RADIOMETRIC CHARTS

CONFIGURATION FOR IRRADIANCE-BASED CALIBRATION OF SIS(100)

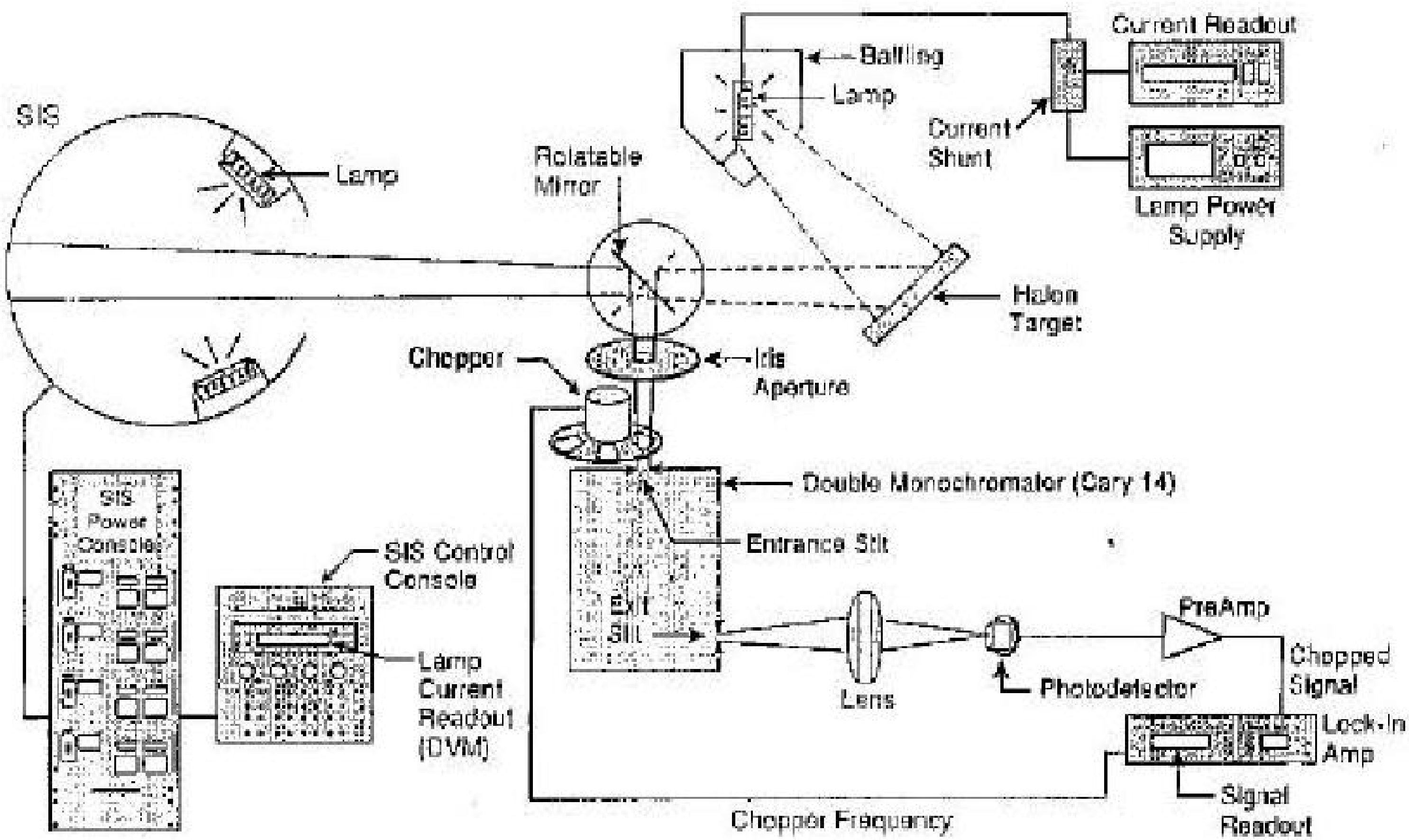
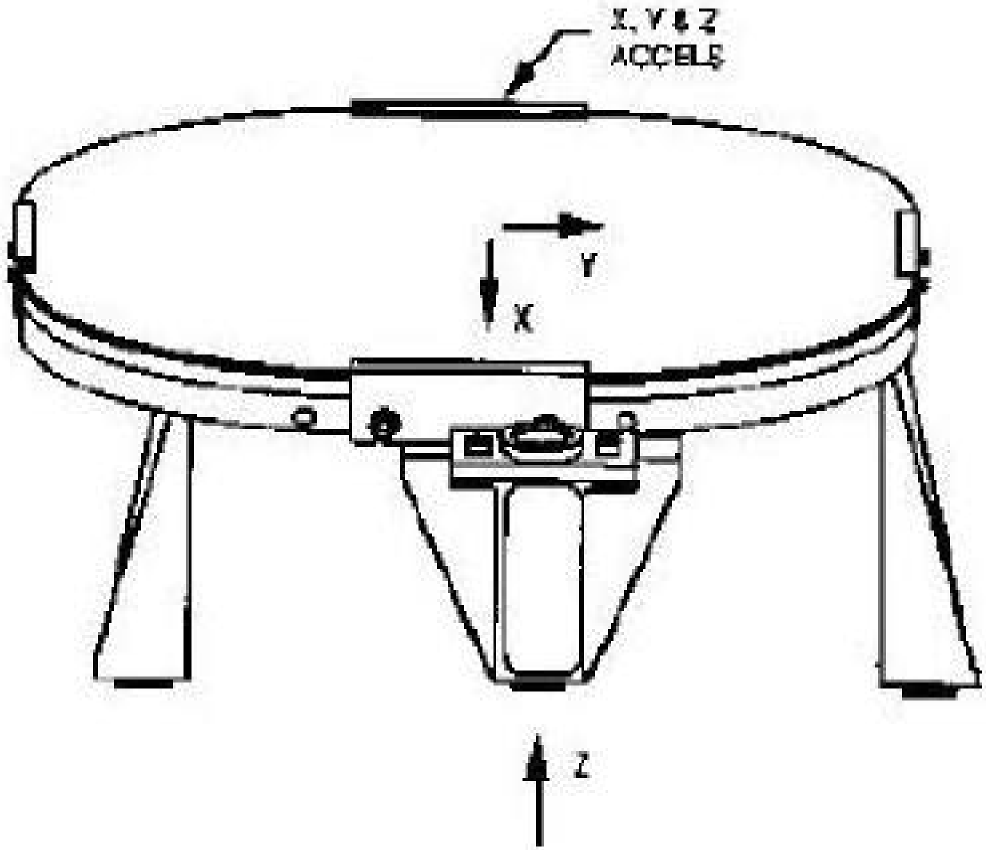


FIGURE 1

Solar Diffuser (SD)

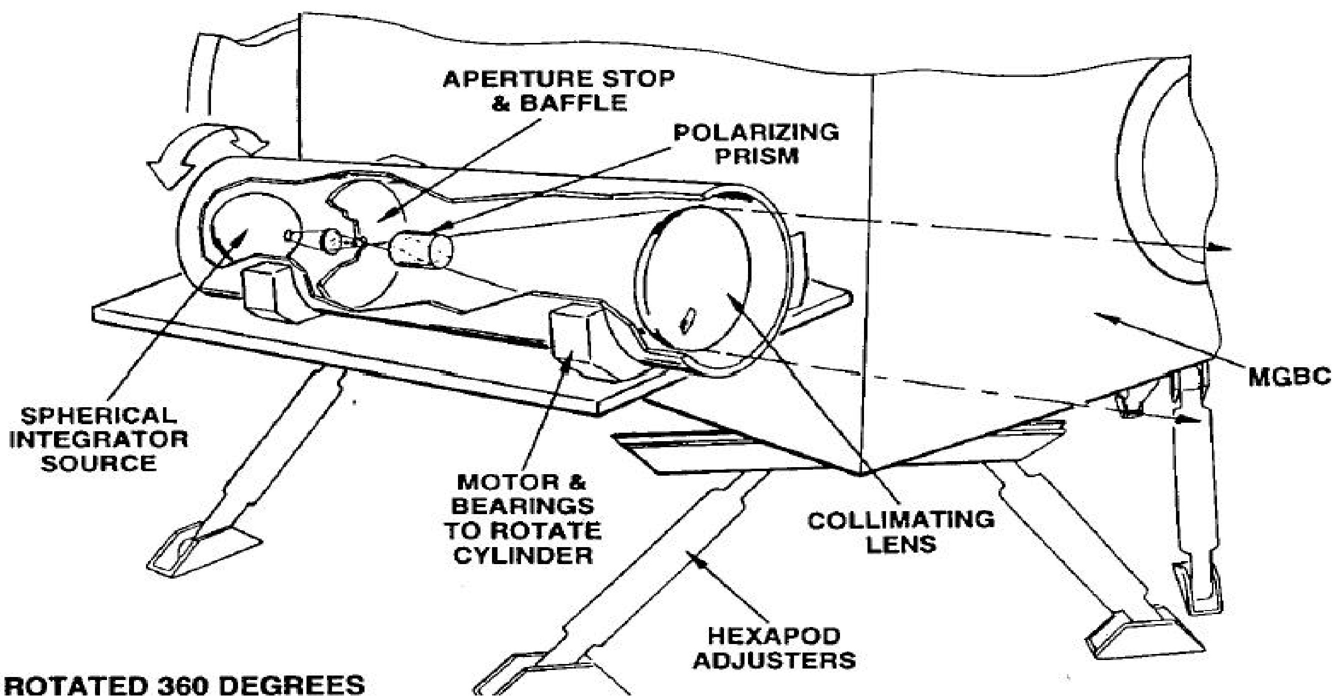


Space grade Spectralon (PTFE) by Labshpere
11.25' by 9.32' by .25' with round corners (R3.5')

MODIS POLARIZANCE IS CHARACTERIZED WITH A STAND-ALONE POLARIZER SUBSYSTEM

HUGHES

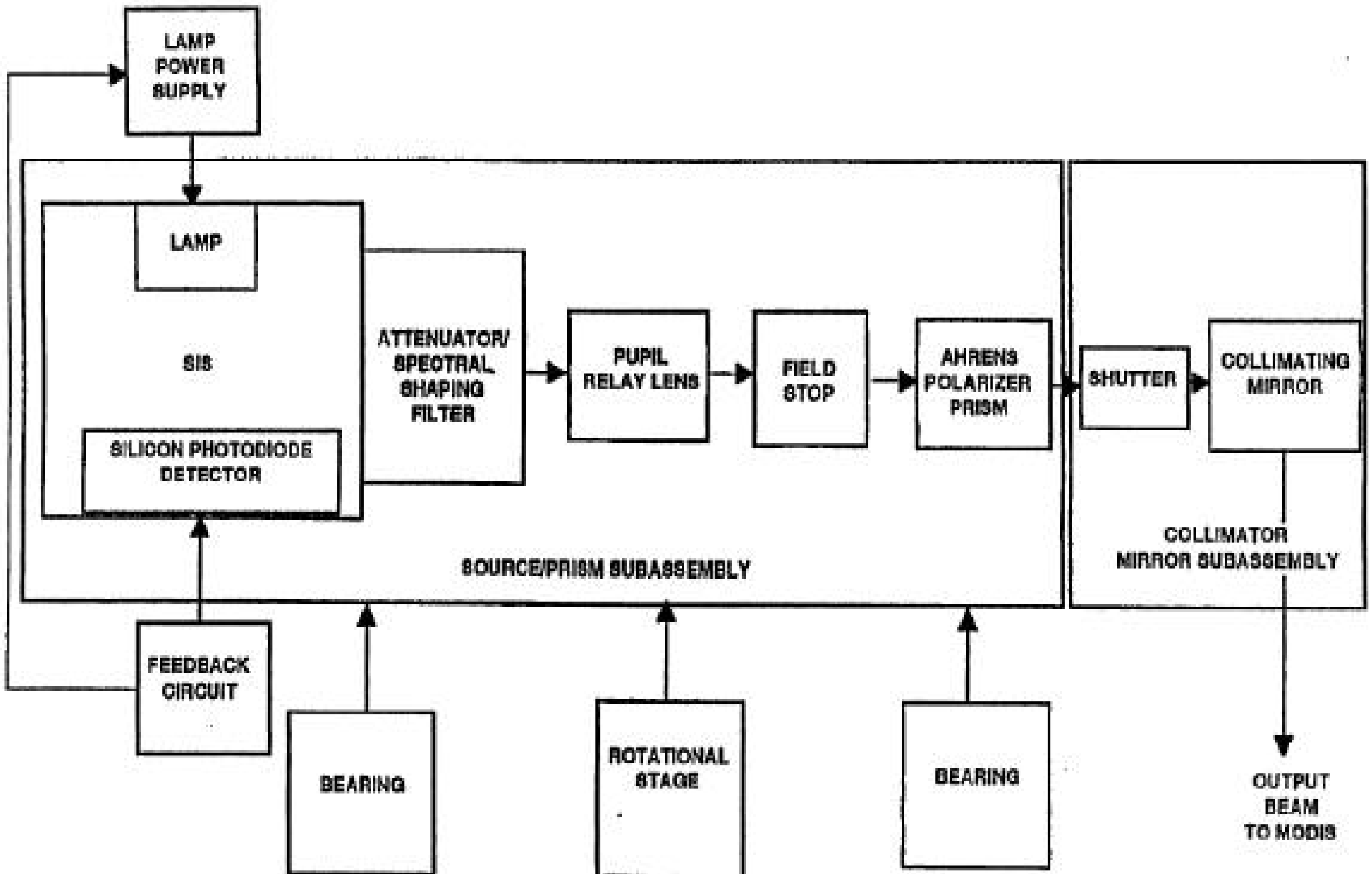
SANTA BARBARA RESEARCH CENTER
a subsidiary



- CYLINDER IS ROTATED 360 DEGREES

PSA FUNCTIONAL BLOCK DIAGRAM

SANTA BARBARA RESEARCH CENTER
HUGHES AIRCRAFT
A HUGHES ELECTRONICS COMPANY



08/95
95-03926-3

DATA ACQUIRED IN 2 FIELD POSITIONS

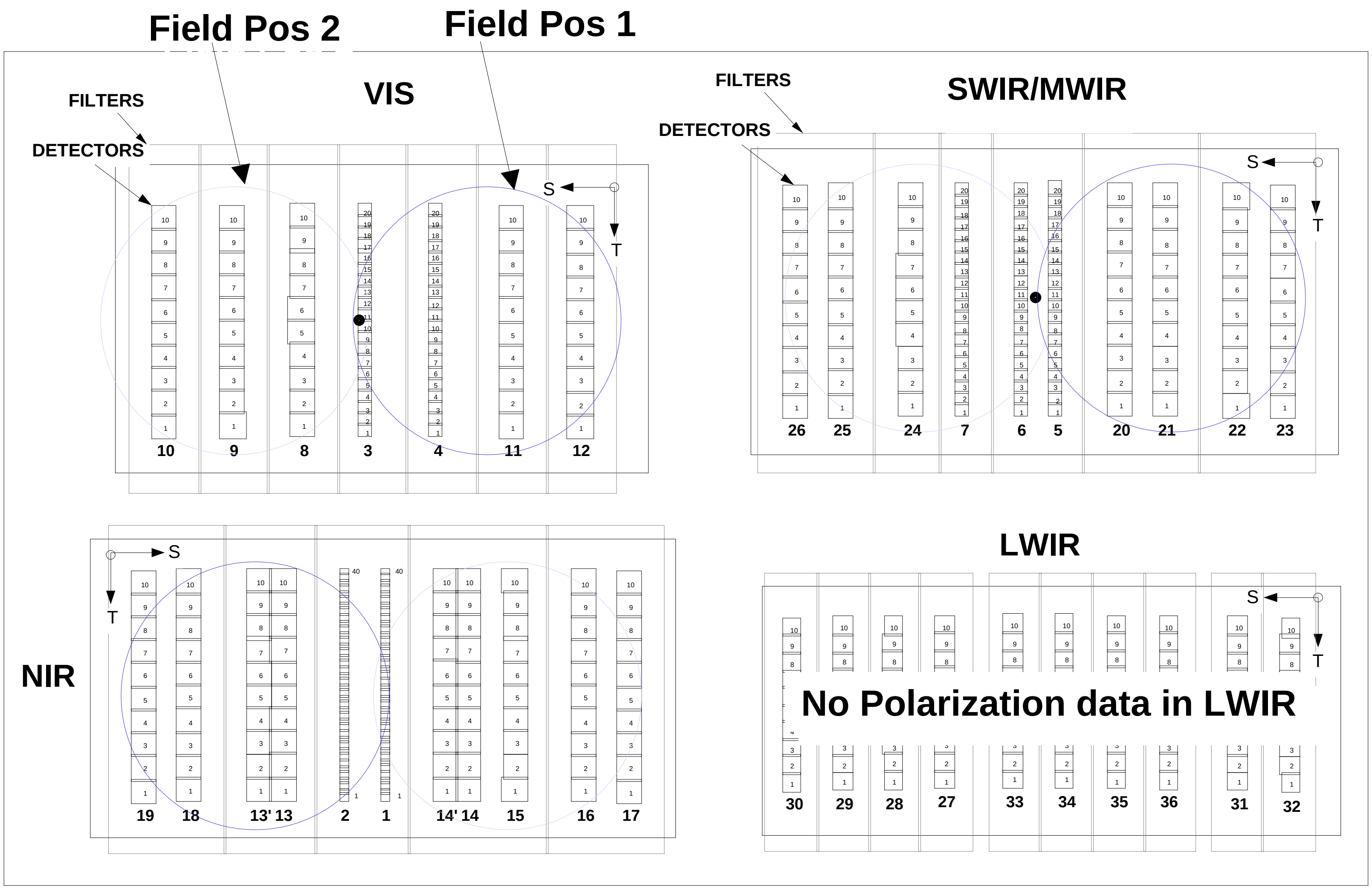


Figure 4 illustrates the effect of polarization on the shape of band 8 relative spectral response.

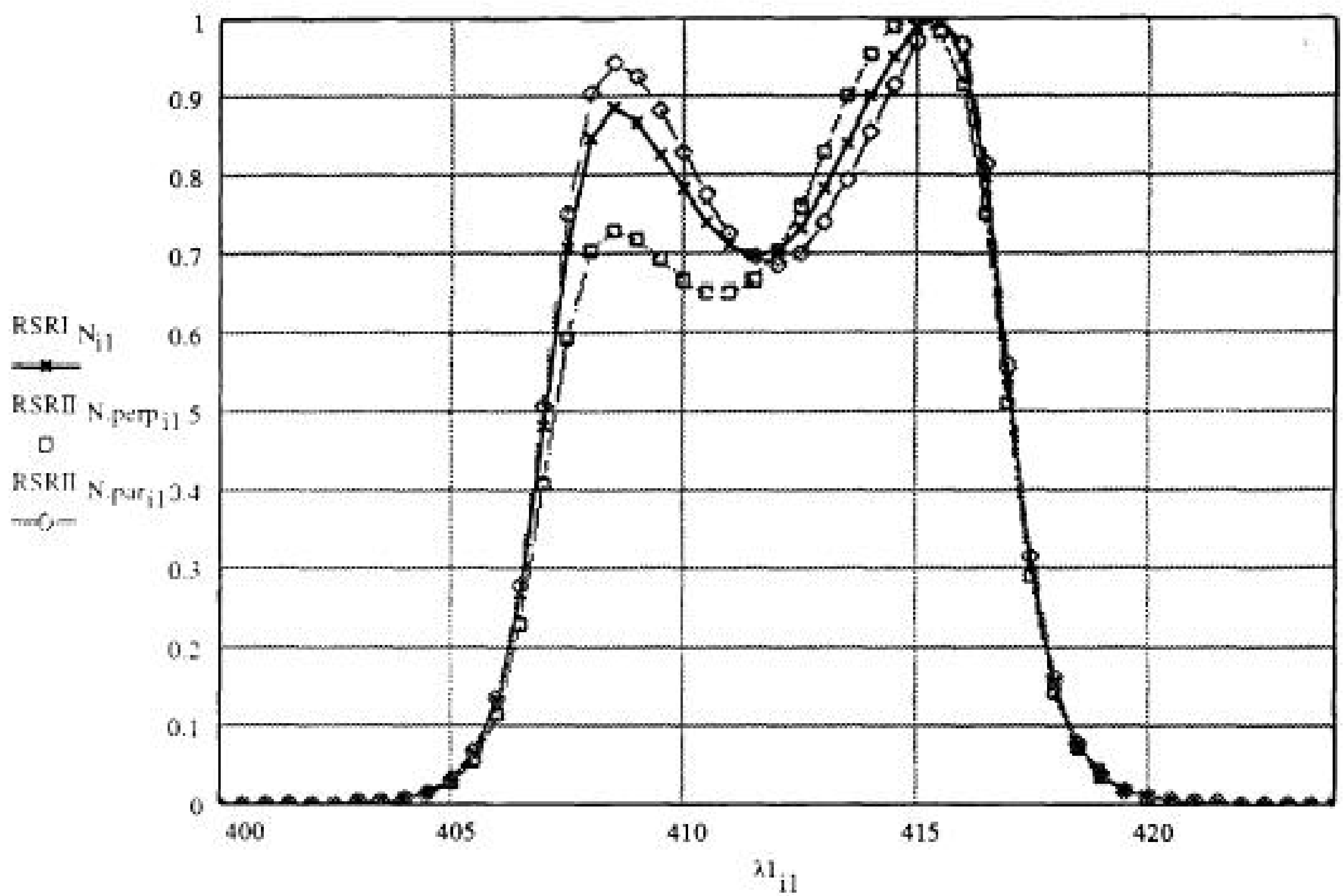
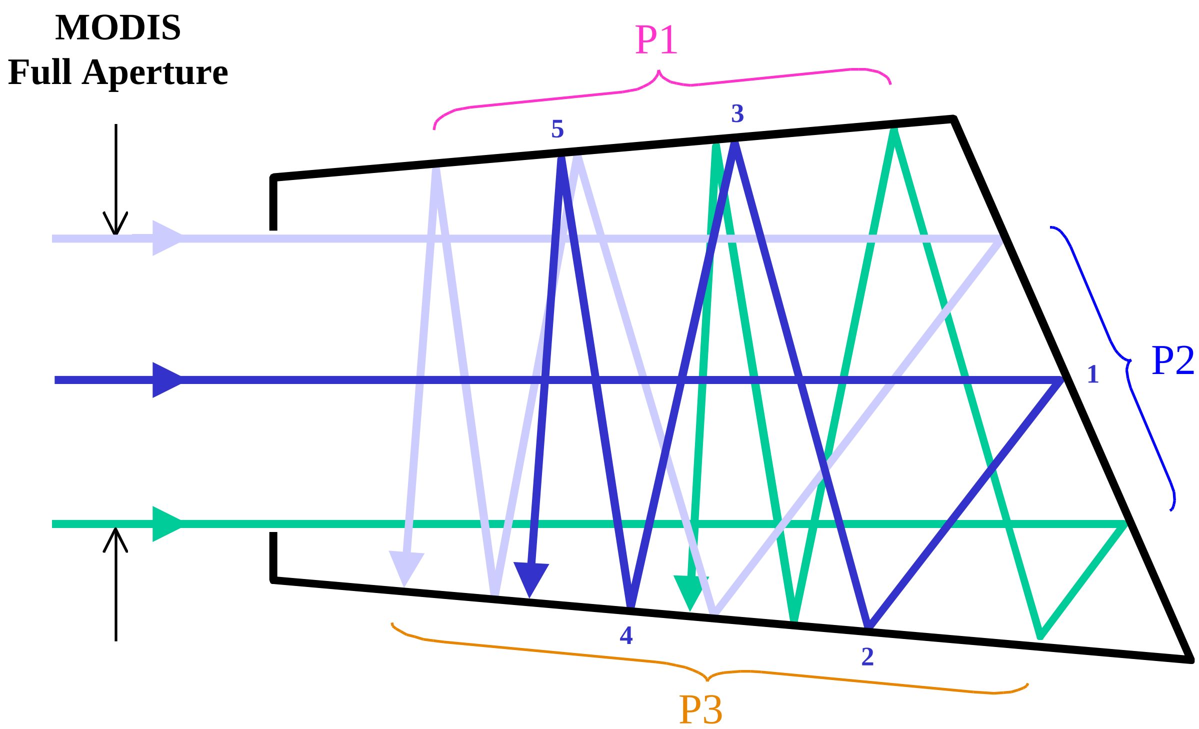


Figure 4. The simulated relative spectral response functions for case I (unpolarized) and case II (polarized).

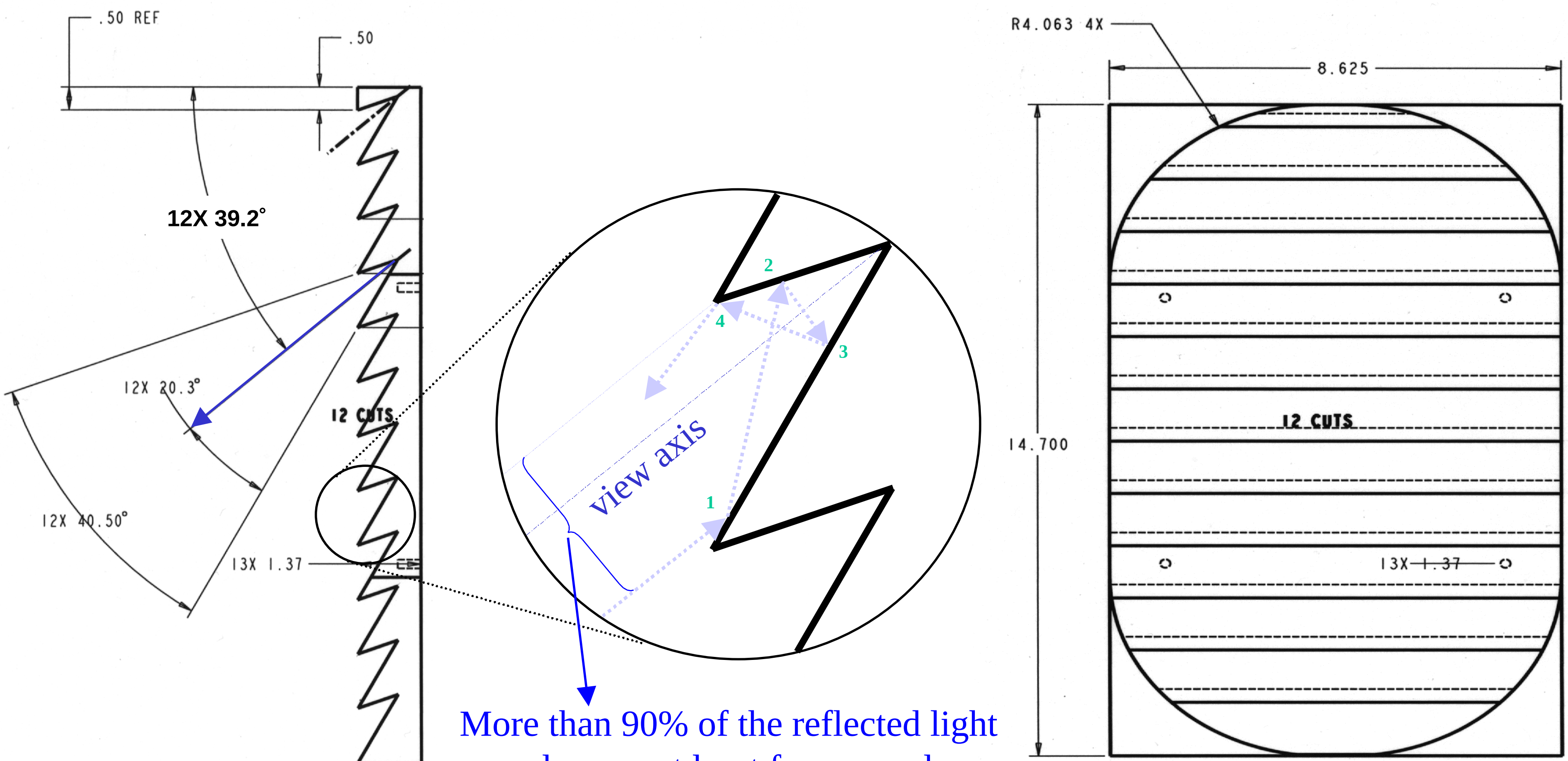
Blackbody Calibration Source (BCS)



$$L_{BCS} = W_{P1} \cdot L(\lambda, T_{P1}) + W_{P2} \cdot L(\lambda, T_{P2}) + W_{P3} \cdot L(\lambda, T_{P3})$$

BCS Trapezoid Configuration Achieves **> 0.9998** Emissivity (From SBRS)

The MODIS On-Board Calibrator (OBC) Blackbody



More than 90% of the reflected light undergoes at least four specular reflections to achieve > 0.992 emissivity

Dimensions: Inches

DATA FORMAT ISSUE

- THE FIRST ARE LAST and
  THE LAST ARE FIRST
  - SBRS detector numbering convention not consistent with COTS Earth-mapping conventions
  - L1A renumbers to COTS-friendly (pixel) order
  - MCST characterization work done in SBRS (detector) numbering conventions
  - L-7 IR band (some channels) saturated for ~ half year due to this issue

NOTE: All the MCST Look-up Tables (LUTs) are published in the SBRS-detector numbering convention and this detector numbering convention is inverted from the pixel convention used in the MODIS Level-1 products. To investigate an “anomoly” in pixel 7 of Band 10 in L1 product, must look at characterization data for detector 3 of that Band.

Detector Number Convention for MODIS Sensor

LWIR (abbrievated)

Band	30	29	28	27	33	34	35	
Scan 1	10	10	10	10	10	10	10	
	9	9	9	9	9	9	9	
	8	8	8	8	8	8	8	
	7	7	7	7	7	7	7	**T**
	6	6	6	6	6	6	6	
	5	5	5	5	5	5	5	
	4	4	4	4	4	4	4	
	3	3	3	3	3	3	3	
	2	2	2	2	2	2	2	
	1	1	1	1	1	1	1	
Scan 2	20	20	20	20	20	20	20	
	19	19	19	19	19	19	19	
	18	18	18	18	18	18	18	
	17	17	17	17	17	17	17	**T**
	16	16	16	16	16	16	16	
	15	15	15	15	15	15	15	
	14	14	14	14	14	14	14	
	13	13	13	13	13	13	13	
	12	12	12	12	12	12	12	
	11	11	11	11	11	11	11	

Above numbering convention is SBRS "detector" convention

The arrow shows the track direction, which is the direction of satellite motion.

Pixel Numbering Convention for L1B Product

Below numbering convention is L1 Product "pixel" numbering convention

LWIR (abbrievated)

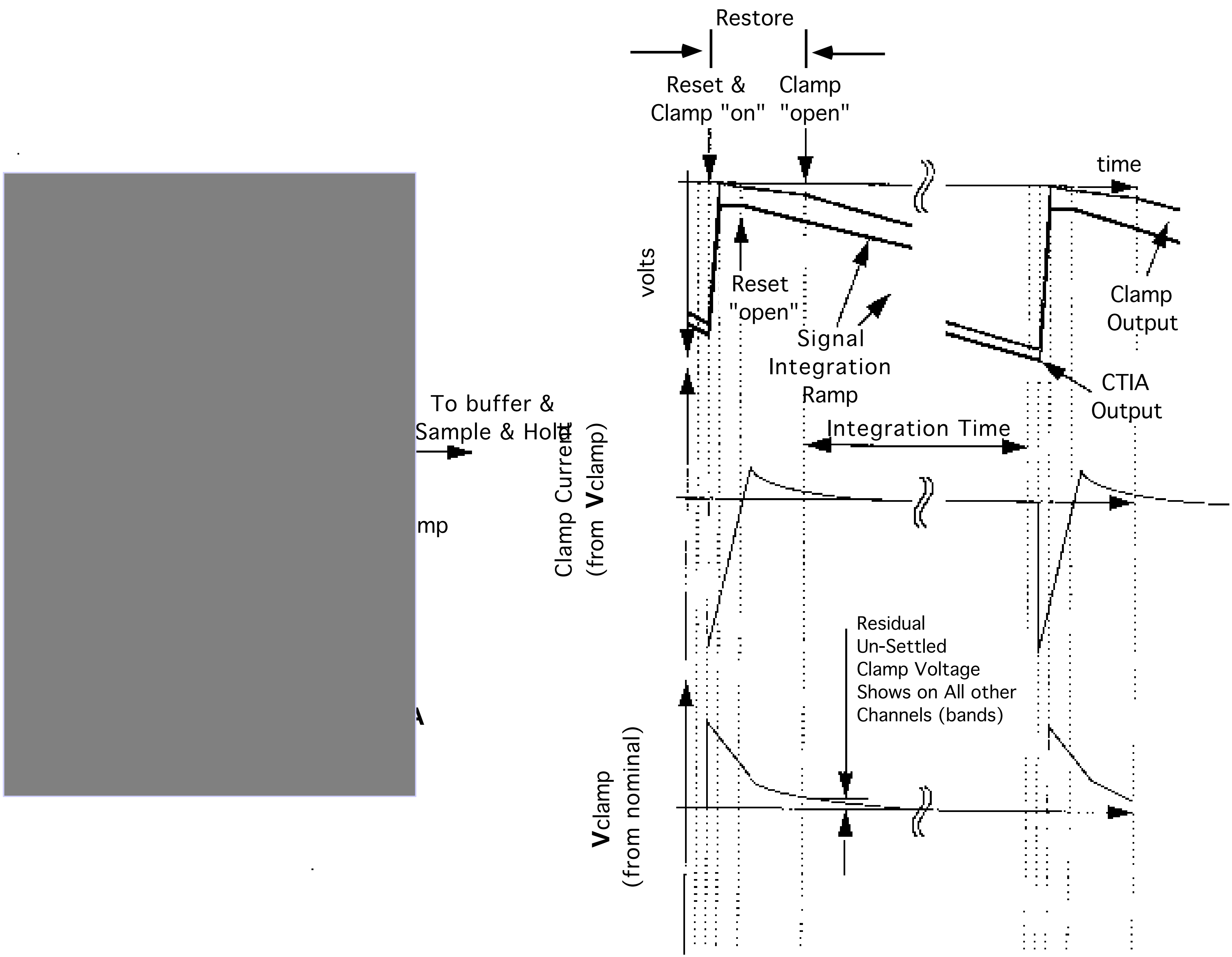
Band	30	29	28	27	33	34	35	
Scan 1	1	1	1	1	1	1	1	
	2	2	2	2	2	2	2	
	3	3	3	3	3	3	3	
	4	4	4	4	4	4	4	T
	5	5	5	5	5	5	5	
	6	6	6	6	6	6	6	
	7	7	7	7	7	7	7	
	8	8	8	8	8	8	8	
	9	9	9	9	9	9	9	
	10	10	10	10	10	10	10	
Scan 2	11	11	11	11	11	11	11	
	12	12	12	12	12	12	12	
	13	13	13	13	13	13	13	
	14	14	14	14	14	14	14	T
	15	15	15	15	15	15	15	
	16	16	16	16	16	16	16	
	17	17	17	17	17	17	17	
	18	18	18	18	18	18	18	
	19	19	19	19	19	19	19	
	20	20	20	20	20	20	20	

Charts showing the SBRS detector (previous chart) and L1 Product pixel (this chart) numbering conventions for consecutive scans at a specific frame or location across scan line, e.g. at nadir. The benefit of the L1 Product pixel convention is the logical progression of samples for mapping software. Sample X from Scan Y is labeled as "X+10*(Y-1)"

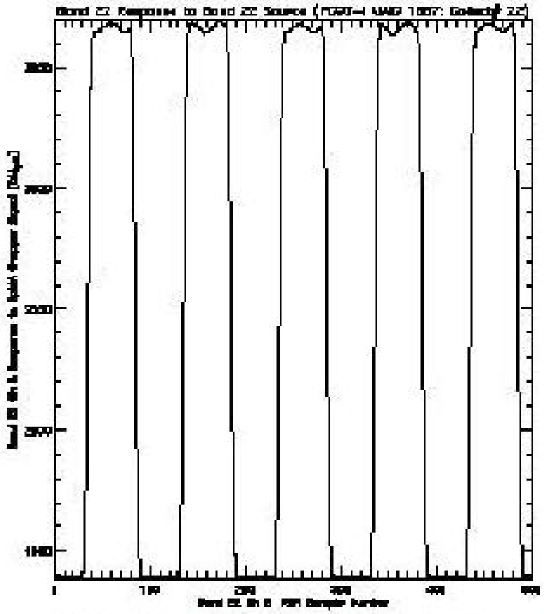
The arrow shows the track direction, which is the direction of satellite motion.

What is Electronic Cross-talk

- Readout integrating capacitor fails to return to baseline voltage following signal reset
- First realized nature of problem from RSR testing
  - Actually "seen" as negative dns & sub-frame differences, B5-7
  - Nearly impossible to detect when observing flat scenes; these calibrations in error, but cannot detect that
- Structured scene analysis in 1998 showed effects of 5-10% or more in SWIR bands & several percent in 4-µm SST bands
- Observed in both SW/MWIR and PV LWIR bands (5-7, 20-30)
- Focus here on SW/MWIR bands (5-7, 20-26)



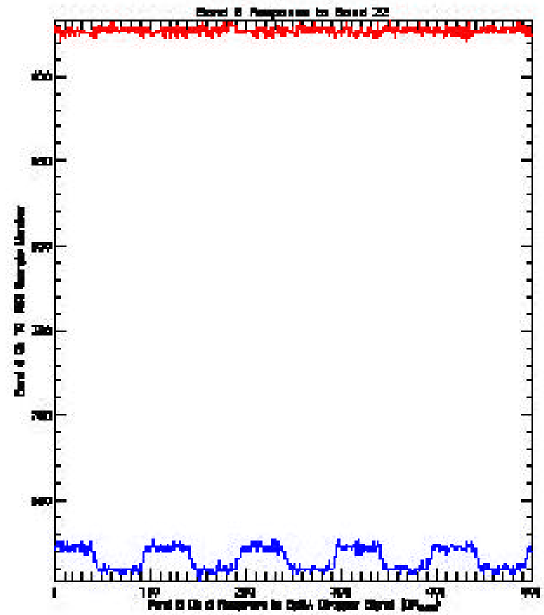
Restore
Reset &
Clamp "on"
Clamp
"open"
time
volts
Reset
"open"
Signal
Integration
Ramp
Clamp
Output
CTIA
Output
To buffer &
Sample & Hold
mp
Integration Time
Clamp Current
(from Vclamp)
Residual
Un-Settled
Clamp Voltage
Shows on All other
Channels (bands)
Vclamp
(from nominal)

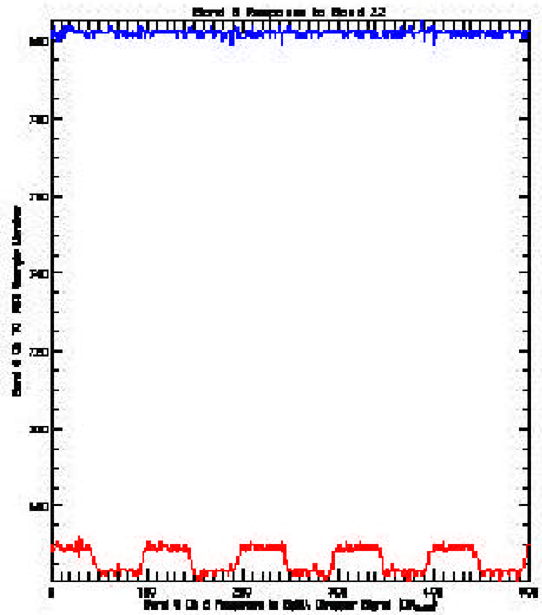


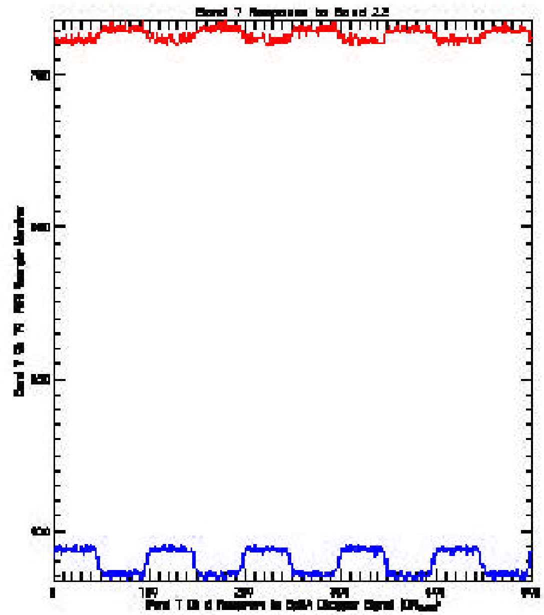
SF1

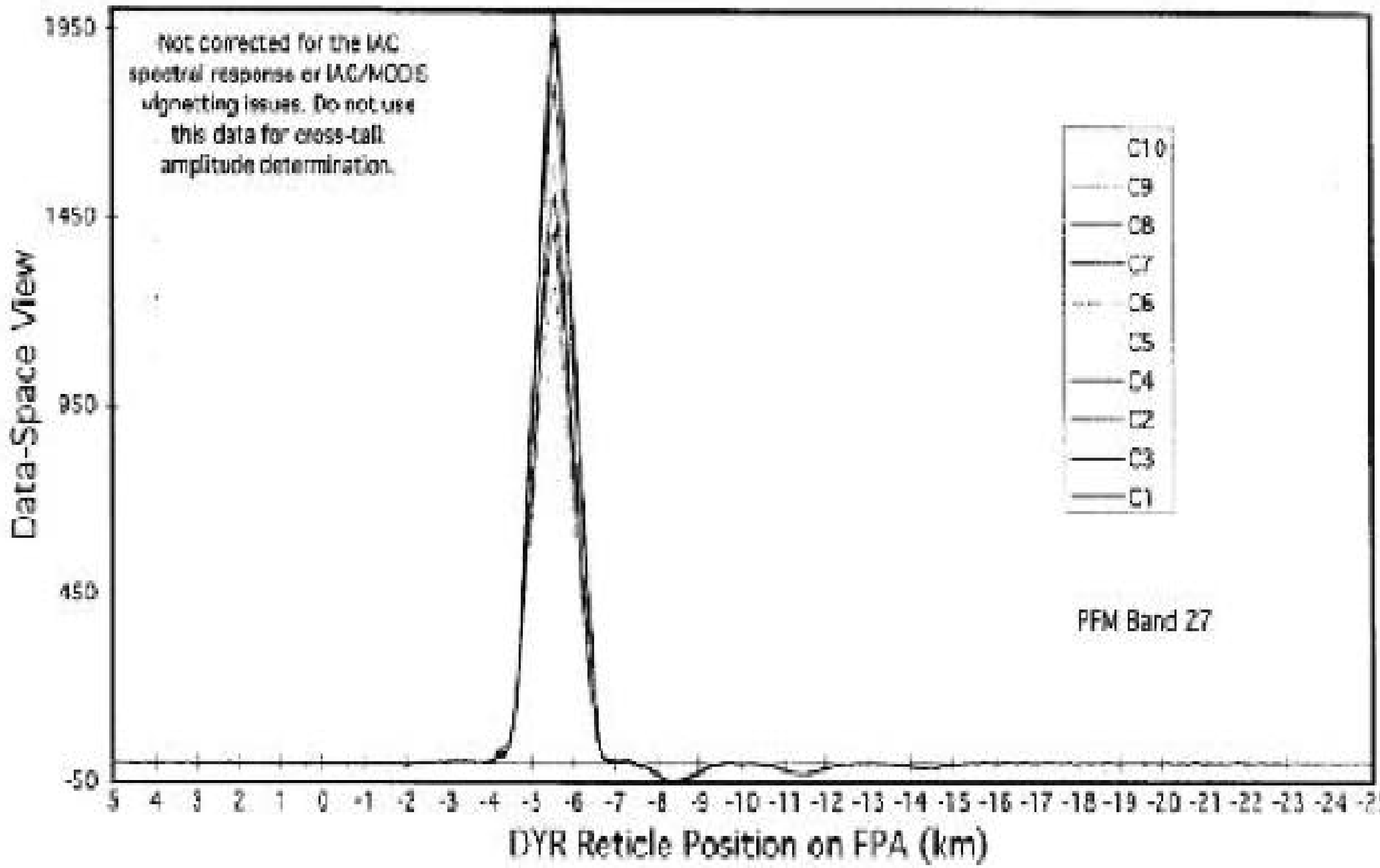
SF2

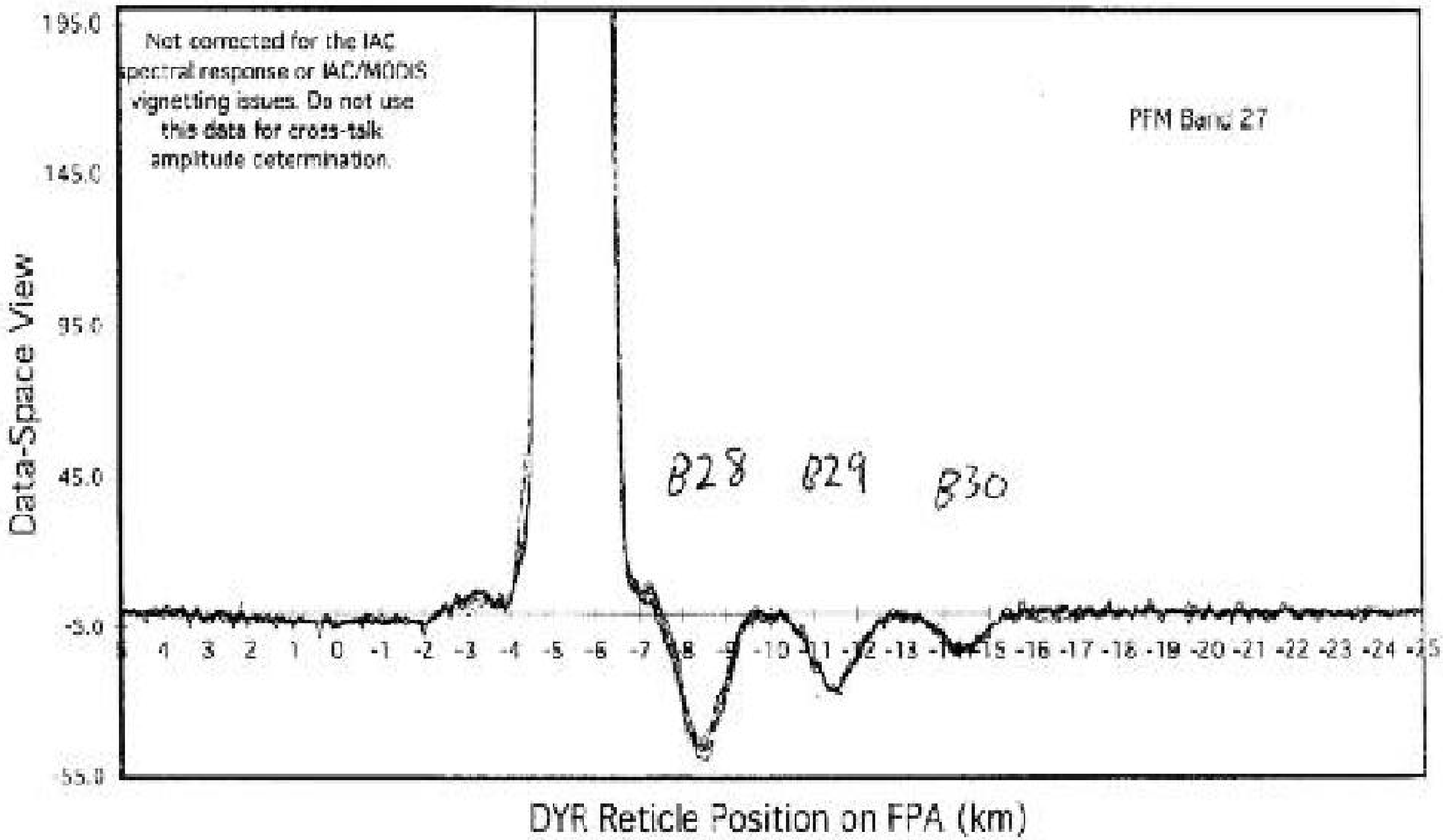
$$L_{SphA} = 1.25 \text{ Watts/m}^2\text{/sr/}\mu\text{m}$$
$$= 0.66\ L_{max}$$
$$= 1.86\ L_{typ}$$
$$= 1.86\ L_{cloud}$$





