Laboratory Project

Detector and trigger: Scintillators, trigger logic and readout

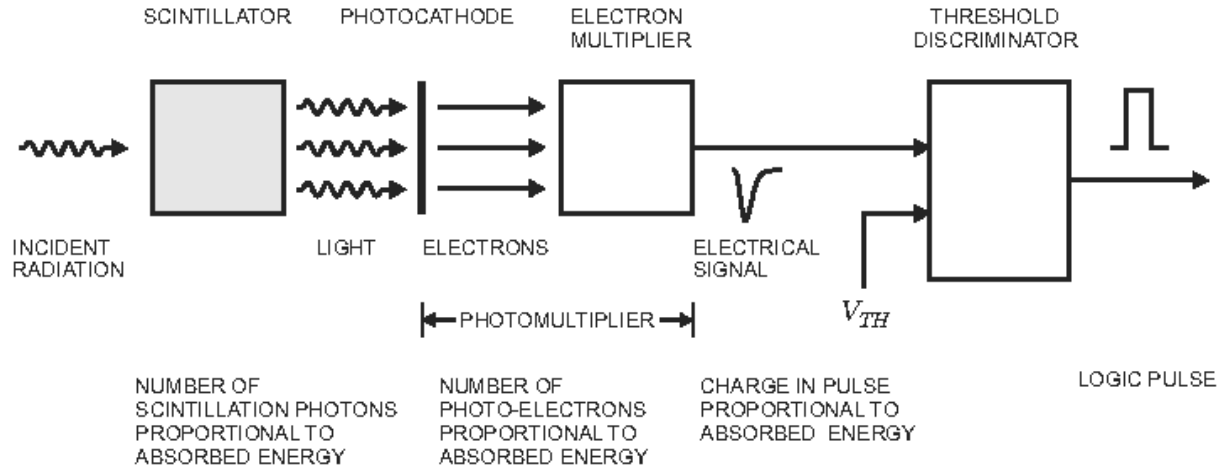
Exercise 1

Introduction

This exercise consists in building the trigger logic and the input signals from the readout modules for a detector along with other NIM modules.

Principle

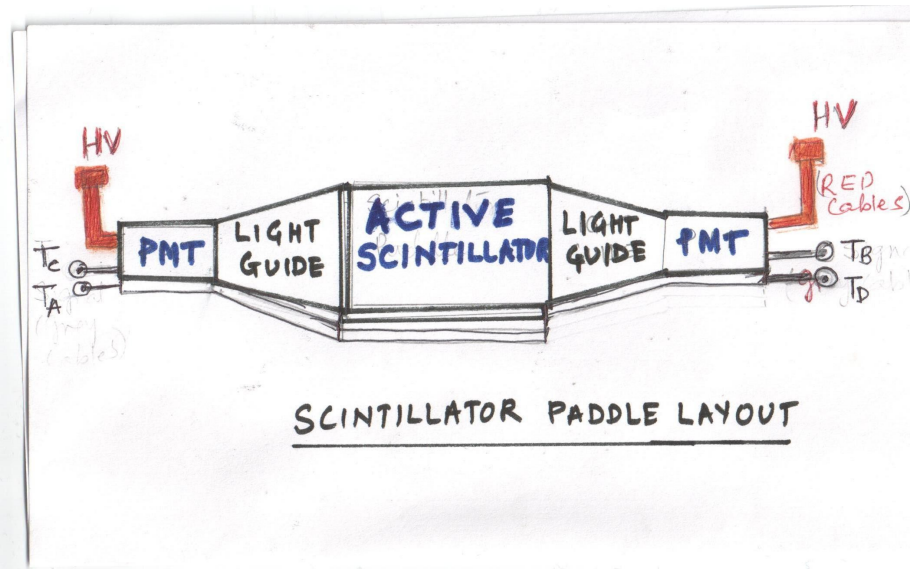
When a charged particle traverses the scintillator, it excites the atoms of the scintillator material and causes light (photons) to be emitted. Through a light guide the photons are transmitted directly or indirectly via multiple reflections to the surface of a photomultiplier (PM), the photocathode, where the photons are converted to electrons. The PM multiplies the electrons resulting in a current signal that is used as an input to an electronics system. The scintillator and light guide are wrapped in black tape to avoid interference with external light.



