INVESTIGATION OF LUMINESCENT PROPERTIES OF CSI(TL) CRYSTALS WITH DIFFERENT ACTIVATOR CONCENTRATIONS

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Signals from PMT with different CsI(Tl) crystals with activator concentrations of 0.04%, 0.05%, 0.069%, 0.09%, 0.11%, 0.12% was registered with Signatec PDA14 100 MHz digitizer. The crystals were identical in size of 18 mm in diameter and 5 mm thick. Reference target ^{226}Ra was used as the source of alpha and beta particles. Signals from different particles were identified by digital signal processing – correlation method. Signals from alpha-particles of different energies and beta-particles are presented. Measurements were carried out with the temperature of -10°C, +20°C, +60°C.

Particle identification.

Digital signal processing – correlation was used for particle identification. Four alpha-particle peaks attributed to different particle energy are clearly seen in upper part of Figure 1. The wide area in lower part denotes beta-particles.

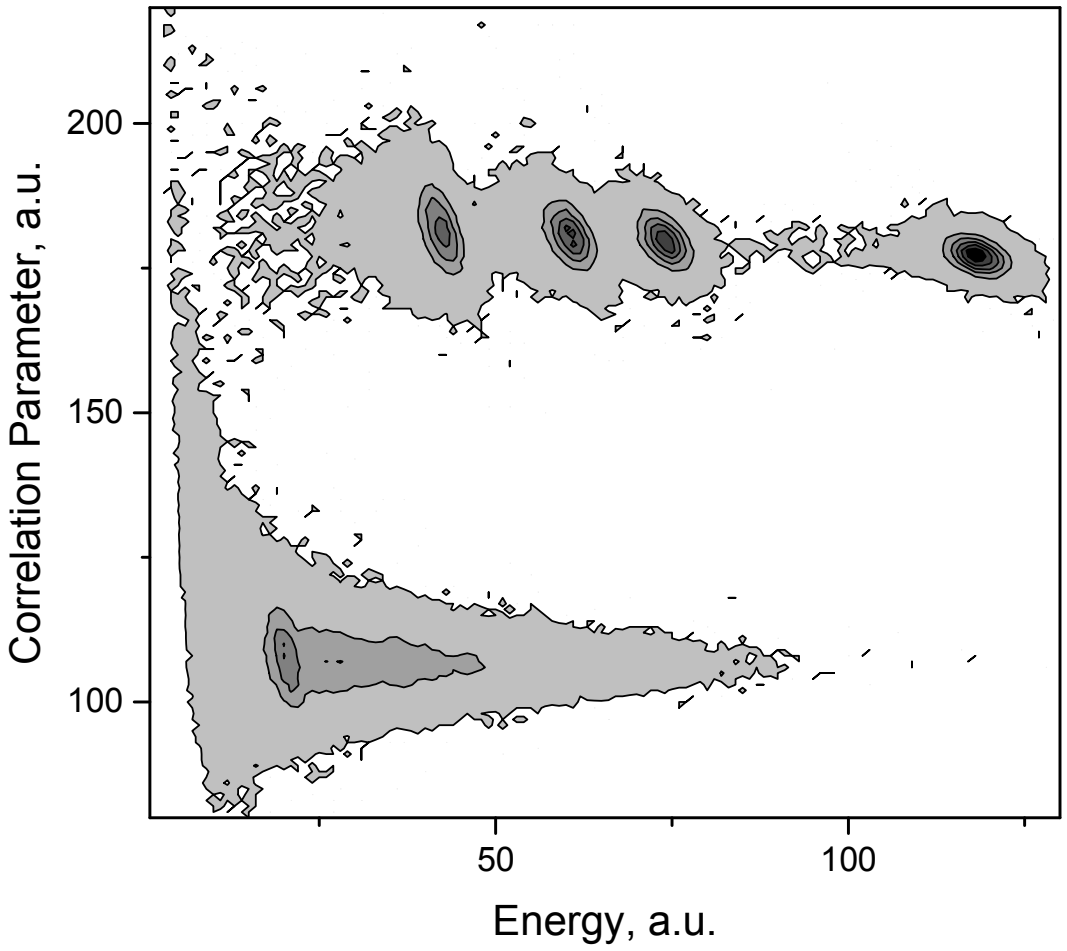

Figure 1. Particle identification with the correlation method.

