Comparison of L1B Product with Sensor Specification

Outline

- **Key PFM Performance and Calibration Issues**
- **MCST Comparison of L1B Product with Sensor Specifications**
- **Reflectance Bands Transient Response Performance**
- **MCST Prototype Scene Restoration**

Key PFM Performance and Calibration Issues

- **Electrical Cross-talk mitigated. Residual effects to be evaluated on-orbit.**
- **L1B optical cross-talk reduction algorithms in place for Bands 5,6 (5.4 micron leak) and Bands 32-36 (Band 31 leak).**
- **Transient response specification not met for any Reflective Band**
- **Thermal Bands RVS adopted from FM1 and NPL witness sample measurements.**
- **Bands 5-7, 20-30 pre-launch calibration suspect; to be updated on-orbit; increased TEB uncertainty due to limited ability to measure non-linearity over OBC BB temperature range**

Comparison of L1B Product with Specification

Band Number		36	35	34	33	32	31	30	29	28	27	25	24	23	22	21	20	26	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Spatial	IFOV																																				
	Co-Registration																																				
	Modulation Transfer Function															?																					
	Transient Response																																				
Spectral	Relative Spectral Response In-band Measurements																																				
	Relative Spectral Response Out of Band Measurements																																				
	Optical Cross-talk																																				
Radiometric	NEdL/NEdT/SNR																																				
	Polarization																		45:ALL (MS1)		45:ALL (MS1)		22:1,10;45:1,10		45:ALL	45:10	45:ALL	45:ALL		>0.02				22:20	45:ALL		
	RVS																																				
	Electronic Cross-talk																																				
	Out-of-Family Channels													10	8																						
	Dynamic Range																																				
	Uncertainty																																				

Reflectance Bands Transient Response Performance

- Watson Gregg chart here

Prototype Scene Restoration

Section Divider

Key Issues Regarding Image Restoration

1) Which bands do we target for restoration? Ocean Bands 8-16?

2) What are scattering effects on various science product algorithms? Do ocean product algorithms require absolute radiometric accuracy, or is relative accuracy sufficient? How does scattering affect band ratio algorithms, band difference algorithms, etc.?

3) How do we handle MODIS cloud saturation? Can we use spectrally close unsaturated bands? Use similar MISR bands?

4) On-the-fly processing of 100% of data versus off-line processing of x% of the data. Desaturation of cloud tops may practically limit us to off-line processing.

5) How do we select x% of the data to provide useful results for science users? e.g., 10 scenes/day (3 granule scenes: 600 scans x 1354 frames)?

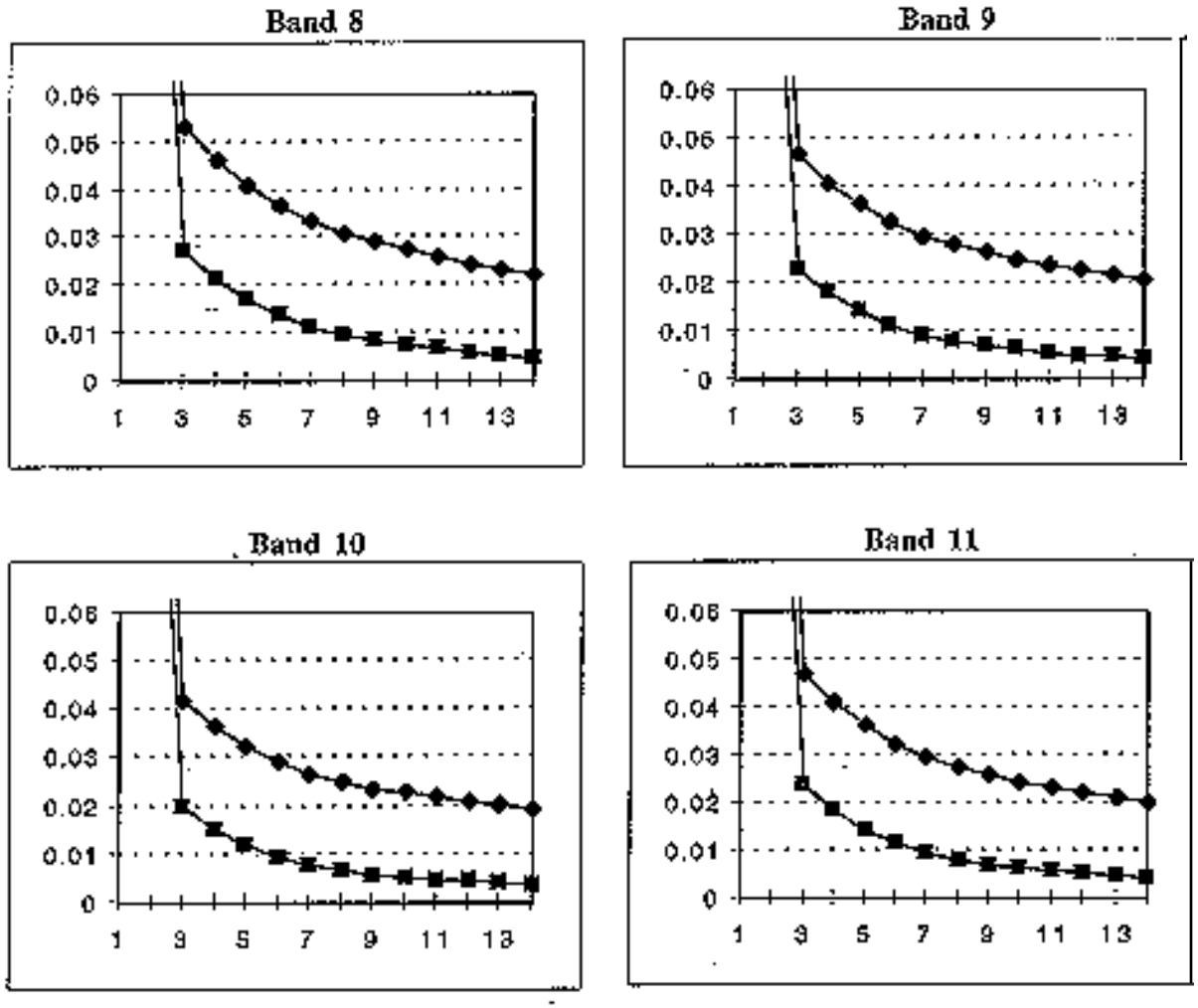
6) How accurately do we need to know the PSF to "do good and avoid harm" to the data? Can we model the PSF this accurately? Can we validate the far-field component of our PSFs using Moon scatter results?

7) How large should the PSF be to get suitably accurate results?

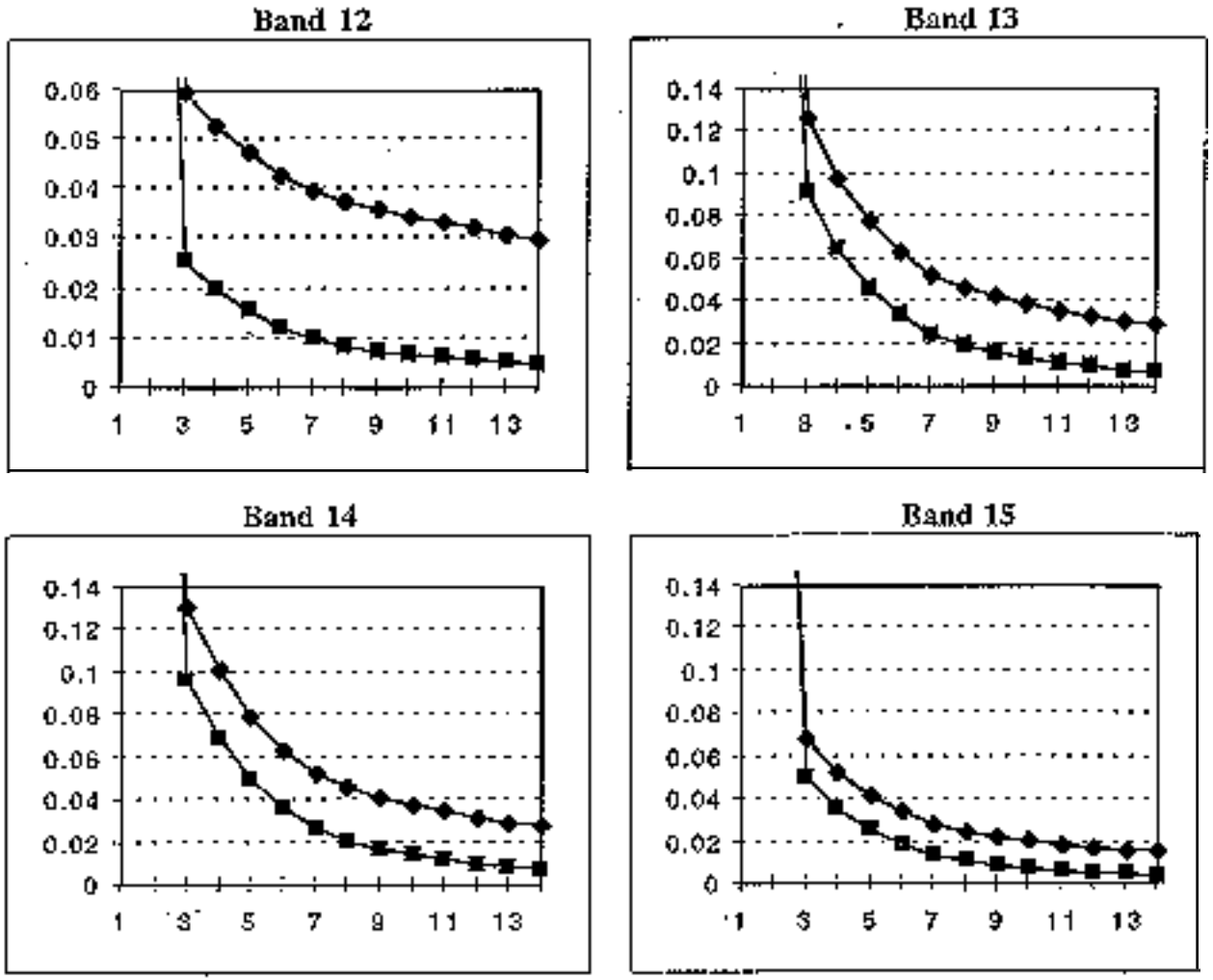
8) What are the restoration error effects due to imperfect desaturation of clouds?

9) What are the restoration error effects due to filling data beyond measured scene to enable FFT processing?