Outline:

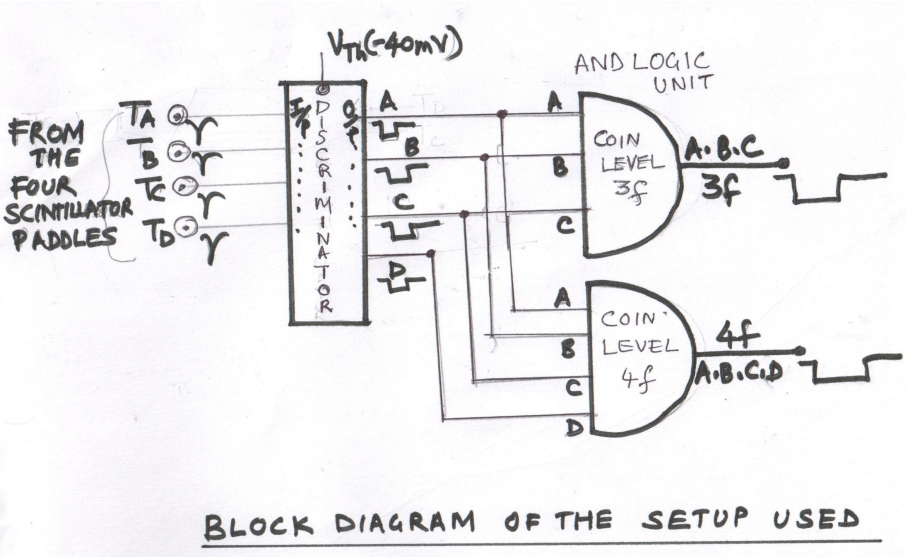
The aim of the exercise is to get an understanding of the plastic Scintillator detector counter and trigger logic used that forms an integral part of any HEP experiment.

The detector trigger counter comprises of four scintillation counters detecting cosmic rays (muons). A schematic diagram of a scintillation counter layout is shown below.



The signals from three scintillation counters are analyzed using an oscilloscope and transformed into logic NIM signals by feeding them to discriminator channels that allow building a trigger based on a coincidence between the signals. The coincidence rate i.e. the rate of cosmic muons is counted using a scalar and the charge content of the scintillator signals is measured on the oscilloscope.

A schematic diagram of the full trigger and read out electronics is shown in Fig.



Work plan:

1. Install the scintillation counters close to each other with maximum overlap between the scintillator areas (It is already done but make sure that the alignment of the paddles is proper).
2. Switch ON the NIM crate (LeCroy model 1403).
3. Measure if the NIM POWER bin is supplying the right voltages to the modules.(using DMM check the front panel test points for the right voltages (+-6,+-12,+-24V)
4. A single Tennelac (TC 952) HV supply is used to power three PMTS (ELECTRON TUBES 9807B)..? Check that the scintillation counters photomultiplier bases are connected to the high voltage supply via the distribution board and note down the values.
5. Measure with the HV probe the HV going to each Paddle A,B and C…note down the same..
6. Connect the signal cables (grey cables) to all three PMTS of the three scintillator paddles A, B, C.
7. Connect the signal cables from the three Paddle PMTs to the three inputs of the discriminator (model P\S 706) using short lemo cables.
8. Set the discriminator threshold to -40 mV: adjust the voltage on the test point using a DC voltmeter and a small screwdriver. This step may require teamwork.
9. Connect an output of the discriminator to the first channel of the NIM counter (N145) using a short cable (1ns).
10. Set the preset timer to 20mins (timer starts count down from 1200 to zero)
11. What is the count rate of each scintillator paddle..? Note it down. Why is it so high..?
12. Vary the threshold around 40 mV and check the variations in the rate and finally leave it set to 40mV.Note them and reason out why it changes so..?
13. Connect all three outputs of the discriminator to the three channels of the counter
14. Before the step 13, the instructor will show the signals from PMT output, discriminator output and coincident output on the oscilloscope. Reason out yourself the different shape, rate of these pulses.

15. Connect the three outputs of discriminator channels then to the inputs of a coincident (Logic unit(model P\S 756)) and make sure that 3fold coincident level is set and connect its output to a counter and note the 3f coincident counts at the end of 20 mins.

16. Also connect the 4th scintillator paddle to the HV that we going to vary, to measure the efficiency of this paddle.

17. Connect the 4th paddle output to the discriminator as in step 7 with a threshold voltage set to -40mV and the output of the 4th discriminator channel to the 4th input of another coincident circuit where all three discriminator outputs of the 3 paddles are also connected.

18. Make sure the coincidence level is set at 4fold level and give the out put of this logic unit to the counter channel and note the counts for 20 mins. This divided by 20 gives the 4 fold rate per min.

