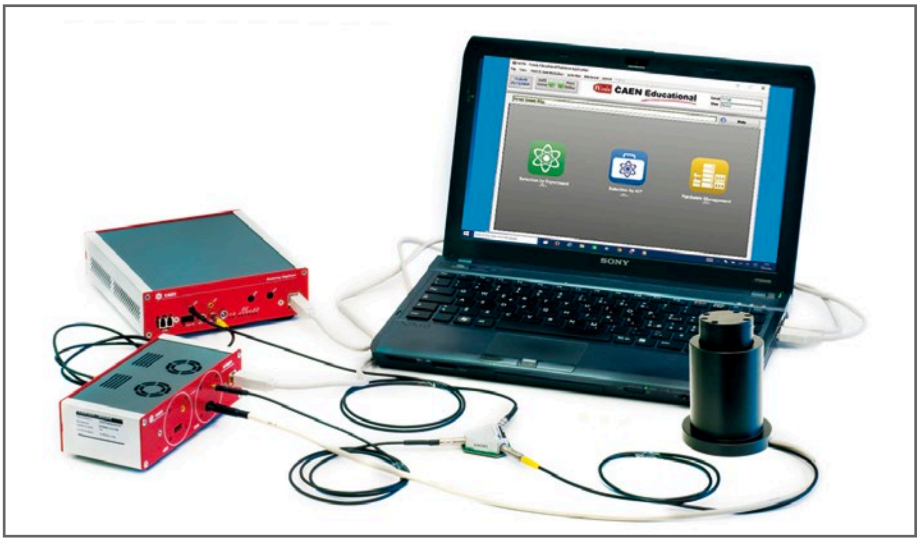
B.1.1 Detecting γ-Radiation

SG6111



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**
WK5640XAAAAA	SP5640 - GammaEDU

Equipment C	
Code	**Description**
WK5630ENAAAA	SP5630EN - Environmental Kit
or the Kit Plus	
WK5630XENAAA	SP5630ENP - Environmental Kit Plus

Purpose of the experiment

Gamma radioactivity detection by using a system composed of a scintillating crystal coupled to a photon detector.

Fundamentals

Gamma rays interact with matter by three processes: Compton Scattering, Photoelectric Effect and Pair Production (whenever the energy exceeds the 1.022 MeV threshold corresponding to the e^+e^- rest mass). The cross section of each process depends on the energy of the gamma ray.

The Compton Effect is the inelastic scattering between the incoming photon and an atomic electron. In the Photoelectric Effect, the incident gamma ray transfers all of its energy to a bound electron which acquires a kinetic energy equal to the incoming gamma energy decreased by the binding energy.

These processes convert, totally or partially, the gamma ray energy into kinetic energy of electrons (or positrons, in case of pair production). The interaction of the charged particles with the atomic and molecular systems of the medium results in excited states whose decay, possibly mediated, leads to light in the visible or UV region, eventually detected by the light sensor. A wide range of scintillator products is available today, differing for the light yield, the material properties, the time characteristics of the scintillation light and, last but not least, cost. The choice of the scintillator is essentially dependent on the specific targeted application.

Marie Skłodowska Curie was a Polish and naturalized-French physicist and chemist who conducted pioneering research on radioactivity. She was the first woman to win a Nobel Prize, the first person and only woman to win twice in multiple sciences. Together with her husband, she was awarded half of the Nobel Prize for Physics in 1903, for their study into the spontaneous radiation discovered by Becquerel, who was awarded the other half of the Prize. In 1911 she received a second Nobel Prize, this time in Chemistry, in recognition of her work in radioactivity. Radium discovery opened the door to deep changes in the way scientists think about matter and energy. She also led the way to a new era for medical knowledge and the treatment of diseases.

https://www.aip.org/history/exhibits/curie/brief/index.html

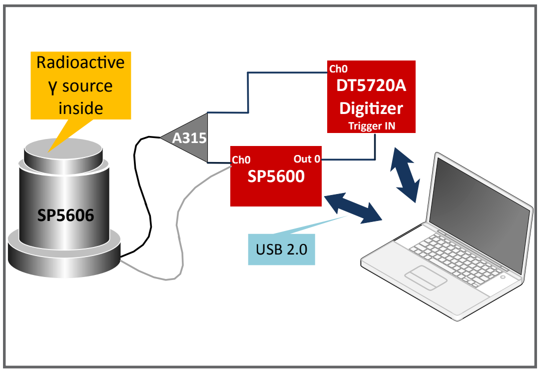
Equipment

SP5600C - Educational Gamma Kit

Model	SP5600	SP5606	A315	DT5720A	SP5607
Description	Power Supply and Amplification Unit 	Mini-Spectrometer 	Splitter 	Desktop Digitizer 250 MS/s 	Absorption tool 
	p. 145	p. 147	p. 147	p. 145	p. 148

Requirements

Gamma Radioactive Source



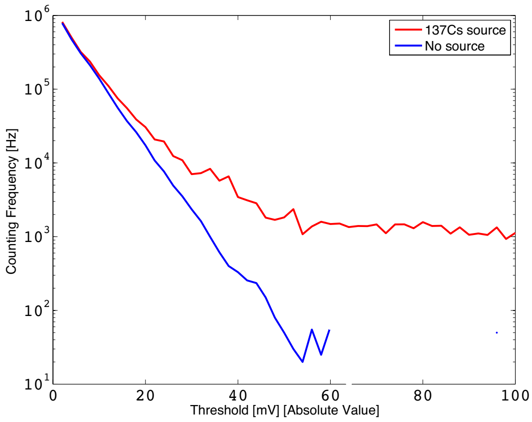
Experimental setup block diagram.

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

Results

The student may get acquainted with the presence of radioactivity with a simple preliminary measurement, namely comparing the counting frequency as a function of the discriminator threshold with/without the source. Presuming the source, essentially in contact to the crystal, to be point like with respect to the crystal surface, and assuming its activity is known, the student may estimate for every threshold value the detection efficiency and the signal over noise ratio, building up an efficiency-purity plot. Exemplary results obtained with a ^{137}Cs source are shown. Moving away the source from the crystal, the law governing the variation of the flux can also be investigated.



Sensor output frequency as a function of the threshold in mV, with and without ^{137}Cs source.