Identification of neutrons and gamma rays using a combination of three algorithms for separating signals of the scintillation detector

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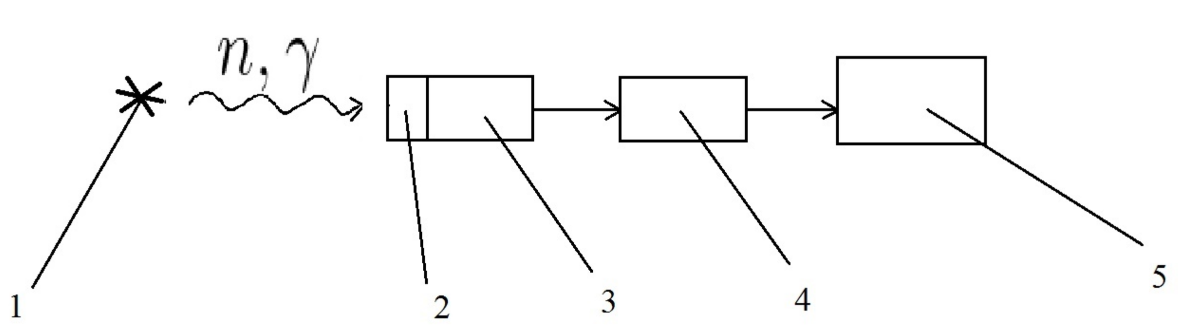
Scintillation detectors with organic scintillators are widely used for fast neutrons detection in high gamma ray background. Traditionally, the Pulse Shape Discrimination (PSD) histogram is used to determine the number of detected neutrons. A typical PSD histogram contains two peaks corresponding to neutrons and gamma rays that overlap in the region between the peaks. With this approach, it is impossible to identify each individual signal in the area between the peaks.

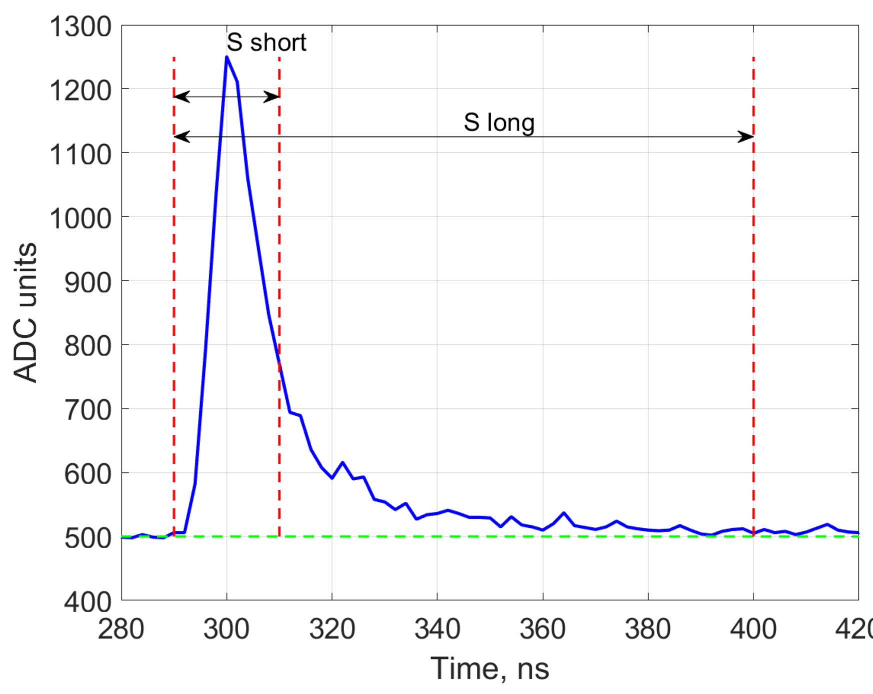
We have proposed a new method for the identification of neutrons and gamma quanta, which includes a combination of three signal separation algorithms: the traditional histogram PSD, the dependence of the area of signals on their amplitude, Tau histogram (tau means the fall constant of the detector pulses).

