Document Title	Initial Science detector 41 test results
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CHANGE RECORD

Issue	Date	Section affected	Change Description
0.1	8/11/02	All	First Draft.

APPLICABLE DOCUMENTS

Reference	Document Title	Document Number	Issue & Date
AD1	WFCAM Functional and Performance Requirements Document	1.1 D 035 G	V1.6. 01/11/01
AD2	WFCAM System Performance Budgets	1.1 D 020 G	V0.3 15/04/02
AD3	WFCAM-UKIRT opto-mechanical ICD	1.1 D050 O	V1.4. 30/04/02

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1 SUMMARY

Tests have been carried out on the first WFCAM science device (no 41), using 8 parallel channel readouts per quadrant. A summary of the results is as follows

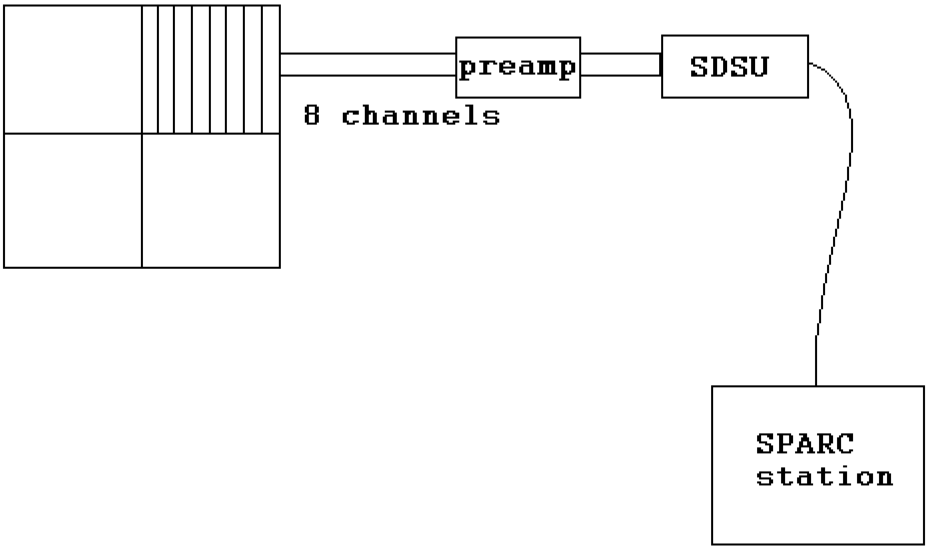
- image persistence effects between exposures are negligible and almost unmeasureable.
- a reset anomaly is present in CDS (correlated double sample) exposures and is dominated by a top to bottom gradient
- the reset anomaly appears stable and the difference of two frames ~10 min apart removes it completely.
- crosstalk between channels and quadrants is at the level of 1.7E-3. The crosstalk arises in the detector rather than the controller.
- system noise is currently unnacceptably high (50e) and work on this is continuing
- there is one bad/hot pixel patch in quadrant two and one dead column (column 408) in quadrant 4.

Test setup

Tests of Hawaii-2 #41 science detector were made in the test cryostat, which includes a He closed cycle refrigerator, and temperature stabilization of the detector. Detector temperature stability was good to the mK level.

In the absence of an SDSU 32 channel system, tests were carried out using an 8 channel controller and separate cabling to enable each quadrant of the detector to be tested separately.

A pulsed IR LED was used for illuminating the detector. Illumination control was achieved by setting the the number of pulses sent to the LED between the two reads of a correlated double sample.



SDSU Voodoo software was used for all testing.

