Aqua MODIS (FM1) On-orbit Calibration and Characterization

MCST Calibration Workshop, July 22, 2002

Aqua MODIS On-orbit Calibration & Characterization

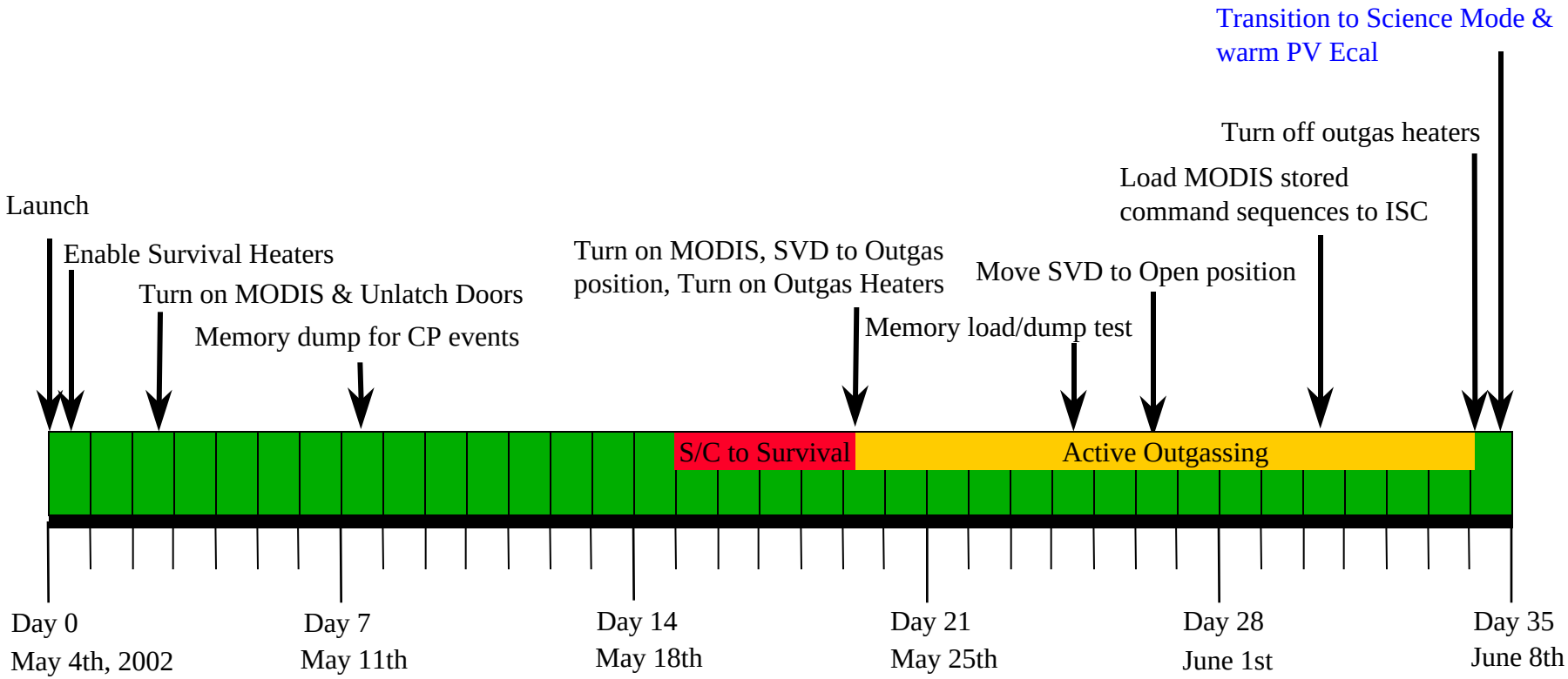
- Aqua MODIS (FM1) Status
  - Operation timeline
  - Major calibration and characterization activities
- Improvements
  - SWIR (electronic/optical) crosstalk reduction
  - PC optical leak removal
- Early calibration and characterization results
  - Thermal emissive bands (TEB)
  - Reflective solar bands (RSB)
  - SRCA and ECAL
- Future plan

Aqua MODIS (FM1) Status

- Aqua launch: May 4, 2002
- MODIS first image: June 24, 2002
- Launch - June 27, 2002
  - B-side with SMIR Itwk/Vdet=102/184
- June 27, 2002 - July 8, 2002
  - B-side with SMIR Itwk/Vdet=102/136
  - Data loss June 27 - July 03, 2002
- July 8, 2002 - Present
  - B-side with SMIR Itwk/Vdet=102/184

As-run Activation Timeline

Launch - MET Day 35



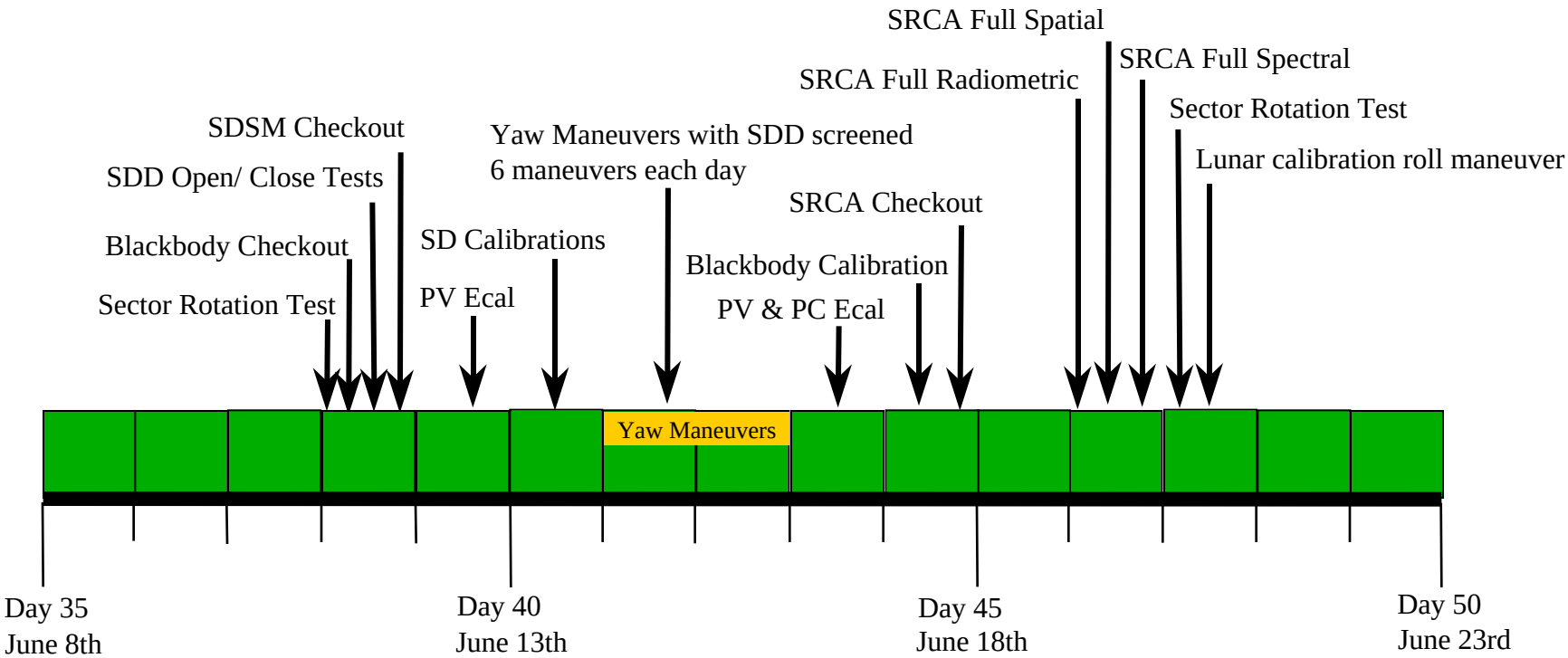
Mission Elapsed Time / Date

May 4th, 2002 => day 124

FM1_4

As-run Activation Timeline

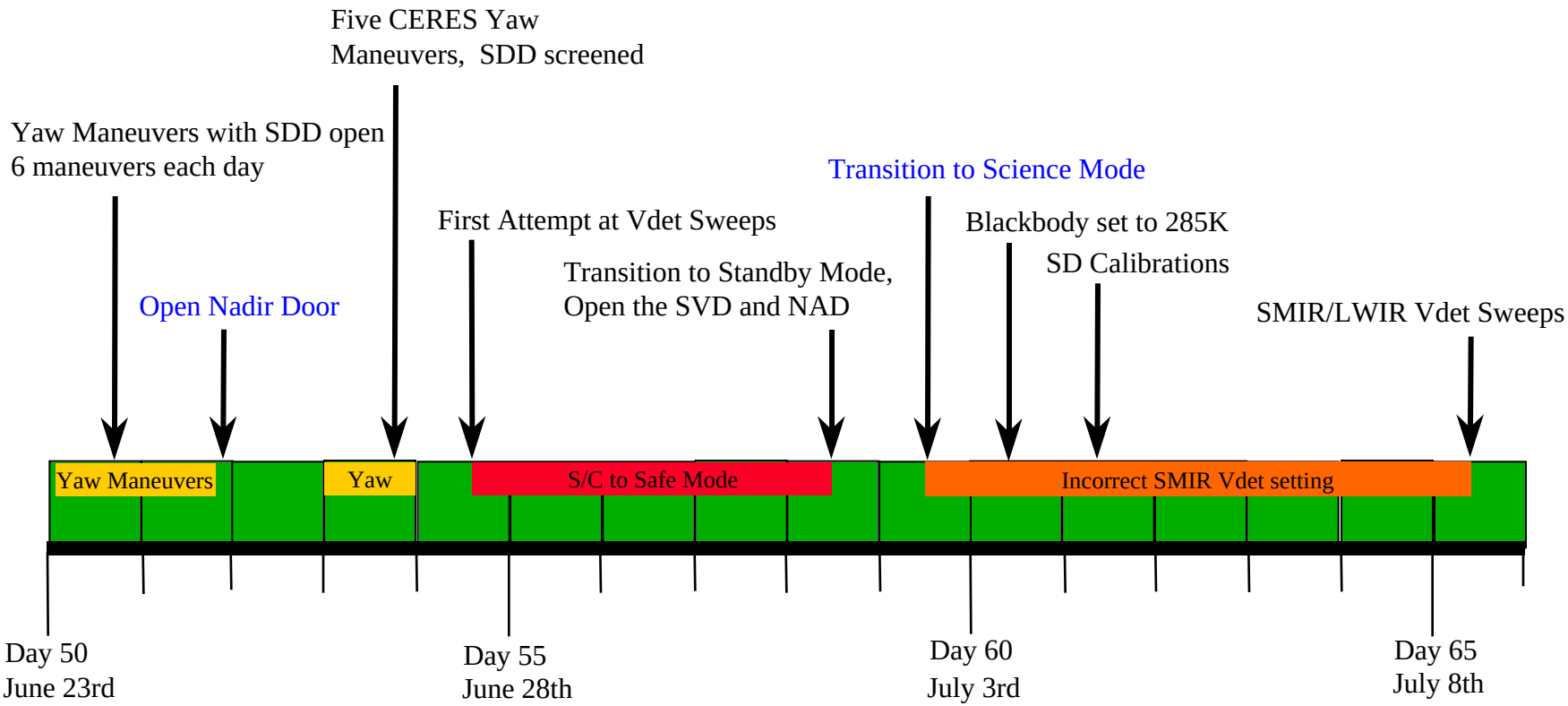
MET Day 35 - MET Day 50



Mission Elapsed Time / Date

As-run Activation Timeline

MET Day 50 - MET Day 66



Mission Elapsed Time / Date

FM1_6

L1B Algorithms & LUTs Status

MODIS/AQUA Level 1B Code Versions		
Version #	Calendar date of 1st use	Version Description Changes apply to subsequent versions unless otherwise noted.
V3.1.0_Aqua	4/1/2002 at GDAAC	• Blackbody warmup saturation corrected on Bands 33, 35, 36. LUT values are used for b1 if the BB temperature is over the saturation threshold. • New flag TEB_B1_NOT_CALCULATED added. Set if b1 cannot be calculated. • Aqua temperature conversion coefficients inserted. • Prelauch LUTs inserted.
V3.1.0.1_Aqua	6/19/2002 at GDAAC	LUT Update: Updated LUTs include esun_over_pi, k_inst, m1, r_star, rsb_nedl, sigma_k_inst, sigma_m1, sigma_r_star, sigma_rvs_rsb_table, a0_table, a1_table, a2_table, and l_max.
V3.1.0.2_Aqua	TBD	LUT Update: m1, r_star, sigma_m1, band_21_b1, and bb_t_sat_default_b1_aqua.
V4.1.0_Aqua	To be submitted to SDST 7/31/2002	• RVS correction changed to piecewise linear. • Code ported to LINUX machines; data type of LUT "dn_sat_ev" changed to float64 for IRIX/LINUX agreement. • ADC correction algorithm stripped out. • Treatment of leading/trailing granules when 5 or fewer scans dropped changed • Code logic altered for efficiency, other minor changes. • Geolocation metadata now obtained from L1AGEO Geolocation input file, not L1A input file.

