Lab #3B:
Scintillator Detectors coupled to Digital readout electronics

The aim of this lab-work is to familiarize the student with the assembling of a scintillator detector from its basic parts, i.e. to couple the scintillator crystal to a photomultiplier tube and to a voltage divider (base). In continuation, adapt the specific parameters of a digital readout electronics for a correct measurment. Finally, to measure the response to different standard gamma sources and analyze the data obtained.

Introduction

The analogue readout electronic system used in LAB3A, Fig. 1, is composed of a charge integrating preamplifier (PA) and a shaping amplifier (A). The signal from the detector is a quantity of charge delivered as a current pulse lasting from 10–9 to 10–5 s, depending on the type of detector and its size. For most applications the parameters of interest are the quantity of charge.

The charge in the photomultiplier output pulse is integrated on the input capacitance of the preamplifier to produce a voltage pulse. A non-inverting voltage amplifier (gain ≈ 1) drives this pulse into the output load. The Amplifier shapes the signal by passing it through low and high pass filters, and amplify the signal from mV to the 0-10 V range in such a way that the amplitude of the output signal is proportional to the original input signal (i.e. proportional to the charge deposited by the particle or gamma quanta in the detector)

Finally, the MCA converts the amplitude of the signal into a binary number related to the energy deposited in the detector and displays the data on the PC as an histogam. Using standard calibration sources the channel number (i.e. the binary number) of the histogram can be related to an equivalent energy.

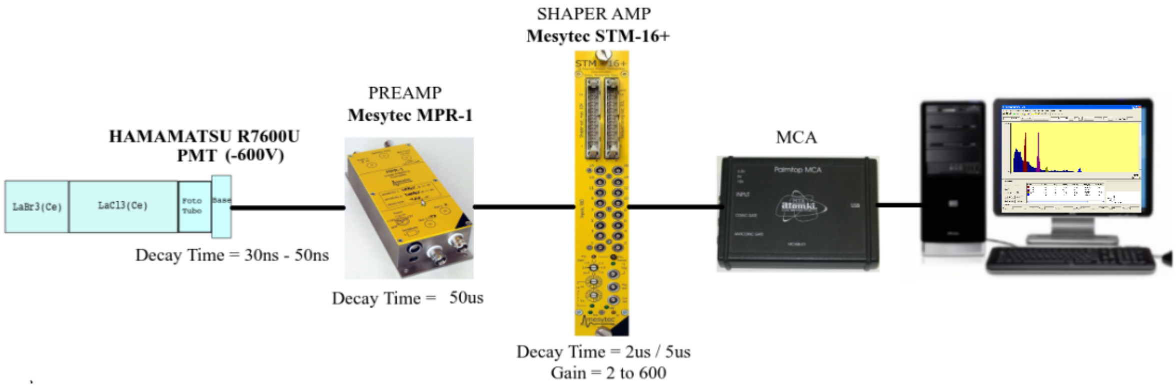

Figure 1. Analog Readout Electronic System.

In part B of this lab practice we will instead use the digital readout electronic system sketched in Fig. 2. This is based on a digitizer and a computer for calculating the energy histogram of the gamma particles detected in the phoswich. In this case we use a Metalpackage and very compact PM-tube, which gain is much higher and thus we do not need to use any PA or A as was used in practice 2.A, instead we can analyze and digitize the output pulse directly.

The digitizer is an electronic module which is responsible for sampling and digitizing the voltage signal coming from the PMT, for each detected quanta. The digital values of the samples are transmitted via USB or optical fiber to a PC, where a "Digital Pulse Processing - Pulse Shape Discriminator" (DPP-PSD) software is installed in order to receive the data and sum the values of the samples for each detected particle, to obtain the integral of the signal (charge/energy), as a Riemann sum.

Figure 2. Digital Readout Electronic System.

Aims

Make the students familiar with the set-up of a digital readout electronic system for scintillator detectors and the parameters and characteristics of a digitizer. For this reason, a high gain PMT is used.

The data obtained from the energy deposition of gamma radiation and intrinsic radiation of the pyramid phoswich scintillator will be analyzed with a digitizer (Caen DT5730) and a PC (Caen DPP-PSD software installed). The PMT output signal will be studied (voltage output, 1D and 2D energy histograms) for different configuration parameters tuned with the software.