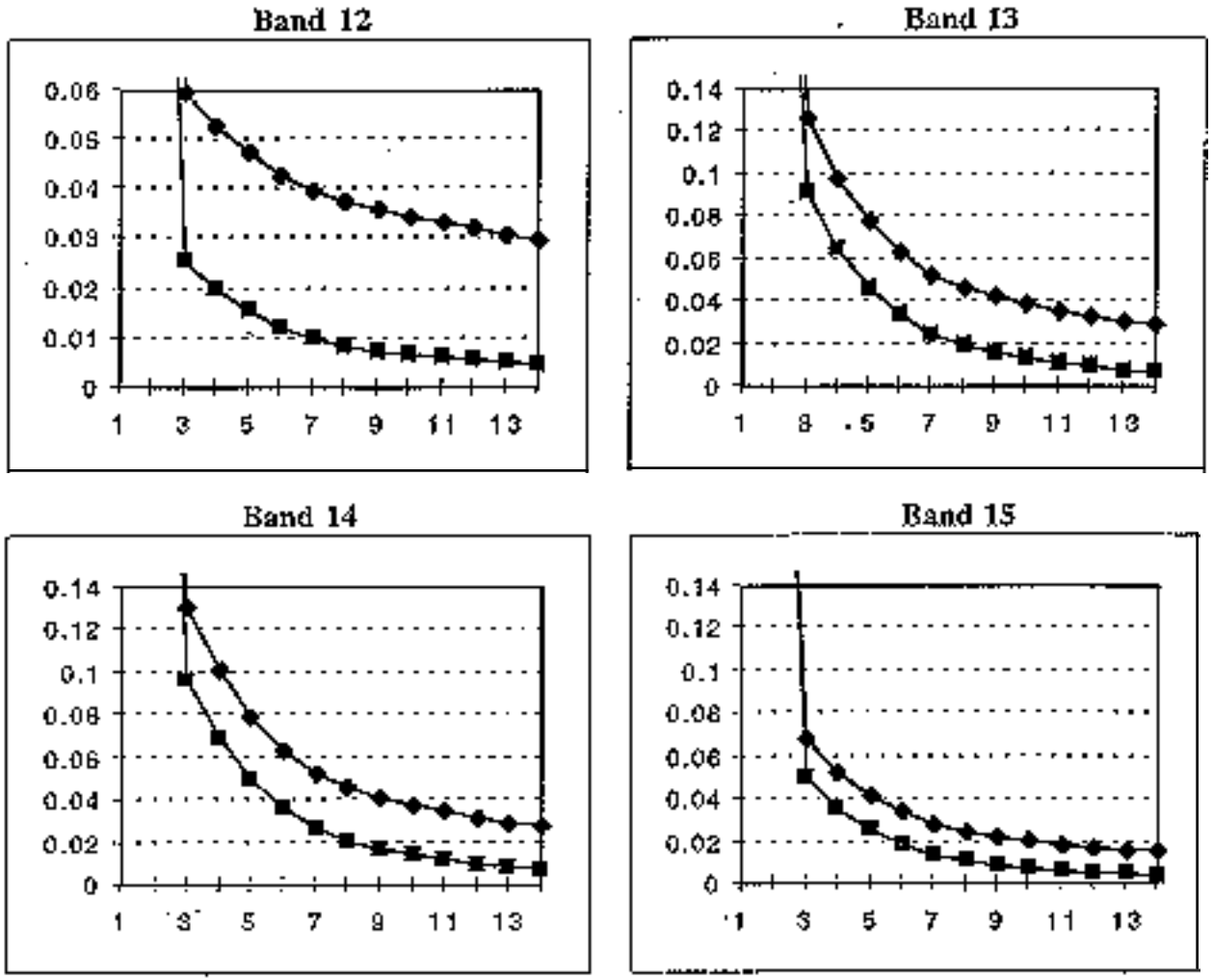
Figures for 20x20 and 120x120 bands 8-11



Figures for 20x20 and 120x120 bands 12-15



Figures for 20x20 and 120x120 bands 12-15

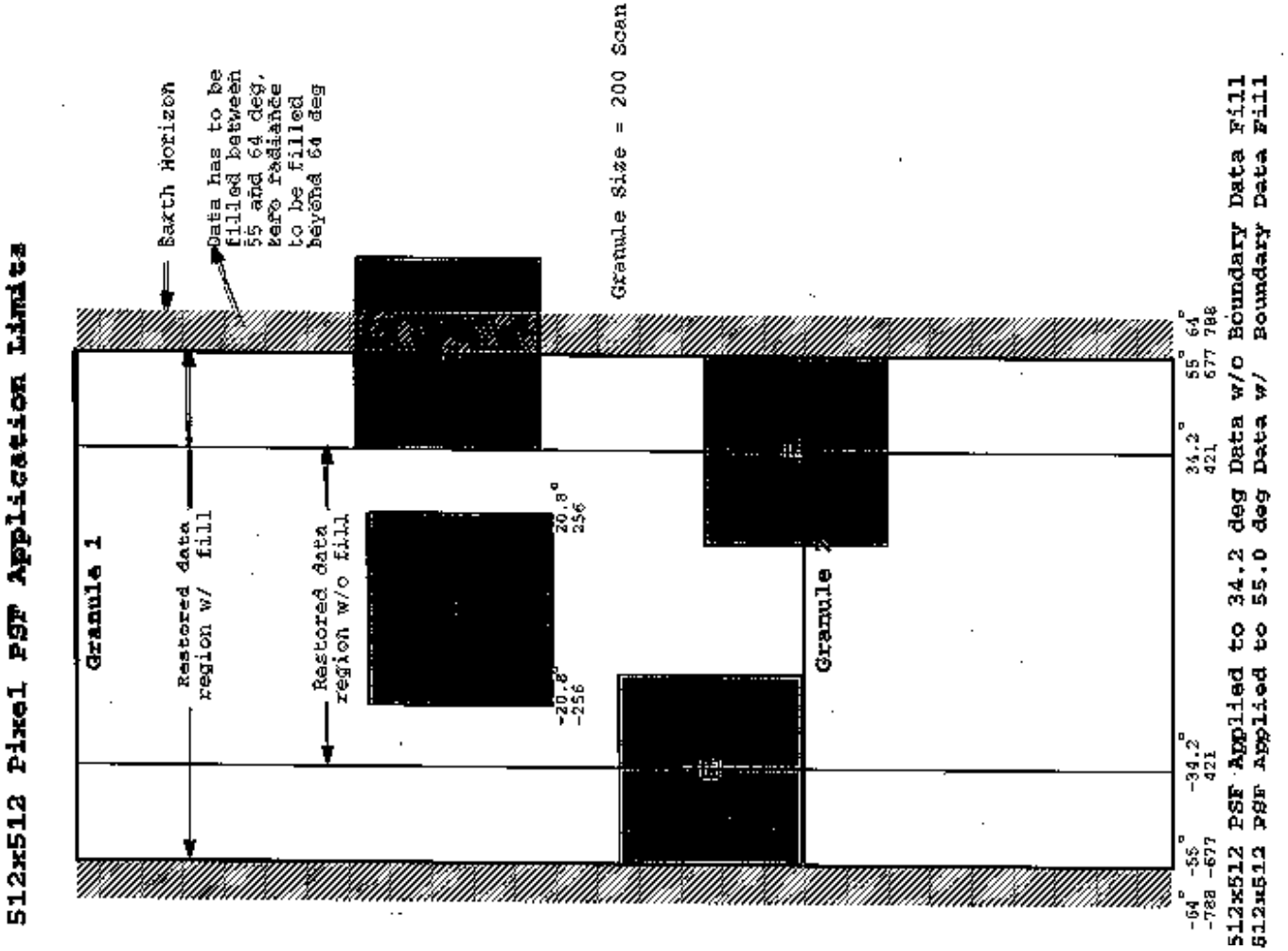


Reflectance Bands Transient Response Performance

WORD OF CAUTION TO L1B USERS!

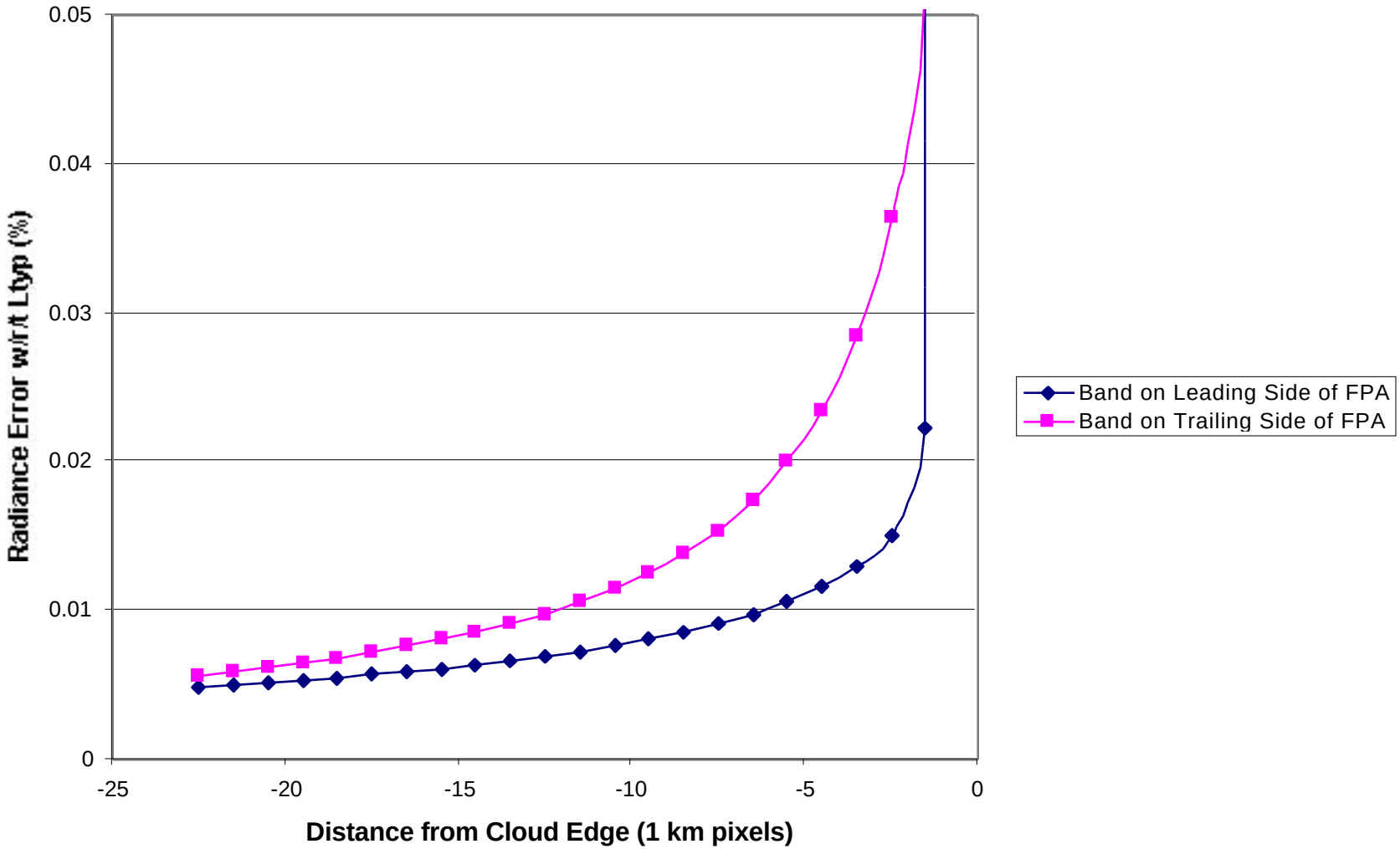
- **Expect significant radiance bias errors near high contrast features (0 to 30 km region depending on contrast ratios)**
  - Bright clouds over ocean or dark forest
  - Land/ocean shore lines
  - Estuary regions
  - Ice/snow boundaries near water
  - Other TBD aspects of data with high contrast ”nearby”
- **No schedule at present for incorporating Scene Contrast Index into the L1B product**

