VIIRS F1 Ambient Performance Summary: RVS, SLR, NFR

NPOESS Preparatory Project (NPP)

Project Science Office (PSO)

Presented by

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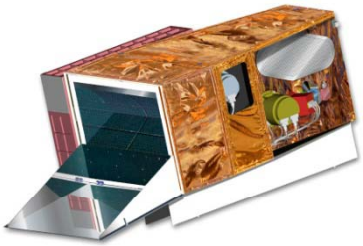
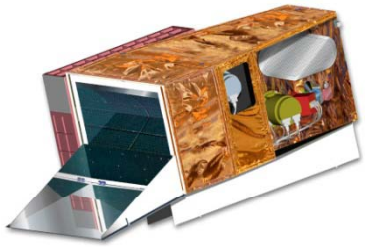
NPP VIIRS F1 Calibration and Characterization Workshop
January 25th, 2010
Lanham, MD

Content



- Ambient Performance Testing-General Comments
- Response vs. Scan (RVS)
- Stray Light Response (SLR)
- Near Field Response (NFR)

Acknowledgements



NASA

- NPP Instrument Characterization Support Team (NICST)
- NPP Instrument Calibration and Support Element (NICSE)
- MODIS Characterization Support Team (MCST)
- VIIRS Ocean Science Team (VOST)
- University of Wisconsin (UW)
- Project Science Office (PSO)

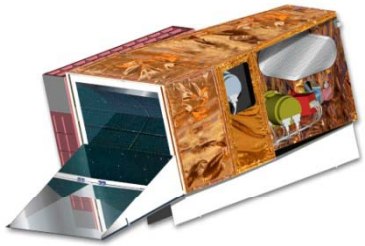
Integrted Program Office (IPO)

- Internal Government Studies (IGS)
- Aerospace Cooperation
- MIT/LL

Contractors

- Northrop Grumman
- Raytheon SBRS and El-Segundo

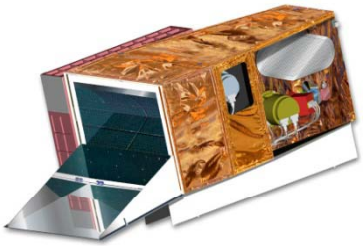
Ambient Performance Testing - General Comments



- **Two phases of ambient testing at Raytheon SBRS**

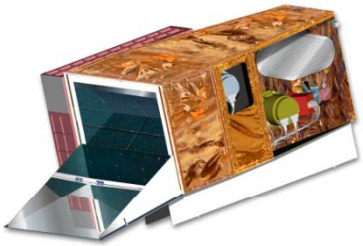
Ambient Testing	
Phase I	**Phase II**
SI-4 Commands and Telemetry	Polarization Insensitivity
SI-2 Electronics Throughput	**Response vs. Scan Angle (RVS)**
FP-5 Pointing Knowledge	**Stray Light Rejection (SLR)**
SI-5 Electronics Self Test	**Near Field Response (NFR)**
SI-6 Noise Test	Crosstalk Point-to-Point
RC-1 Dynamic Range	Radiometric Characterization
FP-1 BB Functional and DC Restore	Mechanical Functions
FP-4 Spectral Band Registration	SD Operation SDSM Functional
FP-6 MTF and HSR	Pointing Knowledge

- **Most ambient tests were made obsolete by TVAC testing.**
- **RVS, SLR, NFR were not measured in TVAC**
  - Their performances are used in the VIIRS F1 calibration error budget
  - Performance summary is presented in the following slides.



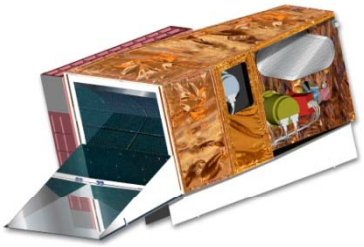
Response Vs. Scan (RVS)

Response Vs. Scan (RVS)

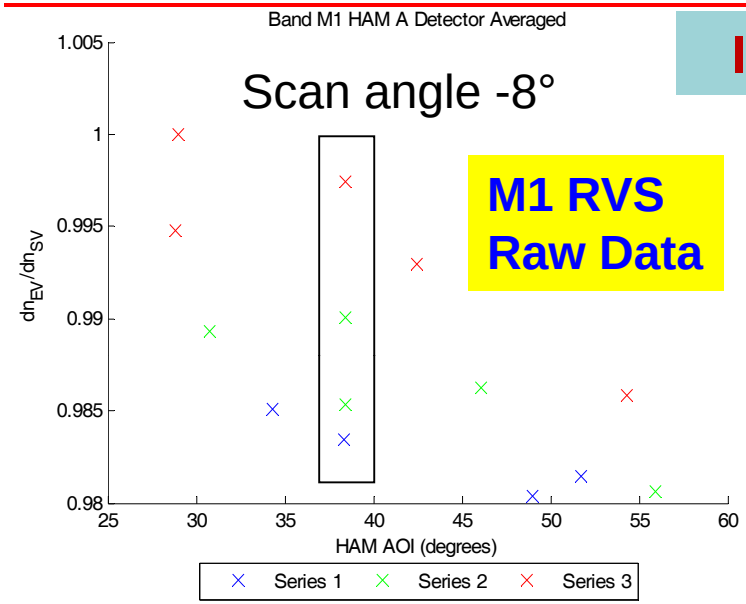


- **VIIRS RVS characterization is important:**
  - *The Response Versus Scan is used directly in VIIRS SDR algorithm and will cause radiometric biases or striping if not characterized adequately.*
  - *On-orbit trending of RVS change will be difficult so accurate pre-launch characterization is important.*
- **History of VIIRS F1 RVS testing**
  - *Several government team suggestions from EDU were implemented in VIIRS F1 RVS test which allowed GSE and test set-up artifacts to be removed and the RVS uncertainty to be more accurately determined.*
  - ***F1 RVS characterization uncertainty requirement is met for all RSB and TEB bands.***

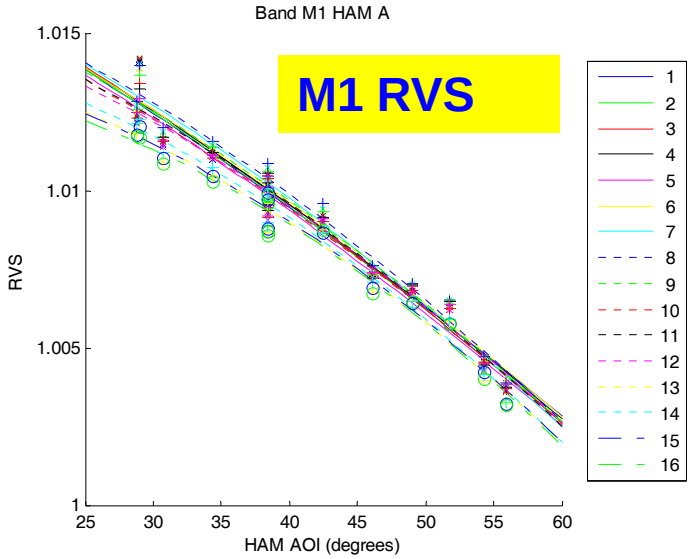
VIIRS F1 RVS Test Improvements



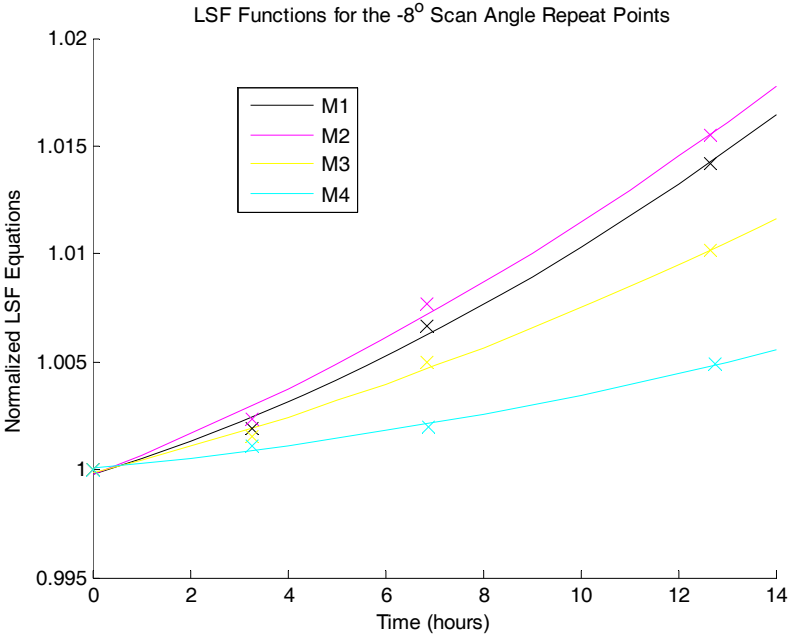
Improved F1 RVS Testing



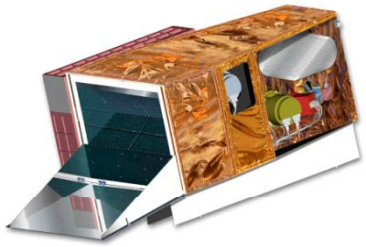
RVS Measured Scan Angle Sequence	
EDU	F1
-8	35
-65.7	-8
-53	-65.7
-51	-8
-45	22
-38	-8
-8	22
-30	-45
-20	-8
6	6
22	-8
-8	-55.5
38	-20
53	-38

