Practical on Scintillator detectors

Introduction

A scintillator is a material that, when excited by ionizing radiation, emits a light pulse. It can be used for spectroscopy, if it is possible to convert this pulse in a electric signal, with pulse height proportional to the number of emitted photons. Scintillators can be sorted in two main groups: organic and inorganic. Organic (plastic) scintillators are typically characterized by good timing properties (fast scintillation time), but poor spectroscopic properties (low light yield). Inorganic scintillators, on the contrary, have typically larger scintillation time, but higher light yield, which reflects in good energy resolution. Nevertheless fast inorganic scintillators have taken wide use in recent years. The YAP ($YalO_3$) is one of them. It has a scintillation time of about 27 nsec and light yield is 10-18 photons per keV. High density and high Z of the material ensure a good efficiency for gamma ray detection.

One plastic scintillator and one YAP scintillator are coupled with Photomultiplier Tubes (PMT). Aim of the experiment is to appreciate and measure timing and spectroscopic properties (scintillation time and resolution).

Exercises

a) Checking and starting up
   - Check that HV module is set to 0 and "inhibit" light is on.
   - Ask the tutor to check the cabling and connect the YAP detector to the HV channel.
   - Connect the signal cable to the scope (remember 50 Ohm terminator).
   - Switch on HV: Remember that the HV must be negative and stay always BELOW 1400 V.

b) Signal observation using the oscilloscope

   - The tutor will place a Cs137 radioactive source near the detector.

   - Choose a good HV value to work. Starting from 0 increase the HV until you get a good signal.

c) Feel free to familiarize yourself with the oscilloscope.

d) Measurement of scintillation time

   - Using the cursors of the scope to measure amplitudes and time intervals.

   - Supposing that the pulse falling has an exponential behavior, one can measure the time that the pulse takes to reduce of a 1/e factor.

   - One can choose otherwise to measure the FWHM of the pulse.

e) Observation of the signal through a shaping amplifier.

- Connect the signal cable coming from the detector to the INPUT connector of the amplifier.
- Look the OUTPUT of the amplifier using the oscilloscope.
- Choose shaping time and gain.

f) Use the ADC to acquire pulse height spectra for Cs137 and Co60.

- Connect the OUTPUT signal of the amplifier to the INPUT signal of the ADC.
- Verify that ADC is connected to the PC and ready to acquire.
- Start MAESTRO software.
- When you have a good spectrum with the Cs137 source, stop the acquisition, save the spectrum and replace the source with Co60. Start again acquisition.

g) Repeat tasks a) b) d) f) using the plastic scintillator detector. Compare the time properties of the two scintillators: which detector is faster?

h) Spectra analysis

- Open the spectra you have acquired with MAESTRO.
- Find peaks and Compton shoulders. Calibrate the spectra using the peaks (if any) or the shoulders (if any). Which detector has the highest efficiency to full energy peak?
- Compare energy resolutions using MAESTRO. Which detector has the best energy resolution?