

1. INTRODUCTION

This report documents the status of the 90Prime CCD camera as of the upgrade in June, 2011. Changes include:

- CCD2 and CCD3 have been replaced with new detectors.
- CCD1 and CCD4 have been swapped (so now **90PrimeOne** mode uses what was CCD4).
- CCD1 and CCD4 have been cleaned.
- A vacuum leak was found and fixed in the dewar.
- New video preamps have been added to all four CCDs in order to reduce crosstalk and improve noise immunity at the telescope.

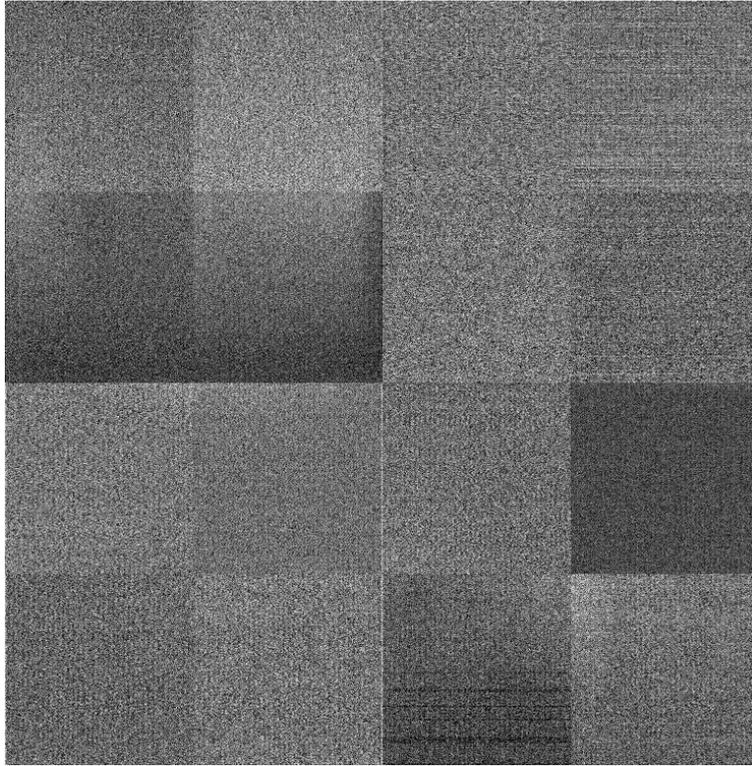
The -125 C focal plane operating temperature is slightly warmer than on previous observing runs. The increase in temperature is due to the heat load from the new preamps.

2. NOISE

We have optimized the noise as much as possible. The average read noise is 8.8 electrons rms. The average gain is 1.5 electrons/DN. The table below shows typical gain and noise values for each channel.

| Channel | Gain | Noise (e) |
|---------|------|-----------|
| 1 | 1.5 | 7.9 |
| 2 | 1.5 | 9.3 |
| 3 | 1.5 | 7.6 |
| 4 | 1.6 | 7.6 |
| 5 | 1.5 | 8.1 |
| 6 | 1.5 | 8.0 |
| 7 | 1.6 | 8.0 |
| 8 | 1.5 | 8.9 |
| 9 | 1.3 | 11.3 |
| 10 | 1.6 | 7.7 |
| 11 | 1.6 | 10.9 |
| 12 | 1.5 | 9.9 |
| 13 | 1.5 | 11.7 |
| 14 | 1.4 | 8.9 |
| 15 | 1.7 | 7.9 |
| 16 | 1.6 | 7.7 |

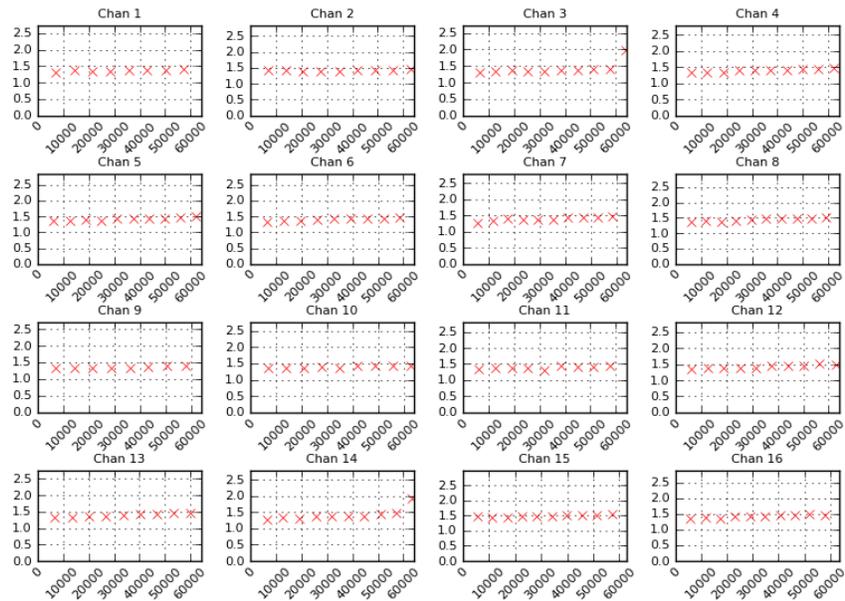
A typical bias frame is shown below.



