OT-2 Test Report

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Table of Contents

Introduction

Optical Test 2 (OT2) for the Ralph instrument was carried out in October 2004 at BATC. OT2 was a cryogenic vacuum test whose objective was to prove out key functionality and performance aspects of the integrated RALPH instrument. The test was to provide a performance baseline preparatory to final environmental acceptance testing. No verification of statement of work level requirements was planned, though testing did reduce risk and build confidence in the instrument. The Test Readiness Review was held on 7/29/04 and was documented under the Principal Investigator Monthly Review (PIMR) #11. OT2 follows OT1 and precedes the final Ralph thermal vacuum test, all of which have similar testing.

The hardware configuration for the test was with the flight TDA, including the flight MVIC and LEISA detectors. The electronics for the test used flight spare LVPS, CD&H, and electronic box, and the "EM2" detector electronics board. EM2 was the flight board that had been downgraded to flight during September of 2004. The test was performed in the Ball 8 thermal vacuum chamber. The test was done per procedure #575017.

The scope of this test report is to review the results and conclusions that were found during OT2 testing. Many of the tests required extensive analyses to be performed. The results of these analyses are summarized here and the SERs that contain the detailed write-ups are referenced. A complete understanding of the test requires that those SERs be read.

OT2 deviated from the original baseline plan presented at the TRR primarily in the area of electronics. The baseline plan had the flight spare electronics being used and the engineering MVIC. The flight MVIC's schedule made it possible to use it for the test. Because of numerous problems in the electronics, an engineering detector electronics board was used and only side A of the electronics was functional. Also, there were numerous electronic noise problems for both the LEISA and MVIC science channels. Because of schedule concerns, the customer directed BATC to proceed into OT2 without resolving all of these open issues (or "liens"). These are discussed in more detail throughout the text and in Appendix 1.

While the test was performed at BATC with BATC personnel, other New Horizons people were involved. Dennis Reuter (NASA GSFC) the mission scientist and LEISA IPT lead performed realtime data reviews. His summary of performance is included in Appendix 3. In addition, a team of SWRI scientists reviewed data in support of anomaly identifications.

OT2 (the original cryogenic test) was extended to include related testing during October and November, 2004. A summary of these test results is also included. Specifically:

- **OT2A –** A room temperature optical focus test of MVIC after the detector was reshimmed to compensate for an error discovered in OT2. This occurred prior to TDA vibe testing.
- **OT2B –** A room temperature optical focus test of MVIC after vibe to verify that no movement in the MVIC flight detector focus had occurred
- **OT2C –** A cryogenic test whose principal goals were to test the focus of MVIC and LEISA (post-vibe), and retest the thermal design after modifications.

A note on analysis tools. Much of the work done in analyzing OT2 data was done using customized software tools developed by the different analysts that match their needs. The primary tools used in creating the data images for analysis (including conversion to FITS format) are Ballview and the Ralph Analysis Tool (SER # 2214454) both by Dina Demara.

Technical Summary of Test

1. MVIC and LEISA flight detector focus locations were measured. An error in the MVIC shim was corrected and retested. Detectors passed derived focus requirements.
2. MVIC passed its MTF requirement for image quality. LEISA met its goal. Air Force target data was collected to illustrate performance and build confidence in image quality.
3. MVIC/LEISA focuses and transverse locations did not change as a result of vibe.
4. Detectors relative location (coregistration) was quantified to support future boresight verification.
5. SIA optical performance was measured for both detectors. LEISA was fully illuminated and field flatness was similar to that measured through the main aperture. MVIC was found to not be fully illuminated by the SIA, likely due to a manufacturing flaw. However, SIA performance and stability was adequate to meet its requirement.
6. No light leakage was measured for the TDA at the 10 DN level.
7. The straylight performance was measured. Both the in-field light leakage between arrays and the out-of-field leakage back into the arrays met requirements.
8. Detector uniformity was measured at multiple light levels with an integrating sphere illuminating the primary aperture for characterization purposes only. No evidence of vignetting by flight hardware was found. There was no independent light monitor on the sphere which will need to be introduced for future testing.
9. MVIC detector noise was characterized at high light levels showing that it was shot noise limited as expected.
10. MVIC dark noise performance showed intermittent systematic errors that were characterized and documented for troubleshooting. All of these errors were observed prior to OT2 with the exception of one associated with testing with a strobed light. These errors prevent MVIC from meeting its performance requirements, including SNR.
11. LEISA dark noise failed its derived requirements on SNR, as expected going into the test. LEISA was not configured for low noise at the start of the test (see Appendix 1).
12. Only side A of the electronics was used on account of known side B problems going into the test. Otherwise, the overall instruments electrical, software, and command/telemetry functionality was good with minor noted exceptions including the LEISA flight temperature monitor.
13. The pin puller was operated numerous times during testing with no failures including pre/post vibe. It passed its derived requirements. However, its performance was inconsistent with recent recommendations on test tolerances that arose from failures associated with annealing in the bimetallic wire in other programs.
14. Thermal performance requirements for the detectors were not met in testing. Modifications in flight hardware and updated modeling are in process.
15. Spectral data on the LEISA detector was collected with a Xenon lamp illuminating the main aperture. A quicklook at the data showed good agreement

with published data. This was not true for a Krypton lamp. This test was for characterization only and will not be repeated.

1. Functional Tests

1.0 Instrument Performance During OT-2

From an operations perspective, the Ralph instrument OT-2 performance was nominal given the known liens going into the test. As opposed to OT-1, the ground system (GSEOS, FrameGrabber) also performed well and was in no way a hindrance to executing the planned sequence of tests.

1.1 Pre-Test Liens

The following were known issues going into OT-2:

- Side B of the LVPS was inoperable. This resulted in not performing any side B functional testing nor performing the side B portion of the radiometric/flat-field testing.
- The detector electronics (DE) board does not allow reliable control of the LEISA DAC offset values when the board temperature falls below 15ºC. To compensate, the board was kept above 20ºC for the duration of the test. This did not affect any planned testing for OT-2 but did preclude any attempts at operating at or near the ICD limit of 0ºC.
- The LEISA temperature sensor was found to be reading out-of-family with all other instrument sensors (both flight and GSE) at room temperature conditions. In the cleanroom, the LEISA sensor read approximately 5.9ºC while all other sensors were reading 20 - 22ºC. Inside the Ball-8 chamber, still at ambient pressure and temperature, the LEISA sensor read approximately -26ºC while all other sensors were reading 25 - 28ºC. To compensate, an additional GSE sensor was added on the thermal strap backshell, as close as possible to the LEISA detector. This did not affect any planned OT-2 testing but does affect the thermal engineer's ability to positively state the temperature the LEISA detector actually reached at cold. Post – test electrical analysis indicates that the source of the error is related to the sensor's being electrically shorted to LEISA's molybdenum baseplate which in turn may have been shorted to the TDA by MLI. (see SER #2216491 by Kubitschek).

1.2 Functional Test Results – OT-2

The Ralph Electronics Box Functional test procedure (574910) was run four times during OT-2:

- In cleanroom 6 to verify instrument functionality prior to moving to the Ball-8 chamber.
- In the Ball-8 chamber at ambient pressure and temperature to verify all connections prior to pumping down the chamber.
- With the Ball-8 chamber evacuated (<1e-5 torr), ambient temperature, to verify the instrument functionally under vacuum prior to transitioning cold.
- At thermal stabilization (cold) to verify instrument functionality. (Note that this test was planned to be run prior to initiating any instrument performance

testing at cold. Due to realtime re-prioritization of tasks, this functional test was actually interleaved with the cold performance testing.)

Table 1-1 identifies the test cases that were run in the functional test.

Test Case	**Description**
EEPROM Write	Tests ability to write to the three code areas and three table areas of EEPROM.
PROM / EEPROM Boot Test	Tests ability to boot from either EEPROM or PROM. Note both cases are timed.
Hardline Reset	Tests C&DH and DE response to a reset received from the spacecraft (Emulator Box)
RAM Test	Tests integrity (read/write) of the various RAM areas.
EEPROM Dump Test	Verifies ability to dump EEPROM contents to the ground. Also checksums all areas of EEPROM
Telemetry Verification	Verifies the values of nearly all Housekeeping (HK) and Instrument State (IS) telemetry items.
One-Pulse-Per-Second (1PPS) Test	Tests ability of C&DH to continue processing w/o receipt of the 1PPS from the spacecraft. Also verifies the integrity of the timestamp in the high speed telemetry stream under the same condition.
"Regular Command" Verification	Verifies parameter checking and processing of non-detector commands (GO, NOP, STATE, etc.)
Group Relay Verification	Verifies the ability to command the group relays in any combination.
MVIC Forced-Mode Data Acquisition	Verifies ability to command and acquire data from all MVIC arrays.
LEISA Offset Verification	Verifies ability to set DAC offset values to the rails as well as nominal settings.
LEISA Forced-Mode Data Acquisition	Verifies ability to command and acquire data in both LEISA raw and subtracted mode.

Table 1-1 Ralph Instrument Box Functional Test Cases

The instrument performance remained consistent across all runs; no environment-specific issues were identified. The test anomalies, which persisted through all runs of the procedure, are as follows:

- Housekeeping telemetry item, RLY_ERR, consistently read the incorrect value. This is a telemetry item which indicates if the group relays are properly configured. Lab testing identified this anomaly, so the occurrence in thermal vacuum testing was expected. The problem has been traced to the C&DH firmware; SwRI software engineers are aware of the issue and a fix is expected in the next revision of their software.

- Efforts to write a valid table into EEPROM yielded a VERIFY-FAIL error code. This error indicates that, following the write of the table contents to EEPROM, a checksum of the table area failed. This error was consistent across all three EEPROM table areas. Note that a write of a test pattern to the same area succeeded as did code and test pattern writes to the code areas of EEPROM. A subsequent checksum of the EEPROM table area, that had failed the checksum during the write process, provided a valid checksum result. This problem was also seen prior to thermal vacuum testing. The SwRI software engineer explained that there existed (still exists in our version) a subtle timing error where the checksum calculation could occur too soon after the final write of data to EEPROM. Seeing this error was subject to the data content that was written to EEPROM (which is why the test pattern worked while the valid table image didn't). This problem has been resolved in the next revision of the C&DH firmware.

1.3 Functional Test Results – OT-2B & OT-2C

An abbreviated version of the Ralph Electronics Box Functional test procedure (574910) was run five times during OT-2 tests B and C:

- In cleanroom 6 to verify post-vibe instrument functionality prior to moving to the Ball-8 chamber (OT-2C).
- In the Ball-8 chamber at ambient pressure and temperature to verify all connections (OT-2B) prior to pumping down the chamber (OT-2C).
- With the Ball-8 chamber evacuated (<1e-5 torr), ambient temperature, to verify the instrument functionally under vacuum prior to transitioning cold (OT-2C).
- At thermal stabilization (cold) to verify instrument functionality (OT-2C).

The abbreviated functional test procedure consisted of running the following sections of 574910 (see Table 1-1):

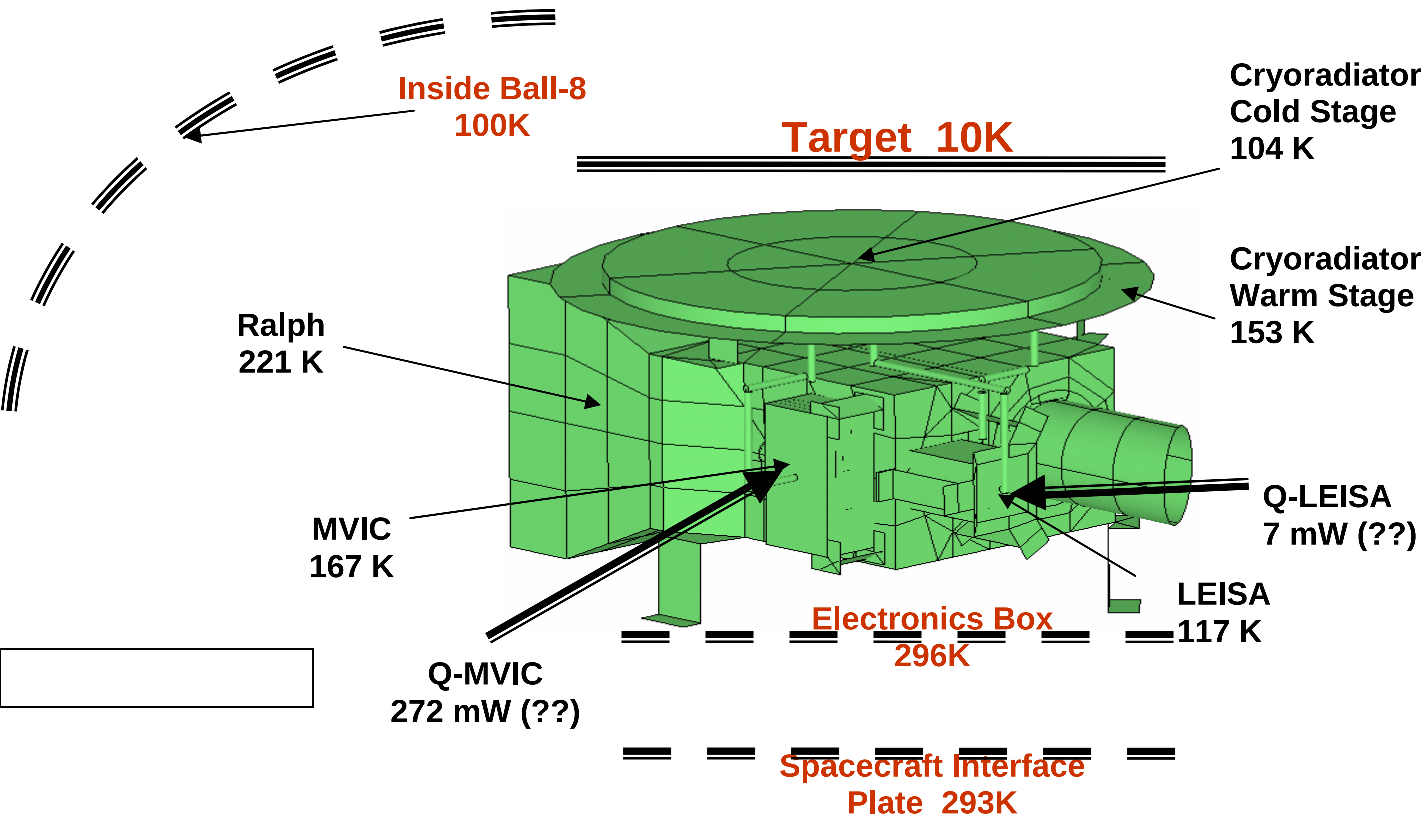
- Telemetry Verification
- Group Relay Verification
- MVIC Forced-Mode Data Acquisition
- LEISA Offset Verification
- LEISA Forced-Mode Data Acquisition

As in OT-2/A, the instrument performance remained consistent across all runs; no environment-specific issues were identified. The RLY_ERR anomaly persisted through these tests. The EEPROM write portion of the functional test is not included in abbreviated runs; consequently the EEPROM write anomaly was not encountered.

