Lab Report:
July 1, 7, and 14

Purpose: To test new counter boards for general functionality, linearity, and for anomalous counts.

Test #1
Purpose: To test is to generally make sure the new boards work, and to see what ND filters would work when the lenslett array is being illuminated by the Zygo

Procedure:
Set-up
The lenslett array was mounted in the Zygo 5 axis stage, secured in place by a hose clamp. In order to get the lenslett array out of its holder, I had to disassemble the holder since the lenslett array is too big to slide out. Once mounted, the Zygo 5 axis stage was placed on an elevation stage to place the optical axis at the same hight as the Zygo. The Zygo itself was placed on its side on the bench immediately in front of the lenslett array.

Alignment
The lenslett array was aligned to the Zygo by back illuminating the lenslett array's central sub-aperture. In the Zygo alignment screen, a bright spot can be seen from this laser source, and the tip and tilt of the Zygo 5 axis stage was adjusted until this spot was on the cross-hairs. Once this rough alignment was done, the system was turned on, and smaller tip-tilt adjustments were made to get uniform illumination through all channels.

Testing
Once the Zygo and lenslett were aligned, the system was brought up in the standard way. With no light on the lenslett array and with lots of NDs in, the dark counts were checked to see that all channels were working. Channel #32 was dead, but all other channels were fine, with an average DC mean of 0.15. Some channels have a DC mean as low as 0.04, and a few as high as 0.5, and #30 had a very high DC mean of about 2.
Next the Zygo was turned on, and various combinations of ND filters were tried to see what combination would give as much signal as possible but stay below a DM mean of ~600 for the linearity test. It was found that using the 2.71mm and 2.16mm thick NDs was the minimum amount of ND for safe use with the Zygo, this arrangement yielding a DC mean of about 488. It was also found that #22 was hot, i.e. I observed about 50% higher counts on this channel than on neighboring channels. If this were just an alignment issue, then I'd expect that neighboring channels to have similar counts, but they do not. Other combinations used are:

NG1 3mm: 50 counts per phase
2.71mm and 2.01mm: average DC mean = 80 (#22 up to 200)
2.71mm, 2.16mm, and NG4 2mm: average DC mean = 44
2.71mm, 2.16mm, and 2.01mm: average DC mean = 0.94

Summary:
I was not able to do the linearity test since the NDs available weren't thin enough to put two together and still have enough light to work with. Channel #32 is dead, and #22 seems to be hot. Otherwise, everything looks fine with the new counter boards.

Test #2
Purpose:

To test for the system linearity and to investigate why channel #32 is dead

Procedure:
Setup and Alignment:
The setup used in test #1 was still in place, so no further alignment was necessary. Do do the linearity test, I got more thin NDs from the H36 bench.

Testing:
To investigate the dead channel, the system was powered up with no light on the lenslett array. As before, the average DC mean was 0.15 and channel #32 showed no counts. I then powered the system down and switched the #30 and #32 cables going into the counter boards. Upon turning the system back on, I found that channel #30 was not showing any counts and #32 was showing counts normally. Thus it seems that APD #32 is dead.
For the linearity test, the 2.71mm and 2.16mm NDs were in at all times. The NDs I used for this test, and the average DC mean I observed, is as follows:

NDs	DC mean	Relative Transmission
2.71mm and 2.16mm	492	100%
", and 1.56mm	165	33.6%
", and NG4 2mm	46.5	9.5%
", and 1.56mm and NG4 2mm	16.5	3.36%

I did notice that the average DC mean was not constant, but varied slowly. At first, when only the 2.71mm and 2.16mm NDs were in, the average DC mean was dropping at a rate of a count every few seconds. When more NDs were in, and thus the DC mean was lower, the average DC mean was slowing increasing at a rate of about a count per minute. This behavior seemed to slow down and eventually stop. I suspect it may have been from the APDs warming up.

Summary:
Based on the transmission of the 1.56mm and NG4 2mm NDs, I expected a combined transmission of 3.2%, which is very close to what was observed. Thus, the system, in the range from 500 to 10 counts, appears to be linear. APD #32 appears to be dead, and all counter channels work. It was observed that the average DC mean was slowly changing, but this may have been an effect of the APDs warming up since this effect slowed down and seemed to have gone away.

Test #3
Purpose:
To test the new counter boards for anomalous counts. Anomalous counts were previously observed with the old boards. We observed high counts on the channel numerically after the one being illuminated. On the computer monitor, we saw a count that was usually 2^n -1 every few seconds, and an unusually high DM mean, signal and signal mean. The computer monitor only shows the mean of 380 measurements, however, so this is not representative of what's happening in real-time.

Procedure
For this test, we want to illuminate each segment individually, and look for anomalous counts on the other channels. To illuminate individual segments, the laser was used rather than the Zygo.

Setup:
As in the first two tests, the lenslett array was mounted in the Zygo 5 axis stage, secured in

place with a hose clamp, and placed on the larger elevation stage. The laser itself was placed on the smaller elevation stage at the other end of the bench, as far away as practical. In addition to the NDs in front of the lenslett array, I placed a ND holder in front of the laser. After alignment, I placed a pinhole just before the lenslett array so a smaller beam would go into the lenslett array.

Alignment:

First, I elevated and swiveled the laser until the laser spot was on the center lenslett array segment (done with the NDs off, and the system powered down of course!). I then back illuminated the central segment and adjusted the tip-tilt of the 5 axis stage until its laser spot was on the aperture of the laser. Once this coarse alignment was done, I put all of the NDs back in and began the test. During the test, I used the tip-tilt adjustment to keep the lenslett array aligned with the laser by trying to maximize the counts in the channel I was illuminating.

Testing:

As before, it was found that with no light on the APDs, the average DC mean was about 0.15, and channel #32 was dead as usual. For use with the laser, I found that I needed the NG1 3mm in the lenslett ND holder, and from 1 to 3 of the NG4 2mm-like filters in the laser's ND holder. A careful eye must be kept on the counts, since this can change a lot from segment to segment, and as the tip-tilt adjustments are made. Once set up, I used the xy screws on the 5 axis mount to translate the whole lenslett array to change which segment the laser spot fell into. By centering on the central segment, I had just enough range with these screws to illuminate all segments. I illuminated each segment individually, and watched for anomalous counts, and saw none. Thus I didn't feel it was necessary to take capture data.

Summary:

Using the laser, each segment was individually illuminated, usually to a DC mean of a few hundred counts. During this time, no anomalous counts were ever observed.

Conclusions:

During these tests, the lenslett array was illuminated by both the Zygo and the laser to test for general functionality, linearity, and anomalous counts. All counter channels are working, although APD #32 is dead and channel #22 is hot. In the range of counts from ~500 to ~10, the system is linear. When the segments were individually illuminated, no anomalous counts were ever observed.