**** Same as Terra L1B with PCX correction and SWIR corrections off, B6 detector flags, B36 D5 flag, and b1 LUT for B33, 35, 36 at high T_BB***

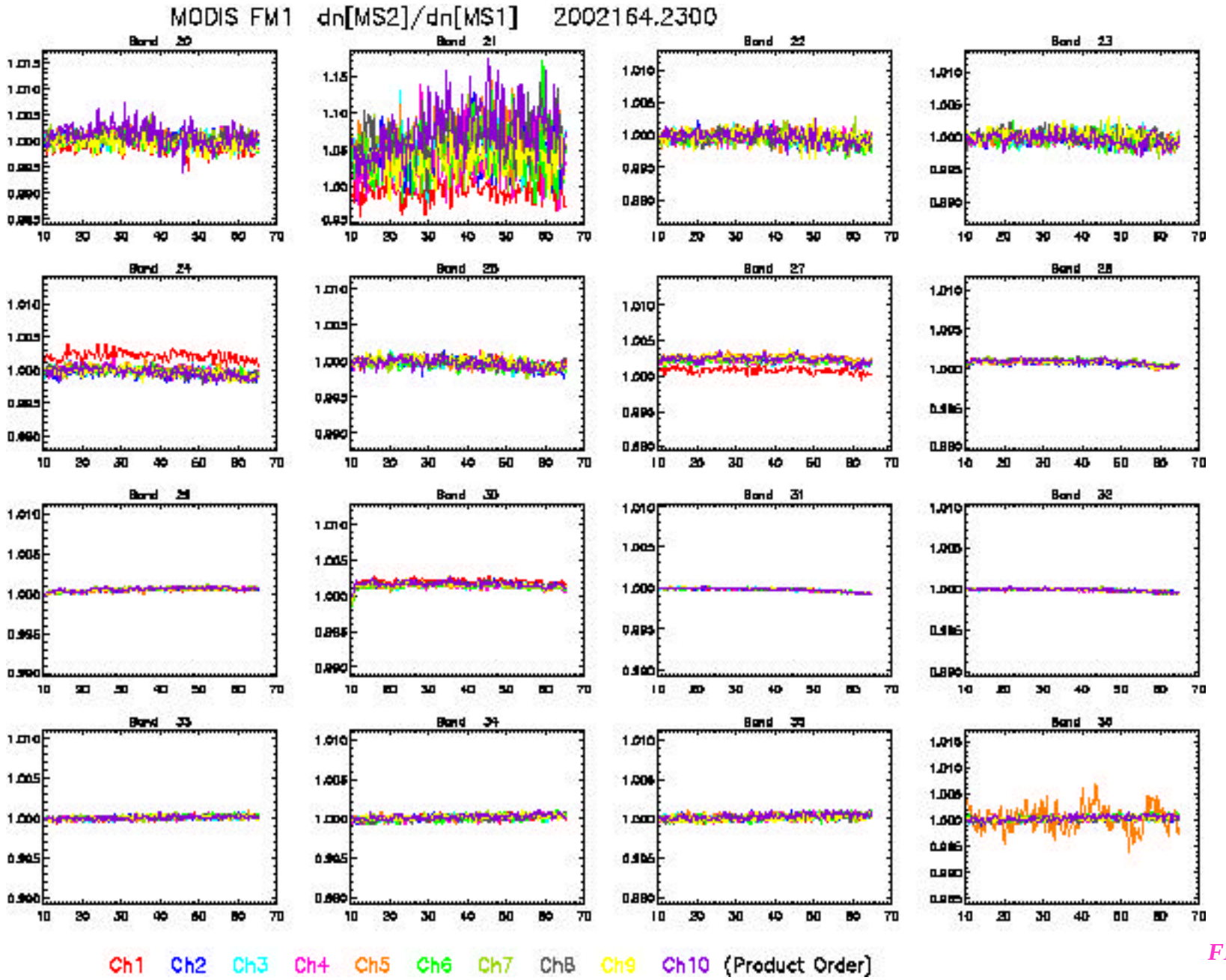
Major Calibration & Characterization Activities

- SD/SDSM (6 planned, 4 implemented, and 4 processed)
- BB warm-up/cool-down (2, 2, 1)
- Ecal (3, 3, 3)
- SRCA (4, 4, 4)
- Lunar observation (2, 1, 1)
- Itwk/Vdet sweep (1, 1, 1)
- Night time day mode observations (1, 1, 0)
- Yaw Maneuver (2, 2, 2)

Aqua Improvements Over Terra

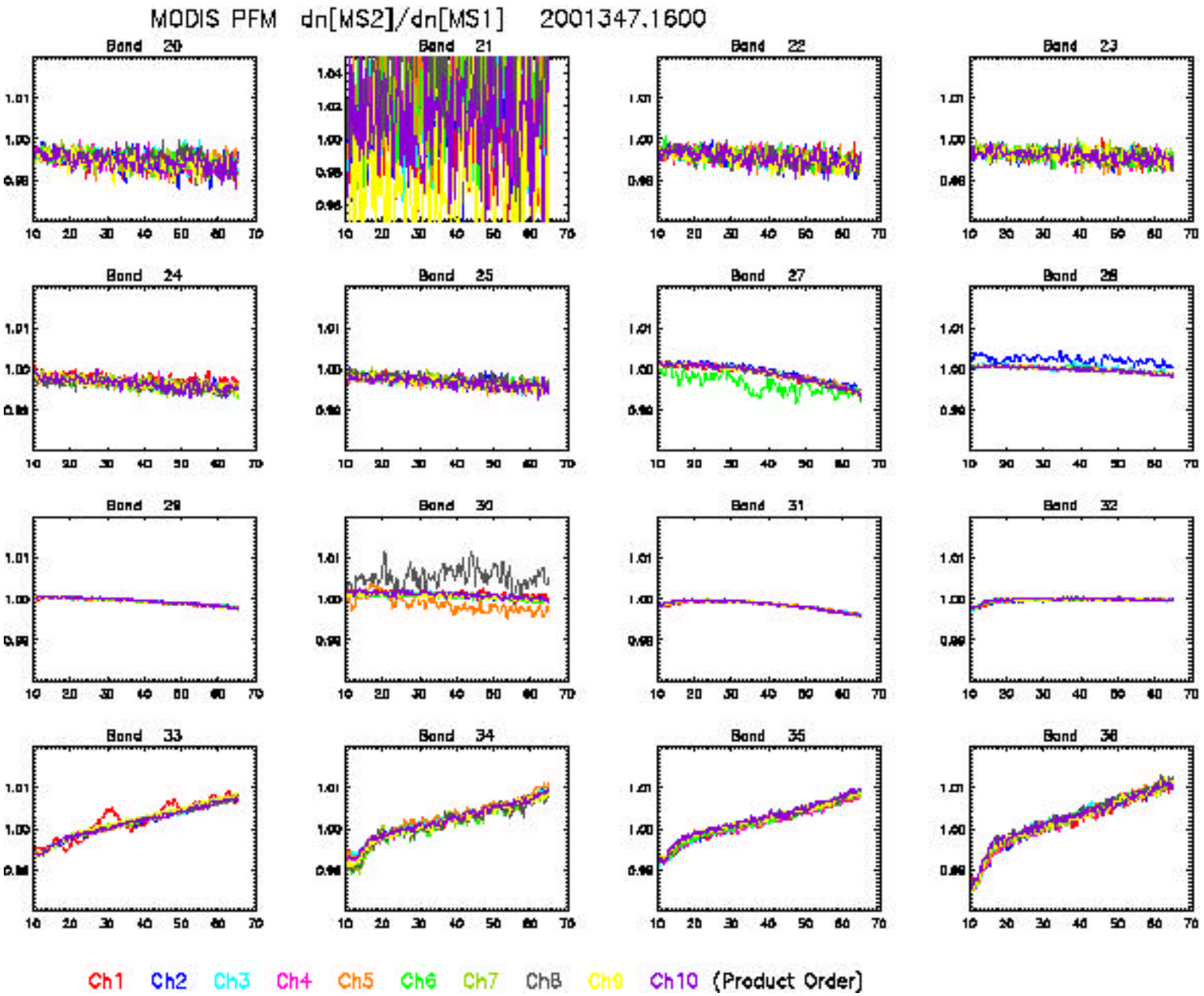
- Pre-launch system level RVS measurements
- Less SWIR thermal leak
- Less SWIR electronics crosstalk
- PC optical leak removal

Aqua NAD scanning (dn_ms2/dn_ms1)



FM1_10

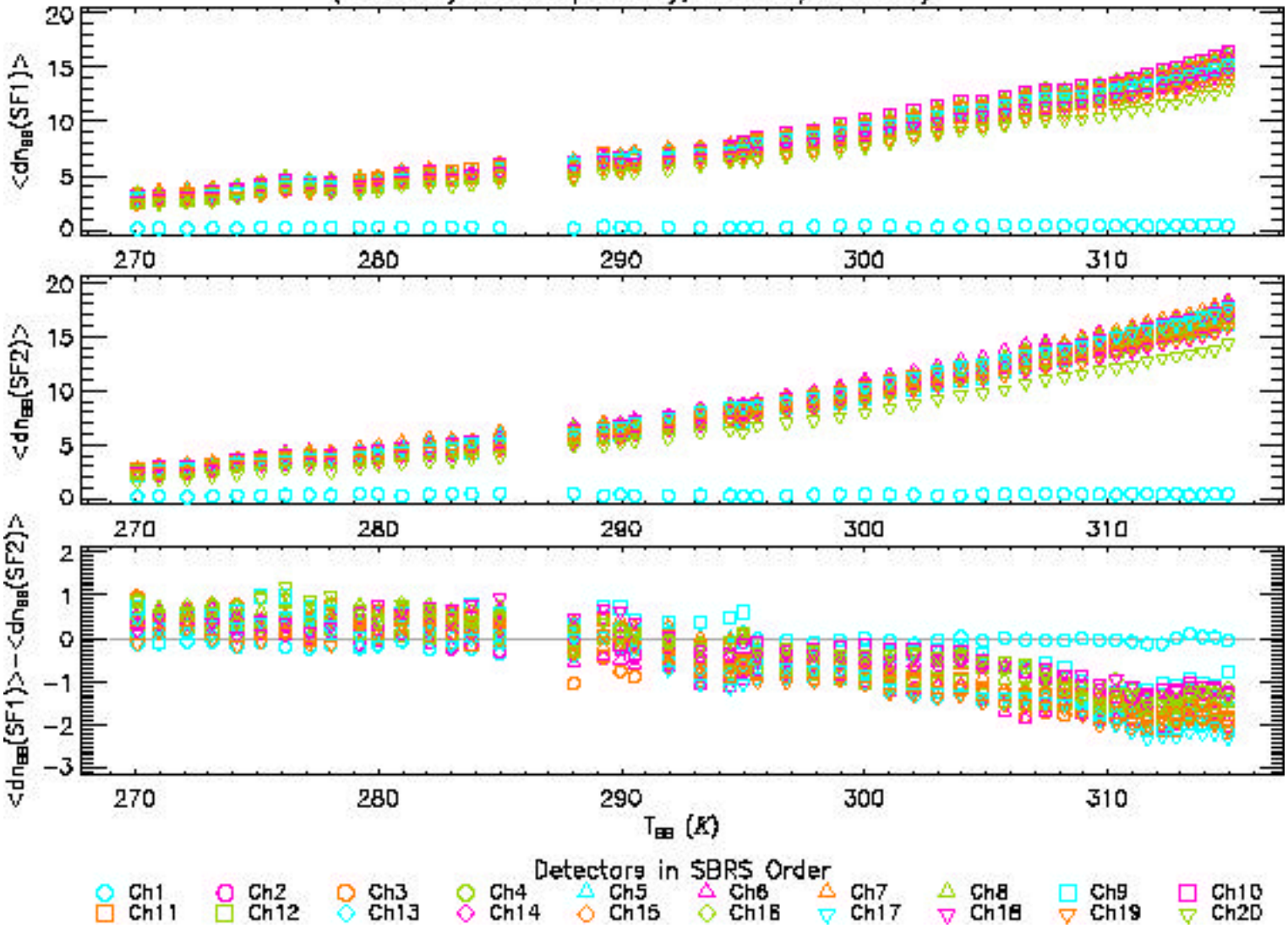
Terra NAD scanning (dn_ms2/dn_ms1)



Aqua MODIS B5 dn_BB

Compared to Terra MODIS: Smaller dn_BB, less SF difference

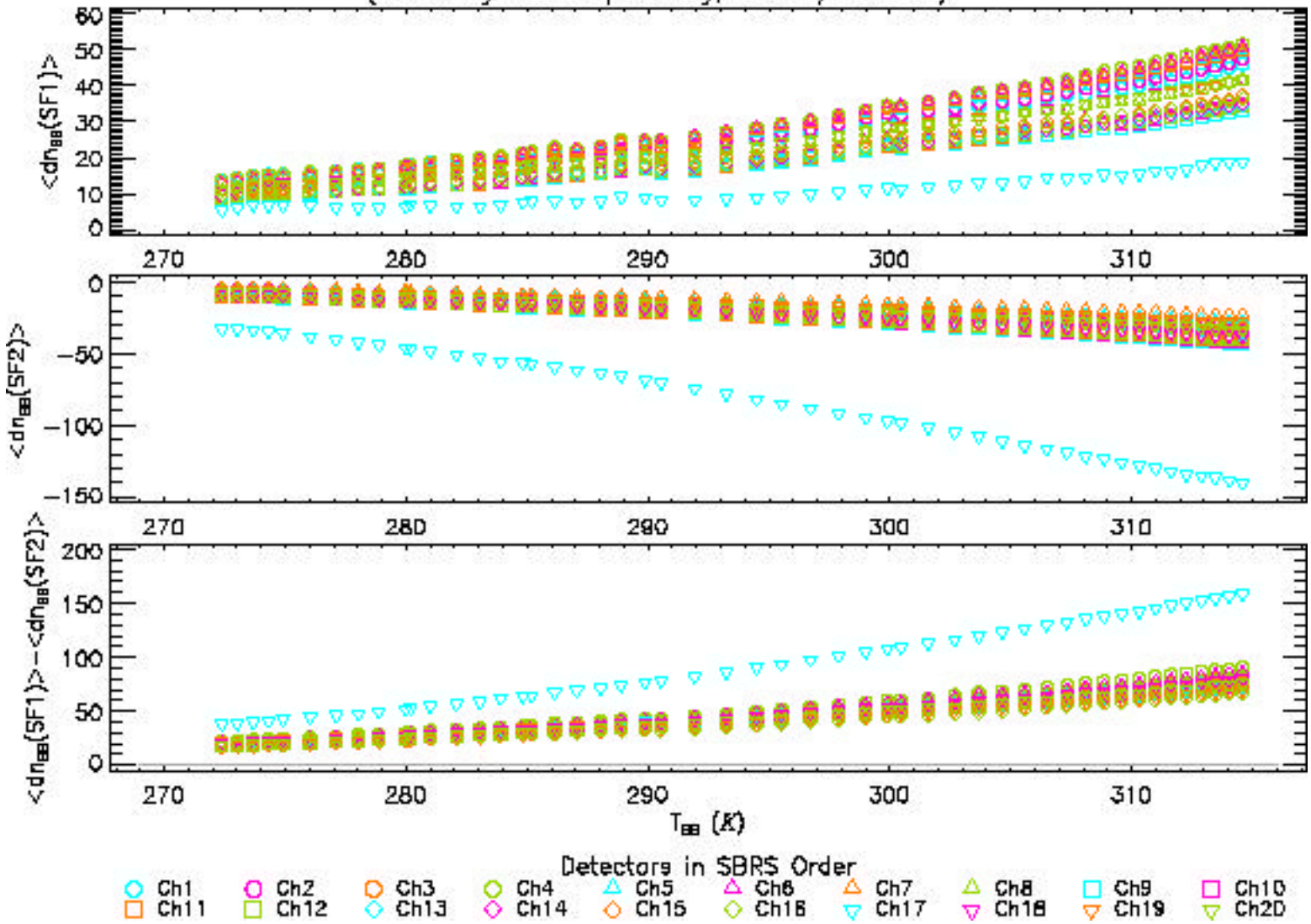
Figure 1. Aqua MODIS B5 <dn_{BB}> of Sub-frame 1, 2, and their Difference
OBC Data Set during Day_2002_190_191
(Blackbody Warm-up Activity; Itwk:102/Vdet:184)



