IR CAMERA

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Notification List

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1 SCOPE

This document presents the results of FPA tests performed during :

- FPA AIT
- Camera AIT-1 thru' AIT-4c.
- Camera 'all-up tests'
- Camera AIT-4d.
- Camera 'all-up tests b'

2 ACRONYMS AND ABBREVIATIONS

ADxx	Applicable Document number xx
ADU	Analog-to-Digital Unit
AG	Autoguider
AIT	Assembly Integration and Test
AIV	Assembly Integration and Verification
ATC	UK Astronomy Technology Centre
AQ16	IRACE 16 channel data acquisition module
CCD	Charge Coupled Device
CDS	Correlated Double Sampling
CLDC	IRACE Clock and Bias module
e-	electron
EMC	Electromagnetic Compatibility
ESO	European Southern Observatory
FPA	Focal Plane Assembly
ICD	Interface Control Document
IR	Infrared
IRACE	Infrared Array Control Electronics
LOCS	Low Order Curvature Sensor
LOCSAG	Low Order Curvature Sensor and Autoguider
PCB	Printed Circuit Board
PID	Proportional Integral Derivative
RAL	Rutherford Appleton Laboratory
RDxx	Reference Document number xx
ROIC	Read Out Integrated Circuit (also known as a mux)
RTD	Real Time Display
RVS	Raytheon Vision Systems
UoD	University of Durham
VIRGO	Raytheon 2K x 2K HgCdTe IR detector
VISTA	Visible and Infrared Survey Telescope for Astronomy
VPO	VISTA Project Office
WFS	Wave Front Sensor

3 APPLICABLE DOCUMENTS

AD 1	VISTA IR Camera Tech Spec	VIS-SPC-ATC-60000-00004
AD 2	IR Camera Focal plane assembly Sub-system Requirements Specification	VIS-SPE-RAL-06030-0010
AD 3	Detector Controller Technical Specification	VIS-SPE-RAL-06035-0005

4 REFERENCES

RD 1	IR Detector Co-Planarity measurement	VIS-PLA-RAL-06093-4036
RD 2	Alignment of optics, report on final configuration	VIS-PLA-RAL-06093-4003
RD 3	RVS Test Data Pack for VISTA Detector Module Serial No.: VM301-nn-SCA.	
RD 4	AIT-2 Optical Alignment Measurement Results	VIS-PLA-RAL-06093-4032
RD 5	Stray Light Observations and Mitigations	VIS-TRE-RAL-06012-3001
RD 6	VISTA IR CAMERA Verification of EMC	VIS-TRE-ESO-24000-0001
RD 7	FPA Circuit Diagrams	VIS-DWG-RAL-06034-0001
RD 8	Summary of Final Dark measurements on VISTA during final testing (3).doc	
RD 9	Dark Exposure Properties of VIRCAM Detectors.htm (Jim Lewis and Sam Newman)	VDF-TRE-IOA-00008-0012 (Draft 20061021)
RD 10	VIRGO multiplexer Cold Tests Report	VIS-TRE-ATC-06032-0004
RD 11	VIRGO Module SCA-26 Test Report	VIS-TRE-ATC-06032-1026
RD 12	VIRGO Module SCA-32 Test Report	VIS-TRE-ATC-06032-1032

5 FPA AIT

During FPA AIT, from February to July 2005, the following operations were carried out :

- Testing of FPA PCBs, cables and flex cables.
- Cleaning of mechanical and electronic parts.
- Martec plate thermal wiring.
- Thermal plate wiring and electrical check.
- Various FPA assembly trial fits.
- IRACE PCI card tests.
- Testing and tuning of the thermal control system, using the 'autotune' facility of the Lake Shore 332 temperature controller.
- Testing of the full IRACE system in the RAL AIV lab.
- Trial fit of FPA into cryostat (no detectors fitted, just 16 dummy aluminium blocks).
- Electronic tests to ensure that it was safe to fit detectors in all 16 locations.
- Mounting of the engineering grade detectors #26 and #32 and four muxes.
- Completion of the FPA assembly (26 July 2005).

6 Camera AIT-1

6.1 Summary

During Camera AIT-1 the following operations were carried out :

- 1 August 2005 - two muxes (mux 4/1D, mux 2/2C) & one engineering grade detector (#32/2D), were operated for the first time (warm).
- 2 August 2005 - an early EMC interference test was carried out, in conjunction with Paul Clark operating the LOCSAG CCDs.
- 4 August 2005 - the IRACE configuration files were modified for operation with two CLDC cards.
- 9 – 15 August 2005 - cold tests were carried out with engineering grade detectors #26 and #32 and the four muxes.

6.2 Early EMC tests

Table 1 shows the results of the warm early EMC interference test, performed on 1 August 2005. During this test the VIRGO IR detectors were read out both with and without the LOCS and AG CCDs running. It can be seen that operation of the WFS and AG CCDs did not cause an increase in the noise of the engineering grade detector and muxes.

LOCSAG CCD status	Standard deviation in ADUs in a 245x289 box on mux 2 image.	Standard deviation in ADUs in a 245x289 box on eng grade detector #32 image.
LOCS off, AG off	175.6 to 176.0	9.27 to 10.22
LOCS on, AG on (5Hz)	174.9 to 175.5	9.13 to 9.79

Table 1 Early EMC interference test results.

Another EMC interference test was performed on 9 August 2005, with the camera cold. It was again found that operation of the AG CCDs did not cause an increase in the noise of the engineering grade detector and muxes.

6.3 Thermal performance

During AIT-1 it was found that, with all 3 cold heads running, the thermal control system was unable to bring the thermal plate up to the required temperature of 70K.

With only 2 cold heads running, however, the required thermal plate temperature of 70K was achieved.

Table 2 shows the camera AIT-1 thermal performance in more detail.

Number of cold heads running	Lake Shore 332 Ts (thermal plate set point)	Lake Shore 332 Ta (thermal plate temperature)	Lake Shore 332 Heater power	Lake Shore 218 #3 Detector temperatures
3	70.000K	~58.0K	100% High	~62.0K
2	70.000K	70.000K +/- 2mK	5% High	75.5K 75.8K 76.5K

Table 2 AIT-1 thermal performance.

This problem was addressed prior to AIT-2 by changing the thermal plate resistor values. This increased the maximum power available from the Lake Shore 332 from 15W to ~35W.

6.4 Images

Figures 1 and 2 show double correlated cold images taken with engineering grade detectors #32 and #26, during Camera AIT-1.

Figures 1 and 2 compare well with images taken at Raytheon [RD 3] and the ATC [RD 11, RD12].

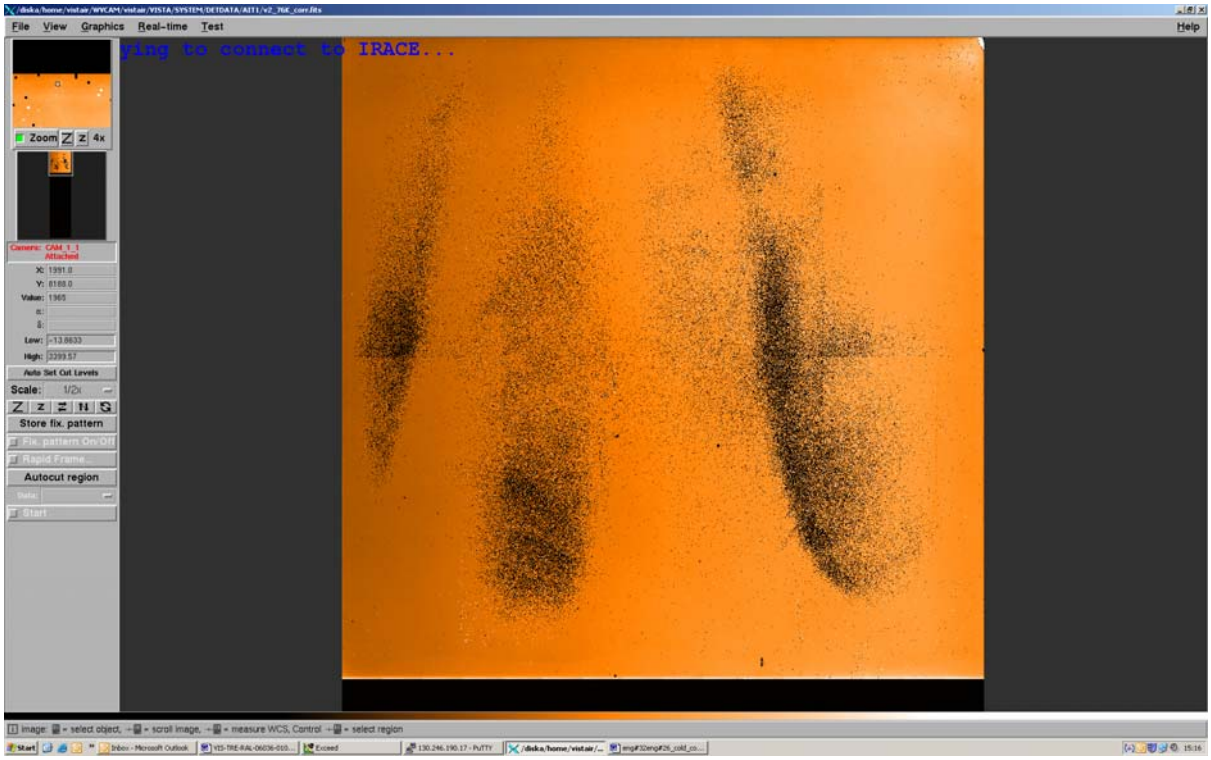

Figure 1 Double correlated cold image taken with engineering grade detector #32, during Camera AIT-1

Figure 2 Double correlated cold image taken with engineering grade detector #26, during Camera AIT-1

Figures 3, 4, 5 and 6 shows double correlated cold images taken with the four muxes, during Camera AIT-1.

Operation of the muxes, using the same bias voltages as the engineering grade detectors, was not entirely satisfactory. Despite this, there is reasonable similarity between muxes 1, 2 and 3 and the results obtained at the ATC [RD 10] (mux 4 was not tested at ATC, as it was on loan from ESO).