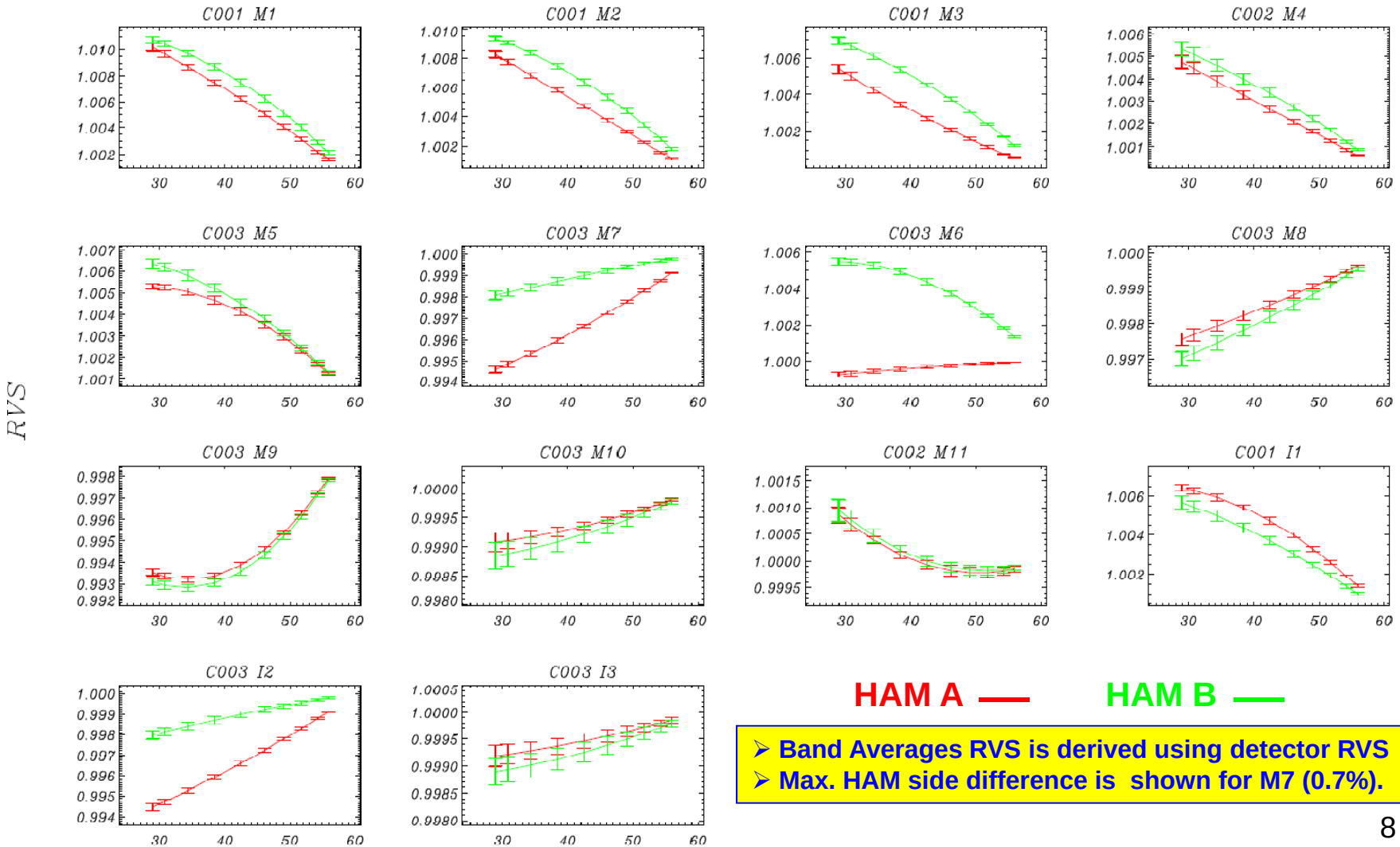


M1 Repeats vs Time



VIIRS F1 Reflective RVS

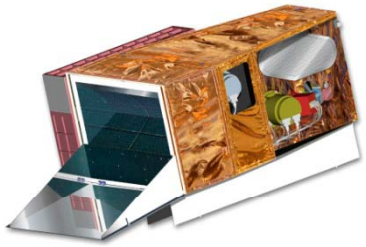


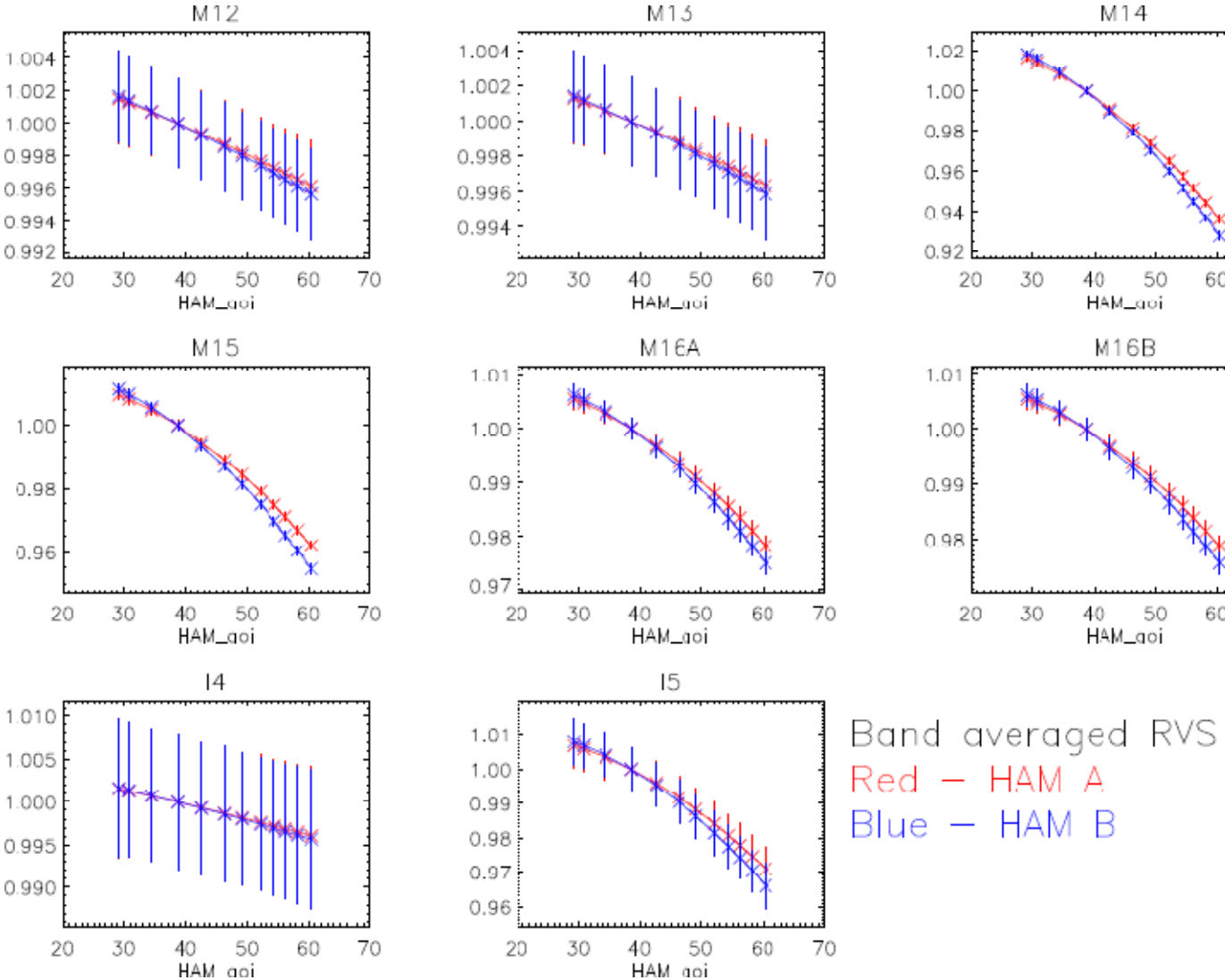


HAM A — **HAM B** —

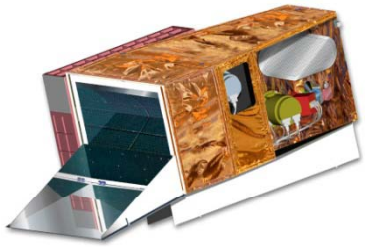
- **Band Averages RVS is derived using detector RVS**
- **Max. HAM side difference is shown for M7 (0.7%).**

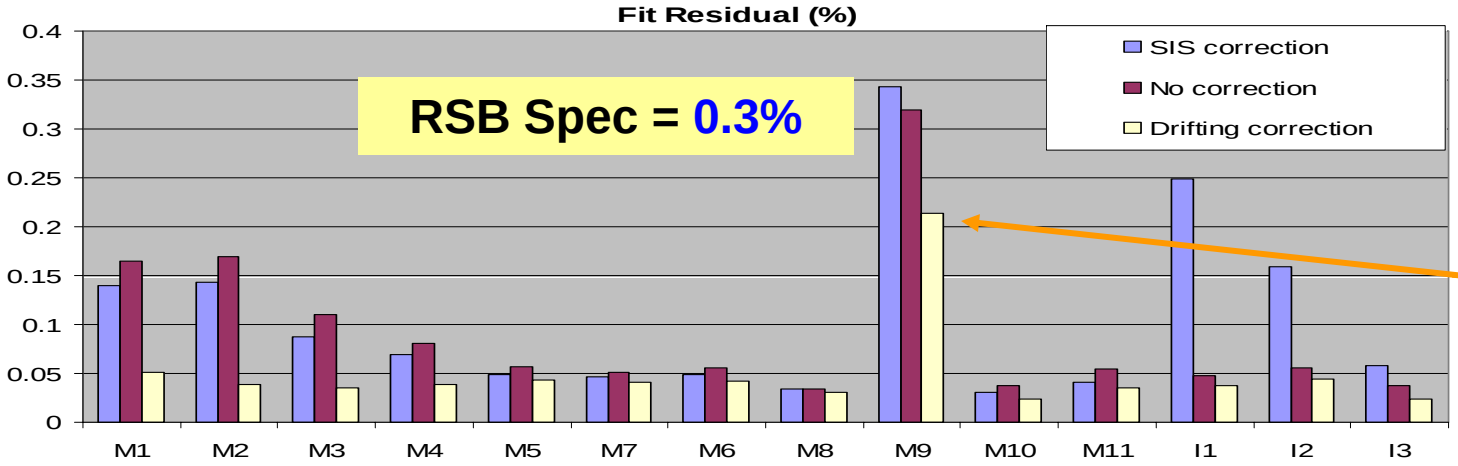
VIIRS F1 Emissive RVS



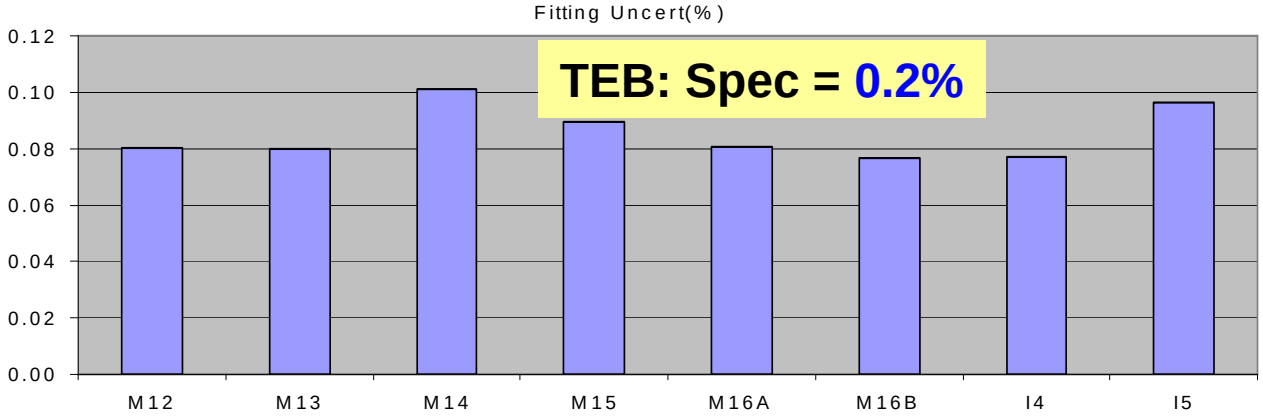


VIIRS F1 RVS Characterization Uncertainty



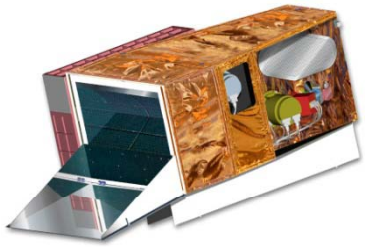


M9 water vapor error in this chart was significantly reduced by both Raytheon and the Govt. (Chris Moeller) using humidity and temperature data as inputs into an atmospheric forward model.