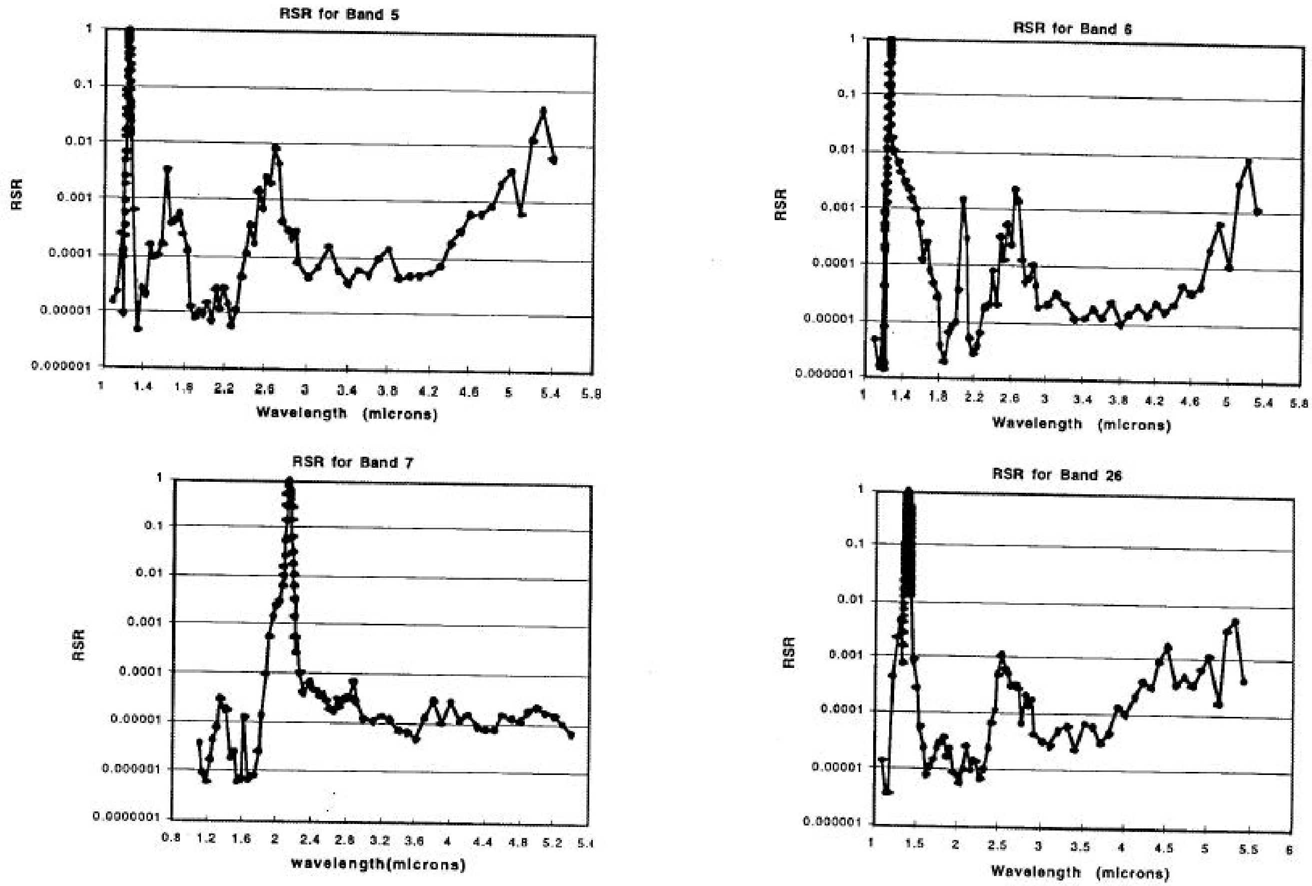



Not corrected for the IAC spectral response or IAC/MODIS vignetting issues. Do not use this data for cross-talk amplitude determination.
Data-Space View
1950
1450
950
450
-50
5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20 -21 -22 -23 -24 -25
DYR Reticle Position on FPA (km)
C10
C9
C8
C7
C6
C5
C4
C2
C3
C1
PFM Band 27

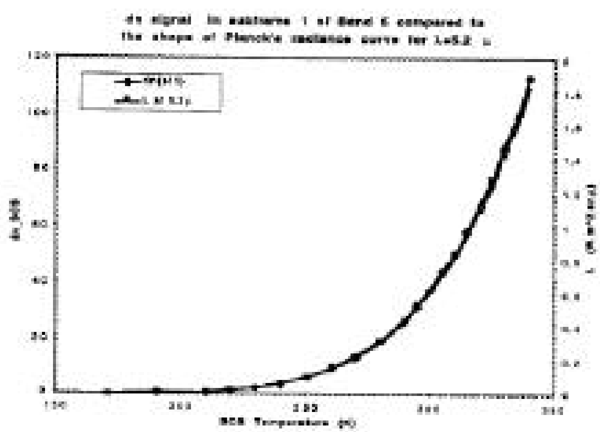


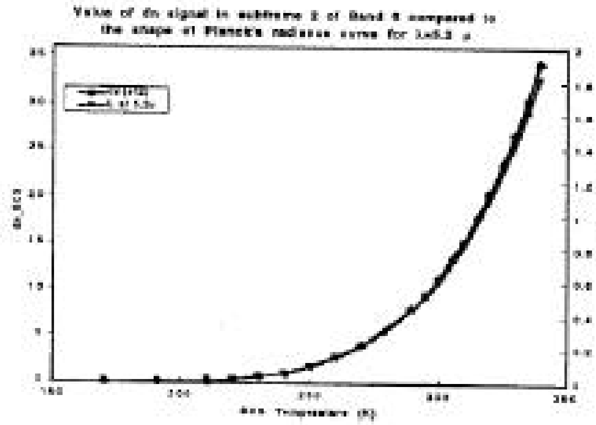
Not corrected for the IAC spectral response or IAC/MODIS vignetting issues. Do not use this data for cross-talk amplitude determination.
PFM Band 27
B28
B29
B30
195.0
145.0
95.0
45.0
-5.0
-55.0
Data-Space View
DYR Reticle Position on FPA (km)

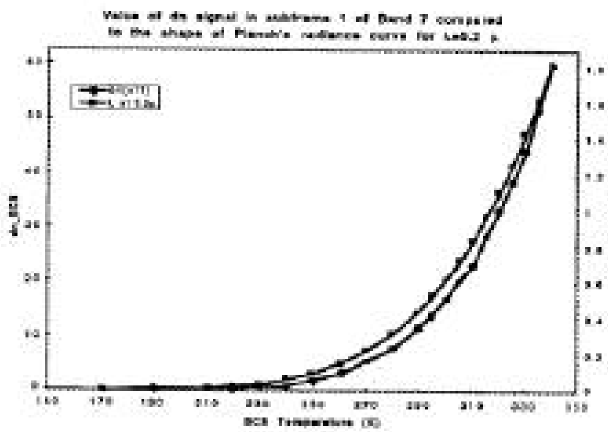
Relative Spectral Response (RSR)

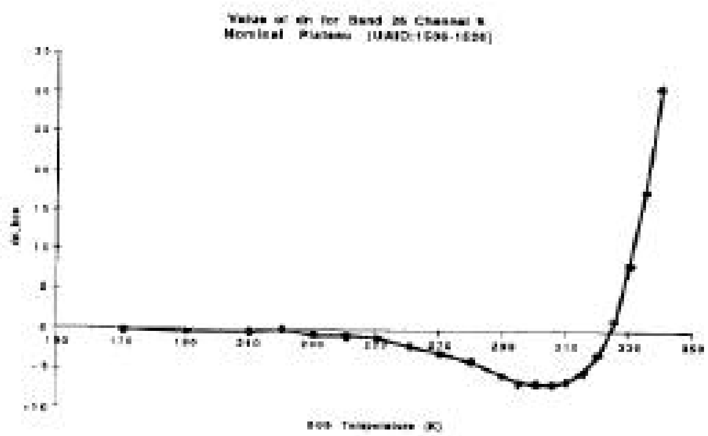


Behavior of SWIR Signal with BCS Temperature





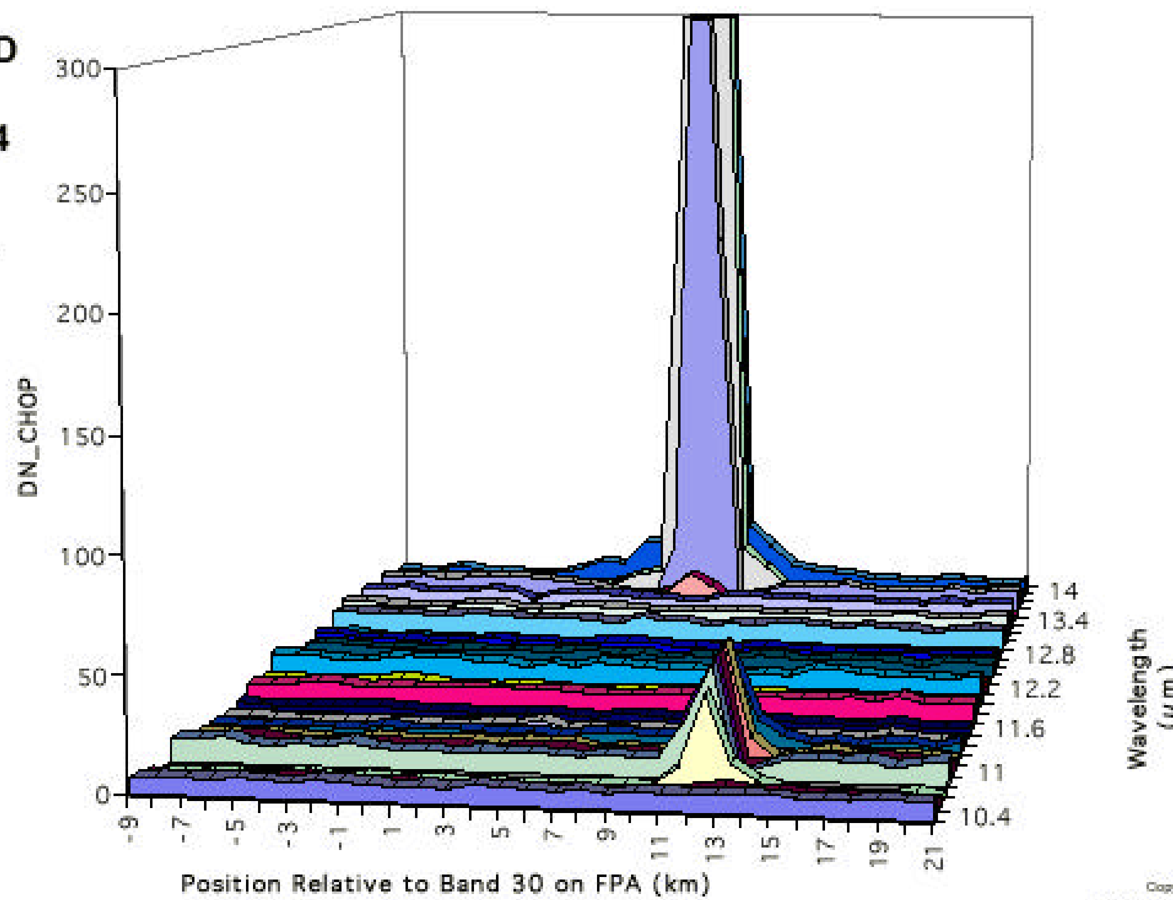


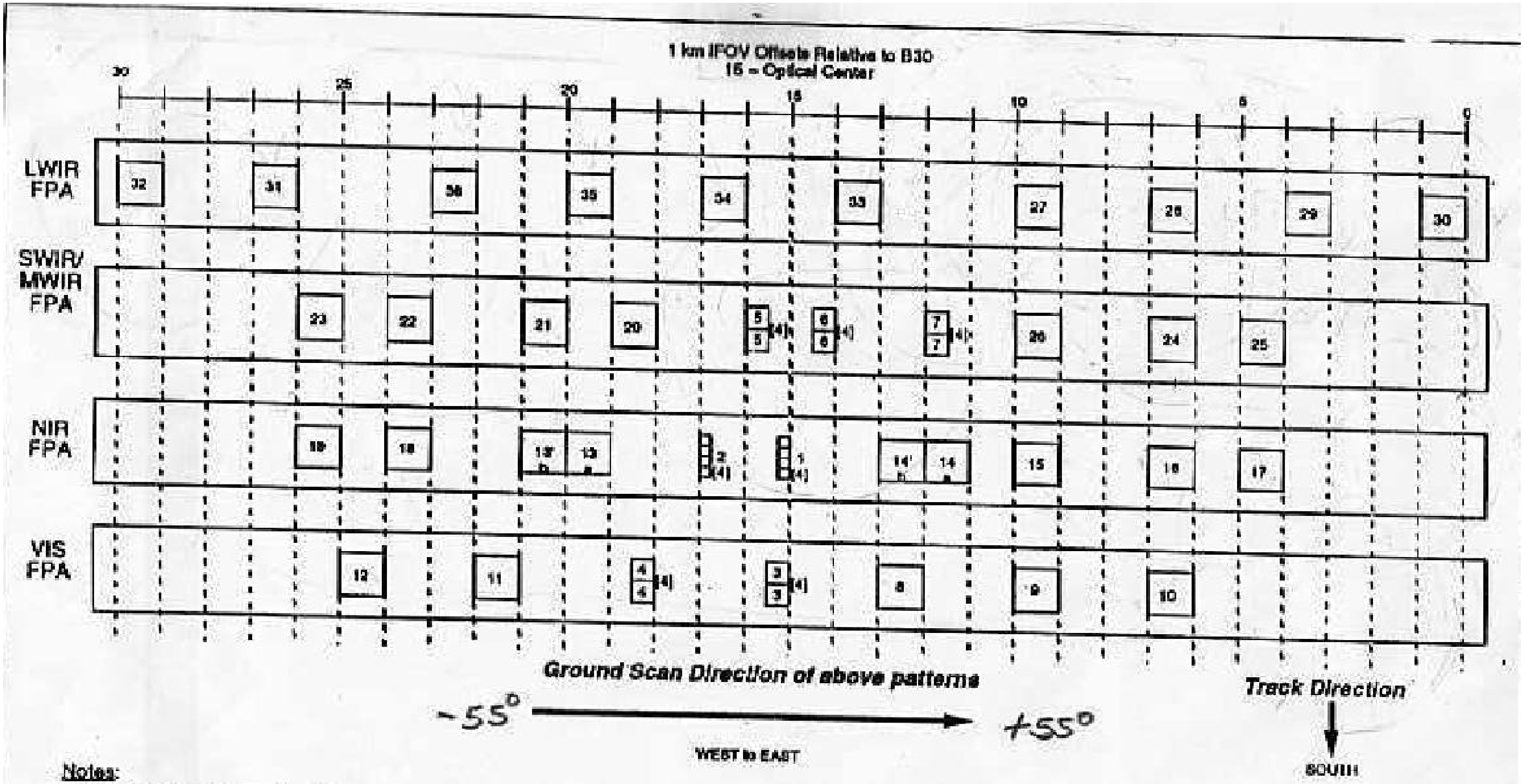


Pre-launch Crosstalk Observation (Spatial/Spectral OOB Response Testing)

BAND 35 SPECTRAL AND SPATIAL RESPONSE

- DATA ACQUIRED DURING OOBD SCAN FROM 10.4 TO 14 µm
- RESPONSE NOT VISIBLE IN BANDS 31-33

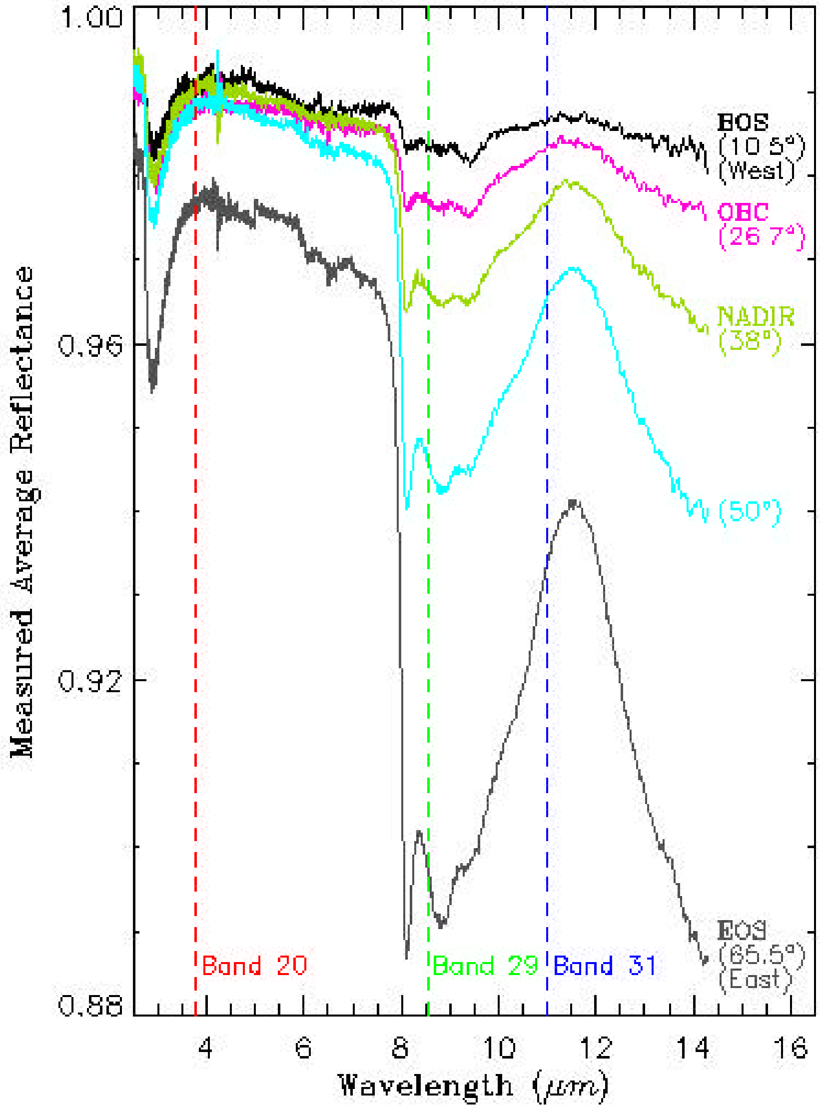


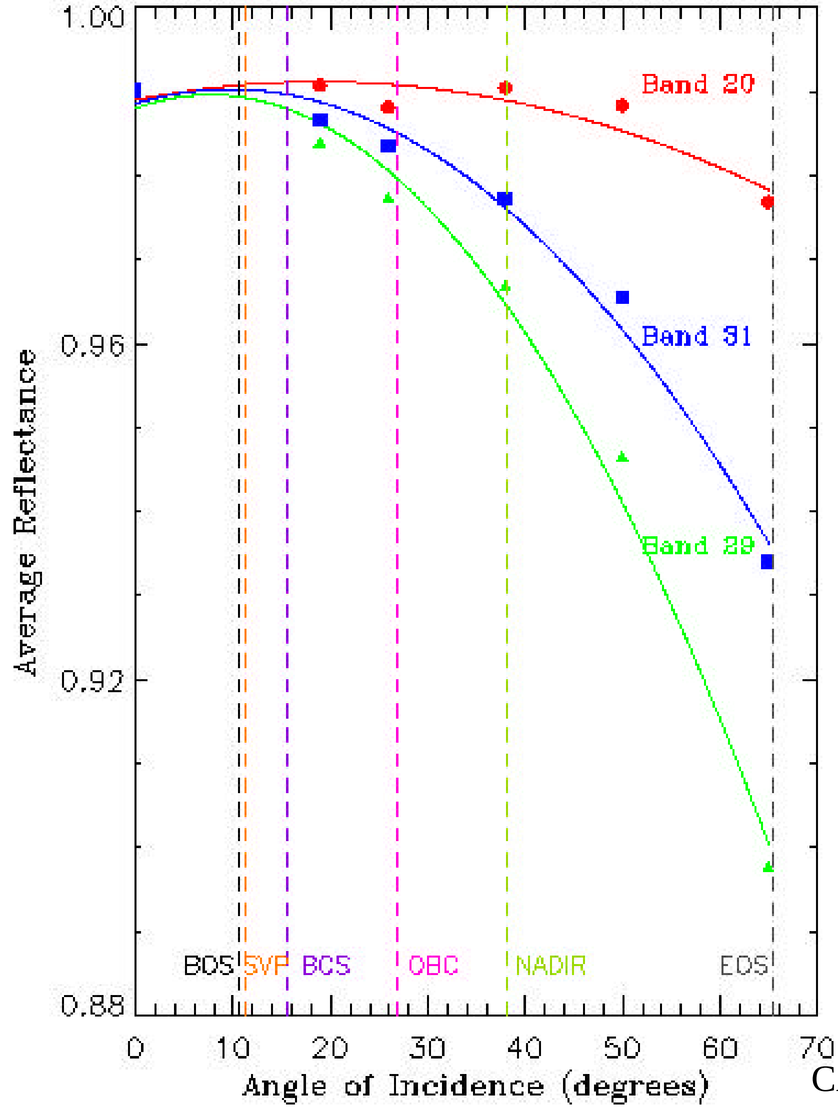


Notes:

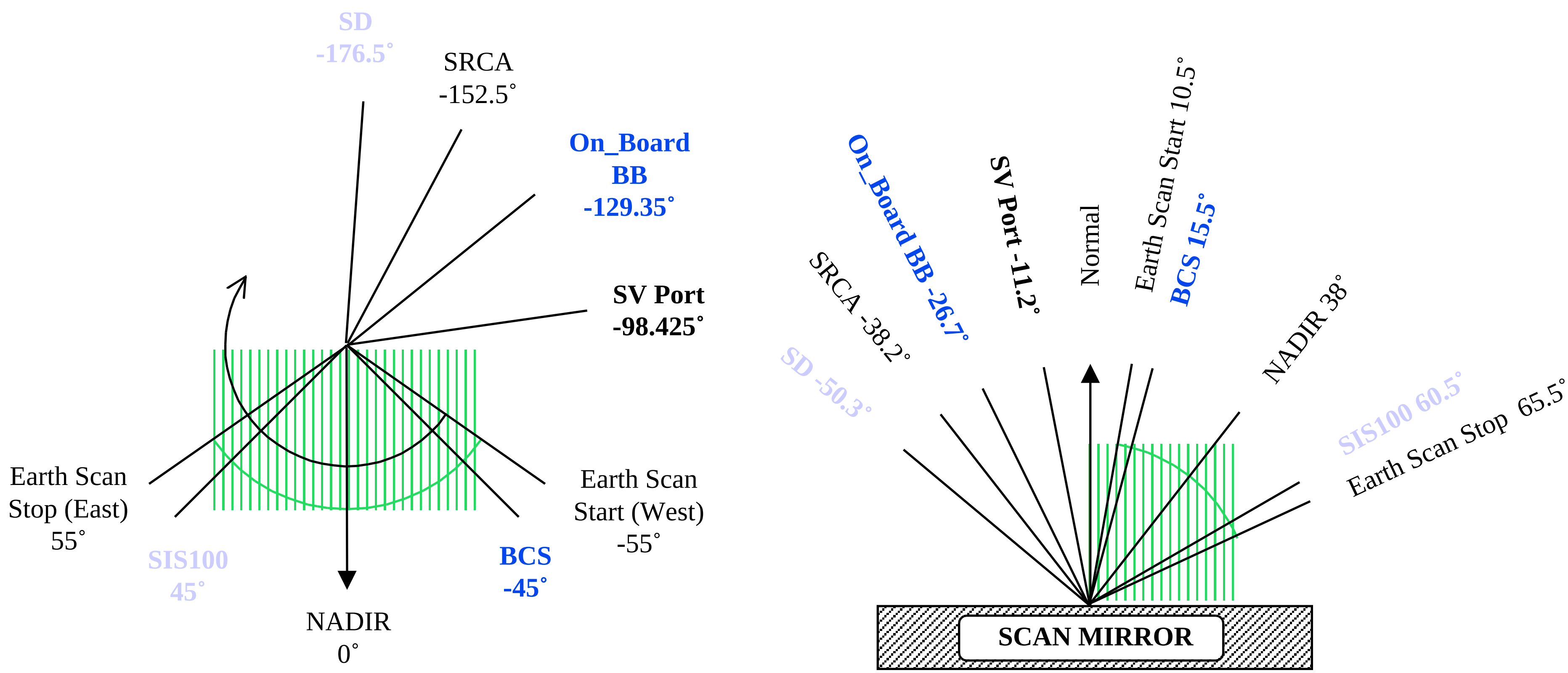
1. Band single detector locations are shown in terms of 1 km IFOV offsets from Band 30, which is first band to see a scene. FPA optical center is at IFOV 15.
2. Ground scan direction of projected pattern is to the right (west to east). FPA's have false vertical separation to clarify individual FPA extent.
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.

Lincoln Laboratory Measured Scan Mirror Average Reflectance





Principal Scan Angles Mapped to Scan Mirror Angles of Incidence



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

RADIOMETRIC

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

MCST/Sun De-striping Algorithm

- PHYSICAL ASSUMPTION: Image should be smooth across channels in-track, at each AOI, for each mirror side
- APPROACH: Uses Least Mean Square Method to determine improved linear gains for each channel, and improved RVS at each AOI, each MS, starts with Scaled Integer from product; best results when applied to scenes that appear to have little to no geophysical structure
- CONSTRAINT: Improved relative linear gains and RVS must be physically realistic, and best to be within measurement uncertainty
- Table on following page contains the pertubation values for measured RVS and linear gains

Table 1. $f_{MD}(F)$ at F = 15, 955, and 1325 for band 8.

	M=1			M=2		
D	F=15	F=955	F=1325	F=15	F=955	F=1325
1	1.0000	1.0000	1.0000	1.0059	1.0043	1.0058
2	1.0059	1.0043	1.0058	1.0071	1.0045	1.0067
3	1.0071	1.0045	1.0067	1.0083	1.0047	1.0074
4	1.0083	1.0047	1.0074	1.0087	1.0048	1.0074
5	1.0087	1.0048	1.0074	1.0119	1.0075	1.0099
6	1.0119	1.0075	1.0099	1.0105	1.0061	1.0078
7	1.0105	1.0061	1.0078	1.0128	1.0080	1.0094
8	1.0128	1.0080	1.0094	1.0131	1.0084	1.0093
9	1.0131	1.0084	1.0093	1.0138	1.0095	1.0097
10	1.0138	1.0095	1.0097	1.0271	1.0203	1.0132

Table 2. Coefficients c^0_{MD}, c^1_{MD}, and c^2_{MD} for band 8.

	M=1			M=2		
D	c0	c1	c2	c0	c1	c2
1	1.00000	0.00000	0.00000	1.00602	-0.00815	0.00810
2	1.00602	-0.00815	0.00810	1.00728	-0.01259	0.01226
3	1.00728	-0.01259	0.01226	1.00854	-0.01649	0.01566
4	1.00854	-0.01649	0.01366	1.00895	-0.01698	0.01573
5	1.00895	-0.01698	0.01573	1.01216	-0.01769	0.01572
6	1.01216	-0.01769	0.01572	1.01073	-0.01578	0.01307
7	1.01073	-0.01578	0.01307	1.01303	-0.01597	0.01253
8	1.01303	-0.01597	0.01253	1.01331	-0.01435	0.01048
9	1.01331	-0.01435	0.01048	1.01397	-0.01143	0.00722
10	1.01397	-0.01143	0.00722	1.02707	0.00221	-0.01674

Table 3. $MI_{M,D}$ for band 8.

D	M=1	M=2
1	0.98589	1.00552
2	0.99019	1.00801
3	0.99041	1.00777
4	0.99062	1.00908
5	0.99072	1.00902
6	0.99337	1.01026
7	0.99195	1.00900
8	0.99381	1.00823
9	0.99418	1.00836
10	0.99523	1.00838

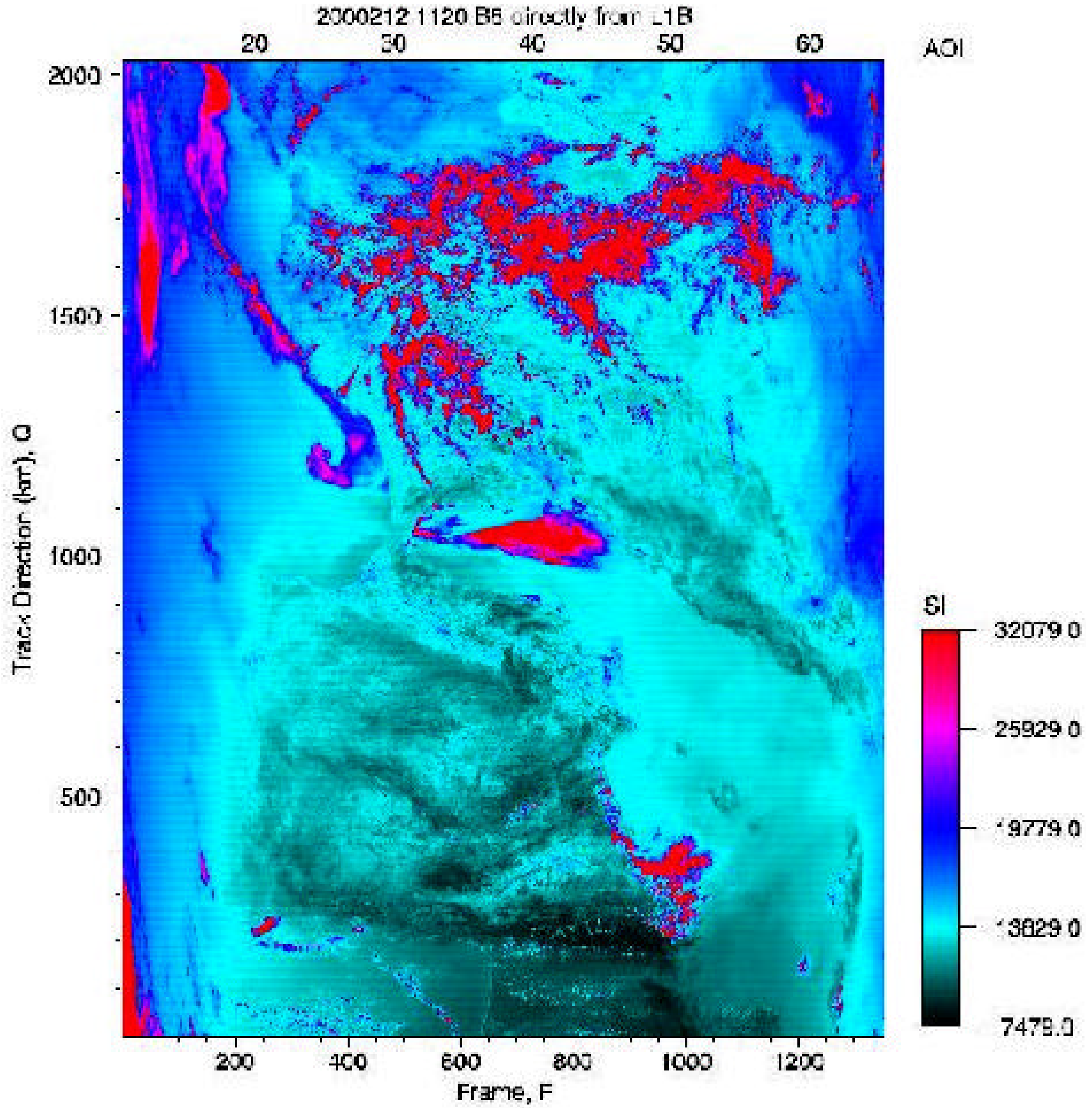


Figure1. Image of original SI from L1B for Band 8.

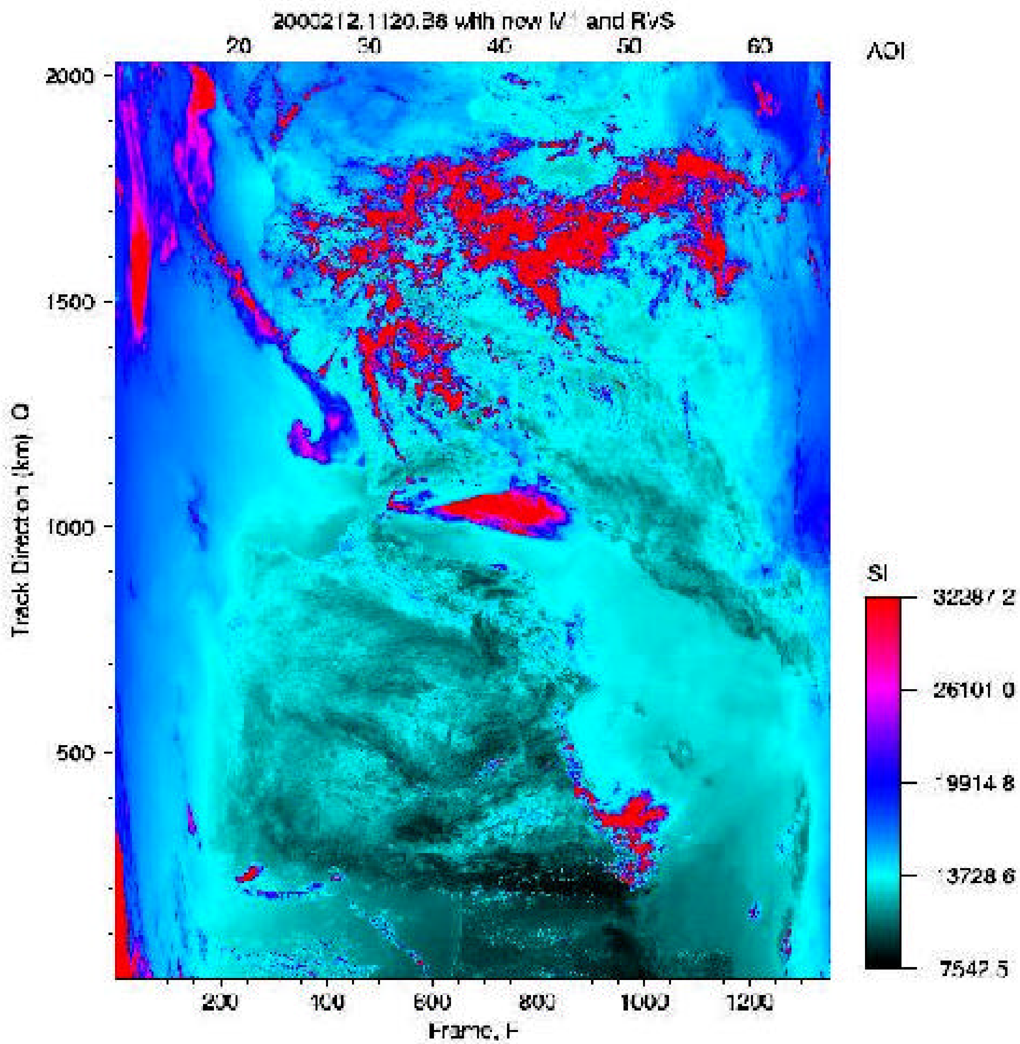


Figure 2. Image of SI reproduced with new *M1* and *RVS* from the same data presented in Figure 1.

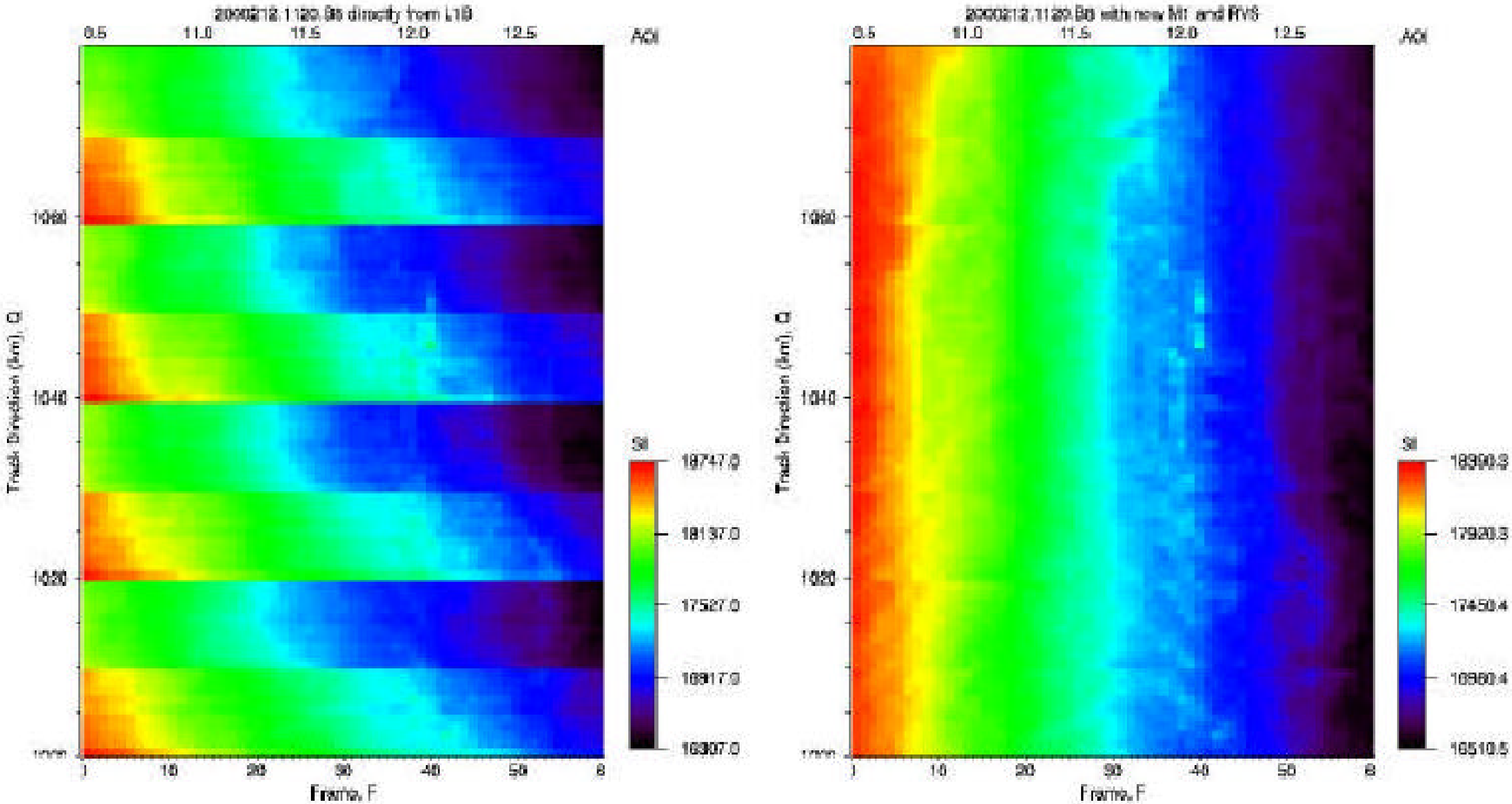


Figure 3. Comparison of the original SI directly from L1B and that reproduced with the new *M1* and *RVS*. The images are taken from left side of Figure 1 and Figure 2.

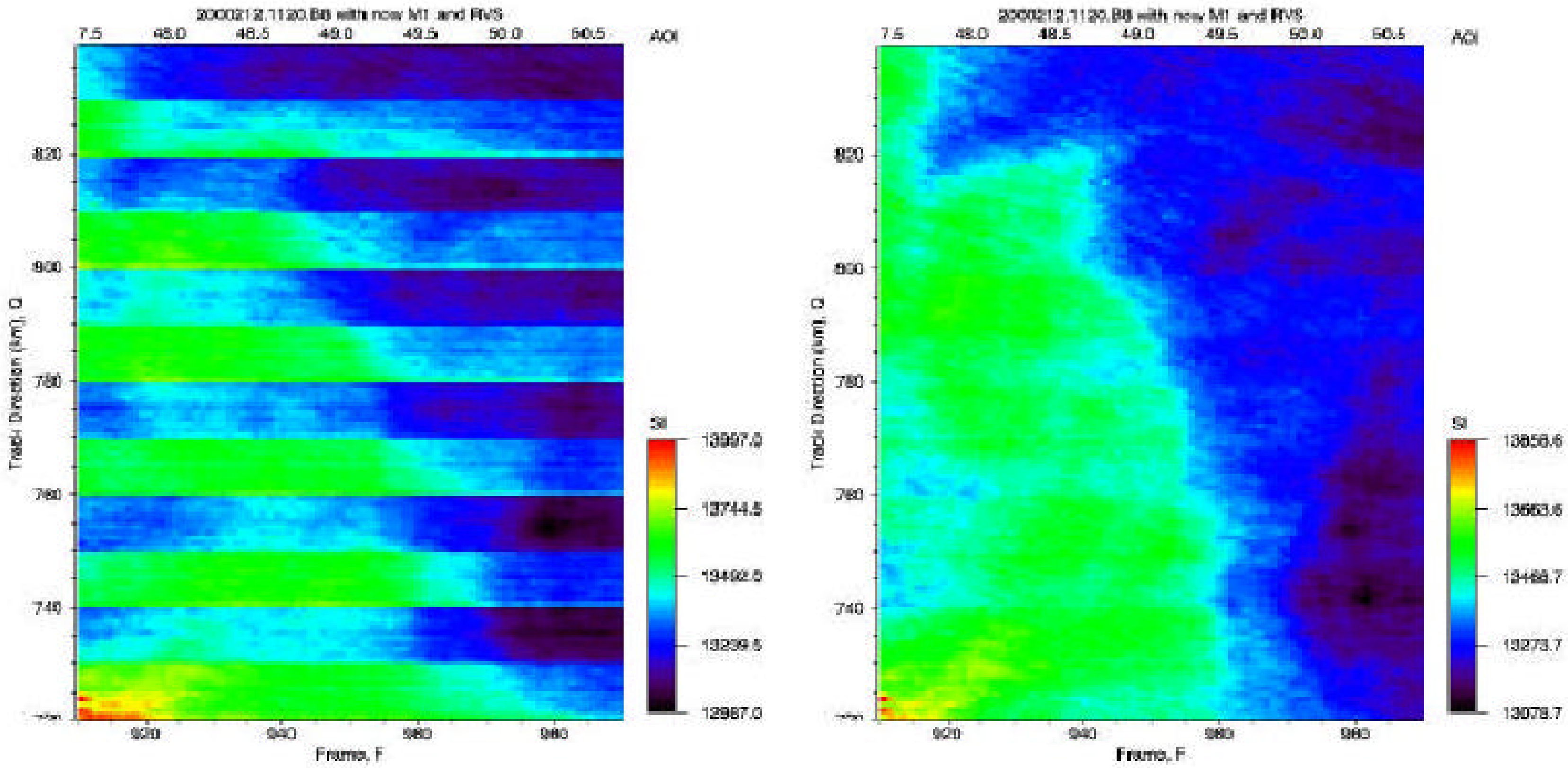


Figure 4. Comparison of the original SI directly from L1B and that reproduced with the new *M1* and *RVS*. The images are taken from middle of Figure 1 and Figure 2.

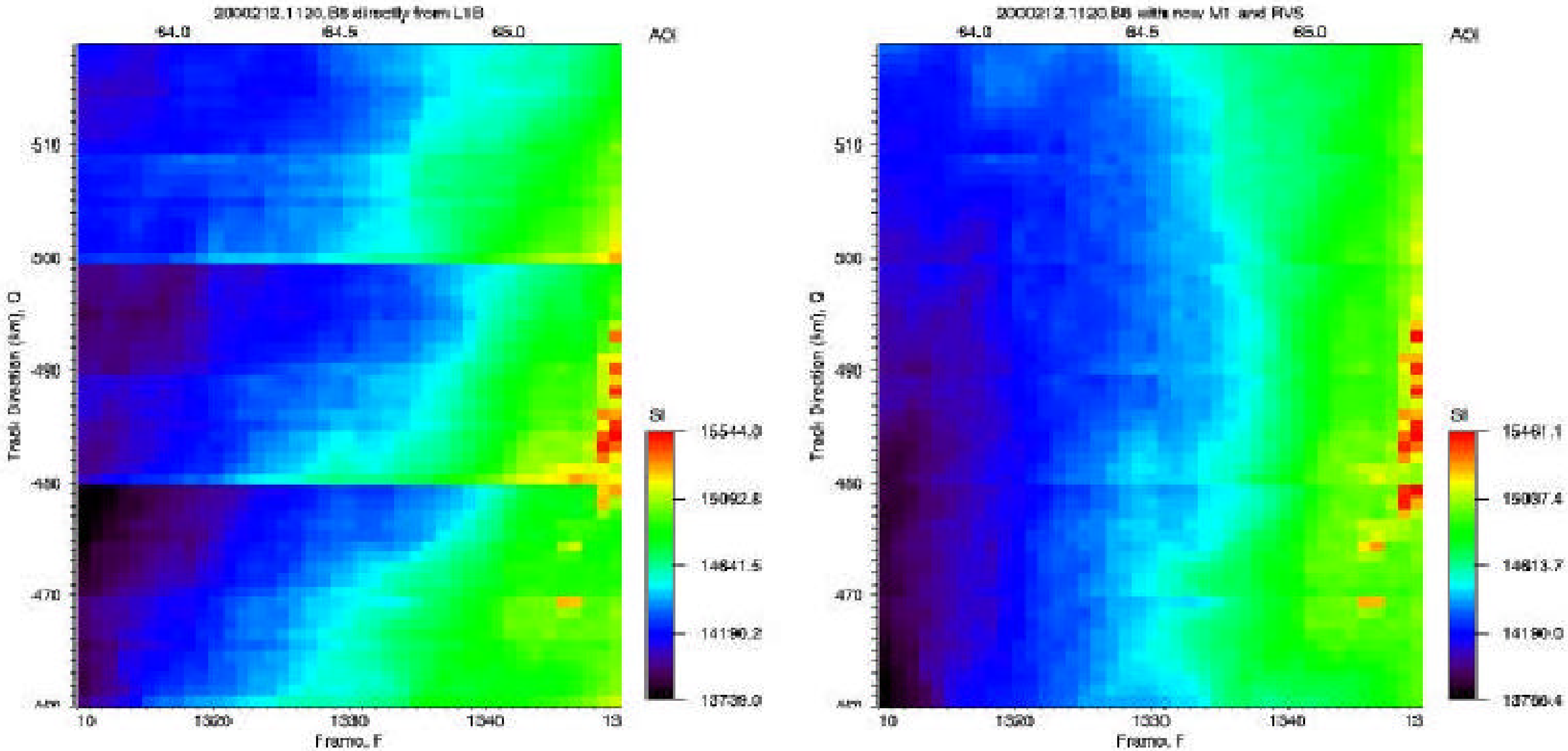


Figure 5. Comparison of the original SI directly from L1B and that reproduced with the new *M1* and *RVS*. The images are taken from right side of Figure 1 and Figure 2.