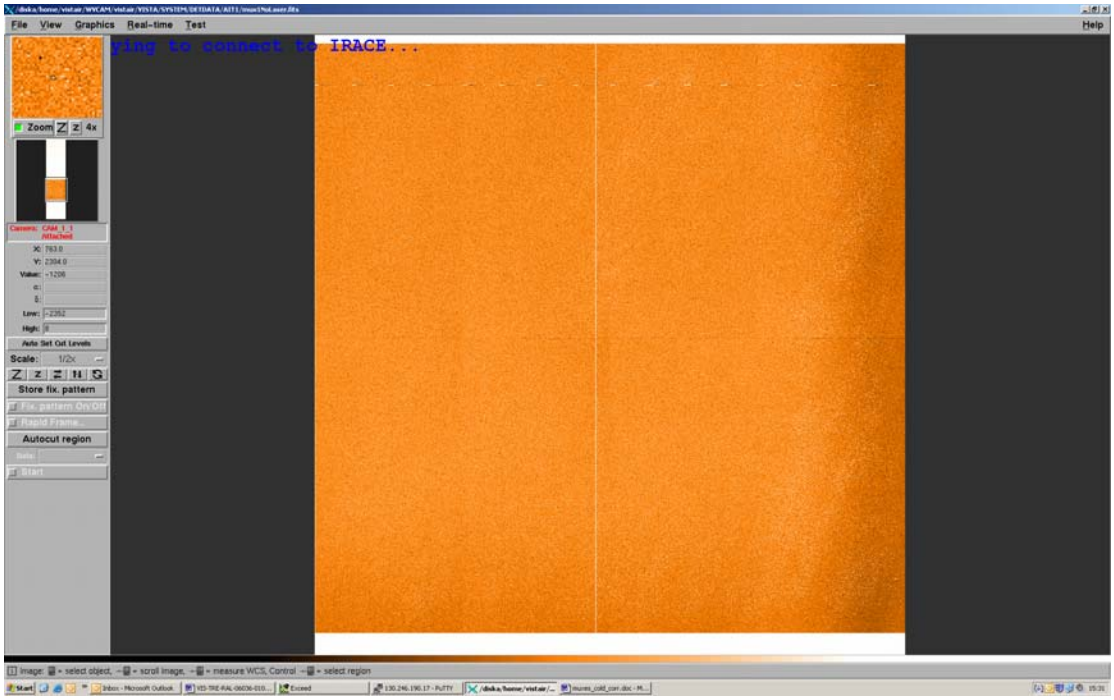

Figure 3 Double correlated cold image taken with mux 1, during AIT-1

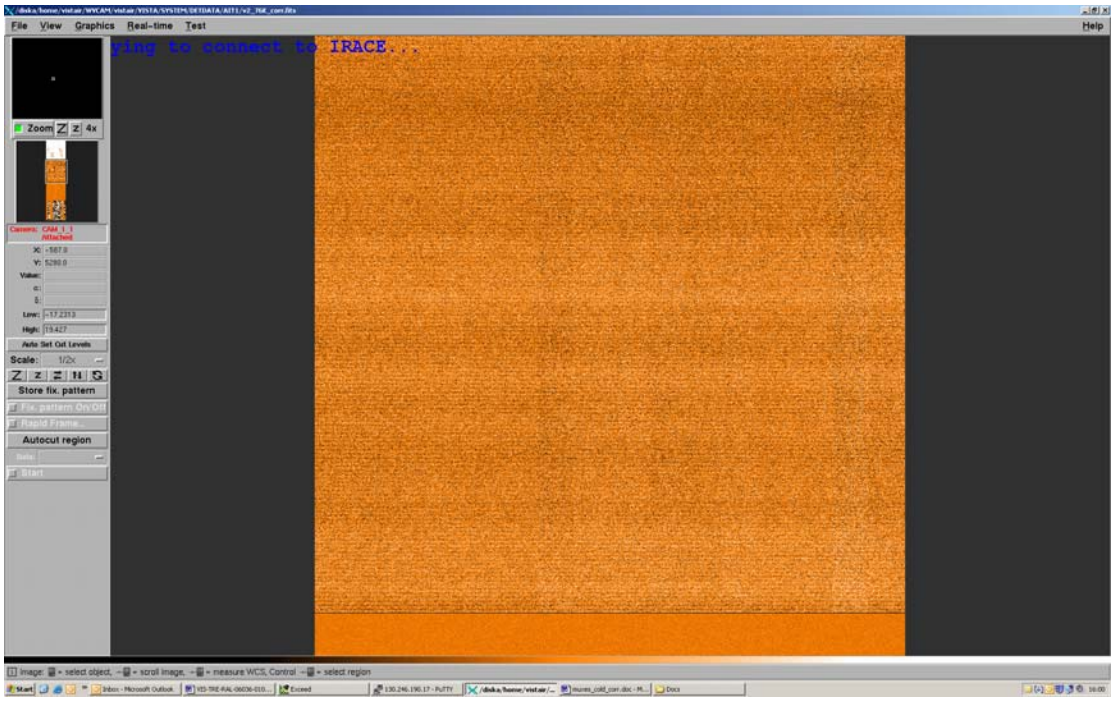

Figure 4 Double correlated cold image taken with mux 2, during AIT-1

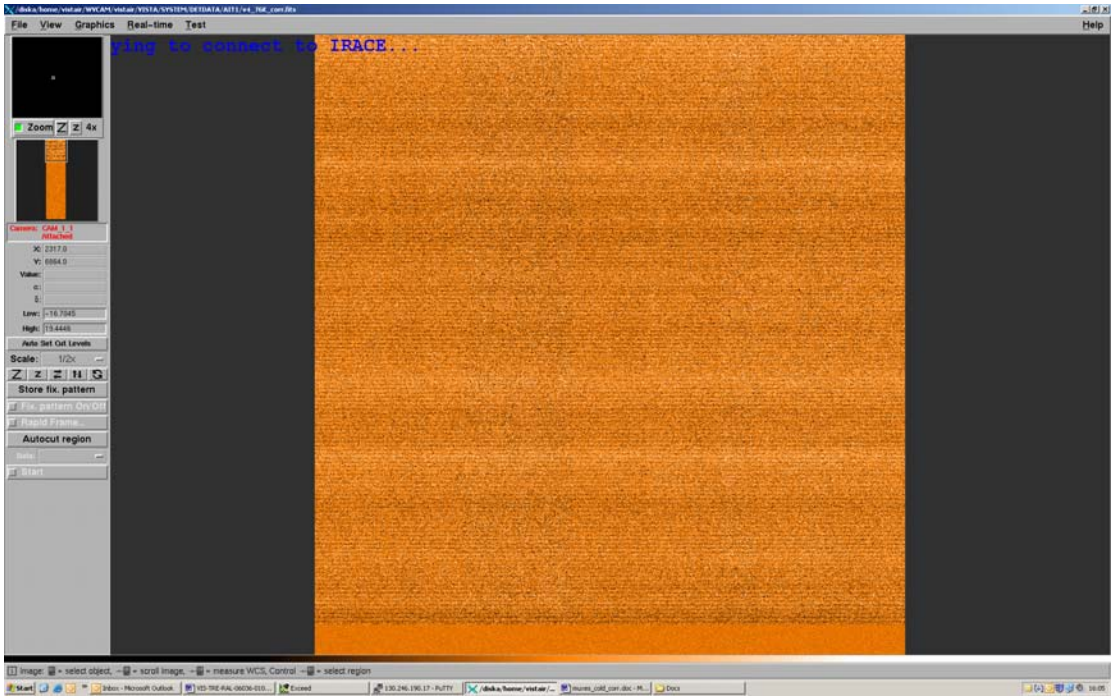

Figure 5 Double correlated cold image taken with mux 3, during AIT-1

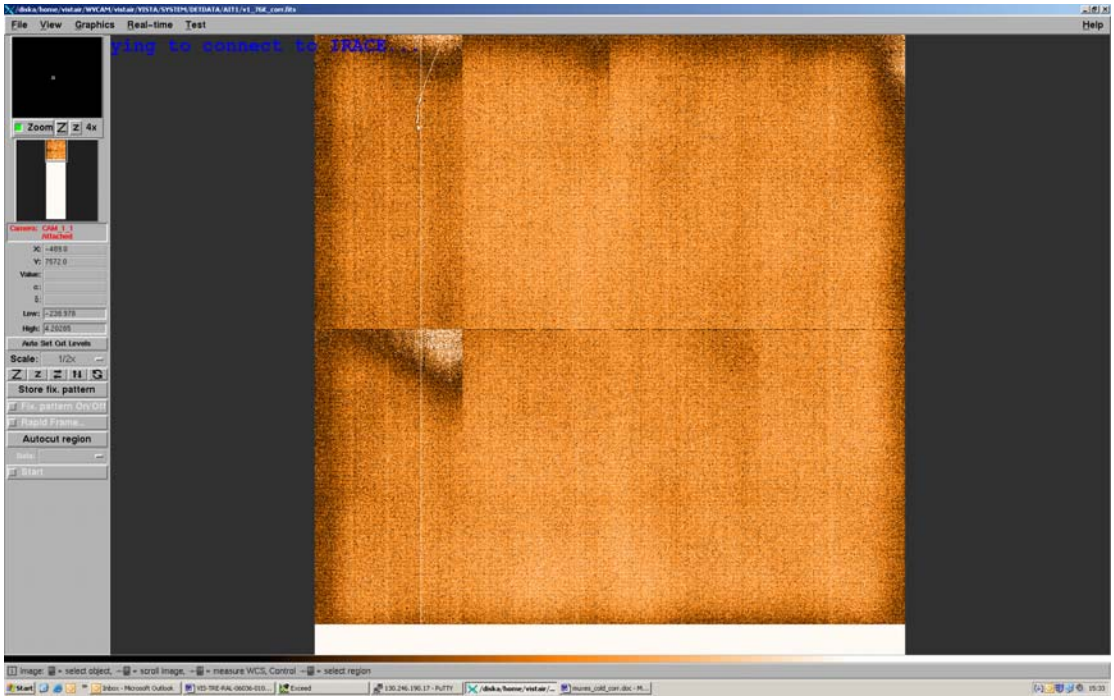

Figure 6 Double correlated cold image taken with mux 4, during AIT-1

6.5 Noise tests

During AIT-1 simplified noise and gain tests were carried as a means of roughly checking the performance. The simplified noise and gain tests makes use of the statistics feature of the ESO RTD and is carried out as follows :

- Pairs of double correlated images are taken for a range of exposure times.
- The first exposure in each pair is stored as a fixed pattern by the display.
- The second exposure in each pair has the first image subtracted from it, by selecting Fixed pattern On.
- The statistics option is then used to measure the standard deviation in a box roughly 1K x 1K. This measured standard deviation is actually root 2 times the real standard deviation of a single image, due to the differencing of the two images.
- The means, from the single images, and the measured standard deviations from the subtracted images are entered into a spreadsheet which calculates the variance and plots variance against mean.
- The resulting plot is the classic photon transfer plot in which the reciprocal of the slope represents the system gain in e-/ADU and the intercept represents the variance of the read noise.

