Separation of signals from neutrons and gamma quanta by the method of normalized signals

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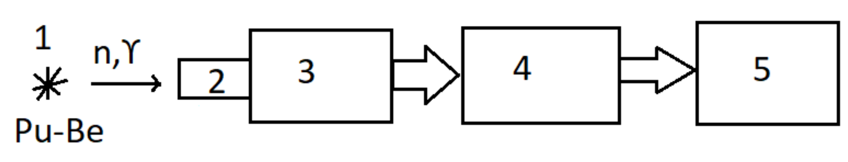
Detectors based on organic scintillators are widely used in the tasks when fast neutrons in the presence of gamma radiation are necessary to detect. Such tasks are control of spent nuclear fuel, measurement of the yield of fast neutrons from neutron generators, monitoring of neutron and gamma background in underground low-background experiments (neutrino and dark matter detectors), and environmental monitoring.

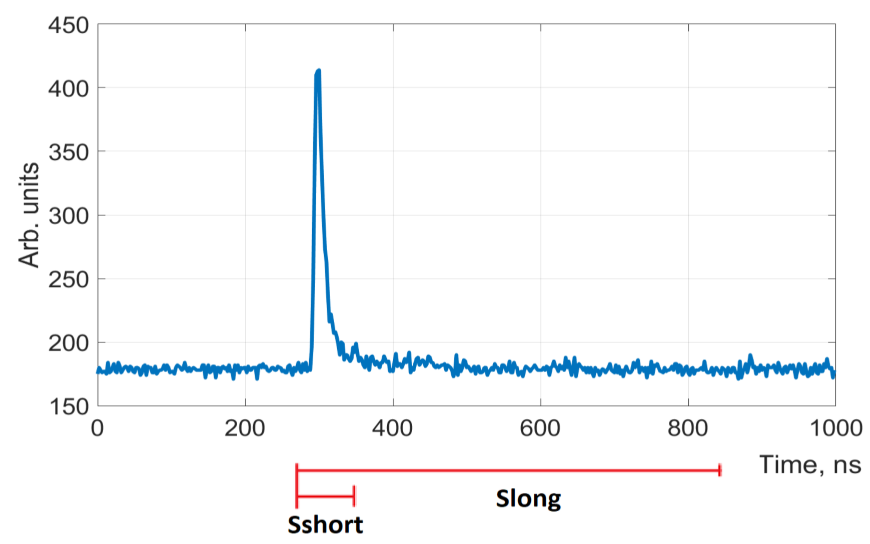
Analysis of the pulse shape of a scintillation detector with an organic crystal makes it possible to separate signals from neutrons and gamma quanta.

We investigated a new method that increases the efficiency of discrimination of signals from neutrons and gamma rays.

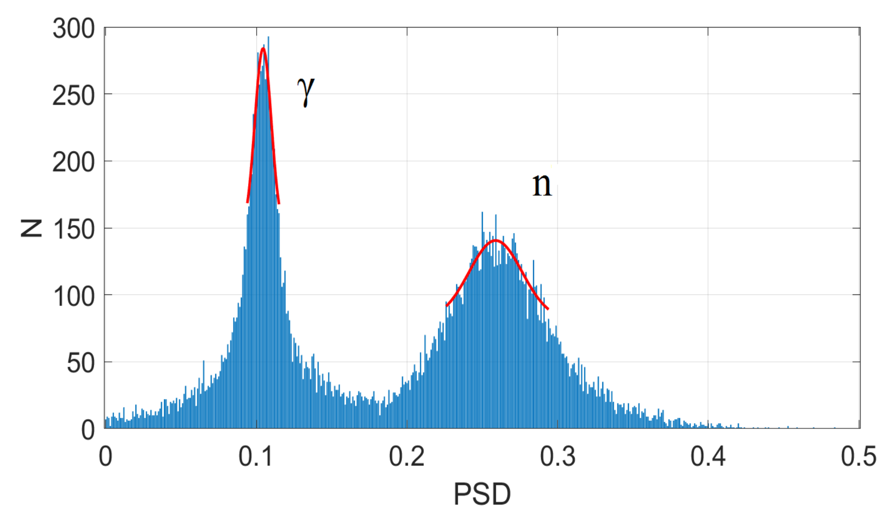
Usually, the Pulse Shape Discrimination (PSD) histogram method is used to discriminate signals from neutrons and gamma quanta



Experimental setup:
1 – Pu-Be neutron source,
2 – p-terphenyl crystal,
3 – PMT R6094,
4 – digitizer DT5730 (14 bits, 500 MHz),
5 – personal computer