512x512 Pixel PSF Application Limits

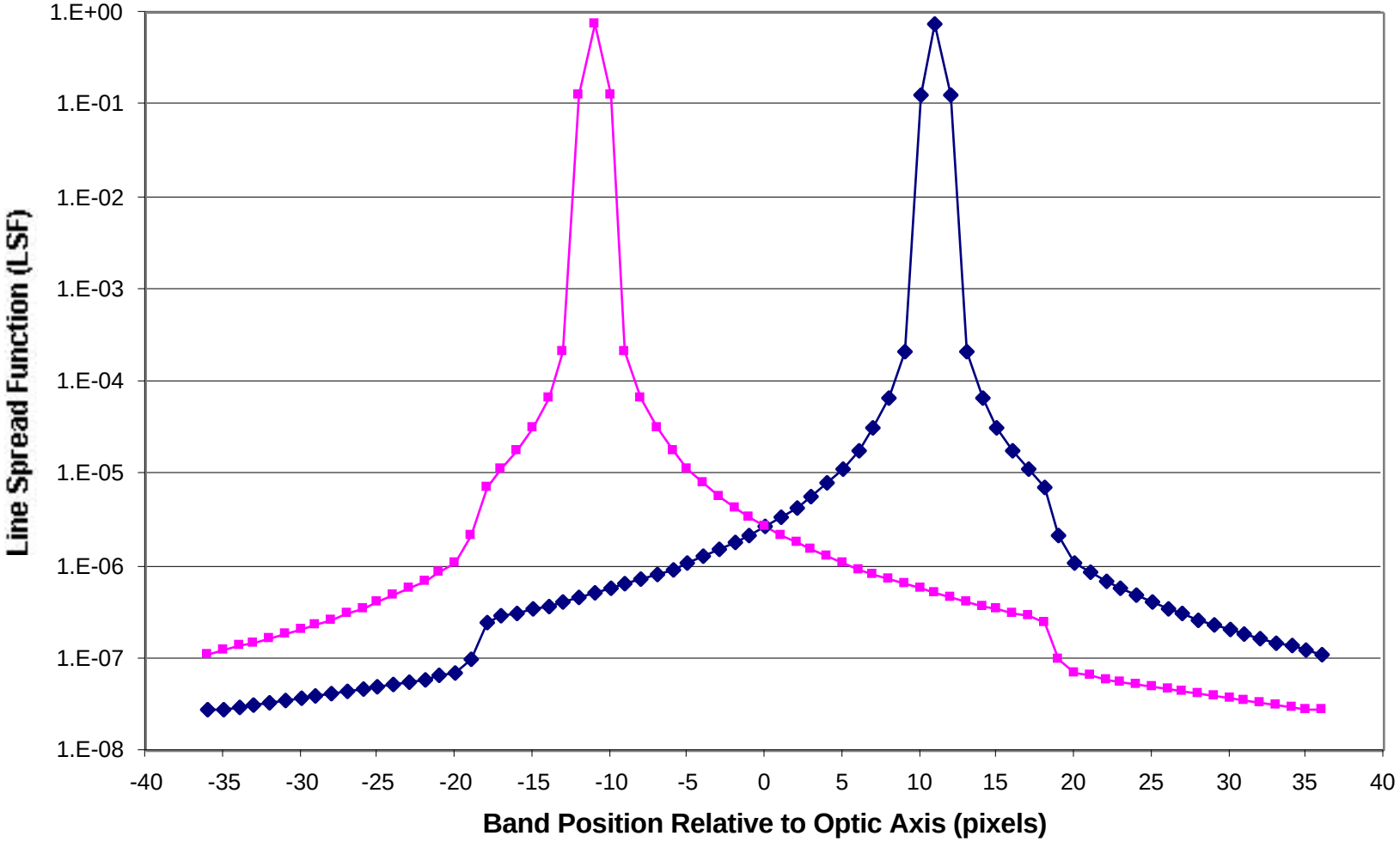


Radiance Error for Two Band Locations on FPA for Lcloud/Ltyp=20

(scanning from ocean onto cloud; both bands have same spectral characteristics)

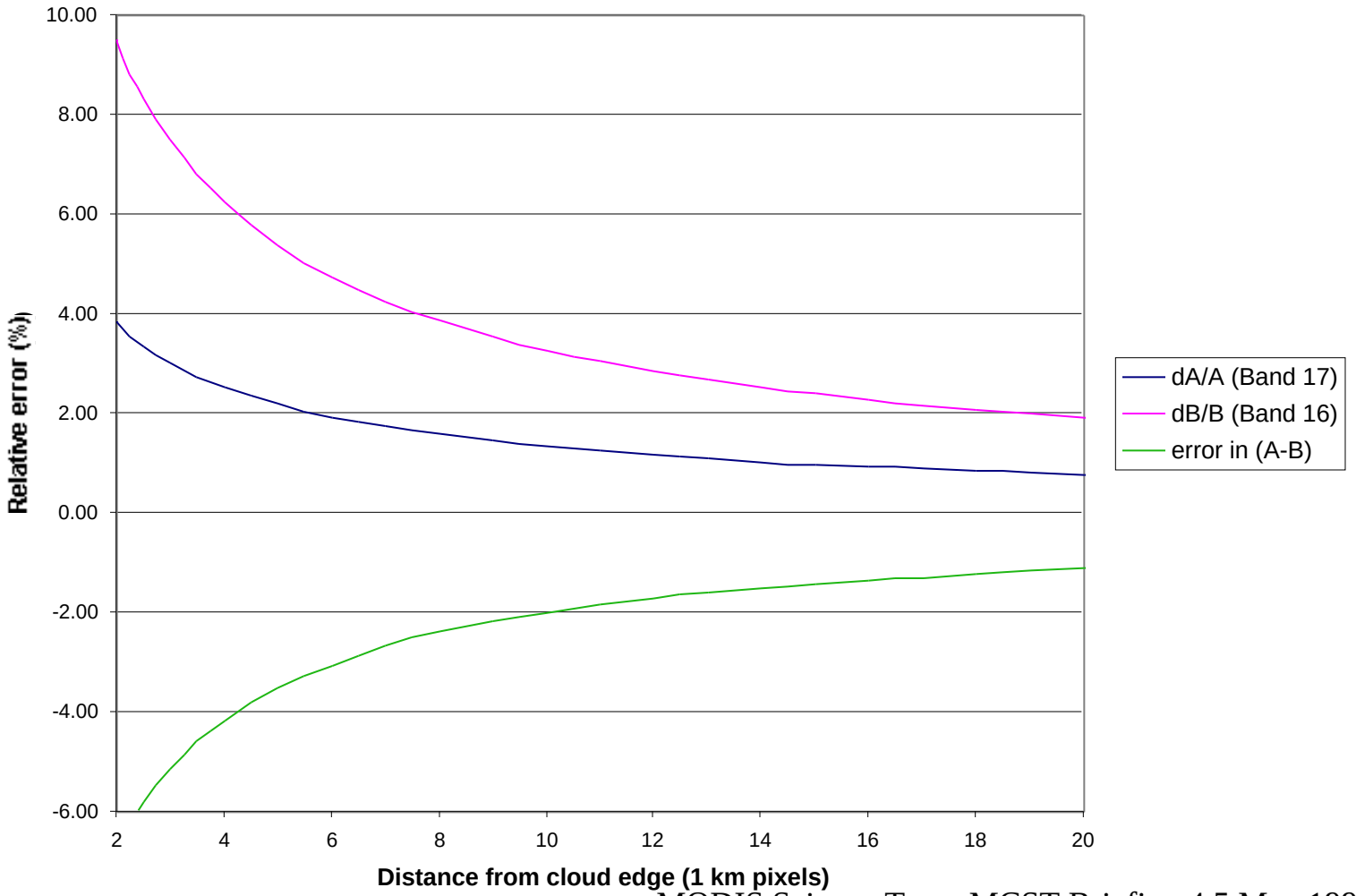


Line Spread Functions for two identical bands located on far-left and far-right of FPA



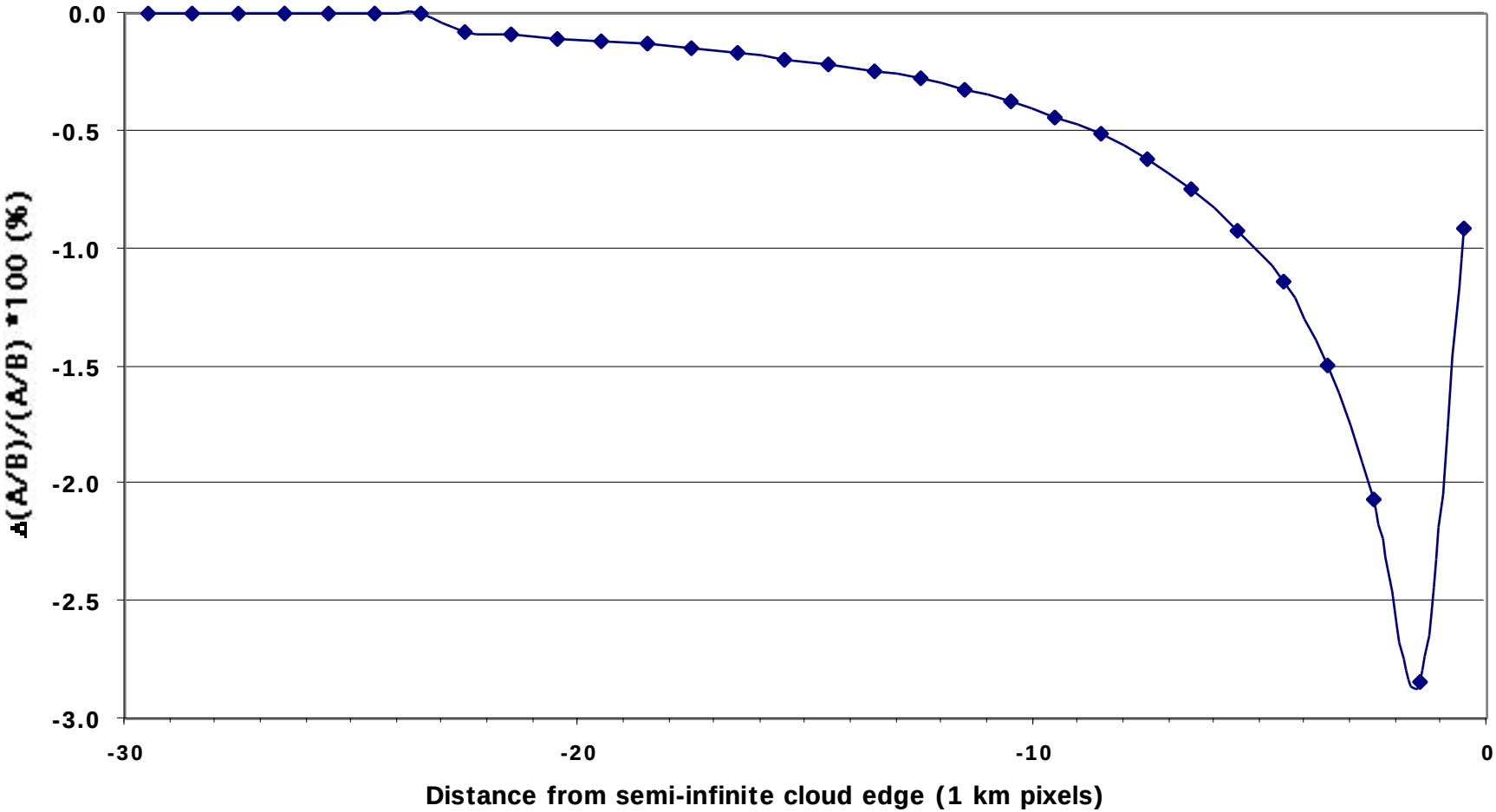
Absolute radiance errors compared to relative error for A-B type algorithm