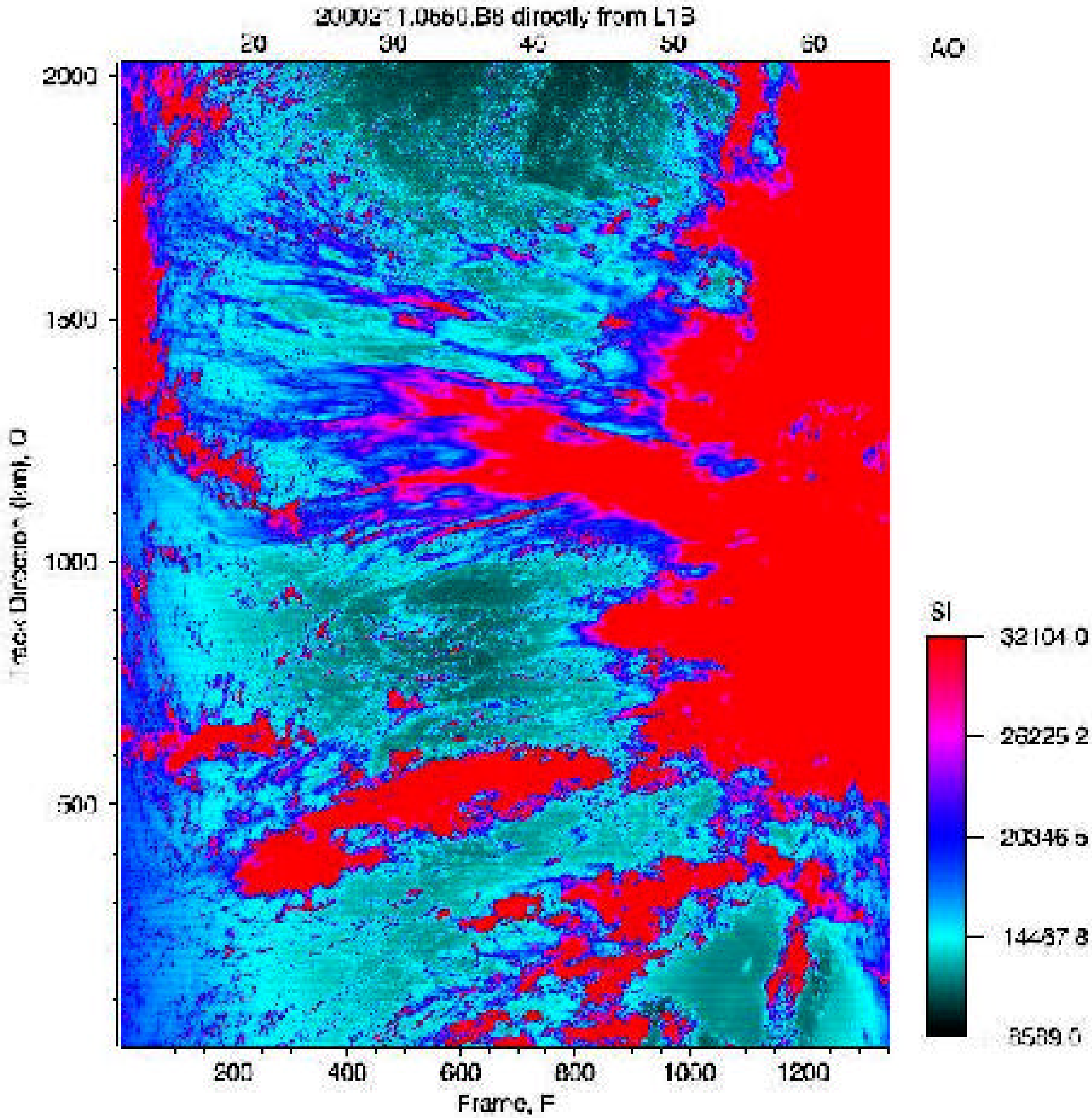


Figure 6. Image of original SI from L1B for Band 8.

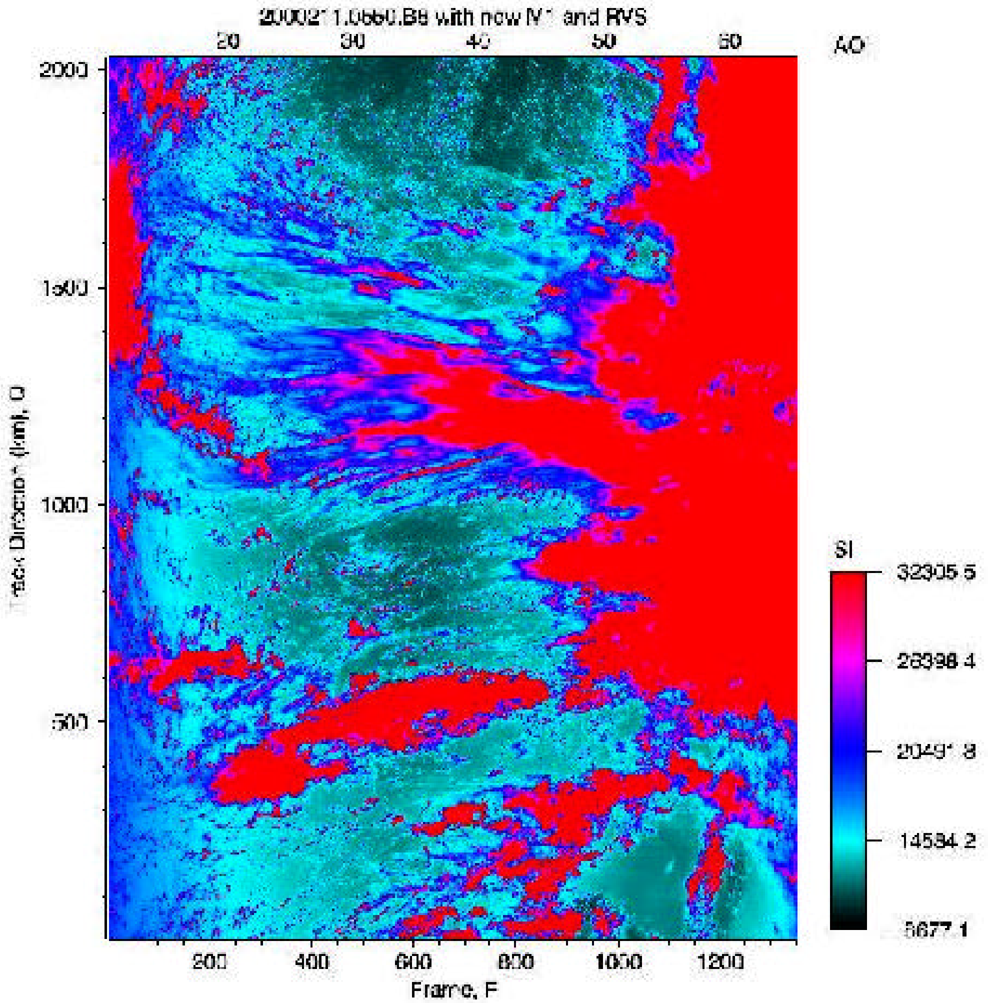


Figure 7. Image of SI reproduced with new *M1* and *RVS* from the data plotted in Figure 6.

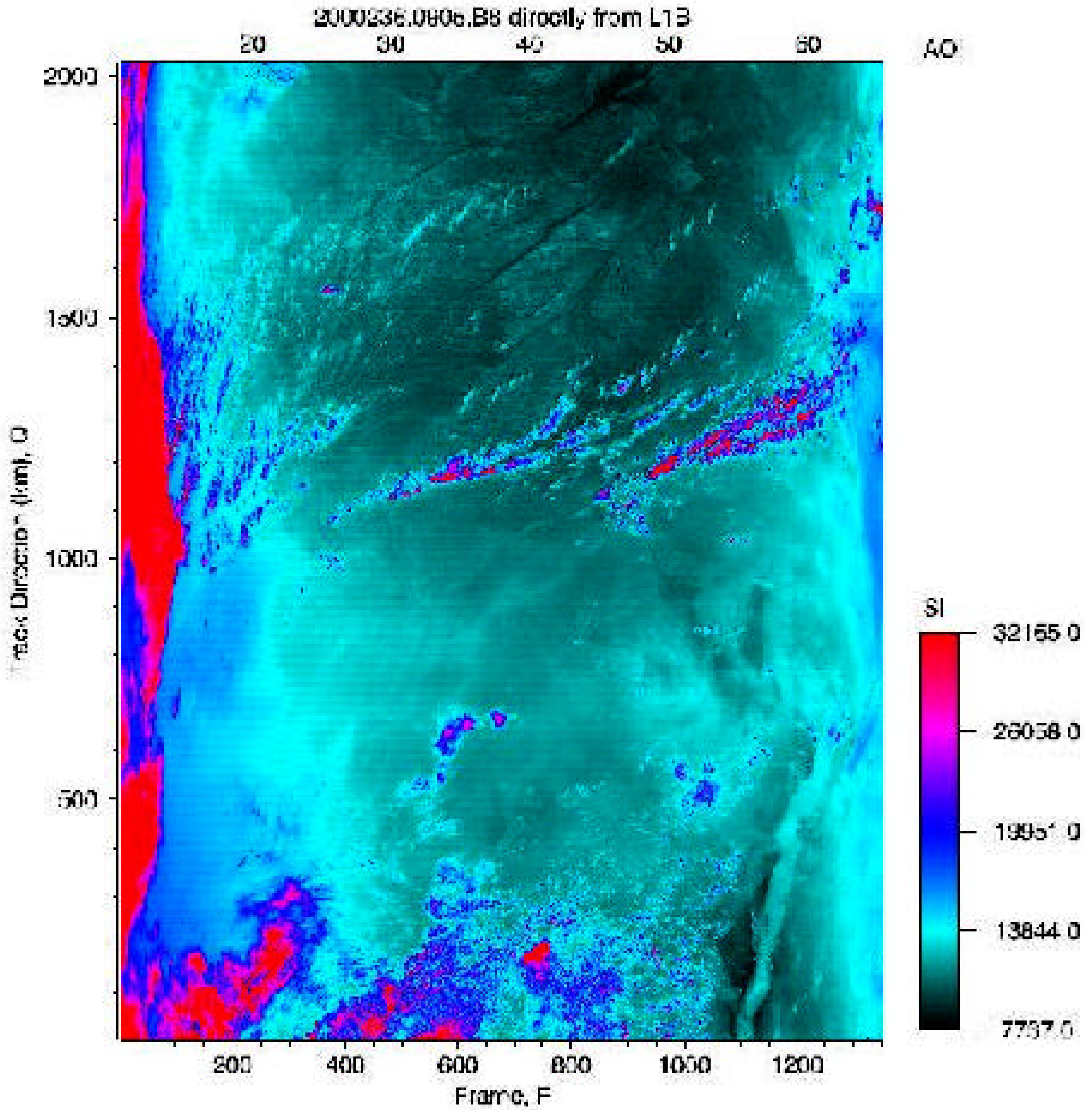


Figure 8. Image of original SI from L1B for Band 8.

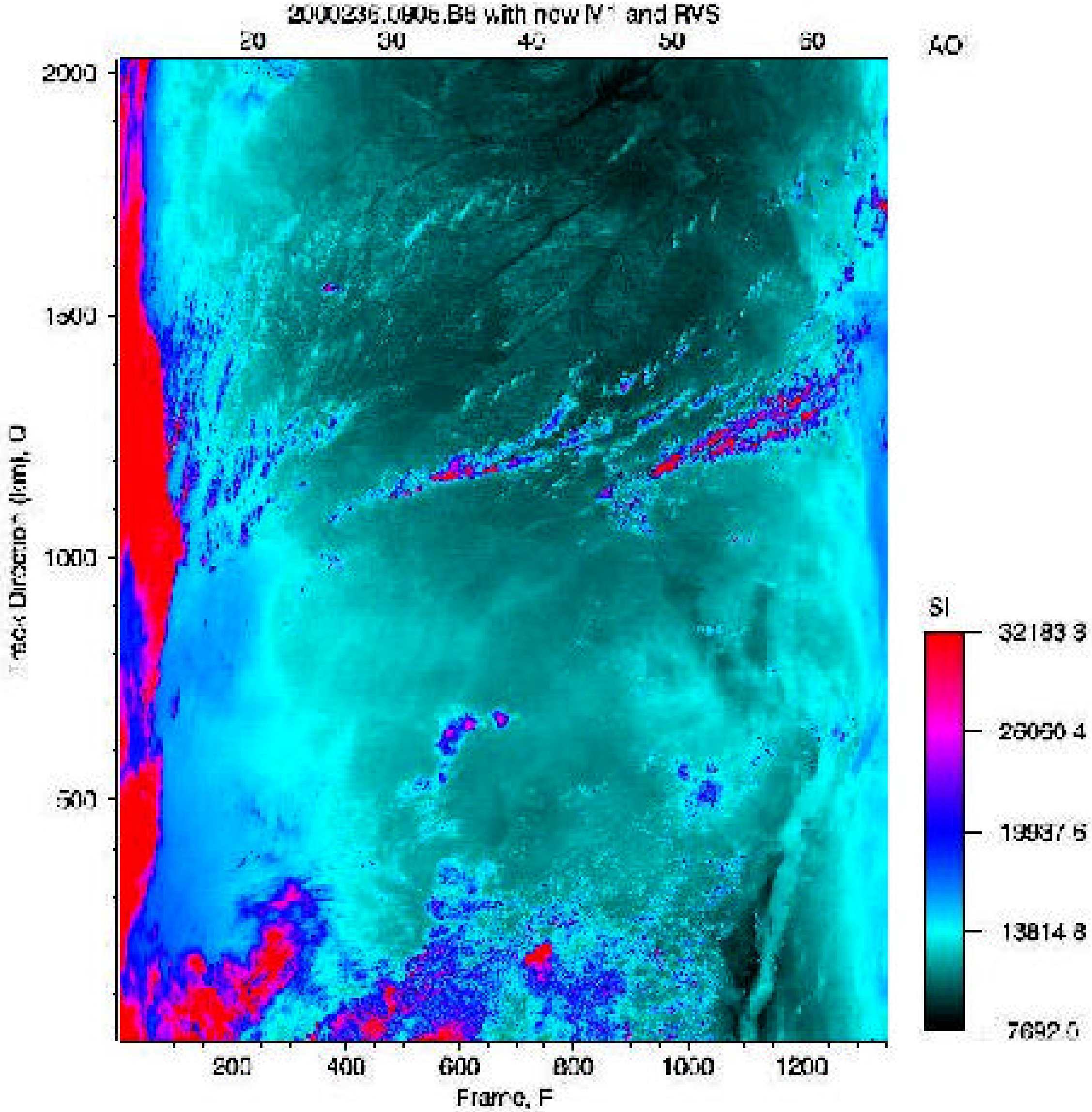


Figure 9. Image of SI reproduced with the new *M1* and *RVS* from the data presented in Figure 8.

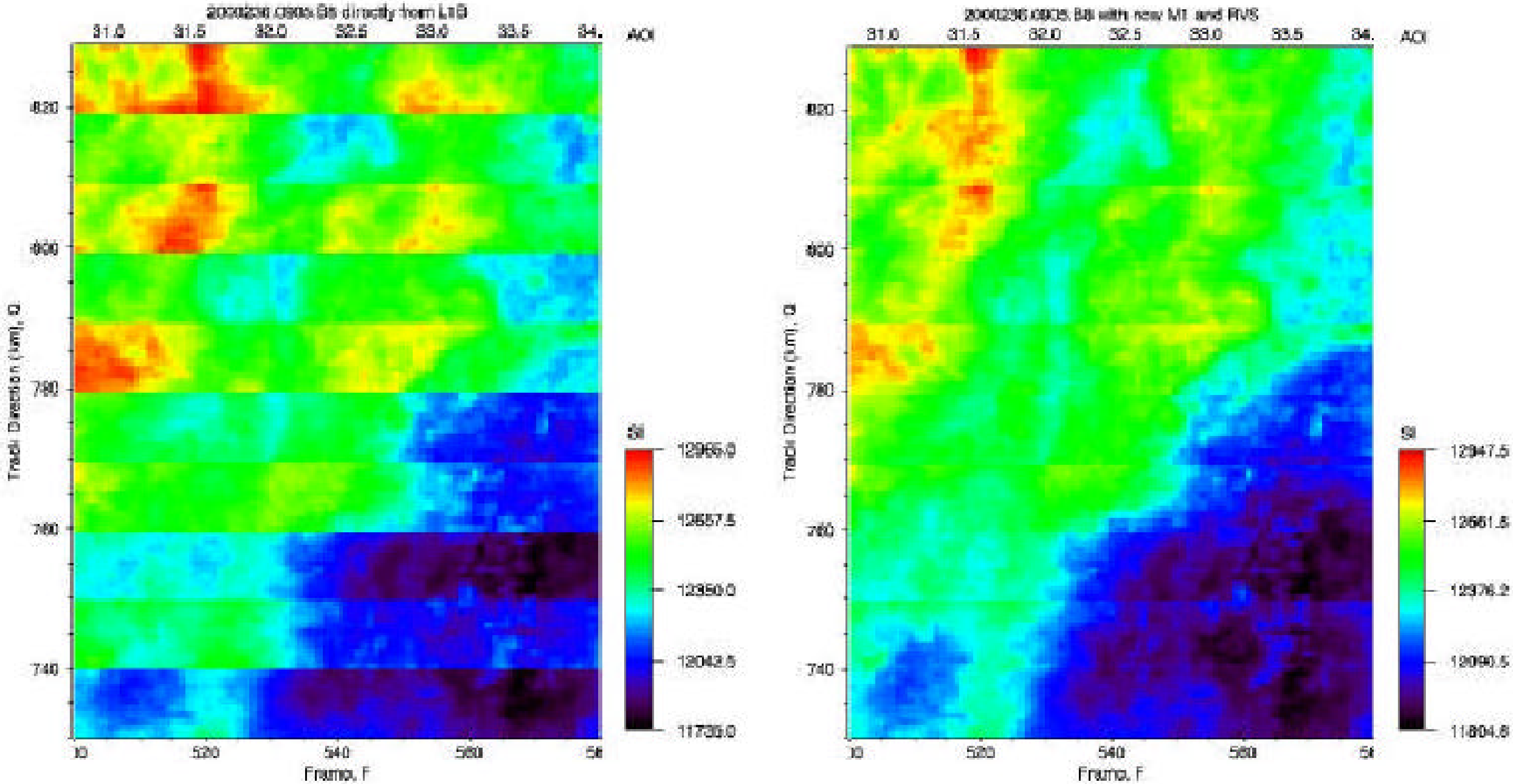


Figure 10. Comparison of the original SI directly from L1B and that reproduced with the new *M1* and *RVS*. The images are taken from right side of Figure 8 and Figure 9.

Conclusions: MCST/Sun Algorithm

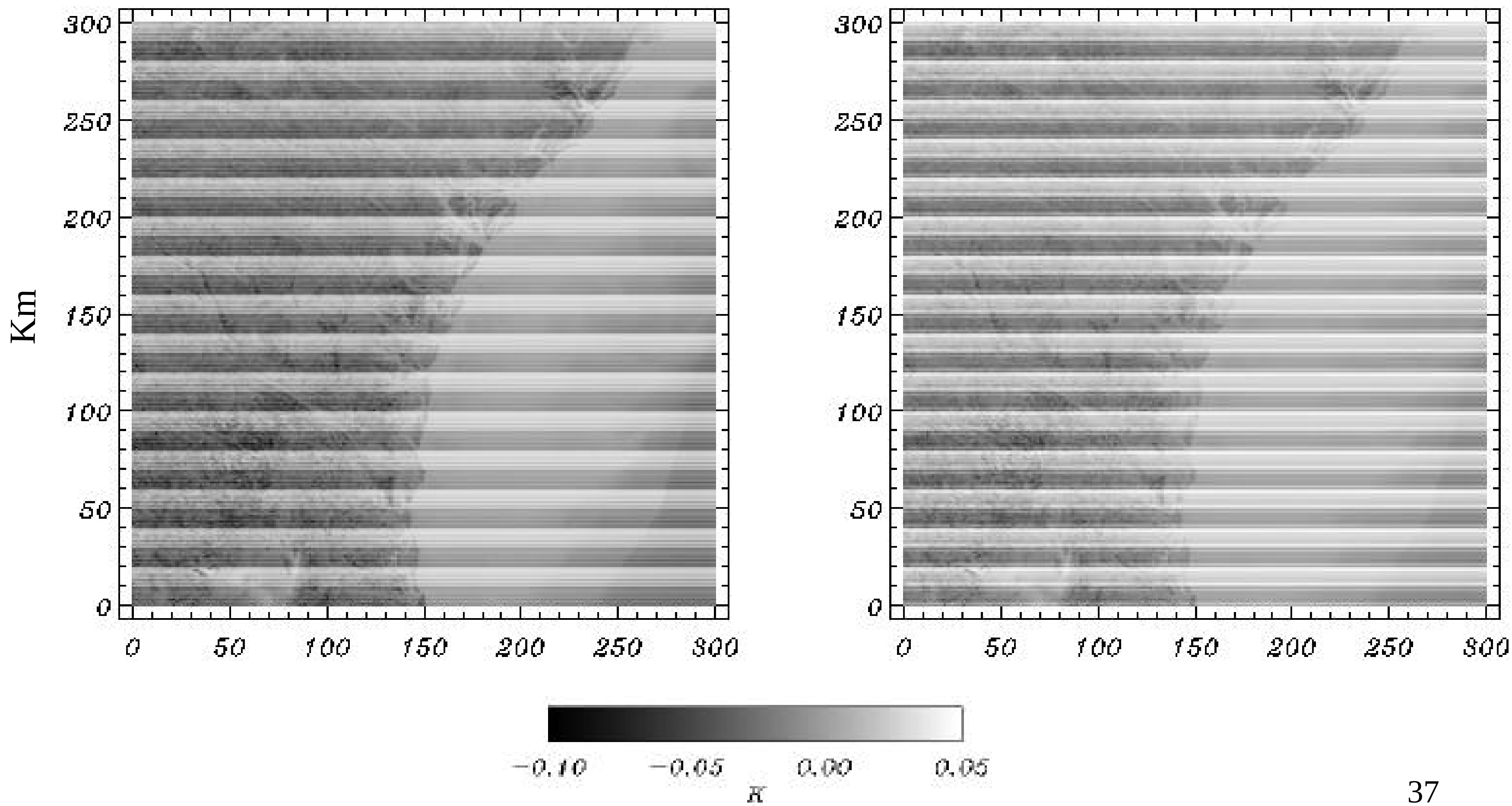
- Shows promise, but algorithm still in experimental stage
- Applied only to Band 8 data so far
- Does much better at beginning of scan than end of scan
  - Such a result may be expected from geophysical basis
- Do not fully understand yet details of how to implement this operationally in L1B, but would need to navigate scenes by hand to determine improved RVS and linear gains
- MCST and users (Miami!) must work closely together to sort out this approach as well as others; hopefully one will be good enough to apply operationally in L1B product

TOA B31 & B32 Temperature Retrieval Difference Between a0, a2 (Pre-launch) and b0, b2 (On-orbit)

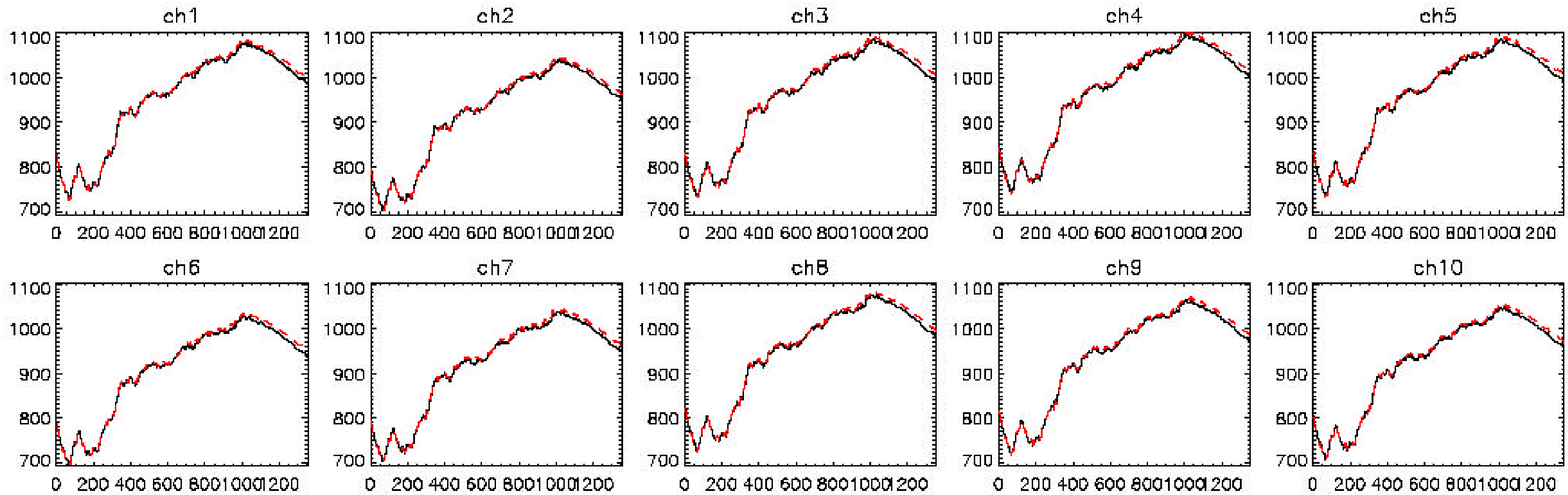
$$\Delta T = T_{EV}(b_0, b_2) - T_{EV}(a_0, a_2)$$

Images begin with mirror side 1

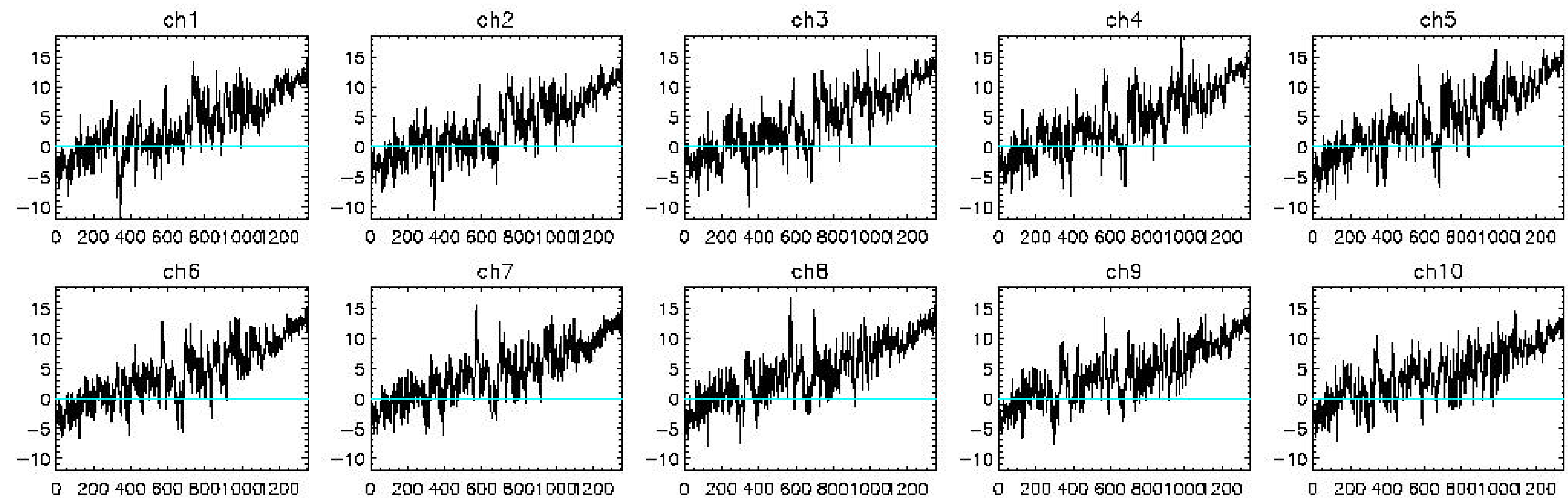
B31 B32



2000088.0350 Band 35 dn

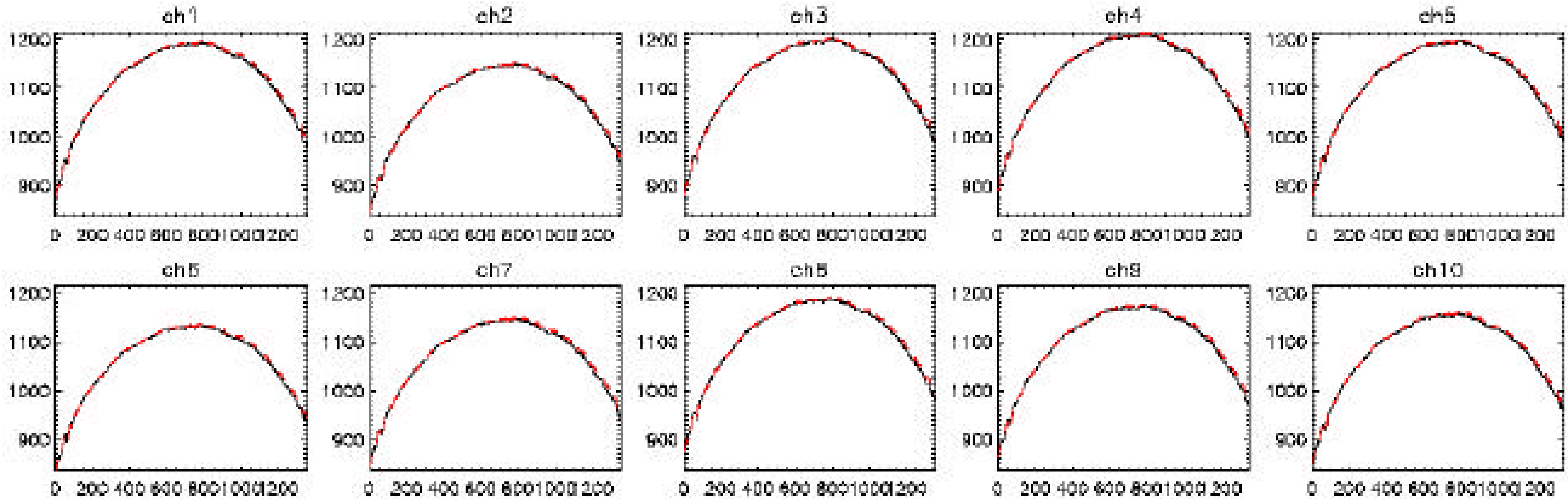


2000088.0350 Band 35 Mirror Side dn Difference (ms2−ms1)

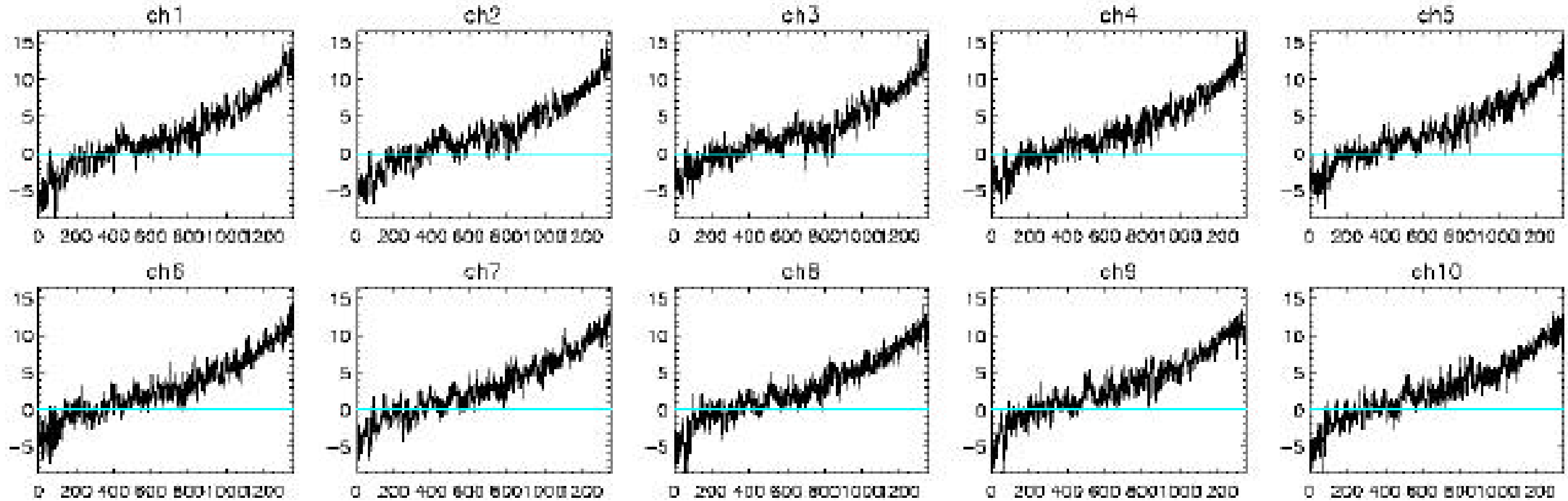


Side 1 ____ Side 2 - - - dn_ev difference

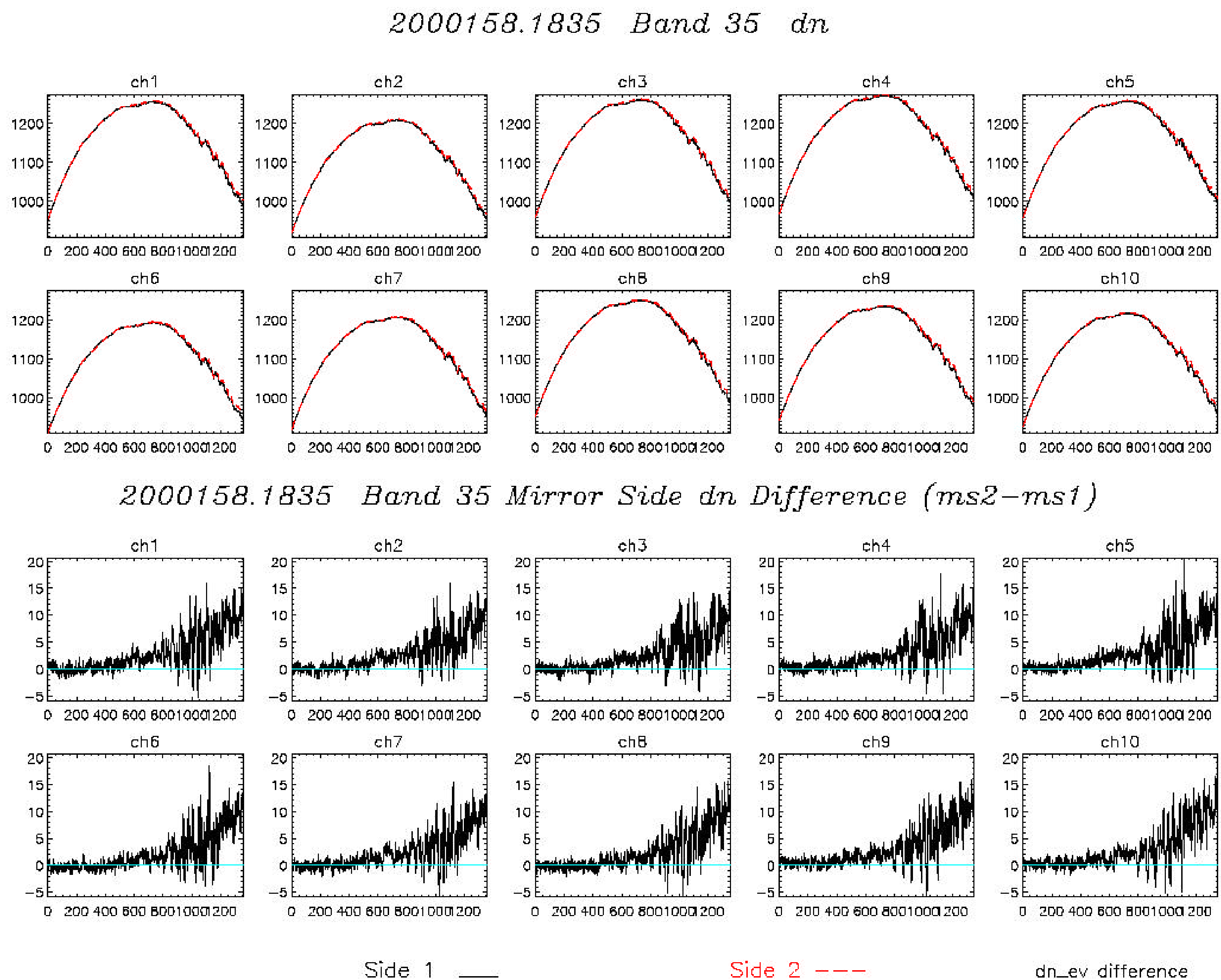
2000103.1830 Band 35 dn



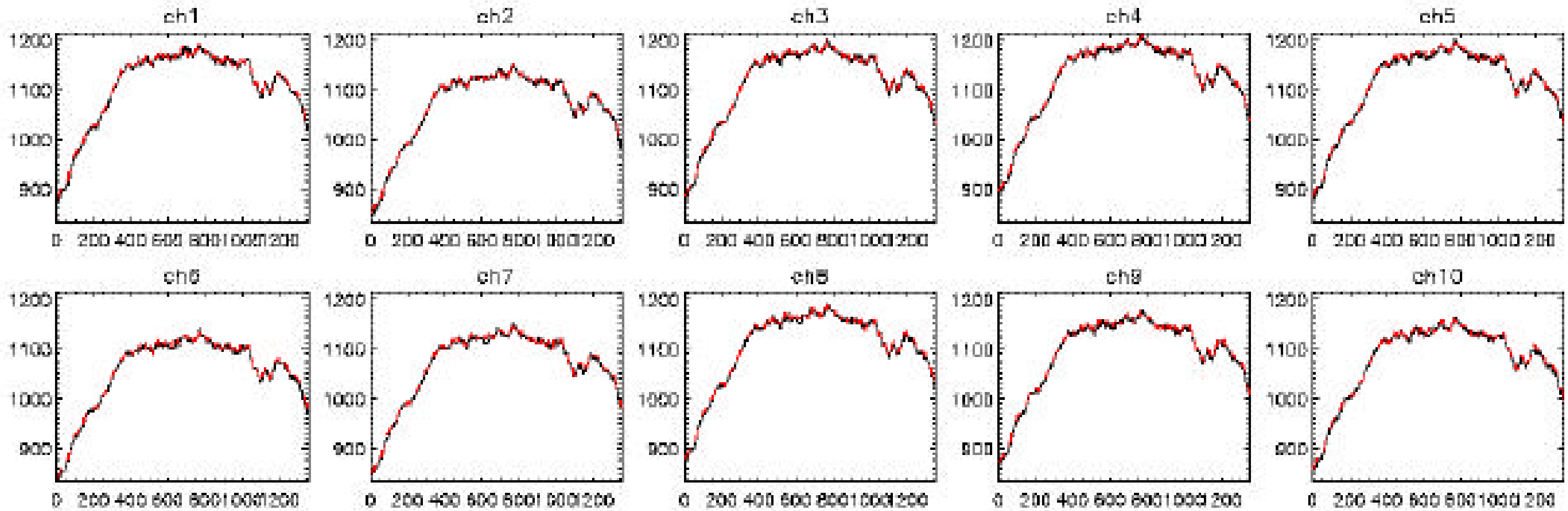
2000103.1830 Band 35 Mirror Side dn Difference (ms2−ms1)



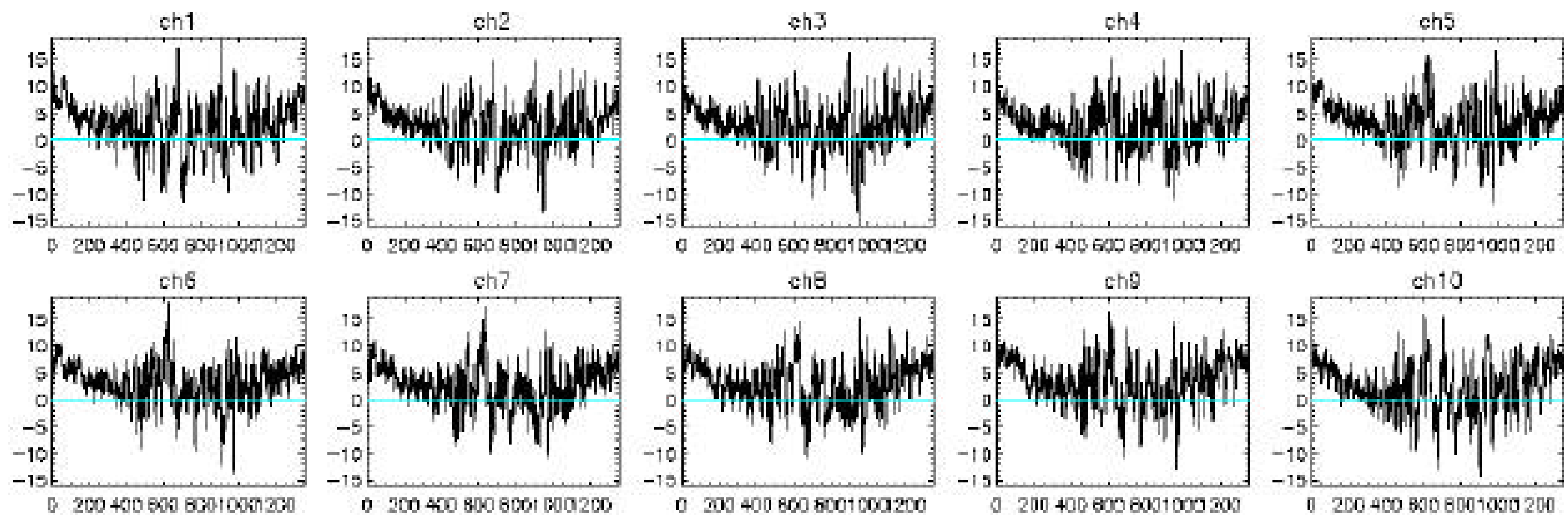
Side 1 ___ Side 2 - - - dn_ev difference


2000158.1835 Band 35 dn
ch1
ch2
ch3
ch4
ch5
ch6
ch7
ch8
ch9
ch10
2000158.1835 Band 35 Mirror Side dn Difference (ms2−ms1)
Side 1
Side 2
dn_ev difference

2000247.1825 Band 35 dn

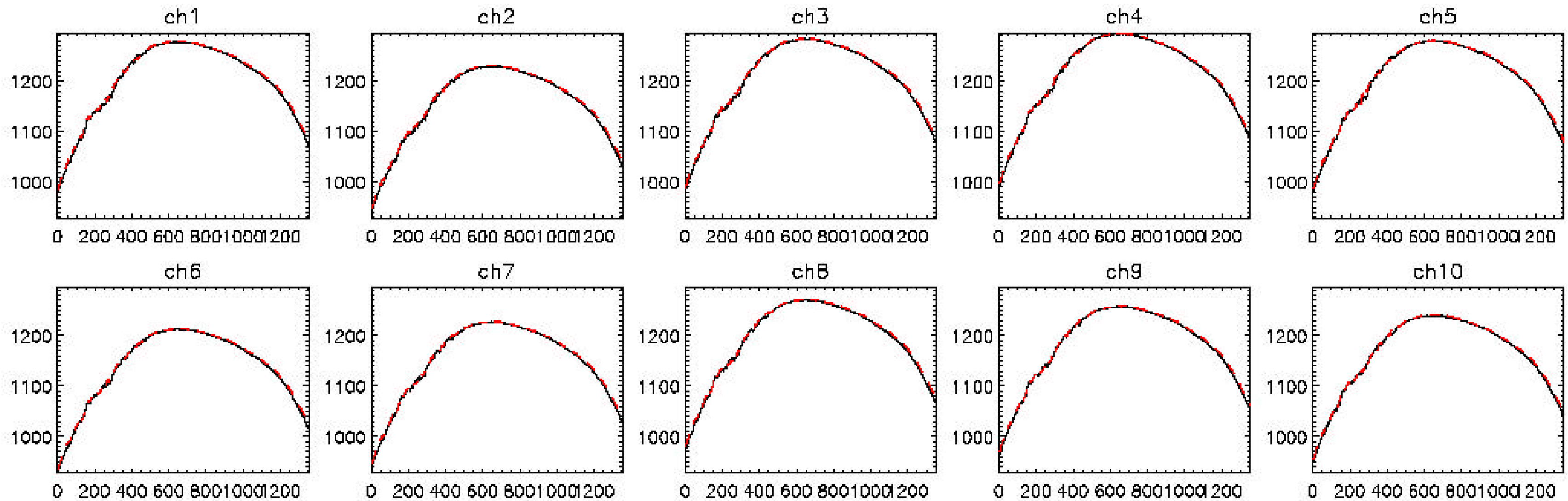


2000247.1825 Band 35 Mirror Side dn Difference (ms2−ms1)

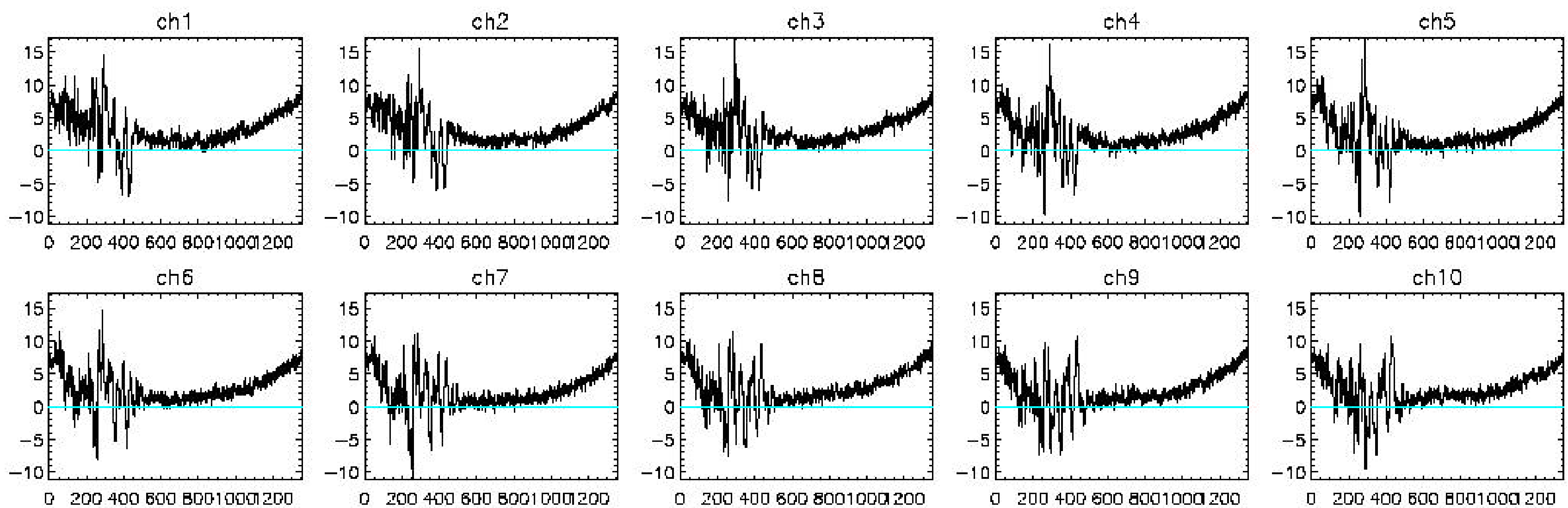


Side 1 ——— Side 2 - - - dn_ev difference

2000278.1110 Band 35 dn



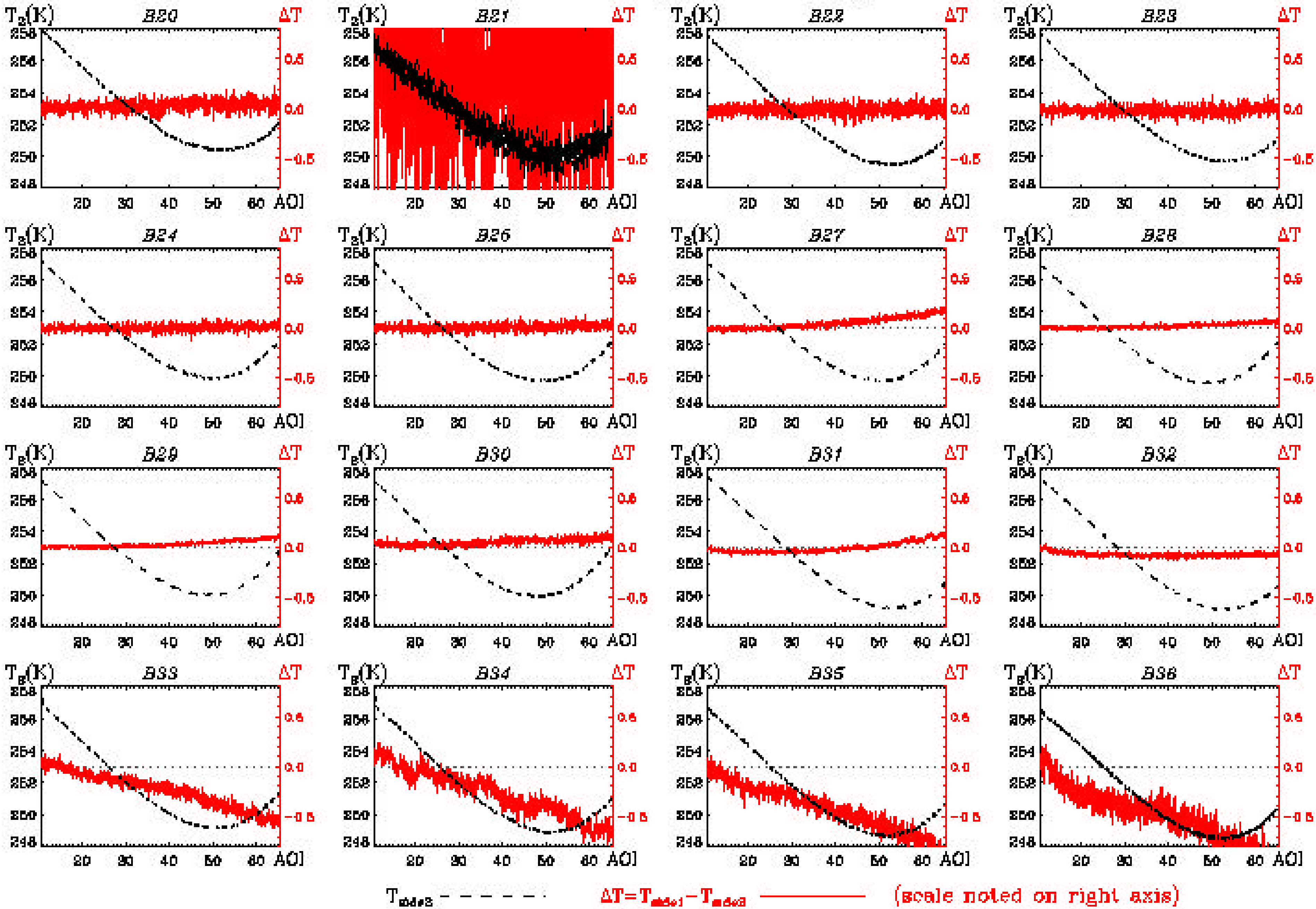
2000278.1110 Band 35 Mirror Side dn Difference (ms2−ms1)