To test a new method for identifying neutrons and gamma quanta, we used a Pu-Be neutron source, a scintillation detector with a p-terphenyl crystal and a CAEN DT5730 Digitizer (14 bit, 500 MHz). When a scintillation detector registered neutrons from a Pu-Be source, the signal identification coefficient was 91.6%.

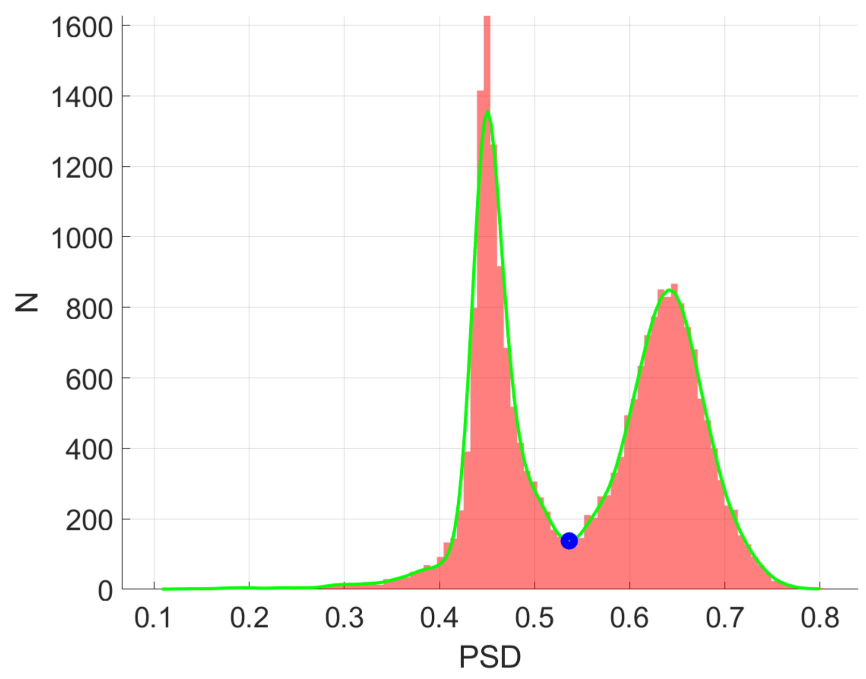
A new method for identifying signals from a scintillation detector is used to register neutrons at the light ion accelerator.



The experimental setup: 1 - Pu-Be neutron source, 2 - p-terphenyl crystal, 3 – PMT R6094, 4 – digitizer DT5730, 5 – personal computer



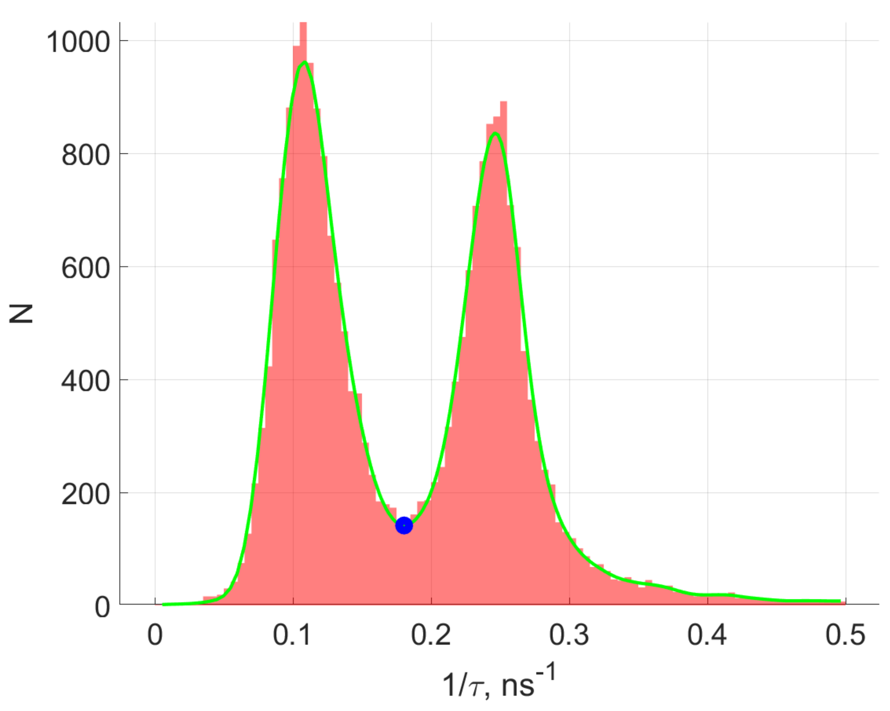
Typical pulse oscillogram with shown short and long gate parameters



