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Detector Assembly and Test Plan

Peter Moore 24th August 1999.

This document outlines the implementation details of a series of planned procedure designed to optimise the performance of the HAWAII detector used in the instrument. It should be read in conjunction with the '*Detector Verification Test Plan'* document that is designed to verify detector performance following these procedures. The '*INGRID Assembly and test schedule*' document controls the temporal progress of the tests and procedures detailed here. This plan represents a 'quick start' method of achieving the most optimum detector parameters and operating conditions in the minimum time. This is because we have only a limited time slot available to achieve reasonable performance and, we as yet do not know what problems we will encounter so this plan leaves the maximum time available for solving problems that are as yet undiscovered. Areas not covered by these procedures include:

1. Optimisation of array reset method.
2. Optimisation of readout time.
3. Implementation of 'read up slope' readout mode.
4. Reduction of noise through Bias Gate voltage optimisation.

More optimum performance can be extracted from the detector at a later date when time is available to concentrate on these details.

Revision History.

Version	Date	Author
DRAFT	28th August 1999.	Peter Moore.

Stage 1. Requires one thermal cycle.

Prerequisites.

✍✍Science cryostat clean and vacuum ready.
✍✍Provision to completely blank detector from external radiation.
✍✍Detector mount , heater subsystem, and cold link operational.
✍✍Bare Mux detector mounted in science fanout assembly.
✍✍Provision to cool detector to < 80K.
✍✍ISP / Host and SDSU controller running version 2.1 software operational.

If possible but not essential.

✍✍Camera barrel mounted in cryostat without optics.

Purpose.

Test cryostat wiring under cryogenic conditions.
Establish detector temperature equilibrium point.
Establish detector temperature servo parameters.
Establish preamplifier offset voltage / temperature curves.

Procedure.

CRYOSTAT TESTS.

1. Electrically test detector grounds for galvanic isolation to cryostat.
2. Test blanked detector at room temperature in cryostat for functionality. Use mndr readout of 1 with zero integration time.

PREAMPLIFIER OFFSET VOLTAGE ANALYSIS.

3. Make a set of measurements of bias level while adjusting preamplifier offset voltage. Log results and obtain the voltage / bias relationship.
4. Adjust preamplifier offsets to obtain closest bias value match across all working quadrants at a level of 30,000 ADU. Log established offset voltages for each quadrant.
5. Disable temperature servo. Begin cool down cycle, log time, bias levels for each quadrant, std deviation of bias.
6. At regular and convenient intervals log time, temperature, bias level and std deviation of bias for each quadrant.
7. As bias level drops below 10,000 ADU or goes above 50,000 ADU in any quadrant, adjust offset voltages (by equal values if possible) to re-establish the 30,000 ADU baseline. Log new offset voltages for each quadrant.

EQUILIBRIUM TEMPERATURE.

8. When detector temperature reaches equilibrium, log final temperature, bias and std deviation.
9. Electrically test detector grounds for galvanic isolation to cryostat.

TEMPERATURE SERVO TESTS.

10. Set temperature servo set point at 3K above equilibrium temperature.
11. At regular and short intervals log time, temperature and heater current until temperature has stabilised and sufficient time has elapsed to show a full two cycles of any temperature oscillations.
12. If oscillations are present, adjust servo parameters and retest. Log new parameters.
13. Set temperature servo set point at 5K above equilibrium temperature. Repeat step 11 & 12.

14. Set temperature servo set point at 10K above equilibrium temperature. Repeat steps 11 & 12.
15. Disable the temperature servo. Log time and temperature until equilibrium temperature reached again.
16. If the equilibrium temperature is less than 67K. Set temperature servo set point at 77K and repeat steps 11 & 12.
17. Set temperature servo set point at 333K.
18. Log time and temperature until detector reaches equilibrium or 300K reached.

CRYOSTAT TESTS.

