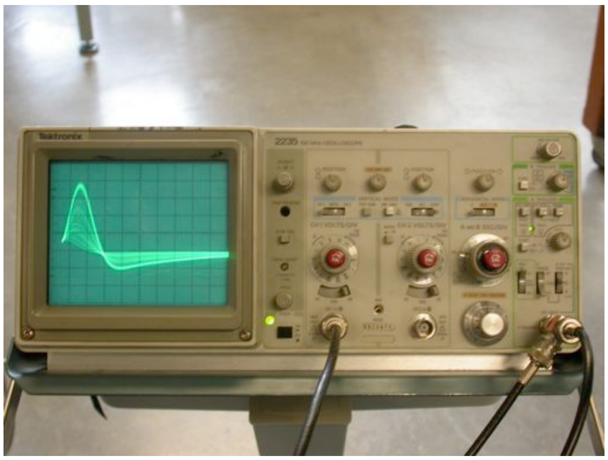
PHYS 575 Radiation and Detectors
No lab reports required – your lab notes are for your own reference
Session 1 – Oscilloscopes and fast pulse basics

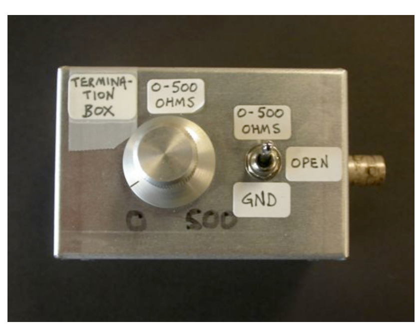
The first lab session is designed to acquaint you with the use of oscilloscopes, processing signals typical of particle detector outputs, and use of NIM modules. You will use the following equipment:

1. Tektronix analogue oscilloscope making use of both internal and external triggers.



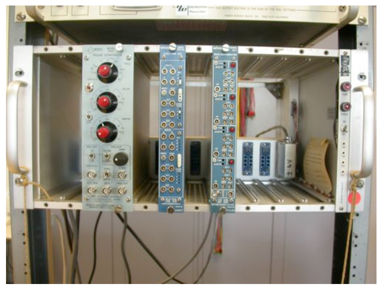
2. Coaxial cables with BNC and LEMO connectors, terminating resistors and attenuators to examine techniques of signal transmission.

3. A small box containing a variable resistor capable of the range 0-500 ohms with a toggle switch that makes the cable open-ended (infinite impedance) or shorted to ground (zero impedance).



4. Pulse generators that output short voltage pulses of tunable peak voltage, time duration and frequency. There are three BNC 8010 units that mount in a NIM bin and produce square pulses, and two “Tail pulse” units that produce pulses that mimic photomultiplier tube output pulses.. The repetition rate should be chosen to give an easily visible scope image but not so high that you get multiple pulses on the screen. Typically setting it at 100 KHz works well.

5. NIM (Nuclear Instrument Module) bin with discriminator, scaler (counter) and logic modules. Examine the NIM bin and how the modules are connected at the backplane.



6. Plastic scintillator attached to Photomultiplier
   Two PMT’s with a round flat piece of scintillating plastic mounted on their windows. Some units have small square paddles attached instead of disks.

There will be 4 stations each containing a rack in which a NIM bin is installed. Pulse generators, NIM units and terminating resistors are located on a near by table. Each station also has two loops of cable with BNC connectors at each end. One cable is RG58 (50 Ω) and one other is a ‘mystery cable’ whose characteristic impedance you are to determine.
A cable rack behind the movable chalkboard contains many 50 Ω coaxial cables that you should use as needed. At the end of the day please return everything where it was found.

Things to do:

1. **Effect of terminating and not terminating a pulse.**
   Connect the output of the pulse generator (square wave) and set up a negative square wave pulse of 0.8 V amplitude. Observe this on the scope using the internal trigger to observe the signal, by connecting to channel 1 via a T-connector. A) Put a 50 Ω terminator at one end of the T. B) Next remove the terminating resistor and attach a 10 or so foot cable to the T, leaving it open-ended. It is important to choose a pulse width compatible with the cable length. Begin with a width of about 30 ns and then widen pulse to about 100 ns is two increments of 30 ns. Note pulse shape characteristics for each of

the three pulse widths. Record your observations; then attach a 50 Ω terminating resistance to the open end of the cable and again observe results. Repeat with the long (approx 50 foot) 50 Ω cable.

2. **Determine the characteristic impedance of the "mystery cable"**
Using the long unidentified cable and the terminator box that contains a variable resistor determine the impedance of the mystery cable. Adjust the variable resistance until the scope shows no reflections, then use the multimeter to measure the box resistance setting at its terminal. How is this related to the cable impedance?

3. **Use of discriminators.**
Put NIM discriminator and logic units in your crate. You can use a square pulse or a tail pulse generator. Look at both input and output simultaneously on the scope, on channels 1 and 2, and notice their time relationship. You can use the setscrews on the discriminator to adjust threshold level (use multimeter to check the test point V, which is 1/10 the threshold setting) and output pulse width (observe width on scope as you turn the screw)

4. **Use coincidence modules.**
Create two simultaneous pulses using two outputs of the discriminator and obtain a coincidence using the NIM logic units (observe input on ch 1 and coincidence output on ch 2 of scope, using tees). Next insert a 50Ω delay box in the second coincidence input. See how much delay between the pulses it takes to kill the coincidence output.

5. **Observe output of phototube**
Most of the phototubes have a small disc of scintillator (particle detector) on their ends, and are marked "USE + POLARITY". If your group uses one of the large scintillator paddles in the muon counter, note they are marked "NEGATIVE POLARITY". When you connect high voltage power to your tube make sure you have the polarity switch on the HV supply set correctly for your tube!! Connect the anode output of a scintillation counter to the oscilloscope and terminate the cable at the scope. Next connect the high voltage input (using a **high voltage cable)** to the provided HV supply and set it to the appropriate output polarity. At this point you should increase the high voltage slowly to about 750 – 800 volts. (Some tubes will have optimum HV setting marked on them) Next take a ^{22}Na source from the source locker and bring it near the plastic cookie at the end of the PM. This will give you an abundant supply of signals from the scintillator. On the scope, set the trigger polarity correctly and adjust the trigger level until you see signals on the scope (green trigger LED is on). Observe and note the characteristics of the PMT pulses. Observe and note the PM output as you change the high voltage setting by decreasing 100V or so (Do NOT exceed 800V). As you increase the voltage on the PMT you may need to adjust the trigger level on the scope.

6. **Repeat discriminator and coincidence exercise with PMT pulses**
Repeat item 3, this time using the scintillator –PMT's Na-22 signal as input to the discriminator. Notice that not all PMT pulses are big enough to fire the discriminator, for some channel 1 (counter pulse) traces you do not get a discriminator output pulse (channel 2) but just see a straight line in the scope trace. Try increasing and decreasing the HV setting by 100 V and notice how the average pulse height from the PMT changes with corresponding response from the coincidence unit.

Repeat item 4 using one PMT's Na-22 signal as raw input. Then power up the 2nd scintillator-PMT module and place the Na source between the 2 PMTs. Instead of using 2 discriminator outputs from one PMT, run the two PMTs through separate discriminator modules. The source emits back-to-back 0.5 MeV photons, in all directions, so coincidences represent decay events where each PMT caught one photon; the rate will be higher if you orient the PMTs so maximum scintillator area faces the source.

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