Figures 7 to 10 show the resulting photon transfer plots for engineering grade detectors #32 and #26, using this simplified noise and gain test.

Table 4 shows the results obtained from figures 8 and 10 (the low signal parts of the photon transfer curves).

Detector	System gain in e-/ADU	Read noise standard deviation in e-
Engineering grade #32	4.03	20.2
Engineering grade #26	3.78	35.9

Table 3 AIT-1 simplified gain and noise test results.

The system gains measured compare reasonably well with the gain measured at the ATC [RD 11, RD 12], provided that the difference in preamp gains is taken into account.

The noise measured for detector #32 agrees reasonably with the noise measured at the ATC. The noise measured for detector #26, however, is considerably higher than the noise measured at the ATC. This is considered to be due to the simplified noise measurement method, in which bad pixels are not removed.

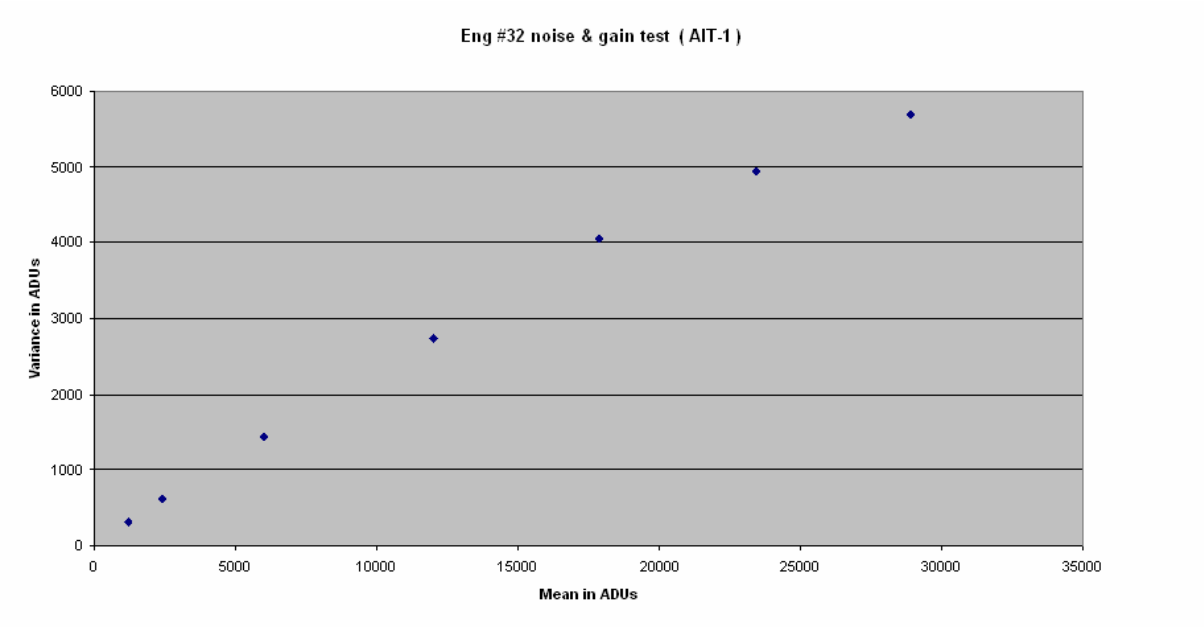

Figure 7 Photon transfer plot of engineering grade detector #32, during Camera AIT-1

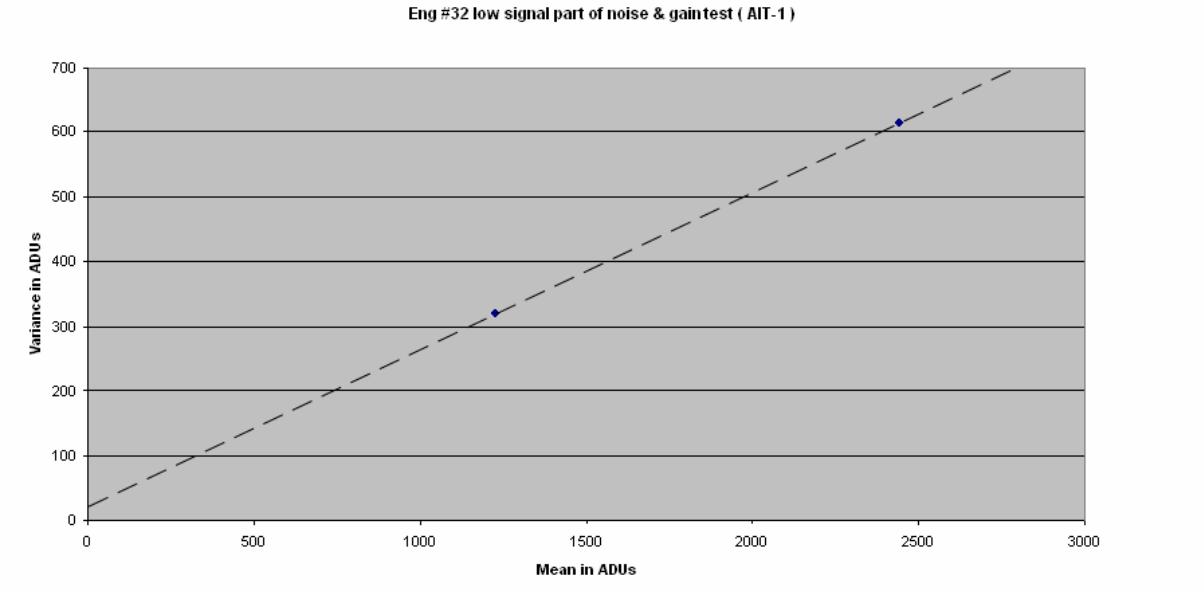

Figure 8 Low signal part of photon transfer plot of engineering grade detector #32, during Camera AIT-1

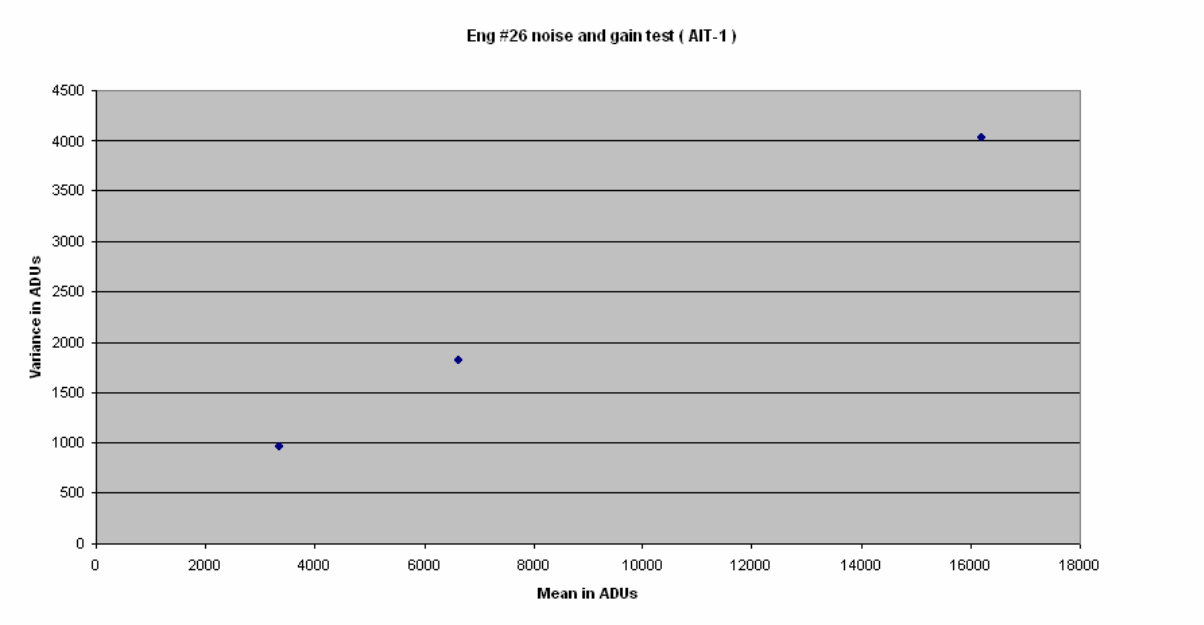

Figure 9 Photon transfer plot of engineering grade detector #26, during Camera AIT-1

