The Troubleshooting Document

CosmicWatch
The Desktop Muon Detector (v3X)

Contacts:
Prof. Spencer N. Axani (saxani@udel.edu)
Masooma Sarfraz (masoomas@udel.edu)
Miles Garcia (milesg@udel.edu)
Katarzyna Frankiewicz (katarzyna.frankiewicz@gmail.com)
Prof. Janet M. Conrad (conradg@mit.edu)

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Chapter 1

Document Overview

If you've built a CosmicWatch v3X detector and need to troubleshoot, this is where you should be.

First, you can find all material for v3X can be found in the GitHub repository located here:

`https://github.com/spenceraxani/CosmicWatch-Desktop-Muon-Detector-v3X`

Since this project

Chapter 2

Troubleshooting

If you followed the component_placement_list.pdf, you would have hit various checks to test different parts of your circuit. For this section, we'll assume you ran into some problem that you couldn't resolve, and describe common troubleshooting techniques.

- **I see smoke from the MAX5026 DC-to-DC booster.** Disonnect immediately. The component is on backwards. You may have fried it. Maybe not though. You need to take it off and double check Pin 1 of the MAX5026 lines up with Pad 1 on the main PCB.

- **I'm not seeing +30V between the HV and GND 6-pin connector going to the SiPM.** This will be caused by a problem in the DC-DC booster area of the PCB. First, check the orientation of the MAX5026 DC-DC booster. Make sure you have greater than 3 V across C2, this is the voltage coming from the RP Pico, used to power the circuit. R2 and R1 set the HV output voltage. Are they connected?

- **I have +30V going to the SiPM, but I don't see any 10mV, 100ns pulses out of the BNC connector (example pulse shown in Fig. 2.1).** First make sure that you are correctly setting up the oscilloscope; set the vertical scale to 10 mV per division and the horizontal scale to 200 ns per division. Set the trigger to 10 mV on the correct channel. I also set the trigger to Normal rather than Auto. You should see pulses triggering the oscilloscope at the hertz level. If you still don't see anything, your problem is with the SiPM PCB. You likely have one of two issues. The smallest light leak will cause problems. Small light leaks will look like a lot of noise on the oscilloscope. Add some additional tape, look for holes in the corners, et cetera. Otherwise, the problem could be with the SiPM, which isn't great, since you have to unwrap the scintillator to check it. The most common problem is that you mounted the SiPM in the incorrect orientation, or a poor connection on the SiPM. Before wrapping up the SiPM scintillator, it's good to check that you have approximately a 0.5 V voltage drop between the Anode and Cathode of the SiPM PCB. This is a good way to test if your SiPM is connected.

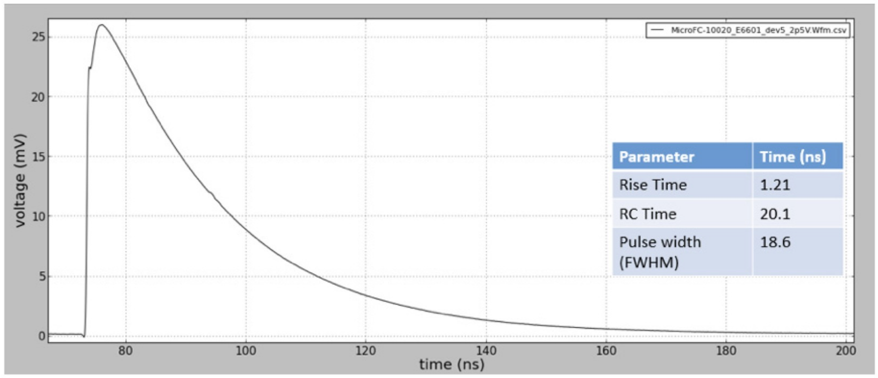

Figure 2.1: A typical SiPM pulse. Given the scale, I estimate this is about 100 photons given a gain of 4×10^6.

- **I see pulses out of the BNC, but my detector isn't triggering.** If this is the case, it means you have a problem with either the amplifier, peak detectors, or trigger circuit. We can use the test points (TP1,TP2,TP3) to identify the problematic area. First, setup the oscilloscope to trigger on the output of the BNC, then connect the scope probe to channel two. We will use channel two to look at the signals on TP1, TP2, and TP3. and see if you have 50x amplification on TP1 and 250x amplification on TP3. If no, that narrows down the problem to the respective amplifiers. If it looks good, check TP4, the high gain peak detector. You should see pulses that are 250x larger than the output of the BNC, but they decay over 100s of microseconds. If you see this, your detector should be triggering, if not, make sure you have the correct software. You can also check TP2, the low gain peak detector. This should be 50x larger than the BNC pulse, but also decay over 100s of microseconds.

- **I see a high power draw (>0.7W).** You have a short somewhere, a misplaced component, or component with the incorrect orientation. Disconnect immediately and go through your circuit again. The most common mistake is mounting the LT1807 op amp backwards. The pin 1 needs to be on the correct side of the footprint. You can often identify the problematic component by touching various parts of the board. None should be hot. If hot, there's likely a problem in that area.

Chapter 3

Conclusion

The CosmicWatch Desktop Muon Detectors offer a versatile platform for exploring diverse natural phenomena. This document provided a comprehensive overview of the underlying physical processes influencing the detectors and demonstrated how valuable insights can be derived from the collected data. The detectors can be employed to investigate a wide range of phenomena related to the geomagnetic field, atmospheric conditions, cosmic-ray shower composition, particle attenuation in matter, radioactivity, and statistical properties of Poisson processes. Students are encouraged to further develop the concepts introduced or design their experiments. Feedback is highly welcomed to enhance and refine this manual. Enjoy your exploration with the CosmicWatch detectors!

Bibliography