Section 12

Hyperion Grating Imaging Spectrometer

. . . Steve Carman
Hyperion Project Manager, TRW Space & Technology

Contents

Hyperion Activities Since Initial PSR

- Recent changes to the verification matrix
  - None
- Configuration changes since the initial Red Team Review
  - None
- Remaining work to be completed prior to shipment
  - None
- Open action items that are still being worked
  - None
- Open test anomalies
  - Primary cal lamp set degradation (Special Topic 12a)
- Could-not-duplicate test anomalies
  - None
- Redbook candidates
  - None

Hyperion Peer Review Activities Since Red Team Review

- *Monthly Instrument Team Meetings*
  - *Weekly instrument team telecons with action item review*
- *April 20: Data Processing, MOC Operations Technical Interchanges at TRW*
  - *Discussed Hyperion Data ICD, visited Hyperion Ops facility*
- *May 19: Participated with GSFC in Pre-launch, Launch, Early Orbit and Contingency Procedures review.*
- *May 23: Hyperion Data Processing Review at TRW*
  - *Visit by Steve Ungar, Lawrence Ong*
- *June 6-8: EO-1 Science Team Meeting in South Dakota*

Special Hyperion Tests in T/V II

- *Hyperion & Atmospheric Corrector viewed common arc lamp source through fiber optics to compare spectral calibration*
  - *Hyperion data looked good, provided to Tim Zukowski for correlation (presented as section 11 of this review)*
- *Additional cal lamp sequences performed to exercise both the primary and redundant lamps.*
  - *Summarized in Special Topic 12a*
- *Hyperion operated VNIR ASP at higher temperatures to verify elimination of coherent noise*
  - *Special Topic 12c summarizes results*

Hyperion Performance in T/V II

- ***Functional tests:*** *All nominal*
- ***CPTs and DCEs:*** *All nominal*
- ***Instrument Turn-on SIM:*** *Hyperion functions nominal. For both ALI & Hyperion, images intended for S-Band dump were too large to be completely downlinked in the simulated S-band dumps. Resolution: S-band downlinks for science data dump will have to be carefully planned to maximize station in-view time.*
- ***Pre-launch Aliveness SIM:*** *All nominal*
- ***STOL Procs:*** *Complete and in order*

Hyperion Performance in T/V II

- ***Final Bake-out: Hyperion was baked out at elevated temperatures under vacuum for 10 hours at end of T/V.***
  - ***TQCM readings were noted to be high during the final bake out. The readings increased when Hyperion cover opened and when the Hyperion temperature was increased from 20 to 30C.***
  - ***Analysis of material accumulated on scavenger plate and cold fingers indicate presence of methyl phenyl silicones and Tris(allyl) cyanurate (TAC).***
  - ***Total amounts of material collected were higher than normal, but acceptable.***

Hyperion PRs During EO-1 T/V II

- ***Three problem reports were written that involve Hyperion:***

WOA No	PR Event	PR No.	PR Description	Assigned to	PR Disposition/Approval
EO1-WOA-1099	20	10	AI 00-187-11:29, TV Step 44a, Proc HYP-CRYO-UPLD-TEST-EXE, line 110 cmd rejected by FEDS; "CPKT data will not fit in single segment".	Schumacher, Steve	7/26/00 FEDS limit is 250 bytes; Command is too long. Resolution: Command can be sent in smaller segments. Sending of commands of various segment lengths followed by a CEA command to execute the received command segments has been verified. Steve Schumacher was requested to "comment out" these particular long cryocooler commands from the data base, as they will not be required except for special diagnostic purposes. There are no remaining issues.
EO1-WOA-1102	20	7	Review of thermal vacuum images indicates Hyperion primary calibration lamp seems to be degrading.	Browne, Bill	26JUL00: Under investigation. See Special Topic 12A.
EO1-WOA-1102	20	8	197-21:07:33 Observed Y5VSUPPLY RL value of 3.55929 for~32 seconds (1 packet) before returning to 4.96672 green. See snap.	Browne, Bill	Resolution: As is stated in the Hyperion Operator's Manual and the Hyperion Cryocooler System Operations Manual, The mnemonic would have to be red for 90 seconds (3 packets) before it could be considered a red limit violation. There are no remaining issues.

Hyperion Cumulative Operating Time

Operation time at TRW up to baseplate failure during vibration test 27 May 1999:	280 hours
Problem-free operations at TRW from 27 May 1999 to Delivery 7 July 1999:	340 hours
Operating time to date during EO-1 I&T at GSFC (no instrument problems):	535 hours
Total trouble-free operating time:	875 hours
Total operating time to date (3/21):	1155 hours
Additional operating time to date:	176 hours
Total operating time to date (7/28):	1331 hours

Hyperion Readiness

- **Present Status**
  - PRs Outstanding — 1 (Cal Lamp)
  - Hardware Discrepancies — None
  - Waivers Open — None
- **Remaining Activity**
  - Calibration lamp investigation concluded lamps are changing for two reasons: 1) they were not burned-in prior to use in the instrument, and 2) they have been operating at such short durations that the glass envelope was not reaching the temperature necessary to activate the Halogen cycle, resulting in a buildup of tungsten reducing the lamp transmission. Flight software changed to increase operation duration to 3 minutes. (Special Topic 12a)
  - Following final integration of the electronics assemblies after S-Band transponder installation, performance tests will verify operational status and launch readiness. (see Special Topic 12b)

Hyperion Special Topics

12a	*Calibration Lamp Anomaly*	*Steve Carman*
12b	*Final Integration*	*Steve Carman*
12c	*VNIR ASP Thermal Noise*	*Jay Pearlman*

Special Topic:

Calibration Lamp Anomaly

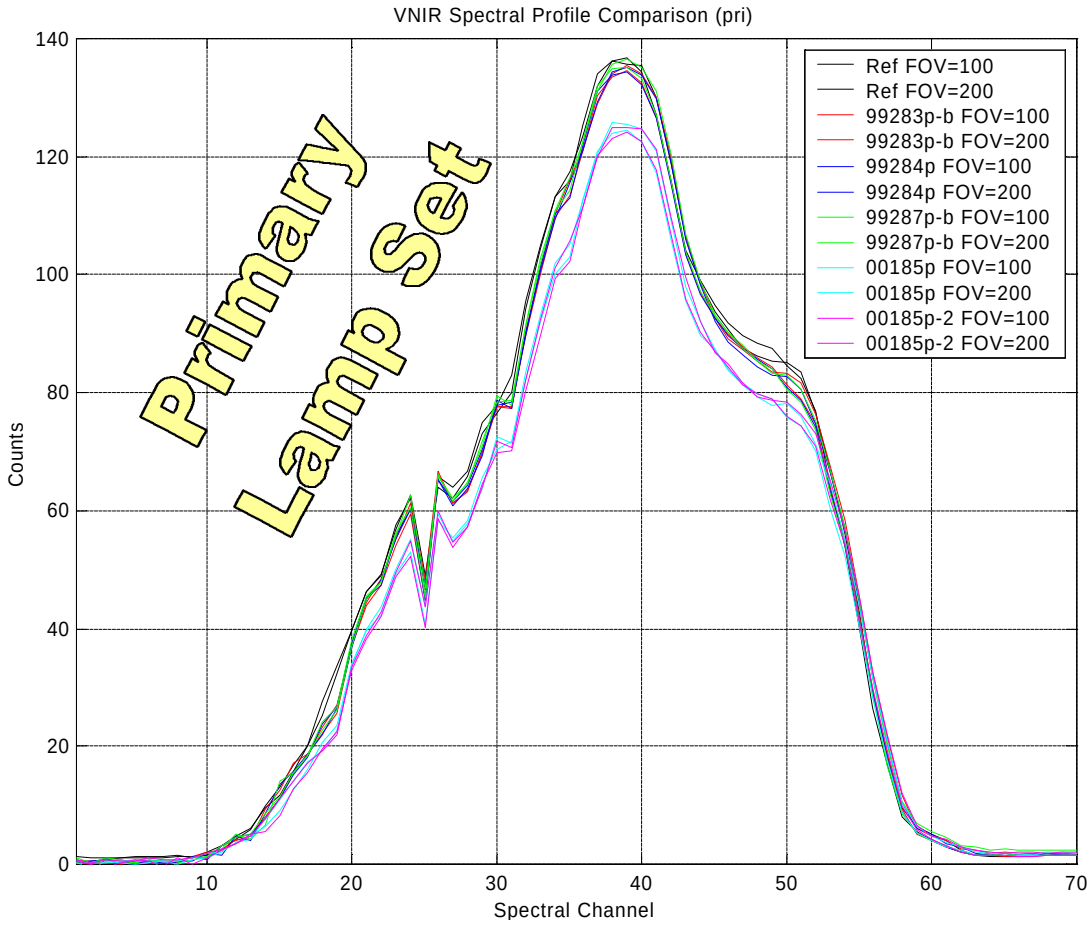
. . . Steve Carman
Hyperion Project Manager
TRW Space and Technology

Calibration Lamp Response Changes

- *May 28, 2000: Analysis of VNIR response to the primary internal cal lamp image from CPT 8, 10 testing under ambient conditions on May 26 found that the response was about 7% lower than a reference image taken during the first EO-1 T/V test.*
  - *Review of data acquired earlier found gradual decreases in response had taken place*
- *A quick check of the secondary lamp, which is operated less frequently, initially found it had been stable over the same period of time, with a small increase.*
  - *VNIR focal plane not suspected to be a problem because the two lamps produced different responses*
  - *Later comparison with TRW data found Redundant lamp response had increased.*
- *Modified plans for T/V II testing to use both cal lamps more frequently*