Bibliography

1. F.Knoll: "Radiation detection and measurement".
2. http://www.hamamatsu.com
3. http://www.detectors.saint-gobain.com/MaterialsGasTubes.aspx
4. http://www.iem.csic.es/departamentos/nuclear/fnexp/r3b/r3bindex.html
5. http://www.caen.it

Materials

The students can use the following tools:

1. Phoswich scintillator pyramid composed of $LaBr_3$(Ce) and $LaCl_3$(Ce) crystals.
2. Rectangular PhotoMultiplier Tube (Hamamatsu R7600U).
3. Base of the rectangular PhotoMultiplier Tube (Hamamatsu R7600U).
4. High voltage power supply (Caen N1471).
5. Digitizer (Caen DT5730).
6. USB Cable.
7. PC, Windows 7 O.S.
8. Caen DPP-PSD Software.
9. Gamma sources (^{137}Cs, ^{60}Co, ^{22}Na).

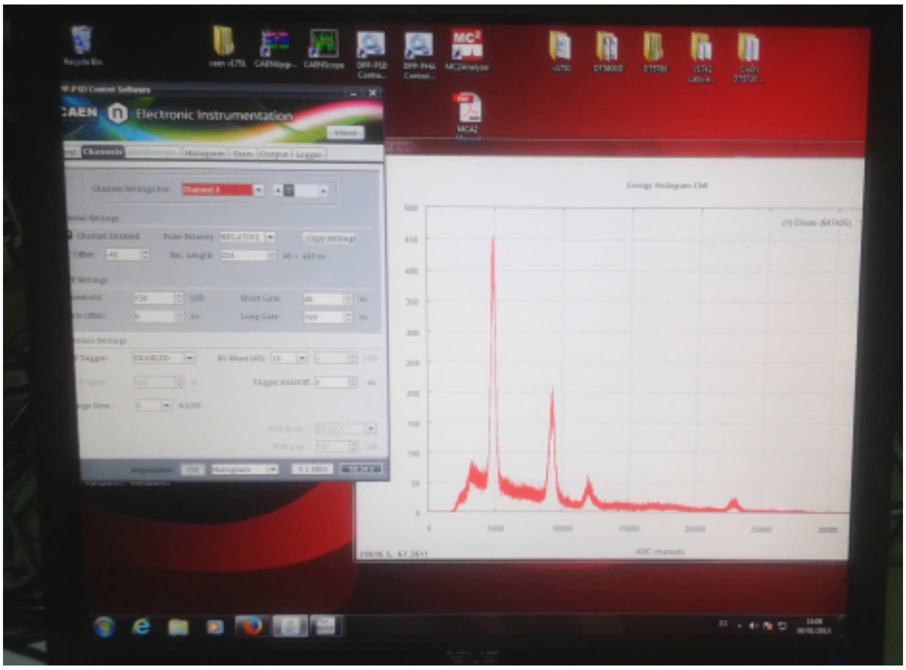

Figure 3. Caen DPP-PSD Software (Windows 7)

Methods

1. The main physical characteristics of the detectors and the electronics used will be determined (using internet, manuals, specifications, etc).

2. Draw a draft of the electronic set-up being used. Identify the main parameters of each module (voltage supply in the PMT, short & long gate in the digitizer, etc).

3. Tune the parameters of the acquisition in DPP-PSD software taking into account the PMT output voltage characteristics for each detected particle, in order to obtain the 1D and 2D histograms best results. Complete a table with the selected values of the next parameters: pulse polarity, DC offset, REC length, threshold, gate offset, short gate, long gate and Charge Sensibility.

4. In the case of our digitizer, within 14 bits and 2 Vpp input voltage range, ¿What is a "LSB"? Which voltage value corresponds to our LSB?

5. Obtain the 1D spectrum of a ^{137}Cs source with the digitizer and the pyramid phoswich. How many peaks can be seen? Explain the results. Characterize the signal obtained.

6. Obtain the 2D spectrum of a ^{137}Cs source with the digitizer and the pyramid phoswich. How many peaks can be seen? How many straight lines can we see? Why? Explain the results. Characterize the signal obtained.

7. Obtain the 1D spectrum of a ^{22}Na source with the digitizer and the pyramid phoswich. How many peaks can be seen? Explain the results. Characterize the signal obtained.

8. Obtain the 2D spectrum of a ^{22}Na source with the digitizer and the pyramid phoswich. How many peaks can be seen? How many straight lines can we see? Why? Explain the results. Characterize the signal obtained.

Laboratory Report

Send the lab reports by e-mail to the following address cfmac_master.nuclear@csic.es before April 12, 2015.