Signals.

Typical signal shape for all registered charged particles shows rather fast grow and much slower decay. The top part of the signal shape for the beta-particles is not so sharp as for the alpha-particles. The higher the energy of the alpha-particles the higher the amplitude and the area of the signals. Decay part of each signal can be fitted by the sum of three exponents (lines on Figure 2). The time constants were defined in several iterations and than fixed in order to have the same approximation for all further processing. Time constants for the beta-particle signal were determined separately from the alpha-particle signal.

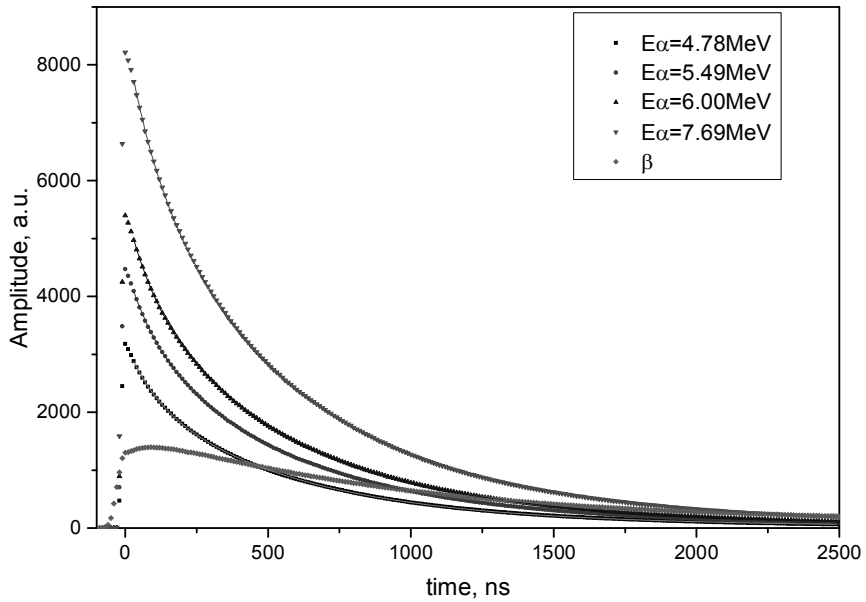

Figure 2. The decay part of the signals fitted by three exponents.

Activator concentration dependence of the signals.

The measurement were performed with the same conditions for all scintillate crystals. In order to compare them correctly the signal amplitude was normalized to the signal area. The higher the concentration the higher the amplitude. In another words, the higher the concentration, the sharper the signal top part (Figures 3). The same behavior is true for alpha-particles with different energies. But for low energy alpha-particles the top of the signal become more sharp.