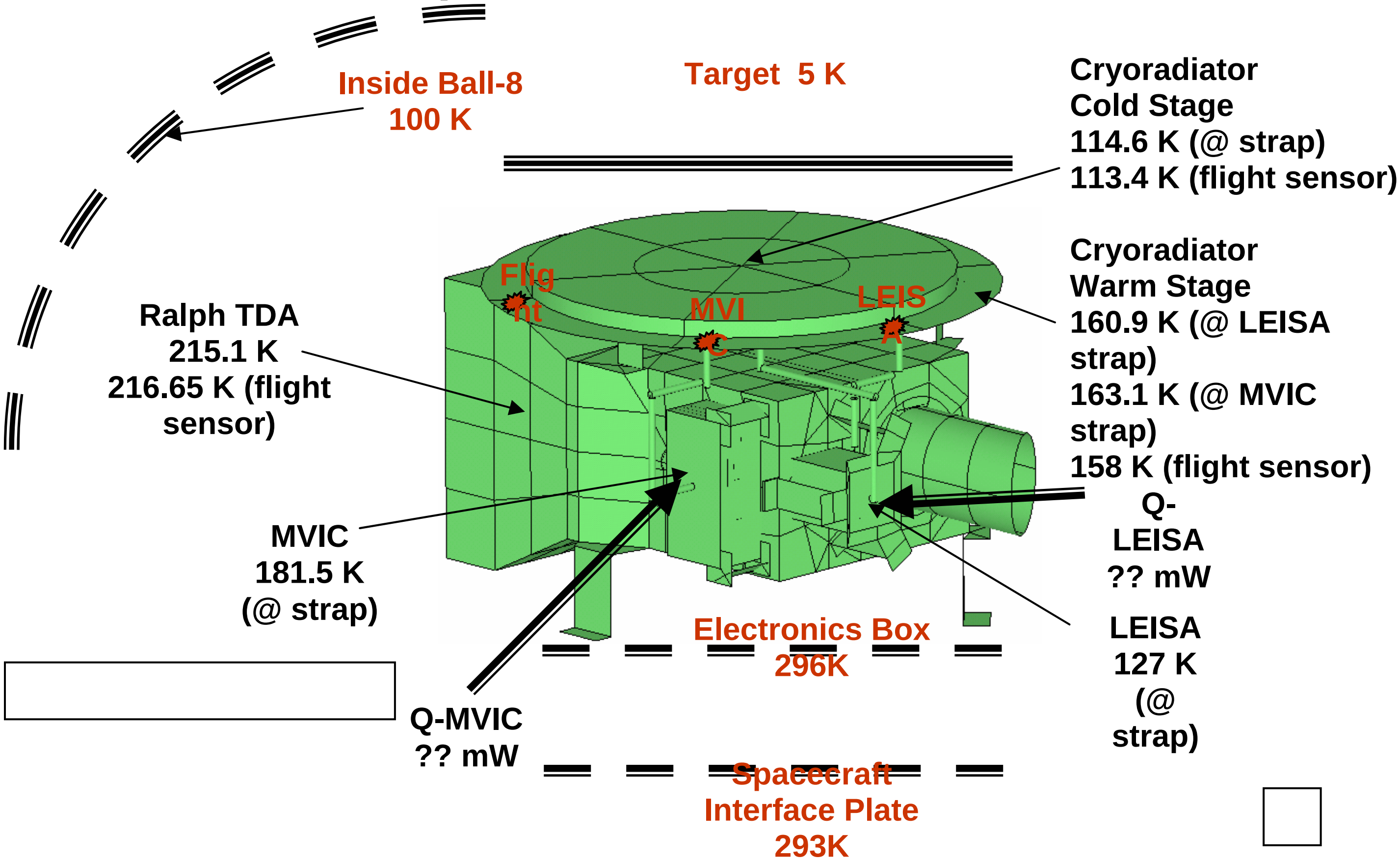
2. Thermal Performance

The thermal performance of the Ralph instrument during OT2 did not agree with model predictions. This included that the flight detectors did not reach their required operating temperatures. LEISA measured 10 K higher than predicted (127 K vs.117 K) and MVIC measured 14.5 K higher (181.5 K vs. 167 K). MVIC did not reach its predicted value but was within specification.

The following figure shows the predicted OT2 temperatures (see Hardaway SER# 2219150):



The achieved temperatures were:



The reasons for the discrepancies have been enumerated in the SER and a plan for correcting them is in process. If left uncorrected, the identified problems in the flight design would result in LEISA meeting its thermal requirements with zero thermal margin. This is viewed as an unacceptable risk on account of error inherent to the model.

3. Pin Puller Performance

The pin puller was tested with both primary and redundant circuits throughout OT2. The actual aperture door was open for the cryogenic testing so optical data could be collected as the system cooled. The data at ambient temperatures was for the door initially closed. The door is defined to be “open” in both cases when the voltage across the pin puller drops to zero. In each case the pin puller is operated off of a GSE 30 V line. In-flight it will be operated by the spacecraft. The time between application of 30 V and door “open” defines the “function time” which is known to change significantly with nominal temperature (see OT2 Test Procedure). The table below shows the data. In each case the pin puller performance passed derived requirements.

Recently, BATC has been told by SWRI that a new failure mode has shown up on this type of pin puller on other New Horizon instruments. This failure mechanism is that the critical bimetallic wire that holds the latch can become annealed. Once this occurs, the pin can be reset but afterwards will not retract again. This annealing might be caused by either applying the voltage for too long, or by friction between the in and mechanism. The annealing it is believed would appear as a subtle resistance change in the wire. The resistance should be 6.5 +/-0.3 Ohms and each test measurement should be within 0.2 Ohms of each other. Subtracting the GSE resistance from the data shown in the table gives 3.1, 5.7, 7.2, and 5.8 Ohms respectively. This obvious lack of agreement with expected resistance and the large range of resistance values for the different measurements has not been yet resolved.

Test	Date	circuit	Temperature K	Item	unit	expected	test value	pass/fail
OT1	5/9/2004	Primary	194	reset circuit resistance release circuit resistance function time pin puller opened	ohm ohm msec	56.0±6.0 10K min Eng info opened	54.1 71M 250* opened	pass pass pass
OT2A	10/7/2004	Primary	218	reset circuit resistance release circuit resistance function time pin puller opened	ohm ohm msec	56.0±6.0 10K min Eng info opened	56.7 OL 230* opened	pass pass pass
OT2B post MVIC shimming pre vibration	10/22/2004	Redundant	ambient	reset circuit resistance release circuit resistance function time pin puller opened	ohm ohm msec	56.0±6.0 10K min Eng info opened	58.2 OL 200* opened	pass pass pass
Post ship from APL	10/30/2004	Redundant	ambient	reset circuit resistance release circuit resistance function time pin puller opened	ohm ohm msec	56.0±6.0 10K min Eng info opened	56.8 18.12K** 190 opened	pass pass pass

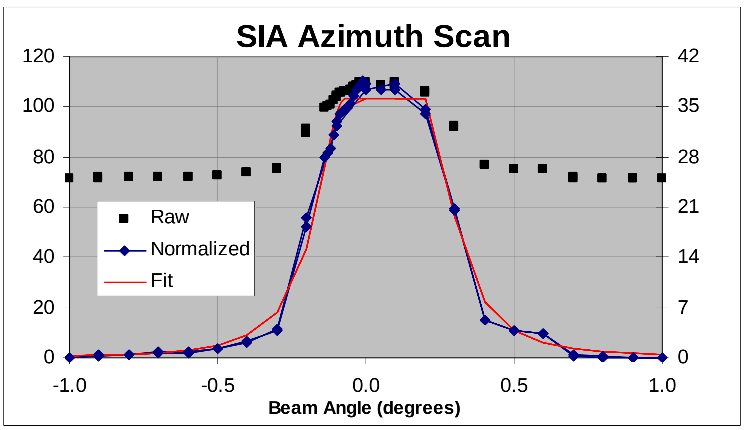
Note:
1) * indicates scope trace was inadvertently not stored.
2) pin puller has in series resistor of 51 ohms.
3) cables used in chamber are different cable than used for ambient operation
4) ** indicates a measurement made with GSE circuit attached, will be repeated

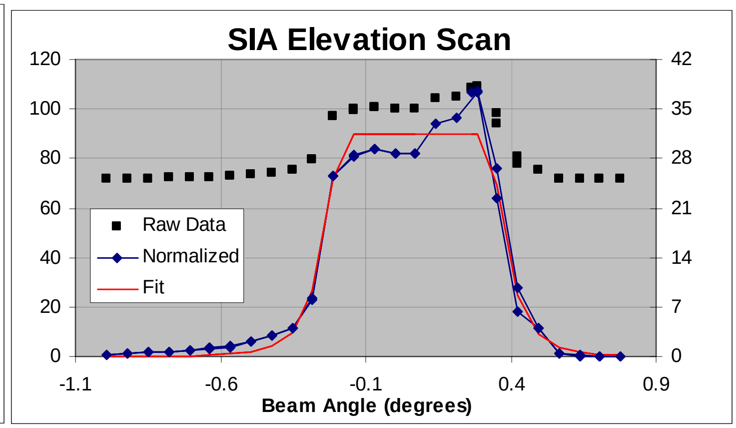
4. Solar Illuminator Aperture (SIA) Performance

The goal of the SIA is to provide flat-field illumination to the LEISA and MVIC arrays to allow their optical characteristics to be monitored over the course of the mission. The requirement on the SIA does not define what is acceptable performance, so testing during OT2 was designed to characterize the performance for future use. The data was analyzed and documented by Jim Baer in SER #2218978. Examples of the data are shown here.

The specific objectives of the testing were to characterize the input acceptance angle of the SIA and characterize how flat the illumination field was as seen by the flight detectors. In addition, comparing the results from OT2 and OT2B/C the stability of the illumination was found.

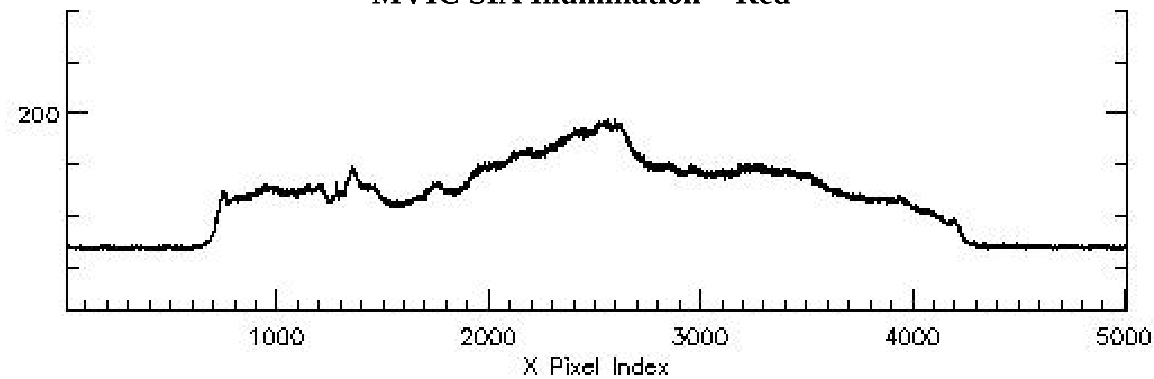
Azimuth and Elevation scans of the SIA input angle yielded repeatable values of 0.490° and 0.634°, respectively. The expected input angles by design are both 0.63° . The reason the azimuth scan is less than expected is believed to be due to the scan not being centered, this needs to be confirmed. However, it should not impact its application.





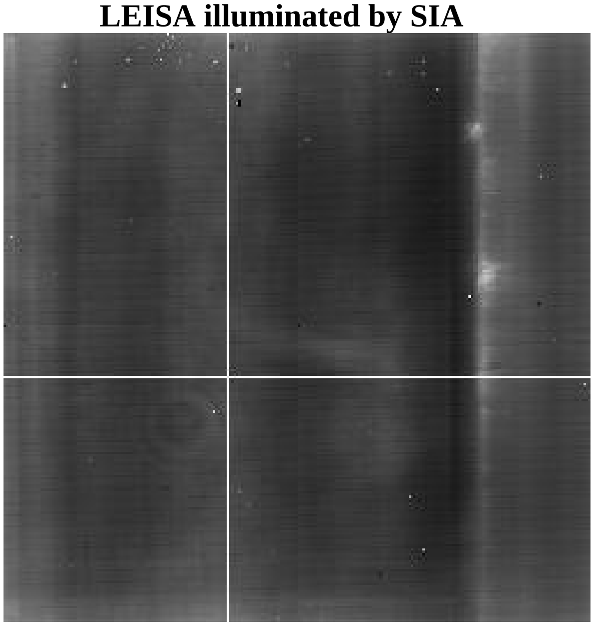
Below is an example of the illumination amplitude measured on the MVIC Red array. Variations in the measured signal amplitude can be seen, this is the "field flatness". This includes here not only the optical effects associated with the SIA itself, but also filter transmission, detector pixel-to-pixel uniformity, and noise. The basic patterns can be seen in the images themselves and were observed to be stable between OT2 and OT2B/C. In addition it can be seen that the illumination did not extend to the edges of the array, but drop to the 40 count offset well within the 5000 pixel width of the array. This was observed on all of the MVIC arrays and is suspected to result from a manufacturing error in the SIA. The addition of a lens to the output coupler by the vendor had the effect of reducing the overall diameter of the illuminated circle to less than that required to fully illuminate all MVIC arrays. This can only be corrected by rework of the SIA within the TDA.

MVIC SIA Illumination - Red

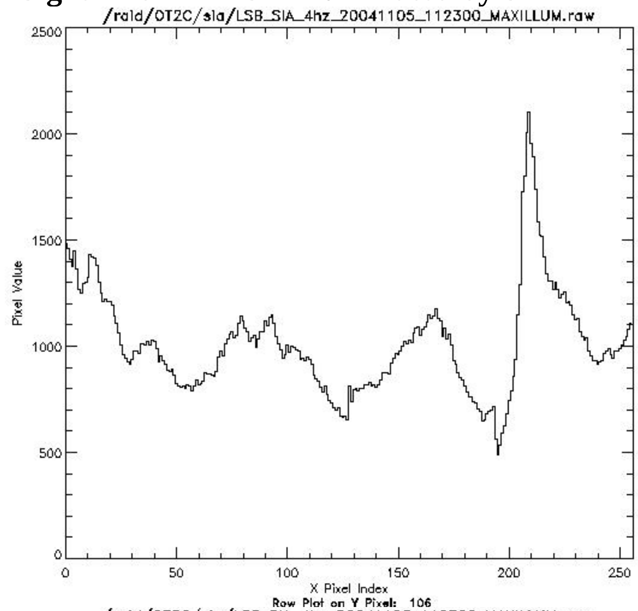


The LEISA array was fully illuminated by the SIA despite the design flaw because of its smaller field-of-view. Below is an example of the results of LEISA illuminated by the SIA. The vertical and horizontal white lines have been added to show where the following line plots are collected. Comparing the images where the detectors were illuminated with the SIA (below) and through the primary aperture (Section 8) shows that the dominant structure comes from the filter/arrays themselves. However intensity rings that occurred in the SIA images on MVIC and LEISA were not observed in the data taken through the main aperture and therefore must be SIA effects.

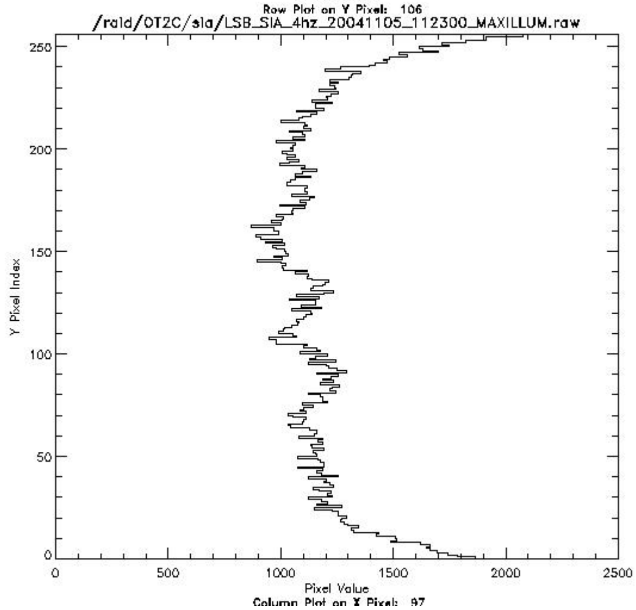
LEISA illuminated by SIA



Signal from LEISA Illuminated by SIA



Along a Row



Along a Column

The peak in the signal near column X=200 is believed to be due to the physical edge in the LEISA etalon filter. For the signal along a column, the rise in the signal at the edges (Y= 256 and Y = 0) is not understood at this time, but similar results were found when the detector was illuminated by a flat field through the main aperture (see Section 8)

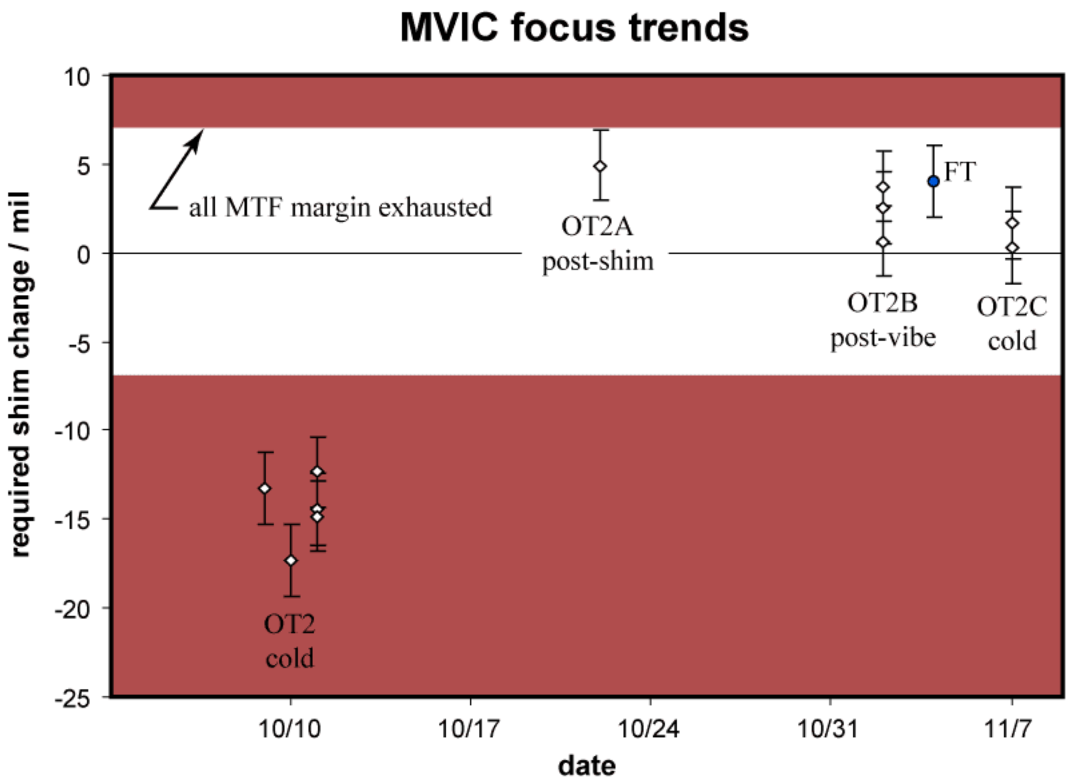
5. Detector Optical Focus

In order for Ralph to collect clear images of Pluto the detectors must be “in-focus”, simply meaning they must be at the rear focal point of the telescope. The flight detectors being shown to be in-focus and stay in-focus over temperature and pre/post vibe was one of the primary objectives of the Optical Test 2 series. Simplified, the measurement starts with the flight detectors shimmed to what was believed to be their correct location for focus. Then, a source of collimated light (simulating light from infinity), was coupled into the TDA and an image collected. The collimation of the light was varied and the image re-collected. The image with the smallest measured spot defined the best focus for each detector. MVIC, because of its much smaller pixel size, provides the more demanding test.