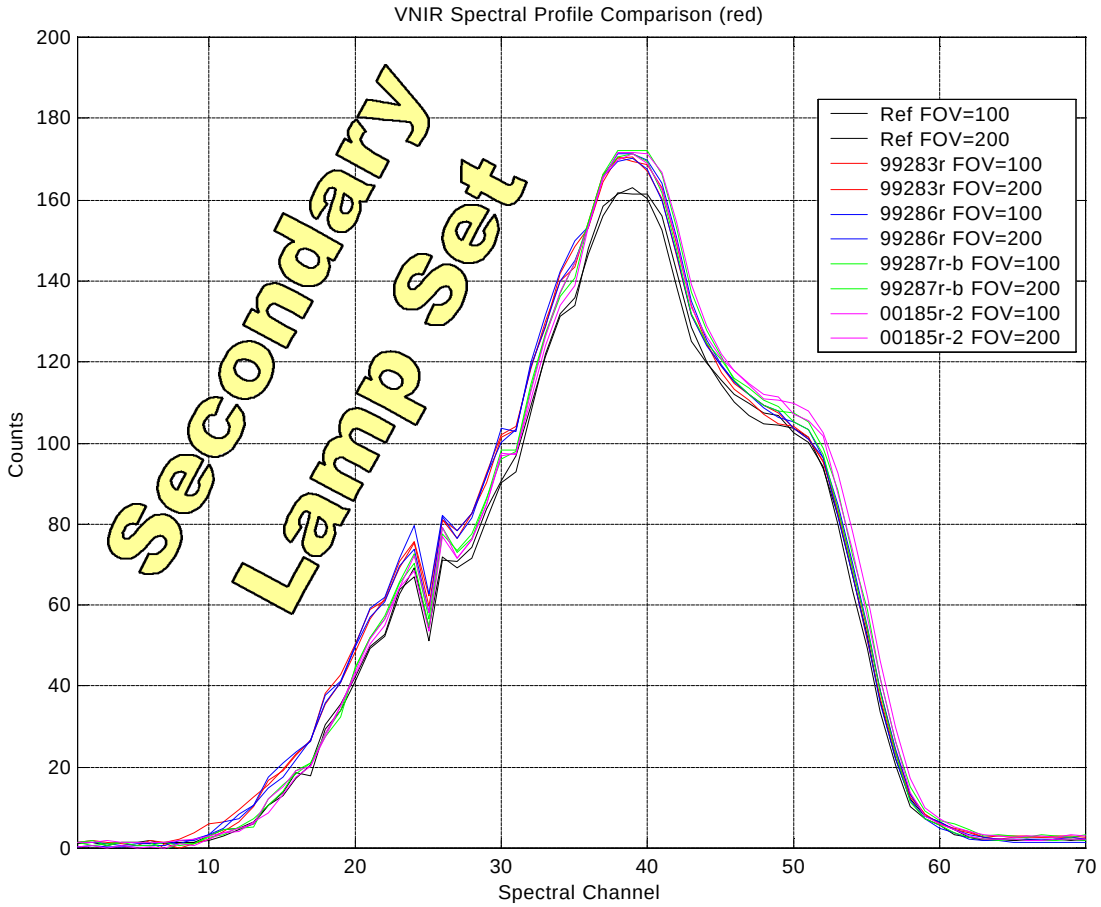
Internal Calibration Lamp VNIR Response

- **Response to primary internal cal lamps is lower than at TRW**
  - **EO-1 TV#1 same as TRW**
  - **EO-1 TV#2 data lower than TV#1**
- **Trend of gradual degradation:**
  - **YR 99 Day 238 [8/25/99] = 0% using as a reference**
  - **YR 99 Day 268 [9/25/99] = 2% decrease at band 40**
  - **YR 99 Day 342 [12/8/99] = 4.3% decrease at band 40**
  - **YR 99 Day 343 [12/9/99] = 5.5% decrease at band 40**
  - **YR 00 Day 147 [5/26/00] = 9% decrease band at 40**
  - **YR 00 Day 157 [6/5/00] = 9% similar to above**

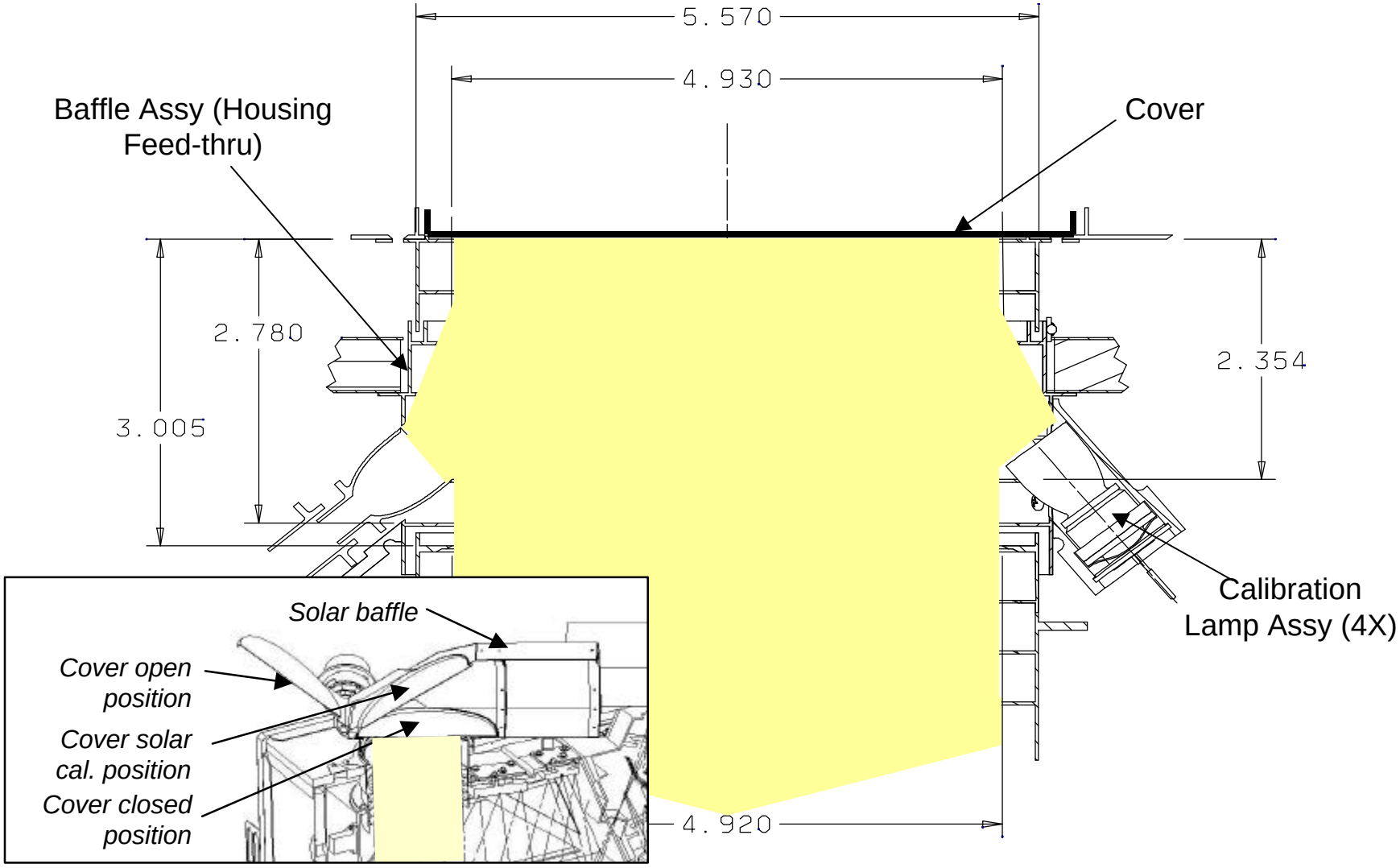


Internal Calibration Lamp VNIR Response

- ***Recent data from redundant internal cal lamps is <u>higher</u> than at TRW by 5%***
  - ***Data acquired at GSFC is stable***
- ***Lamps were not burned-in to stabilize properties before using them***
  - ***Burn-in modifies tungsten filament grain structure, increasing output***