FM1_12

Terra MODIS B5 dn_BB

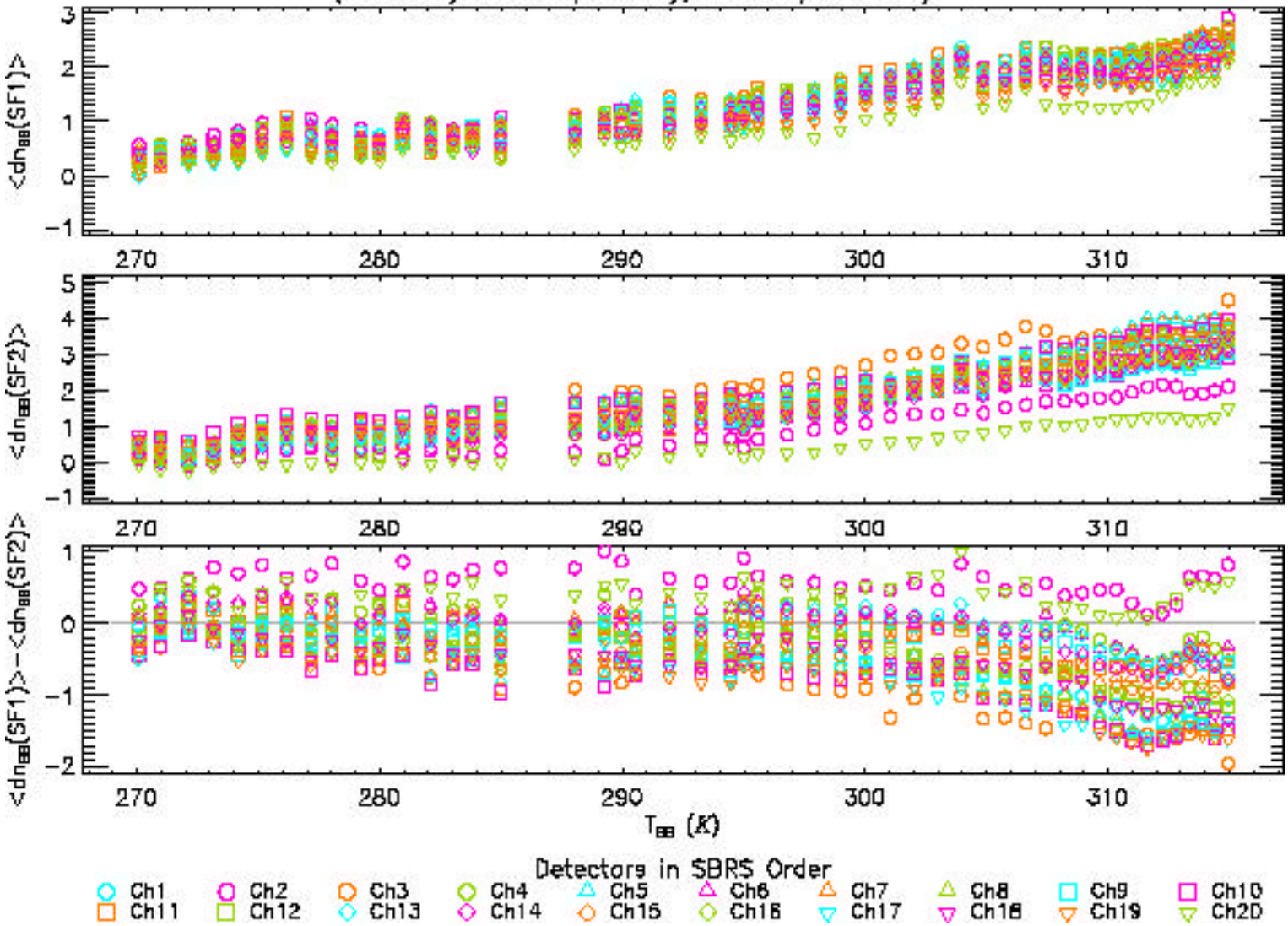
Figure 1. Terra MODIS B5 <dn_{BB}> of Sub-frame 1, 2, and their Difference
OBC Data Set during Day_2002_111
(Blackbody Warm-up Activity; Itwk:79/Vdet:190)



Aqua MODIS B7 dn_BB

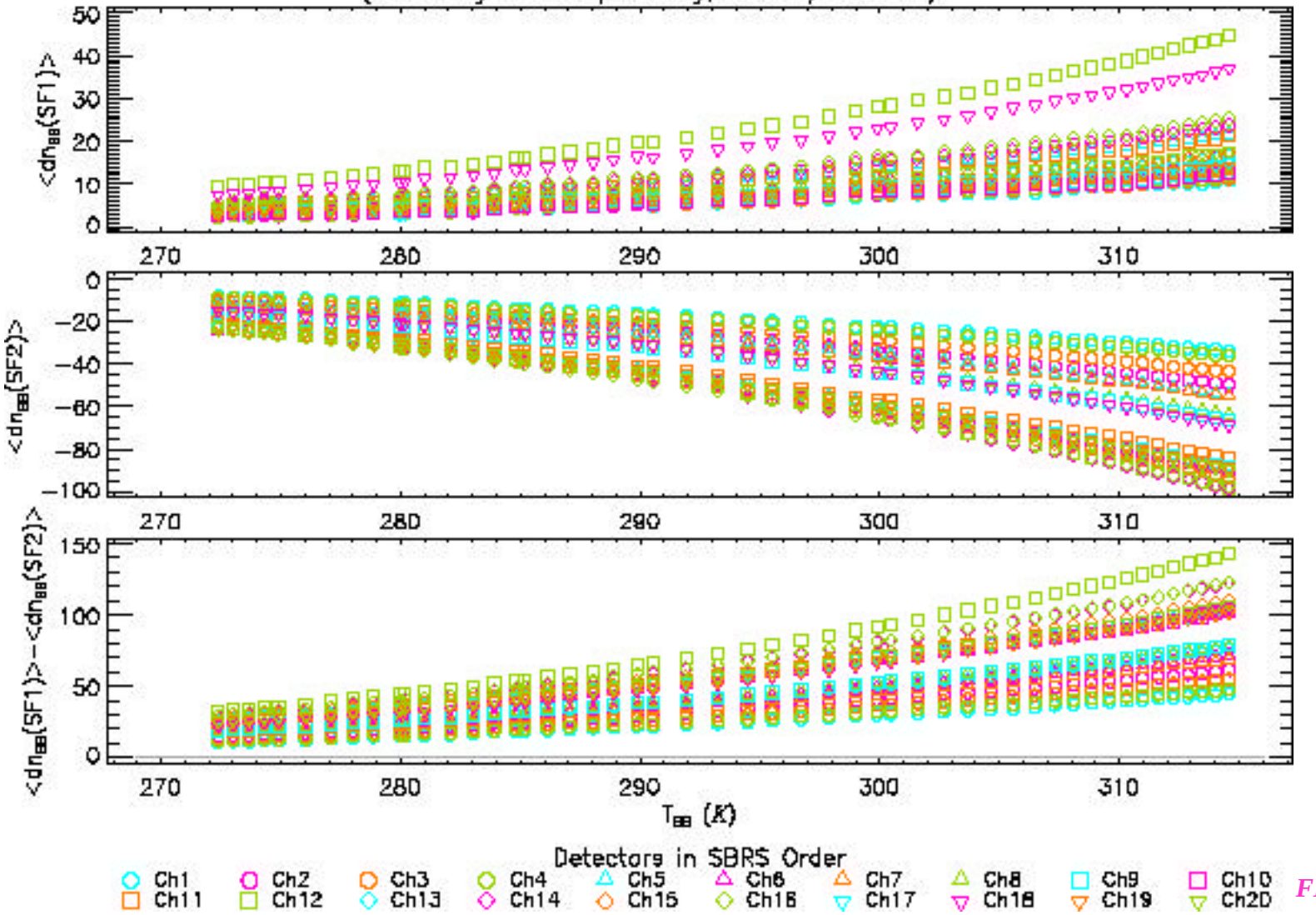
Compared to Terra MODIS: Smaller dn_BB, less SF difference

Figure 3. Aqua MODIS B7 <dn_{BB}> of Sub-frame 1, 2, and their Difference
OBC Data Set during Day_2002_190_191
(Blackbody Warm-up Activity; Itwk:102/Vdet:184)



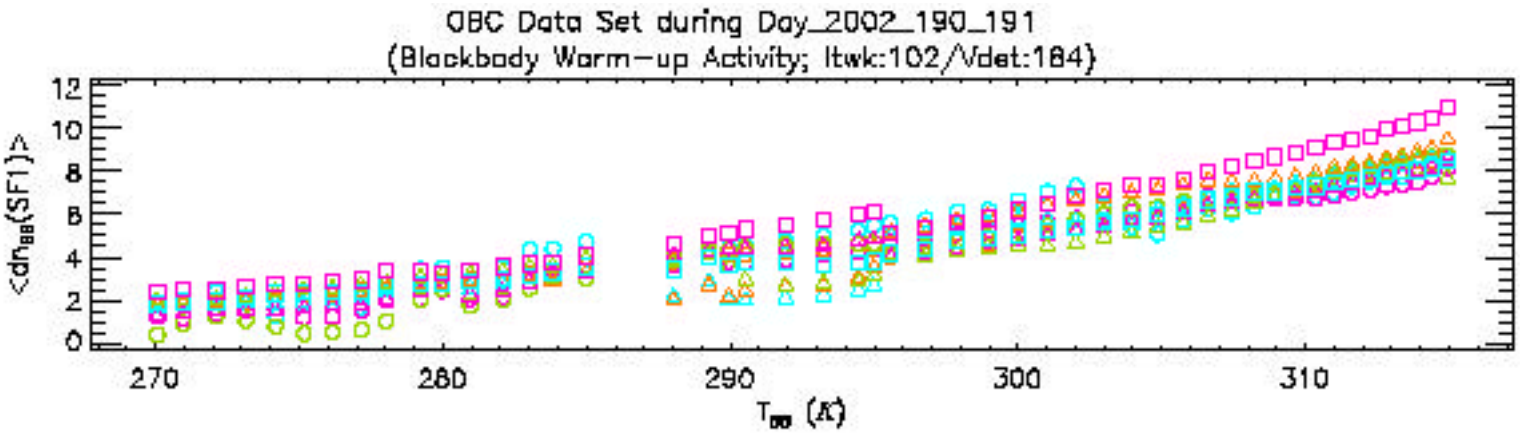
Terra MODIS B7 dn_BB

Figure 3. Terra MODIS B7 <dn_{BB}> of Sub-frame 1, 2, and their Difference
OBC Data Set during Day_2002_111
(Blackbody Warm-up Activity; Itwk:79/Vdet:190)

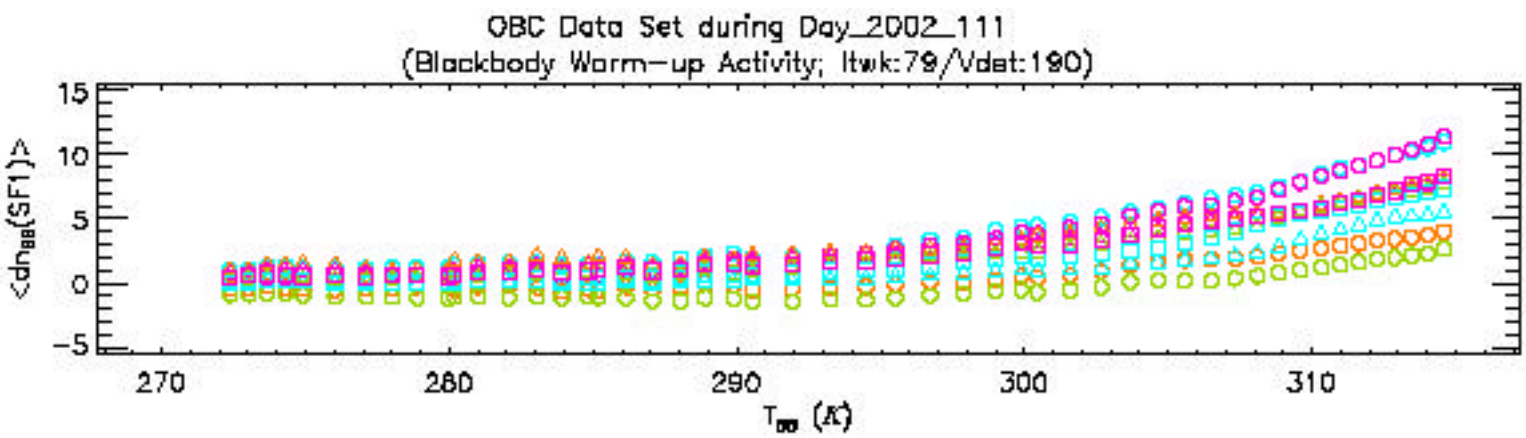


Aqua and Terra B26 Comparison

Aqua MODIS B26 dn_BB

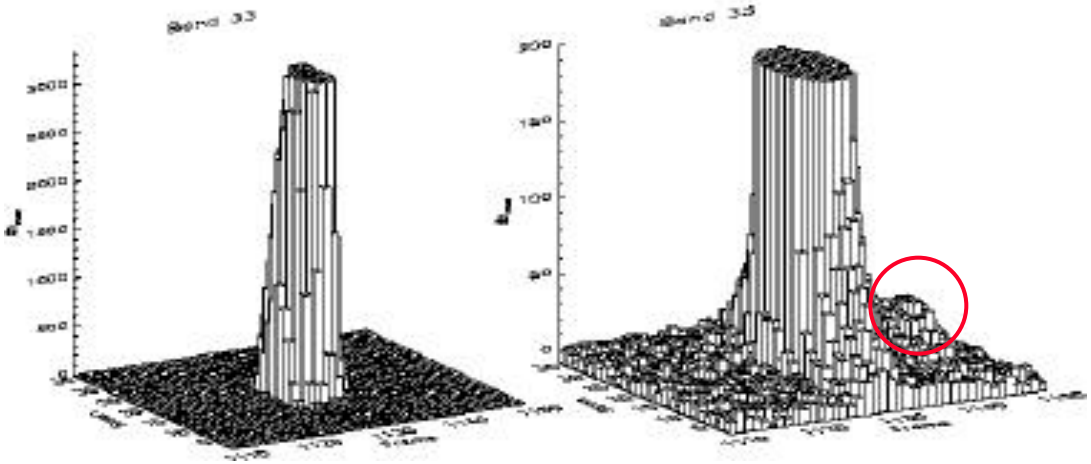


Terra MODIS B26 dn_BB



PC Bands (32-36) 11μ*m* Optical Leak

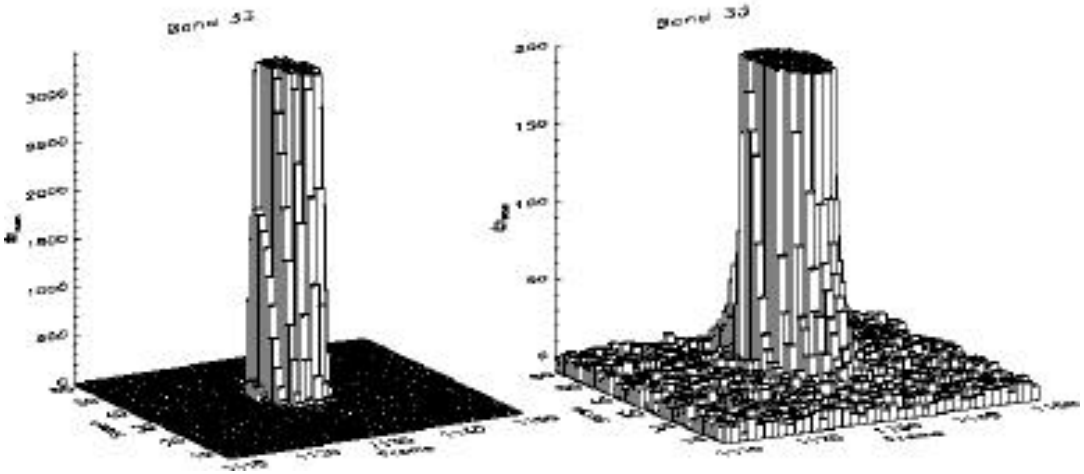
PFM Band 33 (Channel 5) During 2002062/07:15 Moon View Event