PSD histogram with spline approximation of the two peaks and "separation point"

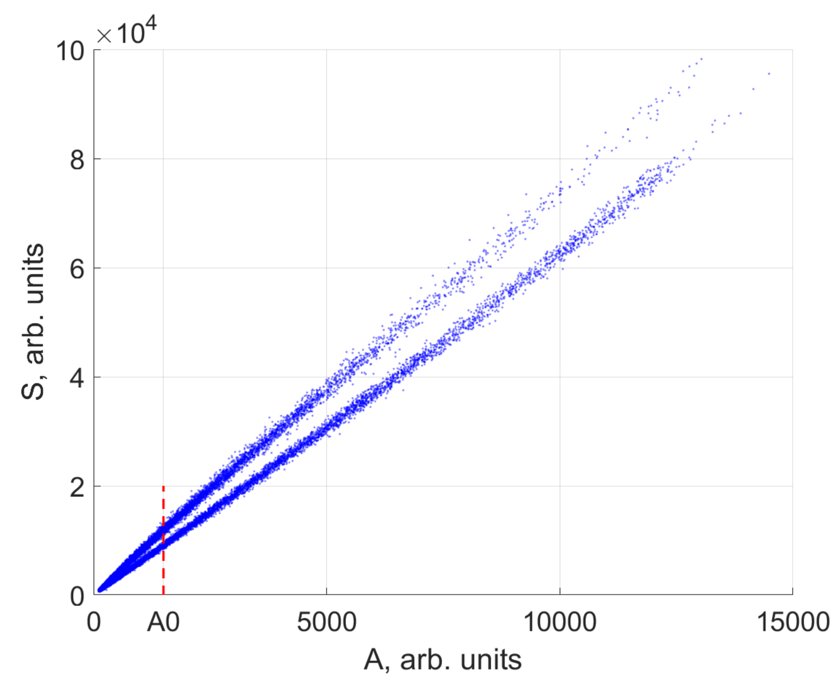
The first algorithm of the discrimination of neutrons and gamma quanta is used PSD (Pulse Shape Discrimination) histogram method.

PSD=(Slong-Sshort)/Slong

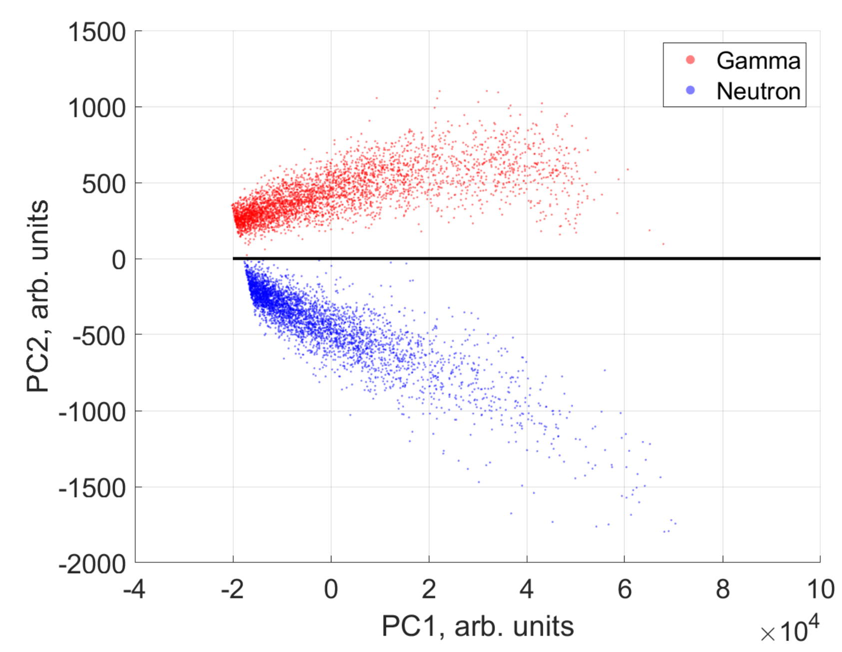


1/τ histogram with spline approximation of the two peaks and "separation point"