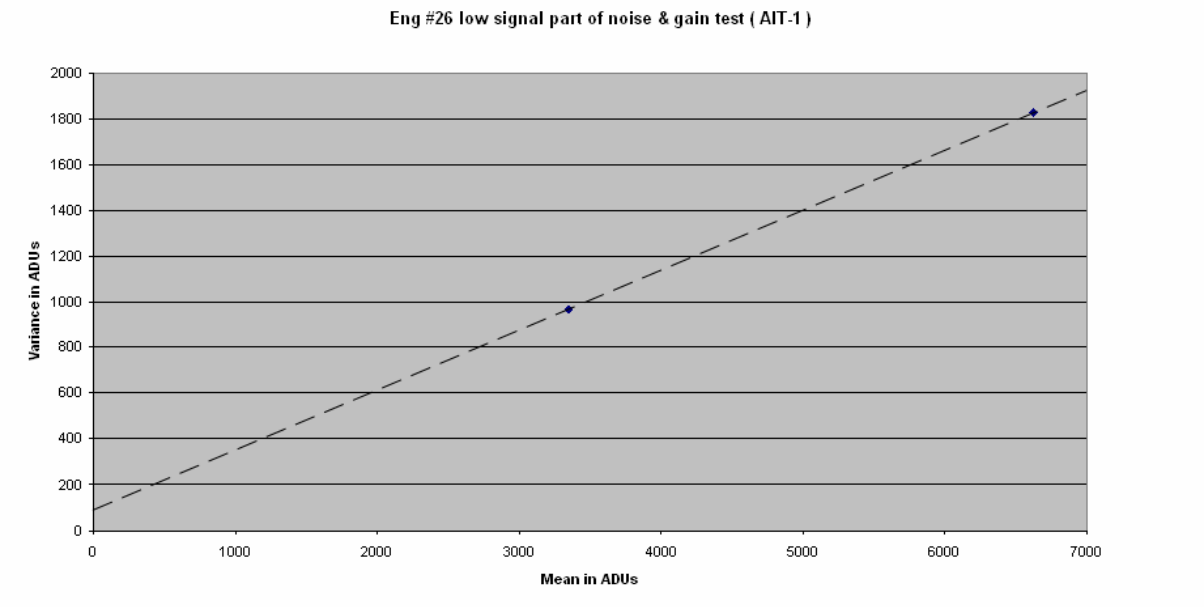

Figure 10 Low signal part of photon transfer plot of engineering grade detector #26, during Camera AIT-1

7 Camera AIT-2

7.1 Summary

In preparation for, and during, Camera AIT-2 the following operations were carried out :

- 2 Sept 2005 - the engineering grade detectors #26 and #32 and four muxes were removed.
- 19 – 29 Sept 2005 - the thermal plate resistors were replaced with resistors of different values and wiring changes were made to the spare temperature diode and the thermocouples, as shown in RD 7.
- 30 Sept 2005 - the FPA was assembled, with the aluminium plate and dummy aluminium detectors.
- 3 Oct 2005 - a trial installation of the FPA was carried out, with the new lifting frame.
- 3 – 6 Oct 2005 – the FPA was assembled with the moly plate, aluminium ball, engineering grade detectors #26 and #32 and three muxes.
- 7 Oct 2005 - the FPA was installed in the camera.
- 10 Oct 2005 - the temperature control was tested warm.
- 12 Oct 2005 – the detectors were tested warm.
- 17 – 28 Oct 2005 - AIT-2 was carried out.

7.2 Thermal performance

During AIT-2, it was found that, with the new values of thermal plate heater resistors, the thermal control system was able to control the thermal plate at the required temperature of 70K.

The temperature control was tested at various set points and the results are shown in table 4.

Number of cold heads running	Lake Shore 332 Ts (thermal plate set point)	Lake Shore 332 Ta (thermal plate temperature)	Lake Shore 332 Heater power	Lake Shore 218 #3 Detector temperatures
3	75.000K	75.000K +/- 2mK	30% High	~79.5K
3	70.000K	70.000K +/- 2mK	28% High	~74.5K
3	67.500K	67.500K +/- 2mK	27% High	~72.0K

Table 4 AIT-2 thermal performance

7.3 Images

Figures 11 shows an uncorrelated 1 second exposure image taken with engineering grade detector #32, during Camera AIT-2.

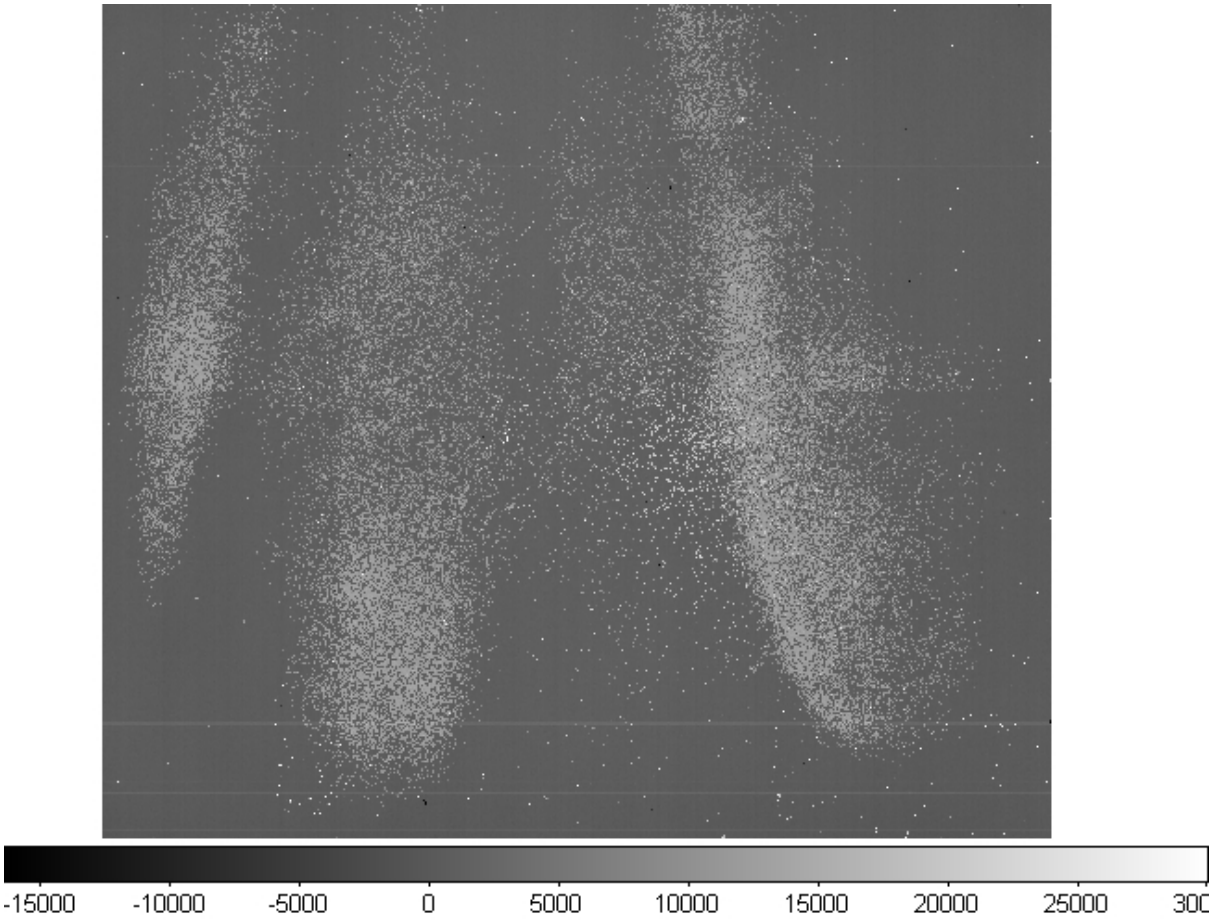

Figure 11 Uncorrelated 1 second exposure cold image taken with engineering grade detector #32, during AIT-2

8 Camera AIT-3a

8.1 Summary

In preparation for, and during, Camera AIT-3a the following operations were carried out :

- 3 – 4 Nov 2005 - the FPA was removed from the cryostat and dismantled.
- 7 – 11 Nov 2005 - the science grade detectors were fitted on the moly plate (moly ball).
- 14 – 18 Nov 2005 - preparation for AIT3a.
- 21 Nov 2005 - the science detectors were operated for the 1st time.
- 21 – 24 Nov 2005 - AIT3a1 was carried out.
- 28 Nov - 1 Dec 2005 - AIT3a2 was carried out.
- 1 Dec 2005 - an EMC interference test was carried out, with Eddy Younger.

8.2 Thermal performance

Figure 11 shows photographs of the front panels of the Lake Shore 332 temperature controller and Lake Shore 218 temperature monitor #3.

These photographs show the Lake Shore 332 display of actual temperature, temperature set point and the heater power and the Lake Shore 218 display of the temperatures of 8 of the VIRGO detectors.

Figure 12 Lake Shore temperature displays during Camera AIT-3a1

8.3 Images

Figure 13 shows a 1 second exposure uncorrelated cold image, with all 16 science detectors, taken during AIT-3a1.