19. Vary the HV of the 4th paddle from -1280 to -1550 V and repeat the step 21 noting down the 3f rate as in step 15 and the 4f rate as in step 17.

20. Calculate the ratio of 3f/4f rate each time of step 22. What do you observe.? How do you explain this..?

21. Where do you find this experimental data useful..? What are the different applications of the plastic Scintillator paddles..? Why is 3f or 4f important..? Can we do with a single scintillator paddle? Answer is No but Why Not..?

22. Can other RPCs also be used as trigger counters..?

23. What is MIPS response of a detector..?

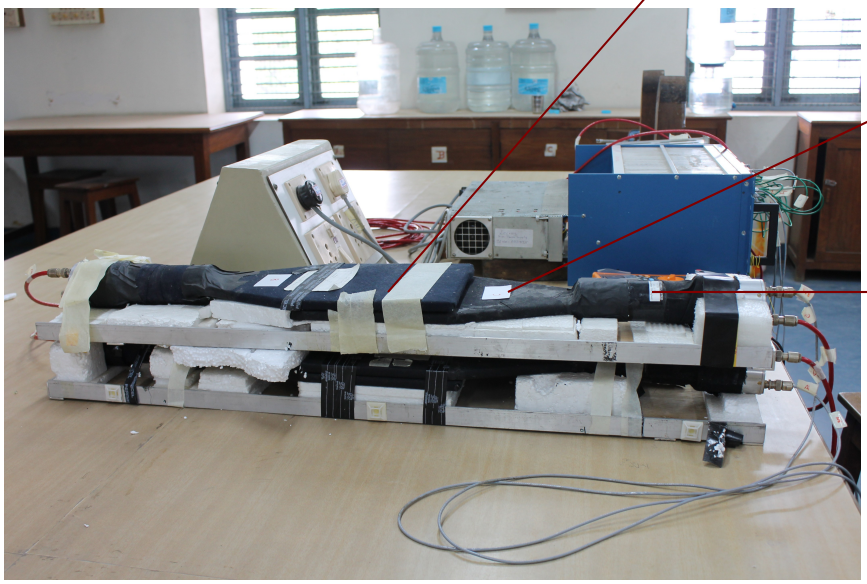
24. Can we call the Muon flux available in the lab for calibrating a HEP detector as a GOD given accelerator... :-)…YES?

    ENJOY the Experiment with lots to learn if you have the correct answers to the questions posed above..!!!!!

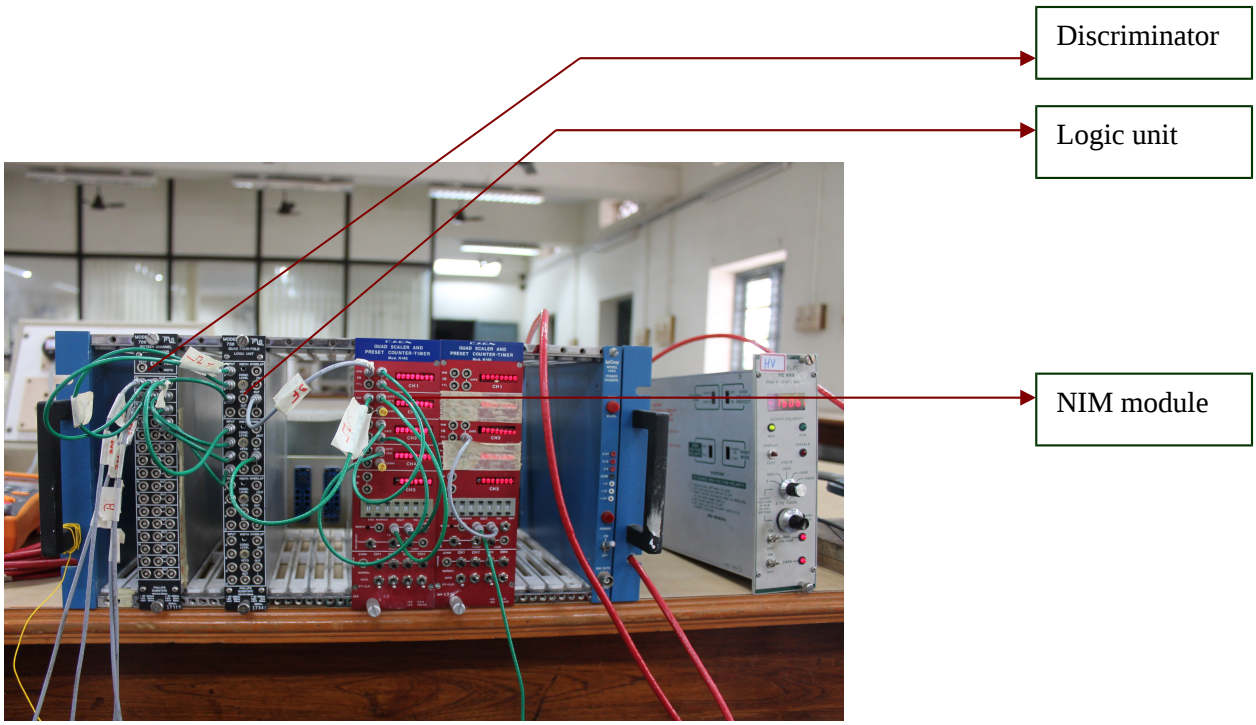
Note 1: Be extremely careful while measuring HV. The HV PROBE to be connected to the test points (AND NOT ANYWHERE ELSE) at the lower side of the HV distribution board.