19. Make test exposures using the preflash led to determine correct operation of detector. Exercise different readout scenarios to prove camera.
20. If camera barrel is fitted, apply 12 volts (3 watts) to camera heater. Log time and camera barrel temperature until equilibrium reached.
21. During the warm up cycle, periodically check that the detector system is operational and verify bias offset voltage adjustments made previously.
22. At room temperature, electrically test detector grounds for galvanic isolation to cryostat.
23. Remove detector from science fanout board, visibly check for any signs of contamination on surface of chip and detector shield packaging.

Post test data processing.

1. Plot temperature / preamplifier offset voltage curves. Derive polynomial for slope.
2. Plot time / temperature curve for detector during initial cool down.
3. Plot time / temperature curve for detector with full heater current.
4. Plot time / temperature curve for detector with zero heater current.
5. Plot temperature / std deviation of bias.
6. Plot heater current / delta temperature / time for all set point cases.
7. If available, plot time / temperature for camera barrel heating.

Analysis.

1. Did the detector hardware function without anomalies during the test?
2. From plot 1, is the effect of temperature on offset voltage coherent for all quadrants? Is there enough offset voltage range? Can an automatic offset voltage be computed based on operating temperature? Can the data be levelled using the offset voltage (i.e. is there enough sensitivity? Too much?).
3. From plot 2, What is the cool down time? Is the rate of detector cool down safe? Is there any point in accelerating it?
4. From plots 3 & 4, is the cooling and heating power equal? What should the servo time constant be? Is heater power adequate? Should we limit the maximum heater current?
5. From plot 5, Is there a thermal knee for the mux electronics? Do the load FETS show signs of deterioration at low temp? Do the noise figures correlate to temperature? Is the noise figure close to that desired?
6. From plot 6, Optimise the servo parameters for best response over operating temperature range. What is the tested temperature stability? Is it adequate?

7. If plot 7 available, is the camera heater adequate for optics protection during warm up?

Stage 2. Requires one thermal cycle.
Prerequisites.
- Science cryostat clean and vacuum ready.
- Provision to blank detector from external radiation.
- Provision to admit Z, H, J band flat field radiation.
- Detector mount , heater subsystem, and cold link operational.
- Engineering detector mounted in science fanout assembly.
- Provision to cool detector to operating temperature.
- ISP / Host and SDSU controller running version 2.1 software operational.

Purpose.
Assess science cryostat for electronic gain, linearity and noise components.
Test optimised temperature control.
Assess the dark current term at decided operating temperature.
Assess science cryostat for thermal radiation leaks.
First assessment of remenance and amplifier glow.
Assess science usefulness of engineering array.

Procedure.

FAMILIARITY OF ENGINEERING ARRAY RESPONSE TO MUX ARRAY.

1. Test blanked detector at room temperature in cryostat for functionality. Use mndr readout of 1 with zero integration time. Test for radiation response using a darkened room and H Band filter.
2. Make a set of measurements of bias level with detector blanked while adjusting preamplifier offset voltage. Log results and obtain the voltage / bias relationship.
3. Adjust preamplifier offsets to obtain closest bias value match across all working quadrants at a level of 30,000 ADU. Log established offset voltages for each quadrant.
4. Disable temperature servo. Begin cool down cycle, log time, bias levels for each quadrant, std deviation of bias.
5. At regular and convenient intervals log time, temperature, bias level and std deviation of bias for each quadrant.
6. As bias level drops below 10,000 ADU or goes above 50,000 ADU in any quadrant, adjust offset voltages (by equal values if possible) to re-establish the 30,000 ADU baseline. Log new offset voltages for each quadrant.
7. When detector temperature reaches equilibrium, log final temperature, bias and std deviation. Set temperature servo set point to operating temperature.

RESPONSE OF TEMPERATURE SERVO.

8. At regular and short intervals log time, temperature and heater current until temperature has stabilised and sufficient time has elapsed to show a full two cycles of any temperature oscillations.
9. If oscillations are present, adjust servo parameters and retest. Log new parameters.