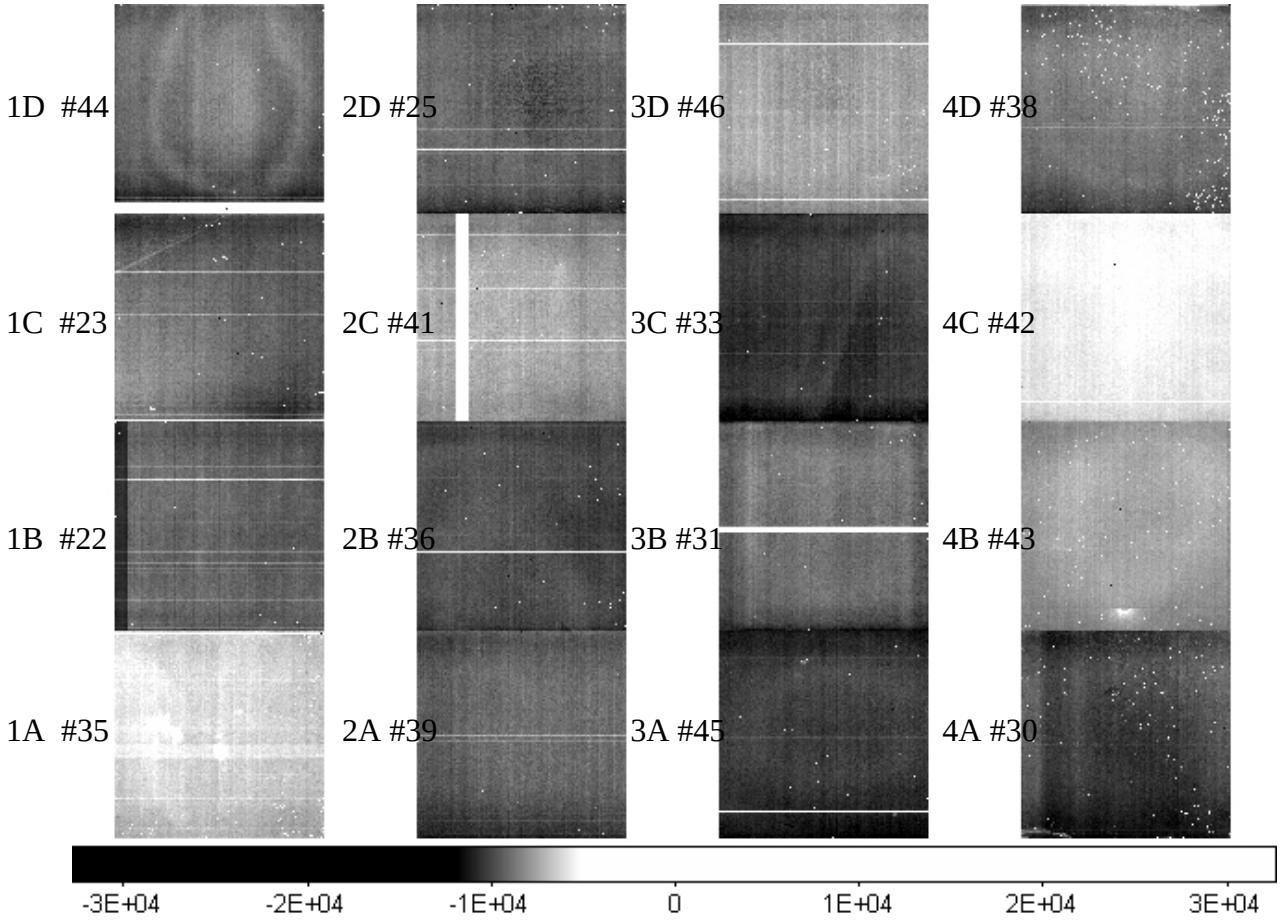

Figure 13 1 s exposure uncorrelated cold image taken during Camera AIT-3a1

It can be seen from figure 13 that channel 1 on detector #22 (position 1B) and channel 4 on detector #41 (position 2C) were not working properly. This was later traced to faulty cable/connectors which were successfully repaired.

Figure 14 shows a 60 second exposure double correlated cold image, with all 16 science detectors, taken during AIT-3a1.

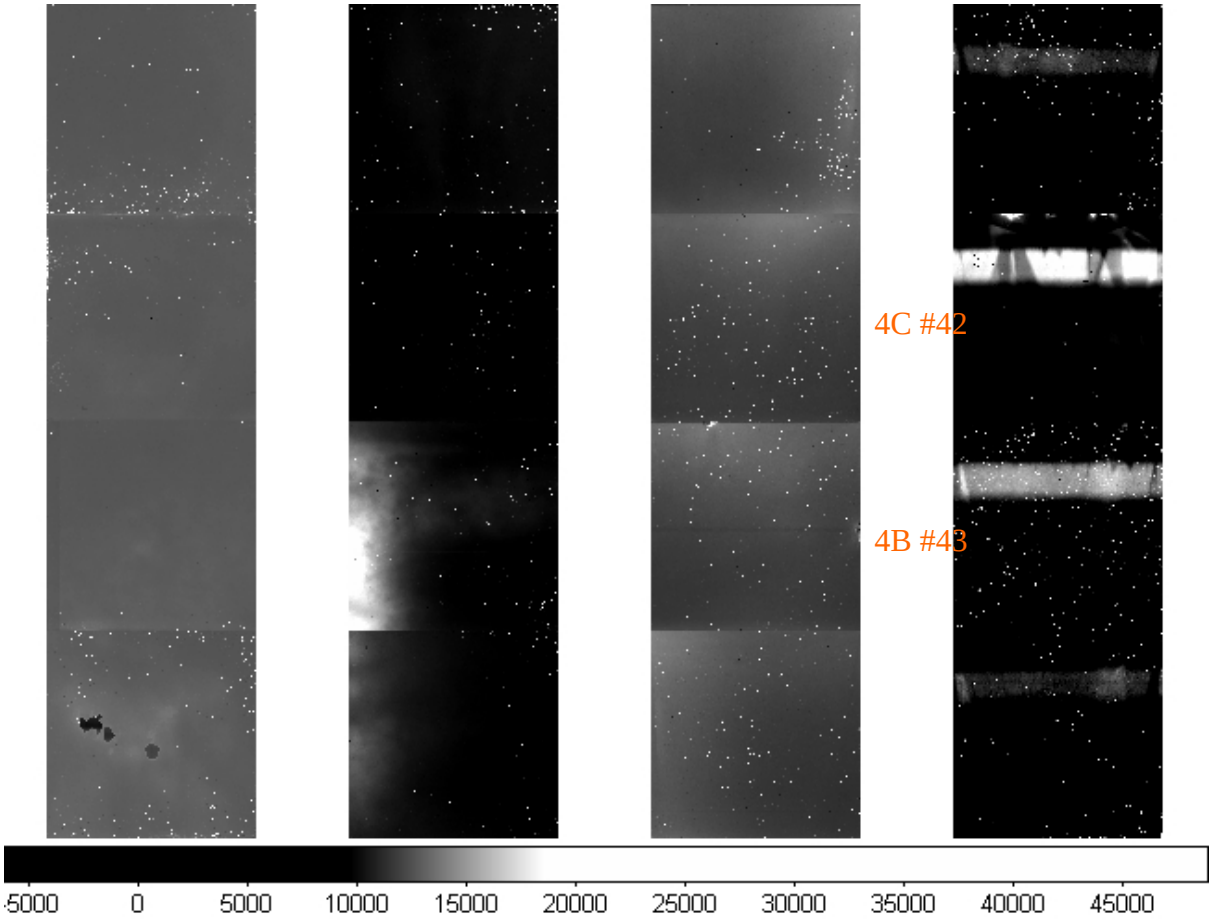

Figure 14 60 s exposure CDS cold image taken during Camera AIT-3a1

It can be seen from figure 14 that there is a distinctive pattern of stray light, particularly on detectors #42 (position 4C) and #43 (position 4B).

Considerable went into understanding the cause of this effect and finding ways of minimising it, during subsequent Camera AIT and 'all-up tests' campaigns.

The results of this work are described in detail in RD 8.

8.4 EMC test

During AIT3a2 an EMC interference test was performed, in which the VIRGO IR detectors were read out both with and without the AG CCDs running.

The standard deviations, of pairs of subtracted images, are shown in Table 5, for the various cases. It can be seen that operation of the AG CCDs did not cause a significant increase in the noise of the science grade detectors.

	Standard deviation, in ADUs, of two subtracted images in a 1K x 1K box			
AG CCD status	detector #44 (position 1D).	Detector #39 (position 2A)	Detector #33 (position 3C)	Detector #43 (position 4B)
Both AGs off	8.7 to 9.7	7.6 to 8.4	9.8 to 11.3	10.8 to 11.9
-Y AG on	8.7 to 9.7	7.6 to 8.4	10.5 to 12.6	10.7 to 11.0
Both AGs on	8.7 to 9.7	7.6 to 8.4	10.7 to 11.1	10.7 to 11.0

Table 5 AIT-3a2 EMC Test Results.

9 Camera AIT-4a thru' AIT-4c

9.1 Summary

In preparation for, and during, Camera AIT-4a thru' AIT-4c the following operations were carried out :

- 5 - 23 Dec 2005 - preparation for AIT-4a
- 3 – 20 Jan 2006 - AIT-4a was carried out.
- 23 – 27 Jan 2006 – the FPA was removed, light shields were fitted to the FPA and the FPA was replaced, in preparation for AIT-4b.
- 30 Jan – 10 Feb 2006 - AIT-4b was carried out.
- 13 – 28 Feb 2006 - preparation for AIT-4c.
- 2 – 7 Mar 2006 - AIT-4c was carried out.

9.2 Images

Figures 15 shows a double correlated cold image taken during Camera AIT-4b.

