NAOMI CCD CAMERAS - TEST RESULTS

IRAF was used for all data reduction. IRAF co-ordinate system is different to SAOTNG system as used with our QI display server. I used the following designation, as is in XIMTOOL, for each quadrant of the CCDs when determining the CCD's characteristics in IRAF.

Q1	**Q2**
Q4	**Q3**

MASTER CCD - EEV No. A5244-10

CCD mounted in line with optical beam.
Water Cooler set to run at 8 C.
Version 1.3 of SDSU software running.
All testing performed at HIH speed, that is 1+1us per sample time. SLW speed testing was not carried out.
All motors in the WFS were powered up and the EPICS software loaded. Motors held in power down state.
Side covers to WFS were not fitted.

Images stored in /net/nenya/export/data/nenya2/dji/A5244-10.

BIAS and NOISE measurements

Taken in room darkness, shutter closed, 100 units of exposure time.
Measured at:-

Q1 = [10:30,50:70], that is, a box size of 20 x 20 pixels was used for statistics.
Q2 = [50:70,50:70]
Q3 = [50:70,10:30]
Q4 = [10:30,10:30]

Bias images are :- hihbias.fit, hihbias1.fit and hihbias2.fit. Calculated bias and noise as an average of the values from each image.

Q1 bias = 2372 ADU Q1 noise = 8.4 ADU

Q2 bias = 1829 ADU Q2 noise = 8.7 ADU
Q3 bias = 1490 ADU Q3 noise = 7.2 ADU
Q4 bias = 2217 ADU Q4 noise = 8.0 ADU

GAIN measurements

Gain calculated using photon transfer method. Light source was room strip lights, shutter opened and 100 units of exposure time. Repeated tests at 2500 ADUs of signal and 8000 ADUs of signal.

Images stored :- hihgain1.fit, hihgain2.fit, hihgain3.fit, hihgain4.fit

Q1 gain = 0.58 e/ADU => noise = 4.9e
Q2 gain = 0.56 e/ADU => noise = 4.9e
Q3 gain = 0.56 e/ADU => noise = 4.0e
Q4 gain = 0.55 e/ADU => noise = 4.4e

DARK Current measurements

Measured with lights out, shutter closed and black cloth over camera. Took 5s and 10s exposures, images are dark5s.fit and dark10s.fit. Calculated dark current as follows:-

$$\text{DARK current rate} = \frac{\text{dark10s} - \text{dark5s}}{5}$$

Dark current rate = 20 e/pixel/second.

Also see image dark10s.fit which shows the few hot pixels on this device. They are not a problem at the normal readout rates to be used from NAOMI.

LINEARITY Measurements

Measured linearity to first order using room strip lighting (not advisable !!!). Did a 10 unit exposure then subtracted this from all subsequent exposures to subtract for bias (!!). Found average mean value from this new image over all four quadrants, this therefore included the linearity errors from all 4 outputs into one figure - not normally advisable but done for speed. Exposure time increased in logical (!!) steps from 50 units to 20000 units. The deviation of the measured value against the expected value was then calculated using the 50 unit exposure as the expected value.

Linearity shown to be good to approximately 1% from at least 20e up to approximately 5000e. I'm sure that its good all the way up another decade but didn't have time to check in more detail. Images stored as lin50.fit, lin100.fit,……lin20000.fit.

EXTERNAL NOISE characterisation

Checked to see the effects of moving motors when reading out the CCDs. Moved the X and Y pick-offs, the fore-optics and the camera mechanisms in a co-ordinated fashion whilst reading out the CCD. No noise increase seen, check image moveallmotors.fit.

OTHER OPERATION MODES

The other readout modes have been checked only for functionality, that they produce the right number of pixels etc. They have not been checked for linearity etc and noise measurements have been hard to quantify because there are so few pixels to get a good statistical analysis. The alternative is to store many frames but time was not available for detailed analysis. Looking at the images visually, they seem "clean". Also most of these other readout modes use the same pixel routines at the full frame readout mode. I therefore expect the linearity etc to be as already quantified above.