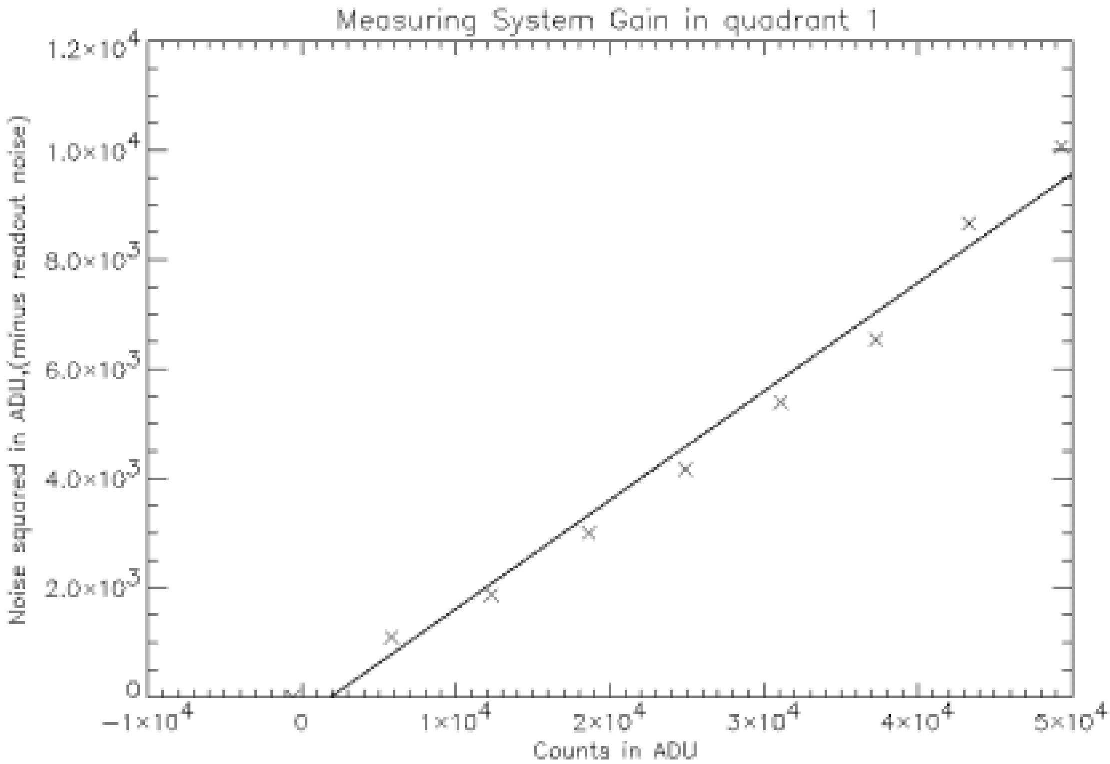
Initial tests were carried out using a row-by-row read/reset/read scheme, but this was then changed to a more usual global reset followed by two reads from which a CDS frame was formed.

2 SYSTEM GAIN AND READ NOISE

System gain was determined through a photon noise curve as follows. Each Correlated Double Sample frame (CDS) is the result of two reads. The difference of two CDS frames has four lots of read noise, so that

$$\sigma^2 = 4.r^2 + \tfrac{2}{a}.N$$

where σ is the standard deviation in the difference of two CDS frames, r is the read noise in a single read and N is the number of photoelectrons detected in each CDS frame, and a is the conversion gain in electrons per ADU. (σ^2-$4r^2$) was plotted against N. The slope was fitted by linear regression to give the value of 2/a and hence the gain.



The following values were derived.

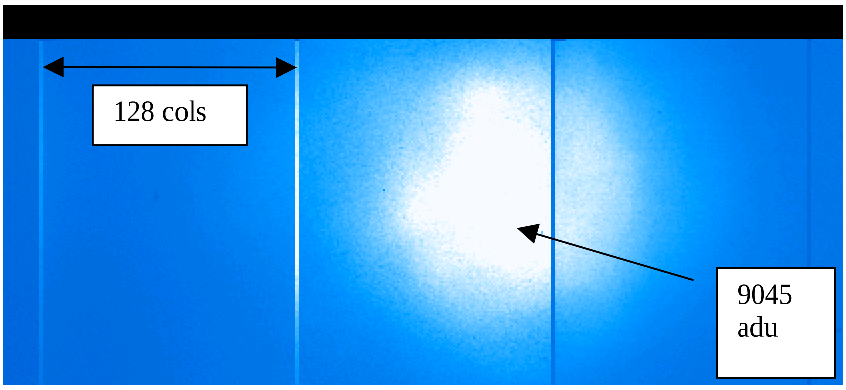
System gain averaged over 4 quadrants : 5.2 electrons per ADU
Read noise in electrons (for a single read) : 50 electrons

The read noise is currently high, and outside specifications. Investigations are continuing as to its cause.