(MODIS Band 16@887 nm with Lcloud/Ltyp-46; and Band 17@904 nm with Lcloud/Ltyp=25.2)



Effect of spectral band location within FPA on A/B type algorithms

(Band A on far left; Band B on far right;
scanning from Ltypical onto semi-infinite cloud, with Lcloud/Ltyp=20)



Instrument Activation Sequence

Section Divider

Instrument Activation Sequence

Outline

- Identify our guiding objectives
- Describe what we are going to do
- Provide major milestones

Identify guiding objectives

- **Safely turn-on MODIS**
- **SBRS Verify nominal functionality**
- **Establish accurate on-orbit performance**
  - Compare on-orbit performance via On-Board Calibrators over operational parameter space with pre-launch performance
- **Establish early performance baselines and trend variation from that performance**
- **Promptly compare pre-launch Reflectance Bands radiance calibrations (SIS100) with on-orbit solar diffuser and TOA solar irradiance (Thuellier) derived radiance values**
- **Initiate vicarious validation activities with surface sites and field campaigns as available**

Operating Constraints

- **Spacecraft final orbit achieved ~ at Day 12**
- **Contamination and Water Vapor outgassing**
  - 14-day cold focal plane assembly bakeout prior to cool-down
- **Door operations**
  - Prefer open NADIR and Cooler doors once only
- **Work from 48 hour command baseline**
- **Bands 1-19 not telemetered for night mode data**

What we are going to do

- **<u>Focal Plane Assemblies operating voltages</u>**
- **<u>SWIR bands thermal leaks</u>**
- **<u>Residual electronic cross-talk shadows assessment</u>**
- **<u>SD/SDSM baselines</u>**
- **<u>SRCA testing</u>**
- **Band 31 leak into Bands 32 - 36**
- **Response vs. Scan Angle via scene statistics**
- **Transient response/scene sharpening**

<u>ITEMS MARKED BY UNDERLINE</u> MUST BE ACCOMPLISHED WITHIN 30 DAYS AFTER FIRST LIGHT

Launch and Early Orbit Operations - I

MODIS L&EO Phase Operations

Day 0:
- Launch and S/C Activities
- Turn on MODIS Survival Heaters 4-6 Hours After Launch

Day 7:
- MODIS Turn On
- Unlatch Space View Door
- Open Space View Door 5°
- Begin 14 Day Outgas Period

Day 21:
- Open Space View Door
- Transition to Science Mode
- Turn Off Outgas Heaters
- Begin Formatter Day/Night BAP
- First Need for EDS

Day 22:
- Electronics Calibrations
- SRCA 1W Functional (Extended Contact)
- BB Functional

Day 23:
- Microprocessor Load
- SDSM Checkout
- Reflective Band Noise Verification (SSR)
- SRCA Full Radiometric (Extended Contact)

Day 24:
- SRCA Full Spectral

Day 25:
- SRCA Full Spatial
- Stray Light Test

Launch and Early Orbit Operations - II

MODIS L&EO Phase Operations

- Unlatch Solar Diffuser Door
- Open/Close SDD Test

- Day 1 of Yaw Maneuvers
- SDD Screened/NAD Closed

- Day 2 of Yaw Maneuvers
- SDD Screened/NAD Closed

- Day 3 of Yaw Maneuvers
- SDD Open/NAD Closed

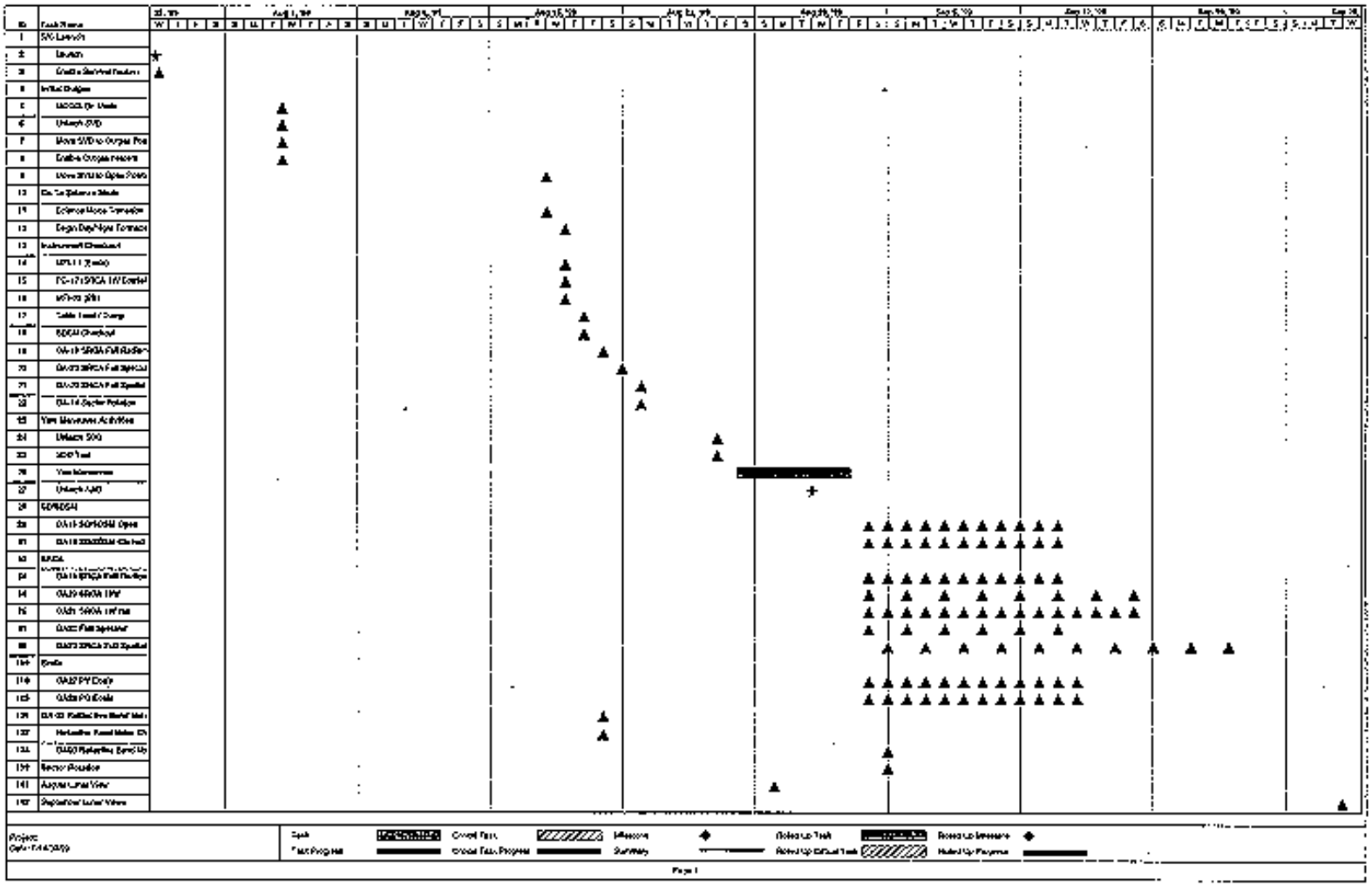
- Day 4 of Yaw Maneuvers
- SDD Closed/NAD Closed

- Unlatch and Open Nadir Aperture Door (Extended Contact)
- Day 5 of Yaw Maneuvers
- SDD Screened/NAD Open

- Day 6 of Yaw Maneuvers
- SDD Screened/NAD Open

- End MODIS Activation Sequence
- Begin Stored Command Calibration Activities

A&E Operations Gannt Chart



Major Milestone Planning Goals (Launch = Day 0)

PRECURSOR EVENTS: NADIR DOOR OPEN (DAY 34), L1A AVAILABLE IMMEDIATELY AND SBRS RELEASES SENSOR FOR SCIENCE

- First Light image w/pre-launch calibration **Day 36**
- Internal L1B product available with 1st calibration and code modification updates **Day 49**
- On-orbit spectral calibration and co-registration via SRCA observations **Day 49**
- L1B files for science checking of L2 code **Day 64**
- First Calibration Validation Workshop **Day 124**