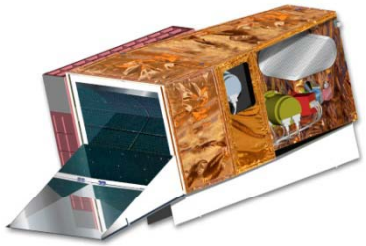
RVS uncertainty included
(1) fitting residuals
(2) measurement errors

Both RSB and TEB RVS characterization meet the requirements (consistent with SBRS analyses and results)



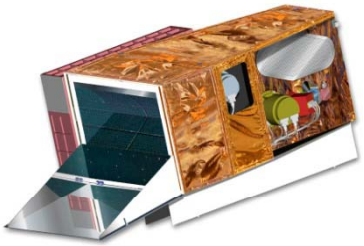
Stray Light Response (SLR)

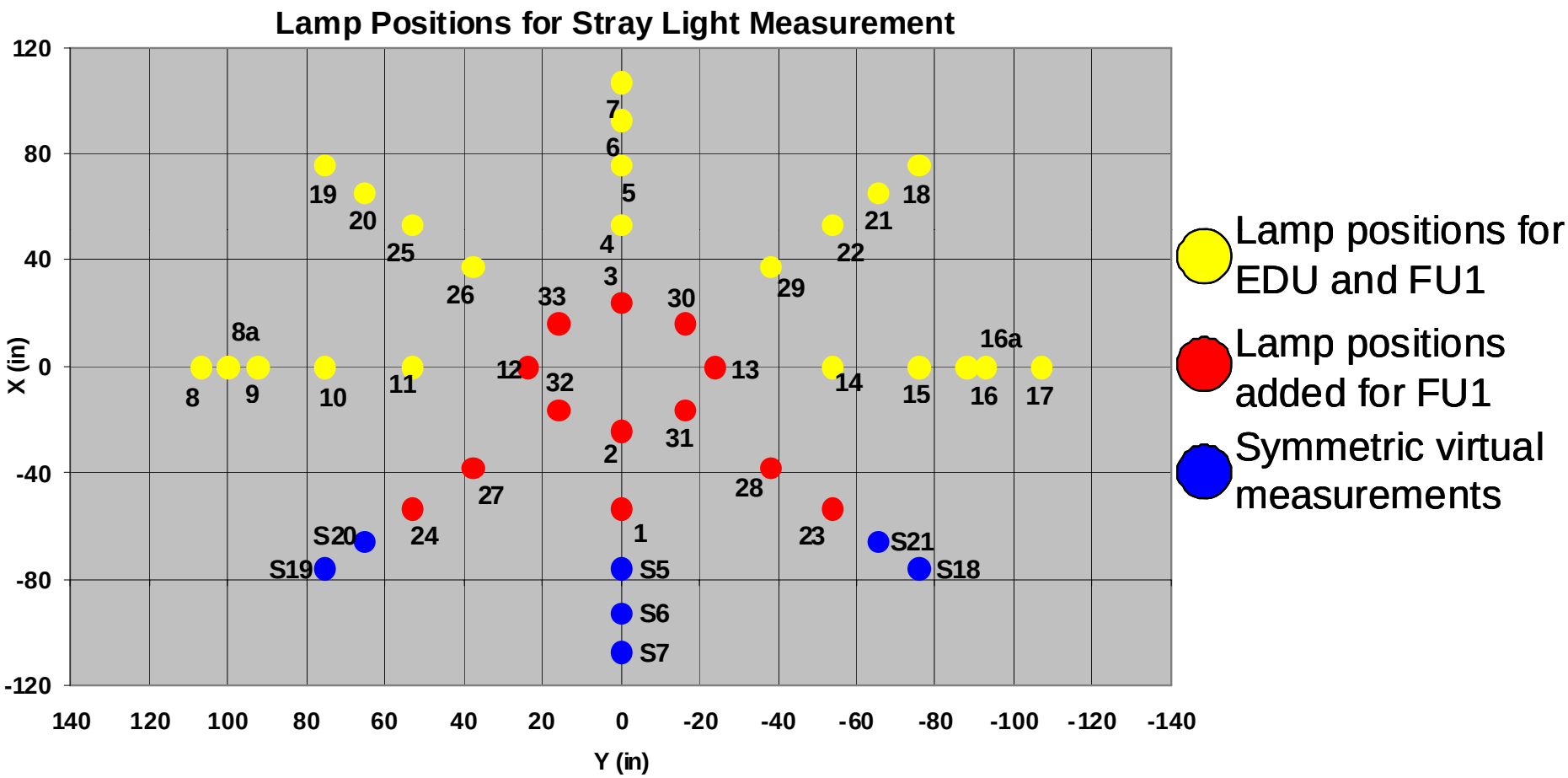
VIIRS F1 SLR (BOL) Summary for the RSB



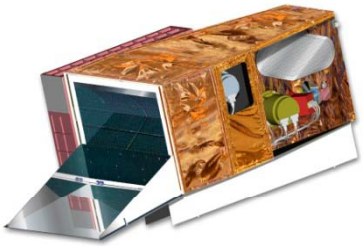
- **VIIRS Stray Light Response (SLR) Characterization is important:**
  - *This test determines whether any optical bounce paths from the Earth's hemisphere which are outside the FOV of the detector reach the detector.*
  - *Stray light can cause radiometric biases which will not be removed during Solar Diffuser calibration and will vary depending on the Earth scene.*
- **History of VIIRS F1 SL testing**
  - *There were two iterations of Stray Light testing due to high signals in the first run near the bore sight of VIIRS. The second iteration showed much lower signal but the cause of this decrease is not known.*
  - *Government analysis team discovered an error in the stray light integration methodology which was over weighting the high signal near the VIIRS bore sight.*
    - *When the proper solid angles were used in the integration the stray light contamination was greatly reduced and allowed most bands to pass the sensor specification.*

VIIRS F1 SLR Measurement Positions

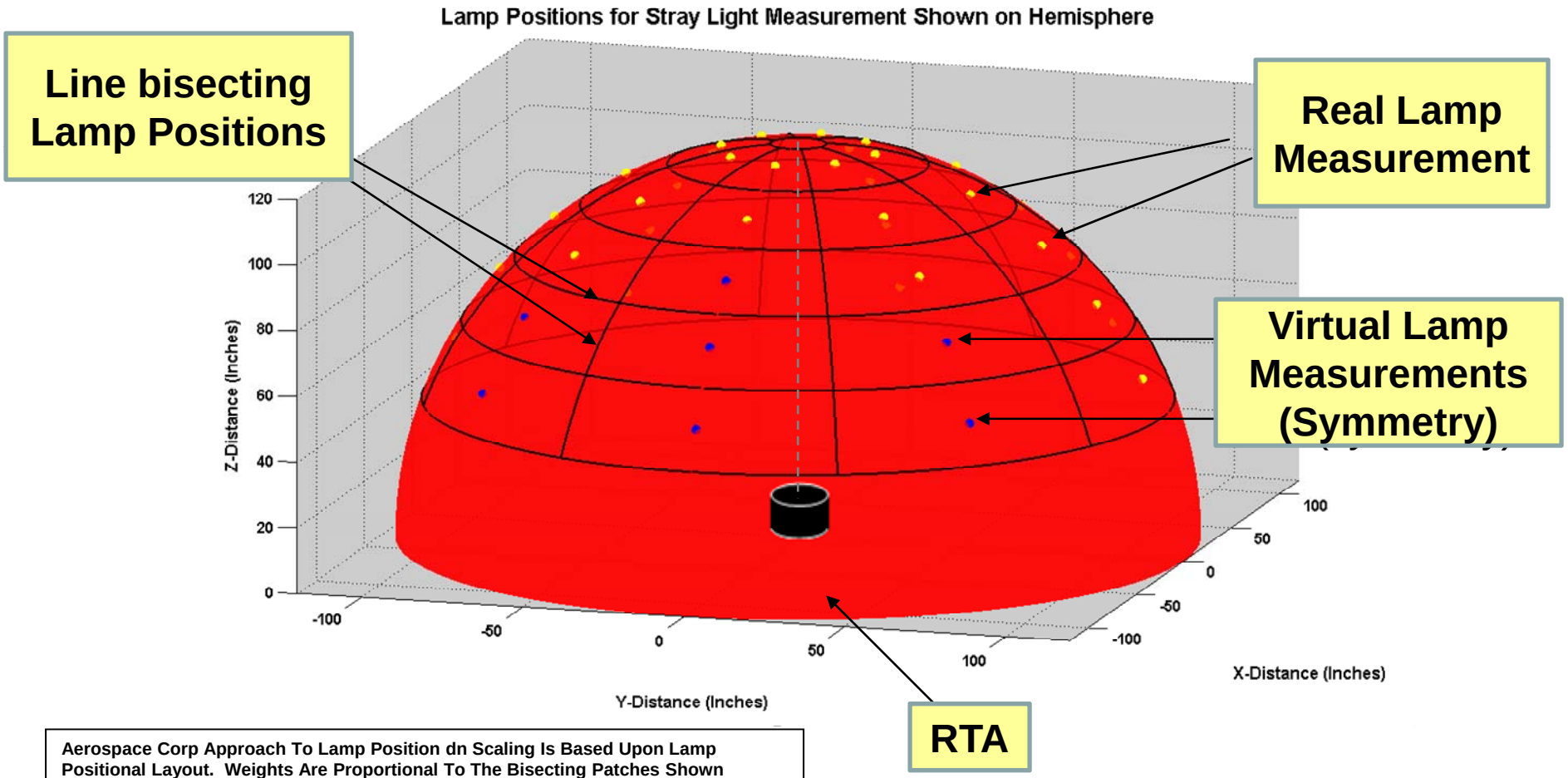




VIIRS F1 SLR Measurements with Solid Angles

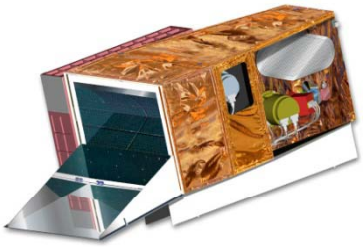


Hemisphere radius=120”



