Mounting a Scintillation Detector

Dietrech Z. Washington

Some general remarks:

(1) Be careful when handling the photomultiplier and the plastic scintillator. Handling the plastic scintillator with bare hands should be avoided.
(2) Do not touch the photomultiplier faces. You can clean the PM faces with alcohol, but never bring the scintillator in contact with alcohol.
(3) The detector needs to be light tight. Any light leak will cause noise that will completely cover up the signal.
(4) The photomultipliers we use in this manual work with a low voltage power supply. The conversion to high voltage takes place inside the base. However, for safety, DO NOT OPERATE THE PHOTOMULTIPLIERS UNDER WATER.

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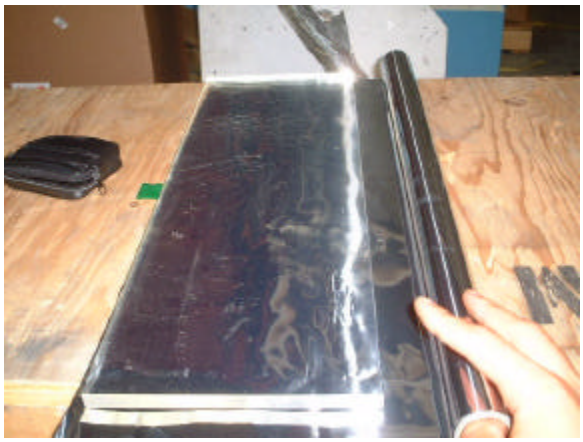
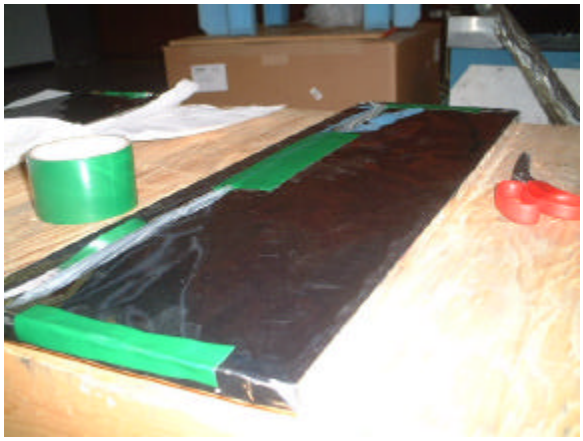
STEP 1:Wrapping the Scintillator.



Neatly wrap the scintillator in aluminum foil as though you were wrapping a present. Fold the aluminum foil around the scintillator loosely. It is important that you don't wrap the foil too tight because you want a thin layer of air to be trapped between both materials. This enhances the total internal reflection, allowing all light to be utilized. Pay close attention to the corner edges. Do not allow the scintillator to rip through the foil. However, if it happens, just neatly put black tape over the ripped areas



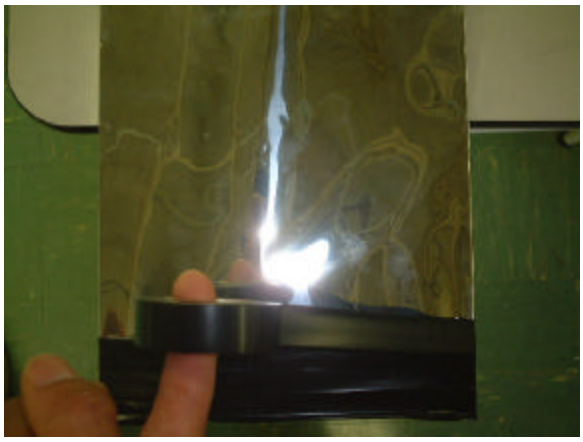
Next, tape the aluminum foil closed using masking tape or duct tape. Don't use the black tape to hold the foil closed, because over time it will weaken. You will need all the black tape you can find for "Light Proofing."

STEP 2: Making the Hole for the PMT.

Carefully trace a 3" diameter circle in the center of your detector using a compass, or anything else you can find around that can get the job done. Once you have your outline, you can use an exacto knife or a box cutter to cut out your circle. As you see here, I used a tiny screwdriver. The important part is to be imaginative and creative, use whatever you can find lying around.

This is what your detector should look like at this point!

STEP 3: Light Proofing.