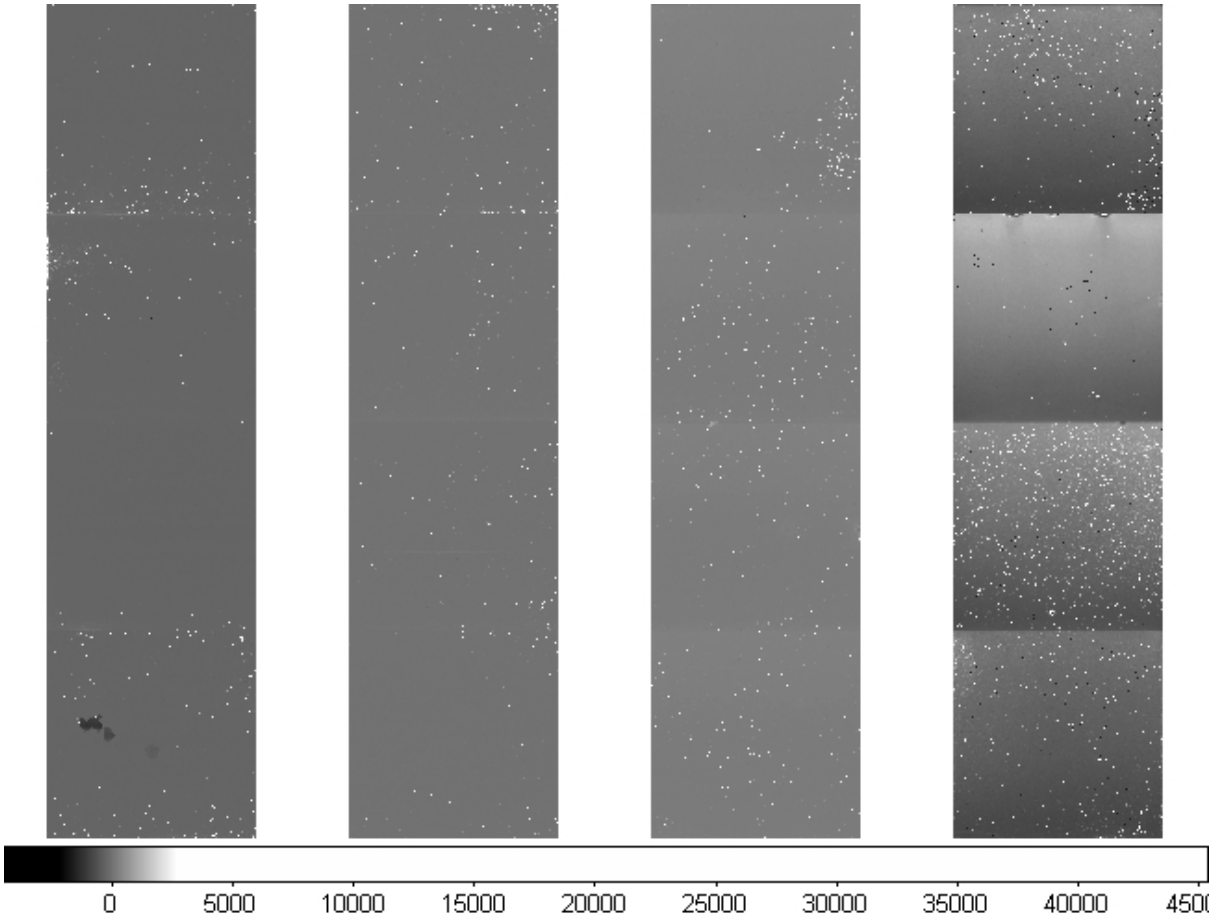

Figure 15 60 s exposure dark CDS cold image taken during Camera AIT-4b

Comparison of figure 15, with figure 14, shows that the interim aluminium fence around the FPA has reduced the patterned structure of the stray light.

Figures 16 shows a double correlated cold image taken during Camera AIT-4c.

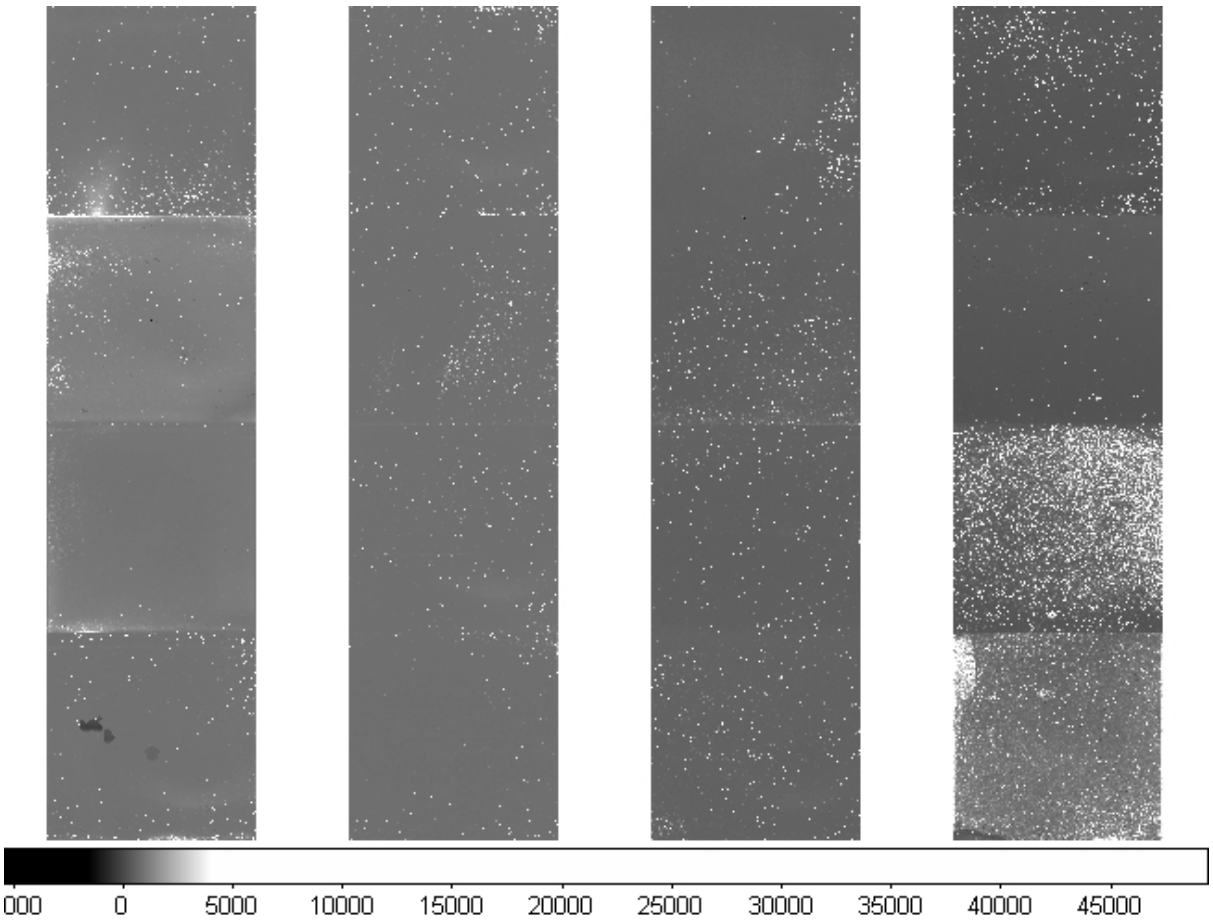

Figure 16 1200 s exposure CDS cold image taken during Camera AIT-4c

Comparison of figure 16, with figure 15, shows that the additional shielding at the back of the FPA has further reduced the stray light.

10 Camera AIT-3b

10.1 Summary

In preparation for, and during, Camera AIT-3b the following operations were carried out :

- 6 – 17 Mar 2006 - preparation for AIT3b.
- Mar/Apr 2006 - AIT-3b was carried out.

The author of this report did not participate in any if the AIT-3b tests and therefore no results are presented in this report.

11 Camera 'all-up tests'

11.1 Summary

In preparation for, and during, Camera 'all-up tests', the following operations were carried out :

- 4 May 2006 - the interim aluminium shields around the FPA were replace by the moly shields and the FPA lifting tool was balanced.
- 4 – 11 May 2006 - preparation for 'all-up tests'.
- 12 May 2006 - the 'all-up tests' cooldown took place.
- 15 – 26 May 2006 – the 'all-up tests' were carried out.
- 24 – 25 May 2006 - ESO EMC tests were carried out.
- 26 May 2006 - warmup commenced.

11.2 Images

Figure 17 shows a double correlated cold image taken during Camera 'all-up tests'.

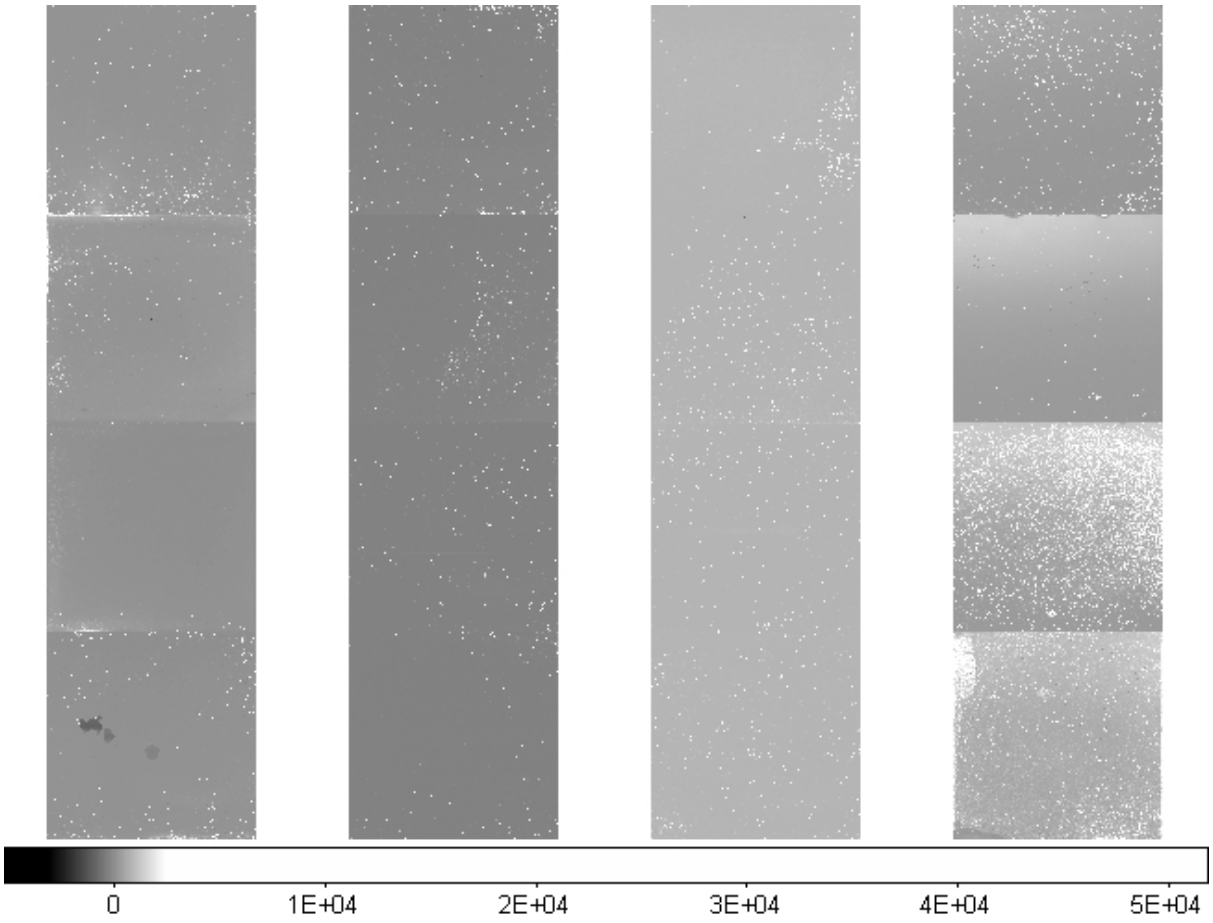

Figure 17 360s exposure CDS cold image taken during Camera AIT-4c

11.3 ESO EMC tests

On 24 and 25 May 2006, EMC tests were carried out by Arno van Kesteren and the results are presented in RD 6.