Aerospace Corp Approach To Lamp Position dn Scaling Is Based Upon Lamp Positional Layout. Weights Are Proportional To The Bisecting Patches Shown

VIIRS F1 SLR (EOL) Specification Verification

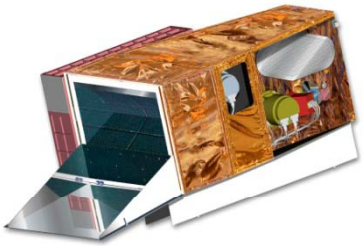


Band		Margin	Basis Of Capability Estimate
Emissive, 315K Scene	M12	57%	7
	M13	90%	7
	M14	89%	7
	M15	94%	7
	M16	94%	7
	I4	58%	7
	I5	66%	7
Reflective, Lat-Adjusted Bright Solar Scene	M1HG	73%	7
	M2HG	67%	7
	M3HG	60%	7
	M4HG	47%	7
	M5HG	13%	7
	M6	19%	7
	M7HG	2%	7
	M8	33%	7
	M9	52%	7
	M10	56%	7
	M11	52%	7
	I1	56%	7
	I2	67%	7
	I3	65%	7

Specification is 1% of Ltyp.

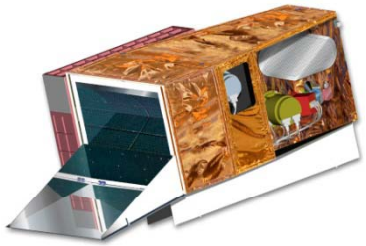
Table is from Raytheon Performance Verification Report (PVR)- VIIRS FU1 Stray Light Response (PVP Section 4.7.4), October 15, 2009

The column entitled Basis Of Capability Estimate is uniformly at "7", which is the designator used in the VIIRS expanded TPMs ("R vs C") to indicate completed test data analysis and correlated model results, which is its final state.



Near Field Response (NFR)

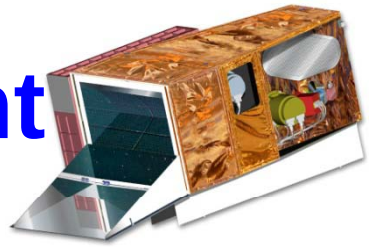
VIIRS F1 NFR (BOL) Summary



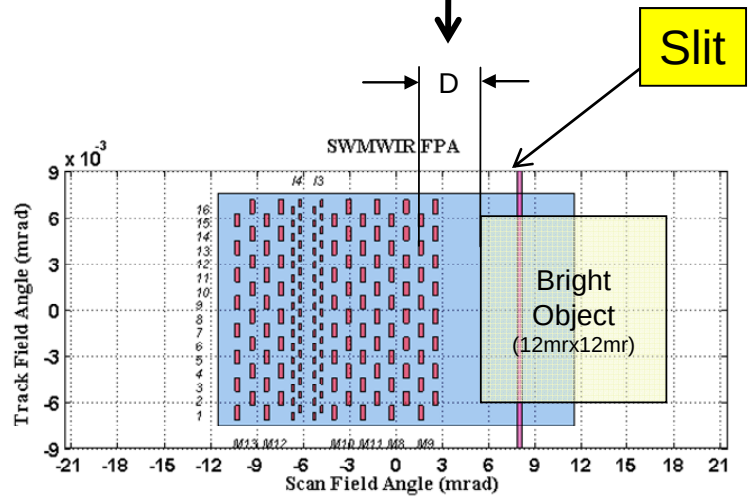
- **VIIRS F1 NFR characterization is important**
  - *Computes radiometric contamination of a given pixel due to bright sources several pixels away.*
  - *Dark scenes such as the ocean or coastal regions can have biases due to bright targets (clouds or land) in close proximity to the area of interest. This data can provide information for EDR corrections or masks.*
- **History of VIIRS F1 NFR testing**
  - *There were several iterations of NFR testing due to xtalk and ghosting artifacts in the data.*
    - *The RSB NFRs were affected by electronic xtalk and required a band pass filter to reduce the xtalk contamination. While the effect of xtalk was mitigated the magnitude of the resulting NFR was expected to fail the sensor requirement for several RSBs.*
    - *The TEB NFRs were affected by ghosting caused by the DEWAR assembly. The ghosting was modeled by both contractor and government teams for root cause purposes.*

Structured Scene Requirement

(NFR testing)

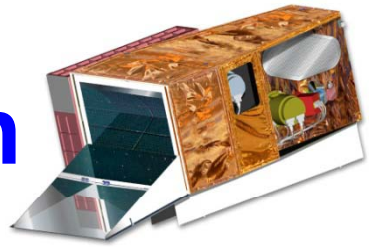


Band	Center Wavelength (nm)	Angular separation from bright target (milliradian)	Maximum allowed ratio of scattered radiance to typical radiance	Lbright(W/(m² sr υm)) or Tbright (K) Note no longer Lmax/Tmax
M1	412	6	0.01	162
M2	445	6	0.01	180
M3	488	6	0.01	160
M4	555	6	0.01	160
M5	672	6	0.01	115
M6	746	12	0.02	147
M7	865	6	0.01	124
M8	1240	6	0.01	57
M9	1378	N/A	N/A	N/A
M10	1610	6	0.01	86.1
M11	2250	6	0.01	1.2
M12	3700	3	0.005	295
M13	4050	3	0.004	321
M14	8550	N/A	N/A	N/A
M15	10763	3	0.001	318
M16	12013	3	0.001	318
DNB	700	6	See SRV0624	See SRV0624
I1	640	N/A	N/A	N/A
I2	865	N/A	N/A	N/A
I3	1610	N/A	N/A	N/A
I4	3740	N/A	N/A	N/A
I5	11450	N/A	N/A	N/A



Relationship of reticle and bright object.

NFR Requirement Verification



ALL DATA ARE GIVEN AS

PERCENT OF REQUIREMENT (PS Revision E, Revised Table 20)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	Avg	Basis Of Capability Estimate	Req't	Notes	Applicable RDWs
M1	47	34	33	34	36	38	40	41	39	40	37	37	42	38	37	42	38	7	SRV0662 SRV0547 SRV0548	Data taken from final PVR VIIRS.02.18.003 Rev B	Comply
M2	57	45	42	42	46	46	46	46	47	48	47	45	45	44	46	53	47	7			Comply
M3	55	40	39	40	45	46	51	49	51	48	47	48	46	45	45	53	47	7			Comply
M4	73	58	55	61	62	66	65	71	65	65	67	68	66	62	65	72	65	7			Comply
M5	92	79	75	73	84	80	90	82	93	83	84	93	84	83	92	94	85	7			Comply
M6	15	12	13	14	15	0	14	15	14	12	13	14	13	13	15	17	14	7			Comply
M7	142	120	112	128	119	116	127	136	132	121	134	126	140	140	0	0	128	7			RDW-112
M8	0	70	0	84	0	86	0	92	0	92	0	87	0	80	82	82	84	7			Comply
M9	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN			N/A
M10	85	78	84	98	104	106	105	107	105	106	105	104	105	102	106	108	100	7			RDW-112
M11	0	51	0	57	0	62	0	65	0	0	0	62	0	61	0	60	60	7			Comply
M12	69	0	86	85	75	85	73	66	75	80	79	0	89	0	71	51	76	7			Comply
M13	0	84	0	78	85	75	92	75	90	78	105	88	102	97	0	63	86	7			RDW-112
M14	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN			N/A
M15	46	42	44	46	47	46	49	46	50	50	49	55	55	54	53	62	50	7			Comply
M16A	106	68	91	67	95	73	89	72	89	76	108	77	97	88	114	98	88	7			RDW-112
M16B	106	68	91	67	95	72	89	72	89	76	108	77	97	88	114	97	88	7			RDW-112
I1	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N/A		N/A
I2	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N/A		N/A
I3	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N/A		N/A
I4	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N/A		N/A
I5	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N/A		N/A

