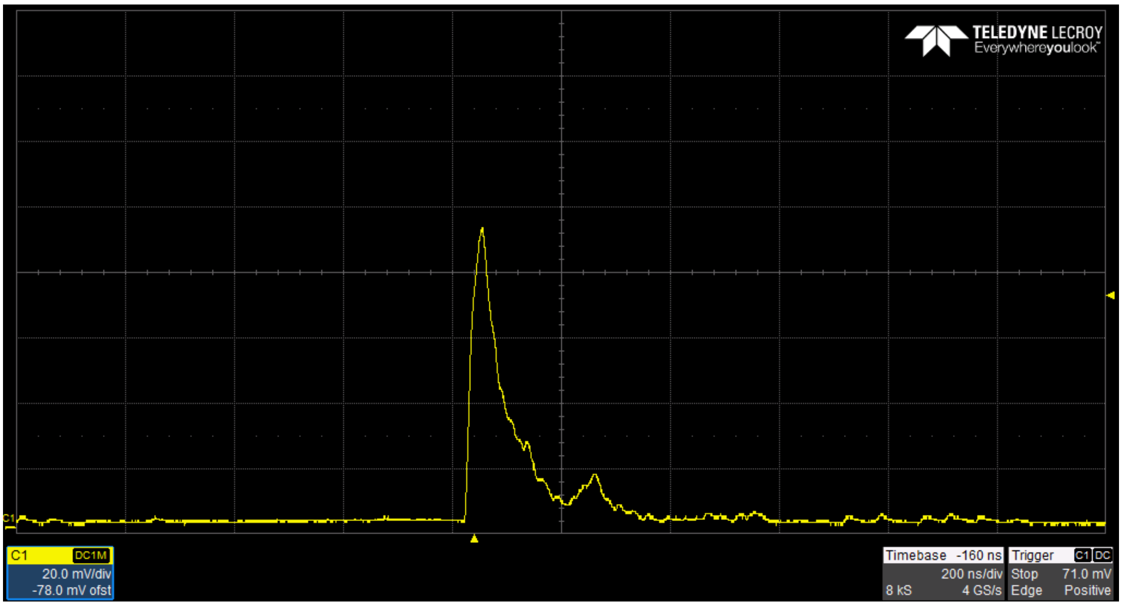


Fig. 7. As can be seen from the presented graphs, the amplitude of the signal varies from 8 (a) to 35 (b) mV

Measurement of cosmic radiation carried out with HAGG crystals: crystal GAGG without exposure in direct sunlight:

The amplitude of the signal varies from 85 to 140 mV (Fig. 8 a - b)