CAVEAT: ASSUMES SUCCESS-ORIENTED INSTRUMENT CHECKOUT AND EDOS/DAAC/CROM DATA OPERATIONS

Impact on SWIR Calibrations of Science Operations Begin Day 30

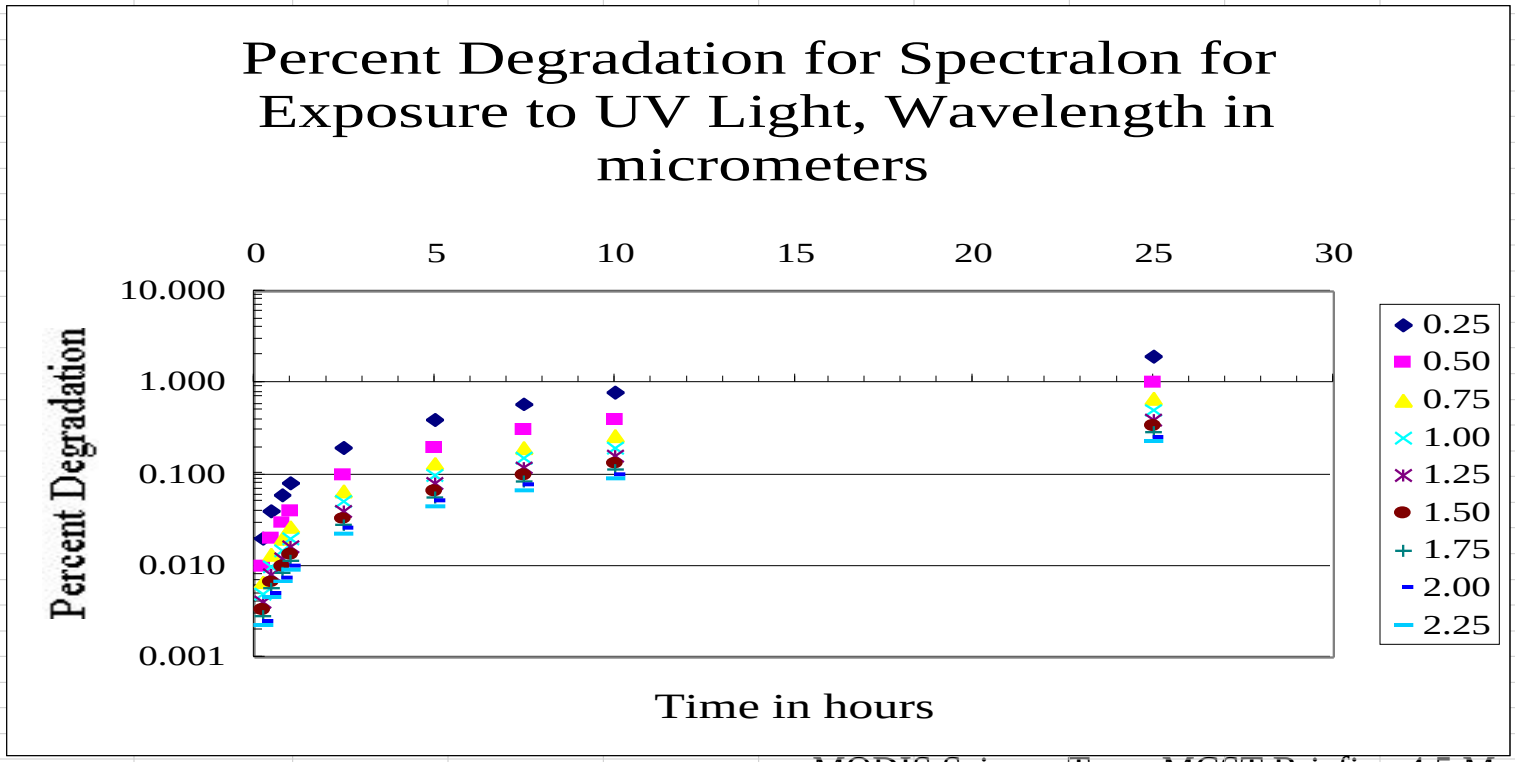
- No SWIR Bands in SDSM, so lunar calibrations needed to track SWIR SD degradation
- What is risk if initial SD observations not matched to 1st lunar observation
  - May delay initiation of science operations by up to 28 days
  - Models of SD degradation in SWIR indicate about 0.1% degradation or less likely in first 30 days of SD operations
  - Will pick-up SD trending with 1st lunar observations regardless of extent of degradation
- Conclusion: little risk to start as planned

SD Degradation Model

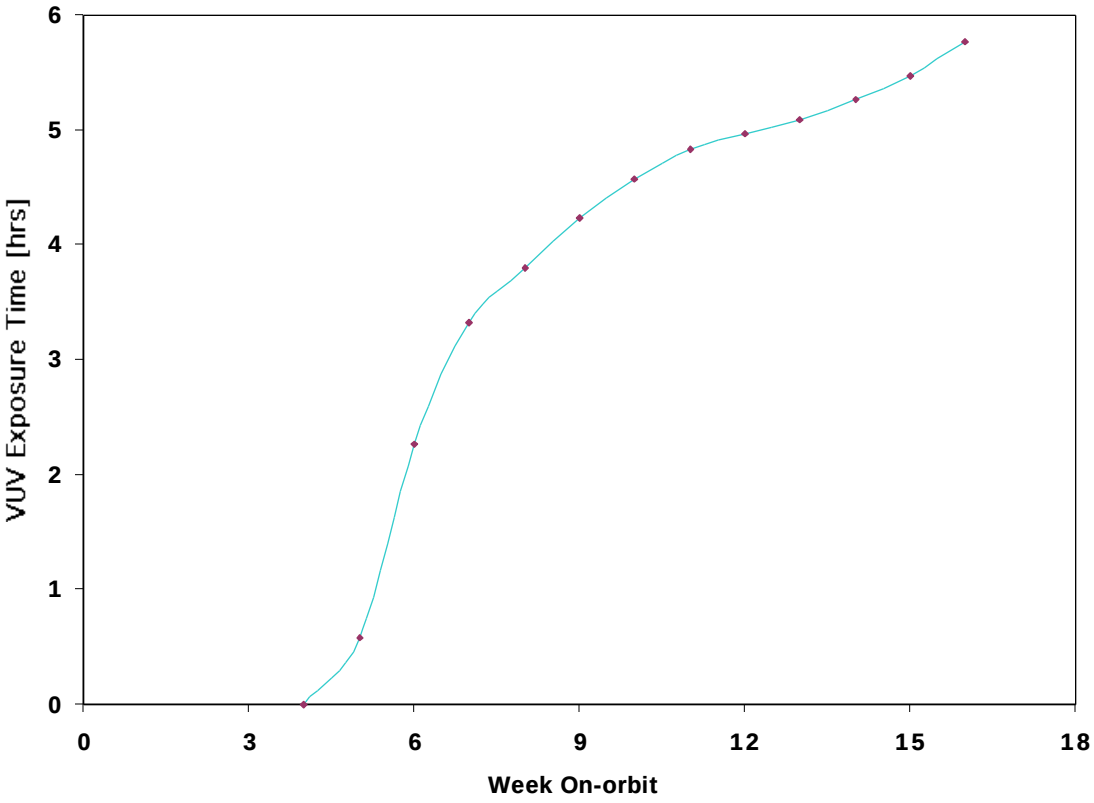
as exp(-c*time/wavelength)

c matched to lab data 0.05% at 1 hour @ 400 nm

Wavelength	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25
0.25	2.000E-02	1.000E-02	6.666E-03	5.000E-03	4.000E-03	3.333E-03	2.857E-03	2.500E-03	2.222E-03
0.5	3.999E-02	2.000E-02	1.333E-02	1.000E-02	8.000E-03	6.666E-03	5.714E-03	5.000E-03	4.444E-03
0.75	5.998E-02	3.000E-02	2.000E-02	1.500E-02	1.200E-02	1.000E-02	8.571E-03	7.500E-03	6.666E-03
1	7.997E-02	3.999E-02	2.666E-02	2.000E-02	1.600E-02	1.333E-02	1.143E-02	1.000E-02	8.888E-03
2.5	1.998E-01	9.995E-02	6.664E-02	4.999E-02	3.999E-02	3.333E-02	2.857E-02	2.500E-02	2.222E-02
5	3.992E-01	1.998E-01	1.332E-01	9.995E-02	7.997E-02	6.664E-02	5.713E-02	4.999E-02	4.443E-02
7.5	5.982E-01	2.996E-01	1.998E-01	1.499E-01	1.199E-01	9.995E-02	8.568E-02	7.497E-02	6.664E-02
10	7.968E-01	3.992E-01	2.663E-01	1.998E-01	1.599E-01	1.332E-01	1.142E-01	9.995E-02	8.885E-02
25	1.980E+00	9.950E-01	6.644E-01	4.988E-01	3.992E-01	3.328E-01	2.853E-01	2.497E-01	2.220E-01



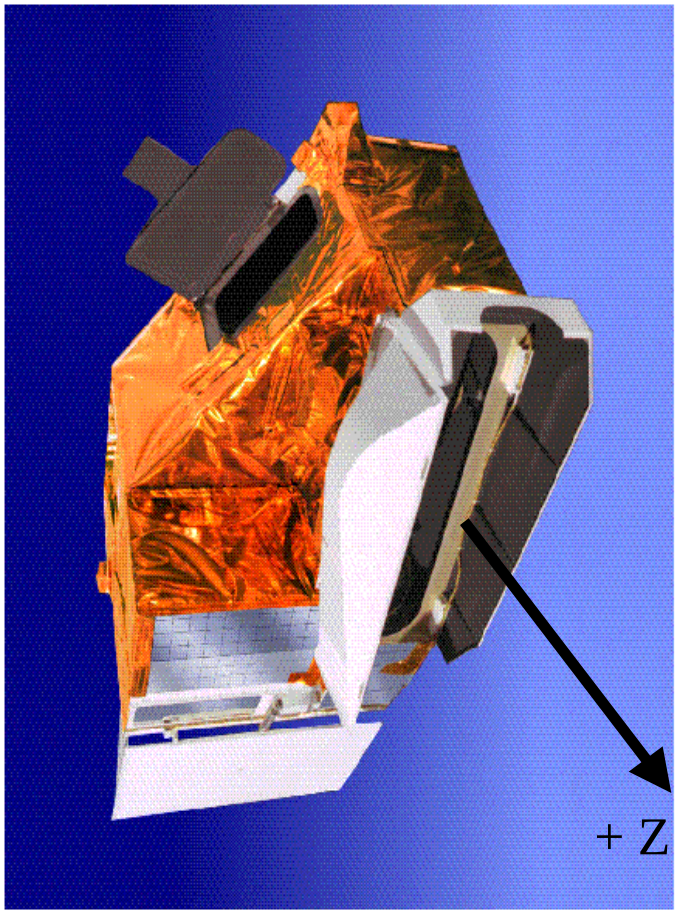
MODIS On-orbit VUV Exposure during A&E Phase