Waveform with short and long gates



PSD histogram FOM=1.62±0.07

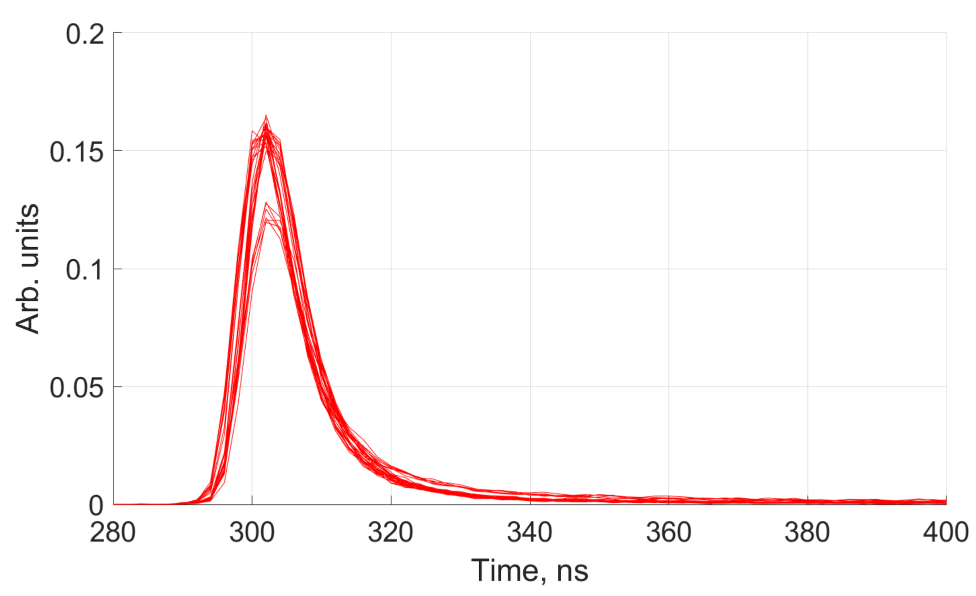
$$\mathrm{PSD} = \frac{S_{long} - S_{short}}{S_{long}}$$

The criterion for the separation of signals:

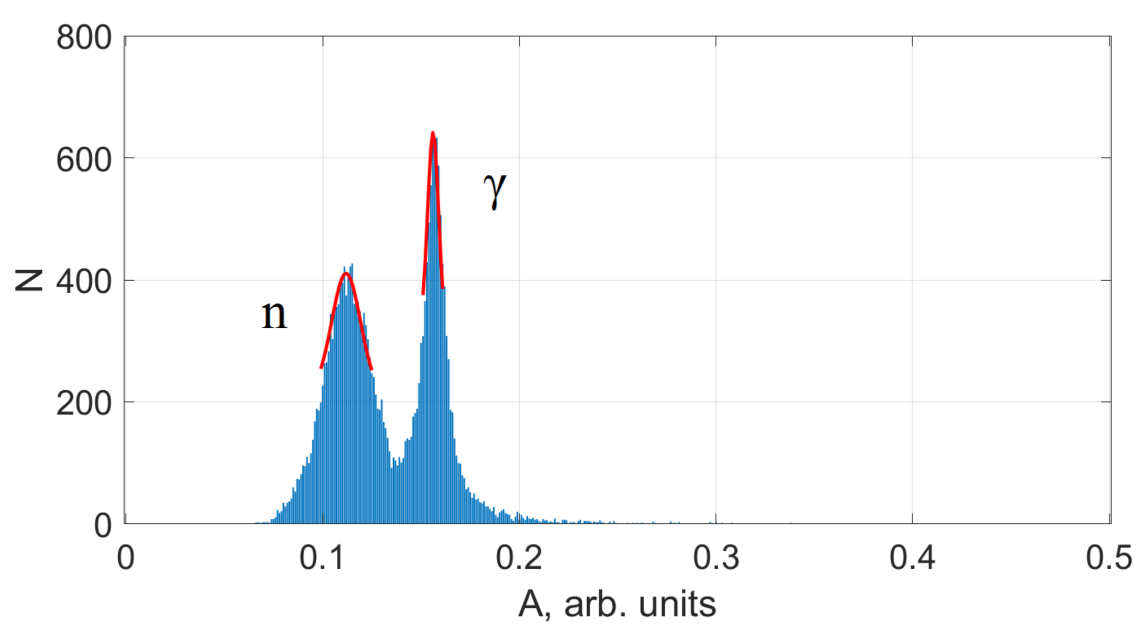
$$\mathrm{FOM} = \frac{\max_2 - \max_1}{\mathrm{FWHM}_1 + \mathrm{FWHM}_2}$$

We fitted the top of each peak corresponding for neutrons and gammas quanta with a Gaussian curves

We propose a new method of signal discrimination – the method of normalized signals. In the new method, each pulse acquired from the scintillation detector is normalized to the area of this pulse.

