With there being a greater importance in being able to do projects at home due to many lab facilities not being available, I found this journey on building a muon detector at home to be quite a valuable experience in teaching me how to handle such a complicated project without aid. Due to how valuable of an experience this was for me, I decided to write this documentation of my work on it in order to help guide others in building a muon detector too. The design that I used is MIT's Muon Detector (https://github.com/spenceraxani/CosmicWatch-Desktop-Muon-Detector-v2), which although was an amazing design in terms of making it be possible for students to make their own detector, it had many faults which I address in this document.
[image of detector]

I first began with obtaining all of the components of the muon detector as guided by the documents on the muon detector github. Immediately I noticed the fact that the cost of many components was greater than what was listed. An example being the cost of the photomultiplier, which was greatly hiked up due to the fact that the original company that they bought the component from was bought by a bigger one. Despite the fact that the item is listed as being 48 dollars on the sheets, it is currently 91.41 dollars instead, having increased almost by 50 dollars. Because that company was the only readily available company that would make photomultipliers at reasonable prices, once it became acquired, the larger company was able to greatly increase the price without much competition, which is something that unfortunately happens quite often.
[photo of photomultiplier]
And that is not even accounting for the cost of solder, other equipment that was needed to make the detector properly, such as suggesting a desoldering hot gun in order to polish the scintillator plastic.

The instructions state that one should use a desoldering hot gun in order to polish the plastic scintillator, and I had wanted to buy one, but unfortunately all of the ones that were at affordable prices were of low quality. With a low quality air gun where the temperature of the hot air cannot be properly regulated, one could easily burn the scintillator, and considering the already high cost of this project, this would be quite discouraging.
[image of desoldering gun]
Due to this, I decided to buy some plastic polishing sprays and mixtures, which ended up working just as well to get rid of all of the scratches, but it did take me a bit to find the mixtures that worked best with this kind of plastic, those being _____.
[image of before and after polishing, or image of those mixtures]

Another problem with a heat gun is that it's easy to burn the scintillator without proper experience, while polishing at least can be done slowly while checking the progress. Of course, that does not mean that the whole polishing process went without any issues. Whilst polishing one of my scintillators, it slipped out of my hands and fell off the table. Not only did I have to chip away a large portion of the corners that became cracked with the fall, but I also had to spend much more time polishing it to ensure that the scratches would not affect the detector. I

encourage you to take the polishing process carefully and to not worry about the speed at which you are doing it, cause a slip could end up ruining your whole scintillator

Before completing the first one, I decided to start building the next one since I would want to have both either way. On my second trial, I noticed a disparity between what was being written and what was actually needed, with the components sheet asking for more components than were actually needed to build the detector. I found this out by noticing that I had parts left over even when I didn't buy them for two detectors. At first I had thought that it was in order to ensure that fragile pieces would be bought in bulk, but it appeared to be more of a mistake that slipped through the cracks because only certain not particularly special parts such as resistors and conductors had this mistake. Keep in mind that at the end of the day, this is open documentation that was made by college students, so some things will not always be perfect.
[image comparison of ordering sheet and sheet that lists where each part goes]

In terms of the actual soldering process, it all went pretty well as long as you are comfortable with SMD soldering. Considering that I had no previous soldering experience, I decided to first buy two practice sets in order to ensure that I would not mess up the soldering on the actual project. The first one I bought was ____, which was a TH project. TH means through hole, which indicates to parts that you solder through a hole, and SMD is a surface mount device, which indicates to parts that one needs to solder directly on the surface.
[picture of TH project]
Starting the process with a fun and simple TH project helps introduce you to the basics whilst giving you gratification of being able to immediately use it afterward as long as you follow the basic instructions. The second one was ____, which was a SMD project.
[picture of SMD project]
Although the code that it executed was much simpler, the enormous amount of little parts that it required you to solder in succession, as well as learning about parts which needed to be soldered in the correct direction all ensured that I would not be making such mistakes in the final project. You are free to try the final project without such preparation of course, but I highly recommend it as some of the parts in the muon project can be quite expensive and it would be a waste to throw them away just like that because of bad soldering.

Considering that there are several parts in the muon detector that are sensitive to static electricity, in order to ensure that I would not break those parts by conducting static electricity to them, I made a grounding lanyard (although the same exact thing can be done for a wrist band instead). I started off by wrapping the lanyard with aluminum foil, and then attached one side of an alligator clip to it. For the other side, I removed the plastic from the wire, and then wrapped it around the metal part that attaches the iron solder to the main device. Considering that the heating device then goes to the outlet, this ensures that all of the static electricity that I may gain goes out of me through the lanyard.
[picture of static electricity lanyard]

The detector is obviously mostly SMD based in order to ensure that it is quite small, but that restricts its capability in being a simple project for beginners. Due to the fact that the

diameter of the solder wire that I used was ___, which is larger than what should have been used for the legs of parts such as the DC Booster (such as a ___ diameter instead), I encountered issues with it when it came to troubleshooting. It was quite obvious from testing the voltage that needed to be after going through the DC booster, that that was the component with issues. But due to the fact that nothing appeared to be off, it was very difficult to figure out the mistake that I made, and it ended up being that on the first one, I simply didn't solder one of the legs properly, and on the second one, some of the solder remained between two of the legs. This is why I recommend making sure to clean out the spaces between the legs of such components. Another issue that arose with the DC booster was the fact that one of them, the ones that I received did not have labeling on it that indicated which direction it needed to face in. It took me going through several pictures and articles on how to identify the direction in order for me to tell by going through leg counts.

Then while wanting to test the OLED, I noticed that no matter how many different ones I used, they simply were not turning on. I decided to test out the arduino to check if there may be something wrong. I connected it to the computer through a breadboard and attempted to run a light flashing program (https://www.arduino.cc/en/Guide/NANOEvery) but could not get it to work or connect to the arduino. Thinking that the issue was due to the program, I attempted to run another one that was specifically made for the OLED which did not function either. Taking a deep dive into the program, I found out that through downloading CH340 where it was already installed on the computer, it interfered with the program. The original MIT design was before a newer Mac OS was released that had a built-in serial driver, which is why in its instructions, it says to download it whereas one should not with a version later than ____. In this situation, I used another computer to run the program, but it still wouldn't work. Uncertain of what was ultimately causing the issues, I decided to look into the manufacturer to find out that the amazon version of the Arduino Nano was in fact a fake and usually would not properly work (one review being: "I have read more websites on what to do to fix this. Yes, I uploaded and installed the CH341 driver. Yes I have tried the 328p processor with the new and old bootloaders. Fact is, I can't upload a program into this Nano. Without a program, it just plain won't work and there appears to be nothing I can do about it other than throw these away and use some other kind of board. Live and learn"), which explained the issue in connecting to the arduino. The creators of this project most likely decided to go with the amazon option in order to decrease the price as on the original website, only one arduino costs 20 dollars where on amazon one could get at least 3 for that amount.

Eventually I was able to fix this issue by installing the FTDIUSBSerialDextInstaller_1_4_7 driver, and finally, I was able to get the proper arduino working not only through a simple led program, but also through an oled program. Wanting to make sure that the oled would then work in the arduino itself, I went through the extremely tasking process of needing to take the already fake arduino out of the pcb, and then solder the new one in. Fair to say, make sure to check your arduino before soldering it because soldering it is an incredible pain. Finally I uploaded the code for the oled into the arduino on the pcb, and the proper screen with the muon count and etc came up!