Side 1 ____ Side 2 - - - dn_ev difference

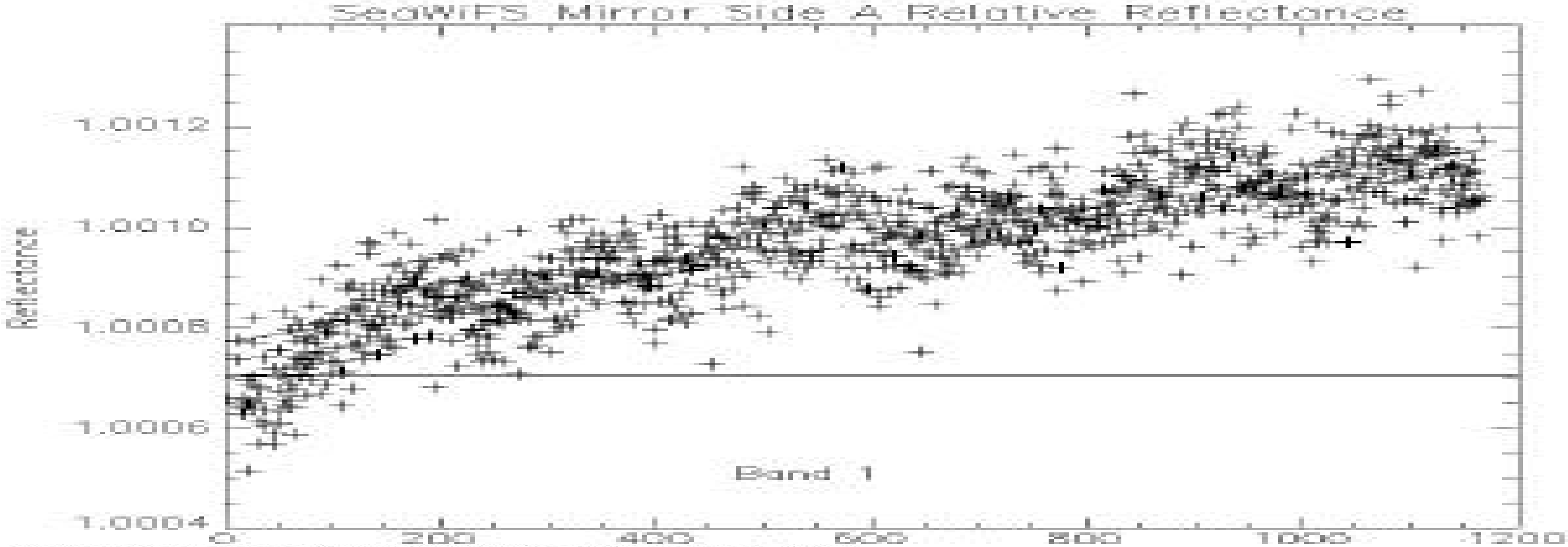
Brightness Temperature Retrieval vs AOI inside the EV Nadir Door

Data shown for Ch5 on L1A:2000116.1215; 30 scans average for each mirror side

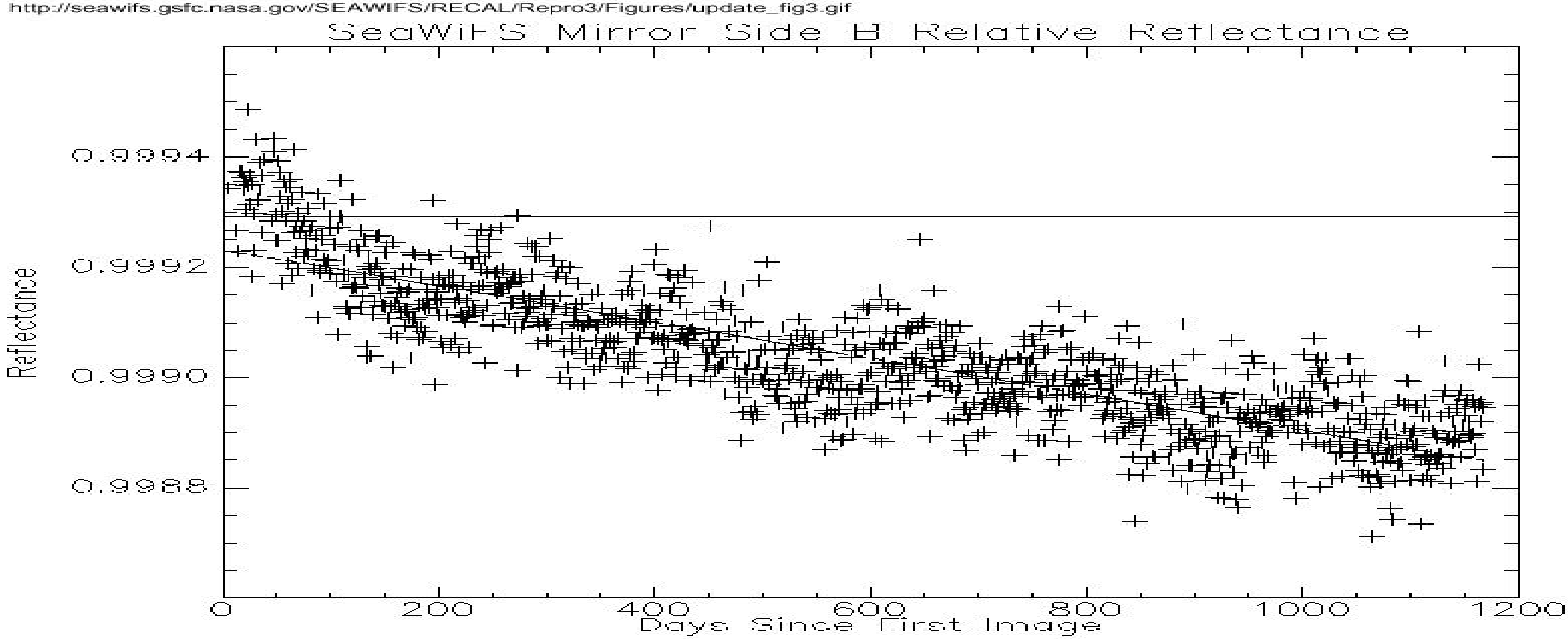


Day	B8					B20					B29					B35				
	DN_SD	DN_BB	DN_SV	dn_BB	dn_EV	DN_SD	DN_BB	DN_SV	dn_BB	dn_EV	DN_SD	DN_BB	DN_SV	dn_BB	dn_EV	DN_SD	DN_BB	DN_SV	dn_BB	dn_EV
66		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
72		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
78						2>1	2>1	2<1	2>1		2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	
80		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
87		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
94		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
101		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
106		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
112		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
120		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
125		2>1	2<1	2>1		2≥1	2≥1	2≤1	2≥1		2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	
125						2≥1	2≥1	2≤1	2≥1		2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	
129		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
136		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≤1	2≤1	2≈1	2<1	P1
143		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≈1	2≈1	2≈1	2≈1	P1
150		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≈1	2≈1	2≈1	2≈1	P1
158		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≈1	2≈1	2≈1	2≈1	P1
164		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≈1	2≈1	2≈1	2≈1	P1
171		2>1	2<1	2>1		2>1	2>1	2<1	2>1	2≈1	2>1	2>1	2<1	2>1		2≈1	2≈1	2≈1	2≈1	P1
178	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
181						2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	
185	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
192	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
200	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
206	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
212	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	P1
212						2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1		2≈1	2≈1	2≈1	2≈1	
218	2<1	2<1	2>1	2<1		2<1	2<1	2>1	2<1	2≈1	2<1	2<1	2>1	2<1		**2≥1**	**2≥1**	**2≈1**	**2≥1**	**P2**
231	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
238	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
243						2≥1	2≥1	2≤1	2≥1		2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	
245	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
253	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
260	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
263						2≥1	2≥1	2≤1	2≥1		2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	
267	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
270	2<1	2<1	2≥1	2<1		2≈1	2≈1	2≈1	2≈1		2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	
273	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
280	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
287	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
294	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
304	2<1	2≤1	2≥1	2≤1		2≥1	2≥1	2≤1	2≥1	2≈1	2≈1	2≈1	2≈1	2≈1		2>1	2>1	2≈1	2>1	P3
305	2<1	2≈1	2≈1	2≈1		2≤1	2≤1	2≥1	2≤1	2≈1	2≈1	2≈1	2≈1	2≈1		2<1	2<1	2≈1	2<1	P1
306	2<1	2≈1	2≈1	2≈1		2≤1	2≤1	2≥1	2≤1	2≈1	2≈1	2≈1	2≈1	2≈1		2<1	2<1	2≈1	2<1	P1

http://seawifs.gsfc.nasa.gov/SEAWIFS/RECAL/Repro3/Figures/update_fig2.gif

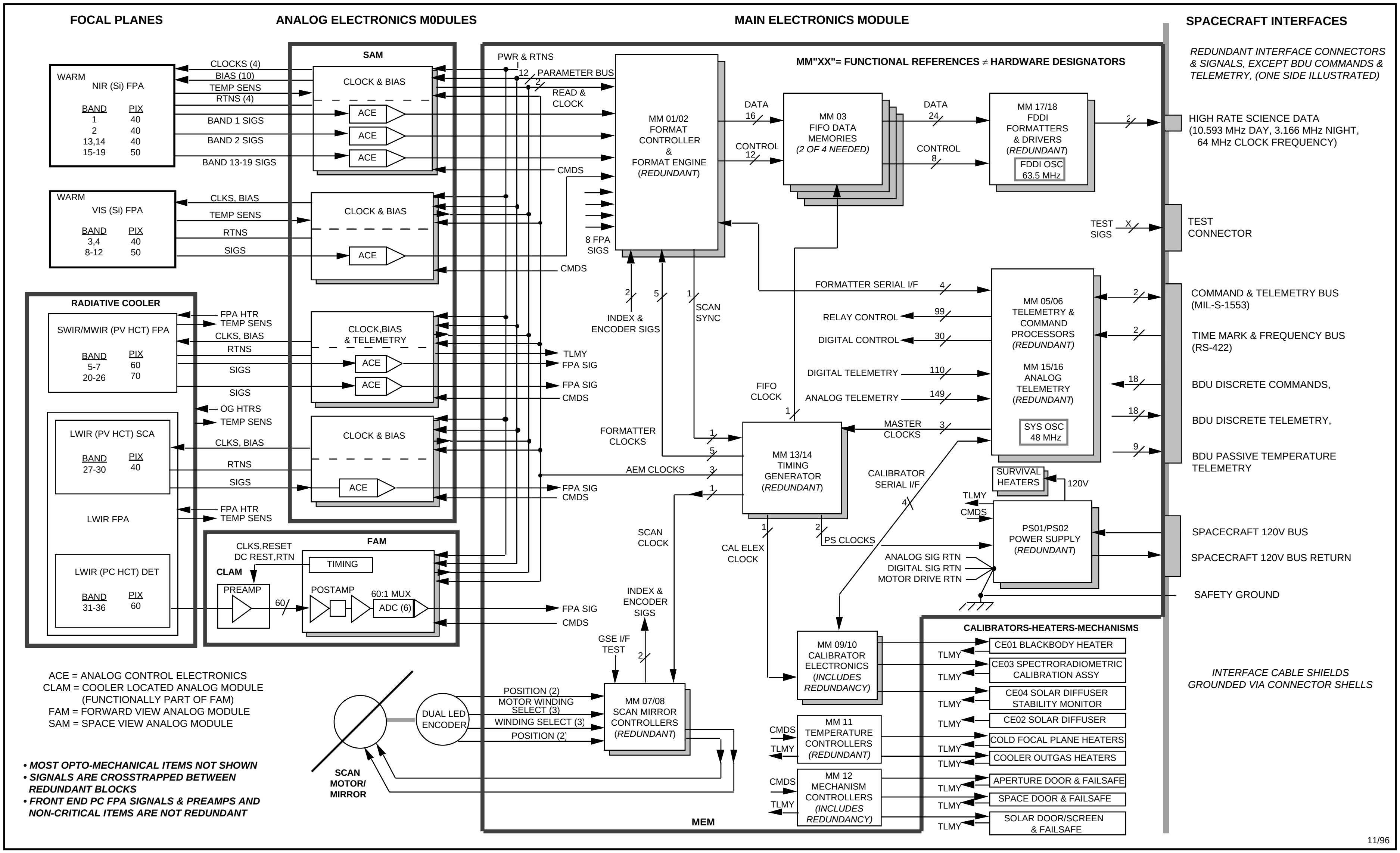


http://seawifs.gsfc.nasa.gov/SEAWIFS/RECAL/Repro3/Figures/update_fig3.gif



Radiometric Section 2

MODIS Electronic Block Diagram



ADC List

ADC #	ADC Name	Bands
1	VIS (p)	3,4, 8-12
2	VIS (r)	
3	NIR1 (p)	1
4	NIR1 (r)	
5	NIR2 (p)	2
6	NIR2 (r)	
7	NIR3 (p)	13-19
8	NIR3 (r)	
9	SMIR5 (p)	5,6,7
10	SMIR5 (r)	
11	**SMIR20 (p)**	**20-26**
12	**SMIR20 (r)**	
13	**LWIR (p)**	**27-30**
14	**LWIR (r)**	

PV Bands ADC Conversion Time: 800 ns

ADC #	ADC Name	Bands
15	PCB31 (p)	31
16	PCB31 (r)	
17	PCB32 (p)	32
18	PCB32 (r)	
19	PCB33 (p)	33
20	PCB33 (r)	
21	PCB34 (p)	34
22	PCB34 (r)	
23	PCB35 (p)	35
24	PCB35 (r)	
25	PCB36 (p)	36
26	PCB36 (r)	

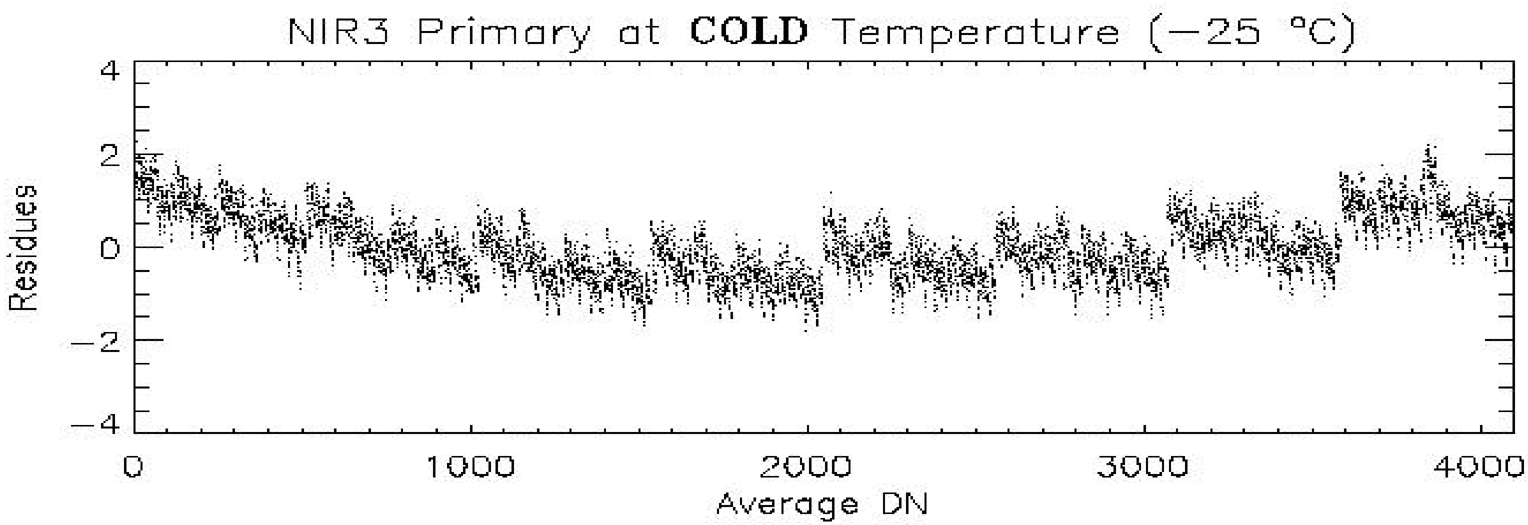
PC Bands ADC Conversion Time: 15 μs

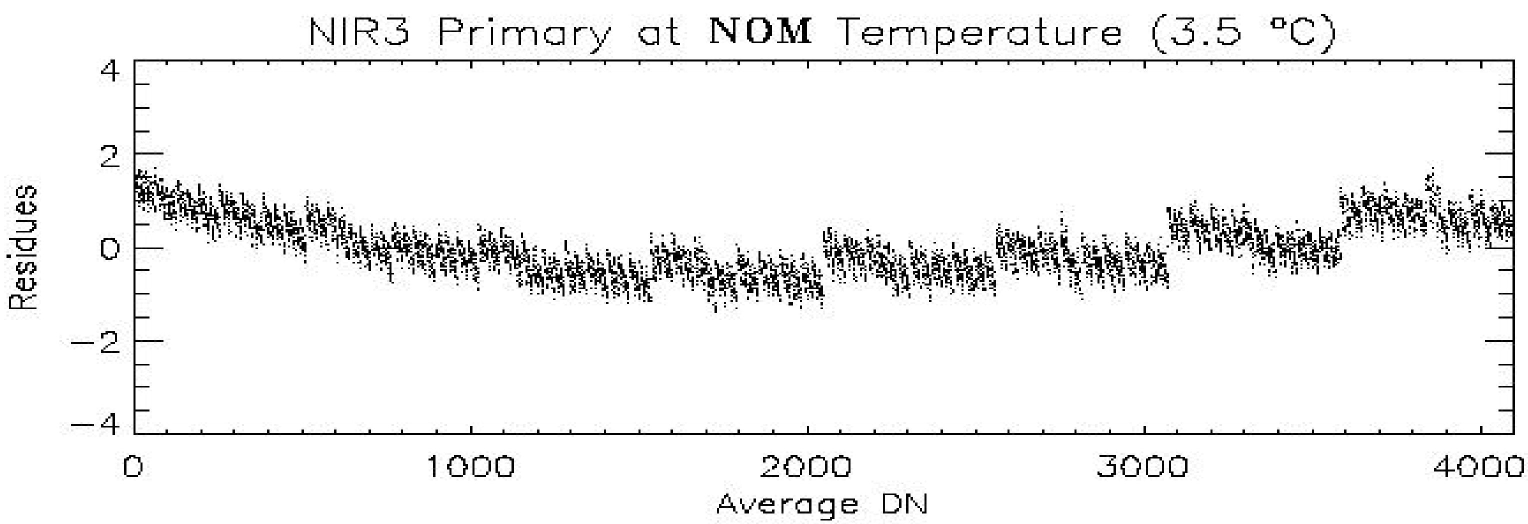
p / r: primary / redundant

Component Level Testing

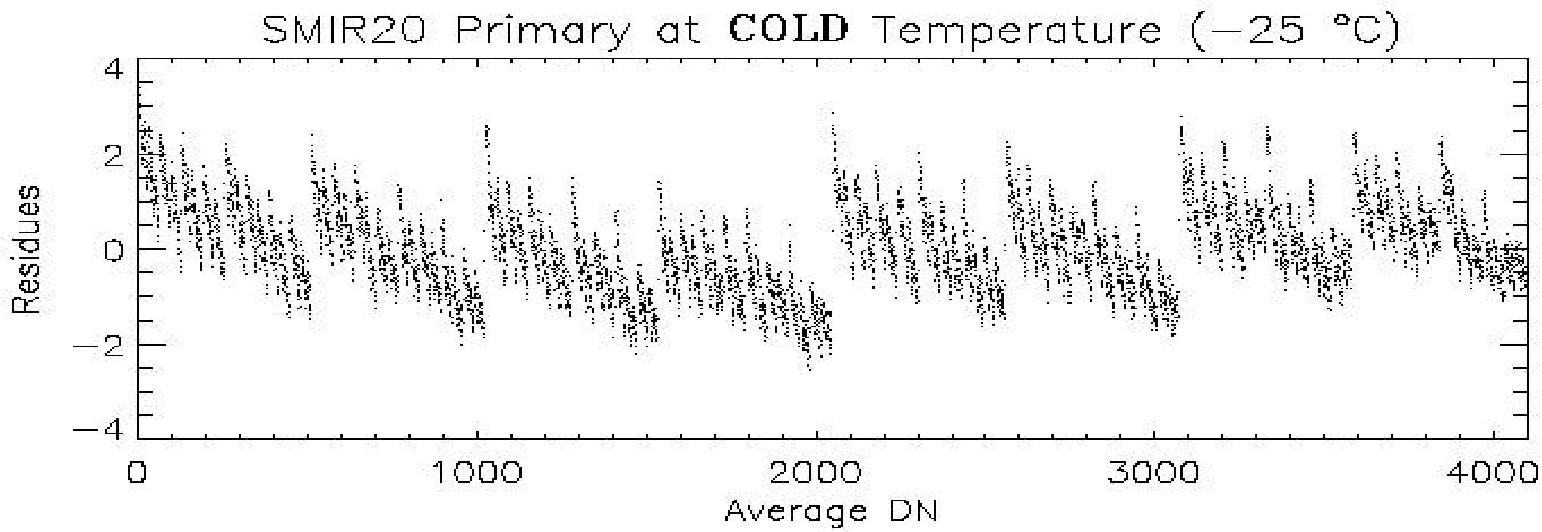
- 16-bit DAC used as calibrator for the 12-bit ADC
- Minimum 2 DAC steps for each of the ADC DN step (level)
- Averaging 200 - 400 samples per DAC step
- BFSL method used to fit the averaged ADC DN data set -> Integral Non-linearity (INL)
- No test for LWIR PC bands ADCs
- Periodic pattern observed

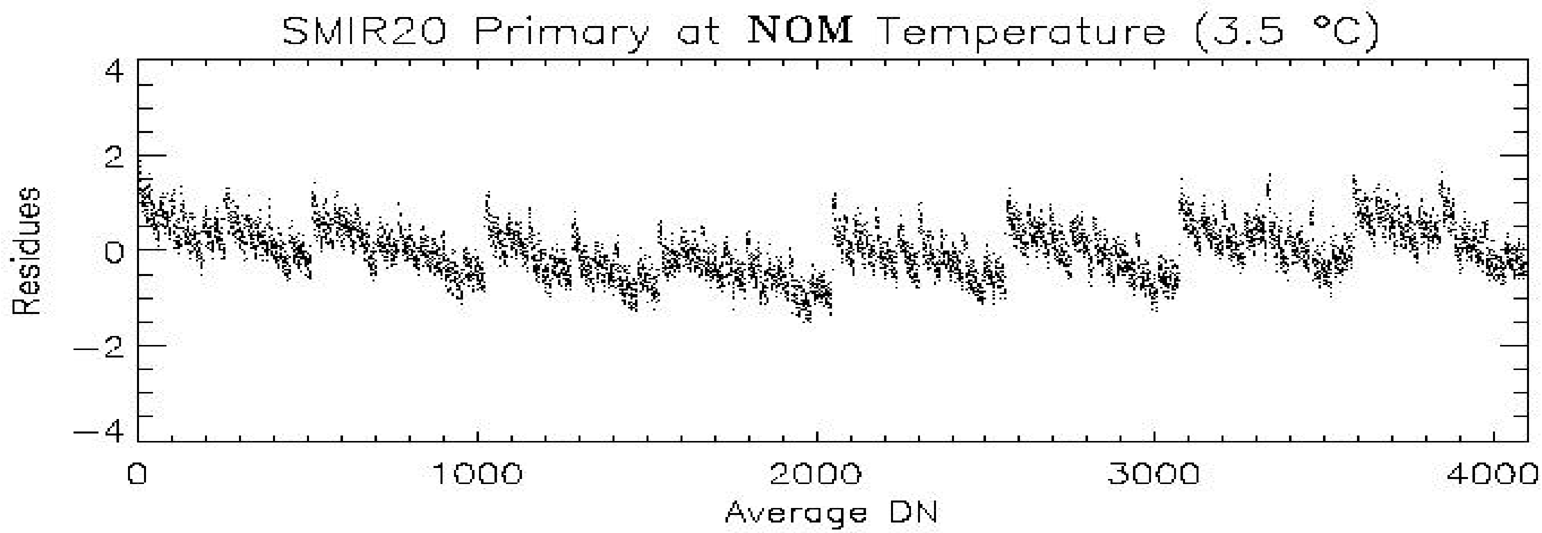
Component Level Testing



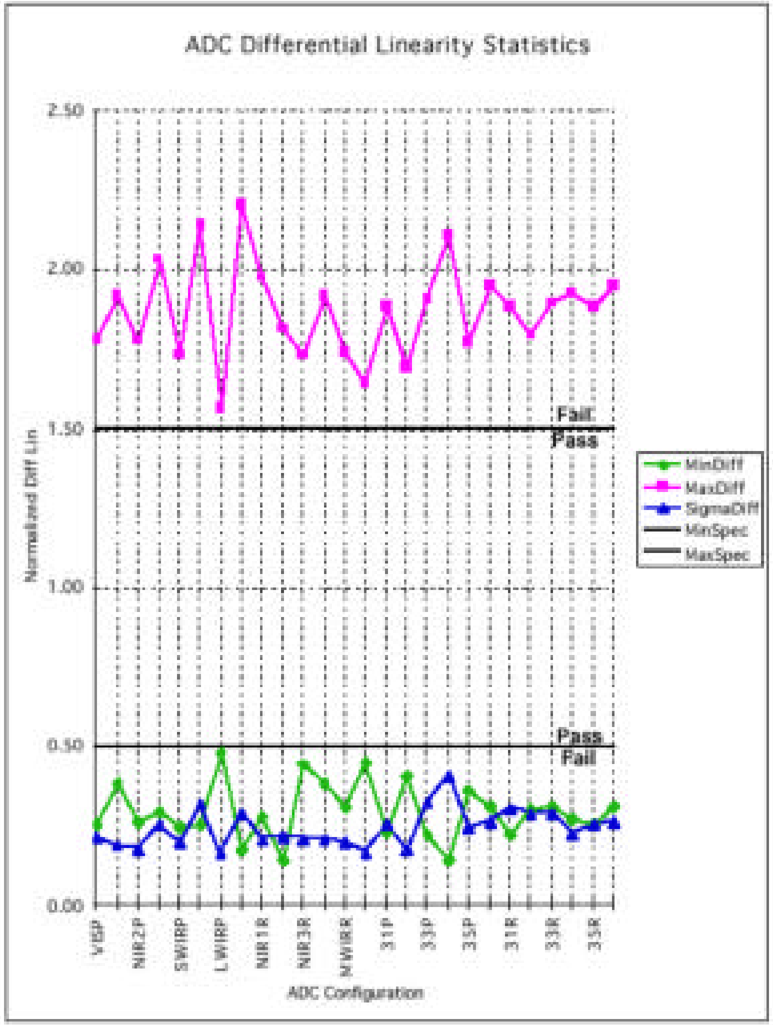


Component Level Testing





3.4.3. Waiver 056: Differential Nonlinearity

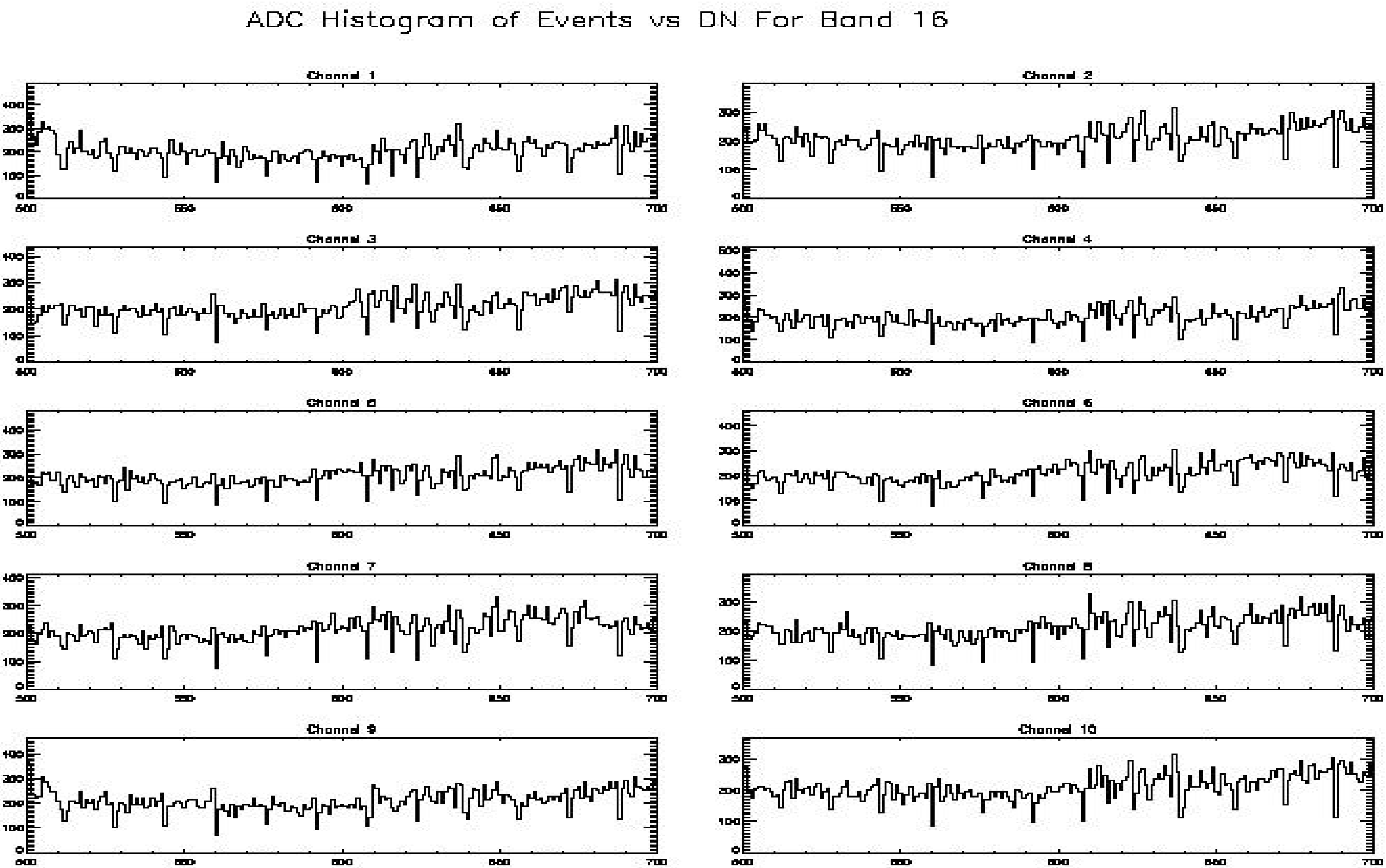


This EPS image does not contain a screen preview.
It will print correctly to a PostScript printer.
File Name : SMIR20R.EPS
Creator : GRAF/DRIVE PLUS

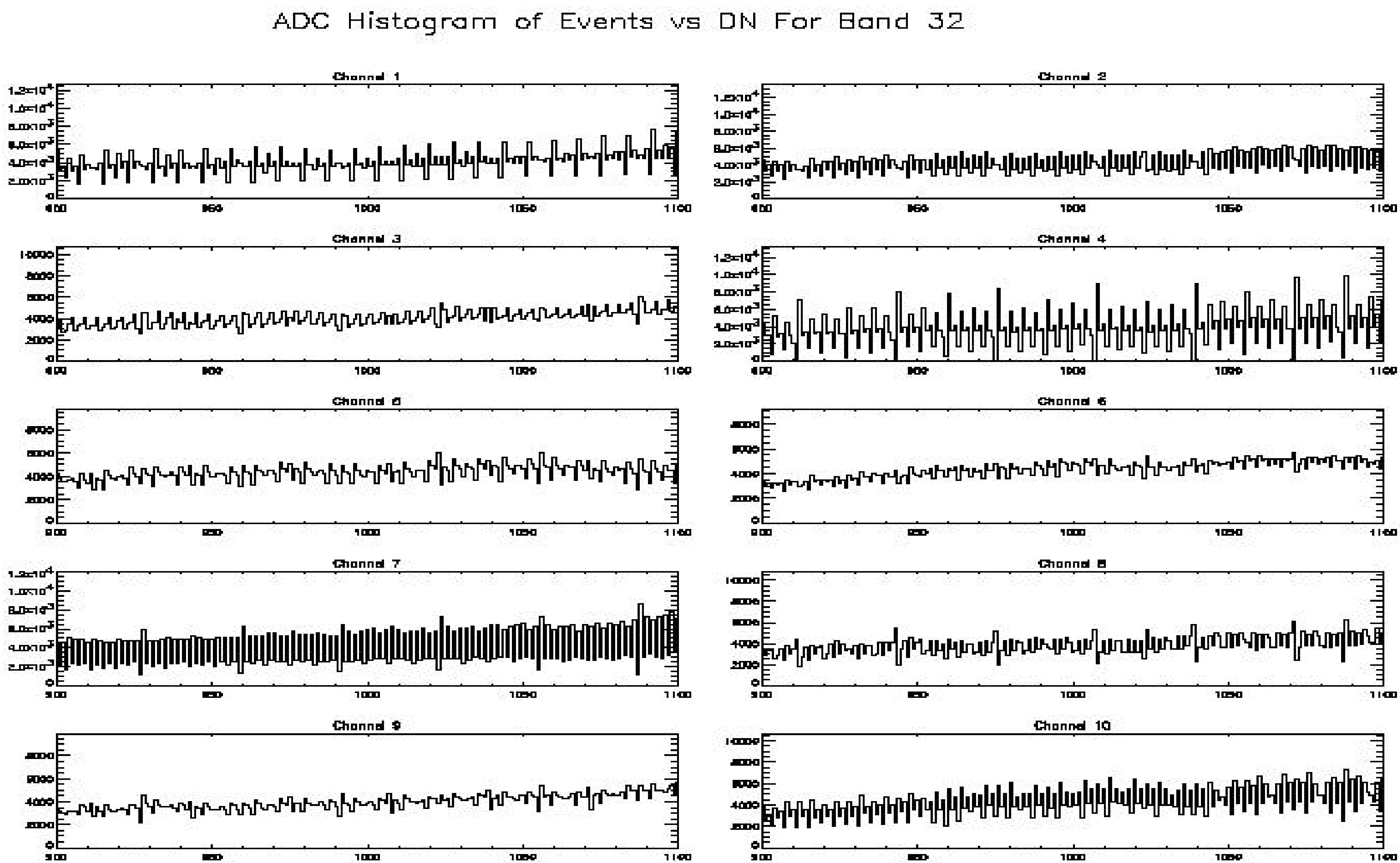
On-orbit ADC Performance

- MCST EV data histogram for RSB and TEB
  - Some periodic patterns observed
  - PC bands (B31-36) show same channel dependent structure
- B-side (day 313, 25 granules) and A-side (day 77, 12 granules) show similar histogram

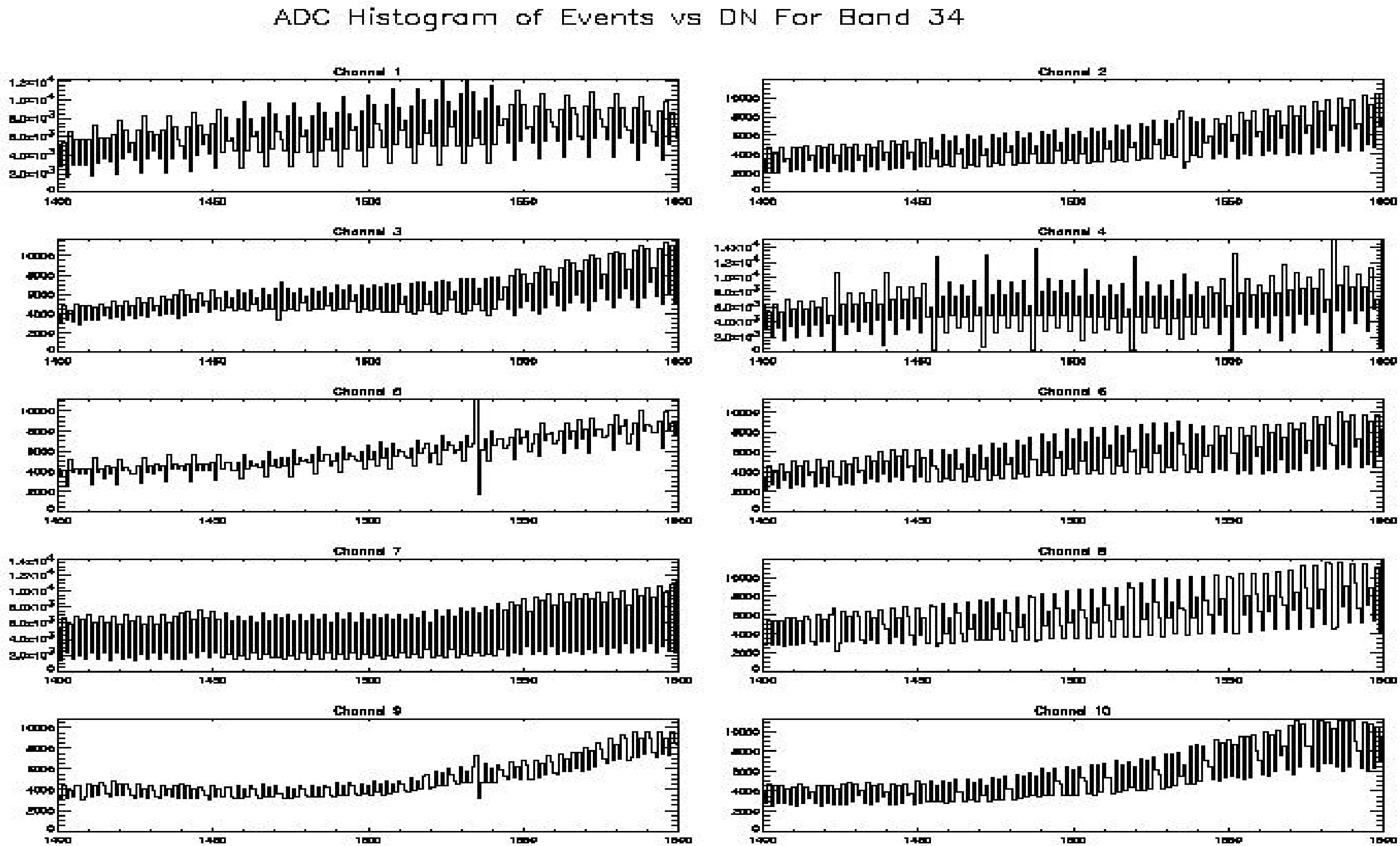
A-Side


ADC Histogram of Events vs DN For Band 16
Channel 1
Channel 2
Channel 3
Channel 4
Channel 6
Channel 7
Channel 9
Channel 10

A-Side

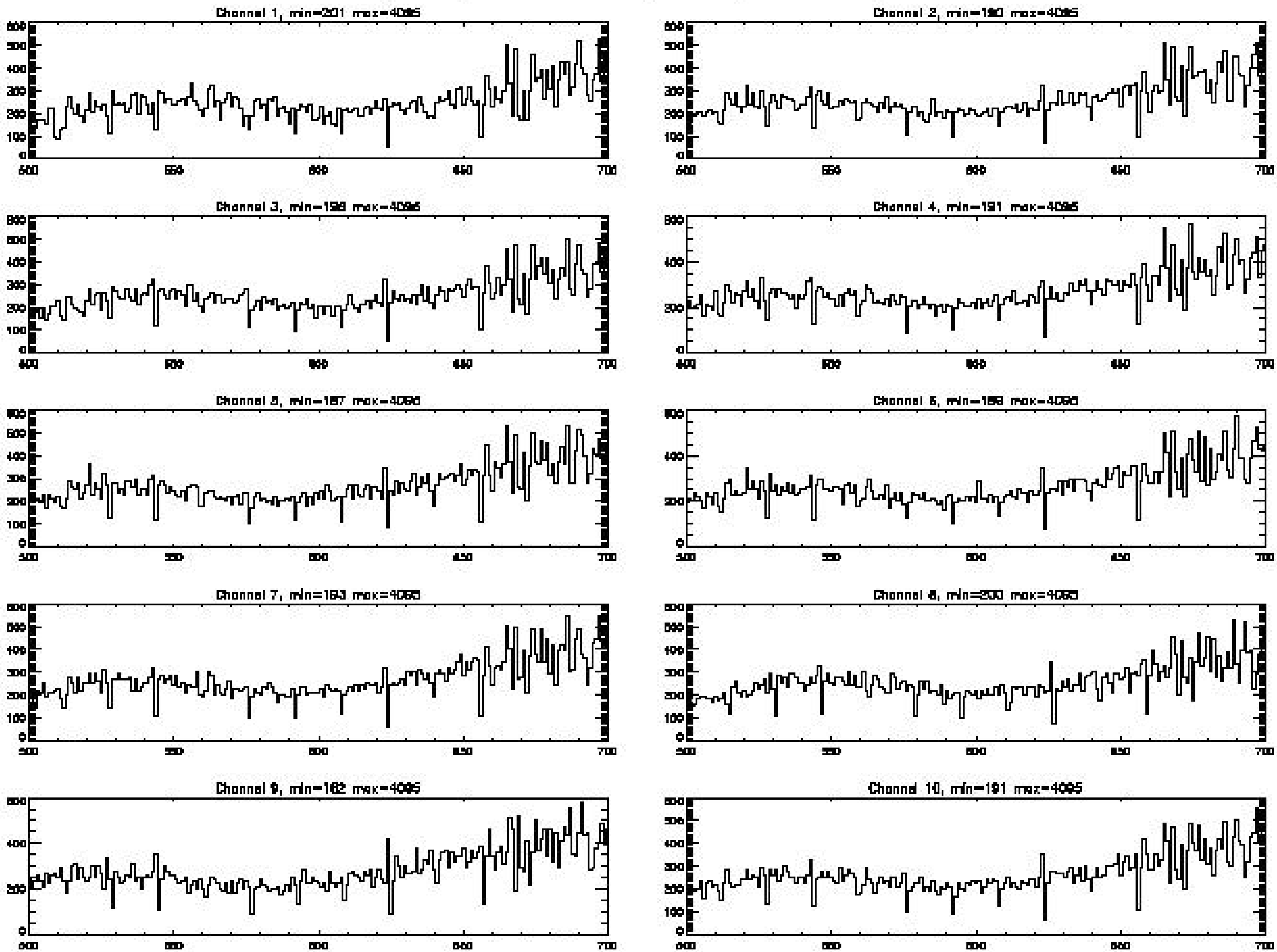

ADC Histogram of Events vs DN For Band 32
Channel 1
Channel 2
Channel 3
Channel 4
Channel 5
Channel 6
Channel 7
Channel 8
Channel 9
Channel 10

A-Side


ADC Histogram of Events vs DN For Band 34
Channel 1
Channel 2
Channel 3
Channel 4
Channel 5
Channel 6
Channel 7
Channel 8
Channel 9
Channel 10