Lunar Response

Terra MODIS B33

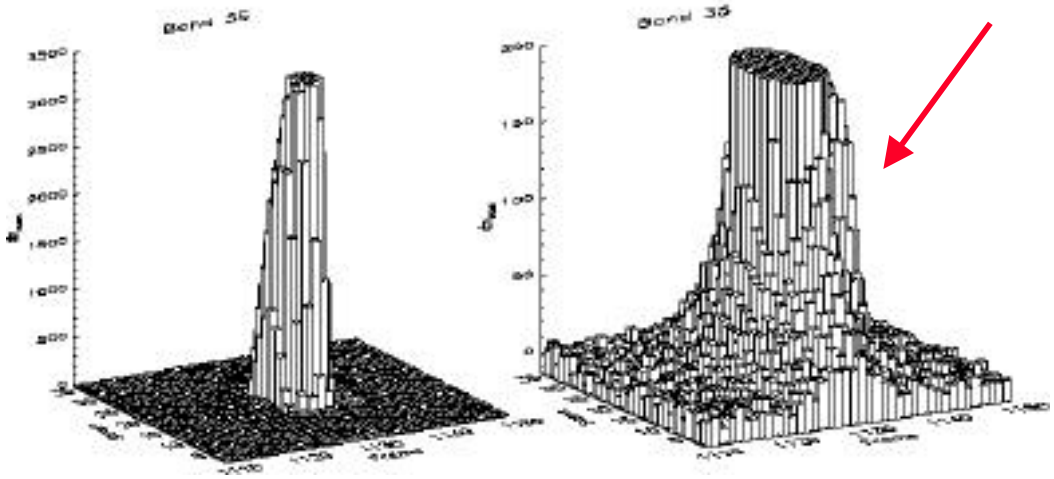
FM1 Band 33 (Channel 5) During 2002171/16:45 Moon View Event



Aqua MODIS B33

PC Bands (32-36) 11μ*m* Optical Leak

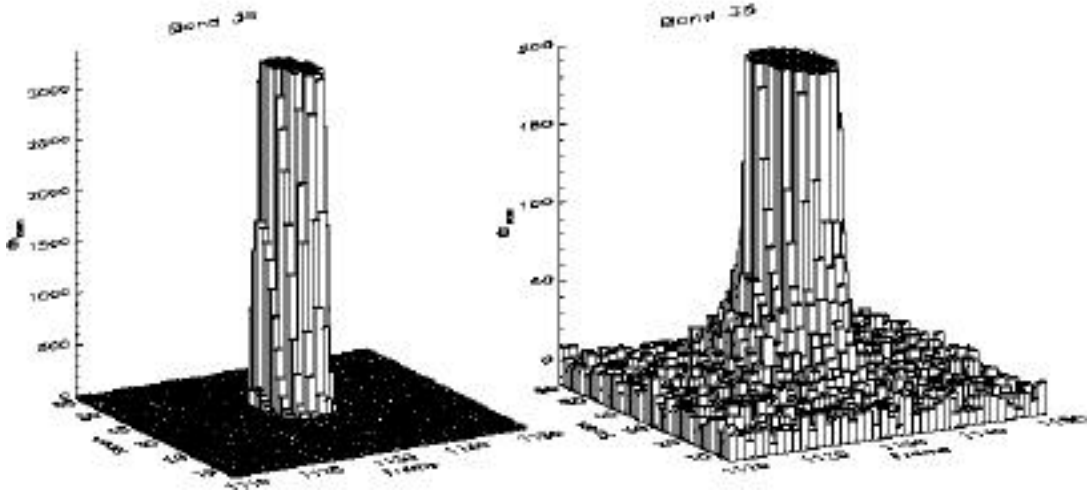
PFM Band 35 (Channel 5) During 2002062/07:15 Moon View Event



Lunar Response

Terra MODIS B35

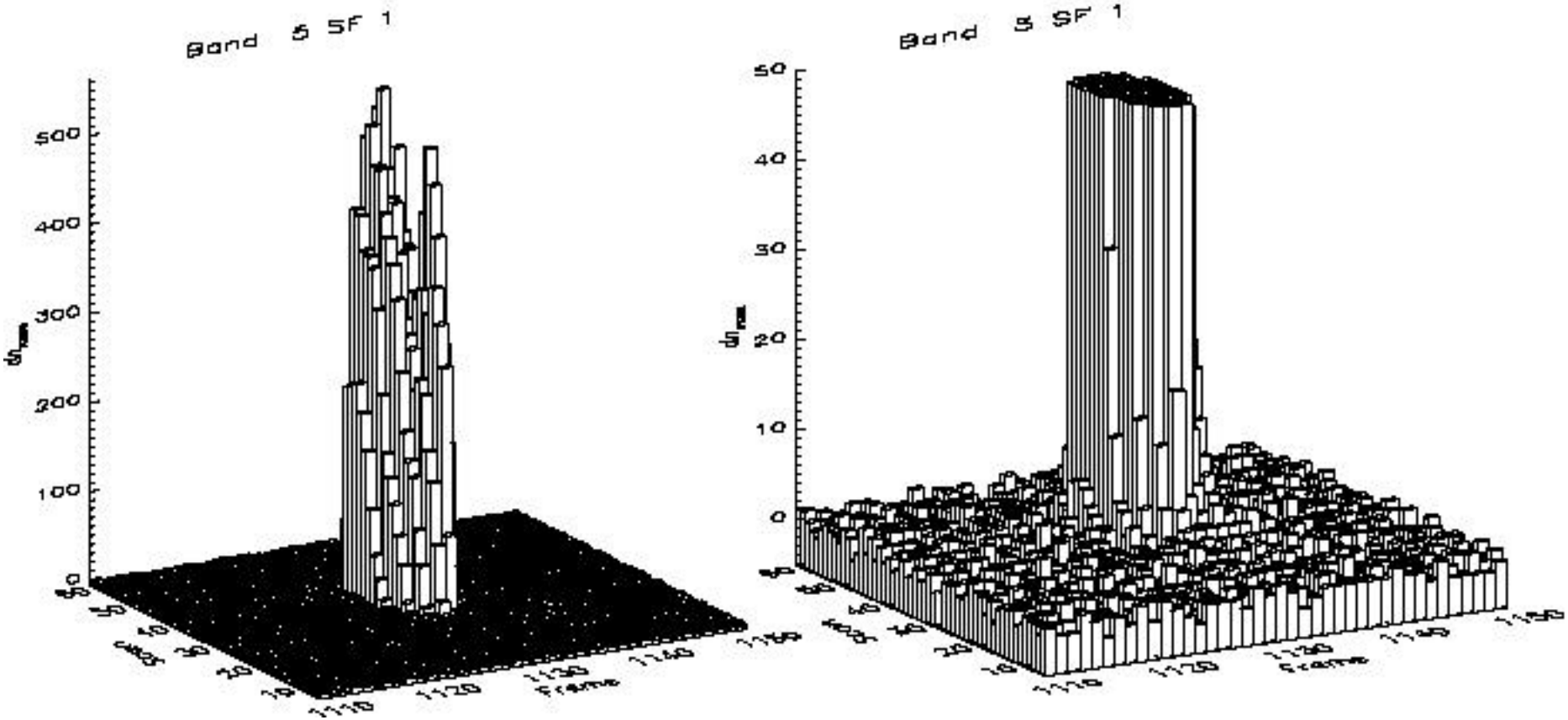
FM1 Band 35 (Channel 6) During 2002171/16:45 Moon View Event



