Muon Lifetime Measurement
ODU-specific addendum
Larry Weinstein, 16 March, 2008

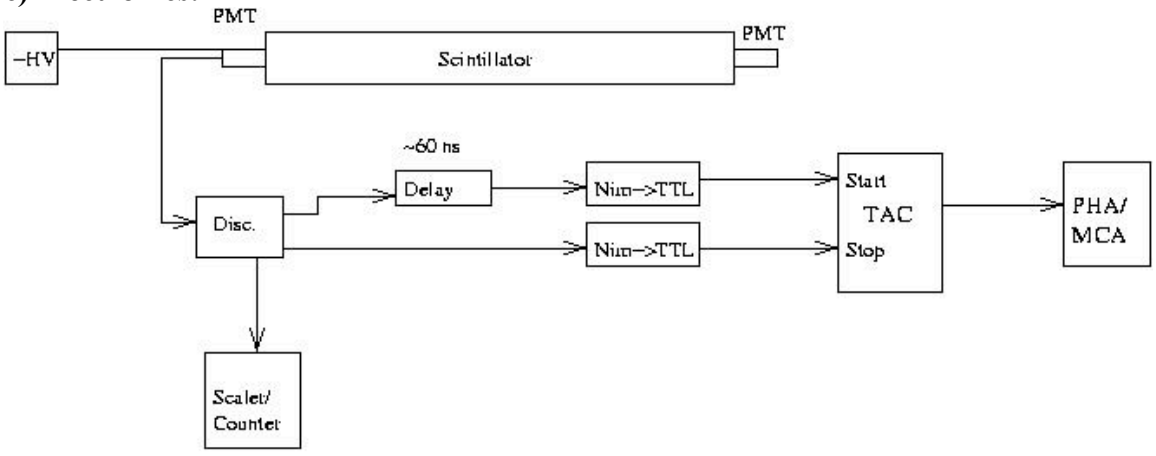
Read "Measurement of the Muon Lifetime" from the University of Michigan Advanced Physics Laboratory course (on the Physics 413 web site). The sections below augment the corresponding sections in the UofM write-up.

4) Experimental Detection of Cosmic Ray Muons

a) Scintillators:
We will use a large plastic scintillator, approximately 2 m x 0.1 m x 0.2 m. The chemistry is similar to the liquid scintillant described in the write-up.

b) Photomultipliers:
Our scintillator has two photomultiplier tubes (PMTs), one on each end. They each require **negative** high voltage (HV), at about **negative** 1500-1800 V. Make sure the power supply is set to **negative** HV. You can use one or both signals for this measurement.

c) Electronics:



This is the general layout of the electronics for the experiment. It is slightly different from the UofM layout. Before setting up the electronics, you should familiarize yourself with the different modules.

5. Experimental Set-up

b) The PMT: Connect the high voltage to the PMT. Turn it up to NEGATIVE 1.8 KV, pausing for a seconds at each turn of the dial. It is always better to turn on HV slowly and smoothly. Look at the output of the PMT on an oscilloscope.

What is the rise time of the signal? The fall time? The range of pulse heights? Are all the pulses approximately the same shape? What happens when you put a source (beta or gamma) on the scintillator?

c) Connect the output of the Discriminator to the scaler/counter. (Make sure that signal is appropriate. There are two types of logic signals that we use here, NIM and TTL. A positive or "TRUE" NIM pulse is -800 mV; a positive or "TRUE" TTL pulse is +5 V. NIM signals need to be terminated with 50Ω [this is done automatically by the logic modules, but not by the oscilloscope]. TTL signals do not need to be terminated.) See how the counting rate of the scaler/counter depends on high voltage, discriminator threshold, and proximity of a radioactive source to the scintillator. Note that you want to set the high voltage and threshold so that the counter counts slowly without a radioactive source (a few Hertz or tens of Hertz) and quickly with a source.

d) Our Time to Amplitude Convertor requires TTL-level input signals. Connect two of the outputs of the discriminator, via a NIM->TTL convertor, to the inputs of a Time to Amplitude Convertor (TAC). Read the documentation on the TAC to make sure you know how it works and how you should set all the stupid little switches on the TAC. Delay the "Start" signal by about 60 ns using a passive delay. Delay the "Stop" signal by 0.25 to 6 microseconds using the delay module. Look at the amplitude of the TAC output on the scope. See how it changes as a function of the Stop signal delay. Measure the time difference between the Start and Stop signals using the scope (to double-check the delay module).

e) Connect the TAC output to the Pulse Height Analyzer. This is the same one used for the Gamma Ray Spectroscopy experiment. Use the 0.25 to 6 microsecond delay module to calibrate the PHA channel numbers corresponding to the different delays.