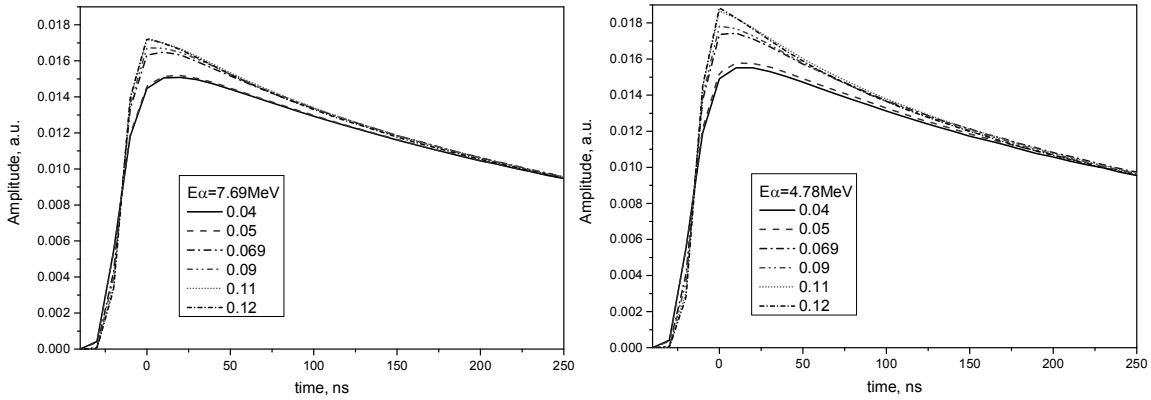

Figure 3. Signals from high and low energies alpha-particles in different concentrations.

Unlike alpha-particles, beta-particles produce signals with opposite behavior on activator concentration (Figure 4). Signals from beta-particles of different energies shows identical behavior.

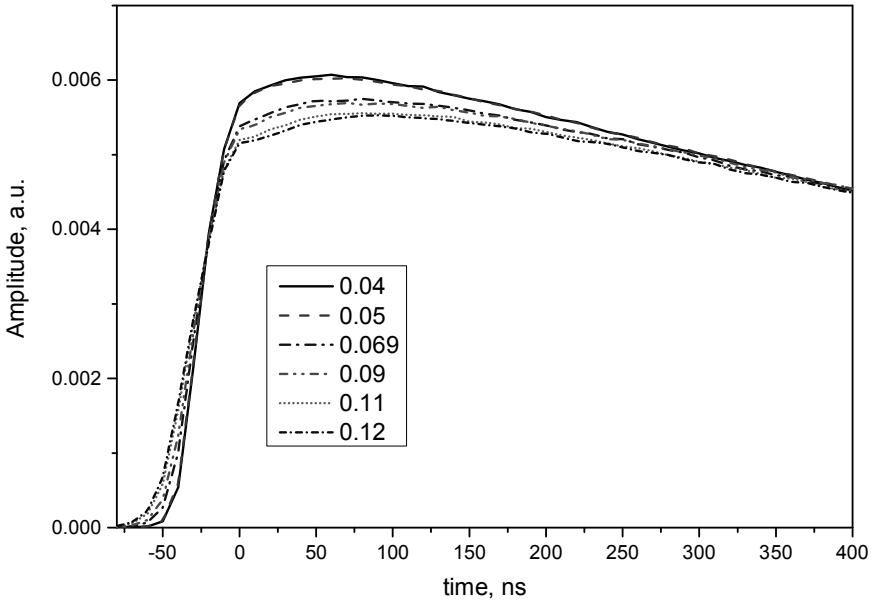

Figure 4. Signals from beta-particles in different concentrations

Fast decay component of alpha-particle signals.

Shares of fast, intermediate and slow decay components change slowly with activator concentration. The share of fast component (decay time constant of 100 ns) getting higher with activator concentration. The intermediate (500 ns) and slow (950 ns) component shares become smaller. The base line levels for all signals decay are slightly above zero. It is a hint on very slow decay component existence.