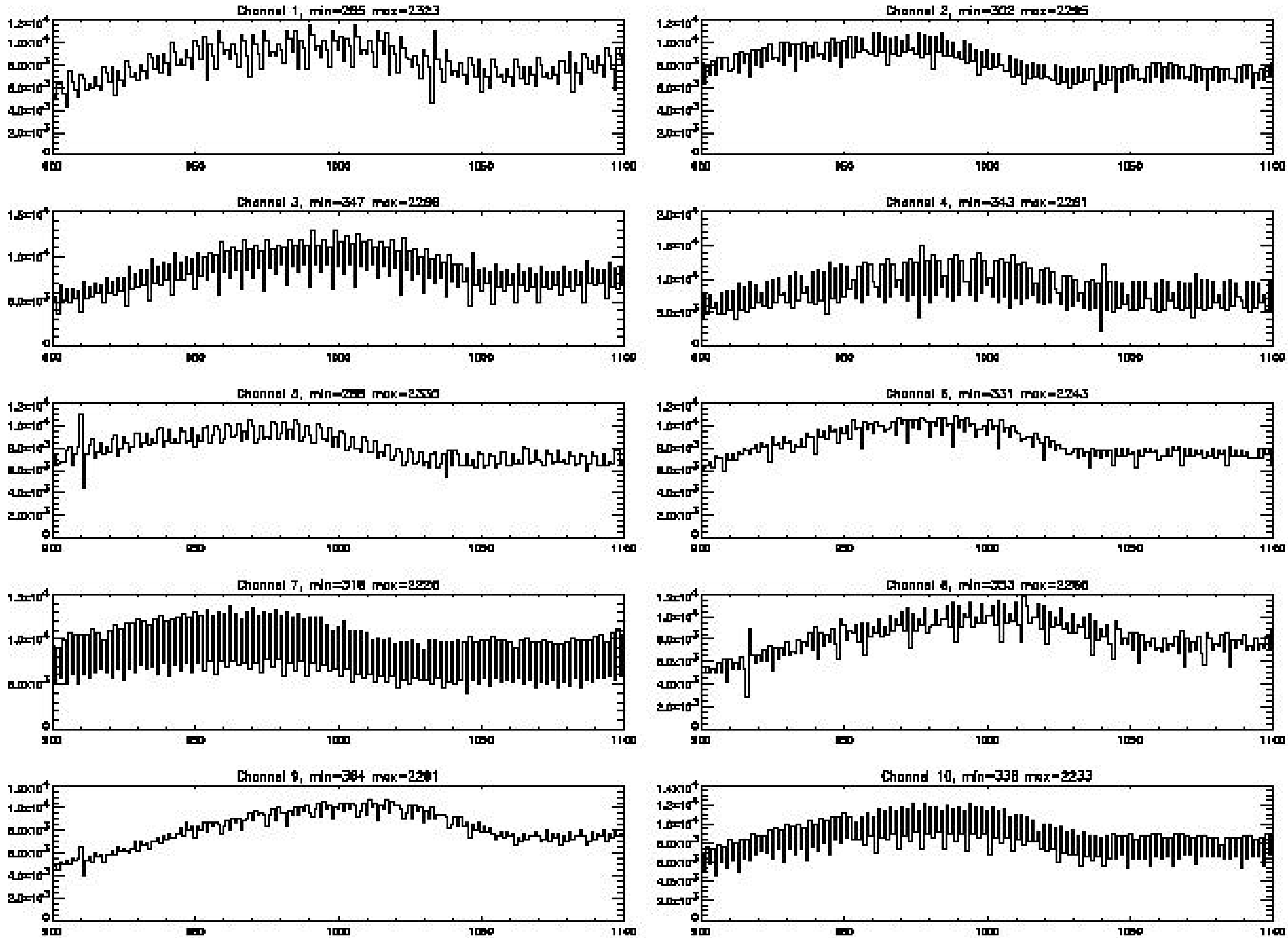
MODIS ADC vs Events for Band 16

Bside, Day313(08:20–10:20), ltwk/Vedt=79/110



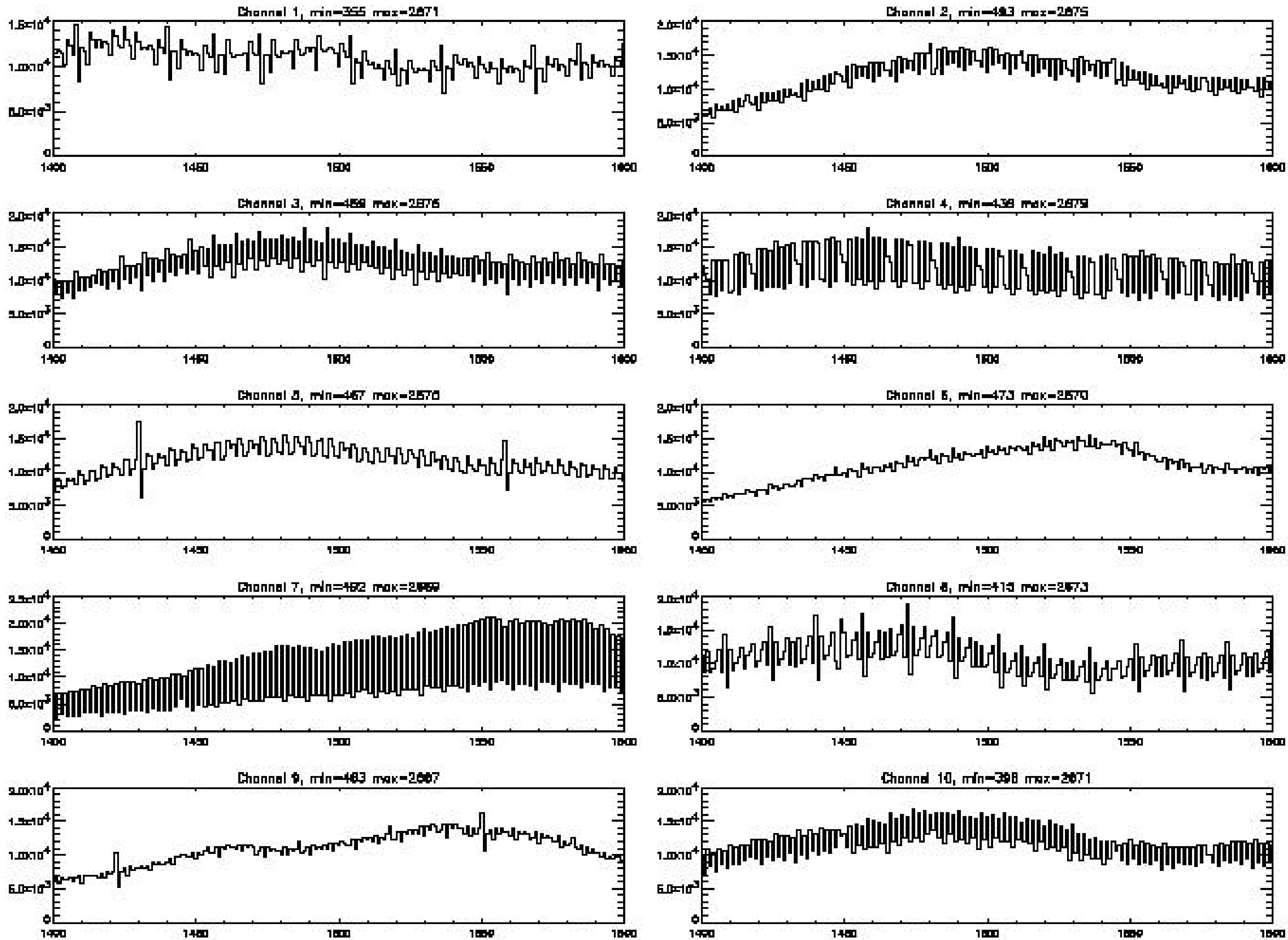
MODIS ADC vs Events for Band 32

Bside, Day313(08:20–10:20), ltwk/Vedt=79/110



MODIS ADC vs Events for Band 34

Bside, Day313(08:20-10:20), Itwk/Vedt=79/110



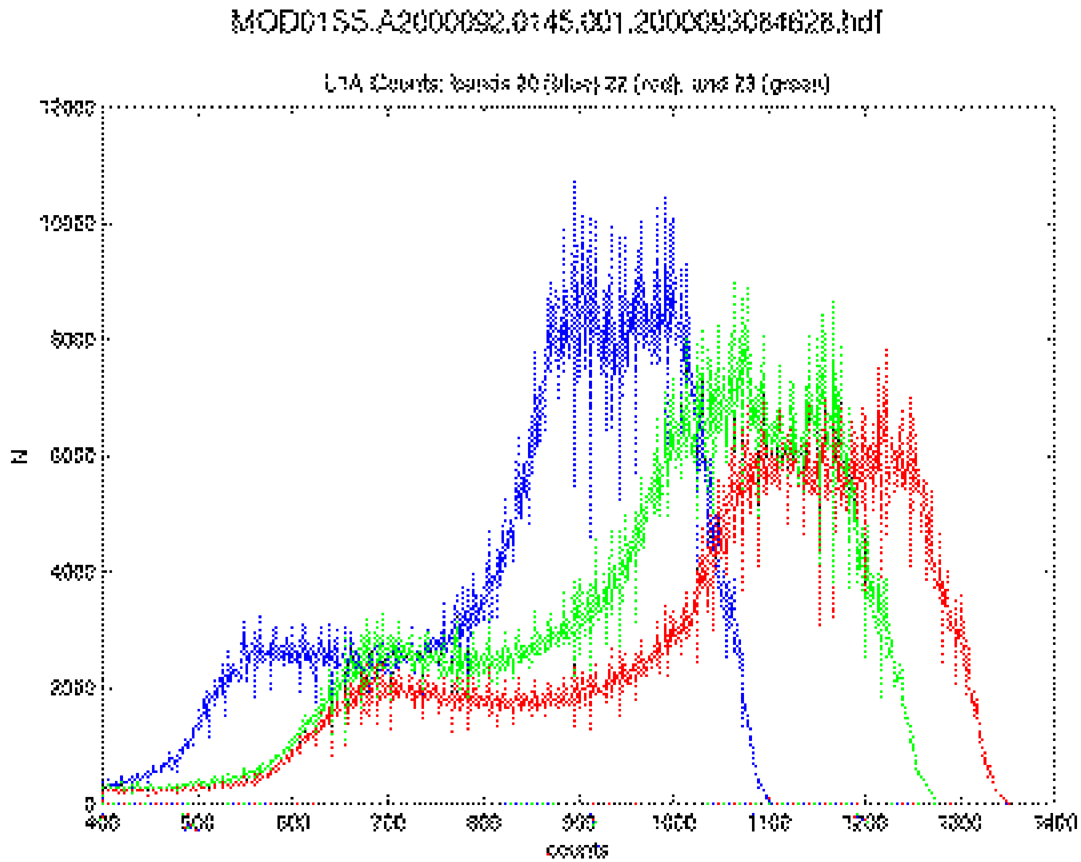


Figure 1. Histogram of the occurrence of digital counts in Bands 20, 22 and 23 at Level 1a processing for one granule. Output from all channels (detectors) are shown. (U. Miami/Minnett, et. al.

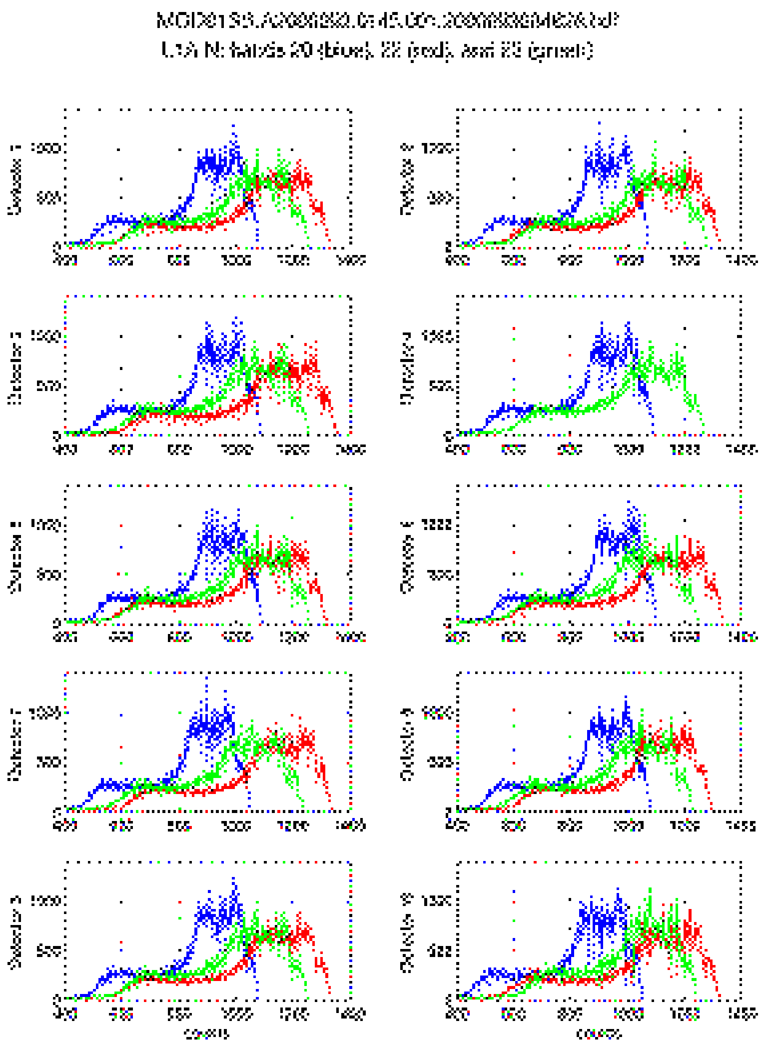


Figure 4. As figure 1, but output from each channel (detector) shown separately. Note the output from detector 4 of band 22 is biased off-scale. (U. Miami/ Minnett, et. al.

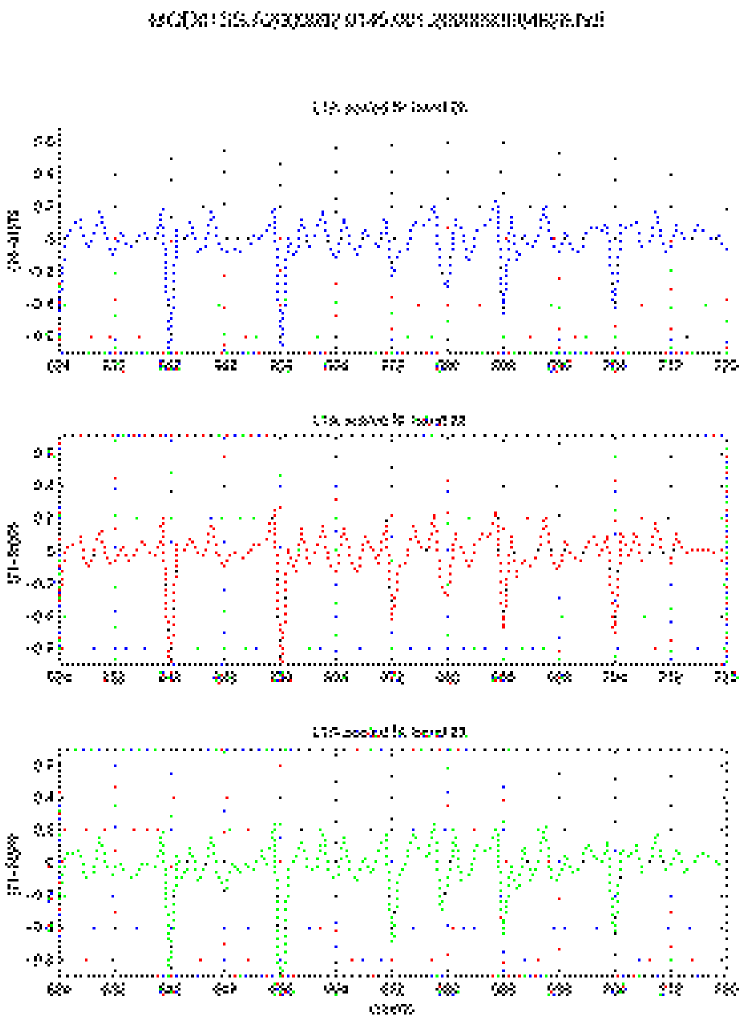


Figure 3. As Figure 2, but on an expanded horizontal scale. (U. Miami/Minnett, et. al.)

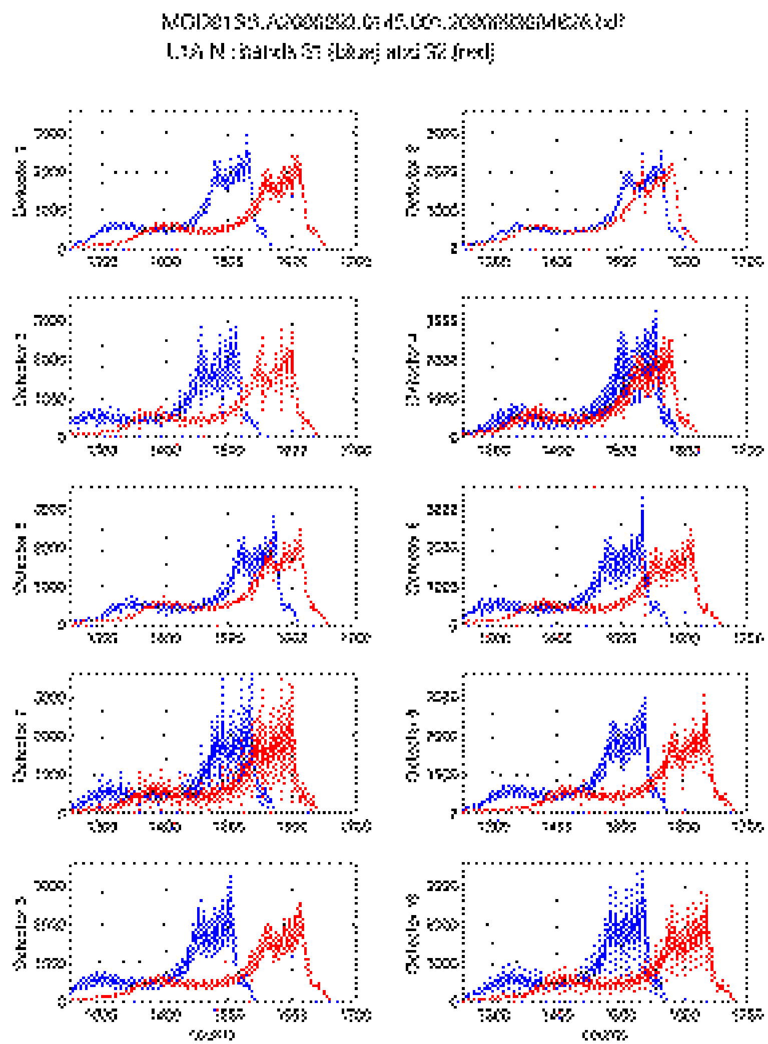
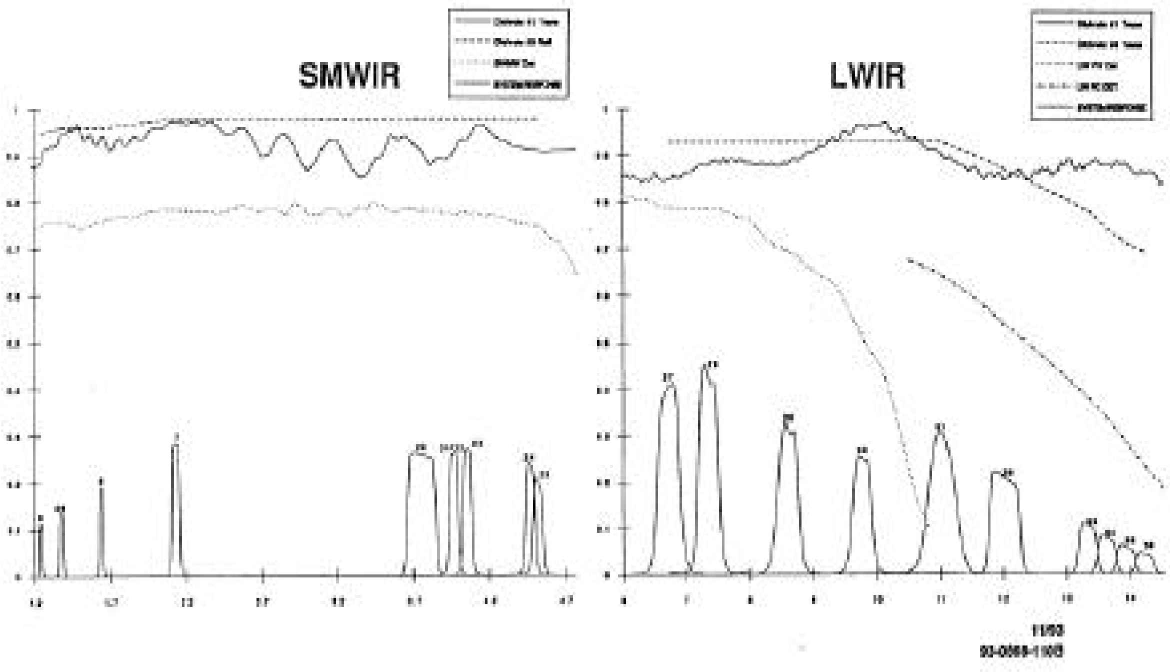


Figure 15. As figure 12, but output from each channel (detector) shown separately. (U. Miami/Minnett, et. al.)

MODEL IDENTIFIES KEY CONTRIBUTORS TO SYSTEM WAVELENGTH, TRANSMISSION (SMWIR, LWIR)

HUGHES

SANTA BARBARA RESEARCH CENTER



Note: Model anticipates SW/MWIR detector roll-off at 4.7 µm

On-orbit to Pre-launch 500m m_1 Coefficients

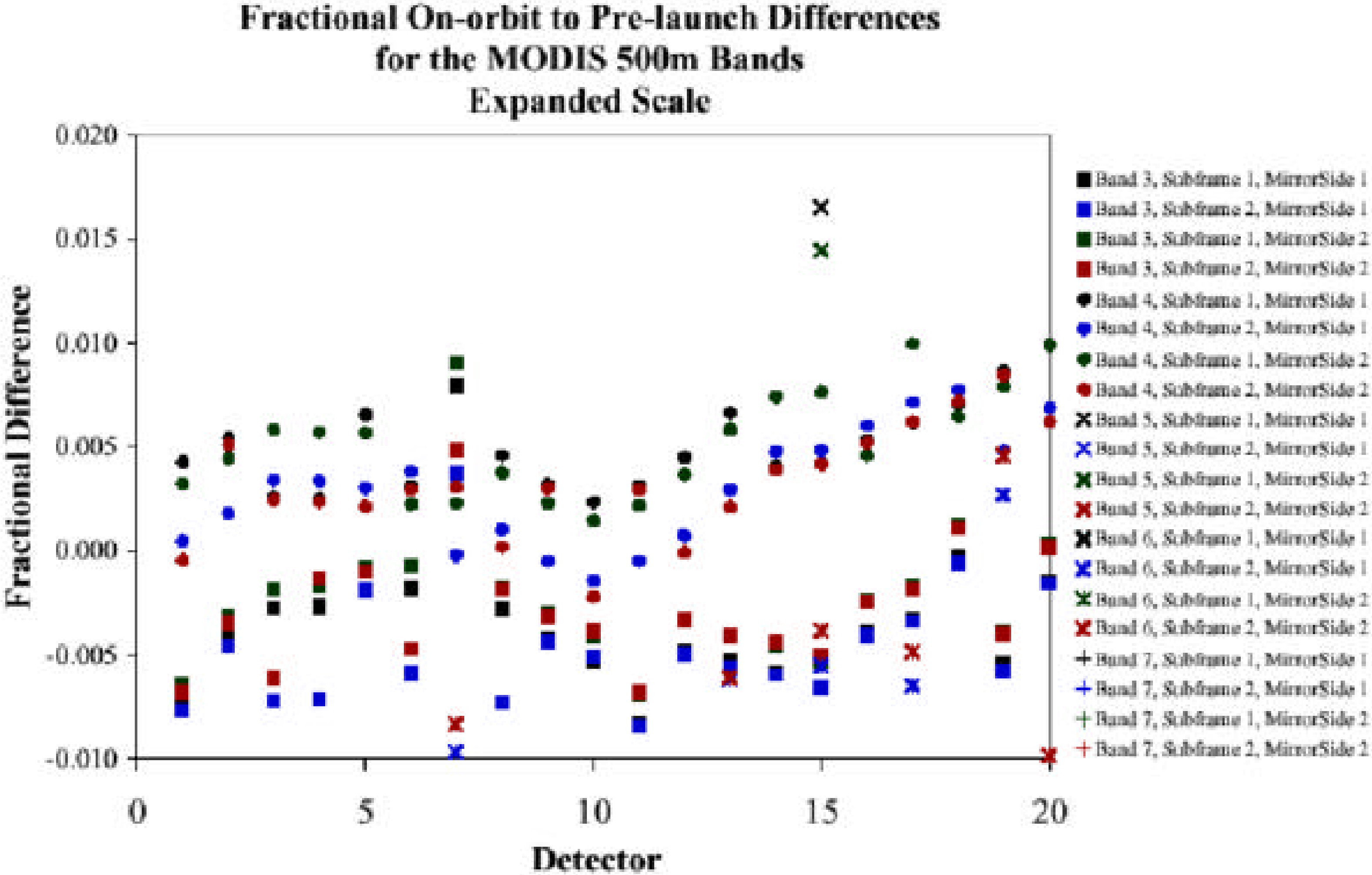
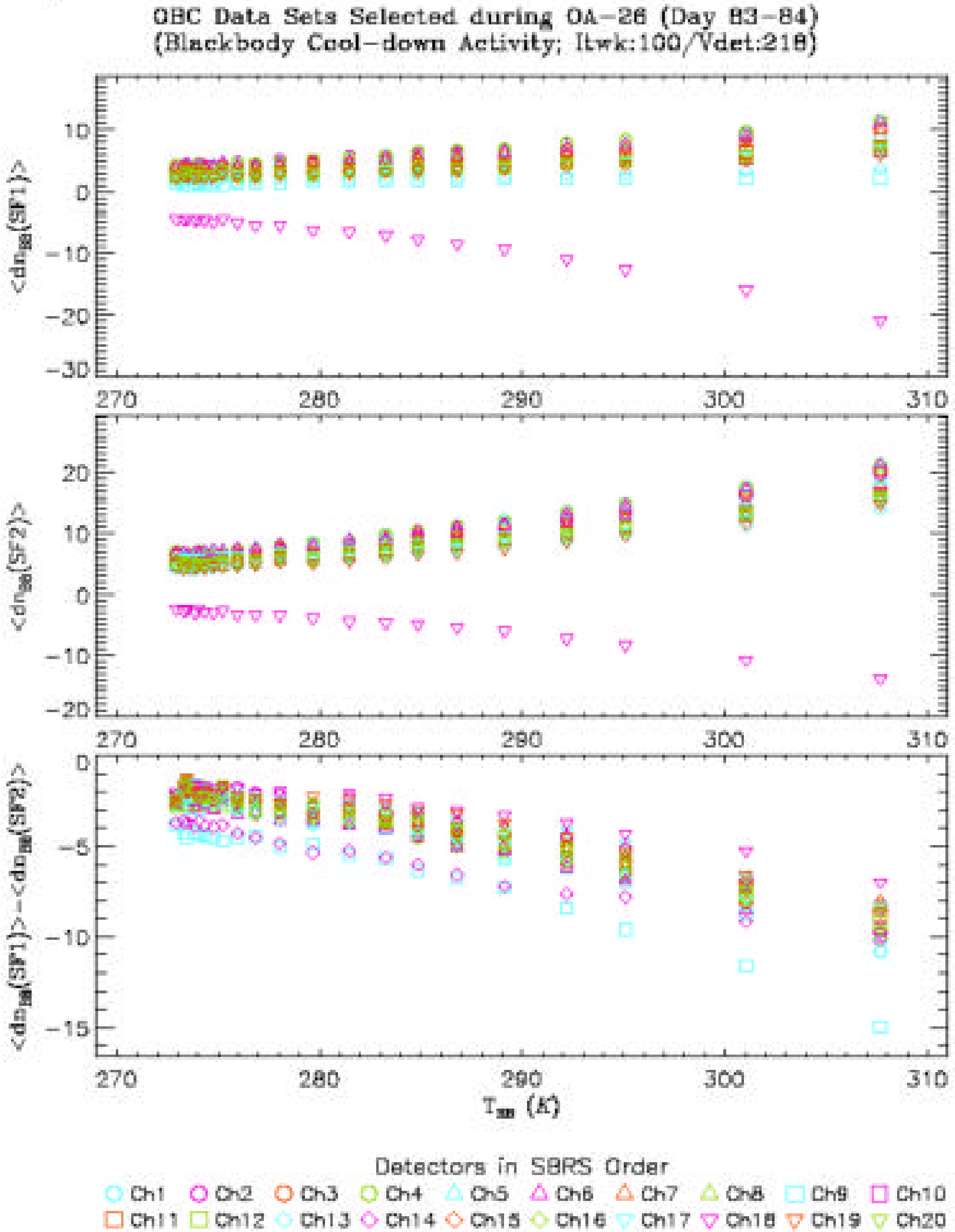
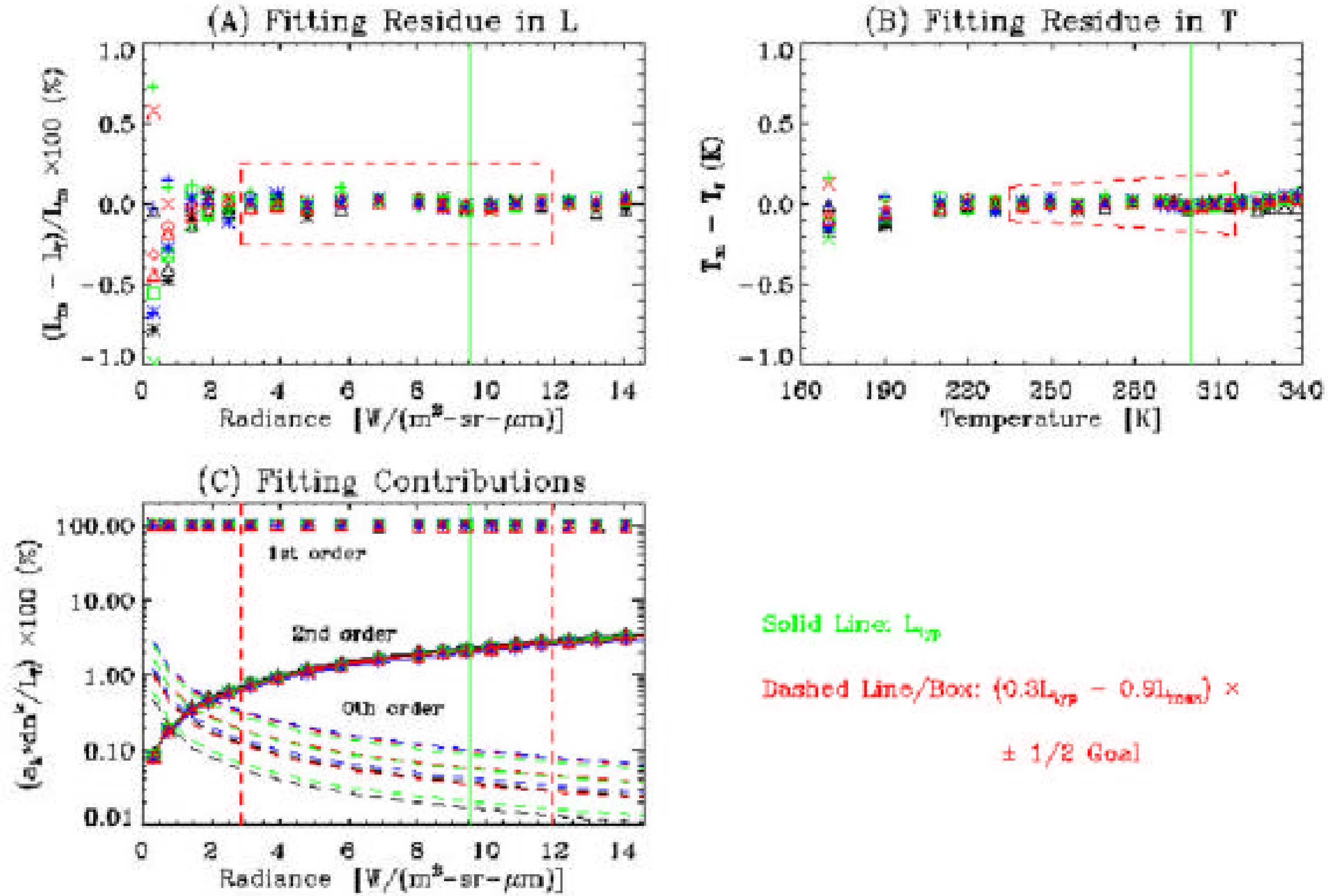
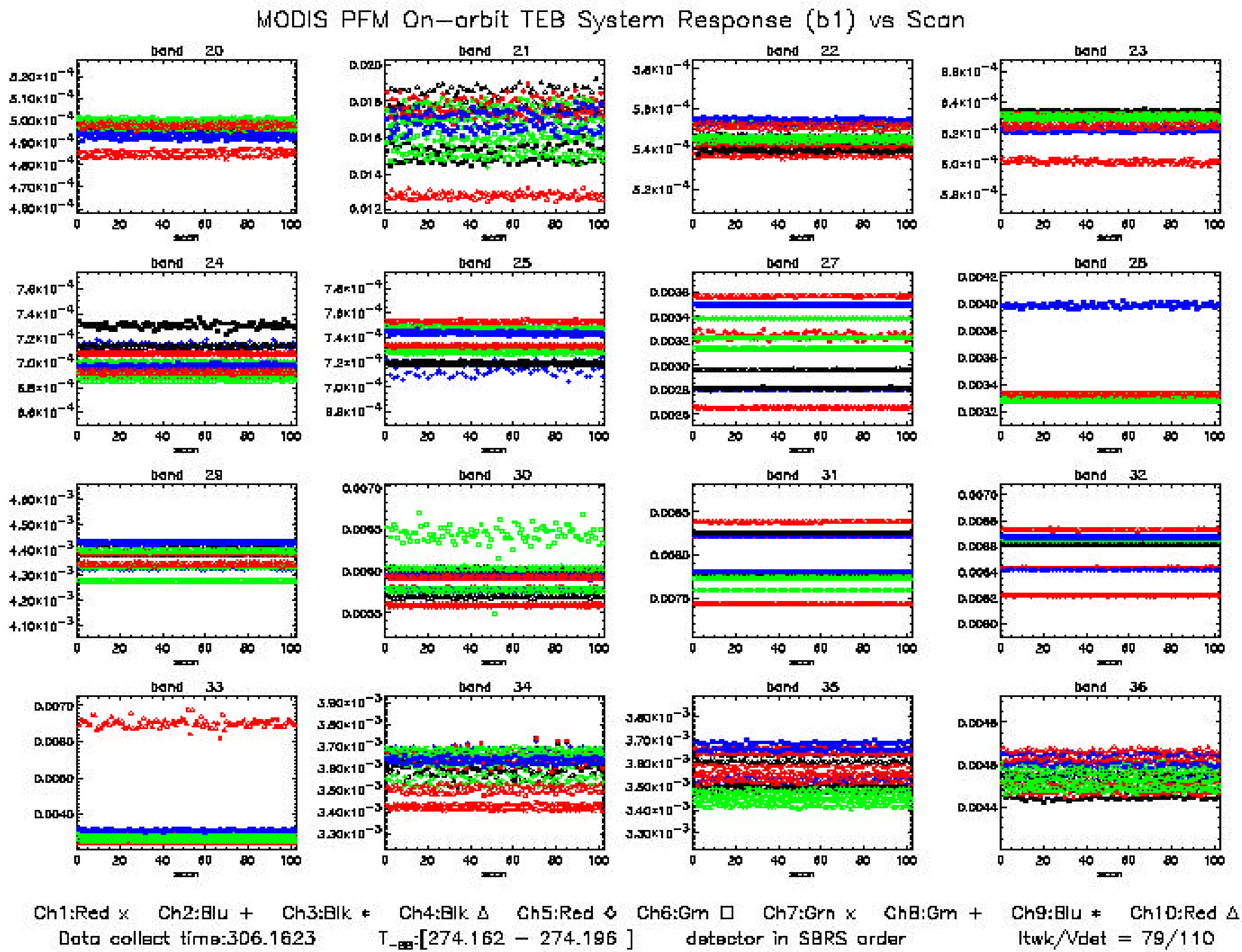


Figure 2. PFM B6 $<dn_{BB}>$ of Sub-frame 1, 2, and their Difference

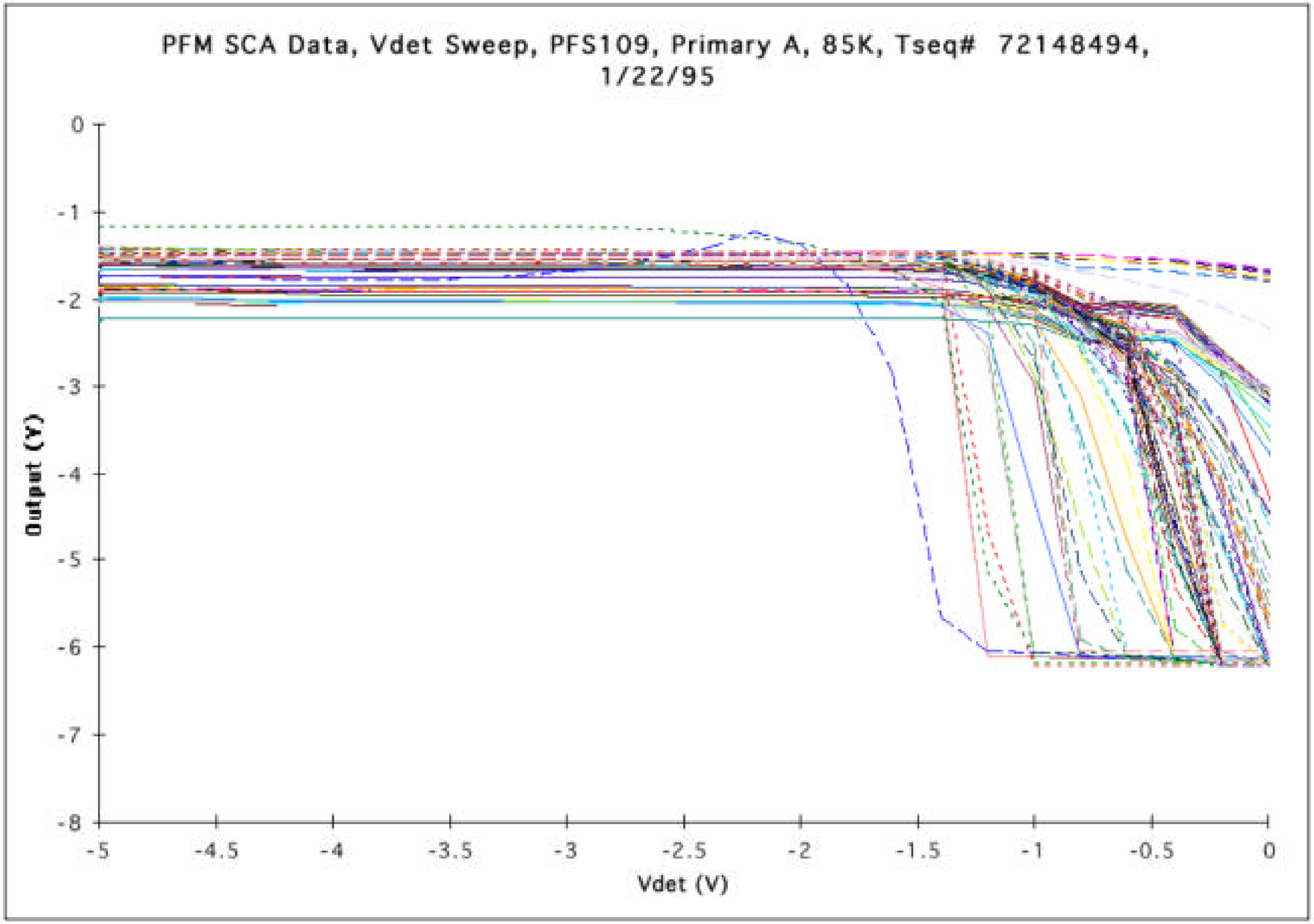


B31 (11.0 μm) L vs DN Quadratic Fitting Results at Nominal Plateau (273 K)



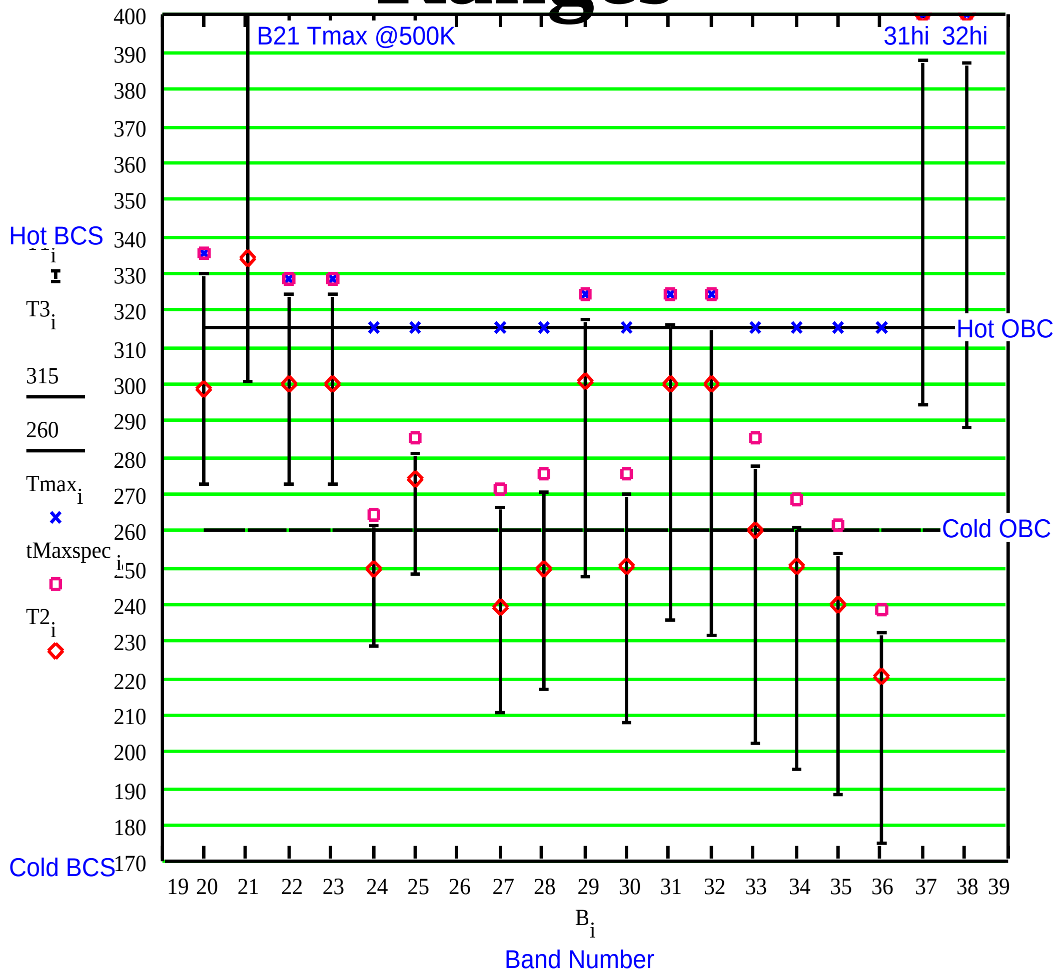


MODIS PFM On-orbit TEB System Response (b1) vs Scan
band 20
band 21
band 22
band 23
band 24
band 25
band 27
band 28
band 29
band 30
band 31
band 32
band 33
band 34
band 35
band 36
scan
Ch1:Red x Ch2:Blu + Ch3:Blk * Ch4:Blk Δ Ch5:Red ◇ Ch6:Grn □ Ch7:Grn x Ch8:Grn + Ch9:Blu * Ch10:Red Δ
Data collect time:306.1623 T_BB:[274.162 - 274.196] detector in SBRS order Itwk/Vdet = 79/110


PFM SCA Data, Vdet Sweep, PFS109, Primary A, 85K, Tseq# 72148494, 1/22/95
Output (V)
Vdet (V)
0
-1
-2
-3
-4
-5
-6
-7
-8
-5
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0

EXTK-A7

MODIS Operational and Calibration Ranges

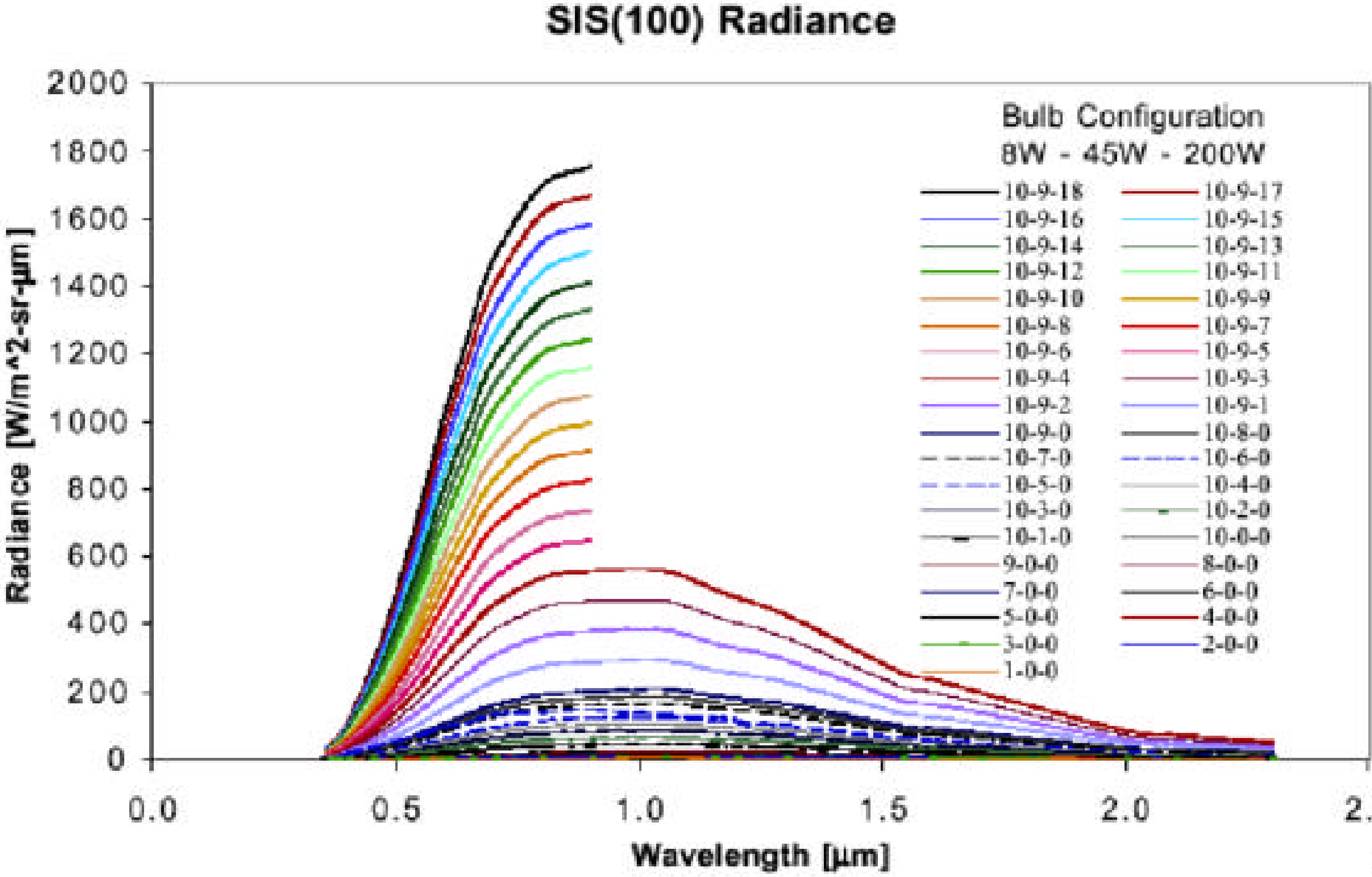


Vertical bars represent temperatures of 0.3Ltyp and 0.9 Lmax. Box symbols represent Tmax_spec, X symbols represent the value of Tmax_set (the higher of tMaxspec or 315K), and the diamond symbols represent the temperature of Ltyp.