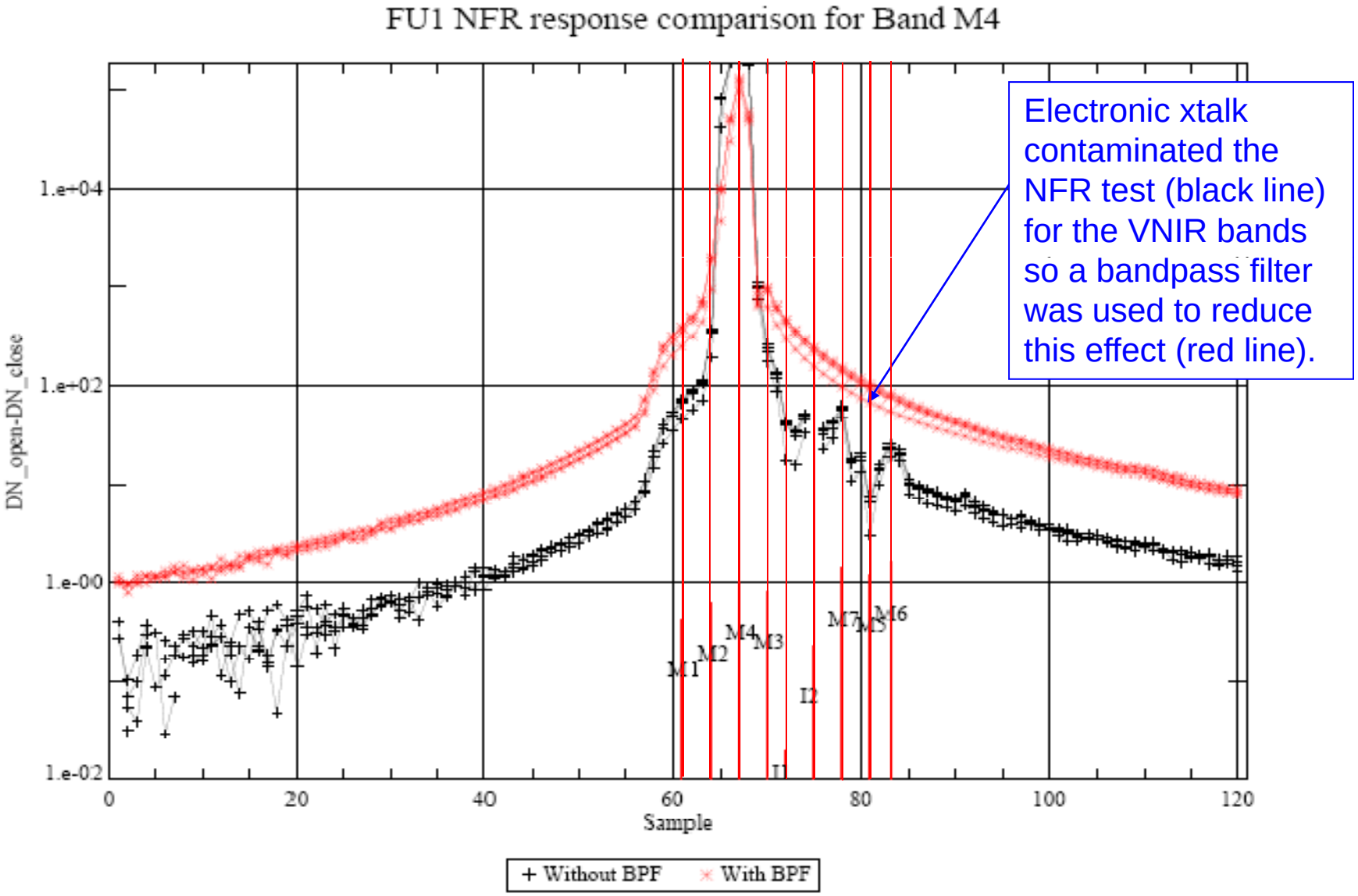
Compliant
No Valid Data
Not Compliant
NaN: No Requirement

From Raytheon Performance Verification Report (PVR), October 15, 2009

The column entitled Basis Of Capability Estimate is uniformly at "7", which is the designator used in the VIIRS expanded TPMs ("R vs C") to indicate completed test data analysis and correlated model results, which is its final state.

Electronic Crosstalk Contamination

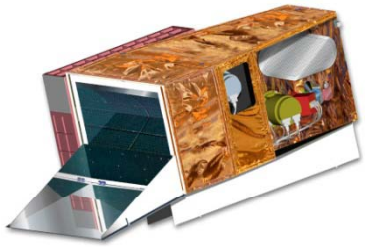
Example: M4

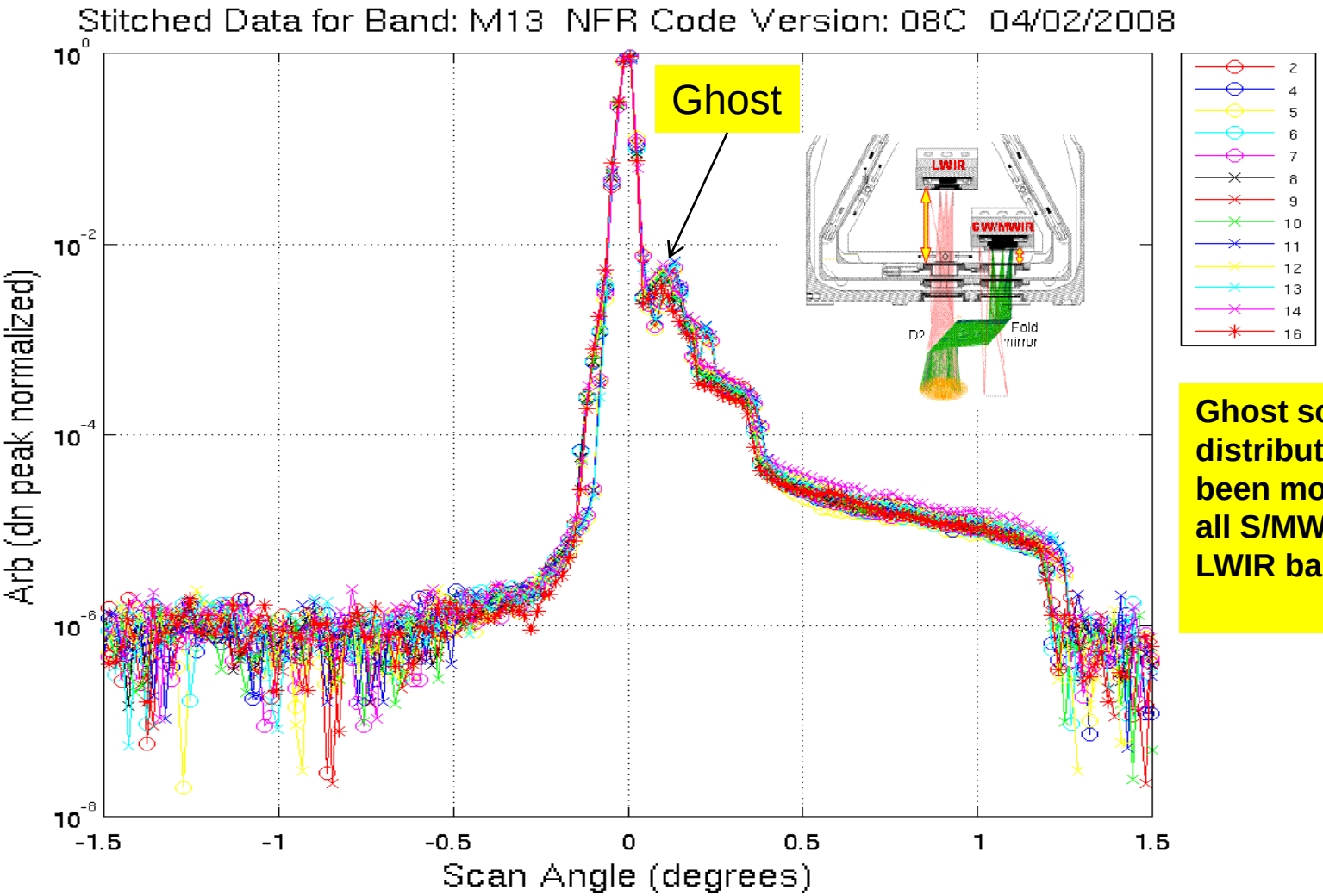


Electronic xtalk contaminated the NFR test (black line) for the VNIR bands so a bandpass filter was used to reduce this effect (red line).

Ghosting Anomaly:

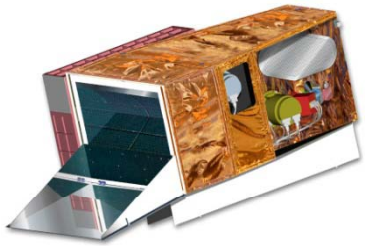
Example: Band M13



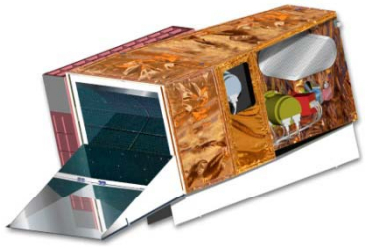


Ghost scattering distribution have been modeled for all S/MWIR and LWIR bands.

Summary

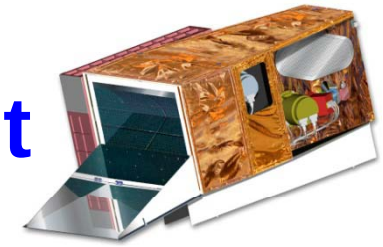


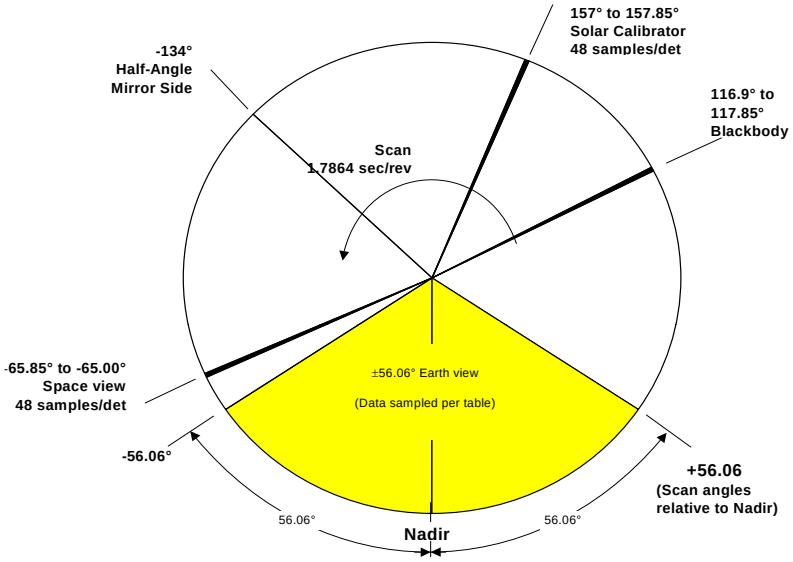
- **VIIRS NFR requirement is not met for M7, M10, M13 and M16A-B.**
- **In general, detector response is smoother when using BPF, indicating that the NFR profile is contaminated by electrical crosstalk,**
- **Ghosting anomaly was observed in cold focal plane bands, due to reflections from the Dewar. Modeling confirmed this anomaly.**
- **VIIRS NFR performance is expected to be at leas as good as MODIS NFR (RTA vs. Scan mirror).**