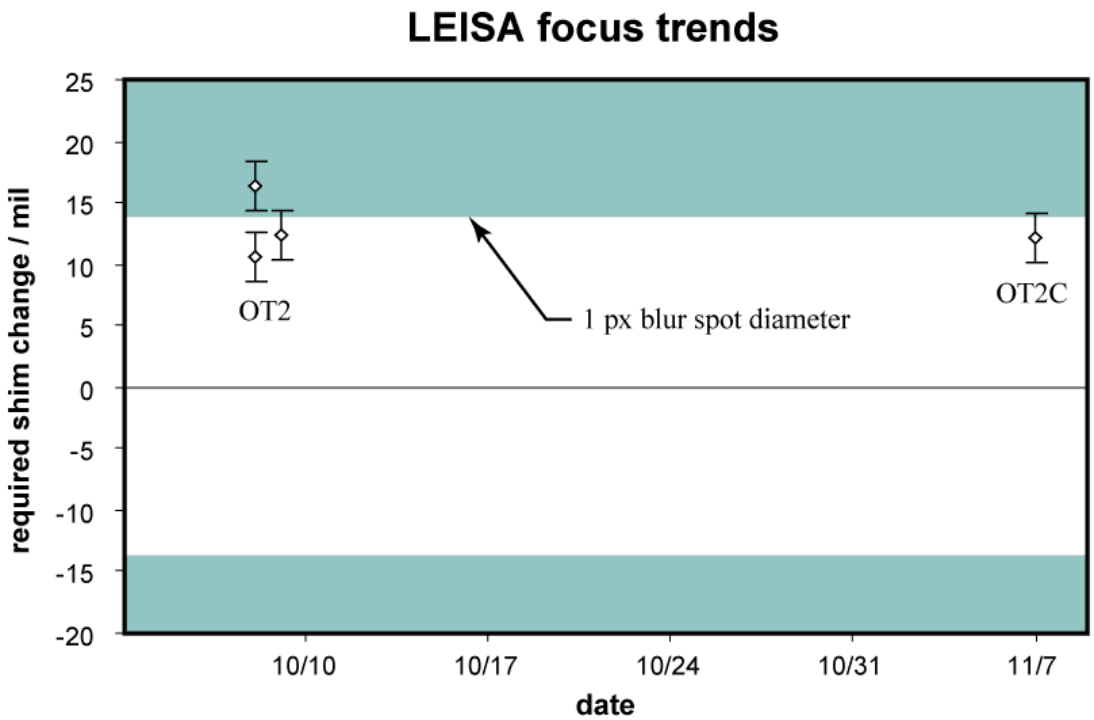
What follows is a summary of the analyses and SER 2216317 by Derek Sabatke.

To ensure that best focus would be obtained at the detectors' physical locations, a series of measurements was made throughout the development of the TDA and detectors to track dimensions and changes that were made. Despite this, the first OT2 measurements found that both MVIC and LEISA detectors were not located at best focus. MVIC was sufficiently out of focus that the models predicted that it would not meet its MTF (Modulation Transfer Function) requirement on image quality. LEISA has no equivalent requirement.

Based on the measurements a new shim value for MVIC was calculated and installed. Shim replacement does not require removal of the detector package. The focus was then re-measured in OT2A at room temperature. The results of OT1 and OT2 both showed that the TDA optical design was sufficiently athermal that there was no significant focal shift going from room temperature to nominal operating temperatures for MVIC. This was confirmed again in OT2. (Focus cannot be measured on LEISA at room temperature on account of degraded noise/responsivity performance). A graph showing the MVIC trend during OT2 compared with its derived requirement is shown below. The shim operation is seen to have brought MVIC within its requirement and no statistically significant shift of the focus occurred in going through vibration testing. The error bars in the graph estimate systematic and random errors in the optical measurement set-up. FT here stands for a measurement made on the frame transfer array, the other measurements all being made on pan (or in one case red) arrays.

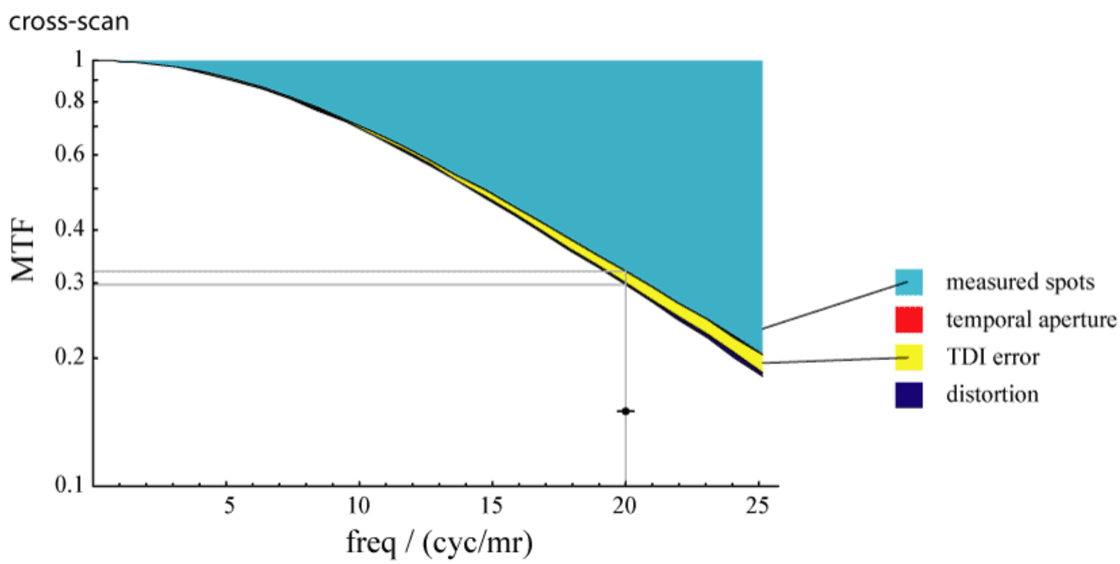


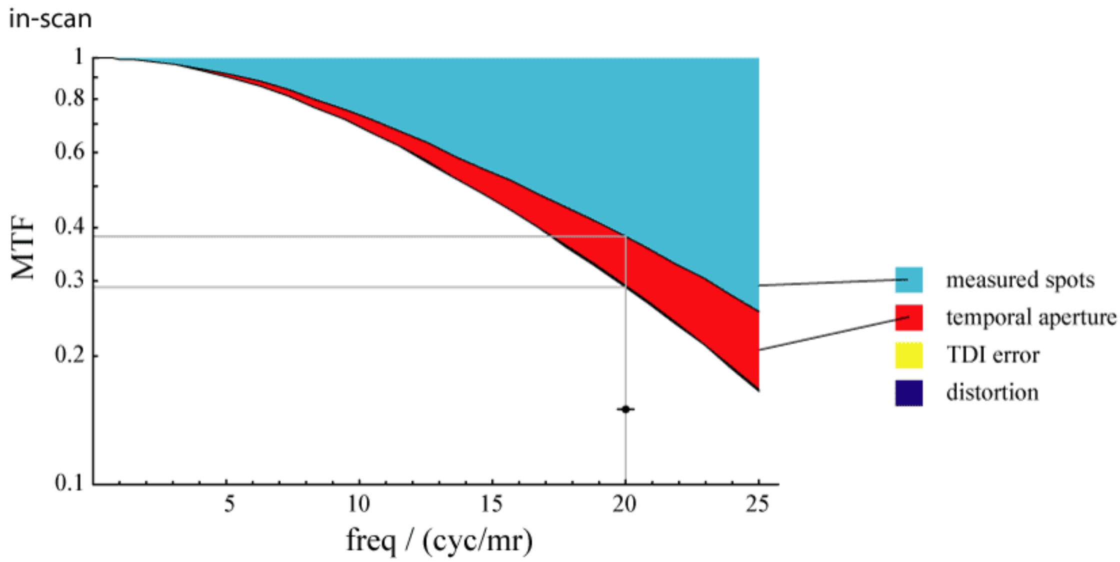
No shim correction was made on the LEISA detector. The trend chart below shows that the installed shim met the goal of having a one pixel spot blur diameter. Note again, LEISA focus data could only be collected at cryogenic temperatures.


LEISA focus trends
required shim change / mil
25
20
15
10
5
0
-5
-10
-15
-20
OT2
1 px blur spot diameter
OT2C
10/10
10/17
10/24
10/31
11/7
date

6. Optical Image Quality

There are many measures of optical image quality. The Ralph Instrument Specification uses the Modulation Transfer Function (MTF) for MVIC. Specifically, “the MTF for data obtained using the TDI data acquisition shall be ≥0.15 at 0.020 cycles/μrad for all wavelength bands”. The MTF is calculated from measurements on the spot size at focus (Sabatke SER 2216317). The calculated values are combined with modeled values of other effects (see Sabatke SER # 2203452) to give a predicted worst-case in-flight performance. This is shown below for both the cross-scan and in-scan directions. The graphs show that the MVIC can meet its MTF requirement (shown as a dot) with significant margin.





While MTF gives a quantitative measure of image quality, imaging a known extended target is a traditional means that is more intuitive and can build confidence in the system performance. During OT2 a standard Air Force target was illuminated by a strobe and imaged onto both MVIC and LEISA. The image was set, near but not at, best-focus and is therefore not a definitive measure. However, it does give some measure of the optical image quality as well as an integrated system performance, in that it also includes detector and electronics performance. Notes are by Jeff Van Cleve.

MVIC Examples
File:
`/raid/OT2/ExtndSource/FITS/MFR_ES_TGT_0p25s_1hzSTROBE_LIGHTSOFF.FITS`

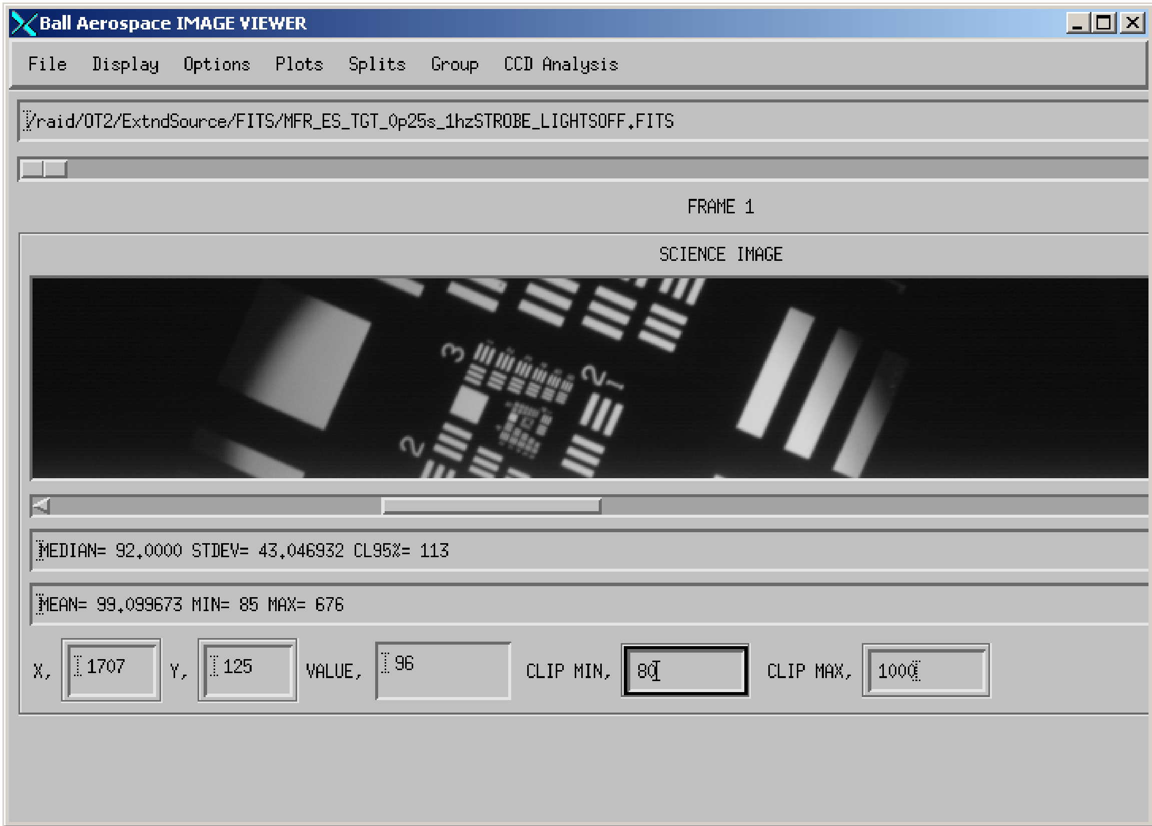


Figure MVIC-1: Frame image of Air Force standard target. Note that our "hard zero" problem does not occur at the bottom of this frame image.

File:
/raid/OT2/ExtndSource/FITS/MP1_ES_TGT_4hz_p07hzSTROBE_LIGHTSOFF.FITS

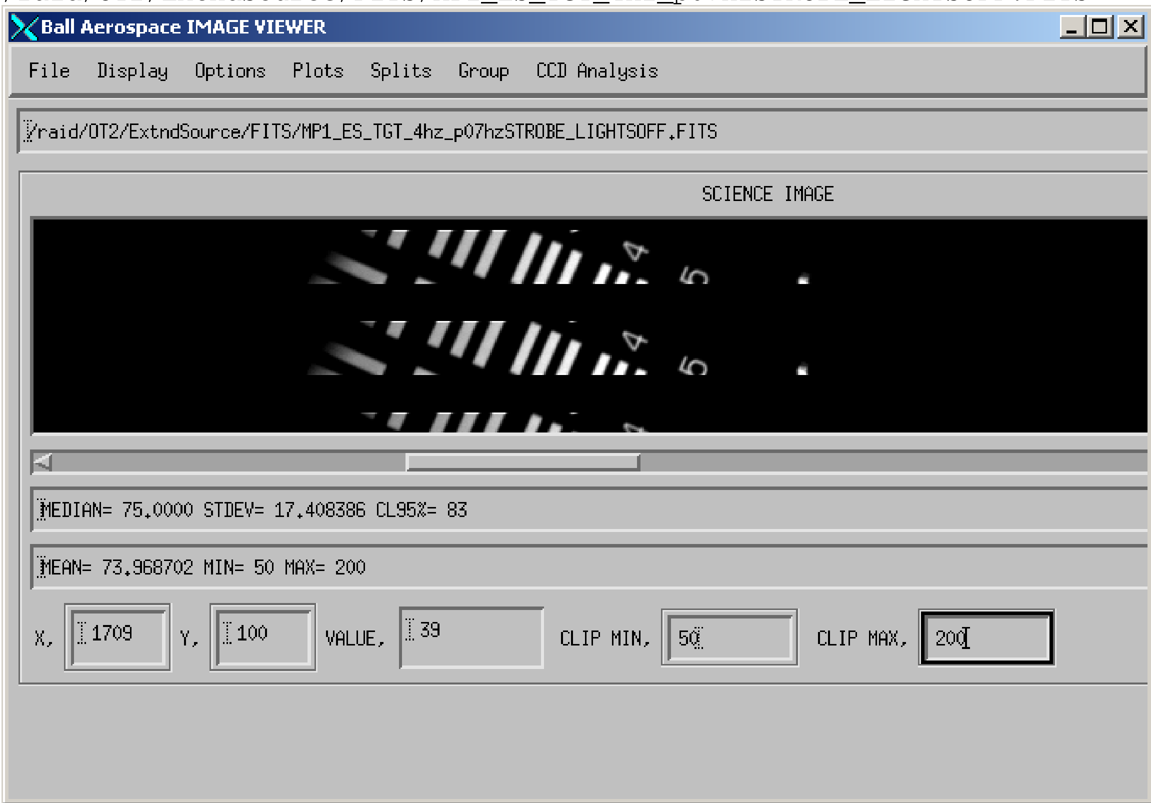


Figure MVIC-2: Pan1 image showing Air Force test target illuminated by strobe to freeze pattern on TDI array.