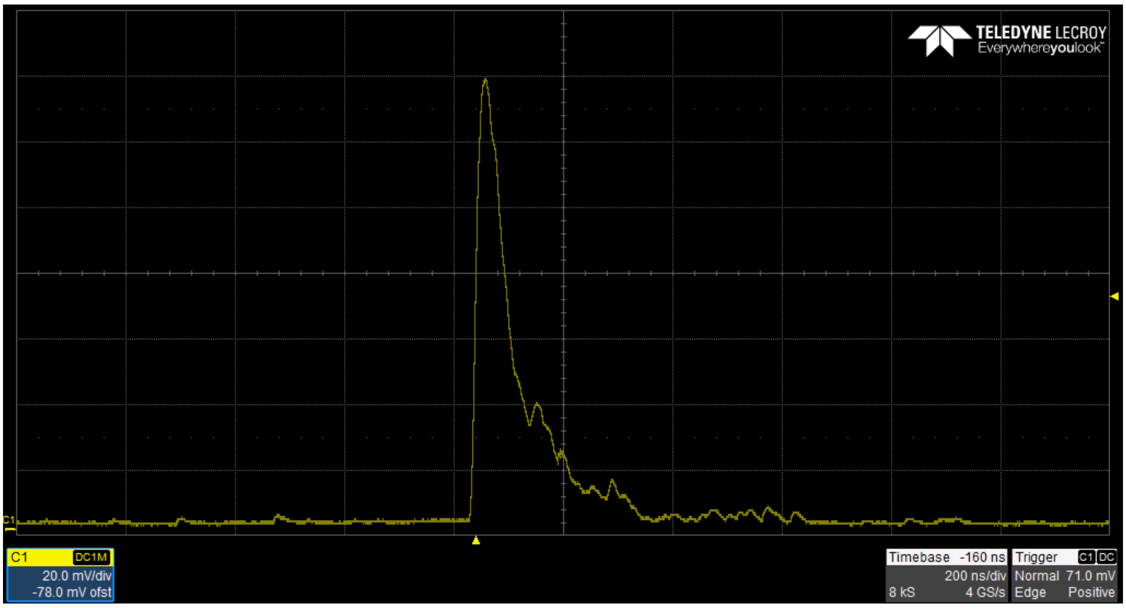


Fig. 8 a-b. absorption curve before exposure

On the fronts, luminescence pulses are visible.

The appearance of additional peaks of secondary damping can be seen on the absorption curve.

After exposure to direct sunlight, an increase in the signal amplitude and luminescence intensity (Fig. 9 a - b)