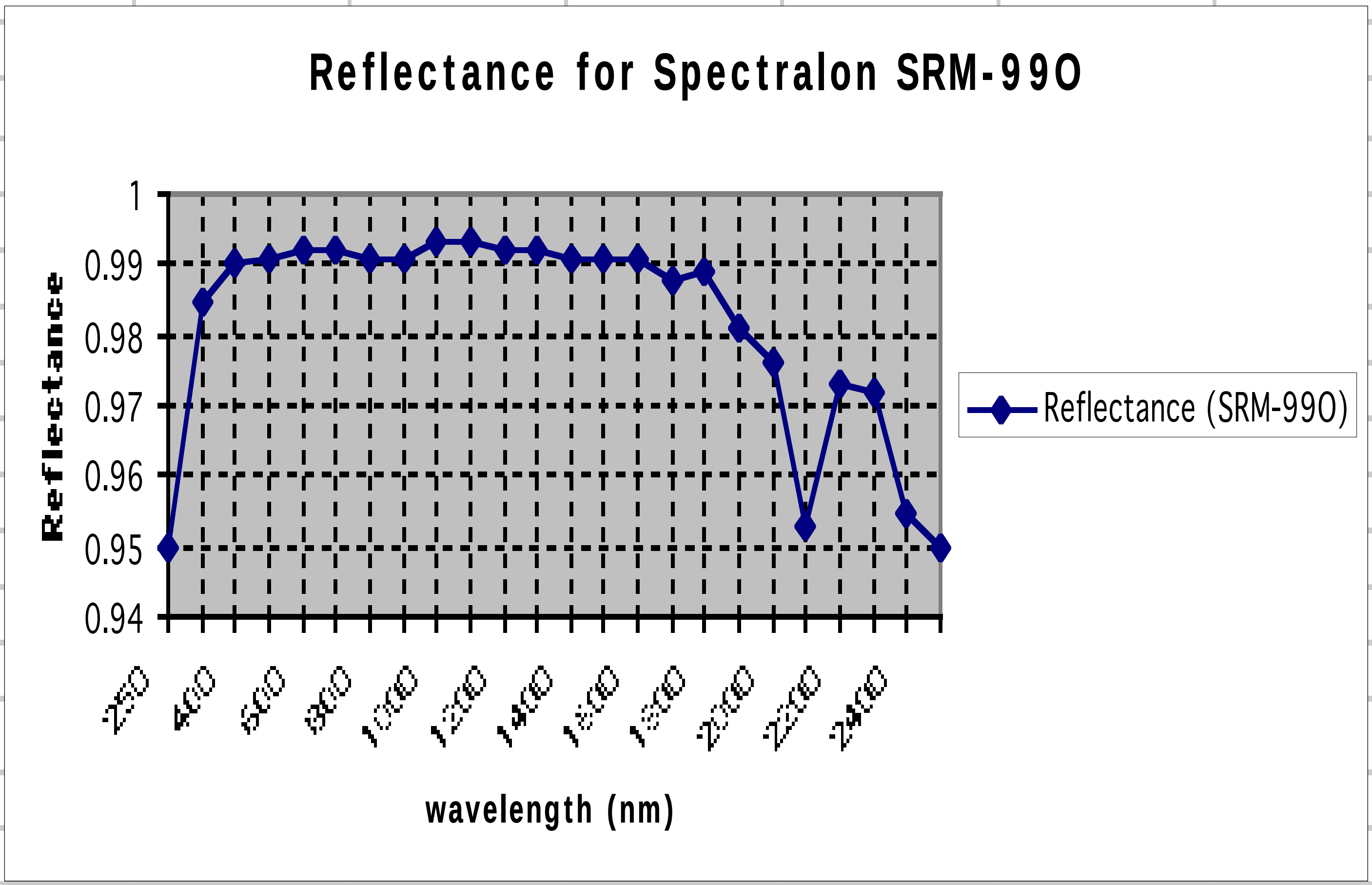
RSB
SIS-100 Round Robin (RR)

- SIS(100) was calibrated at SBRS for the RR in 1996 (PFM) and 1998 (FM1)
- Due to burnout of the 45W bulbs, the PFM SIS(100) calibration has not been RR validated
- The 1998 data has been turned in for the RR and the FM1 calibration will be RR validated when results are published.
- Preliminary results indicate consistency between NIST standards and the SBRS SIS(100) scale at about 2-3% for FM1 Testing

SBRS SIS(100) Radiance as used for FM1



Reflectance of MODIS Solar Diffuser Material



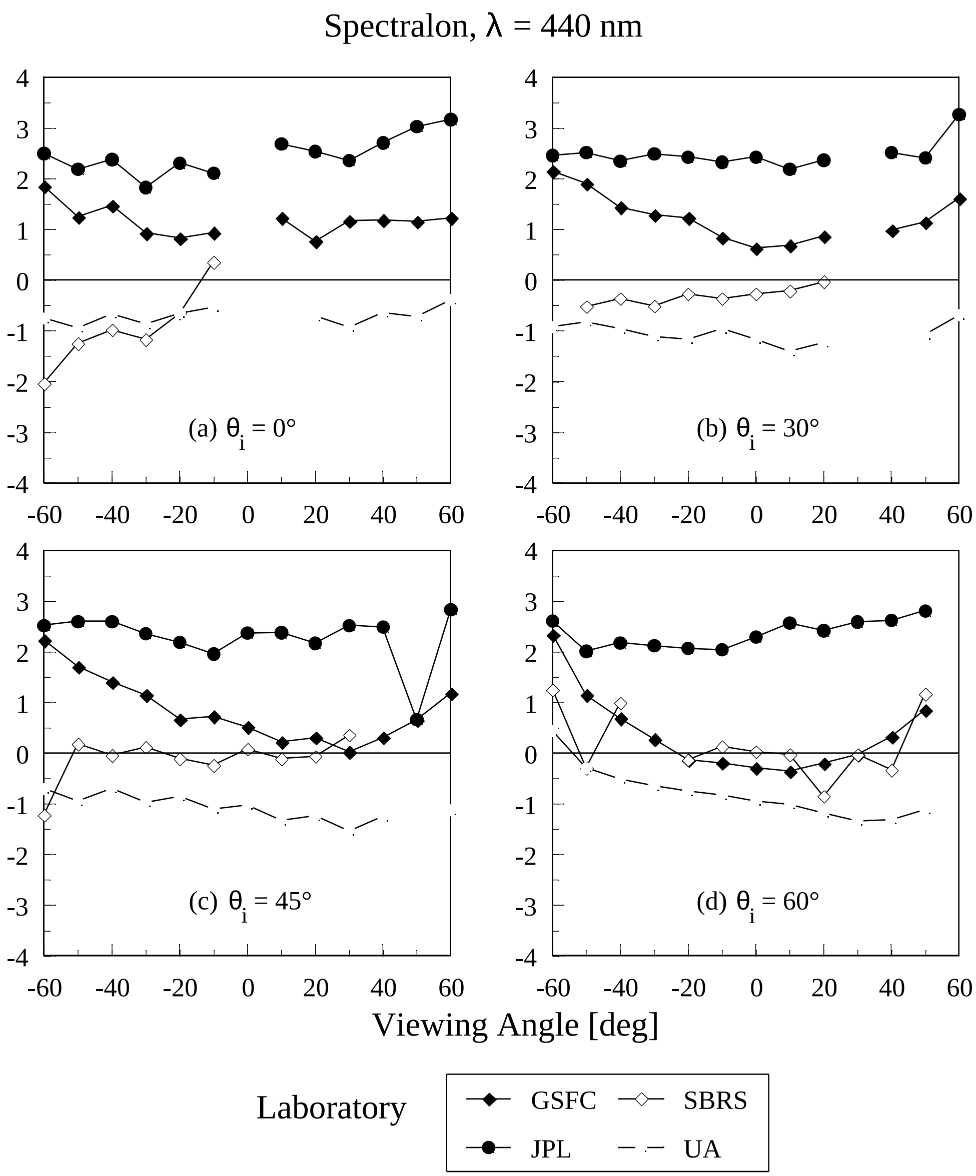


Figure 10. Difference of BRDF relative to the NIST value as a function of viewing angle for Spectralon at 440 nm. The incident angles are indicated in the panels, and the participants are given in the legend. From Early, et.al., J. A. O. Tech, **17**, 1077-1091 (2000)

Figure 10

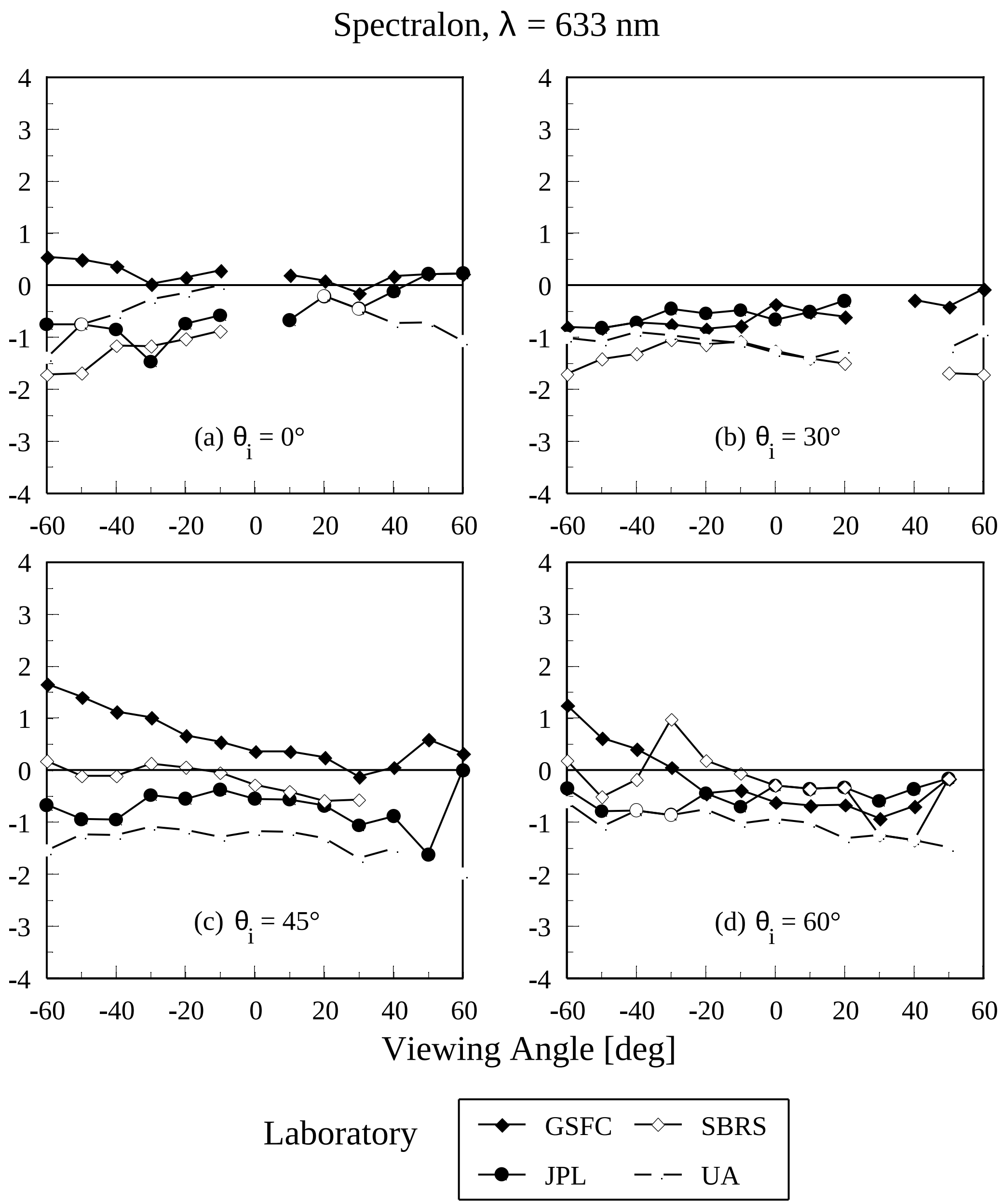


Figure 11. Difference of BRDF relative to the NIST value as a function of viewing angle for Spectralon at 633 nm. The incident angles are indicated in the panels, and the participants are given in the legend. From Early, et.al., J. A. O. Tech, **17**, 1077-1091 (2000)

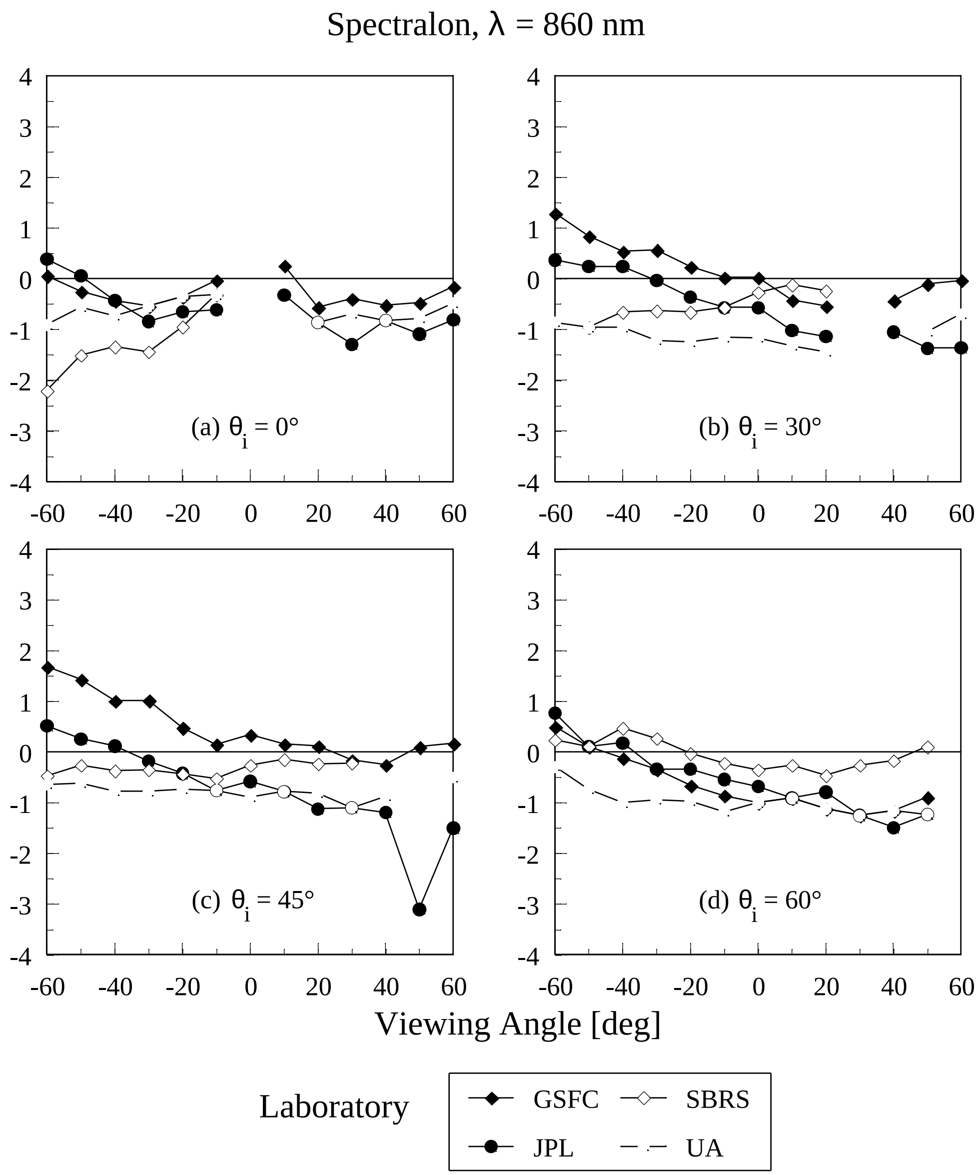


Figure 11. Difference of BRDF relative to the NIST value as a function of viewing angle for Spectralon at 633 nm. The incident angles are indicated in the panels, and the participants are given in the legend. From Early, et.al., J. A. O. Tech, **17**, 1077-1091 (2000)

Figure 12

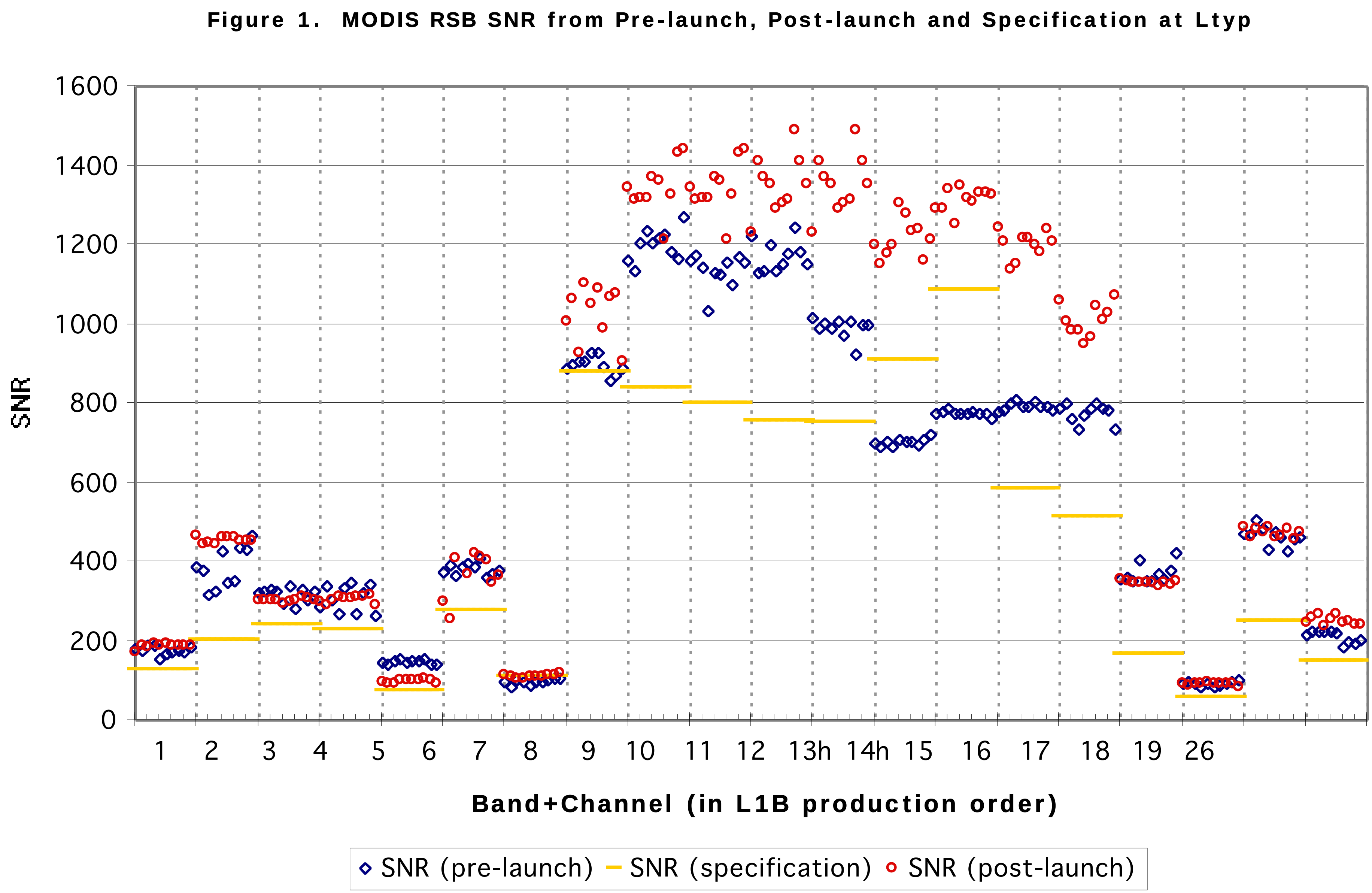
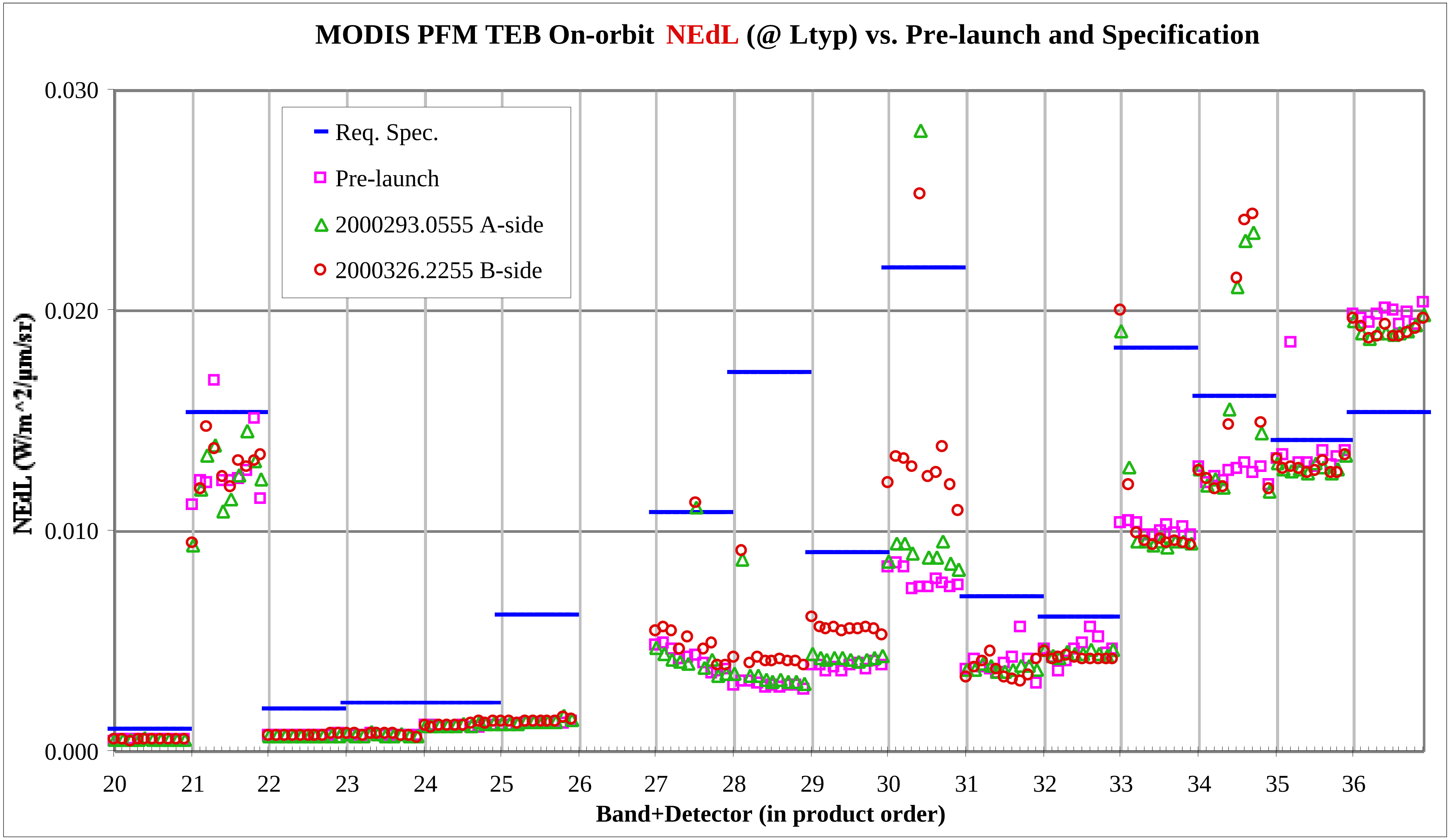
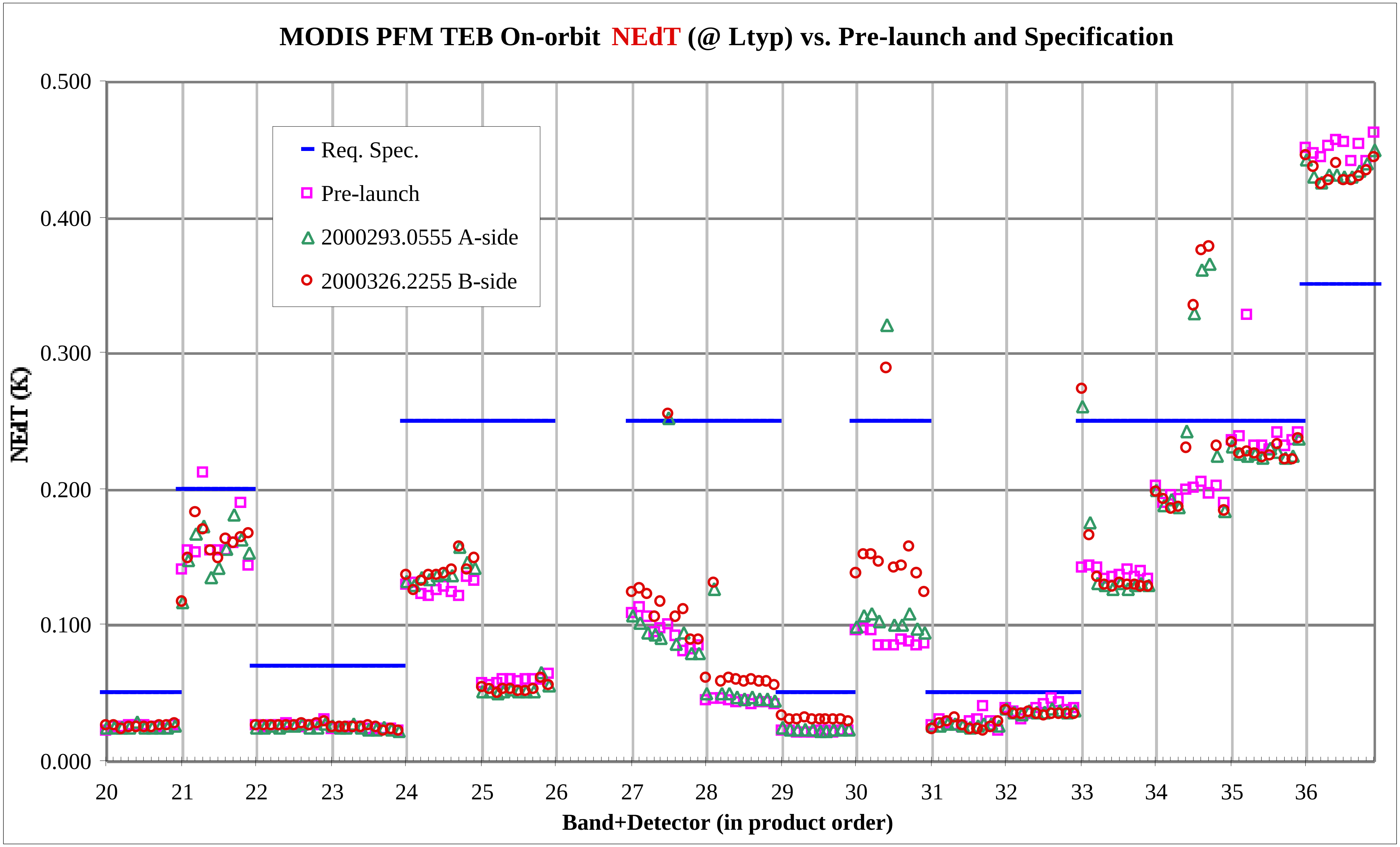


Figure 1. MODIS RSB SNR from Pre-launch, Post-launch and Specification at Ltyp
1600
1400
1200
1000
800
600
400
200
0
SNR
1 2 3 4 5 6 7 8 9 10 11 12 13h 14h 15 16 17 18 19 26
Band+Channel (in L1B production order)
SNR (pre-launch)
SNR (specification)
SNR (post-launch)


MODIS PFM TEB On-orbit NEdL (@ Ltyp) vs. Pre-launch and Specification
0.030
0.020
0.010
0.000
NEdL (W/m^2/µm/sr)
Req. Spec.
Pre-launch
2000293.0555 A-side
2000326.2255 B-side
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Band+Detector (in product order)



MODIS PFM TEB On-orbit NEdT (@ Ltyp) vs. Pre-launch and Specification
Req. Spec.
Pre-launch
2000293.0555 A-side
2000326.2255 B-side
NEdT (K)
0.500
0.400
0.300
0.200
0.100
0.000
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Band+Detector (in product order)

RADIOMETRIC CHARTS - Section 3

MODIS SOLAR DIFFUSER AND SOLAR VIEW DOOR ASSEMBLIES

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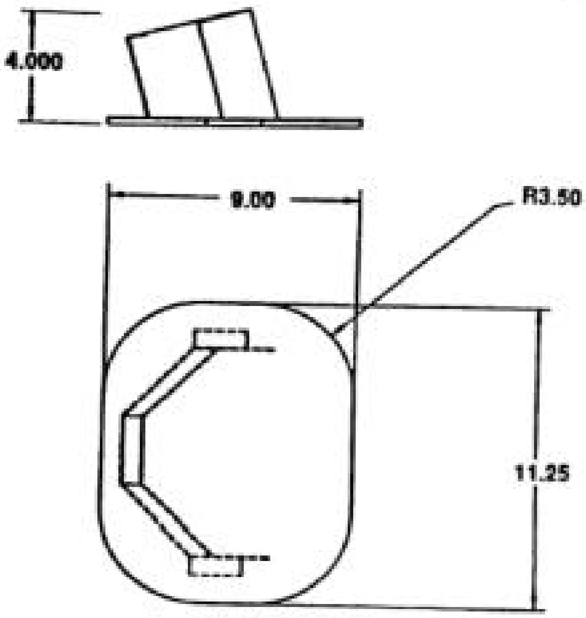
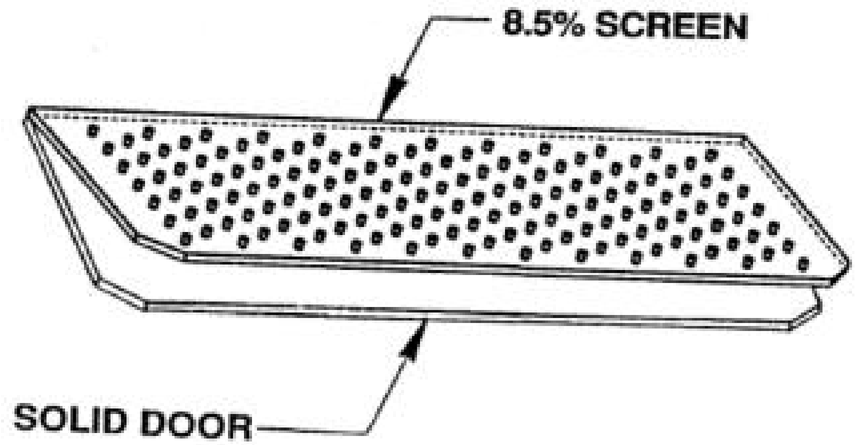


- BRDF: 0.315 sr
- EFFECTIVE ALBEDO: 53%

SOLAR DIFFUSER ASSEMBLY

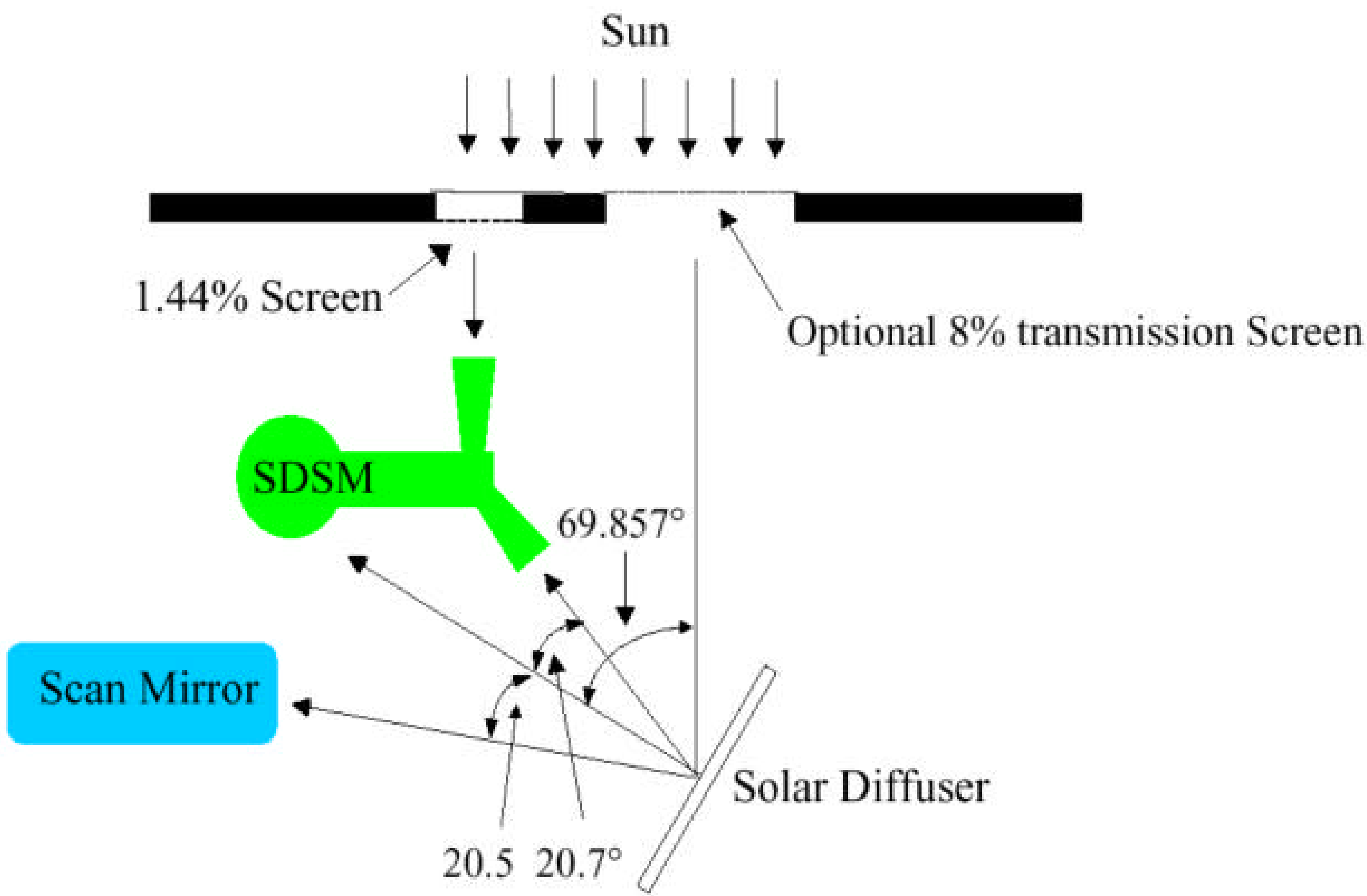


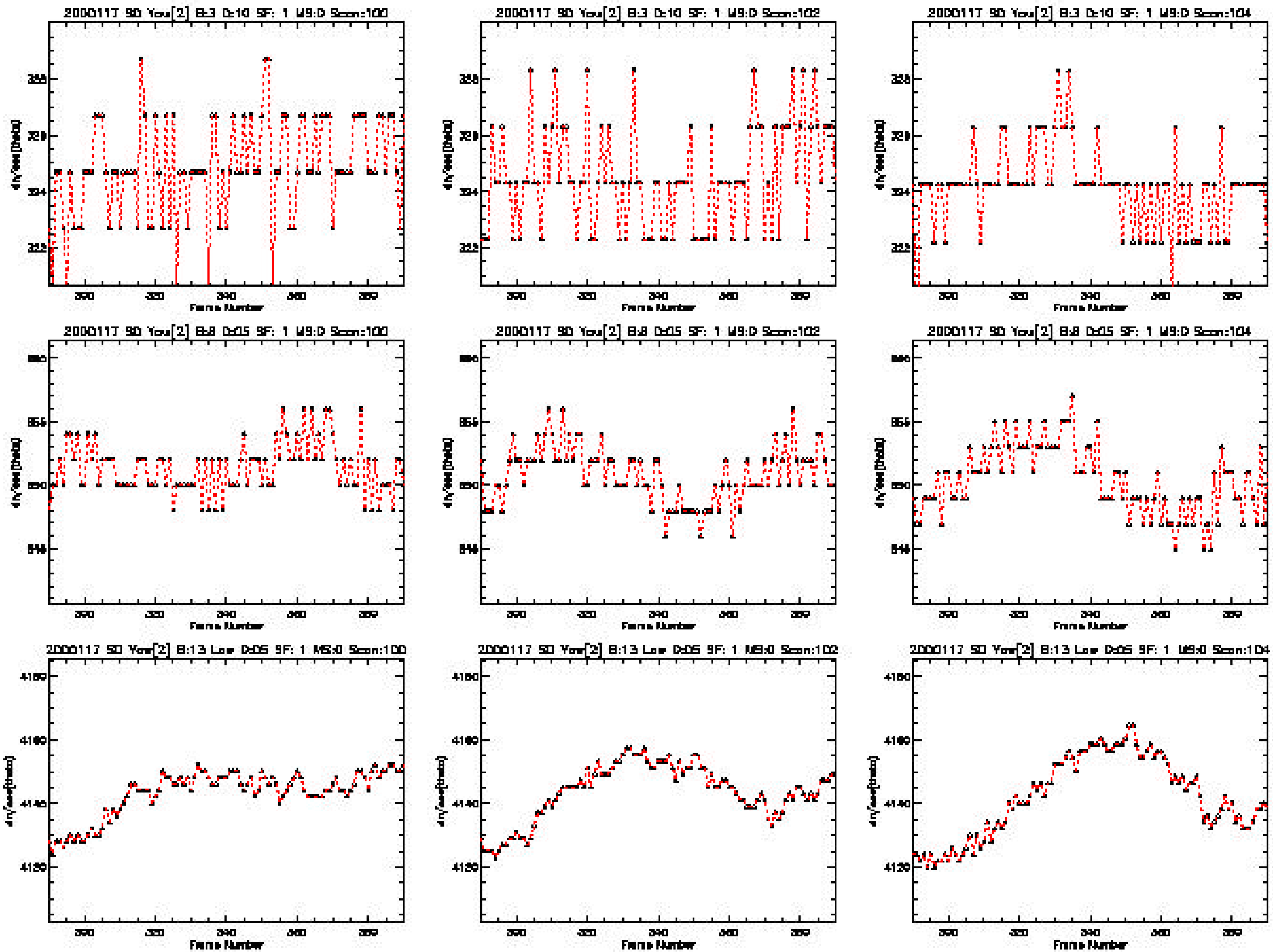
SOLAR VIEW DOOR ASSEMBLY

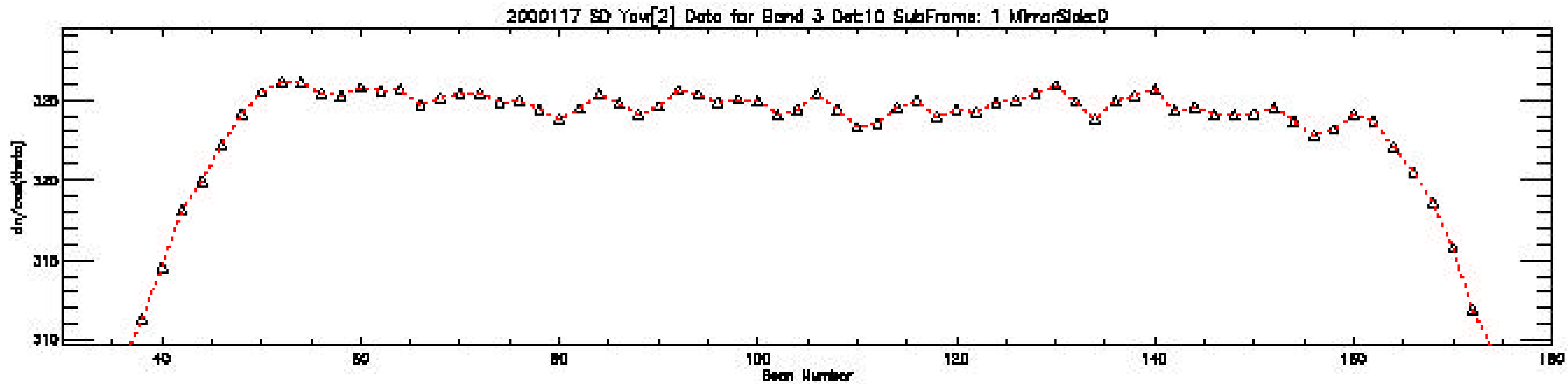
- DIFFUSER MATERIAL IS SPECTRALON (PTFE)

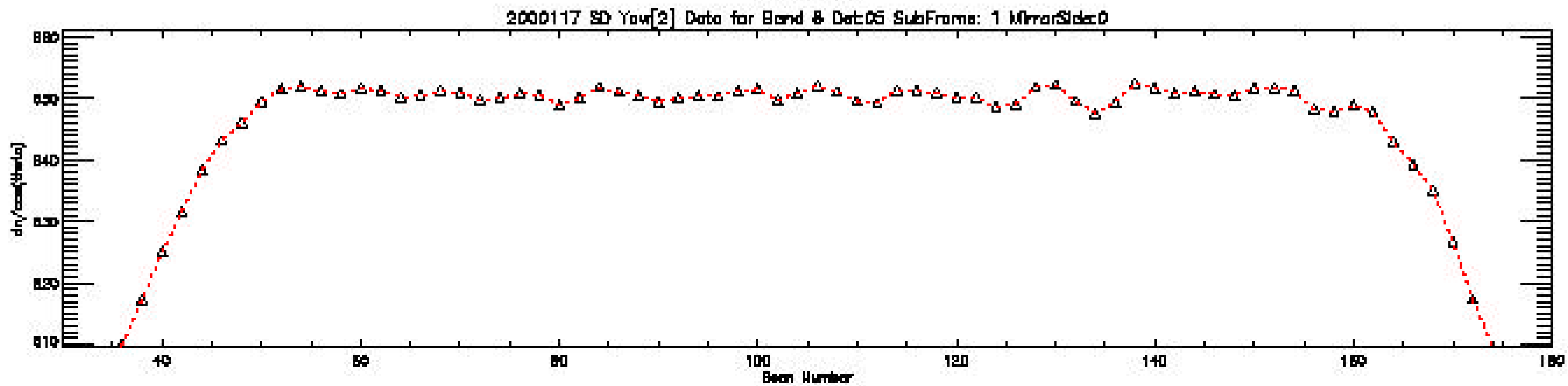
4/93
93-0191-146

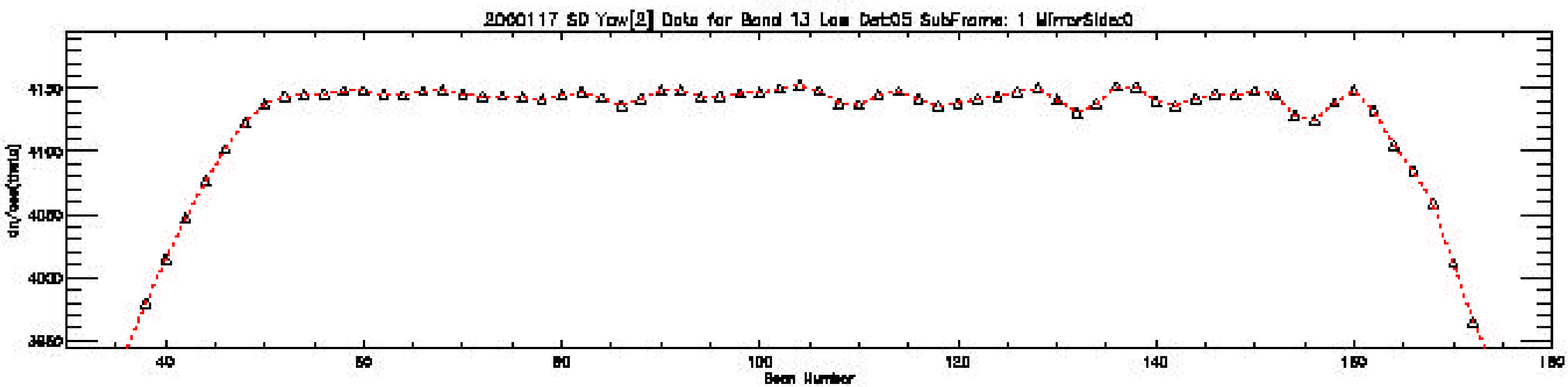
Solar Diffuser Stability Monitor (SDSM)

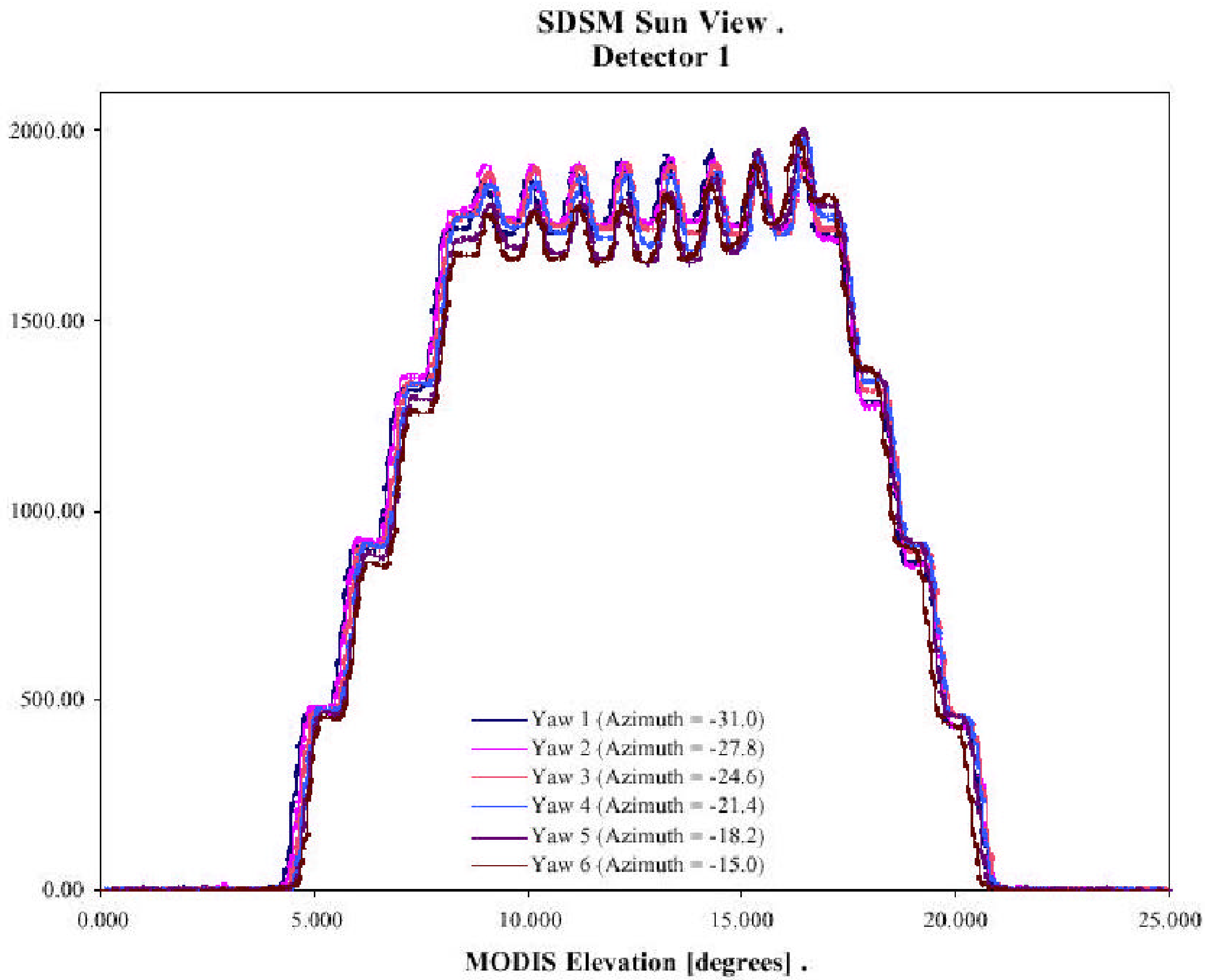



2000117 SD Yaw[2] B:3 D:10 SF: 1 MS:0 Scan:100
2000117 SD Yaw[2] B:3 D:10 SF: 1 MS:0 Scan:102
2000117 SD Yaw[2] B:3 D:10 SF: 1 MS:0 Scan:104
2000117 SD Yaw[2] B:8 D:05 SF: 1 MS:0 Scan:100
2000117 SD Yaw[2] B:8 D:05 SF: 1 MS:0 Scan:102
2000117 SD Yaw[2] B:8 D:05 SF: 1 MS:0 Scan:104
2000117 SD Yaw[2] B:13 Low D:05 SF: 1 MS:0 Scan:100
2000117 SD Yaw[2] B:13 Low D:05 SF: 1 MS:0 Scan:102
2000117 SD Yaw[2] B:13 Low D:05 SF: 1 MS:0 Scan:104
Frame Number