LEISA Examples

File: `/raid/OT2/ExtndSource/FITS/LRW_ES_TGT_1hz_7hzSTROBE_LIGHTSOFF.FITS`

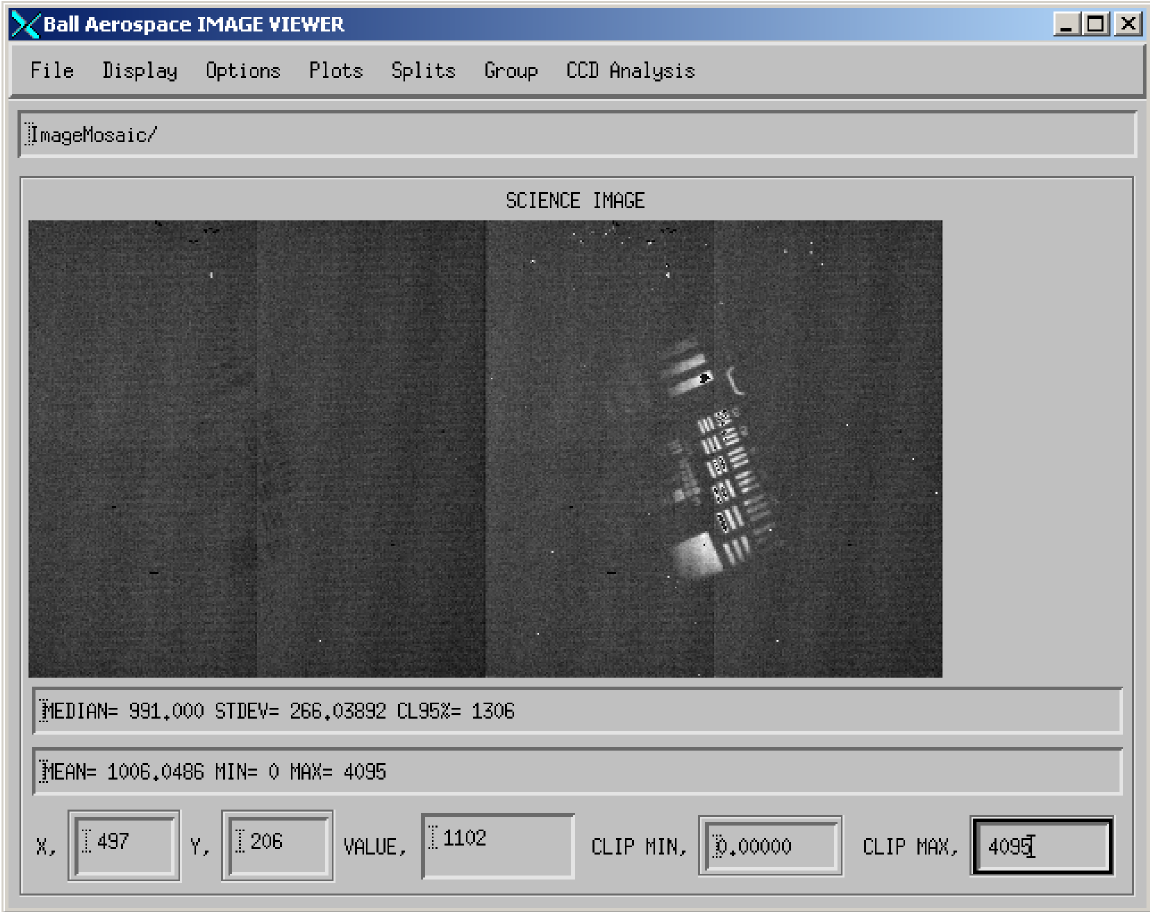


Figure LEISA-1: reset (L) and read (R) images showing the target pattern (R) and a faint negative image of the bright target on the reset image.

Such negative images (as see on left) are routinely observed on Spitzer array reset images after saturation by a bright source. The amplitude of the negative image is at most 200 DN after saturation (see black pixels in R image). Quantitative analysis of this effect on radiometric accuracy for time-varying scenes is TBD.

Note fade on L side of R image as filter throughput and fiber-optic source output decrease.

File: /raid/OT2/ExtndSource/FITS/LRW_ES_TGT_1hz_7hzSTROBE_LIGHTSOFF.FITS

Figure LEISA-2: Same as Figure LEISA-1. This is a read-reset image, square root scaled to bring out detail. Black pixels in illuminated areas are the ADC wraparound and may be restored by adding 4096 to the pixel value.

7. Detector Co-registration

Co-registration of detectors refers to measuring the relative physical orientation of the detectors as regards to the system optical axis. This can be done by imaging a spot onto both detectors and recording the coordinates for each “simultaneously”. If multiple spots not in a line are collected, then the relative location and angular orientation can both be resolved.

Co-registration is used to verify that there hasn’t been any relative motion between MVIC and LEISA in the planes of the detectors. It will also be used as an input to the boresight alignment verification of LEISA planned for future testing.

The analysis of the coregistration was performed by Jim Baer and documented in SER #TBD. A pair of equations were derived that translate a point on LEISA (measured as row and column) to the equivalent point on MVIC. Specifically, LEISA to the MVIC Frame Transfer Array coordinates.

$$Col_{MVIC} = Col_{MVIC-0} + Scale * \left(Row_{LEISA} * Cos(\theta) + Col_{LEISA} * Sin(\theta)\right)$$

and

$$Row_{MVIC} = Row_{MVIC-0} + Scale * \left(Row_{LEISA} * Sin(\theta) - Col_{LEISA} * Cos(\theta)\right)$$

From three spots recorded in OT2B, the constants of this equation are

C_{MVIC0}	R_{MVIC0}	Theta		Scale	
2090.6	295.5	-0.020	Rad	3.082	MVIC pixels per LEISA pixel
		-1.161	Deg	40.06	Micron

The RMS error, per coordinate, is 1.35 pixels.

A pair of different LEISA/MVIC spot pairs was found for OT2 and OT2C. The OT2 data was collected prior to shimming MVIC and vibe testing of the TDA while the OT2C data was after. Comparing the location of the points allows an upper limit of 24 microns to be placed on the relative transverse movement of LEISA/MVIC. This is equivalent to two MVIC pixels or a single LEISA pixel. The error in the above scaling was calculated to be 1.35 pixels, likely due to optical GSE stability problems. Therefore, within the measurement error, there was no measureable change in detector transverse location due to shimming or vibe.

8. Detector Response Uniformity

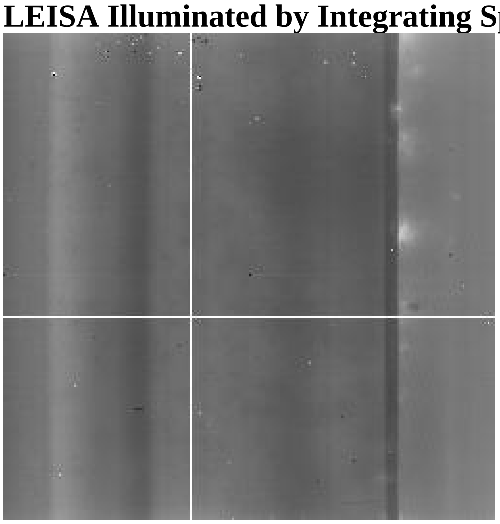
During OT2 a large amount of data was collected using an integrating sphere to provide an extended source and various light levels. The image of the integrating sphere covered all of LEISA but only a fraction of MVIC. To compensate for this, for MVIC measurements the center of the image was set to multiple locations spanning the MVIC arrays. The analysis time required to “stitch” all of these images together to form a set of flat fields for MVIC was time prohibitive. Jeff Van Cleve compiled the filenames and associated illumination levels into a database (flat_field_01.xls) available for further analysis. The data for different radiance levels for a single center were used in Section 13 below. The integrating sphere GSE did not perform well during OT2 in that there was no independent measurement of the light levels that were used.

Below are examples of the data that was collected for both detectors. There are no requirements and they are therefore for characterization only.

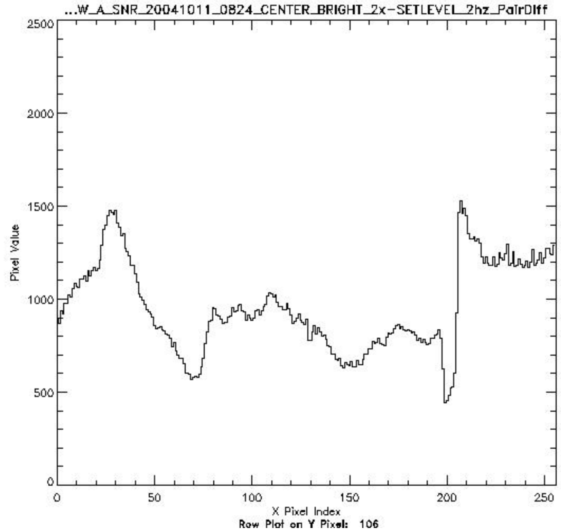
LEISA Detector Uniformity Example

With LEISA illuminated through the main aperture with the integrating sphere, an image was collected and line plots taken along the row and column marked with white lines. Note that these are the same row/column used for the SIA example in Section 4. No intensity “rings” were observed in this data in contrast to the SIA data.

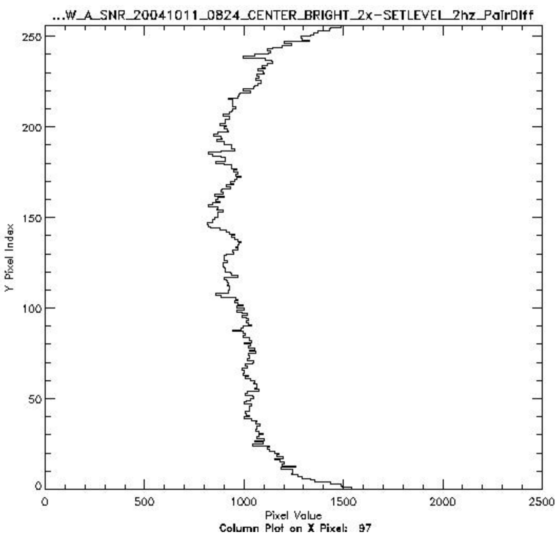
LEISA Illuminated by Integrating Sphere



LEISA Signal while Illuminated by Sphere



Along a Row

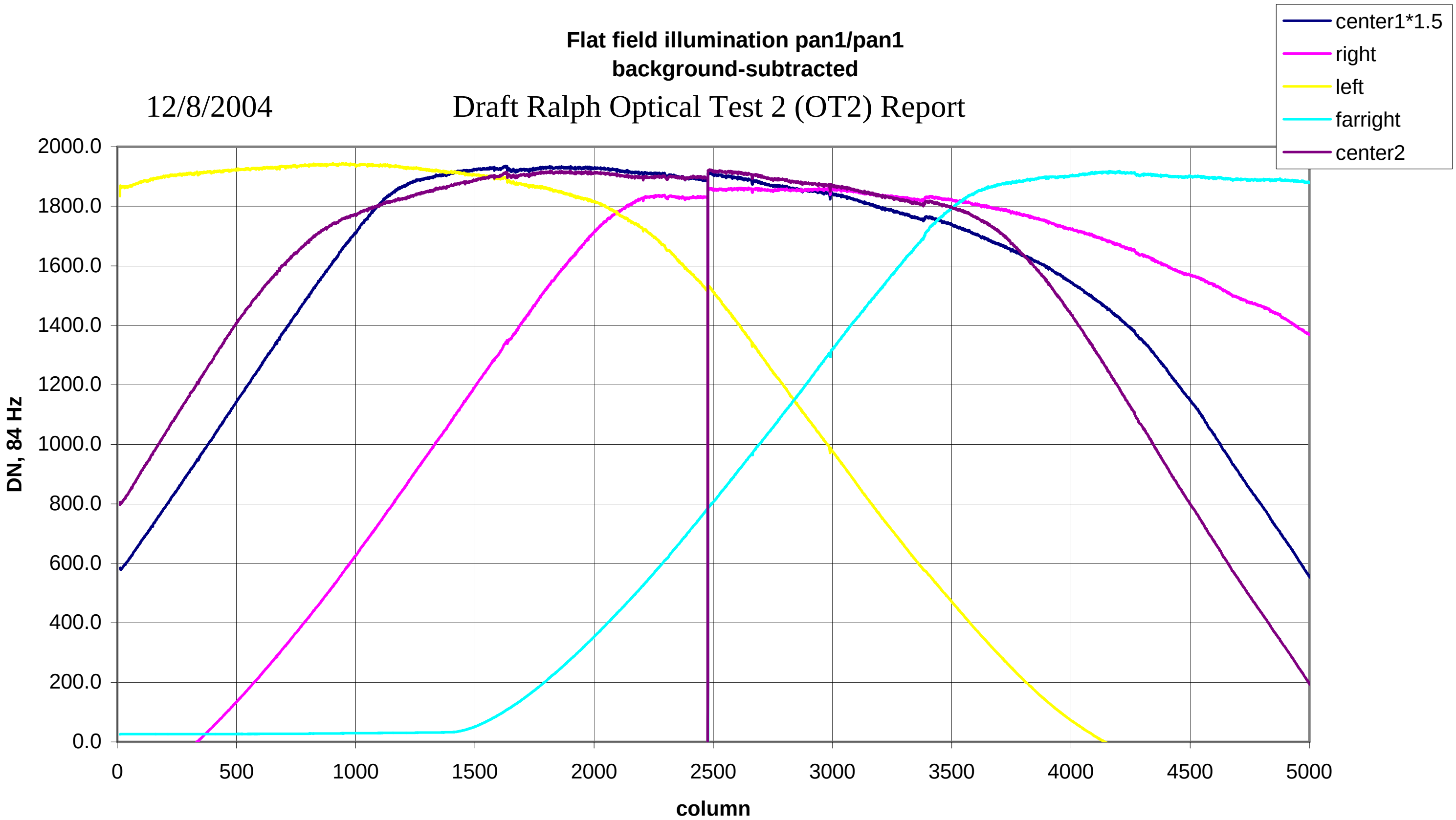


Along a Column

Note the appearance again of the edge in the LEISA etalon near X = 200, and the rise in the signal near the Y= 0 and 256 edges.

MVIC Detector Uniformity Example

Below is an example of data collected for MVIC pan1. The terminology pan1/pan1 in the title is used throughout OT2 uniformity testing to identify that the image was taken on the Pan1 detector with the integrating sphere light level set using the Pan 1 signal (see OT2 Test Procedure for the actual output level counts that were to be set) The background level has been removed . The graph illustrates how data was collected by effectively moving the integrating sphere in order to illuminate across the full width of MVIC (5000 columns).



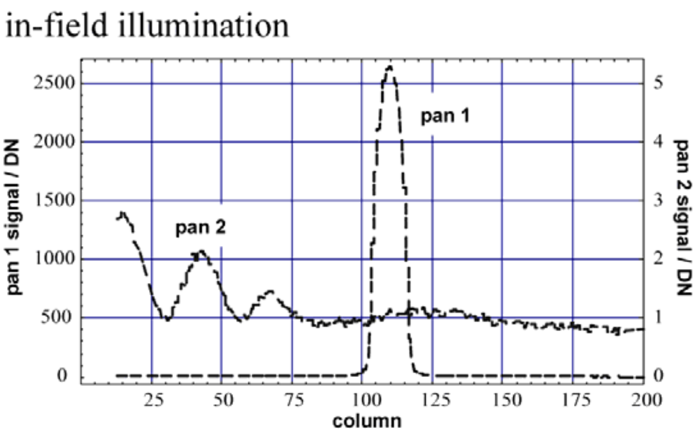
The center location was taken twice. The first time yielded an anomalously low value (requiring multiplication by 1.5 to scale) and an odd shape. The data was then retaken slightly offset from the first.. The vertical line going to zero near the center is a documented FPGA problem. The graphs illustrate that there is very little structure in the MVIC data. This means that for Pan1 the illumination, optical transmission, and detector responsivity are relatively flat.