BIAS VARIATION DUE TO READOUT PARAMETERS, READOUT NOISE COMPONENT, AMP GLOW.

10. Make zero integration time bias exposures while varying the mndr parameter n between 1 and 16. Note average bias value and std deviation for all quadrants.
11. Adjust preamplifier offsets to obtain image bias of approx. 250 ADU above the lowest measured bias offset.

DARK CURRENT GENERATION IN THE ENGINEERING ARRAY.

12. Make a series of bias exposures using a minimum mndr value which gives lowest std deviation and stepping the integration time in equal units between 0 and 600 seconds. Log for each exposure the integration time, temperature, mean bias value, and std deviation of bias. Alternatively, if 'read up ramp' readout mode available, use this to obtain a linear integration series.
13. Adjust temperature to 10 K above operating temperature. Repeat step 12 when temperature is stable.
14. Adjust temperature to 20 K above operating temperature. Repeat step 12 when temperature is stable.
15. Adjust temperature to operating temperature and repeat step 12 when temperature is stable.

ELECTRONIC GAIN AND LINEARITY.

16. Make a series of pairs of flat field exposures in Z Band (adjusting a suitable light source) to provide signal up to full dynamic range (65K ADU). Log integration time, mean signal, signal std deviation for all exposures. Use a mndr setting to that gives minimum bias std deviation. Save the image files.
17. Repeat step 16 in H or J band.

ASSESS REMENANCE AT FULL DYNAMIC RANGE.

18. Make a series of three bias frames with integration time of 10, 100, 600 seconds. Log mean bias and std deviation of bias.

CRYOSTAT RATIATION LEAKS.

19. Heat external cryostat with heat guns and heater tape. Attempt to raise cryostat skin temperature by > +40 K. Whilst heating, make a series of bias frames with integration time of 600 seconds. Log cryostat skin temperature, radiation shield temperature, cold table temperature, mean bias and std deviation of bias.
20. Optional. While cryostat in warm up cycle, take a series of pairs of bias readings at increasing temperatures. Make one zero second integration plus one 100 second integration each convenient step in temperature. Log detector temperature, primary shield temperature, bias mean and std deviation for each pair. This will mean that the preamplifier offset voltages will need to be adjusted to compensate as the temperature increases.
21. Remove detector from science fanout board, visibly check for any signs of contamination on surface of chip and detector shield packaging

Post Test Data Processing.

1. Plot temperature / preamplifier offset voltage curves. Derive polynomial for slope.
2. Plot time / temperature curve for detector during initial cool down.
3. Plot integration time / mean bias / std deviation with data from tests 12, 13, 14, & 15. Plot mean bias and std deviation / temperature. If data from step

20 is available, plot detector temperature / (frame 2 – frame 1) bias mean and std deviation and plot primary shield temperature / (frame 2 – frame 1) bias mean and std deviation.

4. From data taken in steps 16 & 17. Plot photon curves, std deviation ^2 / mean signal for each band.
5. Plot time / mean bias / std deviation from step 18.
6. Plot data taken in step 19 as a function of cryostat skin temperature.

Analysis.

1. From plot 1, is the bias / temperature relationship the same as for the mux device? Is there similarity in the profile suggesting that all bias offset comes from the mux?
2. From plot 2, does the profile and time to reach equilibrium match the mux tests? Did the engineering detector mount with the same thermal characteristics? Do we need to refine the detector mounting procedure?
3. From plots generated in step 3 above, assess dark current generation profile across 20 degrees K. Are we out past the knee? What is the slope (i.e. sensitivity) of dark current to temperature? Is bias level stable over time and temperature excursions? Optimise operating temperature. If step 20 was done, what is the max shield temperature before radiation leaks were seen? At what temperature is the knee?
4. From plots generated in step 3 & 4 above, calculate electronic gain, deviation from linearity, read noise component. Is the gain that expected? Is gain the same in both bands? Did we hit limits of linearity? What is the read noise component? Do these values reflect the initial work done at RGO? Is amplifier glow a factor?
5. From plot 5, is there evidence of remenance? Is this reflected in the linearity data from above?
6. From plot 6, Is there evidence of bias level dependence on cryostat skin temperature? What is the derivative of primary shield temperature to cryostat skin temperature?
7. From test 16, derive a bad pixel map for the engineering array. Is this array suitable for science?