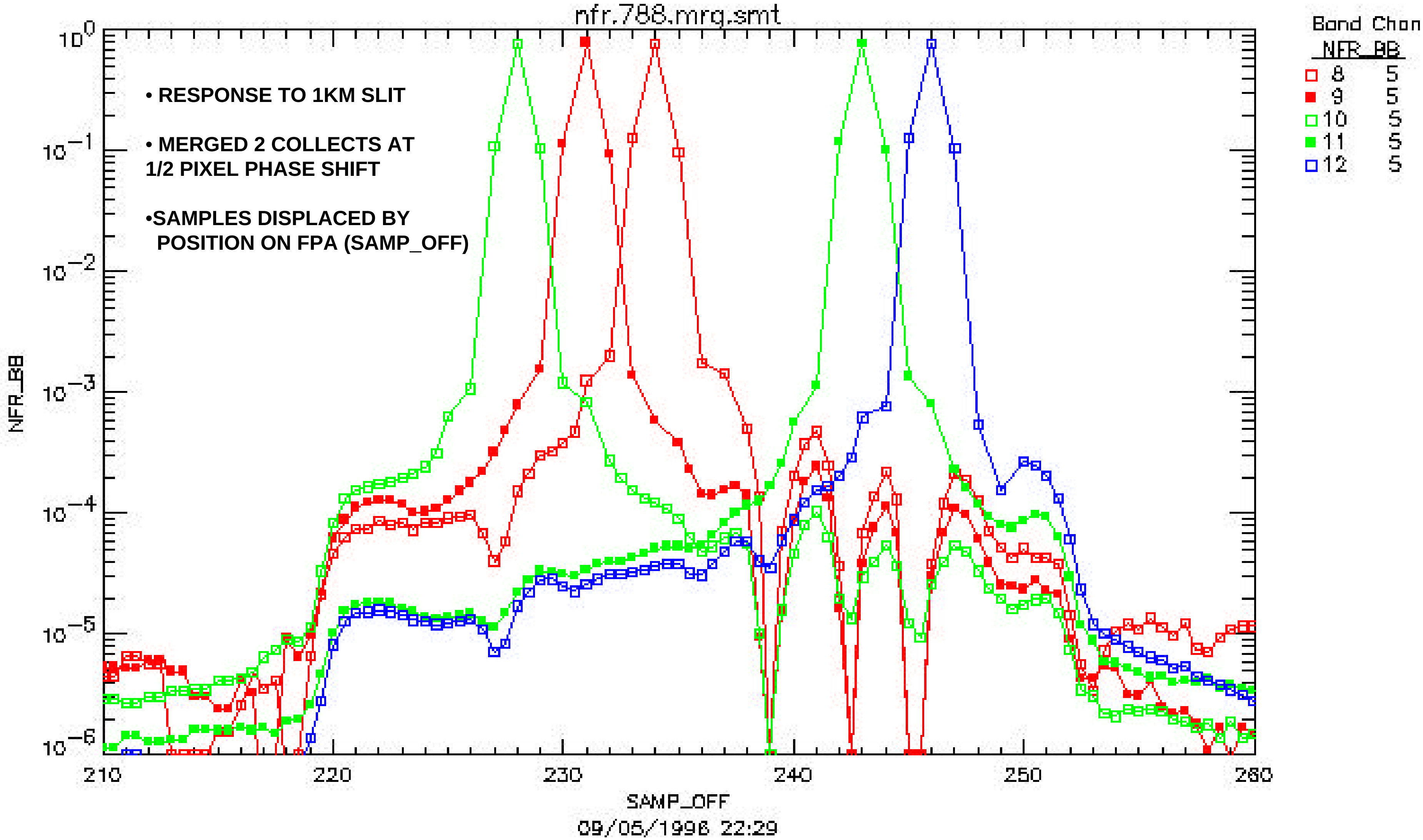

2000117 SD Yaw[2] Data for Band 3 Det:10 SubFrame: 1 MirrorSide:0
dn/cos(theta)
Scan Number
40
60
80
100
120
140
160
180


2000117 SD Yaw[2] Data for Band 8 Det:05 SubFrame: 1 MirrorSide:0
dn/cos(theta)
Scan Number
40
60
80
100
120
140
160
180

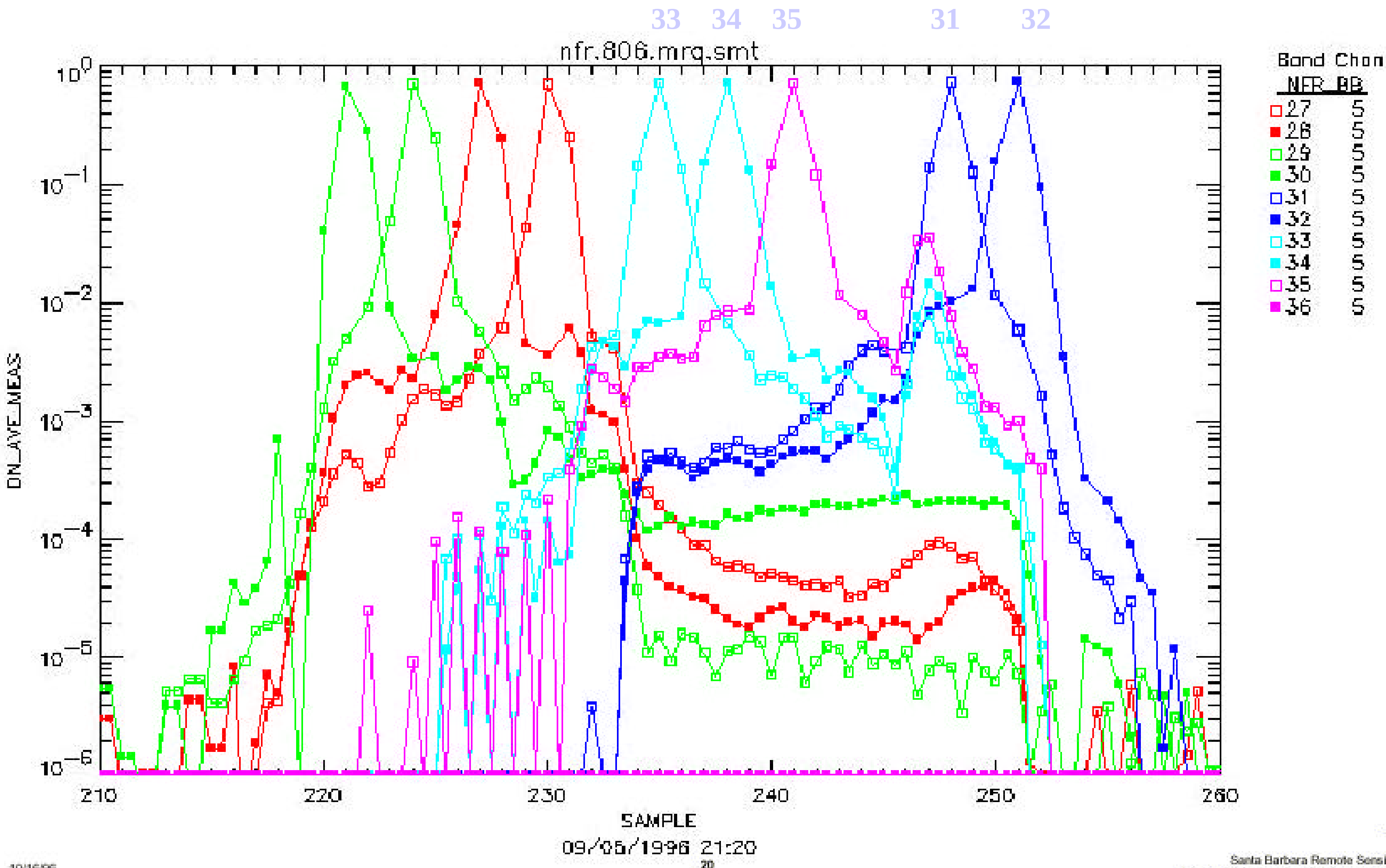

2000117 SD Yaw[2] Data for Band 13 Low Det:05 SubFrame: 1 MirrorSide:0
dn/cos(theta)
Scan Number
40
60
80
100
120
140
160
180


SDSM Sun View .
Detector 1
2000.00
1500.00
1000.00
500.00
0.00
0.000
5.000
10.000
15.000
20.000
25.000
MODIS Elevation [degrees] .
Yaw 1 (Azimuth = -31.0)
Yaw 2 (Azimuth = -27.8)
Yaw 3 (Azimuth = -24.6)
Yaw 4 (Azimuth = -21.4)
Yaw 5 (Azimuth = -18.2)
Yaw 6 (Azimuth = -15.0)

VIS 1 KM LOG SCALE

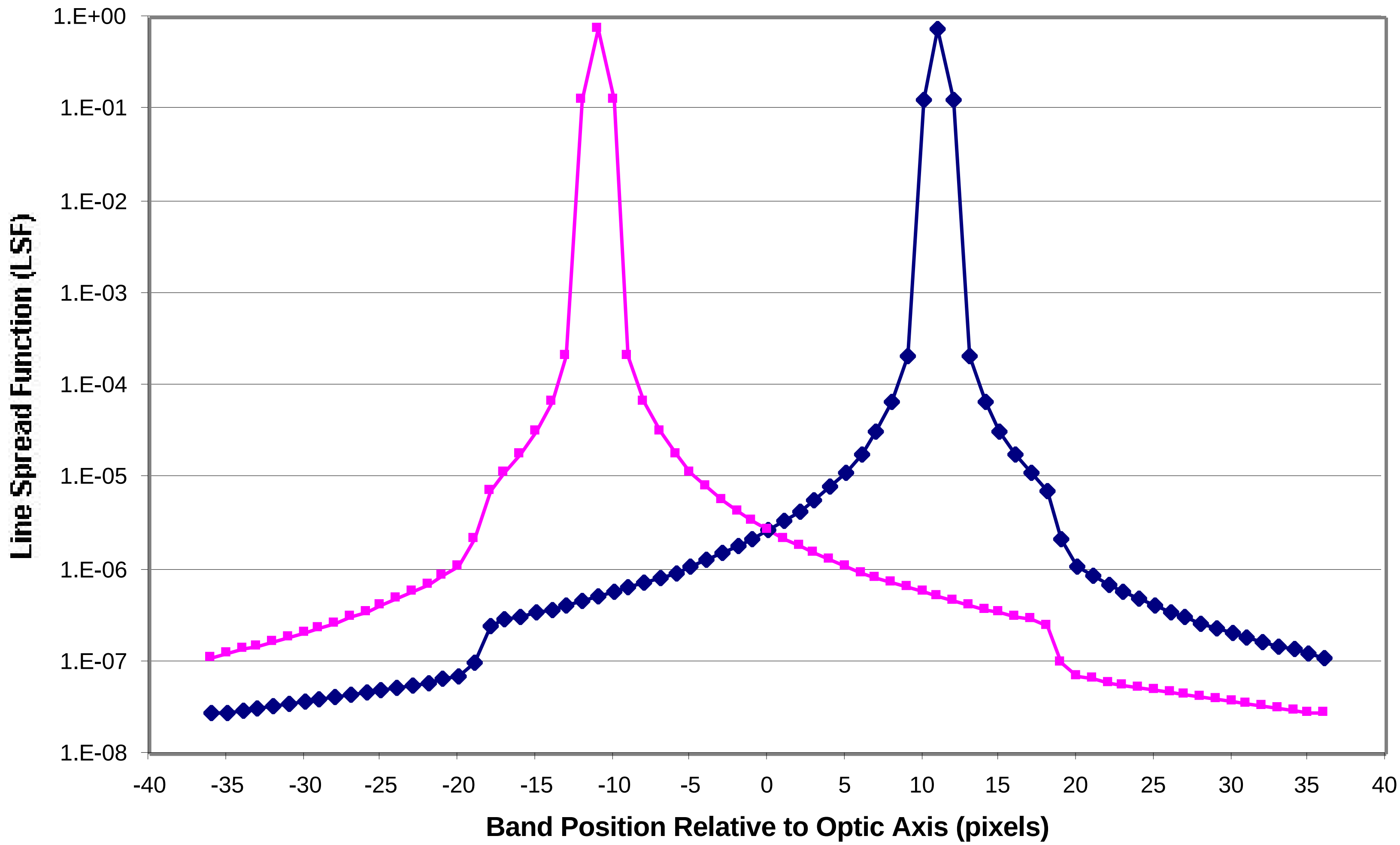


Pre-launch Crosstalk Observation (Near Field Response Testing)

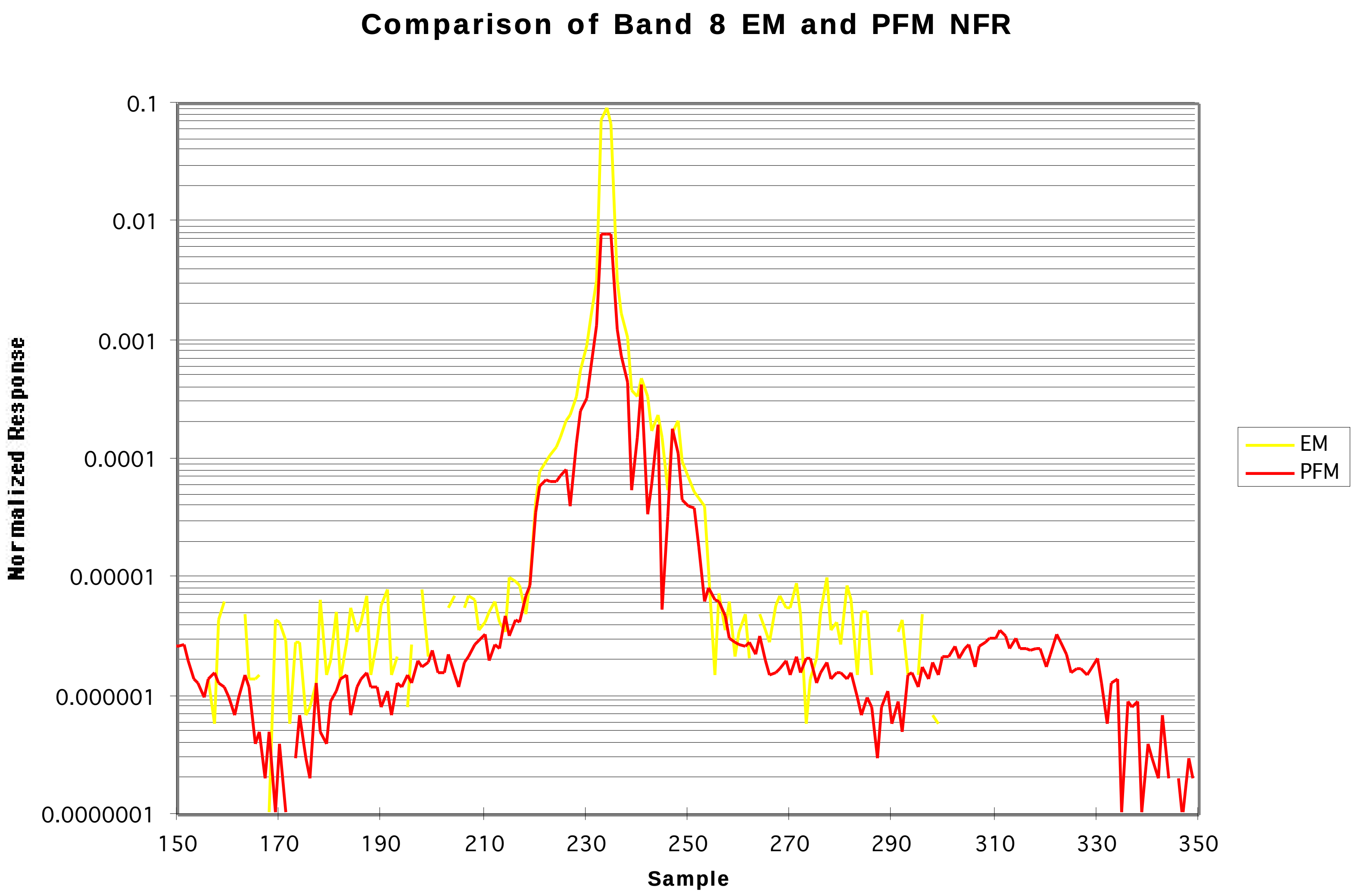


10/16/96

Figure 5.5-1: Line Spread Functions for two identical bands located on far-left and far-right of FPA



PFM RESPONSE CONSIDERABLY BETTER THAN EM



MODIS POLARIZANCE IS CHARACTERIZED WITH A STAND-ALONE POLARIZER SUBSYSTEM

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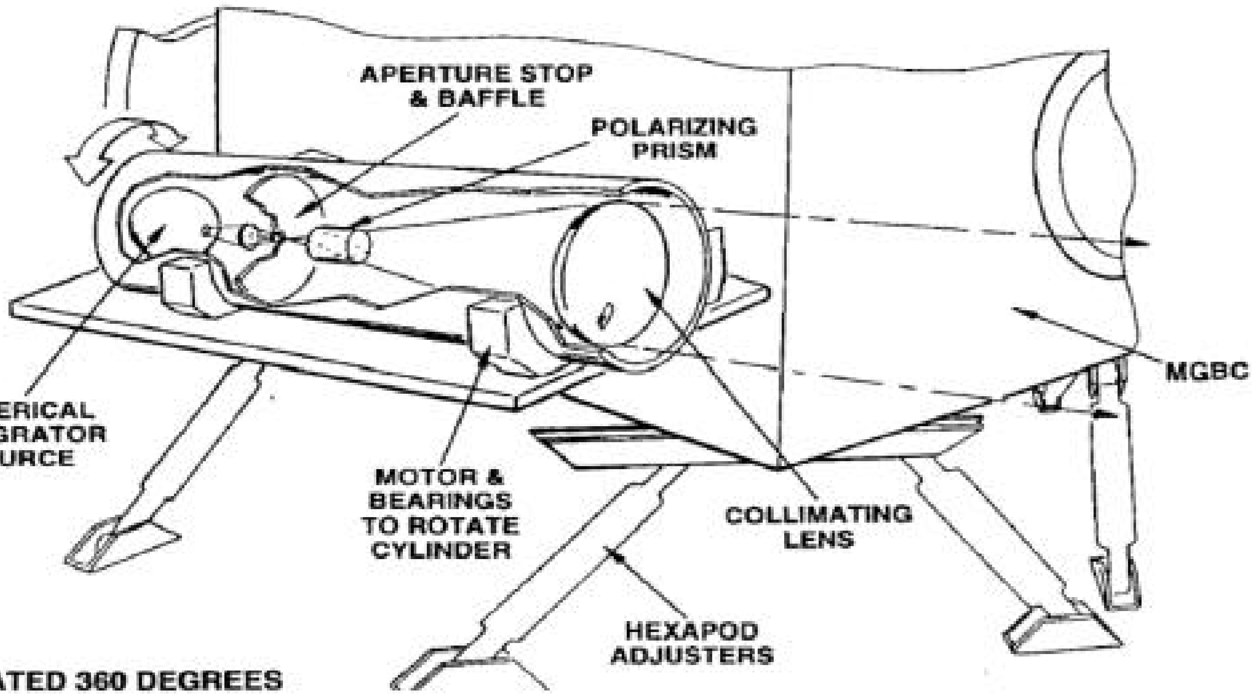
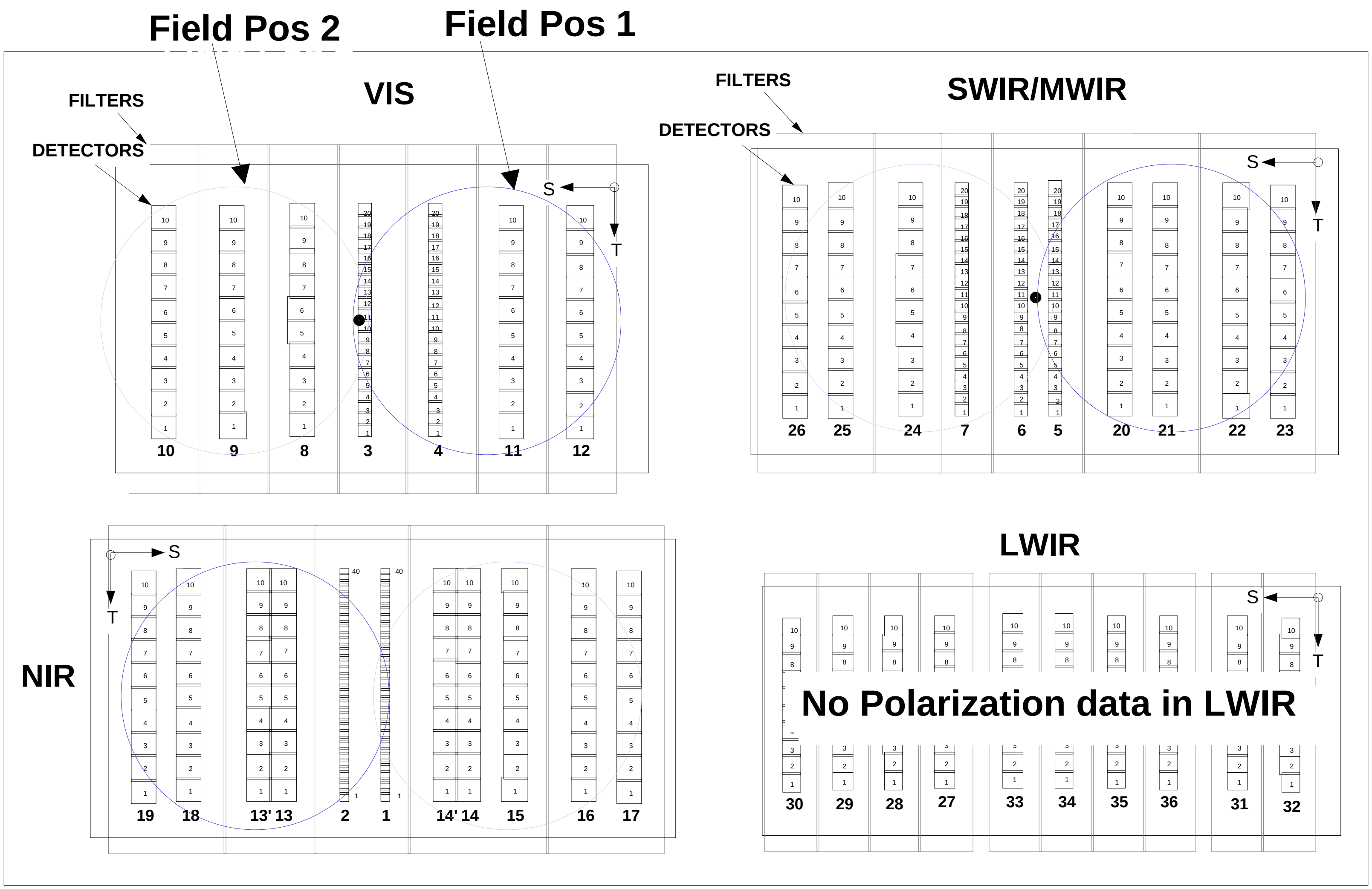
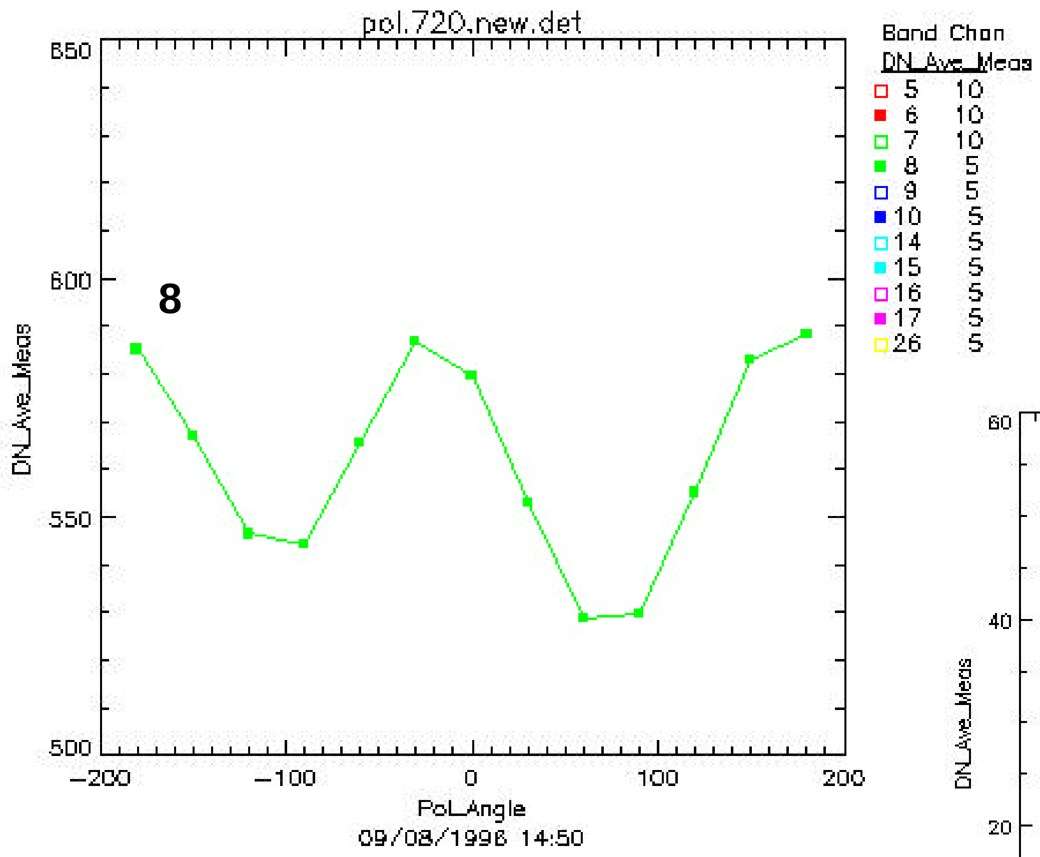


- CYLINDER IS ROTATED 360 DEGREES

DATA ACQUIRED IN 2 FIELD POSITIONS



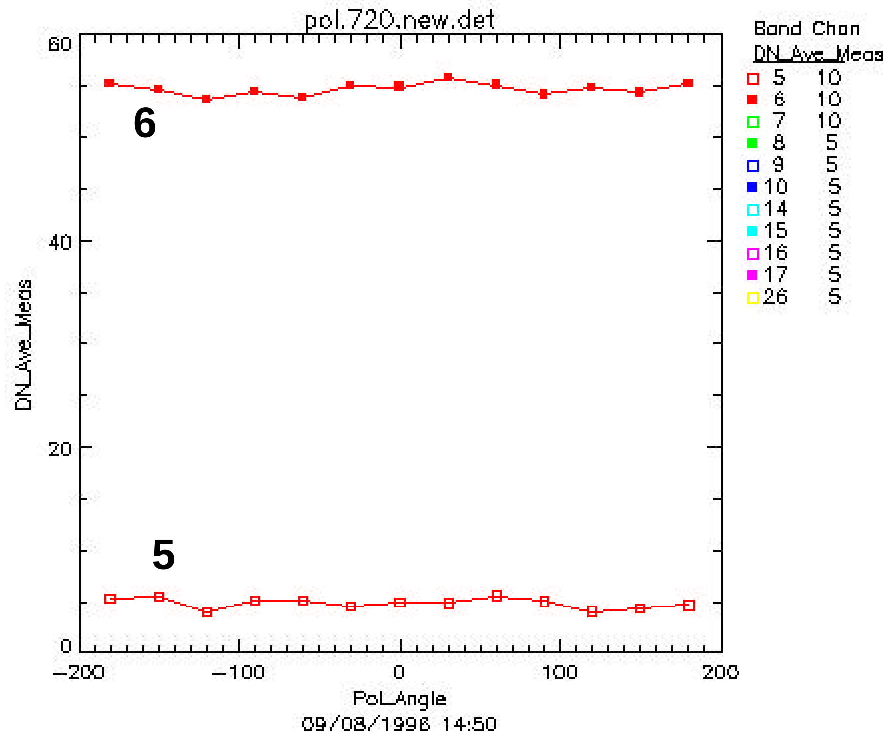
MODIS RESPONSE TO FULLY POLARIZED BEAM BANDS 3, 6 - 10, 14-17, 26 UAID 720, 721, ZERO DEGREE AOI (Cont'd)



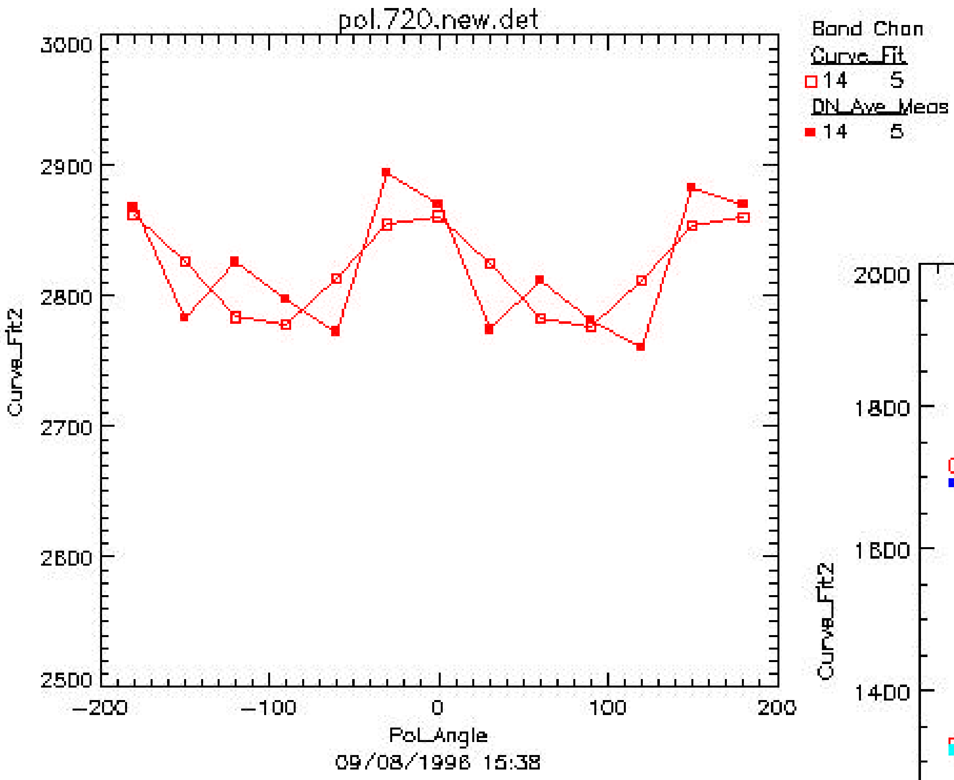
• LARGEST POLARIZATION IN B8

• LOW BUT RETRIEVABLE POLARIZATION IN BAND 6

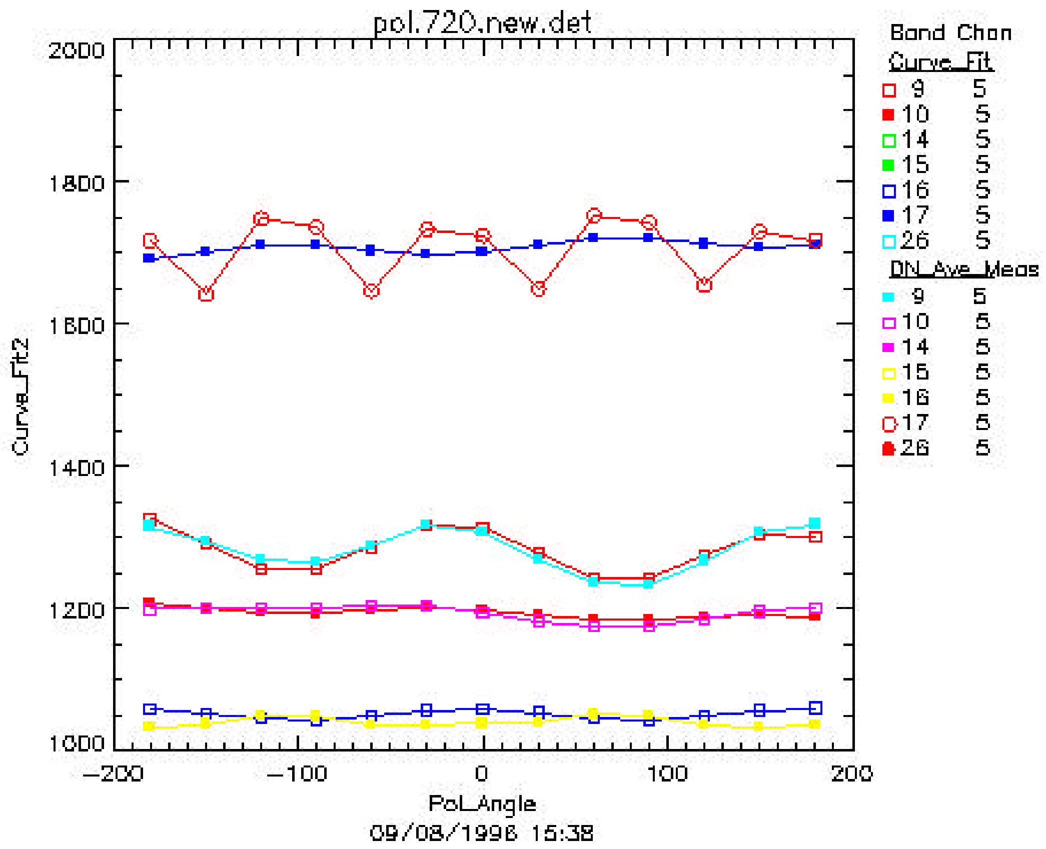
• BAND 5 SIGNAL TOO LOW



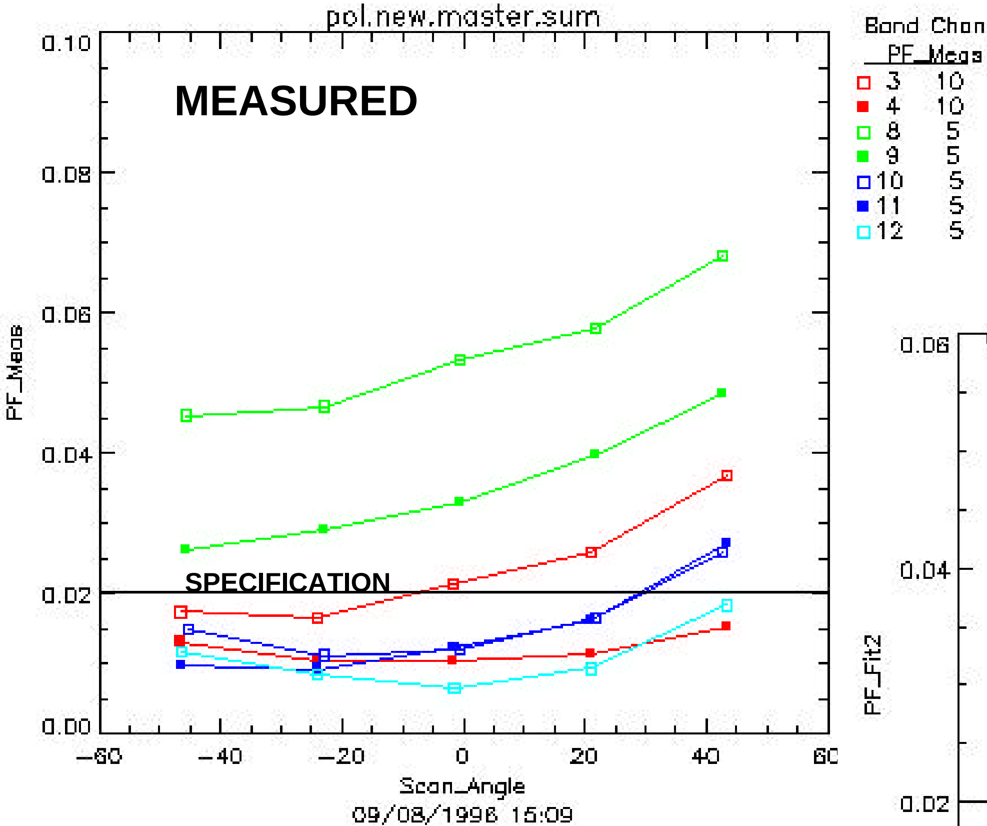
CURVE FIT EXTRACTS COS2θ COMPONENT FROM SIGNAL OBSERVED



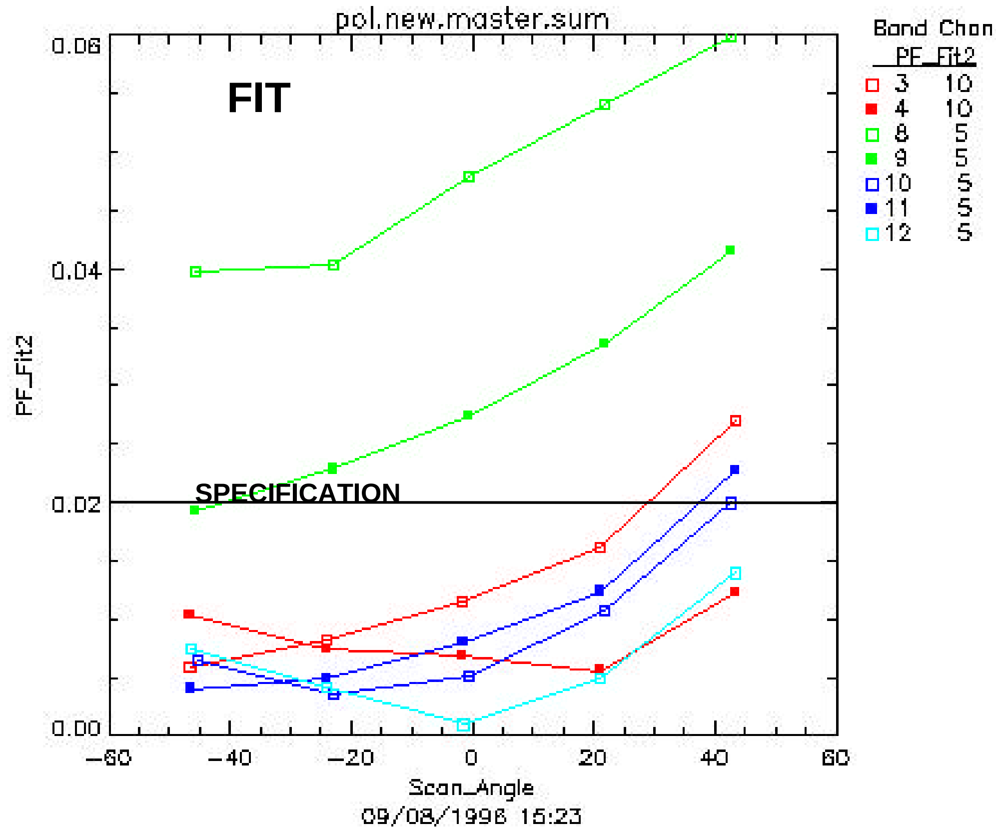
- **RATIONALE FOR CURVE FIT TO BE DISCUSSED LATER IN ADVANCED TOPICS SECTION**



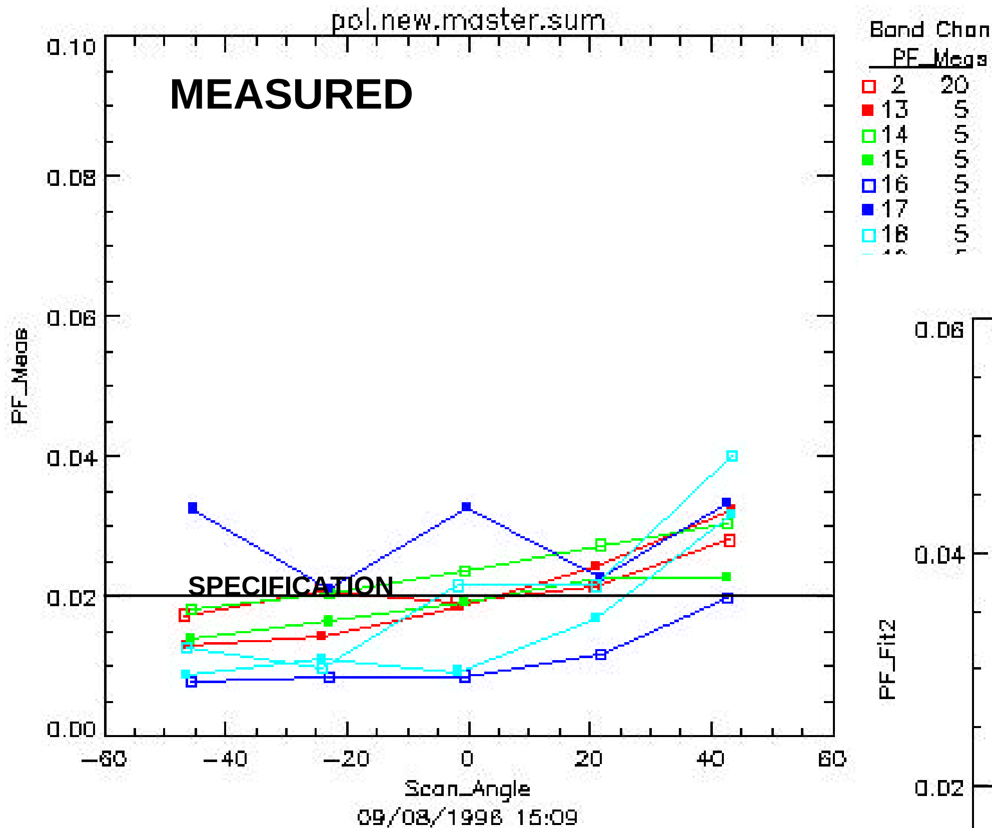
RESULTS: VIS MEASURED AND FIT POLARIZATION FACTOR



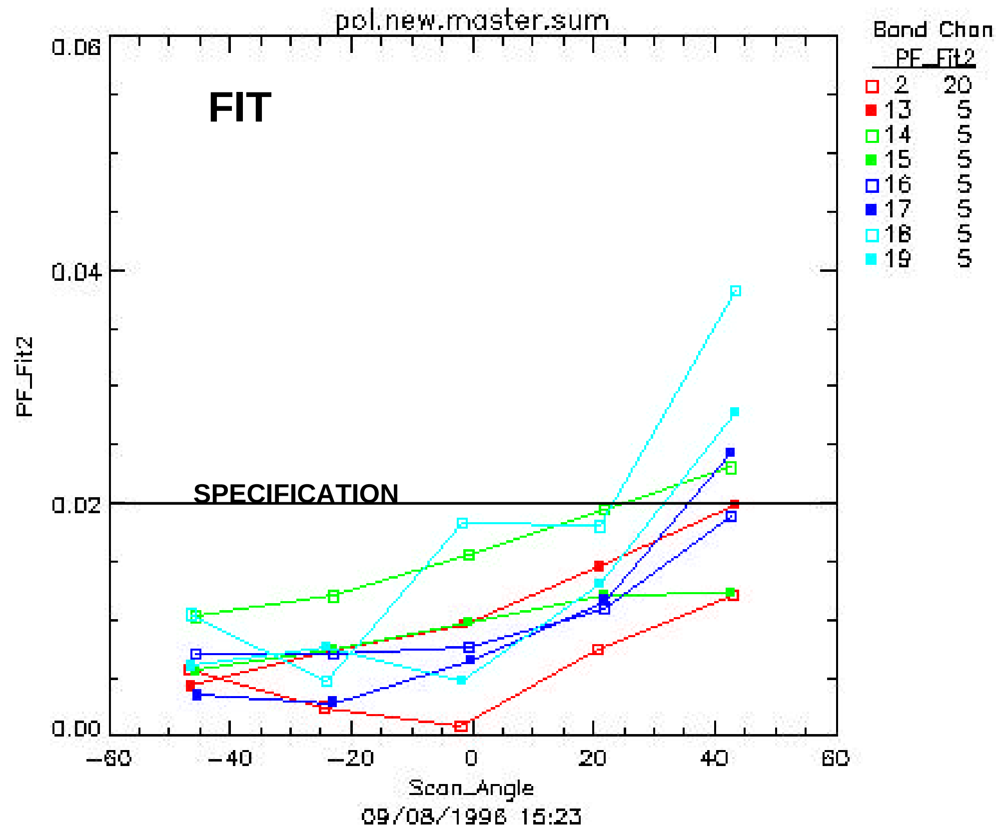
- NO SPEC ON BAND 8
- BAND 9 FAILS AT ALL SCAN ANGLES
- BANDS 3 AND 11 FAIL AT 45°



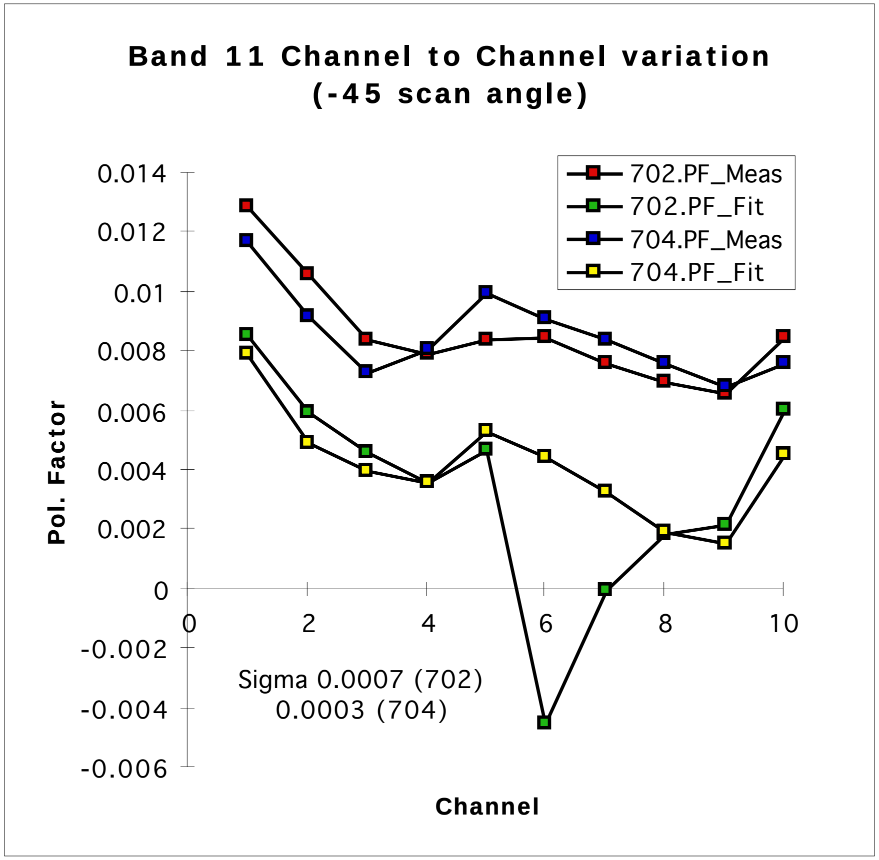
RESULTS: NIR MEASURED AND FIT POLARIZATION FACTOR

