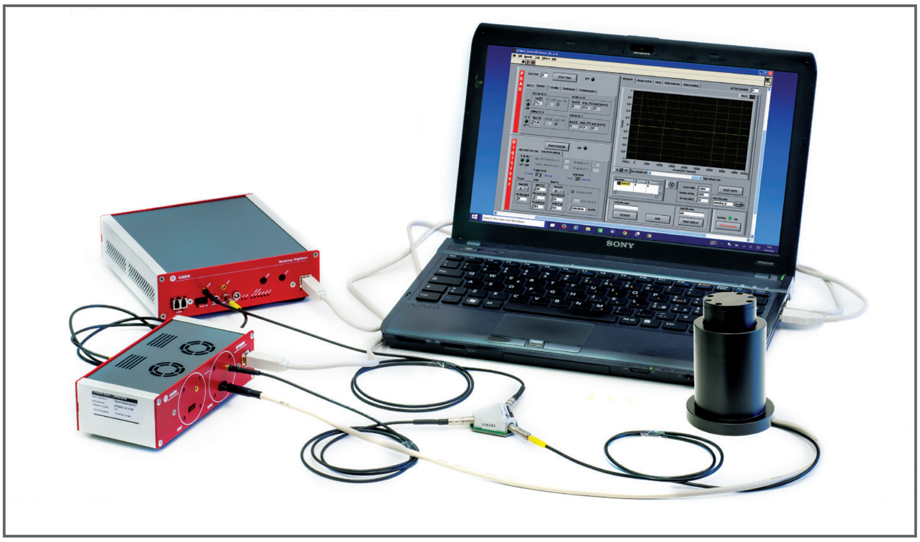
SG6112 Poisson and Gaussian Distribution



Ordering Options

Equipment A	
Code	**Description**
WK5600XCAAAA	SP5600C - Educational Gamma Kit
or the all inclusive Premium Version	
WK5600XANAAA	SP5600AN - Educational Kit - Premium Version

Equipment B	
Code	**Description**
WK5600XEMUAA	SP5600EMU - Emulation Kit

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. The study can be performed both experimentally, with the SiPM kit or simulating it with the emulation kit.

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:

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

Where μ is proportional to the sample size and to the time Δt and inversely proportional to the half-life T1/2 of the unstable nucleus. As long as μ grows, the probability P μ (n) is well approximated by a Gaussian distribution:

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

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

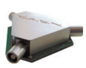
The experiment can be performed by using to different set-ups:

In the English-language literature the t-distribution takes its name from William Sealy Gosset's 1908 paper in Biometrika under the pseudonym "Student ". Gosset worked at the Guinness Brewery in Dublin, Ireland, and was interested in the problems of small samples – for example the chemical properties of barley where sample sizes might be as few as 3. One version of the origin of the pseudonym is that Gosset's employer preferred staff to use pen names when publishing scientific papers instead of their real name, so he used the name "Student " to hide his identity. Another version is that Guinness did not want their competitors to know that they were using the t-test to determine the quality of raw material. Gosset's paper refers to the distribution as the "frequency distribution of standard deviations of samples drawn from a normal population". It became well-known through the work of Ronald Fisher, who called the distribution "Student's distribution" and represented the test value with the letter t.

https://en.wikipedia.org/wiki/Student's_t-distribution

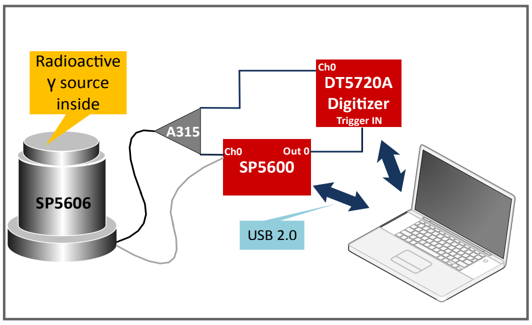
EQUIPMENT A

SP5600C - Educational Gamma Kit

Model	SP5600	SP5606	A315	DT5720A	SP5607
Description	Power Supply and Amplification Unit	Mini-Spectrometer	Splitter	Desktop Digitizer 250MS/s	Absorption tool
					

Requirements

Gamma Radioactive Source

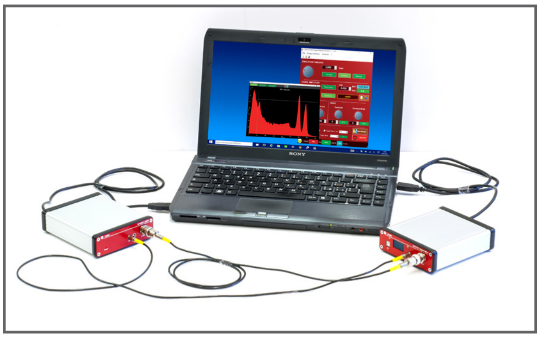


Block diagram of the experimental setup that makes use of the "Educational Gamma Kit" .

Carrying out the experiment

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.

EQUIPMENT B

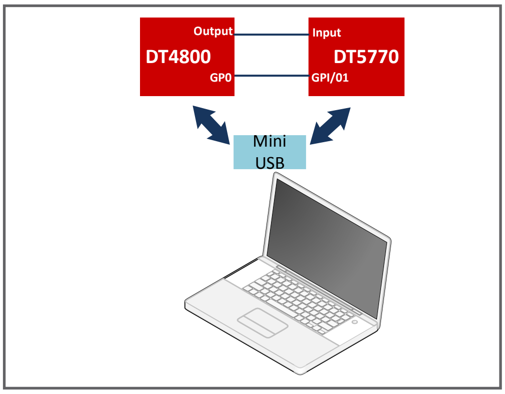


SP5600EMU - Emulation Kit

Model	DT4800	DT5770
Description	Digital Detector Emulator 	Desktop Multi-Channel Analyzer 

Requirements

Gamma Radioactive Source is not needed



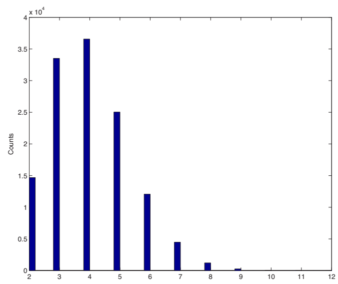
Block diagram of the experimental setup that makes use of the "Emulation Kit" .

Carrying out the experiment

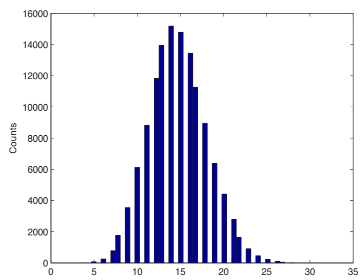
To perform the experiment connect the DT4800 output to the input channel of the MCA DT5770 and use the DT4800 GP0 as digitizer "trigger IN". The DT4800 Control Software Interface allows to generate exponential decay signals with programmable rise time and fall time and it is possible to emulate signals from a real energy spectrum linked to a radioactive source with variable activity.

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.