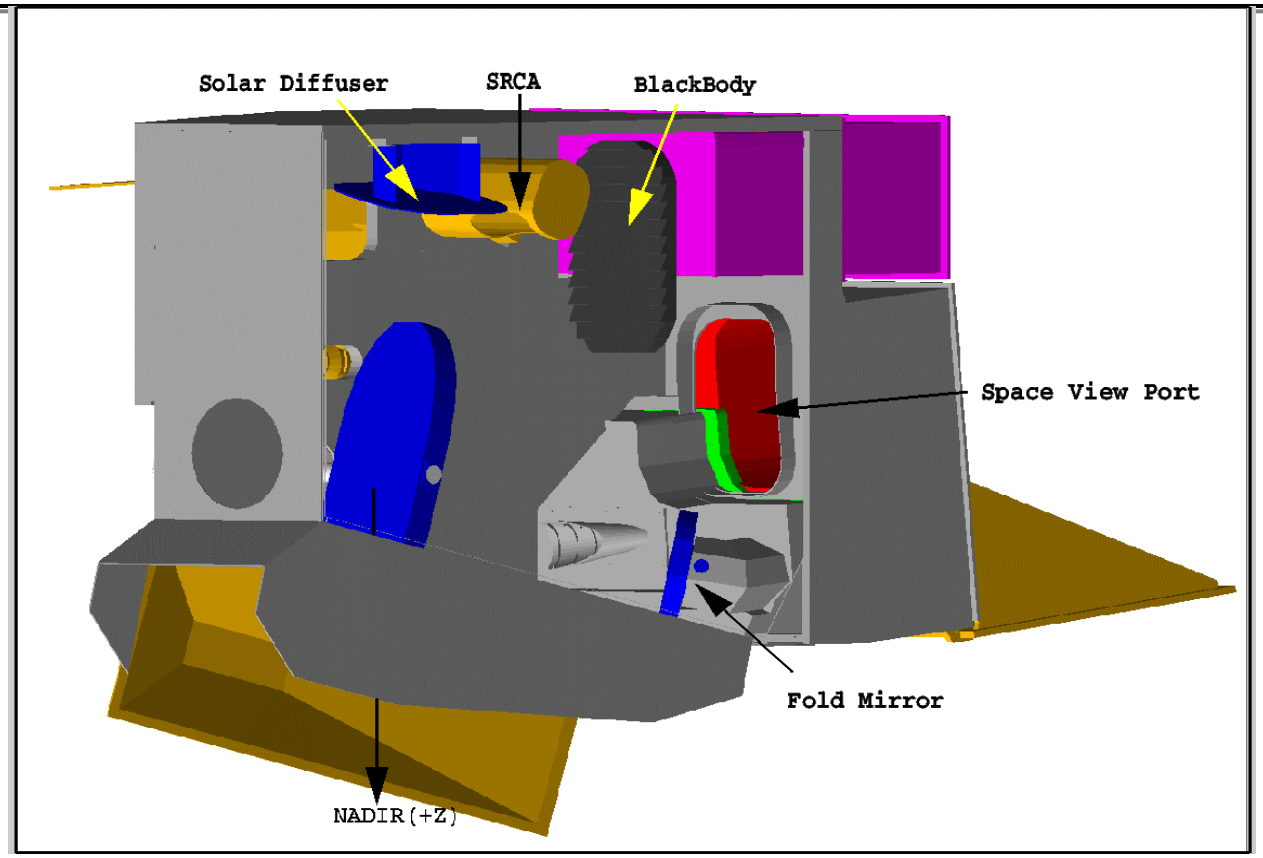
Week On-Orbit	Exposure Time [hrs]
4	0.00
5	0.59
6	2.26
7	3.33
8	3.80
9	4.23
10	4.58
11	4.83
12	4.96
13	5.09
14	5.26
15	5.48
16	5.77

Reference Charts

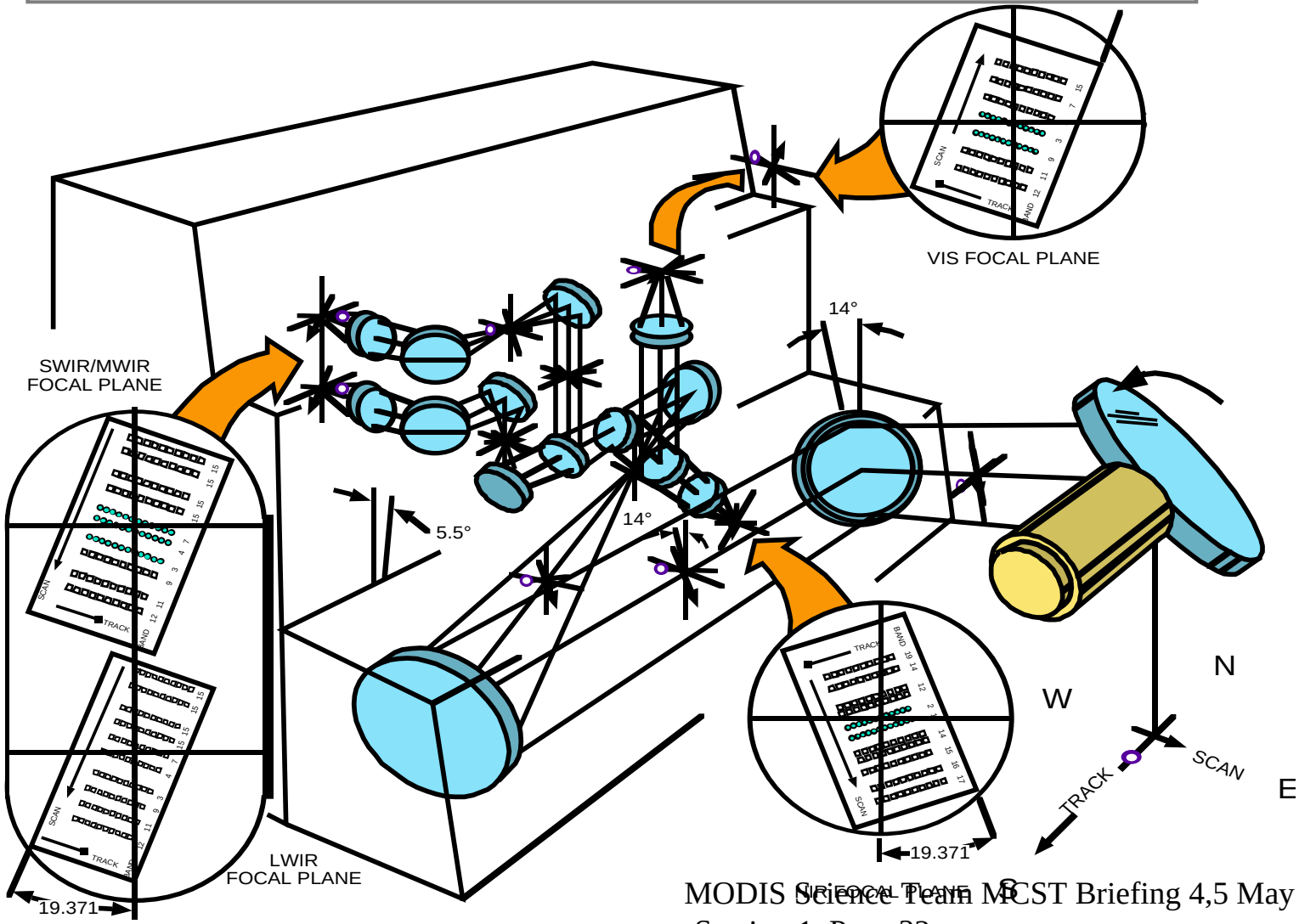
The MODIS ProtoFlight Model (PFM)