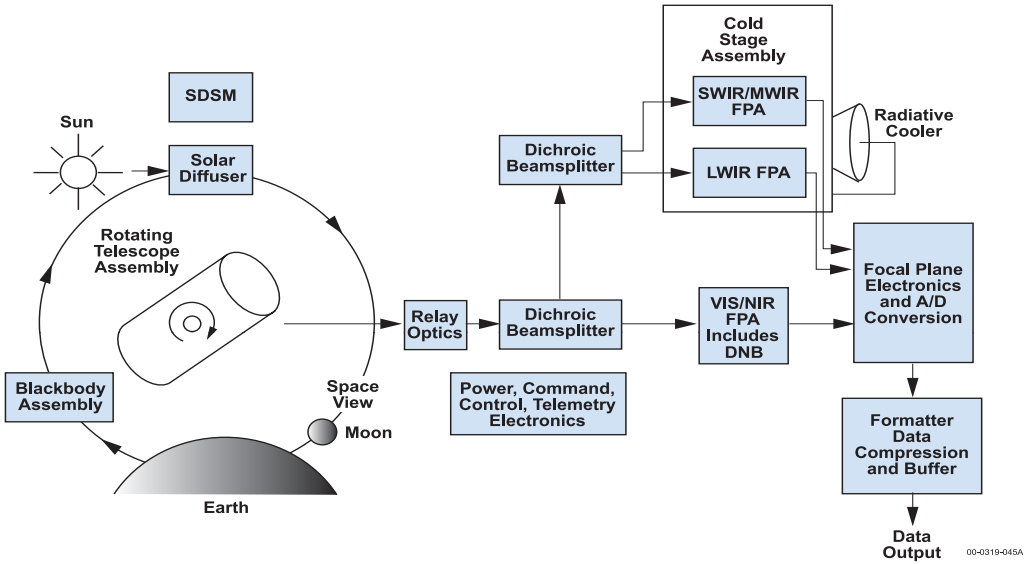


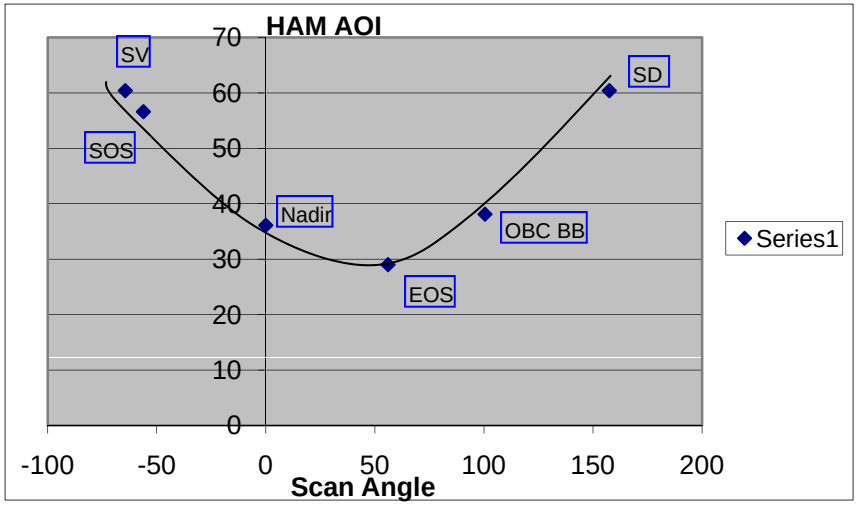
Backup Slides

VIIRS Sensor Photons to DN Out

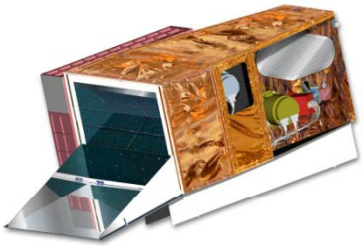




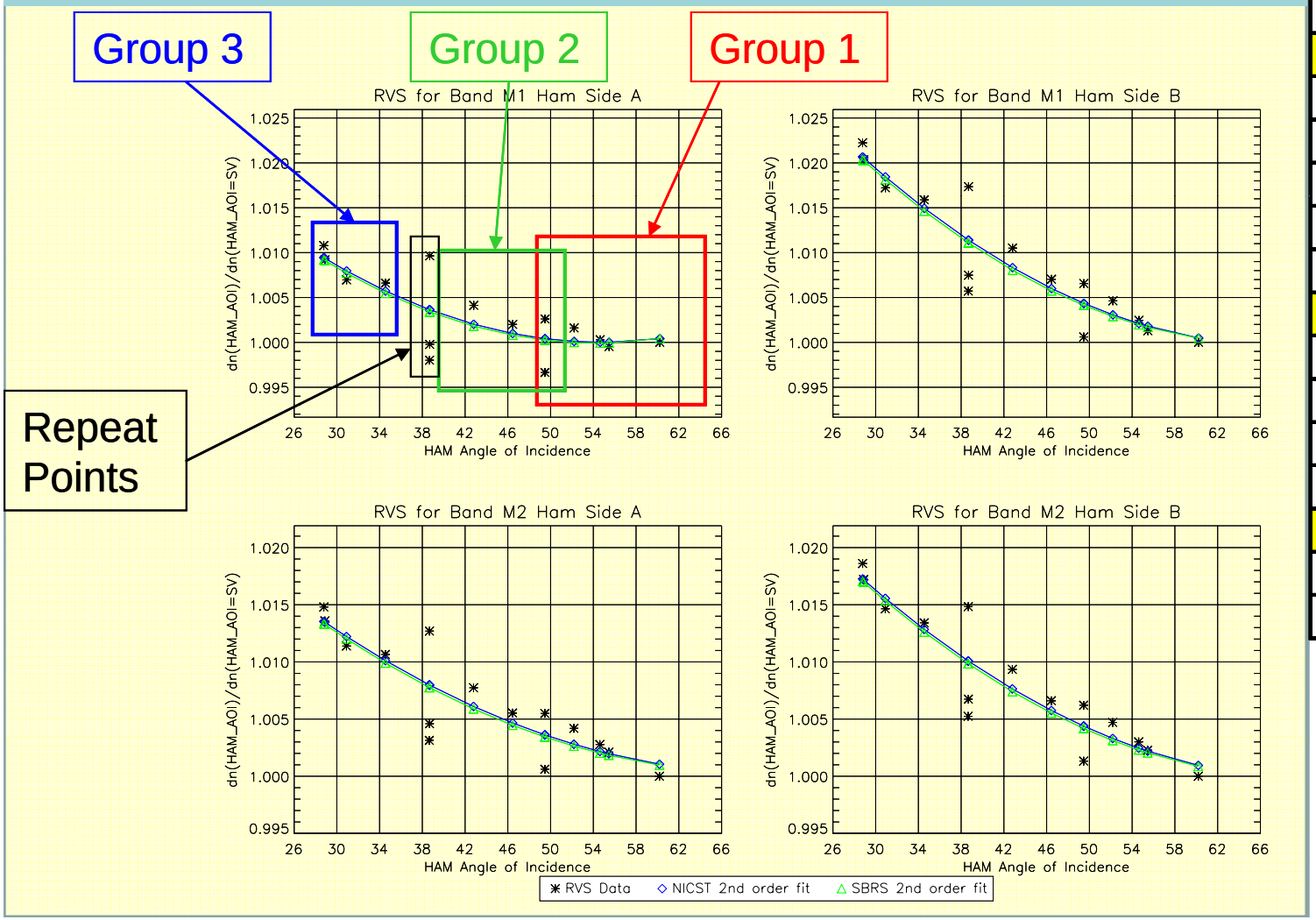




VIIRS F1 RVS Test Improvements

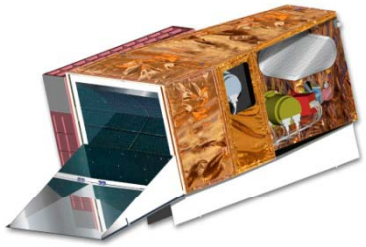


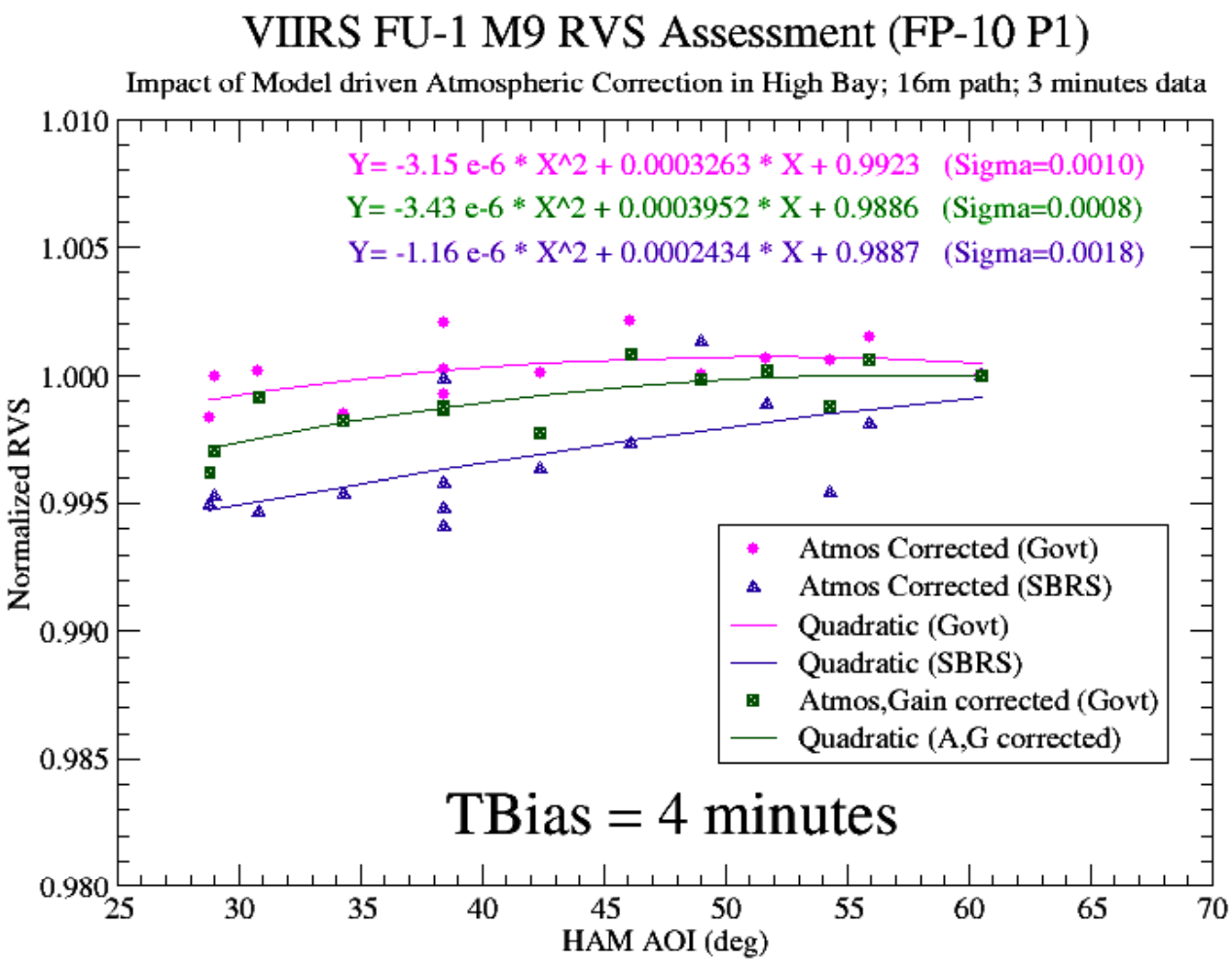
EDU RVS Testing: Difficult to assess uncertainty with this test methodology