3 IMAGE PERSISTENCE TESTS

3.1 UNSATURATED SPOT

- An isolated LED spot was projected onto quadrant 2. An exposure was taken, and then the LED switched off.
- A series of dark frames over 10 minutes were taken.
- CDS frames were obtained.
- A "dark" (the last in the series) was subtracted off the frame with the LED spot, and the first dark frame immediately after it.



Quadrant 2 with LED spot at top.

The first dark frame taken approximately 10 seconds after illumination showed no evidence of any persistence. Statistics in the second frame on the difference between the spot region and a clear region showed a median count of 1 ADU +/- 1. Adopting 3 sigma as 3 ADU, we can say that any persistence is at a level < 3E-4.

What is evident is a peculiar dislocation of the first two columns in each readout, as if columns are allocated to the wrong readout!

3.2 HEAVILY SATURATED SPOT

The LED spot was used and set to saturate in a 5 second exposure. Results were reduced as above, producing two frames,

- CDS with saturated spot - dark taken minutes after
- dark taken immediately after saturation - dark taken minutes later

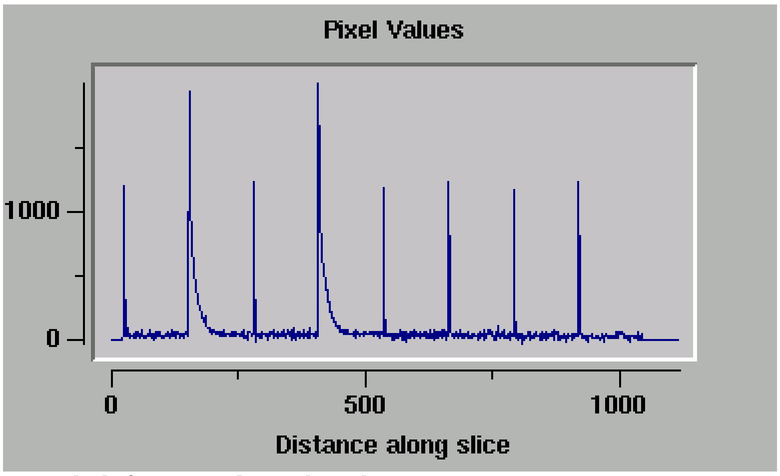
The result showed an extremely faint residual image in the first dark (~20 seconds after saturation) after saturation at a level of 1.8E-4 of the saturation level.

4 RESET ANOMALY

4.1 INITIAL PROBLEMS

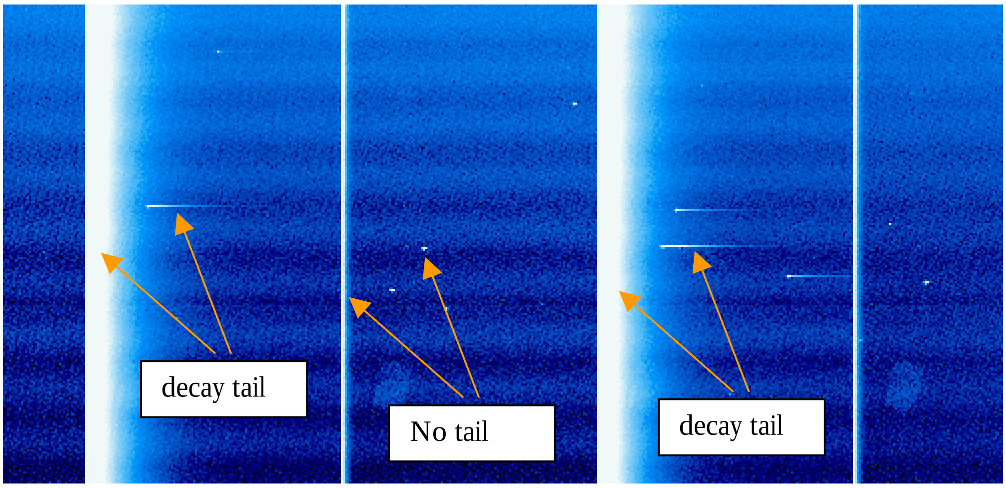
4.1.1 offset for first few columns of each channel

As shown in the cut through the 1024 columns of a quadrant, there seemed to be a glitch associated with the first one or two pixels read out in each row in each CDS frame. The situation is worse in channels 2 and 4 (in this diagram) where the decay occupies 20-40 pixels.