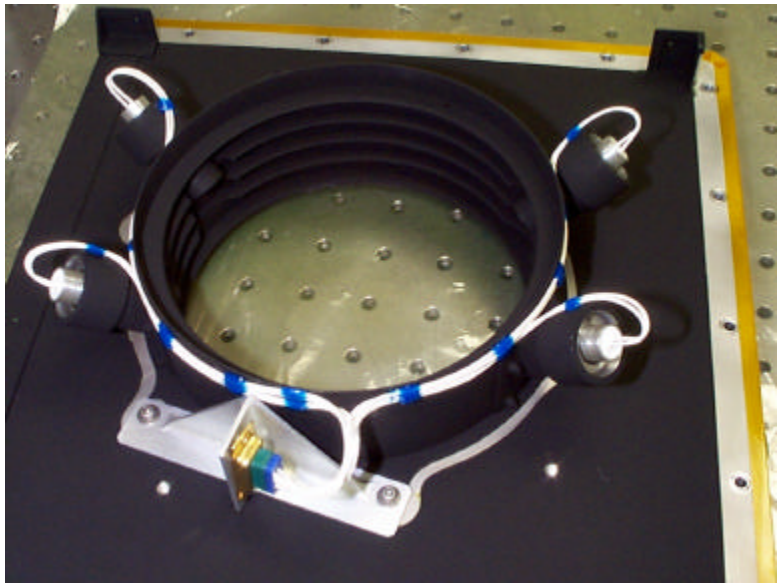


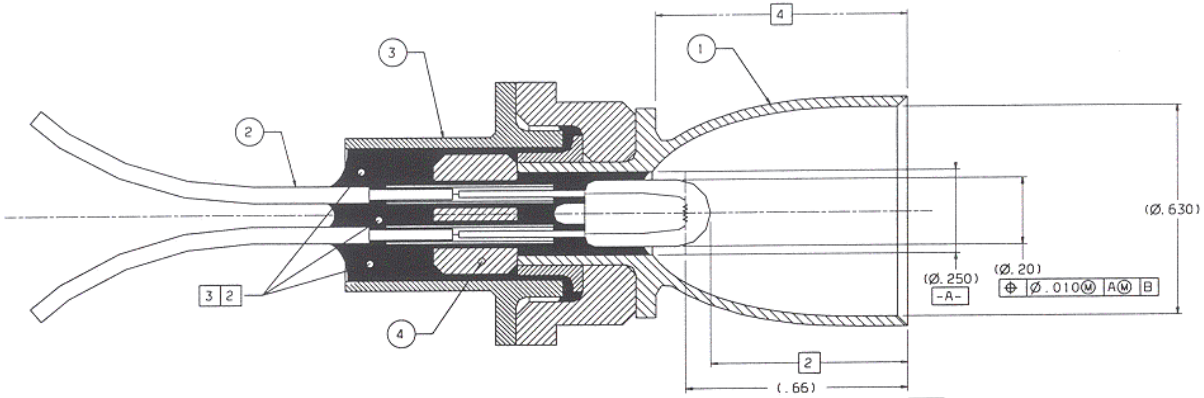
Hyperion Internal Calibration Lamps



Inflight Calibration Lamps installed in the entrance aperture baffle

(view from inside the HSA looking out toward the aperture cover)





Cal Lamp Assembly Cross-Section

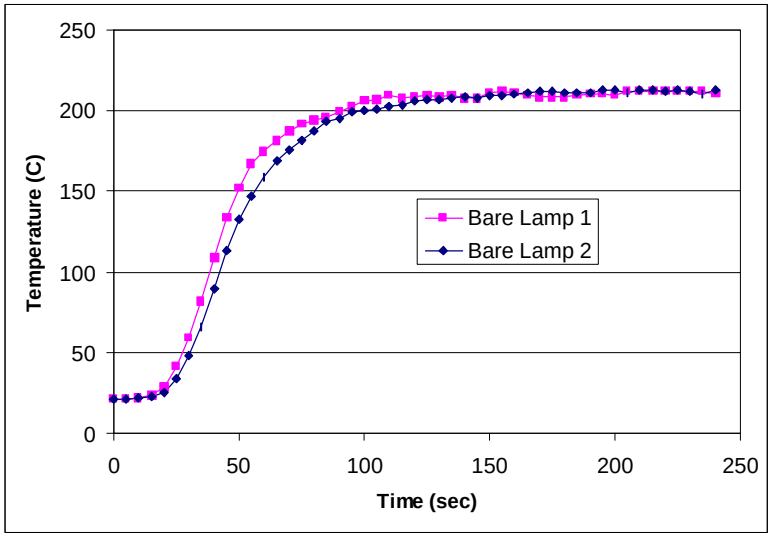
Cal Lamp Anomaly Investigation

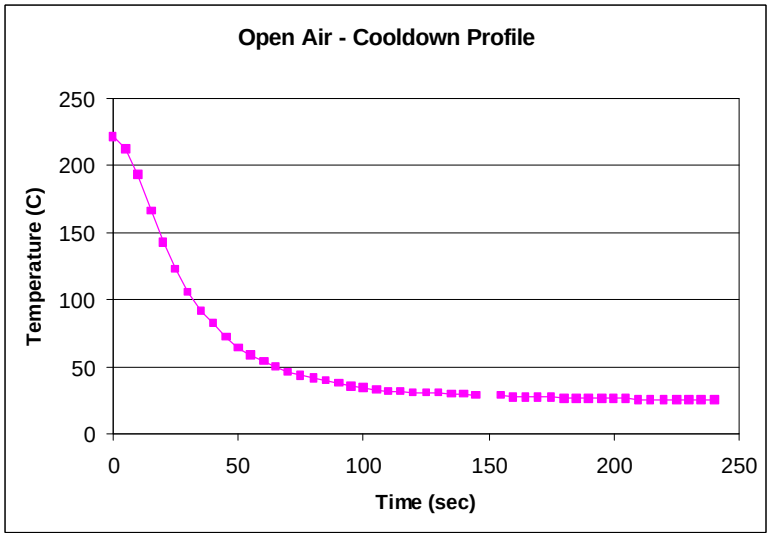
Consulted with several lamp manufacturers and lamp experts...

	Possible cause	**Investigation approach**
1	Lamp envelope not getting warm enough to activate halogen cycle in short duration of operation, causing lamp to darken with tungsten deposits. (Primary lamp on time is 40 seconds, including a 5 second ramp of current; Secondary lamp on time is 75 seconds, including the 5 second ramp of current.)	Measure lamp envelope temperature vs. time. Inspect lamps for possible darkening. Measure bare lamp and, if possible, a flight spare lamp assembly.
2	Lamp filament undergoing changes as part of burn-in, which was not performed in advance.	Inspect lamps using digital microscope to see if filament shows any sign of change.
3	Lamp drive electronics problem in HEA (primary lamp was replaced when intermittent during TV at TRW)	Bench test electronics using Hyperion Instrument Test Set (HITS) and Instrument Simulator Unit, and test tools.