12 Camera AIT-4d

12.1 Summary

In preparation for, and during, Camera AIT-4d the following operations were carried out :

- 5 - 9 June 2006 – preparation for AIT4d
- 12 - 29 June 2006 – cold part of AIT4d was carried out
- 26 June 2006 – the 1st bad image was obtained with detector #31 in position 3B.
- 27 June 2006 – cold investigation of detector #31 was carried out.
- 3 - 11 July 2006 – continued investigation of detector #31 failure (warm).

12.2 Images

Figure 18 shows a cold dark CDS image taken during AIT-4d, prior to failure of detector #31.

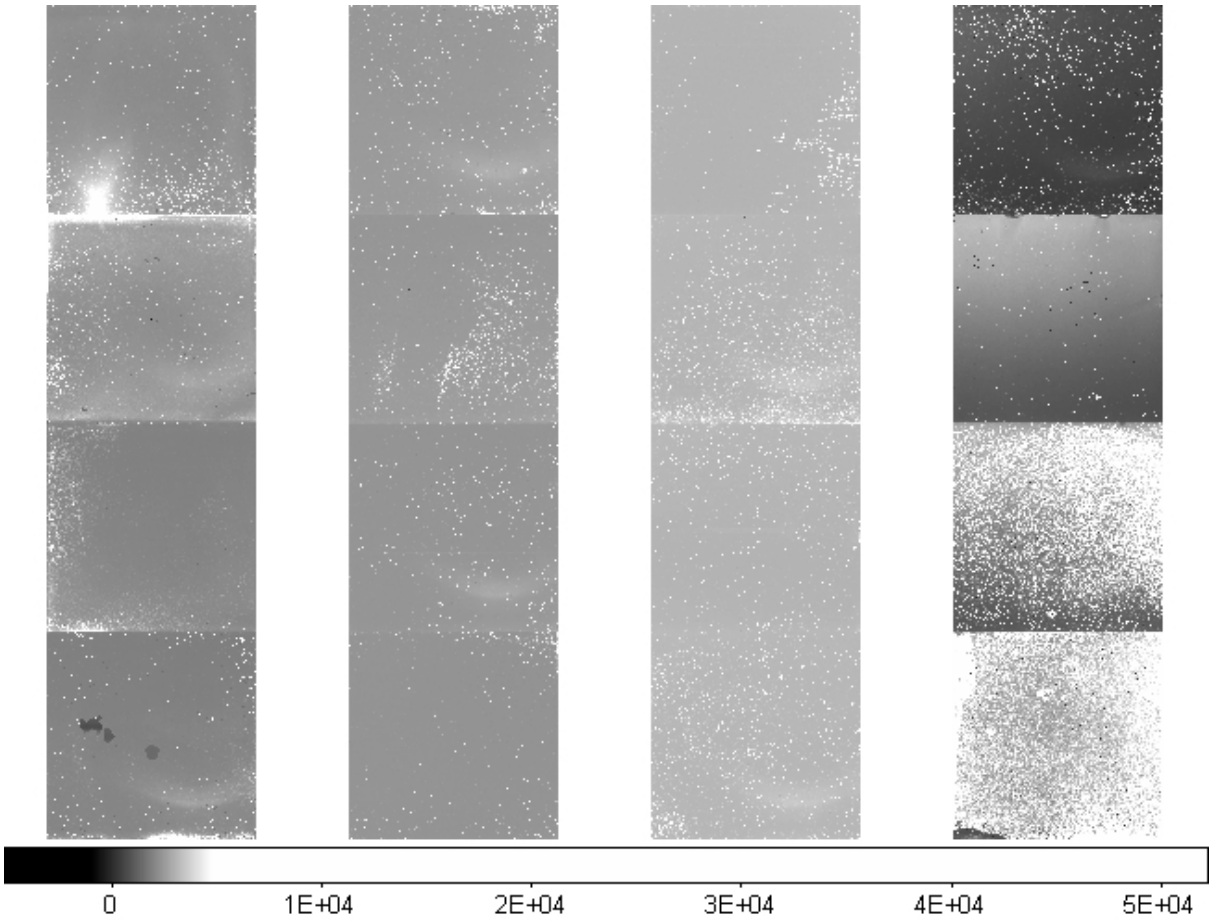

Figure 18 3600s dark exposure CDS cold image taken during Camera AIT-4d

Figure 19 shows a cold dark uncorrelated image taken with detector #31 on 26 June 2006. The failure of channels 15 and 16 of the readout are clearly visible.

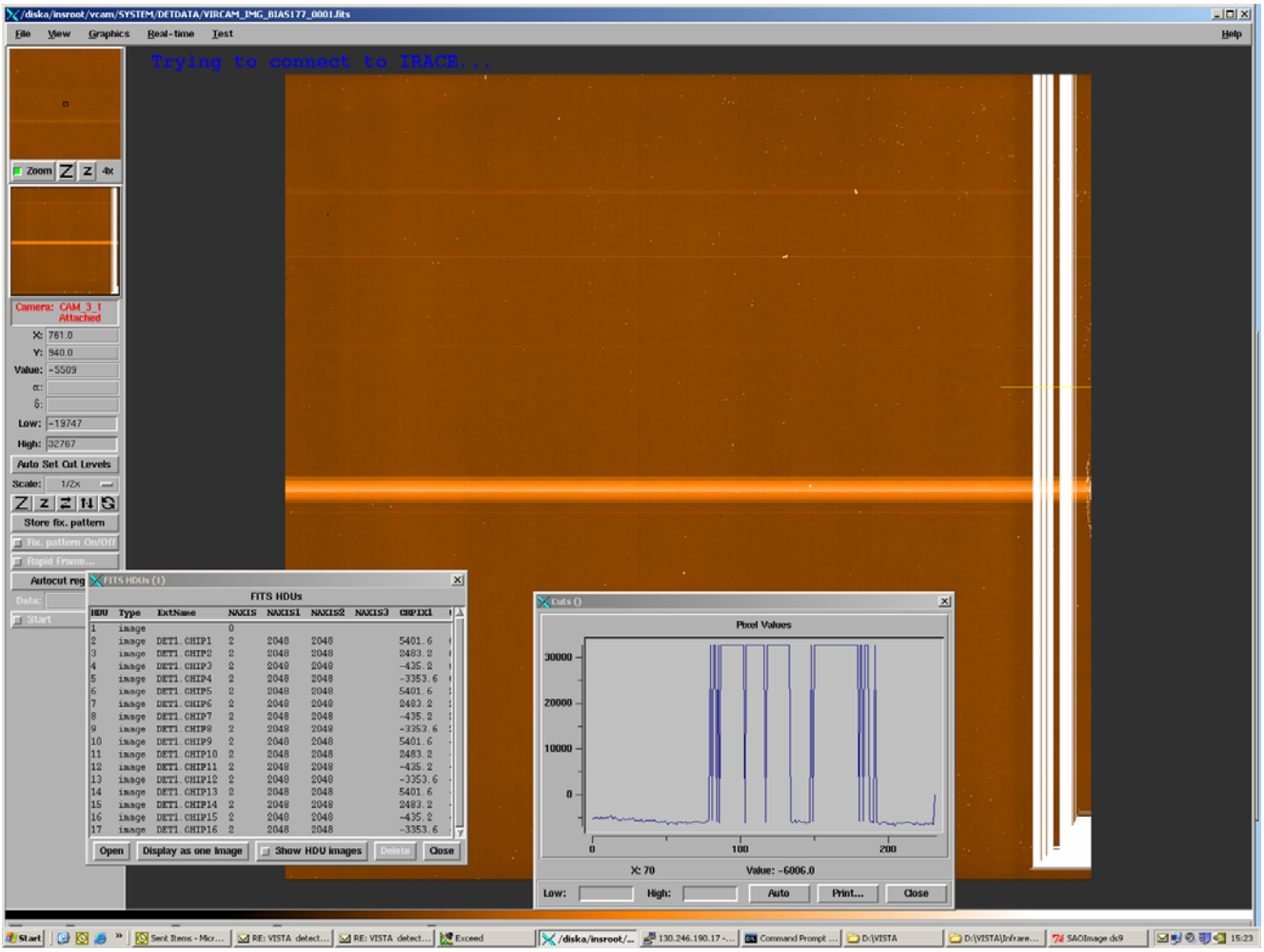

Figure 19 Uncorrelated image taken on 26 June 2006, showing detector #31 failure

Figures 20, 21 and 22 shows oscilloscope waveforms, monitored at test points in the IRACE AQ16 module, of the composite video signals of channels 14, 15 and 16 of detector #31, during readout (warm).