Stage 3. Requires two thermal cycles.
Prerequisites.
✍✍Science cryostat clean and vacuum ready.
✍✍Provision to blank detector from external radiation.
✍✍Provision to admit Z, H, J, K band flat field radiation.
✍✍Provision to project a small (< 10 pixel) image feature on array.
✍✍Detector mount , heater subsystem, and cold link operational.
✍✍Science detector mounted in science fanout assembly.
✍✍Provision to cool detector to operating temperature.
✍✍ISP / Host and SDSU controller running version 2.1 software operational.

Purpose.
Optimise science array for electronic gain, linearity and noise components.
Assess the dark current term at decided operating temperature.
Assess fixed pattern noise of science array at operating temperature.
Optimise full well of science array.
Assess cross talk component in images.
Second assessment of remenance and amplifier glow.
Assess cosmetic quality of science array.
Assess usefulness of science array.

Procedure. Cool down 1.
FAMILIARITY OF SCIENCE ARRAY RESPONSE TO ENGINEERING ARRAY.

1. Test blanked detector at room temperature in cryostat for functionality. Use mndr readout of 1 with zero integration time. Test for radiation response using a darkened room and H Band filter.
2. Make a set of measurements of bias level with detector blanked while adjusting preamplifier offset voltage. Log results and obtain the voltage / bias relationship.
3. Adjust preamplifier offsets to obtain closest bias value match across all working quadrants at a level of 30,000 ADU. Log established offset voltages for each quadrant.
4. Disable temperature servo. Begin cool down cycle, log time, bias levels for each quadrant, std deviation of bias.
5. At regular and convenient intervals log time, temperature, bias level and std deviation of bias for each quadrant.
6. As bias level drops below 10,000 ADU or goes above 50,000 ADU in any quadrant, adjust offset voltages (by equal values if possible) to re-establish the 30,000 ADU baseline. Log new offset voltages for each quadrant.
7. When detector temperature reaches equilibrium, log final temperature, bias and std deviation. Set temperature servo set point to operating temperature.

BIAS VARIATION DUE TO READOUT PARAMETERS, READOUT NOISE COMPONENT, AMP GLOW.

8. Make zero integration time bias exposures while varying the mndr parameter n between 1 and 16. Note average bias value and std deviation for all quadrants.
9. Adjust preamplifier offsets to obtain image bias of approx. 250 ADU above the lowest measured bias offset.

ELECTRONIC GAIN AND LINEARITY.

10. Make two bias exposures plus a series of pairs of flat field exposures in Z Band (adjusting a suitable light source) to provide signal up to full dynamic range (65K ADU). Log integration time, mean signal, signal std deviation for all exposures. Use a mndr setting to that gives minimum bias std deviation. Save the image files.

ELECTRONIC GAIN AND LINEARITY OPTIMISATION.

11. Adjust the Bias gate voltage in a range between -0.7 and + 0.7 volts in 0.2 volt steps. Repeat step 10 for each adjustment.

FULL WELL OPTIMISATION.

12. Reset Bias Gate voltage to nominal. Adjust Vreset voltage between –0.5 and + 0.5 volts in steps of 0.2 volts. Repeat step 10 for each adjustment.

DARK CURRENT GENERATION IN THE SCIENCE ARRAY.

13. Reset Vreset voltage to nominal. Make a series of bias exposures using a minimum mndr value which gives lowest std deviation and stepping the integration time in equal units between 0 and 600 seconds. Log for each exposure the integration time, temperature, mean bias value, and std deviation of bias. Alternatively, if ‘read up ramp’ readout mode available, use this to obtain a linear integration series.
14. Adjust temperature to 10 K above operating temperature. Repeat step 12 when temperature is stable.
15. Adjust temperature to 20 K above operating temperature. Repeat step 12 when temperature is stable.
16. Adjust temperature to operating temperature and repeat step 12 when temperature is stable.