Cal Lamp Investigation Findings (1)

- ***Measured lamp envelope temperature rise vs. time:***
- ***Bare Bulb:***
  - ***Lamp envelope temperature at 40 seconds is up to 100C less than stabilization temperature***
  - ***2 to 3 minutes required to reach 200 to 210C***
- ***Flight Assembly:***
  - ***Peak temperature achieved is 20 to 30C below bare bulb, in same time.***
  - ***Other lamp components get warm (72C)***
- ***Bare bulb cooldown time comparable to warm up***



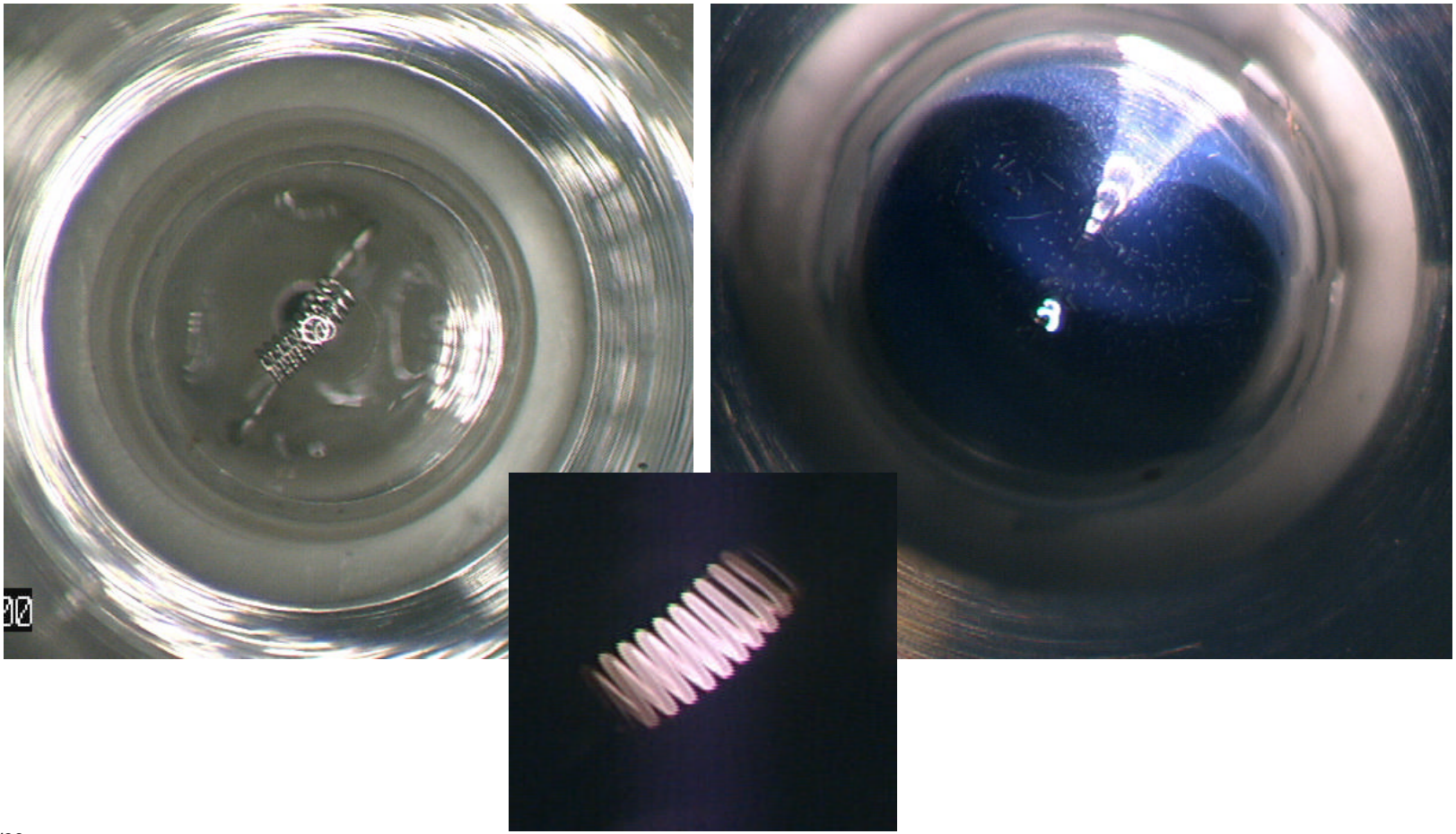


Cal Lamp Investigation Findings (2)

- ***Tested HEA lamp circuits using Hyperion Instrument Test Set & ISU***
  - ***No abnormal operation; circuits stable and linear, as tested at TRW***
- ***Measured resistance of lamps from HEA connector.***
  - ***Measured 4 circuits: 1.1, 1.4, 1.3, 1.3 ohms (normal)***
- ***Inspected & photographed lamps with filament on and off***
  - ***First impression: could not tell any difference between primary and secondary lamps by eye; generally lamps & reflectors looked like new***
  - ***Filaments looked normal unpowered and powered***
  - ***Under some lighting, some speckles evident on envelope***
    - *Swabs taken of primary lamps and reflector - no evidence of anything visible on swab*
      - *Cal sequence run before & after cleaning; very slight difference*
      - *Swabs to be analyzed*
  - ***Note: Maximum lamp on time was 7 minutes during photographic sequence***