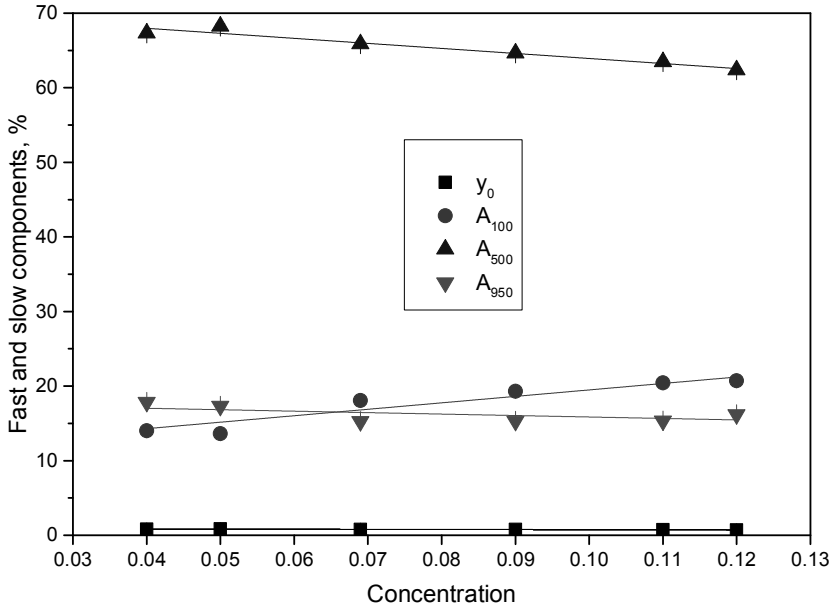

Figure 5. Shares of fast, intermediate and slow decay components vs concentration.

Light output.

The first momentum (mean value) of the energy distribution of the registered alpha-particles with the energy of 7.69MeV shows clear maximum close to 0.07% activator concentration.

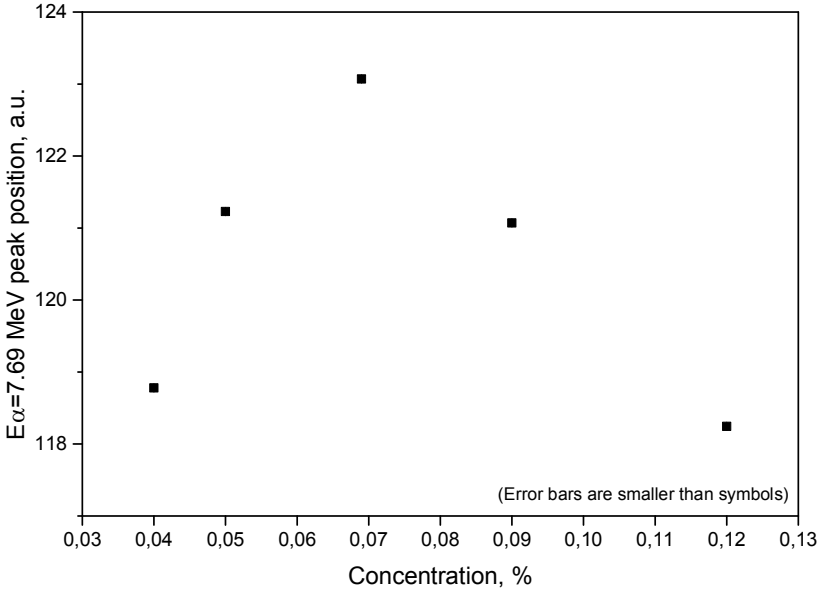

Figure 6. Light output for 7.69MeV alpha-particles.

Temperature dependence of alpha-particle signals for CsI(Tl) with 0.12% concentration.

For -10°C and +20°C temperature of the crystal alpha-particle signals are almost identical, but for +60°C fast component is much higher while slow component is slightly lower.