ASSESS REMENANCE AT FULL DYNAMIC RANGE.

17. Make a series of three bias frames with integration time of 10, 100, 600 seconds. Log mean bias and std deviation of bias.

CROSS TALK ASSESSMENT.

18. Illuminate one small area of one quadrant. After allowing for any remenance effects to dissipate, take a series of increasing integration time exposures up to 10 times full well capacity. Save image files.

DARK CURRENT GENERATION IN THE SCIENCE ARRAY.

19. While cryostat in warm up cycle, take a series of pairs of bias readings at increasing temperatures. Make one zero second integration plus one 100 second integration each convenient step in temperature. Log detector temperature, primary shield temperature, bias mean and std deviation for each pair. This will mean that the preamplifier offset voltages will need to be adjusted to compensate as the temperature increases.

Post Test Data Processing. Cool down 1

1. Plot temperature / preamplifier offset voltage curves. Derive polynomial for slope.
2. If necessary, Plot time / temperature curve for detector during initial cool down.
3. Plot integration time / mean bias / std deviation with data from tests 13, 14, 15.& 16 Plot mean bias and std deviation / temperature. From data taken in step 19, plot detector temperature / (frame 2 – frame 1) bias mean and

std deviation and plot primary shield temperature / (frame 2 – frame 1) bias mean and std deviation.

4. From data taken in steps 10, 11, 12. Plot photon curves, std deviation ^2 / mean signal for each parameter adjustment. Derive gain, linearity and noise for each series.
5. Plot time / mean bias / std deviation from step 17.
6. Plot profiles for original illuminated spot + time equivalent areas of other quadrants for all integration times.

Analysis. Cool down 1.

1. From plot 1, is the bias / temperature relationship the same as for the engineering device?
2. From plot 2, does the profile and time to reach equilibrium match the engineering tests? Do we have ‘normal’ thermal conductivity?
3. From plots generated in step 3 above, assess dark current generation profile across 20 degrees K. Are we out past the knee? What is the slope (i.e. sensitivity) of dark current to temperature? Is bias level stable over time and temperature excursions? Assess and optimise the operating temperature. From step 19, what is the max shield temperature before radiation leaks were seen? At what temperature is the knee?
4. From plots generated in step 3 & 4 above, is the gain that expected? Optimize settings for Bias Gate and Vreset parameters using the priority chain Linearity / noise / Gain / Cosmetics.
5. From plot 5, is there evidence of remenance? Is this reflected in the linearity data from above?
6. Assess impact of cross talk. Do we need to take action on this? Is there evidence of blooming?
7. From test 10, derive a bad pixel map for the science array. Is this array suitable for science?

Apply all corrective measures and optimisation parameters to detector system. Test for primitive functionality.

Procedure. Cool down cycle 2.

1. Allow detector to stabilise at operating temperature. Make a series of 25 zero second bias exposures. Assess readout noise and bias stability within specification.
2. Make two bias exposures plus a series of pairs of flat field exposures in Z Band (adjusting a suitable light source) to provide signal up to full dynamic range (65K ADU). Log integration time, mean signal, signal std deviation for all exposures. Save the image files.
3. Make similar exposure sequences in H, J and K bands. Assess linearity, and gain inside specification. Save the image files.
4. Be sure that any remenance has dissipated. Make a series of 25 bias frames with integration time set to give dark current signal to noise ratio of (ideally) 5.

Post Test Data Processing. Cool down 2

1. Stack the frames taken in step 1 and subtract these from those taken in step 4.

Analysis. Cool down 2.

1. Assess fixed pattern noise from subtracted images.
2. Assure that the detector now meets the required specification in all respects.