Aqua MODIS B35

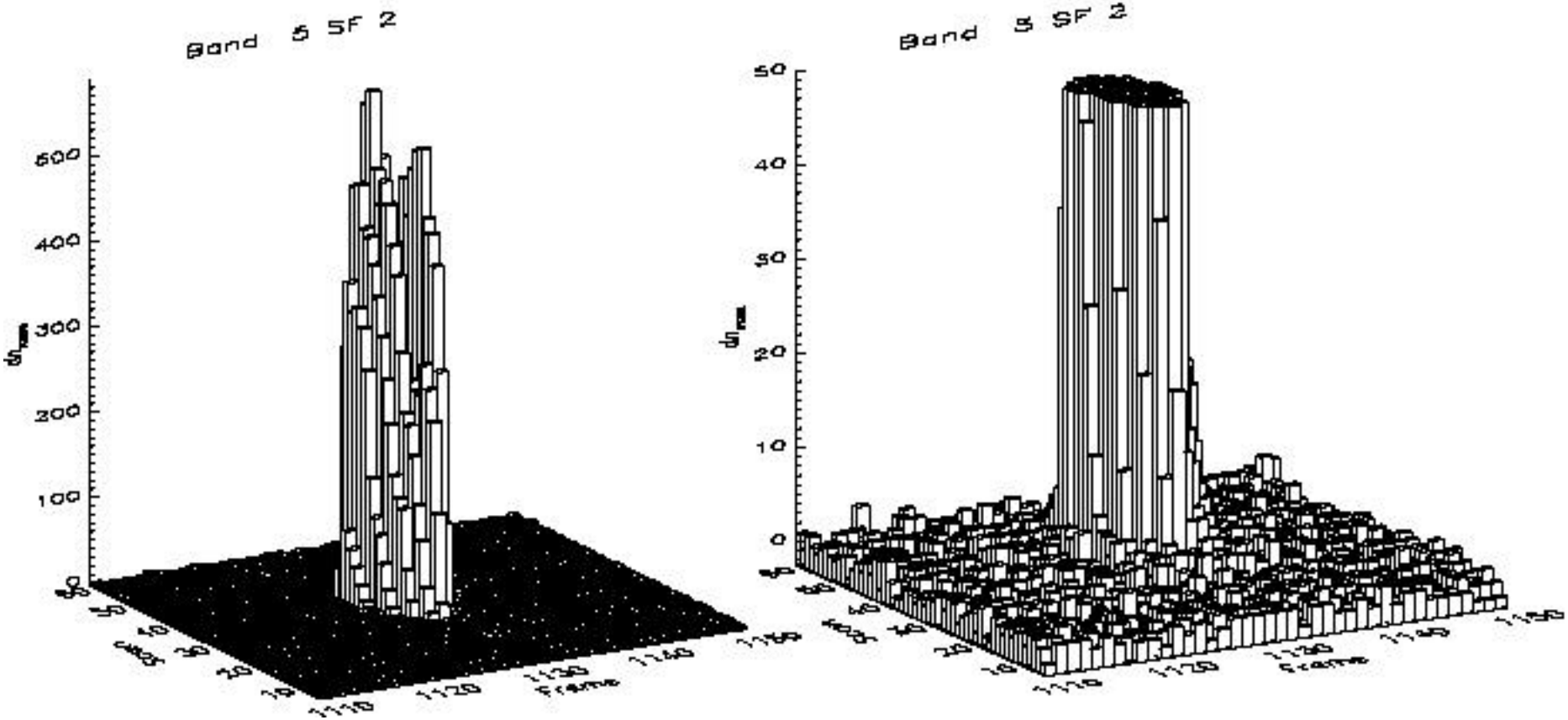
Aqua MODIS Lunar View B5 - SF1

FM1 Band 5 (Channel 10) During 2002171/16:45 Moon View Event



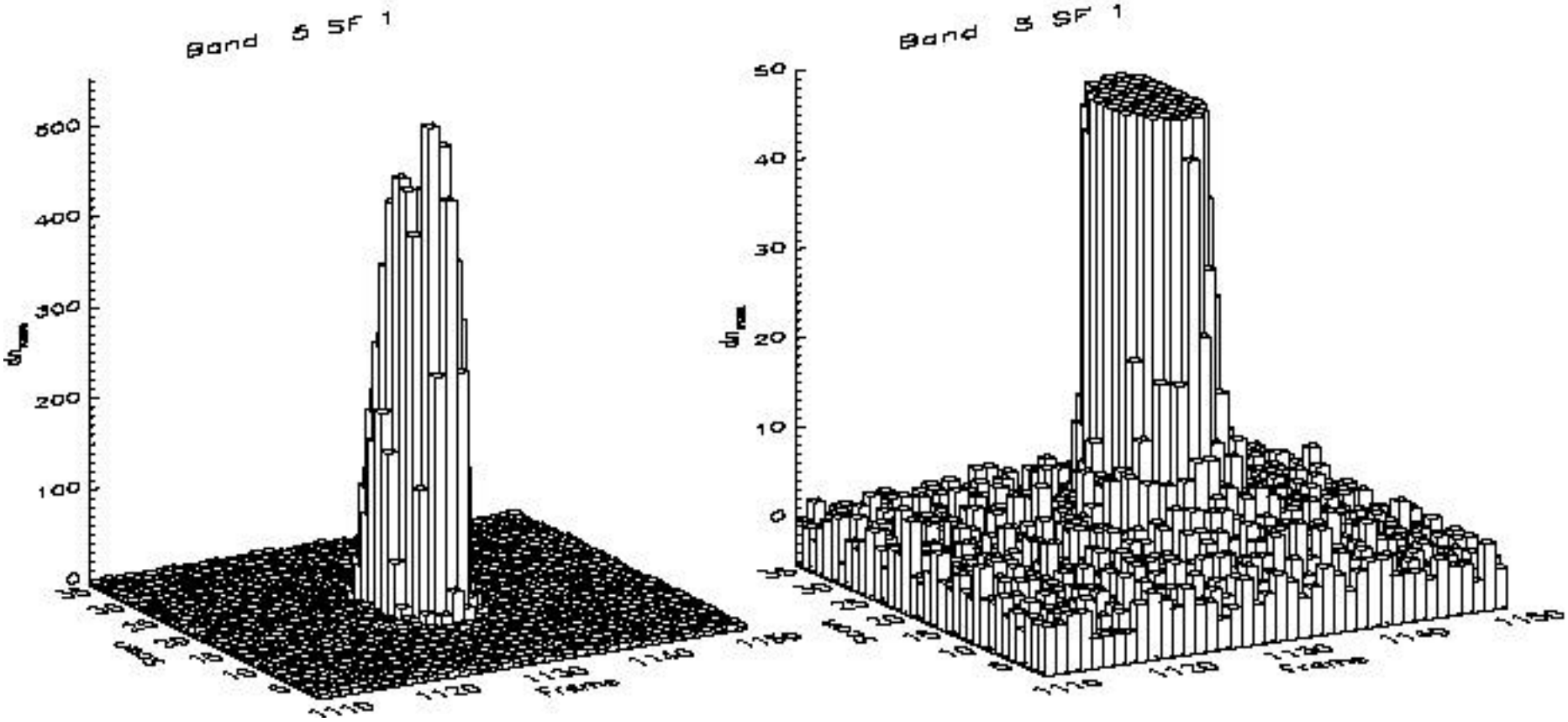
Aqua MODIS Lunar View B5 - SF2

FM1 Band 5 (Channel 10) During 2002171/16:45 Moon View Event



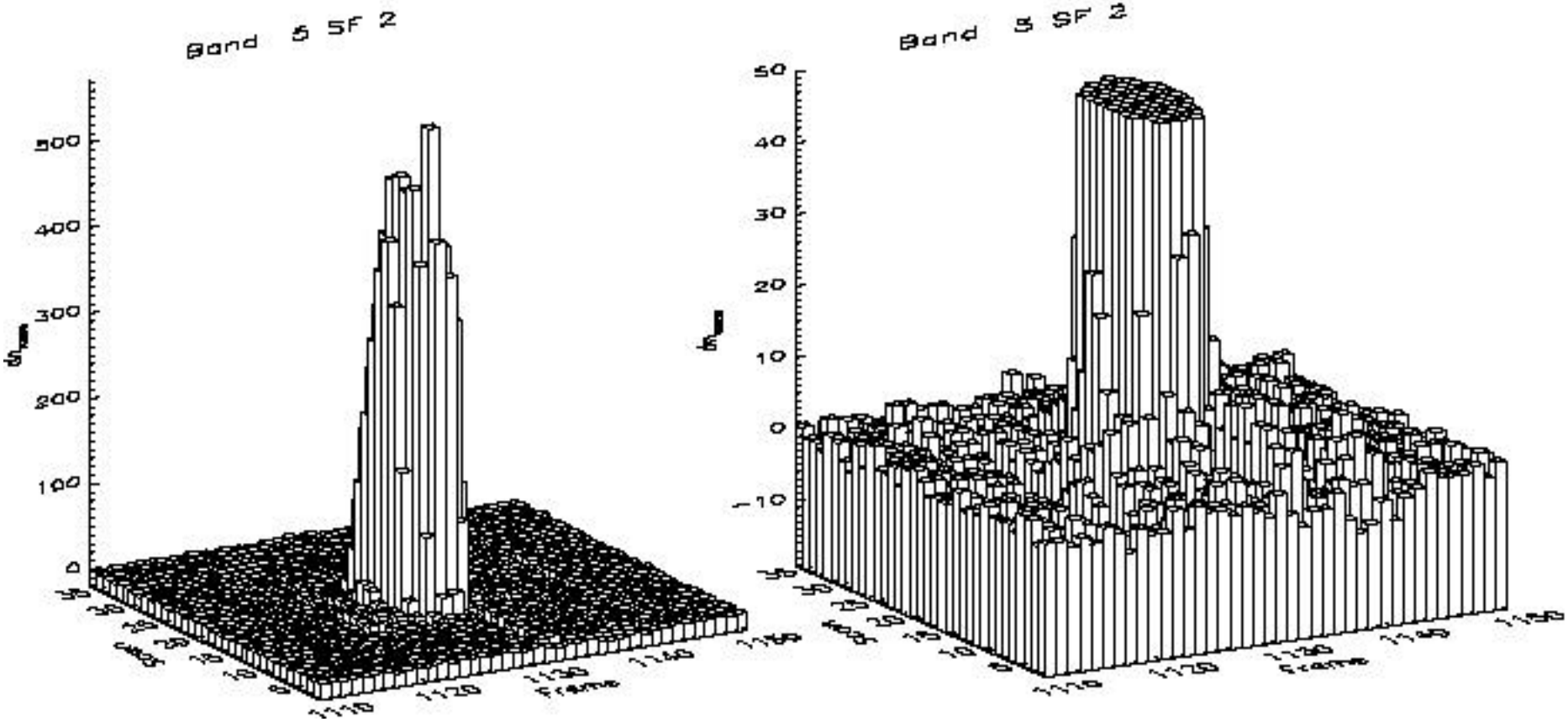
Terra MODIS Lunar View B5 - SF1

PFM Band 5 (Channel 10) During 2002062/07:15 Moon View Event



Terra MODIS Lunar View B5 - SF2

PFM Band 5 (Channel 10) During 2002062/07:15 Moon View Event



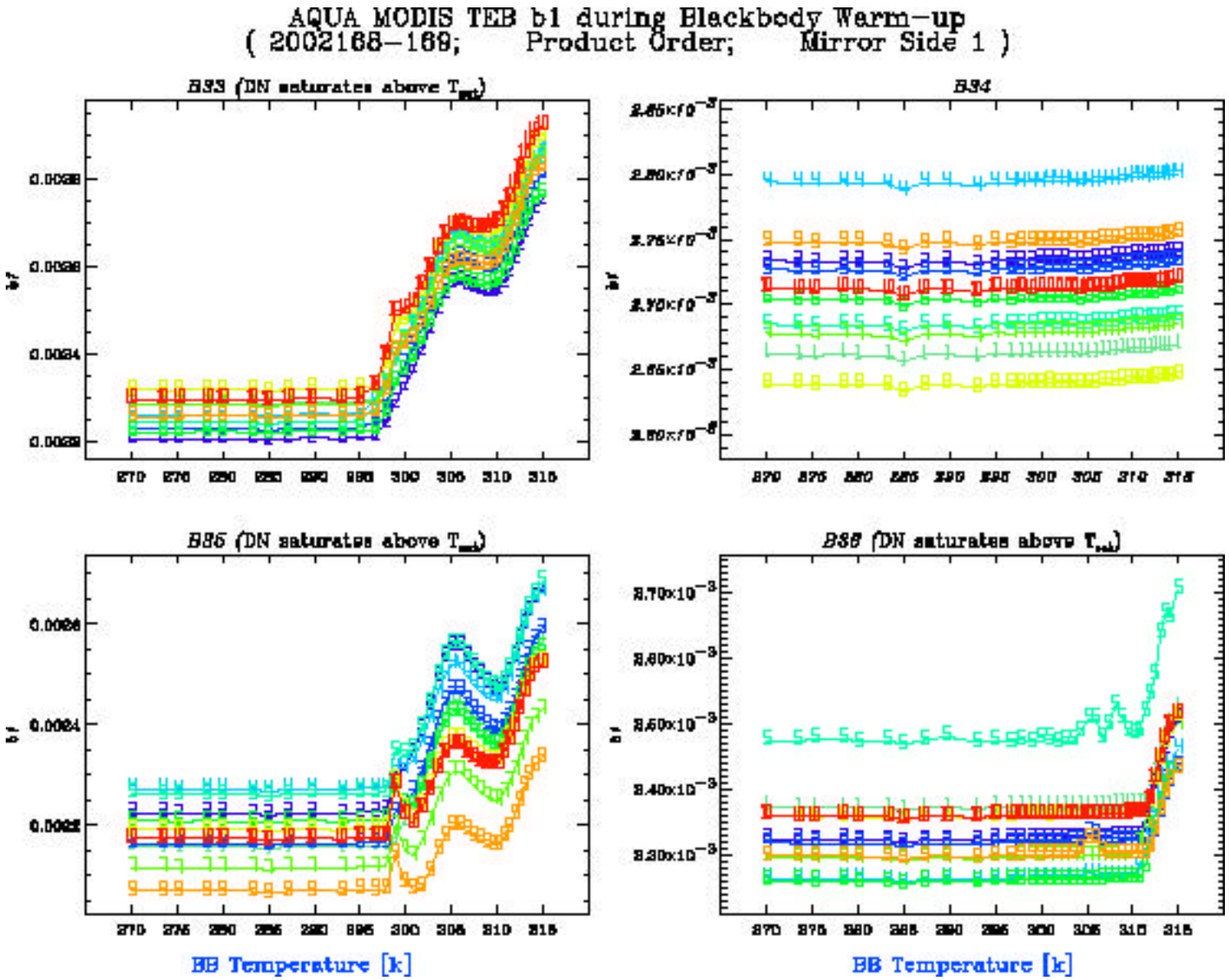
FM1_22

Calibration and Characterization

- TEB
  - Response trending, NEdT (B36 D5)
- RSB
  - Response trending, SNR, B13h/14h coefficients
  - B6 operability
- SRCA and ECAL
  - Spatial & Spectral
  - Electronic gain tracking and dn_sat

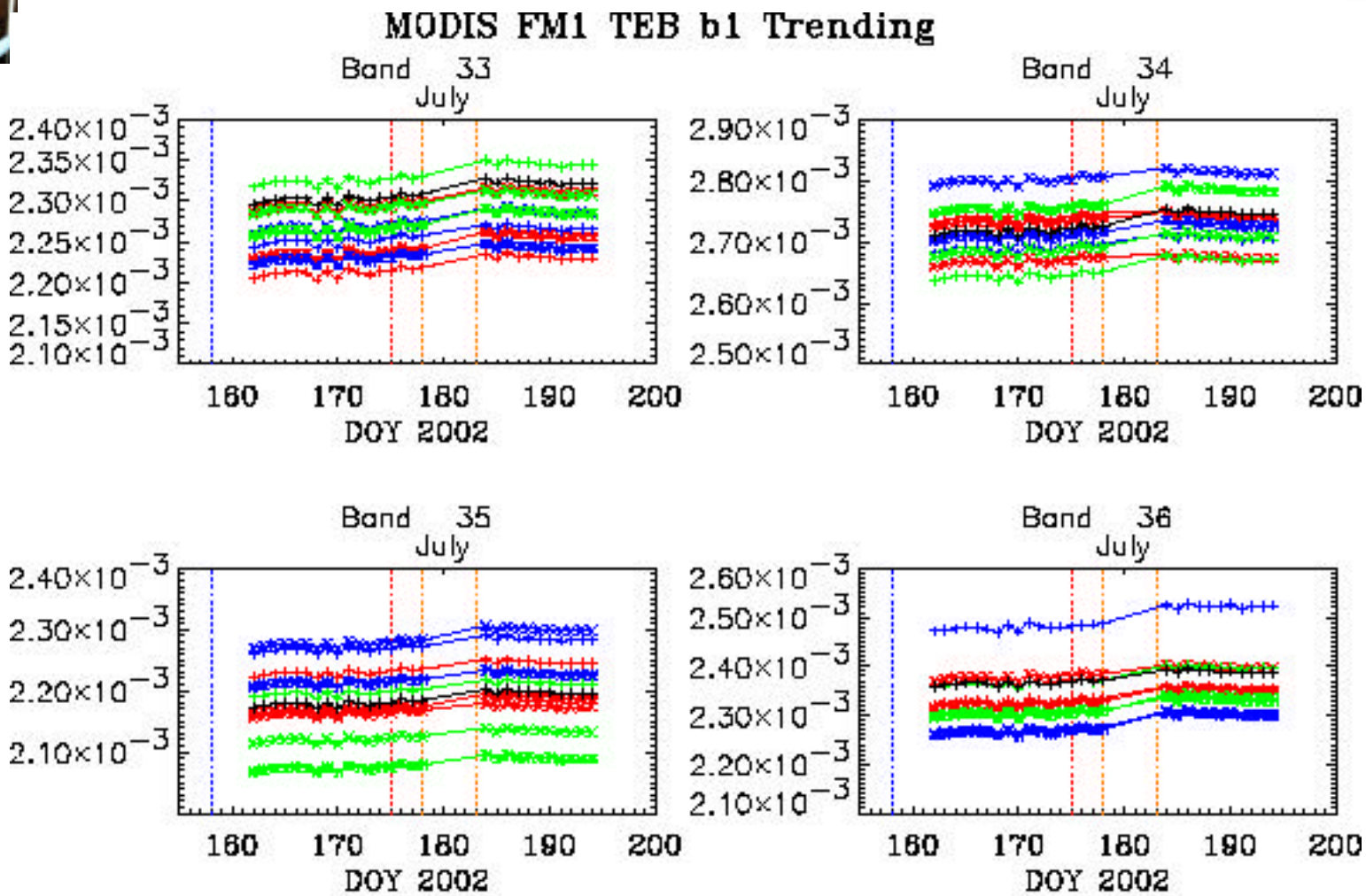
TEB Response Trending

B33, 35, 36 saturate at high T_BB



TEB Response Trending

TEB response is stable



Ch1: x Ch2: + Ch3: * Ch4: x Ch5: + Ch6: * Ch7: x Ch8: + Ch9: * Ch10: + (In Product Order)

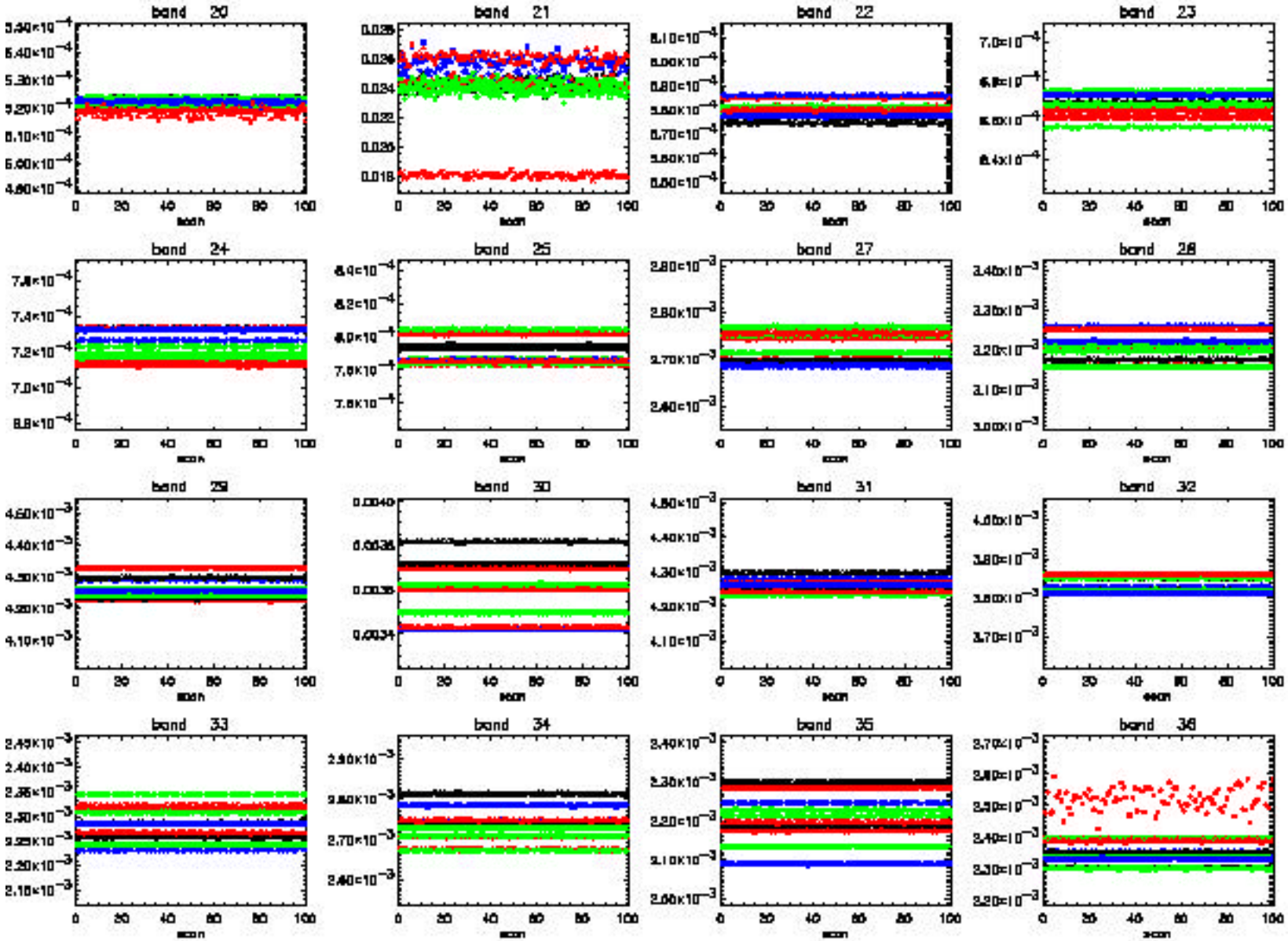
(T_bb @ 265 K)