The second algorithm (TAU) is based on the analysis of the falling age of each pulse. The falling edge of each pulse is fitted by an exponential function a*exp (-t/τ) where τ is the signal decay constant.

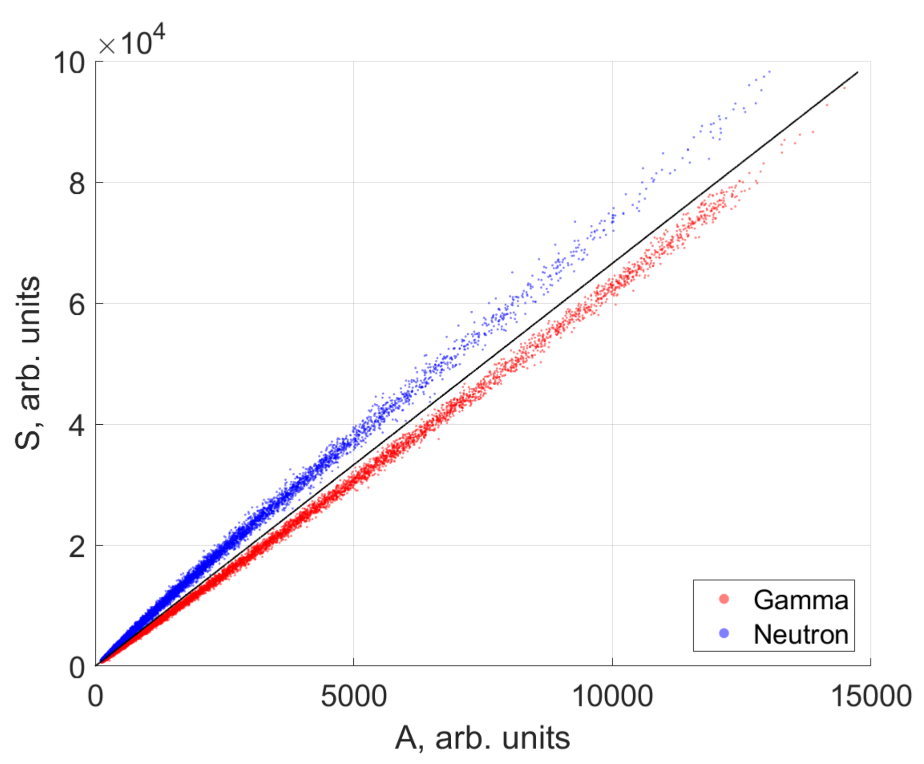


Signal area (S) versus its amplitude (A)

