Lab #3A:
Scintillator Detectors and Phoswich test

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

A scintillator is a material that scintillates, this means that emits luminescence when the ionizing radiation passes through it. When we talk about a scintillator detector, we refer to coupling a scintillator material to a light sensor, as can be a photomultiplier tube or a photodiode. The incident photons strike the photocathode material, which is usually a thin deposit on the entry window of the device. Electrons are ejected from the surface as a consequence of the photoelectric effect. These electrons are directed by the focusing electrode toward the electron multiplier, where electrons are multiplied by the process of secondary emission, then a stack of dynodes each at a higher potential makes the electrons to increase in number, creating a huge amplification of the signal at the anode. To bias the individual dynodes a special optimized voltage divider Fig. 2 is used.

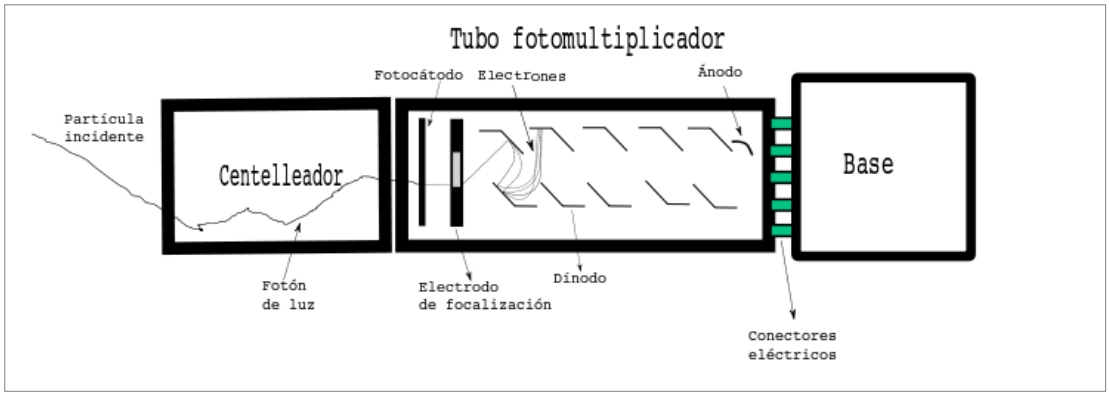

Figure 1. Outline of a scintillation detector with photomultiplier.

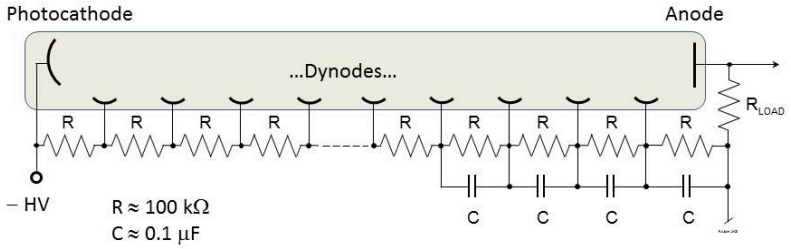

Figure 2. Typical photomultiplier voltage divider (base) circuit using negative HV

A phoswich scintillator detector is based on two crystals coupled together as a sandwich model with the same electronic read-out, Fig. 3. The two materials emit light of different wavelengths and have different time response; the pulse can thus be divided in two different components, one from each material. Our phoswich is made of two new materials: $LaBr_3(Ce)$ (Saint Gobain: Brillance 380) coupled to a crystal of $LaCl_3(Ce)$ (Saint Gobain: Brillance350), as these materials as highly hygroscopic the crystals are encapsulated in an Al can with a glass window in one end.

There are several kind of readout devices that can be used with scintillators e.g. the photomultiplier(PMT), the photodiode(PD) and the Large Area Photo Diodes (LAPD).