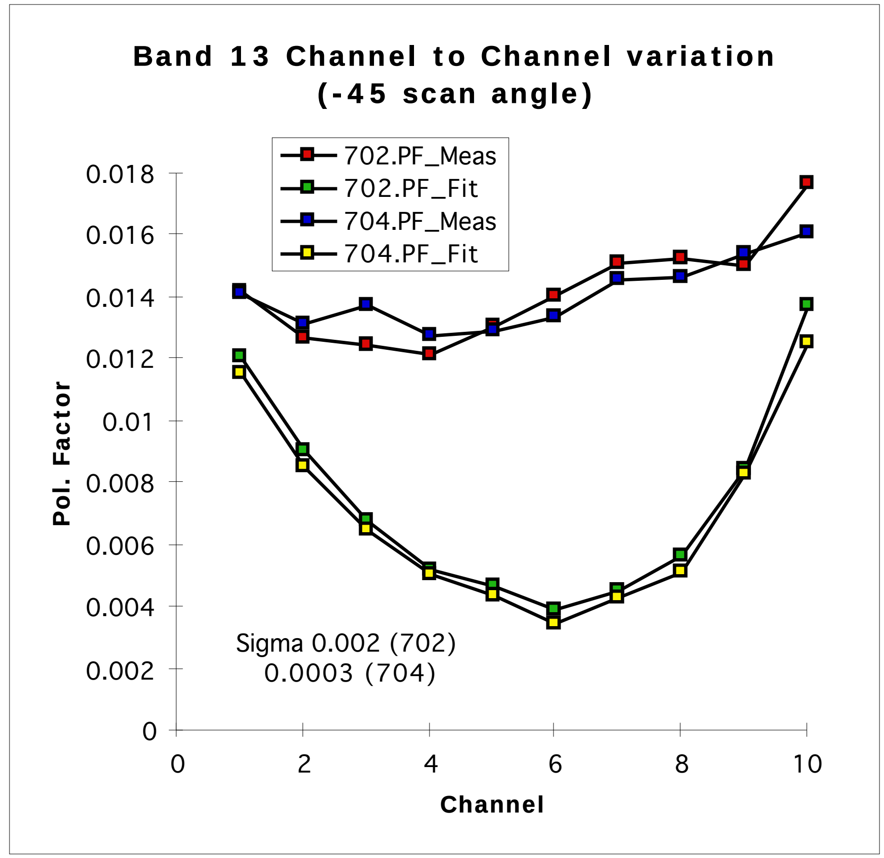


- **BANDS 14, 17, 18 AND 19 FAIL AT 45°**



REPEATABILITY ANALYSIS PERFORMED ON EARLY DATA SETS

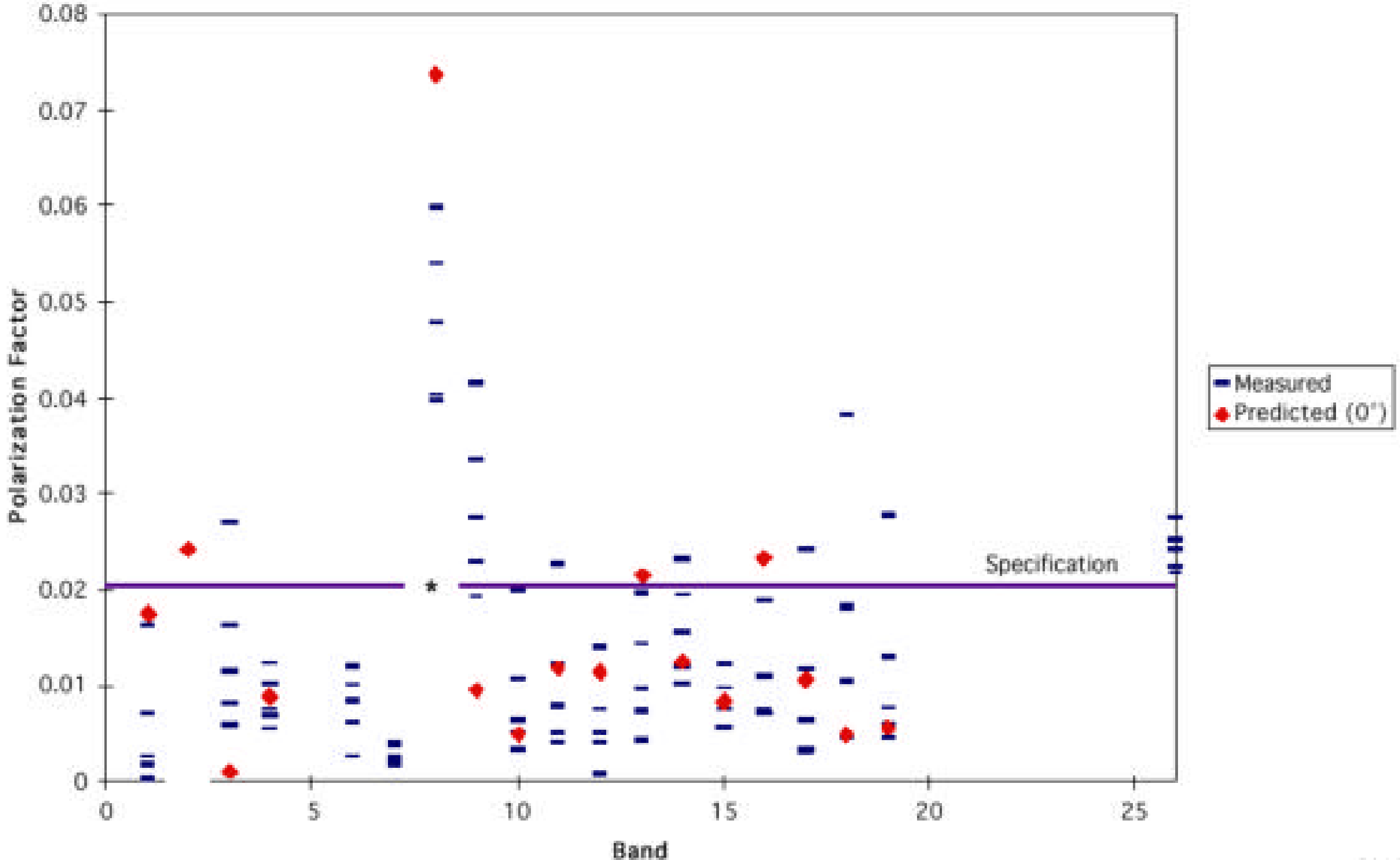




- **TWO DATA SETS, 702 AND 704 SEPARATED BY TWO DAYS**
- **ANALYSIS PERFORMED BY E. KNIGHT**

3.3.5. Waiver 055: Polarization

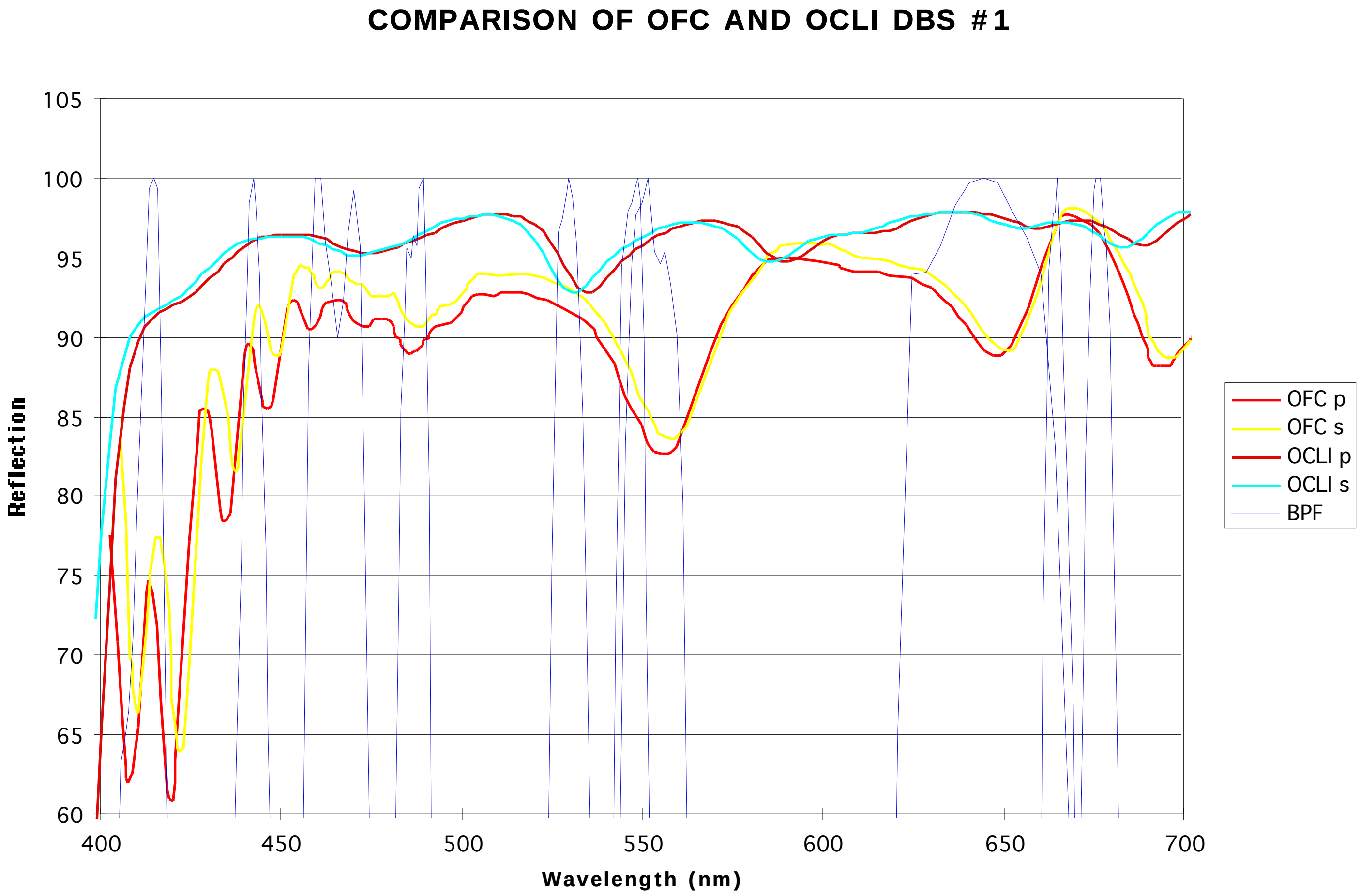
Polarization Factor for the MODIS Bands for Scan Angles of ±45°, ±22.5° and 0°



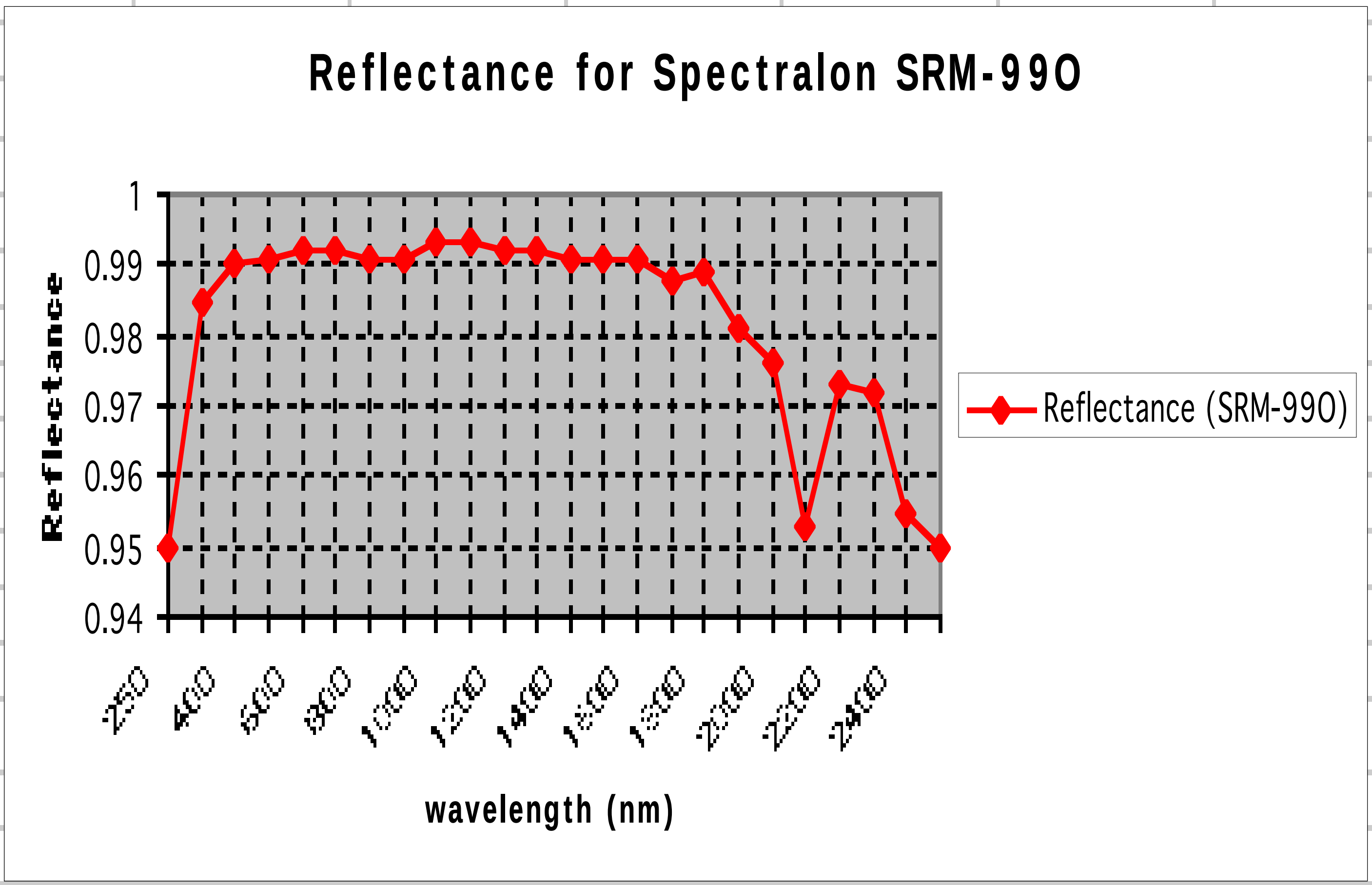
*Note: Low residual polarization desired for band 8, but not covered as a specification requirement

OFC DBS USED IN PFM HAS MORE POLARIZATION

• **OFC DICHROIC SELECTED FOR LOWER SCATTER PROPERTIES**



Reflectance of MODIS Solar Diffuser Material



FM1 SMWIR B5/B6 Operability

- Review of TV3 data uncovered non-responsive detectors on band 6, and 1 non-responsive detector on band 5
- Of 20 channels on Band 6, during TV3
  - 6 are inoperable at 83K (channels 1,2,5,7,8,19)
  - 2 additional channels are inoperable at 88K (channels 4,9)
  - 3 additional channels are inoperable between 88K and 118K (11,16,17)
- Not present in TV2 test
- No direct method of analyzing effects other than in TV
  - Bands do not operate in ambient/bench test cooled environment
  - Band evaluation occurs only in a radiatively-cooled environment
- Indirect method developed recently (DC restore offsets/ECAL ramps) allows for operability assessment in ambient environment

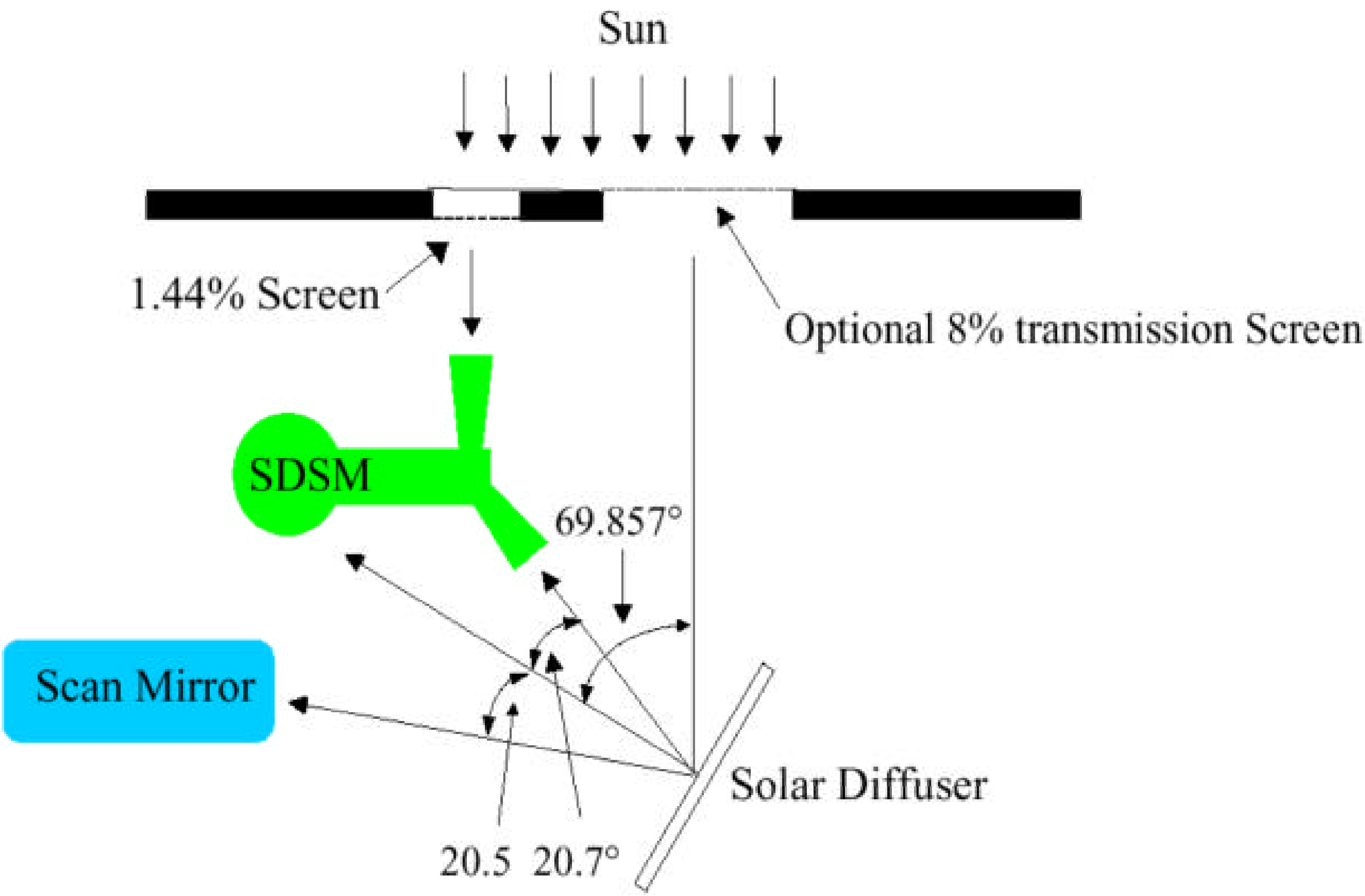
Key Tasks In Process

- PFM –vs- FM1 –vs- FM2 design, manufacturing, testing review
  - Materials, processes, tests, test configurations, fabrication history/performance, yields, major events during fabrication and test cycle, personnel changes, equipment/facilities changes, etc
  - SWMIR FPA –vs- other Modis FPAs comparison
  - Susceptibility to failure mode
- Process and production history review
  - Other customers, performance history (before/after Modis), process maturity
- Modis life/qualification test program review
  - Sample/population size, tests performed/results, further test requirements/needs
- Models/simulations
  - Structural, thermal predictions, reliability analysis
- FM2 FPA reliability/performance/operability assessment
  - Available data
  - Additional testing

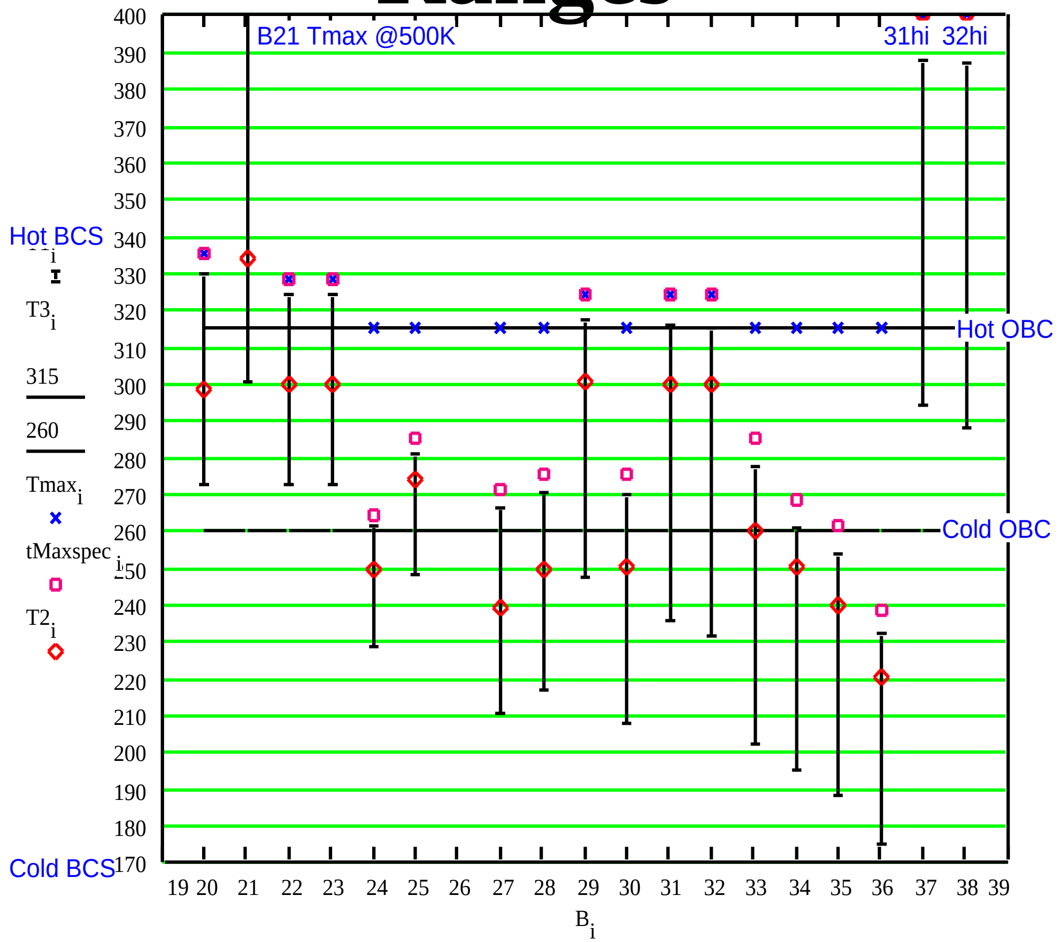
FM1 SMWIR B5/B6 Operability Results to Date

- Anomaly most likely caused by deficiency of Indium bump interface
  - Between the detector and readout chip
    - Electrical tests have supported this conclusion
  - Manifestation of deficiency accelerated by thermal cycling
    - FM1 test history review shows onset at about thermal cycle #70 (vs a 150 cycle spec/expectation)
  - Some evidence of stress relief is apparent
    - Phenomenon has been stable for 15+ thermal cycles
  - Exact cause would require a complete disassembly/destructive diagnostic on the FPA
    - Studies must consider a number of possible causes, along with associated reliability predictions
  - To date, failure investigation results do not imply catastrophic consequences for the FPA
  - Results from planned analyses may give a more quantitative risk assessment
- Effort being coordinated with NASA GSFC
  - Impact to mission objectives
  - Long term stability of operational channels

Solar Diffuser Stability Monitor (SDSM)

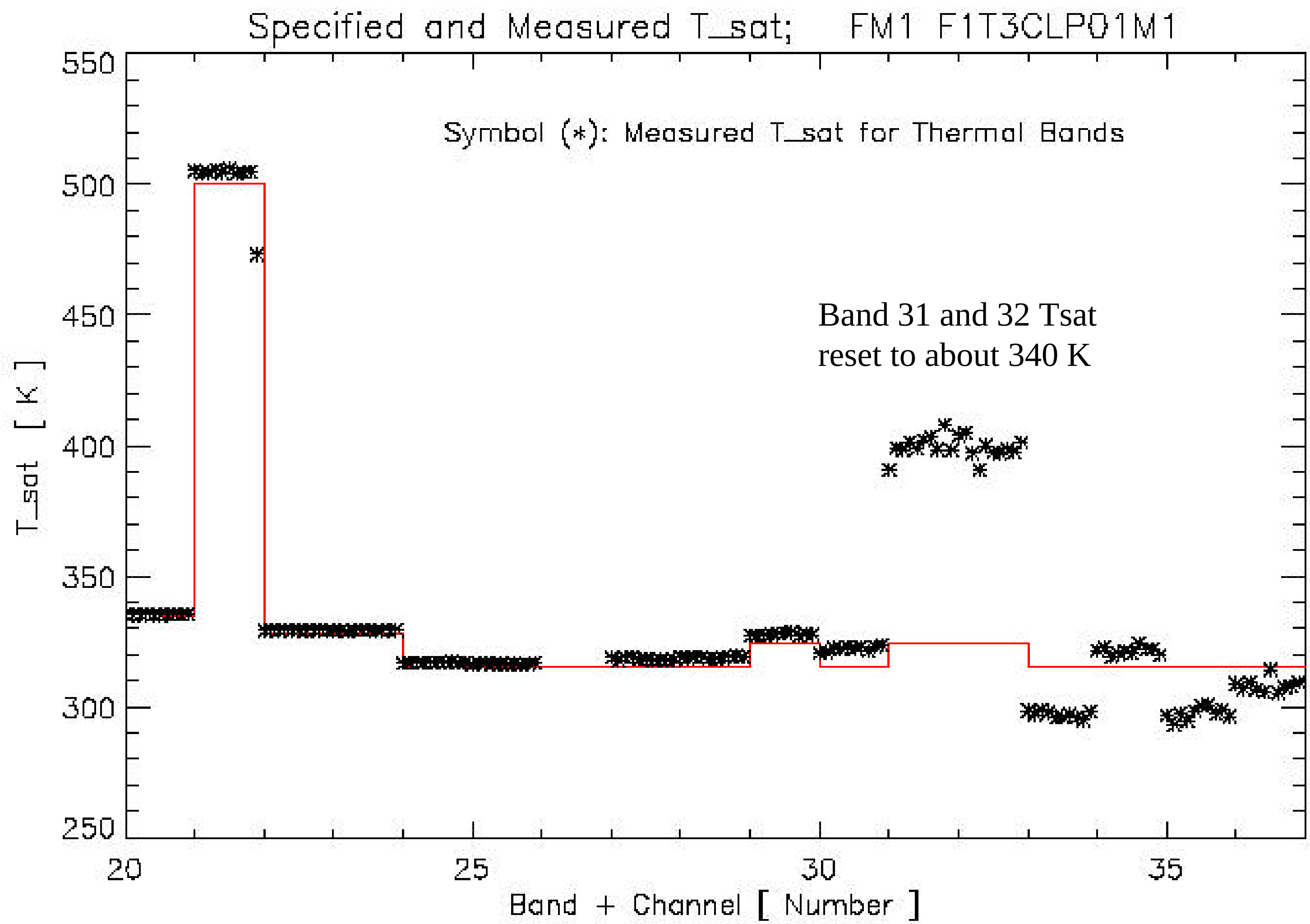


MODIS Operational and Calibration Ranges

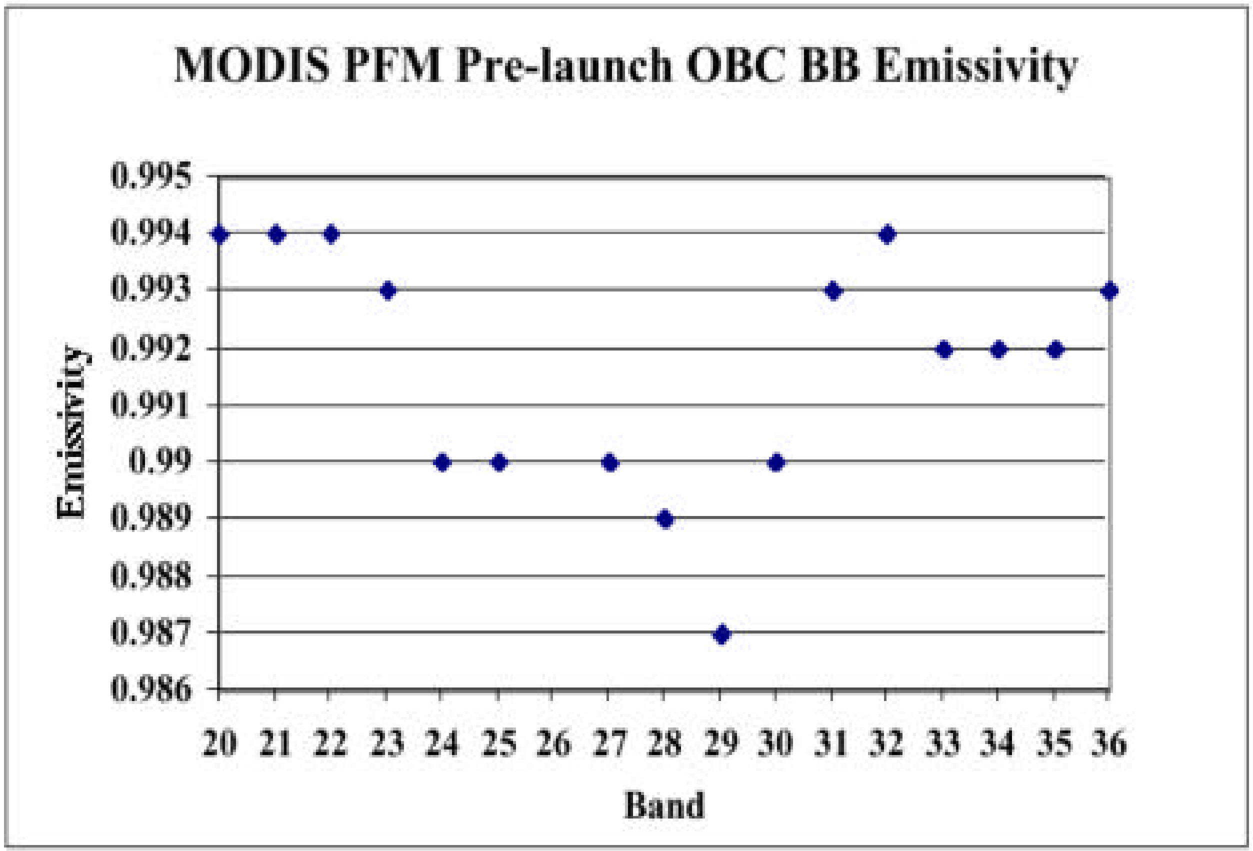


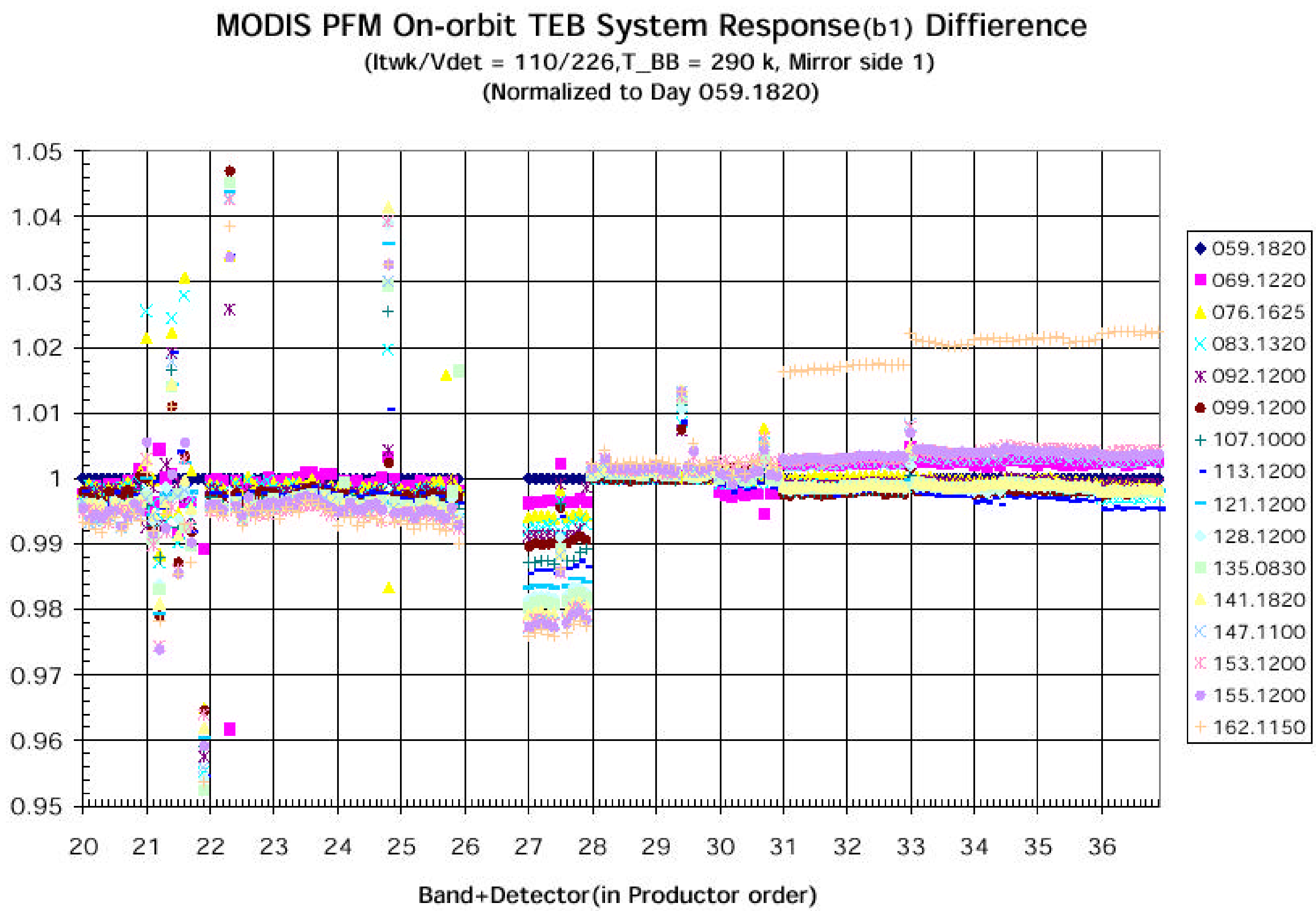
Vertical bars represent temperatures of 0.3Ltyp and 0.9 Lmax. Box symbols represent Tmax_spec, X symbols represent the value of Tmax_set (the higher of tMaxspec or 315K), and the diamond symbols represent the temperature of Ltyp.

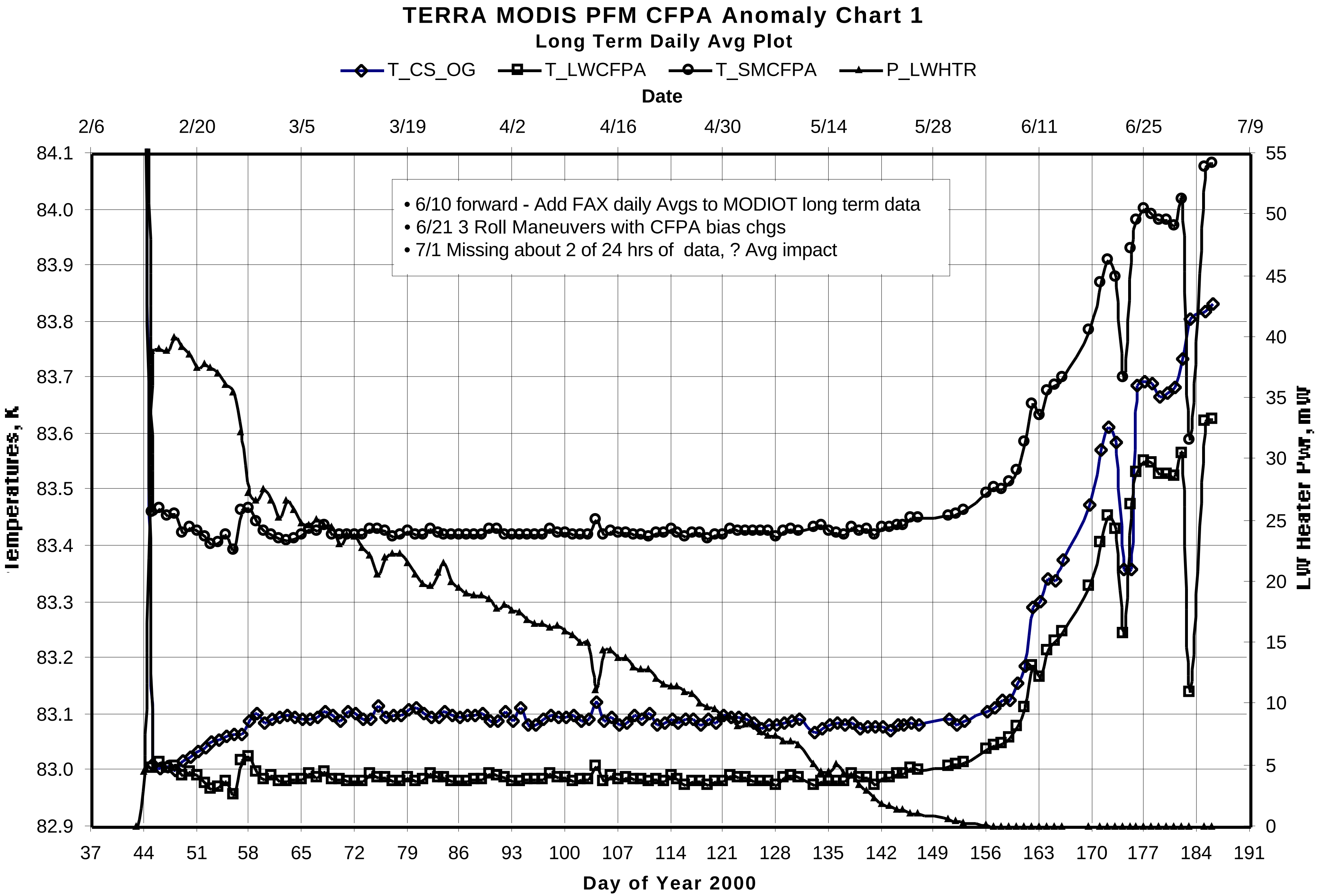
For FM1, Bands 33 and 35, we will not get science data when OBC-BB temperature above about 300 K



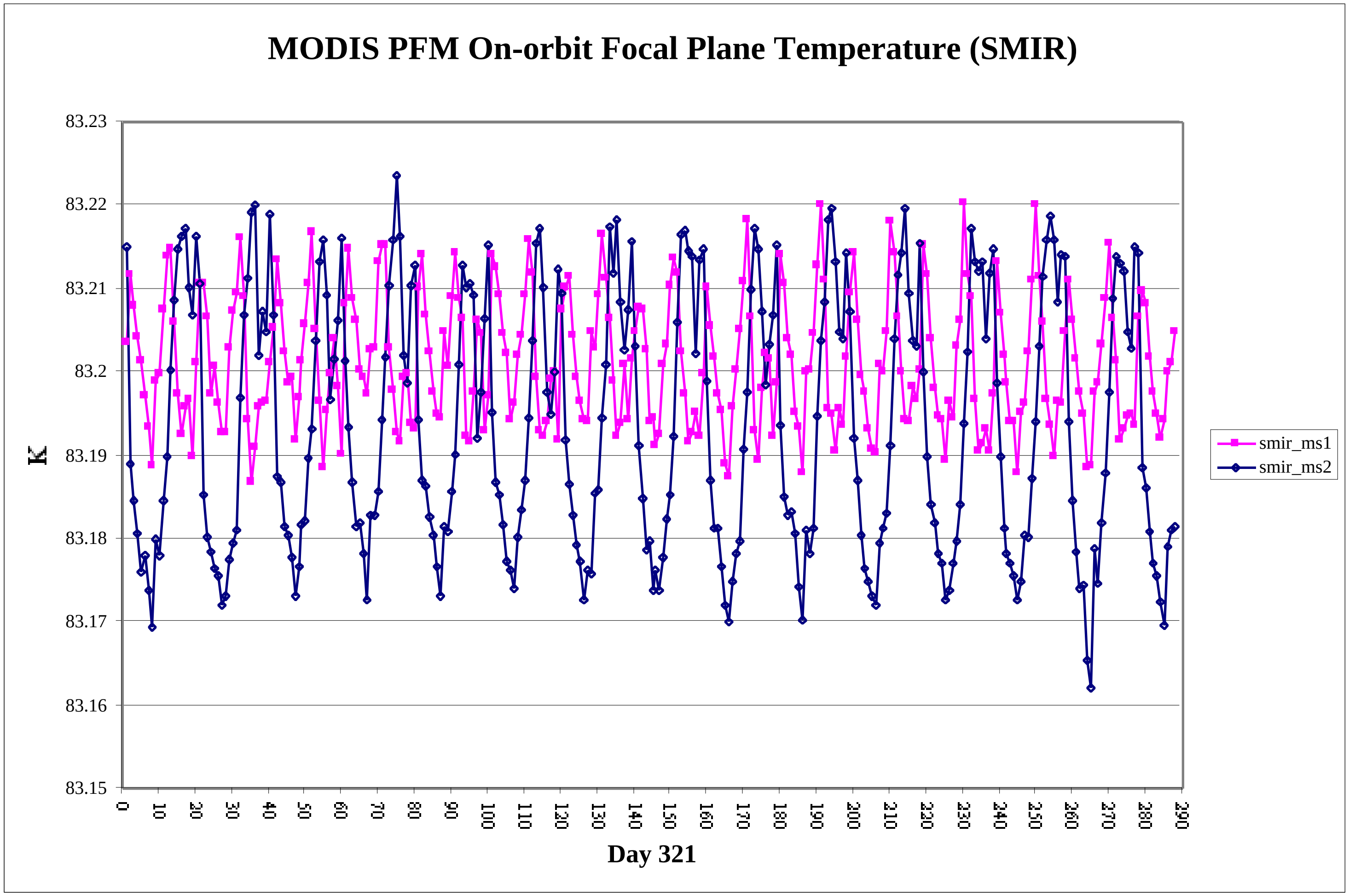
OBC Blackbody Emissivity



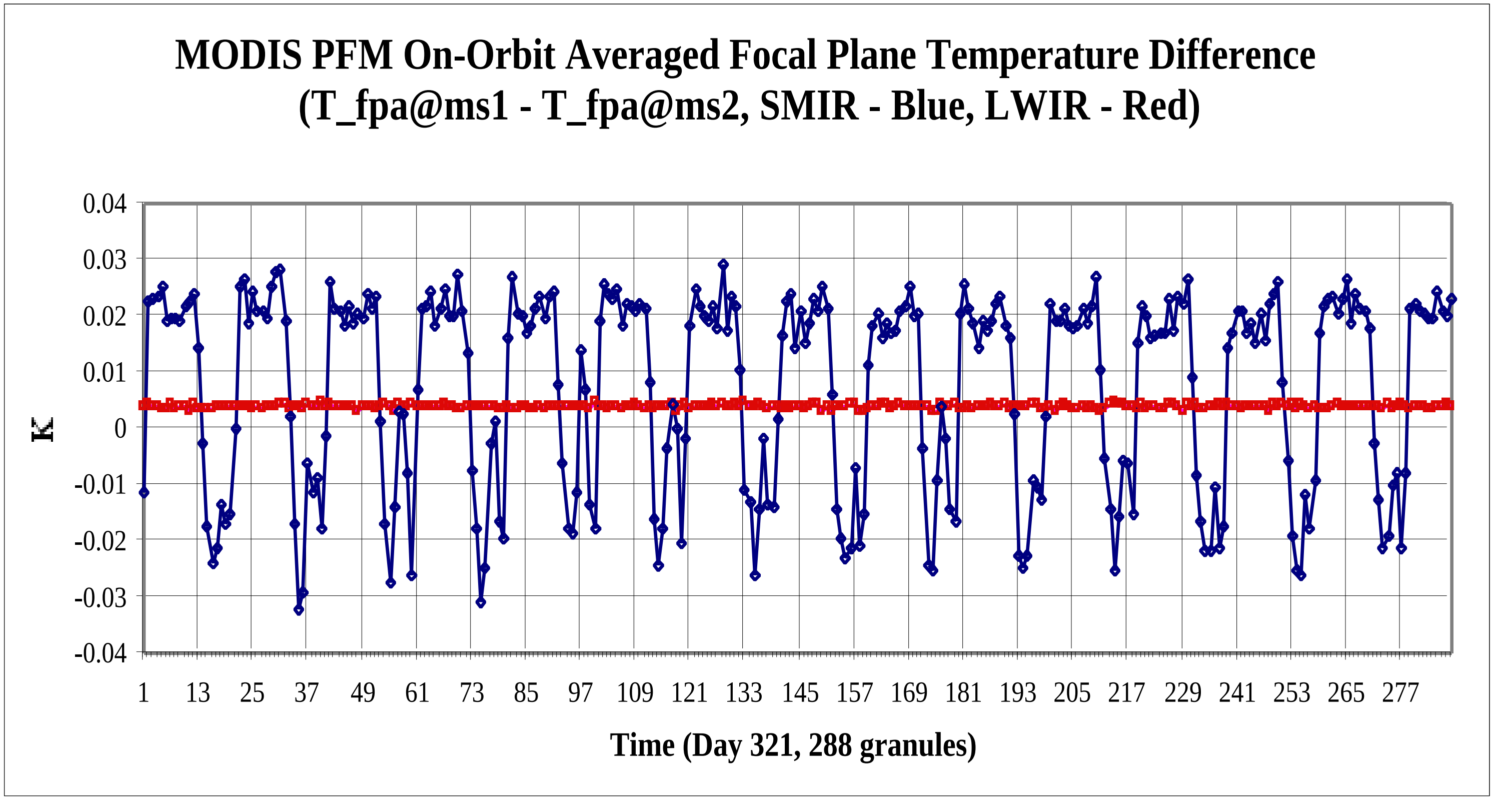

MODIS PFM On-orbit TEB System Response(b1) Diffierence
(Itwk/Vdet = 110/226,T_BB = 290 k, Mirror side 1)
(Normalized to Day 059.1820)
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Band+Detector(in Productor order)
059.1820
069.1220
076.1625
083.1320
092.1200
099.1200
107.1000
113.1200
121.1200
128.1200
135.0830
141.1820
147.1100
153.1200
155.1200
162.1150



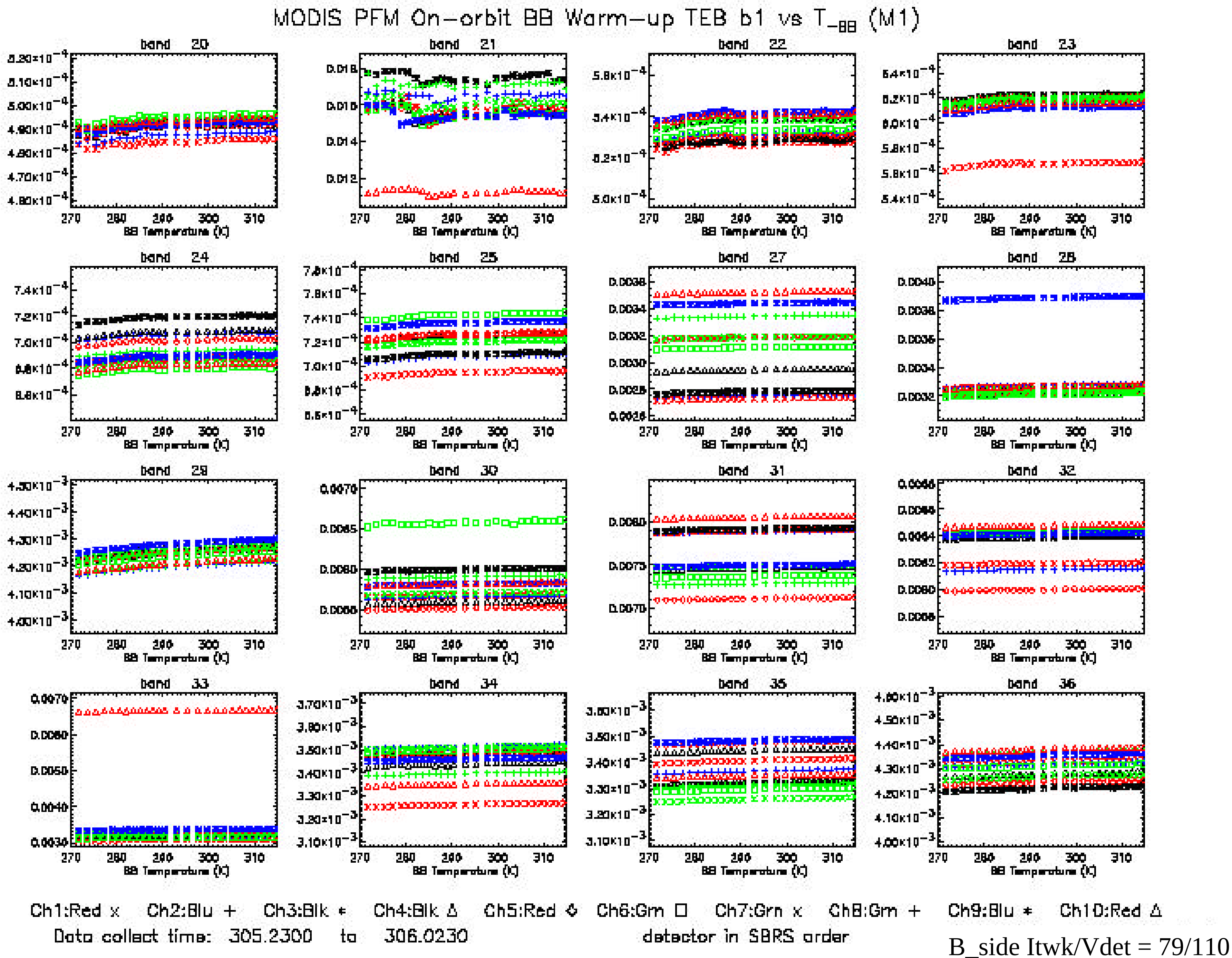
TERRA MODIS PFM CFPA Anomaly Chart 1
Long Term Daily Avg Plot
T_CS_OG
T_LWCFPA
T_SMCFPA
P_LWHTR
Date
2/6
2/20
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
6/25
7/9
• 6/10 forward - Add FAX daily Avgs to MODIOT long term data
• 6/21 3 Roll Maneuvers with CFPA bias chgs
• 7/1 Missing about 2 of 24 hrs of data, ? Avg impact
Temperatures, K
LW Heater Pwr, mW
84.1
84.0
83.9
83.8
83.7
83.6
83.5
83.4
83.3
83.2
83.1
83.0
82.9
55
50
45
40
35
30
25
20
15
10
5
0
37
44
51
58
65
72
79
86
93
100
107
114
121
128
135
142
149
156
163
170
177
184
191
Day of Year 2000



MODIS PFM On-orbit Focal Plane Temperature (SMIR)
K
83.23
83.22
83.21
83.2
83.19
83.18
83.17
83.16
83.15
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
Day 321
smir_ms1
smir_ms2



MODIS PFM On-Orbit Averaged Focal Plane Temperature Difference
(T_fpa@ms1 - T_fpa@ms2, SMIR - Blue, LWIR - Red)
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
K
1 13 25 37 49 61 73 85 97 109 121 133 145 157 169 181 193 205 217 229 241 253 265 277
Time (Day 321, 288 granules)


MODIS PFM On-orbit BB Warm-up TEB b1 vs T_{-BB} (M1)
band 20
band 21
band 22
band 23
band 24
band 25
band 27
band 28
band 29
band 30
band 31
band 32
band 33
band 34
band 35
band 36
BB Temperature (K)
Ch1:Red x Ch2:Blu + Ch3:Blk * Ch4:Blk Δ Ch5:Red ◇ Ch6:Grn □ Ch7:Grn x Ch8:Grn + Ch9:Blu * Ch10:Red Δ
Data collect time: 305.2300 to 306.0230
detector in SBRS order
B_side Itwk/Vdet = 79/110