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Tools for Discovery

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HANDBOOK OF EXPERIMENTS

SG6112A Advanced Statistics based on Silicon Photomultiplier Detectors

Poisson and Gaussian Distribution

Nuclear Physics and Radioactivity

EDUCATIONAL KIT

SP5600C

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Poisson and Gaussian Distribution

Categories: CAEN Experiments, Nuclear Physics and Radioactivity | Tags: Gaussian distribution, Nuclear Physics, Poisson distribution, Statistics

Difficult	Execution Time	Data Analysis	Radioactive Sources
		Yes	Yes

Hardware setup

This experiment guide is referred to the **SP5600C** educational kit. If you don't have this kit, choose your own from the following list to visualize the related experiment guide: SG6112B, SG6112C, SG6112E – Educational Kit

Equipment: SP5600C – Educational Gamma Kit

Model	SP5600	DT5720A	A315	SP5606	SP5607	Additional Tool
Description	Power Supply and Amplification Unit	Desktop Digitizer 250 MS/s	Splitter	Mini Spectrometer	Absorption Tool	Gamma Radioactive Source

Purpose of the experiment

Study the statistical distribution of the counting rates of a gamma radioactive source. Comparison of the data to the Poisson distribution, turning into a Gaussian as the mean number of counts grows.

Fundamentals

The number of radioactive particles detected over a time Δt is expected to follow a Poisson distribution with mean value μ. It means that for a given radioactive source, the probability that n decays will occur over a given time period Δt is given by:

$$P_\mu(n) = (\mu^n / n!)\, e^{-\mu}$$

Where μ is proportional to the sample size and to the time Δt and inversely proportional to the half-life $T_{1/2}$ of the unstable nucleus. As long as μ grows, the probability $P_\mu(n)$ is well approximated by a Gaussian distribution:

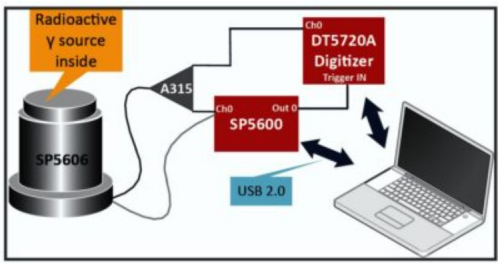
$$P(n) = (1 / \sqrt{(2\pi\sigma)})\, e^{-(n-\mu)^2 / (2\sigma^2)}$$

Where $\sigma = \sqrt{\mu}$ is the standard deviation.

Requirements

Gamma Radioactive Source.

Carrying out the experiment

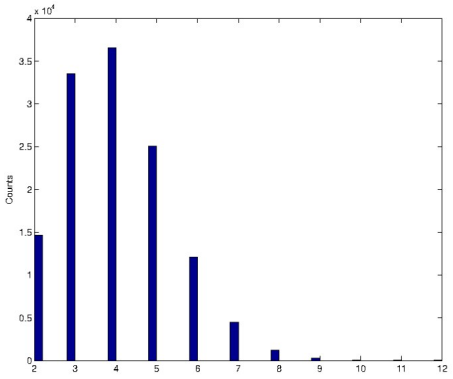


Block diagram of the experimental setup that makes us of the “Educational Gamma Kit”

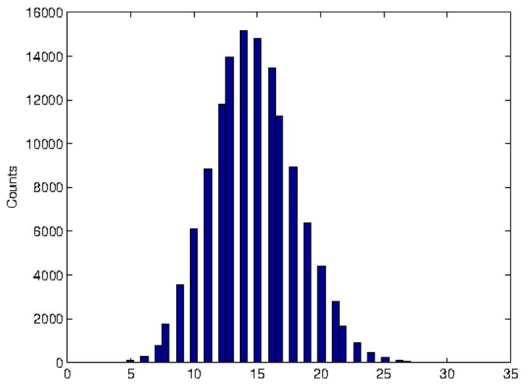
The selected scintillator crystal shall be coupled to the SiPM in the SP5607, through a thin layer of index matching grease to maximize the light collection. In order to avoid saturation, the output of the SiPM is divided using the A315 splitter: one branch is connected to the DT5720A and will be digitized. The other branch will be amplified by the SP5600 module, generating the trigger for the integration signal by the on-board leading edge discriminator or simply counting the pulses induced by the detected gamma ray. The discriminator threshold shall be defined looking at the spectrum and evaluating the dark count rate. Once this is properly set, the counting experiment shall be performed.

Results

Changing the counting window and/or the activity of the source or the threshold, the number of counts changes, with a probability density function moving form a Poissonian to a Gaussian shape. The student may play with the data, fitting them and comparing the expectations to the measurement.



Poissonian distribution



Gaussian distribution

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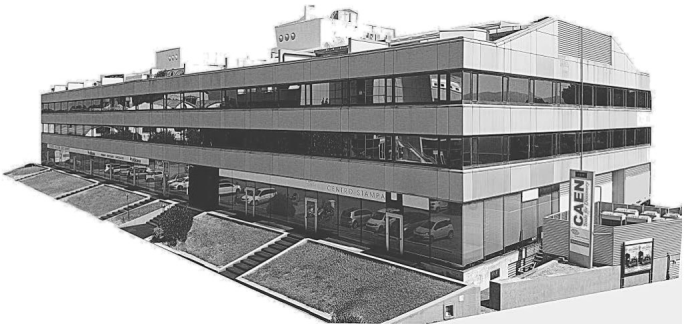

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