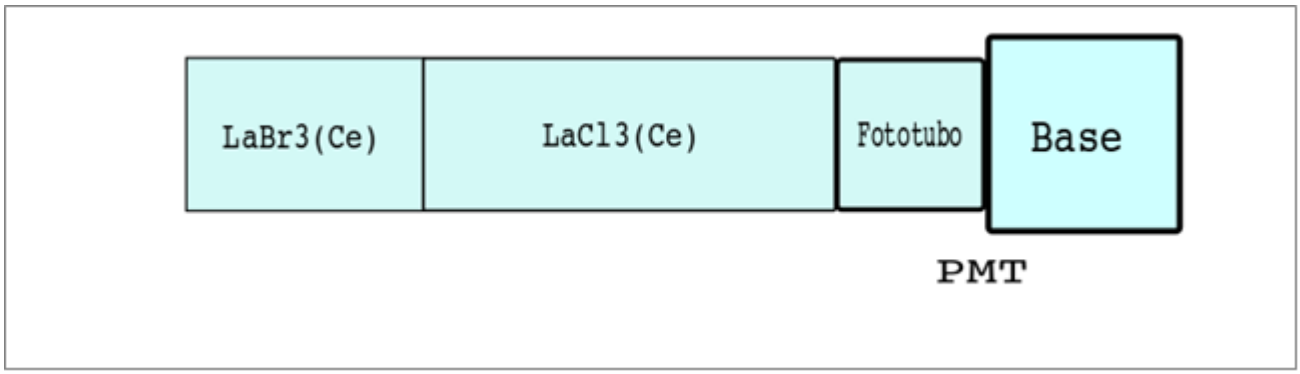

Figure 3. Sketch of the Phoswich scintillator.

Aims

Make the students familiar with the scintillator detectors; mounting, wrapping and try the different detectors elements and their characteristics. For this reason two different scintillators can be used: $LaBr_3$ and $LaCl_3$

The data obtained from the energy deposition of gamma radiation and intrinsic radiation of the scintillators will be analyzed, first using an oscilloscope and afterwards with an analogic readout. Two or three different radioactive sources will be used to check the different response.