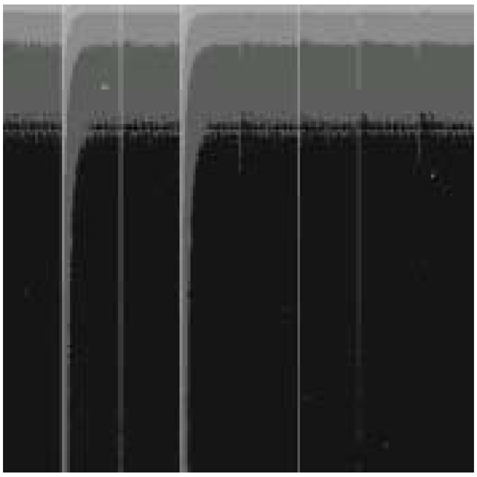
CDS dark frame, 8 channel readout, 1 sec exposure.

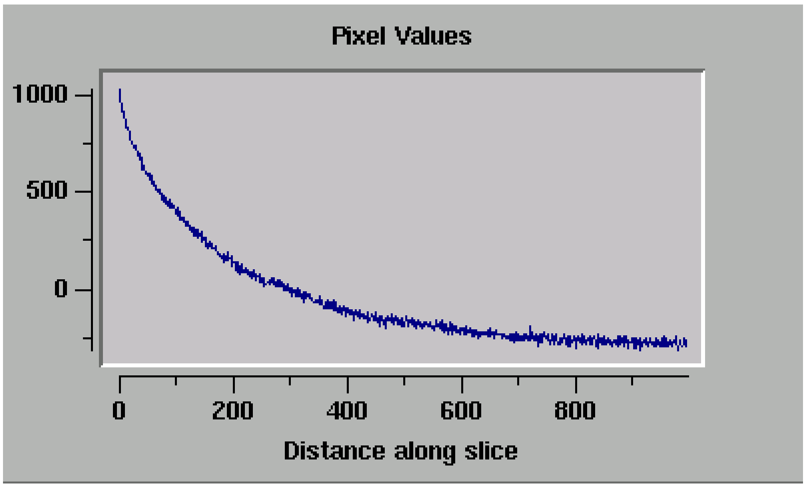
Channels 2 and 4 which appear to have a worse time constant for the decay at the beginning of each row also show a long decay time in hot pixels, which is absent from the other channels as shown here.



4.1.2 offset from top to bottom of the detector quadrant

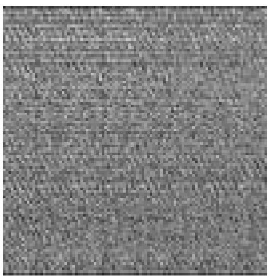
There is also an offset gradient in a CDS frame from top to bottom of each quadrant of the detector of order 1000 ADU. This is illustrated in the following picture and slice from top to bottom of quadrant 4.





4.1.3 stability of offset anomaly

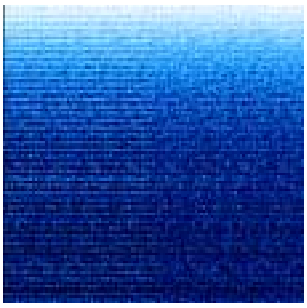
The stability of the offset prior to clock timing adjustments anomaly was studied by subtracting two dark CDS frames taken with 5 second exposures and separated by 1, 5 and 15 minutes. Results are as follows.



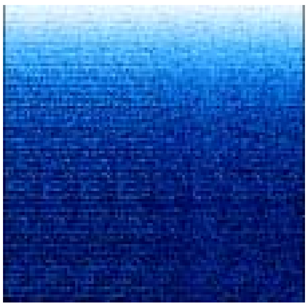
As can be seen there are residual features associated with columns 2 and 4 which seem to drift with time and so do not subtract off on timescales longer than a minute or two. The top-to-bottom gradient seems to be reasonably stable and vanishes in the difference frames. However, the anomaly at the beginning of channels 2 and 4 seems to vary with time and does not subtract off very well in frames separated by more than a minute or so.