Note 2 : Turn off the multimeters when it is not in use.

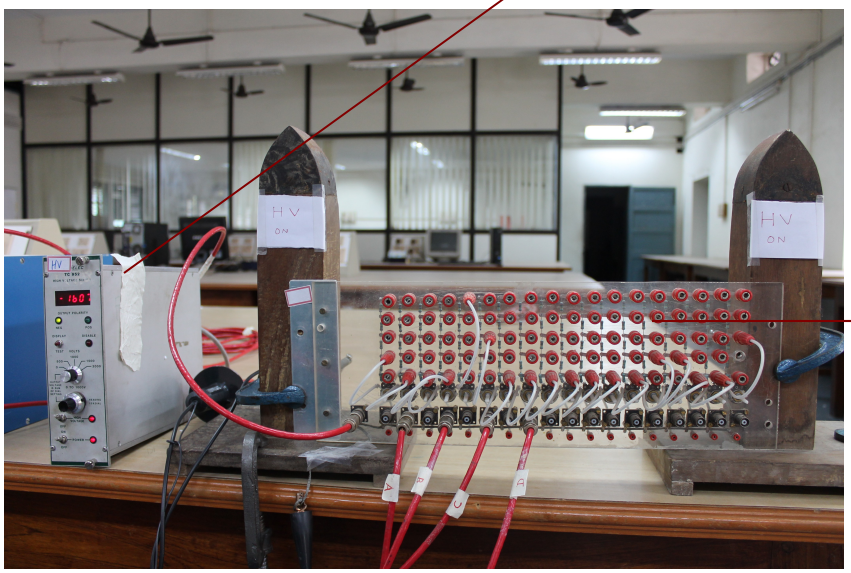
Experimental setup



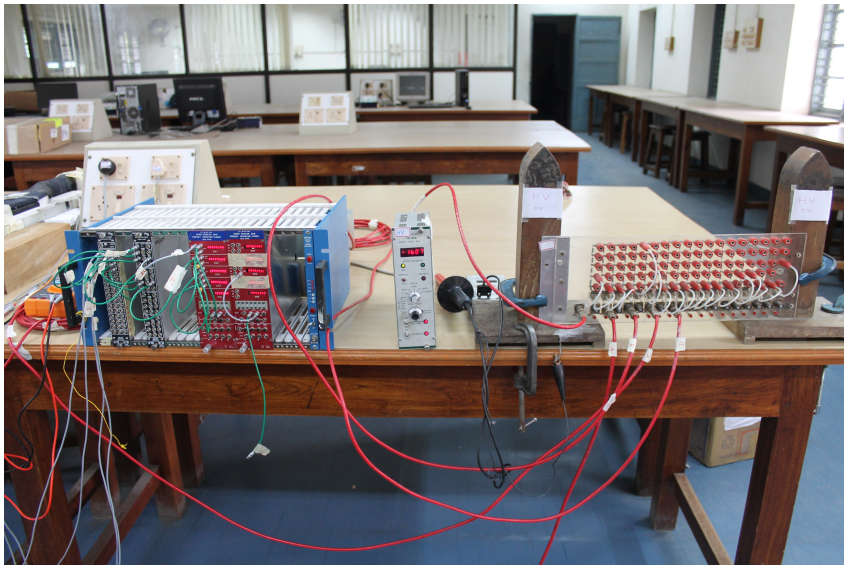
Scintillator paddle stacks



Electronics module



High Voltage Supply



Electronics module and High voltage supply