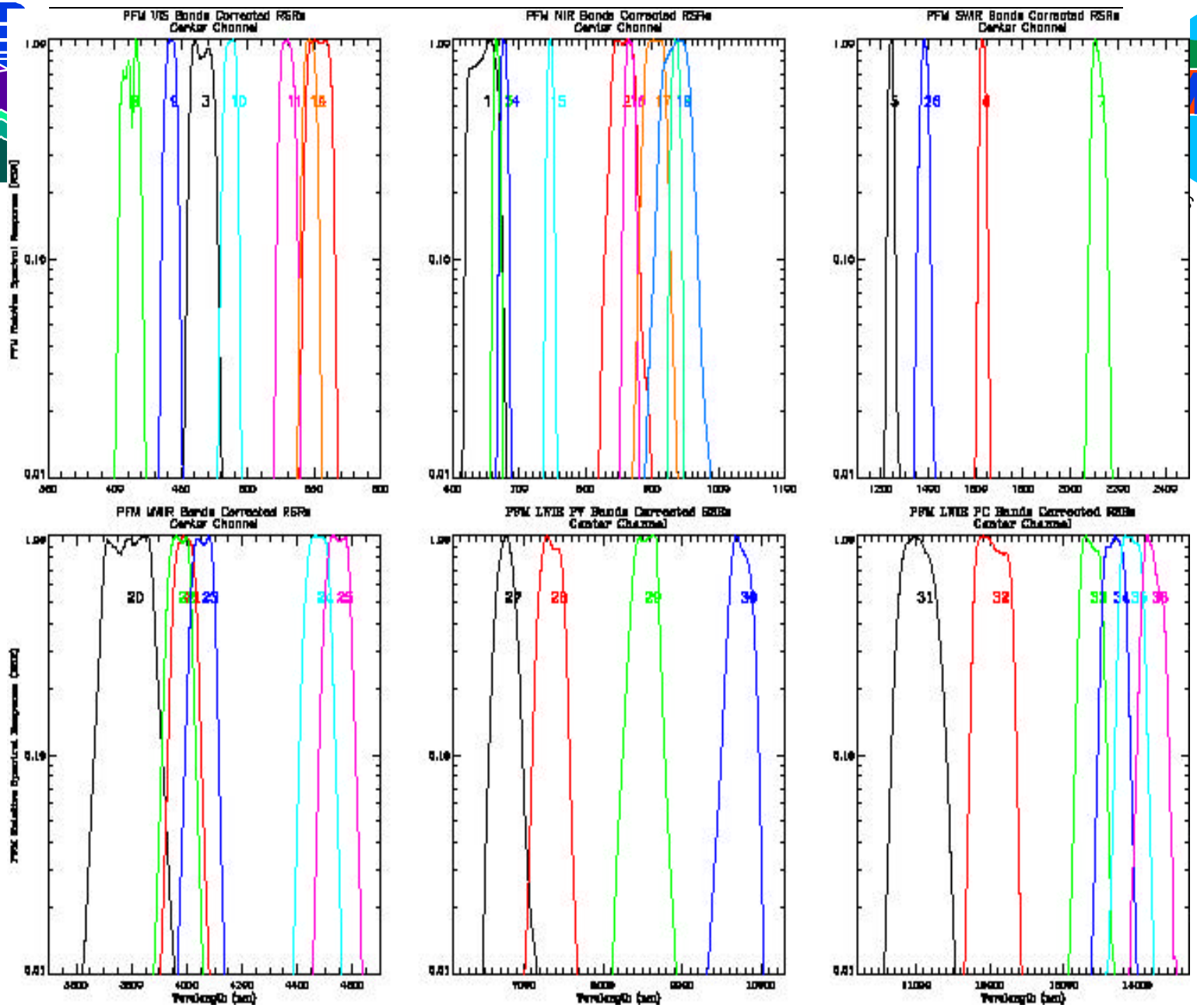


- Sensor on Terra S/C
- S/C at launch site
- 1.0 m x 1.0 m x 1.6 m
- 228 kg

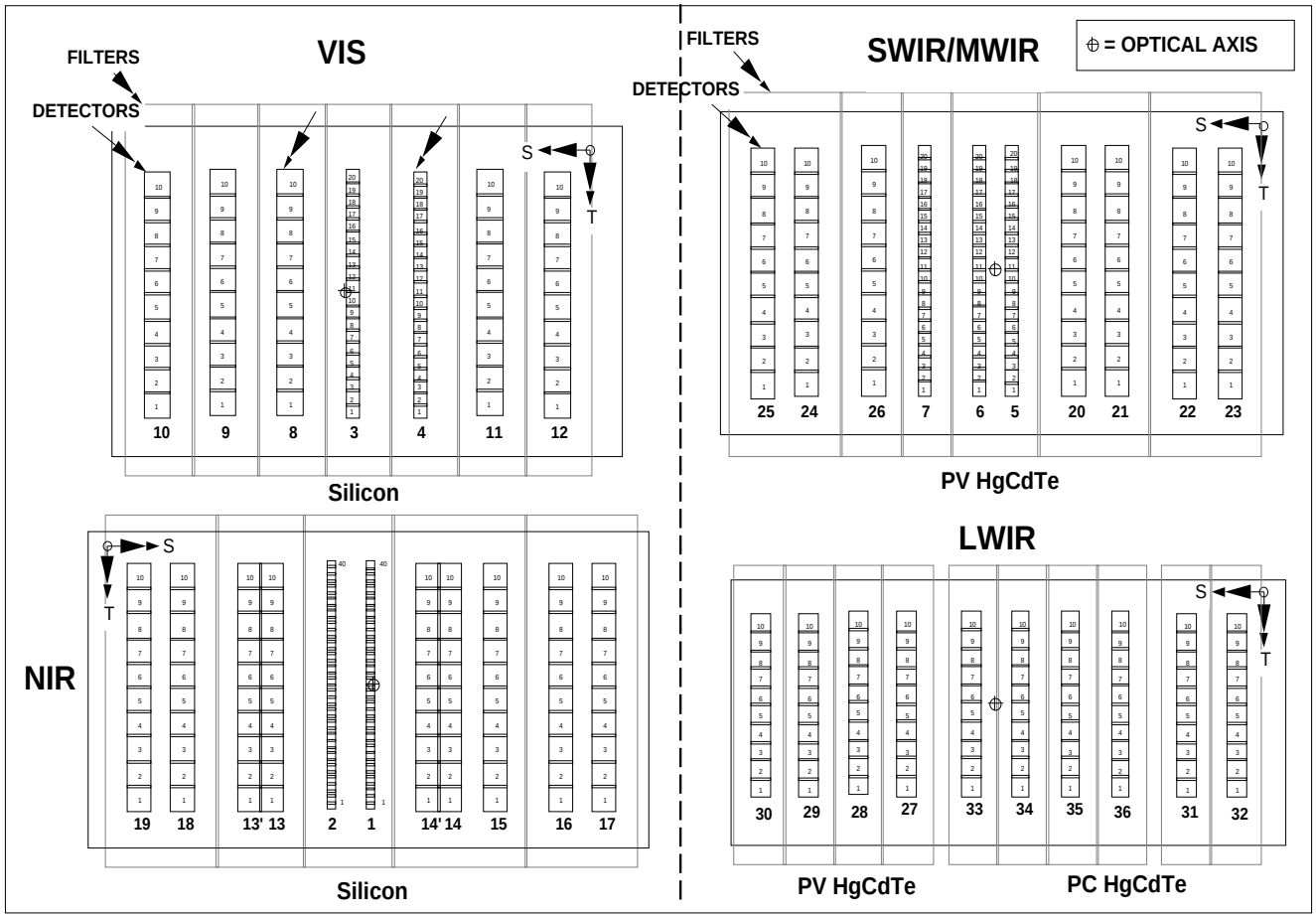

Solar Diffuser
SRCA
BlackBody
Space View Port
Fold Mirror
NADIR(+Z)

MODIS Optical System 1



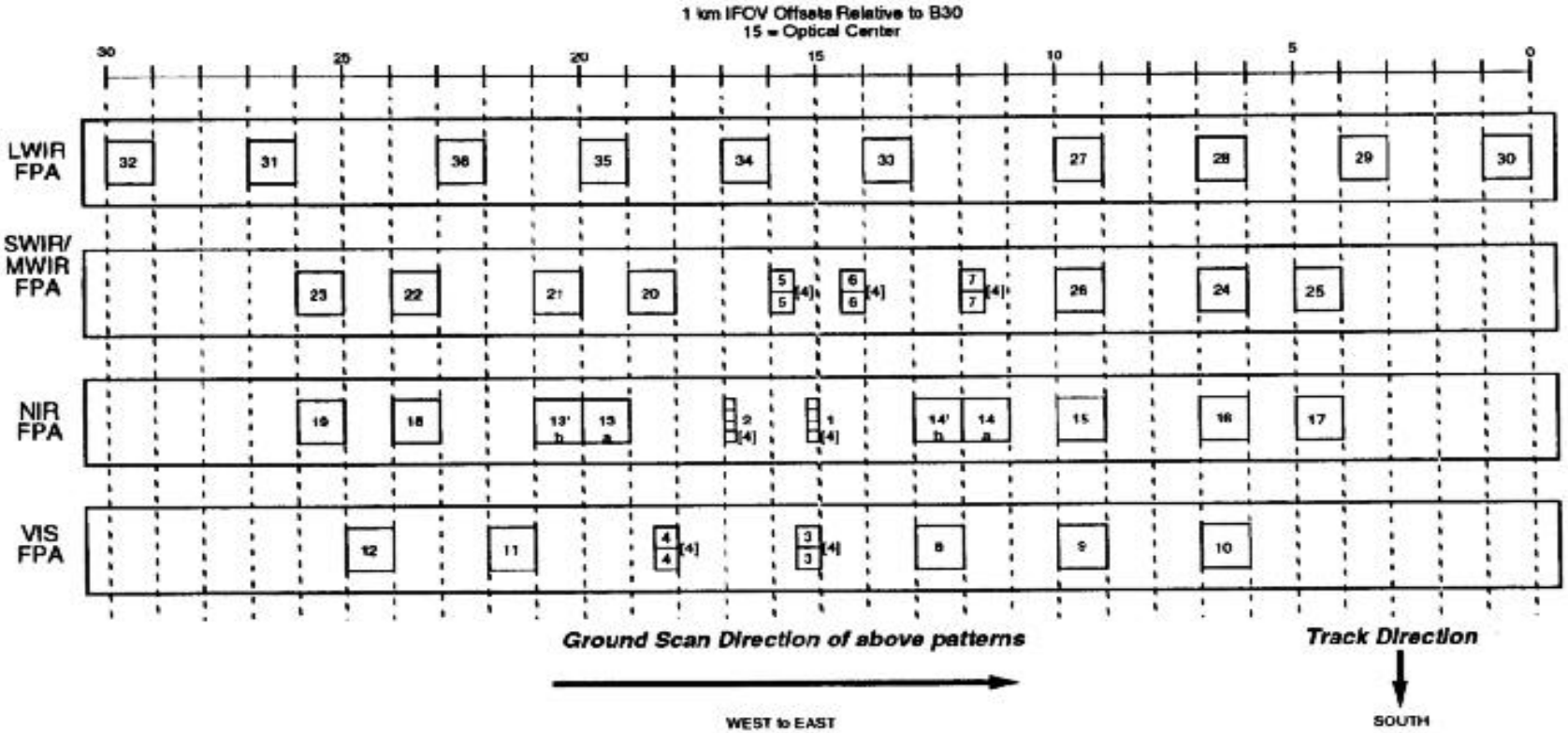

PFM VIS Bands Corrected RSRs
Center Channel
PFM NIR Bands Corrected RSRs
Center Channel
PFM SWIR Bands Corrected RSRs
Center Channel
PFM MWIR Bands Corrected RSRs
Center Channel
PFM LWIR PV Bands Corrected RSRs
Center Channel
PFM LWIR PC Bands Corrected RSRs
Center Channel

MODIS Focal Plane Layouts



Instrument FPA Main Frame Temperature

Cold FPAs: (80. 83, 85k)



Notes:

1. Band single detector locations are shown in terms of 1 km IFOV offsets from Band 30, which is first band to see a scene. FPA optical center is at IFOV 15.
2. Ground scan direction of projected pattern is to the right (west to east). FPA's have false vertical separation to clarify individual FPA extent.
3. During one 1km sample, 250 m Bands 1 & 2 produce 16 samples/each and 500 m Bands 3-7 produce 4 samples/each.
4. The formatter assembles a science packet with bands aligned by the depicted offsets to view a common ground sample. This requires the collection of 30 frames of data before all bands have observed the same ground sample.
5. Science packet locations for TDI Bands 13, 13' and 14, 14' will be at first sample location of 13 and 14. High and low gain data is provided for Band 13 and Band14. Bands 27-30 are sampled 4X, but single sample is sent to ground.

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Figure 30-3. FPA Band Offsets Relative to Band 30