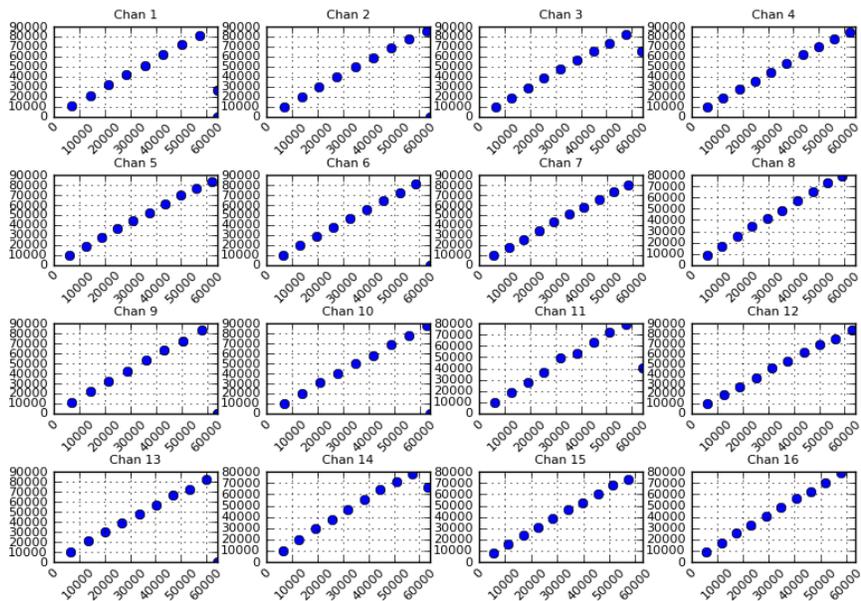
3. GAIN AND PHOTON TRANSFER

Full well is limited by the 16 bit analog to digital converter (ADC). Observations should be made with a maximum exposure level of about 60,000 DN to avoid ADC issues. The gain is set for the combination of best noise and linearity. Full well is about 90,000 electrons/pixel.