4.2 PERFORMANCE AFTER SYSTEM MODIFICATIONS

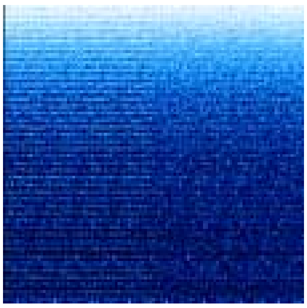
The channel offsets and decay constants were largely removed by DJI through modifications to clock timing. Following these adjustments the frame was much cleaner. The following shows a CDS dark frame. These tests were made with a global reset CDS mode.



With improvements to the reset anomaly the CDS frames are very clean and the top-to-bottom gradient subtracts off cleanly. The following shows the effects of subtracting two CDS frames taken 10 minutes apart.



minus



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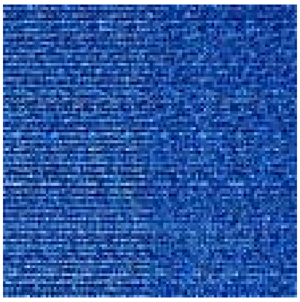
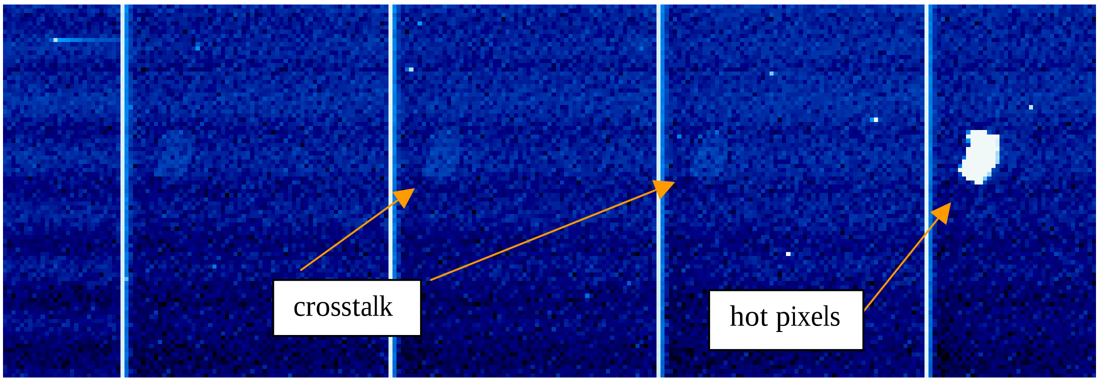


Residual non-Gaussian noise is evident in the final image.

5 CROSSTALK

Crosstalk was examined by studying a small region of hot pixels. Crosstalk "ghosts" are apparent in other channels (and other quadrants!) at the same position.



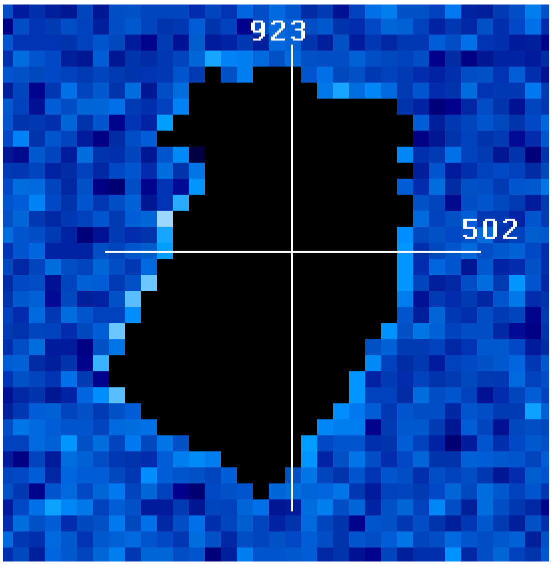
The crosstalk images are weaker by a factor of 1.7E-3 compared to the hot pixels.

The crosstalk is present in ALL quadrants of the detector, even if the controller was not connected to the quadrant having the hot pixel patch. This shows that the crosstalk arises in the detector and not the SDSU controller.

6 BAD/HOT PIXELS

The detector has a scattered distribution of bad pixels, with some larger patches - some of which are probably dust - the surface of the detector does not appear to be very clean.

Two particularly bad areas stand out. The first is a dead pixel area in quadrant 2 at position (923,502). This is shown here.



An estimated 317 pixels in the patch have QE<10% of the median QE.

A second problem is what appears to be a dead column in quadrant 4 at column 408.