Day 156 – Turned to Science Mode

Day 175 – Nadir Door Open

Day 178, 183 – Turned to Safe Mode and back to Science Mode

MODIS FM1 On-orbit TEB b1 vs Scan (MS1) (Detector in Product order)

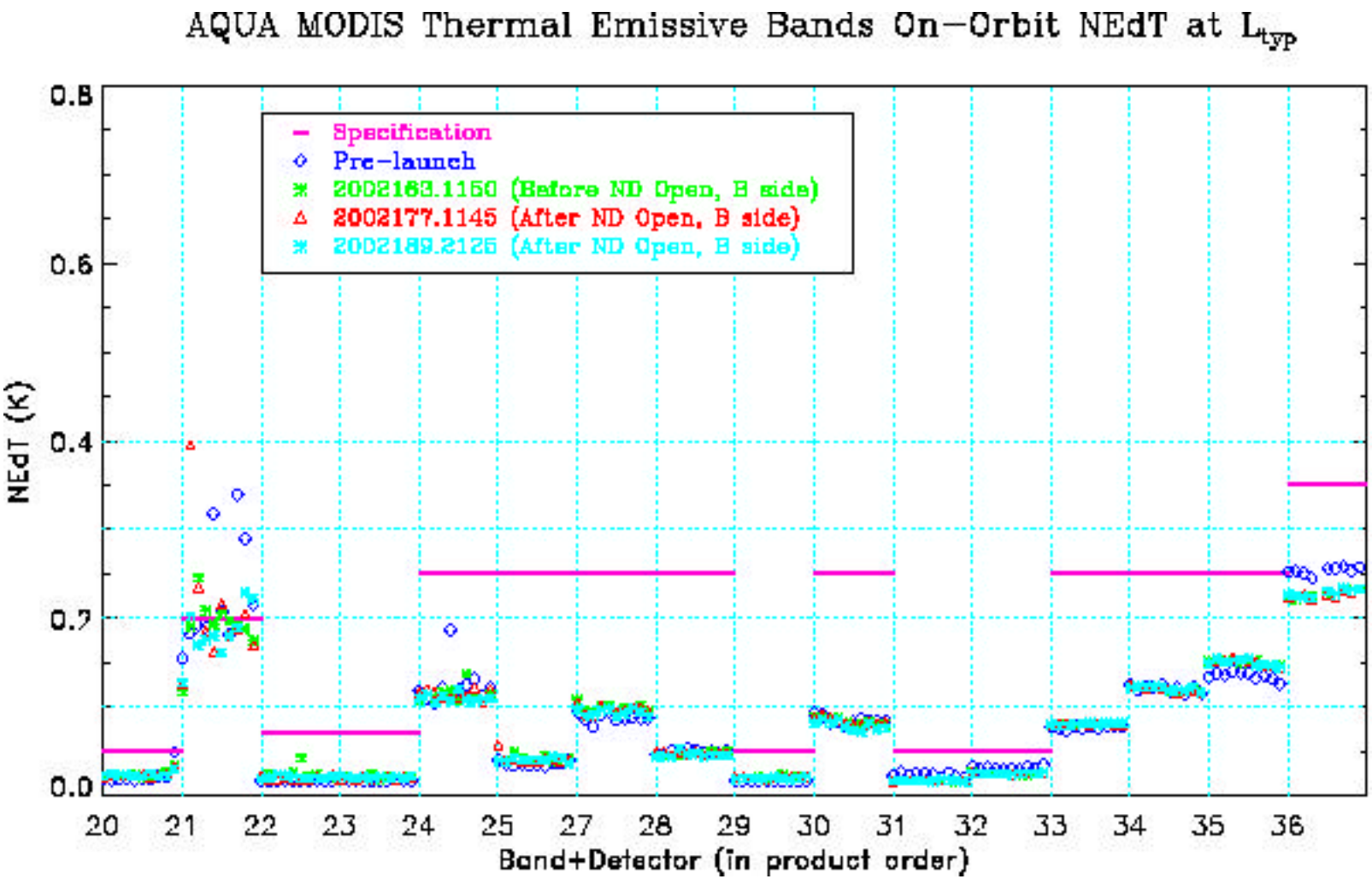


Ch1:Red x Ch2:Blu + Ch3:Blk * Ch4:Blk Δ Ch5:Red ◇ Ch6:Grn □ Ch7:Grn x Ch8:Grn + Ch9:Blu * Ch10:Red Δ

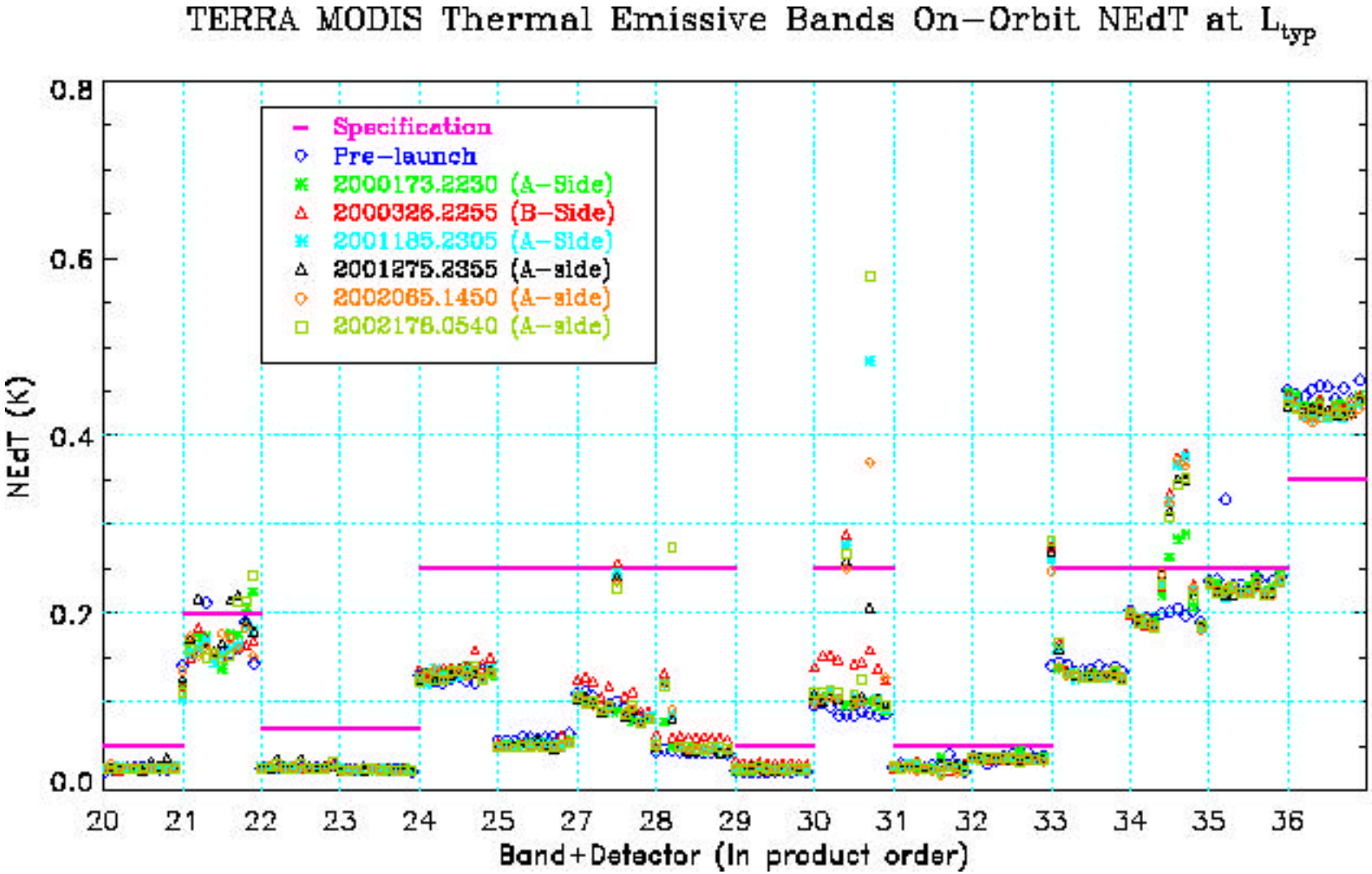
Data collected time: F2002189.2125 T_{-00}: from 284.982 to 285.002 Itwk/Vdet = 102/184