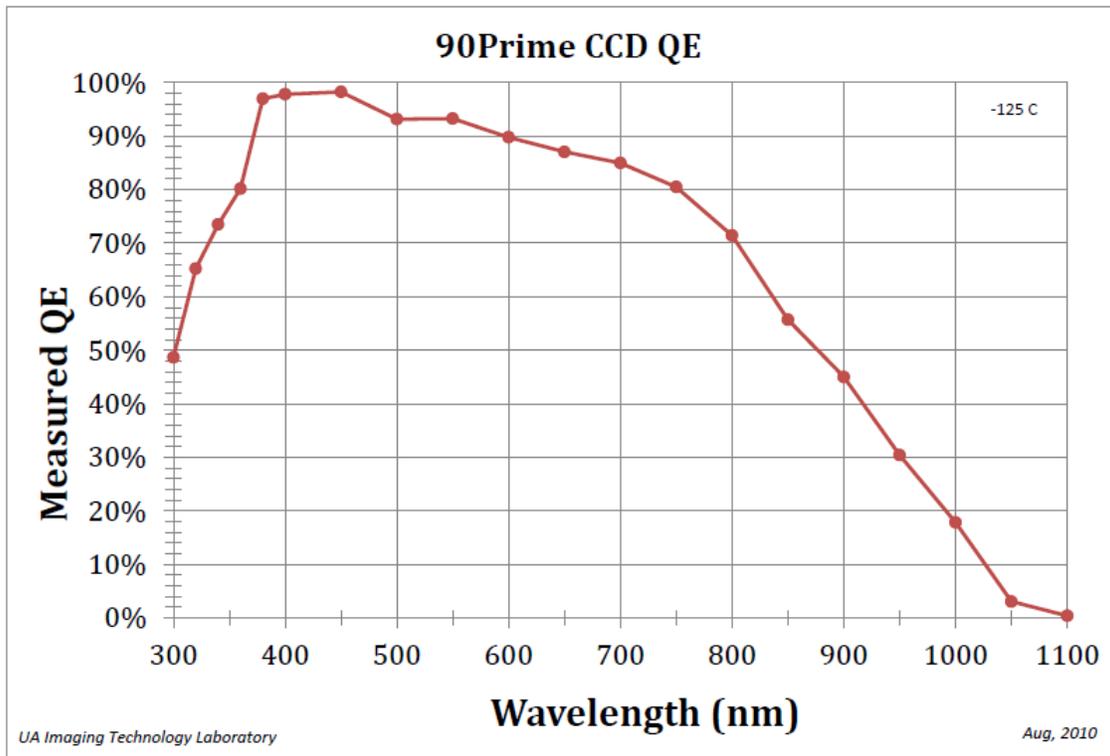
System Gain



Photon Transfer Curve



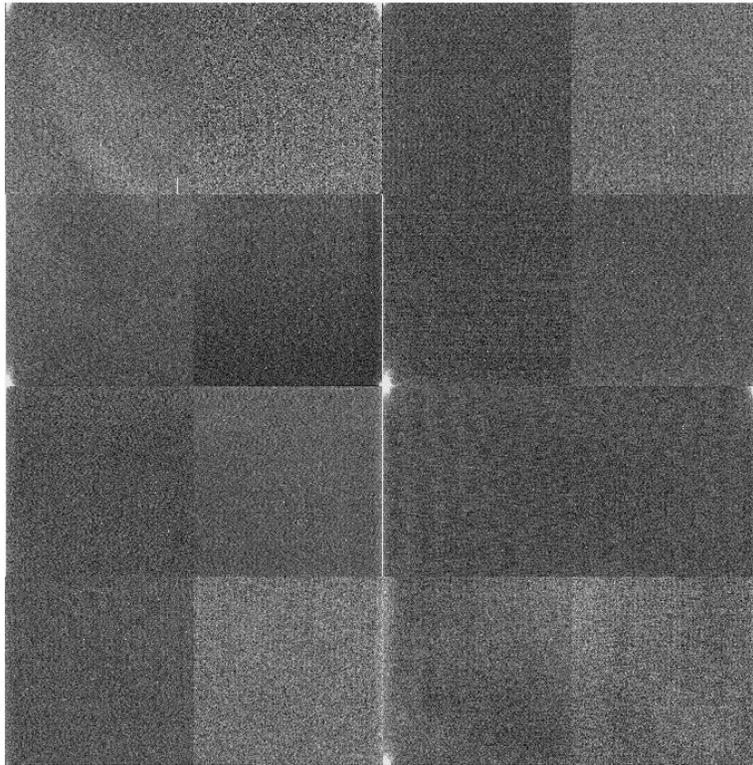
4. QUANTUM EFFICIENCY



5. DARK CURRENT

The average dark current of the four devices is 7.2 electrons/pixel/hour.

A typical 10 minute dark frame is shown below. There is some minor amplifier glow but no other significant features. The glow could be reduced but the read noise would increase.



6. FOCAL PLANE METROLOGY

David Ouellette of the University of Arizona Imaging Technology Laboratory has adjusted and measured the focal plane imaging surface position. A summary of his results are show below.

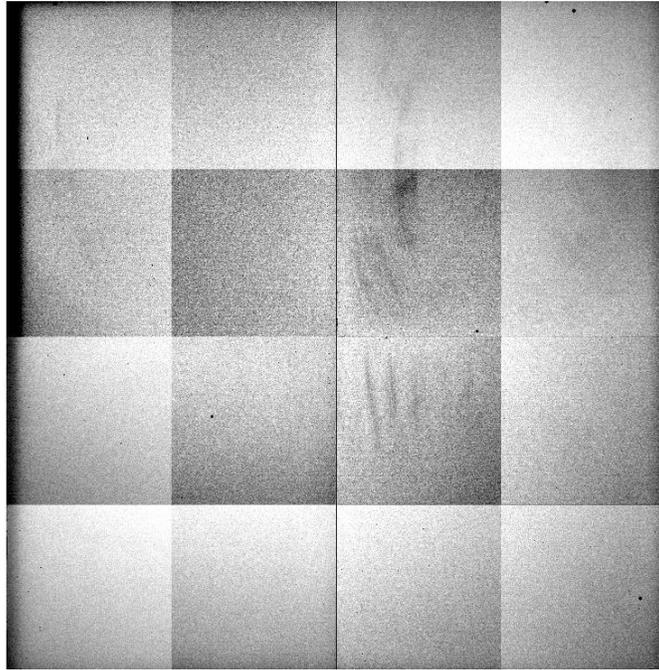
| Max - Min (TIR) | Millimeters |
|-----------------|-------------|
| CCD #1: | 0.013 |
| CCD #2: | 0.012 |
| CCD #3: | 0.014 |
| CCD #4: | 0.012 |
| FP Mosaic: | 0.019 |