RVS Measured Scan Angle Sequence	
EDU	F1
-8	35
-65.7	-8
-53	-65.7
-51	-8
-45	22
-38	-8
-8	22
-30	-45
-20	-8
6	6
22	-8
-8	-55.5
38	-20
53	-38

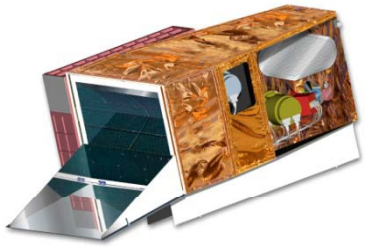
RVS Band M9 Water Vapor Correction

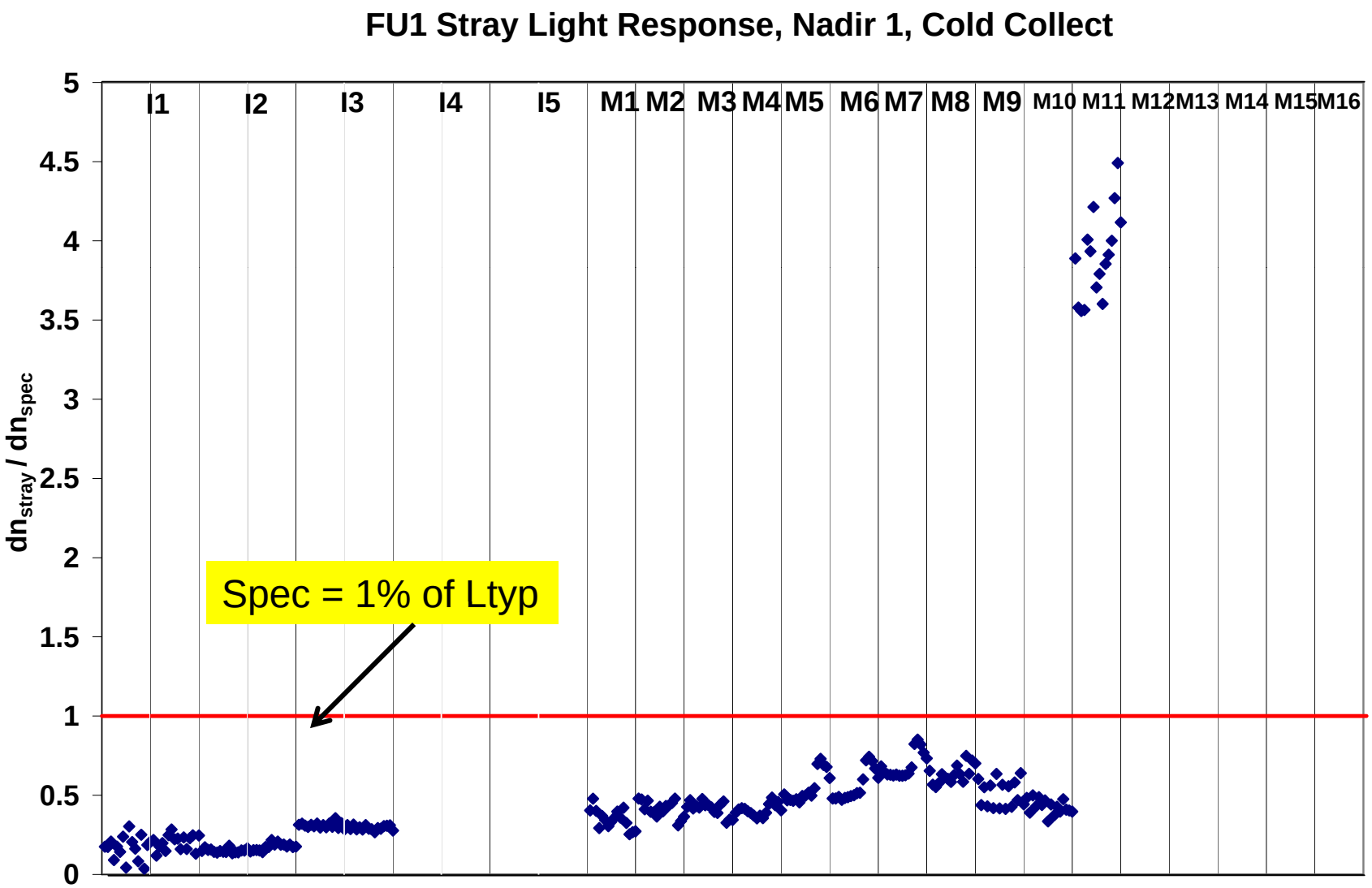




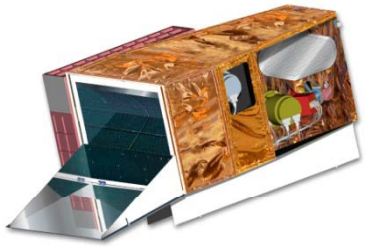
Government Atmospheric Correction for M9 was proposed and applied by Chris Moeller

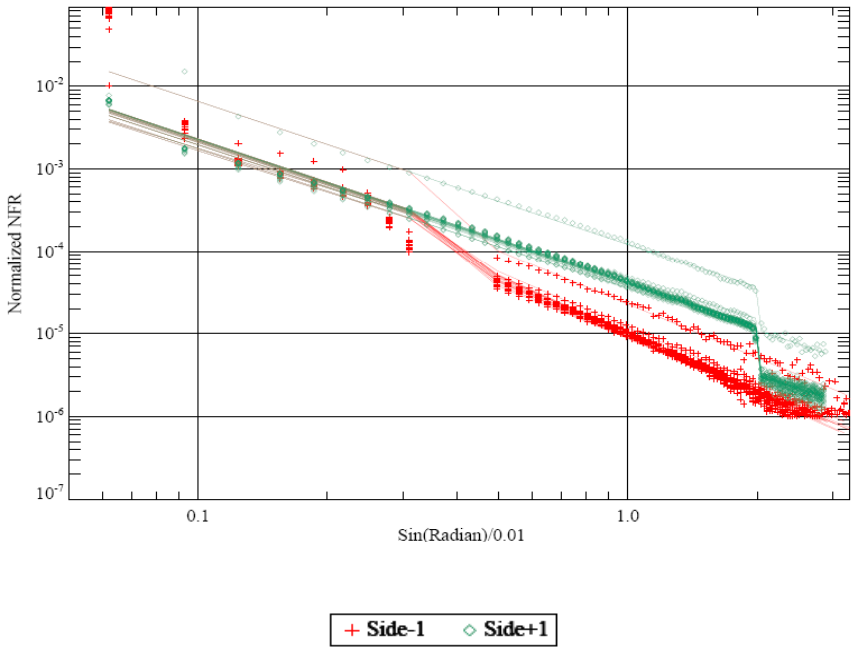
VIIRS F1 SLR (BOL) Specification Verification