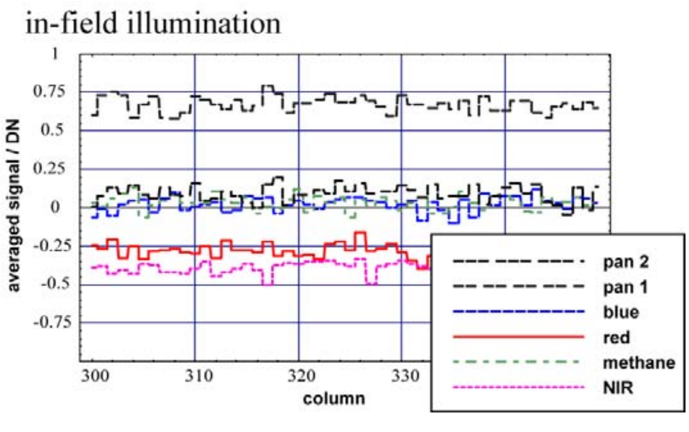
Note that the MVIC arrays cannot be fully illuminated on account of vignetting at the Ball 8 vacuum window and cryoflat mirror. By moving the center of illumination it can be seen that there is no evidence of significant vignetting in the flight hardware, the edges of the array can be illuminated with resulting light levels similar to at the center of the array.

9. Optical Straylight Tests

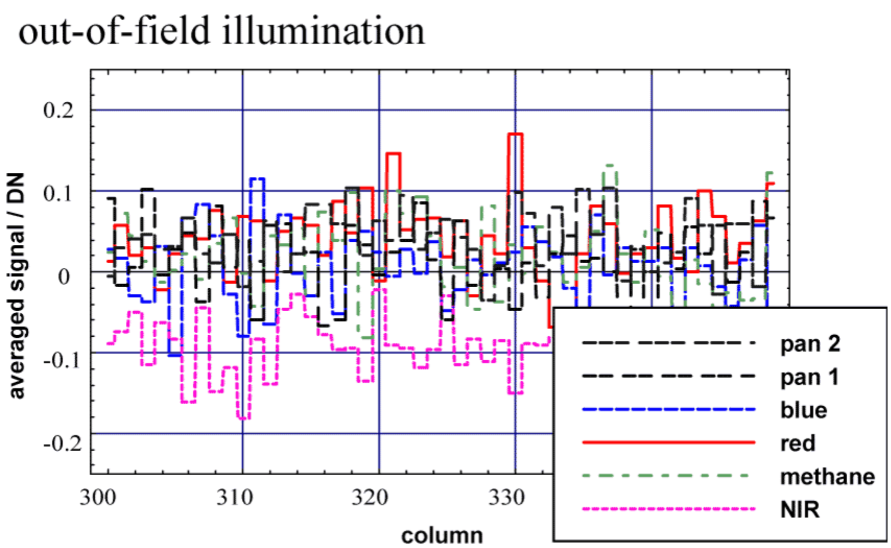
The Ralph Instrument Specification requirements for scattered light are:
RIS2766 The out of field scattered light shall be <=10^{-5}%.
RIS2644 MVIC and LEISA shall meet the performance requirements of this specification when the spacecraft glint is ≥40°from the optical boresight at Pluto.

A test for this was performed during OT2 and the data analysis done by Derek Sabatke. The test was done by first illuminating MVIC pan1 through a 2" diameter aperture aligned within the field of view to give a baseline for the source light intensity. Neutral density filters giving a total attenuation factor of $10^{-4.5}$ were installed to prevent saturation. The first of the following graphs show that there is no significant leakage either optically or electrically from pan1 to pan2 at the same column location when pan1 is strongly illuminated. Similarly, there is no leakage from the strongly illuminated pan1 (spot at column 110) to the other detectors in offset columns (300-350)





The beam was then directed off axis by 13° from the edge of the field of view and the neutral density filters were removed. The angle of 13° was the maximum achievable with the GSE and provided a more demanding test than the RIS requirement of 40°. As a result the beam was directed at the unpainted flight screw heads in the TDA, providing a more stringent test because of the higher scattering. The resulting measured signal was corrected for dark baseline. The results are consistent with the baseline noise, therefore there is no indication of scattered light.



There are different ways to quantify the scattering. The approach taken was to sum the pan2 out-of-field signal across the array (5000 points) and divide it by the sum of pan1 in-field signal (5000 points). This gave an out-of-field scattering fraction for pan2 of < 2×10^{-7}. If instead, the normalized signal on individual pixels are calculated, then this drops to < 10^{-10} . This testing verifies the straylight requirement and won't be repeated in future tests.

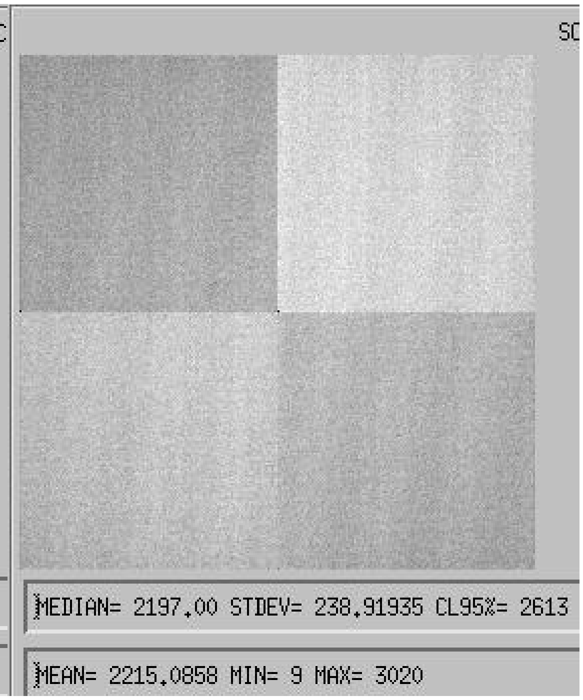
10. Light Leakage Test

At ambient temperatures the TDA was tested for light leaks by shining a flashlight around the TDA away from its apertures while monitoring the signal strength seen on MVIC at room temperature. MVIC noise and drift set the ultimate sensitivity of this approach. Over the time of the test the MVIC signal levels drifted by 10 DN over the test. No light leakage was observed at this level of sensitivity.

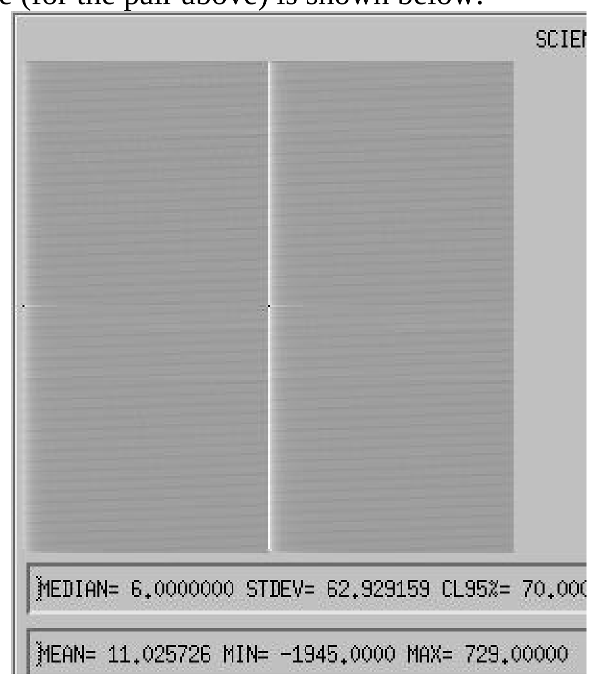
11. Detector/Electronic Noise Performance

Room Temperature and Pressure Examples of Dark Noise Performance of Detectors

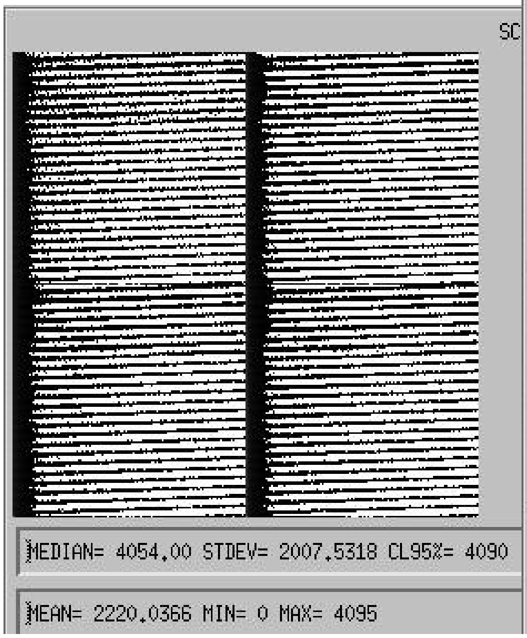
Below are a LEISA raw (reset/read) pair (LRW_A_8p0_20041002_145348.raw) taken in the Thermal Vac chamber at ambient pressure and temperature. This is for information only to support testing and no conclusions can be drawn on predicted in-flight performance.

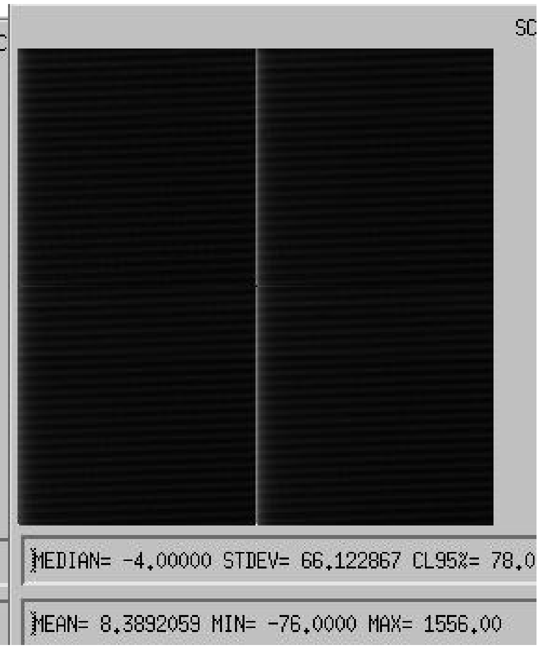


The differenced image (for the pair above) is shown below:



LEISA subtracted images, as shown below (LSB_A_8p0_20041002_145611.raw) are correctable to show detector details:





MVIC images taken at ambient temperature and pressure are shown below, using left/right halves of the detector:

Frame Left (MFR_A_0p25_20041002_144249.raw)

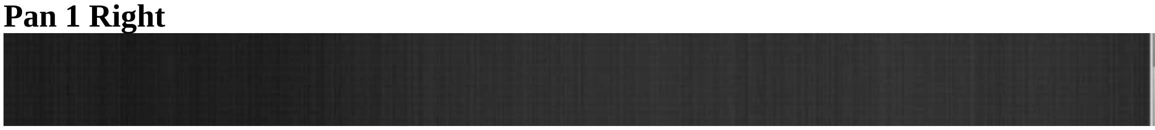
Frame Right

Pan 2 Left (MP2_A_84p0_20041002_144208.raw)

Pan 2 Right

Pan 1 Left (MP1_A_84p0_20041002_144131.raw)

Pan 1 Right



Blue Left (MCL_A_54p9_20041002_143839.raw)

Blue Right

Red Left

Red Right

CH4 Left

CH4 Right

NIR Left

NIR Right

Cryogenic Vacuum Examples of Dark Noise Performance of Detectors

There are two generic types of detector/electronic noise. The first is random Gaussian type that appears white on images. The second is systematic noise that is not random and leads to definite structures appearing in the images. The random type of noise can be handled statistically. Semi-automated “pipeline” code was developed and tested during DE testing prior to OT2 and was used during OT2. This code automatically calculated the median and the mean of the standard deviation of the signal for each detector as well as the 95% value. The resulting data summaries are stored on the Ralph Raid drive (also, see SER #2218850 by Van Cleve)

Dark noise images were also reviewed manually by team members using Ballview and the Ralph Analysis Tool in order to identify systematic noise problems led to image quality problems. These were tracked for post OT2 troubleshooting (see SER #2218850 by Van Cleve and OT2 Summary by Reuter included in Appendix 3).

MVIC Random Noise:

- Met RIS requirements on noise except when systematic image quality images occurred (ie except when systematic noise dominated over random noise)
- Typical values in the 1- 3 counts rms for all detectors and rates
- Note that only Side A was tested and this had a non-flight FPGA

LEISA Random Noise:

- Did not meet RIS requirements. This was expected (see Lien List) and is believed due to noise on the detector bias lines
- Typical noise values for subtracted mode were 20 –40 counts rms and appeared gaussian distributed
- Noise was sufficiently high that systematic image quality issues were not identifiable
- Before OT2, LEISA noise had been as low as 5 counts rms for different DE board configurations for the bias lines

Image quality and systematic noise were studied extensively during OT2 both for dark conditions and illuminated. Results are documented in reports by Reuter (Appendix 3) and Van Cleve (SER #2218850) which includes examples of all of the image problems. Except for one illuminated example, all MVIC image issues were observed prior to OT2 during laboratory work with an EM detector. However, many of the LEISA image issues that could be seen during EM testing immediately prior to OT2 could not be observed in OT2 on account of the higher (gaussian) dark noise resulting from a DE circuit change. For both MVIC and LEISA, a large number of the image issues were of significant amplitude and intermittency such that they would prevent the RIS requirements on signal and noise to be met. The sources of the image problems appear to be varied and spread between FPGA, electronic board, optical, and detector effects. A preliminary plan of action to resolve them is given in SER 2216769 by Curtis Tesdahl.

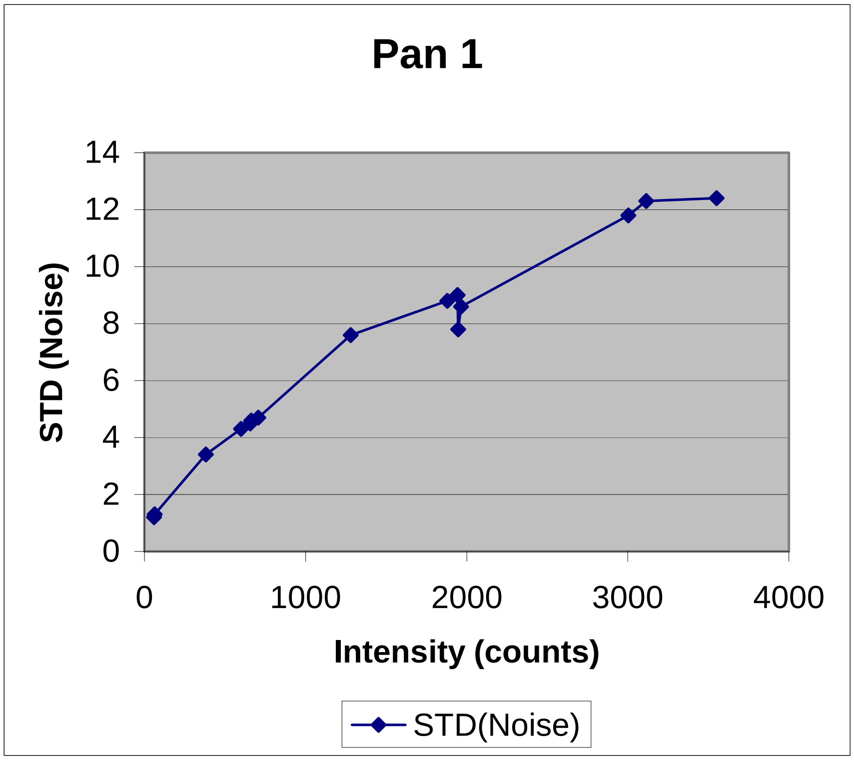
12. Detector Performance with Radiance Level

Data was taken using the integrating sphere to illuminate portions of the detector arrays. The intensity of the light out of the integrating sphere did not have an independent measure of its intensity. This prevents any sorts of linearity testing or detector responsivity measurement. However, as the intensity increases, the noise should become increasingly dominated by the signal shot noise and should be proportional to the square root of the signal intensity (in counts). This is observed for MVIC. Additional analysis can be done to check system gains from this data, but is not currently planned. The data also shows effects at higher signal (count levels) indicating that a saturation in the system response is occurring. Saturation limits will need to be quantified in future testing involving the flight electronics. There are no associated requirements for this data and therefore it is for characterization purposes only.

Dina Demara performed the following analysis.

Pan 1 data was taken at 84 Hz with lower rates saturating. The portion of the images which were evenly illuminated were extracted and analyzed using column statistics to produce the mean illumination (counts) and mean STD. These values were then plotted to show the effect of illumination levels on the noise measurements.