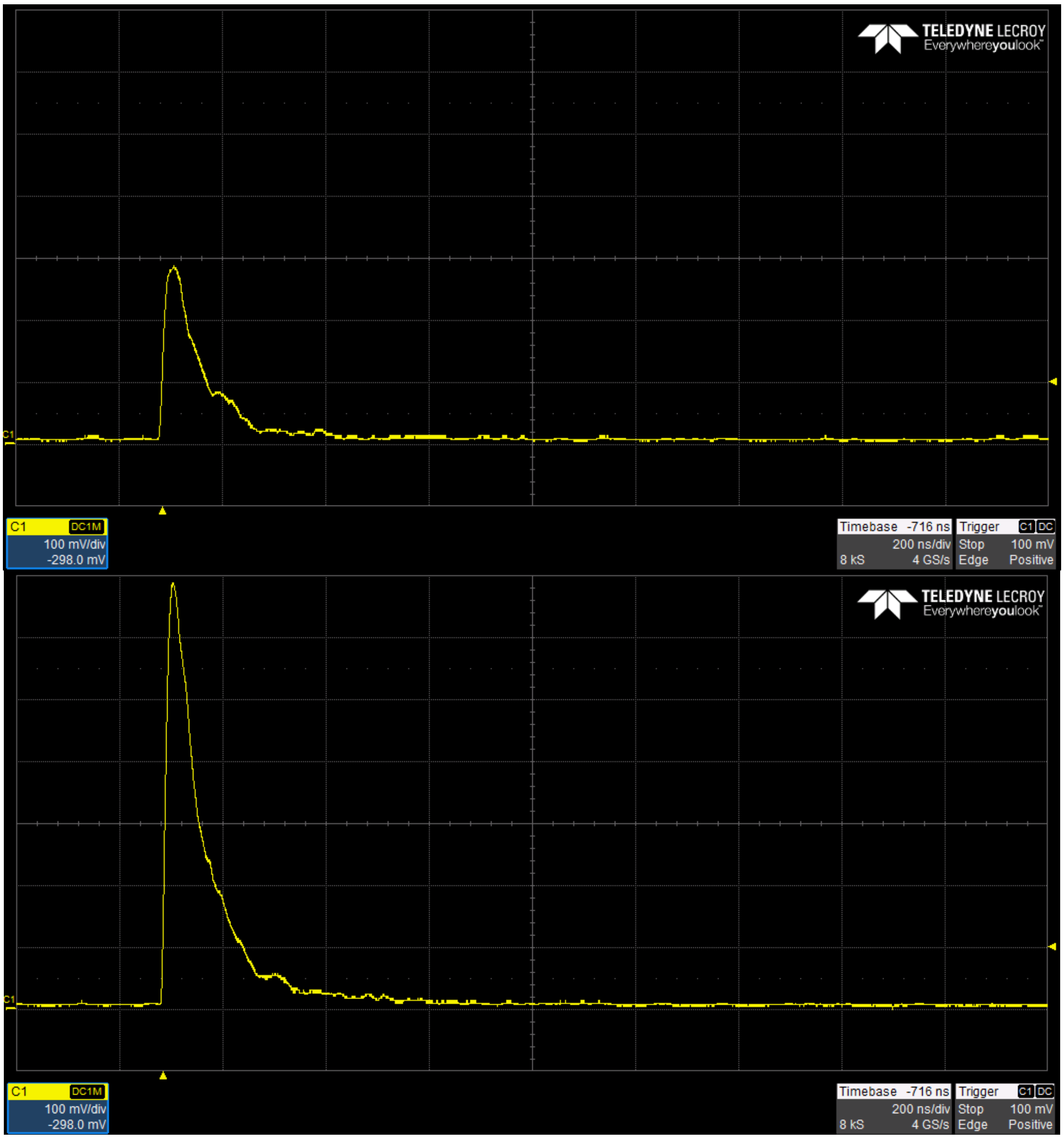


Fig. 9 a-b. The absorption curve of GGAG after illumination

The amplitude of the cosmic radiation signal of the GGG: Al varies from 300 mV to 700 mV. (Fig. 10 a - b)