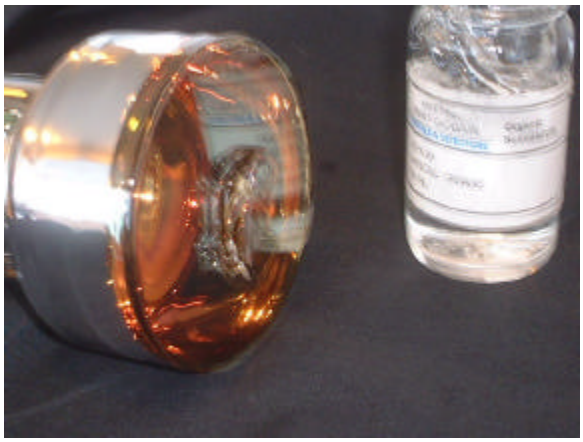


Use your Black electrical tape to neatly seal the detector from light. Start from the ends and work inward as shown. It is very important that no aluminum is showing. The best method is to wrap the detector along its width. Allow the tape to slightly overlap itself. One roll should wrap more than half of the detector.

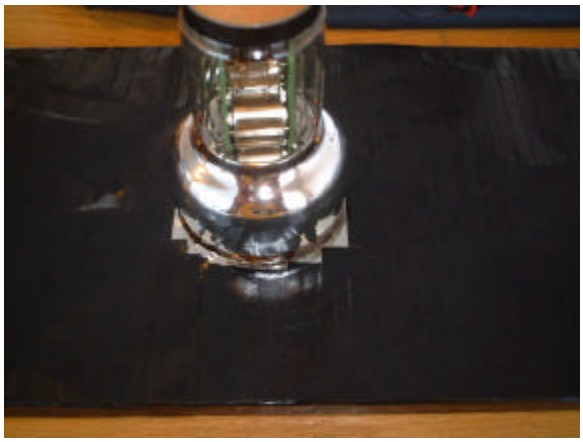
Do not tape over the hole for the PMT. Leave it as shown, and continue wrapping the rest of the detector.

When you get to this stage, you are ready to attach the photomultiplier tube. However, I would suggest going back and wrapping your second detector before moving on to the next step.

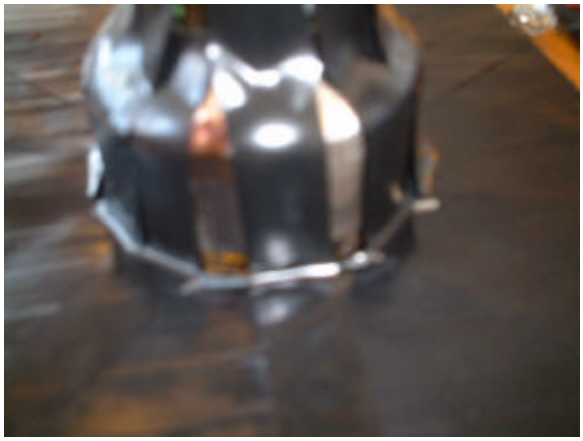
STEP 4: Attaching the Tube.



Apply a glob of optical grease (about the size of a quarter) to the center of the PMT (do not use to much, less is better). The optical grease has a similar index of refraction as the plastic scintillator. This allows light to flow from the scintillator to the tube undistorted.

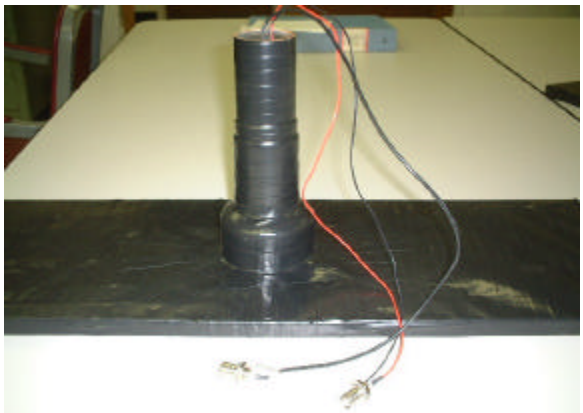


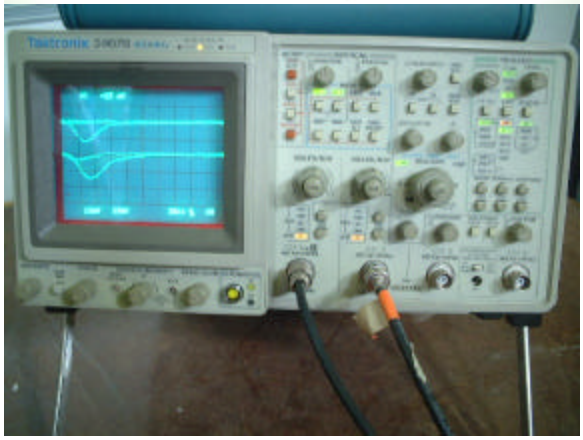
Press the tube into place. Apply enough pressure so that the grease will spread out. At this point you must not allow the tube to separate from the scintillator, because that will create tiny air bubbles in the optical grease.