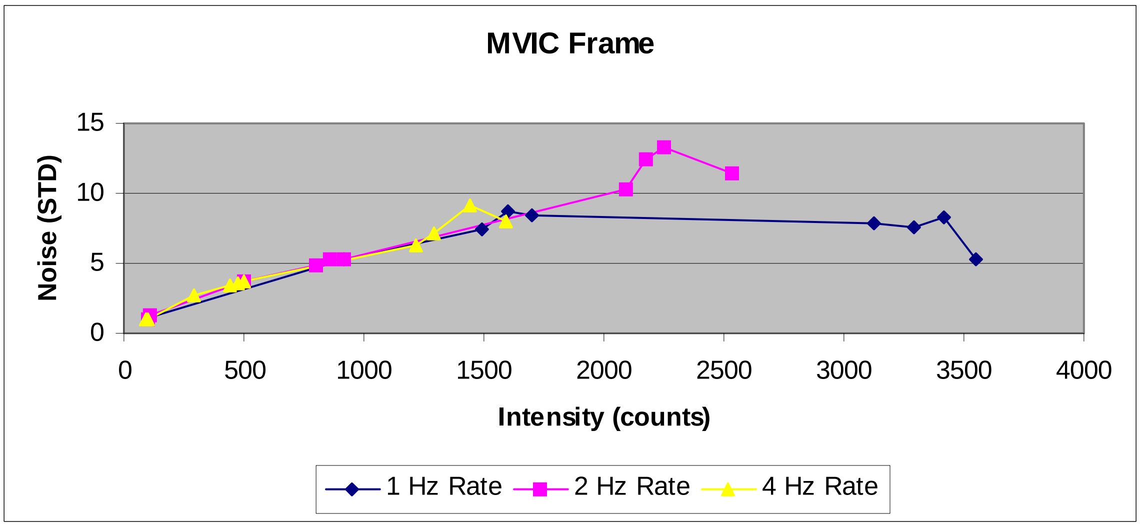
Cols	Mean	STD(Noise)	Filename
12-5000	60	1.2	MP1_A_SNR_DRK_84hz.raw
12-5000	63	1.3	MP1_A_SNR_20041011_0925_CENTER_DARK_84hz.raw
1500-3500	382	3.4	MP1_A_SNR_20041011_0625_CENTER_P1LOWLEVEL_84hz.raw
2000-4000	600	4.3	MP1_A_SNR_20041010_0754_RIGHT_CH4_84hz.raw
2000-4000	657	4.5	MP1_A_SNR_20041010_0614_RIGHT_NIR_84hz.raw
3500-5000	664	4.6	MP1_A_SNR_20041010_1346_FARRIGHT_NIR_CH4_84hz.raw
1500-3500	706	4.7	MP1_A_SNR_20041011_0536_CENTER_NIR_CH4_84hz.raw
1500-4000	1280	7.6	MP1_A_SNR_20041009_2140_Center_84hz.raw
2000-4000	1880	8.8	MP1_A_SNR_20041010_0440_RIGHT_PAN_84hz.raw
1500-3500	1943	9	MP1_A_SNR_20041011_0437_CENTER_SETLEVEL5_84hz.raw
1500-3500	1944	9	MP1_SNR_20041011_0438_CENTER_P1_84hz.raw
3500-5000	1948	7.8	MP1_A_SNR_20041010_1251_FARRIGHT_P1_84hz.raw
12-2000	1966	8.6	MP1_A_SNR_20041010_1013_LEFT_P1_84hz.raw
1500-3500	3004	11.8	MP1_A_SNR_20041011_0519_CENTER_RED_84hz.raw
2000-4000	3114	12.3	MP1_A_SNR_20041010_0558_RIGHT_RED_84hz.raw
12-2000	3551	12.4	MP1_A_SNR_20041010_1101_LEFT_RED_84hz.raw



MVIC Pan Frame data was taken at 3 data rates. The portion of the images which were evenly illuminated were extracted and rows below 43 were deleted due to the roll off and potential FPGA problem in that area. Data was analyzed using group statistics to produce the mean illumination (counts) and mean STD. These values were then plotted to show the effect of illumination levels on the noise measurements. The 1 Hz data shows the effect of saturation at high signal levels.

Cols	Mean	STD	Rate	Filename
1500-3000	2090	10.3	2hz	MFR_A_SNR_20041009_2157_Pan1_Center_2hz.raw
1500-3000	1220	6.3	4hz	MFR_A_SNR_20041009_2157_Pan1_Center_4hz.raw
1500-3000	3418	8.3	1hz	MFR_A_SNR_20041009_2201_Pan1_Center_1hz.raw
12-5000	105	1.1	1hz	MFR_A_SNR_20041010_0110_1hz_DARK.raw
12-5000	97	1.0	2hz	MFR_A_SNR_20041010_0112_2hz_DARK.raw
12-5000	93	1.0	4hz	MFR_A_SNR_20041010_0115_4hz_DARK.raw
2513-4000	2249	13.3	2hz	MFR_A_SNR_20041010_0453_RIGHT_PAN_2hz.raw
2513-4000	1444	9.2	4hz	MFR_A_SNR_20041010_0453_RIGHT_PAN_4hz.raw
2513-4000	3290	7.6	1hz	MFR_A_SNR_20041010_0458_RIGHT_PAN_1hz.raw
12-2000	444	3.5	4hz	MFR_A_SNR_20041010_1136_LEFT_NIR_CH4_4hz.raw
12-2000	799	4.8	2hz	MFR_A_SNR_20041010_1139_LEFT_NIR_CH4_2hz.raw
12-2000	1494	7.4	1hz	MFR_A_SNR_20041010_1142_LEFT_NIR_CH4_1hz.raw
3700-5011	2175	12.5	2hz	MFR_A_SNR_20041010_1258_FARRIGHT_P1_2hz.raw
3700-5011	1290	7.1	4hz	MFR_A_SNR_20041010_1258_FARRIGHT_P1_4hz.raw
3700-5011	3129	7.8	1hz	MFR_A_SNR_20041010_1303_FARRIGHT_P1_1hz.raw
3700-5011	476	3.6	4hz	MFR_A_SNR_20041010_1355_FARRIGHT_NIR_CH4_4hz.raw
3700-5011	861	5.3	2hz	MFR_A_SNR_20041010_1357_FARRIGHT_NIR_CH4_2hz.raw
3700-5011	1598	8.7	1hz	MFR_A_SNR_20041010_1400_FARRIGHT_NIR_CH4_1hz.raw
1500-3000	1592	8.0	4hz	MFR_A_SNR_20041011_0445_CENTER_P1_4hz.raw
1500-3000	2537	11.5	2hz	MFR_A_SNR_20041011_0448_CENTER_P1_2hz.raw

1500-3000	3552	5.3	1hz	MFR_A_SNR_20041011_0523_CENTER_P1_1hz.raw
1500-3000	502	3.7	4hz	MFR_A_SNR_20041011_0546_CENTER_NIR_CH4_4hz.raw
1500-3000	914	5.3	2hz	MFR_A_SNR_20041011_0550_CENTER_NIR_CH4_2hz.raw
1500-3000	1700	8.5	1hz	MFR_A_SNR_20041011_0553_CENTER_NIR_CH4_1hz.raw
1500-3000	293	2.7	4hz	MFR_A_SNR_20041011_0718_CENTER_P1LOWLEVEL_4hz.raw
1500-3000	500	3.7	2hz	MFR_A_SNR_20041011_0720_CENTER_P1LOWLEVEL_2hz.raw
1500-3000	915	5.3	1hz	MFR_A_SNR_20041011_0723_CENTER_P1LOWLEVEL_1hz.raw
12-5000	97	1.0	4hz	MFR_A_SNR_20041011_0947_CENTER_DARK_4hz.raw
12-5000	106	1.3	2hz	MFR_A_SNR_20041011_1007_CENTER_DARK_2hz.raw
12-5000	106	1.2	1hz	MFR_A_SNR_20041011_1010_CENTER_DARK_1hz.raw

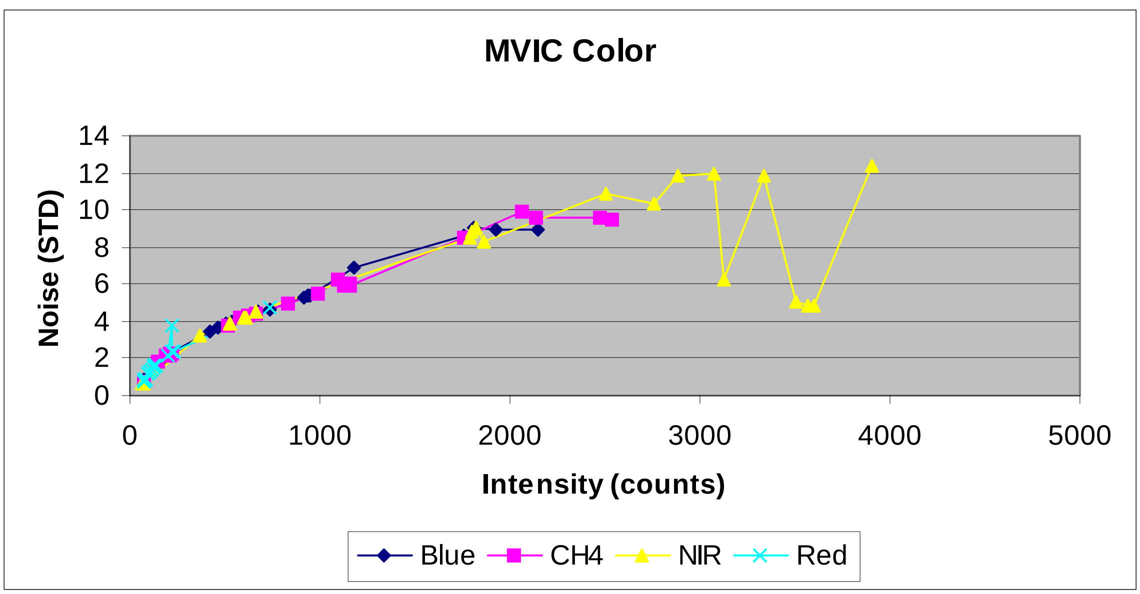


MVIC Color data was taken at 54.9hz with lower rates saturating. The portion of the images which were evenly illuminated were extracted and analyzed using column statistics to produce the mean illumination (counts) and mean STD. These values were then plotted to show the effect of illumination levels on the noise measurements. Again, saturation effects are seen at high signal levels.

Cols	Mean	STD	Color	Filename
12-5000	72	0.9	Blue	MCL_A_SNR_20041010_0919_CENTER_DARK_54p9hz.raw
12-5000	73	0.8	Blue	MCL_A_SNR_20041010_0126_54p9hz_DARK.raw
1500-3500	139	1.7	Blue	MCL_A_SNR_20041010_0648_CENTER_P1LOWLEVEL_54p9hz.raw
2000-4000	154	1.8	Blue	MCL_A_SNR_20041009_2228_NIR_Center_54p9hz.raw
2000-4000	155	1.8	Blue	MCL_A_SNR_20041009_2236_CH4_Center_54p9hz.raw
3000-5000	176	2.0	Blue	MCL_A_SNR_20041010_1121_LEFT_NIR_CH4_54p9hz.raw
1500-2800	179	2.0	Blue	MCL_A_SNR_20041010_0750_RIGHT_CH4_54p9hz.raw
12-1500	185	2.1	Blue	MCL_A_SNR_20041010_1337_FARRIGHT_NIR_CH4_54p9hz.raw
1500-2800	190	2.1	Blue	MCL_A_SNR_20041010_0608_RIGHT_NIR_54p9hz.raw
12-1500	422	3.5	Blue	MCL_A_SNR_20041010_1306_FARRIGHT_P1_54p9hz.raw
3000-5000	468	3.7	Blue	MCL_A_SNR_20041010_1034_LEFT_P1_54p9hz.raw
1500-2800	508	3.9	Blue	MCL_A_SNR_20041010_0526_RIGHT_PAN_54p9hz.raw
1500-3500	540	4.0	Blue	MCL_A_SNR_20041010_0454_CENTER_P1_54p9hz.raw
12-1500	674	4.5	Blue	MCL_A_SNR_20041010_1435_FARRIGHT_CH4JUP_54p9hz.raw
2000-4000	738	4.6	Blue	MCL_A_SNR_20041009_2220_Red_Center_54p9hz.raw
1500-3500	914	5.3	Blue	MCL_A_SNR_20041010_0512_CENTER_RED_54p9hz.raw
1500-2800	935	5.4	Blue	MCL_A_SNR_20041010_0552_RIGHT_RED_54p9hz.raw

3000-5000	937	5.4	Blue	MCL_A_SNR_20041010_1056_LEFT_RED_54p9hz.raw
12-1500	948	5.4	Blue	MCL_A_SNR_20041010_1323_FARRIGHT_RED_54p9hz.raw
2000-4000	1177	6.9	Blue	MCL_A_SNR_20041009_2210_Blue_Center_54p9hz.raw
1500-2800	1753	8.6	Blue	MCL_A_SNR_20041010_0540_RIGHT_Blue_54p9hz.raw
1500-3500	1811	9.0	Blue	MCL_A_SNR_20041010_0500_CENTER_BLUE_54p9hz.raw
3000-5000	1930	8.9	Blue	MCL_A_SNR_20041010_1042_LEFT_BLUE_54p9hz.raw
12-1500	2143	8.9	Blue	MCL_A_SNR_20041010_1313_FARRIGHT_BLUE_54p9hz.raw
12-5000	70	0.8	CH4	MCL_A_SNR_20041010_0126_54p9hz_DARK.raw
12-5000	70	0.8	CH4	MCL_A_SNR_20041010_0919_CENTER_DARK_54p9hz.raw
1500-3500	152	1.8	CH4	MCL_A_SNR_20041010_0648_CENTER_P1LOWLEVEL_54p9hz.raw
2000-4000	190	2.1	CH4	MCL_A_SNR_20041009_2236_CH4_Center_54p9hz.raw
2000-4000	192	2.1	CH4	MCL_A_SNR_20041009_2228_NIR_Center_54p9hz.raw
3000-5000	207	2.2	CH4	MCL_A_SNR_20041010_1121_LEFT_NIR_CH4_54p9hz.raw
1500-2800	208	2.3	CH4	MCL_A_SNR_20041010_0750_RIGHT_CH4_54p9hz.raw
12-1500	211	2.3	CH4	MCL_A_SNR_20041010_1337_FARRIGHT_NIR_CH4_54p9hz.raw
1500-2800	224	2.3	CH4	MCL_A_SNR_20041010_0608_RIGHT_NIR_54p9hz.raw
12-1500	515	3.8	CH4	MCL_A_SNR_20041010_1306_FARRIGHT_P1_54p9hz.raw
3000-5000	583	4.2	CH4	MCL_A_SNR_20041010_1034_LEFT_P1_54p9hz.raw
1500-2800	618	4.3	CH4	MCL_A_SNR_20041010_0526_RIGHT_PAN_54p9hz.raw
1500-3500	658	4.4	CH4	MCL_A_SNR_20041010_0454_CENTER_P1_54p9hz.raw
12-1500	831	5.0	CH4	MCL_A_SNR_20041010_1435_FARRIGHT_CH4JUP_54p9hz.raw
2000-4000	991	5.5	CH4	MCL_A_SNR_20041009_2220_Red_Center_54p9hz.raw
1500-3500	1096	6.2	CH4	MCL_A_SNR_20041010_0512_CENTER_RED_54p9hz.raw
1500-2800	1130	5.9	CH4	MCL_A_SNR_20041010_0552_RIGHT_RED_54p9hz.raw
3000-5000	1162	6.0	CH4	MCL_A_SNR_20041010_1056_LEFT_RED_54p9hz.raw
12-1500	1163	5.9	CH4	MCL_A_SNR_20041010_1323_FARRIGHT_RED_54p9hz.raw
2000-4000	1753	8.5	CH4	MCL_A_SNR_20041009_2210_Blue_Center_54p9hz.raw
1500-2800	2058	9.9	CH4	MCL_A_SNR_20041010_0540_RIGHT_Blue_54p9hz.raw
1500-3500	2136	9.6	CH4	MCL_A_SNR_20041010_0500_CENTER_BLUE_54p9hz.raw
3000-5000	2476	9.6	CH4	MCL_A_SNR_20041010_1042_LEFT_BLUE_54p9hz.raw
12-1500	2538	9.5	CH4	MCL_A_SNR_20041010_1313_FARRIGHT_BLUE_54p9hz.raw
12-5000	68	0.7	NIR	MCL_A_SNR_20041010_0126_54p9hz_DARK.raw
12-5000	70	0.7	NIR	MCL_A_SNR_20041010_0919_CENTER_DARK_54p9hz.raw
1500-3500	372	3.2	NIR	MCL_A_SNR_20041010_0648_CENTER_P1LOWLEVEL_54p9hz.raw
2000-4000	531	3.9	NIR	MCL_A_SNR_20041009_2228_NIR_Center_54p9hz.raw
2000-4000	531	3.9	NIR	MCL_A_SNR_20041009_2236_CH4_Center_54p9hz.raw
1500-2800	605	4.2	NIR	MCL_A_SNR_20041010_0750_RIGHT_CH4_54p9hz.raw
3000-5000	614	4.2	NIR	MCL_A_SNR_20041010_1121_LEFT_NIR_CH4_54p9hz.raw
1500-2800	663	4.5	NIR	MCL_A_SNR_20041010_0608_RIGHT_NIR_54p9hz.raw
12-1500	668	4.5	NIR	MCL_A_SNR_20041010_1337_FARRIGHT_NIR_CH4_54p9hz.raw
3000-5000	1787	8.5	NIR	MCL_A_SNR_20041010_1034_LEFT_P1_54p9hz.raw
1500-2800	1798	8.8	NIR	MCL_A_SNR_20041010_0526_RIGHT_PAN_54p9hz.raw
1500-3500	1817	9.1	NIR	MCL_A_SNR_20041010_0454_CENTER_P1_54p9hz.raw
12-1500	1866	8.3	NIR	MCL_A_SNR_20041010_1306_FARRIGHT_P1_54p9hz.raw
2000-4000	2507	10.9	NIR	MCL_A_SNR_20041009_2220_Red_Center_54p9hz.raw
12-1500	2758	10.3	NIR	MCL_A_SNR_20041010_1435_FARRIGHT_CH4JUP_54p9hz.raw
1500-3500	2879	11.8	NIR	MCL_A_SNR_20041010_0512_CENTER_RED_54p9hz.raw
1500-2800	3069	11.9	NIR	MCL_A_SNR_20041010_0552_RIGHT_RED_54p9hz.raw
2000-4000	3123	6.2	NIR	MCL_A_SNR_20041009_2210_Blue_Center_54p9hz.raw
3000-5000	3341	11.8	NIR	MCL_A_SNR_20041010_1056_LEFT_RED_54p9hz.raw
1500-2800	3504	5.1	NIR	MCL_A_SNR_20041010_0540_RIGHT_Blue_54p9hz.raw
3000-5000	3573	4.8	NIR	MCL_A_SNR_20041010_1042_LEFT_BLUE_54p9hz.raw
1500-3500	3597	4.8	NIR	MCL_A_SNR_20041010_0500_CENTER_BLUE_54p9hz.raw

