Detector Changing SOP

**For Visible PMT:**

Operation: PMT is controlled by box with simple on switch and photosensor button. PMT output can be run through the delay generator to ensure fidelity with FPGA collection. Typically, I triggered on rising peak at around 2.5 V and sent a 5 V pulse from the delay generator. Recently the waveform from the PMT was higher than anticipated but this setting is currently working correctly. The output of the delay generator can be put through either of the FPGA lines for collection it will only change how the data is saved but now how it is extracted.

Alignment: PMT has a custom-built mount for attachment to the XYZ stages in detector box. Four screws mount through the mount plate to the bottom of the PMT which sits on top. Two ¼-20 with washers attach plate to stage. For the visible PMT, I use optical tube with a lens at the correct distance to focus on the detector area. The tube will fasten directly to the front of the PMT. Then the tube itself needs to be aligned to the monochromator output. I use tube from the monochromator focusing lens to bridge the gap to the lens collecting for the PMT to cut down the background. After rough visual alignment I turn down the lamp through the microscope until it is not perceptible through the eye piece. I dial up the lamp slowly while watching the trigger rate of the PMT on an oscilloscope. Once I have some increased trigger rate, I will switch to eye from R and back to double check that the signal is light moving through the monochromator. I then will maximize the signal by moving the stage slowly. Typically, the output spot will be smaller than the detector window for this PMT so this should not be difficult to maximize. I then lower the lamp light iteratively and maximize at each step. Move particle of interest to 989, 1130 for PMT collection before mapping.

**For IR PMT:**

Operation: PMT is controlled by controller with on-off toggle, photosensor button, and voltage dial. PMT on-off toggle should be toggled on. The PMT requires a cooling period before the photosensor button can be engaged. The second green light will turn on after it equilibrates. The PMT can then be fired. The voltage should be dialed down to minimum when it is initially turned on. The voltage can then be dialed to 700 for single photon counting. If the PMT is being used for light measurements instead of photon counting, do not dial to this high of a voltage. The output signal of the IR PMT is a negative TTL signal. I use the current to voltage amplifier set to 10^3 to amplify signal before the delay generator. The delay generator even with this amplification is set to -0.1 falling edge. I use the same output (5V square) from there to the FPGA. If the output seems incorrect, double check the waveform before and after the amplifier to ensure that the above trigger settings are correct (might have to adjust trigger level on delay generator dependent on output level.

Alignment: This PMT has a very large window and I only coarse aligned it. I have aligned this detector twice. I set it on a small box to get it to the correct height and have not fashioned a custom stage mount. With the PMT cap on, set the microscope output to R and turn the lamp up to maximum in a dark room with a big slit on the back of the monochromator. Coarsely align the light coming out of the monochromator with the PMT’s cap with it still on by adjusting the PMT’s and the box’s position. Once the light is hitting the cap, turn off the lamp and remove the PMT cap. Slowly dial up the light and ensure it is receiving light through the monochromator. Remember to use the longer wavelength filter cube. The filter cube will allow 806 nm excitation and collection of wavelengths longer than 900 nm. Move particle of interest to 989, 1130 for PMT collection before mapping.

**For Dual APDs**:

Operation: APDs do not have controller boxes and therefore when plugged in are on and light mitigation should be considered before plugging in. The APD output is adequate to be sent directly to the FPGA and the delay generator is unnecessary. After they are aligned, they can be plugged in and unplugged to turn the detectors off and on. Typically, I do this by plugging in a power strip to the far wall with both APDs connected to it. This is so I don’t have to touch any wires close to the APDs once they are aligned to avoid bumping since the alignment is so sensitive. Each APD will be attached to the FPGA. To check which APD is collecting which wavelength, you can scan the monochromator to 560 and see which APD still collects upconversion. Whichever APD has signal with the monochromator set to 560 is the APD that will collect 525 when the monochromator is set to 535. The file extraction won’t do separate spectrums without further coding (if needed I can do this) but will separate each APD’s time curves.

Alignment: Each APD has a custom-built plate for attachment to the stages. The APDs mount through the holes along the edge of the body of the detector. The plate mounts to the stage also with ¼-20 as with the visible PMT. The use of dual line is enabled by replacing the back slit of the monochromator with the two-slit plate. Place the slit sides out. I use the same lens to collect the monochromator output as used above in PMT alignments. The two wavelengths will come back together, crossing paths and then separate. The prism should be placed sufficiently far enough away where the two wavelengths have separated but close enough that the prism will reflect them both effectively. On either side of the prism’s cube attach lens tubing with the meniscus at the end of the tube. Coarsely align the APDs by placing them on stages such that the meniscus lens at the end of each tube is near each APD detection window. The meniscus lens focal length is short and the detectors will be very close to the lens when aligned correctly. Once they are close, turn on only one APD by plugging it in and sending the output to an oscilloscope. Dial up the lamp on the microscope until there is signal and maximize it. The difficult part here is that the detector window is small and although some signal may be hitting it, it is difficult to find the focus where maximum light will be collected. Maximize the signal in the plane perpendicular to the propagation of light into the detector. Then dial the detector towards or away from the lens and maximize again. If the new maximum is greater you are likely moving towards the focus spot. This can frequently take some time but when the focus is found the difference in signal will be quite apparent. Repeat this process with the other APD. After this has been done with the lamp, signal should be very high in each detector (~20k counts) even when the lamp is barely perceptibly on. Take a dense UCNP sample slide and move a bright object to 989, 1130. Redo the maximization process with UCNP fluorescence signal to ensure maximum signal for temperature detection. Again use 989, 1130 as rough field of vision alignment before mapping.