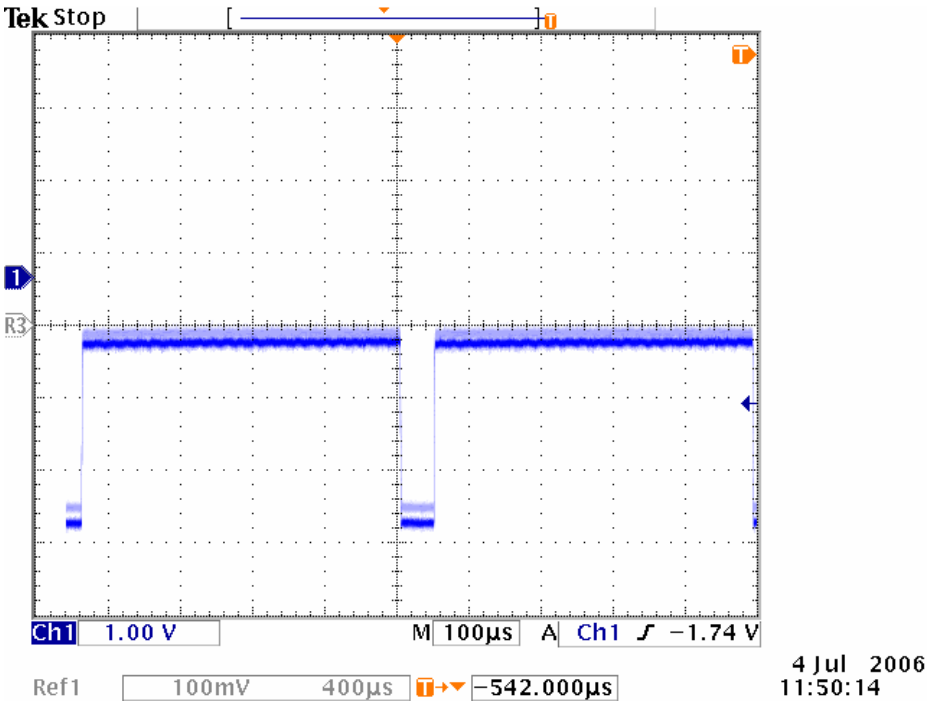

Figure 20 Scope trace of detector #31 channel 14 readout (warm)

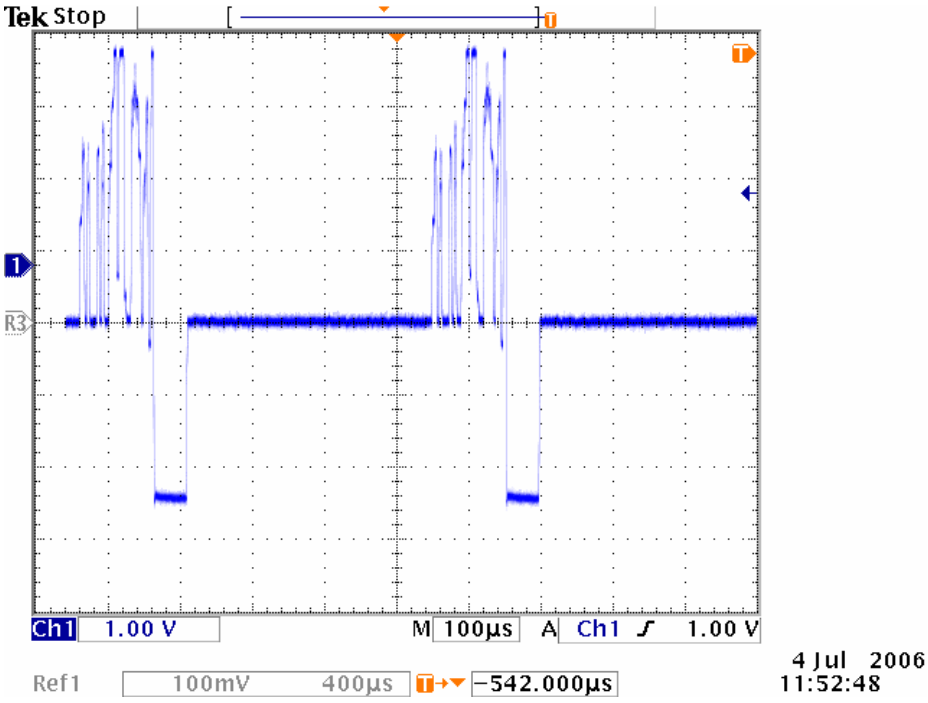

Figure 21 Scope trace of detector #31 channel 15 readout (warm)

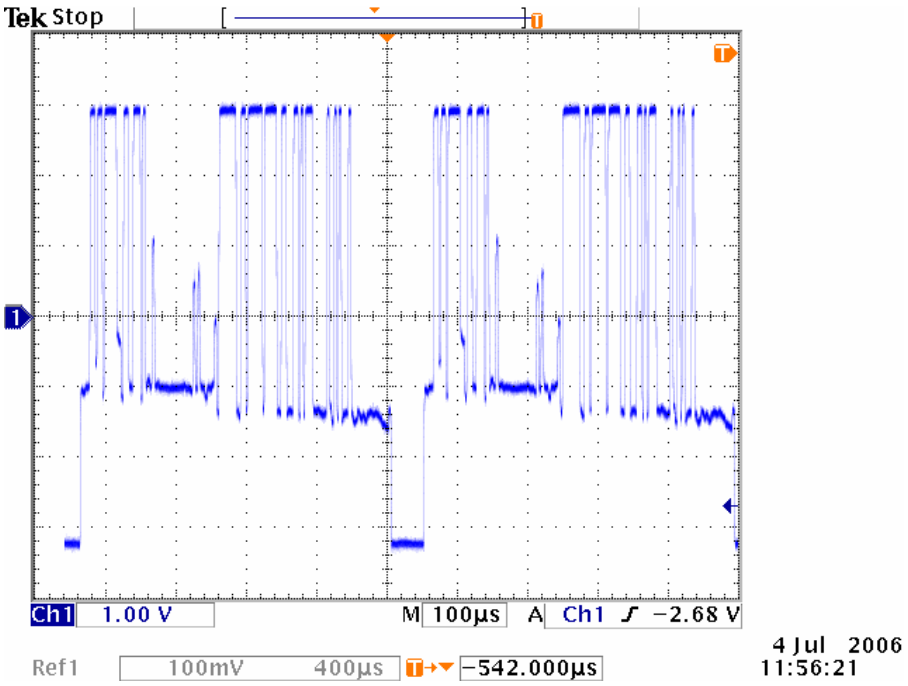

Figure 22 Scope trace of detector #31 channel 16 readout (warm)

Figure 20 shows good channel 14 and figures 21 and 22 show the bad channels 15 and 16.

Further investigation showed that :

- Both halves of the differential signals, on channels 15 and 16, were faulty.
- Swopping cables and/or IRACE channels did not fix the problem.

After discussion between Raytheon, ATC and RAL, it was decided to procure a replacement detector.

Detector #47 was selected, procured and tested at the ATC.

13 Camera ‘all-up tests b’

13.1 Summary

In preparation for, and during, Camera ‘all-up tests b’ the following operations were carried out :

- 30 – 31 Aug 2006 – the faulty detector #31 was replaced by detector #47.
- 4 Sept 2006 – the FPA assembly was completed.
- 6 Sept 2006 – a new light shield was fitted to the camera and the FPA was installed.
- 7 – 8 Sept 2006 – pumping and cooldown took place.
- 11 – 18 Sept 2006 – the ‘all-up tests b’ were carried out.

13.2 Images

Figure 23 shows an uncorrelated 1sec cold image taken during ‘all-up tests b’.

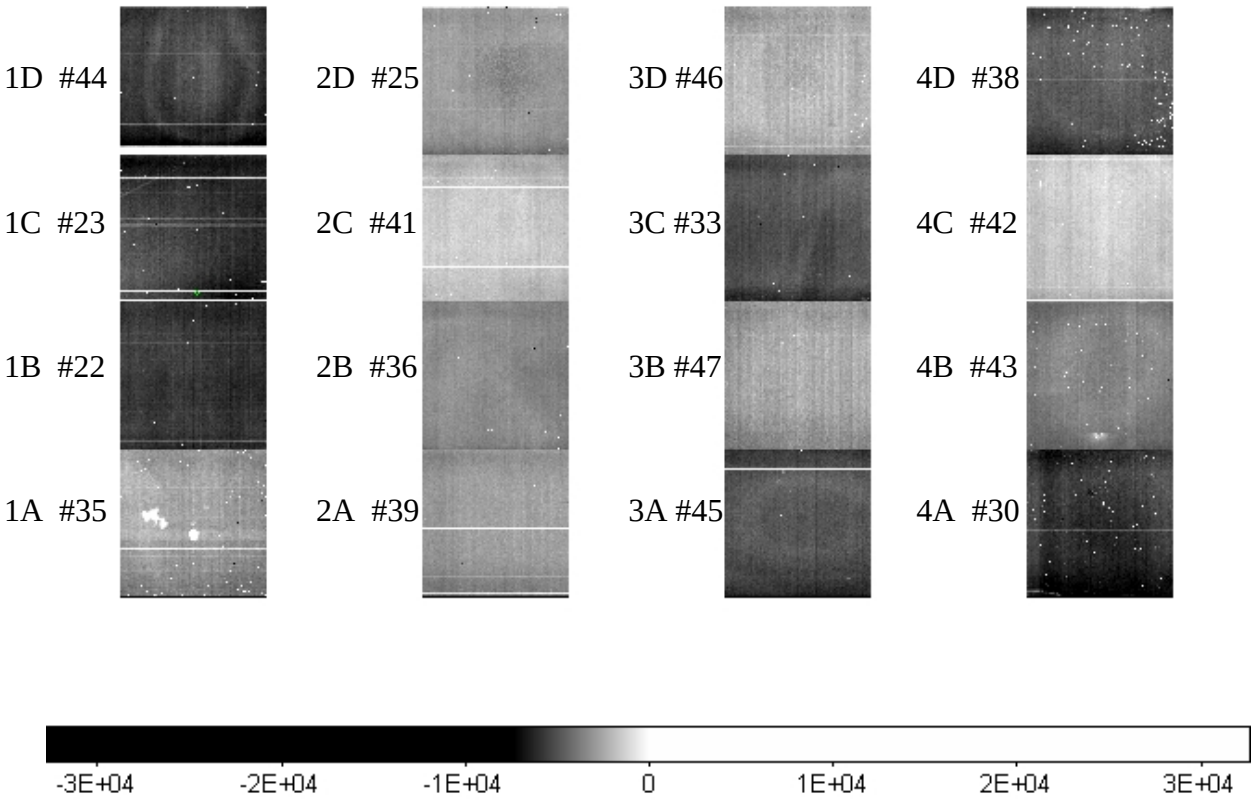

Figure 23 Uncorrelated 1 sec cold image taken during Camera ‘all-up tests b’

Figure 23 shows that the replacement, of the faulty detector #31, by the new detector #47 has been successful.

Figure 23 also shows a small effect in channel 12 of detector #43 (position 4B), which was pointed out in RD 9.

Investigation of images has shown that this is a very small effect, which is not expected to significantly degrade the noise or cosmetic performance. It will however be monitored and investigated further in Paranal.

14 CONCLUSIONS

This report, in conjunction with RD 8 and RD 9, shows that the detectors are performing as expected.

Further tests will be carried out in Paranal during ‘prep-room checkout’ and commissioning.

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