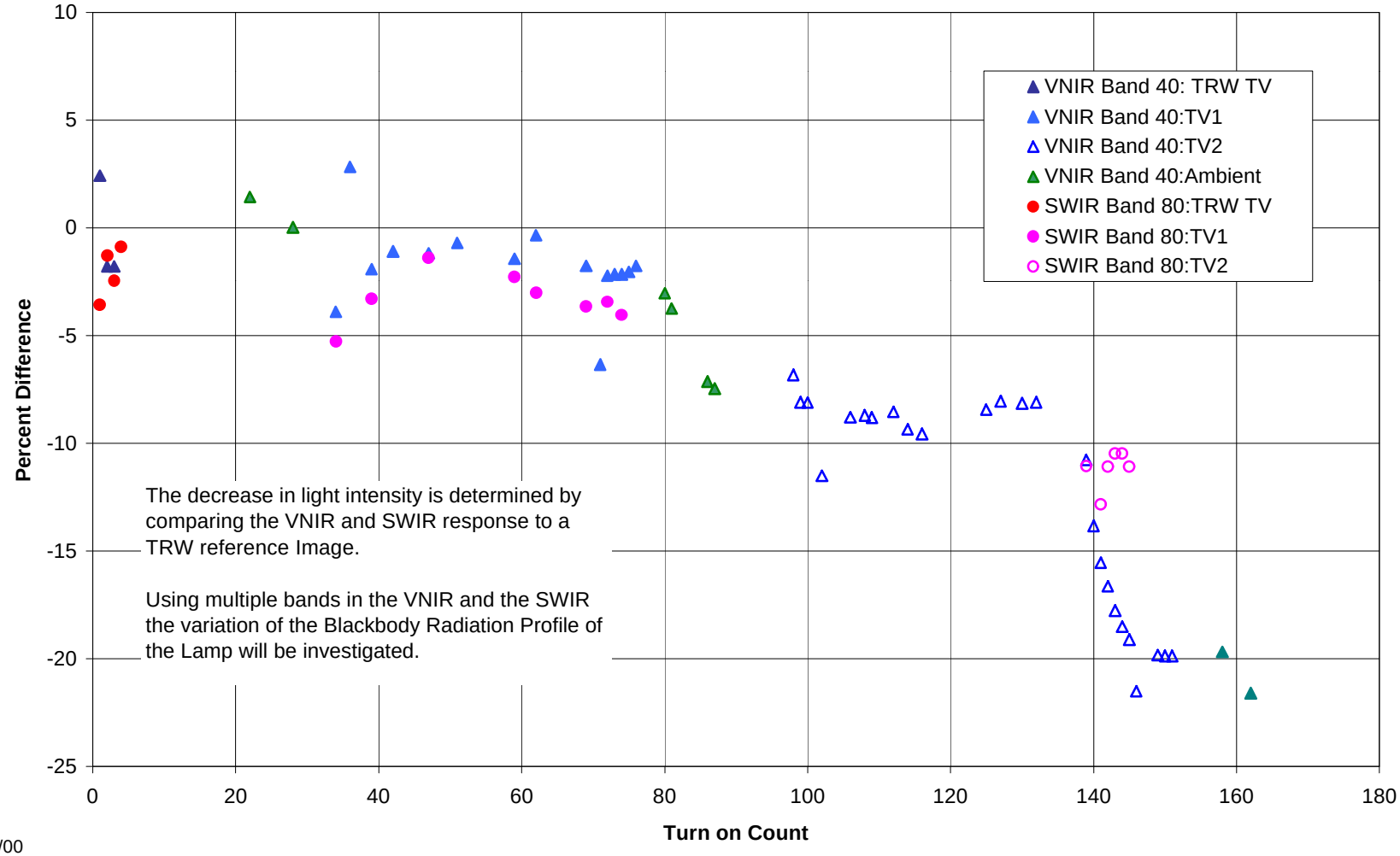
Sample Cal Lamp Photos

- ***Lamp filament off an on (inset), and envelope images***



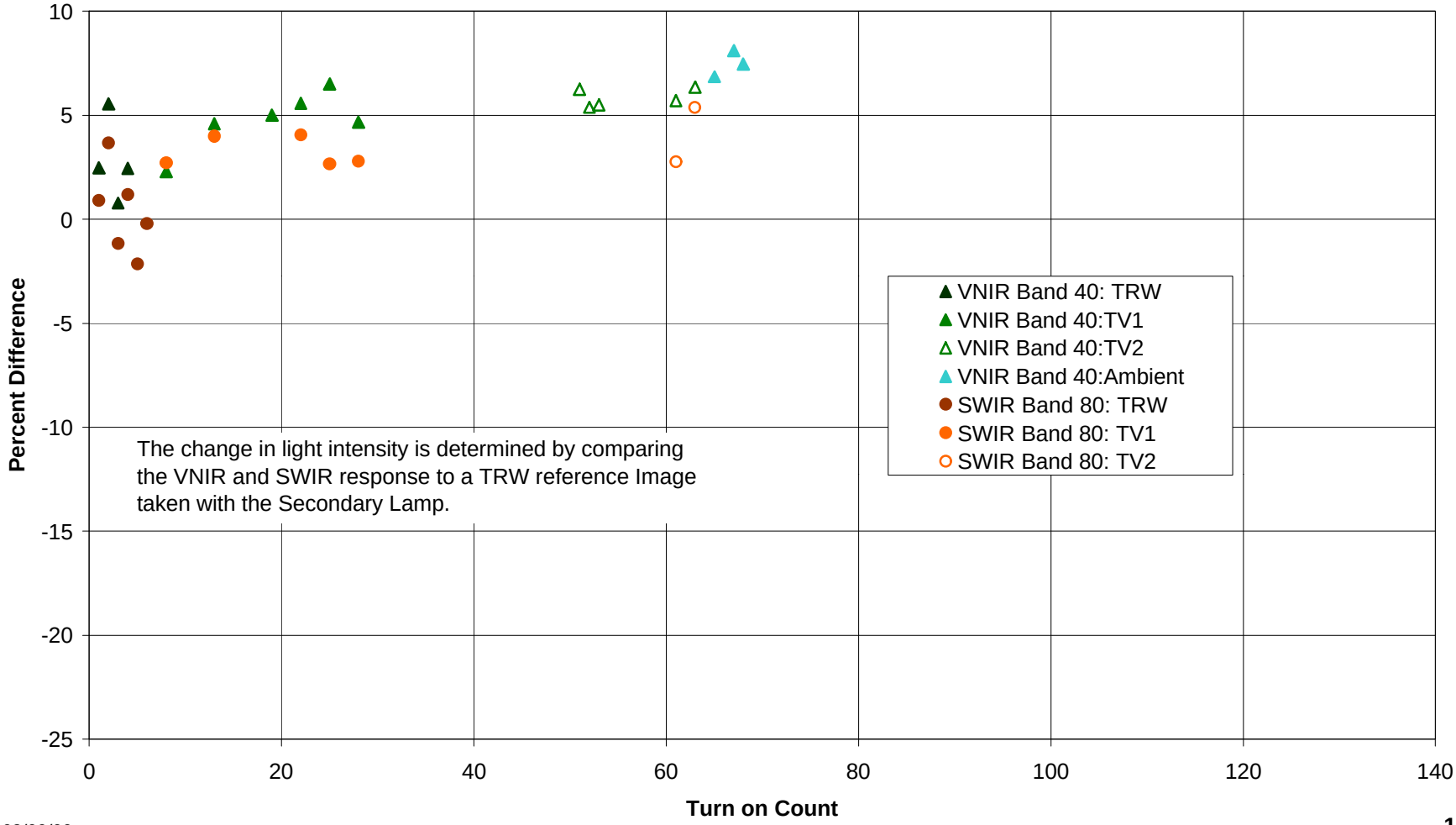
Primary Cal Lamp Response History

- ***Plot of % change of spectral channels 40 & 80 from TRW reference image since time of delivery. Both VNIR and SWIR response shown.***



