SG6132 Positron Annihilation Detection

Ordering Options

Equipment	
Code	**Description**
WSP5700XAAAA	SP5700 – EasyPET
WDT5720AXAAA	DT5720A - 2 Ch. 12 bit 250 MS/s Digitizer: 1.25MS/ch, C4, SE
WDT5770AXAAA	DT5770 – Digital MCA - 1 LVPS ±12V/100mA ±24V/50mA

Purpose of the experiment

Positron annihilation detection by using a couple of detectors composed of a LYSO scintillating crystal coupled to a Silicon Photomultiplier (SiPM).

Fundamentals

The underlying principle to PET systems is the detection of high energy radiation emitted from a chemical marker, a molecule labelled with a radioisotope, administered to a patient. The marker is properly chosen in order to associate to molecules involved in biochemical or metabolic processes under investigation. This allows studying the function of a particular organ or evaluating the presence of disease, revealed by the excessive concentration of the marker in specific locations of the body. The radioisotope emits positrons which, after annihilating with atomic electrons, result in the isotropic emission of two photons back to back with an energy of 511 keV. The two photons are detected by a ring of detectors, which allows a pair of them to detect two back to back photons in any direction.

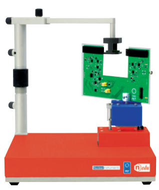
EasyPET comprehends only two detector modules that move together and execute two types of independent movements, around two rotation axes, so as to cover a field of view similar to that of a complete ring of detectors. A fast electronic readout system allows detecting coincident events resulting from the same decay process.

Positron emission tomography (PET) is a test that uses a special type of camera and a tracer (radioactive chemical) to look at organs in the body. The tracer usually is a special form of a substance (such as glucose) that collects in cells that are using a lot of energy, such as cancer cells. During the test, the tracer liquid is put into a vein (intravenous, or IV) in your arm. The tracer moves through your body, where much of it collects in the specific organ or tissue. The tracer gives off tiny positively charged particles (positrons). The camera records the positrons and turns the recording into pictures on a computer. PET scan pictures do not show as much detail as computed tomography (CT) scans or magnetic resonance imaging (MRI) because the pictures show only the location of the tracer. The PET picture may be matched with those from a CT scan to get more detailed information about where the tracer is located. A PET scan is often used to evaluate cancer, check blood flow, or see how organs are working.

http://www.webmd.com/cancer/lymphoma/positron-emission-tomography

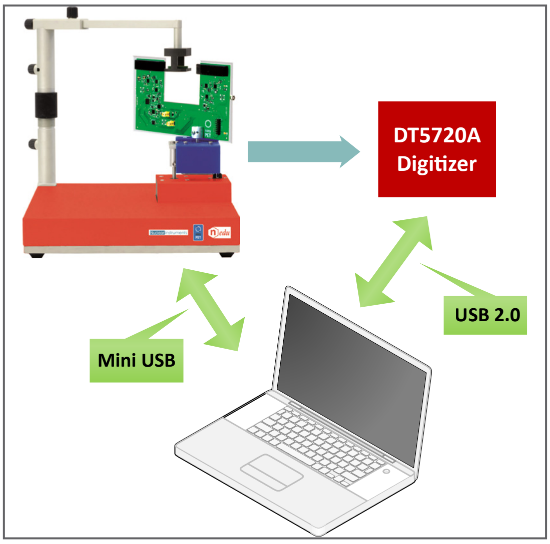
Equipment

SP5700 - EasyPET

Model	SP5700	DT5720A		DT5770
Description	EasyPET 	Desktop Digitizer 250MS/s 	OR	Desktop Multi-Channel Analyzer 

Requirements

^{22}Na Radioactive source (recommended: 1/2 inch disc, 10 μCi)



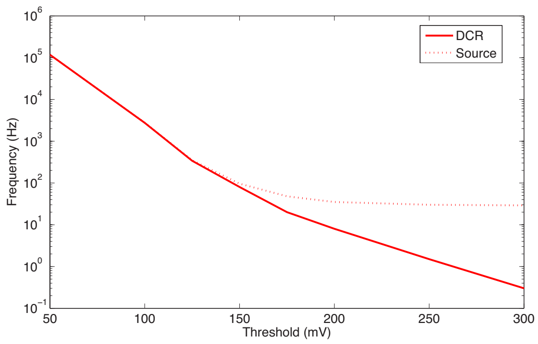
Experimental setup block diagram.

Carrying out the experiment

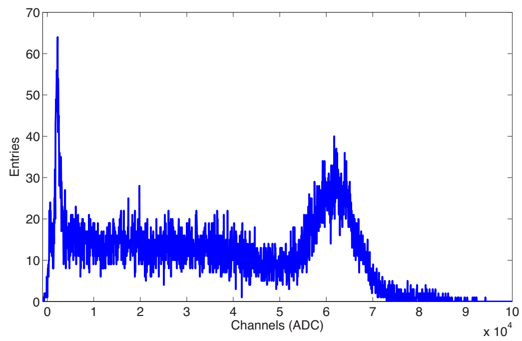
Mount the arm of the source holder on the column fixed on the system base, fix the U–shaped board to the top stepper motor and connect the flat cable to the U-shaped board and to control unit. Connect to PC and power ON the system. Connect the analog output of one detector to channel input of the DT5720A and use as digitizer "trigger IN" the coincidence output characterized by the occurring of the comparator output of each detector within a time window. Place the source holder between the two detectors and measure the DCR frequency as a function of the threshold. Place the ^{22}Na radioactive source in the holder and repeat the measurement. Chose a threshold and acquire the coincidence spectrum thanks to a digitizer that perform charge integration by processing the signals exceeding a fixed threshold..

Results

The coincidence detection allows to reduce significantly the system noise due to the SiPM DCR. In the optimization of the acquisition conditions, the coincidence detection introduces the parameter of the time window width in addition to the bias voltage and the threshold. In order to find the best parameter values is necessary to analyse the response of the system in coincidence mode to the radioactive source with respect to the random events, at fixed operating voltage. The simple geometry of the system with only two opposite and aligned detectors and the implementation of the coincidence detection ensures that, in the energy distribution, the Compton scattering occurring in one or even in both scintillating crystals comes from the same annihilation event.



Coincidence frequency, with and without ^{22}Na source, as a function of the threshold.



Coincidence spectrum of ^{22}Na radioactive source.