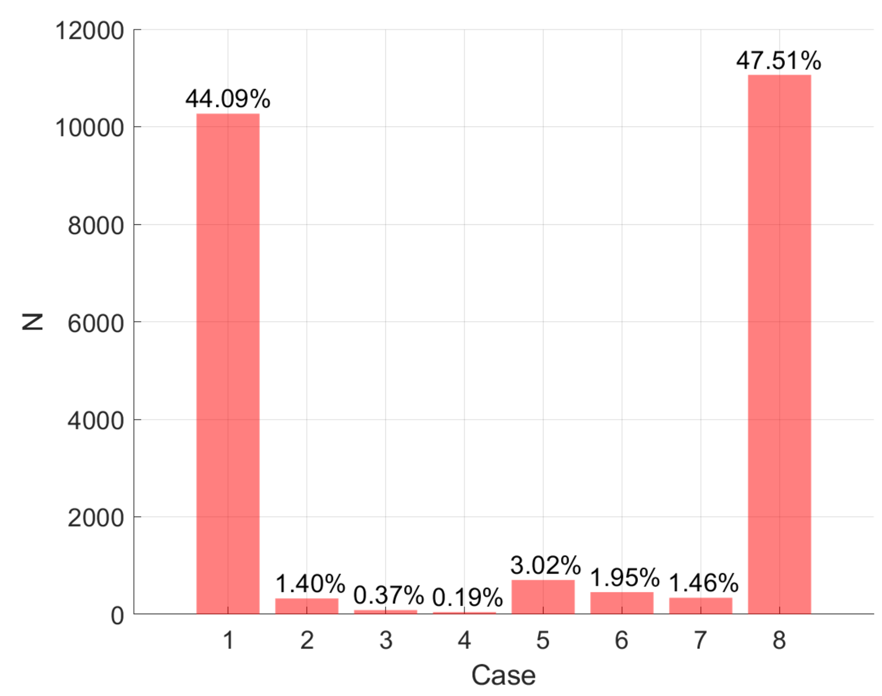


A set of signals in the coordinates of the principal component

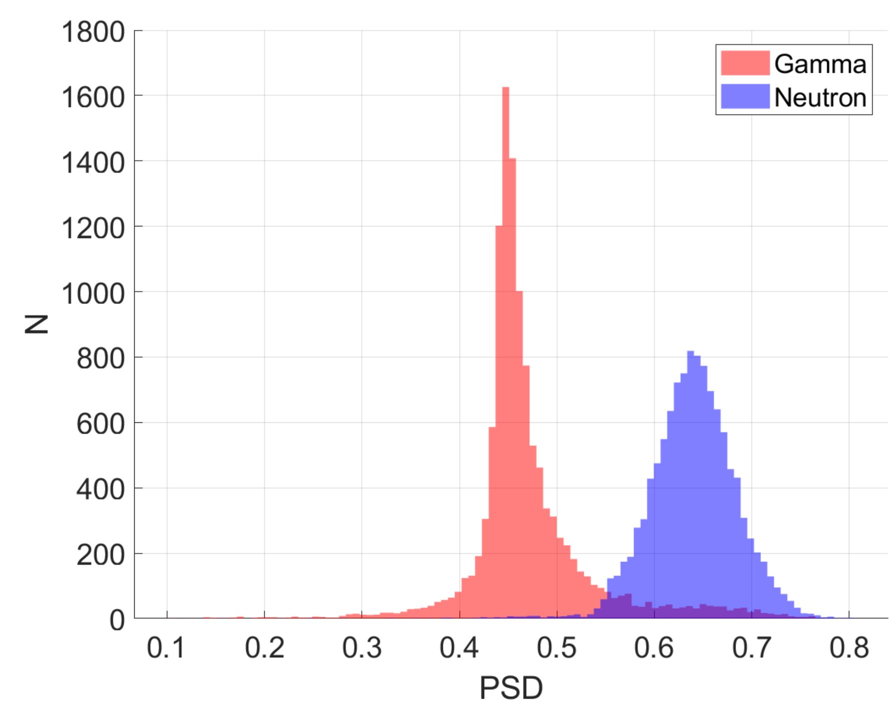
In the third algorithm, signal discrimination is performed by using Principal Component Analysis (PCA)



Dependence of the signal area on the amplitude with a dividing line



The result of a combination of three signal separation algorithms



Divided events on the PSD histogram

PSD - γ PCA - γ TAU - γ	PSD - γ PCA - γ TAU - N	PSD - γ PCA - N TAU - γ	PSD - γ PCA - N TAU - N	PSD - N PCA - γ TAU - γ	PSD - N PCA - γ TAU - N	PSD - N PCA - N TAU - γ	PSD - N PCA - N TAU - N
44.09	**1.40**	**0.37**	**0.19**	**3.02**	**1.95**	**1.46**	**47.51**

The top line of Table shows 8 possible combinations of signal identification results. The bottom line contains the relative number of all signals (in percent) corresponding to this combination of the application of the three algorithms.

Table shows that three independent algorithms indicate the same particle type for 47.51+44.09=91.6% of the detected signals.