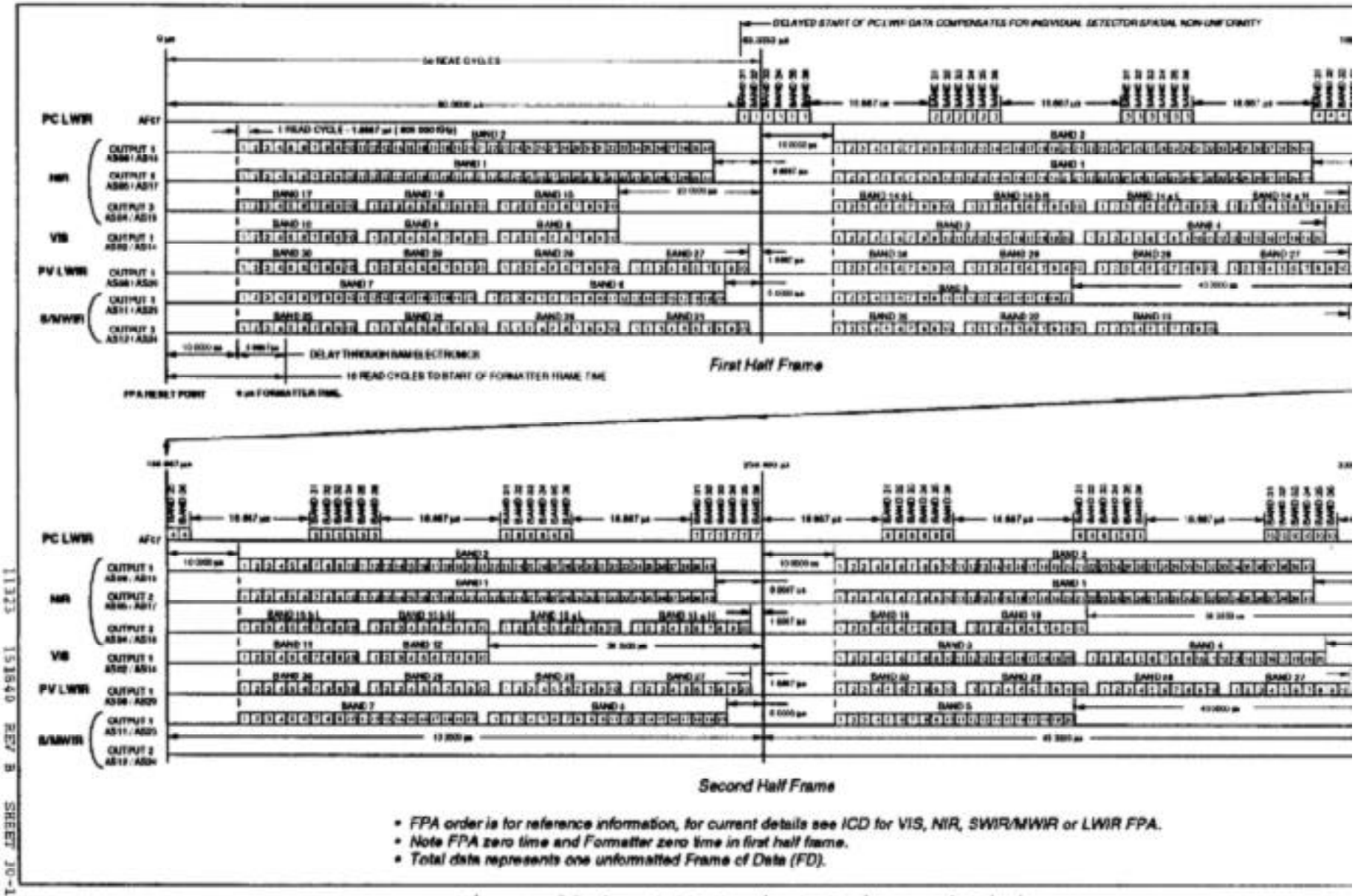
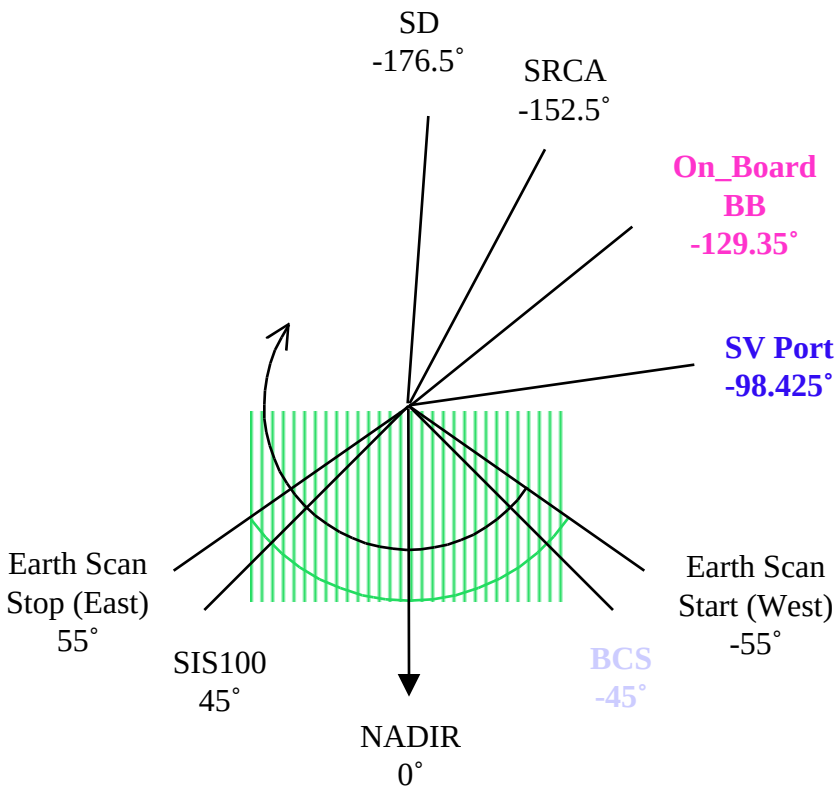
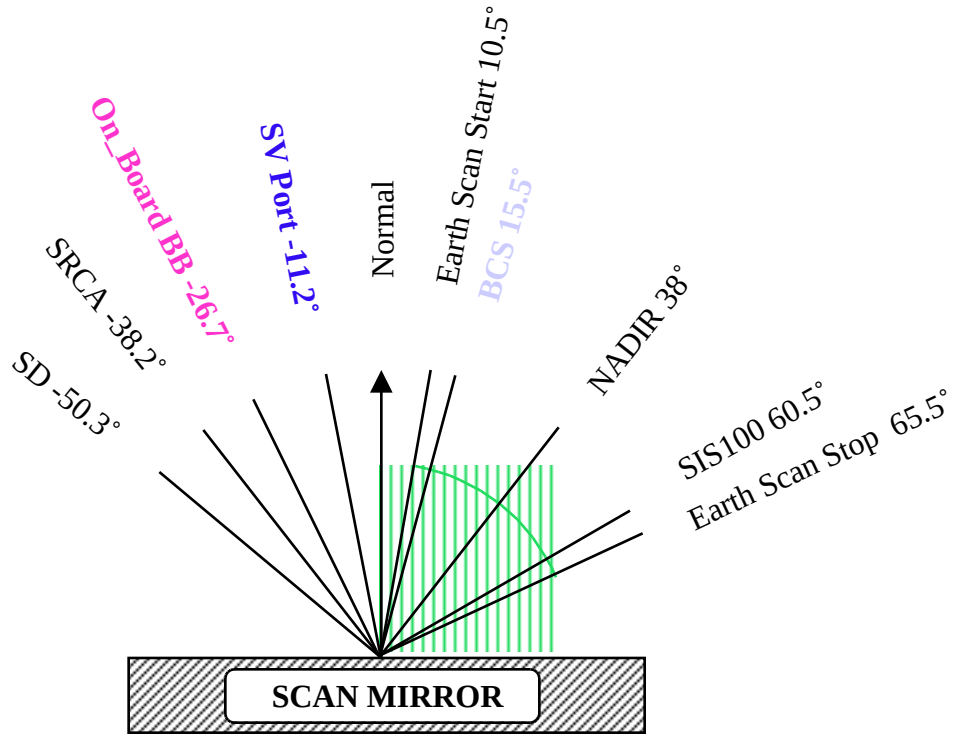


Figure 30-4. FPA Readout Order and Timing

Principal Scan Angles Mapped to Scan Mirror Angles of Incidence



Principal Scan Angles
(Earth View: -55˚ to 55˚)



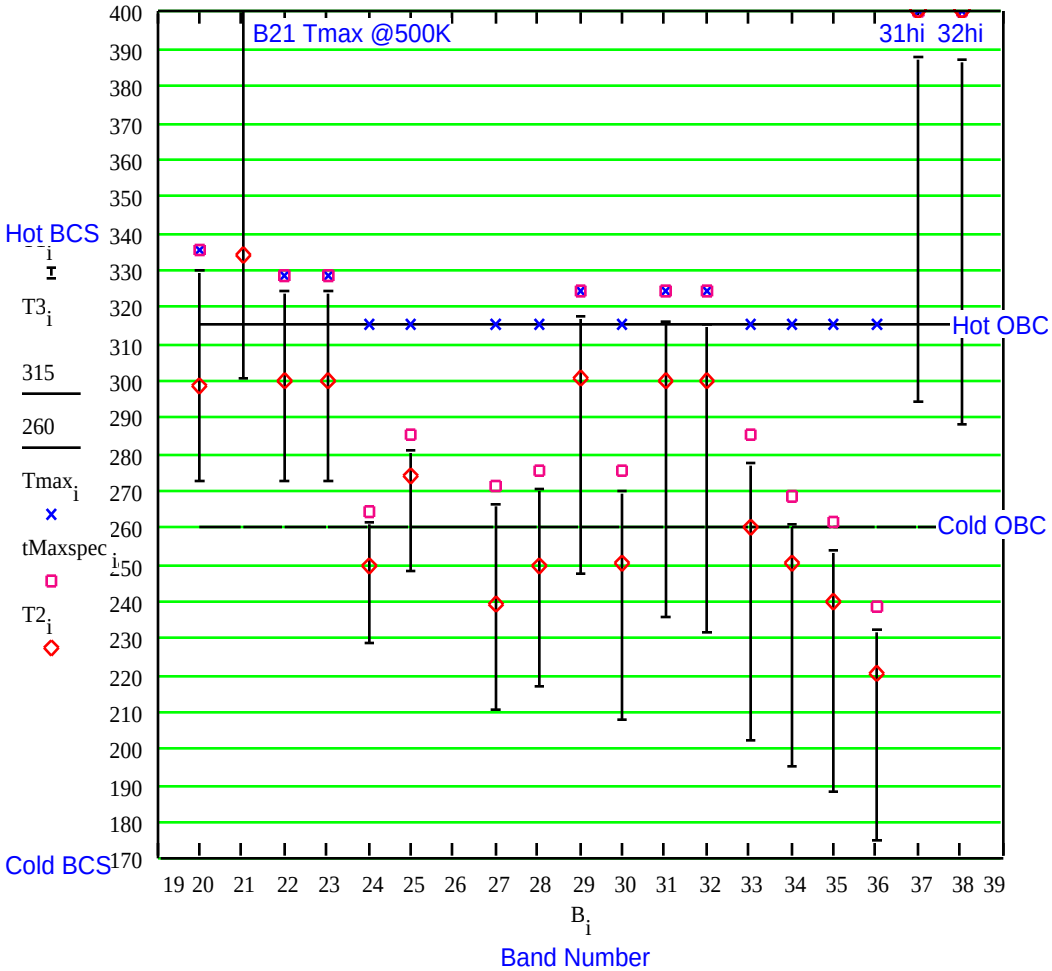
Angles of Incidence
(Earth View: 10.5˚ to 65.5˚)

MST Requested Calibration Temperature Ranges for PFM

			Collect #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
			CPT/ LPT	170	190	210	220	230	240	250	260	270	280	290	295	300	305	310	315	320	325	330	335	340
Band	Tcal_lo	Tcal_hi																						
20	220	330																						
21	260	340																						
22	220	325																						
23	220	325																						
24	220	315																						
25	240	315																						
27	210	315																						
28	210	315																						
29	210	318																						
30	210	315																						
31	220	316																						
32	220	315																						
33	190	315																						
34	190	315																						
35	170	315																						
36	170	315																						

BCS Temperatures Levels Used for Limited Performance Tests (LPTs) are noted with box outline.

MODIS Operational and Calibration Ranges



Vertical bars represent temperatures of 0.3Ltyp and 0.9 Lmax. Box symbols represent Tmax_spec, X symbols represent the value of Tmax_set (the higher of tMaxspec or 315K), and the diamond symbols represent the temperature of Ltyp.

Back-up Charts

Notes for: Comparison of L1B Product with Sensor Specifications

Notes and References for the Comparison of L1B Product with Sensor Specifications are provided in accompanying Microsoft Word Document