FM1_26

Aqua MODIS TEB NEdT

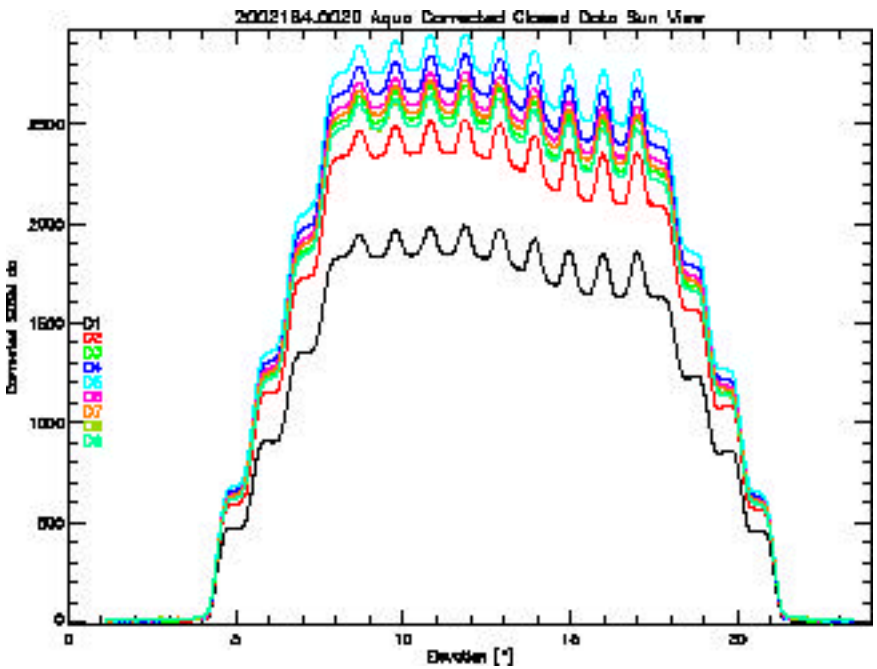


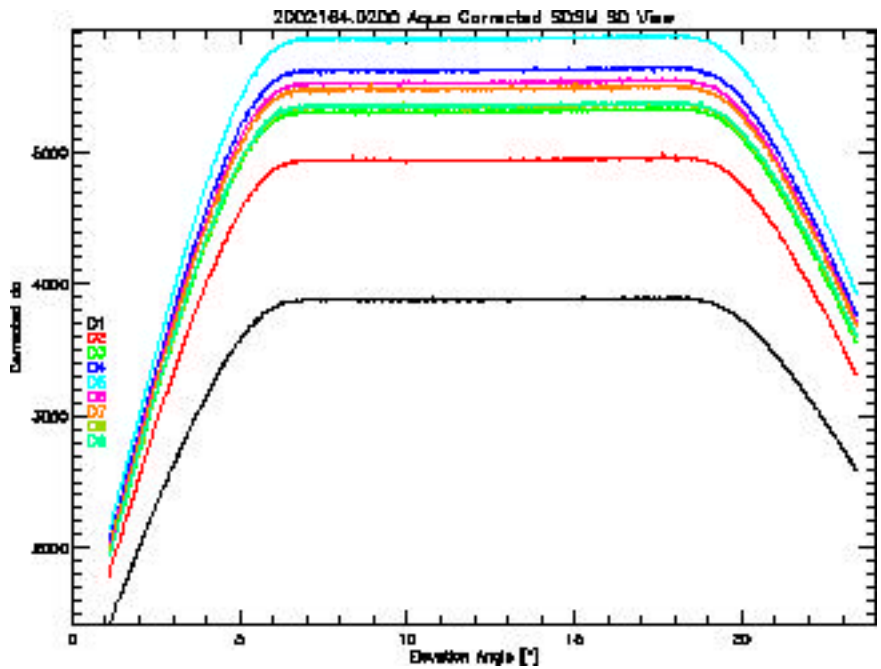
Terra MODIS TEB NEdT



SD Degradation Approach

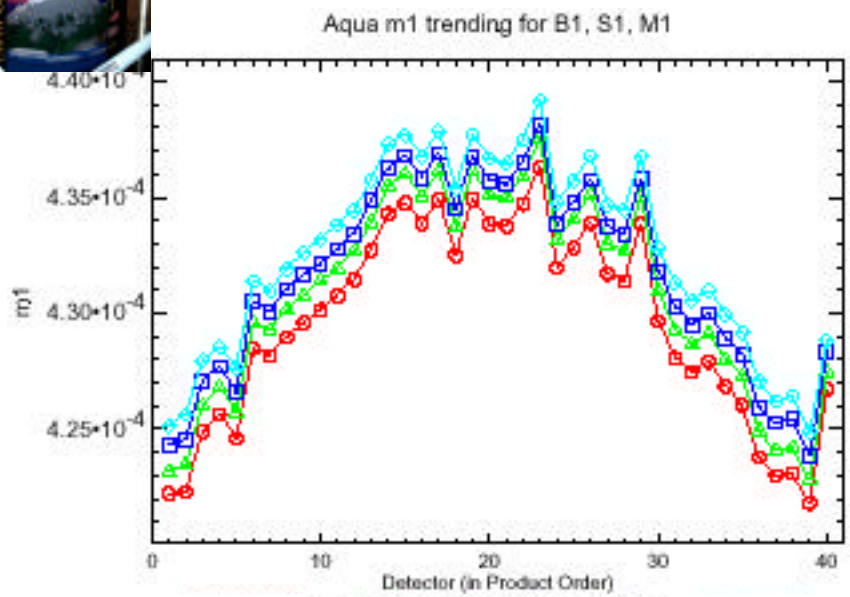
Use approach developed for Terra

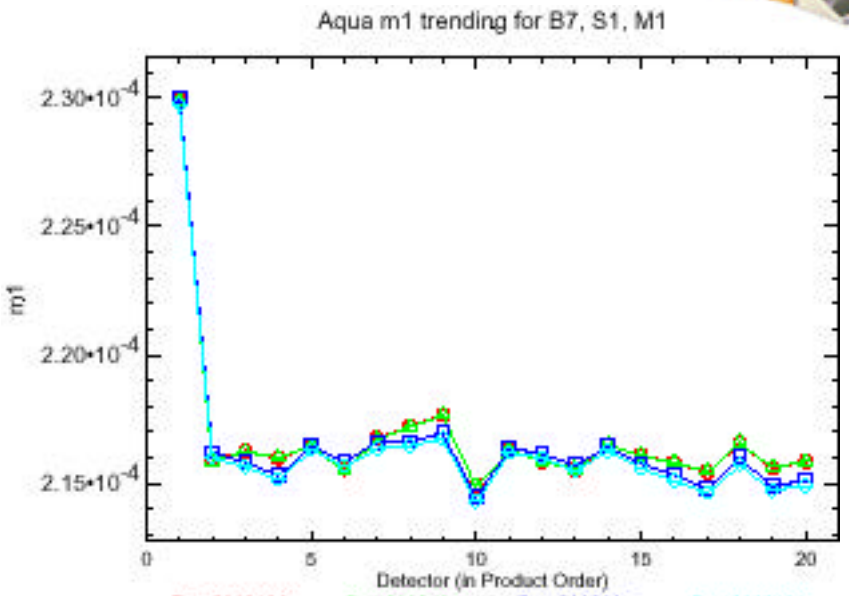


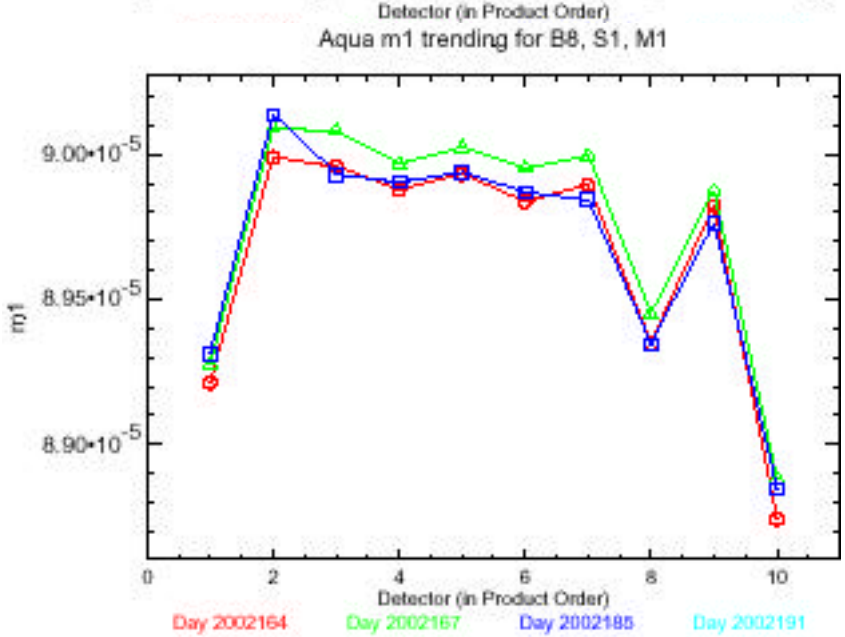


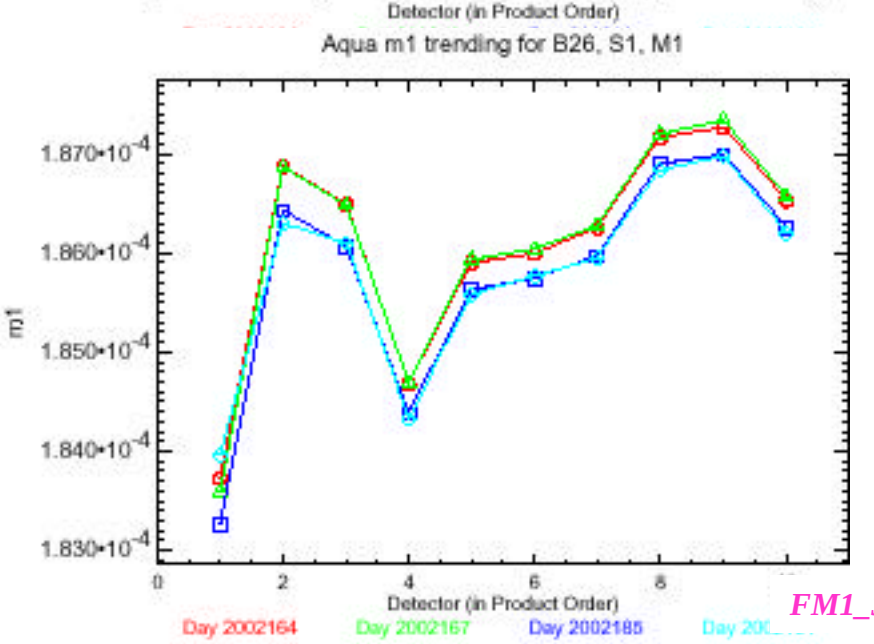
$$\Delta_{SD} = \frac{\overline{dc_{SD}}}{\overline{dc_{Sun}}} \quad \Rightarrow \quad \left(\frac{dc^{D1}_{SD_view} / dc^{D1}_{Sun_view}}{dc^{D9}_{SD_view} / dc^{D9}_{Sun_view}} \right)$$

RSB On-orbit m1 (samples)

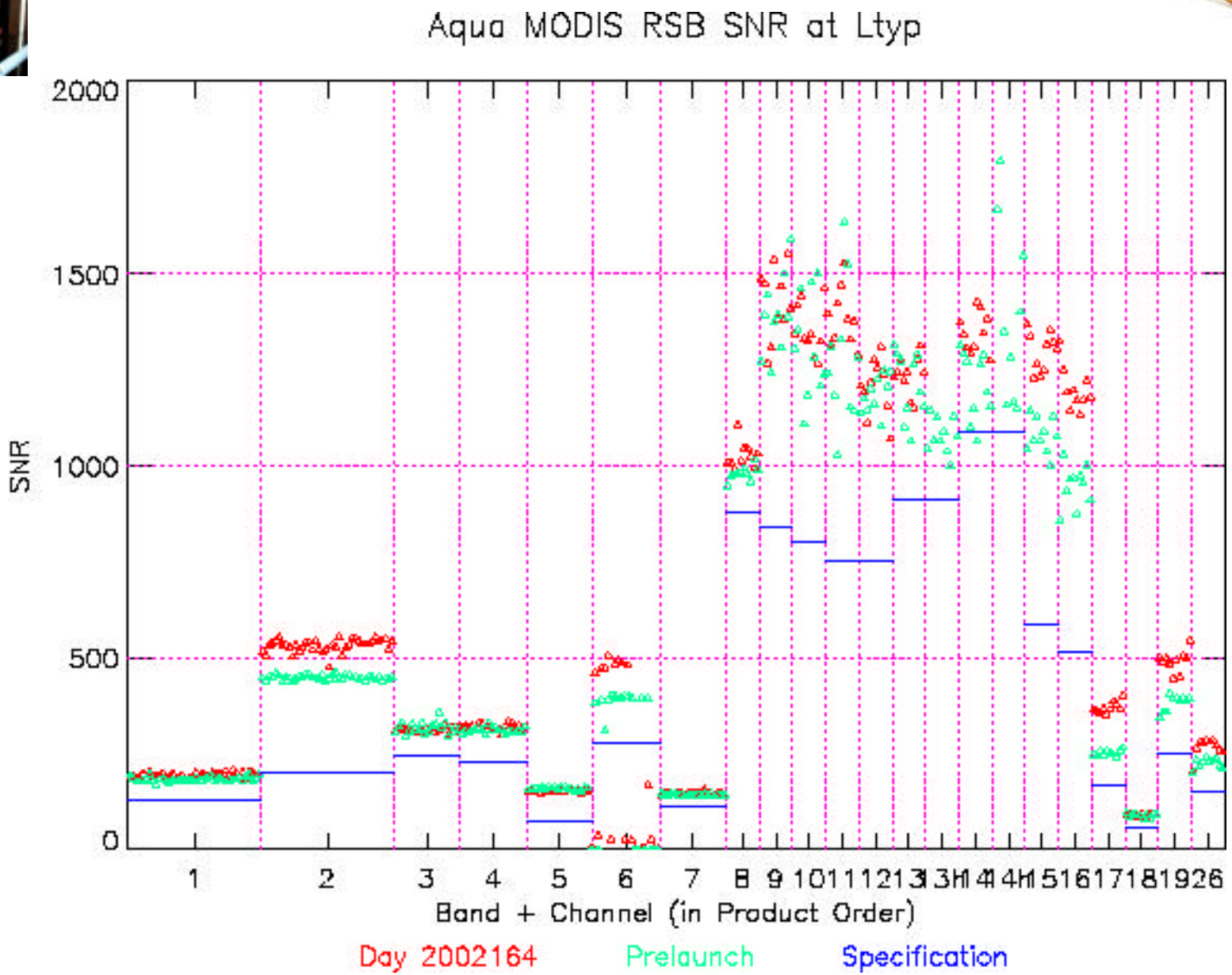








RSB SNR (prelaunch and on-orbit)



B13h/14h Calibration

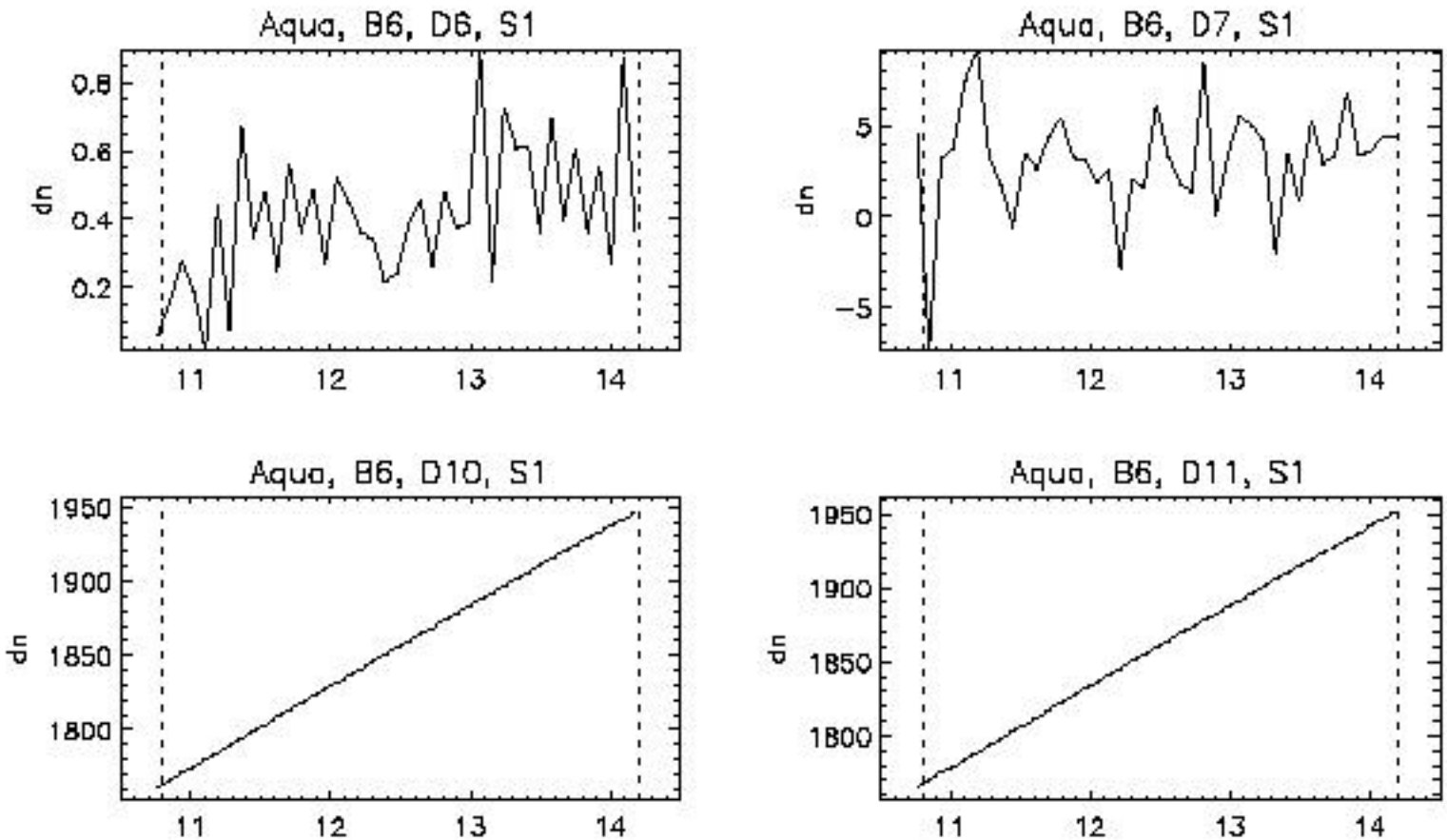
Same approach used for Terra MODIS B14h

Band 13		
Detector	SRCA On-orbit	EV On-orbit
1	2.210	2.209
2	2.153	2.154
3	2.140	2.140
4	2.112	2.112
5	2.100	2.099
6	2.086	2.087
7	2.074	2.076
8	2.061	2.062
9	2.049	2.048
10	2.024	2.026

Band 14		
Detector	SRCA On-orbit	EV On-orbit
1	2.723	2.722
2	2.722	2.721
3	2.744	2.744
4	2.742	2.744
5	2.744	2.745
6	2.766	2.766
7	2.743	2.745
8	2.744	2.745
9	2.745	2.746
10	2.721	2.722

B6 Operability Issue

B6 dn_SD (before BRF and cosine correction)



B6 Operability Issue

- SD calibrations

Planned	SD Screen	Implementation	Itwk/Vdet	Data Processed	m1 obtained	Dead detectors in B6 (SBRS order)
June 13 (2002164)	Down	Successful	102/184	Processed	1-17,17-19,26	1,2,3,5,6,7,8,9,11,15,19
	Up	Successful	102/184	Processed	8-16,13h,14h	1,2,3,5,6,7,8,9,11,15,19
June 16 (2002167)	Down	Successful	102/184	Processed	1-17,17-19,26	1,2,3,5,6,7,8,9,11,15,19
	Up	Successful	102/184	Processed	8-16,13h,14h	1,2,3,5,6,7,8,9,11,15,19
June 29 (2002180)	Down	Failed (Safe Mode)	102/136			
	Up	Failed (Safe Mode)	102/136			
July 4 (2002185)	Down	Successful	102/136	Processed	1-17,17-19,26	1,2,3,5,6,7,8,9,11,15,16,19
	Up	Successful	102/136	Processed	8-16,13h,14h	1,2,3,5,6,7,8,9,11,15,16,17,19
July 10 (2002191)	Down	Failed	102/184			
	Up	Successful	102/184	Processed	1-7,17-19,26	1,2,3,5,6,7,8,9,15,19
July 17 (2002198)	Down					
	Up					