Tape the tube down with long strips of black tape. Be careful that the tube doesn't shift around while taping. For best results, don't put any tension in the tape. When the base is completely covered, use several more pieces of tape to make an octagonal shape around the tube's base.

Next, start from the bottom and tape around the tube all the way to the top. Make sure you cover the whole tube, and there are not cracks or holes in the tape.



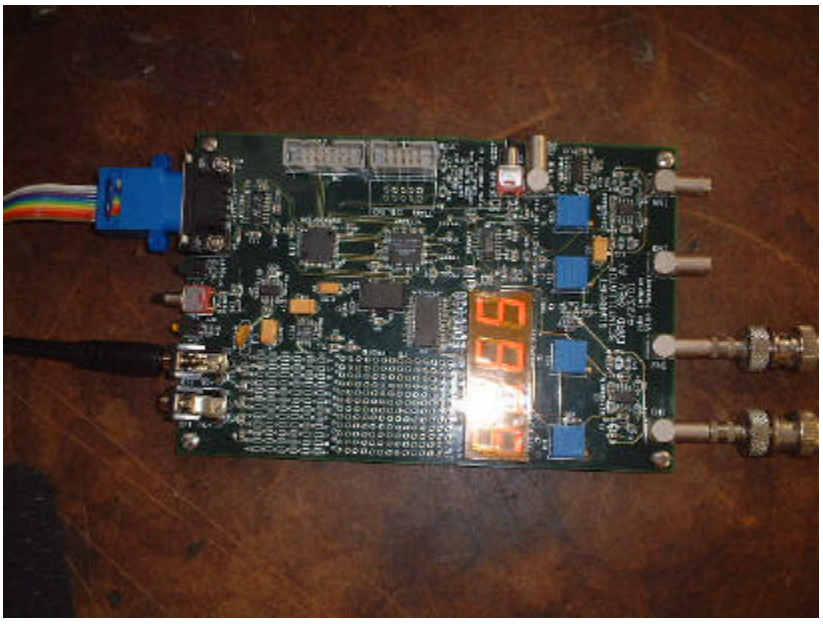


Once both of your detectors are assembled, you must test them to make sure there are no light leaks. The red and black banana plugs are your power inputs, the thick black wire is your signal output. First attach your signal outputs to the oscilloscope using the long black BNC cables provided. Then attach your power inputs to your Radio Shack® power supply. Red plugs into red, and black plugs into black. Set your power supply to 4.5 volts.

Once both detectors are connected to the oscilloscope (ch 1 & ch 2), and the power supplies are set to 4.5 volts, locate your signals on the scope. I'm not going to tell you how to do this, because becoming familiar with the scope and learning to find signals on your own is very important. You will have to become proficient at it, if you plan to complete these experiments.

The signals should look like this. I suggest you take notes and write down the settings (**e.g.**. Volts/div. & time/div.) on the scope so you can easily find the signals again.

The next step is to set up your QuarkNet Coincidence Logic Board. On the left side, you will see the power cable (black) and the serial cable (multi-colored). Plug the power cable into either one of the two power jacks. Next, plug in your signal cable. Also on the left side you will find the Card Reset button. The Card Reset button resets the card to its default settings. On the right side you'll find four inputs channels. Connect your detectors to the first two channels, as shown. Make sure the top detector panel it connected to channel 1.



ch4

ch3

ch2

ch1

Now that your QuarkNet Card and detectors are set up, you are ready for a few experiments.

Experiment #1: Simple Rate Measurement.

Step1- Set the voltage on the power supplies to 6V.

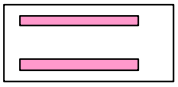
Step2- Set the QuarkNet Card thresholds for channels one and two to 30mV. (This should be explained by an instructor).

Step3- Open the HyperTerminal program and press the Card Reset button, located on the QuarkNet Card. There are two reset buttons on the card. The "Card Reset" and the "Scalar Reset." To reset the whole card to its default values, use the "Card Reset." To reset the LED scalar displayed in red, use the "Scalar Reset".