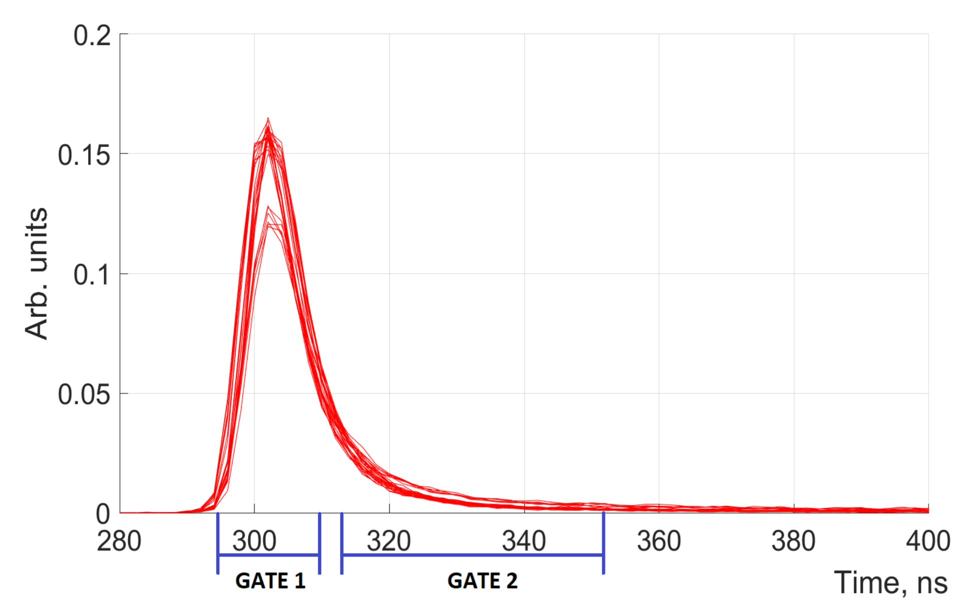


Oscillogram of a group of normalized signals



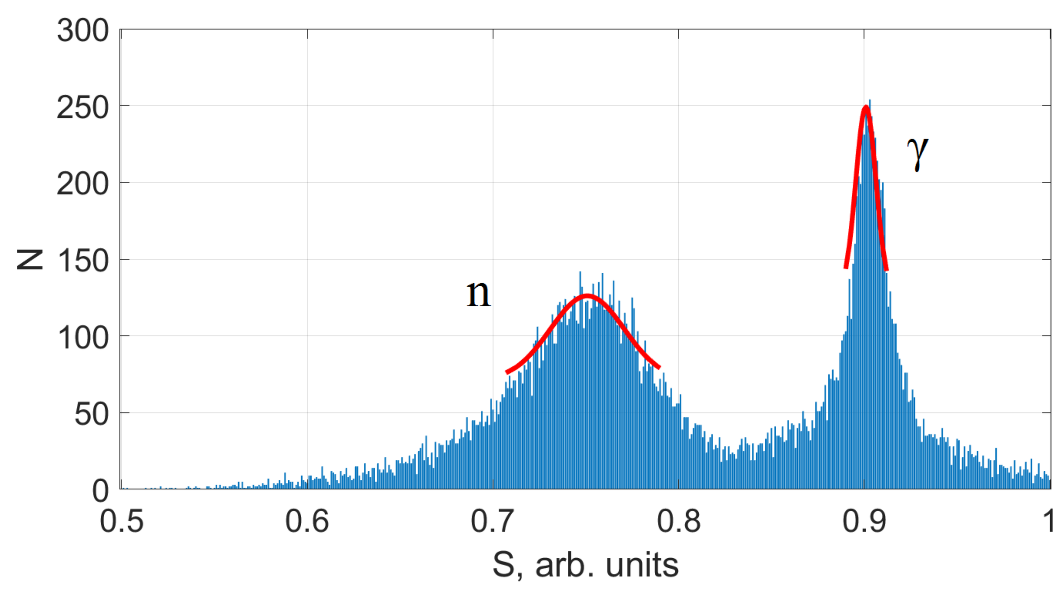
Histogram of amplitudes of normalized signals