To finish this project a phoswich scintillator response will also be analyzed

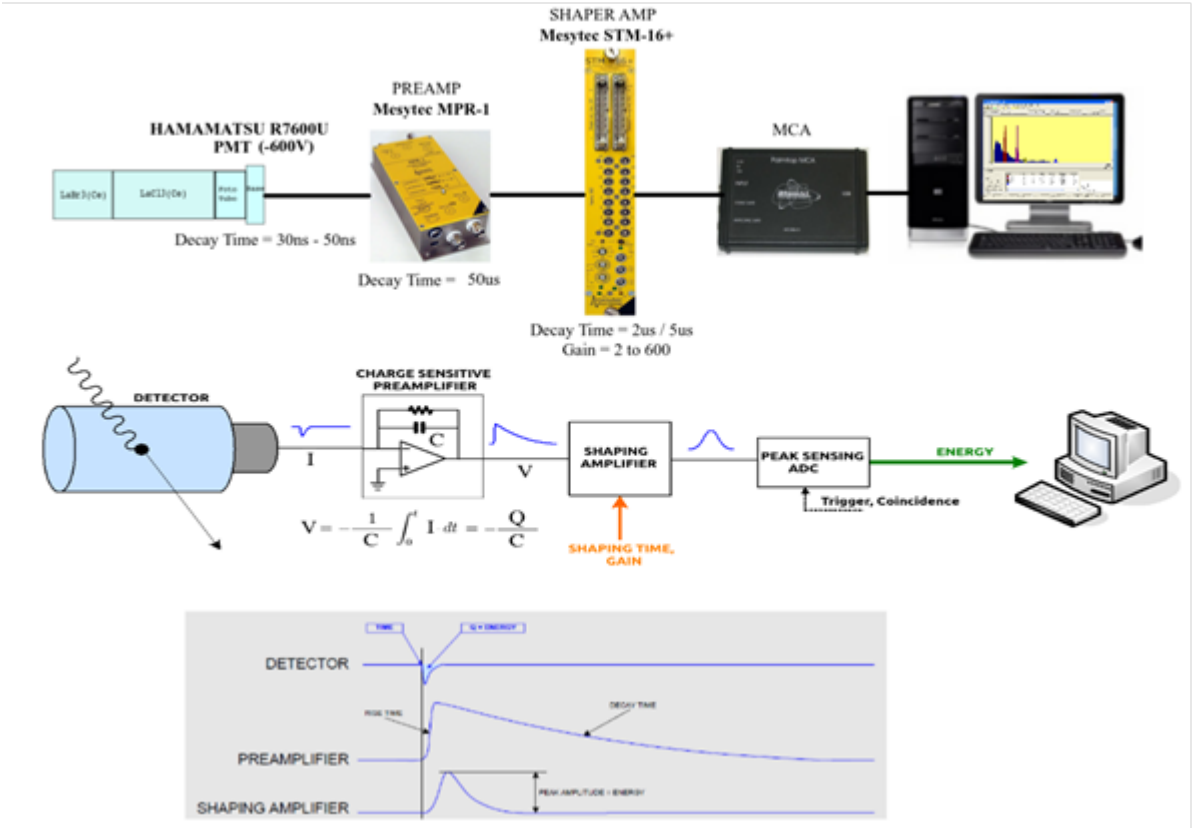

Figure 3. Analog Readout Electronic System.

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

Materials

The students can use the following tools:

1. Crystals scintillators of $LaBr_3$ and $LaCl_3$
2. Cylindrical PhotoMultiplier Tube (Hamamatsu R5380).
3. Base of the Photomiltiplier (Hamamatsu R5380)
4. PMT High voltage power supply (NHQ 203M).
5. Charge preamplifier (Mesytec MPR-1).
6. Preamplifier power supply(Mesytec MNV-4)
7. Shaper amplifier (Mesytec STM-16+).
8. Oscilloscope
9. Multichannel Analyzer (MCA)
10. Black tape
11. Optical Grease.

12. Gamma sources (^{137}Cs, ^{60}Co, ^{22}Na).

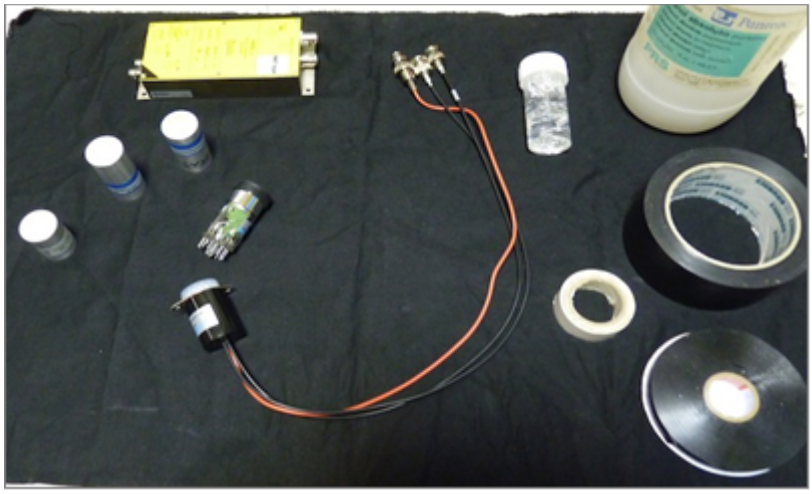

Figure 4.Material used to couple the scintillator detector.

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 components.

3. To couple the crystal scintillators to the PMT window with optical grease, and wrapping all together with black tape.

4. Obtain the spectrum of a one of the sources(^{137}Cs, ^{60}Co, ^{22}Na) with the analog chain and the MCA for every scintillator material. How many peaks can be seen? Explain and compare the results for the different crystals. Characterize the signal obtained.

5. Obtain the spectrum of a different source(^{137}Cs, ^{60}Co, ^{22}Na) with the analog chain and the MCA for every scintillator material. How many peaks can be seen? Explain and compare the results for the different crystals. Characterize the signal obtained.
6. Repeat the steps 5 and 6 with the phoswich detector and compare the results.

Laboratory Report

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