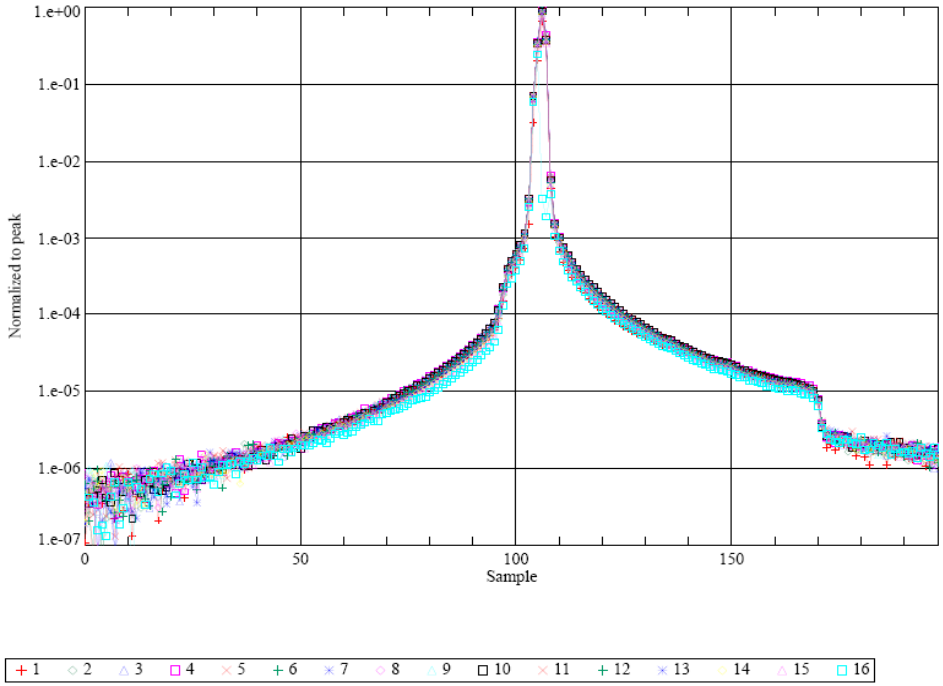




Stitched NFR with BPF: Example of band M4

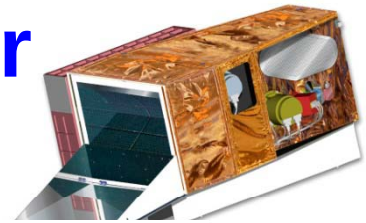


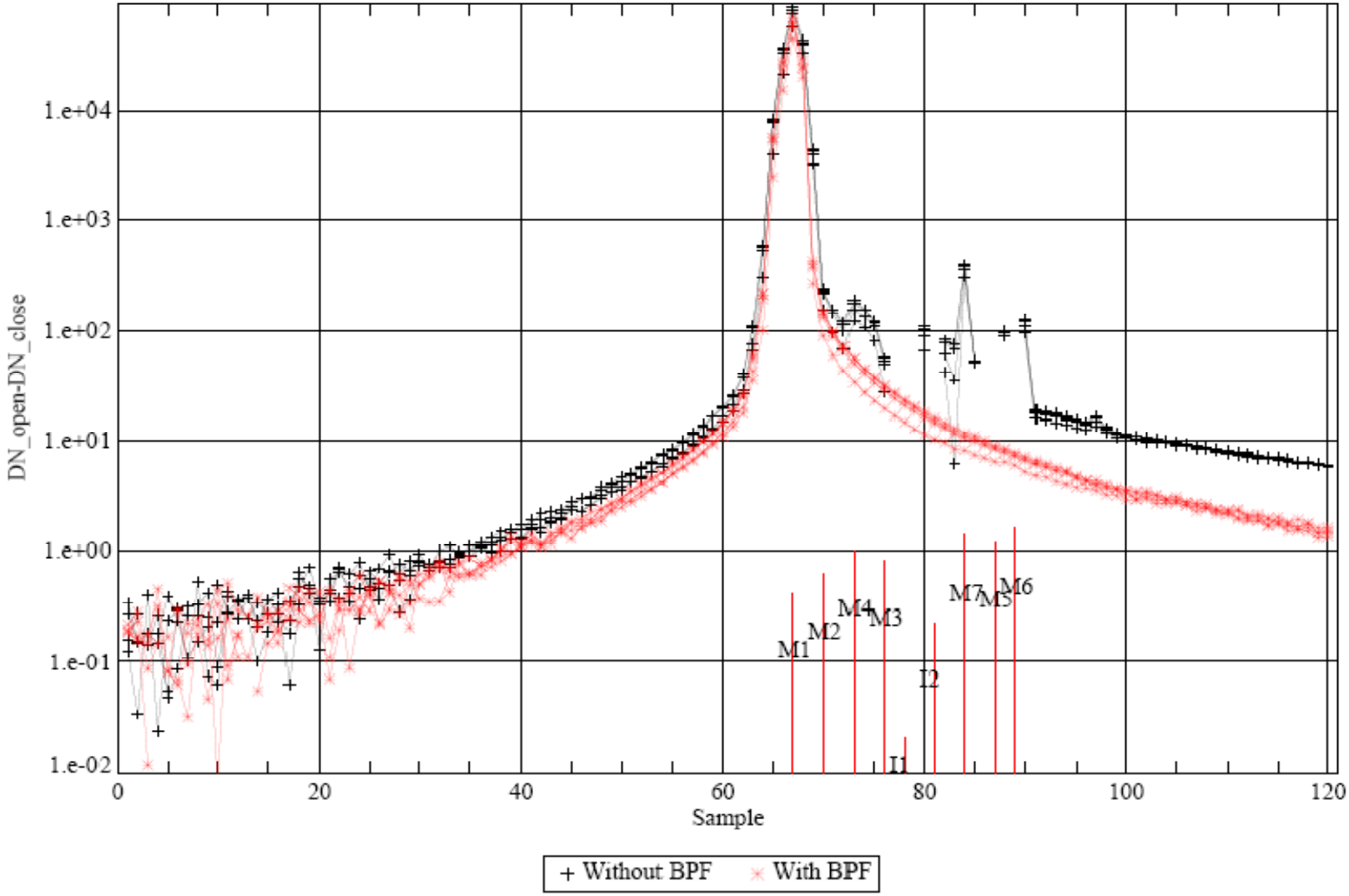




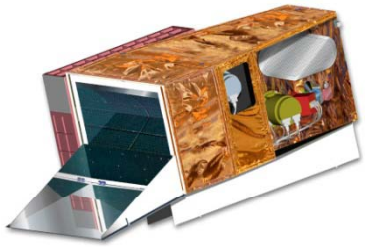
- The Harvey-Shack coefficient A and M is updated from FP-14 test data.
- Harvey-Shack fitting coefficient were generated for all bands

Comparison of composed NFR for band M1



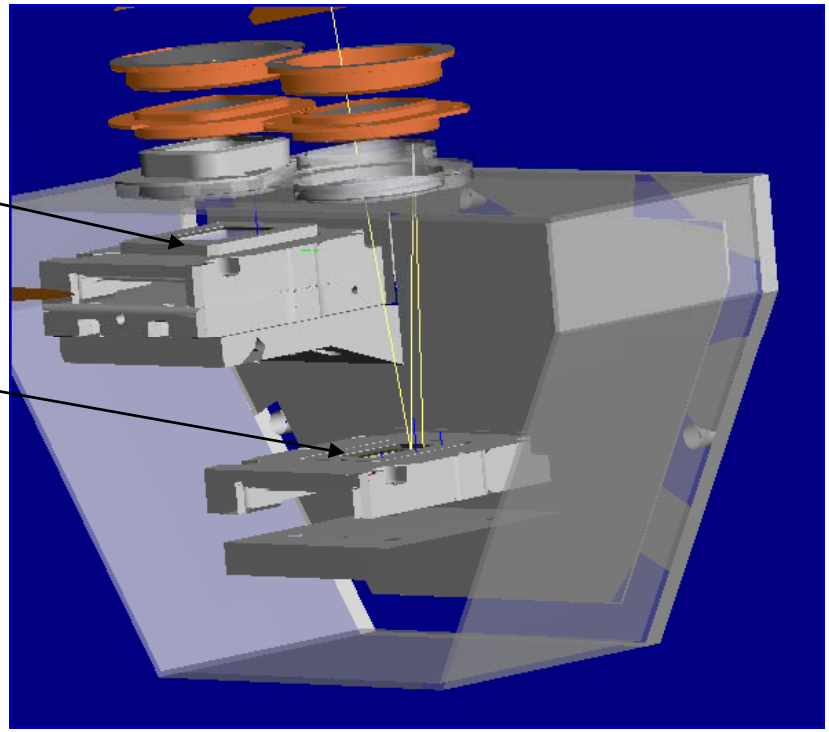


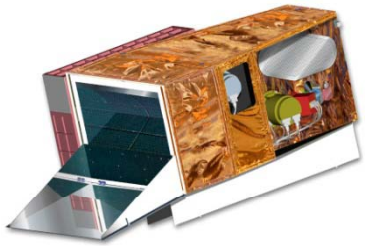
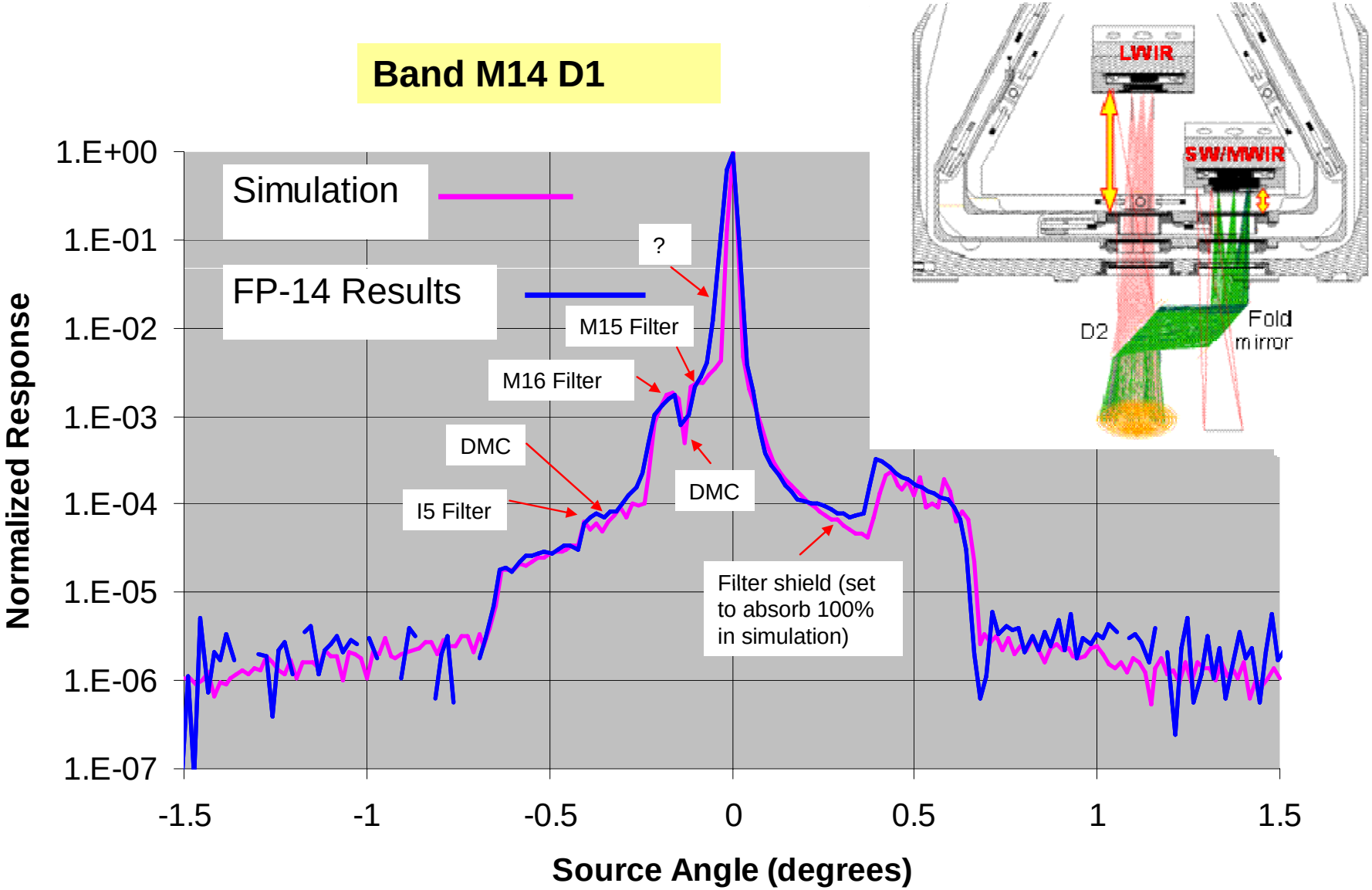
Configuration of Dewar Windows and FPAs



SMWIR IFA/FPA

LWIR IFA/FPA



- Ghosting identified as reflection of OOB light off IFA surface and reflected back by dewar windows to adjacent bands/detectors
- Larger spread angle expected for LWIR due to a larger separation between IFA and dewar windows
  - As observed in the analysis

VIIRS F1 NFR LWIR: Band M14