12-1500	3900	12.4	NIR	MCL_A_SNR_20041010_1323_FARRIGHT_RED_54p9hz.raw
12-5000	71	0.8	Red	MCL_A_SNR_20041010_0126_54p9hz_DARK.raw
12-5000	72	0.8	Red	MCL_A_SNR_20041010_0919_CENTER_DARK_54p9hz.raw
3000-5000	78	0.9	Red	MCL_A_SNR_20041010_1121_LEFT_NIR_CH4_54p9hz.raw
1500-3500	78	0.9	Red	MCL_A_SNR_20041010_0648_CENTER_P1LOWLEVEL_54p9hz.raw
2000-4000	79	0.9	Red	MCL_A_SNR_20041009_2228_NIR_Center_54p9hz.raw
2000-4000	79	0.9	Red	MCL_A_SNR_20041009_2236_CH4_Center_54p9hz.raw
12-1500	79	0.9	Red	MCL_A_SNR_20041010_1337_FARRIGHT_NIR_CH4_54p9hz.raw
1500-2800	81	0.9	Red	MCL_A_SNR_20041010_0750_RIGHT_CH4_54p9hz.raw
1500-2800	82	0.9	Red	MCL_A_SNR_20041010_0608_RIGHT_NIR_54p9hz.raw
12-1500	94	1.2	Red	MCL_A_SNR_20041010_1306_FARRIGHT_P1_54p9hz.raw
3000-5000	98	1.2	Red	MCL_A_SNR_20041010_1034_LEFT_P1_54p9hz.raw
1500-2800	104	1.3	Red	MCL_A_SNR_20041010_0526_RIGHT_PAN_54p9hz.raw
1500-3500	106	1.3	Red	MCL_A_SNR_20041010_0454_CENTER_P1_54p9hz.raw
12-1500	111	1.4	Red	MCL_A_SNR_20041010_1435_FARRIGHT_CH4JUP_54p9hz.raw
2000-4000	125	1.5	Red	MCL_A_SNR_20041009_2220_Red_Center_54p9hz.raw
3000-5000	130	1.6	Red	MCL_A_SNR_20041010_1056_LEFT_RED_54p9hz.raw
12-1500	130	1.6	Red	MCL_A_SNR_20041010_1323_FARRIGHT_RED_54p9hz.raw
1500-3500	133	1.6	Red	MCL_A_SNR_20041010_0512_CENTER_RED_54p9hz.raw
1500-2800	135	1.6	Red	MCL_A_SNR_20041010_0552_RIGHT_RED_54p9hz.raw
2000-4000	197	2.2	Red	MCL_A_SNR_20041009_2210_Blue_Center_54p9hz.raw
1500-2800	219	3.8	Red	MCL_A_SNR_20041010_0540_RIGHT_Blue_54p9hz.raw
12-1500	225	2.4	Red	MCL_A_SNR_20041010_1313_FARRIGHT_BLUE_54p9hz.raw
3000-5000	228	2.4	Red	MCL_A_SNR_20041010_1042_LEFT_BLUE_54p9hz.raw
1500-3500	236	2.4	Red	MCL_A_SNR_20041010_0500_CENTER_BLUE_54p9hz.raw
12-1500	734	4.7	Red	MCL_A_SNR_20041010_1500_FARRIGHT_BLUEJUP_54p9hz.raw



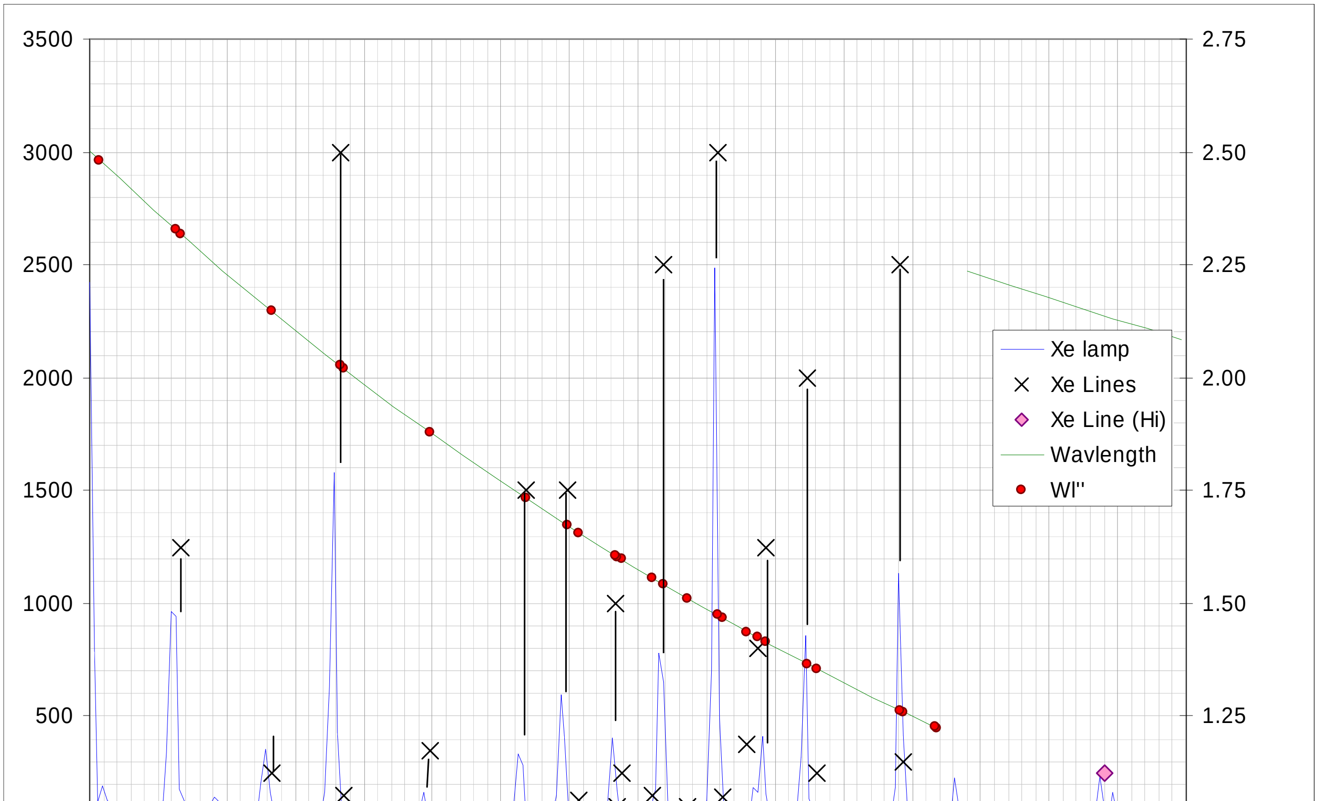
For LEISA, the dark noise levels were so high for OT2 testing that the system was never able to get to the signal shot noise limited regime. For all light levels it was dark noise limited.

12. Spectral Data

A test that was unplanned at the TRR was performed because of a window of opportunity. Oriel spectral calibration lamps were available that allowed a quick end-to-end spectral performance test of the LEISA detector. These were mounted at the output window of the integrating sphere. The spectral lines measured on LEISA were compared with published data in the CRC handbook for the line centers and relative line strength by Jim Baer (SER #TBD). Using a wavelength-to-detector-column calibration provided by Dennis Reuter, the measured and published values were graphed together. A preliminary review showed good agreement for a Xenon lamp for both center wavelength and relative amplitude, but not for a Krypton lamp. The Krypton discrepancy is not understood and no further analysis work is planned.

A graph for the Xenon case is shown below with the “Xe lamp” line showing the measured data and the “x” showing CRC line location data. The height of the “x” shows the relative line strength, there is no absolute scale on the amplitude of the published spectral lines.

This test was for characterization only and was not part of requirements verification. Optical bandwidth requirements will be verified using component and subassembly level data. This test is not planned to be repeated.



Appendix 1: Status of Electronics at start of OT-2

Notes on Meeting and Test Results on Ralph on 9/29/04 - Evening

Two meetings/telecons were held with BATC, SWRI, and GSFC today regarding results of electronic testing and planning for Optical Test 2 (OT2). A plan was laid out in the morning that BATC began implementing throughout the day. New information and test results were found during the day. I wanted to review all of this information to ensure that we (BATC) are implementing what SWRI wants implemented.

BATC participants: Bob Parizek, John Eterno, Jim Kubitschek, Curtis Tesdahl, Carl Weimer
SWRI participants: Alan Stern, Bill Gibson, John Scherrer, John Stone, John Andrews, plus more on telecon
GSFC: Dennis Reuter
Baja Technologies: Bud Hill

1. The goal is to get into OT2 by tomorrow (9/30). To do this:
    a. Stop work on the B-side of the electronic box. Do not pursue troubleshooting of the LVPS 12 V anomaly prior to OT2. Do not power up the B-side.
    b. Separate the LEISA 5 volt “High” bias and power it separately from the 5.2 V line to try and mitigate the “latch-up” (see below).
    c. Measure and record the start-up voltages on all of the Detector Electronics board outputs that drive the LEISA detector. Verify that the ICD requirement that the “High” line is the largest potential on the board is met and that there are no “glitches” on any of those lines that could cause “latch-up” or exceed the maximum 5.5 v rating for LEISA.
    d. Re-baseline the detector performance for OT-2 with the above rework. It was discussed that the latch-up mitigation in 1b might result in higher LEISA noise because the 5.2 V line would be unfiltered to ensure that the “High” voltage was always the largest voltage even during start-up.

2. Results:

a. 1a) No work was done on the B-side. The command interface was modified so that B-side could not be commanded on manually. The test scripts were reviewed and the B-side tests were removed.
b. 1b) “High” bias line was separated on side A from the other 5 volt bias lines and powered directly from the 5.2 V power.
c. 1c) All of the lines to LEISA were measured at start-up relative to the “High” signal. With the LEISA detector detached from the electronics, it was found that the ICD requirement on “High” was met and no glitches were observed on the lines. With LEISA attached and the lines monitored via a BOB, it was found that the ICD requirement on “High” was not met, the other three 5 volt bias lines for LEISA were equal to “High” at all points in the start-up.

   After discussion with Rockwell and review of the schematics it was found that the test cable and test dewar wiring for LEISA has “High” plus two of the biases tied together electrically. This prevents the testing of the 1b) fix without rewiring the test cable and dewar. It is unlikely that the latch-up mitigation attempted in 1b) was functional for this test configuration.
d. Data was collected for side A, MVIC and LEISA, both dark and illuminated. MVIC dark noise passed its requirements. LEISA noise was high, 45 counts rms compared to 3-6 counts rms last week. With no filtering on the “high” line, and it attached to the other 5 V biases (1c), it is likely that the LEISA noise is coming from noise on “High”. Both detectors were responsive to light.

3. It was pointed out that if the LEISA detector had a failure internally on its “High” line that shorted that line to ground, there is no current limiting on the 5.2 V line so more damage could result. BATC received verbal instruction not to implement this and precede to OT2 because of the low risk.

As of 9/29 20:00 we are proceeding tomorrow to OT2. Because of the dewar/cable configuration for test not matching that for flight (used in OT2), we are missing some key information:

- We do not know that the latch-up mitigation will work.
- We do not have an accurate noise baseline for the LEISA detector.
- We have not been able to confirm that the Detector Electronics meet the ICD requirements with LEISA integrated and in its flight configuration. The electronics alone do meet the LEISA ICD with regards to the start-up voltages..

Differences between current configuration and final flight:

1. DE A side FPGA in socket. Replaced after OT2.
2. DE B side FPGA not current rev (due to limited solder cycle issue). Requires special checks during science reviews. Replaced after OT2.

3. Both DE FPGAs are plastic (non-flight). Replaced after OT2 with ceramic and final rev.
4. EM detectors for LEISA and MVIC . Replaced with flight for OT2
5. Detectors in dewars – GSE cables. Eliminated for OT2.
6. EM daughter board (DE A side only). OT2 determines future need.
7. B side DAC 8420 is plastic (non-flight). Replaced after OT2
8. Op Amps AD 8038 are flight, however they have a lien on them from Reliability awaiting test results.
9. CD&H and LVPS Boards are non-flight. Replaced after OT2.
10. Electronic box frame is non-flight. Replaced after OT2.
11. No conformal coating of boards.

Appendix 2: SOW Requirements on Noise from SNR

Summary of Predicted Signal Levels for Flight (BATC Radiometric Model) and maximum allowed noise for flight (here assumed all random noise) :

Detector - Channel	Signal (e^-) Radiometric Model	Signal (counts)	SNR Reqd. Per pixel	Maximum Allowed Noise (counts rms) Derived
MVIC - Pan	35597	1240	≥50 (0.3 sec)	25
Blue	6324	221	≥50 (0.6 sec)	4.4
Red	19730	690	≥50 (0.6 sec)	14
NIR	16216	567	≥50 (0.6 sec)	11.3
CH4	3596	126	Goal ≥15 (0.6 sec)	8.4
LEISA –1250 nm	1363	170	≥31 (0.25 sec)	5.5
- 2000 nm	1395	160	≥27 (0.25 sec)	5.9
- 2150 nm	890	100	≥18 (0.25 sec)	5.6

Notes:
1. MVIC integration time is set by the TDI rate. 0.6 sec corresponds to 55 Hz, 0.3 sec corresponds to 108 Hz (both with a 1.7 Hz margin included).
2. LEISA integration time is set by frame rate, so 0.25 sec integration corresponds to 4 Hz frame rate.

3. There is no explicit requirement on systematic noise.
4. MVIC conversions for flight: 6.67 $\mu V/e^-$ and 191μV/lsb, therefore 28.6 e^-/lsb
5. LEISA has 1.4 μV/photon @2150 nm and 2000 nm, 1 μV/photon @ 1250 nm. Board gain is 19.3 μV/lsb.

SOW - Other Noise Requirements:

MVIC:
1. The detector dark current shall be less than or equal to 0.01e/s/pixel at the nominal temperature
2. The detector read noise shall be less than or equal to 10 e for fram transfer and TDI sensors.
4. The Ralph electronics shall contribute less than or equal to 20 e to the overall MVIC system noise, excluding quantization noise

LEISA

1. The detector read noise shall be less than 30 e.
2. The detector dark current shall be less than or equal to 20e/s at the nominal operating temperature
3. The Ralph electronics shall contribute less than or equal to 20 e, excluding quantization noise, to the overall LEISA system noise.

Appendix 3 – Ralph Issues after OT2 by Dennis Reuter, 10/18/04

The following is a list of issues with the Ralph instrument as it stands immediately after OT2. It includes the issue, an estimate of its effect on science, possible or probable causes and solutions and whether there is an operational work-around. The last sentence under the "*Probable solution*" heading indicates whether the issue can be addressed with dewar testing. This list has significant overlap with John Stone's FPGA list. (Issues that are already identified on John's list are marked FPGA JS. FPGA issues that are not included in John's list are marked FPGA *not in* JS.)