- EV Observations

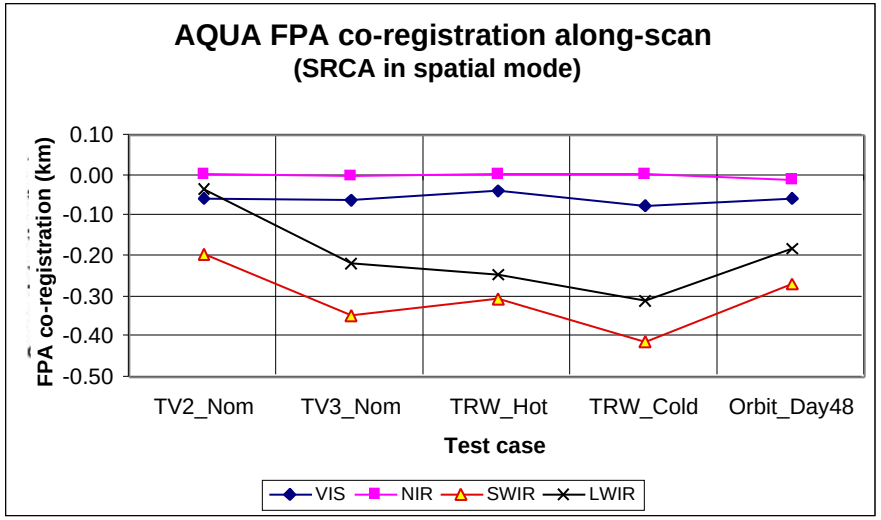
Date	Dead Detectors in B6 (SBRS order)
June 25 (2002176)	1,2,3,5,6,7,8,9,11,15,19
June 26 (2002177)	1,2,3,5,6,7,8,9,11,15,19
June 27 (2002178)	1,2,3,5,6,7,8,9,11,15,19
July 4 (2002185)	1,2,3,5,6,7,8,9,11,15,16,19
July 5 (2002186)	1,2,3,4,5,6,7,8,9,11,15,16,19
July 6 (2002187)	1,2,3,5,6,7,8,9,15,19
July 7 (2002188)	1,2,3,5,6,7,8,9,15,19
July 8 (2002189)	1,2,3,5,6,7,8,9,15,19
July 9 (2002190)	1,2,3,5,6,7,8,9,15,19

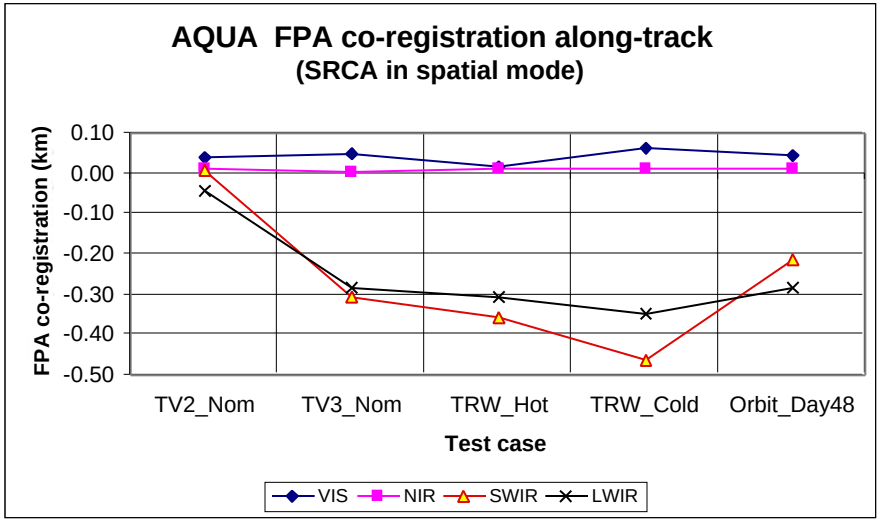
Spatial and Spectral Characterization with SRCA

- Spatial characterization
  - BBR
  - SMIR and LWIR FPA shift (0.21km along scan, 0.33 along track)
- Spectral characterization - stable
  - Center wavelength
- Radiometric mode will be used for RSB response trending (Terra experience)

Spatial Characterization

♦ **FPA co-registration is relative to band 1**

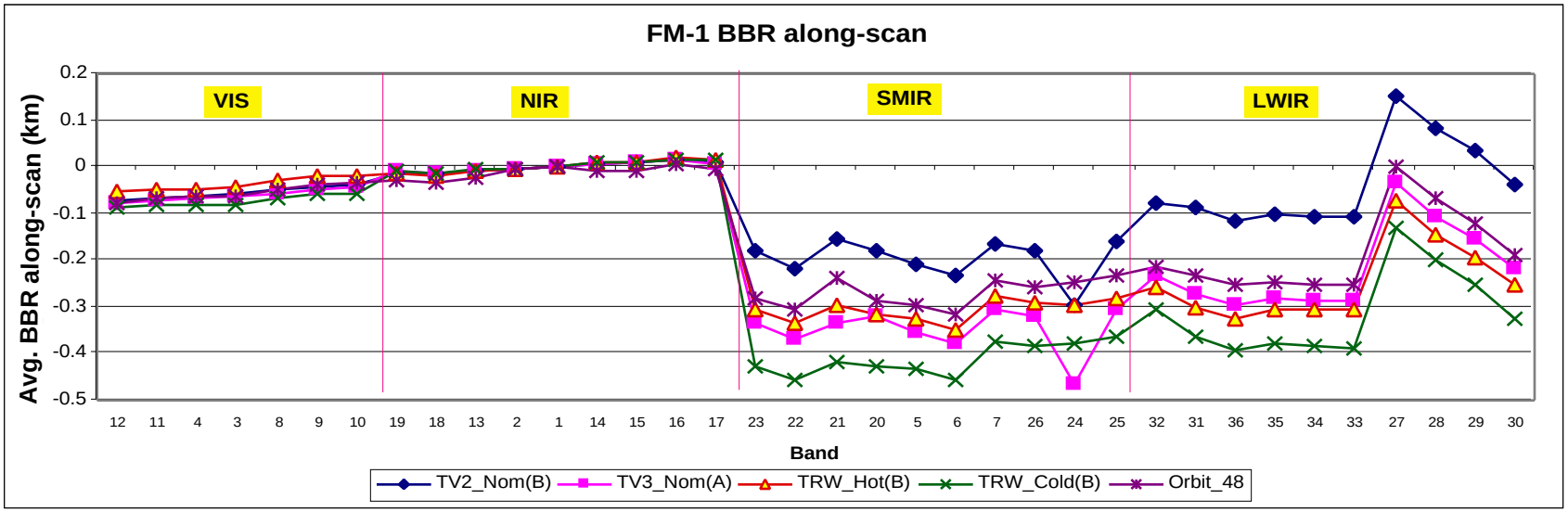


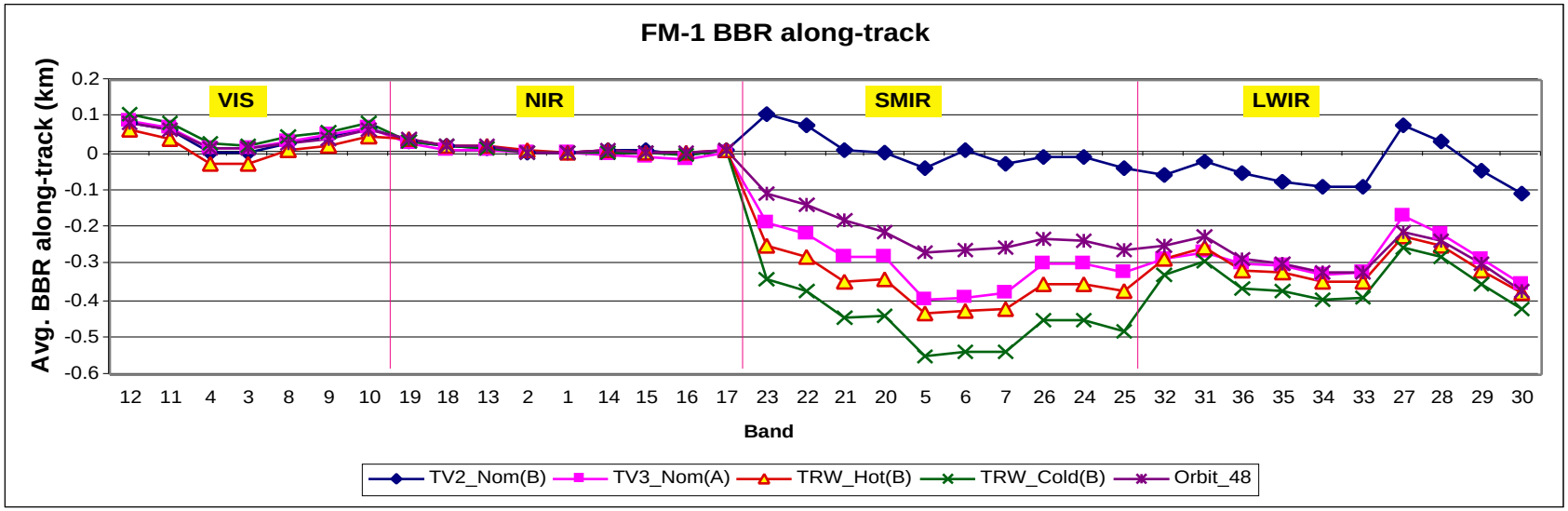


AQUA FPA co-registration tracking from prelaunch to on-orbit

	FPA	TV2_Nom	TV3_Nom	TRW_Hot	TRW_Cold	Orbit_Day48
Along-scan	VIS	-0.056	-0.060	-0.036	-0.074	-0.056
	NIR	0.001	0.000	0.001	0.002	-0.012
	SWIR	-0.198	-0.349	-0.307	-0.412	-0.270
	LWIR	-0.036	-0.216	-0.246	-0.312	-0.183
Along-track	VIS	0.042	0.050	0.018	0.061	0.045
	NIR	0.011	0.003	0.012	0.010	0.012
	SWIR	0.009	-0.306	-0.359	-0.461	-0.215
	LWIR	-0.043	-0.283	-0.304	-0.346	-0.282

Spatial Characterization

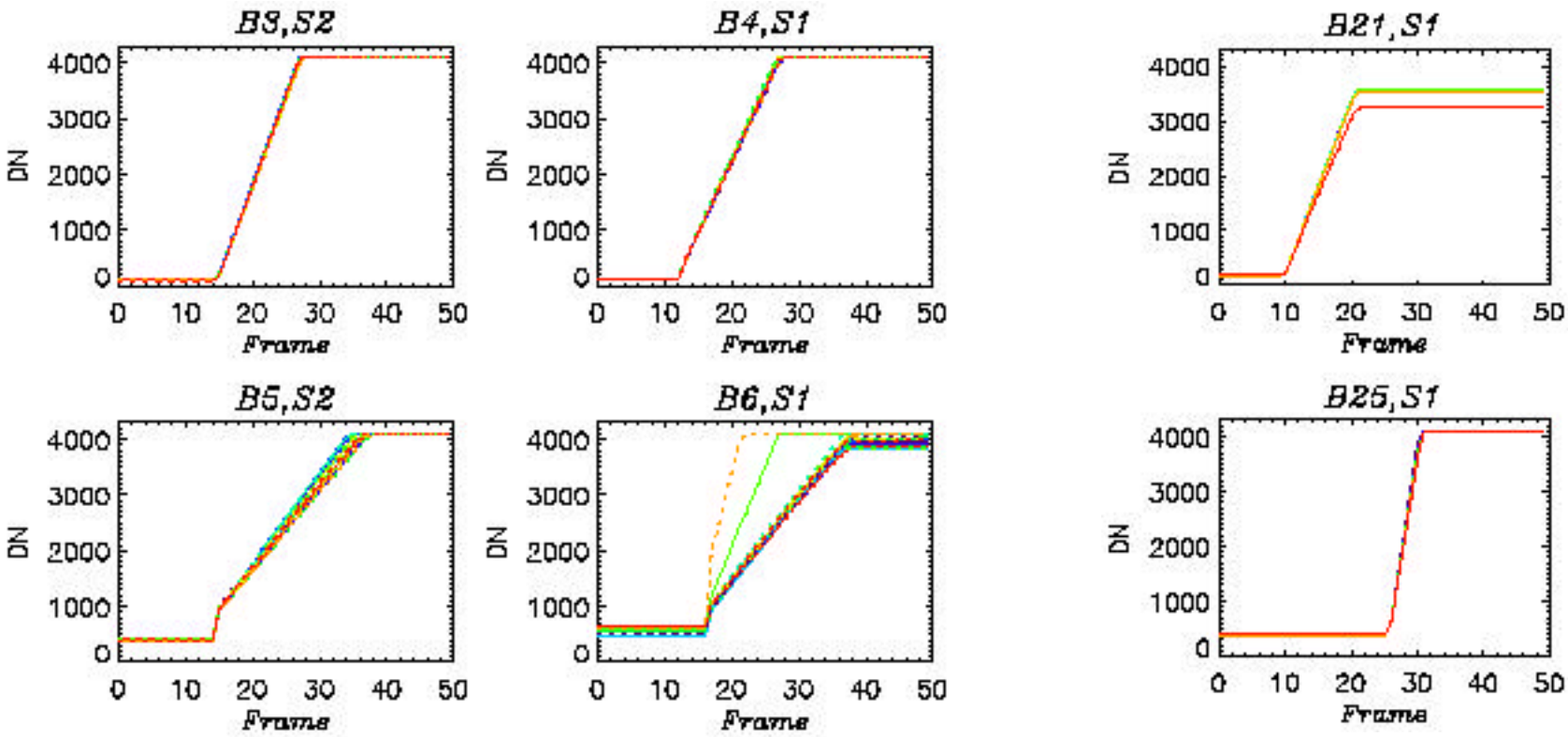




Spectral Characterization

FM-1 Center wavelength (nm)				
Band	Specification	Δλ	SpMA	Orbit_day49
1	645	±4	646	646.2
2	858	±2.2	857.3	857.8
3	469	±4	466.1	466.2
4	555	±4	553.9	553.9
5	1240	±5	1242.1	1242.7
6	1640	±7	1627.8	1627.5
7	2130	±8	2114.3	2114.6
8	412	±2	412.5	412.5
9	443	±1.1	442.3	442.4
10	488	±1.2	487.5	487.6
11	531	±2	530.1	530.1
12	551	±5	547.3	547.4
13	667	-2, +1	666.1	666.2
14	678	±1	677.7	677.8
15	748	±2	746.9	747.0
16	869	±5	866.9	867.0
17	905	±2.3	904.6	904.8
18	936	±2.3	936.4	936.4
19	940	±2.4	936.5	936.6
26	1375	±6	1382.2	1382.1

ECAL



Applications:

Electronic gain trending

Electronic gain saturation (dn_sat)

Current Work and Future Plan

- Complete ALL Early Calibration and Characterization (apply lessons learned from Terra) activities
- Key Issues:
  - SWIR crosstalk (optical/electronic), B6 detectors operability, BBR tracking, SD and optics degradation, B33, 35, 36 stability tracking, striping
- Others:
  - Same as Terra Work Plan