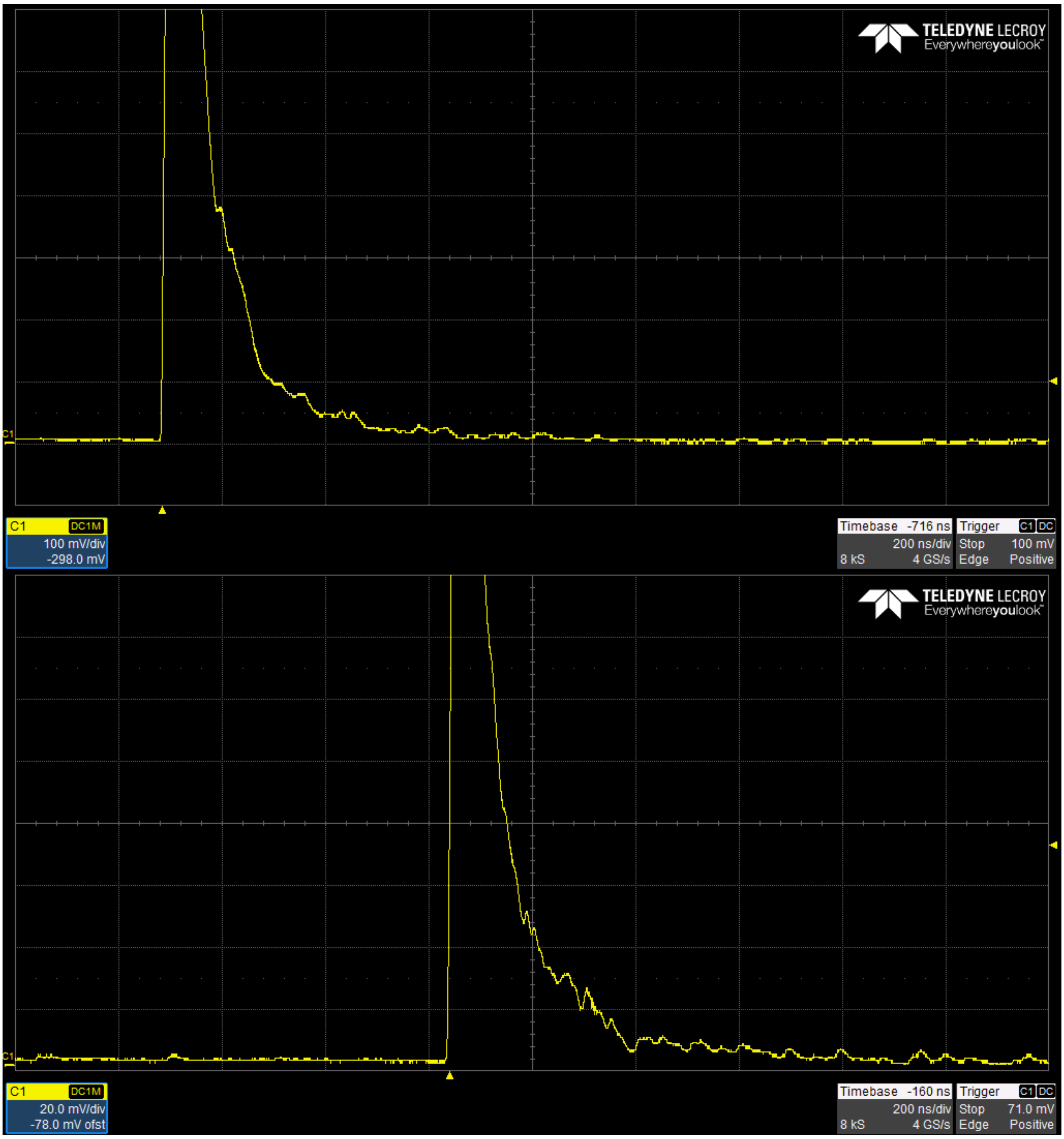


Fig. 10 a – b. The signal registered by the oscilloscope with a photomultiplier, GGG after illumination

The photocathode of the photomultiplier, connected to the oscillograph, was placed a YGGG: Ce crystal without exposure: (Fig. 11)

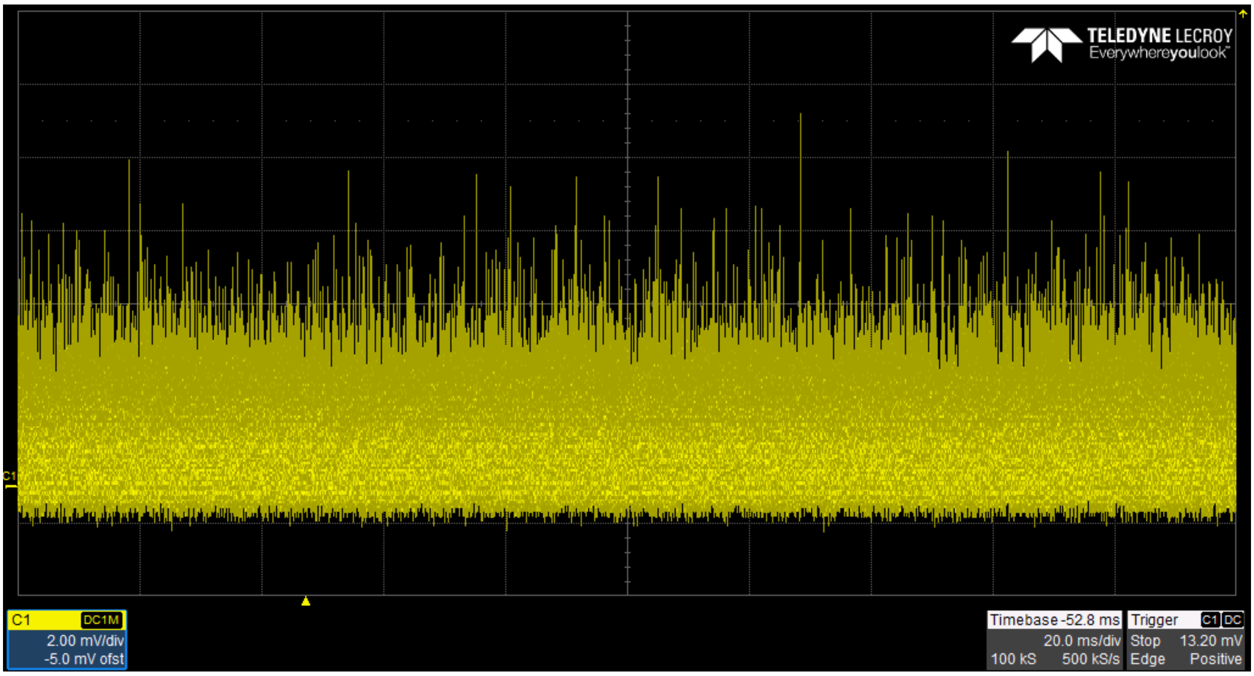


Fig. 11. The level of the noise path when measuring the pulse on an oscilloscope was not more than +/- 4mV