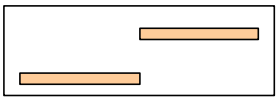
Step4- Enter the following commands;

- **A. "**EC" (Echo Character. Allows you to see what you type).
- **B.** "ES" (Enable Singles. Tells the board to record single pulse events as well as double pulse events).
- **C. "**WC 13" (Write Control. This command allows the user to specify which channels to enable. For this rate experiment and most other experiments we will enter "13", which enables channels 1&2, and looks for coincidences between them. For an explanation of specific bit choices and their hexadecimal notation, see Appendix H in your *QuarkNet Scintillation System Manual.*
- **D.** Select "Transfer" from the HyperTerminal menu bar. Scroll down to "Capture Text" and enter a location where you want the data to be saved, then select the "Start" button. To stop the data capture select "Transfer" from the HyperTerminal menu bar. Scroll down to "Capture Text" then select "Stop."
- **E.** Analyze the Data. (Refer to *Working in Excel* and *Data Analysis* on pages 11 & 12 of your *QuarkNet Scintillation Systems Manual*.)

The point to the rate experiment is to position the top detector panel (ch1) directly above the bottom detector panel (ch2) with about 1-2 feet of separation, then capture the data for about an hour. Then offset the top panel to the side about a panels length, and then start the rate capture again (Be sure to give each rate capture a different name **e.g.** Position1, Position2,... etc.). Do rate captures for three positions. Be sure to offset the top panel further to the side each time.



Position 1 **Capture for 1 hour**



Position 2 **Capture for 1 ½ hours**

Position 3 **Capture for 2 hours**

Experiment #2: Muon Lifetime.

Step1- Set the voltage on the power supplies to 4.5V.

Step2- Set the QuarkNet Card thresholds. Set "Channel 1" (top panel) to 30mV. Set "Channel 2" (bottom panel) to 15mV. (This should be explained by an instructor).

Step3- Open the HyperTerminal program and press the Card Reset button, located on the QuarkNet Card. There are two reset buttons on the card. The "Card Reset" and the "Scalar Reset". To reset the whole card to its default values, use the "Card Reset". To reset the LED scalar displayed in red, use the "Scalar Reset."

Step4- Enter the following commands;

F. **"**EC" (Echo Character. Allows you to see what you type).

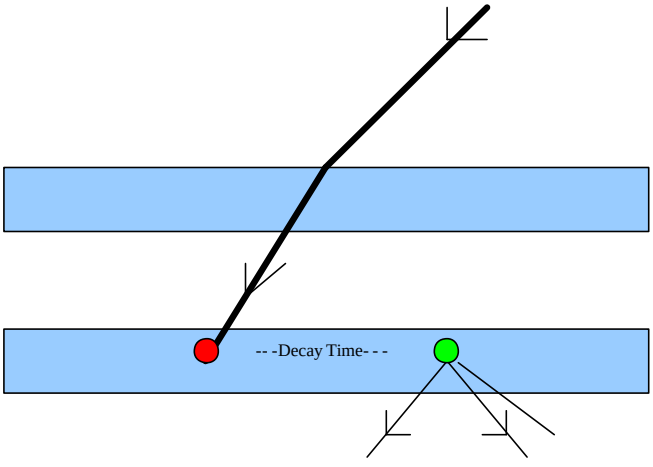
G. "SS" (Suppress Singles. Tells the board to record only double pulse events).

H. **"**WC 13" (Write Control. This command allows the user to specify which channels to enable. For this rate experiment and most other experiments we will enter "13", which enables channels 1&2, and looks for coincidences between them. For an explanation of specific bit choices and their hexadecimal notation, see Appendix H in your *QuarkNet Scintillation System Manual.*

I. Select "Transfer" from the HyperTerminal menu bar. Scroll down to "Capture Text" and enter a location where you want the data to be saved, then select the "Start" button. To stop the data capture select "Transfer" from the HyperTerminal menu bar. Scroll down to "Capture Text" then select "Stop"

J. Allow the Data Capture to continue overnight. This is necessary in order to get a sufficient amount of data to analyze.

K. Analyze the Data. (Refer to *Working in Excel* and *Data Analysis* on pages 11 & 12 of your *QuarkNet Scintillation Systems Manual*.)



The muon enters the top panel and alerts the QuarkNet Card to look for the particle to continue on to the bottom panel. When the card observes the muon in the bottom panel, it checks for a double pulse. A double pulse occurs when the muon looses all of its energy, stops in the scintillator, and then decays into an electron and two neutrinos.

Sample Lifetime Data:

The plots show histograms of the time distance between the two pulses in the lower panel. The distance is in microseconds (μs). This experiment gives a muon lifetime of 2.18 μs.