FOM=1.13±0.04



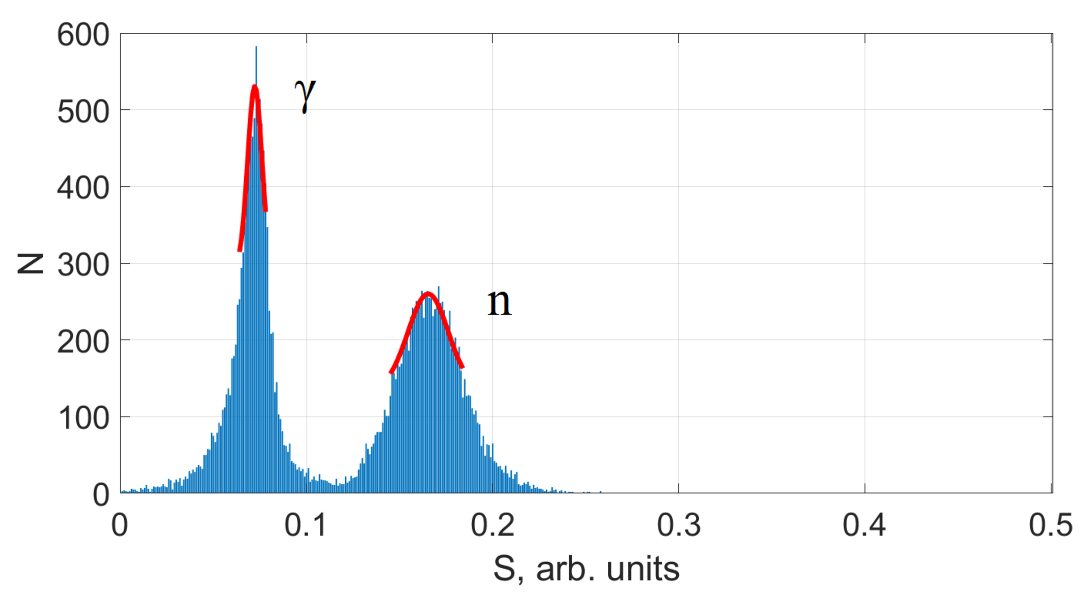
Normalized signals oscillogram with Gate 1 and Gate 2

Three variants of the new method using histograms of signal areas at Gate 1 and Gate 2



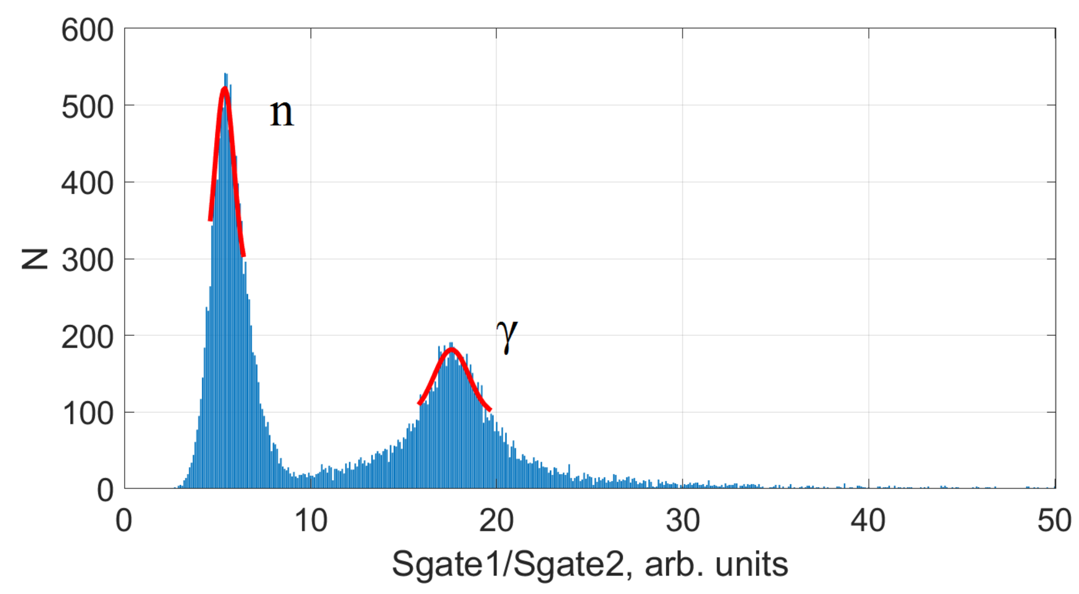
Histogram of a areas of signals at Gate 1

FOM=1.57±0.07



Histogram of a areas of signals at Gate 2

FOM=1.71±0.10



Sgate1 / Sgate2 ratio histogram

FOM=2.12±0.10

The value of FOM = 2.1 was obtained in our new method for the scintillation detector with the p-terphenyl crystal.

The method of normalized signals is used to register fast neutrons in an installation for the development of a compact neutron generator.
A small-sized monochromatic neutron generator is required to calibrate low-background detectors of neutrinos and dark matter particles.

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