Secondary Cal Lamp Response History

- ***Plot of % change of VNIR spectral channel 40 & SWIR channel 80 from TRW reference image since time of delivery.***



Proposed Preparations for Orbital Operation

- ***Perform additional burn-in time on both lamps until response is repeatable***
  - *Accumulate on-time necessary to stabilize, at least 6.5 hours.*
  - *Primary lamp set has accumulated approximately 4 hours.*
  - *Secondary cal lamp has accumulated approximately 1 hour.*
- ***Increase lamp on time to 3 minutes after each DCE***
  - *Ensure glass envelope achieves sufficiently high temperature to activate the halogen cycle*
- ***Consider revised calibration sequence to utilize both lamps***
  - *Image (dark file)*
  - *Lamp 1 on 3 minutes, image lamp 1*
  - *Lamp 2 on 3 minutes, image (both lamps)*
  - *Lamp 1 off 3 minutes, image lamp 2*
  - *Lamp 2 off 3 minutes, image (dark file)*

Hyperion Cal Lamp Contingency Plan

At Launch:	Plan:
Primary Circuit is OK	- Use Primary Lamp or dual lamp sequence
Secondary Circuit is OK	- Periodic Secondary Lamp used to establish comparison with Primary
	- Solar Cal ASAP

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At/After Launch:	Plan:
Primary Circuit is suspect	- Switch to Secondary Lamp
Secondary Circuit is OK	- Maintain Solar Cal schedule: determine rate of calibration drift
	- Initiate tracking of VNIR/SWIR responsivity (using Redundant lamp) vs. ASP, FPE temperatures on orbit

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After Launch:	Plan:
Primary Circuit is suspect	- Discontinue use of cal lamp after DCE
Secondary Circuit is suspect	- Use tracking data to correct for shifts in responsivity with ASP, FPE temperatures (in lieu of cal lamp file)
	- Use tracking data to calculate resultant uncertainty in radiometric correction
	- Use data on rate of calibration drift to re-define solar cal schedule (for periodic adjustment of calibration file for Level 1 processing)

Special Topic:

Hyperion Final Integration

. . . Steve Carman
Hyperion Project Manager
TRW Space and Technology

Potential Issues

- ***Final integration issues***
  - ***Grounding and securing the test heater, thermocouple, and accelerometer cables***
    - *Strip & tape to conductive enclosure on HSA*
  - ***Mating the wrong connectors***
    - *Damage to the Hyperion hardware (HEA and CEA)*
  - ***Damaging the Hyperion 1773 fiber optic connectors***
    - *Possible loss of S/C commands and telemetry*
  - ***Mishandling of hardware***
    - *Possible ESD damage to the Hyperion hardware (HEA and CEA)*
  - ***Caging the cryocooler before launch***
    - *Special procedure must be run to cage the cryocooler or possible damage can occur during launch*

Hyperion Final Integration Procedure

- *Mechanically mount HEA and CEA assemblies to S/C*
- *Discharge HEA, CEA, and cable connectors*
- *Mate connectors w/ BOB and inspect for proper mating pairs*
- *Perform S/C-to-Hyperion electrical procedures to verify power and 1773 interfaces*
- *Perform WARP-to-Hyperion safe-to-mate procedures*
- *Perform Hyperion functional tests including DCE and Cryocooler @10% stroke*
- *Demate/remove BOB and install flight cables*
- *Perform full CPTs*

Residual Risks

- *Reinstallation procedures have been developed and tested during previous Hyperion/EO-1 integration*
- *Same personnel that integrated Hyperion previously are supporting re-integration and testing*
- *There is minimum residual risk for Hyperion final integration*

Special Topic:

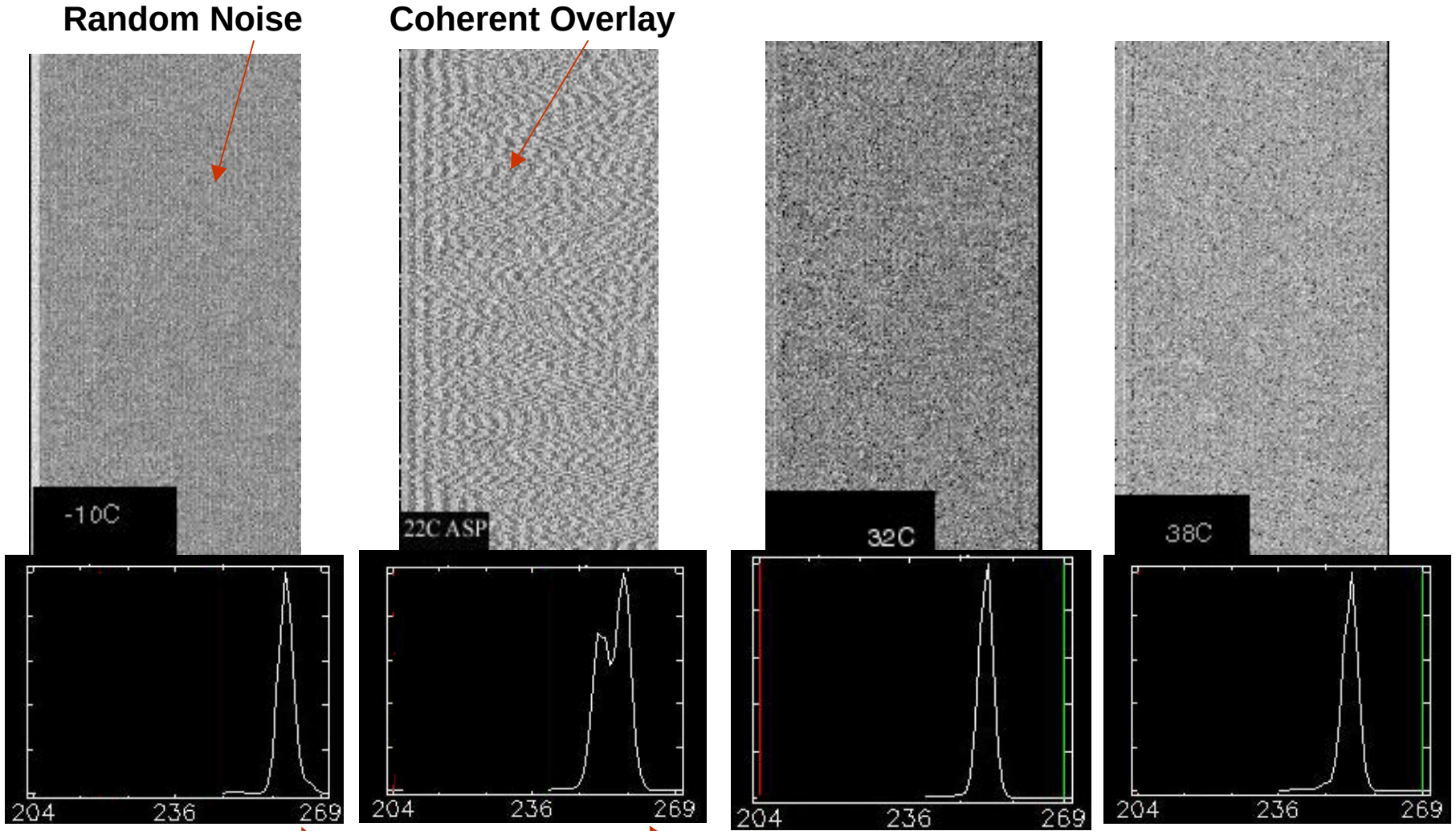
VNIR ASP Thermal Noise

. . . Dr. Jay Pearlman
Hyperion Deputy Project Manager, Science and Operations
TRW Space and Technology

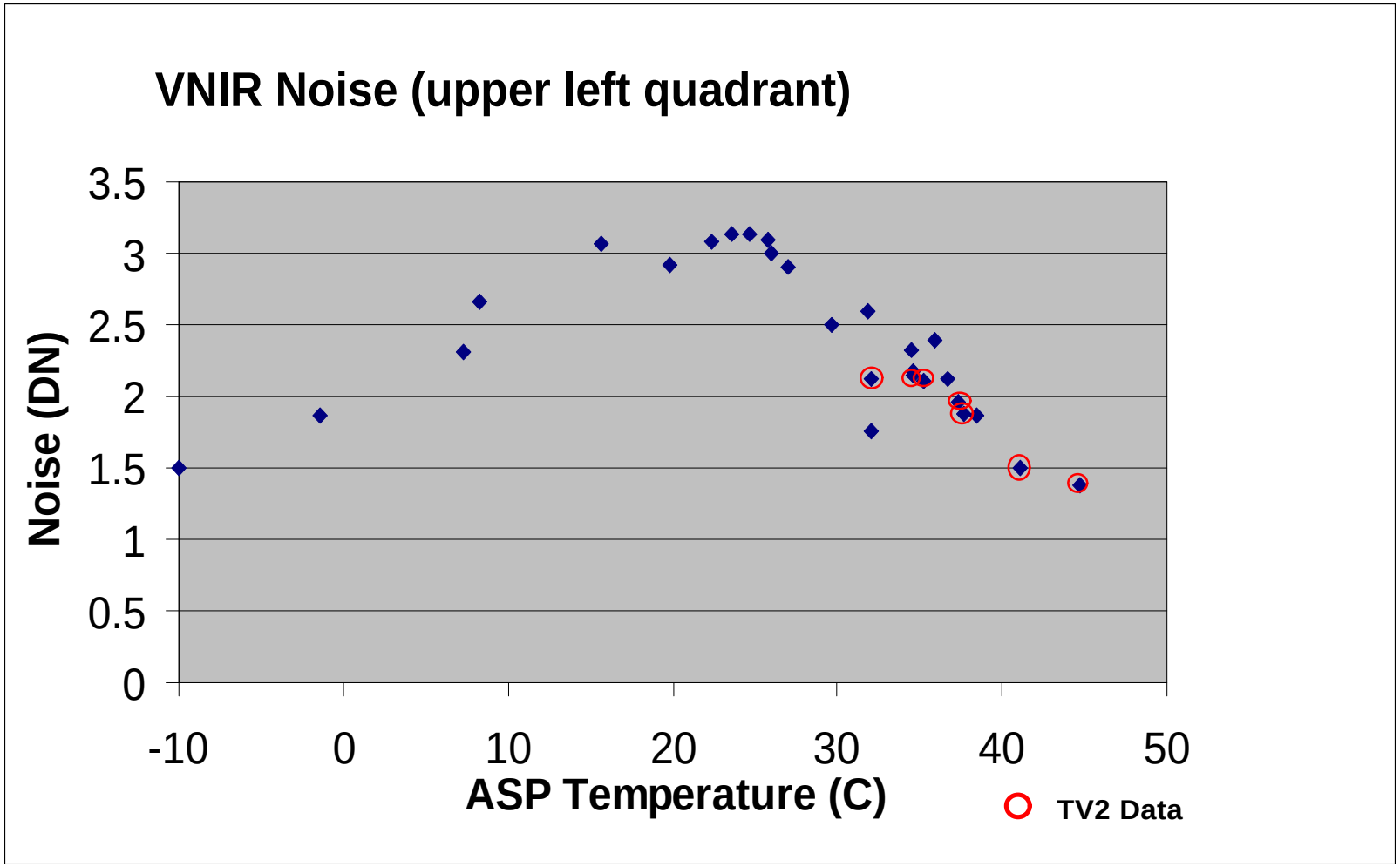
VNIR ASP Thermal Noise

- *Increased noise in the VNIR data is observed for ASP operating temperatures between 5C and 32C.*
- *The noise level increased only for the two quadrants associated with shorter wavelengths of the VNIR. The noise levels in the other two quadrants are independent of ASP temperature.*
- *The noise characteristics indicate both a broader dual Gaussian distribution and a small coherent overlay. This increase is due to the temperature sensitivity of the signal processing electronics.*
- *The noise has been characterized and can be avoided by operating the ASP at temperatures above 32C, but below the red limit of 50C. This was demonstrated during T/V II.*

Impact of ASP Temperature on VNIR Image



VNIR Noise Dependence on ASP Temperature



Conclusion

- *The VNIR noise increase was characterized and increased noise can be avoided by operating the ASP at temperatures above 32C. This was tested during T/V II.*
- *Thermal models predict ASP temperature ranges of 32C to 41C when the ASP heater setpoints are 32C on and 34C off; 41C is acceptably below the upper ASP operating limit of 50C.*
- *Noise Performance during T/V II was measured with ASP temperatures from 32C to 45C and noise decreased with increasing temperature as predicted in the earlier analysis.*
- *The issue has been resolved through a change in heater set point and operating conditions.*