LEISA ISSUES

Electrical and Array

1) **Non-illuminated system noise 40 – 50 counts**
Effect on Science: Serious (essentially fatal) impact. These levels are more than an order of magnitude worse than expected. (Speced system noise is ~ 3 counts, maximum allowable is ~ 5 counts.) OT2 measured levels would give a maximum SNR of 3-5 at Pluto for 0.5 sec frame time.
Probable Cause: Electrical noise on the 5V inputs to the array, particularly on the load resistor for the source follower output ("SOURCE" or "PULLUP"). This may be caused by capacitive coupling of relatively noisy 5.2 V used on "HIGH" input to avoid latch-up (see next issue). There is a periodic pattern on the arrays with a period

of about 5 rows. (2-D FFTs of the quadrants give peaks at 25 cycles/128 rows and 50 cycles/128 rows. There are also peaks at 25 cycles/128 rows and 1-2 cycles/128 columns. It takes 0.0512 sec to read a quadrant. The row readout rate is 0.0004 sec., so 25/cycles/128 rows corresponds to an electrical signal at 500 Hz. The other peaks are at harmonics of this.) Note that there were a few cases in OT2 where the noise was lower. One in particular gave counts in the 6-8 range, within a factor of 2 of the required levels. For some reason the best noise performance in OT2 was for 4 Hz frame rate, but not all 4 Hz data had low noise.
Problem identified prior to OT2?: Probably. The excessive LEISA noise has been seen for some time. Comparison of data taken with the E-grade array in the test dewar immediately prior to OT2 (when the 5.2 V was connected directly to "SOURCE") show similar noise patterns (but not quite identical in FFT components) and noise amplitudes (but noise in the dewar tests was generally lower than in OT2).
Probable solution: Less noisy voltage inputs to array. May be addressed with dewar testing.
Operational workaround: None. Theoretically, massive averaging would help, but the spectral/spatial resolution is not acceptable.

2) **Latchup, with no data flow (includes one FPGA JS)**
Effect on Science: Fatal, no data produced.
Probable Cause: Voltage level on "HIGH" array input lower than levels on other biases. Causes activation of protection circuitry and excessive current flow that DE can't source so "HIGH' never reaches voltage level higher than other biases.
Problem identified prior to OT2?: Yes. Problem was not seen in OT2 because "HIGH" signal was tied to 5.2 V supply. But this may be the source of excessive LEISA noise. Note that John Stones FPGA problem list includes "LEISA FSYNC and LSYNC Reset State: FSYNC and LSYNC should be low during reset, not high" which was a contributing factor to latchup prior to the use of the 5.2 V signal for "HIGH"
Probable solution: Keep 5.2 V attached to "HIGH", but improve noise. May be addressed with dewar testing.
Operational workaround: None.

3) **Inability to set offsets at low electronics temperatures (<13 ° C) (FPGA JS)**
Effect on Science: Fatal, no data produced.
Probable Cause: FPGA problem identified prior to OT2. "DAC is not working properly: The timing parameters are most likely being violated, i.e. Clock pulse width low, tcl=120 ns minimum."
Problem identified prior to OT2?: Yes. Not seen in OT2 because electronics temperature was kept > 20 ° C).
Probable solution: "Change serial clock from 8MHz to 2MHz.". May be addressed with dewar testing.
Operational workaround: None.

4) **Temperature of array too high (OT2 >127 ° K, expected 113 ° K)**

Effect on Science: Significant decrease in SNR. Increased average noise (perhaps 3-5 counts on the average, added to read noise and photon noise in quadrature). In addition to the average effect, there are numerous "hot" pixels that have much increased dark current.
Probable Cause: Unknown. The array temperature is about what was seen in OT1.
Problem identified prior to OT2?: Possibly. OT1 array temperature was high also, but there was a heat source present in OT1 (non-flight MVIC cables) that was removed prior to OT2.
Probable solution: Unknown. Can not be addressed with dewar testing.
Operational workaround: Theoretically, averaging would help with the mean noise and multiple acquisitions would mitigate the effects of the "hot" pixels. This is a solution of last resort (more a rationalization than a solution).

5) **B-side electronics do not work (Problem common to both MVIC and LEISA)**
Effect on Science: No electrical redundancy.
Probable Cause: Short or failed component
Problem identified prior to OT2?: Yes.
Probable solution: Fix electronics. May be addressed with dewar testing.
Operational workaround: None.

6) **1 Hz noise (Electrical pattern on array with a 1 Hz period).**
Effect on Science: Degraded SNR.
Probable Cause: 1 Hz interrogation of DE board by C&DH
Problem identified prior to OT2?: Yes. But in lowest noise dewar testing prior to OT2 this effect was not too large.
Probable solution: Inhibit 1 Hz interrogation during data collection event. Depending on level of inhibit, some housekeeping data could be lost. May be addressed with dewar testing.
Operational workaround: None.

7) **A-side array temperature sensor had unusual offset (B-side condition unknown)**
Effect on Science: Possible calibration uncertainty, but not large magnitude effect
Probable Cause: Unknown.
Problem identified prior to OT2?: No. T sensor worked at GSFC. OT2 was first test using flight electronics on this array. This issue has somewhat of a complex history. When the electronics were first attached to the TDA the T sensor read ~ 5° C. This was consistent with behavior observed at GSFC in which room temp. measurement was off 10 – 15 degrees, but was correct at 95 K. However, when the instrument was placed into the chamber, the T sensor reading dropped 31° C to –26° C. This was ~ 50° C colder than T sensor on thermal strap. The T sensor reading dropped as the array temperature decreased. Final reading was ~ 20 colder than T sensor on thermal strap.
Probable solution: Unknown. Flight array will stay with TDA so this can't easily be addressed with dewar testing, however, T sensor on e-grade array in dewar may be used to check electronics.

Operational workaround: Several. Involve using in-flight standard flux sources to check calibration and in-flight dark current measurements to estimate temperature.

8) **Negative image seen on reset frame at moderate to high light levels.**
Effect on Science: None at Pluto light levels. Small effect possible at Jupiter in regions of high signal gradient
Probable Cause: Inherent to array
Problem identified prior to OT2?: Yes.
Probable solution: None
Operational workaround: None.

9) **CDS ("subtracted") noise less than noise on "raw"data. (FPGA JS)**
Effect on Science: None. CDS is data mode in flight.
Probable Cause: Additional noise introduced by additional data rate when both "read' and "reset" images are sent to the high speed data system
Problem identified prior to OT2?: Yes. This is probably a bit of a non-issue and I include it mainly because it is on John Stone's list. During dewar testing at high noise levels prior to OT2, it was noticed that the noise in "subtracted' mode (in which the "reset" frame is subtracted from the "read" frame by the FPGA) was about 50% that of the noise found when the "reset' frame was subtracted from the "read" frame in IDL after both were recorded in "raw" mode. However, the mean signals were the same in both cases. One would expect that the two modes would give the same result and the reduced noise in subtracted mode was puzzling. This was flagged as a possible clue to the high noise levels observed in all modes prior to the electronics fix that reduced the noise on the 5 V biases.
Probable solution: Unknown. May be addressed with dewar testing
Operational workaround: None needed.

10) **Wrap-around on the A/D.**
Effect on Science: None at Pluto light levels. Possible interpretation difficulty at Jupiter levels. This effect may be seen in the target images obtained by LEISA in OT2.
Probable Cause: LEISA uses the middle 12 bits of a 14 bit A/D converter (Only 12 bits are used to decrease data rate, the middle 12 bits are used to reduce first stage gain). To reduce quantization noise, the LEISA gain is set such that 4095 on the A/D only corresponds to about 1/5 of the array well. The effect of this is that for high light levels (higher than will be seen at Pluto, but that will be seen at Jupiter) highly illuminated areas can appear darker than neighboring areas with lower illumination (a signal of 1000 counts can really mean 5096 counts). The only way to unravel this is from context (which is a bit dicey)
Problem identified prior to OT2?: Yes, in dewar testing with the illumination source.
Probable solution: First stage gain can be reduced by ~2/3, then even Jupiter light levels (at 8 Hz frame rate) will not get above 4095 counts. (This could also be done if there was concern that high first stage gain was decreasing SNR). The only way to completely remove this is either to reduce the first stage gain so much that the array saturates at 4095 counts (which will increase quantization noise) or to increase the

first stage gain and use the first 12 bits of the A/D (which means saturation at 4095 counts will occur at a lower light level). May be addressed with dewar testing.
Operational workaround: None. This issue is mentioned to familiarize the reader with the system. I would tend to leave it as it is.

Optical

11) **Apparent best focus is 0.0125” from present position**:
Effect on Science: Some degradation of spatial resolution. This is about 1 pixel of defocus. The overall degradation effect is muted because the diffraction spot size is ~ 0.65 pixel at 1.25 μm and 1.3 pixel at 2.5 μm and the Nyquist sampling requirement is two pixels
Probable Cause: Unknown. There is a bit of uncertainty on the OT2 focus results.
Problem identified prior to OT2?: No. LEISA didn’t work during OT1.
Probable solution: Shim focal plane if necessary. May not be addressed with dewar testing
Operational workaround: As mentioned, the resolution degradation is not too significant, however, in principle, the two scans planned for LEISA and deconvolution could kinda sorta improve spatial resolution.

12) **Filter/array non-uniformities.**
Effect on Science: Small if accurate flat field obtained. Some decreased SNR
Probable Cause: Inherent to array and filter
Problem identified prior to OT2?: Yes.
Probable solution: Accurate flat fields. Has been addressed with dewar testing
Operational workaround: None.

13) **Scattering at boundary between high and low resolution segments (Flashes at boundary).**
Effect on Science: Some areas will have decreased SNR and interpretation will be more difficult
Probable Cause: Small flakes in top filter surface let in out-of-band light which is not suppressed by high resolution wedged filter.
Problem identified prior to OT2?: Yes.
Probable solution: This occurs on the high-resolution segment, for which data is obtained at low resolution. The main reason for the high-res segment is to determine solid N_2 band shape for temperature and this relative measurement should be relatively unaffected. Has been addressed with dewar testing.
Operational workaround: 2 scans are already planned. This and data from the low-res segment should mitigate the effect of this issue.

MVIC ISSUES

Electrical and Array

1) **System can come up in a state that prevents data acquisition (FPGA JS).**
Effect on Science: Fatal. No data obtained.

Probable Cause: "MVIC Reset, ØR, sometimes occurs one cycle too early, at negative edge of RØ2 instead of positive edge of RØ2 (see page 23 of the DE FPGA Op. Requirements, SER 2202851, Rev B)"
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None, unless one wants to take a chance that two data collections will get at least one past this problem

2) **Occasionally zeros (so-called "hard zeros") fill significant portions of the color TDI arrays (Possibly FPGA *not in* JS).**
Effect on Science: Serious to fatal. Data corrupted.
Probable Cause: You got me, but I'm guessing it is FPGA related
Problem identified prior to OT2?: Unknown. It is not clear whether any data was saved when operating in this condition. It was a transient seen some times during setup.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None, unless one wants to take a chance that two data collections will get at least one past this problem

3) **Occasionally the TDI's came up in weird states (odd data patterns completely unrelated to anything). Some of these were stored and flagged by the science team. (Possibly FPGA *not in* JS but read on).**
Effect on Science: Serious to fatal. Data corrupted.
Probable Cause: Could be FPGA related, but then again it may be related to timing of relay setting commands manually issued from framegrabber. It was possible to reproduce some of the data patterns by issuing framegrabber commands at what appears to be a reasonable rate, but one which may confuse the C&DH system. Strongly suggest conversations with operators. Chuck Harguth in particular.
Problem identified prior to OT2?: Unknown. Requires review of test data.
Probable solution: Unknown. May be addressed with dewar testing.
Operational workaround: None, unless one wants to take a chance that two data collections will get at least one past this problem

4) **Odd structure in PanBin data. (Possibly FPGA *not in* JS).**
Effect on Science: Serious to fatal. Data corrupted. But PanBin is not group 1.
Probable Cause: Possibly FPGA related
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None, unless one wants to take a chance that two data collections will get at least one past this problem.

5) **Hard zeros and other anomalies in the first 40 rows of the frame array. (FPGA JS).**
Effect on Science: Serious. Data corrupted. Frame also used for optical navigation.
Probable Cause: Possibly FPGA related
Problem identified prior to OT2?: Yes.

Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: One could treat the frame array as a 5000 x 88 device instead of a 5000 x 128, if one wished to take the chance that the problem wouldn't expand.

6) **Fast flush not working properly. (FPGA JS).**
Effect on Science: If still flushing when on target, data is corrupted.
Probable Cause: Possibly FPGA related. This issue was supposedly solved in testing in the CCD lab and the solution was supposedly incorporated correctly into the flight electronics. The time for flush depends on the illumination level.
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: Possibly take a few hundred extra rows of data before target to flush CCD. Number required is function of frame rate.

7) **PanBin not meeting noise requirements. (FPGA JS).**
Effect on Science: Possible SNR degradation at very low light levels.
Probable Cause: Possibly FPGA related. "May be an issue with how overflows are handled in FPGA." Note that the is a mixture of analog binning on the CCD (3 columns) and digital binning by the FPGA (3 rows). This is not optimal (3 x 3 analog binning on CCD preferred). At any rate, because of digital binning, the PanBin noise requirement should be relaxed by a factor of sqrt(3) from Pan noise requirement
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None.

8) **Vertical line appears in TDI data at highest rate. (FPGA JS).**
Effect on Science: One line of data is corrupted for Pans, 2 lines (different lines for the two color groups) for color TDI.
Probable Cause: Probably FPGA related. The electronics team believes it understands the root cause. This happens at the maximum TDI rate (and maximum rate -?)
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: Accept loss of 1 or 2 lines of data. Or operate at slower scan rates (possible spatial resolution degradation).

9) **Keyboarding in injection region of CCD. (FPGA JS).**
Effect on Science: Unknown.
Probable Cause: Probably FPGA related.
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None.

10) **Streaks in TDI data near edges of illumination. (Possible FPGA *not in* JS).**
Effect on Science: Data degradation. (See J. VanCleve's e-mail of 10/09.)

Probable Cause: Certainly electronic. Probably FPGA related.
Problem identified prior to OT2?: Yes.
Probable solution: Fix FPGA. May be addressed with dewar testing.
Operational workaround: None.

Optical

11) Apparent best focus is -0.0133" from present position (Note similar magnitude but opposite sign of LEISA shift)
Effect on Science: 50% or more degradation of spatial resolution. This is about 3 pixels of defocus. Because MVIC has pixels about 1/3 the size of the LEISA pixels, and the diffraction limit is smaller, this effect is much more significant for MVIC than LEISA.
Probable Cause: Unknown. There is uncertainty about the OT2 focus results.
Problem identified prior to OT2?: No. This result is very confusing. During OT1 the best focus for MVIC was found to be within 0.0011" of where the focal plane was. When the bond line was increased by 0.004" the shim was adjusted by 0.003" to account for both effects. Now we are off by 0.0133", which is more than can be accounted for even by going the wrong direction with the shim after OT1. The optics were aligned the same way in OT1 and OT2 and the optical power (focus) of the window was removed interferometrically in the same way. So there is no evidence of a mechanical cause or an optical cause, but the focus is way off.
Probable solution: Shim focal plane if necessary. May not be addressed with dewar testing
Operational workaround: In principle, one could take the MVIC Pan scan closer to Pluto to regain the resolution, but then Pluto will overfill the array and either more than 1 scan will be required or coverage will be lost. In addition, for scans closer in, Pluto is getting quickly larger, so the array surface coverage is decreasing with time.
***Cautionary Note*: The MVIC and LEISA images of the Air Force target that were sent out during OT2 were taken near best focus (i.e. the source was not collimated and does not appear as if it were very distant. This is part of the focus test.) They images are better than what would be seen with shims as they are now.**

SIA ISSUES

1) **SIA has very strange output pattern including what appear to be diffraction rings for a supposedly white light input and a very truncated distribution in the direction toward the color TDI's.**
Effect on Science: SIA only has output over ~ 3 degrees in the across track direction, and it is decidedly not flat. In the along track direction, only 1 of the 4 color TDIs shows appreciable signal. The input angle is as predicted in one dimension and ~ 25% larger than predicted in the other.
Probable Cause: Unknown.
Problem identified prior to OT2?: No. In fact the flight spare that was measured during the summer had, I believe, what appeared to the eye at least, a reasonably flat output pattern.

Probable solution: Possibly a scattering element in the output beam, but this would involve opening the TDA, and is not too likely.
Operational workaround: None.

Appendix 4: References

Baer, Jim; SER 2216782 “Magic Decoder Ring”.
Baer, Jim; SER TBD - Co-registration
Baer, Jim; SER 2218978 “SIA Testing from OT2 and OT2C”.
Baer, Jim; SER TBD – LEISA Spectral Data
Demara, Dina; SER 2214454 “Ralph Analysis Tool” .
Hardaway, Lisa and Anthony Gurule; SER # 2219150 “OT #2 Test Data Comparisons with Model Predictions”.
Kubitshek, Jim; SER 2216491 “Leisa Temperature Measurement System”.
Sabatke, Derek; SER 2203452 “MVIC MTF Analysis and Budget”.
Sabatke, Derek; SER 2216317 “OT2 through-focus testing results”.
Tesdahl, Curtis; SER 2216769 “Ralph OT2 Detector Properties – Electronics Response”.
Van Cleve, Jeff; SER 2218850 “Ralph OT2 Detector Properties”