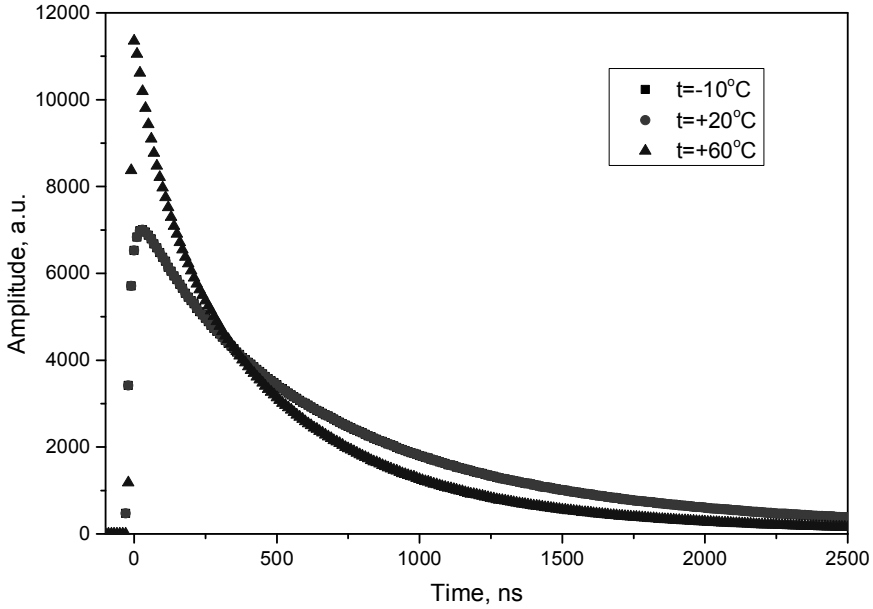

Figure 7. Signals from alpha-particles produced by crystal under different temperatures.

Temperature dependence of beta-particle signals for CsI(Tl) with 0.12% concentration.

The amplitude grows almost linearly with the temperature of the crystal. The shape of the signals is different.

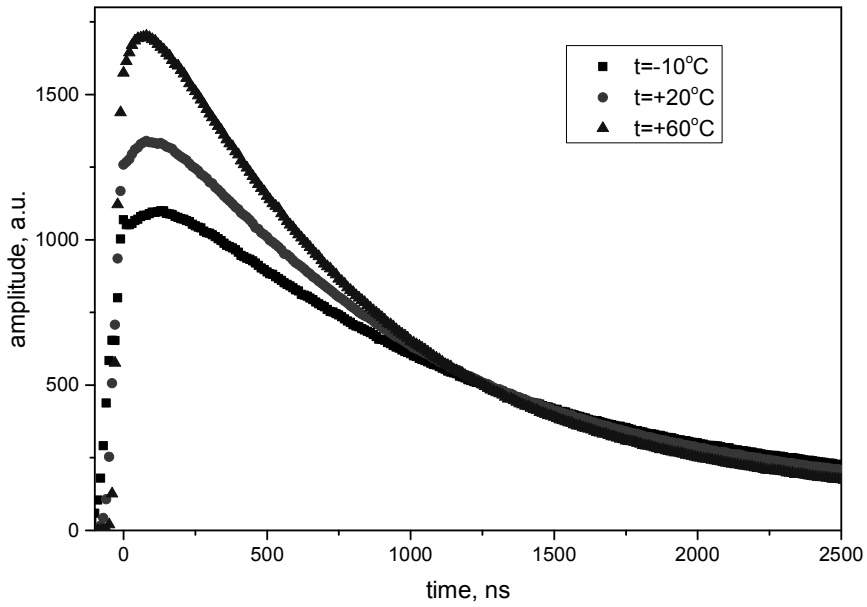

Figure 8. Signals from beta-particles produced by crystal under different temperatures.

References

[1] Ляпидевский В.К., Сцинтилляционный метод детектирования излучений, М.: Изд. МИФИ, 1981

[2] 197. Хрячков В.А., Дунаев М.В., Кетлеров В.В., Семенова Н.Н., Тараско М.З. Новый метод разделения заряженных частиц с использованием кристаллов CsI(Tl). ПТЭ, 2000, №3, с.29-37.

[3] V.A.Khryachkov, M.V.Dunaev, V.V.Ketlerov, N.N.Semenova, M.Z.Tarasko. Investigation of the CsI(Tl) Scintillator Properties for Registration Low-Energy Charge Particles. Proceeding International Workshop Nuclear Fission Physics, Obninsk 2000, pp.158-163.

[4] J .D . Valentine, V.T. Jordanov, D.K . Wehe and G.F., Knoll, Nucl . Instr. and Meth. A314 (1992) 119

[5] J .D . Valentine William W. Moses b , Stephen E. Derenzo, Wehe and G.F .Knoll, A325 (1993) 147-157

[6] А.М.Кудин, А.А.Ананенко, Ю.Т.Выдай, В.Ю.Гресь, Б.Г.Заславский, Д.И.Зосим, Сцинтилляционный отклик кристаллов CsI(Tl) и CsI(Na) на возбуждение рентгеновскими и гамма-квантами низких энергий, НТК «Институт монокристаллов» НАН Украины