SLAVE CCD - EEV No. A5244-11

CCD mounted in line with optical beam.
Water Cooler set to run at 8 C.
Version 1.3 of SDSU software running.
All testing performed at HIH speed, that is 1+1us per sample time. SLW speed testing was not carried out.
All motors in the WFS were powered up and the EPICS software loaded. Motors held in power down state.
Side covers to WFS were not fitted.

Images stored in /net/nenya/export/data/nenya2/dji/A5244-11.

BIAS and NOISE measurements

Taken in room darkness, shutter closed, 100 units of exposure time.
Measured at:-

Q1 = [10:30,50:70], that is, a box size of 20 x 20 pixels was used for statistics.
Q2 = [50:70,50:70]
Q3 = [50:70,10:30]
Q4 = [10:30,10:30]

Bias images are :- hihbias.fit, hihbias1.fit and hihbias2.fit. Calculated bias and noise as an average of the values from each image.

Q1 bias = 1924 ADU Q1 noise = 7.6 ADU
Q2 bias = 1556 ADU Q2 noise = 7.5 ADU
Q3 bias = 1560 ADU Q3 noise = 7.1 ADU

Q4 bias = 1976 ADU Q4 noise = 7.8 ADU

GAIN measurements

Gain calculated using photon transfer method. Light source was room strip lights, shutter opened and 100 units of exposure time. Repeated tests at 2500 ADUs of signal and 8000 ADUs of signal.

Images stored :- hihgain1.fit, hihgain2.fit, hihgain3.fit, hihgain4.fit

Q1 gain = 0.55 e/ADU => noise = 4.2e
Q2 gain = 0.57 e/ADU => noise = 4.3e
Q3 gain = 0.57 e/ADU => noise = 4.1e
Q4 gain = 0.55 e/ADU => noise = 4.3e

DARK Current measurements

Measured with lights out, shutter closed and black cloth over camera. Took 5s and 10s exposures, images are dark5s.fit and dark10s.fit. Calculated dark current as follows:-

$$\text{DARK current rate} = \frac{\text{dark10s} - \text{dark5s}}{5}$$

Dark current rate = 13 e/pixel/second.

Also see image dark10s.fit which shows the few hot pixels on this device. They are not a problem at the normal readout rates to be used from NAOMI.

LINEARITY Measurements

Measured linearity to first order using room strip lighting (not advisable !!!). Did a 10 unit exposure then subtracted this from all subsequent exposures to subtract for bias (!!). Found average mean value from this new image over all four quadrants, this therefore included the linearity errors from all 4 outputs into one figure - not normally advisable but done for speed. Exposure time increased in logical (!!) steps from 50 units to 100000 units. The deviation of the measured value against the expected value was then calculated using the 50 unit exposure as the expected value. Images stored as lin50.fit, lin100.fit,……lin100000.fit.

Linearity shown to be good to approximately 1% from at least 20e up to approximately 20000e. I'm sure that its good all the way up another decade but didn't have time to check in more detail.

EXTERNAL NOISE characterisation

Checked to see the effects of moving motors when reading out the CCDs. Move the X and Y pick-offs, the fore-optics and the camera mechanisms in a co-ordinated fashion whilst reading out the CCD. No noise increase seen, check image moveallmotors.fit.

Tests not performed.

At a earlier stage of development the CCDs were tested for best noise performance and figures of < 3.5e were easily obtained. However these figures were obtained at the SLW readout speed which slows the pixel routines down by a factor of two and likewise the frame readout rates. Likewise the linearity was not checked in this readout mode. This mode of operation is still available to the NAOMI system by sending the relevant command to the SDSU controllers.

The effect of moving other mechanisms in the whole system on the CCD noise performance was not evaluated. Usually these other mechanisms will not move during readout. However we still await to see the effects of the FSM and the DM on the detector noise performance.

I have sometimes seen sudden bias changes on one of the CCDs while moving the camera carriage. This did not occur often so it has been hard to chase this problem. I believe it due to movement on the cables, especially the output/bias cable.

The Quantum Efficency (QE) of the CCDs was not tested because of lack of time. Normally this type of CCD is very stable and it is expected that their QE will be as advertised by EEV for this device type. This equates to approximately 60% at 400nm, 80% at 600nm, dropping to approximately 25% at 900 nm.