| | | | | | | |
|--|-----------|-------|-------|-------|-----------|-------|
| | 0.010 | 0.005 | 0.008 | 0.007 | 0.008 | 0.003 |
| | | | | | | |
| | 0.009 | 0.002 | 0.007 | 0.015 | 0.007 | 0.009 |
| | #3 | | | | #4 | |
| | 0.004 | - | - | 0.003 | 0.013 | 0.005 |
| | | 0.007 | 0.004 | | | |
| | | | | | | |
| | 0.004 | 0.010 | 0.001 | 0.001 | 0.008 | 0.006 |
| | | | | | | |
| | 0.008 | 0.003 | 0.006 | 0.004 | 0.004 | 0.009 |
| | #1 | | | | #2 | |
| | 0.002 | 0.002 | 0.003 | 0.003 | 0.003 | 0.001 |
| | | | | | | |

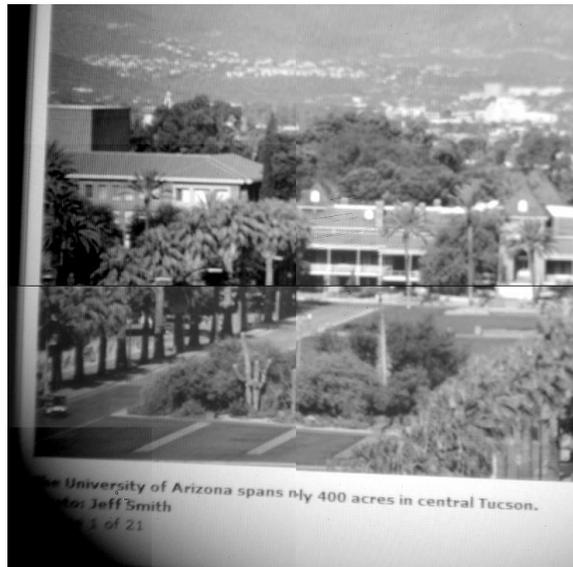
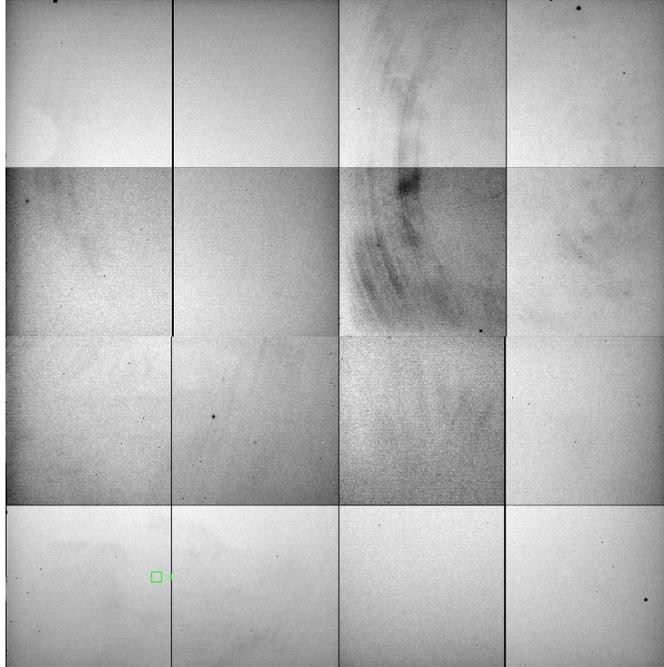
7. U-BAND FLATS

Below is a flat field image in the lab using our white LED projection system. Photo Response Non-Uniformity (PRNU) is ~1%, measured as

$$\left\langle \frac{\sigma_{amp\ n}}{\text{mean}_{amp\ n}} \right\rangle_{16\ \text{amps.}}$$



Below is a flat field laboratory image using 360 nm UV LEDs. PRNU for this near U-Band exposure is about 2%. The darkest region (CCD4, inner quadrant) is about 7% lower than the mean.



Screenshot of 90Prime image (from a web site) which verifies video de-interlace. The projection system vignettes in the lower left corner.

8. 90PRIMEONE MODE

90PrimeOne mode reads out only CCD1. This is now the detector which was previously CCD4. Specifications are the same as for 90Prime mode. We measure noise and gain as:

| Chan | Mean[DN] | Gain[e/DN] | Noise[e] |
|------|----------|------------|----------|
| 1 | 6311 | 1.52 | 7.5 |
| 2 | 7164 | 1.46 | 8.1 |
| 3 | 5642 | 1.48 | 6.9 |
| 4 | 5185 | 1.71 | 7.8 |