Figure 12 shows a graph comparing the responses from the pulses of GGG: AL and YGGG: Ce

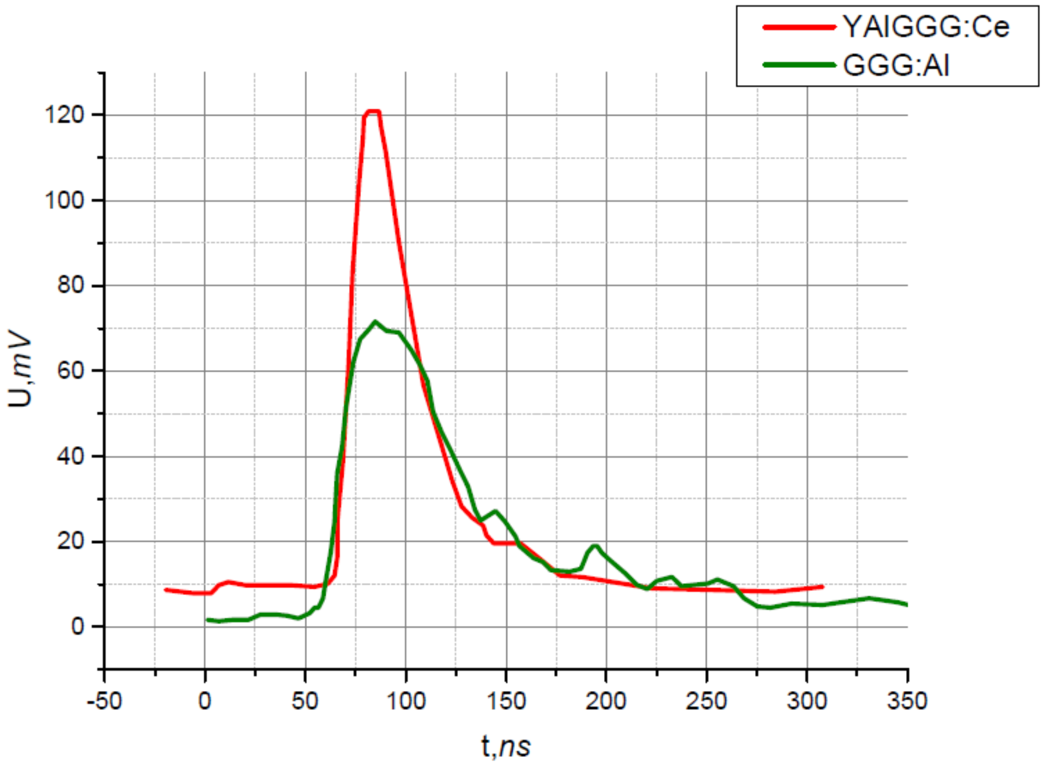


Fig. 12. The graph comparing the responses from the pulses of GGG: AL and YGGG: Ce

Conclusion

1. The kinetics of GGG: Al was studied using an oscilloscope recording single-photon signals with a photomultiplier;
2. The measurements of GGG: Al are differentiated before and after exposure;
3. The noise level is measured;
4. The effect introduced by cosmic radiation passing through the sample was noted;

Results:

1. Sample constructional (crystal GGG: Al Fomos)
the duration of the leading edge of GGG: Al is ~ 25ns, the trailing edge is modulated by the afterglow pulses of ~ 125 ns
2. Crystal YAGG: Ce (Kharkov) the duration of the leading edge is approximately 22ns. And the length of the trailing edge is ~ 70ns.

References

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